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ANNOTATED BIBLIOGRAPHY ON EFFECTS OF SALINITY AND SALINITY CHANGES ON LIFE IN COASTAL WATERS

by

S. H. Hopkins

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August 1973

Sponsored by Office, Chief of Engineers, U. S. Army

Conducted for U. S. Army Engineer Waterways Experiment Station
Vicksburg, Mississippi

Contract Nos. DACW39-72-C-0002, DACW73-69-C-0043, and
DACW73-70-C-0004

Department of Biology, Research Foundation, Texas A&M University
College Station, Texas

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ARMY-MRC VICKSBURG, MISS.

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FOREWORD

This bibliography was prepared by the Texas A&M Research Foundation under contract No. DACW39-72-C-0002 with the U. S. Army Engineer Waterways Experiment Station (WES) and contracts Nos. DACW73-69-C-0043 and DACW73-70-C-0004 with the Department of the Army, Office of the Chief of Engineers (OCE). Preparation of the bibliography was initiated on the recommendation of the OCE Estuarine Ecological Consultants Board in an Interim Report entitled "Effects of Engineering Activities on Coastal Ecology," September 1969.

The annotations were written or reviewed by Dr. S. H. Hopkins, and he was assisted by the following persons in writing the annotations: Judith Dickensheets, Thomas Rennie, Sandra Rennie, and Patricia Maxwell.

The contract was monitored by Mr. F. A. Herrmann, Jr., Chief of the Estuaries Division, WES, under the general supervision of Mr. H. B. Simmons, Chief of the Hydraulics Laboratory.

Directors of WES during the conduct of this study and the publication of the bibliography were BG Ernest D. Peixotto, CE, and COL G. H. Hilt, CE. Technical Director was Mr. F. R. Brown.

PREFACE

This bibliography is intended primarily for use in the estimation of probable ecological effects of engineering projects affecting the entrance of fresh water or sea water into coastal water bodies, but should also be helpful to all physiologists and ecologists interested in coastal life. It started with some 500 annotated references accumulated for my own use in various research projects. This collection was expanded and brought up to date with the help of contracts from the Corps of Engineers, U. S. Army; some of the older annotations were rewritten to make them more useful for the environmental experts of that organization. It is not claimed that the coverage is complete, but only that the search for more references had reached the point of diminishing returns.

The library of Texas A&M University was the main source of reference material. This library is unusually rich in pertinent literature because, as a land grant college, the university was strong in a number of biological fields and had numerous courses and researchers in aquatic, estuarine, marine, coastal, ecological, and physiological subjects even before it became a sea grant college and, even earlier, before it had departments of Oceanography and of Wildlife and Fisheries Science. Pertinent publications in the Texas A&M library provided lists of additional references which were then sought out, abstracted, and searched for still other references. Over 100 references not in the A&M library were obtained on interlibrary loans. For more recent references, the current and recent files of a number of journals were searched, and such standard sources as Biological Abstracts were used systematically. As a rule, author's abstracts in journals and those in Biological Abstracts were not used unless the paper was in a language such as Russian or Japanese that I could not read. I translated the key portions of articles in French, German, Italian, Spanish, Portuguese, and Dutch, with the aid of dictionaries. Most of the annotations are from the text, not from abstracts or summaries.

Authors are listed alphabetically, and each author's works are listed chronologically. Works by two or more authors are entered under the first author's name, following the reports of which he was sole author and in alphabetic order by second author, third author, etc.

The subject index provides for cross-indexing by subject. The classification of subjects is shown under "Categories of Subject Index." Cross-indexing is based on the annotations and other knowledge of contents of articles, not on the titles which are usually lacking in some essential information and frequently even misleading.

Judith Dickensheets, Thomas Rennie, Sandra Rennie, and Patricia Maxwell worked as library searchers in different stages of the project and wrote most of the annotations that were not written by me. William Kirk, Beverly Kirk, and Darla Guidry did odd jobs such as photocopying, cutting and pasting, and preliminary alphabetizing. Linda Harper was the typist throughout most of the project, including the crucial final stages. My wife, Pauline, helped in many ways in the evenings and on weekends. Credit for good features of the bibliography should go to these faithful helpers. I will take credit for all of its faults.

Sewell H. Hopkins
June 5, 1972

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ABSTRACT

References with annotations are given for about 1400 published and unpublished reports, dated 1972 and earlier, on physiological and ecological effects of salinity, salinity differences, and changes in salinity on organisms living in estuaries and other coastal waters. A subject index with cross-indexing is provided.

ANNOTATED BIBLIOGRAPHY

Adams, D. A. 1963. Factors influencing vascular plant zonation in North Carolina salt marshes. Ecology, 44:445-455.

Salinity increased landward from the "tall Spartina alterniflora" zone through the "medium S. alterniflora" zone, etc., reaching its highest level in the salt flats that contained no vegetation, then decreased abruptly in the Distichlis spicata and Spartina patens zones. From combined field and laboratory studies it was concluded that most salt-marsh plants show reduced growth and fertility with increasing salinity, and that 70 ppt (twice ocean salinity) prevents establishment and survival of all salt-marsh plants. S. alterniflora is restricted to low marsh by its requirements for moderate salinity and high iron concentration. Neither D. spicata nor S. patens suffers when grown in low-iron media. D. spicata and S. alterniflora are salt obligates, requiring salt for good growth; S. patens is a facultative halophyte and can grow without salt. (S. H. Hopkins)

Adolph, E. F. 1925. Some physiological distinctions between freshwater and marine organisms. Biol. Bull., 48:327-335.

Maximum survival concentrations of sea water and other solutions shown in table I, p. 330, for Gammarus fasciatus (100% sea water 5 hr), Phagocata gracilis (flatworm) (35% sea water 24 hr), Paramecium caudatum (17% 1 hr). These were freshwater animals. Marine animals: Gammarus locusta survived 5 hr in sea water diluted 99-1/2% with distilled water, Procerodes wheatlandi (flatworm) 24 hr in sea water diluted 98% with distilled water, copepod (unidentified) 1 hr in 60% dilution.

"It appears, therefore, that freshwater organisms are strongly contrasted to marine organisms with respect to their ability to adjust to changes in their chemical environment. Marine organisms, in general, maintain a higher degree of interchange of inorganic material with their surroundings. Freshwater organisms...have a more restricted and selective interchange, and thus dissolved materials are kept inside their bodies and water...outside." Dendrocoelum, Lumbricus, Phascolosoma were also studied. (S. H. Hopkins)

Ahuja, S. K. 1963. Salinity tolerance of Gambusia affinis. Indian Jour. Expt. Biol., 2:9-11.

Experiments with the freshwater bony fish G. affinis in experimental salt solutions made up of NaCl, KCl, $MgSO_4$, Na_2SO_4, and $Na(C)_3)_2$ showed that approximately 50% survived in salinity of 50 ppt; above this salinity, mortality is high. About 5% of fish survived 35-41 days in salinity of 80 ppt. Fish were acclimatized in a series of solutions of increasing salinity, as direct transfer to 20-30 ppt from fresh water kills fish in 75-90 min. Only 3-5% mortality occurred in 10 ppt. Temperature was 19-22 C. (S. H. Hopkins)

Alabaster, J. S. 1967. The survival of salmon (Salmo salar L.) and sea trout (S. trutta L.) in fresh and saline water at high temperatures. Water Research, 1:717-730.

Smolts were more sensitive than parr in fresh water when exposed to higher temperatures, although the difference was never more than 1.5 C. Acclimation to higher temperatures raised the lethal thermal limits. Increased body length had an adverse effect on lethal limit.

Salmon smolt are more sensitive to high temperature in full strength sea water than in fresh water. They are slightly less sensitive in 30% sea water (10.5 ppt). Acclimation increases resistance. (S. Rennie)

Albertini-Berhaut, Jocelyne. 1970. Distribution des trachymeduses Persa incolorata McCrady 1857 et Aglaura hemistoma Peron et Lesueur 1809 dans le Golfe de Marseille. (Distribution of the trachymedusae Persa incolorata McCrady and Aglaura hemistoma Peron and Leseur in the Gulf of Marseilles.) Bull. Soc. Zool. France, 95(4):677-687. (English summary.)

Both species are abundant throughout the year (34.28% of the hydromedusae observed). P. incolorata is relatively more abundant in the winter and especially in layers of cold water with higher salinity. (From Biol. Abstr.)

Alderdice, D. F. 1963. Some effects of simultaneous variation in salinity, temperature and dissolved oxygen on the resistance of young coho salmon to a toxic substance. Jour. Fish. Res. Bd. Canada, 20(2):525-550, illus.

Using a solution of 3 mg/l of sodium pentachlorophenate as the test poison, a complex formula was developed for the effect of combinations of the three factors. The maximum resistance was at 17.68 ppt, 4.86 C, and 7.66 mg/l of oxygen. (S. H. Hopkins)

Alderdice, D. F. and Forrester, C. R. 1968. Some effects of salinity and temperature on early development and survival of the English sole (Parophrys vetulus). Jour. Fish. Res. Bd. Canada, 25:495-521.

The eggs of P. vetulus are euryhaline, but successful development over a range of salinity is restricted by temperature. Incubation time increases with decreasing temperature. Largest larvae and greatest hatching efficiency were obtained at 25 ppt and 8 C (nearly identical with salinity at fertilization and temperature at the time of collection). Salinity of neutral buoyancy was constant at about 28-28.5 ppt. These eggs would probably sink (upon changing density) in waters of 27-30 ppt and remain floating above 30 ppt. Salinities above and below 25 ppt may delay development between 6 and 12 C.

Ecological implications of temperature and salinity effects over the geographical range of the English sole on the east Pacific coast are discussed. It is suggested that range and abundance are influenced more by temperature and that the extremes of the geographic range may be populated through larval drift or migration of older animals from the more central part of the range. (S. Rennie)

Alderdice, D. F. and Forrester, C. R. 1971. Effects of salinity and temperature on embryonic development of the petrale sole (Eopsetta jordani). Jour. Fish. Res. Bd. Canada, 28(5):727-744.

Newly fertilized eggs were incubated at 13 combinations of levels of salinity and temperature between 20 and 35 ppt and 4.1 and 8.5 C.... The percentages of eggs hatching (total hatch) and producing viable larvae (viable hatch) are examined with respect to salinities and temperatures of incubation. Calculated optima were: total hatch 29.47 ppt S, 6.65 C; viable larvae of the largest size at yolk exhaustion would occur from incubation at 27.5-29.5 ppt S and 6-7 C. Laboratory results are related to available hydrographic and meteorological data for a spawning area off the west coast of Vancouver Island. (From Biol. Abstr.)

Aldrich, David V. and Wilson, William B. 1960. The effect of salinity on growth of Gymnodinium breve Davis. Biol. Bull., 119(1):57-64.

G. breve (the dinoflagellate that causes Florida "red tide") grew well at salinities of 27-37 ppt, at least 80% of cultures reaching 750 or more cells per milliliter in 5 weeks. Outside this range results were variable, usually poorer. Optimum growth never occurred below 24 ppt or above 44 ppt. Cultures reach high populations more rapidly at 27-37 ppt. Some survival occurred from 22.5 to 46 ppt for 5 weeks, and at 18.3 and 17.8 ppt for 10 days. (S. H. Hopkins)

Aleem, Anwar Abdel. 1961. Effect of salinity on the growth and reproduction of a brackish water Spirogyra (S. salina nov. sp.). Vie et Milieu, 12(3):497-506, illus.

The new species of green alga, Spirogyra salina, in southeastern France inhabits "étangs" and thrives in salinities between 5 and 17.5 ppt. Optimum growth was at 13 ppt and optimum sexual reproduction was at 7 ppt (range 3-15 ppt). Sexual reproduction is suppressed by salinity of 20 ppt, but parthenogenetic spores develop in salinities above 5 ppt. (From author's abstract)

Alexander, W. B., Southgate, B. A., and Bassindale, R. 1932. The salinity of the water retained in the muddy foreshore of an estuary. Jour. Marine Biol. Assoc. U.K., 18:297-298.

In the Tees Estuary, the following salinities were found: 6 miles from sea, 28.4 ppt in mud, 12.6 in water at low tide, and 30 in water at high tide; 10 miles from sea, 11.5 ppt in mud at low tide, 0 in water at low tide, and 25 in water at high tide; and 11-1/4 miles from sea, 5 ppt in mud at low tide, 0 in water at low tide, and 21 in water at high tide. It is shown that in Tees and Tay Estuaries, the number of species of burrowing animals, as percentage of species at estuary mouth, decreases going upstream from 70% 4-1/2 to 6 miles from sea to 13% 9 to 10-1/2 miles from sea in Tees, and from 52% 7-1/2 to 10 miles from sea to 24% 15 to 17-1/2 miles from sea in Tay, compared with decrease of nonburrowing animals from 28% to 1% in Tees and from 57% to 13% in Tay at the same distances from sea. This is accounted for by the more stable salinities in the mud than in the water. (S. H. Hopkins)

Allee, W. C. 1934. Concerning the organization of marine coastal communities. Ecol. Monogr., 4:541-554.

Mostly a review of literature, including Verrill and Moebius on oyster beds. Macoma baltica, a brackish water species, replaced by Venus in higher salinities (Baltic region). (S. H. Hopkins)

Allee, W. C., Park, O., Emerson, A. E., Park, T., and Schmidt, K. P. 1949. Principles of animal ecology. W. B. Saunders Co., Philadelphia, xii + 837 pp.

Written by inland ecologists, this great book contains little marine or estuarine information.

The concept of "biocoenosis" from the study of oyster-bed communities by Moebius (1877) is explained in Moebius' own words, pp. 35-36; oceanography is discussed (historically), pp. 37-40; coastal and other substrates, pp. 158-163; osmosis and ionic exchange, pp. 167-172; the section on "dissolved salts as limiting factors" does not mention NaCl or salinity; salinity is discussed briefly on pp. 340-341 with references to Andrews (1940) on size of the snail Neritina virginea and to Cowles (1930) on diatom distribution; oyster-bed communities are mentioned again on p. 436; zonation of sea margins is described briefly, pp. 453-458; on pp. 191-192 it is mentioned that oxygen is about 17% less soluble in sea water than in fresh water; on p. 626, the relations of size to salinity in marine organisms, and number of fin rays and vertebrae to salinity in fishes, are examples of "ecoclines," and on p. 583 the brackish transition zone between river and sea water is called an "ecotone"; on p. 171 it is stated that salinity increases percentages of fertilization of eggs by sperm cells even in freshwater fish (trout). (S. H. Hopkins)

Allen, E. J. and Todd, R. A. 1903a. The fauna of the Exe Estuary. Jour. Marine Biol. Assoc. U.K., 6:295-335.

See also Allen & Todd, The fauna of the Salcombe Estuary. These two estuaries differ markedly and are compared. The Exe estuary has fewer species

because the intertidal bottoms are at a higher vertical level and are exposed longer, hence become drier, between tides. Also strong currents in Exe scour the bottoms, and more fresh water enters. The Exe has a watershed of 584 square miles compared with 33.25 square miles for Salcombe, and hence has lower salinity, since the estuaries are nearly equal in size. Many Salcombe species (17 are named) are absent from Exe, and others are rare or occur only at mouth. On the other hand 10 Exe species do not occur in Salcombe and others are less abundant in Salcombe. The species found farthest up Exe estuary, in Zostera bed, were Nereis diversicolor, Arenicola marina, Carcinus maenas, Scrobicularia piperata, Littorina littorea, and Hydrobia ulva. N. diversicolor and Hydrobia ulvae do not occur in Salcombe estuary. (S. H. Hopkins)

Allen, E. J. and Todd, R. A. 1903b. The fauna of the Salcombe Estuary. Jour. Marine Biol. Assoc. U.K. (N.S.), 6:151-217.

Only small streams enter Salcombe Estuary, and the salinity except in times of flood is very nearly that of English Channel water. The faunas of 12 regions of the estuary are discussed, followed by a complete list of the species identified by five authorities, but faunal differences are evidently determined by substrate, exposure, vegetation, and other factors other than salinity.

Redeke, 1932, says it is almost impossible to divide estuary of small British river with channel, such as Salcombe or Exe, into any zones at all (see Allen and Todd, The fauna of the Exe Estuary). (S. H. Hopkins)

Allen, J. Frances. 1960. Effect of low salinity on survival of the curved mussel, Brachidontes recurvus. Nautilus, 74(1):1-8.

Hooked mussels grew in large clusters on oysters on Hackett's Bar in the upper Chesapeake Bay while salinity fluctuated between 5.20 and 16.24 ppt, with mortality of only 1-2%. In January 1951 salinity dropped to 3.84, and to 2.85 in February, then rose to 6.91 ppt 5 March. From 5 March through 16 April there was 54.9% mortality in a bushel sample. Laboratory studies showed that there was no mortality at 6-6.5 ppt, 6% mortality at 5.6-5.9 ppt, 15% at 4.6-5.5 ppt, 98% at 3.6-4.5 ppt, and 100% at 0.9-3.5 ppt, in 19 days, at 18-21 C. It was concluded that at this temperature 4.5 ppt is the probable critical salinity. Apparently survival is better at low salinities when temperature is lower (it was 1.8-5.3 C in the bay when the January-February low salinity occurred). (S. H. Hopkins)

Allen, Kenneth. 1961. The effect of salinity on the amino acid concentration in Rangia cuneata (Pelecypoda). Biol. Bull., 121(3):419-424.

Specimens of this brackish water clam were taken from San Jacinto River near Houston, Tex., and placed in 5-gal aquaria with water mixed to the following salinities (with sea water and distilled water): 3, 6, 10, 17, 20, and 25 ppt. Amino acids were extracted after 2 days (20 days made no further change). Percent dry weight (in wet weight) increases in proportion to salinity from 18.18-20.38 in 3 ppt to 24.62-26.86 in 25 ppt (means 19.34 and 25.7, respectively). Percent ash weights also increase with salinity, glycogen decreases with an increase in salinity, indicating work done to maintain osmotic equilibrium. Concentrations of the amino acids alanine, aspartic, glutamic, and glycine increase with increase in salinity up to 17 ppt (but not all amino acids increase at same rate), then all decline in 20 ppt and further in 25 ppt. Loss of tissue water and gain of inorganic ions reach maximum in 17-20 ppt, then level off. Results suggest a shift in osmotic control at 17-20 ppt. Loss of amino acids after 17 ppt may be associated with this phenomenon. (S. H. Hopkins)

Allen, K. O. and Avault, J. W., Jr. 1970. Effects of salinity and water quality on survival and growth of juvenile pompano, Trachinotus carolinus. Pp. 147-155. In: Louisiana State University, Coastal Studies Bull. No. 5,

Special Sea Grant Issue, xvii + 184 pp.

Though normally found in moderate to high salinities, juvenile pompano can be stocked directly into waters with salinities as low as 3.5 ppt, and after 12 days of acclimation at this salinity these fish can then be stocked at salinities as low as 1 ppt. Juvenile pompano can grow in salinities as low as 5 ppt. Moe, Lewis, and Ingle (1968) in Florida got results suggesting that pompano grow faster at such low salinities. (S. H. Hopkins)

Allen, O. and Avault, J. W., Jr. 1971. Notes on the relative salinity tolerance of channel and blue catfish. Progr. Fish Cult. 33(3):135-137,

In aquariums, blue catfish (Ictalurus furcatus) had a significantly greater salinity tolerance ($P < 0.05$) than channel catfish (I. punctatus) of a similar age and size. Fish of both species took food at 14-ppt salinity, but they lost weight and mortalities were heavy over the 37-day test period. Blue catfish also exhibited a greater ability to reacclimate back to fresh water from saline water. (From Biol. Abstr.)

Amemiya, Ikusaka. 1926. Notes on experiments on the early developmental stages of the Portuguese, American and English native oysters, with special reference to the effect of varying salinity. Jour. Marine Biol. Assoc., U.K., 14:161-175.

This study examined the effect of different salinities on the early developmental stages of three oysters, and determined the salinity range in which development is possible for each. Temperatures were 18-21.5 C. Salinities (in ppt) were as follows:

	Ostrea virginica	Ostrea angulata	Ostrea edulis
Lowest limit	1.5 ppt	21 ppt	24 ppt
Too low	17-21	22-24	25-26
Favorable	22-24	25-27	27-30
Optimum	25-29	28-35	31-35
Favorable	30-33	36-38	36-40
Too high	34-38	39-42	41-43
Highest limit	39	43	45

In unfavorable salinities, retardation of development occurs. Nonsegmentation or nondivision of eggs and abnormal forms also occur in unfavorable conditions. (S. Rennie)

Amemiya, I. 1928. Ecological studies of Japanese oysters with special reference to the salinity of their habitats. Jour. College of Agriculture, Imperial Univ. of Tokyo, 9(5):333-382; 5 plates, 3 figs.

In the common Japanese species of Ostrea (gigas, spinosa, circumpicta, densellamellosa, rivularis) in high concentrations of salinity, the embryos have a tendency to lie apart from one another, frequently resulting in abnormal larvae. O. circumpicta and O. spinosa are adapted to high salinities, while O. gigas and O. rivularis are adapted to low salinities. O. densellamellosa is stenohaline in a relatively narrow range of salinity. (S. Rennie)

Amos, William H. 1957. Animals of the estuary. Estuarine Bulletin. (Univ. of Delaware Marine Lab.), 2(6):3-4.

Discussion of Nereis succinea as a typical estuarine animal. In Delaware Bay, found in salinities ranging from 8.8 to 30.7 ppt (outside of capes at mouth of bay). Greatest populations in midbay where salinity averages 20-21 ppt. Stomach contents show it is important item of food for many

estuarine fishes, also for crustaceans. (S. H. Hopkins)

Anderson, J. D. and Prosser, C. L. 1953. Osmoregulating capacity in populations occurring in different salinites. Biol. Bull., 105:369-370.

According to Martin (1968) in Ecology 49:1186, Callinectes and Venus show considerable variation in osmoregulatory ability according to where in the estuary they live. Crabs (Callinectes sapidus) from low salinity had significantly better survival than crabs from high salinity when put in sea-water solutions of less than 10% sea water. Regulation of blood concentrations failed in high salinity crabs at about 0.1 N NaCl equivalent and in low-salinity crabs at 0.04 N NaCl equivalent. After a week in 100% sea water both groups had same blood concentrations and critical external concentrations. Quahogs (Mercenaria mercenaria) and marsh mussels (Modiolus demissus) adjust their blood to external concentrations if they pump, but quahog failed to pump below 50% sea water and mussels stopped pumping when sea-water concentration was below 35%. Quahogs from low-salinity areas tended to pump at lower salinities than did those from higher salinity areas. (S. H. Hopkins)

Anderson, John B. 1968. Ecology of foraminifera from Mississippi Sound and surrounding waters. Jour. Alabama Acad. Sci., 39(4):261-269.

Definite foraminiferal facies exist as a result of ranges in and fluctuations of salinity. Elphidium gunteri and Ammonia beccarii indicate fluctuating salinity with A. beccarii apparently able to withstand greater fluctuation and lower salinity. Ammobaculites salsus and Miliammina fusca indicate low salinity, with M. fusca able to tolerate much lower salinities. (From Biol. Abstr.)

Anderson, W. W., King, J. E., and Lindner, M. J. 1949. Early stages in the life history of the common marine shrimp, Penaeus setiferus (Linnaeus). Biol. Bull., 96:168-172.

At the end of two postlarval stages and 15-20 days after hatching, the young shrimp is 5-6 mm long and still planktonic. During this period of early development, young shrimp have moved from the saline offshore spawning area to the brackish inside marshes, bays, and estuaries, the "nursery grounds," where for the first time they become benthic. It is believed they must use incoming currents to accomplish this inshore movement. Young shrimp approximately 7 mm long are found in early spring in brackish inside areas, their nursery grounds for the next 4-8 weeks, in shallow, muddy-bottomed, moderate- to low-salinity areas. They can be caught in great numbers there with nets which catch none of this size on ocean or gulf beaches. As they grow, they move from shallow marsh, bayou, and lagoon waters into deeper creeks, rivers, and bays, making first appearance on inside fishing grounds when about 50 mm long. Louisiana, which has more passes and a larger inland water area than any other state, produces about two-thirds of the shrimp caught. Number of passes and extent of nursery grounds are two major factors for production. (S. H. Hopkins)

Andrews, E. A. 1940. The snail, Neritina virginea L., in a changing salt pond. Ecology, 21:335-346.

According to Allee et al. (1949) Principles of Animal Ecology, pp. 340-341: Snail Neritina virginea in "salt pond" near Kingston, Jamaica; during periods when pond is connected with ocean the salinity is lower, much like salinity of sea, and snails are larger but less numerous; when pond is cut off from sea for considerable periods salinity increases by evaporation and snails become more numerous, but dwarfed in size. (S. H. Hopkins)

Andrews, F. B. 1925. The resistance of marine animals of different ages. Publ. Puget Sound Biol. Sta., 3:361-363.

Tests of capacity of the common animals of the Pugent Sound area to resist extreme conditions were made. Size was used as the criterion of age. Comparisons were made of different stages of 16 species in high temperature, increased acidity, reduced salinity, fresh water, stagnant water, and strong light. In one test, Strongylocentrotus drobachiensis, Achmaea pelta, and Hyas lyratus were taken from sea water and placed in ordinary drinking water (f.w.). For all three groups, the smaller animals died first. It was suggested that this might have resulted from the decrease in surface in proportion to the volume in the larger animals. When young isopods (Pentidotia wosnessenskii) were removed from the brood pouch of the parent and tested, the young lived 107 min compared with 159 min for the adult. The survival time for the young decreased rapidly with increase in time in the sea water. (T. Rennie)

Andrews, J. D. 1964. Oyster mortality studies in Virginia IV. MSX in James River Public Seed Beds. Proc. Nat. Shellfish. Assoc. (1962), 53:65-84.

"MSX," an unnamed pathogen of oysters, caused an epizootic in Chesapeake Bay which removed from production nearly half of Virginia's private oyster-planting acreage between 1959 and 1961. The organisms did not appear in James River seed beds until fall of 1960. A tongue-shaped distribution of MSX was apparently related to influx of salt water along the channel. In 1960-61 and 1961-62, infections of MSX appeared at Wreck Shoal in the middle of the seed area in October, and disappeared the following April coincident with lowest salinities. Infection levels were approximately 30-35% each year in populations adjacent to the channel. No appreciable cold-season mortality occurred at Wreck Shoal. MSX was nearly absent from Wreck Shoal oysters during the warm season in summer salinities of about 15 ppt, but at Brown Shoals, with salinities 2 or 3 ppt higher, it persisted through spring freshets and caused summer deaths. From observations for three rather wet years, it is concluded that persistence of MSX infections in the James River seed area depends upon importation of infective material from the saltier waters of lower James River and Hampton Roads. Also, damage to the seed area will probably be reflected in quality of seed rather than direct mortality. Planting infected seed in high salinity waters leads to serious losses. (Abstract)

Andrews, J. D., Haven, D., and Quayle, D. B. 1959. Fresh-water kill of oysters (Crassostrea virginica) in James River, Virginia, 1958. Proc. Nat. Shellfish. Assoc. (1958), 49:29-49.

Fresh water invaded the upper half of James River seed (oyster) area in winter and spring of 1958. Many oysters died between 1 May and 15 Jun. On some grounds, salinities did not become suitable until 1 Jul when temperature had reached 23 C. Death rates of native oysters were as high as 90%. Oysters exposed to fresh water from midwinter were "conditioned" to a low physiological state as evidenced by absence of heartbeat, ciliary motion, and mantle sensitivity when first opened. Oysters held in trays at one extremity of the seed area withstood freshwater conditions in a manner similar to that of oysters on natural bottoms...in accordance with their previous history of exposure. Oysters in pans of fresh well water at the laboratory endured unsuitable conditions for periods similar to those in James River. Once broken, the "conditioned" state could not be regained at temperatures favoring activity. Apparently slow conditioning of oysters at low salinities and low temperatures induces a state of "narcosis" that permits conservation of food supply and evasion of effects of temperature rises. This state lasts only as long as closure is continuously enforced by fresh water or other factors. Salinities from 22 Apr to 23 Jun were from less than 1 to less than 5 ppt. (Author's abstract)

Annandale, N. 1907. The fauna of brackish ponds at Port Channing, Lower Bengal. Part III. An isolated race of the actinian Metridium schillerianum (Stoliczka). Rec. Indian Mus., 1:47-74.

Sea anemone, adults buried in mud and young attached to solid objects and also in water passages of Spongilla cerebellata, in ponds with salinity of 2 ppt. Green (1968, pp. 114-115) cites with comment that this seems to be the only sea anemone whose range overlaps that of a freshwater sponge (Spongilla). (S. H. Hopkins)

Annandale, N. 1915a. Fauna of the Chilka Lake. Memoirs Indian Mus. Calcutta, 5:1-146.

The Chilka Lake is a shallow (8 ft deep) coastal lagoon with a very narrow pass connecting it to the Bay of Bengal. The salinity varies seasonally; much of the lake is fresh part of the year, but salt water enters the outer channel all during the year and spreads through the lake during the dry season. A few pond-weed-type plants occur. The fauna is a peculiar mixture of fresh water, estuarine, and marine. The sponges are most interesting because both fresh-water Spongillidae (Spongilla alba, S. lacustris) and marine sponges (the boring sponge Cliona vastifica, Suberites sericeus, Laxosuberites aquae-dulicoris, L. lacustris, Tetilla dactyloidea) occur in the same parts of the lake though not necessarily at the same time. Other animal groups include 8 sea anemones, 1 scyphozoan, 10 hydrozoans, 1 ctenophore, 2 ectoproct bryozoa, 1 entoproct, 2 barnacles (Balanus amphitrite and a goose barnacle on gills of the crab Scylla serrata), 3 oligochaetes of terrestrial type (but in the water), and 1 echiuroid (Thalassema dendrorhynchus). (S. H. Hopkins)

Annandale, N. 1915b. Indian boring sponges of the family clionidae. Rec. Ind. Mus., Calcutta, 11:1-24; plate i.

Key to genera; key to Indian species of Cliona; 16 species known from Indian Ocean, of which at least 12 found in Bay of Bengal and Gulf of Manaar. Cliona carpenteri is circumtropical, C. celata, C. vastifica, and C. viridis cosmopolitan. C. vastifica, by far the commonest species in Indian littoral zone, extends far into brackish water, destructive to oysters and pearl oysters. C. annulifera n. sp. at depth over 700 fathoms, Bay of Bengal. Other Indian species described: C. margaritiferae, C. mucronata Sollas, C. ensifera Sollas, C. orientalis, C. acustella, C. patera (Hardwicke), and 4 species of Thoosa. (S. H. Hopkins)

Annandale, N. 1922. The marine element in the fauna of the Ganges. Bijdr. Bierk. Amsterdam (Feest-Num., M. Weber), pp. 143-154.

In discussing the fauna of the Ganges, three groups are distinguished: those of the upper waters where there is no marine element, those in the middle reaches which lie beyond the limits of tidal influence and comprise a fluviatile fauna in which the marine element is small and is completely cut off from the sea. It is called the relict fauna of the Ganges. In the lower Deltaic tract, where tidal conditions exist, are organisms that withstand transitions from fresh to salt water. They are mainly of marine origin and are called Euryhaline fauna by the author. This fauna is rich and varied and includes members of most of the macroscopic phyla except the Echinodermata. Specific mention is made of the Hydrozoan, Campanulina ceylonensis whose medusae were originally described from the sea, but since had been found in brackish waters of India and Thailand. In waters of 1.0085 specific gravity around Calcutta, medusae and hydroids become abundant, but when the rainy season comes and the specific gravity decreases, they become scarcer and finally disappear when the specific gravity reaches 1.0060. (T. Rennie)

Anonymous. 1945. Hydrology in oyster farming. Fisheries Newsletter (Australia), September 1945, Vol. 4, No. 5, p. 16.

P. 16--Mr. D. J. Rochford, Hydrologist, said "that extensive surveys of estuarine systems had been made, and for the purpose of research, all estuarine systems had been divided into four defined zones--the fresh water, the conflict (where salt and fresh waters intermingle), the stable zone (occupying the middle region of the estuarine system), and the marine zone (adjacent to the entrance). It was suggested that the important feature of the stable zone, in which oysters were fattened, was the availability of bottom muds with a high phosphorous content, from which the oyster ultimately obtained its supply of this necessary element.... In those estuarines where good spat falls are obtained, there was a predominance of marine zone characteristics. For the first two or three weeks of its existence, the larval oyster is a voracious feeder upon small plankton, and it was in the marine zone that these food requirements could best be met.

"Mr. Rochford said that the reason spat did not develop commercially in the areas in which it was best caught was apparently because of the general absence of phosphorus-rich muds in the marine zone." (S. H. Hopkins)

Anonymous. 1946. Oyster production decline worries Maryland oystermen. Southern Fisherman, VI(7):99-100.

"The mortality of oysters in a 100-square-mile section of upper Chesapeake Bay, ranging as high as 75 percent on certain bars...has been disclosed by a survey...[which] began last November.... Recent mortality on these bars, affecting both young and adult oysters, varied from 7 to 75 percent...most severe in the northern part of the affected area, gradually decreasing toward the south.... Milton C. James of the Fish and Wildlife Service announced at the completion of the survey that the heavy mortality was due to the fact that the salinity of the water in the upper bay has been only one-half to one-third of the normal content during the past year, and that this unfavorable condition is believed responsible.... Daily records made at Solomons Island...show that from July 1945 to March 1946 salinities have remained at the lowest levels reached in the past 9 years. These unfavorable conditions are due, in part, to local heavy rains in the areas feeding into the bay during the latter part of last summer, thus preventing the normal recovery of oysters after spawning season, and also seriously affecting their feeding. As a result, oysters in the upper bay regions were in poor condition in the fall, and unable to withstand continuous exposure to low salinity conditions.

"...high death rates of oysters have occurred...in 1908, 1916, 1928, 1936, and 1943. In each instance, high mortality coincided with an abnormally high runoff of the Susquehanna River and low salinity of the bay water." (S. H. Hopkins)

Anonymous. 1947. Pests that prey on oysters. (Australian) Fisheries Newsletter, The Commonwealth Fisheries Office, Dept. of Commerce and Agriculture, Sydney, N.S.W., June 1947, Vol. 6, No. 3, pp. 8, 24.

P. 8--"Drills are responsible for oyster losses in restricted parts of the Australian area. The drills are conical shellfish of the whelk family, which attack their prey by boring with a rasplike tongue known as a radula through the oyster shell. The clean circular hole produced is seen in many shellfish washed up on the beaches, as well as on affected oysters.

"Three types of borer occur. They are known by different names in different localities but most usually as the Common borer, Black borer, and Hairy borer, names which are self-descriptive. The only means devised to combat these pests is to remove them from the water whenever found. Fortunately the periodical freshets to which most oyster beds are subject destroy the borers."
(S. H. Hopkins)

Anonymous. 1947. Pests that prey on oysters. Fisheries Newsletter (Australia), 6(3):8, 24.

P. 8--"Occasional periods in near-fresh water are good for oysters. For some reason they grow better under such conditions than when always immersed in salt

water, but long continued flooding by fresh water is disastrous and occasional heavy killings result, particularly in the northern rivers of New South Wales. Silt from these same floods may also submerge and smother beds of oysters. ... Fortunately [starfish] are rare in Australian oyster districts.... Fortunately the periodical freshets to which most oyster beds are subject destroy the borers."

Anonymous. 1944. Spawn, hatch and survive? Maryland Tidewater News, 1(5):2.

Although egg-bearing female blue crabs (Callinectes sapidus) are sometimes found in upper Chesapeake Bay, the newly hatched crab larvae die because of the low salinity. (Fide Tagatz and Hill, 1971, p. 47.) (S. H. Hopkins)

Anonymous. 1959. The Delaware river estuary. A report on its biological productivity. Estuarine Bulletin 4(4):17-19.

Brief review of history of diversion of Delaware River water to New York City, increasing salinity of Delaware Bay to detriment of shellfisheries. In 1931, U. S. Supreme Court awarded 440 million (of 600 million asked for) gallons of Delaware River water to New York City. In 1954 U. S. Supreme Court approved use of maximum 800 million gallons of Delaware River water by New York City. Figures are gallons per day. (S. H. Hopkins)

Anonymous. 1931. The Louisiana oyster. Louisiana Dept. of Conservation, Bull. No. 1 (revised):1-32. (Apparently edited by McConnell, J. N., from data furnished by Burkenroad, M. D.)

P. 11--"out-pouring of fresh water" from rivers helps give Louisiana "ideal conditions for the propagation and cultivation of the oyster." Pp. 27-32 constitute a section entitled, "Notes on the life-history of the Louisiana oyster-drill, Thais haemastoma, Linn," in which it is stated that this predator is "limited to waters of fairly high salinity" and is "killed by water in low salinity." On p. 32 it is suggested that, during periods at higher salinity in upper bays where mussels overcrowd oysters, drills could be trapped in high salinity areas and transported to the mussel-infested beds to eat the mussels, which they prefer to oysters. (S. H. Hopkins)

Anonymous. 1945b. Virginia crab, oyster losses caused by rains. Atlantic Fisherman, xxvi (8):38.

"It is reported that oysters in the James, York, Rappahannock, and Potomac Rivers, as far down as points 30 miles from their mouths, were killed from water freshened by the rains." (Not true!-S.H.H.) (S. Rennie)

Archer, A. F. 1947. A scientific study of conditions and effects of the 1947 hurricane on oyster reefs in Alabama. Alabama Conservation, 19(6):7, 12. (Mentions Thais floridana among enemies of oysters.)

Thais was found in 5 dredge hauls out of 12; shells with Bryozoa or sponges were found in only 2 dredge hauls. Archer calls attention to scarcity of sponges and other fouling organisms due to the fact that "a sufficient quantity of fresh water enters the sea to prevent the rapid reproduction of both these pests" (fouling organisms and drills). The trip was made 27-28 October 1947. (S. H. Hopkins)

Arnold, Edgar L. and Thompson, John R. 1958. Offshore spawning of the striped mullet, Mugil cephalus, in the Gulf of Mexico. Copeia, 1958:130-132.

Striped mullet were observed spawning offshore in the northern gulf in 755 fathoms (fm) at approximately lat. 28°20' N., long. 88°45' W. Positive

identification of adults, planktonic eggs, and several larval stages confirmed this report. Other large schools offshore in the gulf were reported 50 miles southeast of Aransas Pass, Tex., in 42-59 fm, and 65 miles south of Mobile, Ala., in 20-25 fm. In these cases spawning behavior was not observed. The authors state that the first observation does not exclude the possibility of inshore spawning. [However, all cases of M. cephalus spawning have been observed in gulf or ocean--S.H.H., 1971.] (S. Rennie)

Aron, W. I. and Smith, S. H. 1971. Ship canals and aquatic ecosystems: equilibrium has not been achieved since the Erie, Welland, and Suez canals were built. Science, 174(4004):13-20. (1 Oct.)

Reviews the ecological effects of the three canals, especially the movements of species through these canals into new ranges. In the Suez Canal the high salinity (originally 68 ppt) of the Bitter Lakes was one of the main obstacles to migrations of fishes, etc., through the canal from Red Sea to Mediterranean. Deepening of the canal in middle 1950's has reduced Bitter Lakes salinity to about 41 ppt, increasing possibility of passage of species from one sea to the other. The former "brackish barrier" due to Nile River flow has been "basically eliminated" by the Aswan Dam impoundment. The eastern Mediterranean is still in a state of disequilibrium due to entrance of new species and the changes mentioned. The proposed sea level canal across Central America, differing from the present Panama Canal which has a freshwater barrier in Gatun Lake, is predicted to cause changes in Atlantic and Pacific ecosystems which may be modest during next 50 years, on basis of Suez Canal experience, but might ultimately be great--better, worse, or neutral as to impact on man. (S. H. Hopkins)

Atwater, W. O. 1888. Fattening of oysters, chemical changes produced in floating. Appendix B. Troy Press. Reprinted from Trans. Amer. Fish. Soc. 16th Annual Meet., New York, 1887:37-52.

The practice of putting oysters into fresher water before or after opening results in the increased plumpness and weight of the bodies. This is thought to be caused by osmosis. In addition some nutritive material is lost in the process, probably due to secretory action. (S. Rennie)

Awati, P. R., and Rai, H. S. 1931. Ostrea cucullata (The Bombay oyster). The Indian Zoological Memoirs on Indian Animal Types, III. Lucknow (Methodist Publishing House), xi + 107 pp; 51 figs., 57 refs.

P. 9--Ostrea cucullata "...inhabits largely the brackish water area and is found attached to pieces of rock in the intertidal zone, the most suitable places being the mouths of estuaries where there is a constant flow of fresh water." P. 11--"The oyster seems to have many enemies in the organic as well as in the inorganic world. Amongst the latter, mud, slime, drifting sand, and more than the usual amount of fresh water are the chief enemies. During the monsoon, the mortality amongst oysters due to these causes is very high. During this period, the density of sea water falls below 1.020 by the admixture of a large quantity of fresh water brought into the sea by different rivers and this has an adverse effect on the metabolism of the oyster. Further, these rivers bring down a great amount of mud and silt which are deposited in the intertidal zone where oysters mostly live. Consequently, they are buried beneath the mud and silt and destroyed. Lastly, sand drifts are numerous and dangerous in the monsoon and bury entire beds under them."

P. 91--"Along the coast of Bombay, spawning continues almost throughout the year except during the monsoon--from the middle of June to about the end of September. During the monsoon, there is a sudden change in the density of sea water which may fall below 1.012. This affects the metabolism of the oyster and causes a great deal of mortality amongst them. The spawning period starts about the middle of October, when the average temperature of the land is about 83.7 F

and the density of the sea water is 1.021. It continues throughout the winter months, but owing to the low density of sea water during these months, the spawning is not so regular or prolific. The principal season seems to start during the month of March and is indicated by a heavy spat formation."

P. 92--"Salinity and temperature of sea water seem to be the two chief factors controlling the spawning of the oyster. The optimum salinity for the spawning of O. cucullata seems to be in the proportion of 3:1 of brine and fresh water and the optimum temperature from 80 to 87 F.... Culture media of various strengths were prepared (for study of development of larvae) by mixing sea water with fresh water...the mixture that gave the best results for this species was found to be of about 1.020 or 1.021 density, the proportion being about three parts of sea water to one part of fresh water."

Bacesco, M. C. and Margineanu, C. 1959. Eléments méditerranéens nouveaux dans la faune de la mer Noire, rencontrés dans les eaux de roumélie (norde ouest Bosphore). Données nouveaux sur le problème du peuplement actuel de la mer Noire. Arch. Oceanogr. Limnol., Roma, 11. Supplement: Symposium on the classification of brackish waters, pp. 63-74.

The sea cucumber Leptosynapta inhaerens is reported from the Black Sea in a bottom salinity of 18 ppt. (Fide Binyon 1966, which see.)

Baggerman, Bertha. 1960. Salinity preference, thyroid activity and the seaward migration of four species of Pacific Salmon (Oncorhynchus). Jour. Fish. Res. Bd. Canada., 17(3):295-322.

Chum, pink, coho, and sockeye salmon changed preference from fresh to salt water at the onset of seaward migration and maintained this preference throughout the migration season. At the end of this migration period coho and sockeye changed preference from salt to fresh water if retained in fresh water, indicating a readaptation to this medium in which they may survive for several years. Chum and pink fry did not show this. (Author's abstract in part)

Bahl, K. N. 1947. Excretion in the Oligochaeta. Biol. Rev., 22:109-147.

Classification, structure, and deposition of nephridia are discussed to a considerable extent.

In the earthworm Pheretima posthuma, osmotic concentration of the blood and coelomic fluid is higher than that of the surrounding medium. Hypotonic urine is produced. When immersed in fresh water, as much as 11-26% gain in weight takes place during the first 5 hr. After 8 or 9 days the weight varies only about 2-3%. Urine flow in the natural environment is very slow. (S. Rennie)

Baid, Inder Chand. 1963. The effect of salinity on growth and form of Artemia salina L. Jour. Exptl. Zool., 153(3):279-284.

Female Artemia reared in 12.5% (125 ppt) salinity grow faster than in 6.5% (65 ppt). Size of adults varies inversely with salinity. In lower (65 ppt) salinity, Artemia have longer body, small and thick abdomen with longer caudal furca, and later sexual maturity (associated with slower growth); those in 125 ppt have the opposite features. (S. H. Hopkins)

Bailey, J. E. 1971. Osmoregulatory capability in juvenile sockeye salmon (Oncorhynchus nerka). Canadian Jour. Zool., 49(6):841-845.

The osmoregulatory capability of O. nerka embryos and fry was tested at weekly intervals by exposing them for 5 days to sea water with a salinity of 29 ppt. Juveniles that survived the 5-day test were considered to be euryhaline. The fry acquired a salinity tolerance in March 1968 when they were 64 days old and less than 35-40 mm long. The juvenile salmon retained the ability to survive direct transfer to sea water during the 12-month period following March 1968. (From Biol. Abstr.)

Baird, R. H. 1966. Factors affecting the growth and condition of mussels (Mytilus edulis L.) Fishery Invest., London (2) 25(2):1-33.

To determine whether reduced salinities affected growth of the mussel, Mytilus edulis, four cages of 50 mussels each were placed sublittorally at four places in the Conway Estuary, Wales, ranging from the upper limit of mussels (lowest salinity) to the most seaward point of naturally occurring mussels in the estuary. The two higher stations had higher growth rates than the growth rate of the seaward station. It is mentioned that the "normal functioning" of mussels takes place at a specific gravity

of 1.014 and ceases at about 1.010-1.012. (T. Rennie)

Balasubrahmanyan, K. 1960. Studies in the ecology of the Vellar Estuary. I. A preliminary survey of the estuarine bottom and its fauna conducted on 11-9-59. Jour. Zool. Soc. India, 12(2):209-215, illus.

The grade analysis of the bottom deposits and the hydrological conditions of the various stations are given and the description of the dominant species of each station is given. (D. B. Sayena)

Ballard, Buena S. 1968. Osmotic accommodation in Callinectes sapidus Rathbun. Ph. D. thesis, Mississippi State College, 1967. Dissert. Abs., 28(9):3921B.

"Crabs passed through a series of salinities demonstrated good hyperregulatory ability, were nearly homoiosmotic at medium salinities, and approached isoosmoticity at high salinities. Males had lower concentrations than females at salinities less than 20 ppt. Seasonal effect. Factors that might affect crab distribution patterns are discussed." (Tagatz and Hill, 1971, pp. 6-7.) (S. H. Hopkins)

Ballard, Buena S. and Abbott, Walter. 1969. Osmotic accommodation in Callinectes sapidus Rathbun. Comp. Biochem. Physiol., 29:671-687.

Salinity and temperature influence blood osmoconcentration of adult C. sapidus. Osmoregulation is possible over a wide salinity range, but hyporegulation is exhibited only at high temperatures. An inverse relation exists between temperature and blood concentration. A seasonal effect persists under experimental conditions of constant temperature. Males have lower blood concentrations than females at salinities below 20 ppt except at extreme dilutions. Both sexes exhibit hysteresislike response at salinities of about 15 ppt. Blood concentration after acclimation is higher when a given salinity is approached from a higher salinity than when approached from a lower one. Total organic substances and ninhydrin in reactive substances in the blood vary without apparent relation to blood osmoconcentration. Inorganic substances change with blood concentration. (Author's abstract)

Banner, A. H. 1968. A fresh-water "kill" on the coral reefs of Hawaii. Hawaii Institute of Marine Biology, University of Hawaii, Technical Report No. 15, October 1968. Honolulu. 29 pp., processed.

Severe rainstorm 1-3 May 1965, with total precipitation 10-28.5 in. over drainage area of Kaneohe Bay, killed coral during week of 2-8 May. Surface waters were muddy and almost entirely fresh on 3 May, with salinities as low as 7.84 ppt (at freshest station) on 7 May. By 8 May surface salinities were 20 ppt or higher. During this period southern Kaneohe Bay developed H_2S odor, and water became "slimy," with lowered oxygen content (3.01 ml/l at 2 m, 2.89 ml/l at 3 m) on 12 May. There was a bloom of an unknown "green plankter" on 9 May, which became more and more extensive subsequently. Animals killed included the three most common sponges, all Pennaria (Hydrozoa), sea anemones, zoanthids, reef corals, some annelids, some shrimps and crabs, some molluscs, and nearly all echinoderms; also some fishes. Most animals were reestablished in 3 yr, but reef corals were only beginning to recolonize the killed areas. (S. H. Hopkins)

Barans, C. A. 1972. Spotted hake, Urophycis regius, of the York River and lower Chesapeake Bay. Chesapeake Sci., 13(1):59-68.

Young-of-the-year fish were found in York River and lower Chesapeake Bay from March to June when bottom water temperatures were 6.5-25 C, but were not found in salinities lower than 7 ppt and were caught in progressively higher salinity as water temperature increased above 18 C. In April, fish upriver were larger

than those downriver, presumably because of faster growth in the higher temperature and richer food supply of the upriver (lower salinity) waters. (S. H. Hopkins)

Barker, Dennis. 1963. Size in relation to salinity in fossil and recent euryhaline ostracods. Jour. Marine Biol. Assoc. U. K., 43(3):785-795.

Ostracods live mostly in interstitial water in bottom. Studies on living ostracods in mud samples from the Tamar Estuary along the salinity gradient from the sea to fresh water show that there is a decrease in size of each species with decreasing salinity. The same principle is presumed to apply to fossil ostracods and to explain the observed graduations in size. (S. H. Hopkins)

Barlow, John P. 1955. Physical and biological processes determining the distribution of zooplankton in a tidal estuary. Biol. Bull., 109(2):211-225.

The estuary studied was Great Pond, an inlet of Vineyard Sound, Mass. The planktons studied were mainly copepods, especially Acartia. Where salinities were less than 15 ppt the "arm" (upper end of estuary) replacement rate of Acartia was so high that concentration was increasing in spite of seaward movement of water. At 15-25 ppt, replacement about balanced outward movement of copepods as water moved seaward. At salinities above 25 ppt, Acartia were being removed faster than they could be replaced. The highest reproduction rates were in salinities of 10-15 ppt, where the population could double in 2 days. Mortality was high in the lower (more saline) end of the estuary, and reproduction was slower. The species studied was Acartia tonsa. (S. H. Hopkins)

Barlow, John P. 1958. Springs changes in phytoplankton abundance in a deep estuary, Hood Canal, Washington. Jour. Marine Res., 17:53-67.

The observations were made January-May 1953. Throughout this period there was always a surface layer of lower salinity water, 15-29 ppt (means by months, 27.24-28.83 ppt) 5-20 m thick, overlying sea water of 30.80-31.87 ppt, with very little vertical mixing. Spring phytoplankton (especially diatom) bloom occurred, not due to change in stability of water column, but by seasonal increase in solar radiation and transparency which cause more illumination in the mixed surface layer and more photosynthesis, so that there was an increase in the plant pigments measured. (S. H. Hopkins)

Barlow, John P., Lorenzen, Carl J., and Myren, Richard T. 1963. Eutrophication of a tidal estuary. Limnol. and Oceanogr., 8(2):251-262, illus., map.

Force River, which runs into Moriches Bay, Long Island, N. Y., has a maximum depth of only 6 ft but is definitely stratified with a fairly distinct halocline 1/4 m deep near landward end, 1/2 m deep over most of the estuary. Most of the river water moves seaward through the brackish surface layer. No salinity data are given, though salinity determinations were made and it is stated that the deeper layer is only slightly less saline than the adjacent Moriches Bay, while the surface layer was apparently nearly fresh. (S. H. Hopkins)

Barnes, H. 1953. The effect of lowered salinity on some barnacle nauplii. Jour. Animal Ecol., 22:328-330.

Kreps 1929, Borusk & Kreps 1929, had established that adult Balanus balanoides (L.) and B. crenatus Brug. stand large salinity changes. At a salinity of 6 ppt, cirri stopped moving, respiration fell to a low level, and animal remained in state of "salt sleep" in which it could survive 3 weeks in fresh water. Cirral beating was normal in 12-ppt salinity. In present paper, reactions of early nauplii of B. balanoides, B. crenatus, and B. balanus to

salinity changes are compared. Results indicate clearly that salinity range tolerated by nauplii could be important in determining distribution. None of these three is likely to spread into water of salinity much less than 16 ppt, unless a distinct brackish-water race is developed. Nauplii of B. balanus are less resistant to lowered salinity than other two species. B. balanoides larvae are slightly more resistant to low salinity than those of B. crenatus. Known distribution of the three species is in agreement with these results (in North Sea, Skagerrak, Katteget, and Baltic, B. crenatus enters Baltic, B. balanus is not found east of Katteget, B. balanoides extends into Katteget but not into Baltic). B. improvisus, however, is really euryhaline. (S. H. Hopkins)

Barnes, H. and Barnes, M. 1958. A note on the opening response of Balanus balanoides (L.) in relation to salinity and certain inorganic ions. Veroff. Inst. Meeresforsch. Bremer, 5:160-164.

If barnacles that have been in air are put in sea water, the valves open, gas escapes from mantle cavity, and cirri beat, establishing a regular rhythm in 2 min. In fresh water, valves open, gas escapes, then valves close tightly again. At salinities below 17 ppt, barnacles from marine locations open valves slightly but cirri do not beat. At salinities above 17 ppt, normal cirral activity usually occurs. In NaCl solution of 35 ppt there may be a few beats of cirri but no normal activity, but if Ca salts are added to this NaCl solution the cirri will beat normally. Fide Green, 1968, pp 166-167. (S. H. Hopkins)

Barnes, H. and Barnes, Margaret. 1961. Salinity and biometry of Balanus improvisus. Soc. Sci. Fennica, Commetat. Biol., 24(4):3-7.

Animals were collected from Hjerting, Denmark (25-30 ppt), and Tvärminne, Finland (5-6 ppt). Measurements of several gross shell and body features showed no significant difference between animals from the two environments. (S. Rennie)

Barnes, R. S. K. 1967. (Dep. Zool., Univ. Queensland, Brisbane, Queensland, Australia.) The osmotic behavior of a number of grapsoid crabs with respect to their differential penetration of an estuarine system. Jour. Exptl. Biol., 47(3):535-551.

The five species studied were Macrophthalmus crassipes, Mictyris longicarpus, Macrophthalmus setosus, Australoplax tridentata, and Paracleistostoma mcneilli listed in order of their adaptability to low salinity. M. crassipes is in bay only, salinity 33.5-36.8 ppt. Para. mcneilli, at other extreme, is only one found entirely in Brisbane River and never in Moreton Bay (in field, 3-3¼ ppt). All were tested in laboratory for survival and blood osmoconcentration in test salinities of near 0 up to 50 or 70 ppt. Australoplax tridentata are most euryhaline and show most tolerance and adaptability to low salinity, and all except A. tridentatus adapt to hypersaline conditions which they are unlikely ever to experience in nature. It is concluded that for four species salinity is probably a limiting factor in hyposaline conditions, and for one species only (A. tridentatus) salinity is probably a limiting factor in hypersaline conditions. The relative abundance of two species in the estuary appears to be a function of their capabilities for osmoregulation. Habitat preferences (other than salinity) probably limit the upstream penetration of one species, and may limit the downstream penetration of a second species. (S. H. Hopkins)

Barrington, E. J. W. 1965. The biology of Hemichordata and Protochordata. W. H. Freeman and Co., San Francisco, vi + 176 pp.

Although Enteropneusta, one of the two division of Hemichordata, often live in estuaries, in shallow water (mud flats, etc.), and in the intertidal zone,

and are thus exposed to changes in salinity, there is no mention of salinity or of osmoregulation in the account of this group. Pp. 63-67 contain a discussion of excretion and ionic regulation in Urochordata, which remains a mystery because no organs for the purpose have been identified; nevertheless, some Urochordates live in estuaries, in changeable salinities, though none have adapted to life in fresh water. In pp. 142-152 the distribution and habitats of Cephalochordata are discussed. Salinity is mentioned as one of the limiting factors, but it is stated that about all that is known comes from the ecological studies in Lagos Harbour, Nigeria, by Webb (1958a, 1958b) and Webb and Hill (1958), who have described the life history of Branchistoma nigeriense and its adaptation to salinity as low as 12.5-13 ppt (and death in lower salinities). (S. H. Hopkins)

Barrows, Albert L. 1917. An unusual extension of the shipworm in San Francisco Bay, California. Univ. of Calif. Publ. in Zool., 18(2):27-43.

Unusually dry conditions in 1910 and 1911 caused a slight increase in salinity in San Pablo Bay allowing the invasion of shipworms into that part of Upper San Francisco Bay. A salinity of at least 10 ppt at 6-19 C seems to be required for the existence of Teredo diegensis. Where the average salinity is 13 or 14 ppt at those temperatures, damage may be extensive.

Limnoria did not invade San Pablo Bay at the same time although it usually accompanies the Teredo in other localities. (S. Rennie)

Barth, R. and Da Costa, P. Ferreira. 1968. Estudos sobre os Leuciferinae na regiao entre Recife e Cabo Orange. (Studies on the Leuciferinae in the region between Recife and Cabo Orange.) Publ. Inst. Pesqui Mar., 30:1-25.

L. faxoni and its larvae seem to tolerate greater modifications to salinity than L. typus does. Adults and larvae of L. faxoni were found in water with 17.88-36.94 ppt of salinity. The corresponding values for L. typus were 22.70-36.90 ppt. (From Biol. Abstr.)

Bary, B. M. 1963a. Temperature, salinity and plankton in the eastern North Atlantic and coastal waters of Britain, 1957. II. The relationships between species and water bodies. Jour. Fish. Res. Bd., Canada, 20(4):1031-1065, illus., map.

"Occurrences of 17 species of zooplankton from near-surface oceanic and coastal waters about Britain have been correlated with temperatures and salinities...." These species are divided into four groups, of which three are oceanic and the fourth is confined to coastal waters. The fourth group contains only three species: the copepod Temora longicornis and the chaetognaths Sagitta setosa and S. elegans. Even these were in oceanic salinities, 34.5-35.1 ppt. It is claimed that as little as 0.2-ppt difference in salinity made a difference in occurrence of plankton species (p. 1042). (S. H. Hopkins)

Bary, B. M. 1963b. Temperature, salinity and plankton in the eastern North Atlantic and coastal waters of Britain, 1957. III. The distribution of zooplankton in relation to water bodies. Jour. Fish. Res. Bd., Canada, 20(6):1519-1548, maps.

Continuation and largely repetition of points made in Part II. The copepod Temora longicornis is said to be an unusually tolerant species found in a wide range of conditions. This oceanographic paper has little application to estuarine and inshore coastal studies. (S. H. Hopkins)

Bary, B. M. 1964. Temperature, salinity and plankton in the eastern North Atlantic and coastal waters of Britain, 1957. IV. The species' relationship to the water body; its role in distribution and in selecting and using indicator species. Jour. Fish. Res. Bd., Canada. 21(1):183-202, illus.

Besides temperature and salinity, the author theorizes that the three primary water bodies of the region are each characterized by an unidentified "unique property," A for southern, B for northern, and C for coastal water. Each water body is characterized by certain species of zooplankton [copepods and chaetognaths].

Bassindale, R. 1942. The distribution of Amphipods in the Severn Estuary and Bristol Channel. Jour. Animal Ecol., 11:131-144.

Species found in this estuary were Hyale nilssoni and Melita palmata (mostly in Bristol Channel but in Severn up to Sheperdine), Calliopus crenulatus (not extending quite so far up or down estuary), Gammarellus homari (almost entirely in Bristol Channel), Marinogammarus obtusatus (entirely in Bristol Channel), Marinogammarus marinus (extending far upstream to Sharpness), Gammarus locusta (not even extending to upper Bristol Channel), and Gammarus zaddachi (which occurs in three forms, A, B, and C; A being least tolerant of low salinity and C being adapted to fresh water, with B intermediate). The distribution of amphipods in seven estuaries is shown below:

	Severn	Deben	Tees	Tay	Tamar	Dee	Afon
G. pulex	Not to fresh	To fresh	Not to fresh	Not to fresh	Not to fresh	Not to fresh	Absent
G. duebeni	Absent	No details	28-0	25-0	20-0	Absent	Rare
G. zaddachi	28-0	28-0	28-0	10-0	No details	34-0	16-0
G. locusta	35-28	35-28	35-25	35-5	No details	35-13	35-25
M. marinus	28-10	No details	35-23	35-10	35-10	35-2	34-11

G. zaddachi (three forms) is commonest amphipod in Severn, from fairly salt to fresh water. Not much seasonal change, but greater abundance in summer. Juveniles alone occupy less saline end of range in winter. (S. H. Hopkins)

Bassindale, R. 1943a. Studies on the biology of the Bristol Channel. XI. The physical environment and intertidal fauna of the southern shore of the Bristol Channel. Jour. Ecology, 31:1-29.

This is a long, gradually narrowing estuary in which tide increases inland, developing a bore on spring tides 4.5 ft high which travels at a maximum speed of 14 knots to Gloucester at upper end. The maximum range of an extreme spring tide is nearly 50 ft. Turbidity is high in midreach, where it remains all year, so maximum turbidity is in saltier water in summer than winter. Freshwater floods in winter push the brackish zone seaward. There is no vertical salinity gradient. In winter, salinity conditions are stable only to Weston; zone of maximum variation stretches down to Aust (Aust is upriver from Weston). In summer, salinity is stable up to Aust, and zone of maximum variation is farther upriver. The twice-daily-salinity variation at Weston is not more than 1 ppt and is less than seasonal variation of 7 ppt. Marine fauna is rich at Ilfracombe (Mouth of Bristol Channel (bay)), less so from Blue Anchor (30 miles inland) upstream, and dies out more rapidly above Avonmouth (at Bristol, where estuary narrows more rapidly) than below. Distribution of Gammarus species shows little seasonal change. A new form of G. zaddachi and a new species of Corophium were identified. (S. H. Hopkins)

Bassindale, R. 1943b. A comparison of the varying salinity conditions of the Tees and Severn Estuaries. Jour. Animal Ecol., 12:1-10.

Most salinity data are in 8 figures, charts, and graphs. The Tees is a smaller river with a shorter estuary and 1/18 the freshwater flow in 24 hr, with

weaker currents (three compared with 6-8 knots). It is not easy to say which is the more arduous ecologically. In both, animals are rare in the central reaches where changes in salinity are most extreme and rapid. Arenicola marina and Nereis diversicolor have been shown by Wells and Ledingham (1940) to withstand changes in the laboratory greater than those in the field. On the other hand, in the Baltic Arenicola lives at a salinity it cannot withstand in the laboratory, perhaps due to a special Baltic variety, perhaps due to gradual acclimatization. There are other adverse factors in an estuary besides salinity change, current and turbidity, instability of bottom, etc., so it is not surprising that when subjected to only one instead of many adverse factors animals stand more change than in the field. On the other hand, in the field animals may slow up change by burrowing or closing up and thus withstand more change than in laboratory. In Tees maximum rate of salinity change is 5 g/l/hr compared with 15 in Severn, though maximum range is greater in Tees.
(S. H. Hopkins)

Batchelder, C. H. 1926. An ecological study of a brackish-water stream. Ecology, 7:55-71.

"The coves and inlets and the brackish-water creeks along shore are the pantry shelf of the ocean." The creek studied is Bunker's Creek, a tributary of Oyster River which flows into Great Bay, New Hampshire. It holds 9.5 acres of brackish water at full tide. The upper end is Spartina marsh. Two brooks run into it. Great Bay itself is brackish. Salinity was measured as density, which fluctuated with tidal cycle from 1.01 to 1.023 in winter and from 1.015 to 1.024 in fall (during dry weather). At low tide the creek drains dry except for channel and tide pools. Plants include Fucus, Ulva, Enteromorpha, Monostroma, Lyngbya, the fungus Ascophylum, and seed plants Zostera marina (in channel), Spartina, and along the land margin Sclerochloa spp. Bottom includes both mud and rocks. The animal communities or associations are channel tide-pool, bottom debris, mud-flats, muck-flats, lower sand belt, shore stones, fucus-Ascophylum, and border marsh. About 60 species of animals occur including Crassostrea virginica, Macoma balthica, Mya arenaria, and several kinds of Littorina among molluscs, Balanus improvisus, Asellus communis, Carinogammarus mucronatus, Gammarus species, Palaemonetes vulgaris, Eurypanopeus depressus, and other crustaceans. The number of species decreases going upstream, and so does abundance.

Oysters live in deep channel and tide pool at mouth of creek but not in intertidal zone. "Cliona sulphurea" and Urosalpinx cinereus occur at the same station. Highest density of water at this station was 1.024. At the head of the creek 1.0002 was the lowest ever found. At G, near head of creek, salinity ranged from 1.0006 to 1.013; regular changes in salinity accompany the tidal cycle. (S. H. Hopkins)

Bateman, J. B. 1933. Osmotic and ionic regulation in the shore crab, Carcinus maenas, with notes on the blood concentrations of Gammarus locusta and Ligia oceanica. Jour. Exptl. Biol., 10:355-371.

Gill membrane of C. maenas seemed almost impermeable to water; no evidence for active water regulation; KCN and hypertonic solutions cause no change in water transfer. Isolated gill tissue showed no secretory activity. Ligia oceanica in dilute solutions has high osmotic independence for a short time, then resistance breaks down and animal dies. Data on Gammarus insignigicant. (S. H. Hopkins)

Bateman, J. B. and Keys, Ancel. 1933. Respiration of isolated gill tissues of the eel. Jour. Physiol., 77:271-286.

The eel was Anguilla vulgaris. Various concentrations of Ringer's solution and dilutions of sea water were used in tests of respiration rate. Respiration increased with increase in salt content of the environment. This effect is believed to be related to secretory activity in the gills. Fins do not show

any effect of salt concentration on respiration. (S. H. Hopkins)

Battaglia, Bruno. 1967. Genetic aspects of benthic ecology in brackish waters. Pp. 574-577. In: Lauff, G. H., ed. Estuaries. Am. Assoc. Adv. of Sci., Publ. 83, Washington, D. C., xv + 757 pp.

This is mostly on the bottom-dwelling harpacticoid copepod Tisbe reticulata of European marine and brackish waters. The species is claimed to have two populations, one adapted to marine and the other to brackish-water salinities, which are genetically different, as shown by low survival of F hybrids, etc. Tisbe furcata is claimed to have three geographic races, one from high salinity waters at Plymouth, England, and the other two from brackish Italian lagoons on the Adriatic coast. These also are claimed to be genetically distinct as shown by reactions of their hybrids to different dilutions of sea waters. (S. H. Hopkins)

Bauchau, A. 1966. La vie des Crabes: anatomie, physiologie, developpement, croissance, systematique, ecologie, comportement. Editions Paul LeChevalier, Paris, France, 138 pp.

Salinity is discussed as an environmental factor of crabs on pp. 91-92. Hymenosoma lacustris lives in fresh waters of New Zealand; all other oxyrhynchids are marine. Carcinus maenas, Hyas araneus, and Macropodia rostrata penetrate into brackish water, as in the Baltic Sea. The Chinese mitten crab, Eriocheir sinensis, was introduced accidentally into Europe about 1900 and now lives in many rivers, even mountain streams and headwaters far from the sea, but it has to return to the sea to lay its eggs, which are still small and numerous as in marine crabs and have a full life cycle (prezoea, zoea, megalops, Juvenile crab). Other tropical land and freshwater crabs (Gecarcinus, Sesarma, Cardisoma) also reproduce and develop through larval stages in salt water. The vast family Potamonidae is fully adapted to fresh water, its species laying eggs of large size in fresh water and juvenile crabs hatching. (S. H. Hopkins)

Baughman, J. L. 1948. An annotated bibliography of oysters, with pertinent material on mussels and other shellfish and an appendix on pollution. Texas A&M Research Foundation, College Station, Texas, 794 pp.

As described in the title and subtitle. Contains an estimated 8000 references ranging from newspaper stories to important research publications, with annotations ranging from a few lines or none up to several pages. References to salinity as an important factor in the oyster's environment are found on almost every page. (S. H. Hopkins)

Baumberger, J. P. and Olmsted, J. M. D. 1928. Changes in osmotic pressure and water content of crabs during the molt cycle. Physiol. Zool., 1:531-544.

Studies were made with the estuarine crabs Hemigrapsus oregonensis, H. nudus, and Pachygrapsus crassipes. Water content and specific gravity of crabs during six molt stages were determined; also pH, alkali reserve, and osmotic pressure of the blood. On molting, crabs increased in volume 30% to 40% by absorbing water. Hard crabs had a lower water content, "pillans" (ready to molt) higher, and newly molted crabs much higher water content, with the water content dropping off in later stages as crabs hardened. Specific gravity varied inversely to water content. Osmotic pressure varied during the molt cycle in such a way as to account for absorption of water during molting. The osmotic pressure of sea water was 1.06 mol, of hard crab tissue fluid 0.71 mol, of "pillans" 1.02 mol, of crabs about to molt 1.40 mol, and of newly molted crabs 1.18 mol. (T. Rennie)

Bayly, I. A. E. 1963. A revision of the coastal water genus Gladioferens (Copepoda:Calanoida). Austral. Jour. Mar. Freshw. Res., 14:194-217.

The five species of Gladioferens form a graded series adapted to different salinities, from fresh water through estuaries to the sea, in Australia. See Bayly (1965). (S. H. Hopkins)

Bayly, I. A. E. 1964. A new species of Isias (Copepoda:Calanoida) from the Brisbane River Estuary and a comparison of the Australasian centropagid genera. Austral. Jour. Mar. Freshw. Res., 15:239-247.

This species is one of a series of related planktonic copepods adapted to a series of graded salinities. See Bayly (1965). (S. H. Hopkins)

Bayly, I. A. E. 1965. Ecological studies on the planktonic Copepoda of the Brisbane River Estuary with special reference to Gladioferens pectinatus (Brady) (Calanoida). Austral. Jour. Mar. Freshw. Res., 16:315-350.

The most striking features of the distribtuion of G. pectinatus were its continuous presence at the freshwater end of the salinity gradient, and its downstream extension into water of high salinity during the colder months. The relative proportion of immature stages decreased with increasing depth. Mature females had diurnal vertical migrations. Other species discussed are: Oithona, Acartia, Pseudodiaptomus (three species), Labidocera, Isias uncipes, and Sulcanus conflictus. The range of salinity tolerance of Sulcanus is less than that of Gladioferens. Isias uncipes occurred only in winter and early spring, with population densities greatest at the bottom and decreasing rapidly to zero at higher levels. (S. H. Hopkins)

Bayly, I. A. E. 1967. The fauna and chemical composition of some athalassic saline waters in New Zealand. New Zealand Jour. Mar. Freshw. Res., 1:105-117 (Sept 1967)

Sutton Lake, salinity 15 ppt, with Na and Cl dominating, contained the rotifer Brachionus plicatilis, the copepod Microcyclops monacanthus, the ostracod Diacypris, and larvae of the fly Ephydrella. A saline pond near Patearoa, salinity 6 ppt with Na and HCO3 dominating, contained only Ephydrella larvae and three species of hemipteran insects. (S. H. Hopkins)

Bayne, B. L. 1965. Growth and the delay of metamorphosis of the larvae of Mytilus edulis. Ophelia, 2:1-47.

Showed that the effect of salinity on mussel larvae varies with locality. Larvae from the sound between Sweden and Denmark, where surface waters are less saline than in North Sea, showed slower growth rate when salinity fell below 18 ppt or was raised above 26 ppt. Larvae from Menai Straits, where salinity is higher, did not show any decrease in growth rate at salinities between 26 and 30 ppt, but showed a drop in growth rate when salinity was below 20 ppt. (Fide Green, 1968, pp. 147-148.) (S. H. Hopkins)

Bayowmi, A. R. 1969. Notes on the occurrence of Tilapia zillii (Pisces) in Suez Bay. Mar. Biol. (Berlin), 4(3):255-256.

T. zillii Gervais is recorded for the first time from Suez Bay off the Institute of Oceanography and Fisheries, Ataqa (UAR), during October and November 1965 and 1966. Salinities and temperatures of surface sea water ranged from 42 to 42.79 ppt and from 23 to 24.4 C, respectively. The occurrence of specimens of T. zillii in the bay indicates that it can tolerate high salinities and survive in the sea. (P. Maxwell, from Biol. Abstr.)

Beach, N. W. 1969. The oyster crab, Pinnotheres ostreum Say, in the vicinity of Beaufort, N. Carolina. Crustaceana, 17(2):187-199.

Oysters from bars near Beaufort, N. C., were studied to determine the abundance and the developmental stages of P. ostreum (the oyster crabs.... Under experimental conditions the zoeae died when salinity dropped below 10 ppm; they survived at 15 ppm or above. Two female adult crabs survived at 5 ppm but they became inactive and their eggs did not develop. Other animals died within 96 hr at 5 ppm...the abundance of the species does not seem to be affected by salinity which perhaps plays a role only in the upper reaches of the Newport River. [For "ppm" read "ppt."]. (From Biol. Abstr.)

Beadle, L. C. 1931. The effect of salinity changes on the water content and respiration of marine invertebrates. Jour. Exptl. Biol., 8:211-227.

Experiments were made on Nereis diversicolor, N. cultrifera, and marine triclad turbellarian Gunda ulvae. On transfer to water of low salinity (16.6% sea water in distilled water), weight of N. diversicolor increased first 20-30 hr, tended to decrease after that. Respiratory rate also increased, then decreased. With N. cultrifera, weight increased to higher value and did not fall later; respiratory rate increased, but less than with N. diversicolor; specimen died during experiment in 16.6% sea water but survived in 25% sea water. N. diversicolor was active in 16.6% and 25% sea water, N. cultrifera inert in both. Exposure to M/1000 KCN or to anaerobic conditions causes N. diversicolor to absorb water at such a rate that weight curves approach N. cultrifera in form. Respiratory rate of G. ulvae increases progressively with dilution of the sea water, roughly in proportion, and worm swells due to absorption of water by gut cells (only). Swelling is increased, in G. ulvae, by M/1000 KCN or anaerobic conditions. Results support Schlieper's hypothesis that "homoiosmotic" but not "poikilosmotic" species respire more rapidly in diluted sea water. (S. H. Hopkins)

Beadle, L. C. 1934. Osmotic regulation in Gunda ulvae. Jour. Exptl. Biol., 11:382-396.

This triclad turbellarian in its normal habitat daily stands changes from 100% to 5% sea water and the reverse, or to fresh water for short times. Experimentally it can live permanently in 5% sea water [1.75 ppt]. When the flatworm is put in 10% sea water: (1) Water flows through ectoderm into parenchyma which swells; (2) This water is taken up by gut cells and forms intracellular vacuoles, with expenditure of energy; this process can be stopped by cyanide. Parenchyma is restored to original condition and full activity is recovered; (3) Animal resists further inflow of water by decrease in permeability of ectodermal membrane; (4) This resistance is maintained and gut cells remain vacuolated as long as animal remains in dilute sea water. The water-vascular (excretory) system plays no part in this. Permeability of ectodermal membrane can be reversibly increased by Ca deficiency, but osmotic resistance of its individual cells cannot. If water is diluted to 2% sea water cells swell and disintegrate, an irreversible process which can be retarded but not prevented by adding Ca. It is suggested that both vacuole formation by gut cells and resistance of other cells are active processes. (S. H. Hopkins)

Beadle, L. C. 1937. Adaptation to changes of salinity in the polychaetes. I. Control of body volume and of body fluid concentration in Nereis diversicolor. Jour. Exptl. Biol., 14:56-70.

Worms collected from the same locality in the Blythe Estuary, at different times, gained less weight in 25% sea water during winter than in summer. In spite of great variations in the weight curve, the body fluid curve was very constant. The maintenance of hypertonic body fluids and regulation of body

volume are largely unconnected. Lowering of weight curve below that theoretically expected from concentration curve is not due to passive salt loss through body surface, but to removal of fluid through nephridia under pressure produced by contraction of body wall muscles. Animals from dilute sea water, placed in water isotonic with body fluids, increase concentration of latter. Results suggest that nephridia remove fluid hypotonic to body fluid. Ca deficiency and cyanide in dilute sea water cause increase in weight and ultimately inhibit maintenance of hypertonic body fluids, but effects are reversible. Mechanism for keeping body fluids hypertonic to external medium is not sufficiently developed to be of survival value in the locality in which the worms lived. Survival is possible because worms can prevent excessive swelling of the body caused by osmotic inflow of water. Worms consume more O_2 in dilute sea water not because of osmotic work but because of work done by body wall muscles in resisting swelling. (S. H. Hopkins)

Beadle, L. C. 1943. Osmotic regulation and the faunas of inland waters. Biol. Rev., 18:172-183.

Many marine animals can endure a considerable dilution without regulating body fluids, if change is slow enough (Aurelia aurita in 6 ppt, Membranipora pilosa in 4, Mytilus edulis in 4.5, Mya arenaria in 5 ppt in Baltic where there is a stable salinity gradient). Nereis diversicolor shows beginnings of osmoregulation. By these means such animals have invaded brackish waters. Fresh waters may have been penetrated by immediate lowering of blood concentration and later development of a regulatory mechanism. On the other hand, some crustacea (Eriocheir sinensis, Telphusia fluviatilis) have invaded brackish water by a regulatory mechanism which prevents much decrease in body fluid concentration, actively absorbing salt through some part of body surface, uptake of food from gut, and renal reabsorption of salts. Many can actively absorb ions from fresh water. Several have remarkable powers of retaining salts by impermeability of body surface. Some animals depend on food to maintain salt level. The lower the blood concentration of a freshwater animal, the lower the concentration of brackish water to which it can adapt. Inland saline waters of low concentration have been invaded by some freshwater and some brackish-water species. Highly saline lakes are invaded by freshwater species adapted to dehydration. (S. H. Hopkins)

Beadle, L. C. 1957. Comparative physiology: osmotic and ionic regulation in aquatic animals. Ann. Rev. Physiol., 19:329-358.

This paper is a review of the subject, with the literature survey complete to July 1956. The groups reviewed are Protozoa, Coelenterata, Annelida, Crustacea, Insecta, Mollusca, Nematoda, Tunicata, Fish, Cyclostomata, and Amphibia. A discussion on energetics of regulating mechanisms as it was known at the time and genetic variations in osmoregulatory capacity is included. He generally concludes that no new fundamental concepts had been introduced, but improvement in microtechniques have made possible some important advances. He advocates investigation of regulatory mechanisms during embryonic and larval life. 171 references are cited. (S. Rennie)

Beadle, L. C. and Cragg, J. B. 1940a. The intertidal zone of two streams and the occurrence of Gammarus spp. on South Rona and Raasay (Inner Hebrides). Jour. Animal Ecol., 9:289-295.

Gammarus duebeni, a common brackish-water amphipod crustacean, occupied the upper part of the intertidal zone, mainly above the range of Marinogammarus marinus and Gammarus zaddachi. G. duebeni penetrated the streams to 5 ft above spring high-water level and lived in permanently fresh water, as well as in tide pools within the splash zone where salinity ranged from 0 to approximately 120% of sea water salinity. (T. Rennie)

Beadle, L. C. and Cragg, J. B. 1940b. Studies on adaptation to salinity in Gammarus spp. I. Regulation of blood and tissues and the problem of adaptation to fresh water. Jour. Exptl. Biol., 17:153-167.

Four species of Gammarus studied were freshwater G. pulex, brackish water G. duebeni, and marine G. locusta and G. obtusatus. The marine species maintain hypertonic blood in dilute sea water. G. obtusatus can stand 50% and G. locusta 25% sea water. G. duebeni tolerates range from pure sea water to water with only a trace of salt, but does not tolerate fresh water as well as G. pulex. For wide tolerance two things are needed (1) mechanism to regulate blood concentration within limits, and (2) mechanism to keep intracellular concentration of certain ions low (Cl, especially), in spite of blood changes. Adaptation to fresh water may have proceeded by two stages: (1) keeping blood concentration high by active ion absorption, and (2) evolution of renal salt-reabsorption mechanism, and lowering blood and tissue Cl concentration to level more easily maintained (as in G. pulex). (S. H. Hopkins)

Beanland, F. L. 1940. Sand and mud communities in the Dovey Estuary. Jour. Marine Biol. Assoc. U.K., 24:589-612.

The area investigated is near high tide level on intertidal flats in an English estuary, whose bottom is nearly all exposed by normal low tides. The fauna is that of Macoma balthica and Corophium volutator communities. Soil type and exposure to drying are the primary factors. Salinity is mentioned only to say that it is probably not the primary factor in C. volutator distribution. (S. H. Hopkins)

Beaven, G. F. 1955. Virginia planters suffer serious oyster losses from hurricanes; heavy rains the damaging factor. Maryland Tidewater News (Nov 1955), 12(6):1, 3, 4 (condensed version of same article in Comm. Fish. Rev. (Dec 1955), 17(12):37-38).

Chesapeake Bay was visited by hurricane Connie on 12 Aug, Diane, 17 Aug, both with torrential rains, a foot or more, causing heavy mortalities of oysters in certain areas. Hardest hit was Rappahannock River, Virginia, where an estimated 1,000,000 bushels died. (S. H. Hopkins)

Becker, G. 1959. Biological investigations on marine borers in Berlin-Dahlem. Pp. 62-83. In: Marine borers and fouling organisms, ed. by Dixy Lee Ray, Univ. of Washington Press, Seattle, xii + 536 pp.

Teredo navalis, a common pest in the North Sea and western Baltic, did not extend east into Baltic Sea beyond Warnemunde before 1929. During hot summers of 1933 to 1936 this borer extended its range up to the Darsz Peninsula, where the salinity is about 8 ppt, and is still an important pest on western shores of Darsz Peninsula.

Limnoria tripunctata (boring crustaceans called "gribbles") from water of 35-ppt salinity continue to develop well if changed to 30 or 25 ppt, but when exposed to 20 ppt most of them die. Those that survived could no longer reproduce. If suddenly transferred from 35 to 15 ppt, all died after 11 days at the longest, and more rapidly in lower salinities. But they can withstand 30 min in fresh water without harm if afterward transferred to water of high salinity. Gribbles changed from 35 to 25-30 ppt become more active and produce four to five times as much excrement, but after some weeks begin to feed more slowly, and at 25 ppt the decline continues. They breed best, according to Kampf, when there is an intermittent salinity drop of 5 ppt [from 35 ppt?]. (S. H. Hopkins)

Belyaev, G. M. and Zelikman, E. Z. 1950. (Trematode infection of some invertebrates of the White Sea and its dependence on their osmoregulative

potentialities). Akademiya Nauk. S.S.S.R., Doklady, 71(4):813-815. (In Russian.) (Not seen. S. H. H.)

Berger, E. 1931. Über die Anpassung eines Süsswasser-und eines Brackwasserkrebses an Medien von verschiedenem Salzgehalt. Pflüg. Arch. Ges. Physiol., 228:790-807.

The question investigated was whether fresh- and brackish-water animals have the outer surface covered by a semipermeable membrane, as generally stated, or whether the membrane is permeable to salts as in marine invertebrates. The test animals were the river crayfish, Astacus fluviatilis, and the mitten crab, Eriocheir sinensis. From the results of experiments it is theorized that the relative constancy of the salt content of the blood during residence in fresh water, and, on the other hand, the quick changing of the salt content of blood by transfer to sea water and from sea water back into fresh water, is due to the skin becoming less permeable upon attaining a certain level for the physiological ions. (S. H. Hopkins)

Berger, V. Ya., and Lebskii, V. K. 1969. I zmenenii solenostno ustoichioosti v ontogeneze polikhetz Eulalia viridis (L.). (Change of salinity resistance during ontogeny of the polychaete Eulalia viridis (L.).) Akademiya Nauk. S.S.S.R., Doklady, 186(6):1422-1428.

One hour after artificial insemination, the fertilized eggs of E. viridis were transferred from water of normal salinity (24 ppt) to diluted sea water. In doing so it was found that dilutions from 0 to 14 ppt caused loss of pigment, rupture of the membranes, and death of ovocytes. At 16 ppt only the first three divisions were noted; water with a salinity of 18 ppt also inhibited the course of development, retarding it at the stage of 64-128 blastomeres. Normal development up to the formation of trochophores occurred only at a salinity of 20-24 ppt. A parallel investigation of salinity resistance of spermatozoids showed that their life span increased beginning with 16 ppt and reached a maximum at 20-24 ppt. (From Biol. Abstr.)

Bernard, M., Braci, M., Lalami, Y., and Moueza, M. 1969. Tolerance des oeufs de copepodes pelagiques aux variations de salinité. (Tolerance of the eggs of pelagic copepods to variations in salinity.) Pelagos Inst. Oceanogr. Alger. Bull., 7:86-93.

The influence of diluted and hypertonic sea water on the development and hatching of a euryhaline species, Centropages typicus, and a stenohaline one, Temora stylifera was studied. Sea water diluted to 80% with distilled water, natural sea water, and three hypertonic solutions obtained by an addition of 1, 2, and 3 g/l NaCl were used as media. The salinity ranged between 35.86 ppt and approximately 41.18 ppt. Eggs were picked up 1 to 2 hr after laying and put into the media until hatching. The salinity tolerance of C. typicus is excellent, much better than that of T. stylifera, but nauplii died at once while Temora were alive and swimming. In lethal salinities, about one-fourth of the Temora eggs hatched but larvae were dead. The embryogenesis of Centropages: a number of them hatched late in media 4 and 5. Eggs of both species are more resistant to salinity variations than adults and larvae. (From Biol. Abstr.)

Bernstein, Leon. 1967. Plants and the supersaline habitat. Contrib. to Mar. Sci., Univ. of Texas, 12:242-248.

In estuaries and tidal inlets, plants alternately exposed to nearly fresh water and sea water as tides ebb and flow are euryhaline, but only in regard to lower limit; the upper limit of salinity tolerance does not exceed that of sea water. Algae of the intertidal zone (Enteromorpha, Fucus, Porphyra, Ulva) can tolerate a salinity range of 0.1 to 3.0 times sea water. Sublittoral red algae

have a range of 0.5 to 1.5 times sea water. Several planktonic algae studied under controlled conditions showed decrease in growth rate at salinities higher than about 40 ppt, but some such as Dunaliella salina flourish over much wider range. Survival of an alga in hypersaline waters does not mean that it can live indefinitely in such conditions; a period of lower salinity may be needed for growth and reproduction to maintain a population. Many marine plants are sensitive to as little as 20% increase in salinity. (S. H. Hopkins)

Berrier, H. and Jullien, A. 1934. Synergie et antagonisme ioniques dans le fonctionnement du coeur chez l'Huitre. Compt. Rend. Hebdom. Soc. Biol., Paris, 117:925-926.

The most active ions are those which, in the most favorable solution for studying the beating of the isolated oyster heart, are present in the weakest concentrations: K and Ca. K increases automatic beating and Ca decreases it. K raises the diastolic tonus and consequently tends to stop the heart in systole. Na acts less strongly in the same way. In addition to its negative chronotropic effect, Ca is inotrope positive and tends to make systole irregular (big and little ones alternating). Mg is more weakly inhibitory and regularizes the amplitude of contractions. The ratio between each one of the alkaline and each of the alkaline-earth ions is not significant, but the ratio Na + K/Ca + Mg is significant. (S. H. Hopkins)

Bersamin, Silvestre V. 1957 [1958]. Fluctuations in the planktonic population of the estuaries of Navotas and Malabon. Philippine Jour. Sci., 86(4):339-357, illus.

These "estuaries" were also called "lagoons." Rainfall decreased plankton counts. The periods of greatest plankton production, April and June, corresponded with salinities of 13 to 15.5 [units?]. Drop in plankton production occurred in August when salinity dropped to "2 per cent" [was ppt meant?]. The phytoplankton species are listed. (S. H. Hopkins)

Bert, P. 1883. Sur la cause de la mort des animaux d'eau douce qu'on plonge dans l'eau de mer et réciproquement. Compt. Rend. Acad. Sci., Paris, 97:133-136.

Answer to Varigny 1883 (which see). Says he (Bert) reported the same conclusions in 1871. But Bert went on to seek and find the mechanism by which death is produced by NaCl. Epithelium of gills become opaque and circulation of blood in gills is stopped in animals protected by mucus coat; also anterior layers of crystalline lens in eyes become opaque. Animals not protected by mucus, such as frog and toad, become so desiccated they lose one-third or one-quarter of their weight and then die. Eels, which can stand sudden changes in salinity, are killed by the same changes if mucus is removed from part of skin. The lower the temperature, the more resistant all animals become to being killed by salinity changes. Also, the larger the individual, the more resistant. Daphnia of fresh water can be acclimated to one-half sea salinity by gradually adding sea water over a period of some days, and are then killed if suddenly returned to fresh water. Claims adaptation of species, since eggs develop in salt water. Generally, freshwater animals die in one-third sea-water salinity. Now trying to repeat Beudant's work. (S. H. Hopkins)

Bethe, A. 1908. Die Bedeutung der Elektrolyten fur die rhytmischen Bewegungen der Medusen. I. Thiel: Die Wirkung der in Seewasser enthaltenen Salze auf die normale Meduse. (The importance of electrolytes for the rhythmic movements of medusae. Pt. I. The effect of sea water salts on the normal medusa.) Pflüger's Arch. Physiol., 124:541-577.

Topics include the making of artificial sea water and comparison with natural (Gulf of Naples) sea water, effect of dilution of natural sea water with

distilled water (no effect when diluted to 80% for 48 hr, but slowing of movements after 20-30 min in 75% sea-water solution, stopping of movements after 30-60 min in 50%); effect of changing Ca concentration in artificial sea water (permanent stopping of movement after 2.5-4 min with no Ca, after 60-65 hr in artificial sea water with $CaSO_4$, after 68-72 hr with $CaCl_2$, etc.); effect of changing NaCl content; effect of changing concentrations of calcium salts; effect of $MgCl_2$ and $MgSO_4$; effect of potassium chloride (KCl): effects of various combinations. Rhizostoma and Carmarina (species not identified) were the jellyfish used in experiments. It was concluded that the different salts interact, and counteract each other like toxin and antitoxin, to give the favorable environment of natural sea water. (S. H. Hopkins)

Bethe, A. 1920. Ionendurchlassigkeit der Korperoberflache von wirbellosen Tieren des Meeres als Ursache der Giftigkeit von Seewasser abnormer Zusammensetzung. Pflüger's Arch. Ges. Physiol., 221:344-362.

In normal crabs, Carcinus maenas, and sea snails, Aplysia punctata, the ionic composition of the blood is subject to fluctuations, but on the average Ca and K are more concentrated than in sea water. Mg content of crab blood is far below that of sea water, but that of Aplysia almost equals it. If the animals are held in artificial sea water whose ions are in different proportions, or lack one ion, the ions in the blood alter in the same direction. These changes are much more rapid in Aplysia than in hard-shelled crabs. The outer surface of both animals is permeable in both directions to Ca, K, Mg, and Cl. It can apparently become so for SO_4. Permeability for Na is not proven. Physiological effects of the changes in internal ionic milieu thus produced are described. It is notable that in both animals, unlike the situation in vertebrates, Ca decrease causes decrease in tonus and in reflex sensitivity, Ca increase increases both of these. The physiological changes thus caused are completely reversible. Reestablishment of the functions follows quickly when the animals are put in sea water of normal compositon, and the salt content of the blood returns to normal, though more slowly. The decrease in Ca became functional at the 50% level. (S. H. Hopkins)

Bethe, A. 1928. Jonendurchlässigkeit det Körperoberfläche von wirbellosen Tieren des Meeres, als Ursache der Giftigkeit von Seewasser abnormer Zosammensetzung. (Ion permeability of the integument of invertebrate marine animals as cause of toxicity of sea water of abnormal composition.) Pflüger's Arch. Ges. Physiol., 221:344-362.

In normal crabs (Carcinus) and sea hares (Aplysia) the blood has a higher concentration of Ca and K than the normal external medium. Mg content of Carcinus blood is far below that of sea water, while in Aplysia the Mg content of blood almost equals that in sea water. When artificial sea water lacking or having an excess of certain ions is used, the integument of both animals proves permeable in both directions for Ca, K, Mg, and Cl, also probably for SO_2; permeability for Na was not proved. Decrease in Ca, internally, causes decrease in muscle tonus and reflexes, while Ca increase strengthens tonus and reflexes. Changes thus produced are completely reversible. Decrease in Ca content of blood becomes functionally significant at 50% normal. (S. H. Hopkins)

Bethe, A. 1930. The permeability of the surface of marine animals. Jour. Gen. Physiol., 13:437-444.

Working with Aplysia and Carcinus maenas in dilute and concentrated sea water solutions, Bethe concluded "The surfaces of all marine invertebrates which have been experimented upon are permeable for water and also for both the salts or their ions which are in solution in their blood and in sea water. The forces which tend to bring the salt content of the blood into equilibrium with the salt content of the surrounding sea water are just as great as the

forces which strive to prevent osmotic differences. The skin of these animals, save in the cases where special modifications have arisen, serves only as a protecting barrier preventing the loss of the body colloids." (T. Rennie)

Beudant, F. S. 1816. Sur la possibilite de faire vivre de Mollusques d'eau douce dans les eaux salines et des Mollusques marins dans les eaux douces. Ann. de Chimie et de Physique, 2:32-41.

Experiments were started in 1808 in attempt to explain how marine and freshwater shells became mixed in the same strata in certain fossil beds. Freshwater molluscs were killed when put immediately into 4% NaCl, also by water charged with $CaSO_4$, and by water with 2% $FeSO_4$, and water saturated with H_2S. In 1809 Beudant collected many freshwater molluscs from around Paris and divided each species into two lots, one of which was kept in Seine water while the other was gradually acclimated to salt water, first in water containing only one grain of salt per pound (= about 0.00011), then adding one grain every 2 days, then a grain every day, finally 3 grains per day. After 5 months the liquid contained 0.04 of its weight of salt, including about 0.005 of CaCl. Most molluscs were completely acclimated to live in the salt water and showed no signs of illness. All species of Lymnaea and Planorbis, the Physa of springs, Ancylus fluviatilis (Patella lacustris), the "Paludine porte-plumet," lived perfectly in salt water. In the 5 months 54% of these molluscs died in fresh water and 57% in salt water. On the other hand, other species of Paludines (Helix vivipara, Helix tentaculata) and the "nerites" of the Seine had higher mortality than in fresh water: 40% died in fresh water and 71% in salt water. All bivalve molluscs died in salt water, but they lived perfectly in water with salinity of 2%. Attempts to acclimate freshwater molluscs gradually to $CaSO_4$ were unsucessful; all died before the water reached saturation.

In 1812-1813 Beudant collected many marine molluscs, Patellas, Fissurellas, Crepidulas, Haliotids, Sabots, Cerites, Buccins, Rochers, Tellines, Venus, Oysters, Combs, Mussels, Barnacles, etc. When placed directly into fresh water, these died. By gradually diluting the sea water, they were acclimated to fresh water in 5 months. Patella vulgaris, sabots, "Pourpre teinturiere," Cerites, Columbellas, Arcs, Venus, "Bucarde sourdon," oysters, mussels, and Balanus lived in fresh water with 36% mortality compared with 34% for those kept in sea water. But "Patelles bonnet de dragon," Fissurellas, Rochers, "Buccin onde," Cames, the Peignes, Limes, Tellines, Donaces, all died during the experiment, though they lived perfectly in salinity of 2%. Marine molluscs were also acclimated gradually to live in 31% salt solution. (S. H. Hopkins)

Bhatnager, K. M. and Crisp, D. J. 1965. The salinity tolerance of nauplius larvae of cirripedes. Jour. Animal Ecol., 34:419-428.

Nauplii of the barnacles Balanus balanoides, Elminius modestus, and Chthamalus stellatus are immobilized by salinities below 12 ppt, but active in higher salinities up to 50 ppt, where they are again immobilized. Survival in abnormal salinities is strongly influenced by temperature, survival being better in equal salinity at higher temperature (31 C). (Fide Green, 1968, pp. 170-171.) (S. H. Hopkins)

Bialaszewicz, K. 1931. Sur la regulation de la composition minerale de l'hemolymphe chez le crabe. Arch. Internat. Physiol., 35(2):98-124.

Maja squinado, having in the hemolymph electrolytes of composition and concentration close to those of sea water, shows very marked power to regulate the composition. If salts which are normal components of hemolymph are introduced in excess, they disappear rapidly from hemolymph. Elimination of different minerals is at different rates; KCl, very toxic, is eliminated fastest, Na_2SO_4 slowest. Experiments with injecting two or more salts equally in excess of normal concentration show that salts disappear from circulation in following

order of speed: KCl > $CaCl_2$ > $MgCl_2$ > $MgSO_4$. The antennary gland can eliminate surplus electrolytes from hemolymph, as proved by analyses simultaneously on urine and hemolymph, but its action is so slow (eliminating 3% of body weight per 24 hr) that it is not very important in eliminating large quantities of electrolytes from hemolymph. There are facts which allow supposition that in these processes the principal role is played by body tissues which seize and absorb the surplus mineral components introduced into the circulatory system. (S. H. Hopkins)

Biebl, Richard. 1956. Zellphysiologisch-oekologische Untersuchungen an Enteromorpha clathrata (Roth) Greville. Ber. deutsch. bot. Ges., 69(2):75-86, illus.

This seaweed in salt ponds at Moss Landing near Monterey, Calif., stands concentrations up to 2.9 times the concentration of sea water. In 24-hr laboratory experiments it survived in salinities from distilled water up to five times sea-water concentration. In six times sea-water concentration, cells were partly killed, and in seven times concentration they all died. In 7 days cells died in distilled water but survived in 0.1 sea-water concentration. (S. H. Hopkins)

Biernacka, Izabella. 1968. Influence de la salinite et de la thermique sur les protistes de la Mer Baltique et de la lagune de la Vistule. (Influence of the salinity and of heat upon the protists of the Baltic Sea and of the lagoon of the Vistula.) EKOL. POL. SER. A, 16(12):261-278.

This work comprises a short review of the conditions of salinity and of heat existing in the southern Baltic and in the lagoon of the Vistula. In the Baltic the degree of salinity effects the dislocation of the vertical and horizontal faunas and governs the spreading of protists in the coastal regions. (P. Maxwell)

Biglane, K. E. and Lafleur, R. A. 1967. Notes on estuarine pollution with emphasis on the Louisiana Gulf Coast. Pp. 690-692. In: Lauff, G. E., ed. Estuaries. Am. Assoc. Adv. of Sci., Publ. 83, Washington, D. C., xv + 757 pp.

Pp. 691-692 apparently include under "pollution" the increase in salinity of marshlands by leveeing of Mississippi River, intrusion of salt water into low salinity areas through dredged channels (including Gulf Outlet Project), and damming or diversion of freshwater flow by spoil banks, pipelines, etc. (S. H. Hopkins)

Binns, R. 1969a. The physiology of the antennal gland of Carcinus maenae (L.). I. The mechanism of urine production. Jour. Exptl. Biol., 51:1-10.

In dilute media (75% and 50% sea water) urine production of this crab is increased. Sorbitol is excreted faster in dilute media. Inulin was excreted fastest in 50% sea water and slowest in 100%. (S. Rennie)

Binns, R. 1969b. The physiology of the antennal gland of Carcinus maenae (L.). II. Urine production rates. Jour. Exptl. Biol., 51:11-16.

There is a gradual increase in urine production of the crab as the medium becomes more dilute (from 100% sea water, 4.7% of body weight, to 40% sea water, 22.4% of body weight). (S. Rennie)

Binyon, John. 1961. Salinity tolerance and permeability to water of the starfish Asterias rubens L. Jour. Marine Biol. Assoc. U.K., 41:161-174.

North Sea starfish (A. rubens) can tolerate dilution of sea water only to

23 ppt, while in Baltic Sea the same species lives at salinity as low as 8 ppt, so they are probably different "physiological species." Adult A. rubens from North Sea is incapable of any weight regulation in diluted media within ecological range, or of any osmotic regulation. (S. H. Hopkins)

Binyon, John. 1962. Ionic regulation and mode of adjustment to reduced salinity of the starfish Asterias rubens L. Jour. Marine Biol. Assoc. U.K., 42(1):49-64.

Perivisceral and ambulacral fluids are not only isosmotic but isionic with sea water, even if sea water is diluted by nearly half. However, there is a slight accumulation of Ca and a much more marked accumulation of K in water vascular system. This is attributed to an active process, as integument is permeable to all ions. Salt loss is small; animal takes in water so fast that isosmotic condition is reached before appreciable salt loss can occur. (S. H. Hopkins)

Binyon, John. 1966. Salinity tolerance and ionic regulation. In: Boolootian, R. A. (ed.), Physiology of Echinodermata. Interscience Publishers, New York.

Generally, echinoderms are exclusively marine and tolerate little dilution of sea water, but there are some exceptions; most of these are among Ophiuroidea (10 species are listed in table 15-1 as euryhaline plus 2 listed as experimentally tolerant of 23 ppt in table 15-2), but 6 asteroids are also reported to tolerate lowered salinity, Asterias rubens in the Baltic Sea living in salinities as low as 8 ppt, comparable to 8 ppt for the ophiuroids Ophiura albida in the Baltic and Ophiophragmus filograneous (actually 7.7 ppt) at Cedar Key, Fla. Among Holothuroidea, 6 species are listed as euryhaline (living in salinities of 18 ppt), 5 of which are in the Black Sea. The lowest salinity tolerated by any echinoid is also 18 ppt (Echinus acutus in the Black Sea). The only crinoid mentioned is Tropiometra carinata which experimentally tolerates salinity as low as 32 ppt. Echinoderms have no osmoregulatory organs and their integuments are permeable or semipermeable, so such ability as they have to penetrate estuaries is due to intracellular mechanisms. There is some ability to regulate ions within the body, partly by active transport. At the other extreme, some Red Sea species tolerate salinity of 46 ppt.) (S. H. Hopkins)

Bishai, H. M. 1961. The effect of salinity on the survival and distribution of larval and young fish. Jour. Cons. Int. Explor. Mer, 26:166-179.

Fish used in the experiments were herring (Clupea harengus L.), lump-sucker (Cyclopterus lumpus L.), salmon (Salmo salar L.), sea trout (Salmo trutta), and brown trout (Salmo trutta f. fario).

Herring larvae were kept at salinities from 30.04 to 2.5 ppt. Controls were kept at sea water, 33 ppt. The larvae lived better and longer at 10-15 ppt (12-13 days). In ordinary sea water and 5 ppt they lived for only 7 days. Bishai concludes that low salinities are not harmful over short periods of time.

Over the same salinity range, lump-sucker larvae survived at least 14 days in salinities as low as 9 ppt. Survival fell off rapidly below this salinity. Acclimation to a lower salinity increased survival time at that salinity, but did not affect the lower lethal limit (4-5 ppt). Age of larvae has no effect on survival at low salinities.

Young plaice (Pleuronectes platessa L.) survived at least 10 days at 5 ppt. At 3-4.4 ppt they lived at least 5 days with no mortality. In fresh water they lasted only 20 hr.

Newly hatched alevins of salmon, sea trout, and brown trout survived at least 10 weeks in the salinity range 1.64-8.20 ppt. At higher salinities (40-50% sea water) salmon survived better than brown trout and sea trout, in that order. At 50% sea water all alevins died within 11 days. When placed in sea water for short exposures (2-1/2 to 8 hr) all three were able to recover when returned to fresh water. (S. Rennie)

Black, V. S. 1948. Changes in density, weight, chloride and swimbladder gas in the Killifish, Fundulus heteroclitus, in fresh water and sea water. Biol. Bull., Woods Hole, 95:83-93.

Adjustment of this estuarine and shore fish to fresh water involves significant changes in the swim-bladder gas, chloride content, weight, and density of the fish. Complete adjustment takes 24 hr. Gain of weight, due to absorbing water, is temporary; weight returns to normal in 18 hr. Chloride decreases during first 12 hr but some is regained after 24 hr. After 4 days in fresh water the fish have 60% less chloride than in sea water. Fish put in fresh water sink at first, then pass oxygen and some carbon dioxide into swim bladder and regain normal buoyancy. These adjustments decrease density of fish to that of fresh water in 24 hr. Fish replaced in sea water after 2 days in fresh water regain normal chloride, density, and swim-bladder gas within 6 hr. (S. H. Hopkins)

Black, V. S. 1951a. Some aspects of physiology of fish. II. Osmotic regulations in teleost fishes. Univ. Toronto Studies, Biol. Series, 59:53-89.

This review paper discusses osmotic regulation in freshwater and marine teleost fishes, anadromous and catadromous teleost fishes (eel, salmon, rainbow trout, shad), and euryhaline teleost fishes (distribution, water and salt balance, internal factors). In addition, biochemical characteristics of fish in fresh water and sea water are reviewed. These characteristics (alkaline reserve, pH, protein content, isoelectric point, corpuscle sedimentation rate) are different for stenohaline and euryhaline fish. Literature cited includes 138 references. (S. Rennie)

Black, V. S. 1951b. Changes in body chloride, density and water content of chum (Oncorhynchus keta) and coho (O. kisutch) salmon fry when transferred from fresh water to sea water. Jour. Fish. Res. Bd., Canada, 8:164-177.

Both species tolerated 50% sea water (8-9 ppt Cl). Chum fry survived direct transfer from fresh to sea water (15-17 ppt Cl), but showed marked increase in body Cl during first 12 hr, returning to normal range in 12-24 hr. Coho died within 36 hr after 60% increase in chloride. Coho fry lost more water than chum fry in sea water. Density of both approximated that of sea water after 1 hr. Returned to fresh water after 12 hr in sea water, body chloride, density, and water content of both regained normal levels within 10 hr. Chum salmon go to sea as fry, cohos remain in fresh water a year or more. Although coho fry seem capable of some adjustment to sea water after a preliminary period in 50% sea water, permanent acclimatization could not be demonstrated under the experimental conditions. (Author's abstract in part)

Blanc, F., Leueau, M., and Stekielda, K. H. 1969. Effects eutrophiques au de bouche d'un grand fleuve (Grand Rhone). (Eutrophic effects at the mouth of a great river (Grand Rhone.).) Mar. Biol. (Berlin), 3(3):233-242.

A study of hydrographical and biological parameters has been undertaken in surface waters near the mouth of the Rhone. Salinity, temperature, and nutrient salts were recorded, and the phytoplankton, as well as the zooplankton, quantitatively and qualitatively analyzed. Furthermore, the concentrations of chlorophyll A, seston, and organic matter have been determined. The hydrographical structure near the Rhone is heterogeneous. The biological results are difficult to explain on the basis of hydrographical parameters. The numerical data of zooplankton in the investigated areas are ten times higher than those of the Mediterranean Sea. There is a great abundance of brackish and freshwater phytoplankton in the dilute zone, but these cells are dead or almost dead; these observations coincide with the low concentrations of chlorophyll A. (P. Maxwell)

Blanc-Livini, Nelly and Abraham, M. 1970. The influence of environmental salinity on the prolactin and gonadotropin secreting regions of the pituitary of Mugil (teleostei). Gen. Comp. Endrocrinol., 14(1):184-197.

Specimens of two species of Mugil were collected from three environments differing in salinity (freshwater, sea water, and a hypersaline lagoon). Volumetric and histological changes in the proximal and rostral pars distalis of pituitaries from these fish are described. The most pronounced changes occur in the size of the rostral pars distalis of M. capito. This lobe (whose main component is the prolactin-secreting region) varies, occupying from 8% of the total hypophysis in fish from the hypersaline lagoon (7.8% salinity) to 42.6% in fish from fresh water. This increase in the size of the rostral pars distalis is accompanied by an increase in the size and granular content of individual eta cells. The volumetric changes of the proximal pars distalis are the inverse of those of the rostral pars distalis. Proximal pars distalis changes were most pronounced in M. cephalus, where this lobe occupies 35% of the hypophysis in specimens collected from the Mediterranean Sea during the spawning season, as compared with 7.3% of the hypophysis in specimens collected from fresh water. The prolactin content of the pituitary in M. cephalus as assayed by the water-drive test in Triturus vulgaris and T. alpestris is high in the freshwater specimens and low or almost nonexistent in specimens collected from the sea. Striking histological changes possibly indicative of a degenerating process are observed in the nucleus lateralis tuberis of M. cephalus specimens confined to fresh water for several years. These changes and their relation to the volumetric variations of the rostral and proximal pars distalis of the pituitary are discussed. Data on the mucus and chloride cells of the gills and on the Na plasma level are presented. (From Biol. Abstr.)

Blum, H. F. 1922. On the effect of low salinity on Teredo navalis. Univ. of Calif. Publ. in Zool., 22:349-368.

This shipworm is normally active in salinities as low as 9 ppt. Below this salinity, activity decreases with decrease in salinity, very rapidly below 7 ppt; at 3 ppt no teredos extend siphons. Average lethal salinity is 5 ppt. Can protect themselves in low salinity by stopping mouth of burrow with pallets, thus surviving short periods of salinity below 5 ppt.

Period of 33 days in a salinity below 4 ppt destroyed 90% of teredo in piles, at Crockett, Calif. Period necessary to kill remaining 10% cannot be determined at present. Teredos show remarkable recovery from sudden changes of salinity in aquaria and in the bay. (S. H. Hopkins)

Boettger, C. R. 1950. Ein Beitrag zur Frage des Ertragens von Brackwasser durch Mollusken Populationen. Hydrobiologia, 2(4):360-379.

"Description of molluscan populations of brackish sloughs and ponds in vicinity of Insel Rugen with data on size ranges of populations indicating smaller sized individuals in lower salinities." --W. G. Hewatt and J. W. Hedgpeth, 1957, in Geol. Soc. Amer. Memoir 67, Vol. 1, p. 1144.

Boguckl, M. 1932. Recherches sur la regulation osmotique chez l'isopode marin, Mesidotea entomon. Arch Internat. Physiol., 35:197-213.

The osmotic pressure of the hemolymph of Mesidotea (freezing point 1.07 C) is more than two times higher than that of Baltic water (freezing point 0.41 C). The mineral composition of Mesidotea's hemolymph differs from that of sea water in proportions of ions as well as in concentration. Mesidotea withstands without visible trouble varied concentrations of sea water, from that of ocean (20 mg Cl per cc) to that of Baltic water, diluted to 25% (0.93 mg Cl per cc). In concentrated media (15-20 mg Cl per cc) the blood of Mesidotea is isotonic to the outside medium. As the concentration of the outside milieu decreases,

salts in the blood decrease also, but slower, and, consequently, become hypertonic to the outside medium. In fresh water Mesidotea quickly loses Cl of its blood and dies in a few days. (S. H. Hopkins)

Bookhout, C. G. 1964. Salinity effects on the larval development of Pagurus bernhardus (L.) reared in the laboratory. Ophelia, 1(2):275-294.

10 C in five different salinities in 15 ppt-35 ppt range: there was an increase in mortality with a decrease of salinity. 15 ppt too low for first stage zoeae to molt to second zoeal stage. 25 ppt, 30 ppt, and 35 ppt molted at uniform rate.

Bookhout, C. G. and Costlow, J. D., Jr. 1959. Feeding, molting, and growth in barnacles. Pp. 212-225. In: Marine borers and fouling organisms, ed. by Dixy Lee Ray. Univ. of Washington Press, Seattle, xii + 536 pp.

P. 223: "From field studies and the geographical range given for various species of barnacles, we assume that larvae can exist over wide ranges of temperature and of salinity or that there are different physiological races."

Bookhout, C. G. and Costlow, J. D., Jr. 1962. Variations in development of crabs in relation to salinity and temperature (Abstract). In: Summer Meeting of American Society of Zoologists, Oregon State University, Corvallis, Oreg., August 1962. Amer. Zool., 2(3):393.

Twenty species of crab larvae were reared in laboratory at Beaufort, N. C., of which four or five species are considered here. In some species, salinity tolerances of larvae are similar to those of adult; in other species, larvae are limited to a narrower range of salinity than adult. In some, each larval stage may have a different salinity tolerance, not necessarily broader with age. Temperature may retard or accelerate development, and may also alter the salinity range that is tolerated. (S. H. Hopkins)

Boon, D. D. and Tatro, M. C. 1971. Blowing oysters for increased salt content. Chesapeake Sci., 12(1):51-52(Mar 1971).

When oysters from low-salinity waters are "blown" (washed in water agitated with air) in a 3% (30 ppt) salt solution they gain in salt content but lose 10-25% of their weight. Salty oysters, with 1% salinity or higher, are preferred by consumers, and the higher price they bring may compensate for the weight lost in the blowing process. (S. H. Hopkins)

Borsuk, Vera and Kreps, E. 1929. Untersuchungen uber den respiratorischen Gaswechsel bei Balanus balanoides und Balanus crenatus bei Verschiedenem Salzgehalt des Aussenmilieus. III. Mitteilung. Uber den Sauerstoffverbrauch im Luftmilieu bei verschiedenem Saltzgehalt der Korperflussigkeiten bei Balanus balanoides. Pflüger's Arch. Ges. Physiol., 222:371-380.

Intensity of gas exchange and O_2 consumption in air depends on salt concentration of the internal medium of the barnacle. After being held in water of 0-6 ppt salinity, the barnacle enters salt sleep and low level of O_2 use is unchanged by lowering salinity from 6 to 0 ppt. Raising salinity to 8-10 ppt causes strong rise in O_2 consumption in air. A further rise to oceanic salinity 33.5 ppt) is accompanied by only a slight change, if any, in gas exchange. The critical salinity appears to be that in which gas exchange rises from the low level of salt sleep to a higher level which corresponds to normal activity of the animal. In constant salinity, gas exchange fluctuates insignificantly in middle range. Barnacles living several months in aquaria reduce gas exchange slightly. (S. H. Hopkins)

Borut, S. Y. and Johnson, T. W., Jr. 1962. Some biological observations on fungi in estuarine sediments. Mycologia, 54:181-193.

Fungi (Phycomycetes, Ascomycetes, and Deuteromycetes) of over 150 species were collected from bottom sediments of the Neuse-Newport Estuarine system in North Carolina, under water of salinities from 0-0.3 to 20.5-36.3 ppt. Spore germination and growth were studied in eight species, and physiological reactions (activities) were studied in 20 species. (S. H. Hopkins)

Bose, Benoy B. 1959. An experimental study of the optimum salinity for the growth of the benthic blue-green alga, Oscillatoria splendida Greville of brackish-water ponds. Proc. Nat. Inst. Sci. India, 26B(1):19-21.

It was found that salinities ranging from 5 to 17 ppt are favorable for the growth of this alga. Inflection points of second-degree parabolas suggest that any salinity within a range is favorable for growth. (S. Rennie)

Boulenger, E. G. 1936. A Natural History of the Seas. New York (D. Appleton-Century Co.), 215 pp.; 9 plates; 50 figs.

P. 16--"The Boring Sponges (Cliona) are too abundant to please those responsible for oyster farms or the maintenance of sea walls. They tunnel both oyster shell and hard limestone boulder until the solid matter is reduced to so much honeycomb and disintegrates from erosion. A peculiar boring sponge excavates long galleries in the oyster's shell, covering the outside of the shell with a slimy film of white or creamy tint. At some oyster stations it is common to grow the oysters on wire frames which can be raised at intervals and exposed to a shower of rain. The fresh water kills the sponge, but the oyster by closely shutting its shell remains unscathed." (S. H. Hopkins)

Bourdeau, P. F. and Adams, D. A. 1956. Factors in vegetational zonation of salt marshes near Southport, N. C. Bull. Ecol. Soc. Amer., 37(3):68.

Studied effects of elevation, soil texture, and salinity on the distribution of Spartina patens, Juncus, roemerianus, and the tall, medium, and short growth forms of Spartina alterniflora. The salinity of the soil solution at low tide, equal to that of tidal water in the tall form zone of S. alterniflora, increased landward to a value more than twice as high in the zone occupied by the short form of S. alterniflora and the Salicornia perennis flats, and then decreased farther shoreward in the S. patens zone to its lowest level. Cited from Adams (1963, pp. 445-456). (S. H. Hopkins)

Bourne, Neil. 1971. The effects of temperature, salinity and food on the development of the larvae of butter clams (Saxidomus giganteus, Deshayes). (Abs) Proc. Nat. Shellfish. Assoc., 61:1.

Larvae were reared under combinations of four temperatures, 10, 15, 20, and 25 C, and three salinities, 20, 25, and 29 ppt, and fed different concentrations of three species of cultured algae. Optimum growth of larvae was at temperatures of 15 and 20 C, though survival was better at lower temperatures. No differences in growth rate were found in the three salinities. Larvae fed a mixture of two or three algae grew faster than those fed any one. Under optimum conditions, larvae settled in 20-25 days at lengths of 230-250 microns.

Bousfield, Edward L. 1955. Ecological control of the occurrence of barnacles in the Miramichi Estuary. Bull. Nat. Museum of Canada, 137:1-69.

The species occurring in the estuary are Balanus improvisus, B. crenatus, and B. balanoides. The normal range of salinity for B. improvisus larvae is 8-25 ppt for all stages with the extreme range extending from 0 to 27 ppt. For

B. crenatus larvae the normal range is 15-27 ppt with the extremes being 8-27 ppt. Ranges for B. balanoides larvae could not be observed in the study, but were assumed to be similar to B. crenatus.

Lethal low salinities seem to determine the upriver limit of adult barnacles. Ranges for the three species are as follows: B. improvisus, 0-15 ppt; B. crenatus, 6-21 ppt; B. balanoides, 12-23 ppt. (S. Rennie)

Bouxin, H. 1931. Influence des variations de la salinité sur la consommation d'oxygène chez Mytilus edulis. Bull. Inst. Océanogr. [Monaco], No. 569:1-11.

Mytilus edulis var. galloprovincialis bears, without apparent trouble to its oxygen consumption, variations in salinity from normal to 30% fresh water [i.e. 70% sea water]. More than 60% fresh water, or more than 35% of water concentrated to one-half [i.e. water of twice normal sea-water salinity] causes respiration to become zero in 2 hr. Variations of respiration of different animals in the range of 30-60% fresh water and 5-35% supersaline water show notable differences between animals. The same animal reacts in the same manner in the two ranges, in hypo- and hypersaline media. These molluscs have individual sensitivity showing individual physiology, individuality which would not be shown by experiments made previously by other authors (Bruce, 1926) who studied 20 animals at once. (S. H. Hopkins)

Bowman, H. H. M. 1956. Salinity data on marine and inland waters and plant distribution. Ohio Jour. Sci., 56(2):101-106.

Data include tables on quantities of various ions in sea water, salinities of "certain special ocean areas" (30-41 ppt), types of saline lakes, and quantities of components of Great Salt Lake (salinity 243 ppt). "Inland waters" refers to saline lakes. About 30 genera of seed plants live in shallow waters of sea close to shore. Blue-green algae are not well represented but a few species are abundant in places, including Trichodesmum erythraeum which makes Red Sea red. Green algae (including Ulva and Enteromorpha) thrive where fresh and salt water mix. Brown algae are abundant on coasts, especially rocky ones, but sparse in brackish water. Red algae are the only algae that live beyond the continental shelf (presumably excluding plankton). Diatoms, Halosphaera, Dinoflagellates, and Coccolithophores are mentioned as planktonic groups. (S. H. Hopkins)

Bowman, Thomas E. 1964. Mysidopsis almyra, a new estuarine mysid crustacean from Louisiana and Florida. Tulane Stud. in Zool., 12(1):15-18.

The new species is described from Lake Pontchartrain, Louisiana, where it is very abundant and together with the copepod Acartia tonsa dominates the zooplankton; also from St. Andrews Bay and north end of Buttonwood Canal, in southern Florida. Of interest as an estuarine species which can live in salinity of 27.3-33.7 ppt (in Florida), but abundant in very low salinity. (S. H. Hopkins)

Braarud, T. and Føyn, B. 1958. Phytoplankton observations in a brackish water locality of south-east Norway. Nytt Mag. Bot., 6:47-73.

Topographical and hydrological data on the study area (Hunnebunnen) are given by Klavestad (1957). Only the upper water layer is brackish (0-4 m in summer). Phytoplankton peaks occur during the summer--Sceletonema costatum in May; Euglenaceae in June; Cyclotella caspia in July; Peridinium triquetrum in August along with Exuviaella battica, Dinophysis borealis, and Chaetoceros socialis; E. battica in September; and S. costatum in October. In winter, populations are poor under the ice cover. Seasonal light supply affecting oxygen controls the depth of the H_2S layer, which is deepest in summer and sometimes at 2 m in winter. The Euglenaceae are able to live at the H_2S stratum all year long and even in it at times. (S. Rennie)

Brady, F. 1943. The distribution of the fauna of some intertidal sands and muds on the Northumberland coast. Jour. Animal Ecol., 12:27-41.

At Cullercoats Harbour and at Black Middens, mouth of River Tyne (England), the animals in 0.25-sq-m sample areas were counted and measured along transects from outer to inner edge of intertidal flats. At Cullercoats the bottom was sand, at Black Middens fine sand with 0.3-16.4% silt. pH and salinity were measured at each station. Animals down to a depth of 10 in. were dug out of each sample plot. Animals most common in Cullercoats were Scolecolepis girardi, Nerine cirratulus, Arenicola marina, Eteone picta, Enchytraeus albidus, Eurydice pulchra, and Phyllodoce maculata. At Black Middens the common species were Scolecolepis girardi, Scoloplos armiger, Nephthys hombergi, Nereis diversicolor, Phyllodoce maculata, Arenicola marina, Eteone picta, Macoma balthica, Spio filicornis, and Tellina tenuis. The pH ranged from 7.6-8.2, the salinity from 24-33.6. Budle Bay was also studied. (S. H. Hopkins)

Brandt, K. 1897. Die Fauna der Ostsee, insbesondere die der Kieler Bucht. Verh. Deutsch. Zool. Geselsch., 19:10-34.

(Series Die Binnengewasser.) Fauna study of Baltic Sea as a whole, listed as important brackish-water reference by Redeke, 1932. (S. H. Hopkins)

Brattstrom, H. 1941. Studien über die Echinodermen des Gebietes zwischen Skaggerak und Ostsee, besonders des Öresundes mit einer Übersicht uber die physische Geographie. Unders Öresund, Lund., 27:329.

Asterias rubens penetrates the Baltic Sea and lives there in salinities lower than it tolerates anywhere else, even as low as 8 ppt. (Fide Binyon, 1966, which see.)

Brattstrom, H. 1954. Notes on Victorella pavida Kent. Lunds Univ. Arrssk., N.F., 50(9):1-29.

The most widespread of the estuarine ectoproct bryozoans (moss animals): London, Egypt, Japan, Australia, Brazil, Bengal, Chesapeake Bay, etc. Tolerates salinites from fresh water to about 27 ppt. (Fide Green, 1968, pp. 132-133.) (S. H. Hopkins)

Brawn, V. M. 1960. Survival of herring (Clupea harengus L.) in water of low salinity. Jour. Fish. Res. Bd., Canada, 17(5):725-776.

Herring 10.2-24.2 cm long were kept in tanks of water from <0.1- to 31.9-ppt salinity at 5.5-9.1 C, 20 fish per tank. Mortalities in 4 weeks were 0 in 31.9 and 25.6 ppt, 20% in 20.1 ppt, 5% in 10.2 ppt, 15% in 5.2 ppt, and 100% in <0.1 ppt. It was concluded that low salinity is unlikely to have any direct adverse effect on herring unless the salinity falls below 5 ppt. (S. H. Hopkins)

Breder, C. M. 1933. The significance of calcium to marine fishes invading fresh water (Abstract). Anat. Rec. (Suppl.), 57:57.

A variety of marine fishes invade Lake Forsyth, Andros Island, British West Indies, which has a Ca content of about 1.1 mm and a Cl content of about 13.6, compared with 13.5 Ca and 561 Cl in nearby sea water. Water synthesized to reproduce Lake Forsyth water kept Hippocampus hudsonius, Pomacentrus leucostictus, and Centropristes striatus alive for 1 week. Water saturated with $CaCO_3$ and $CaSO_4$ also supported these fishes, plus Stenotomus chrysops, Lytianus synagris, L. apodus, Anisorremus virginicus, Angelichthys ciliaris, and Abudefduf saxatilis. Freshwater fishes Carassius auratus and Eupomotis gibbosus lived with these marine species. Transfer from sea water was gradual over 3 days.

The longest test, 20 days, was with L. apodus. The experimental fish, when jarred, would show nervous tremors and sometimes die; perhaps tetanus due to small amount of Ca in water. (S. H. Hopkins)

Breder, C. M., Jr. 1934. Ecology of an oceanic fresh-water lake, Andros Island, Bahamas, with reference to its fishes. Zoologia, 18:57-88.

The ponds on this island are true fresh water, but have a lime bottom and consequently a very high Ca content. Marine fishes of many kinds invade these freshwater lakes by way of streams and live well there, but no marine invertebrates could be found. A large variety of marine fishes are able to exist in fresh water saturated with respect to Ca, while the "soft" fresh waters are quickly disastrous. However, the saturation point of Ca is lower in fresh than in sea water, and fish in fresh water are subject to "shock," going into convulsions when frightened, sometimes recovering and sometimes dying.

Marine invertebrates, in general, are not so adaptable to Ca-saturated fresh water, but are peculiarly sensitive to slight chemical changes in sea water. (S. H. Hopkins)

Brenko, M. H. and Calabrese, A. 1969. The combined effects of salinity and temperature on larvae of the mussel Mytilus edulis. Mar. Biol., 4(3):224-226 (Nov 1969).

Tests were made at 36 combinations of salinity (15, 20, 25, 30, 35, and 40 ppt) and temperature (5, 10, 15, 20, 25, and 30 C). Effects of salinity and temperature were significantly related only as tolerance limits of either were approached. Survival of larvae was 70% or better at all salinities at temperatures from 5 to 20 C but was reduced drastically at 25 C, especially at 40 and at 15 and 20 ppt. Growth of larvae was rapid at 15 C in salinities from 25 to 35 ppt, and at 20 C in salinities from 20 to 35 ppt. Optimum growth occurred at 20 C and in salinities of 25 and 30 ppt. Growth decreases at 25 C and at 10 C, and decreases drastically in salinities of 40 ppt and 20 ppt, at those temperatures. (S. H. Hopkins)

Brereton, A. J. 1971. The structure of the species populations in the initial stages of salt marsh succession. Jour. Ecology, 59(2):321-338.

The factors controlling the vegetational development during the initial stages of the salt marsh succession were examined. Population structure of Salicornia europaea and Puccinellia maritima...was described and factors responsible for this structure were analyzed.... The various successional stages were determined by the overall level of waterlogging as controlled by the height of the marsh surface relative to sea level. Within each successional phase the species distribution was controlled by variations in salinity and waterlogging which were associated with local differences in soil texture. Salicornia tended to occur in highly saline nonwaterlogged areas whereas Puccinellia tended to occur in nonsaline waterlogged areas. (From Biol. Abstr.)

Breuer, J. P. 1957. An ecological survey of Baffin and Alazan Bays, Texas. Publ. Instit. Mar. Sci., Univ. of Texas, 4(2):134-155.

The study area is the saltiest part of the normally hypersaline Laguna Madre system. Salinity during the study period (June 1951-May 1953) ranged from 1.40 to 75.05 ppt and averaged 51.68 ppt; pH was 7.30-8.65, mean 7.91; transparency or percent light transmitted was 5.0-100, mean 85.4. No temperatures are reported, although they were measured; it is stated only that water temperatures in the study area "can vary from 0 to 38 C." There are no seed plants in these waters, only algae, mostly Enteromorpha. The total number of both plant and animal species is very limited (21 species of plants, including diatoms and dinoflagellates, and invertebrates, of which only 3 algal and 8 invertebrate

species "can be considered normal residents," and 26 fish species of which only 10 are "normal residents.") Those species which are "normal residents" are "available in large quantity," especially the black drum, Pogonias cromis, "by far the most important food fish of the area." Among the invertebrate "normal residents" are the shrimp Penaeus aztecus and the crab Callinectes sapidus. (S. H. Hopkins)

Breuer, J. P. 1962. An ecological survey of the Lower Languna Madre of Texas, 1953-1959. Publ. Instit. Mar. Sci., Univ. of Texas, 8:153-183.

This shallow, hypersaline marine bay extends 76 miles north from the delta of the Rio Grande. Water in the Laguna flows north from the pass (from the Gulf of Mexico) in summer and south toward the pass in winter. Salinity normally is 32-35 ppt near the passes and 50-55 ppt at the northern end. In spite of adverse conditions for many species, the incomplete list of fauna includes 79 fishes, 101 invertebrates, 31 algae (including 5 dinoflagellate species as algae), and 5 seed plants, a total of 216 kinds of organisms; however, many of these occur only near the passes. Among fishes, invertebrates, and plants, the number of species decreases away from the pass as salinity becomes more different from the Gulf in either direction (higher or lower); and as salinity deviates more from Gulf salinity the total number of individuals of the remaining species increases. (S. H. Hopkins)

Bricteux-Grégoire, S., Duchâteau-Bosson, G., Jeuniaux, C., and Florkin, M. 1962. Constituants osmotiquement actifs des muscles du crabe chinois Eriocheir sinensis, adapté a l'eau douce ou a l'eau de la mer. Arch. Internat. Physiol. Biochim., 70:273-286.

When Chinese mitten crabs are transferred from fresh water to sea water, the osmotically active components of muscle rise to a level which prevents a change in percentage of water in muscle. Taurine and glycocoll-betaine do not increase in concentration, but Na, K, Cl, alanine, glycocoll, total glutamic acid, proline, arginine (including phosphoarginine), and the oxide of trimethylamine contribute in an important way to the adjustment. There are strong similarities to the process in crustacea which live in the sea: Carcinus maenas, Nephrops norvegicus, and Homarus vulgaris. (S. H. Hopkins)

Brisou, J. and Doublet, Menantaud and M. 1958. Contribution à l'étude de la flore microbienne normale des estuaries. Les Pseudomonadaceae des bouces de la Charente. Bull. Inst. Océanogr. [Monaco], 1129:1-8.

"We present a study of the germs which can be easily classified in the huge family Pseudomonadaceae. These bacteria belong to the normal microbial flora or rivermuds in the unstable zone of estuaries. We have found in Charente species already described in America, isolated from the Ohio, from shores of North Carolina, from seaweeds, in sea fruits in the water of rades, etc. Such correlations show the universality of certain species and their plasticity or adaptability, for they accommodate themselves to very unstable living conditions. Variations of salinity, composition of muds, do not have any notable effect on them, at least under the conditions in which our observations were made."--Conclusions, pp. 4-5.

Broekema, M. M. M. 1941. Seasonal movements and the osmotic behaviour of the shrimp, Crangon crangon L. Arch. Neederland. de Zool., 6(1):1-116.

To help determine factors controlling distribution of Crangon crangon in Dutch waters, laboratory experiments were conducted combining various temperature and salinity levels and observing their effects on Crangon of various ages, egg development, and osmotic behavior. For shrimp about 2 yr old, with increasing temperature the salinity optimum shifted toward less saline water. At 20 C,

a salinity of about 29 ppt was optimal, whereas at 4 C, 33 ppt was optimal. For 1-yr-old shrimp, salinity optimum at 22 C was 18-19 ppt, indicating that with increasing age the optimum shifts toward a higher salinity. A combined influence of temperature and salinity of the same nature as those above was also shown for newly hatched shrimp larvae. Likewise, the salinity range available for normal development of eggs depended on temperature in a similar fashion. The higher and lower salinity limits shifted downward with increasing temperature. The salinity range for normal egg development was wide, 12-42 ppt. Development was slightly retarded at low and extremely high salinities. The high rate of development was 35-41 ppt at 8-10 C and 25-33 ppt at 16-18 C. Osmotically, Crangon was homoiosmotic. Although the concentration of the blood followed the concentration of the external medium to a certain extent, Crangon was able to maintain a difference in concentration between blood and medium. In salinities higher than 21-23 ppt, the blood was hypotonic; in salinities lower than 21-23 ppt, hypertonic. The difference between internal and external concentration was greater at high than at low temperatures. (T. Rennie)

Broekhuysen, G. J. 1936. On the development, growth and distribution of Carcinides maenas (L.). Arch. Neederland. de Zool., 2(2 & 3):257-399.

Distribution of crab depends on combination of temperature and salinity. Salinity tolerance of developing eggs is increased if temperature is raised. Broekema (1941) got similar results with Crangon. (S. H. Hopkins)

Broekhuysen, G. J. 1940. A preliminary investigation of the importance of desiccation, temperature and salinity as factors controlling the vertical distribution of certain intertidal marine gastropods in False Bay, South Africa. Trans. Roy. Soc. S. Africa, 28(3):255-292; 6 text-figs., plates, 52, 53; 2 pp. refs.

The vertical distribution or zonation of the Prosobranch snails Littorina knysnaensis Philippi, Thais dubia (Krauss), Oxystele variegata (Anton), Oxystele tigrina (Dillwyn), Oxystele sinensis (Gmelin), Cominella cincta (Roding), and Turbo sarmaticus Linn. had recently been worked out by Bokenham and Neugebauer (1938) at False Bay (Cape Colony). This is a study of the factors responsible for that zonation, including salinity. The salinity data are presented in fig. 6 and tables VIII, IX, X, and XI, showing salinity tolerances of the six snail species and extremes of salinity resisted. The best correlation is between vertical distribution and resistance to desiccation (pp. 256-269, figs. 1, 2, 3A, 3B, 4, and tables I, II, III). (S. H. Hopkins)

BroLarsen, E. 1951. On subsocial beetles from the salt-marsh, their care of progeny and adaptation to salt and tide. Trans. IXth Internatl. Congr. Ent., 1:502-506.

Bledius spectabilis eats algae which contain 5-6% NaCl. The blood concentration is relatively stable, fluctuating around 1.2% NaCl. To keep the body fluid concentration low, NaCl must be excreted into the hindgut, via the Malpighian tubules, and water reabsorbed. The midgut swells greatly when in a hypotonic solution. Given a preference, animals will select the high salt concentration. B. spectabilis as well as B. diota and B. taurus can be found in low salinities, but they do not do well there. They are more subject to attack from parasites and predators in such places. (S. Rennie)

Bromhall, J. D. 1954. A note on the reproduction of the grey mullet, Mugil cephalus L. Hong Kong Univ. Fish. Jour., 1:19-34.

In a discussion of the culturing and reproduction of the gray mullet in Asia, the author states that M. cephalus has a wide range of salinity tolerance (from less than 4 to 40 ppt), and has a habit of entering freshwater rivers and lakes. In Hong Kong, Mugil is cultured in brackish-water ponds. He also notes that

near Hong Kong, ripe females sought high salinity water to lay their eggs, not brackish water. Mugil cephalus has a slightly wider salinity tolerance than M. capito. (T. Rennie)

Brongersma-Sanders, Margaretha. 1957. Mass mortality in the sea. Pp. 941-1010 (Chap. 29). In: Hedgpeth, J. W., ed. Treatise on marine ecology and paleoecology. Geol. Soc. Amer. Memoir. 67, Vol. I, Ecology, viii + 1296 pp.

The emphasis is on mass mortalities of marine organisms caused by plankton "blooms" such as the "red tides" caused by hugh increases in abundance of certain species of dinoflagellates. However, on pp. 945-947 mass mortalities caused by sudden changes in salinity are discussed, with about 25 references to specific cases, some caused by increase and some by decrease in salinity. On pp. 977-978 nine cases of mass mortality caused by salinity increases (as in Laguna Madre of Texas, Gulf of KaraBugaz, U.S.S.R.) are described in more detail, with references. (S. H. Hopkins)

Brown, A. C. 1959. The ecology of South African estuaries. Pt. ix. Notes on the estuary of the Orange River. Trans. Roy. Soc. S. Africa, 35:463-473.

The Orange River Estuary has an extremely poor fauna, lacking a true estuarine component. During low spring tide, fresh water extends down the channel with little sea-water mixture, even outside the mouth (4.5-6.3 ppt). At high spring tide, high salinity water (34.7 ppt) pushes up the channel. The estuary exists for a short period in winter and disappears completely in summer. (S. H. Hopkins)

Brown, M. E., ed. 1957. The physiology of fishes. Academic Press, New York. 2 volumes: Vol. 1, Metabolism; Vol. 2, Behavior. Vol. 1, xiii + 447 pp. Vol. 2, xi + 526 pp.

Vol 1, pp. 163-205, chapter on excretion and osmoregulation by Virginia S. Black discusses salinity relations of stenohaline marine and freshwater fishes, anadromous, catadromous, and euryhaline fishes. Vol. 2, pp. 409-411, chapter by Peter Duodoroff on water quality requirements discusses behavior of fishes in relation to salinity and osmotic pressure, and points out that both freshwater fishes and marine fishes that cannot live in fresh water can live in brackish water--some freshwater fishes living in salinities up to 4 ppt, some up to 14 ppt and above, while some marine fishes tolerate equal salinities, so the salinity tolerance is not closely related to freezing point depression of the blood. (S. H. Hopkins)

Brues, C. T. 1917. Occurrence of the marine crab, Callinectes ornatus, in brackish and fresh water. Amer. Naturalist, 61:566-569.

C. ornatus occurs at Belmonte, Rio Caonao, near Cienfuegos, Cuba, where density of river water is about one-fourth that of sea water. Farther up dry river bed "we found another large male (Callinectes ornatus Ordway) in a small pond of quite fresh water...perfectly active and happy and quite belligerent when removed from the water where he had been living for at least 3 months."
Also mentions records of Callinectes sapidus as much as 55 miles above mouth of Hudson River, N. Y. (S. H. Hopkins)

Brunberg, L. 1964. On the nemertean fauna of Danish waters. Ophelia, 1:77-111.

Twenty-six species of nemerteans were found in Danish waters. A few of the nemerteans were euryhaline, but the majority were stenohaline. Of those that were stenohaline, most were truly marine, with only a few being adapted to brackish water. The euryhaline forms were Lineus ruber and Malacobdella grossa (both found in the Atlantic and the Baltic proper) and Amphiporus lactifloreus

and Tetrastemma melanocephalum which ranged from the Atlantic to the Kieler Bucht. Prostomatella obsura was found in the Gulf of Finland where the salinity was less than 6 ppt. The freshwater nemertean Prostoma graecense also occurred there. (T. Rennie)

Bryan, G. W. 1963. The accumulation of ^{137}Cs by brackish water invertebrates and its relation to the regulation of potassium and sodium. Jour. Marine Biol. Assoc. U.K., 43:541-565.

Equilibrium ^{137}Cs (radioactive caesium) concentration factors in the brackish-water isopod Sphaeroma hookeri vary from about 7 in 100% sea water to 200-300 in 2.5% sea water. In the snail Potamopyrgus jenkinsi a ^{137}Cs concentration factor of about 3 is reached in 100% sea water while a factor of about 300 is reached in 0.1% sea water. In accumulating ^{137}Cs to high levels in dilute media, brackish-water species are potentially much more hazardous than marine species. (S. H. Hopkins)

Bryan, G. W. 1964. The accumulation of radio-caesium by marine and brackish water invertebrates. Jour. Marine Biol. Assoc. U.K., 45:559.

Laboratory experiments on the absorption by marine invertebrates of radio-caesium dissolved in sea water are discussed in relation to the K concentration of the animal, body size, temperature, and the inactive Cs and K concentrations of sea water. (Author's abstract in part)

Buchanan, D. and Billemann, R. E. 1969. The prezoeal stage of the Dungeness crab, Cancer magister Dana. Biol. Bull., Woods Hole, 137(2):250-255.

The study was undertaken to determine if salinity affects hatching of C. magister eggs, the type of larva that emerges from the egg, and larval development. Ninety-four percent of eggs of the crab held in sea water at 10.5 or 17.5 C and at salinities of 10-32 ppt hatched into prezoeae during a 36-hr observation period. The highest and lowest numbers of eggs hatched at salinities of 15 and 10 ppt, respectively. At a salinity of 32 ppt, the mean percentages of eggs that hatched at 10.5 and 17.5 C were 30% and 73%, respectively. With increase of salinity, the percentages of prezoeae that molted to first-stage zoeae increased from 0% at 10 ppt to 100% at 30 and 32 ppt. With increase of salinity from 15 to 32 ppt the mean duration of the prezoeal stage decreased from more than 60 min to 11 min. The occurrence of a free prezoeal stage of short duration is normal in the life history of C. magister. The possibility that this is true for other Brachyura is discussed. (P. Maxwell)

Bull, J. M. and Morris, R. 1967. (Dep. Zool., Univ. Nottingham, Nottingham, Eng., U.K.) Studies on fresh-water osmoregulation in the ammocoete larva of Lampetra planeri (Bloch):1. Ionic constituents, fluid compartments, ionic compartments and water balance. Jour. Explt. Biol., 47(3):485-494, 1967.

There is no significant variation in water content and freezing-point depression or of osmotically active ions in the blood, muscle, or in whole final-year ammocoetes taken in July and November. The urine output (198 ml/kg/day) is similar to that of other freshwater lampreys, and there is evidence of a very efficient controlling mechanism for salt-H_2O balance in these animals.
(S. H. Hopkins)

Bullivant, J. S. 1961. The influence of salinity on the rate of oxygen consumption of young quinnat salmon (Oncorhynchus tschawytscha). New zealand Jour. Sci., 4(2):381-391, illus.

It had been reported previously that salmon grew faster in brackish water than in fresh water. The author tested young salmon in fresh water, sea water, and a

1:1 mixture. Fresh and brackish water gave approximately equal growth rates, but growth in sea water was much less. Rates of oxygen consumption in 1-yr-old quinnat salmon were found not to differ significantly in fresh water, sea water, and half sea-half fresh water. "Evidence suggests that a large change in respiration rate accompanying a change in the osmotic strength of the surrounding medium of an aquatic animal may result from an initial breakdown in osmoregulation." (S. H. Hopkins)

Burbanck, W. D. 1959. The distribution of the estuarine isopod, Cyathura sp., along the eastern coast of the United States. Ecology, 40:507-511.

This isopod, later identified as Cyathura polita, was found in estuaries from Maine to Florida. It is a low-salinity species, often found with caddis-fly, damselfly, and mayfly larvae, and with leeches. Being very adaptable, it is also found in bays in fairly high salinity, but is not found breeding. (S. H. Hopkins)

Burbanck, W. D. 1961. The disappearance of Cyathura polita from the Ashepoo River, South Carolina, after hurricane "Gracie" in 1959. Ecology, 42:606-607.

Over 3 years this isopod was found at all three stations sampled in this swamp river, but on 31 Oct-1 Nov 1959 none could be found after diligent search. Gammarids and nereids usually found with Cyathura were also lacking. The hurricane 29 Sep 1959 had been accompanied by the heaviest rain in 100 yr and there was a tremendous fish kill reported. The stirring up of organic matter might have released enough H_2S to kill fish and invertebrates. Ten months after the hurricane there were still no cyathurans in the river, but there had been some recovery of fish. (S. H. Hopkins)

Burbanck, W. D. 1962a. An ecological study of the distribution of the isopod Cyathura polita (Stimpson) from brackish waters of Cape Cod, Massachusetts. Am. Midland Naturalist, 67:449-476.

This estuarine isopod was found at 40 of 62 estuaries and tidal marshes visited on Cape Cod and nearby, usually at a depth of 5-8 cm, in concentrations of 108-1080/sq m. Animals most frequently found with it were Scolecolepides, Heteromastus, nereids, and gammarids. The largest populations of C. polita were in creeks having the coolest inflow of fresh water. In higher salinites Macoma baltica and Mya arenaria occur, in deeper water, at same locations as C. polita. C. polita thrives on stable substrates having some sand and moving water under tidal influence. It cannot survive in salinity as high as 28 ppt, but can withstand very low salinity. (S. H. Hopkins)

Burbanck, W. D. 1962b. Further observations on the biotope of the estuarine isopod, Cyathura polita. Ecology, 43(4):719-722.

This isopod occurs where there is a mixing of fresh and brackish waters from southern Maine to Lake Pontchartrain, La. At Lake George, Fla., it was in practically fresh water associated with insect larvae, leeches, freshwater snails, and crayfish. At the high salinity extreme, it was found at a beach on Sapelo Island, Ga. (S. H. Hopkins)

Burbanck, W. D. 1967. Evolutionary and ecological implications of the zoogeography, physiology and morphology of Cyathura (Isopoda). Pp. 564-573. In: Lauff, G. H., ed. Estuaries, Am. Assoc. Adv. of Sci. Publ. 83, Washington, D. C., xv + 757 pp.

The author has made a lifetime career of research on a single crustacean species, Cyathura polita, of the east coast of North America. The knowledge of this isopod is reviewed, and other species of the genus Cyathura are compared:

C. carinata of Europe and Asia, and C. estuaria of South Africa. All are estuarine. Another species, C. indica (-C. pusilla) has been reported from the coasts of the Indian Ocean, East Africa to Singapore; C. crucis from the West Indies is very similar. C. siamensis and C. munda are other marine species. C. curassavica of Curacao, C. milloti of Reunion Island, and C. specus of Cuba live in freshwater springs. Other less-known forms are mentioned. It is postulated that such widespread species as C. polita, with many geographically isolated populations, may be in the process of splitting into distinct races. (S. H. Hopkins)

Burckhardt, G. 1913. Zooplankton aus ost und sud-asiatischen Binnengewassern. (Zooplankton from eastern and southern Asiatic inland waters.) Zool. Jahrb. (Syst.), 34:341-472.

The copepod genus Centropages of the Northern Hemisphere contains about 23 species, mostly marine but some penetrate brackish waters; C. hamatus enters Britain's estuaries but never enters fresh water and rarely enters waters of salinities below 14 ppt. The genus Limnocalanus resembles a Centropages with some structures reduced; L. macrurus lives both in Baltic Sea and in lakes, though the brackish-water form is sometimes referred to as L. grimaldi. Cited by Green, 1968, p. 88. (S. H. Hopkins)

Burger, J. W. 1957. The general form of excretion in the lobster, Homarus. Biol. Bull., 113:207-223.

In dilute sea water (60-70% of full sea-water salinity) lobsters conserve magnesium. Under these same conditions, blood calcium decreases and blood chlorides increase. When placed in diluted sea water (60-90%), osmotic uptake is completed in less than an hour, with a gain of 1-2% in body weight. (S. Rennie)

Burkenroad, M. D. 1931. Notes on the Louisiana conch, Thais haemastoma Linn., in its relation to the oyster, Ostrea virginica. Ecology, 12:656-664.

This snail is an important enemy of oysters and it kills large numbers of oysters, especially small ones. It prefers mussels to oysters, It cannot tolerate salinities as low as those oysters can tolerate, and part of the oyster range is therefore free of Thais. Man-made changes in drainage of land cause shifts in range and numbers of Thais. Strong negative geotropism in breeding season makes trapping of Thais feasible during part of year. Thais produces large numbers of free-swimming larvae which can extend its range quickly when conditions are suitable for survival. It is therefore hard to control. (S. H. Hopkins)

Burkholder, P. R. 1933. A study of the phytoplankton of Frenchman's Bay and Penobscot Bay, Maine. Intern. Rev. ges. Hydrobiol., 28:262-284.

In a summer study of the marine phytoplankton in the region of Mt. Desert Island, it was found that Frenchman's Bay, which had relatively little influx of fresh water, supported a larger volume of phytoplankton than Penobscot Bay, where large quantities of fresh water were contributed by the Penobscot River. The dilute brackish waters in the region where the Sullivan River emptied into the bay were found to be very poor in plankton and in the narrow headwaters where the tides mix the water masses, an aggregation of fresh, brackish, and marine bottom and planktonic species was encountered. In Penobscot Bay, total plankton volume was less in the dilute waters near the River inlet than at the mouth of the bay. The greatest production of diatoms in this bay occurred in the more saline waters (surface incoming waters). (T. Rennie)

Burton, R. W. 1963. Distribution of oyster microparasites in Chesapeake Bay, Maryland, 1959-1960. Proc. Nat. Shellfish. Assoc. (1961), 52:65-74.

The U. S. Bureau of Commercial Fisheries Laboratory, Oxford, Md., examined 663 oysters from 165 oyster beds in 1959 and 1960, finding "MSX" (=Minchinia nelsoni), Dermocystidium marinum, Ancistrocoma species, Hexamita species, Bucephalus cucullus, and Nematopsis ostrearum; 543 oysters had no parasites. In Pocomoke Sound 25.5% of the oysters had "MSX" in fall 1960 and there was a noticeable mortality. No other extensive mortality was found. "These studies indicate that the upper Chesapeake Bay is relatively free of oyster parasites. This may be attributable to a rather high flushing rate in the upper Bay from land and river drainage and an over-all lower salinity than in the lower Bay." (P. 72.) (S. H. Hopkins)

Butler, P. A. 1949a. An investigation of oyster producing areas in Louisiana and Mississippi damaged by flood waters in 1945. U. S. Fish and Wildlife Serv., Special Scientific Report: Fisheries No. 8. vi + 27 pp.

To protect New Orleans from a flood, Bonnet Carré Spillway was open from 24 Mar to 17 May 1945, a period of 56 days, diverting 318,000 sec/ft of fresh water from the Mississippi River into Lake Pontchartrain, from which it flowed into oyster-growing waters of Mississippi Sound, depressing the salinity to an average below 1 ppt. Butler made his studies in the spring of 1949. In the meantime the area had been visited by a hurricane in September 1947. Also floodwaters from the Pearl River had emptied into the area in 1946, 1947, and 1949. Butler recommended spending funds for rehabilitation of oyster beds farther east in Mississippi Sound but not in the west end which he considered to be marginal because it was subject to frequent flooding from both natural and man-made causes. He also examined Lake Mechant, which receives some floodwaters from the Atchafalaya River, and considered it to be too marginal also to justify expenses of rehabilitation. (S. H. Hopkins)

Butler, Phillip A. 1949b. Gametogenesis in the oyster under conditions of depressed salinity. Biol. Bull., 96(3):263-269, 3 graphs.

A "high-salinity" area (6-23 ppt) and a "low salinity" area (0-14 ppt) in Chesapeake Bay are compared for spawning activity, development of gonads, etc. In the low salinity area, gametogenesis was inhibited in 90% of the surviving population until the salinity rose above 6 ppt in August. After the salinity rise, oysters rapidly improved in condition. Effect is believed due to lack of feeding in extreme low salinity rather than direct effect of fresh water. (S. H. Hopkins)

Butler, P. A. 1953. The southern oyster drill. Proc. Nat. Shellfish. Assoc. (1953), 44:67-75.

The oyster-drilling snail Thais haemastoma floridana, a major enemy of oysters in the Gulf of Mexico estuaries, is normally absent from areas having a sustained salinity level of less than 15 ppt. However, it can live in fresh water several days without harm by keeping its operculum closed. Snails acclimated to 35-ppt salinity are seriously damaged by a drop to 15 ppt, while those adjusted to 20 ppt can withstand a drop to 12 or even 10 ppt without ill effects. At Pensacola, snails on pilings, adjusted to salinities of 14-19 ppt, were unaffected when salinity at low tide periods dropped to 8 ppt for short times. When fresh water floods an estuary, killing all Thais on reefs, many in deep pockets and channels survive, as happened in Mississippi Sound in 1950; after an apparently complete kill, Thais had repopulated the entire area by the following year. (S. H. Hopkins)

Butler, P. A. 1954. Summary of our knowledge of the oyster in the Gulf of Mexico. Pp. 479-489. In: Galtsoff, P. S., ed. Gulf of Mexico, its origin, waters, and marine life. Fish. Bull. 89, U. S. Fish and Wildlife Serv., Vol. 55, Washington, D. C., xiv + 604 pp.

Most gulf oyster communities fall into one of four categories: (1) Near head of estuary, salinity 0-15 ppt, average near 10 ppt, often killed by fresh water, low spatfall and growth, few pests. (2) Salinity 10-20 ppt, average near 15 ppt; population density, reproduction, spatfall maximum; relatively few pests, except in drought years. (3) Near the mouth of a typical estuary, salinity 10 or 12 to 30 ppt, average near 25 ppt; usually good growth, but much shell erosion and predation; reproduction maximum, but population density held down by parasites and predators; mortality rates high. (4) At junction of estuary with gulf, salinity consistently high, population sparse, growth slow, spat mortality high, adult mortality high.

Calabrese, A. 1969a. The early life history and larval ecology of the coot clam, Mulinia lateralis (Say) (Mactridae: Pelecypoda). Ph. D. Thesis, University of Connecticut, Storrs.

Calabrese studied the combined effect of salinity and temperature on larvae of this clam, and found that although a significant percentage of the larvae survived a wide range of salinities (10-35 ppt) and temperatures (7.5-27.5 C), they grew best within the salinity range of 20-35 ppt (highest tested) and the temperature range of 22.5-27.5 C.

Calabrese, A. 1969b. Individual and combined effects of salinity and temperature on embryos and larvae of the coot clam, Mulinia lateralis (Say). Biol. Bull., 137(3):417-428(Dec 1969).

In salinities of 22.5-30 ppt and at temperatures of 25 ± 1 C, 70% or more of maximum embryos developed; a salinity of 27.5 ppt was optimum. Some embryos developed normally at salinities as low as 15 ppt and some at salinities as high as 37.5 ppt (10% and 1.2%, respectively). Some larvae survived in all salinities tested (7.5-37.5 ppt), but 70% or more larvae survived only in a salinity of 20-27.5 ppt. In salinities of 20-30 or 32.5 ppt, 70% of maximum larvae grew satisfactorily; a salinity of 25 ppt was optimum. In salinities of 27 ± 0.5 ppt, embryos developed satisfactorily at temperatures of 15-25 C; 20 C was optimum. Some embryos developed normally at 10 and 30 C (17.3% and 39%, respectively). Some larvae survived at temperatures of 7.5-32.5 C; survival was satisfactory at 7.5-27.5 C and growth at 20-30 C, 27.5 being optimum. Salinity and temperature effects were significantly related only when tolerance limits were approached. (S. H. Hopkins)

Calabrese, A. and Davis, H. C. 1970. Tolerances and requirements of embryos and larvae of bivalve molluscs. Helgolaender wiss. Meeresunters, 20:553-564.

The hard clam (Mercenaria mercenaria) is much less tolerant of low salinities than other bivalves. Rearing of larvae is possible only in salinities above 22 ppt; below this, most embryos fail to develop to the straight-hinge stage, although larvae can survive and grow at salinities of 17.5 or even 15 ppt. Larvae of Long Island Sound oysters (Crassostrea virginica) can be reared in salinities of 17.5 ppt and more. Like hard clam larvae, oyster larvae after reaching straight-hinge stage can survive and grow at lower salinities. Embryos of oysters developed to straight-hinge stage at 12.5-15 ppt could then be reared to metamorphosis at salinities of 10 or even 7.5 ppt, but their growth was slower than that at 17.5 ppt or above.

Calabrese, in a 1969 Ph. D. thesis (which see), found that a significant percentage of Mulinia lateralis larvae survived salinities of 10-35 ppt (temperatures 7.5-27.5 C) but grew best at salinities of 20-35 ppt (temperatures of 22.5-27.5 C). (S. H. Hopkins)

Caldwell, David K. 1955. Notes on the distribution, spawning, and growth of the spot-tailed pin fish, Diplodus holbrooki. Quart. Jour. Florida Acad. Sci., 18(2):73-83.

Regular collecting trips were made between February 1953 and May 1954 to various areas at Cedar Key, Fla. Trawl, bag seine, and hook and line methods were used to collect D. holbrooki. From the author's collections and previous researches, he states that "D. holbrooki inhabits open waters of relatively high salinity, occurring only rarely in brackish waters, and probably not at all in true fresh waters." He found the fish in bay waters ranging in salinities from 24.4 to 31.0 ppt. One previous researcher (G. K. Reid, Jr.) found it at Cedar Key in salinities from 9.7 to 28.6 ppt. (T. Rennie)

Callamand, O. 1943. L'anguille européenne (Anguilla anguilla L.) les bases physiologiques de sa migration. Ann. Inst. Oceanogr. (Monaco), 21:361-440.

When leptocephalus metamorphoses into "civelle" or eellike stage, water is lost so that there is a disequilibrium between internal and external salinities. Callamand theorizes that young eels enter estuaries and then rivers and streams seeking water not so different in salinity from their own tissue fluids. The sexually mature eel swallows water and loses minerals, due to change in endocrine control, and then it goes downstream toward sea water which is closer to its newly established internal salinity. (S. H. Hopkins)

Canagaratnam, P. 1959. Growth of fishes in different salinities. Jour. Fish. Res. Bd., Canada, 16:121-130.

"Sizes attained by several species of fish inhabiting both sea and fresh water [in literature reviewed in this paper] suggest that the larger size of the marine form is due to the higher osmotic content of the medium. This theory was tested experimentally by comparing fresh and salt water growth of juvenile coho, sockeye, and chum salmon and adult goldfish. Such factors as temperature and food were rigidly controlled. In general, the salmonids (coho, chum, or sockeye under-yearlings) grew more rapidly in saline than in fresh water. Adult goldfish did not show any significant difference in weight increase." (Author's abstract)

Canagaratnam, P. 1966. Growth of Tilapia mossambica Peters in different salinities. Bull. Fish. Res. Sta., Ceylon, 19(1/2):47-50. (No abstract in Biol. Abstr.)

Capstick, C. K. 1959. The distribution of free-living nematodes in relation to salinity in the middle and upper reaches of the River Blyth Estuary. Jour. Animal Ecol., 28(2):189-210, illus.

In the middle reaches salinity is stable and marine, and populations of nematodes per 100 cm^2 vary from 3000 in sand to 28,300 in thick black mud. In the upper reaches, three transects were made across intertidal zone from channel to shore: lower, middle, and upper (going upstream). Population density of the large species Enoplus brevis, and of other individual species, and nematode populations, collectively, decrease toward upper and lower ends of each transect, and decrease from lower to upper transect, i.e., toward head of estuary, although a few species show the reverse trend in population (i.e., increase toward head of estuary). However, the differences in interstitial salinities are not large (21-32 ppt in upper transect to 26-34 ppt in lower transect). The trend to lower populations in lower salinities, and the recorded geographic distribution of the species concerned, "suggest that the nematode population of the estuary is primarily marine in origin." There were 37 species in the populations studied. (S. H. Hopkins)

Carpelan, L. H. 1964. Effects of salinity on algal distribution. Ecology, 45(1):70-77.

The author studied algae in Buena Vista lagoon (brackish coastal lagoon in southern California) and in a series of salt-producing ponds with a gradient of salinity. In Buena Vista a salinity change from 5.8 to 3.0 ppt did not produce significant change in algae, which were much more influenced by availability of nutrients. The salt ponds ranged in salinity from near 0 at one end of the series to 350 ppt at the other. The relative growth of algae at various salinities is shown (fig. 3). Stichococcus had maximum growth at 17.5 ppt but still grew at 70 ppt (but not beyond this salinity). Platymonas growth was not affected by salinity from 3.5 to 70 ppt, but grew less at 105, and not at all beyond that. Stephanoptera had peak growth at 140 ppt but survived in salinities

from 17.5 to 350 ppt. Dunaliella had peak growth at 105 ppt but grew fairly well at all salinities, from 0 to 350 ppt. (S. H. Hopkins)

Carpelan, L. H. 1967. Invertebrates in relation to hypersaline habitats. Contrib. to Mar. Sci., Univ. of Texas, 12:219-229.

Author's abstract: "Organisms in supersaline waters have been of interest for their distribution and also osmotic and ionic regulation. Few physiological generalizations are possible. The organisms in waters other than fresh or marine have been of interest as "indicators" to characterize waters. Lack of stability characterizes brackish and supersaline waters. The environment is constantly changing and the organisms must be sufficiently euryhaline to include either fresh or marine waters within their range of tolerance. Restriction to some range of salinity other than fresh or marine would be an adaptation to extinction. The species tolerating supersaline conditions attain tremendous numbers. Few productivity studies have been made...."

Following Kinne (1964), the author calls water with salinity of 40 to 80 ppt "hypersaline" and higher concentrations "brine." "Brines have a peculiar fauna, hypersaline waters no not"--i.e., they have a selected fauna of euryhaline animals rather than a fauna that lives in hypersaline waters only. The author says he has worked with brine in which organisms live in salinities up to 300 ppt: Dunaliella, Artemia. But apparently he has no first-hand experience with hypersaline lagoons such as Laguna Madre. All species discussed are cited from published literature. (S. H. Hopkins)

Carriker, M. R. 1951. Ecological observations on the distribution of oyster larvae in New Jersey estuaries. Ecol. Monogr., 21:19-38.

Summary, p. 36, mentions salinity: "Larval swarms" tend to remain in definite lanes or areas; both salinity gradients and current velocity influence larval movements; larvae occur in salinities as low as 3.1 ppt and as high as 30.6 ppt; more larvae are generally present on flood than on ebb tide; younger stages tend to drop near or onto the bottom on ebb and rise into water on flood tide, and flow rather passively with tide; older stages tend to drop near or onto the bottom on the ebb and rise into water on flood tide; relatively large numbers of mature and eyed larvae may be present on the bottom during ebb tide; thus older larvae tend to migrate into headwaters of estuaries, and set farther upbay than tidal conveyance would otherwise make possible.
(S. H. Hopkins)

Carriker, M. R. 1955. Critical review of biology and control of oyster drills, Urosalpinx and Eupleura. U. S. Fish and Wildlife Service Spec. Sci. Rept.; Fish., 148:1-150.

A literature review of the biology of the two genera of oyster-drilling snails was presented with little information being given for Eupleura. The only mention of salinity for this genus is the suggestion that the two genera may possess similar minimum salinity death times. In the discussion of Urosalpinx, salinity effect is divided into six sections: (1) Minimum survival salinity--For summer temperatures, it appears to vary from 12 to 17 ppt in different regions. U. cinerea frequently inhabits estuaries where seasonal fluctuations in salinity restrict upbay distribution. At summer temperatures, drill mortality rates increase rapidly as salinities fall, but this rate is markedly reduced as temperatures drop, so that at low winter temperatures, drills can withstand unusually low salinities for long periods. (2) Movement--Rates of movements of Urosalpinx in the narrow salinity zones at higher extreme of its normal salinity range have not been satisfactorily explored. Conflicting reports have been made. Some Urosalpinx have been found inactive below 15 and above 29 ppt, others below 20 and above 30 ppt. One author found drills were able to attach and crawl in almost every salinity they could survive. (3) Drilling and

feeding--Little known; one researcher found drills ceased drilling below a salinity of 10-12 ppt; above this level the rate of drilling was not appreciably altered by an increase of salinity up to 25 ppt. Another author noted no apparent correlation between the number of drills captured on baited drill traps and the salinity. (4) Growth--Federighi collected drills in different salinities and after measuring them, felt that drills grew to a larger size in brackish water than in saline water, but that other unknown factors may control their growth. Other reports show differences in size, though salinities did not differ much. Carriker therefore felt that the factors which may influence the degree of size attained by drills were unknown. (5) Oviposition--Several works have shown that drills may not be able to reproduce in areas where they can survive; although they may be able to oviposit the ova might not survive. One author suggested that salinities close to 15 ppt are necessary for drill oviposition. (6) Egg case stages--Experiments indicate (at least in Delaware Bay) that lower salinities (5 ppt) suppressed the rate of development, particularly of the youngest stages, to the point of death, and that salinities higher than 10 ppt were required for complete development of the egg case stages. Another researcher showed cleavage to be stopped when salinities were lower than 8 ppt.

Carriker suggests low salinity barriers as one type of control of the drills. (T. Rennie)

Carriker, M. R. 1957. Preliminary study of newly hatched oyster drills, Urosalpinx cinerea (Say). Jour. Elisha Mitchell Sci. Soc., 73:328-351.

Although none of the experiments were designed to show salinity effects, it was found that dispersion and emigration of young drills are accomplished when they crawl onto floating objects and are transported gradually toward the head of the estuary. This supports the idea that drill distribution in estuaries is governed by salinity barriers. The drills move as far up the bay as lethally low salinities permit. (S. Rennie)

Carriker, M. R. 1959. The role of physical and biological factors in the culture of Crassostrea and Mercenaria, in a salt-water pond. Ecol. Monogr., 29(3):219-266.

Experiments in breeding and culture of clams (Mercenaria mercenaria) and oysters (Crassostrea virginica) were conducted in Home Pond, a 21-acre saltwater pond surrounded by 18 acres of Spartina marsh which is flooded at high tide. The pond is connected to Gardiner's Bay by an open inlet and is regularly flushed by tides. Salinity normally varies from about 25 to 30 ppt, but at low water after heavy (4-5 in.) rains there is some water of 10-12 ppt salinity on surface at end farthest from the inlet. Salinity is never low enough to be a handicap in clam and oyster culture. (S. H. Hopkins)

Carriker, M. R. 1961. Interrelation of functional morphology, behavior, and autecology in early stages of the bivalve, Mercenaria mercenaria. Jour. Elisha Mitchell Sci. Soc., 77:168-241.

Trochophore and early straight-hinged stages of the hard clam (M. mercenaria) are strong swimmers and can pass through sharp salinity transitions separating layers of water which differ by as much as 5 ppt with no loss in swimming speed. In water of between 20- and 15-ppt salinity the swimming speed decreased and larvae swam slowly in circular patterns just above the 20- to 15-ppt interface (laboratory experiment).

The hydrography of Little Egg Harbor, N. J., the site of collecting, results in relatively uniform high summer salinities throughout the bay with no vertical salinity or thermal stratification. Before 1920, salinities in Little Egg Harbor were low and Crassostrea virginica dominated. A heavy storm cut a new inlet from the Atlantic Ocean, permanently accelerating exchange and elevation of salinity in the bay. Oysters declined and M. mercenaria became a dominant mollusc.

Under present conditions in the harbor at mean daily water temperatures of 23.4-26.2 C and salinities of 30.4-31.4 ppt, veligers grow to setting size (about 200μ) in 8 days (comparable with laboratory studies). (S. Rennie)

Carriker, M. R. 1967. Ecology of estuarine benthic invertebrates: a perspective. Pp. 442-487. In: Lauff, G. H., ed. Estuaries. Am. Assoc. Adv. of Sci. Publ. 83, Washington, D. C., xv + 757 pp.

A review paper in which "estuary" and different types of estuaries, the classes of saline waters (Venice System, 1959), the biotic categories of estuarine organisms, and other terms are defined, mainly in reference to salinity. Although salinity is mentioned on almost every page, the main discussion of its biological effects is on pp. 450-452, 462-465 (as a factor in determining distribution of species). The well-known principles are repeated, that fewer species are found in estuaries than in shallow sea nearby, that species are fewest in "the zone of steepest gradient between the marine and freshwater regions" (which is also the zone of largest and quickest changes in salinity from day to day or tide to tide), that the number of species increases only slightly with increase in distance inland where lower salinities prevail but increases greatly toward the sea, and that individuals of most species reach larger size in the sea and decrease in size up the estuary. (S. H. Hopkins)

Carter, N. 1932. A comparative study of the algal flora of two salt marshes. Pt. I. Jour. Ecology, 20:341-370.

Two salt-marsh areas near Benfleet, Canvey Island, Essex, England, were studied and compared with marsh of Dovey Estuary previously studied (Yapp, Jones, and Johns, 1917). The principal vegetative zones were bare mud, Aster Salicornia, Obione, and Glyceria, in order of increasing elevation. Salicornia is the first seed plant to invade mud flats. (S. H. Hopkins)

Carter, N. 1938. New or interesting algae from brackish water. Arch. Protistenk., 90:1-68.

Describes, from standpoint of taxonomist or morphologist, the algae found in a small brackish pool at Bembridge, Isle of Wight, off south coast of England. The salinity of the pool was usually between 2.6 and 3.2 ppt but may be as low as 1 ppt or as high as 4 ppt. Higher plants included Spartina townsendii, Juncus maritimus, Ruppia maritima, and Salicornia. Thirty-five algae are described, many of which were new species, and the list was said to be incomplete. (S. H. Hopkins)

Cary, L. R. 1906a. Further studies on the oyster at Calcasieu Pass. Bull. Gulf Biol. Sta., 6:7-28.

A freshet of the Calcasieu River in May 1905 and its effects on oysters. On a reef at the mouth of the river all oysters above low tide level and down to 6 ft below low tide level were killed by the freshet; with increasing depth the proportion of survivors increased rapidly, but even at 16-ft depth some oysters died. More oysters survived on jetties than on reefs. (S. H. Hopkins)

Cary, L. R. 1906b. The conditions for oyster culture in the waters of the parishes of Vermilion and Iberia, Louisiana. Bull. Gulf Biol. Sta., 4:1-27; map.

"By far the most formidable destructive agent to be encountered in this region is the annual spring freshet, which lowers the salinity of the water in the bay and its tributaries during the feeding season of the oyster." (S. H. Hopkins)

Cary, L. R. 1907a. A preliminary study of the conditions for oyster culture in the waters of Terrebonne Parish, Louisiana. Bull. Gulf Biol. Sta., 9:1-62.

The conch, snail or borer (Purpura haemostoma), is found in oyster beds in practically all parts of the parish but is most abundant where the salinity is highest. Although considerable damage is attributed to the attacks of this enemy, evidence of its depredations is very meager. Some few small oyster shells are found with a hole in one valve such as might be made by this snail, but the number of shells attacked in this way is always small and there is no first-hand evidence that the borings were made by the Purpura. Since any conclusive evidence in this matter is lacking it is safe to consider this form as an enemy and to destroy them whenever possible. Much can be accomplished toward their eradication by destroying the egg capsules, which are conspicuous, brightly colored bodies, attached to stakes and other pieces of wood about the oyster beds. Numerous adult snails are taken up when the beds are being worked in winter; if these were destroyed instead of being thrown back with the cullings, the number on any bed would be materially reduced. (S. H. Hopkins)

Cary, L. R. 1907b. The cultivation of oysters in Louisiana. Bull. Gulf Biol. Sta., 8:1-56.

Oysters are found in waters of densities of 1.002-1.025. Lengthy exposure to lower densities is usually fatal. At densities of less than 1.007, oysters which survive are of poor quality. Salinity (density) over the best beds varies from 1.010 to 1.022, with the former being in shallow water.

Reef damage by freshets from small rivers may be more prolonged and cause destruction over a greater area than mass mortalities caused by breaks in the levees of the Mississippi River. (S. Rennie)

Caspers, H. 1955. Limnologie des Elbeastuars. Verhandl. Intern. Ver. Limnol., 12:613-619.

The title, "Limnology of the Elbe Estuary," is deceptive, as this paper deals entirely with bottom flora and fauna, mainly on the flats, in the freshwater, brackish-water, and marine parts of the estuary. Based on all publications (especially Hentschel, 1922, Verhandl. Intern. Ver. Limnol. 1), the freshwater zone is said to be richer in species than the brackish zone, but poorer than the sea. The brackish zone is said to be the poorest also of the three zones in biomass. Apparently in the Elbe most organic sediment settles before reaching the brackish zone, which has mostly sandy bottom. In individuals, 1 sq m of freshwater bottom yields 86,500 animals (55,000 tubificidae; 27,000 Chirononomid larvae; 4500 Pisidium (fingernail clams)). Marine flats yield 20,100 individuals per square meter (19,000 Polychaeta, 1025 Mollusca, 75 Crustacea). Brackish flats yield 7025 individuals per square meter (6500 Corophium, 500 Tubificids, 25 polychaeta). No salinity figures are given. (S. H. Hopkins)

Caspers, Hubert. 1957. Black Sea and Sea of Azov. Pp. 801-889 (Chap. 25). In: Hedgpeth, J. W., ed. Treatise on marine ecology and paleoecology. Geol. Soc. Amer. Memoir. 67, Vol. I, Ecology, viii + 1296 pp.

Describes, from first-hand field studies and literature, the physical geography, geological and faunistic history, hydrography, chemistry, sediments, and ecology of these connected seas (Sea of Azov is an embayment of Black Sea north and east of the Crimean Peninsula). The Black Sea is strongly influenced by rivers and has a rather stable salinity, like the Baltic; surface salinity ranges from about 17 to 18 ppt and salinity at 100-m depth from 19 to 21 ppt; the Sea of Azov is even more influenced by rivers and has a lower salinity, averaging about 13 ppt but reaching 3-4 ppt at some times and places. The flora and fauna are mostly similar to the Mediterranean but with fewer species and greater biomass. The Sea of Azov is especially productive in commercial fish. Many details and statistics are presented. There are over 340 references. (S. H. Hopkins)

Caspers, H. 1967. Estuaries: analysis of definitions and biological considerations. Pp. 6-8. In: Lauff, G. H., ed. Estuaries. Am. Assoc. Adv. of Sci. Publ. 83, Washington, D. C., xv + 757 pp.

Analysis of definitions, limits between estuaries and rivers, difference between estuaries and lagoons, etc. Biological considerations: distribution of organisms in estuaries is based on a complex of many factors, not on a single factor such as salinity.

Cassie, R. Morrison. 1960. Factors influencing the distribution of pattern plankton in the mixing zone between oceanic and harbour waters. New Zealand Jour. Sci., 3(1):26-50, illus., map.

Analyzing plankton counts by regression analysis, the author finds a negative correlation between salinity and numbers of Oithona similis (copepod), Elminius modestus (barnacle) nauplii, Polydora polybranchiata (polychaete annelid) larvae, and Coscinodiscus wailesi (diatom). He states that a positive correlation was found between Paracalanus parvus (copepod) numbers and salinity, but his graph (fig. 3, p. 30) gives a contrary impression. In general, temperature and salinity increased together so that their effects on density tended in opposite directions. Since temperature ranged only from 11.95 to 12.29 C and salinity only from 34.3 to 35 ppt, all relations claimed were somewhat suspect. Only temperature, density, and salinity (among all possible physical and chemical factors) were recorded, so the apparent correlations could have been caused by unmeasured factors. (S. H. Hopkins)

Castagna, Michael and Chanley, Paul. 1966. Salinity tolerance and distribution of Spisula solidissima, Mulinia lateralis and Rangia cuneata, family Mactridae. Rep. Am. Malac. Union, Pacific Div., 1966:35 (Abs.).

In their natural distribution the three species of Mactrid clams are found in the following salinities: Spisula, above 29 ppt; Mulinia, 8-25 ppt; Rangia, 0-10 ppt. In the laboratory, salinity ranges were determined as follows: Spisula, 10-30 ppt; Mulinia, 2.5-30 ppt; Rangia, 0-30 ppt. These differences suggest that distribution in the field is controlled primarily by other factors. (S. Rennie)

Caulfield, H. P., Jr. 1966. Comprehensive planning in relation to the use and management of estuaries. Pp. 121-126. In: A symposium on estuarine fisheries. Am. Fish. Soc. Special Publ. No. 3, Washington, D. C., viii + 154 pp.

P. 122: Commercial and sport fishing interests have two concerns: "The intrusion of saline waters too far in the direction of freshwater areas and the discharge of industrial and other damaging wastes from freshwater areas into the otherwise 'natural' salt water environment." (S. H. Hopkins)

Causey, N. B., Prytherch, J. P., McCaskill, J., Humm, H. J., and Wolf, F. A. 1946. Influence of environmental factors upon the growth of Gracilaria confervoides. Bull. Duke Univ. Mar. Sta., 3:19-24.

To determine the effect of salinity on the growth of Gracilaria confervoides, fresh weights of plants growing in waters around Beaufort, N. C., were determined periodically, and 2-cm lengths of Gracilaria were placed in test tubes and grown in the laboratory in media having different salinities (5 to 60 ppt). In the field, salinities ranged from 15 to 50 ppt. Data showed that salinity could not be regarded as a limiting factor in the growth of Gracilaria (low temperature and insufficient light were the major limiting factors). Optimum growth occurred between 25 and 35 ppt. There was evidence that new tips of thalli fragments were more sensitive to change in salinity than were the older plant parts. In spring, when water temperature was favorable for growth, low salinity might have

inhibited growth for brief periods. In the laboratory experiments, fragments in 5-ppt salinity lived for 10 days but showed no growth. At 10 ppt the plants lived 6 weeks and also failed to grow. After 2 months at 15 ppt, fragments were still alive and some had produced short branches. At 20 to 45 ppt all plants exhibited growth and lived to the end of the experiment. At 50 ppt, three of four plants produced short branches; the fourth plant lived 6 weeks but showed no growth. At 55 ppt all plants lived 5 weeks but showed no growth. Plants at 60 ppt died within 1 to 6 weeks. (Gracilaria confervoides is the seaweed used for commercial production of agar during World War II and for about 3 years afterward, until the Japanese recaptured the American market.) (T. Rennie)

Chadwick, H. K. 1971. Striped bass and water development in the Sacramento-San Joaquin Estuary. Pp. 58-68. In: A symposium on the biological significance of estuaries. Ed: Douglas, P. A. and Stroud, R. H. Sport Fishing Institute, Washington, D. C., xi + 111 pp.

The California Water Plan for sending water from the central valley south to the Los Angeles area, and for changing drainage patterns on the river system, is described with the aid of charts, diagrams, and photographs. It is pointed out that striped bass spawning is now limited to a small area, "apparently, primarily by salinity conditions," and that the number of young bass surviving is directly correlated with freshwater flow. Modifications of engineering plans are suggested that might save the valuable sport fishery for striped bass. (S. H. Hopkins)

Chambers, G. V. and Sparks, A. K. 1959. An ecological survey of the Houston Ship Channel and adjacent bays. Publ. Instit. Mar. Sci., Univ. of Texas, 6:213-250.

A study of the highly polluted inland portion of the Houston waterway was made from the summer of 1957 to the summer of 1958. Biological sampling was by otter trawls, which caught 43 species of fish, the 3 commercial species of Penaeus, grass shrimp identified only as Palaemonetes species, and blue crabs, Callinectes sapidus. Approximately two-thirds of the fishes were predominantly marine; marine species tended to predominate in the summer, when salinity as well as temperature was high, and freshwater species in the winter when salinity and temperature were low. The number and diversity of fish decreased upstream with decrease in salinity and increase in pollution. (S. H. Hopkins)

Chanley, Paul E. 1958. Survival of some juvenile bivalves in water of low salinity. Proc. Nat. Shellfish. Assoc. (1957), 48:52-65.

The minimum salinities at which juvenile clams, Venus mercenaria, Ensis directus, and Mya arenaria, survived were 12.5, 7.5, and 2.5 ppt, respectively. Juvenile oysters, Ostrea edulis and Crassostrea virginica, survived in salinities as low as 12.5 and 5.0 ppt, respectively, and juvenile mussels, Brachidontes recurvus, survived at 2.5 ppt. E. directus and M. arenaria survived at 7.5 and 2.5 ppt only after first becoming acclimated to intermediate salinities. They did not survive if transferred directly to these salinities from 26.0 to 27.0 ppt. V. mercenaria ranging in size from 10.0 to 21.5 mm survived at 12.5 ppt, but 15.0 ppt was the minimum salinity at which those ranging in size from 1.8 to 3.6 mm could survive. Growth was retarded at salinities of 22.5 ppt and lower. The optimum salinity for growth of recently set C. virginica was 15.0 to 22.5 ppt. (Author's abstract)

Chapman, C. R. 1966. The Texas Basins project. Pp. 83-92. In: A symposium on estuarine fisheries. Am. Fish. Soc. Special Publ. No. 3, Washington, D. C., viii + 154 pp.

The plan includes 18 reservoirs supplying water to a trans-Texas canal which would intercept river flow to all coastal bays and marshes. The average annual

freshwater flow of 26.5 million acre-feet now reaching Texas estuaries would be reduced by one-half, perhaps by three-fourths in dry years; the Texas Basins project would account for one-third of total reduction. At present 1.33 million acres of Texas tidewater yield about 200 million pounds of fish and shellfish annually to commercial fishermen, and support more than 7 million man-days of sport fishing. Planned diversion of fresh water, plus pesticides from irrigation projects, could cause losses of an estimated 118 million pounds of commercial fishery products and nearly 3 million man-days of sport fishing. The estimate of loss due to cutting off freshwater flow is based partly on actual loss due to lessened flow in dry years (fig. 6, p. 91), and on comparative fishery harvest in different estuaries with different freshwater flows (fig. 5, p. 90). (S. H. Hopkins)

Chapman, C. R. 1971. The Texas water plan. Pp. 40-57. In: A symposium on the biological significance of estuaries. Ed: Douglas, P. A. and Stroud, R. H. Sport Fishing Institute, Washington, D. C., xi + 111 pp.

Description, tables, and charts present the Texas Water Plan, "the largest, most complex and costly water plan ever conceived." Tables also show how the flow of fresh water to Texas estuaries would be changed. It is stated "the Texas Water Development Board is now restudying the plan to improve it. Hopefully, the revision will provide total planning to assure that the estuaries receive sufficient high quality water." A quotation from the Board is presented to show that the Board realizes that there will be an annual loss to Texas of more than $150 million worth of commercial fisheries and $300 million from tourism if the "ecology and aesthetic quality of the bays" are not maintained by release of sufficient fresh water. (S. H. Hopkins)

Chapman, V. J. 1939. Studies in salt-marsh ecology, Sections IV and V. Jour. Ecology, 27:160-201.

IV. Chloride, exchangeable sodium and calcium, and moisture. Total chloride content is at a minimum in early spring at a time when seed germination may be expected to commence. Factors which control salinity in the Norfolk marshes are rainfall, presence or absence of vegetation and type of vegetation, tides, height of marshes, physical character of the soil in relation to evaporation, and proximity of fresh water in the uplands.

V. The vegetation. A description of the marsh vegetation is give, but a correlation with known physical factors should appear somewhere else. (S. Rennie)

Chapman, V. J. 1940. Studies in salt-marsh ecology. Sections VI and VII. Comparison with marshes on the east coast of North America. Jour. Ecology, 28:118-152.

Salinity, pp 132-141: fig. 9, p. 133, diagrams distribution of vegetation types in reference to soil salinity. Fig. 11, p. 136, diagrams annual drift in salinity in different vegetation types. Fig. 15, p. 140, shows chloride ranges of various marsh plants in New England.

Chater, E. H. and Jones, H. 1957. Some observations on Spartina townsendii, H. and J. Groves in the Dovey Estuary. Jour. Ecology, 45(1):157-167.

The cordgrass species Spartina townsendii ("rice grass") was introduced into the Dovey Estuary in 1920 and spread slowly until 1939; during the war it increased more rapidly due to amphibious vehicles and general military operations. It is still increasing. From the present study it is concluded that establishment and linear spread is determined by substrate and not, at least in this area, by differences in immersion time or salinity. (S. H. Hopkins)

Cherbonnier, G. 1960. Sur la presence en Mer Noire de Stereoderma kirschbergi (Heller). Hidrobiol. Istanbul, 5B:52-53.

The sea cucumber Stereoderma kirschbergi (Cucumaria orientalis) is reported from the Black Sea in bottom salinity of 18 ppt. (Fidé Binyon 1966, which see.)

Chew, Frank. 1956. Red tide and the fluctuation of conservative concentrations at an estuary mouth. Bull. Mar. Sci. Gulf and Caribbean, 5(4):321-330.

The effect of varying river discharge is to modulate the amplitude of the salinity fluctuation both in time and space, the greater the river discharge the more intense is the transition zone. It has been suggested that red tides (blooms of dinoflagellates, Gymnodinium breve) have tended to occur near periods of spring tides. But an effect of a spring tide is due to other causes, such as stirring of the estuary bottom, rather than the presence of a strong, sharp transition zone at the estuary mouth. The extension of the mixing length theory of tidal flushing to river and tidal fluctuation of conservative concentrations at an estuary mouth appears valid. (S. Rennie)

Chin, Edward. 1961. A trawl study of an estuarine nursery area in Galveston Bay, with particular reference to penaeid shrimp. Dissert. Abs., 22(5):1751.

From January 1958 through January 1959, the seasonal occurrence, relative abundance, and size composition of each species of fish and motile invertebrate from 363 otter trawl collections in Galveston Bay were determined. With the possible exception of Anchoa mitchilli diaphana, seasonal changes in relative abundance of all species found appeared to be independent of salinity changes. (T. Rennie)

Chitwood, B. G. 1951. North American marine nematodes. Texas Jour. Sci., 3(4):617-672.

Describes 43 species from Rockport, Tex., and reviews the literature on the marine eelworms of North America. A total of 251 species was known in 1951 from N. American coasts, of which 40% were also known from European waters. After writing this, Chitwood located two papers by C. A. Allgen (1947a, 1947b) in which 15 species of marine nematode are listed from Tobago, British West Indies, and 100 from the west or Pacific coasts of North America and Panama. In all, Allgen named 54 new species. On p. 618 Chitwood says that even in Europe, where nematodes are much better known than in North America, no true brackish nematode fauna is known; "one finds a quick change from freshwater to marine species, genera, and superfamilies. The transitional zone is usually rather poor in both number of specimens and diversity of genera." The superfamily Dorylaimoidea contains freshwater, soil and brackish-water, or marine species, but Kreis (1927) failed in attempts to adapt the freshwater Dorylaimoides stagnalis to a marine life. (S. H. Hopkins)

Choe, S. 1966. On the eggs, rearing, habits of the fry, and growth of some Cephalopoda. Bull. Mar. Sci., 16:330-348.

Pp. 335-336. Resistance of the egg to low salinity is shown below.

Species	Hatching Record	
	Chlorinity, ppt	%
Sepia esculenta	8.4 & 10.5	0
	12.6	46
	14.7	65.5
	16.8	57.7

Species	Hatching Record Chlorinity, ppt	%
Sepiella maindroni	8.4	0
	10.5	19
	12.6	37.5
	14.7	50
	16.8	62.5
Sepioteuthis lessoniana	8.4 & 10.5	0
	12.6	9
	13.1	10.6
	14.7	22.5
	15.8	25
	16.8	47.6

Resistance to salinity of the newly hatched fry at water temperatures ranging from 21.3 to 27.7 C is shown below.

Species	Chlorinity, ppt	Survival Time, hr, to 50% Mortality	100% Mortality
Sepia esculenta	8.3	>0.5	1
	10.2	4.3-5	6-8
	12.2	13-22.5	34->120
Sepia subaculeata	8.3	<0.5	
	10.2	3-3.5	8.5-12.5
Sepiella maindroni	8.3	1	
	10.2	39-51	>120
Sepioteuthis lessoniana	8.3	0.3	1
	10.9	4.5	9.5
	12.9	61	77

The presumed minimum chlorinity that affects the survival of each species is listed below:

Species	Chlorinity, ppt
Sepia esculenta	13.3
Sepia subaculeata	12.5
Sepiella maindroni	12.5
Sepioteuthis lessoniana	14.6

Churchill, E. P. 1919. Life history of the blue crab. Bull. U. S. Bur. Fish., 36:91-128 (Document 870)

The author discusses the general ecology of the blue crab in Chesapeake Bay, including habitat and distribution, development of the young, molting, autotomy, migration, reproduction, and length of life. Salinity is mentioned only as it pertains to their general distribution, i.e., "...it is especially abundant in the bays and mouths of the rivers. Although its natural medium is salt water, instances are known in which specimens have been found in brackish, and even in fresh, water." (T. Rennie)

Churchill, E. P., Jr. 1920. The oyster and the oyster industry of the Atlantic and Gulf coasts. Report of U. S. Comm. Fish. 1919, App. 8, Bur. Fish. Doc. No. 890:1-51.

Salinity is measured as density by salinometer (hydrometer) graduated from 1.000 to 1.031, fresh water having density of 1.000 and pure sea water 1.025-1.026. Oysters are found in water with densities from 1.002 to 1.025, but cannot withstand densities lower than 1.008 for indefinite periods. "In general they seem to thrive best in densities between 1.011 and 1.022," and are not found where the density is 1.025 or more (p. 15). (S. H. Hopkins)

Clarke, L. D. and Hannon, Nola J. 1971. The mangrove swamp and salt marsh communities of the Sidney district. IV. The significance of species interaction. Jour. Ecology, 59(2):535-553.

The growth in association of dominant species from each zone along an artificial gradient of elevation, salinity, soil, and waterlogging produced a species zonation pattern which closely resembled the zonation pattern that occurs in the field. An assessment is made of the factors restricting the landward and seaward migration of all the prominent species in these communities under present conditions; consideration of the history and future development of these communities is foreshadowed. (From Biol. Abstr.)

Coche, A. G. 1967. (Oreg. State Univ., Corvallis, Oreg., USA) Osmotic regulations in juvenile Oncorhynchus kisutch(Walbaum). I. The salinity tolerance of 50 day old fry. Hydrobiologia 29 (3/4):426-440.

Experiments on 44- to 65-day-old coho salmon fry, Oncorhynchus kisutch, showed that the youngest tolerated 18-ppt salinity and those 59 days old tolerated 22 ppt, and had 50% survival in 26 ppt. Fry acclimatized for 9 days in 24 ppt survived for the next 7 days in 28 ppt. Direct transfer of 59-day-old fry from 24 ppt to fresh water could be entirely successful. (S. H. Hopkins)

Cole, W. H. 1940. The composition of fluids and sera of some marine animals and of the sea water in which they live. Jour. Gen. Physiol., 23:575-584.

Includes data obtained by Homer W. Smith with his own. Cole worked at Mt. Desert Island, Maine, Smith at Mt. Desert Island and at New York Aquarium. Electrolyte composition, pH, and freezing points of 14 invertebrates and lamprey Myxine glutinosa were measured after living in waters of various salinities. Fluids of worms, echinoderms, and Venus were isotonic with sea water, fluids of Arthropoda were hypertonic.

Ratios to sea water indicated (1) uniform distribution of ions between internal and external media for echinoderms and Venus; (2) differential distribution of potassium and magnesium in the worms (Glycera, Amphitrite, Echiurus); (3) differential distribution of sulfate, Mg, K, and Ca in the Arthropoda; and (4) differential distribution of Ca, Mg, and sulfate in Myxine. Unequal distribution of ions implies expenditure of energy against a concentration gradient across the membranes. Sera of Arthropoda from diluted sea water showed higher concentrations of Na, K, Ca, and chloride ions relative to the concentrations in the external medium than in normal sea water, and also different orders for those ions. Increase in osmotic pressure of sera of animals moving into brackish water is caused by unequal accumulation of Na, K, Ca, and Cl ions. Sulfate and Mg ionic ratios do not change. (S. H. Hopkins)

Cole, W. H. 1941. The calcium and chloride content of lobster serum as affected by dilution of the environmental sea water. Bull. Mt. Desert Island Biol. Lab., 1941:22-24.

Twelve lobsters, Homarus americanus, were kept in full-strength sea water and

later transferred to 75% sea water. The total calcium and chloride content of the blood serum and the two experimental sea water concentrations were determined periodically. The ratios of the concentrations in the sera to those in the experimental sea water gave a measure of the net distribution of the ions across the absorbing and excreting membranes. In the sera of lobsters in full-strength sea water, the chloride content was 5% less than in sea water, but the calcium content was 59% greater. After 8.5 hr in 75% sea water, the sera contained 18% less chloride but 255% more calcium. After 60 hr more in the 75% sea water, the ratios slowly tended toward that of full-strength sea water, where the chloride content increased to a concentration 75% higher than the surrounding sea water. Up to the end of 118 hr, no further significant changes occurred. (T. Rennie)

Colgan, Nathaniel. 1910. Notes on the adaptability of certain littoral Mollusca. Irish Nat., 19:127-133.

Specimens of the marine snails Purpura lapillus and Littorina rudis collected from high-water-mark areas showed a greater endurance to exposure to air and immersion in fresh water than those collected from low-water or half-tide marks. High-water-mark individuals of both species were less tolerant to high salinities (three times normal sea water) than those from lower levels. (S. Rennie)

Collier, A. W. 1970. Ocean and coastal waters as life-supporting environments. Chapter 1, pp. 1-93. In: Kinne, O. (ed.) Marine ecology, a comprehensive, integrated treatise on life in oceans and coastal waters. Vol. I, Environmental factors. Wiley - Interscience, New York, ix + 681 pp.

The first 46 pages are purely physical, chemical, and geological oceanography. From p. 47 on, the physical and chemical information still dominates, but there are more references to the ecological effects of the factors discussed. The thermal, mechanical, photic, acoustical, electrical, and chemical properties of sea water of different salinities are discussed on pp. 53-80 in relation to the living organisms in the sea, with special stress on organic chemical constituents of sea water. (S. H. Hopkins)

Collier, Albert, Ray, S. M., Magnitzky, A. W., and Bell, Joe O. 1953. Effect of dissolved organic substances on oysters. Fish. Bull. 84, U. S. Fish and Wildlife Serv., 54:167-185.

In salinities between 15 and 31 ppt, there is an apparent negative correlation between salinity and carbohydrates in estuarine waters. From 7 to 15 ppt, this relation is not clear and may not exist. The association of salinity to carbohydrates could be the result of physical dilution of rich low-salinity inshore water with carbohydrate-poor high-salinity gulf water. Or it may be the adverse effect of high-salinity water on the growth of the organisms creating the carbohydrates. The reason remains obscure. (S. Rennie)

Cones, Harold N. and Haven, Dexter S. 1969. Distribution of Chrysaora quinquecirrha in the York River. Chesapeake Sci., 10(2):75-84.

Laboratory studies showed that polyps of this stinging jellyfish collected at 20 C and 20-ppt salinity retracted tenacles when exposed to a 5-ppt or greater change of salinity. Those transferred to 2.5 ppt gradually decreased in length until encystment after 11 days. Encystment took place after 4 days in 5 ppt. At 10 ppt and above, shock reactions were similar with recovery after 12 to 96 hr. At 35 and 40 ppt, colony size increased by stolon formation and budding.
In the river, upstream distribution was probably limited by low salinity. Relation of salinity levels and downstream distribution are unclear. Mean annual salinities ranged from 13 to 19 ppt, well within the limits established in laboratory tests. However, there may exist different tolerance levels for

setting of larvae and for established polyps.
Temperature did not appear to limit polyp distribution. (S. Rennie)

Conger, Paul S. (U. S. Nat. Mus.). 1953. Unique features of the diatom ecology of Chincoteague Bay. (Paper read at Madison, Wis., meeting of Ecological Society and Amer. Soc. of Limnology and Oceanography, Sept. 1953.)

In 1920, storm cut a new inlet through barrier at upper end of Chincoteague Bay. Inlet remained open until 1926, then closed. During period inlet was open, oysters in bay died out and a clam (Venus) population developed. After closure of inlet in 1926, conditions returned to normal, i.e. favorable for oysters, not clams. Autumn storm of 1933 opened inlet again, and it has been open ever since. Oysters have practically disappeared from Chincoteague Bay. In 1952, 10 million clams were harvested from Chincoteague Bay; clams have taken the place of oysters. Bay is only 2 to 4 ft deep except for 6- to 8-ft-deep channels. Salinity is sometimes higher in bay than in ocean in dry summers, but because of shallowness of water the salinity is quickly lowered by rains. There is poor diatom flora which is attributed to high turbidity and variable salinity. (S. H. Hopkins)

Conover, John T. 1958. Seasonal growth of benthic marine plants as related to environmental factors in as estuary. Publ. Instit. Mar. Sci., Univ. of Texas, 5:97-147, maps.

Local plant distribution in estuarine waters was controlled by salinity and temperature, with some plants being less tolerant of low salinities at high water temperatures. The "transition zone" supported a large portion of the total plant material in the estuary. Some species of marine plants remained sterile as long as they were in brackish water. For Vaucheria fruiting appeared to be related to prolonged immersion in water of higher than normal salinity.
There was also some evidence that seasonal distribution was related to water density.

Conover, R. J. 1956. Oceanography of Long Island Sound, 1952-54. VI. Biology of Acartia clausi and A. tonsa. Bull. Bingham Oceanogr. Coll., 15:156-233.

Acartia has a less efficient feeding mechanism than other copepods and may not be successful in competition with true filtering forms. Consequently the Acartia may attain an important position in the zooplankton community only when salinity restricts distribution of other copepods. Both Acartia species are euryhaline. (S. Rennie)

Conrad, W. 1926. Recherches sur les Flagellates des nos eaux saumâtres. II. Chrysomonadines. Arch. Protistenk., 56:167-231.

Taxonomic descriptions with brief ecological notes on 36 species of flagellates (Chrysomonads) belonging to the superfamilies (?) Chrysomonadales, Chrysocapsales, Chrysosphaerales, and Chrysotrichales, in European brackish waters. Some of these are primarily freshwater forms. Density of water at point of find is given in most cases. (S. H. Hopkins)

Conte, F. P. and Wagner, H. H. 1965. Development of osmotic and ionic regulation in juvenile steelhead trout Salmo gairdneri. Comp. Biochem. Physiol., 14(4):603-620.

Young trout from fresh water were exposed to sea water, salinity 30 ppt, at 3-day intervals throughout the year. Smaller ones had high mortality; as they grew larger they survived better, the largest (16-18 cm, and 19 cm or over) sometimes showing 100% survival for 30 days. (This fish migrates to sea before maturity.) (S. H. Hopkins)

Conte, F. P., Wagner, H. H., Fessler, J., and Gnose, C. 1966. Development of osmotic and ionic regulation in juvenile coho salmon Oncorhynchus kisutch. Comp. Biochem. Physiol., 18:1-15.

When transferred at various sizes and ages from fresh water to sea water (30 ppt) it was found that the fish showed a great deal of euryhalinity in the premigratory months of July through March. Survival in sea water of 20-30 ppt was best at 24 ppt and more size-dependent than age-dependent. Fish of greater size had better survival. For juvenile O. kisutch survival of fry, parr, and smolts is better than in four species of Salmo.

Blood osmotic concentrations for the freshwater fish remained rather stable. Upon transfer to sea water, osmotic concentrations go up considerably (from 295 mOsm/l to 400 mOsm/l). Following this rise, the osmotic and ionic concentrations return to near freshwater levels. The migratory and postmigratory levels tend to remain near those of the premigratory, freshwater level. (S. Rennie)

Cooper, M. J. 1966. The destruction of marine flora and fauna caused by the hurricane of 1965. Pacific Sci., 20(1):137-141.

Killing of reef corals and associated organisms by flooding of the Mbau waters of Fiji after heavy rains caused by the near-miss of a hurricane in 1966. (S. H. Hopkins)

Copeland, B. J. 1966. Effects of decreased river flow on estuarine ecology. Water Pollution Control. Fed., 38(11):1831-1839.

Some points included in this general discussion are: importance of river flow in maintaining current and salinity patterns, importance of estuaries as source of protein for man, control of oyster diseases and predators by decrease in salinity, importance of estuaries as nursery grounds for shrimp, importance as places where nutrients accumulate, correlation of rainfall and white shrimp catch, extension of southern species northward due to decreased river flow in northern Gulf of Mexico, relation of blue crab population to salinity, high primary productivity in estuaries. Relative productivity in terms of shrimp, oysters, and blue crabs in different Texas bays is correlated with their salinity conditions, and amounts of river inflow.

Copeland, B. J. 1967. Environmental characteristics of hypersaline lagoons. Contrib. to Mar. Sci., Univ. of Texas, 12:207-218.

Most of the paper is devoted to the physical and chemical environmental factors, but important biological data are presented on pp. 208-209 in connection with the increase in salinity of Laguna Tamaulipas, the Mexican continuation of the Texas Laguna Madre, after it was naturally cut off from the gulf. During 1961-1965 the salinity increased from below 50 ppt to about 300 ppt, and the number of fish species gradually decreased from 29 in 1961 to 8 in February 1963 (salinity 95 ppt), 5 in March 1963 (salinity 110 ppt), and 2 (Cyprinodon variegatus and Menidia beryllina) in February 1964, when salinity had been 110-120 ppt for almost a year. When salinity reached 140 ppt, no fish survived and brine shrimp, Artemia salina, replaced them. (S. H. Hopkins)

Copeland, B. J. and Hoese, H. D. 1966. Growth and mortality of the American oyster, Crassostrea virginica, in high salinity shallow bays in central Texas. Publ. Instit. Mar. Sci., Univ. of Texas, 11:149-158.

Four oyster reefs in Redfish Bay and at Harbor Island, near Port Aransas, Tex., were examined irregularly between February 1964 and July 1965. Five semirandom square-meter samples were taken at each reef; the oysters were counted and the first 100 measured. Salinity, temperature of water and mud, water depth,

evidence of recent mortality, presence of predators, presence of spat, and general conditions of the reef were recorded. Salinity varied from 28 to 43.5 ppt, but the salinity range of the Harbor Island reef was less than that at the other reefs, due to the proximity of the gulf. Areas to the south of Corpus Christi had salinities over 45 ppt, commonly, and oysters were absent; therefore, the authors suggest that such values limit oyster distribution.

Population size of oysters fluctuated rapidly, and reached its greatest number in winter and its lowest in summer when tides were lowest and salinities and temperatures were highest. However, the authors believed there was no evidence that salinity was responsible for the fluctuations in numbers, but "the effect of summer hypersalinities coincided with other adverse factors." (T. Rennie)

Costa, H. H. 1966. Salinity responses of two species of Ceylon freshwater atyid shrimps. Ceylon J. Sci. (Biol. Sci.), 6(1):33-36.

Caridina simoni Bouvier and C. pristis Roux were the experimental animals. Salinities of 50, 25, 18, 12, and 6% sea water (33 ppt) were tested. C. pristis showed a negative response to 18% while C. simoni was indifferent to even 50% sea water. In the field, C. simoni has a wider distribution (including brackish water) than C. pristis. (S. Rennie)

Costlow, J. D., Jr. 1965. Variability in larval stages of the blue crab, Callinectes sapidus. Biol. Bull., 128(1):58-66.

In discussing the literature on work done on factors causing variability in crustacean larvae, Costlow comments that, the "pre-zoea" stage in the development of C. sapidus occurred most frequently when the eggs were hatched in a salinity lower than 20 ppt, but this example of variability early in larval development was more closely related to abnormal hatching than to variations in rate of larval development or an actual stage of development. Other studies have either noted that salinity or temperature did not affect the number of larval stages, or no comment was made on variability that might have existed. (T. Rennie)

Costlow, John D. 1967a. Larval studies of blue crab. Report of the Bureau of Commercial Fisheries Biological Laboratory, Beaufort, N. C., Circular 264:13.

Larvae of blue crab were raised in water at 77 F and 30-ppt salinity until they reached the megalops stage. They were transferred to four temperature and six salinity combinations (59, 68, 77, 86 C and 5, 10-40 ppt). At all but 59 F the megalops survived in salinities of 10-40 ppt. At 59 F, 10-50% survival was obtained at 20-40 ppt. No megalops survived at 59 F, 10 ppt, and 68 F, 5 ppt. At 59 C high salinity delayed metamorphosis to the first crab stage. Relatively high survival was obtained at 59 F and 35 ppt. (S. Rennie)

Costlow, John D., Jr. 1967b. The effect of salinity and temperature on survival and metamorphosis of megalops of the blue crab Callinectes sapidus. Helgolaender wiss. Meeresunters, 15:84-97.

Megalops, maintained through all zoeal stages at 25 C, 30 ppt, were then kept in 23 combinations of salinity and temperature until metamorphosis (to first crab stage). Survival was similar at 20, 25, and 30 C except for larvae in 5 and 10 ppt. At 15 C survival never exceeded 50%. In 5 and 10 ppt, survival decreased with decrease in temperature. At 15 C, duration of megalops stage was further extended as salinity increased from 20 to 40 ppt.

The delay of metamorphosis in waters of high salinity and low temperature may have contributed to the distribution of C. sapidus in the estuaries along a major part of the Atlantic and Gulf of Mexico coasts of the United States. (S. H. Hopkins)

Costlow, John D., Jr., and Bookhout, C. G. 1959a. The effects of salinity and temperature on larval development of Sesarma cinereum. (Abs.) Anat. Rec., 134:546.

Larvae were hatched and reared under constant conditions in 12 temperature-salinity combinations: 20, 25, and 30 C, and 12.5, 20.1, 26.7, and 31 ppt. Hatching was successful in all conditions with no "prezoea." At 12.5 ppt there was some delay in molting, and at 12.5 and 31.1 ppt no larvae completed development to first crab stage. At 12.5 ppt, zoeal mortality was highest in first zoeal stage, and at 31.1 ppt during fourth zoeal stage, usually while molting to megalops. At 20.1 and 26.7 ppt, development to first crab stage occurred at all temperatures. Temperature affects length of larval development and time of molting, and in combination with salinity it contributes to mortality and success in development. Those larvae that completed development to first crab stage always passed through four zoeal and one megalops stage. (S. H. Hopkins)

Costlow, J. D., Jr., and Bookhout, C. G. 1959b. The larval development of Callinectes sapidus Rathbun reared in the laboratory. Biol. Bull., 116:373-396.

Blue crab larvae were reared from hatching to postlarval stages (crab form) in 20, 25, and 30 C and salinities of 10.5, 15.6, 20.1, 26.7, 31.1, and 32 ppt (18 temperature-salinity combinations). From 1% to 8% of zoeae hatched completed development, all at 25 C and 20.1, 26.7, and 31.1 ppt. Seven zoeal stages and one megalops stage occurred in those that completed development. Development to megalops took 31-49 days and megalops persisted 6-20 days. There was no significant difference in time required for zoeal development in salinities of 20.1, 26.7, and 31.1 ppt, but the megalops took longer to metamorphose to first crab in 31.1 ppt. Below 20.1 ppt, zoeae rarely completed the first molt. (S. H. Hopkins)

Costlow, J. D., Jr., and Bookhout, C. G. 1962a. The larval development of Hepatus epheliticus L. under laboratory conditions. Jour. Elisha Mitchell Sci. Soc., 78:113-125.

Eggs of this crab were hatched in sea water salinities of 20, 25, 30, 35, and 40 ppt and maintained at a temperature of 25 C. Hatching occurred in all salinities, but complete development to the first-stage crab was observed only at 30 and 35 ppt. At 20 and 40 ppt the larvae did not complete the first zoeal molt. Survival was higher in 35 ppt than in 30 ppt. Development time was 21-26 days at 30 and 35 ppt, and at 25 ppt it was 33-38 days.

Complete descriptions and drawings of all stages are included. [H. epheliticus is present in salinities of 28.7-35.2 ppt along the Texas coast.] (S. Rennie)

Costlow, John D. and Bookhout, C. G. 1962b. The larval development of Sesarma reticulatum Say reared in the laboratory. Crustaceana, 4:281-294.

All crabs were raised at 25-ppt salinity and 25 C. Larval stages are described and drawn. In artificial light, a high percentage of the zoea in all photoperiods tested (0-24 hr) molted. Little difference was observed in the time of any one molt, and the length of time required for development to the crab stage was not affected by differences in photoperiod. Survival was better in natural light, but mortality during the megalops stage cannot be attributed to the use of artificial light. [No doubt salinity of 25 ppt was chosen because this approximates the salinities in which this estuarine marsh crab is usually found in nature--SHH.] (S. Rennie)

Costlow, John D., Jr., and Bookhout, C. G. 1968. The effect of environmental factors on development of the land-crab, Cardisoma guanhumi Latreille. Amer. Zool., 8:399-410.

Larvae were maintained in 24 different combinations of salinity and

temperature from the time of hatching. Survival to the first crab stage occurred in salinities of 15-45 ppt, 25 and 30 C. Duration of the five zoeal and one megalops stages was similar in salinities of 20-40 ppt, but at 15 and 45 ppt a greater period of time was required for total development. Mortality of all the larvae at 20 C suggests that temperature plays a more important role in survival and distribution of the larvae of C. guanhumi than salinity. Increments of size in crabs during the first seven postlarval molts were similar in salinities of 5-35 ppt, 25 C, but in fresh water (0 ppt) increase in size at the time of molting was reduced. The duration of intermolt was reduced in crabs kept in fresh water (but not in salinities of 5-35 ppt), and survival was also lower in fresh water. (S. H. Hopkins)

Costlow, J. D., Jr., Bookhout, C. G., and Monroe, R. 1960. The effect of salinity and temperature on larval development of Sesarma cinereum (Bosc) reared in the laboratory. Biol. Bull., 118:183-202.

Zoeae of S. cinereum (wood crab) were reared in laboratory under 12 conditions of salinity and temperature. Hatching of first zoea occurred successfully at 12.5, 20.1, 26.7, and 31.1 ppt. Optimum salinities exist for each larval stage; at 12.5 ppt there was delay in molting, at 26.7 and 31.1 ppt molting was more rapid. At 12.5 and 31.1 ppt no larva successfully completed development to first crab stage. Mortality was highest at 12.5 ppt especially in early instars. "Mortality was highest in fourth zoeal stage at 31.1 ppt." Highest survival (24%) to first crab stage was at 26.7 ppt; some zoeae completed development to first crab stage at 20.0 ppt. Temperature affects speed of development more than mortality. At 20 C development to first crab stage took 35-39 days, at 30 C only 20-22 days. Variations in temperature and salinity did not affect number of stages; always four zoeal and one megalops stage. Fourth stage can withstand reduction of salinity to 3 ppt at 35 C, but at lower temperatures mortality increases with slight changes in salinity. Same trend is shown by megalops, but it tolerates wider range of temperature and salinity. "Salinity is chief...factor which confines S. cinereum to estuarine environment." (S. H. Hopkins)

Costlow, J. D., Jr., Bookhout, C. G., Monroe, R. 1962. Salinity-temperature effects on the larval development of the crab, Panopeus herbstii Milne-Edwards, reared in the laboratory. Physiol. Zool., 35:79-93.

Larvae were reared in 12 combinations of salinity (12.5, 20.1, 26.5, and 31.1 ppt) and temperature (20, 25, and 30 C). All larvae hatched as first-stage zoeae. Succeeding stages show highest survival under different conditions. Increasing salinity reduces time required for larval development. Low salinity (12.5 ppt) does not permit development to the crab stage. Development from egg to first crab stage was completed in 48-52 days at 20 C and 18-28 days at 30 C. There were four zoeal and one megalops stage in all salinity-temperature combinations. Survival to first crab stage was 17% in all salinities, other than 12.5 ppt, at 30 C. At 12.5 ppt, mortality of first zoeae was highest at all temperatures. It is theorized that temperature limits the productive spawning period of P. herbstii and favors spring over fall broods of larvae. (S. H. Hopkins)

Costlow, J. D., Jr., Bookhout, C. G., and Monroe, R. 1966. Studies on the larval development of the crab, Rhithropanopeus harrisii (Gould). 1. The effect of salinity and temperature on larval development. Physiol. Zool., 39:81-100.

Larvae were reared from hatching to first crab stage in laboratory, in 24 combinations of salinities (1.0, 2.5, 5.0, 15.0, 25.0, 33.0, 35.0, and 40.0 ppt) and temperatures (20, 25, and 30 C). Hatching of normal first-stage zoeae occurred in salinities of 5-33 ppt and temperatures of 25 and 30 C. At 2.5 and 40 ppt there is a slight reduction in development of larvae, but time required is not

significantly affected by salinities from 5 to 35 ppt. Survival to first-crab stage occurred in all salinites except 1.0 ppt. No optimum salinity was detected; 66%-90% survived to megalops in 15-25 ppt with reduction in lower and higher salinities outside of this range. In salinities below 15 ppt more larvae survived in 30 C than in 20 C, while in 15-40 ppt more survived in 20 C. Larval development was completed in 26-41 days at 20 C, and in 11-18 days at 30 C (to first-stage crab). There were four zoeae and one megalops in all conditions in which development was completed. (S. H. Hopkins)

Courtright, R. C. and Bond, E. 1969. Potential toxicity of Kraft mill effluent after oceanic discharge. Progr. Fish Cult., 31(4):207-212.

The foam resulting from agitation of Kraft pulp mill waste with sea water contains a heavy concentration of toxic materials. Foam blown onto the shore after oceanic discharge of waste can present a potential hazard to intertidal animals. This hazard was studied in bioassays using the foam fraction with larvae of the bay mussel, Mytilus edulis, and the waste with the fluffy sculpin, Oligocottus snyderi. Foam from the beaches is more toxic to mussel larvae than waste before discharge. Interaction of temperature, salinity, and waste shows that the fluffy sculpin has decreased tolerance for the waste when under stress of the extremes of salinity and temperature that can occur in exposed tidepools. The sculpin can survive 72 hr at 16 C over a salinity range of 3 to 50 ppt. (P. Maxwell)

Cowles, R. P. 1930. A biological study of the offshore waters of Chesapeake Bay. U.S. Bureau of Fisheries, Washington, D. C., Bull. U.S. Bur. Fish., 46:277-381 (Bur. Fish. Doc. No. 1091).

Includes 15-page section on salinity with five charts of horizontal distribution and four graphs of vertical distribution. Biological section includes diatoms and invertebrates, including lower chordates, but not vertebrates. Salinities are given for most species recorded. Only species collected in nets and dredges handled by deep-draft vessels (U.S.S. Fish Hawk and U.S.S. Roosevelt) are included; no shore collecting was done (as indicated by title), so many shallow-water species were missed. (S. H. Hopkins)

Craigie, J. S. 1969. Some salinity induced changes in growth pigments, and cyclohexane tetrol content of Monochrysis lutheri. Jour. Fish. Res. Bd. Canada, 26(11):2959-2967.

Growth rates of M. lutheri Droop increased with light intensity in sea water medium (SWM), whereas cells grown at either low NaCl (0.013 m) or high NaCl (1.02 m) showed reduced growth at higher light intensities with an optimal intensity near 0.05 gCal/cm^2 per min. Chlorophyll and total carotenoids usually declined with increasing light intensity except in cells maintained on a high salt regime, when the carotenoid content remained high at all light intensities. The concentration of intracellular cyclohexanetetrol in SWM cells was approximately 0.3 m and was dependent upon the osmotic properties of the medium. Added NaCl, mannitol, sucrose, but not glycerol, caused accumulation of the cyclitol, whereas dilution of the medium caused its expulsion from the cells. Addition of 0.5 mole/l of NaCl to SWM cells caused an 80% to 90% increase in cyclitol concentration within 4 hr; dilution of the medium reduced the cyclitol to the new steady-state level within 10 min. (From Biol. Abstr.)

Crawford, G. I. 1937a. A review of the Amphipod Genus Corophium with notes on the British species. Jour. Marine Biol. Assoc. U.K., 21:589-630.

Thirty-two species are listed. These are described in some cases with brief ecological notes and in all cases with localities recorded. C. volutator is called estuarine, and "lives in almost fresh water" with insect larvae in some

places. C. mucronatum "is found in salt, brackish, and fresh water." C. insidiosum "has frequently been found in salinities of about 15 ppt." C. lacustre "lives in water of a salinity from practically 0.0 to about 15 ppt." Other species are all called marine, but one of those listed, C. louisianum, is actually estuarine in Louisiana. (S. H. Hopkins)

Crawford, G. I. 1937b. The fauna of certain estuaries in West England and South Wales, with special reference to the Tanaidacea, Isopoda and Amphipoda. Jour. Marine Biol. Assoc. U.K., 21:647-662.

The paper is based on collections made in summer 1935 in estuaries of Tamar, Tavy, Lynher, Plym, and Exe Rivers, intertidally or in shallow water, in brackish reaches, with a hand net and a 1-mm sieve. Many species are listed, with collection notes, and the ecology is discussed, but without quantitative salinity data. (S. H. Hopkins)

Creutzberg, F. 1961. On the orientation of migrating elvers (Anguilla vulgaris Turt.) in a tidal area. Neth. Jour. Sea Res., 1:257-338.

From field work the author established that elver migration was controlled by tidal fluctuations of ebb and flood stages. In the lab a circular stream apparatus was constructed which imitated the ebb phase by a salinity decrease and the flood stage by a salinity increase. Mixtures of sea water and tap water were used. No satisfactory results could be obtained in showing an "inward migration" of the elvers. In experiments to show a preference for different salinity water, fresh water (0-ppt chlorinity) and 5.8-, 11.5-, and 17.3-ppt chlorinity sea water were used. When tap water was used, no preference for fresh water was found. When natural fresh water was used instead of tap water, the elvers preferred the fresh water. This seemed due to the occurrence of an attractive "odor" substance (which could be removed by a charcoal filter) in the natural water. The inland water could lose its attractiveness after a period of time. The experiments using the circular stream apparatus and natural water were repeated, and a distinct increase of positive rheotaxis and a decreased negative rheotaxis occurred during the ebb phase, while a reverse occurred during the flood phase. (T. Rennie)

Crisp, D. J. 1965. The ecology of marine fouling. Pp. 99-117. In: Goodman, G. T., Edwards, R. W., and Lambert, J. M., editors, Ecology and the industrial society. John Wiley, New York, viii + 395 pp.

Although salinity is one of the most important factors in the ecology of fouling organisms, it is mentioned in only one sentence (p. 104): "Unless such areas (estuarine harbors) are excessively polluted...they will tend to retain in the plankton very high densities of the larvae of marine foulers...many of which are very tolerant to reduced salinity." (S. H. Hopkins)

Crisp, D. J. and Costlow, J. D., Jr. 1963. The tolerance of developing cirripede embryos to salinity and temperature. Oikos; Acta Oecologica Scand., 14(1):22-34.

Egg masses of three barnacles, Balanus eburneus Gould, B. amphitrite Darwin, and Chelonobia patula Ranzani, developed at a series of different temperatures and salinities. Between 25 and 40 ppt, development was at the normal rate. Between 15 and 25 ppt or between 40 and 60 ppt only a portion of the eggs hatched, and development was delayed. Salinity tolerance was not influence appreciably by temperature within the range normally encountered by the animals. The salinity tolerance of the first- and second-stage nauplii was similar to that of the embryos; however the actual limits were to some extent dependent on the salinity to which the eggs had been exposed during development. The hatched nauplii were identical in size whatever the salinity at which they developed. Successful

development of 50% of the larvae occurred at the widest range of salinity in B. amphitrite (34 ± 21.5 ppt). (S. H. Hopkins)

Crisp, D. J. and Southward, A. J. 1958. The distribtuion of intertidal organisms along the coasts of the English Channel. Jour. Marine Biol. Assoc. U. K., 37:157-208.

Distributions are listed geographically in general terms, north-south, east-west. A map of mean salinities throughout the year is shown, but it is not specifically related to distribution. The channel shows both east-west and inshore-offshore gradients influenced by land runoff. "The differences are greatest in winter, when more rain falls, but are probably of little importance to most shore organisms, which experience larger local changes in salinity from the direct effect of rainfall and streams on the shore." (p. 162)

The east-west distribution coincides with the topographical limits separating two basins. The line extends from the Cherbourg Peninsula to the Isle of Wight. The north-south distribution is less conspicuous and is probably related to temperature differences. (S. Rennie)

Croghan, P. C. 1958a. The mechanism of osmotic regulation in Artemia salina (L.): The physiology of the branchiae. Jour. Exptl. Biol., 35:234-242.

The use of $AgNO_3$ on Artemia adults showed AgCl to be precipitated on the cuticle of the first ten pairs of branchiae. There was no staining of the eleventh pair or any other part of the animal. Correlation of the physiological effects of $KMnO_4$ treatment with the localization of damage to the first ten pairs of branchiae and the silver-staining work indicates that the opithelium of the first ten pairs of branchiae is the site of active NaCl excretion in hypertonic media, and probably of active uptake from hypotonic media. In nauplii, apparently the dorsal neck organ is concerned in NaCl excretion and then when the branchiae develop, the neck organ degenerates. (T. Rennie)

Croghan, P. C. 1958b. The osmotic and ionic regulation of Artemia salina (L.) Jour. Exptl. Biol., 35:219-233.

Brine shrimp (Artemia salina) adults were acclimated to salinities from 0 to 600% of sea water salinity, then osmotic pressure and chemical composition of haemolymph and whole animal were compared with external medium. Haemolymph concentration was relatively constant over range of medium concentration, showing independence from external medium. A. salina could adapt down to 0.26% NaCl, but died within 24 hr in fresh water. Nauplii (larvae) were hypotonic to sea water and had haemolymph fairly similar to that of adults. Na, K, Mg, and Cl concentrations of haemolymph were determined, and presented as function of haemolymph osmotic pressure. Ionized Na salts accounted for 90% of total haemolymph osmotic pressure. Haemolymph and medium ionic ratios were very different. NaCl is actively excreted against concentration gradient. Most of the permeability seen previously was across gut epithelium; external surface is much less permeable. Croghan claims physiological confirmation of fresh-water ancestry for Artemia; "evolution has been a process of superimposing upon a basically fresh-water type of physiology a method of stabilizing the haemolymph composition at a level which the cells and tissues can tolerate." (T. Rennis)

Croghan, P. C. 1958c. The survival of Artemia salina (L.) in various media. Jour. Exptl. Biol., 35:213-218.

Adult brine shrimp were placed in over 18 different media and their reactions were noted. Artemia survived in different concentrations of sea water, from 10% of sea water (=3.5 ppt) to a saturated crystallizing sea water brine. Survival in glass-distilled or tap water was relatively short. Most organisms were dead by 24 hr. Prolonged survival was only possible in media in which

certain sodium salts (principally NaCl) predominated. The animals seemed appreciably permeable. (T. Rennie)

Croker, Robert A. 1968. Distribution and abundance of some intertidal sand beach amphipods accompanying the passage of two hurricanes. Chesapeake Sci., 9(3):157-162.

Macrofaunal populations of intertidal haustoriid amphipods at Sapelo Beach, Sapelo Island, Ga., showed little change in zonation accompanying the passage of two hurricanes despite changes in beach morphology. Abundance data showed a general decrease of amphipod (primarily Neohaustorius schmitzi) densities in fall samples 2 months after the second hurricane. Some mortality of amphipods probably occurred where large volumes of fresh water overflowed the sand beach. (T. Rennie)

Cronin, L. E. 1967. The role of man in estuarine processes. Pp. 667-689. In: Lauff, G. H., ed. Estuaries. Am. Assoc. Adv. of Sci., Publ. 83, Washington, D. C., xv + 757 pp.

P. 669, biological effects of changing salinity in estuaries by increasing or decreasing inflow of fresh water, e.g. from Lake Okeechobee to St. Lucie Estuary (by Army Corps of Engineers), diversion of water from Delaware River system to New York City reservoirs, change of flow in San Joaquin River, California. Pp. 670-672, "selected cases" of man-made changes in freshwater flow into estuaries, with salinity effects: Mississippi River levees, Bonnet Carré Spillway, Potomac River dams and reservoirs, the Delaware River diversion. Other examples of the effects of changed salinity are given on pp. 673-674: Zuider Zee and other Dutch drainage projects. (S. H. Hopkins)

Cronin, L. E., Daiber, J. C., and Hulbert, E. M. 1962. Quantitative seasonal aspects of zooplankton in the Delaware River Estuary. Chesapeake Sci., 3:63-93, text, figs. 1-20.

Over a 2-yr period Clarke-Bumpus samples were taken each 3 months at 20-ft-depth intervals at 13 channel stations along length of Delaware Estuary. Zooplankton of 44 species were identified. At all seasons river stations had least zooplankton volume, mouth of bay next, and estuary proper the most. Eighty-five percent of volume was made up by five species: Gammarus fasciatus 54%, Acartia tonsa 22%, Eurytemora affinis and E. hirundoides 7%, and Neomysis americana 6%. A. tonsa had largest number of individuals (65% of total). A tonsa and Eurytemora spp. made the region between isohalines of 5 and 20 ppt the richest in microcrustacea. Regions, according to salinity and principal crustacean species: (1) Polyhaline, 18-30 ppt - Centropages typicus, C. hamatus, Labidocera aestiva, Temora longicornis, Penilia avirostris, Paracalanus parvus, Evadne nordmanni (oceanic forms); (2) Mesohaline, 5-18 ppt - Eurytemora affinis, E. hirundoides, A. tonsa, Pseudodiaptomus coronatus, Neomysis americana (estuarine forms); (3) Oligohaline, 0.5-5 ppt - Gammarus fasciatus; and (4) Limnetic, less than 0.5 ppt - Cyclops viridis and Cladocera. The principal species in regions 3 and 4 were freshwater forms. Volumes, all stations and seasons, ranged from 0 to 1.2 cc/m^3. (S. H. Hopkins)

Cronin, L. E. and Mansueti, Alice J. 1971. The biology of the estuary. Pp. 14-39. In: A symposium on the biological significance of estuaries. Ed: Douglas, P. A. and Stroud, R. H. Sport Fishing Institute, Washington, D. C., xi + 111 pp.

General description of estuaries, their hydrography, and the ecology as related to the hydrography, bottom types, etc. Diagrams show relations of various plants and animals to environmental factors including salinity. (S. H. Hopkins)

Cronin, L. E., Van Engel, W. A., Cargo, D. G., and Wojcik, F. J. 1957. A partial bibliography on the genus Callinectes. Virginia Fisheries Lab., Gloucester Point, Va., Special Scientific Report No. 8, and Maryland Dept. of Research and Education, Ref. No. 57-26, 21 pp.

Includes complete published references, incomplete or unchecked references, and manuscripts. A subject index is included. (Cited from Tagatz and Hill, 1971, which see.) (S. H. Hopkins)

Crothers, J. H. 1969. The distribution of crabs in Dale Roads (Milford Haven: Prembrokeshire) during summer. Field Studies, 3(1):109-124.

The distribution of eight common crab species in Dale Roads was investigated by baited trapping. The resultant patterns suggest the presence of a critical factor, yet to be isolated but probably related to salinity, that effectively limits most Carincus maenas (L.) to water of less than 3-fathom (5.5 m) depth and all other species to deeper water. A second critical depth zone, apparent for three of the other species, may possibly be related to a change of substrate. (From Biol. Abstr.)

Crowell, Sears and Darnell, Rezneat M. 1955. Occurrence and ecology of the hydroid Bimeria franciscana in Lake Pontchartrain, Louisiana. Ecology, 36(3):516-518.

This hydroid, originally described from San Francisco Bay, is the species called B. tunicata by Fraser (1944, 1945) and Frey (1946, Potomac River oyster beds). It is found in large quantities in Lake Pontchartrain in areas with high organic content of bottom and some current, in salinities from 2.5 to 12 ppt in the lake and from 1 to 35 ppt in the laboratory. Best growth occurs at summer water temperature of 34 C. (S. H. Hopkins)

Cuénot, L. 1895. Études physiologiques sur les Crustacées Decapodes. Arch. Biol., Paris, 13:245-303.

This is a monograph of the morphology, histology, and physiology of gills, kidney (green gland), liver, digestive system, connective tissue, pericardial pouches, and blood cells (especially amoebocytes and phagocytes) of crayfish (Astacus fluviatilis) of fresh water, and marine caridean shrimps (Palaemon, Palaemonetes), brachyuran crabs (Carcinus, Portunus, Xantho, Pilumnus, Dromia), anomuran crabs (Eupagurus, Galathea), and lobsters (Homarus, Palinurus). The marine forms have a greater excretory surface area on the gills and can eliminate injected solutions more rapidly. This is the only connection with the study of effects of salinity changes on organisms. (S. H. Hopkins)

Culliney, J. L. 1971. Laboratory rearing of the larvae of the mahogany date mussel Lithophaga bisulcata. Bull. Mar. Sci., 21(2):591-602.

This bivalve mollusc, a member of the family mytilidae, bores into calcium carbonate substrates such as coral heads in the ocean and clam shells in estuaries, from North Carolina to Gulf of Mexico and West Indies. Most of this paper deals with development and morphology of the larvae, which were reared through pelagic stages in the laboratory under constant conditions of 25 ± 1 C temperature and 30 ± 2 ppt salinity, and were fed unicellular algae, chiefly Isochrysis galbana. (S. H. Hopkins)

Cuzon du Rest, Rene. 1963. Distribution of the zooplankton in the salt marshes of Southeastern Louisiana. Publ. Instit. Mar. Sci., 9:132-155.

Preceding the construction of a ship channel between New Orleans and the Gulf of Mexico, the zooplankton of the marsh area was examined at three locations:

(1) nearly fresh Bayou Dupre (2.9 ppt), (2) an intermediate area (4.2 ppt), and (3) Breton and Chandeleur Sounds (9-22 ppt).

Acartia tonsa was the most common at all three locations. Eurytemora hirundoides was present at locations 1 and 2, while Oithona sp. was more common at location 3. Copepod nauplii were at all stations but had greatest numbers at 1 and 2. Cirripedia nauplii were abundant at 3 and present at the others, as were the crab zoeae. All of the above-mentioned except crab zoeae showed spring maxima in April. Crab zoeae probably bloomed in July. Seasonal distribution of other zooplankters are noted. The plankton of the project area were brackish water forms with freshwater and marine forms being transient. (S. Rennie)

Dahl, E. 1956. Ecological salinity boundaries in poikilohaline waters. Oikos, 7:1-23.

A general discussion including many other areas but centered on the Transition Area between the North Sea and Baltic Sea. It is maintained that the salinity interval of about 15 to 28 or 30 ppt should be regarded as a polyhaline brackish zone, positively characterized by the presence of brackish water species and negatively by the absence of the majority of marine forms. It is suggested that all brackish and estuarine waters dependent upon the sea for their salinity should be referred to as poikilohaline because of the lack of stability of their salinity conditions, while the stable freshwater and marine environments should be referred to as homoiohaline. The terminology of Redeke as amended by Hedgpeth is recommended. (S. H. Hopkins)

Dahl, Fr. 1891. Untersuchungen ueber die Thierwelt der Unterelbe. Ber. Komm. Unters. deutscher Meere Kiel, 6.

Study of ecology of brackish-water animals in Elbe Estuary, Germany, according to Redeke, 1932. Copepod Eurytemora affinis and its food-supplying diatom Coscinodiscus rothi form bulk of plankton in weakly brackish water of lower Elbe. (S. H. Hopkins)

Dailey, M. E., Fremont-Smith, F., and Carroll, M. P. 1931. The relative composition of sea water and of the blood of Limulus polyphemus. Jour. Biol. Chem., 93:17-24.

The average freezing point depression determinations for serum of L. polyphemus and sea water show the serum to be isotonic with the sea water, 1.785° and 1.787°, respectively. Determinations after a heavy rainfall, causing dilution of the sea water, gave the same relation. The data on individuals are not as convincing as the overall average. (S. Rennie)

Dakin, W. J. 1931. The composition of the blood of aquatic animals and its bearing upon the possible conditions of origin of the vertebrates. Nature, 128:66-67.

P. 67 - "Comparative and experimental physiology gives little support to the view that the regulated blood salinities of the vertebrates represent the salinity of the media in which their ancestors evolved that constancy. We can only accept the universal saline composition of the blood of metazoa--with its variations--as a possible reflection of a long-continued existence and probably origin in a saline medium." (Author)

Dales, R. P. 1951. An annual history of a population of Nereis diversicolor O. F. Müller. Biol. Bull., Woods Hole, 101:131-137.

The population studied was at Chalkwell, Essex, north shore of Thames Estuary, England. Density was seasonal, dropping gradually from 130/sq m in October to 35 in May, then rising steeply to peak of 281/sq m in August, then dropping again. Length of life not over 18 months, including one breeding season. Worms grew rapidly, 1-2 cm over each month during summer; worms hatched in February reached length of 10 cm in October. No growth in winter, but germ cells matured and spawning occurred in early spring, after which adults died off. Unspawned females lived longer and reached large size. Salinity studies were not included in this work, but reference is made to well-known resistance of N. diversicolor to varying salinity. (S. H. Hopkins)

Dales, R. P. 1967. Annelids. (2d edition.) Hutchison University Library, London. 200 pp.

"Excretion and regulation of the body fluids," including osmoregulation and adaptations to salinity differences with special attention to the species of Nereis, pp. 98-109. (S. H. Hopkins)

Dall, W. 1967. Hypo-osmoregulation in Crustacea. Comp. Biochem. Physiol., 21:653-678.

Metapenaeus bennettae were kept at 20 and 35 ppt. Regardless of previous salinity history, oral intake of water is significantly higher at 35 ppt. Uptakes at 15 and 20 ppt were identical, indicating a basic level of water uptake which probably serves some function other than osmoregulation. Measurements of Na^+, Cl^+, ^{22}Na, ^{36}Cl indicated that the anterior diverticula of the midgut, and not the gills, were the sites of salt excretion in Metapenaeus. Regardless of the salinity (20 or 35 ppt), ^{36}Cl output was greater by the cephalothorax than the abdominal region. Experiments with Metapograpsus and Scylla also indicate that salts are probably excreted via the proventriculus part of the gut. (S. Rennie)

Dall, W. 1970. Osmoregulation in the lobster Homarus americanus. Jour. Fish. Res. Bd., Canada, 27:1123-1130.

Adaptation from 32 to 20 and 37 ppt took 75 and 25 hr, respectively. At the lower salinity all body fluids remained hyperosmotic to the environment. At 37 ppt, body fluids were isosmotic with the external medium. When tested at 30, 37, 25, and 20 ppt, the animal was able, at the two lower salinities, to resist a drop in external salinity. At the higher salinities resistance to external medium was less obvious. Salt-loading experiments showed that salt can be rapidly eliminated from the body and that the gut, not the antennal glands, is the major site of excretion. (S. Rennie)

d'Ancona, Umberto. 1954. Fishing and fish culture in brackish-water lagoons. F. A. O. Fish. Bull., 7(4):147-172.

He defines brackish water and presents a classification of brackish waters based on the work of others. Lagoon waters are characterized by their instability in terms of temperature and salinity (0-260 per mill. = 0-260 ppt). The productivity of brackish lagoons appears to be high but easily hindered by insufficient oxygenation which causes eutrophication, reducing the productivity. Fishing in lagoons is mostly for migratory species which are attracted by the abundant food supply. Production from several lagoons around the world is summarized.

Rearing of fish in a tropical lagoon is begun by retaining fish seeking to return to the sea, or by capturing fish from another location and transporting them. Ideally, fry are fed on natural food organisms occurring in the lagoon or pond (plankton or algae).

Valli culture in Adriatic lagoons includes collection, rearing, and distribution of fry. The principal skill of valli culture is knowing how to regulate the flow of salty, fresh, and cold waters according to necessity (no specific data given). Summer eutrophication is a danger. Ways to increase valli production are planting of fry, artificial fertilization, artificial feeding, manuring of the lagoon to improve the natural food supply, and improve complete utilization and mineralization of organic materials by increasing circulation of the water and ploughing and harrowing the bottom, and periodic mowing of subsurface vegetation. (S. Rennie)

Danglade, Ernest. 1919. The flatworm as an enemy of Florida oysters. Report U.S. Comm. Fish. 1918, App. V, U.S. Bur. Fish. Doc. No. 869:1-8; plates I and II.

R. E. Coker in unpublished field notes, March 1916, said that a worm known locally as the "leech" was reported to occur occasionally on some oyster bars

near Tampa and sometimes to cause enormous mortality among planted oysters. In December 1916, T. R. Hodges, Florida Shellfish Commissioner, sent to Bur. Fish. an oyster from Cedar Keys with the worms. These were first reports known to Bureau. R. E. Gibson, oysterman of Tampa, said "leeches" have been known for 20 yr in Tampa Bay region, disappear for 2-3 yr, and then reappear and produce mortality, the worst period being 10 yr ago; Gibson claimed regular cycle. Outbreak of flatworms reported 10 yr ago at 3-4 points on Indian River, Florida east coast, has not recurred since. In 1916-17, flatworm abundant on west coast, Cedar Keys to Tampa Bay. Some earlier outbreaks said to have extended as far south as Cape Sable. Port Inglis another center of infestation. Damage worst in more saline waters. Loss from 10%-20% to complete destruction of one bed in Tampa Bay. Port Inglis and Cedar Keys, 1916-17 mortality 30%, with some mortalities up to 90%. Usually 1-3, sometimes 8-10 worms in each infested oyster. Not in small oysters. Not found after cold spells or freshets. Dry warm weather favors destructive outbreaks; most active August and September and on into fall as long as weather stays warm. Leech enters oyster, which succumbs only after long struggle during which it attemps to wall out the intruder; oyster becomes poor and weak, finally starves and dies. (S. H. Hopkins)

Dannevig, Alf. 1946. A revival of natural oyster beds. Nature, London, 158(4026):951.

In southeast Norway, great mortality among oysters reared in netting trays often occurs. This mortality only affects oysters taken as spat from different hydrographic conditions; local spat never fail. Mortality is not due to transportation, as it is not greatest just after arrival, but may take place a year or two after transplantation. "We are inclined to believe that oysters from the western coast of Norway are not able to stand the rather large variations in salinity occurring on the Skagerrack coast." (S. H. Hopkins)

Daribaev, A. K. 1967. Vliyanire osoloneniya na gidrobiologicheskii rezhim nerestilishch Aral skogo morya. [Effect of increased salinity on the hydrobiological conditions of Aral Sea spawning grounds.] In: Biologicheskie osnovy Rybnogo Khozyaistva navodoemakh Srednei Azii i Kazakhstana. [Biological bases of the fishing industry in Central Asian and Kazakhstan waters.] Nauka: Alma-Ata. 93-95. 1966. From Ref. ZH. Biol. 1967 No. 71170.

"In 1962-64 observations were carried out on the Muinak and Kusatav-Karakchin spawning grounds in southern Aral Sea. Data were gathered on the hydrochemical conditions, on the fauna composition at the spawning grounds, and on the extent of their quantitative development. The increased silt content has led to a reduction in the abundance and biomass of zooplankton and zoobenthos and has impoverished the spawning conditions of commercial semimigratory fishes and the feeding conditions of their young. The most important measure for improving the reproductive conditions of semimigratory Aral Sea fishes is amelioration."

Darlington, P. J., Jr. 1957. Zoogeography: the geographical distribution of animals. John Wiley & Sons, Inc., New York, xi + 675 pp.

Pp. 41-47: "What are fresh-water fishes?" Divides them into three categories, the primary and secondary divisions proposed by Myers (1938, Smithsonian Report for 1937, pp. 339-364) and the peripheral division of Nichols (1928, Amer. Mus. Novitates, No. 319, pp. 6-7). Primary freshwater fishes are strictly confined to fresh water. Secondary group lives chiefly in fresh water but have a little salt tolerance. The peripheral fishes occur in fresh water but have much salt tolerance; the freshwater fish fauna of Australia and of oceanic islands is made up of such fishes derived from marine ancestors. P. 45: "Paleontologists and physiologists agree that the common ancestor of all fishes probably lived in fresh waters: the earliest fossil fishlike vertebrates are in freshwater deposits (Romer, 1945: 44-45), and all fishes possess kidneys of a sort

that probably originated in fresh water (H. W. Smith, 1932)." P. 79: "The only barriers that are fully effective against freshwater fishes seem to be those of salt water." Other barriers, such as temperature, deserts, mountains, only slow dispersal, do not stop it. Pp. 102-122, annotated list of freshwater fish groups. Refs., pp. 122-127. (S. H. Hopkins)

Darnell, Rezneat M. 1954. An outline for the study of estuarine ecology. Proc. Louisiana Acad. Sci., 17:52-59.

Outlines a program for a cooperative investigation of Lake Pontchartrain, Louisiana, including (pp. 55, 57) salinity measurements.

Darnell, R. M. 1958. Food habits of fishes and larger invertebrates of Lake Pontchartrain, Louisiana, an estuarine community. Publ. Instit. Mar. Sci., Univ. of Texas, 5:353-416.

Food studies were carried out on 35 of the most important species in this low-salinity, brackish-water body, 31 fishes (21 predominantly marine or estuarine and 10 of freshwater origin) and 4 invertebrates: Rangia cuneata, brackish-water clam; Penaeus setiferus, white shrimp; Macrobrachium ohione, river shrimp; and Callinectes sapidus, blue crab. The salinity during the study period had extremes of 1.2 and 18.6 ppt but monthly averages ranged only from about 6 to 9 ppt. High turbidity interfered with phytoplankton production and the food chain seemed to be based largely on organic detritus.
(S. H. Hopkins)

Darnell, Rezneat M. 1959. Studies of the life history of the blue crab (Callinectes sapidus Rathbun) in Louisiana waters. Trans. Amer. Fish. Soc., 88:294-304.

The study was done in Lake Ponchartrain and the surrounding area. Salinity in the lake is generally less than 8 ppt. In adjacent Lake Borgne and Chandeleur Sound higher salinities occur, up to 35 ppt. Although the life history pattern was not definitely established for this area in the study, it appears as if mating occurs in the lake (fresher water) in the warmer months and the females retreat to the saltier water for the winter, and to lay the eggs. Then the young migrate into the fresh areas of the lake to feed in the spring.
(S. Rennie)

Darnell, R. M. 1962a. Ecological history of Lake Pontchartrain, an estuarine community. Am. Midland Naturalist, 68(2):434-444, maps.

Reviews geological history of Lake Pontchartrain; has gone through filling and freshening process in last 2000 yr and become more subject to sudden changes. Over 300 species are known in the lake, but only four maintain large endemic populations: the clam Rangia cuneata, the crab Rithropanopeus harrisii, the copepod Acartia tonsa, and the fish Anchoa mitchilli; other species are abundant but migratory and spawn elsewhere. Population levels and species composition of the fauna change according to physical conditions. There is much organic detritus and turbidity. Many consumers depend on organic detritus for much or all of their nutrition, and are among the most successful species in the lake.
P. 439: Salinity normally varies from 3 to 8 ppt with an average around 5 ppt and extremes of 1.2 and 18.6 ppt. (Condensation of author's abstract.)
(S. H. Hopkins)

Darnell, R. M. 1962b. Fishes of the Rio Tamesi and related coastal lagoons in East-Central Mexico. Publ. Instit. Mar. Sci., Univ. of Texas, 8:299-365.

Fish were collected from streams and from marshes and lagoons of variable salinity along the coast. Sixty species were recognized, 23 freshwater and 37 euryhaline. These were classified ecologically as strictly fresh water (15),

sporadic invaders of low-salinity water and frequent invaders of low-salinity water (from fresh water) (4 in each group); the 37 euryhaline fishes included anadromous species (4), catadromous species (2), frequent invaders of fresh water (5), sporadic invaders of fresh water (9), and marine species that are facultative invaders of low-salinity water (17). By "water of low salinity" approximately 4.5 ppt is meant. A detailed listing of species in each category and more detailed accounts are given on pp. 354-355 (classification based on salinity tolerance) and pp. 319-351 (annotations in annotated list of species). (S. H. Hopkins)

Daugherty, A. M. and Altman, L. C. 1925. Influence of hydrogen ion concentration, salinity and oxygen upon the rheotaxis of some marine fishes. Publ. Puget Sound Biol. Sta., 3:365-368.

Rheotaxis activity was noted for young sockeye salmon (Oncorhynchus nerka), herring (Clupea pallasi), and tomcod (Microgadus proximus) placed in an Allee straight current box under various oxygen, pH, and salinity conditions (normal sea water, 1/2 fresh water, 2/3 fresh water, and fresh water). The rheotaxis of the cod was more positive than that of the other fish types in all solutions used. Reduced salinity caused decreased positive rheotaxis in all species, but reduced oxygen content of the water seemed to be a much stronger controlling factor. (T. Rennie)

Daugherty, F. M., Jr. 1952. Notes on Callinectes danae Smith in Arkansas Bay, Texas, and adjacent waters. Texas Jour. Sci., 4(2):264-267.

In 1950 this small relative of the commercial blue crab, Callinectes sapidus, was caught in bays of the Aransas Bay system, in Aransas Pass, and in Cedar Bayou, in every month of the year (except January). Largest numbers were caught in April, when there was a large peak, and in October (smaller peak). All sizes, 10- to 114-mm carapace width, were found in the bays, including many mature males and many females in next to last instar, but only 8 of 200 females examined were mature. Ovigerous females were seen going toward gulf in November, and many ovigerous females were found in the gulf in November and December. Salinities in the bays in 1950 ranged from 23.7 to 36.9 ppt, and temperatures ranged from 11.7 to 30.0 C. "Breeding" (copulation, presumably) was seen in the bays. (It is not mentioned, but 1950 was the second of seven very dry years in Texas, and bay salinities were higher than normal.) (S. H. Hopkins)

Davies, T. T. 1965. Effect of environmentally induced growth rate changes in Mytilus edulis shell. Spec. Pap. Geol. Soc. Am., 87:42. (Abs.)

In most cases growth rate increases with water temperature. The effect of reduced salinity on growth rate can be deduced from an increase in the magnesium concentration of the shells. (S. Rennie)

Davis, C. C. and Williams, R. H. 1950. Brackish water plankton of mangrove areas in Southern Florida. Ecology, 31(4):519-531; 5 tables.

Thirty-nine plankton samples from 28 mangrove-bordered, inland bodies of water along the lower west coast and south coast of Florida were analyzed. Salinities varied from 0.61 ppt in Broad River Bay to 29.09 in Garfield Bight of Florida Bay. Water bodies of similar salinity varied in plankton probably due to isolation. Chokoloskee Bay (23 ppt) contained more species than other west coast localities, and more of the oceanic type. The five bays with lowest salinities contained "a good proportion" of freshwater types. Bays with intermediate salinities were more closely similar to Chokoloskee. Within the two groups of lakes (south and west coasts) differences of plankton content were probably associated most closely with salinity differences. Free-swimming parasitic copepods, tychopelagic species, and abundant larval forms were encountered. Acartia

tonsa and A. floridana were in Chokoloskee Bay; A. tonsa was in bays and A. floridana in lakes on south coast. Gastropod and pelecypod veligers were abundant in west coast lakes and south coast waters. Oysters were found on mangroves in Broad River Bay, but they had been dead a long time (salinity 0.6). (S. H. Hopkins)

Davis, Harry C. 1957. Some effects of lowered salinities on propagation and early development of clams and oysters. Ann. Rept. Amer. Malacol. Union, 1957:6.

"The optimum salinity for the development of eggs of Long Island Sound clams (Venus mercenaria) was about 27.5 ppt. No normal larva developed at salinities of 17.5 ppt or lower. The upper salinity limit for development of clam eggs appeared to be 35.0 ppt and only an occasional normal larva developed at this salinity. Straight-hinged clam larvae grew reasonably well at 17.5 ppt and many reached metamorphosis. At 13.2 ppt none of the larvae reached metamorphosis, although some lived to 10 days or more and showed appreciable growth. At 12.5 ppt straight-hinged clam larvae showed no growth and all were dead by the eighth or tenth day.

The optimum salinity for the development of eggs of the Long Island Sound oyster (Crassostrea virginica) was found to be 22.5 ppt although some normal larvae developed in salinities as low as 12.5 ppt and as high as 35.0 ppt. The optimum salinity for growth of the straight-hinged larvae, however, was 17.5 ppt, and older oyster larvae grew quite well and set at salinities as low as 12.5 ppt. Growth even of older oyster larvae at 10.0 ppt was considerably slower than at 12.5 ppt." (Author's abstract)

Davis, H. C. 1958. Survival and growth of clam and oyster larvae at different salinities. Biol. Bull., 114:296-307.

Venus mercenaria larvae develop from eggs hatched in laboratory to straight-hinge stage at salinities from 20 ppt (16%-21% of eggs develop) to 35 ppt (only 1% or less develop); the optimum for this phase of development is 27.5% for Long Island Sound clams. After they reach straight-hinge stage, larvae develop to metamorphosis at 17.5-27.5 ppt or higher, with some growth (but not to metamorphosis) at 15 ppt. In Crassostrea virginica the range and optimum salinity for development of straight-hinge larvae from eggs depend on the salinity at which gonads matured. Oysters from Hodges Bar, Md., developed gonads at 8.74 ppt; the optimum salinity for development of eggs to straight-hinge larvaewas 10-15 ppt. When oysters of the same stock matured gonads in laboratory at 26-27 ppt, the optimum salinity was the same as that for Long Island Sound oysters under the same conditions, 22.5 ppt. The range for development was 7.5-22.5 ppt for oysters matured at 8.74 and 12.5 to 35 ppt for oysters matured at 26-27. The optimum salinity for growth of larvae from Hodges Bar oysters conditioned and spawned in laboratory at 26-27 ppt was about 22.5 ppt. "It is still undetermined whether the optimum salinity for growth of larvae is influenced by the salinity at which oysters develop gonads." (S. H. Hopkins)

Davis, Harry C. 1962. Survival and growth of larvae of the European oyster, Ostrea edulis, at lowered salinities. Biol. Bull., 122(1):33-39.

The European oyster Ostrea edulis is found primarily in oceanic or near-oceanic salinities. Laboratory experiments indicate that it cannot be cultured in low salinities (20 ppt or lower) because it cannot reproduce therein. At salinities of 25 and 22.5 ppt, growth of larvae was not significantly different from that at 26-27 ppt. At 20 ppt, growth of larvae was appreciably slower and intensity of setting was reduced. At 17.5 and 15.5 ppt, larvae lived for some time and grew appreciably, but all died without metamorphosis. At 12.5 ppt, larvae showed no growth and 90% died in 10 days. At 10 ppt, all larvae died in less than 4 days. Some larvae that were reared to setting size in 26-27 ppt set in salinities as low as 15 ppt. No normal larvae were obtained from oysters kept at salinities of 20 or 17.5 ppt. (S. H. Hopkins)

Davis, Harry C. 1963. The effect of salinity on the temperature tolerance of eggs and larvae of some lamellibranch mollusks. Proc. Int. Congr. Zool., Washington, 16(1):226. (Abs).

Davis determined the temperature tolerances of hard clam, Mercenaria mercenaria, and oyster, Crassostrea virginica, eggs and larvae at a series of decreased salinities, but neither temperatures nor salinities were listed. (S. Rennie)

Davis, H. C. and Calabrese, A. 1964. Combined effects of temperature and salinity on development of eggs and growth of larvae of M. mercenaria and C. virginica. Fish. Bull., U.S. Fish and Wildlife Serv., 63:643-655.

Clam (M. mercenaria) and oyster (C. virginica) larvae could ingest food at lower temperatures than those required for digestion and assimilation, and could digest and assimilate naked flagellates at lower temperatures than algae with cell walls. When fed naked flagellates, clam larvae grew at minimum temperature of 12.5 C and oyster larvae at minimum of 17.5 C. Optimum salinity for clam larva development was 27 ppt. No optimum salinity was established for oyster larvae, which grew in 15-27 ppt (20-27 ppt at lower temperature). Optimum temperatures for clam larvae were from 25 to 30 C, and for oyster larvae 30 to 32.5 C, except in salinity of 7.5 ppt where optimum temperature was 27.5 C. Reduced salinity reduced the range of temperature tolerance at both ends. Clam larvae were affected most at high temperatures. Setting time for oyster larvae was 10-12 days at 30-32.5 C and 36-40 days at 20 C. (S. Rennie)

Dawson, C. E. 1955. A study of the oyster biology and hydrography at Crystal River, Florida. Publ. Instit. Mar. Sci., Univ. of Texas, 4(1):279-302.

Oyster reefs extend 3.5 miles into the Gulf of Mexico off the mouth of Crystal River. Salinities are estuarine, and mean salinities are lower than in other Florida oyster regions studied. Backswamp salinities were 4.3-19.6 ppt, and Crystal Bay salinities 3.2-28.4 ppt, with means of 12 and 16 ppt, respectively. Growth of oysters is faster than in northern states but much slower than in Apalachicola Bay. Growth and mortality both increased with temperature. (S. H. Hopkins)

Day, J. H. 1951. The ecology of South African estuaries. Part I. A review of estuarine conditions in general. Trans. Roy. Soc. S. Africa, 33(Part I):53-91.

(First of a series on team survey by Dept. Zoology, University of Cape Town, on ecology of S.A. estuaries, 1947-1950.)

Contents: Introduction. The Geography of an Estuary (The Limits of an Estuary, The Shape of the Estuarine Basin, The Effect of the Shape...on the Physical Environment and on the Fauna and Flora). The Physical Environment (Wave Action, Current System, Turbidity, Penetration of Light, Effect of Turbidity and Silt on Estuarine Community, Substratum, Effect of Substratum on Fauna, Salinity, Open Estuaries Without Vertical Salinity Gradients, Estuaries with a Vertical Salinity Gradient, Blind Estuaries, Estuaries with a Reversed Salinity Gradient, Rate of Change of Salinity, Effects of Salinity Changes on the Estuarine Populations, Temperature, Effect of Temperature on the Estuarine Populations, Nutrient Salts, Excess Base: O_2 Concentration: pH). The Plant Population (Relation Between Plants and Animals). The Animal Population (Origin, Components of an Estuarine Fauna). Distribution of Plants and Animals. Bionomics of Estuaries. References (2 pp.).

Pp. 69-72 (The Effects of Salinity Changes on the Estuarine Populations):

Estuarine waters are constantly varying in salinity, so animals living there are continually subject to osmotic changes, and an animal having wide distribution up and down an estuary must have an efficient osmoregulatory mechanism.

Stenohaline marine animals tolerate passively a limited and slow reduction of salinity to about 25 ppt, while typical estuarine animals are euryhaline, can live in salinities much lower than 25 ppt, and where rate of change is high. Freshwater animals are homoiosmotic (maintain their body fluids at a constant osmotic pressure higher than that of fresh water). Surprisingly few successfully colonize estuaries, and these few are limited to 5-8 ppt or lower. Water bodies of salinity 40-60 ppt contain a limited selection of the animals found in 5-20 ppt. "No special hypersaline fauna has been found."

"The effect of age on salinity tolerance is unknown, but it is certain that most of the migratory forms found in estuaries breed in the sea." (S. H. Hopkins)

Day, J. H. 1967. The biology of Knysna Estuary, South Africa. Pp. 397-407. In: Lauff, G. H., ed. Estuaries. Am. Assoc. Adv. of Sci. Publ. 83, Washington, D. C., xv + 757 pp.

The ecology of this estuary was described by Day, Millard, and Harrison (1952, Trans. Roy. Soc. S. Africa, 33:367-413), with a list of fauna. Climate is temperate, rainfall in drainage basin is 36.3 in. evenly spread over the year, and salinity is stable, mouth being always open. Of the 310 species of animals, 7 (2.3%) are classed as "fresh-water" and are found at head of estuary in 1.1-14 ppt. "Estuarine only" species number 27 (8.6%), of which 3 occur at mouth of estuary, 20 in lagoon, 12 in middle reaches, and 12 at head (salinities 34.5-35.7, 29.1-34.8, 18.9-26.5, and 1.1-14 ppt, respectively). "Euryhaline and marine" species total 137 (44.1%), of which 80 are at mouth, 108 in lagoon, 46 in middle reaches (71.9% of all species in middle reaches), and 14 at head of estuary. "Stenohaline and marine" species numbered 139, of which 96 occurred at mouth, 71 in lagoon, 6 in middle reaches, and none at head. Thus the fauna was predominantly marine, and factors other than salinity were important in distribution.

Dean, Bashford. 1893. Report on European methods of oyster culture. Bull. U.S. Fish. Comm., XI:357-406.

"It may be stated that the specific gravity of the water in regions of maximum production throughout Europe appears to be uniform at about 1.023 in the case of the 'flat' oyster (Ostrea edulis) and about 1.021 in the case of the Portuguese species (Ostrea angulata)." (S. H. Hopkins)

Dees, Mrs. 1949. Chipman reports on progress of oyster studies at Beaufort, North Carolina. Oyster Institute of North America, Vol. XV, Bull. No. 14, p. 3.

"Dr. Chipman states that the sea water temperatures in the vicinity of Beaufort remained high during September. Examination showed that many of the oysters contained considerable spawn. For the most part, the oysters were poor in September; only a few showed the start of a small accumulation of reserve glycogen. Heavy rains late this summer created freshwater conditions over many shellfish beds, resulting in the death of many hard clams. The condition, sufficiently transient, allowed the oysters to survive.

Of particular interest is an oyster bed located in an area where there is almost constant high salinity. The oysters there were in excellent condition and gave evidence of good shell growth. Dr. Chipman plans further observations on the environment of this bed and of the oysters, for this area never receives much, if any, freshwater." (S. H. Hopkins)

Dehnel, Paul A. 1959. The effect of temperature and salinity on the oxygen consumption of two species of estuarine crabs, Hemigrapsus nudus and oregonensis. (Abs.) Anat. Rec., 134:551.

In both species, summer crabs use O_2 faster than winter crabs at the same

temperature. Winter crabs show heat depression at the same temperature and cold depression at a lower temperature than summer ones. When summer crabs were acclimated to 5, 10, 15, or 20 C, and to either low (25%) or high (75%) salinity, O_2 consumption decreased as acclimation temperature increased, when all crabs were tested at 10 C. At all acclimation temperatures, H. oregonensis had the faster O_2 consumption at the low salinity. For H. nudus, O_2 consumption was higher at low salinity only in group acclimated to low temperature and low salinity. At all other acclimation temperatures and salinities, O_2 use was higher at the higher salinity. Size of crabs made no significant difference at any temperature or either salinity. (S. H. Hopkins)

Dehnel, P. A. 1960. Effect of temperature and salinity on the oxygen consumption of two intertidal crabs. Biol. Bull., 118:215-249.

Tests were performed at acclimation temperatures of 5, 10, 15, and 20 C and at low (25% of sea water) and high (75% sea water) salinities. (100% sea water is 31.88 ppt.) At 10 C and both salinities, as acclimation temperature increases oxygen consumption decreases for Hemigrapsus oregonensis. Response by H. nudus to the same conditions is the same. The trends for both at 20 C are the same.

Oxygen consumption for H. oregonensis tested at 10 C is higher at the low salinity. At 20 C the rates are not significantly different in both salinities. For H. nudus at 10 C and acclimated to low temperature and salinity, oxygen consumption is higher than when acclimated to low temperature and high salinity. At 20 C no significant difference is seen.

In H. oregonensis, oxygen consumption of small animals, except at low temperatures, is affected by increase of acclimation temperature to a greater degree than large animals at all salinities. Animals acclimated to high temperatures are less size-dependent. With H. nudus, large animals are affected to a greater extent as acclimation temperature increases. Animals acclimated to higher temperatures are more size-dependent. (S. Rennie)

Dehnel, P. A. 1962. Aspects of osmoregulation in two species of intertidal crabs. Biol. Bull., Mar. Biol. Lab., Woods Hole, 122:208-227.

Total osmotic pressure measurements of blood were made on two Pacific Coast estuarine intertidal crabs, Hemigrapsus oregonensis and H. nudus, over a salinity range of 6% to 175% sea water, a temperature range of 5 to 25 C, during both summer and winter. Major changes in blood concentration occurred at 48 hr. Both species at either season were hypertonic to all test salinities. Below 100% sea water, osmotic regulation accelerated as salinity decreased, and both species regulated hyperosmotically in hypotonic media. Winter crabs maintained greater gradients below 100%-125% sea water, and were better regulators in hypotonic media. Summer crabs were better regulators, and maintained greater gradient, in hypertonic media. Summer crabs of both species were similar in from 6% to 125% sea water. In H. oregonensis, as external salinity decreased (75%-12% sea water), blood concentrations increased with decreasing temperature. Summer crabs had no real difference in blood concentrations at different temperatures and salinities, but had lower blood concentrations than winter crabs at lower salinities. H. nudus showed same trend. Low temperature (5 C) affected blood concentration of winter crabs only. Different sea-water concentrations caused no weight changes. It could not be concluded that increased osmotic work could be measured by oxygen consumption. (S. H. Hopkins)

Dehnel, P. A. 1963. Ion regulation in two species of estuarine crabs. Helgolaender wiss. Meeresunters, 9(1-4):474-475.

At low salinities, ion concentrations (sodium, potassium, and calcium) in the blood of both Hemigrapsus nudus and H. oregonensis were hypertonic to the media, while at high salinities, ion regulation was less effective and concentrations

approached isotonicity. The principal site of ion uptake from the medium for Hemigrapsus was the lamellar epithelium of the gill. Winter animals of both species appeared more effective regulators of calcium ion at low salinities. It was found that the main function of the antennary glands was to maintain the blood magnesium concentrations hypotonic to all salinities. Chloride regulation demonstrated that the blood was hyperosmotic at low salinities and hypoosmotic at higher salinities. Urine was hyperosmotic over the entire salinity range tested, and its salt content was approximately 36% to 40% higher than that of the blood. (T. Rennie)

Dehnel, Paul A. 1966. Chloride regulation in the crab Hemigrapsus nudus. Physiol. Zool., 39:259-265.

These intertidal crabs were kept in dark laboratory in plastic dishes in water of 6%, 12, 25, 75, 100, 125, 150, and 175% sea water (made by diluting stock 200% sea water, made by adding appropriate amounts of 5 salts to 75% natural sea water), and at temperatures of 10 ± 1.0 C. Crabs were of two lots, "summer" (previously exposed intertidally to 20 C and 11% salinity) and "winter" (previously exposed intertidally to 5 C and 24% salinity). "Summer" animals were kept 24 hr under experimental conditions and "winter" animals 3 days. Results were shown in figures, giving curves. Blood was regulated at hypertonic levels in sea water 6%-100%, but became hypotonic above 100% in summer; winter blood was isotonic at 100%-125% and hypotonic at higher concentrations. Winter blood concentrations were higher than in summer, in all salinities (especially lower ones). Urine chloride concentrations were hypertonic to media and to blood, and were higher in winter. Winter chloride gradients between urine and blood were higher than in summer. Chloride was excreted renally and extrarenally. (S. H. Hopkins)

Dehnel, P. A. 1967. Osmotic and ionic regulation in estuarine crabs. Pp. 541-547. In: Lauff, G. H., ed. Estuaries. Am. Assoc. Adv. of Sci. Publ. 83, Washington, D. C., xv + 757 pp.

The title is deceptive, as the paper is exclusively a review of the author's own work on Hemigrapsus nudus, a shore crab that is not even a typical estuarine species. For a single species, it is a good detailed account of the title subject. (S. H. Hopkins)

Dehnel, Paul A. and McCaughran, Donald A. 1964. Gill tissue respiration in two species of estuarine crabs. Comp. Biochem. Physiol., 13:233-259.

Oxygen consumption of gill tissue of Hemigrapsus nudus and H. oregonensis was measured at 35%, 75, 100, and 125% sea water, experimental temperatures of 5, 12.5, and 20 C, and acute (Warburg) temperatures of 5, 10, 15, and 20 C for all combinations for summer and winter animals. It was found that summer animals have higher rates of consumption at all acute temperatures than winter animals of both species. The effect of experimental temperature is a small degree of partial compensation for H. oregonensis but no compensation for H. nudus. The main effect of experimental salinity on H. nudus is significant with the lowest rate of respiration between 75% and 100% and the highest rate at 35% sea water. The lowest rate for H. oregonensis is at 100% and the highest at 35% sea water.

Gill respiration compared with blood and urine concentrations may be seasonal. In the summer, blood and urine of both species are equal in osmotic concentration and gill respiration rate is highest at low experimental salinities, decreasing as the blood approaches isotonicity with the medium. Winter animals show variable rates of gill respiration, and no correlation with salinity is evident. Salinity is the major factor causing the large seasonal difference in respiration rate of gill tissue, while temperature has little effect.

Interactions of temperature, salinity, and season indicate that there are no major physiological differences between the two species, except that

H. oregonensis shows more variation than H. nudus, indicating a more variable population. (S. Rennie)

Dehnel, P. A. and Stone, D. 1964. Osmoregulatory role of the antennary gland in two species of estuarine crabs. Biol. Bull., 126:354-372.

Total osmotic pressure measurements of urine were determined for Hemigrapsus nudus and H. oregonensis at three temperatures (5, 15, and 25 C), eight salinities (6%-175% of sea water) and two seasons, summer and winter. Under each experimental condition, urine samples were taken after 3-, 24-, and 48-hr acclimation. In summer, no H. oregonensis survived 48 hr in 175% sea water. Changes in urine of summer H. oregonensis were rapid and a steady state was reached after 24 hr, with blood and urine hyperosmotic to high salinities in media. Winter H. oregonensis survived 48 hr in 175% of sea water, and in high salinites urine was hypo-osmotic to blood and to media, with antennary gland participating in osmoregulation, while in salinities lower than sea water, hyperosmotic regulation occurred. H. nudus in summer survived 48 hr in 150% but not in 175% of sea water. Blood and urine were hyperosmotic to all salinities. Winter H. nudus survived 48 hr in 175% of sea water but not in lower than 12% of sea water. Urine was hypo-osmotic to media in high salinities.

Dekhuyzen, M. C. 1905. Waarom eene Zuiderzee-Expeditie? Utrecht, 1905. (In Dutch.)

According to Redeke, 1932, Dekhuyzen said that plants and animals in the polyhaline zone of estuaries live in a "rough osmotic climate," being exposed to most severe changes of salt content. This reference, cited from Redeke, has not been located. (S. H. Hopkins)

Dekhuyzen, M. C. 1920. Sur la semi-pérmeabilité biologique des parois extérieurés des sipunculides. C. R. Acad. Sci., Paris, 172:238-241.

Liquids in body cavity of marine invertebrates are isotonic to surrounding sea water, the walls being at least partly permeable to water, gases, and salts. The outer walls of Phascolosoma vulgare and of Sipunculus nudus, two sipunculid worms, are biologically semipermeable, that is, pure water, CO_2, and O_2 pass through much faster than salts, as the experiments described show. They are further protected from passage of salts by keeping most of body buried in sand. (S. H. Hopkins)

Delchamps, John J. 1896. Notes respecting oysters of Mobile Bay and Sound in Mobile County, Alabama. Appendix to Ritter, H. P., 1896. Bull. U.S. Fish. Comm., XV:339.

Delchamps was a local resident, described by Ritter as "a gentleman of wide information and experience, whose study of the oyster extends over many years." Delchamps mentions the drumfish and the "whelk" as the enemies of the oyster here. Of the "whelks, which bore through the shell and destroy the oyster," he says "This is the first year that I have heard serious complaint of their destructiveness...I assume the reason of their prevalence to be the long continuance of salt water...." (S. H. Hopkins)

De Leersnyder, Monique. (Lab. Zool., Fac. Sci., Lille, Fr.). 1967. Influence de la salinité et de l'ablation des pedoncules oculaires sur la mue et sur le developpement ovarien d'Eriocheir sinensis H. Milne-Edwards. (Influence of salinity and ablation of ocular peduncles on molting and ovarian development of Eriocheir sinensis.) Cah. Biol. Mar., 8:421-435, illus. (German and English Summary.)

Fresh water is more favorable for survival and growth, but does not permit

reproduction, for which more salinity is required. (S. H. Hopkins)

Den Hartog, C. 1963. The distribution of the snail Aplexa hypnorum in Zuid-Beveland in relation to soil and salinity. Basteria, 27(1-2):8-17, maps.

The species appeared to have a preference for light sandy clay, while it is not very sensitive to the lime content of the soil. It was found in fresh water and oligohaline brackish water with a maximum Cl content of 1.85 ppt. The species tolerates a rather strong contamination with household refuse, but data on the influence of industrial waste and pollution by agricultural poisons are lacking. (S. H. Hopkins)

Denne, L. B. 1968. Some aspects of osmotic and ionic regulation in the prawns Macrobrachium australiense (Holthuis) and M. equidens (Dana). Comp. Biochem. Physiol., 26:17-30.

Freezing point depressions of blood and urine of the caridean shrimps M. equidens (brackish water) and M. australiense (fresh water) were measured in water of salinities from 2 to 40 ppt. Blood of M. equidens had a freezing point of -1.03 C over a wide salinity range, above and below which osmoregulation failed with rapid rise or drop in blood concentration (and freezing point). M. equidens tolerates salinities from 2 to about 40 ppt, M. australiense from 0 to about 25 ppt. Neither could tolerate direct transfer to higher or lower salinity for more than a few hours; salinity had to be changed gradually. Blood of M. australiense had freezing point of -0.96 C in fresh water and in salinities (diluted sea water) up to 17.5 ppt. At higher salinities, blood concentration rose sharply and was hyperosmotic to medium up to the lethal salinity of approximately 25 ppt. The Na and Cl concentrations of blood and urine of both species showed that both ions could be regulated by the urine to some extent. (T. Rennie)

Denton, E. J. 1971. Examples of the use of active transport of salts and water to give buoyancy in the sea. Philos. Trans. Roy. Soc. London, Ser. B, 262(842):277-287.

"To give themselves buoyancy several families of squid and crustaceans accumulate large amounts of NH_4^+ ions in special compartments within their bodies. This is often in high concentrations, approximately 0.5 mol/l, and very acid; sometimes 2/3 of the body weight consists of such strong ammoniacal solutions. Possible mechanisms...are discussed." Cephalopods with chambered shells, Sepia, Spirula, and Nautilus, are given special attention. All function alike; while being formed a chamber is full of liquid isosmotic with sea water. Later this liquid is pumped out against hydrostatic pressure. Gases play no part in the "pumping." Salts are eliminated first and water follows. (Presented at a symposium on "active transport of salts and water in living tissues.")
(S. H. Hopkins)

Deubler, Earl E., Jr., and White, J. C., Jr. 1962. Influence of salinity on growth of postlarvae of the summer flounder, Paralichthys dentatus. Copeia, 1962(2):468-469.

Postlarvae 12-15 mm long, mean preserved weight 29 mg, were collected in Bogue Sound, N. C., in February 1961 and put in 5-gal aquaria of water of salinities of 10, 20, 30, and 40 ppt. Duplicate samples in each salinity after 33 days at 14 C had mean weights of: 82 and 84 mg in 10 ppt, 86 and 87 mg in 20 ppt, 88 and 88 mg in 30 ppt, and 76 and 86 mg in 40 ppt. Average percent increase was 186.5 in 10 ppt, 198.5 in 20 ppt, 203 in 30 ppt, and 177.5 in 40 ppt. Data showed increase with increasing salinity in that range naturally encountered by postlarvae but less increase in weight in 40 ppt which is never encountered by the fish in nature. Salinity per se merits consideration as a

controlling factor in growth. Growth is optimum at salinities found commonly in lower reaches of estuaries. (S. H. Hopkins)

Devanesan, D. W. and Chacko, P. I. 1943. On the possibility of culture of certain marine mullets in freshwater tanks. Proc. Nat. Inst. Sci. India, 9:249-250.

In four salinity acclimation experiments with Mugil troschelii and M. waigiensis, best survival of fry was obtained when salinities were lowered gradually from about 33 ppt to 15-20 ppt to 1-2 ppt over a period of 3 days, with one change being made each day. It was concluded that M. troschelii would be the best species for transplantation to freshwater tanks since it was the commonest species found in large numbers. (S. Rennie)

D'Iakonov, A. M. 1955. On the resistance of echinoderms to lowered salinity. C. R. Acad. Sci., U.S.S.R., 102:373-374. (In Russian.)

According to Binyon (1966) this paper reported Stegophiura nodosa and Ophiocten sericeum, both Ophiuroidea, living in Chukotsk Sea in salinity of 27.5 ppt, and Ophiocten sp. living with the asteroid Solaster sp. at Cape Shelagsk, U.S.R.R., in salinity of 24.5 ppt. On the basis of these observations, D'Iakonov warned that care should be taken in interpreting the paleontological record, i.e., presence of echinoderms does not necessarily indicate oceanic salinity.

Dice, James F., Jr. 1969. Osmoregulation and salinity tolerance in the polychaete annelid Cirriformia spirabrancha (Moore, 1904). Comp. Biochem. Physiol., 28:1331-1343.

Adult C. spirabrancha were collected in the intertidal region at Monterey, Calif., transferred to Hopkins Marine Station, and placed in aquaria having fresh sea water. Salinity tolerance was determined by placing adults in 300 ml of 0%, 25, 50, 75, 100, 125, 150, 200, 250, and 300% sea water (100% sea water = 33.7 ppt) for 6 hr, after which behavioral differences and deaths were recorded (LD_{50}). Osmoregulatory capabilities were examined by determining coelomic fluid and blood osmoregularities of animals placed directly in 0%, 25, 50, 75, 100, 125, 155, and 200% sea water for 4 hr. Osmoregularities were determined by melting point depression. Finally, volume changes of animals were examined in 50%, 75, 100, 125, and 150% sea water, and in a solution osmotically equivalent to the above-listed solutions, with one-half of the osmoregularity made up of sucrose.

The salinity tolerance limits (determined by LD_{50} values) were at 23% and 220% sea water for animals buried in substrate and 32% and 210% for those not in substrate. There were no obvious behavioral differences between worms in salinities from 75% to 125% sea water. At 150% sea water, shrinking occurred and there was a slight decrease in body and tentacle movement. At higher salinities, there was a decrease in movement, and the tentacles were drawn close to the body. At 50%, movements were decreased and swelling was apparent. At lower salinities body movement was slight with tentacles drawn close to the body.

A detailed account is given of volume control and volume changes in different salinities, and of the effect of sucrose added to salt solutions. (T. Rennie)

Dietz, G. 1963. Beitrag zur kenntnis der Ciliatenfauna einiger Brackwassertumpel (étangs) der franzosischen Mittelmeerkuste. Vie et Milieu, 15(1):47-93.

Study of ciliates of four brackish lagoons on French Mediterranean coast, and three hypersaline water bodies with salinities of 47, 73, and 110 ppt. For each water body a table lists the species found. In Etang de Canet (salinity 0.5-15.6 ppt) 21 ciliates were found, in Etang de Lapalme (salinity 4.7-18 ppt) 13 species, in Etang de Salses (34.4 ppt) 4 species, in Etang de Sigean (0.03-31.7 ppt) 22 species, in "old harbor of Oulous" (salinity 47 ppt) 9 species, in

"Graben der Saline de Sigean" (73 ppt) 2 species, and in "Etang auf Oulous" (110 ppt) 2 species. The species found in 73 ppt were Loxophyllum setigerum and Placus salinus; those in 110 ppt were Fabrea salina and Chlamydodon cyclops. Of these four species, only Fabrea salina was found in 47 ppt and none in the lower salinities. (S. H. Hopkins)

Dogiel, V. A., Petrushevski, G. K., and Polyanski, Y. I. 1961. Parasitology of fishes. Oliver & Boyd, Edinburgh, 384 pp.

During the first part of their lives, in fresh water, young salmon acquire about 12 metazoan parasites including trematodes, cestodes, acanthocephalans, and nematodes. When young salmon migrate to sea all these parasites are lost, and marine parasites are acquired including the trematode Derogenes varicus, the cestode Eubothrium crassum, the acanthocephalan Echinorhynchus gadi, the nematode Terranova decipiens, and the copepod Lepeophtheirus salmonis. When adult salmon return from sea to fresh water their marine parasite fauna is reduced; the copepods, being most exposed to the external medium, are lost during the first few weeks, and the acanthocephalan E. gadi is next to disappear, possibly being weakened by lack of nutrition (since salmon do not feed in fresh water) as well as by lowered salinity. Body cavity parasites (Terranova) survive as long as the salmon. The copepod Salmincola salmonea on the gills survive in the sea but breeds only in fresh water. (S. H. Hopkins)

Doroshev, S. I. 1963. The survival of White Amur and Tolstolobik fry in Sea of Azov and Aral Sea water of varying salinity. Symposium on the fisheries exploitation of plant-eating fishes in the water-bodies of U.S.S.R. Turkmen S. S. R. Ashkhabad. (In Russian.) (This book has not been seen. S.H.H.)

Doroshev, S. I. 1965. Soleustoichivoist' nekotorykh vidov ryb, rekomendovannykh dlya vseleniya v Azovskoe more. [Salinity tolerance of certain fish species recommended for introduction into the Sea of Azov.] TR. Vses. Nauch-Issled Inst. Morskogo Rybn. Khoz. Okeanogr., 55:97-107, 1964. From: Ref. Zhur Biol., 1965, No. 12I84.

A study was made of the salinity tolerance of Aral carp, bream, and "shemaia" (Chalcalburnus chalcoides) at early developmental stages in Azov and Aral waters. Observations were also made on the salinity tolerance of grass and silver carps in connection with the problem of their acclimatization in the Aral sea basin. Bream withstood a salinity of up to 6 ppt in Azov water and up to 9 ppt in Aral water; "shemaia," up to 7 ppt and 10.5 ppt, respectively; fingerlings, up to 10 ppt and 14 ppt, respectively; and fingerling silver carp up to 8 ppt and 11 ppt, respectively. The introduction of grass and silver carps into the Sea of Azov is regarded as very promising, whereas the introduction of Aral fishes into the Azov is inadvisable.

Douglas, P. A. and Stroud, R. H., editors. 1971. A symposium on the biological significance of estuaries, sponsored by the Sport Fishing Institute in cooperation with the Sportsmen's Clubs of Texas and the National Wildlife Federation, on 13 Feb 1970, Houston, Texas. Sport Fishing Institute, Washington, D. C., xi + 111 pp.

Papers were presented or talks given by P. A. Douglas; R. H. Stroud; R. A. Geger; L. E. Cronin and Alice J. Mansueti; C. R. Chapman; H. K. Chadwick; J. E. Sykes; D. H. Wallace; E. D. Salo and Q. J. Stober; and W. H. Massmann. No new information was presented, but the papers serve as a good source of general information and for statistics on many aspects of the title subject, and fairly extensive lists of references are included. (S. H. Hopkins)

Dovel, W. L., Mihursky, J. A., and McErlean, A. J. 1969. Life history aspects of the hogchoker, Trinectes maculatus, in the Patuxent River Estuary, Maryland. Chesapeake Sci., 10(2):104-119.

Eggs were collected from salinities of 0-24 ppt with the greatest number being found in the lower estuary in 10-16 ppt. Larvae and juveniles moved to and congregated in low-salinity waters. Young of the first year were found in 0-8.9 ppt.

Maximum egg size occurred at 15 ppt. Size of fish is positively correlated with salinity and downriver distance during the summer. Juveniles are found upriver in the low salinity nursery areas (0-8 ppt). As fish reach the successive year class they migrate farther downstream until they reach the spawning area in in the second, third, and fourth years. The spawning area shows the most stable conditions with reference to temperature, salinity, and turbidity relative to the upstream areas. The nursery area is located in the estuarine zone having the highest food production potential. (S. Rennie)

Drabkina, B. M. 1962. Vliyanie vody razlichnoi solenosti na vyzhivaemost' spermy, ikry i lichinok osetrovykh ryb. [Effect of water of different salinities on the survival of sperm, eggs, and larvae of sturgeons.] In: Voprosy ekologii Vysshaya Shkola, Moscow, 8:54-55. Ref. Zhur., Biol., 1962, No. 17I66. (Transl.)

"Experiments were carried out at the Kura River experimental sturgeon breeding plant. For an active life of sperm, the most favorable water was 2 ppt salinity. Water with 6- to 8-ppt salinity had an inhibiting effect. Fertilization of the sturgeon eggs was possible in water of 1.2- and 4-ppt salinity."

Dregol'Skaya, I. N. 1961. Viryanie solenosti morskoi vody na reploustoichivost' mertsatel'nogo epiteliya aktinii. [The effect of sea water salinity on heat resistance of ciliated epithelium of Actinia.] Tsitologiya 3(4):475-477. Ref. Zhur. Biol., 1961, No. 23A236. (Transl.)

Heat resistance was determined by how long movement of cilia of the mesenterial filaments of actinia (Actinia equin) was maintained when pieces of epithelium were placed in sea water of specific salinity at temperatures of 38-42 C. A study was made of the change in heat resistance of the cells of Black Sea Actinia as a result of their acclimatization through successive transfers to water with a 35-ppt salinity (the normal salinity in the Black Sea being 17.5 ppt). The increase in salinity of the water led to an average increase of 68% in heat resistance of cells in all ranges of temperatures used. At the same time in acclimated Black Sea Actinia the heat resistance was higher than in cells of A. from the Barents Sea where salinity is also 35 ppt. Consequently, the difference in heat resistance observed earlier between cells of Actinia from the Black Sea and those from Barents Sea cannot be explained by a difference in salinity of the water of the animals' habitat.

Dubois, A. 1968. Observations sur la morphologie et la biologie des formes naines de Lamprothamnium papulosum J. Groves (Characées). (Observations on the morphology and biology of depauperate forms of Lamprothamnium papulosum J. Groves (Characeae). Jour. Natur. Monspeliensia Serie Bot., 19:37-41.

Lamprothamnium papulosum is a polymorphic species. Germination and development of the alga were studied. The influence of salinity on development is detailed. Depauperate forms develop under high salinity. (P. Maxwell)

Duchateau-Bosson, G., Florkin, M., and Jeuniaux, C. 1961. Rôle de la variation de la composante amino-acide intracellulaire dans l'euryhalinité d'Arenicola marina L. Arch. Internat. Physiol. Biochem., 69:30-35.

When changed from sea water (freezing point depression -2.08 to -2.14 C) to water diluted to half sea-water concentration (freezing point depression -1.05 to

-1.12 C) these polychaete annelid worms absorb little water (weight in sea water 10.3147 g, weight in diluted sea water 10.7712 g; percent water in tissues 78.1 in sea water, 83.5 in dilution). Meanwhile, the amino acid content decreases from 2795 mg per 100 g of tissue in sea water to 1289.5 mg per 100 g of tissue in 50% sea water, or from 3579 mg per 100 g of water, in sea water, to 1544 mg per 100 g of water in sea water diluted to 50% sea-water concentration. The amino acids contributed about 0.4 C to the lowering of osmotic pressure as indicated by freezing point depression. (S. H. Hopkins)

Dunnington, E. A. 1956. Oyster parasite distribution studied in Maryland waters; recently described fungus believed responsible for oyster losses in certain areas. Maryland Tidewater News (Maryland Dept. of Research and Education), 12(9):1-2.

Dermocystidium marinum, a fungus which causes slow growth or death in oysters, is being studied by the Chesapeake Biological Laboratory. High temperature and high salinity favor its development. In Maryland it is found on both sides of Chesapeake Bay, "roughly from the mouth of the Patuxent River southward." (S. H. Hopkins)

Dunson, W. A. and Ehlert, G. W. 1972. Effects of temperature, salinity and surface water flow on distribution of the sea snake Pelamis. Limnol. and Oceanogr., 16(6):845-853.

P. 850, salinity tolerance. Most sea snakes are truly marine but at least three species live in freshwater or brackish lakes (Philippine and Solomon Islands). Marine species have been kept in fresh water 6 and 8 months (2 species) with no apparent harm. (S. H. Hopkins)

Dupaul, W. D., and Webb, K. L. 1970. The effect of temperature on salinity-induced changes in the free amino acid pool of Mya arenaria. Comp. Biochem. Physiol., 32(4):785-801.

The accumulation of free amino acid (FAA) and ninhydrin-positive substance (NPS) in the adductor muscle of M. arenaria in response to an increased salinity was not linear with time. Three components in the process of NPS and FAA accumulation are proposed. A fast component active during the first 24 hr, a slow component, effective from 36 hr, and a taurine component effective during the time lapse between the fast and slow components. The increase in the alanine concentration accounted for 80%-90% of the observed increase in NPS concentration; the high correlation between the decrease in the concentration of aspartic acid and the increase in the concentration of alanine indicates a direct relation in the formation of alanine from aspartic acid. The rate-temperature functions of NPS accumulation for warm and cold acclimated M. arenaria did not conform to standard patterns described for warm- and cold-acclimated poikilotherms. (From Biol. Abstr.)

Durve, V. S. and Alagarswami, K. 1964. An incidence of fish mortality in Athankari Estuary near Mandapam. Jour. Marine Biol. Assoc. India, 6:147-151.

Widespread mortality of mullet fingerlings, Tilapia, the clam Meretrix casta, and prawns was observed in the estuary of the Vaigai River, which is intermittent and was dry at the time. Salinity was 105.39 ppt at upper end of estuary and 96.97, 43.51, and 38.14 ppt at other stations going toward Palk Bay at mouth of estuary. Mortality was attributed to high salinity. A week later, after heavy rain, salinity was 24.07 ppt and fish were seen swimming in estuary. Natives said mortality is annual (summer) event when river goes dry.
(S. H. Hopkins)

Dutta, N., Malhotra, J. C., Bose, B. B. 1954. Hydrology and seasonal fluctuations of the plankton in the Hooghly Estuary. Indo-Pacific Fish Counc. Proc., Sect. II, 5:35-47.

Seasonal and periodic fluctuations of the plankton in the Hooghly Estuary from September 1949 to August 1951. Three types of plankton: (1) marine, (2) fresh water, and (3) brackish water. Certain forms were strictly marine or fresh water, while brackish-water forms were more adaptable to various salinities. Phytoplankton was much less abundant than zooplankton. Seasonal variation and succession in plankton seemed to be influenced by physicochemical factors such as temperature, turbidity, and salinity, and by biological factors such as changes in reproductive activity of different forms. Plankton increased with decrease in turbidity and reached maxima during periods of low turbidity and low temperature, especially phytoplankton. Zooplankton had two maxima in both the low and the high salinity areas, while phytoplankton had only one maximum each year. Increase of zooplankton influences density of phytoplankton which serves as food.

Duval, M. and Prenant, M. 1926. Concentration moléculaire du milieu intérieur d'une Ascidie (Ascidia mentula Müll). C. R. Acad. Sci., Paris, 182:96-98.

The following measurements were made on freezing point and NaCl content (g/l) of blood of sea squirt and of surrounding sea water:

Freezing Point, °C		NaCl, g/l	
Blood	Sea Water	Blood	Sea Water
-2.08	-1.98	34.7	33.0
-2.08	-1.98	34.7	33.0
-2.09	-2.00	35.0	33.2

The blood of Ascidia, unlike that in other marine invertebrates studied, is not isotonic but is very distinctly hypertonic to sea water, and contains more salt. The blood of selachians (sharks) is also hypertonic to sea water in about the same degree (0.10 C difference in freezing point between blood and sea water). But in sharks the difference is due to organic substances, while in Ascidia it is due entirely to minerals. Claims this shows relation of ascidians to vertebrates, sea squirt being transitional between invertebrates and vertebrates. The pH of ascidian blood was found to be 7.1. (S. H. Hopkins)

Dybern, Bernt I. (Inst. Mar. Res., Lysekil, Swed.). 1967. The distribution and salinity tolerance of Ciona intestinals (L.) f. typica with special reference to the waters around southern Scandinavia. Ophelia, 4(2):207-226.

This sea aquirt occurs worldwide at many salinities. Its outermost (southern or eastern?) distribution in southern Scandinavia at entrance sills of the Baltic Sea proper is where salinity averages 11 ppt. Populations living at different salinities have different salinity tolerance ranges for development of fertilized eggs and larvae to metamorphosis. The low-salinity limit for this development is 11 ppt. Tolerance ranges for larvae are wider than for the fertilized eggs, permitting a wider distribution of the species. Adults have still wider salinity tolerance limits. (S. H. Hopkins)

Dybern, B. I. 1969. Distribution and ecology of the tunicate Ascidiella scabra (Muller) in the Skagerak-Kattegat area. Ophelia, 6:183-201.

The distribution of the typical form of the ascidian A. scabra in the Skagerak-Kattegat area and its relation to the very complex salinity conditions are described.... The species seems to demand an average salinity above 24 ppt, but adults can temporarily stand values as low as 15 ppt. Development from zygotes

is possible in salinities down to c. 20 ppt, while larvae endure c. 18 ppt. The highest salinities reached in the area, c. 35 ppt, are endured by all developmental stages. The demand for not too low salinity values and certainly to some extent the influence of suboptimal temperatures cause a marked submergence of the species in the Kattegat area. Different populations have different salinity tolerance ranges, a fact which seems to be mainly phenotypical. (P. Maxwell)

Ebbs, N. Kenneth, Jr., and Staiger, Jon C. 1965. Some osmotic adaptations of Onuphis magna (Polychaeta: Onuphidae). Bull. Mar. Sci. Gulf and Caribbean, 15:835-849.

Onuphis magna is a hyperosmotic regulator at less than 15 g/L chloride concentrations. Respiratory rates decrease slightly with increasing dilutions of sea water, down to 25% of sea water. Under hyposaline conditions O. magna swells and then exhibits a noticeable volume regulation. Initial swelling is general, but the first 10-15 segments are much more swollen. They show no response to mechanical stimulation at 33% dilution while the remaining segments show reduced response up to 25% dilution. Fluid from the anterior segments is clear while that from the posterior segments is darker and more viscous. Nephridia in the anterior segments were either very small or lacking while those of the posterior segments were very enlarged. (S. Rennie)

Edmondson, C. H. 1928. The ecology of a Hawaiian coral reef. B. P. Bishop Mus. Bull., 45:1-64.

Includes information on the tolerance of reef coral polyps to flooding by fresh water, or to low salinity. (S. H. Hopkins)

Eisler, R. 1969. Acute toxicities of insecticides to marine decapod crustaceans. Crustaceana, 16(3):302-310.

Twelve insecticides (which contribute to water pollution problems) were tested on three species of marine Decapod Crustacea with a 24-ppt salinity and a 20 C temperature.... The temperature and salinity strongly influenced the death rate due to pesticides.... As for organophosphorus compounds, the increase of salinity from 12 to 36 ppt intensifies the toxic effect; salinity had little effect, or at least its action could not be perceived, with regards to organochloride insecticides. (From Biol. Abstr.)

Elliott, Francis E., Myers, William H., and Tressler, Willis L. 1955. A comparison of the environmental characteristics of some shelf areas of eastern United States. Jour. Wash. Acad. Sci., 45(8):248-259.

Salinity patterns are relatively stable throughout the year along the Continental Shelf. Most alterations occur next to shore by spring freshening from river runoff. Surface salinities increase in autumn. Fouling in the harbors is variable in species and abundance. Marine borers are a serious problem in all harbors studied except New York Harbor (which is relatively free of fouling organisms). This is believed to be caused by the shape of the bay and the large inflow of fresh water from the Hudson River, both of which tend to decrease the salinity. (S. Rennie)

Elliott, H. A., Ellison, R., and Nichols, M. M. 1966. Distribution of Recent Ostracoda in the Rappahannock Estuary, Virginia. Chesapeake Sci., 7(4):203-207.

Recent Ostracoda (living and dead) were determined in 69 bottom samples from the estuary of Rappahannock River. Three biofacies were established on the basis of dominant forms: (1) Freshwater Biofacies, upper estuary where salinity averaged less than 5 ppt in summer, dominated by Darwinula stevensonii and Cytheromorpha fuscata. (2) Shoal Biofacies, in the freshened surface water of shallows in the estuary proper, dominated by Cushmanidea seminuda, Hulingsina cf. H. sulcata Puri, Cytherura cf. C. gibba Miller, and Limnocythere sp. A. (3) Channel and Basin Biofacies, in the salty deep lower layer of the estuary proper, dominated by Perissocytheridea brachyforma and Limnocythere sp. B. One of the most significant features is the abundance of specimens and variety of species in the middle estuary, which is the gradient zone of rapid salinity change. This zone is either best suited for live ostracods or is the most

likely area for deposition of carapaces. (S. H. Hopkins)

Ellis, A. E. 1932. The habitats of Hydrobiidae in the Adur Estuary. Proc. Malacol. Soc., 1932, 20:11-18.

"Peringia ulvae was found to be the most tolerant of changes of salinity and to be especially characteristic of salt marsh and temporary pools. Hydrobia ventricosa was only found in practically pure sea water, in association with a marine fauna. Hydrobia jenkinsi occurred only in slightly brackish and fresh water." These are snails and the locale is in Sussex, England. (From summary, p. 18)

Ellis, W. G. 1933. Calcium and the resistance of Nereis diversicolor to brackish water. Nature, London, 132:748.

It was shown that for Nereis diversicolor resistance to immersion in brackish water (17% of sea water) depends on the presence of calcium in the environment. The presence of calcium allows the animal to eliminate excess water from the body after immersion in a more dilute medium. (S. Rennie)

Ellis, W. G. 1939. Comparative measurements of water and electrolyte exchange in a stenohaline and in a euryhaline polychaete. Jour. Exptl. Biol., 16:483-486.

Nereis diversicolor (Müller), a euryhaline polychaete, is able to regulate in brackish waters, while Perinereis (Nereis) cultrifera (Grube), a stenohaline species, cannot regulate its water exchange. Both species were kept in a dilution of 20% sea water with measurements made of their chloride output and water intake at 2, 4, 7, 10, and 12 hr after transfer to the dilute water. The chlorine output of N. diversicolor was significantly greater than that of N. cultrifera. The ratio of salt output/water intake was also much greater for N. diversicolor, and this ratio increased during imbibition to about double its initial value. In N. cultrifera, there was little or no ratio increase. Therefore, N. diversicolor swelled less than N. cultrifera because the salt loss of N. diversicolor, relative to water intake, was more rapid than that of N. cultrifera. Ellis suggests that there might be active excretion of chlorine and other ions by N. diversicolor, accelerating the chloride output in the same direction as the osmotic gradient. (T. Rennie)

Eltringham, S. K. 1961. The effect of salinity upon the boring activity and survival of Limnoria (Isopoda). Jour. Marine Biol. Assoc. U.K., 41(3):785-787, illus.

Boring decreased linearly with salinity and stopped altogether below 10 ppt. The limiting salinity was 12 ppt at 17.6 C and 15 ppt at 14.9 C, average temperatures. The only lethal salinity found during the 65 days of experiments was 6 ppt, fatal in 15-20 days. The next higher salinity tested for lethality was 12 ppt. The highest tested, 48 ppt, caused no mortality. (S. H. Hopkins)

Eltringham, S. K. 1964. Blood concentrations of Limnoria (Isopoda) in relation to salinity. Jour. Marine Biol. Assoc. U.K., 44:675-683.

Freezing point measurements of the blood of three species of Limnoria (tripunctata, lignorum, and quadripunctata) acclimated at 5, 8, 12, 15, 17, 18, 24, 31, 36, and 39 ppt showed that at all salinities the blood remained hyperosmotic to the medium, the freezing point averaging 0.17 C. Further experiments with L. tripunctata showed that blood concentrations decreased to the hyperosmotic value within a few hours after transfer to a reduced salinity. (S. Rennie)

Eltringham, S. K. 1965. The respiration of Limnoria (Isopoda) in relation to salinity. Jour. Marine Biol. Assoc. U.K., 45:145-152.

Respiration was measured in 16 solutions ranging from 6 to 36 ppt. In a second series, respiration was measured in 100% sea water and in dilutions with salinities of 7, 14, 21, and 28 ppt. No significant correlation was found between the respiratory rate and the degree of dilution of the medium. (Author's abstract in part)

Emery, K. O. and Stephenson, R. E. 1957. Estuaries and Lagoons. I. Physical and chemical characteristics. Pp. 673-693. In: Marine ecology and paleoecology. Geol. Soc. Amer. Memoir. 67, Vol. 1, viii + 1296 pp. New York.

Salinity is discussed throughout the article, but pp. 685-687 give the most intensive treatment of salinity. On p. 685 it is stated: "The ecologically significant aspect of salinity is not the mean condition but its range on a daily and seasonal basis, and its rate of change through the tidal cycle."

Engel, D. W. and Angelovic, J. W. 1968. The influence of salinity and temperature upon the respiration of brine shrimp nauplii. Comp. Biochem. Physiol, 26:749-752.

Respiration rates of day-old nauplii of Artemia salina were significantly affected by salinities of 5 to 200 ppt and by temperatures which ranged from 10 to 30 C ($P < 0.01$).

The Q_{10}'s for Artemia nauplii were significantly affected by temperature ($P < 0.01$) and the temperature-salinity interaction ($P < 0.10$). (Author's abstract)

Engle, James B. 1948. Investigations of the oyster reefs of Mississippi, Louisiana, and Alabama following the hurricane of September 19, 1947. U.S. Fish and Wildlife Service, Special Scientific Report No. 59:1-70, 3 maps.

P. 10 (Mississippi)--"The relation of salinity to the presence of the conch Thais sp. is of considerable importance. Conches were found in most of the dredged samples of bottom material from the inshore stations east of Biloxi, while they were generally absent from the inshore stations west of this point. Most of the off-shore stations from east to west had conches in the dredged samples. Where to draw the salinity line that inhibits the existence and development of the conches is hardly possible from the limited salinity data collected during this survey, but is is reasonable to suppose that some check exists.... This check is no doubt imposed by the lower salinity that exists in the area temporarily when the spring rains reduce the salinity proportionally more here (west of Biloxi and inshore) than elsewhere. The control of the conch may in some measure account for the higher oyster production from the western reefs."

P. 39 (Louisiana)--"The relative scarcity of conches in the region (east Plaquemine and St. Bernard Parishes) would indicate a possible range of salinity which occasionally must be low enough to impose a restriction on the spread of the snail."

P. 57 (Alabama)--"There seemed to be no direct correlation in the distribution of conches with the present salinity picture of the area. The fact that conches were absent from the samples dredged north to Cedar Point in Mobile Bay... indicates...spring flood conditions...." (S. H. Hopkins)

Estcourt, I. N. 1967. Ecology of benthic polychaetes in the Heathcote Estuary, New Zealand. New Zealand Jour. Mar. and Freshw. Res., 1:371-394(Sept 1967).

The distributions of 19 species of polychaete annelid worms burrowing in intertidal sand and mud banks are related to salinity, sediment grade, and length of time of exposure at low tide. Only Nicon aestuariensis Knox and Scolecolepides benhami Ehlers appear to be truly estuarine species reaching their greatest population densities in low salinities, according to the author. The species are listed in the order of their tolerance of low salinity (least tolerant to most tolerant): Minimum salinity 25 ppt: Lumbrinereis sphaerocephala. Minimum

salinity about 15 ppt: Perinereis vallata var. brevicirris, Platynereis australis, Orbinia papillosa, Armandia maculata. Minimum salinity about 5 ppt: Perinereis nuntia var. vallata, Aglaophamus macroura, Glycera americana, Haploscoloplos cylindrifer, Scolecolepides sp., Aonides trifidus, Prionospio pinnata, Heteromastus filiformis, Abarenicola affinis affinis, Pectinaria australis. Minimum salinity 0.4 ppt: Boccardia polybranchia, Capitella capitata. Minimum salinity often 0: Nicon aestuariensis and Scolecolepides benhami only. (S. H. Hopkins)

Fange, Ragnar and Fugelli, Kjell. 1963. The rectal salt gland of elasmobranchs, and osmoregulation in Chimaeroid fishes. Sarsia, 10:27-34.

The rectal gland of the shark Selache maxima and a corresponding glandular mass in the wall of the postvalvular intestine of the chimaeroid fish (Chimaera monstrosa) were examined histologically. The glands probably excrete sodium chloride. Analysis of Chimaera blood showed a very high concentration of sodium chloride and indicated that the blood was isosmotic with sea water. Chimaera thus took an intermediate position between sharks, rays, and Myxine (hagfish), concerning mode of osmoregulation. (T. Rennie)

Farmer, G. J. and Beamish, F. W. 1969. Oxygen consumption of Tilapia nilotica in relation to swimming speed and salinity. Jour. Fish. Res. Bd., Canada, 26(11):2807-2821.

Oxygen consumption of T. nilotica (L.) at 25 C was measured for various swimming speeds at salinities of 0, 7.5, 11.6, 22.5, and 30 ppt. Oxygen consumption for a given swimming speed and salinity increased linearly with weight when expressed on a double logarithmic grid. Slopes of regression lines relating oxygen consumption and weight were less than unity, ranging from 0.5117 to 0.9887. Generally, oxygen consumption at 0, 7.5, and 22.5 ppt was approximately equal; values at 11.6 ppt were lowest and those at 30 ppt highest. Presumably, energy required for osmoregulation was least in the absence of an osmotic gradient (11.6 ppt) and greatest when the gradient was highest (20.0 ppt). Assuming energy required for osmoregulation was zero at the isosmotic salinity (11.6 ppt), it was estimated that approximately 29% of the total oxygen consumption was required for osmoregulation at 30 ppt and 19% at 0, 7.5, and 22.5 ppt. Plasma osmotic concentration was used as an index of capacity for osmotic regulation. Concentration for unexercised fish remained about the same at 0, 15, and 30 ppt. At no salinity were plasma osmotic concentrations for exercised and unexercised fish statistically different at $P < 0.05$. However, there was a trend for concentrations for exercised fish to decrease from the unexercised level at 0 ppt and to increase from the unexercised level at 30 ppt. Only at 15 ppt were concentrations similar for exercised and unexercised fish. Of the salinities tested, fish were able to osmoregulate most efficiently at 15 ppt, the salinity closest to the isosmotic salinity. (P. Maxwell)

Fassett, N. C. 1928. The vegetation of the estuaries of northeastern North America. Proc. Boston Soc. Nat. Hist., 39:73-130.

The effect of different salinities on vegetation has been studied on the estuary of the Kennebec River, Maine. Salinity affects distribution on the estuary longitudinally and altitudinally. Those plants occurring in the freshwater areas are Sagittaria latifolia, S. graminea, Sium suave, Pontederia cordata, Polygonum sagittatum, Potamogeton epihydrus, Bidens hyperborea, varieties cathancensis and colpophila, B. Eatoni, varieties Kennebecensis, interstes, and mutabilis, Scirpus Smithii, var. levisetus. Plants in semisaline waters are Lophotocarpus calycinus var. spongiosus, and Lilaeopsis lineata. Those found in salt water are Spartina alterniflora and Scirpus nanus. Plants which are covered only at high tide will be the freshwater ones, while below them will be the semisaline and saline plants, determined by the density of the water. Upstream where tides have less influence, the saline plants will disappear. Similarly, downstream where there is great tidal influence, the freshwater plants will not be found.

Very few actual salinities are given. A mudflat at low tide above Woolrich had salinities of "8.48%" and "13.33%" at two different places on the same day. Other references to salinity are only as high and low.

Several examples of plants are cited in which the form has changed due to life in the estuary, such as erect to creeping, and development of short, thick coriaceous leaves. This is not attributed to salinity at any time, but rather

to the physical action of tides going in and out. (S. Rennie)

Fearnhead, E. A. and Fabian, B. C. 1971. The ultrastructive of the gill of Mododactylus argenteus (a euryhaline teleost fish) with particular reference to morphological changes associated with changes in salinity. Oceanogr. Res. Inst. (Durban) Invest. Rep., 26:2-39. (Dutch summary.)

This study supports the original Keys-Willmer hypothesis which assigns a salt-secretory role to a specialized cell (the Cl cell) in the teleost gill. Another cell in the gill filaments that is apparently also involved in osmoregulation is described. (From Biol. Abstr.)

Federighi, Henry. 1930. Salinity and size of Urosalpinx cinerea. Amer. Naturalist, 64:183-187.

Measurements on Urosalpinx from two localities with different salinities but similar temperatures (Beaufort, N. C., and Norfolk, Va.) indicate that they grow to larger size in brackish than in saline waters. Attempts are made to explain contradictory results in other forms.

Federighi, Henry. 1931a. Further observations on the size of Urosalpinx cinerea Say. Jour. Conch., London 19(6):171-176; figs.

The author stated that the salinity at Woods Hole (30-32 ppt) was 2-3 ppt lower than at Beaufort and 10 ppt higher than at Norfolk, which "would tend to make the individuals considerably smaller than at Norfolk, but slightly larger than those at Beaufort." In previous work, Federighi (1930) found that certain relations existed between the length of the shell of U. cinerea and the environmental salinity, e.g., the animals had an optimum salinity, and lowering or raising this might bring about dwarfing. (Urosalpinx cinerea is a predacious snail that drills and eats oysters. S. H. H.) (T. Rennie)

Federighi, H. 1931b. Salinity death-points of the oyster drill snail, Urosalpinx cinerea Say. Ecology, 12(2):346-353.

Oyster drills collected from Hampton Roads where summer salinity was 15 and 20 ppt had salinity death points of 12.5 and 11.7 ppt. Snails of the same species from Beaufort, N. C., in salinity over 30 ppt, showed lethal salinities of 15.6 and 17.6 ppt. "This is interpreted to mean that the environmental salinity influences the death-point salinity, although the relation is not directly proportional, since, as the animal becomes adapted to lower salinities, the salinity factor of safety (the difference between the average environmental salinity and the death-point salinity) becomes smaller." [The criterion of death was lack of response of the mantle to pricking with a needle.] (S. H. Hopkins)

Federighi, Henry. 1931c. Studies on the oyster drill (Urosalpinx cinerea) Say. Bull. U.S. Bur. Fish., 48:85-115; 7 figs., 8 tables.

Laboratory experiments show that the salinity death point varies according to the environment from which the animal has been collected, i.e., the snail is capable of a large degree of adaptation to low salinities.

Felton, Blanche H. and Aiello, E. 1971. The relationship between ions and ciliary activity in the gill of Mytilus edulis (Abstract). Amer. Zool., 11(4):665.

The effect of Na, K, Mg, Ca, and Cl in artificial sea water on response to 5-hydroxy tryptamine (Ht) to tetrodotoxin, etc., was tested on isolated gills of sea mussels, timing waves of ciliary beating with a stroboscope. The data suggest that Na slightly inhibits response to 5-Ht and Cl accelerates it. (S. H. Hopkins)

Fenchel, T. 1965. Ciliates from Scandinavian molluscs. Ophelia, 2:71-174.

The ciliate Ancistrum caudatum from the mantle cavity of the marine horse mussel, Modiolus modiolus, was found to be less resistant to dilution of sea water than Ancistrum mytili from the mantle cavity of the more euryhaline blue mussel, Mytilus edulis. Fide Green, 1968, p. 319. (S. H. Hopkins)

Ferronniere, G. 1901. Bull. Soc. Sci. Nat. Ouest Nantes, 11:1-456.

According to Pearse, 1926, Animal Ecology, p. 154: "Ferronniere (1901) made extensive studies of the distribution of the plants and animals at the mouth of the Loire. He found that in going upstream representative marine plants and animals dropped out in the following order: Arenicola marina, Lineus gesserensis, Carcinas moenas, Sphaeroma serratus, Fucus and Lichina, Balanus, Amphitrite, Cardium edule, Heterochoeta, Vermiculatus, Phragmites communis, Boccardia ligerica, Nereis diversicolor, Palaemon edwardsi. This writer notes that when salinity changes there may be various responses, which he lists as follows: (1) immediate death, (2) autotomy, (3) violent contractions or irregular movements, (4) tropisms, etc., (5) exaggeration of certain natural functions, (6) establishment of a new equlibrium, or (7) acclimatization without observable change." Note that Cardium edule is even more tolerant of low salinity than Carcinas moenas and Balanus. (S. H. Hopkins)

Filice, Francis P. 1954. A study of some factors affecting the bottom fauna of a portion of the San Francisco Bay estuary. Wasmann Jour. Biol., 12(3):257-292.

In studying the patterns of bottom fauna near sources of domestic and industrial wastes in ports of San Francisco Bay estuary, there was seen a difference in the amount of animals contained in various types of substrate: sand contained smaller volumes and yielded more stations devoid of life than mud, and mud contained smaller volumes than stations containing rock. This correlated to distance or depth from the freshwater source in the estuary. Likewise, the orientation of the relatively uninhabited substrate toward the river end could be explained on the basis of the salinity gradient that existed in the same direction. (T. Rennie)

Filice, Francis P. 1958. Invertebrates from the estuarine portion of San Francisco Bay and some factors influencing their distributions. Wasmann Jour. Biol., 16(2):159-211.

Bottom samples (for substrate and animals) and physical data were taken at 460 stations in the northern arm of San Francisco Bay and its estuarine tributaries. Distribution and ecological data, including salinities, are given for 53 species. All species found by the Albatross in 1912-1913 (except Mya californica) were collected, and eight species not found by the Albatross, four of which are species introduced since then. The number of species decreases toward the freshwater source. Five species are unusual in response to salinity: Nereis succinea occurs from 25 to 1 ppt; at 1 ppt it is sharply replaced by Nereis lighti. Balanus improvisus was found at all salinities. Corophium spinicorne extends from 19 ppt to fresh water. Capitella capitata, a quiet water species, is in two widely separated areas at opposite ends of the salinity gradient (at 24 and at 0.4-0.6 ppt). Polydora uncata is in lower salinities than Polydora brachycephala, the opposite of what would be expected from the literature. The remaining species break into two groups at Carquinez Straits (the overlap zone is at salinity of 9.5 ppt): the freshwater-estuarine-marine group and the estuarine-marine group. Substrate affects distribution, but not as much as salinity. Depth also has a secondary effect. (S. H. Hopkins)

Filice, Francis P. 1959. The effect of wastes on the distribution of bottom invertebrates in the San Francisco Bay estuary. Wasmann Jour. Biol., 17(1):1-17, map.

Bottom invertebrates were collected at 312 stations in the northern arm of San Francisco Bay. Forty-three species were studied with regard to distribution and abundance, which was found to be related to amount and type of pollution rather than to salinity. (S. H. Hopkins)

Fingerman, Milton. 1959. Technical note No. 50 - Effects of temperatures and salinity on ciliary activity in the oyster Crassostrea virginica. Comm. Fish. Rev., 21(2):10-11.

Ciliary activity increased with increasing temperature up to 38 C at an unspecified salinity. In the salinity experiments, media with a freezing point depression of almost 1.10 C caused the greatest ciliary activity at an unspecified temperature. This salinity corresponded to the salinity of the environment from which the oysters were taken. (S. Rennie)

Fingerman, Milton and Fairbanks, Laurence D. 1956a. Osmotic behavior and bleeding of the oyster Crassostrea virginica. Tulane Studies in Zool., 3:151-168.

Most fluid loss in shucked oysters occurs within 15 min after removal from the shell. Uninjured oysters lose 26% of their body weight in 2 hr while punctured animals lose up to 50% in 2 hr. Oysters must be free to open and close their shells for weight and volume regulation. They have a limited ability to osmoregulate, and tend to keep the "salinity of their blood" constant when environmental salinities are altered. Osmoregulatory abilities of an American and a Japanese oyster are compared, the former being more efficient. (S. Rennie)

Fingerman, Milton and Fairbanks, L. D. 1956b. Some factors affecting fluid loss in Southern oysters. Comm. Fish. Rev., 18(1):10-11.

The conditions by which fluid loss occurs in Crassostrea virginica were investigated. Wedged oysters were placed in normal, diluted, and concentrated sea water and weighed at several time intervals (no salinity readings given). Fluid loss was greatest in concentrated sea water and least in diluted sea water. Both were explained by simple osmosis. Nonwedged oysters were placed in sea water at different salinities and at selected intervals had body weights and body fluid of different body parts measured. "The normal oysters in the water of different salinities neither gained nor lost weight yet the salinity of some of the body fluids changed." The general observation was made that the deeper in the body the fluid was obtained, the less tendency there was for the salinity of the fluid to follow changes in the salinity of the environment. The blood in the heart showed the least change. (T. Rennie)

Firly, S. 1932. Influence des variations de salinité sur la pression osmotique de civelles. C. R. Soc. Biol., Paris, 110:247-248.

Mlle. Firly determined tissue fluid freezing points, using very small young eels caught in the Loire Estuary, and kept in fresh water. In fresh water, the freezing point of tissue fluid was -0.76 to -0.68 C. Young eels were then put in sea water, and individuals were removed for tissue fluid freezing point measurement after 30 min, 2 hr, 8 hr, 1 day, and several days. After 8 hr and after several days the freezing point was depressed 0.99 C (i.e., tissue fluid froze at -0.99 C). Young eels were then thoroughly wiped to remove mucus, and placed in sea water. Freezing point was depressed 1.13 C after 30 min, and after 1 hr it was depressed 1.37 C in sea water that had a freezing point depression of -2 C. Eels were in bad shape as a result of rough treatment and none lived 2 hr. She concluded that the mucus coating plays a critical role in

protecting even these young eels against too rapid changes in salt content. (S. H. Hopkins)

Firly, S. and Fontaine, M. 1932. Sur la teneur en protéines du sérum d'Anguille et ses variations au cours de changements de salinité. Compt. Rend. Acad. Sci., Paris, 194:1854-1856.

Eels from the Loire River lost proteins over a period of 6 days but did not lose more in 11 days. Eels kept in fresh water lost less protein. Eels moved from fresh to salt water lost proteins in first 3 weeks, but regained some by end of month. Eels kept several years in sea water had no lower protein than those kept in sea water 8 days. (S. H. Hopkins)

Fischer, E. 1928. Sur la faune littorales, due facies rocheuse en particulier, dans un milieu à salure très variable. (Note préliminaire.) Bull. Inst. Océanogr., Monaco, No. 511, pp. 1-8.

Many of the principal rock-dwelling animal species of Brittany are capable of penetrating far into the "rivers" or estuaries, being very resistant to salinity variations. The currents are important to this penetration. The list includes 3 sponges, 7 hydroids, 7 sea anemones, 1 echinoderm (Asterina gibbosa), 8 bryozoans, 7 polychaetes, 16 molluscs, 8 crustaceans (of which 5 are balanoid barnacles), and 4 sea squirts. All of these can live in salinity of 35 ppt. The minimum salinity at which each species was found is given in the list. For instance, all 3 sponges were found at the minimum salinity of 10.3 ppt, which is the lowest figure mentioned in the list. However, in the text on p. 8 it is mentioned that at Mordreux, Fischer found numerous Actinia equina, Mytilus edulis, and the barnacles Balanus crenatus, B. improvisus, and B. perforatus, "very prosperous," in a salinity of 6.4 ppt, and the same barnacles lived in 0.4 ppt for a long time. (S. H. Hopkins)

Fischer-Piette, E. 1931. Sur la penetration des diverses especes marines sessiles dans les estuaires et sa limitation par l'eau douce. Ann. Inst. Océanogr. (Monaco), 10(8):213-243.

According to Moore, Marine Ecology, p. 400-401, this paper "provided a demonstration that salinity is the actual factor involved in setting the upper limitation of penetration of many estuarine species." Illust. by Moore's figs. 11-11 and 11-12 on pp. 400 and 401. Also see Moore, p. 44.

Fischer-Piette, E. 1933. Nouvelles observations sur l'ordre d'euryhalinité des espèces littorales. Bull. Inst. Océanogr., Monaco, 619:1-16.

According to Moore, Marine Ecology, pp. 401-402, in 1931 paper and this one, Fischer-Piette followed retreat of fauna down estuary in wet years and advance of species up estuary in dry years. Some species were unable to live as far up estuary in winter low salinity as in summer high salinity, but nevertheless they lived at lower salinity in winter than in summer.

Fischer-Piette, E., Gaillard, J. M., and Delmas, D. 1966. On the variations of Littorina saxatilis. VIII. The Populations of the estuary of Camarinas (Galicia). Bull. Mus. Nat. Hist. Natur., 38(6):874-897.

Low salt concentrations seemed to be the chief factor that prevented penetration of some color varieties. (S. H. Hopkins)

Fleming, C. A. 1952. A Foveaux Strait oyster-bed. New Zealand Jour. Sci. and Tech., 34B:73-85.

The associated fauna and flora of this New Zealand oyster bed are listed and

discussed. No salinity data are given, but the list of associates seems to indicate it is in fairly high salinity. The oyster is Ostrea sinuata Lamarck. A community that closely resembles the Foveaux Strait oyster bed is a Strongylocentrotus-Argobuccinum biome in Puget Sound, described by Shelford in 1935. (S. Rennie)

Flemister, Launce J. and Flemister, Sarah C. 1951. Chloride ion regulation and oxygen consumption in the crab Ocypode albicans (Bosq). Biol. Bull., 101:259-273.

Ocypode, the ghost crab or sand crab, maintains a steady chloride ion concentration in the blood when in air and external concentrations ranging from 120-600 mM Cl/L. Outside this range a drift toward the higher or lower value is observed.

The chloride concentration of the urine varies in the same direction as that of the environment. The antennal gland is active in controlling the concentration of the internal medium.

Oxygen consumptions of crabs from sand and from varying salinities indicate that work is being done to maintain the internal chloride concentration. In water the muscular use of gill bailers and gill rakers raises the respiratory rate. In isotonic concentrations the elevation in rate is smallest. (S. Rennie)

Florkin, Marcel. 1960. Ecology and metabolism. Pp. 395-410. In: Waterman, T. H., ed. The physiology of Crustacea, Vol. I, metabolism and growth. Academic Press, New York, xvii + 670 pp.

A very brief review of the subject. Osmotic changes, pp. 399-401. (S. H. Hopkins)

Florkin, M. and Schoffeniels, E. 1965. Euryhalinity and the concept of physiological radiation. In: Studies in Comparative Biochemistry. Pergamon Press, Oxford.

A study of proteins in muscles of Chinese mitten crabs, Eriocheir sinensis, during transfer from fresh to sea water revealed no differences detectable by electrophoresis, so the main regulators of intracellular osmotic pressure seem to be the smaller nitrogenous molecules, especially nonessential amino acids such as glycine, glutamic acid, and alanine, according to Green (1968, p. 199). (S. H. Hopkins)

Flugel, H. 1959. Zum Problem der Osmoregulation in tropischen Brackwasser. Naturwissenschaften, 46:213.

Marine species penetrate farther into brackish and fresh water in the tropics. Only such species could enter water poor in salt as could keep the inner medium hypertonic to the outer medium. It is hypothesized that the higher temperature of tropical waters favors osmoregulation. This was tested on the crab Heteropanope tridentatus Maitland, the amphipod Gammarus duebeni Lill, and the shrimp Crangon crangon L. In the first two species, the hypertonicity of the inner medium in water of 5- to 15-ppt salinity is greater at 7 C than at 20 C. On the other hand, the inner medium of Crangon in salinity of 15 ppt has a more concentrated salt content at 21 C than at 4 C. Unfortunately, Crangon was not tested in still lower salinities. The C. crangon have been tested from the western Baltic after adaptation in 5, 10, and 15 C. They lived longer and osmoregulated better in low salinity at low temperatures than at high temperatures. Near 0 C the mortality in 5 ppt salinity increased. The osmoregulation fails at temperatures near the limit of its range. (S. H. Hopkins)

Flugel, H. 1966. Uber den Einfluss der Temperatur auf die osmotische Resistenz und die Osmoregulation der decapoden Garnele, Crangon crangon L. Kieler Meeresforsch., 16:186-200.

In laboratory experiments, the resistance of adult shrimps of the genus Crangon against low (1-5 ppt) and high (30-90 ppt) salinities in the external medium was higher at 5 C than at 15 or 20 C. Crangon lived in a 10-day experiment at 5 C in a range from 1 to 50 ppt, at 15 C from 4 to 50 ppt and at 20 C from 4 to 35 ppt. Osmotic resistance in sea water of 5, 15, and 30 ppt at 1 C and 2.5 C was lower than at 5 C. The homoiosmotic character of Crangon was not perfect. It was isotonic to sea water at salinities of 27-28 ppt, hypertonic between 3 and 26 ppt, and hypotonic between 30 and 40 ppt. Osmoregulation efficiency was always higher in Crangon adapted to 5 C than to 10-20 C, and efficiency decreased at temperatures below 5 C (between 2.5 and 0 C). In an extended experiment, efficiency was lower at 1 C than at 15 C. This explains why, in the northern Baltic Sea, Crangon is not capable of living in low salinity brackish waters having temperatures near freezing point. No difference in osmoregulation between males and females was found, but small individuals had lower osmoregulatory performance than larger ones. (T. Rennie)

Fontaine, M. 1930a. Recherches sur le milieu intérieur de la lamproie marine (Petromyzon marinus). Ses variations en fonction de celles du milieu extérieur. Compt. Rend. Acad. Sci., Paris, 191:680-682.

In sea lampreys in fresh water the normal ratio of the osmotic pressure due to Cl to the total osmotic pressure is 0.75 to 0.80. When salinity of the external medium is increased, this ratio falls to 0.66 at freezing point of -0.81 and -1.00, but is 0.76 at -1.96, at which point the fish become agitated and appear to suffer. Sea lampreys from rivers will die in a few hours in pure sea water. Increase of salinity involves the passage of substances other than NaCl from certain tissues into the blood. (S. H. Hopkins)

Fontaine, M. 1930b. Sur le parallélisme existant chez les poissons entre leur résistance aux variations de salinité et l'independance de leur milieu intérieur. Compt. Rend. Acad. Sci., Paris, 191:796-798.

Fontaine studied sea lampreys and compared his results with those of Duval and Portier (1922) on the carp and the eel. The lines showing freezing point depressions of blood serum in relation to those of the external medium are shown in a graph on p. 797, for all three fishes. The sea lamprey falls between the carp and the perfectly euryhaline eel in its ability to resist variations in salinity; this resistance to salinity variations is based on independence of internal milieu from the external milieu. (S. H. Hopkins)

Ford, E. 1929. Herring investigations at Plymouth. VII. On the artificial fertilization and hatching of herring eggs under known conditions of salinity, with some observations on the specific gravity of the larvae. Jour. Marine Biol. Assoc. U.K., 16:43-48.

Eggs of Clupea harengus fertilized at 37.8 ppt and later transferred to additional salinities of 18.8, 9.34, and 4.75 ppt showed better survival at the higher salinities, but survived at all salinities. When fertilized at 37.8, 19.0, 4.8, and 2.4 ppt and tap water, eggs at the three highest salinities had successful fertilization. Development in these three salinities was also successful to hatching.

By incubating eggs in diluted sea water and allowing the newly hatched larvae to develop at the same salinity, the specific gravity of the larvae becomes reduced (allowing them to float) at a rate dependent upon the degree of dilution, thus, to more easily maintain a position in the water column.
(S. Rennie)

Forrester, C. R. and Alderdice, D. F. 1966. Effects of salinity and temperature on embryonic development of the Pacific Cod (Gadus macrocephalus). Jour. Fish. Res. Bd., Canada, 23(3):319-340.

Experiments were conducted at constant salinities ranging from 19 to 31 ppt and at constant temperatures from 2 to 10 C. Although hatching occurred at all combinations of salinity and temperature, maximum hatching was in 19.4 ppt and at 5.3 C. Changes of 10 C appeared equivalent in effect to a change of about 1.2 ppt. Development time ranged from 8.8 days (10 C, 31 ppt) to 28.9 days (2 C, 19 ppt). Mean larval size at hatching was from 3.52 (10 C, 25 ppt) to 4.16 mm (6 C, 19 ppt). The eggs in the study were probably subjected to hypoxial conditions, resulting in a depression of survival to hatching at all combinations. (S. Rennie)

Foster, B. A. 1970. Responses and acclimation to salinity in the adults of some balanomorph barnacles. Philos. Trans. Roy. Soc., Ser. B (London), 256 (No. 810).

The barnacles studied were Elminius modestus, Balanus balanoides, B. crenatus, B. improvisus, B. hameri, B. balanus, and Chthamalus stellatus. Blood concentration in all conforms to external salinity, but remains slightly hyperosmotic to the mantle cavity fluid and external medium. When salinity changes suddenly, blood concentration conforms in a few hours. In such low salinity that activity is inhibited, all but B. hameri close opercular valves, but change in blood still occurs slowly and in time blood concentration approximates external salinity. E. modestus, B. balanoides, and B. improvisus from low salinity habitats tolerate lower salinities (in laboratory) than individuals of same species from normal salinities. B. crenatus conditioned to low salinity in laboratory also tolerate lower salinity than those acclimated to normal salinity. The estuarine B. improvisus can be active in salinity of 2 ppt. (S. H. Hopkins)

Fox, Denis L. 1936. The habitat and food of the California sea mussel. Bull. Scripps Inst. Oceanogr., 4(1):1-64.

Mytilus californianus is capable of surviving long periods of immersion in aerated sea water of widely different salt concentrations, varying from hypotonic solutions of about half the salt content of natural sea water to hypertonic solutions which are about one-third again as concentrated in sea salts. This heterosmotic adaptation on the part of the mussel would permit an extended range of habitation.

Fox, Denis L. 1941. Changes in the tissue chloride of the California mussel in response to heterosmotic environments. Biol. Bull., 80:111-129.

Adult Mytilus californianus is heterosmotic, yet potentially euryhaline, but gametes and larvae are highly stenohaline. Tissue-chloride content is close to 1%, wet weight. Mussels can survive indefinitely sudden, continued exposure to 50% sea water or 150%. Beyond these limits sudden immersion is fatal. Within these limits tissue chlorides maintain ratio of 1:1.60 (grams per 100 ml internal:external water). Individuals differ in rate of establishing equilibrium. Mussels could adapt to sea water concentrations less than 50% and more than 150% if the change were gradual. When so adapted, mussels in diluted sea water of chlorinity 0.625% had fall in tissue chloride to 0.26%-0.38%, and mussels in concentrated sea water of 3.48% Cl had rise in tissue chloride of 2.25%; at both points animals were sluggish and at threshhold of tolerance, but recovered in running sea water, and tissue chlorides returned to normal. Both water and chloride migrate between internal and external media when mussels are in the diluted or concentrated solutions. (S. H. Hopkins)

Fox, H. M. and Simmonds, B. G. 1933. Metabolic rates of aquatic arthropods from different habitats. Jour. Exptl. Biol., 10:67-74.

Oxygen consumption of freshwater amphipods is 1-1/2 times that of marine amphipods of a different species. Similarly, oxygen consumption of freshwater isopods is three times greater than that of marine isopods. Among all freshwater forms, those from swift-moving habitats showed higher consumption than those from lentic or stagnant habitats.

Organisms studied were the amphipods Gammarus marina, G. locusta, and G. pulex, the isopods Asellus aquaticus and Idotea neglecta, the mayflies Chloeon dipterum and Batis rhodani, and the trichopterans Hydropsyche sp. and Molanna sp. (S. Rennie)

Frankenberg, Dirk. 1963. A comparison of the physiology and ecology of the estuarine isopod Cyathura polita (Stimpson) in Massachusetts and Georgia. Dissert. Abs., (1):443.

A comparative study was made of two latitudinally isolated populations of the estuarine isopod Cyathura polita, one on Sapelo Island, Ga., the other in an estuary in Marsh Field, Mass. The results of physiological studies showed that animals from the two populations had similar osmoregulatory behavior and oxygen consumption rates. C. polita was found to have a type of osmoregulatory behavior called limited hyperosmotic regulation. It maintained a body fluid concentration hypertonic to its environment at low to medium salinities but became isosmotic with the environment at all salinities greater than about 28 ppt. Oxygen consumption increased at higher temperatures, but did not change significantly over a salinity range from 1 to 37 ppt. The physiological similarity between the two populations seemed to indicate that distinct physiological races had not developed within the wide range of C. polita. (T. Rennie)

Frankenberg, Dirk and Burbanck, W. D. 1963. A comparison of the physiology and ecology of the estuarine isopod Cyathura polita in Massachusetts and Georgia. Biol. Bull., 125:81-95.

The habitats in both regions had sandy sediments, well-aerated water, and wide fluctuations in salinity and temperature. In experiments, isopods from both populations kept body fluids hypertonic to environment at low medium salinities but became isotonic at salinities above 28 ppt. Oxygen consumption remains relatively uniform over a salinity range from 1 to 37 ppt. The two populations were similar physiologically and there was no indication that different "physiological races" were involved. (S. H. Hopkins)

Fraser, J. H. 1931. On the size of Urosalpinx cinerea (Say) with some observations on weight-length relationship. Proc. Malacol. Soc., London, 19(5):243-254.

Urosalpinx grows to a much larger size in England than in the U.S. It is believed that the difference is due to temperature. Although mean temperature corresponds nicely to mean length, the mean salinity is also greater in the British than in the American localities as the data show also.

The equation for weight-length relation of the shell is:
$W = 0.00004467 \times L^{3.215}$. (S. Rennie)

Fraser, J. H. 1932. Observations on the fauna and constituents of an estuarine mud in a polluted area. Jour. Mar. Biol. Assoc., U.K., 18:69-85.

This ecological survey was made on Dingle Beach on the north bank of Mersey Estuary between Liverpool and Garston, where the river is badly polluted with sewage. The river has a salinity of 13 ppt at low water and 20 ppt at high water, on the average, has a pH of 7.9, and has chemical pollution from industrial plants; it is also turbid. The constituents of the mud, sand, and gravel are analyzed. The molluscan fauna from a number of stations is analyzed quantitatively. Bottom type and fauna at different tidal levels are correlated. Mya arenaria is abundant only where there are stones. Macoma balthica is abundant

wherever there is thick mud. This is a Macoma community but it differs markedly from the typical Macoma community described by Petersen (1918). Importance of sewage as silt and as part of food chain is discussed. Other animals found in abundance were: Clitellio arenarius, Nereis diversicolor, Littorina littorea, and Corophium volutator. Hydrobia ulvae were fairly common in places. Less frequent were Mytilus edulis, Littorina littoralis, Carcinus maenas, Gammarus locusta, Balanus balanoides, Crangon vulgaris, and Gobius minutus. (S. H. Hopkins)

Fredericq, L. 1922. Action du milieu marin sur les Invertebres. Arch. Internat. Physiol., 19:309-357. (also) Bull. Acad. Roy. Bruxelles, Ser. 5, 8:423-426 (shorter version).

There are three stages in isolation of animal from surrounding sea water: A, characteristic of internal milieu of marine invertebrates, in which this milieu is in both osmotic and saline equilibrium with sea water; B, characteristic of solid tissues of marine invertebrates and the blood and tissues of Plagiostome fishes, osmotic equilibrium is attained but not saline equilibrium. In stage C, characterizing blood and tissues of vertebrates other than Plagiostome fishes, there is complete independence of blood and tissues, on one hand, and sea water on the other. Several experiments were made with medusae, sea anemones, echinoderms (sea urchins), sipunculids, Mytilus edulis, gastropods Janus and Tethys, cephalopods Eledone and Octopus, crustacean Palinurus vulgaris, and other marine species at Naples. It was concluded that when sea water is modified in concentration or in composition it exerts on invertebrates two different actions: (1) physical action, transport of water according to laws of osmosis across semipermeable membrane, rapidly putting interior in equilibrium with exterior, and (2) a slower action depending on chemical nature of dissolved substances. (Abstract of article in Arch. Internat. Physiol., S. H. Hopkins, 4 Aug 1969.)

Freeman, P. J. 1966. Observations on osmotic relationships in the holothurian Opheodesoma spectabilis. Pacific Sci., 20:60-69.

Animals could survive in 50% sea water for at least 24 hr. They could not be returned directly to 100% sea water, but needed to be placed in 70% or 80% for a day. Experiments in dilutions of 80% indicated this organism was not an osmoconformer. No mechanism for osmoregulation was found, although the mucus coating made it impermeable to water. Tissue fluids were found to be less concentrated than coelomic fluid in both feeding and starved animals. Feeding animals had more concentrated fluids than starved animals, due to presence of digestive products. (S. Rennie)

Freeman, R. F. N. and Rigler, F. H. 1957. The responses of Scrobicularia plana (da Costa) to osmotic pressure changes. Jour. Marine Biol. Assoc. U.K., 36(3):553-567.

This estuarine clam can tolerate almost marine salinity, salinities of about 20 ppt, and, at least for short periods, salinities as low as 2 ppt. Blood osmotic pressure is not significantly different from that of external medium except in very low salinities. Open clams equilibrate to 80% sea water in 4-5 hr and to 60% sea water in 5-6 hr. Closed clams show decrease in osmotic pressure, in dilute media, as slow as 1.5% per hour. Closed animals changed to different salinity tend to remain closed, but open most readily in salinities closest to that to which they were equilibrated. Open animals exposed to changed salinity tend to close. It is the total osmotic pressure of the medium they respond to. (S. H. Hopkins)

Fretter, Vera. 1955. Uptake of radioactive sodium (^{24}Na) by Nereis diversicolor Müeller and Perinereis cultrifera (Grube). Jour. Marine Biol. Assoc. U.K., 34:151-160.

At 35 ppt and 14 C the polychaete annelid N. diversicolor takes up sodium in the range 275-240 µg/h/g wet weight. At 17.5 ppt, uptake is 160 µg/h/g and at 9 ppt it averages 180 µg/h/g wet weight. For salinities of 43 ppt and 33.4 ppt, influx of sodium is approximately proportional to the degree of dilution or concentration.

The integument of Perinereis is more permeable to ions than that of Nereis. Permeability is three times greater in normal sea water and 1.5 times greater at 25% sea water.

For Nereis at 9 ppt the amount of exchangeable sodium approaches 3.2 mg/g wet weight. In normal sea water it is almost doubled.

During acclimation to a lower salinity Nereis will take up about as much sodium as worms already acclimated to that lower salinity. (S. Rennie)

Frey, David G. 1946. Oyster bars of the Potomac River. U.S. Fish and Wildlife Service, Special Scientific Report 32:1-93 (Mimeo).

An ecological survey of the flora and fauna of natural oyster beds in the long estuary of the Potomac River. This stretch of the estuary has a well-defined salinity gradient which determines the distribution and abundance of many organisms. There are also large seasonal changes in salinity, as well as temperature, which change ecological characteristics of each oyster bed. Distributions of species and salinities are given by time and place in such a way that correlations can be seen. The Potomas River estuary is highly productive for oysters because many pests, such as the oyster-drilling snails Urosalpinx cinerea and Eupleura caudata, are excluded by the frequent occurrence of salinities low enough to kill them. (S. H. Hopkins)

Friedrich, Hermann. 1969. Marine biology. Univ. of Washington Press, Seattle, xii + 474 pp.

Salinity (general), pp. 56-59; includes some representative sea (including Baltic) salinities, table showing relation to freezing point and osmotic pressure, graph showing salinity influence on lethal temperature of a copepod, and table of salinity tolerances of some copepods. Elements and ions in sea water, pp. 79-81. "Brackish waters, estuaries and coastal submarine waters," pp. 419-426; includes good diagrams of relations of living organisms to salinity on pp. 420, 421 (showing a low point in number of species at about 5 ppt where salinity is too high for most freshwater organisms and too low for most marine and estuarine species), and p. 422, where number of individuals as well as number of species is shown in relation to salinity in three curves. The same phenomenon in respect to diatoms is mentioned in text, p. 425. Diagram, p. 424, shows "possible displacement of brackish region if Elbe estuary" according to Caspers (1959), but this is not discussed in text. Subterranean outflow of fresh water to sea, p. 425, and diagram, p. 424. Gunter (1961) is quoted twice. (S. H. Hopkins)

Frolander, H. F. (Oregon State U.). 1964. Biological and chemical features of tidal estuaries. Jour. Water Pollut. Contr. Fed., 38(8):1037-1048.

Variations in biological populations were studied in physiochemically distinct estuarine environments in Yaguina Bay, Oreg., and Narragansett Bay, R. I. These were related to seasonal, daily, and vertical variations in salinity, temperature, light intensity, speed of tidal movement, and magnitude of tidal prism.

Fukusho, K. 1969. The specific difference of salinity tolerance among cichlid fishes genus Tilapia and histological comparison of their kidneys. Bull. Jap. Soc. Sci. Fish., 35(2):148-155.

The present study was undertaken to compare the salinity tolerance of T. mossambica with T. nilotica and T. sparrmani, and to obtain fundamental information

on the specificity of the adaptability. Structure of kidney of these species was examined in connection with their salt tolerance. The same study was extended to several species of cichlid fishes at hand compared with marine pomacentrid. (P. Maxwell)

Fulton, C. 1962. Environmental factors influencing growth of Cordylophora. Jour. Exptl. Zool., 151:61-78.

Studies indicate that Na^+, K^+, Ca^{++}, Mg^{++}, and Cl^- are required for growth of the hydroid coelenterate Cordylophora. In the absence of Na^+, K^+, or Ca^{++} the hydranths cannot survive, whereas in the absence of Cl^- they can survive and feed but no growth takes place. In the absence of Mg^{++} growth proceeds at a reduced rate.

Experiments with different ionic combinations showed there was a definite interaction between Na^+ and K^+, but no interaction between Ca^{++} and Mg^{++}. (S. Rennie)

Fulton, Chandler. 1963. The development of a hydroid colony. Developmental Biol., 6:333-369.

Colonies of Cordylophora lacustris clone A grown in 50% sea water were taller than those grown in fresh water. In fresh water, stolon length was found to account for 76% of the total length of the tubes, while in 50% sea water the stolons accounted for only 16%. (S. Rennie)

Fustec-Mathon, Eliane, Neuville, D., and Daste, P. 1969. Adaption à la salinité de differentes souches d'Azotobacter, isolees de sols du littoral Atlantique du Centre-Ouest de la France. (Adaptation to salinity of different strains of Azotobacter isolated from the soils of the Atlantic coast in the center-west of France.) Compt. Rend. Hebdom. Seances Acad. Sci. Ser. D. Sci. Natur. (Paris), 269(1):98-100.

These strains present an adaptation to salinity that increases with subjection to the action of sea water. (P. Maxwell)

Gaarder, T. and Sparck, R. 1932. Hydrographisch-biochemische Untersuchungen in norwegischen Austern-Pollen. Bergens Mus. Arbok, Naturvidenskapelig Rekke, 1932(1):1-144; 75 figs.

Pools were cut off from the fjord May to October, during which time rain and seepage produced a brackish water layer on the surface of a salinity as low as 7 ppt. Great variation occurred in the first meter layer, but the lower 3 m remained very constant between salinities of 26.0 and 27.7. The locking up of the lower waters by an overlying stratum of low salinity makes the pool a closed system in which light is the limiting factor in production.

Galhano, Maria Helena. 1970. Contribucao para o conhecimento da fauna intersticial em Portugal. (Contribution to the knowledge of the interstitial fauna in Portugal.) Publ. Inst. Zool., Dr. Augusto Nombre, Fac. Cienc. Porto, 110:9-206. (English summary.)

A comparative study was made of the qualitative and quantitative mesopsamon, particularly crustaceans, along the Francelos shore, Carbedelo and Areinho de Valbom Estuaries. The largest numbers of species found were in the seashore (Carbedelo) area which is most probably due to the salinity factor. Faunal density was seasonal, being maximum during the summer and least during the autumn. (From Biol. Abstr.)

Galtsoff, P. S. 1930. Destruction of oyster bottoms in Mobile Bay by the flood of 1929. Report U.S. Comm. Fish., 1929, App. XI, Doc. 1069:741-758; 3 figs., 5 tables.

Salinity in Mobile Bay ranges from 15 to 30 ppt in the dry season and from 0 to 25 ppt in spring. In 1929 a large mortality of oysters resulted from simultaneous flooding of the Tombigbee and Alabama Rivers for an unusually long duration. In addition, the Mobile area had a record rainfall of 20.23 in. during March, compared with the normal 6.27 in., further lowering bay salinities. Procedures for rehabilitating the oyster beds are recommended.

Galtsoff, P. S. 1931. Survey of oyster bottoms in Texas. U.S. Bureau of Fisheries, Invest. Report VI:1-30; 14 figs., chart.

Redfish Reef in Galveston Bay, an example of an overcrowded reef where oysters do not survive more than 1 or 2 yr, being killed either by freshets or by exposure during low tide stages in winter. In Galveston and Trinity Bays the reefs form barriers which should be cut through to permit mingling of fresh and salt waters.

Galtsoff, P. S. 1954. Gulf of Mexico, its origin, waters, and marine life. Fish. Bull. 89, U.S. Fish and Wildlife Serv., Vol. 55, U.S. Government Printing Office, Washington, D. C., xiv + 604 pp.

Salinity, p. 135; salinity-temperature relations, p. 135. Other sections with some emphasis on salinity as an ecological factor are "Bottom Communities" by Hedgpeth, pp. 203-214; "Copepoda" by Schmitt, pp. 439-442; "Decapoda" by Behre, pp. 451-455; "Biology of Commercial Shrimps" by Lindner and Anderson, pp. 457-461; "Mollusks" by Rehder, p. 472 especially; "Commercial Fishes" by Rounsefell, pp. 507-512; and especially "Summary of our knowledge of the oyster" by Butler, pp. 479-489. Discussions of many other organisms to which salinity is a critical factor have omitted consideration of salinity. (S. H. Hopkins)

Galtsoff, P. S. 1964. The American oyster, Crassostrea virginica Gmelin. U.S. Fish and Wildlife Serv., Fish. Bull., Vol. 64. U.S. Government Printing Office, Washington, D. C., iii + 480 pp.

Most of this monograph is on the structure and physiology of the individual

oyster, and its reproduction and development. Chapter XVIII, pp. 397-456 (including bibliography, pp. 446-456) is on "Environmental factors affecting oyster populations" (including salinity on pp. 404-407). On p. 404 it is stated that: "The range of salinity favorable for C. virginica falls within two zones (according to the Venice classification of saline waters, 1958), the polyhaline, from 30 to 18 ppt, and the mesohaline, from 18 to 5 ppt. Populations of oysters found beyond the upper or lower limits of the range exist under marginal conditions...they are often decimated either by floods, in the lower zone of the range, or by predators which usually remain in more saline waters." On p. 406 it is stated that influx of fresh water is sometimes beneficial: "Periodical flushing wipes out the predators and restores the productivity of beds." A formula is given for "evaluation of the salinity factor." (S. H. Hopkins)

Galtsoff, P. S., Chipman, W. A., Engle, J. B., and Calderwood, H. N. 1947. Ecological and physiological studies of the effect of sulfate pulp mill wastes in the York River, Virginia. U.S. Fish and Wildlife Serv., Fish. Bull. 43, 51:58-186.

"Some of the pests (Bailey) mentions, namely the oyster drill (Urosalpinx cinerea) and the star fish (Asterias forbesi) are so sensitive to lowered salinity of water that the latter constitutes a barrier protecting the upstream oyster groups."

Galtsoff, P. S., Chipman, W. A., Hasler, A. D., and Engle, J. B. 1938. Preliminary report on the cause of the decline of the oyster industry of the York River, Va., and the effects of pulpmill pollution on oysters. U.S. Bureau Fisheries Invest. Report., 37:1-42.

Studies of the cycles of temperature, salinity, and plankton did not indicate the existence of abnormal conditions that might be regarded as responsible for the oyster decline. Direct evidence of the harmful effect of the pulpmill effluent (black liquor) on the oyster was shown by studying ciliary epithelium movement in gills, pumping rates, and time oysters remained open when subjected to different concentrations of pulpmill effluent. (T. Rennie)

Galtsoff, P. S. and Prytherch, H. F. 1927. An investigation of the coastal waters of South Carolina with reference to oyster culture. U.S. Bureau of Fisheries Econ. Circ. 61:1-8.

It is suggested that the oyster industry could be improved on the South Carolina coast if certain factors, including salinity, are observed. A salinity chart is provided for that coast. (P. Maxwell)

Galtsoff, P. S., Prytherch, H. F., and Engle, J. B. 1937. Natural history and methods of controlling the common oyster drills (Urosalpinx cinerea Say and Eupleura caudata Say). U.S. Bureau of Fisheries, Fish. Circ. No. 25:1-24.

Low salinities limit the inland or upbay penetration of these oyster-drilling predacious snails, so that they cannot reach the oyster beds in upper ends of estuaries. Laboratory experiments showed that salinity of 11 ppt is lethal to these snails and constitutes a natural barrier to their distribution, while 5 ppt kills them more quickly (in 4 days, compared with 7 days required for killing in 10 ppt). (S. H. Hopkins)

Ganapati, S. V. and Alikunhi, K. H. 1952. Experiments on the acclimatization of salt water fish seed to fresh water. Proc. Indian Acad. Sci., (B)35:93-109.

Experiments on fry and fingerlings of mullet (Mugil spp.), Megalops cyprinoides, Elops saurus (leptocephalus and later stages), Gerres filamentosus, Scatophagus argus, Sillago sihama, Hemirhampus gaimardi, and Ambassis spp. have shown that acclimatization of these species to fresh water is possible.

Mechanical injury during collection and transport definitely weaken the fry. Feeding during acclimatization reduces mortality and dilution of the salt water in gradual steps, 9 ppt at 6-hr intervals and 5 ppt at 4-hr intervals was found to be successful. Longer periods produced greater mortality due to decrease of O_2 and increase in metabolites.

It was though that each species probably has an optimum acclimatizable rate at which it could be changed to fresh water with minimum mortality. (S. Rennie)

Ganning, B. 1970. Population dynamics and salinity tolerance of Hyadesia fusca (Lohman) (Acarina, Sarcoptiformes) from brackish water rockpools with notes on the microenvironment inside Enteromorpha tubes. Oecologia, 5(2):127-134.

The salt water mite H. fusca is very tolerant of salinity variations. In laboratory experiments more than 4 weeks of survival, copulation, breeding, and larval growth were found to be almost equally successful in salinities between 0.5 and 40 ppt. (P. Maxwell)

Garry, W. C. 1916. The resistance of fresh water fish to changes of osmotic and chemical conditions. Amer. Jour. Physiol., 39(1916):313-329.

Found that freshwater fish will readily tolerate diluted sea water, or similar "balanced" solutions, of osmotic pressure equal to that of their blood, but that higher concentrations are rapidly fatal, according to J. R. E. Jones, 1964, "Fish and River Pollution," Butterworth, London (p. 66). (S. H. Hopkins)

Gates, W. H. 1907. A few notes on oyster culture in Louisiana. Bull. Gulf Biol. Sta., 15:1-32, figs., map.

"The brackish waters of the inland bays and bayous are more favorable to oyster culture than those of higher salinities which prove satisfactory to the Maryland oysterman because food is more abundant, and the denser water, having the greater surface tension, becomes overheated during the summer months, which generally proves fatal to the young oysters."

Gavard 1927. De quoi se nourrisent les huitres? Leur nourriture envisagée au apont de vue "ostreiculture." Bull. Trav. Publ. Stat. Agric. et Pêche de Castiglione, 1927(1):238-254, 1 fig.

Oysters feeding in the laboratory on either animal or vegetable detritus gained weight; those which had no contact with organic matter lost weight steadily. Thus, they grow most rapidly in polluted waters. The density of the water seems to have no effect on the growth of oysters. (S. H. Hopkins)

Gee, J. M. 1961. Ecological studies in South Benfleet Creek, with special reference to the amphipod genus Corophium. Essex Nat., 1961:291-309.

Studied differences in ecology between C. volutator and C. arenarium. The former is found in wet mud with high silt and clay content, the latter in drier, coarser substrates. Green, 1968, cites this paper and goes on to say that C. arenarium in tap water dies in less than an hour while C. volutator lives 16 days in tap water, but it is not certain from the context that he is quoting Gee. (S. H. Hopkins)

Gegelius, Goran. 1965. Adaptations of the sea urchin Psammechinus miliaris to different salinities. Zool. Bidrag Upsala, 35:329-337.

"S" form adapted to surface water and "Z" form to deep water. Cleavage rate of eggs at given temperature depends upon salinity at which the organism was adapted. Salinity limits of sex cells and those of the adult differ.

Gessner, F. 1969. Photosynthesis and ion loss in the brown algae Dictyopteris membranacea and Fucus virsoides. Mar. Biol. (Berlin), 4(9):349-351.

The sublittoral brown alga D. membrancea (Stachhouse) Batters is very sensitive to low salinities. A 1-min exposure to distilled water causes total breakdown of photosynthesis and respiration. The breakdown phenomena were studied as aftereffects following reexposure to sea water. Since rate of ion loss is highest during the first minute of osmotic stress, the irreversible metabolic depression appears to be due to fast ion loss. Photosynthesis of F. virsoides is not affected by distilled water, even over very long periods. (From Biol. Abstr.)

Gibb, D. C. 1957. The free-living forms of Ascophyllum nodosum (L.) Le Jol. Jour. Ecology, 45:49-83.

This seaweed (fucoid alga) has a dwarfed form associated with low salinity. Cited by Green, 1968, p. 61. (S. H. Hopkins)

Gibson, M. B. and Hirst, C. B. 1955. The effect of salinity and temperature on the pre-adult growth of guppies. Copeia, 1955:241-243.

Guppies (Lebistes reticulatus) reared in 1/4 sea water grew faster than those reared in fresh water. Growth rate was still faster in 1/2 sea water. As experiments were terminated when the first mature male appeared, it is not known how the final size of adults would compare. Optimum temperature in all media was 23-25 C. Growth was most rapid and first males appeared sooner at this temperature than at 20, 30, or 32 C. (S. H. Hopkins)

Giere, O. 1968. Die Fluctuationen des marinen Zooplanktons im Elbe-Aestuar. Beziehungen zwischen Populationsschwankungen und hydrographischen Faktoren im Brackwasser. (Fluctuation of the marine zooplankton in the Elbe Estuary. Relations between fluctuations of populations and hydrographic factors in brackish water.) Arch. Hydrobiol., Suppl. 31:379-546. (English summary, pp. 525-527.)

The brackish-water region could be divided into four subregions each characterized by indicator species. The "alpha mesohaline" and "alpha oligohaline" zones were regions of high plankton mortality for marine and freshwater species, the "beta mesohaline" zone therefore being a region of plankton depletion to which only some characteristic brackish-water species are adapted. The outer regions of the estuary, with fairly high salinity, have a high species-diversity index and a high number of individuals. Going upstream, both diversity and number of species decrease continuously. Even in the upper regions, marine species dominate although there are few compared with lower regions. (S. H. Hopkins)

Gifford, C. A. 1962. Some aspects of osmotic and ionic regulation in the blue crab, Callinectes sapidus, and the ghost crab, Ocypode albicans. Publ. Instit. Mar. Sci., Univ. of Texas, 8:97-125. (Also Ph. D. thesis, Univ. of Illinois, 1958. Dissert. Abs. 18(5):1905.)

From Abstract, Publ. Instit. Mar. Sci. 8:97: Analyses were made of constituents of body fluids in these two crabs, relative to hyposaline and hypersaline environments in bays of south Texas, concentrations from 14% to 197% that of sea water. All ions were regulated to some extent in all salinities. Osmoregulatory ability of Ocypode is reduced at temperatures above 29 C; at 30 C it can live only a few days in 190% sea water, but can live at least 2 weeks in 190% at 20-25 C. C. sapidus from Laguna Madre can stand high salinity and high temperature better than other crabs, but are less tolerant of low salinity. (S. H. Hopkins)

Gillard, Robert Moore. 1969 (unpubl.). An ecological study of an oyster population, including selected associated organisms in West Bay, Galveston, Texas.

Master's thesis in marine biology, Texas A&M Univ., May 1969, xi + 136 pp., processed.

West Bay has the highest salinities in the Galveston Bay system, and the oyster population studied is believed to be a good example of a natural oyster bed that is marginal because of high salinity and associated high mortality rates. (S. H. Hopkins)

Gillespie, D. M., Wirick, C. D., and Stephens, D. W. 1971. The Great Salt Lake: plankton ecology in a rigorous environment. Bull. Ecol. Soc. Amer., 52(2):31 (Abstract in program of August 1971 meeting, Ecological Society of America, Colorado State Univ., with AIBS).

An engineering change, construction of the railroad causeway, divided Great Salt Lake, Utah, into a northern basin containing saturated brine with a depauperate biota consisting of the alga Dunaliella salina plus some protozoans and bacteria, and a less saline southern basin with a planktonic energy flow sequence (Dunaliella fed upon by brine shrimp, Artemia) and a benthic energy flow sequence (blue-green algae + detritus feeding the larvae of the brine fly, Ephydra), with some crossover between the two. Population dynamics and productivity data are presented (in the paper of which this is an abstract). (I flew over Great Salt Lake at jet altitude, and even at that height the sharp difference between the reddish northern basin and the greenish southern basin was striking.) (S. H. Hopkins)

Gillham, Mary E. 1957. Vegetation of the Exe Estuary in relation to water salinity. Jour. Ecology, 45:735-756.

Angiosperms: Upstream, the zonation is from Spartina townsendii in the highest salinity through Scirpus maritimus in the brackish zone, then Phragmites communis, to Phalaris arundinacea in fresh water. Few angiosperms are obligate halophytes; most are only salt-tolerant and become abundant in salinity too high for competitors, but grow better without salt if freed from competition. Downstream, halophytic communities appear: Zostera marina meadows, Salicornia spp., Spartina townsendii (started here by man in 1935, now dominant over native Spartina maritima), Juncus maritimus, Halimione portulacoides, and others.

Algae: Few freshwater species can live in water containing even traces of salt, while many marine species, especially Chlorophyceae, can penetrate considerable distances upstream into fresh water. Euryhaline genera abundant in brackish part of estuary include Blidingia, Enteromorpha, Rhizoclonum, and Vaucheria. Many marine species reach only to upstream limit of Zostera: Rhodophyceae Cystoclonium purpureum, Gracilaria verrucosa, etc., brown algae Petalonia fascia, Fucus spiralis, F. serratus. (S. H. Hopkins)

Ginetsinskii, A. G., Vasíleva, V. F., and Natochin, Yu. V. 1962. Reaktsiya ryb na izmenenie solenosti sredy. [The reaction of fishes to a change in the salinity of the water.] In Problemy Evolyutsii funktstii i Enzimochimii Protsessov Vozbuzhdeniya. Moscow: Akademija Nauk. SSSR, 89-102. Ref. Zhur., Biol., No. 9I64. (Transl.)

This reaction was studied in the freshwater fishes Perca fluviatilis and Esox lucius and in the saltwater fishes Raja clavata, Trigon pastinaca, Spicara smaris, and Odontogadus merlangus. In all fishes the sole substrate for the reaction to the change in salinity is the filtration apparatus; the tubules do not participate in compensatory reactions. In freshwater fishes the chief part in the reabsorption of Na is played by the distal canaliculi of the nephron. Freshwater fishes are not capable of regulating Na transport. Saltwater fishes have a sodium-regulating system and the excretion of Na takes place through the gills. The basic reaction of the kidneys of the fish to a change in the level of salinity in the water consists of a change in diuresis in which the properties

of the urine do not change. Freshwater fishes and skates, depending on the salinity of the water, excrete a larger or smaller amount of osmotically free water; the saltwater bony fishes excrete a larger or smaller amount of solution of chloride salts which are isotonic with the blood. The osmotic regulation process in the kidneys is of a quantitative nature. In freshwater fishes an increase in salinity causes an oliguric reaction. The kidney does not take part in the removal of the excess Na: reabsorption in the kidney is always maximal. In saltwater bony fishes when the salinity increases or decreases the fundamental homeostatic reaction is the rate of excretion of Na via the gills. The kidney, however, always reacts with polyuria to a change in salinity.

Glaser, Otto C. 1904. The conditions for oyster culture at Calcasieu Pass. Bull. Gulf Biol. Sta., 2:9-31.

Salinity is favorable for oysters during the summer, but there are unfavorable periods every spring due to "high water" in Calcasieu River. The freshet of 1903 endured so long that the majority of the oysters in the pass were killed. Some of the deeper beds survived to the extent that they yield about half a barrel of edible oysters as the result of a hard day's tonging. Oysters on the west jetty survived well. (S. H. Hopkins)

Gnanamulhru, C. P. 1965. Hydrostatic pressure of body fluids in relation to osmoregulation in the brackish water prawn, Metapenaeus monoceros. Indian Jour. Exptl. Biol., 3(1):271-272.

When the brackish water prawn is transferred from dilute sea water to full sea water, its body volume is reduced but when it becomes acclimatized to higher salinity, its body volume is more than the initial volume though the volume of blood is reduced; the reverse changes are observed in reverse transfers. As the exoskeleton of the prawn is not elastic, the changes in pressure are augmented by sealing or contracting the gut in such a way as to arrest or even reverse osmotic movements of water.

Goodbody, Ivan. 1961. Mass mortality of a marine fauna following tropical rains. Ecology, 42(1):150-155 (Jan. 1961).

Describes three cases of mass mortality of sessile marine animals near Port Royal, Kingston Harbour, Jamaica, after heavy rains. Local runoff in lagoons in mangrove swamps along edge of bay, not from rivers. Ascidians, sipunculoids, holothurians, echinoids, ophiuroids, nereids, asteroids, sabellids, and hydroids were among those killed by low salinity. "Oysters" Isognomon alatus and Crassostrea rhizophorae and mussel Brachidontes exustus among best survivors and recolonizers. (S. H. Hopkins)

Goodhart, C. B. 1941. The ecology of the Amphipoda in a small estuary in Hampshire. Jour. Animal Ecol., 10:306-322.

See Jones, N. S. (1948), Melita palmata in outer estuary, M. pellucida in inner part (in lower salinity). (S. H. Hopkins)

Goodwyn, Frank. 1968. The occurrence of the Cladoceran Leptodora kindtii in the upper Chesapeake Bay. Chesapeake Sci., 9(1):63.

In June and July 1967, 26 specimens of L. kindtii were collected from upper Chesapeake Bay in salinity of 0.2 ppt or less. Females were not carrying eggs, indicating that this was not a normal breeding area for these freshwater animals. The only identifiable male was collected in July, contrasting to a former statement that males do not occur until October, typical of those in Wisconsin lakes. (S. Rennie)

Gopalakrishna-Murtie, K. and Nagabhushanam, R. 1968. Observations on the spawning and reproductive cycle of Chiton granoradiatus Lelop (Mollusca). Broteria Ser. Cienc. Natur., 37(3/4):223-233.

Observations were made on the spawning of C. granoradiatus in the laboratory during June 1964 to July 1964.... Gonads structure and spawning behavior were noted in both sexes. Factors controlling spawning in the laboratory included temperature and salinity. The animals spawned in salinities between 32.6 and 35.53 ppt and in temperatures between 27 C and 29.8 C...spawning in nature was not observed. (P. Maxwell)

Gordon, M. S. 1957. Observations on osmoregulation in the Arctic char (Salvelinus alpinus L.). Biol. Bull., 112:28-33.

After transfer from salt water (salinity 28.6 ppt) to fresh water, the fish decreased their plasma concentration by about 25% over a period of 20 hr. After 35 hr, plasma concentrations were below the normal freshwater levels. When transferred back to salt water, they regained their original values. A second experiment using fish from water of 26 ppt salinity essentially confirmed the results of the first. (S. Rennie)

Gordon, M. S. 1963. Chloride exchanges in rainbow trout (Salmo gairdnerii) adapted to different salinities. Biol. Bull., 124(1):45-54, illus.

^{36}Cl was used to trace chloride movements in trout acclimatized to various salinities between fresh water and sea water (salinity 32 ppt). "Neither Cl exchanges nor integumentary exchanges varied in proportion with changes in the magnitude of the transintegumentary osmotic gradients maintained by the fish." Interpretation: changes in permeability to water of the integument (especially of the gills) are important in salinity adaptation in rainbow trout. (S. H. Hopkins)

Gordon, M. S. 1965. Intracellular osmoregulation in skeletal muscle during salinity adaption in two species of toads. Biol. Bull., 128(2):218-229.

The European green toad lives naturally in waters of salinities as high as 29 ppt. This species, Bufo viridis, is compared with the western North American Bufo boreas, in salinities from fresh water to 50% sea water (16 ppt). B. viridis tolerated 50% sea water indefinitely. B. boreas lived well in 40% but died in a week in 50% sea water. Both species are osmoconformers, changes in plasma osmotic concentrations being due almost entirely to changes in NaCl concentrations. Muscle dry weight increases only 35% in both when plasma has 80%-135% increase in osmotic concentration. Intracellular solutes increase. Different intracellular free amino acids accumulate in the two species. Intracellular urea concentration is higher than plasma concentration. (S. H. Hopkins)

Goreau, T. F. 1964. Mass expulsion of zooxanthellae from Jamaican reef communities after Hurricane Flora. Science, 145(3630):383-386.

Very extensive bleaching of coral reef communities occured after severe flood rains over eastern Jamaica. The loss of color was due to the mass expulsion of zooxanthellae from the tissues of Millepora, Scleractinia, Zoanthidea, and Actiniaria living in the shallow reef zones. The polyps of the bleached individuals contined to expand and feed in their normal fashion. It is believed that expulsion of the zooxanthellae was induced by contact with water of lowered osmotic pressure on the surface of the sea, rather than by sedimentation or fouling. Regeneration of the depleted zooxanthellar populations was very slow; many of the bleached colonies survived well despite the near total absence of zooxanthellae from their tissues for over 2 months. (Author's abstract)

Gosner, K. L. 1971. Guide to identification of marine and estuarine invertebrates. Wiley-Interscience, New York, xix + 693 pp., illus.

Salinity, and classification of waters according to salinity, is discussed on pp. 5-7; tides and currents on pp. 7-10. The principal discussion of biological aspects of salinity differences is in "The tidal marsh ecotone and estuarine transition," pp. 20-22 and references, pp. 22-23. Plants are discussed on pp. 20-21, and fauna associated with tidal marshes and other vegetation, especially eelgrass, Zostera marina, on pp. 21-22. On p. 21 it is stated that Allee (1923: Biol. Bull., 44:167-191) listed 140 animal species in 11 phyla as members of eelgrass community at Woods Hole; 55 species were considered "characteristic" of this community, and that a third of the eelgrass fauna "disappeared" after the disease epidemic of Zostera ("wasting disease" of eelgrass) began in 1931. Eelgrass recovery was stated to be still incomplete in 1964. (S. H. Hopkins)

Gosselink, J. G. 1970. Growth of Spartina patens and S. alterniflora as influenced by salinity and source of nitrogen. Pp. 97-109. Louisiana State Univ. Coastal Studies Bull. No. 5., xvii + 184 pp.

Greenhouse cultures of two salt-marsh cord grasses in fresh water and water of 10- and 20-ppt salinities showed that they are facultative halophytes which grow best in fresh water; growth is slowed as salinity increases. In 10 and 20 ppt, cells expend energy to accumulate chlorine and exclude sodium. (S. H. Hopkins)

Gowanloch, J. Nelson and Hayes, F. Ronald. 1927. Contributions to the study of marine gastropods. I. The physical factors, behavior, and intertidal life of Littorina. Contr. Canadian Biol. and Fish., 3:135-165.

A series of salinity tolerance experiments showed the following lower lethal limits for three species of Littorina: L. Rudis, 13.75 ppt; L. palliata, 12.50-13.75 ppt; and L. littorea, 12.50 ppt. (S. Rennie)

Goyacheva, N. V. 1969. Vlizanie solenosti, temperatury i osveschchewnosti na razmnoz henie zhgotik onostsed Bodo marina. (The effect of salinity, temperature, and illumination on the reproduction of the mastigophoran Bodo marina.) Tr. Inst. Biol. Unvtr. Vod. Akad. Nauk S.S.S.R, 19(22):105-108.

A study was made of the reaction of Bodo marina to different concentrations of salts in the medium, temperature, and illumination. Optimal parameters were salinity 20-40 ppt, temperature 20-25 C, and weak illumination or darkness. (From Biol. Abstr.)

Green, J. 1957. The growth of Scrobicularia plana (Da Costa) in the Gwendraeth Estuary. Jour. Marine Biol. Assoc. U.K., 36:41-47.

Ability to retract siphons and close shell enables clam to survive in places where salinity falls to very low level for a short period, as in Gwendraeth Estuary where a population of 500 clams/m^2 (54-mm length) thrived in a mud flat where salinity of overlying water in winter fell to 2 ppt for short time as tide ebbed. Fide Green, 1958, p. 1960. Population densities were up to 1025 clams/m^2. Salinity varied from 15 to 25 ppt. (S. H. Hopkins)

Green, James. 1961. A biology of Crustacea. Quadrangle Books, Inc., Chicago, Ill., xv + 180 pp.

Chap. IX, Distribution. Crustacea of the inland seas, pp. 132-135, discusses faunae of Mediterranean, Red (in connection with passage of species from Red to Mediterranean), Black, Azov, Caspian, and Baltic Seas. Black Sea (half the salinity) has 4 barnacles compared with 40 in Mediterranean, and 35 decapods compared with over 200. The Caspian, with salinity only two-thirds that of Black Sea, has even fewer species of crustaceans, and the Aral Sea still fewer

(no crabs, 1 amphipod, under 30 of the smaller Crustacea; Aral salinity is less than Caspian. The Baltic Sea is a large body of low-salinity water with such stable conditions that some marine and some freshwater species, as well as typical brackish-water forms, have become adapted to it; temperature, as well as salinity, limits spread of some crustaceans that have entered the Baltic. On pp. 135-140 salinity is specifically discussed as a factor in distribution of Crustacea, and some of the mechanisms for adaptation to different salinities are described. On pp. 149-150 the species of Gammarus adapted to live in different salinity zones of European estuaries are discussed. (S. H. Hopkins)

Green, J. S. 1968. The biology of estuarine animals. Univ. of Washington Press, Seattle, x + 401 pp.

Undergraduate textbook. Author is British and book is better for European estuaries, but includes many references to American work also. Chap. 2, pp. 29-46, is on "salinity and other chemical factors," but salinity effects on animals (or plants) are discussed or mentioned on pp. 51-52, 53, 54, 56, 61 (vegetation); 65, 66, 67, 68, 69, 74, 75, 76, 77, 78, 79, 80 (fauna); 81, 82, 83, 84, 85, 86, 87, 88, 89, 91, 92, 94, 95, 96, 97, 98, 99, 100, 101, 102, 104, 107, 109 (plankton); 111, 112, 113, 114, 115, 116, 117, 118, 119, 122, 126, 128, 130, 131, 132, 133, 136, 137, 138, 139-140, 144, 145, 147-148, 151, 155, 159-160, 165, 166-167, 170-171, 172, 173, 174, 176, 177, 179, 183, 184, 185, 186, 188, 189, 191-192, 193, 194, 195, 197, 198, 199, 200, 201, 207 (larger bottom animals); 212, 213, 214, 215, 216, 217, 218, 219, 220, 223, 224, 225, 226, 227, 230, 231, 232, 235 (smaller bottom animals); 236, 238, 239, 240, 241, 242, 243, 244, 247, 249, 250, 251, 252, 253, 254, 255 (freshwater component of estuarine faunas); 262, 272 (land component of estuarine faunas); 274, 275, 276, 278, 279, 280, 281, 284, 285, 288, 289, 293, 294, 296 (fishes); 326, 332, 334 (parasites and epibionts). (S. H. Hopkins)

Green, J. W., Harsch, M., Barr, L., and Prosser, C. L. 1959. The regulation of water and salt by the fiddler crabs, Uca pugnax and Uca pugilator. Biol. Bull., 116:76-87.

Analyses were made of the serum, urine, gill, and stomach fluids for total osmotic concentration and the electrolytes Na, Mg, K, Ca, NH_4, Cl, and SO_4 in these two crabs when kept in 100% and 175% sea water. Results are shown in five tables and one graph. Water and electrolytes enter mainly through stomach and gills. Antennary glands and gills are chief sites of regulation, with some regulation by stomach and possibly midgut gland. (S. H. Hopkins)

Greenwald, L. and Kirschner, L. B. 1971. Sodium extrusion across the gills of rainbow trout in seawater (Abs.) Amer. Zool., 11(4):664.

Sodium extrusion across gills of rainbow trout, Salmo gairdnerii, adapted to sea water, was measured in a recirculating gill-irrigation system. Results showed that exchange diffusion (which accounts for 80%-95% of sodium efflux in most marine fish) is absent in rainbow trout. Efflux of sodium was not affected by changing the external medium to Na-free sea water. Further experiments showed that Na extrusion is dependent on potassium in the external medium but not on any other ions in sea water. (S. H. Hopkins)

Grindley, John R. 1964. Effect of low-salinity water on the vertical migration of estuarine plankton. Nature, 203(4946):781-782, illus.

Previous workers showed that low-salinity layer at surface inhibits vertical migration of most species of estuarine zooplankton; plankton concentrates just below the low-salinity surface water during the night instead of rising to the surface as they do in absence of a salinity gradient. An apparatus is described for field experiments on this phenomenon. Tests were made with a population of

the estuarine copepod Pseudodiaptomus hessei near Cape Town, under various light and salinity conditions, and the previous reports were confirmed. Water of 8.5 to 19 ppt was used in the surface layer, over water of 24 and 35 ppt. (S. H. Hopkins)

Gross, W. J. 1957a. A behavioral mechanism for osmotic regulation in a semi-terrestrial crab. Biol. Bull., 113:268-274.

The shore crab Pachygrapsus crassipes prefers 100% sea water to 50%, 75, 125, and 150% sea water. This preference was only altered by acclimating to 150% sea water. The preference suggests a mechanism which restricts this crab to intertidal and subtidal zones of the sea. This crab also tends to maintain normal sodium and potassium blood concentrations when given free choice of salinities. Desiccated animals may overcompensate when offered a choice of media and achieve blood sodium concentrations below the normal range. (S. Rennie)

Gross, Warren. 1957b. An analysis of response to osmotic stress in selected decapod Crustacea. Biol. Bull., 112:43-62.

It was determined that Emerita, Callianasa, Upogebia, Cancer antennarius, C. gracilis, and Pugettia cannot regulate osmotically and are stenohaline. Pachygrapsus, Birgus, Hemigrapsis, and Uca can regulate osmotically in concentrated and dilute sea water. When it occurs, osmotic regulation is established immediately. Changes in blood concentrations of Pachygrapsus and Emerita are caused mostly by salt rather than water exchanges. A dynamic flux of salt and water in the gill chamber of Pachygrapsus furnishes further evidence that the gills are osmoregulatory organs. The osmotically regulating crustaceans have less permeable exoskeletons than the nonregulators. Individual variation among animals suggests that increases in metabolism are not direct reflections of increased osmotic work, but of muscular or other activity. (S. Rennie)

Gross, W. J. 1960. Hypo-osmotic regulation in two species of crab. [Abs.] Anat. Rec., 137:360-361.

Populations of the intertidal crabs Hemigrapsus oregonensis and Pachygrapsus crassipes inhabited a lagoon isolated from the sea with salinity of 56 ppt, 160% of sea water salinity. In next 4 months salinity increased to 190% of sea water. Hemigrapsus regulated internal salt concentration in salinity as high as 168% of sea water; some survived in 180% sea water, but with blood isotonic to external medium. None lived in 190% sea water. Pachygrapsus was regulating in 180% sea water and survived in 190% sea water by tolerance alone. (S. H. Hopkins)

Gross, W. J. 1961. Osmotic tolerance and regulation in crabs from a hypersaline lagoon. Biol. Bull., 121:290-301.

The crabs Pachygrapsus crassipes and Hemigrapsus oregonensis in Los Penaquitos Lagoon, near San Diego, Calif., lived in water whose salinity was more than 175% that of sea water. Both were found to be strong hypo-osmotic regulators, Hemigrapsus at as high as 175% but never above 180% sea water salinity, and Pachygrapsus going above 185% sea water salinity. In 175% sea water, Mg concentration in urine was about equal in the two crabs. After months of isolation in the lagoon, Pachygrapsus showed a preference for normal sea water (35 ppt) when offered a choice between waters of 50%, 100%, 130%, and 180% sea water salinity, and avoided salinities above sea water strength.

Gruvel, A. 1934. Sur quelques-unes des causes qui arretent la penetration des especes animales dans le canal de Suez. C. R. Acad. Sci., Paris, 198(13): 1265-1267.

High salinity in deeper parts of the canal and of lakes through which it passes cited as one barrier to passage of marine animals through the canal. (S. H. Hopkins)

Gruvel, A. 1936. Contribution à l'étude de la bionomie générale et de l'exploitation de la faune du canal de Suez. Mem. l'Instit. Egypte, 29:1-255.

Pp. 184-187: Pelecypods: Meleagrina occa Reeve = Pinctada vulgaris Schumacher from the Red Sea is very abundant all through the canal and in Grand lac Amer. Ostrea stentina Peyraud from Mediterranean is less abundant. Mytilus pharaonis Fischer = Brachydontes variabilis Krauss is extremely abundant in the canal and in the lakes; originally from Red Sea. Modiola barbata L. is less abundant. Other species were Callista florida Lam., Tapes decussatus, Cardium edule L., Cardium papyraceum Gmelin, Tridacna elongata.

Gunter, Gordon. 1937. Observations on the river shrimp, Macrobrachium ohionis (Smith). Am. Midland Naturalist, 18:1038-1042.

This paper is based mostly on observations of shrimp taken in bated screen-wire traps at Port Allen, across the Mississippi River from Baton Rouge, La., where the shrimp are fished commercially, in fresh water. M. ohionis moves into Barataria Bay in spring and is caught along with Penaeus setiferus (white shrimp) in trawls. Of 93 M. ohionis 38-91 mm long caught in Barataria Bay, over 80% were females carrying eggs. The bottom salinity of Barataria Bay where river shrimp were caught ranged from 1.38 to 14.24 ppt and averaged 6.97 ppt. The eggs carried by the shrimp seemed to be developing normally. (S. H. Hopkins)

Gunter, G. 1938a. Notes on invasion of fresh water by fishes of the Gulf of Mexico, with special reference to the Mississippi-Atchafalaya River System. Copeia, 1938:69-72.

The following fish were reported in fresh water at Simmesport, La., in 1936: the gulf shark, Carcharinus platyodon; the common stingaree, Dasyatis sabina; "little flounders," Trinectes maculatus; mullet, Mugil cephalus; and tarpon. Reports of the same species from other freshwater areas are cited. Migration into fresh water by marine fish is not uncommon. "The discovery of fossils in freshwater deposits does not mean necessarily that the species was a freshwater fish or originated in fresh water" (p. 72). (S. Rennie)

Gunter, G. 1938b. Seasonal variations in abundance of certain estuarine and marine fishes in Louisiana with particular reference to life histories. Ecol. Monogr., 8:313-346.

Data are presented for October 1931 to March 1934, on 28 teleost and 1 elasmobranch fish caught by trawl in Barataria Bay and the adjacent gulf. Results are presented in 3 tables and 16 graphs. Sequential, seasonal, and yearly variations were found. Fish taken in the bay were smaller than those caught in the gulf because the bay serves as nursery grounds for most of the species studied. (S. H. Hopkins)

Gunter, G. 1938c. The common blue crab in fresh waters. Science, 87(2248):87-88.

A specimen of juvenile Callinectes sapidus Rathbun was reported 160 miles from the sea in the Atchafalaya River at Simmesport, La. The range of C. sapidus is Nova Scotia to Uruguay, and it probably invades pure fresh water over its whole range. Other reports in fresh water are cited. (S. Rennie)

Gunter, Gordon. 1938d. The relative numbers of species of marine fish on the Louisiana coast. Amer. Naturalist, 72:77-83.

Based on trawls, data show the croaker Micropogon undulatus to be the most abundant species of fish on the Louisiana coast, followed by Stellifer lanceolatus and Anchioviella epsetus. Of the last two, the former predominated in the gulf while the latter was most numerous in the bays. Due to the small size of the anchovy, it easily passed through the trawl mesh, and could very well have been the most abundant fish along the coast, although the sampling method did not show it.

The most common family was the Sciaenidae, and the most common order the Acanthopteri. The data did not show which groups were the most successful. (S. Rennie)

Gunter, G. 1942a. A list of the fishes of the mainland of North and Middle America recorded from both fresh water and sea water. Am. Midland Naturalist, 28:205-326.

Gives long list of species with specific records from literature. Discusses problems of adaptation to changes in salinity. Table 1, p. 320, gives numbers in taxonomic groups adaptable to both fresh and salt water, and percentage of total number of species: Cyclostomes, 4 (28.6%); elasmobranchs, 9 (5.7%); ganoids, 5 (27.8%); isospondylids, 43 (12.6%); isospondylids to acanthopterygiids, 26 (2.2%); and acanthopterygiids, 86 (3.5%). Table 4, p. 322, lists species found in both fresh and salt water by environmental affinities, and text (p. 322) points out that purely marine species on list outnumber freshwater species by 9 to 1. In addition, there are 17 predominantly marine fishes on list to 8 predominantly freshwater species. Added are 31 anadromous and 1 catadromous. Altogether, the list numbers 175 species, according to table 4 (173 according to text, p. 323). (S. H. Hopkins)

Gunter, G. 1942b. Seasonal condition of Texas oysters. Proc. and Trans. Texas Acad. Sci., 1941, 25:89-93.

Data from the Crawford Packing Co., Palacios, Tex., for 1937-1939 show that the condition of oysters was better during the spring than during the fall. This is probably due to the greater food reserves stored in the spring and the presence of gonadal material at that time. The yield for wild reefs in east Matagorda Bay declined after March 1934, when the Colorado River mouth was opened up artificially and induced to cross the east arm of the bay and empty into the Gulf of Mexico, thus reducing flow of fresh water into the bay and raising its salinity. (S. Rennie)

Gunter, Gordon. 1945. Studies on marine fishes of Texas. Publ. Instit. Mar. Sci., Univ. of Texas, 1(1):1-190.

This paper establishes distributional relations of Texas coastal fish to salinity, noting certain effects of temperature. Life history notes on many species are included. The coastal study area, described in detail, included a back bay, part of the lagoon, and the adjacent Gulf of Mexico near Port Aransas. Nearly the entire salinity gradient from fresh to salt water was covered.

Overall, 119 species were caught. The anchovy, menhaden, mullet, and croaker have the largest species masses of any fish on the Texas coast. Distribution according to habitat, salinity, and temperature is discussed. Seasonal migrations related to temperature are discussed. In winter the migration is out of the bays into the gulf. Spawning times are noted. Most of the fish in the brackish bays are marine rather than fresh water. In general, the smaller specimens were usually found in the freshest water and the largest in saltier water.

The effects of a mild cold spell are discussed pointing out which species suffered the most losses, and where they were located.

Extensive data on distribution, species composition, sizes, and hydrographic parameters are included. (S. Rennie)

Gunter, Gordon. 1947a. Distributions related to salinity, and seasonal population changes of certain marine invertebrates of Texas. Anat. Rec., 99(4):615 (Abs.).

"Invertebrates were taken in nets over an area extending from fresh water to pure sea water from March 1941 to November 1942. Shrimp of the family Penaeidae are the predominant macroinvertebrates of the Texas coast. Seasonal variations in total abundance are dominated chiefly by changes in the populations of the penaeid shrimp, swimming crabs, and palaemonid shrimp, the latter being confined to bay shores. Small shrimp and crabs tend to remain in the shallows. Invertebrates in waters of low salinity average smaller than those of the same species in saltier water. Most species can withstand high salinities but many cannot withstand low salinities. Therefore, as the salinity decreases along the salinity gradient toward fresh water, certain species disappear. There is no increase in number of species by invasion from fresh water. Therefore, the number of species in waters of low salinity are low, but those present are marine and the number of species in the gulf is greater than in the bays. Certain gulf species enter the bays and many species grow up there in the warm months. There is a movement of crustacea away from the shallows and a vast seaward movement in the fall, that of the commercial shrimp being most striking. Several species leave the bays entirely during the winter. Similarly certain gulf species go to deeper water and disappear. In the spring most species spawn and the young start growing up in the bays again." (Author's abstract)

Gunter, G. 1947b. Paleoecological import of certain relationships of marine animals to salinity. Jour. Paleont., 21(1):77-79.

Ancient animals were probably more euryhaline than those of today. Paleontologists should be very careful when deciding if a fossil in freshwater deposits is actually a freshwater species. Number of species and size of individuals both increase as salinity increases (to oceanic salinity), based on present-day findings. (S. H. Hopkins)

Gunter, G. 1947c. Size of marine fishes entering fresh water. Anat. Rec., 99(4):643 (Abs.).

"Marine fishes in waters of low salinity are smaller than members of the same populations in salt water, due to characteristics of life histories. Marine fishes invading fresh water, except for anadromous species, come from the smaller fishes in brackish waters. Records in the literature show clearly that many small marine fishes invade fresh water. The few records giving length measurements show that marine fishes in fresh water run smaller in size than their congeners in salt water. Certain ichthyologists have made the same general observation in the field. These facts are all taken as mutually supporting evidence for proof by the inductive method that marine fishes which enter fresh water are chiefly the small, young individuals. Physiological differences between old and young animals must be considered in connection with the problems of euryhalinity." (Author's abstract)

Gunter, Gordon. 1947d. The euryhalin fishes of North America. Anat. Rec., 99(4):612 (Abs)

"Most large rivers offer instances of marine fishes entering fresh water and some freshwater fishes invade the sea. A species which may be found in both fresh water and sea water, under natural conditions, is considered for the present purpose to be euryhalin. A list of the euryhalin fishes of North and Middle America contains 134 species. All anadromous fishes, except two, are of lower, less specialized types and all are confined to the northern and temperate zones. A greater proportion of marine fishes entering fresh water are higher fishes in the tropics than is the case in temperate North America. The percentage of euryhalin species is much greater for the lower fishes than for advanced fishes. The number of marine fishes which enter fresh water outnumber by 10 to

l the freshwater species which go to sea." (Author's abstract)

Gunter, Gordon. 1950. Seasonal population changes and distributions as related to salinity of certain invertebrates of the Texas coast, including the commercial shrimp. Publ. Instit. Mar. Sci., Univ. of Texas, 1(2):7-51.

Sampling took place during 1941-1942 from the headwaters of Copano Bay to 5 miles offshore in the Gulf of Mexico, covering nearly the entire salinity gradient. Although collecting was primarily for fish, data on some invertebrates were adequate. Penaeus setiferus and P. aztecus with P. duorarum made up 82% of the numbers of invertebrates caught.

Fewer species were taken in the bays than in the gulf due to the lowered salinities. Seasonal migration of fish, shrimp, and other motile invertebrates in winter is related to temperature, not salinity. Generally, in the bays the greatest numbers were caught in the fall and the fewest in the winter. For the gulf, few were caught in winter and most in spring and fall, while generally catches were smaller year-round than in the bays. Invertebrates in less salty water are usually smaller than those of the same species in high salinities. In this case, the correlation between size and salinity is due to movement during the life cycle of the whole population of a species.

Life history notes on several species are presented in the text. (S. Rennie)

Gunter, Gordon. 1951. The West Indian tree oyster on the Louisiana coast, and notes on growth of the three gulf coast oysters. Science, 113:516-517.

The three oysters on the gulf coast are Crassostrea virginica (Gmelin), Ostrea equestris Say, and the West Indian tree oyster Ostrea frons (Linnaeus). Minimum daily growth rates for the three are 0.26, 0.23, and 0.19 mm, respectively. An oil platform 5 miles SE of Barataria Pass, Louisiana, in 1950 had an association of the three oysters present at the same time. C. virginica was found living higher up in the less saline water, while the others were located in the deeper saltier water. This is the first report of all three living together in one locality or on one structure, and of tree oysters growing on the northern gulf coast. (S. Rennie)

Gunter, G. 1952. Historical changes in the Mississippi River and the adjacent marine environment. Publ. Instit. Mar. Sci., Univ. of Texas, 2(2):119-139.

Levee construction started gradually in 1717 until around 1880 when it was accelerated to the 1930's. At that time it was greatly extended and stabilized, resulting in the highest flood heights due to containment of the river. By 1904 three of the four main distributaries of the Mississippi were cut off from the main channel, forcing more water to pass down the Atchafalaya River to the west. Today at minimum stages the Atchafalaya is exceeded in flow only by the Ohio and Mississippi. As a result there is less of an annual cycle of salinities in the bays and the bay salinities are higher.

Breaks in levees cause extreme effects on local areas since the flows come higher and faster. Construction of spillways has alleviated formation of these crevasses during flood time, for the most part. The area around the Mississippi Delta is sinking. The sea level is rising due to melting of polar ice caps.

"...the influence of man (has caused) the Mississippi River to carry greater... amounts of silt and flood water all the way down to its mouth and into the gulf...." Spawning areas for fish, and feeding areas for water fowl, have decreased with loss of the overflow areas.

With the major source of sediment cut off and a sinking coastline, the islands and surrounding land have begun to waste away, so islands are moving shoreward. This results in a deepening of the bays and a possible increase in salinity. The extent of the intertidal zone will not change but it will move progressively inland. While there is a general decrease in the amount of nutrient salts reaching the bays, there is an increase at the mouths of the Mississippi and Atchafalaya.

There is evidence from the oyster industry that the salinity of certain Louisiana bays has increased in historic times. The change in the distribution of salt and fresh water probably came with the white man and the levees.

The main effect of changes in the coast on the marine life is a reduction in the white shrimp populations due to elimination of spawning grounds, and reduction of oyster production due to increased salinities. (S. Rennie)

Gunter, G. 1953. The relationship of the Bonnet Carré Spillway to oyster beds in Mississippi Sound and the "Louisiana Marsh" with a report on the 1950 opening. Publ. Instit. Mar. Sci., Univ. of Texas, 3(1):17-71.

"In two out of three openings (of the spillway) the effect has been all good.... In the long run...the total beneficial aspect of the spillway to the marine life of the affected area outweighs the oyster mortality in some years." "Spillway discharges kill out oyster pests and predators and put thousands of tons of nutrient salts into the area."

The relation of the Bohemia Spillway and Baptiste Collette Gap to oysters of nearby waters is described in comparison with the Bonnet Carré Spillway area. In the former cases, oysters lie closer to the source of fresh water and oysters are subject to more violent fluctuations of salinity. The oysters are also subject to siltation due to a lack of a settling basin, although this is not serious. Generally, mortalities from low salinity can be expected here more often.

Extensive appendixes give detailed descriptions of the oyster beds studied in Mississippi Sound and the Louisiana Marsh and results of water analyses of the 1950 Bonnet Carré Spillway operation. (S. Rennie)

Gunter, G. 1955. Mortality of oysters and abundance of certain associates as related to salinity. Ecology, 36(4):601-605.

Oysters were placed in trays at each of five stations in Copano and Aransas Bays, Texas, and mortality was followed from July 1949 to January 1950. The stations were arranged along a salinity gradient. Mortality known to be caused by predators (Thais, Menippe) and mortality from unknown causes both increased from low to high salinity. Salinity ranged from 17.1 to 21.1 ppt at sta I, from 18.2 to 22.9 ppt at sta II, from 18.7 to 25.9 ppt at sta III, from 21.3 to 29.7 ppt at sta IV, and from 23.1 to 36.1 at sta V. Even the small differences in salinity from one station to the next were accompanied by differences in fauna associated with the tray oysters, and these differences between stations persisted through salinity fluctuations. The numbers of species of marine animals decline along the salinity gradient as it approaches fresh water. Thus, oysters are subjected to greater predation and parasitism at higher salinities. Apparently that situation explains the higher incidence of predatory and nonpredatory mortality in higher salinity, as observed in this and other studies. (S. H. Hopkins)

Gunter, G. 1956a. A revised list of euryhalin fishes of North and Middle America. Am. Midland Naturalist, 56:345-354.

Excluding all but species reliably recorded from both true fresh and pure sea water (which excludes all Florida records because fresh water is abnormally saline), the list contains 150 species: 1 catadromous (eel, Anguilla rostrata), 34 catadromous, 10 fishes living in salt water but derived from freshwater stock, 9 living in fresh water but derived from marine stock, 8 freshwater fishes, and 88 marine fishes including 5 elasmobranchs. Table I on p. 353, like Table 1 in Gunter (1942a), tabulates euryhalin species by taxonomic groups. Marine fishes invading fresh water (other than anadromous species) are predominantly small or young individuals. (S. H. Hopkins)

Gunter, Gordon. 1956b. Principles of shrimp fishery management. Proc. Miami Univ. Lab. Gulf and Caribbean Fish. Instit., 8:99-106.

The three major commercial shrimps harvested in the Gulf of Mexico are, in order, the brown shrimp, Penaeus aztecus Ives, white shrimp, Penaeus setiferus (Linnaeus), and pink shrimp, Penaeus duorarum Burkenroad. The shrimping grounds for these are, briefly, two discrete areas in the southern gulf for pink shrimp, the northern and western gulf down to Yucatan for the brown shrimp, and the mouth of the Mississippi for white shrimp.

The salinity limits are only slightly lower for white shrimp than for browns, the whites being more common in fresher waters. Pink shrimp do not often invade low-salinity waters.

Considering growth, spawning, and mortality rates in terms of maintaining the large population of shrimp available for fishing, he proposes that bays should be completely closed to shrimping in July, August, and September, if not at all times. This is based on the idea that the fast growth rate of bay shrimp more than compensates for mortality. Therefore, it is best to wait for small shrimp to grow in the bays and not catch them until the fall. (S. Rennie)

Gunter, Gordon. 1956c. Some relations of faunal distributions to salinity in estuarine waters. Ecology, 37(4):616-619.

Based on recent study of lower Mermenteau River basin (Louisiana) and earlier work, Gunter presents some general conclusions on the title subject, backed up by three tables on his 1951-1953 work. P. 617: "The tables presented here show that both in species and numbers of specimens the marine species predominate [in brackish water], and in number of specimens the predominance is overwhelming." "The statement that the fauna of low-salinity estuarine waters is marine applies to the invertebrates as well as the fishes." P. 618: "Redeke (1932) came to the conclusion that the chloride content of the water was the most important factor governing the distribution of estuarine species, a view which has been questioned by other workers. The works of Segerstrale (1951, 1953) and Kilby (1955) agree with Redeke's conclusions. The observations recorded here also tend to confirm his views." ...animals distribute themselves over definite salinity ranges and seem to be quite sensitive to salinity differences near the lower side of these ranges.... Nearly all estuarine animals, except a few transients from fresh water, can tolerate full sea water." (S. H. Hopkins)

Gunter, Gordon. 1957a. Predominance of the young among marine fishes found in fresh water. Copeia, 1957(1):13-16.

Evidence from the literature shows many examples of young marine fish entering fresh water. Among 22 species of fish, those taken in water of lower salinity were smaller than those taken in saltier water. Several species showed direct relation between salinity and size. Marine fish in brackish water are of smaller size than fish of the same species in saltier water. Such differential size distribution of fish as related to salinity is a result of the life history cycle, and is not due to separate populations of fish living in waters of different salinity. The physiological differences of young and old animals must be considered in connection with the relations of marine animals to the salinity of the environment. (S. Rennie)

Gunter, G. 1957b. Wildlife and flood control in the Mississippi Valley. Trans. N. American Wildlife Conf., 22:189-196.

Natural and artificial changes in the Mississippi River watershed are reviewed. Flood levels have generally become higher due to channelization of the river. Reservoirs have helped relieve this problem. Cutting off distributaries has dried up swamps formerly used as nursery areas for aquatic life and has increased salinity in estuaries, to the detriment of oyster beds. Reservoirs have added new shallow-water and swampy areas for waterfowl and aquatic life, and kept some silt inland that used to be carried to sea. Control structures at the heads of distributaries could be used to make effects of man-made changes less adverse

or more beneficial. Moving levees back from the river, in sparsely inhabited areas, would give wildlife new places to live and reproduce, on the lower river, and would raise the groundwater level. Greater demands for fresh water may cause more floodwaters to be diverted for later use and thus partly relieve the flood problem. (S. H. Hopkins)

Gunter, G. 1961a. Salinity and size in marine fishes. Copeia, 1961(2):234-235.

The papers of Reid and Hoese (1958) and Reid (1956) are criticized, especially the conclusion that salinity is not the cause of the size distribution of the two species of croakers studied. Gunter points out that the salinities in East Bay in the years concerned were intermediate, not representing a large part of the gradient from fresh water to sea water, and the data of Reid and Hoese only show that mixed sizes occur in intermediate salinities. (S. H. Hopkins)

Gunter, G. 1961b. Some relations of estuarine organisms to salinity. Limnol. and Oceanogr., 6:182-190.

The endemic fauna of estuaries is largely sessile, the few endemic motile species being chiefly fishes and crustaceans. Motile fauna is mostly young of species that spawn offshore in higher salinity. Estuaries are nursery grounds. Sessile or slightly motile marine organisms become stunted when salinity is above or below optimum for growth. The young of motile animals distribute themselves in the lower salinities and migrate toward sea as they grow, so that size gradient corresponds to salinity gradient. All marine and most estuarine organisms can stand full sea water, but some cannot stand lowered salinities, so the number of species declines going up estuary to lower salinity. A similar decline in species numbers occurs going up salinity gradient in hypersaline lagoon. (S. H. Hopkins)

Gunter, Gordon. 1967a. Some relationships of estuaries to the fisheries of the Gulf of Mexico. Pp. 621-638. In: Lauff, G. H., ed. Estuaries. Am. Assoc. Adv. of Sci. Publ. 83, Washington, D. C., xv + 757 pp.

Salinity effects are referred to throughout, but especially in the section "Relations of the salinity factor to distributions of estuarine organisms," pp. 628-631. Effects of salinity on populations of fishes, shrimps, and oysters are emphasized. The part of the Gulf of Mexico around the mouth of the Mississippi River, from the Alabama-Mississippi line to southeastern Texas, is called the "fertile fisheries crescent" (map, fig. 1, p. 622) because of the fresh water and nutrients poured into the gulf by this great river. (S. H. Hopkins)

Gunter, Gordon. 1967b. Vertebrates in hypersaline waters. Contrib. to Mar. Sci., Univ. of Texas, 12:230-241.

The author excludes nonmarine or inland hypersaline waters, which contain no fishes, and limits discussion to hypersaline waters derived from partly enclosed arms of the sea, such as the Gulf of Karabugaz, Bulgarian limans, the Santa Lucia Estuary of Zululand, and especially the Sivash, narrowly connected with the sea of Azov in southern USSR, and the Laguna Madre of southern Texas and northeastern Mexico.

Most of the discussion is based on firsthand knowledge of the Laguna Madre of Texas. The only vertebrates in this coastal lagoon are elasmobranch and teleost fishes, euryhaline estuarine species that can adapt to salinities of 50 to 75 ppt often found in the Laguna. Elops saurus, Anchoa hepsetus, Fundulus similis, Cyprinodon variegatus, Menidia beryllina, Mugil cephalus, Lagodon rhomboides, Cynoscion nebulosus, Pogonias cromis, and Micropogon undulatus can live in salinity as high as 75 ppt, but all fish die in occasional extreme seasons when salinity goes to 100 ppt. During high salinity years many old fish become blinded. Yet this is the most productive bay in Texas, based on catch of fish. Extension

of the Intracoastal Waterway through the Laguna improved fish conditions. (S. H. Hopkins)

Gunter, G., Christmas, J. Y., and Killebrew, R. 1964. Some relations of salinity to population distributions of motile estuarine organisms, with special reference to penaeid shrimp. Ecology, 45:181-185.

The kinds of shrimp in coastal waters change as salinities rise or fall. Lower salinity limits are: Penaeus fluviatilis 0.42, P. aztecus 0.80, and P. duorarum 2.5 ppt, in northern gulf waters. Different workers have shown that young white shrimp were most abundant in salinities below 10 ppt, brown shrimp in salinities of 10-20 ppt, and pink shrimp in salinities of 18 ppt and above. Commercial catches of white shrimp are greatest in low-salinity waters of Louisiana, brown shrimp catches are greatest in saltier bays of Texas, and greatest catches of pink shrimp are in waters around south Florida islands in oceanic salinity. The three commercial species can be ranked in order of salinity "preference" as: low, white (P. fluviatilis); intermediate, brown (P. aztecus); high, pink (P. duorarum). Also, pink shrimp have been taken in Laguna Madre at salinity of 65 ppt, and the other two species have not been taken above 45 ppt. Salinity is a limiting factor to the distribution and abundance of shallow water penaeid shrimp. (S. H. Hopkins)

Gunter, Gordon and Hall, G. E. 1963. Biological investigations of the St. Lucie Estuary (Florida) in connection with Lake Okeechobee discharges through the St. Lucie Canal. Gulf Research Reports (Ocean Springs, Miss.), 1(5):189-307.

The outflow of fresh water through the lock and dam does not damage commercial fishing. It causes temporary turbidity and pushes a few high-salinity species into lower estuary or ocean, but no fish are killed, and reproduction of common estuarine species is enhanced. These forage fishes serve as food for larger fishes. Total production and fertility of the area are increased by outflows of fresh water. (S. H. Hopkins)

Gunter, Gordon and Hildebrand, Henry H. 1954. The relation of total rainfall of the state and catch of the marine shrimp (Penaeus setiferus) in Texas waters. Bull. Mar. Sci. Gulf and Caribbean, 4(2):95-103.

The authors have shown that the catch of shrimp in Texas marine waters is correlated with the total rainfall of the state from 1927 to 1952. Specifically, the rainfall amounts of 1 to 3 years previous are more indicative of a year's shrimp production than the rainfall of that year. Although coastal rainfalls add little nutrients to the bays, they are instrumental in lowering salinity of the bays and, with extreme amounts, raise the water level, creating more and better environmental conditions for shrimp to grow in. (S. Rennie)

Gunter, G. and Shell, W. E., Jr. 1958. A study of an estuarine area with water-level control in the Louisiana marsh. Proc. Louisiana Acad. Sci., 21:5-34.

The area studied included two large estuarine lakes and a connecting bay in the coastal marsh of the Mermentau River Project. Salinities ranged from 0.08 to 4.05 ppt and the fauna was predominantly marine. Menhaden, anchovy, croaker, and commercial shrimp were the most abundant species caught, while Rangia cuneata and Ictalurus furcatus were common in the lakes.

The present program of opening and closing the lock gates was found not to interfere with the commercially and economically import marine species except for the white shrimp.

The chloride contents of samples of marsh waters were found to be higher than adjacent bay waters, except after rains. (S. Rennie)

Gunter, G., Williams, R. H., Davis, C. C., and Smith, F. G. W. 1948. Catastrophic mass mortality of marine animals and coincident phytoplankton bloom on the west coast of Florida, Nov. 1946 to Aug. 1947. Ecol. Monogr., 18:309-324.

Mass death of marine invertebrates and fishes (also turtles and dolphins) was due to abnormal abundance of the dinoflagellate Gymnodinium brevis, whose toxicity was demonstrated in laboratory experiments. Salinity was 30.6 to 37.0 ppt except in Estero Bay (21.4 ppt), and was not abnormal. (S. H. Hopkins)

Gurney, Robert. 1923. Some notes on Leander longirostris M. Edwards, and other British prawns. Proc. Zool. Soc. London, 1923(7):97-123.

Leander serratus, L. squilla, L. adspersus, L. longirostris, and Palaemonetes varians are discussed. Although all have been reported from brackish water at some time, L. longirostris and P. varians are specifically located in brackish waters of estuaries and salt marshes, respectively. (S. Rennie)

Gurney, R. 1931. British freshwater Copepoda. Ray Society, London, Vol. I, 238 pp.

Discusses the family temoridae which has a number of brackish-water species, some of which penetrate into fresh water. Best known brackish-water genus is Eurytemora with about 16 species. E. velox lives in both fresh and brackish water, some others live only in brackish water. E. affinis and E. hirundoides live in both European and North American estuaries. Fide Green, 1968, pp. 89-90. (S. H. Hopkins)

Habas, L. B. and Prosser, C. L. 1966. Effect of acclimation to various salinities on potentials in isolated crab gills. Biol. Bull., Woods Hole, 125:379.

Callinectes sapidus maintains blood hyperosmotic to dilute media. The electric potential of isolated gills is +3 to -4 mv in sea water, 0 in 80% sea water, -6 mv in 50% sea water, and +6 mv in 150% sea water. The point of 0 potential is changed by acclimation of crab. Crabs acclimated to 120% sea water show a negative gill potential below 130% sea water. Crabs kept in 3% sea water for 3 weeks then show positive potential down to 50% sea water. It is postulated that negative gill potential results from passive loss of Na, while positive potential is due to active uptake of Na exceeding the passive loss. Acclimation is thought to increase active transport capacity, enabling the gill to maintain a positive potential in more dilute sea water. In isolated gills of Libinia emarginata (a stenohaline, osmoconforming crab) there are no potentials at all in 50% to 100% sea water. (S. H. Hopkins)

Hada, Y. 1936. Studies of the Foraminifera of brackish waters. I. Hijirippu and Mochirippu lakes. Zool. Mag., 48(8,9,10):847-860. (Japanese with English summary.)

The fauna of two brackish-water lakes is described with notes on the occurrence and ecological conditions under which the species live. (E. H. Myers and W. S. Cole, 1957, Geol. Soc. Amer. Mem. 67, Vol. 1, p. 1077.)

Hada, Y. 1937. Studies on the Foraminifera of brackish waters. II. Hachiro-Gata. III. Koyama-Ike. Zool. Mag., 49(10):341-347. (Japanese with English summary.)

Cosmopolitan species are commonly found in brackish waters, and these species have strong resistance against changes of temperature and salinity. However, brackish-water species are usually smaller than those from normal marine waters. Species adapted to brackish waters produce large numbers of individuals. (E. H. Myers and W. S. Cole, 1957)

Haefner, Paul A., Jr. 1963. On the growth increment of blue crabs, Callinectes sapidus Rathbun, during ecdysis in different salinity waters. Dissert. Abs., 23(8):3041.

Field studies on immature, female blue crabs (Callinectes sapidus Rathbun) were conducted to determine if environmental salinity was responsible for known differences in body size of adult female blue crab populations of the Delmarva Peninsula. Premolt crabs from each of three geographical areas (representing three different saline environments) on the Delmarva Peninsula were retained through the mature molt in each area and analyzed for increase in length. Analysis of variance failed to indicate that either geographical area or salinity caused a significant difference in increase in body size.

Growth in crabs was studied under more controlled laboratory conditions, emphasis being placed on effects of salinity and calcium variations on weight increase.

Hemolymph-to-sea-water-calcium ratios were found to differ markedly depending upon salinity, due to constancy of hemolymph concentration and variation of the sea-water calcium. Significant differences in percent weight change appeared in the late postmolt period between high salinity (30 ppt) and low salinity (9 ppt) crabs. Water uptake, however, was similar for all crabs regardless of environmental salinity.

The greater increase in weight in high-salinity crabs seems to be the result of more rapid calcium deposition in the shell. This difference is due to the lower hemolymph-to-sea-water-calcium concentration gradient (1/1) existing in high saline water as opposed to a gradient of 5/1-8/1 in the low saline water.

The data collected during this research do not support the thesis that

naturally occurring differences in body size of adult female blue crabs found in the Delmarva Peninsula region are due to different hemolymph-to-sea-water-calcium ratios established in waters of various salinities. (Author's abstract)

Haefner, Paul A. 1964. Hemolymph calcium fluctuations as related to environmental salinity during ecdysis of the blue crab, Callinectes sapidus Rathbun. Physiol. Zool., 37(3):247-258.

Three experimental salinities were used, 9, 22, and 30 ppt. Water content of crabs increased during molting process in all salinities, from 62%-67% to 85%-86%. Percent weight change was significantly different between 9 and 30 ppt but not between either and 22 ppt. Hemolymph calcium fluctuated during premolt period in all salinities, in all cases fell to a postmolt value near 250-300 ppt, and was significantly different in the three salinities. Growth in length during and after molt was not significantly different in different salinities. It is speculated that crabs in low salinity may have lighter shells, but to test this hypothesis will require more research. (S. H. Hopkins)

Haefner, Paul A., Jr. 1967. Hydrography of the Penobscot River (Maine) Estuary. Jour. Fish. Res. Bd., Canada, 24(7):1553-1571.

Temperature, salinity, density, pH, and dissolved oxygen were monitored along a 29-mile stretch of the estuary. River discharge controls the effect of tidal salinities. The lower estuary is subject to some stratification throughout the year.

Effluents from paper, pulp, and tanning industries pollute the upper estuary. Benthic organisms are nearly absent there due to poor substrate (sawdust) as well as chemical pollution and low oxygen supply. Benthic forms increase in numbers seaward due to improvement of environmental conditions. Salinities were 25-32 ppt and the fauna was characteristically marine. (S. Rennie)

Haefner, P. A., Jr. 1969. Temperature and salinity tolerance of the sand shrimp Crangon septemspinosa Say. Physiol. Zool., 42(4):388-397.

Male and female sand shrimp, C. septemspinosa, were subjected to 12 temperature-salinity combinations within the ranges of 4-23 C and 5-40 ppt salinity. Mortality data from this design were used in fitting response surfaces for the purpose of estimating the temperature-salinity conditions at which the adult shrimps would exhibit maximum survival. They exhibited greatest survival to a wide range of salinity (18-39 ppt) within a limited temperature range of 10-14 C. Lower or higher temperatures reduced the salinity range in which maximum survival occurred. Experimental results were compared with field data on this species. The data of C. septemspinosa were compared with information available on a European species, C. crangon. C. septemspinosa shows maximum tolerance over a wider range of salinities at higher temperatures than does C. crangon. (P. Maxwell)

Haefner, P. A., Jr. 1970. The effect of low dissolved oxygen concentrations on temperature salinity tolerance of the sand shrimp Crangon septemspinosa Say. Physiol. Zool., 43(1):30-37.

Adult sand shrimp, C. septemspinosa, were subjected to low dissolved O_2 concentration (2-3 ppm) at 12 combinations of temperature and salinity within ranges of 5-23 C and 5-45 ppt, respectively. Mortality data from this design were used to fit response surfaces for estimating the influence of low O_2 tension on the temperature-salinity tolerance of the species. Maximum survival (100%) of adult shrimp is not possible within thermohaline environment of estuaries if low O_2 tensions persist for several days. Female shrimp are more sensitive to low O_2 concentrations than males while berried females are most susceptible. The lowest observed mortalities occurred at 5 C at a salinity of 25 ppt for male and non-ovigerous females and 45 ppt for ovigerous shrimp. A noticeable difference

between the response surfaces derived for shrimp maintained in aerated and hypoxic conditions is that, in the latter case, the tolerance zones are shifted toward lower temperatures and higher salinities. It would appear that, in a hypoxic estuarine zone, any seaward or offshore migration to cooler, more saline water would be of survival value to the species. (From Biol. Abstr.)

Haefner, Paul A., and Shuster, C. N., Jr. 1964. Length increment during terminal molt of the female blue crab, Callinectes sapidus, in different salinity environments. Chesapeake Sci., 5(3):114-118.

Three groups of "peeler" crabs were placed in live boxes through the molting stage in three different salinity range environments (8-17 ppt, 14-20 ppt, and 23-35 ppt). Cephalothorax length was measured before and after ecdysis. When analyzed statistically, the percent increment of growth of the crabs at the three salinity ranges showed no significant differences at the 5% level. (T. Rennie)

Haertel, Lois and Osterberg, Charles. (Dept. Oceanogr., Oreg. State Univ., Corvallis, Oreg., USA). 1967. Ecology of zooplankton, benthos and fishes in the Columbia River Estuary. Ecology, 48(3):459-472, illus., map.

Changes in the salinity of the estuary were reflected in the composition of the plankton. Majority of fish and benthic invertebrates in estuary are euryhaline. Where plankton blooms occur so does the largest number of fish species and largest number of individuals. (S. H. Hopkins)

Hagerman, Lars. 1969. Environmental factors affecting Hirschmannia viridis (O. F. Müller) (Ostracoda) in shallow brackish water. Ophelia, 7(1):79-99.

Between 1966 and 1969, the ostracod ecology was studied in Saluiken, Øresund, with particular emphasis placed on H. viridis. These ostracods live among green and brown algae in rock pools and in shallow water. This gives them a salinity range between 4 and 22.5 ppt in open water (annual mean 9-10 ppt) and between 0.5 and 40 ppt in isolated pools. (From Biol. Abstr.)

Hagerman, L. 1970a. The oxygen consumption of Crangon vulgaris (Fabricius) (Crustacea, Natantia) in relation to salinity. Ophelia, 7(2):283-292.

The O_2 consumption rate (OCR) of the sand-living C. vulgaris was measured at various temperatures and salinities. The OCR was compared for animals weighing 100 ± 10 mg and 200 ± 20 mg (wet weight) at various salinities at the temperatures +6, 13, and 20 C. At all temperatures, OCR was found to increase at salinities lower than about 20 ppt and at +6 and +13 C. It also increased at higher salinities, while no significant increase at higher salinities was found at +20 C. It is suggested that this OCR pattern reflects the osmoregulatory work, as Crangon is a homoiosmotic animal with isotony in 21-23 ppt. Only a small part of the respiratory increase is caused by higher activity at high and low salinities. (From Biol. Abstr.)

Hagerman, L. 1970b. The influence of low salinity on survival and spawning of Elysia viridius (Montagu) (Opistobranchia, Sacoglossa). Sarsia, 42:1-6.

The embryonal development and survival of adults of E. viridius in lowered salinities were investigated. Adults survived to 15 ppt but produced egg masses only to 17.5 ppt. Embryonal development normally took 5-6 days in 30 ppt, but was prolonged to over 8 days in 17.5 ppt. The percentage of abnormally developing eggs increased in low salinities, more than 90% abnormal in 17.5 ppt. The larvae hatched in a normal way within the range 30-20 ppt. (From Biol. Abstr.)

Hall, D. N. F. 1962. Observations on the taxonomy and biology of some Indo-West-Pacific Penaeidae (Crustacea:Decapoda). Colonl. Fish. Publ., London, 17:1-229.

Young penaeids penetrate far into low salinities in Malaya. Hall records 11 species in the mangrove swamps near Singapore. (S. H. Hopkins)

Hammer, L. (Inst. Oceanografico., Comana, Venezuela). 1968. Salzgehalt und Photosynthese bei marinen Pflanzen. (Salinity and photosynthesis in marine plants.) Mar. Biol., 1(3):185-190.

Marine plants, phanerogams and algae, show a proportional decrease of photosynthetic rate when salinity is lowered. Salinity may indirectly affect photosynthesis due to differences in C supply. The direct influence is caused by exosmosis and is irreversible. (S. H. Hopkins)

Hand, William G., Collard, P. A., and Davenport, D. 1965. The effects of temperature and salinity change on swimming rate in the dinoflagellates, Gonyaulax and Gyrodinium. Biol. Bull., 128(1):90-101.

Gonyaulax polyedra reached maximum swimming speed at 31 ppt, its speed decreasing above (up to 42 ppt) and below (down to 11 ppt) this salinity. Gyrodinium sp. reached maximum velocity in approximately 25 ppt, swimming at slower rates in higher salinities up to 45 ppt and in lower salinities down to 5 ppt, and at much slower rate in 2 ppt. These experiments were run at 20 C. The maximum swimming rate of Gonyaulax was attained at approximately 24 C, and of Gyrodinium at approximately the same temperature (24-26 C). (S. H. Hopkins)

Hanks, Robert W. 1964. A benthic community in the Sheepscot River Estuary, Maine. U.S. Fish and Wildlife Service Fish. Bull., 63(2):343-353.

Fifteen species accounted for 80% of total number of organisms. Variations within community are described, and some factors that may control size composition in the community are discussed. (S. H. Hopkins)

Hansen, D. V. 1967. Salt balance and circulation in partially mixed estuaries. Pp. 45-51. Lauff, G. H., ed. Estuaries. Am. Assoc. Adv. of Sci. Publ. No. 83., Washington, D. C., xv + 757 pp.

Kinematic relations. Dynamic relations. Some similarity solutions: solutions with constant salinity gradient, solutions with exponential salinity gradient. A nonsimilarity solution. Conclusion, many formulae, 11 graphs, 14 references.

Hardenberg, J. D. F. 1951. Estuarine problems in South East Asia. Proc. Indo-Pacific Fisheries Council, 2(2-3):175-180.

He describes the tropical estuary in the same general terms used to define a temperate system, noting one major difference. A stable, horseshoe shaped bar is located just in front of the river mouth, opening toward the river. The origin of the bars, which are also present where tributaries enter major streams, is not known. Tropical estuarine waters are highly colored by land runoff, often have low pH's, and are high in phosphates.

The fish and plankton are abundant. Shrimps (Penaeopsis and Parapenaeopsis) and Sergestids are common Crustaceans. The fish, which often inhabit only the deeper, dark waters, show surprising affinities to deep sea fish. Generally, the fish can be categorized as real estuarine, coastal, anadromous, catadromous, and occasional, all of which he gives examples. Throughout the paper he emphasizes how little is known of the fauna and hydrography of tropical estuarine systems. (S. Rennie)

Hargis, W. J. 1961. Research on the tidal Potomac. Pp. 38-44 In: Water management in the Potomac Estuary. Interstate Commission on the Potomac River Basin, 1961. (Reprinted as Contrib. No. 107, Virginia Institute of Marine Science, Gloucester Point, Va.)

Several hundred engineering projects are contemplated for the Potomac basin, including large and small dams, channels, wetland fill and drainage, etc. These will affect freshwater flow and turbidity, changing salinity, and silting in the estuary. This could affect biological productivity in the estuary, either beneficially or adversely; e.g., increase in salinity will change areas of setting but will also allow pests to invade oyster-growing areas. Model studies are needed to make possible prediction of effects. Physical and biological research is needed. (S. H. Hopkins)

Harper, D. E., Jr. 1968. Distribution of Lucifer faxoni (Crustacea:Decapoda: Sergestidae) in neritic waters off the Texas Coast, with a note on the occurrence of Lucifer typus. Contrib. Mar. Sci., Univ. of Texas, 13:1-16.

Low ranges of temperatures and low ranges of salinity were both associated with low numbers of this planktonic crustacean, and the highest numbers were associated with the highest temperature and salinity ranges. The same was true for larvae, as for adults, but temperature seemed to affect abundance of larvae more than salinity did. (S. H. Hopkins)

Harrington, R. W., Jr. 1971. How ecological and genetic factors interact to determine when self-fertilizing hermaphrodites of Rivulus marmoratus change into functional secondary males, with a reappraisal of the modes of intersexuality among fishes. Copeia, 1971(3):389-432.

Hermaphrodites of R. marmoratus, each in lifelong isolation, were exposed to one or another of eight combinations of alternative temperatures, salinities, and light intensities, for the first 3-6 months from 3/4 blastoderm or earlier ("early-rearing period"). For the rest of their lives they were kept in 40% sea water at near 25 C and exposed to natural day lengths except for one artificial short day season.... Scheduling of the sex changes was apparently unaffected by salinity, light intensity, or any of three morphoses (nonadaptive modifications) induced by early exposure to dim light and morphosis-specific salinity-temperature combinations. (From Biol. Abstr.)

Harshberger, J. W. 1909. The vegetation of the salt marshes of northern coastal New Jersey. Proc. Acad. Nat. Sci., Philadelphia, 61:373-400.

In field studies, reported observations on relative salt tolerance of various salt-marsh plants; e.g., reported Distichlis spicata to be more salt-tolerant than Spartina patens, according to Adams (1963, p. 454). (S. H. Hopkins)

Harshberger, J. W. 1911. An hydrometric investigation of the influence of sea water on the distribution of salt marsh and estuarine plants. Proc. Amer. Philos. Soc., 50:457-496.

Under field conditions (in New Jersey) found Spartina alterniflora and Spartina patens tolerant of salinities of 5-40 ppt and Distichlis spicata tolerant of 12-39 ppt, according to Adams (1963, p. 454). (S. H. Hopkins)

Hart, T. J. 1930. Preliminary notes on the bionomics of the Amphipod, Corophium volutator Pallas. Jour. Marine Biol. Assoc. U.K., n.s., 16:761-789; 4 text-figs., 23 refs.

This species lives on muddy bottoms in estuaries, but not where organic content is high and decomposition is taking place. Found at one place where salinity was 0.7-3.6 ppt, but author concludes it is an animal capable of standing great changes of salinity, but not a low-salinity animal, for it is as much or more abundant in high salinities. Chemical and physical character of substratum is the main factor determining its abundance. Analyses of bottom samples are given.

It is a "selective deposit feeder," mainly vegetarian, not a plankton feeder or carnivore on worms, etc.

Burrows into mud, making U-shaped burrows not more than 5 in. deep. In aquaria where mud is not deep enough for burrows they agglutinate mud into tubes. Corophium crassicorne regularly glues mud into tubes in which it lives.

Hartley, P. H. T. 1939. The Saltash tuck-net fishery and the ecology of some estuarine fishes. Jour. Mar. Biol. Assoc. U.K., 24:1-68.

The net described is used in the estuaries of the Tamar and Lynher Rivers, England. The fish fauna of the estuaries is essentially marine, all species spawning at sea except Salmo spp. and some Gobiidae. The flounder Pleuronectes flesus is the most typical fish. Other fish are listed with notes on life cycles, growth, food, etc. No salinity data are given. (S. H. Hopkins)

Hartley, P. H. T. and Spooner, G. M. 1938. The ecology of the Tamar Estuary. I. Introduction. Jour. Mar. Biol. Assoc. U.K., 22:501-508.

This introduces physical and biological studies made by several Phymouth Laboratory workers. Studies include salinity, temperature, penetration of daylight, macrofauna and microfauna of the intertidal zone, sessile flora and fauna of buoys, fish and their food, and birds. Tamar is tidal for 19 miles; 3 miles from sea it is joined by Lynher River to form a common estuary. Mudflats border the channel; only high intertidal is stony. Upriver there are "saltings" (salt marshes) of which Salicornia is the pioneer. Depth steadily decreases upstream in channel, from 124 km in harbor to 5 km from mouth, beyond which there are only two small spots more than 49 ft. Lynher shallows to 5 m at wide part, and 1 m at Sheviock Wood. Tamar above junction with Tavy exceeds 5 m in only two places. There is strong tidal scour in lower reaches. Mean high water spring tides are 7.28 ft above mean low water and ordinary high tides 5.58 ft at Devenport; mean high water neaps are 3.8 ft. Mean low water springs are -8.24 ft, making spring range average 15.5 ft; ordinary tide range is 11.6 ft, neap range 7.56 ft. Range decreases to 12.5 at Calstock and 8.5 at Marstow (spring). Greatest speed of tide current is 2-3/4 knots. (S. H. Hopkins)

Haskin, H. H. 1936. Investigations on the boring and reproductive activities of the oyster drills, Urosalpinx cinerea Say and Eupleura sp. Unpublished typed report. U.S. Bureau Fisheries, Washington, D. C.

Oyster-drilling snails in Delaware Bay could still move to oysters and drill through their shells when salinity was as low as 10-12 ppt; rate of drilling was the same as that at higher salinities. Drills (drilling snails) surviving in an area where some died each week from low salinity were unable to lay eggs. At slightly higher salinities, some egg cases were produced but all eggs died without hatching. Salinities fluctuated with each tide at these stations. Cited by Stauber in unpublished report, circa 1943 (Rutgers Univ.). (S. H. Hopkins)

Haskin, H. H. 1938. Effect of low salinity on embryos of Urosalpinx cinerea. Unpublished typed report. New Jersey Oyster Research Laboratory.

In areas where drilling snails were dying each week from low salinity, no eggs were laid; in areas with slightly higher salinity and lower death rate, a few egg cases were produced but eggs died without hatching. Salinity fluctuated with tides; e.g., falling more than 10 ppt in 4 hr during one observation period. Cited by Stauber, unpublished report, circa 1943. (S. H. Hopkins)

Haskin, H. H., Krueger, F., and Tweed, S. 1971. River flow and salinity on Delaware Bay. (Abs.) Proc. Nat. Shellfish. Assoc., 61:4-5.

In 1952-53, at the time of the second Delaware Diversion Case, it was predicted that the diversion of 800 mgd of water from Delaware River to New York City would adversely affect Delaware Bay oysters by allowing the drilling snail to move farther upbay and eat more oysters. On the basis of much data gathered since then, it has been found that given points in the bay have higher salinities than before the diversion during periods of higher river flow (above 15,000 cfs), but there is little difference between present and prediversion salinities during the critical periods of low river flow, and, consequently, there has been little movement of the oyster-drilling snails upbay.

Hatai, Shinkisshi. 1930. Contribution to the biology of the oyster, being a résumé of the 21 papers presented by the Japanese zoologists before the Fourth Pacific Science Congress to be held at Batavia-Bandoeng, Java. Proc. Fourth Pacific Science Congress (Batavia-Bandoeng, Java), 1929, Vol. III: 221-237; 8 figs.

[Reviews papers by Amemiya (2), Fujita, Hamada, Hirase, Ikari, Kobayashi, Kokubo, Kumagai, Kumano, Nozawa, Okazaki, Sawano, Sekine, Seno (3), Takatsuki, Tamura, Wakiya, Yazaki.] Pp. 226-228, and figs. 1-3, from Amemiya: Vertical distribution and salinity range of six species compared. Fig. 1, vertical distribution, graph: O. gigas, O. rivularis, and O. sikamea intertidal, sikamea most abundant in middle between low and high tide level, other two just above low tide level, O. rivularis entirely in lower half intertidal zone. O. spinosa in upper two-thirds intertidal zone, most abundant in upper half. O. denselamellosa entirely subtidal, 1-7 fathoms. O. circumpicta from upper intertidal zone to 5 fathoms below l.t.m.

Fig. 2, O. circumpicta, O. spinosa, and O. denselamellosa are high-salinity oysters, range approximately 25-35, while O. gigas, O. sikamea, and O. rivularis range from 8 or 10 to 30 or 33 (in habitat). Fig. 3, range salinity for development; the three low salinity species develop from 0-8 to approximately 35, others 14-18 to 40-50 ppt.

Haven, D. 1961. Eurasian water milfoil in the Chesapeake Bay and the Potomac River. In: Water management in the Potomac Estuary. Interstate Commission on the Potomac River Basin, 1961. (Reprinted as Contrib. No. 108, Virginia Institute of Marine Science, Gloucester Point, Va.)

This introduced plant, Myriophyllum spicatum, has within the last few years become a serious pest, blocking waterways, interfering with navigation and fishing, etc., in many fresh and brackish estuaries in Virginia and Maryland. It thrives in waters of salinities of 13 ppt and lower, but cannot become successfully established in areas with salinities above 15 ppt. (S. H. Hopkins)

Haven, D. S. 1957. Distribution, growth, and availability of juvenile croaker, Micropogon undulatus, in Virginia. Ecology, 38(1):88-97.

Croakers spawn in ocean not far from mouth of bay, and young enter bay. They grow slowly in winter, rapidly in spring and summer, and reach 175-180 mm by fall. Circulation in Chesapeake Bay is such that newly hatched young are carried to upper limits of saltwater intrusion in a few days; as they grow they move downstream. Smallest fish are farthest up estuaries. During their first year, juveniles are concentrated in waters of 0- to 18-ppt salinity. During the year, as they grow, they move downstream, and by the end of the first summer the brood of the previous late-summer-to-winter hatch has almost entirely vacated the estuarine area. (S. H. Hopkins)

Havinga, B. 1930. Der Granat (Crangon vulgaris Fabr.) in den hollandischen Gewassern. Jour. Cons. Perm. Int. Explor. Mer, 5(1):57-87.

A general account of the biology and life history of this shrimp in estuaries

of Holland (Zuiderzee, West Scheldt), referring to distribution of females and eggs of different stages, etc., in relation to salinity zones but not giving actual figures on the salinities. (S. H. Hopkins)

Hazel, C. R., Thomsen, W., and Meith, S. J. 1971. Sensitivity of striped bass and stickleback to ammonia in relation to temperature and salinity. California Fish. and Game, 57(3):138-153.

Toxicity of undissociated NH_4OH to striped bass (Morone saxatilis) and stickleback (Gasterosteus aculeatus) was determined by static bioassay at 15 and 23 C in fresh water, 33% sea water, and sea water. The 96-hr median tolerance limits (TLm) of striped bass in milligrams/liter of NH_4OH were as follows: at 15 C--fresh water 2.8, brackish water 2.8, and sea water 2.0; at 23 C--fresh water 1.9, brackish water 2.1, and sea water 1.5. The 96-hr TLm of sticklebacks were: at 15 C--fresh water 2.1, brackish water 5.2, and sea water 10.4; at 23 C--fresh water 1.8, brackish water 2.4, and sea water 2.3. The influence of salinity and temperature on the toxicity of undissociated ammonia was less for striped bass than for sticklebacks; or, sticklebacks were more resistant to ammonia poisoning at the higher salinities and the lower temperature. Striped bass were slightly more tolerant in brackish water than in fresh or sea water. (From Biol. Abstr.)

Hedgpeth, J. W. 1957a. Classification of marine environments. Pp. 17-27. In: Marine ecology and paleoecology. Geol. Soc. Am. Memoir. 67, New York, Vol. 1, viii + 1296 pp.

A review of the literature on classification of marine and estuarine environments. Fig. 4 and table 1, pp. 23-25, classifications of estuarine waters according to salinity, with accompanying terminology and corresponding salinities. Fig. 5, p. 25, "hydrographic climate polygons" including salinity with other factors.

Hedgpeth, J. W. 1957b. Estuaries and lagoons. II. Biological aspects. Pp. 693-729. In: Marine ecology and paleoecology. Geol. Soc. Am. Memoir. 67, New York, Vol. 1, viii + 1296 pp.

The colonization of estuaries, pp. 693-700, table 2, figs. 12-15. The estuarine facies: flora and fauna, pp. 700-711, figs. 16-20 and tables 3-6. Hypersaline lagoons, pp. 711-718, tables 7 and 8, figs. 21-23. Borders of estuaries, pp. 718-729, figs. 24-30, plates 1-3. Salinity relations are treated throughout.

Hedgpeth, J. W. 1966. Aspects of the estuarine ecosystem. In: A symposium on estuarine fisheries. Am. Fish. Soc. Publ. No. 3, Washington, D. C., viii + 154 pp. (pp. 3-11.)

P. 4: McGuire (1961) found that Palaemonetes kadiakensis can tolerate mildly saline water, but P. paludosus cannot tolerate strictly freshwater habitat after its internal salt balance has been upset. There are many such twin species in estuaries.

P. 8: In many estuaries of prevailingly low or high salinity such as the Sea of Azov, the Sivash, and the Laguna Madre there are often dense populations of short-lived clams which support considerable numbers of fish.

P. 10: Zenkevitch says diversion of Don River waters since 1951 reduced flow from 26.2 km^3/yr to 19.4 km^3/yr, resulting in a loss of nutrients, rise in average salinity of Sea of Azov by 2 ppt, and drop in fish production, now 2.5 times less (73 kg/hectare in recent years).

San Francisco Bay has been even more damaged by man-made changes.

Hedgpeth, J. W. 1967. Ecological aspects of the Laguna Madre, a hypersaline estuary. Pp. 408-419. In: Lauff, G. H., ed. Estuaries. Am. Assoc. Adv. of Sci. Publ. No. 83, Washington, D. C., xv + 757 pp.

The Laguna Madre is a series of coastal lagoons stretching 120 miles along southern part of Texas coast in an area with 27-in. annual rainfall and 21-in annual evaporation, according to author. Until Intracoastal Waterway was dredged through Laguna in 1949, salinities in excess of 80 ppt were frequent, and in some years salinity exceeded 100 ppt. These high salinities accompanied high summer water temperatures and fish mortalities. On the other hand, heavy rains reduced salinity to as low as 2 ppt. Low temperatures of "northers" also caused great fish kills. In spite of the extremes, Laguna Madre contributed as much as 50% of the fish catch of the entire Texas coast. Since the channel was dredged, conditions have been less extreme. Passes dredged to connect the Laguna directly with the gulf have had little effect. Redfish, Sciaenops ocellatus, and black drum, Pogonias cromis, are among major fish species, and are unusually large in the Laguna.

Table 4, p. 415, shows by horizontal lines the salinity distribution of 25 invertebrates and 20 fishes that occur in salinities of 45 ppt and above in the Laguna Madre. These include all three species of commercial penaeid shrimps. On p. 414 it is stated that at least 25 species of animals persist in salinities of 75-80 ppt in Laguna Madre, including some that also live in salinities as low as 15 ppt. The Laguna has grass flats containing Diplanthera and Ruppia.

Hedgpeth, J. W. 1968. The atyid shrimp of the genus Syncaris in California. Int. Rev. Ges. Hydrobiol., 53(4):511-524.

S. pacifica shows limited powers of adjustment to increased salinity, but cannot survive exposure to salinities of about 24 ppt. (P. Maxwell)

Hedley, C. 1925. The natural destruction of a coral reef: Roy. Georg. Soc. Australasia Trans., 1:35-40, 1 plate, 1 fig. (Rep't Great Barrier Reef Comm.)

The beautiful flourishing reef fringing the southwest corner of Stone Island, Queensland, recorded by Saville Kent, was destroyed in 1918 by fresh water from an extraordinarily heavy rain being lowered onto the reef by low tide during a cyclone. At present the reef is dead and wave erosion has planed the surface quite smooth. (J. W. Wells, Corals, Annotated Bibliography, in Geol. Soc. Amer. Memoir. 67, Vol. 1, p. 1095 (1957).)

Heinle, D. R. 1972. Possible effects of vertical stratification on spatial distribution of copepods in estuaries (Abs.). Abstracts of Papers Submitted for the 35th Annual Meeting, Amer. Soc. of Limnology and Oceanography, Tallahassee, Florida, March 19-22, 1972.

Scottolana canadensis copepodites are epibenthic and, therefore, are carried upstream in the bottom-water circulation (higher salinity). Acartia tonsa has a similar distribution. Eurytemora affinis nauplii and sexually mature copepodites show no persistent stratification while immature copepodites are more abundant in the deeper (and saltier) strata. In the part of the estuary where E. affinis is most abundant, all age groups are unstratified. Farther up the estuary, nauplii and immature copepodites are more abundant at the surface; mature copepodites are unstratified. (S. H. Hopkins)

Hela, Ilmo. 1956a. A pattern of coastal circulation inferred from synoptic salinity data. Bull. Mar. Sci. Gulf and Caribbean, 6(1):74-83.

A synoptic operation was performed during the forenoon and noon hours on December 4, 1954, when 28 vessels occupied 250 limited hydrographic stations off the west coast of Florida [Tampa Bay to Sanibel Island]. The salinity distributions are shown for the surface [Fig. 1, chart] and for 40 ft [Fig. 2, chart]. The pattern of coastal circulation is referred to the cyclonic eddy off the Florida west coast. Two major indrafts of high salinity water toward the shoreline are found. The mechanics of this phenomenon, and also the permanency

of the observed pattern are discussed. (Author's abstract)

An attempt is made to correlate salinity pattern with occurrence of red tide organism, Gymnodinium brevis. G. brevis often occurs in isolated patches, and similarly discrete patches of water differing in salinity from surrounding water were observed. (S. H. Hopkins)

Hela, Ilmo. 1956b. Ecological observations on a locally limited red tide bloom. Bull. Mar. Sci. Gulf and Caribbean, 5(4):269-291.

Conditions were studied in Boca Grande Pass, Florida. Maximum concentrations of Gymnodinium brevis appear in salinities of around 32-33 ppt. This is not necessarily an optimum condition. It is possible that a local red tide bloom occurs only where all other factors are or have been favorable for the bloom and where salinity is about 31-34 ppt. (S. Rennie)

Hellier, T. R., Jr. 1962. Fish production and biomass studies in relation to photosynthesis in the Laguna Madre of Texas. Publ. Instit. Mar. Sci., Univ. of Texas, 8:1-22.

Biomass was estimated from catches made with a drop net. Fish production is "the weight increase of the fish per unit time while the fish were in the study area." Five of the 31 species of fish caught made up 70% of the biomass: Mugil cephalus (mullet), Lagodon rhomboides (pinfish), Leiostomus xanthurus (spot, or flat croaker), Anchoa mithelli (anchovy), and Menidia beryllina (silversides). Biomass estimates of fish and larger invertebrates (mostly blue crabs and commercial shrimps) ranged from a summer maximum of 337 lb/acre (37.8 g/m^2) to a winter minimum of 18 lb/acre (2.0 g/m^2). The annual fish production estimate was 137 lb/acre (dry weight 15.4 g/m^2) as compared with an annual gross primary plant production estimate of 4177 $g/m^2/yr$. "The seasonal migration and growth of fish stocks are in phase with the primary production of food." Graphs show that maximum biomass of fish and crustaceans was in the months when salinity was highest (36-56 ppt) and the minimum biomass was found in months when salinity was lowest (26-28 ppt), coinciding with the highs and lows in temperature. (S. H. Hopkins)

Hempel, Christine. 1957. Zur oekologie einiger Spioniden (Polychaeta Sedentaria) der deutschen Kusten. Kieler Meeresforsch., Univ. of Kiel, 13:275-288.

P. 279: In the Laguna Madre Polydora ligni occurs in serpulid reef in salinity of up to 80 ppt. No authority cited.

P. 286: Pygospio elegans was found by the author in North Sea-Baltic Canal in salinity of 2.1 ppt.

P. 287: Streblospio shrubsolii, which may be a Cirratulid rather than a spionid, occurs with P. elegans in the canal. Remane (1934) says this is a true brackish-water species. (S. H. Hopkins)

Henderson, John C. 1958. A preliminary study of the distribution of some copepods in upper Laguna Madre. M.S. Thesis. Texas A&M University.

Acartia tonsa was the most abundant copepod found. No correlation between numbers and salinity was made although evidence indicated it could not tolerate rapid salinity changes and that this species preferred higher salinities.

Oithona brericornis showed a decrease in numbers with an increase in salinity, but may also have decreased due to a heavy phytoplankton bloom. (S. Rennie)

Henri, V. and Lalou, S. 1903a. Regulation osmotique des liquides internes chez les Holothuries. C. R. Soc. Biol., Paris, 55:1244-1245.

The sea cucumbers studied were Holothuria tubulosa and Stichopus regalis.

Experiments showed that the water lung (poumon aqueux) membrane, the membrane of the polian vesicle, and that of the digestive tube are perfect semipermeable membranes, letting pass neither chlorides, saccharose, sulfates, nor even urea. The only animal semipermeable membrane previously known is that of the stomach of the sea hare, Aplysia, but they are probably much more common among the lower animals than had been thought. (S. H. Hopkins)

Henri, V. and Lalou, S. 1903b. Regulation osmotiques des liquides internes chez les Echinodermes. Compt. Rend. Acad. Aci., Paris, 137:721-723.

The echinoderms studied were the sea urchins Strongylocentrotus lividus, Sphaerechinus granularis, and Spatangus purpureus, and the sea cucumbers Holothuria tubulosa and Stichopus regalis. Normal sea urchins have a lower chlorinity in their perivisceral fluid than normal sea water. When placed in a solution of 3 parts sea water to 1 part fresh water, sea urchin perivisceral fluid decreases in salinity until equilibrium is reached with internal chlorinity again lower than in the external medium. Exact figures are given in a table. The feet swell during this period of adjustment. Sea cucumbers normally have chlorinity of perivisceral fluid the same as in sea water, but the ambulacral fluid is a little lower in chlorinity and the stomach fluid still lower. When sea cucumbers are placed in the diluted sea water, all three of these fluids decrease in chlorinity. It is concluded that the membranes of sea urchins are semipermeable, as are some of the membranes of sea cucumbers. (S. H. Hopkins)

Henri, V. and Lalou, S. 1903c. Regulation osmotiques du liquide interne chez les Oursins. C. R. Soc. Biol., Paris, 55:1242-1244.

The sea urchins studied were Strongylocentrotus lividus, Sphaerechinus granularis, and Spatangus purpureus. While sea water (at Villefranche) contains 0.61 mol. Cl/l, perivisceral liquid of sea urchins contains only 0.58 mol. Cl/l. Freezing point of perivisceral liquid is the same as that of sea water, freezing point depression being 2.22 C in both. Electric conductivity of perivisceral liquid is 700 ($K.10^4$), that of sea water 7.32. So the lesser chlorinity is compensated by nonconductive substances, i.e., nonelectrolytes. Sea urchins placed in diluted sea water undergo lowering of concentration of perivisceral liquid and increase in weight, in proportion. When sugar is added to the diluted sea water to make it isotonic, there is no change in perivisceral liquid in 2-hr period. Swiftness of change in diluted sea water is affected by conditon of sea urchin as well as by degree of dilution. (S. H. Hopkins)

Henry, Dora P. 1959. The distribution of the amphitrite series of Balanus in North American waters. Pp. 190-211. In: Marine borers and fouling organisms, ed. by Dixy Lee Ray. Univ. of Washington Press, Seattle, xii + 536 pp.

This paper includes a key to four species and six subspecies of these estuarine barnacles, then a discussion of distribution and biology of each. B. a. nivens and B. a. inexpectatus are found in waters of close to oceanic salinity, and three other subspecies of B. amphitrite in waters with a wide range of salinity: B. a. denticulata in African and North American waters from nearly fresh to 50 ppt (in Suez Canal), but not in Laguna Madre; B. a. saltonensis in Salton Sea at 28 ppt and in Los Angeles Harbor at nearly 35 ppt; B. a. pallidus of West Indies is probably intertidal. B. eburneus is found in salinities from normal estuarine, as at Solomons Island, Md., to oceanic and even to hypersaline (50 and 61 ppt in Laguna Madre and Baffin Bay). Balanus improvisus is found from low-salinity brackish (actually, from fresh water) to oceanic salinities. B. concavus pacificus is found in Baja, California, and from an unknown California location; ecology unknown. (S. H. Hopkins)

Henry, Kenneth A. 1967. Report of the laboratory director. Report of the Bureau of Commercial Fisheries Biological Laboratory, Beaufort, N. C., Circular 264:1-3.

Studies of blue crabs showed that those kept at 6.9 to 25.8 ppt had a greater increase in size than those kept at less than 1 ppt. At low temperatures (59 F) the time required for larvae to molt to the first crab stage is dependent on salinity, while at higher temperatures (68-86 F) the molt is temperature-dependent over a wide range of salinities.

Temperature tolerance studies of menhaden showed that at low (4.5-5.4 ppt) salinity, small juveniles die quickly when the water temperature reaches 95 F. (S. Rennie)

Hepper, B. T. 1955. Environmental factors governing the infection of mussels, Mytilus edulis, by Mytilicola intestinalis. Min. Agric. Fish and Food (Great Britain), Fish. Invest., 20(3):1-21.

The copepod Mytilicola intestinalis is a common gut parasite of mollusks, particularly in Mytilus edulis around the coast of Great Britain. A field survey was conducted to study the distribution and biology of this copepod in five British coastal areas. In a study of the effect of salinity on parasite numbers, examination of mollusks along a salinity gradient at Milford Haven showed a steady rise in parasite content from the marine end of the estuary to Neyland, approximately the lowest point at which substantial influence of fresh water was evident (31 ppt). Farther upstream there was a decline in parasite content in the less saline regions of the estuary, where salinity dropped from 30 to 9 ppt. It seemed that Mytilicola was best suited to waters having a slight reduction of salinity and less suited to waters of full marine or very low salinities. (T. Rennie)

Herbert, D. W. M. 1965. Pollution and fisheries. Pp. 173-195. In: Goodman, G. T., Edwards, R. W., and Lambert, J. M., eds., Ecology and the industrial society. John Wiley, New York, viii + 395 pp.

Pp. 177-178 and 183, experiments show that salmon smolts and rainbow trout are more suceptible to poisoning by zinc sulphate (and perhaps other pollutants) at salinities lower or higher than the salinity that is isotonic with the blood of the fish (figs. 3 and 9). (S. H. Hopkins)

Herbert, D. W. M. and Shurben, D. S. 1965. The susceptibility of salmonid fish to poisons under estuarine conditions. Air Water Pollut., 9(1/2):89-91.

The resistance of rainbow trout to ammonium chloride increases with salinities up to 30% sea water; then with further increase to full strenth sea water the resistance decreases.

Herman, Sidney S. 1968. Zooplankton and environmental characteristics of the Patuxent River Estuary 1963-1965. Chesapeake Sci., 9(2):67-82.

This paper represents a compilation of data on temperature, salinity, turbidity, nutrients, chlorophyll, and zooplankton of the estuary. No attempt was made to correlate any of the zooplankton data with the water quality data.

Salinities ranged from 0.1 ppt at Lower Marboro to 19.2 ppt at Broome Island. Salinity patterns in the upper estuary were less stable due to greater freshwater inflow. Bottom salinities were consistently higher than surface salinities especially after periods of freshwater runoff. Higher salinity conditions in 1964 are attributed to drought and low freshwater input. (S. Rennie)

Herre, A. W. C. T. 1929. An American cyprinodontid in Philippine salt ponds. Philippine Jour. Sci., 38:121-127.

Mollienisia latipinna Le Sueur is native to the coast region of southern United States. It occurs from Virginia to northern Mexico and was found in a new locality (salt ponds along the shore of Manila Bay, Philippine Islands) by the author.

In the Philippines, Mollienisia showed a "remarkable" tolerance for salt. It was rare in ponds filled with water from the bay (3.1% to 3.2%), but it was abundant in ponds having 3.5% salinity. It was abundant in ponds having salinities up to 8.7%, but near this point its tolerance limit was reached, for in ponds having 9.4% salinity the fish had entirely disappeared. (This fish is called "sailfin molly" in U.S. The salinities given have following equivalents in ppt: 3.1%-3.2% = 31-32 ppt and 9.4% = 94 ppt.-SHH.) (T. Rennie)

Hesse, R., Allee, W. C., and Schmidt, K. P. 1937. Ecological animal geography. John Wiley, New York, xiv + 597 pp.; 135 figs.

P. 9 -- "The reduction in size of marine animals with decrease in the salinity of the water" is example of "somatic change in consequence of environmental stimuli," "of indifferent value to the organism."

P. 23 -- Littoral areas of tropical seas afford "most favorable environment of all" because "the salt content is subject to little variation" [temperature is constant, abundant food from land]. Wherever environmental conditions deviate from this optimum, the number of major groups and of species diminishes.

P. 25 -- Variation in salt content of sea water, deviation from optimum. "If this variation is large, great demands are made on the adaptability of the organisms concerned. This form of selection causes reduction in kinds of animals. "The complete elimination of a species is frequently preceded by the production of stunted forms."

P. 29 -- Competition and struggle for existence is most severe under optimum conditions, as in tropic seas. "Many animals are able to maintain themselves in physically unfavorable environments after they have given way elsewhere to more modern competitors."

P. 30 -- "However the adaptation to adverse conditions may have been reached, the number of competitors for the food supply will be reduced in the new environment, and when a sufficient food supply is available the numbers of individuals of the few adapted species may become enormous. Thus in regions equally well supplied with food, of which one has other environmental conditions favorable and the other unfavorable, the numbers of individuals of the species will be in inverse proportion to the number of species present. The brackish-water fauna is characterized by the presence of few species, often of reduced size, but with enormous numbers of individuals."

P. 35 -- "Such marine animals as possessed the basic requirements for adaptation to life in less saline water at once found favorable opportunities in brackish water, on account of the decreased competition."

P. 36 -- "The immigration of marine forms into fresh water has taken place for ages and still continues."

P. 37 -- "The immigration of marine animals into fresh water continues in recent time primarily in the tropics." This may be due to the small variation in temperature in tropical streams, the tropic rainstorms which accustom marine animals to a lower salinity, or to direct effect of temperature. Alosa finta in scandinavia spawns at sea, from North Sea south it occasionally ascends streams to spawn, and in Adriatic region some have become permanent residents of fresh water. Where high calcium content occurs, it makes the transition to fresh water less difficult.

P. 39 -- "There are indications that fresh water checks fertility." A number of European fishes which enter rivers or Baltic do not spawn or become sexually mature. "The oyster plantations of the river mouths of the west coast of France would die out if they were not constantly replenished with spawn from salt water."

P. 195 -- "The excessively resistant Cardium edule" listed among mollusks (lamellibranchs) which dig themselves in between tide marks, where "only euryhaline and eurythermal animals can live." P. 158 -- Cardium edule listed as eurythermal. P. 25 -- "The complete elimination of a species (by too high or too low salinity) is frequently preceded by the production of stunted forms, as in Cardium edule."

Heubach, William. 1969. Neomysis awatschensis in the Sacramento-San Joaquin River Estuary. Limnol. and Oceanogr., 14(4):533-546.

Population densities of this opossum shrimp were highest in summer from fresh water downstream to 4-ppt chlorinity. Reproduction was greatest in spring and summer from the lowermost freshwater stations to 2 ppt Cl and was the principal factor affecting seasonal and geographical abundance. Mysid densities were lowest where chlorinity was greater than 10 ppt, little or no flow reversal occurred during floodtide, and light intensity in the water exceeded 10^{-5} lux. (From author's abstract)

Hewatt, W. G. 1937. Ecological studies on selected marine intertidal communities of Monterey Bay, Calif. Am. Midland Naturalist, 18:161-206.

This was a study of the fauna and flora of a transect 1 yd wide and 108 yd long across the littoral zone on the southern margin of the bay, where the shore is rocky. Temperature of water was 11 to 13.5 C, surface salinity, 32.12 to 33.82 ppt, and water was always saturated with oxygen. (Salinity graph and discussion, p. 168.) Seven species of sponges, 9 of coelenterates, 1 of flatworms (turbellarian), 3 of nemertines, 3 of Bryozoa, 9 of annelids (polychaetes), 1 of sipunculids, 41 of crustaceans, 2 of arachnids, 9 of amphineurans (chitons), 51 of gastropoda (snails), 10 of bivalve mollusks, 1 octopus, 12 species of echinoderms (4 classes), 4 tunicates (sea squirts), and 4 fishes were found, a total of 165 species--a typically rich rocky shore fauna. Seaweeds included Pelvetia and Fucus. Zonation and its causes, and food and other relations of the various animals, are discussed. (S. H. Hopkins)

Hickling, C. F. 1970a. A contribution to the natural history of the English grey mullets (Pisces, mugilidae). Jour. Marine Biol. Assoc. U.K., 50:609-633.

Thick-lipped gray mullet cannot tolerate direct transfer from sea water to fresh water. Acclimation through one or two stages is required, although the first jump can be as low as 5 or 3 ppt. Transfer from fresh water to sea water can be made directly without harmful effects. (S. Rennie)

Hickling, C. F. 1970b. Estuarine fish farming. Pp. 119-213. In: Russell, F. S. and Yonge, M. (eds.), Advances in Marine Biology, Vol. 8. Academic Press, London and New York, xi + 481 pp.

Pp. 122-123, definitions of estuaries.

P. 135, "harsh" estuarine environment with rapid changes of salinity, so only euryhaline species can live in estuaries.

P. 140, great fertility and productivity of estuaries, much greater than in ocean waters; e.g., Chesapeake Bay and Sea of Azov produce 80 lb of fish/acre/year.

Pp. 149-151, "selection of organisms by salinity" so that only animals able to tolerate salinity changes can live in estuaries. Estuarine fish are predominantly euryhaline marine fish; those of freshwater origin are usually restricted to salinity below 10 ppt. In the USSR some carps have been acclimated to salinities as high as 12 ppt, in experiments, and Indian major carp has been acclimated to 13 ppt. Salinity tolerances for many estuarine fishes of marine origin are listed; i.e., species used in estuarine fish culture. For instance, the striped mullet, Mugil cephalus, grows well in fresh water but also lives in 40 ppt, in Egypt and can tolerate 75 ppt, and its fry can be transferred directly from sea to fresh water. For best health, this fish needs 1 part of sea water to 9 of fresh (i.e. about 3.5 ppt). (S. H. Hopkins)

Hickman, C. P., Jr. 1959. The osmoregulatory role of the thyroid gland in the starry flounder, Platichthys stellatus [Abs.] Anat. Rec., 134:580.

Energy demands were studied in this euryhaline fish. Individuals adapted to fresh water had lower standard metabolic rates than those in sea, while those in supernormal salinities had higher rates. This agrees with theory that energy demands for electrolyte transport are higher in sea than in fresh water. Salt-water fish were shown to have much higher rates of thyroid clearance of radio-iodine from blood, and hence more active thyroid glands, than those adapted to fresh water. The greater activity of the thyroid correlates with greater oxygen demands in sea water and suggests a direct or adjunctive osmoregulatory role of the thyroid gland of fish. (S. H. Hopkins)

Hickman, Cleveland P., Jr. 1962. Effect of salinity on the metabolic rate of gill and kidney of starry flounder, Platichthys stellatus. In: Summer Meeting of Amer. Soc. of Zool., Oregon State Univ., Corvallis, Oreg., Aug 1962. Amer. Zool. 2(3):414.

Transfer from sea to fresh water caused immediate absolute increase in rate of gill respiration, followed by a gradual fall over a 2-week period to pretransfer level. Kidney metabolic rate fell gradually following transfer to fresh water. Total metabolic rate of the flounder also drops after transfer to fresh water. (Condensation of author's abstract)

Hidu, H. and Haskin, H. H. 1971. Setting of the American oyster related to environmental factors and larval behavior. Proc. Nat. Shellfish. Assoc., 61:35-50.

In a combined field and laboratory study, laboratory-reared oyster larvae (Crassostrea virginica) were subjected to increases in salinity and increases in temperature, simulating the conditions they would encounter coming into the area of heavy setting on the tidal flats along the west shore of Cape May. They were stimulated to set in response to increase in temperature, but not by change in salinity. (S. H. Hopkins)

Higgins, Elmer. 1931. Progress in Biological Inquiries, 1929. Rept. U.S. Comm. Fish., 1930, App. 15, Doc. 1096:1069-1121.

Reports on the effect of salinity changes on setting of oysters along the east and gulf coasts were made, with emphasis on work done in Galveston, Tex., and Milford, Conn. (P. Maxwell)

Higgins, E. 1933. Progress in biological inquiries, 1932. Rept. U.S. Comm. Fish., 1933, App. II:79-147.

P. 125 -- Oyster investigations in Florida; surveys made by Dr. Prytherch, Apalachicola Bay and Choctawhatchee Bay, Florida. "In the fall serious destruction of oysters was reported in St. George Sound on the natural and planted beds in the vicinity of Porters Bar. Studies made there in November showed that 50 to 74 percent of the oysters had been killed by a parasitic flatworm or so-called "leech." From one to four flatworms were found in each affected living oyster or in the empty shells of recently killed specimens. Similar outbreaks of this parasite have occurred previously at Tampa, Cedar Keys, and Indian River Inlet during dry warm seasons and similar conditions were apparently responsible for the high mortality of oysters in St. George Sound."

Higgins, E. 1936. Progress in biological inquiries, 1934. Rept. U.S. Comm. Fish., 1935, App. III:331-399.

P. 378 -- "Destruction of oysters by parasitic flatworm. A parasitic natural enemy of the oyster known as the "wafer" or so-called "leech" has become a serious menace to the continued natural production and private cultivation of this shellfish in Apalachicola Bay, Florida. Investigations conducted by Dr. Herbert F. Prytherch...show that this pest in the last 3 years has completely destroyed

the seed and adult oysters on several of the best natural beds and is spreading rapidly to other valuable areas. The parasite is a turbellarian flatworm, Stylochus inimicus, measuring from 1/2 to 3/4 in. in diameter, that enters the shell of the oyster and feeds gradually upon the meat until it has killed its host. Since the fall of 1932 the parasite has destroyed the oysters on five natural beds comprising an area of 800 acres on which a crop estimated at 350,000 bushels, having an approximate value of $175,000, has been lost. Recently this natural enemy has spread to other beds at a distance of 12 miles from the original outbreak and to a nearby oyster reef, which is the largest in this region and contains nearly half of the entire crop. The Bureau's investigations show that the rapid growth, reproduction, and spread of the leech in Apalachicola Bay is associated with an unusually dry period, a considerable decrease in river discharge, and an increase in salinity of the coastal water of this region." Recommends dredging to destroy leech. Found North Carolina to Texas. (S. H. Hopkins)

Higgins, E. 1937. Progress in Biological Inquiries, 1935. Rept. U.S. Comm. Fish., 1936, App. IV:418-435.

P. 431 -- "Other pests found [in Texas]...were the borer, Thais haemostoma... the common conch, Fulgur perversa....

P. 436 -- "In Core and Bogue Sounds [N. C.] where the salinity is high, ranging from 27.16 to 35.61 parts per mille, the destruction of 14% to 68% of spat and seed oysters by drills...was observed on beds located below low water mark. Drills were found to be most abundant on public beds in the vicinity of Harbor Island and Atlantic where 13 to 22 specimens were collected per bushel sample."

P. 427 -- "During the period from September 15 to November 15 a general survey of the oyster pests on the Georgia coast was conducted in cooperation with State department of game and fish. Observations made at 141 stations extending from the Savannah River to the St. Mary's River, show an abundance of drills on the natural beds, and an extensive and severe infestation of oysters by the boring sponge."

P. 428 -- "Oyster-pest investigations were undertaken on the gulf coast covering the inshore waters of Florida, Alabama, and Texas. Previous surveys and reports from members of the fishing industry showed that the most destructive pests in this section are the borer, Thais, and the leech, or wafer, Stylochus.

Higgins, Elmer. 1940. Progress in biological inquiries, 1939. Rept. U.S. Comm. Fish., 1940., App. I, Admin. Rept. No. 39:1-96.

P. 65. "Setting of oyster [in Long Island Sound] in 1939 was probably the heaviest since 1930.... In 1939 the spawning and heavy setting of oysters took place during a period of prolonged and very severe drought.... The question naturally arises whether the inflow of fresh water carrying certain substances is really important in inducing the setting of larvae."

P. 69. "In East Pensacola Bay...there was a large mortality during a period of low salinity.... The oysters had been heavily infested with a sporozoan parasite...which appeared to render the oysters less resistant to handling or transplanting. Also, the period of low salinity occurred...immediately after the oysters had completely spawned out and their resistance was greatly lowered. It is probable that low salinity decreases the feeding activities of Ostrea virginica." The same relationship was found in Ostrea gigas. (S. Rennie)

Hildebrand, H. H. 1954. A study of the brown shrimp (Penaeus aztecus Ives) grounds in the western Gulf of Mexico. Publ. Inst. Mar. Sci., Univ. of Texas, 3(2):228-366.

The blue crab Callinectes sapidus was caught in the oceanic salinities of the offshore gulf in much less abundance than in shallow inshore waters and in estuaries, and only females, mostly mature and many ovigerous, were caught on the

brown shrimp grounds in the gulf, while Callinectes danae, which is much less abundant than C. sapidus in bays, was caught in very large numbers in the gulf the year around -- both sexes and all sizes. (S. H. Hopkins)

Hill, L. G. and Holland, J. P. 1971. Preference behavior of the Red River pupfish, Cyprinodon rubrofluviatilis (Cyprinodontidae), to acclimation-salinities. Southwestern Naturalist, 16(1):55-63.

This freshwater fish lives in upper reaches of Red and Brazos Rivers (Oklahoma and Texas) where there are salt springs and salty streams, so that salinity varies from 0.67 ppm in freshet periods to 714 ppm (0.7 ppt) during droughts. Fish were acclimated for 2 weeks in aquaria containing water ranging from lake water (Lake Texoma, fresh but containing measurable salinity) to 40 ppt. Salinity test solutions were made with pickling salt, nearly pure NaCl. After 2 hr in a test chamber, a test salinity was admitted in one end so that a salinity gradient existed, as shown by dye tests. In every case where 10 ppt or more difference existed between salinities in opposite ends of the test chamber, a larger percentage of the fish "chose" the salinity closest to that to which it had been acclimated than would be expected by random selection or by chance. This was true even in tests of 40 ppt versus lake water or versus 5 ppt. (S. H. Hopkins)

Hill, C. L. and Kofoid, C. A., eds. 1927. Marine borers and their relation to marine construction on the Pacific coast. Final report of the San Francisco Bay Piling Committee. Univ. of California Press, Berkeley, ix + 357 pp.

In 1849 gold rush days many wharves were built of untreated timber and hundreds of ships, abandoned by crews, filled the harbor. These wooden structures soon began to show the destructive action of a shipworm, now known as Bankia setacea. Gribble activity was reported first in 1873 with the statement that Limnoria had first appeared only recently. Both of these borers require fairly high salinity. In San Pablo Bay at the north end of San Francisco Bay the wharves of Mare Island Navy Yard and other installations, and many industrial wharves in Carquinez Strait, Suisun Bay, and lower Sacramento River, were built with untreated piling because salinity was low enough to make them safe from all known borers. In 1914, 1917, and subsequent years these "protected" structures were badly damaged by Teredo navalis, apparently newly introduced, a species tolerant of low salinities. To study piling damage, its causes and means of prevention, the San Franciso Bay Piling Committee was formed. (S. H. Hopkins)

Hill, M. B. (Dept. Zool., Univ. Ibadan, Nigeria). 1967. The life cycles and salinity tolerance of the serpulids Mercierella enigmatica (Fauvel) and Hydroides uncinata (Philippi) at Lagos, Nigeria. Jour. Animal Ecol., 36(2):303-321.

In laboratory experiments, Mercierella enigmatica lived and grew at salinities as low as 0-0.5 ppt for as long as 80 days. It lived and grew at 18 ppt but not at 21 ppt. In the field, many settled and grew at the harbor entrance in 33 ppt and a few survived in 1 ppt. It responded best in high salinities (within its optimum range), grew best in medium salinities, and survived best in low salinities.

Hydroides uncinata settled only when the high tide salinity was above 30 ppt and the low tide salinity was 20 ppt or over. Growth was faster in the upper and middle harbor than at the harbor mouth where salinity at low tide was over 30 ppt for a long period. The best growth was between 20 and 30 ppt. A few in upper harbor survived salinity below 1 ppt June to August, then died.

Ficopomatus sp. at Lagos is marine, occurring only in 33 ppt or higher. (S. H. Hopkins)

Hiscock, I. D. 1953a. Osmoregulation in Australian freshwater mussels. I. Water and chloride ion exchange in Hyridella australis (Lam.). Austral. Jour. Mar. Freshw. Res., 4:317-329.

Chlorinities of the blood and pericardial fluid of H. australis are similar and are hypertonic to the external medium. The urine is hypotonic to the blood and remains relatively stable, indicating that the kidney functions independently of the external medium.

The response to a change in environmental concentration is immediate and equilibrium is reached within 24 hr. Mussels respond to the different (hypotonic) medium by a change in weight. A slight drop in blood chlorinity was also observed. It was shown that normal shell movements aid in maintaining water balance in different media, including desiccation. Shell closure is accompanied by a decrease in respiration and heartbeat. Urinary flow is reduced by reduction of heartbeat. (S. Rennie)

Hiscock, I. D. 1953b. Osmoregulation in Australian freshwater mussels (Lamellibranchiata), II. Respiration and its relation to osmoregulation in Hyridella australis (Lam.). Austral. Jour. Mar Freshw. Res., 4:330-342.

Oxygen consumption of H. australis is three times greater when the valves are open than when they are closed. As the chlorinity of the external medium rises, oxygen consumption, chloride concentration, and water content of the clams decrease. A suggested possible scheme of pathways of osmoregulatory control is "Stimulation" (toxicity of medium) → chemoreceptors (?) → nervous system → respiration (energy production), osmoregulation. Effect of various drug depressants was demonstrated, resulting in reduced osmoregulatory control. All but KCN showed this. Data suggest (but do not conclusively prove) that osmoregulatory and respiratory mechanisms are under nervous control. (S. Rennie)

Hodge, D. 1963. The distribution and ecology of the mysids in the Brisbane River. Univ. of Queensland Pap. Zool., 2:91-104.

Gastrosaccus dakini penetrated farther into the estuary (i.e., into lower salinities) than Rhopalophthalmus brisbani; most G. dakini juveniles were in 2-6 ppt, while most R. brisbani juveniles were in 7-17 ppt; both moved upstream in autumn, later downstream. Cited by Green, 1968, p. 92. (S. H. Hopkins)

Hodge, D. 1964. A redescription of Tenagomysis chiltoni (Crustacea:Mysidacea) from a freshwater coastal lake in New Zealand. New Zealand Jour. Sci., 7:387-395.

This species found in a coastal dune lake with salinity of only 0.2 ppt had previously been known only from an estuary; other species of Tenagomysis live in the open sea or in estuaries. Fide Green, 1968, p. 95. (S. H. Hopkins)

Hodgkin, E. P. and Rippingale, R. J. 1971. Interspecies conflict in estuarine copepods. Limnol. and Oceanogr., 16(3):575-575.

In Australian estuaries, the copepod Gladioferens imparipes lives in a wide range of salinity, but in the Swan River Estuary, West Australia, it is plentiful only in low salinity. It is seldom present where either Sulcanus conflictus or Acartia clausi, which prefer higher salinity than does Gladioferens, are abundant. S. conflictua is abundant only in salinities of 4-15 ppt, though it tolerates 1-26 ppt. In winter, rains lower the salinity in Swan River Estuary and Gladioferens becomes abundant, but in spring and summer rains decrease and finally stop; as salinity increases G. imparipes is replaced by Acartia clausi in the lower estuary, while in the upper estuary Sulcanus conflictus becomes the dominant copepod in the advancing wedge of brackish water. By midsummer Gladioferens is restricted to a short stretch at the head of the estuary. In other estuaries where Acartia is absent, Gladioferens is abundant in high salinity downstream from Sulcanus. Experiments show that Acartia and Sulcanus eat nauplii of Gladioferens, thus preventing recruitment. (S. H. Hopkins)

Hoese, H. D. 1958. A partially annotated check list of the marine fishes of Texas. Publ. Inst. Mar. Sci., Univ. of Texas, 5:312-352.

Of interest because it records a number of freshwater fishes entering bays and Gulf of Mexico: Lepisosteus productus, L. spatula, Dorosoma petenense, D. cepedianum, Gambusia affinis, Mollienesia latipinna, and Gobionellus shufeldti. (S. H. Hopkins)

Hoese, Hinton Dickson. 1959a (Jan., M.S.). Hydrographic and ecological studies in Mesquite Bay and Cedar Bayou, Texas. Master of Science Thesis, A&M College of Texas (Zoology), January 1959.

[Copies in A&M College main library and in office of Department of Biology.] 108 pp. + 5 pp. biblio., 15 figs., 5 tables.
See Hoese (1960a), "Biotic changes in a bay associated with the end of a drought" which is a condensation of this thesis.

Hoese, H. D. 1959b. Job report. Basic ecological survey of Area M-3. A checklist of fishes of Area M-3, Sept 1, 1958-Sept 1, 1959. Job No. A-3. Texas Game and Fish Commission, Marine Fisheries Division, Job Reports 1959. Mimeo.

"Area M-3" is lower Galveston Bay, East Bay, and West Bay. During the study salinities were almost always over 20 ppt in West Bay, "a polyhaline bay" with a high salinity fauna including Ostrea equestris, while in East Bay salinity was less than 5 ppt in the upper end and only 12-15 ppt in the lower end. West Bay had a richer fauna and contained 11 species of fish (named) not found in East Bay, plus juveniles of Cynoscion nebulosus (speckled sea trout) of which only adults were found in East Bay. (S. H. Hopkins)

Hoese, H. D. 1959c. Job report. Project No. M-3-R-1, basic ecological survey of Area M-3, Sept 1, 1958, to Sept 1, 1959; Job No. E-3: Hydrographic studies related to Rollover Pass and possible effects on the fauna. 3 pp. Texas Game and Fish Commission, Marine Fisheries Division, Job Reports 1959. Mimeo.

Rollover Pass is a short artificial inlet dredged to connect East Bay to the gulf. After a period of closure, it was reopened May 29, 1959. Prior to this reopening East Bay waters were usually "fresh," salinities in May varying from 3 ppt in the extreme upper end to 12 ppt at Hanna Reef (mouth of bay), with lowest salinities along northern shore. Immediately after the pass reopening, heavy rains lowered salinity still more. By June 11 salinities in the upper bay had risen to 7-8 ppt, but in Rollover Bay, next to the pass, salinity had risen to 25.1 ppt. Rollover Pass is more outlet than inlet and saltier water encroaches only slowly and gradually. Macoma mitchelli and Rangia cuneata, most abundant bivalve mollusks in East Bay, are low salinity forms to which higher salinity may be detrimental. Oysters, Crassostrea virginica, were killed by low salinity while the pass was closed. (S. H. Hopkins)

Hoese, H. D. 1960a. Biotic changes in a bay associated with the end of a drought. Limnol. and Oceanogr., 5(3):326-336.

This ecological study of Mesquite Bay, Texas, began in August 1956, which was the last and driest of a series of drought years beginning in 1948. In 1956, Mesquite Bay salinities were higher than in the gulf, 44.5 to 50 ppt. Heavy rains began in the spring of 1957 and salinities dropped to 2.3-12.2 in May and 1.7 ppt in June, then rose to 12 ppt because Hurricane Audrey caused influx of gulf water. Before the rains, Mesquite Bay had a high-salinity fauna: Mercenaria campechiensis, Chione cancellata, Tagelus divisus, Trachycardium muricatum, Ostrea equestris, Brachidontes exustus, Crepidula plana, Zoobotryon pellucidum, Suberites undulatus, Petrolisthes armatus, Alpheus armillatus, Neopanope texana, Penaeus aztecus, P. setiferus, P. duorarum (these three species were present also

after the low-salinity period), Callinectes danae, Aurelia aurita, Cliona celata, Menippe mercenaria, Libinia dubia, Squilla empusa, etc., with the fishes Micropogon undulatus, Leiostomus xanthurus, and Chloroscombus chrysurus, among others. Many invertebrates and masses of seaweeds died during the low-salinity period. besides the penaeids, Mnemiopsis mccradyi, Clibinarius vittatus, Callinectes sapidus, C. danae, Mulinia lateralis, and Ensis minor survived high and low salinity. A new low-salinity fauna populated the bay in 1957, with fewer species. (S. H. Hopkins)

Hoese, H. D. 1960b. Juvenile penaeid shrimp in the shallow Gulf of Mexico. Ecology, 41(3):592-593.

Juvenile Penaeus setiferus 20-83 mm long (rostrum to telson) were seined in quantity (52 per haul along 60 miles of shore) in surf on Texas outside beach between Sabine Pass and Bolivar Roads, September-November 1958, in high turbidity and salinity of 22.6-26 ppt. About the same time juvenile P. setiferus were abundant in Intracoastal Waterway (12 ft deep) north of West Bay, and juvenile P. aztecus were abundant there in spring of 1959, in salinities of 19-26 ppt, over bottom covered with red algae (Gracilaria). Juvenile P. duorarum occur in Thalassia testudinum (turtle grass) flats in West Bay near San Luis Pass. All of these locations have in common with the usual shallow-water low-salinity nursery grounds good protection from predators, by the high turbidity in the surf and by thick vegetation cover in other places. (S. H. Hopkins)

Hoese, H. D. 1967. Effect of higher than normal salinities on salt marshes. Contr. to Mar. Sci., Univ of Texas, 12:249-261.

"Salt marshes occur...(1) where salinity seldom falls below 30 ppt, (2) where waters may become fresh at times, and (3) where salinity may exceed 40 ppt. Most, however, exist in waters between about 10 (and) 30 ppt. Increasing salinity may move the salt-brackish-fresh water boundaries landward as has occurred in Louisiana. Increase in salinity allows many high salinity organisms to invade landward which may cause immediate harm to fisheries. Effects of rising salinities are known neither for all salt marsh animals nor for all salt marshes, and may differ. Also as salinity rises there are changes in other important factors that vary among salt marshes. There is little proof that primary productivity will decrease with rising salinity, but it may follow different channels. The U.S. Atlantic and Gulf salt marsh system based on Spartina alterniflora would probably be destroyed as salinity approaches 50 ppt. Effects of lower salinities are much less certain and require intensive study." (Author's abstract)

P. 250: "It is well documented that American Atlantic salt marsh is predominately (sic!) composed of a single species...Spartina alterniflora. All other marsh plants are either submergent and seldom exposed (...Zostera, Ruppia, etc.), essentially salt tolerant terrestrial types...(Distichlis, Salicornia) or brackish types.... There is no salt marsh in the hypersaline Laguna Madre."
(S. H. Hopkins)

Hoese, H. D., Copeland, B. J., Moseley, F. N., and Lane, E. D. 1968. Fauna of the Aransas Pass Inlet, Texas. III. Diel and seasonal variations in trawlable organisms of the adjacent area. Texas Jour. Sci., 20(1):33-60.

Trawl catches over 24-hr periods and in each season of the year were compared at one station in the middle of Aransas Bay and at five stations in gulf in 3, 6, 9, 12, and 15 fathoms. Salinity in Aransas Bay varied from 24 to 36 ppt. The number of invertebrate species caught per haul (13, 9.5, 6.5, and 4.3 in winter, spring, summer, and autumn, respectively) was not much less than the number caught in gulf except in autumn, and was higher than gulf catches in spring. Catches of some species of fish and invertebrates were much different between night and day. Common invertebrates caught in bay were Polinices duplicatus, Callinectes similis, Pagurus pollicaris, Squilla empusa, Penaeus setiferus,

Penaeus aztecus, Penaeus duorarum, Trachypeneus similis, Loliguncula brevis, and Sicyonia dorsalis. Common fishes were Anchoa mitchelli, Brevoortia patronus (both caught mostly at night), Synodus foetens, Galeichthys felis, Bagre marina, Chloroscombrus chrysurus, Eucinostomus gula, Vomer setapinnas, Trichiurus lepturus, Poronotus burti, Stellifer lanceolatus, Cynoscion arenarius, C. nothus, Leiostomus xanthurus, Micropogon undulatus, etc. (S. H. Hopkins)

Holland, J. S., Aldrich, D. V., and Strawn, K. 1971. Effects of temperature and salinity on growth, food conversion, survival and temperature resistance of juvenile blue crabs, Callinectes sapidus Rathbun. Texas A&M University Sea Grant Program (TAMU-SG-71-222), College Station, Tex., xxii + 166 pp.

Two experiments were conducted testing effects of different salinities. In the first, 10 crabs were placed in each of two aquaria with water of salinities of 1, 6, 11, 16, and 21 ppt, and all 10 aquaria were maintained at 20 C to test growth; 100% died in the 1-ppt tanks in 19 days while no more than 10% died at any other salinity. These juvenile crabs died while molting, and it was theorized that they absorbed too much water while soft and therefore were unable to survive molting. However, conditions must have been unfavorable as 70%-75% of crabs at other salinities had died by the 45th day. No effect of salinity on growth rate was detected among the survivors. In the second experiment, 10 crabs were put in each of two aquaria in salinities of 2, 4, and 6 ppt and 10 crabs were put in each of three aquaria using water with 1-ppt salinity; temperature was kept at 29 C. An identical set of aquaria with 10 crabs each was kept at 15 C. At 29 C, 40% of the juvenile crabs died during the 30-day experiment in the water of 1-ppt salinity, while none died in other salinities. At 15 C, 2, 4, 4, and 3 crabs died in 1, 2, 4, and 6 ppt, respectively, showing no significant difference. These results are discussed at length but actually one could only say that the results were inconclusive, especially when it is well known that crabs smaller, as well as larger, than those used do live naturally in salinities below 1 ppt, and in great abundance, summer and winter. (S. H. Hopkins)

Holliday, F. G. T. and Blaxter, J. H. S. 1960. The effects of salinity on the developing eggs and larvae of the herring. Jour. Marine Biol. Assoc. U.K., 39(3):591-603.

Salinity on spawning grounds of the sea herring, Clupea harengus L., may vary from 5 ppt (in Kiel Canal) to 35 ppt. Ford (1929) fertilized and incubated herring eggs in 4.8 ppt, successfully. In the present work, 100% fertilization was attained only in salinities over 20 ppt, which was also optimum for hatching (lower and higher salinities than 20 were both less favorable). Eggs decreased in size with increasing salinity up to 35 ppt. Larvae showed at least 50% survival for 24 hr in salinities from 1.5 to 60 ppt, and for 168 hr in salinities from 2.5 to 52.5 ppt.

"It seems unlikely that the osmotic forces met with in nature will constitute a serious hazard to the herring larvae." (Summary, p. 602) (S. H. Hopkins)

Holliday, Frederick G. T. and Blaxter, John H. S. 1961 The effects of salinity on herring after metamorphosis. Jour. Marine Biol. Assoc. U.K., 41(1):37-48, illus.

Herring (Clupea harengus L.) 9-24 cm long tolerate salinities from 6 to 40-45 ppt. When changed from one salinity to another, extensive changes occurred from blood, which changed within range 13-22.5 ppt without death. High glomerular count of kidney accounted for tolerance to low salinity. Intact skin is important to survival when salinity changes. (S. H. Hopkins)

Holliday, F. G. T. (Biol. Dept., Univ. of Stirling, Stirling, Scotland, U.K.) and Jones, M. Pattie. 1967. Some effects of salinity on the developing eggs and

larvae of the plaice (Pleuronectes platessa). Jour. Marine Biol. Assoc. U.K., 47(1):39-48.

High mortalities of all stages in salinities below 17.5 ppt. Most eggs died in blastula or early gastrula. Yolk sac larvae tolerated salinity of 15-60 ppt. After metamorphosis the tolerance was less in high salinity (1 week 45 ppt) but tolerance and regulation in low salinity was greater (2.5 ppt for 1 week). It is suggested that functional changes in the epidermis and kidney underlie these changes in tolerance. (S. H. Hopkins)

Holthuis, L. B. 1952. A general revision of the Palaemonidae (Crustacea Decapod Natantia) of the Americas. II. The subfamily Palaemonidae. Allan Hancock Foundation Publ. Occasional Paper No. 12, Univ of Southern California Press, Los Angeles, 396 pp., illus.

All species of Macrobrachium occur in fresh water only, except M. acanthurus, M. ohion, and M. carcinus, which occur in both brackish and fresh water. Pseudopalaemon bouvieri (only species) is fresh water, as are all species of Cryphiops, Troglocubanus, and Creaseria. Leander tenuicornis, only American species of the genus, is found in marine and occasionally brackish waters. Palaemon has marine, brackish-water, and freshwater species. Palaemonetes kadiakensis is the only truly freshwater member of its genus, except P. antrorum from subterranean waters at San Marcos, Tex., and P. paludosus from fresh waters of the Atlantic coastal states, so far as North America is concerned (there are freshwater P. in South America). The other North American species of Palaemonetes are marine or estuarine: P. vulgaris, P. intermedius, and P. pugio (brackish to almost fresh water). This monograph is well provided with keys and good illustrations, and lists all locations from which each species has been recorded. (S. H. Hopkins)

Holtzman, S. and Schreibman, M. P. 1971. Histophysiological responses of the prolactin cell to changes in the environmental salinity of the fresh water teleost, Xiphophorus maculatus. (Abs.) Amer. Zool., 11(4):653-654.

Prolactin secreted by special cells is required for this platyfish to survive in fresh water. Hypophysectomized fish, lacking these cells, may be maintained in one-third sea water solutions. Normal fish show decrease in size of prolactin cells and nuclei after 3 weeks in one-third sea water. Cells and nuclei increased 25% and 11%, respectively, within 4 hr after change from one-third sea water to fresh water. These cytological changes (including changes in staining properties) presumably mirror requirements for prolactin in brackish and in fresh water. (S. H. Hopkins)

Hoop, M. 1940. Der Einfluss des Salzgehaltes des Wassers auf die Gewebe von euryhalinen Muscheln. Zool. Jahrb., Abt. Syst., Oekologie, LXXIII:391-442. (Abs. by Korringa, May 1950.)

Dwarf forms of marine mollusks occur in brackish water. Hoop sectioned Zenker-fixed specimens to see if there are histological differences accompanying the dwarfing effect of low salinity.

Mya arenaria: The faster the growth, the larger the mantle cells. Specimens from brackish estuary showed smaller cells, but clams from Baltic did not differ from North Sea clams. Slime glands of mantle fold rather poorly developed in brackish waters.

Cardium edule: Large specimens showed large epithelial cells. Specimens from very brackish waters had slightly smaller cells, those from Baltic and North Sea did not differ.

Macoma balthica: No significant difference with salinity. Small individuals have smaller cells, but nuclei always same size.

Hoop concluded that salinity limits shell growth at salinities of 10 ppt and

lower, but no histological difference caused by slightly brackish Baltic as compared with North Sea. (S. H. Hopkins)

Hopkins, A. E. 1931. Factors influencing the spawning and setting of oysters in Galveston Bay, Texas. Bull. U.S. Bur. Fish., 47:57-83.

Because of increased river discharge in spring and early summer the salinity of the water in Galveston Bay remained low for a considerable time. In early spring the salinity in the bayou (Offats Bayou, Galveston) was 22-24 ppt, while early in June it was 7. At the same time in West Bay it was only 4 ppt. In East Bay late in June it was below 2 ppt. During July and August the salinity rose to between 20 and 30 ppt. The effects of abnormal salinities on reproduction and on development of larvae to the setting stage are discussed. (S. H. Hopkins)

Hopkins, A. E. 1936. Adaptation of the feeding mechanism of the oyster (Ostrea gigas) to changes in salinity. Bull. U.S. Bur. Fish., 48:345-364, 11 figs., 1 table.

Both the activity of the gills and that of the adductor muscle are markedly affected by any considerable change in salinity. The initial effect is to cause partial or complete contraction of the adductor muscle and slowing or cessation of the flow of water. Recovery, or adaptation, following a rise in salinity is very rapid as compared with adaptation following the same change in the opposite direction. The former may require a few hours, while several days may be necessary in the latter case. The optimum is probably not greatly different from that of ocean water, for salinities between about 25 and 39 ppt appear to produce similar effects. While the oyster will tolerate a salinity as high as 39 and pump at the maximum rate, a salinity of 56 is definitely too high for it to tolerate. As salinity is reduced below 20 the oyster becomes increasingly sensitive, a longer time is required for adaptation, and it is probable that rate of pumping would never become as high as at about 28. The minimum salinity at which water is pumped effectively is between 10.5 and 13 ppt. At 13 ppt little water is pumped even after several days, but recovery to normal occurs readily when salinity raised. Salinity of 10.5 ppt produces harmful effect after which recovery in high salinity is extremely slow. (S. H. Hopkins)

Hopkins, A. E. 1937. Ecological observations on spawning, larval development, and setting, in the Olympia oyster, Ostrea lurida. Bull. U.S. Bur. Fish., 48:439-503.

Salinity of water on oyster beds in Oyster Bay at high tide is about 26 ppt in winter and about 29 ppt in summer; in Mud Bay the range is about 27 to 29.5 ppt. Salinity of the surface water, however, is subject to greater variation. (S. H. Hopkins)

Hopkins, Hoyt S. 1946. The influence of season, concentration of sea water and environmental temperature upon the oxygen consumption of tissues in Venus mercenaria. Jour. Exptl. Zool., 102:143-158.

"It was found that the rate of oxygen consumption of the gill of Venus mercenaria was about one-third greater in sea water of density 1.015 than in natural sea water (1.025); and this was true whether the animals had been living in sea water at the lower or at the higher concentration. The increased respiratory rate was therefore not a temporary effect of the dilution, as was the case for Mytilus gill (Schlieper, 1929)" (See Hopkins, H. S., 1949, p. 297)

Hopkins, Hoyt S. 1949. Metabolic reactions of clams' tissues to change in salinity. I. Ciliary activity, narcotic and cyanide effects, and respiratory quotient. Physiol. Zool., 22(4):295-308, 44 refs.

P. 306: "The rate of oxygen consumption of [excised, Venus mercenaria] gill tissue was found to be inversely proportional to the density of the sea water between 1.012 and 1.030 for clams living in sea water of density 1.024. The rate of respiration in sea water 1.015 was more than 40% higher for gill, and 12% higher for mantle tissue, than in sea water of density 1.025; it was 15% lower for muscle sections.

The ciliary action of the gill in sea water at this dilution was definitely lower than in natural sea water, so that this can be eliminated as a factor in the increased respiration. Chloretone 0.1% also increased O_2 consumption and retarded ciliary activity.

An increase of 47% in the O_2-consumption of gill was observed in isotonic NaCl solution. This was largely suppressed when $CaCl_2$ was present in the solution in the same concentration as in sea water. In a mixture of isotonic NaCl with sea water, in a 3:2 or a 1:1 ratio, there was no increase in the respiratory rate over that in sea water.

Cyanide (M/1000) was without effect upon the O_2-consumption of the gill during July and August, but it produced moderate inhibition during the autumn months... about 60% in mantle and muscle tissues.... It seems probable that V. mercenaria possesses more power of osmotic regulation than do other [Lamellibranchs]...."

Hopkins, Sewell H. 1956a. Notes on boring sponges in gulf coast estuaries and their relation to salinity. Bull. Mar. Sci. Gulf and Caribbean, 6(1):44-58.

Four species of Cliona have been identified in Louisiana oyster shells: C. celata Grant, C. lobata Hancock, C. vastifica Hancock, and C. truitti Old. These differ in tolerance to low salinity and may be used as salinity indicators. A tentative division of Louisiana estuarine waters into six zones is made on the basis of presence or absence and relative abundance of C. truitti (low salinity species) and C. celata (high salinity). The zones correspond to differences in frequency of low salinities, as shown by daily or continuous salinity records over periods of 1 year or more. (Author's abstract)

Hopkins, S. H. 1956b. The boring sponges which attack South Carolina oysters, with notes on some associated organisms. Bears Bluff Laboratories, Wadmalaw Island, S. C. 30 pp.

The study was made in the seventh year of a period of below-normal precipitation, and high salinities prevailed throughout the coast of South Carolina. The high-salinity oyster Ostrea equestris, normally absent from South Carolina estuaries, was found at 12 of 17 stations. Urosalpinx cinerea was also found far inland. Under these conditions Cliona celata was the most abundant species of boring sponge at all stations, although at the most inland station, Rantowles Creek, it made up only 38% of the specimens compared with 29% for C. lobata, 3% for C. vastifica, and 30% for C. truitti. In 1950 a collection of shells showed 89% C. truitti and only 11% C. celata at this same station. Unpublished field notes by G. R. Lunz showed that in 1935, a wet period following a very dry year, Cliona celata was being killed by low salinity in water ranging from fresh to 7.9 ppt. (S. H. Hopkins)

Hopkins, S. H. 1962. Distribution of species of Cliona (boring sponge) on the eastern shore of Virginia in relation to salinity. Chesapeake Sci., 3(2):121-124.

Of the four species of Cliona found (C. celata, C. vastifica, C. lobata, and C. truitti), C. celata is the one most abundant in high salinities but is not found in the bayside creeks with lowest salinities, where oysters flourish. C. truitti is rare in the higher salinities but is the most abundant species in bayside creeks and becomes more predominant as the salinity gets lower, going up Chesapeake Bay, within Virginia waters of the eastern shore. At the time observations were made (summers of 1961 and 1962) the salinities at the stations where C. celata was found ranged from 18 to 36 ppt and the salinities in the three "freshest"

creeks where C. celata did not occur ranged from 3 to 22 ppt. C. lobata and C. vastifica were more abundant than C. celata but less abundant than C. truitti in intermediate salinities. (S. H. Hopkins)

Hopkins, S. H. 1967. Biological and physiological basis of indicator organisms and communities. Pp. 291-292. In: Olson, T. A. and Burgess, F. J., eds. Pollution and marine ecology. Interscience Publishers, John Wiley, New York, xvi + 364 pp.

The effects of fresh water flowing into coastal waters are compared with the effects of pollution: both cause decrease in number of species, change relative abundance of individuals in some of the species, and may increase production of tolerant species including some valuable ones. In studying such changes it is important to identify species accurately, as different species of the same genus often serve as indicators of different environmental conditions; for instance, in the sponge genus Cliona and the mussel genus Brachidontes, one species indicates high salinities and another indicates low salinities. (S. H. Hopkins)

Hopkins, S. H. 1969. Evidence from "living tags" that fish go eight hundred miles up Atchafalaya-Red River to Denison Dam. Texas Jour. Sci., 20(3):295. (Abstract of paper presented at 1968 annual meeting of Texas Academy of Science.)

Spiny skins of Kinorhyncha and living marine trematodes in digestive tracts or air bladders of fish show that some threadfin shad, Dorosoma (Signalosa) petenense, and striped mullet (Mugil cephalus) must have gone all the way from salt water to Denison Dam, 800 miles upstream, during the lifetime of individual fish. Marine trematodes were found in gars (Lepisosteus osseus and L. spatula), which probably got them by eating mullet containing metacercariae. The mullet must have come all the way from the gulf, since Mugil cephalus reproduces only in water of oceanic or nearly oceanic salinity. Movement of fish up Red River may be easier because it has a salinity of 0.7-0.9 ppt, a high calcium content, and a slow current (0.7 fps) during low-water periods, such as in 1956 when the shad were taken. (S. H. Hopkins)

Hopkins, T. L. 1958. On the breeding and occurrence of opossum shrimp (order Mysidacea) in Indian River Inlet, Delaware. M.S. Thesis, Univ. of Delaware, 36 pp.

Biweekly plankton tows were made on flood tide at night in Indian River Inlet, Delaware, from July 1956 to January 1958. The mysids Neomysis americana, Mysidopsis bigelowi, Metamysidopsis munda, and Gastrosaccus dissimilis were found. Neomysis americana had a fluctuating population which averaged 80% of the total mysid population. Salinity fluctuations might have been one of the factors that influenced the success of reproduction and survival. The summer with the large catches of Neomysis did show a slightly higher sustained salinity than the previous summer, albeit only 1 ppt higher. (T. Rennie)

Hopkins, Thomas L. 1963. The variation in the catch of plankton nets in a system of estuaries. Jour. Marine Res., 21(1):39-47, illus, maps.

Variability in copepod catch during a tidal cycle was studied at 17 stations in St. Andrew Bay system, gulf coast of northern Florida. It was concluded that several tows spaced over a portion of a tidal cycle give more accurate estimates of copepod populations than a single large sample. Vertical salinity gradient was a main factor in variability of samples. Acartia tonsa, Oithona brevicornis, and Paracalanus crassirostris were common species. (S. H. Hopkins)

Hopkins, T. L. 1966. The plankton of the St. Andrew Bay system, Florida. Publ. Inst. Mar. Sci., Univ. of Texas, 11:12-64.

Monthly zooplankton and phytoplankton samples were collected from 11 stations within the St. Andrew Bay complex. Also temperature, salinity, Secchi disk, and chlorophyll measurements were taken. Salinity increased from the heads of the bays toward the gulf with mean annual salinities ranging from 19.4 ppt to 32.7 ppt. Surface salinities were less than bottom salinities at all stations. For the phytoplankton, Chaetoceros, Rhizosolenia, and Thalassiothrix were of greatest importance at stations near the gulf having relatively high salinity (>28 ppt). Bacteriastrum also showed a slight positive trend with increasing salinity. Skeletonema was most abundant at intermediate salinites (26 ppt). Total diatom biomass and diatom species diversity increased with increasing salinity, but chlorophyll a concentrations showed the opposite having highest concentrations near the heads of bays.

Each of the zooplankton groups and major species are discussed, many in relation to salinity. The variety of zooplankters decreased with decreasing salinity. Multiple linear regression analyses showed that salinity was not linearly related to zooplankton biomass to a statistically significant degree. (T. Rennie)

Hopper, Arthur F. 1960. The resistance of marine zooplankton of the Caribbean and South Atlantic to changes in salinity. Limnol. and Oceanogr., 5(1):43-47.

P. 43: "The majority of forms studied will withstand salinity changes [both increases and decreases] much greater than they would be expected to encounter in their normal environment, thus suggesting that salinity may not be a limiting factor in their distribution."

P. 46: Animals studied are listed in the order of their decreasing resistance to salinity changes:

	Max % Salinity Change Without More Mortality than Controls
Barnacle	-50 to ?
Brachyuran larvae	-20 to +20
Natantia	-20 to +15
Natantia (Lucifer)	-20 to ?
Annelida	-20 to +8
Sagitta	-18 to +3
Amphipoda	-15 to +5
Copepoda	-7 to +5
Euphausiacea	-2 to +2
Hydrozoan medusae	--
Tunicata	--

(From abstract)

Horst, R. 1919. Twee sedentaire Polychaeten uit het brakke water van Nederland. (In Dutch.) Zool. Meded. Leiden, 5(2).

Cited by Redeke 1932: Described the small polychaete annelid Alcmaria romijini from the Alcmaader Meere, Holland. This is one of the most abundant bottom animals of mesohaline inland waters, along with Polydora redeki, etc., according to Redeke. (S. H. Hopkins)

Houston, A. H. 1957. Responses of juvenile chum, pink, and coho salmon to sharp sea-water gradients. Canadian Jour. Zool., 35:371-383.

Juvenile salmon were tested with fresh water and the following salinities, respectively: chum fry, 5.10-6.02 and 19.43-23.69 ppt; pink fry, 8.27 and 20.34 ppt; coho fry, 7.31 and 23.96 ppt; coho smolt, 21.83 ppt.

Chum fry showed a marked preference for both concentrations of sea water.

Prior acclimation to either concentration evoked the same response, but less rapid than in those not acclimated. Response of pink fry was similar to that of chum, but in both concentrations not as strong. Concentrated sea water gave a more positive response than the dilution. The response of coho fry to dilute sea water was rapid and intense. The response to concentrated sea water was not positive. For the smolts, response to the concentrated sea water was slow but positive. As with all fry tested, activity of the smolts was less than that in fresh water. (S. Rennie)

Houston, A. H. 1959. Locomotor performance of chum salmon fry (Oncorhynchus keta) during osmoregulatory adaptation to sea water. Canadian Jour. Zool., 37:591-605.

When transferred from fresh water to sea water (22-24 ppt) cruising speed was depressed immediately. Recovery was complete in 36 hr, but at no time reached the speed attained in fresh water, even after 80 hr.

Chloride content varied inversely with size in the case of fish in fresh water. When transferred to sea water total body chloride content increased massively. It reached a maximum after 14 hr (corresponding to greatest depression of cruising speed) and then fell off again, until after 36 hr it was somewhat above that of the fry in fresh water.

Total body water decreased when fry were transferred to sea water. The maximum loss (3%) was after 14-hr exposure. (S. Rennie)

Houston, A. H. 1964. On passive features in the osmoregulatory adaptation of anadromous salmonids to sea water. Jour. Fish. Res. Bd., Canada. 21(6):1535-1538.

Many of the changes induced in the body fluids of migrating salmonids following entry into sea water are passively self-restrictive. Uptake of Na and Cl leads to redistribution of tissue water, so incoming electrolyte is diluted at cost of slight cell dehydration. Uptake of divalent cations by soft tissues and bone may restrict increases in extracellular electrolyte concentrations, and where associated with surfaces may cause decreases in permeability which further restrict ion uptake. Changes in pH may supplement or reinforce the latter action. Alone, passive effects of the type noted can only reduce the rates and magnitudes of changes in the body fluid system, and will have no alleviative action. However, they may be of real importance in the adaptive process in the sense of providing time for the changes in regulatory activity which ultimately restore the internal state to the regulated condition. (S. H. Hopkins)

Hubbs, Clark. 1961. A checklist of Texas fresh-water fishes. Division of Inland Fisheries, Texas Game and Fish Commission, Austin, Texas. IF Series, No. 3, Rev. June 1961, 14 pp.

Of interest because it records a number of marine and estuarine fishes in fresh water: the elasmobranchs Apriodon isodon, Carcharhinus leucas, Pristis pectinatus, and Dasyatis sabina, and the teleosts Elops saurus, Megalops atlanticus, Harengula pensacolae, Brevoortia gunteri, Anchoa mitchilli, A. hepsetus, Bagre marinus, Galeichthys felis, Strongylura marina, Syngnathus scovelli, Lucania parva, Adinia xenica, Fundulus similis, Fundulus grandis, Cyprinodon variegatus, Mollienesia latipinna, Mugil cephalus, Mugil curema, Menidia beryllina, Membras martinica, Polydactylus octonemus, Centropomus undecimalis, Caranx hippos, Eucinostomus argenteus, Bairdiella chrysura, Sciaenops ocellata, Leiostomus xanthurus, Micropogon undulatus, Pogonias cromis, Cynoscion arenarius, Cynoscion nebulosus, Lagodon rhomboides, Archosargus probatocephalus, Dormitator maculatus, Eleotris pisonis, Gobiomorus dormitator, Evorthodus lyricus, Gobionellus shufeldti, Gobionellus stigmaticus, G. boleosoma, G. oceanicus, G. hastatus, Microgobius gulosus, Gobiosoma robustum, Gobiosoma bosci, Gobioides broussonneti, Citharichthys spilopterus, Etropus crossotus, Paralichthys lethostigma, Trinectes maculatus, Achirus lineatus, and Sphoeroides nephelus. (S. H. Hopkins)

Hubby, Turner E. 1926. Survey of Texas waters with regard to oyster culture. Annual Report, Game, Fish, and Oyster Comm. of Texas, 1926(130):11-14.

Special attention was directed to the distribution of salinity of the water, and isohalines were drawn from every bay visited (between Corpus Christi Bay and Matagorda Bay). Fresh water was found in upper San Antonio Bay, Lavaca Bay at the Lavaca River, and opposite the mouth of the Colorado River in Matagorda Bay. San Antonio Bay was considered suitable for oyster culture because of its low (but not too low) salinity. (S. Rennie)

Huf, Ernsl. 1934. Uber den Einfluss der Narkose auf den Wasser-und Mineralhaushalt bei Susswassertieren. Pflüger's Arch. Ges. Phsiol., 235:129-140.

Blood chlorine content and weight changes in the freshwater snail Lymnaea stagnalis and the freshwater crayfishes Potamobius astacus and Potamobius leptodactylus before and after anesthetizing them in ether or chloroform water solutions, in dilute artificial sea water solutions. Lymnaea (unanesthetized) gained blood Cl, lost weight, and took up salts from sea-water solution. After equilibrium with outside was reached, weight lost was regained. Changes were reversible. Lymnaea did not live well even in strongly diluted sea water (blood Cl = 0.0625_n). Both Lymnaea and Potamobius during anesthesis lost blood Cl and gained weight (in fresh water?), Lymnaea taking up water much more than Potamobius. In Lymnaea these processes were easily reversible, so long as narcosis was short (3 hr). Longer narcosis (7 hr) led to a long Cl deficiency in the blood. Crayfish, which still showed a lower value for blood Cl 3-5 days after narcosis in fresh water, raised it during stay in diluted sea water (blood Cl = 0.125_n) to the same value as in nonnarcotized animals. Na, Ca, and Mg content of blood also were lowered (research on Lymnaea), K was raised. (S. H. Hopkins)

Huggins, A. K. and Munday, K. A. 1968. Crustacean metabolism. Pp. 271-378. In: Lowenstein, O., ed. Advances in comparative physiology and biochemistry, Vol. 3, Academic Press, New York.

Includes information on effects of salinity on rate of oxygen consumption and enzyme activity. (S. H. Hopkins)

Hughes, G. C. 1961. III. Ecological aspects of some lignicolous fungi in estuarine waters. Dissert. Abs., 21(8):2086.

The occurrence and distribution of lignicolous Ascomycetes and Deuteromycetes in the Neuse-Newport estuarine system in eastern North Carolina were studied. Fungi were collected by submerging wood test panels at stations established along the salinity gradient in the estuary. The fungi found fell into six basic distributional types based on their apparent salinity tolerances. Distribution seemed to be determined primarily by salinity and secondarily by water temperature. The distribution of seven fungi were analyzed to determine if a dual stress of salinity and water temperature might control their distribution patterns. Only Lignicola laevis showed a possible distributional response to salinity-water temperature stress in the Neuse-Newport Estuary. A series of lab experiments was designed to determine the effects of salinity-temperature stress on the growth, in vitro, of three species from the estuary. They were grown on a graded series of saline media, 0-40%, at temperatures ranging from 10 to 35 C. The growth pattern of Phoma sp. indicated that temperature affected the salinity at which optimum growth occurs. Growth at low temperatures was greatest when the salinity was low and greatest at high temperatures when the salinity was high. The reaction of Pseudoeurotium indicum was the inverse of Phoma sp. Its growth rate increased at higher temperatures only when the salinity of the medium was too low. Although the culture studies showed that salinity-temperature stress may affect in vitro fungi growth, the field data indicated that it does not necessarily have any effect on the growth and distribution of

the same fungi in estuarine waters. (T. Rennie)

Hughes, G. C. 1969. Marine fungi from British Columbia: Occurrence and distribution of lignicolous species. Syesis, 2(1/2):121-140.

Forty-two species of lignicolous marine fungi, including 12 Fungi imperfecti, 29 Ascomycetes and one Basidiomycetes, are from 47 collecting stations in southwestern British Columbia coastal waters.... Comparisons of fungal distribution in three hydrographic regions of the study area show the genus Corollospora largely restricted to more saline environments, whereas Remispora species are equally distributed in marine, estuarine, and low-salinity areas. Fifteen of the species reported were restricted to the marine region and five were limited to the low-salinity region. The possible roles of salinity and surface currents as factors limiting marine fungal distributions are discussed. (From Biol. Abstr.)

Hukuda, K. 1932. Change of weight of marine animals in dilute media. Jour. Exptl. Biol., 9:61-68.

The crabs Portunus puber, P. depurator, Carcinus maenas, Maia squinado, and Cancer pagurus were kept in dilute (2/3) sea water and changes in weight were frequently measured. The increase of body weight was compared with the resulting dilution of the body fluids. Body weight increase never exceeded 4% of the initial weight with equalization of osmotic pressure being almost complete in less than 24 hr. The equalization occurred mainly by the disappearance of salts and other dissolved substances from the internal medium, not by transfer of water, thus indicating membranes permeable to salts. The dogfish (Scyllium) was kept at 3/4 and 4/5 sea water dilutions. A considerable increase of weight was usually observed, together with marked diffuse edema especially on the abdominal surface, followed by a slow decrease in weight. The bounding membrane of the elasmobranch seemed to be semipermeable. There was a close quantitative agreement between the osmotic swelling observed and the diminution of the osmotic pressure of the blood. (T. Rennie)

Hulburt, E. M. 1957. The distribution of Neomysis americana in the estuary of the Delaware River. Limnol. and Oceanogr., 2:1-11.

Length measurements of planktonic shrimp Neomysis americana (Smith) over 2-yr period showed increase in size from ocean toward river end of estuary (4-ppt isohaline). Data are interpreted to mean shrimp grew larger with age as they drifted upbay in deeper water, and tended to accumulate in estuary by avoiding downbay-flowing surface currents due to negative reaction to light. Spring and summer reproduction within the bay contributed to abundance there. (From abstract)

Hulburt, Edward M. 1963. The diversity of phytoplanktonic populations in oceanic, coastal, and estuarine regions. Jour. Marine Res., 21(2):81-93, illus., map.

In deep ocean north of Bermuda, during spring and summer, conditions for growth are poor but high salinity and great depth are favorable to marine phytoplankton. When good growth conditions resulting in extreme dominance are coupled with adverse physical environment, as in New England estuaries, there is a reduction in diversity. Lower salinity is one of the factors making the estuaries adverse. (S. H. Hopkins)

Hulburt, E. M. and Rodman, Janet. 1963. Distribution of phytoplankton species with respect to salinity between the coast of southern New England and Bermuda. Limnol. and Oceanogr., 8(2):263-269.

"The distribution of phytoplankton species throughout a range of salinities from 31.68 to 36.53 ppt indicates that a considerable number are favored by

Ingle, Robert M. 1950. Variations in salinity and their relation to the Florida oyster. Part I: Salinity variations in Apalachicola Bay. [Talk presented at meeting of Gulf and Caribbean Fisheries Institute, Miami, November 1950; abstract in mimeographed program.]

Oysters were sold from parts of Apalachicola Bay which has 5 to 10 ppt salinity change between tides, but their glycogen content was low (1% to 1.5% wet weight). Variations from fresh water to 43.5 ppt encountered in 18-month period in areas that normally are heavily fished. Glycogen content seemed higher as salinity change rate slowed, even though change was of large magnitude. Weekly variations of 22 ppt were not uncommon in areas of commercial production.

Ingle, Robert M. 1962. Potential research benefits to be derived from estuarine heterogeneity. Tulane Studies in Zool., 9(5):295-299.

Estuaries are rigorous habitats, but those species that can live in them get such rewards that they have a rich and valuable fauna. They differ so that as many should be studied as possible; the laboratories on estuaries should expand and standardize activities. Besides estuaries, these studies should embrace outside waters nearby. (S. H. Hopkins)

Ingle, R. M. and Smith, F. G. W. 1949. Oyster culture in Florida. State of Florida, Board of Conservation, Educational Series, No. 5. 22 pp.; 2 text-figs; 2 tables.

Pp. 8-9: "Conchs. In Florida, sporadic visits by these snails, Thais haemostoma, wreak havoc in the oyster beds. Since conchs must have a water of high salinity, their depredations usually coincide with periods of drought, high tides, and other times when the fresh water supply of nearby streams becomes depleted. Then, in the nearly pure salt water of the sea Thais enters."

"The conch is equipped with mouth parts that are able to chip away small bits of shell from the bill of an oyster. As soon as the slightest space exists between the valves (shells) where they meet at the bill, the conch inserts a long, slim, tongue-like projection inside and gives the coup de grace."

"The conch is a serious threat to oyster production in Florida and research is needed on its life history and habits in order that investigation may be carried out into possible methods of control."

"It is known that if a great many poles be stuck into the mud bottom of a conch infested area at the proper season, the snails will crawl up the poles. Periodic visits to the poles, perhaps daily, enable workers to pull the poles out of the water and scrape the conchs off into a container. They can later be destroyed."

"Perhaps the finest method of control is to find a commercial use for the conchs. They would then be tracked down and caught in great numbers and a very effective control would be accomplished." (S. H. Hopkins)

Ingmanson, D. and Ross, A. 1969. Seasonal changes in Foraminifera at Seahorse Key. Quart. Jour. Florida Acad. Sci., 32(2):108-118.

Seasonal fluctuations in shallow water, marginal marine, calciferous foraminiferal populations at Seahorse Key, Florida (29°07' N, 83°05' W), are attributed largely to availability of food and water temperatures. Peak population densities were encountered during the low hydrothermal, high salinity months of January, February, and at one station in May. Low population densities between the months of June and September probably result from lower salinity and lethal temperatures during daylight exposure of the environments sampled. Apparently, optimal reproductive hydrotemperatures may not be the sole major factor necessary for population expansion under conditions where abundant nutrients are available. (From Biol. Abstr.)

Isyban, A. V. and Shnaidman, V. A. 1969. O statisticheskom podkhode pri izuchenii ekologii morskikh bakterii. (Statistical approach in the study of the ecology of marine bacteria.) Dokl. Akad. Nauk. SSSR, 188(5):1159-1162.

For a quantitative determination of the frequency of individual species of heterotrophs as a function of their temperature-salinity environment, a special method was developed called the method of prismatic ecograms. The essence of this method is described. (From Biol. Abstr.)

Ivanov, A. I. 1965. Vliyanie vody razlechnoi solenosti na vyzhivanie lichizok chernomoroskikh ustrits (Ostrea turica). (The effect of water differing in salinity on the survival of Ostrea turica larvae.) Dokl. Akad. Nauk. SSSR, 163(5):1256-1258.

Larvae were raised in media varying in salinity from 5 to 45 ppt and in control water from the Egorlytskii Bay (14-15 ppt). The water temperature was maintained at 22.5 ± 1.5 C. Death occurred at the lowest and highest concentrations after 2 days. The survival was longest (19.1 days) at 30 ppt. These results indicate that commercial oyster farmers should select sites of fairly high salinity for their operations. (From Biol. Abstr.)

Iversen, E. S. 1968. Farming the edge of the sea. Fishing News (Books) Ltd., London. 301 pp.

Pp. 49-51 -- Estuaries, the principal areas for "farming," are discussed. Reported to be 20 times as productive as open sea and 7 times as productive as average wheat field. Floods may make water too fresh, kill oysters, etc. Low salinities keep many predators and parasites away, allowing more adaptable species to build up large populations. Tides are also important.
(S. H. Hopkins)

Jackson, C. R. 1952. Some topographic and edaphic factors affecting distribution in a tidal marsh. Quart. Jour. Florida Acad. Sci., 15:137-146.

Included studies on effects of salinities on marsh plants. Found that Distichlis spicata grew best at salinities of 11.8-17.1 ppt. Distribution of the various marsh plants was considered to be determined by a complex of several factors of which the most important are inundation and salinity, according to Adams (1963, pp. 446 and 454). (S. H. Hopkins)

James, M. C. 1946. Oyster mortality high in Chesapeake Bay. Southern Fisherman, 6(6):67.

High oyster mortality in upper Chesapeake Bay was due to abnormally low salinities (1/2 to 1/3 of normal). This coincided with high runoff of the Susquehanna River as did other instances of high mortalities in 1908, 1916, 1928, 1936, and 1943. (S. Rennie)

Jansen, K. P. 1970. Effect of temperature and salinity on survival and reproduction in Baltic populations of Sphaeroma hookeri Leach, 1814 and S. rugicaudae Leach, 1814. (Isopoda.) Ophelia, 7(2):177-184.

Populations of S. hookeri from Copenhagen Harbour (Sydhaun) and S. rugicauda from Selsø (about 40 km west of Copenhagen) were studied during the summer of 1969. Tests were carried out at 5, 15, and 25 C, at salinities from 0 to 60 ppt; a greater percentage of adults of S. hookeri survived at lower salinities (0, 2, and 5 ppt) at the three temperatures; at the lower salinities females of S. hookeri produced more young which survived longer. The depressing effect of low salinities on reproduction in S. rugicauda is considered to be a significant factor limiting the distribution and abundance of this species in the Baltic Sea. (From Biol. Abstr.)

Jansson, Bengt-Owe. 1962. Salinity resistance and salinity preference of two oligochaetes Aktedrilus monospermatecus Knöllner and Marionina preclitellochaeta n. sp. from the interstitial fauna of marine sandy beaches. Oikos. 13(2):293-305, illus.

A. monospermatecus from 6 ppt tolerated 1.25-20 ppt and M. preclitellochaeta from 2 ppt tolerated 2.5-10 ppt for 5-6 days (length of experiment). A. monospermatecus from 6 ppt preferred 2.5-5 ppt and M. preclitellochaeta from 0 ppt preferred 0.2-0.3 ppt. A. monospermatecus still preferred 5 ppt after 8 days at 20 ppt. (S. H. Hopkins)

Jansson, B. O. R. 1972. The Baltic as an ecosystem - a Swedish research project in an area of increasing pollution (Abs.). Abstracts of Papers Submitted for the 35th Annual Meeting, Amer. Soc. of Limnology and Oceanography, Tallahassee, Fla., March 19-22, 1972

Stable "halokline" a factor in increasing occurrence of anoxic bottom water, containing H_2S. Brackish water, with low and stable salinity, keeps number of plant and animal species comparatively low. (S. H. Hopkins)

Jaworski, Eugene. 1970 (unpublished manuscript). Biogeography of the blue crab fishery, Barataria Estuary, Louisiana. Ph. D. Dissert., Department of Geography and Anthropology, Louisiana State University, Baton Rouge. 143 pp.

Salinity is referred to often throughout, but is discussed particularly in a section headed "The Effect of Salinity," pp. 23-24. Also in discussion of commercial crab fishing, especially pp. 53-55, 63, 70-72, 75-76, 79-80, and 87-88. Fig. 13 on p. 78 is a graph showing "salinity" (acutally chlorinity) in Bayou Barataria at Lafitte throughout 1 year, by months. Among the explanations given

by fishermen for a decline in the catch of blue crabs is the theory that the estuary is getting more saline. On the other hand, the author (p. 108) blames decreased salinity due to greater flow of Atchafalaya River for drastic decline of crab catch in Grand Lake. The life history of the blue crab in Barataria Estuary and associated seasonal changes in crab fishing are described in detail. The entire life history is completed in the estuary and along nearby gulf shores. (S. H. Hopkins)

Jefferies, Harry P. 1960. Winter occurrences of Anguilla rostrata elvers in New England and middle Atlantic estuaries. Limnol. and Oceanogr., 5:338-440.

No salinity data are given, but the implied presumption is that low salinity attracts the young eels from the sea into estuaries.

Jefferies, Harry P. 1962a. Copepod indicator species in estuaries. Ecology, 43(4):730-733.

The eight species considered were: Pseudocalanus minutus, Oithona similis, Centropages hamatus, C. typicus, Paracalanus crasirostris, Temora longicornis, Labidocera aestiva, and I. stylifora. Plankton samples were taken weekly in summer, biweekly the rest of the year, with No. 12 net in Clarke-Bumpus device, and frequency index calculated for each species at seven stations in Raritan Bay and three in Lower Bay. These reproduce in Lower Bay, not Raritan Bay, and are significantly (22-23%) more abundant in the "net flood drift" along northern shore of the estuary. Although it is stated that abundance is directly proportional to salinity, the real correlation is with circulation pattern, inward along northern shore, turning counterclockwise, and out along southern (right) shore. No surface salinities are given. Bottom salinities given range only from 20.8 to 24.5, not enough to account for distribution differences. Other species not listed as indicators, especially Acartia tonsa, were more abundant than species listed in summer-fall, and most abundant in inner (upper) end of estuary. (S. H. Hopkins)

Jefferies, Harry P. 1962b. Salinity-space distribution of the estuarine copepod genus Eurytemora. Intern. Rev. Ges. Hydrobiol., 47(2):291-300.

When more than one-third of the length of an estuary is between 5 and 15 ppt isohalines, copepods of genus Eurytemora make up preponderance of holoplanktonic forms in winter-spring period. Pettaquamscutt River, Rhode Island, is such an estuary and Eurytemora makes up 95% of holoplanktonic copepods in salinity of 20 ppt, density of population being maintained by dispersal from the low-salinity region upstream. In Charlestown Pond, Rhode Island, where only 5%-6% of total length is between 5 and 15 ppt, only trace numbers of Eurytemora were found. (S. H. Hopkins)

Jefferies, Harry P. 1962c. Succession of two Acartia species in estuaries. Limnol. and Oceanogr., 7(3):354-364, illus., maps.

Plankton observations in Narragansett Bay, Raritan Bay, the York River and Charlestown-Green Hill ponds, Rhode Island, show seasonal alternate cycles of dominance between the Calanoid copepods, Acartia clausi (a winter-spring form) and Acartia tonsa (a summer-fall form). Succession from clausi to tonsa during spring starts near the head of an estuary and spreads seaward. Summer warming was not the sole factor in the species replacement pattern. When temperatures were intermediate for reproduction and interaction for both species, A. tonsa did better in the lower salinities than did A. clausi. In some areas, clausi persisted in relatively slowly warming and high salinity areas, so competition with tonsa was delayed. But when temperatures increased and salinities decreased, A. tonsa began increasing in areas once dominated by clausi. (T. Rennie)

Jefferies, H. P. 1967. Saturation of estuarine zooplankton by congeneric associates. Pp. 500-508. In: Lauff, G. H., ed. Estuaries. Amer. Assoc. Adv. of Sci. Publ. No. 83, Washington, D. C., xv + 757 pp.

Includes an "ecological classification of the major Entomostraca species in estuarine plankton" (table 1, p. 501): true estuarine, reproducing only in salinities between 5 and 30 ppt; estuarine and marine, propagating throughout major part of length of estuary but population development usually limited by salinities less than 10 ppt; euryhaline marine, all stages found in "marine zone" of estuary, but these are carried in from ocean where reproduction occurs; stenohaline marine, characterize open neritic waters though adults and other late stages may occur in estuary "marine zone." Examples of each category are shown in the table. Different species of the same genus replace each other seasonally as salinity conditions change to favor one or the other in intrageneric competition, as shown in fig. 5, p. 504. (S. H. Hopkins)

Jeuniaux, C., Duchâteau-Bosson, G., and Florkin, M. 1961. Variation de la composante amino-acide des tissus et euryhalinité chez Perinereis cultrifera Gr. et Nereis diversicolor (O. F. Müller). Jour. Biochem. 49(6):527-531. (In French, English summary.)

Of these two polychaete annelid worms, Nereis is more euryhaline than Perinereis. Both possess osmoregulatory mechanisms which employ the exchange of free amino acids. (S. Rennie)

Jeuniaux, C. and Florkin, M. 1961. Modification de l'excrétion azotée du crabe chinois au cours de l'adaptation osmotique. Arch. Internat. Physiol. Biochim., 69:385-386.

In this freshwater crab, as in the euryhaline shore crab Carcinus maenas, the intracellular osmotic pressure keeps in equilibrium with that of blood, in the course of a change in salinity, by a change in intracellular concentration to which certain free amino acids contribute. Experiments are described in which Chinese mitten crabs (Eriocheir sinensis) from French rivers are gradually changed from fresh to sea water over a 4-day period, and from sea to fresh water over a 4-day period, while excretions are analyzed and measured. It is concluded that the change in concentration of the intracellular amino acids is the result of a regulation of the catabolism of amino acids. (S. H. Hopkins)

Job, S. V. 1969. The respiratory metabolism of Tilapia mossambica (Teleostei) II. The effect of size, temperature, salinity and partial pressure of oxygen. Mar. Biol. (Berlin), 3(3):222-226.

Tilapia mossambica (Teleostei) weighing 5 to 80 g were acclimated at 30 C to salinities of 0.4 ppt (tap water), 12.5 ppt (50% sea water), and 30.5 ppt (100% sea water). Their respiration was measured at routine activity and the partial pressure of ambient oxygen gradually reduced from 250 to 50 mm Hg. Respiration is salinity-dependent; the proportionate ability to use oxygen in any one salinity is above the critical pO_2--the same in all experimental groups. This ability is a function of temperature and increases from 15° to 40° as long as the pO_2 remains above 150 mm Hg. At 50 mm Hg pO_2, the limiting effect is minimal, with fish kept in an isotonic medium (12.5 ppt S), allowing greater scope for the activity and a higher rate of oxygen uptake. (From Biol. Abstr.)

Johnson, D. S. 1965. A review of the brackish water prawns of Malaya. Bull. Nat. Mus., Singapore, 33(2):7-11.

Lists representatives of five families found in brackish estuaries and even fresh waters of Malaya, according to Green (1968, p. 193) in commenting on the greater number of shrimps penetrating estuarine and fresh waters in the tropics.

See also Hall, D. N. F. (1962). (S. H. Hopkins)

Johnson, L. C. 1891. Transition of fauna in the Mississippi delta. Pop. Sci. Mo., 38:140.

"In a paper read in the American Association, in his absence, by W. J. McGee, Mr. L. C. Johnson said that he had made use of the Nita crevasse of 1890 of the Mississippi River to illustrate the manner in which the abrupt changes of freshwater to saltwater fauna, and vice versa, of which frequent evidences appear in the delta, have been brought about. The crevasse was the most extensive that has been formed for many years; and through it flowed a volume of fresh water sufficient to transform the previously brackish lakes and saline bays on the left of the river into freshwater lakes and estuaries. One of the prominent results of the flood was the destruction of the saltwater fauna and the substitution of a freshwater and mud-loving fauna over an immense area. The oyster-beds along the coast, which were the basis of an important industry, were injured, and in many cases destroyed. The sea-fishing region was also ruined, and the pickerel and other characteristic fishes of the Mississippi may now be taken where four months ago only saltwater forms were found. Hitherto the geologist employed in the lower Mississippi region has been puzzled to account for the sudden transitions of fauna; but here we have a case where one of them was affected in a single week, over as wide an extent as all of those which have so embarrassed the student."

Johnson, M. W. 1939. Pseudodiaptomus (Pseudodiaptallus) euryhalinus, a new subgenus and species of Copepoda with preliminary notes on its ecology. Trans. Amer. Micr. Soc., 58(3):349-355.

A new Pseudodiaptomus species is described. This species is extremely euryhaline in nature, being found in waters (open bay, lagoons, ponds) ranging from 1.8- to 68.4-ppt salinity along the California and upper Mexican Pacific coast. Reproduction occurred throughout this range. No specimens were taken from fresh water. (T. Rennie)

Johnson, Ralph G. 1967. Salinity of interstitial water in a sandy beach. Limnol. and Oceanogr., 12(1):1-7.

Salinity in upper 20 cm of intertidal sand was studied at two stations in Tomales Bay, California. In summer, elevation is not important except for evaporation. In winter, with more fresh water, interstitial salinity at high points on beach remains low throughout tidal cycle. At elevations below 1 m, interstitial salinity varies, but less than in adjacent open waters of the bay. The environment of interstitial fauna in low intertidal zone is more stable than that of epifaunal or pelagic organisms in shallow water. Although data presented do not show it, the author says variations high in beach, due to drying and flooding with fresh water, "must constitute a major obstacle to the spread of marine organisms into this area," and thus the beach is unlikely to have been an important avenue to freshwater or terrestrial habitats. (S. H. Hopkins)

Johnson, Roy B. 1966. The effects of engineering projects on Galveston Bay estuaries. Project 2-12-R-1. The effects of engineering projects on the ecology of Moses Lake. Texas Parks and Wildlife Department, Coastal Fisheries, Project Reports 1966. Mimeo.

Hurricane protection levee under construction crossed mouth of Moses Lake, and "when completed will close it except for closable navigation and tide opening 56 ft wide, 13 ft deep" (natural mouth 0.5 mile wide, 3 ft average depth). Moses Lake had salinity of 5-25 ppt during study, water temperature 10-30 C (April 1966-May 1967). Oyster reefs occurred here, with Brachidontes recurvus (indicating prevalent low-salinity oyster regime). "Pelecypods frequently taken

in benthic samples" included Rangia flexuosa (but not R. cuneata), Macoma mitchelli, Mulinia lateralis, and Tagelus plebeius.

Johnson, T. W., Jr. 1967. The estuarine mycoflora. Pp. 303-305. In: Lauff, G. H., ed. Estuaries, Amer. Assoc. Adv. of Sci. Publ. No. 83, Washington, D. C., xv + 757 pp.

All major groups of fungi are represented in estuaries. They are not greatly different from terrestrial and freshwater fungi, and in many cases are of the same species. Some estuarine species have wide salinity tolerances and some grow better in NaCl solutions.

Jones, Lowell L. 1941. Osmotic regulation in several crabs of the Pacific coast of North America. Jour. Cell. Comp. Physiol., 18:79-92.

The osmotic pressure relations of the following crabs were determined: Uca crenulata and Pachygrapsus crassipes, hyperosmotic in brackish water, hypo-osmotic in higher salinities; Hemigrapsus nudus, H. oregonensis, Rhithropanopeus harrisii, and Cancer magister, hyperosmotic in brackish water, no regulation in higher salinities; Cancer antennarius, Lophopanopeus heathii, and Speocarcinus californiensis, no regulation in brackish water.

In the two species of Hemigrapsus temperature had little influence on the osmotic pressure of the blood. Upon extreme exposure to air the osmotic pressure of the blood in the two crabs was highly variable near death. In the field osmotic pressures after maximum exposure between high tides were high, but did not approach those obtained under experimental conditions.

Hypo-osmotic crabs are able to regulate against the increasing salinity of the water of the branchial chamber when they are in air, whereas the osmotic pressure of the blood of crabs without this type of regulation rises to the same extent as does that of the water around the gills. This ability to regulate has probably been of great importance in the development of terrestrial life in crabs. (S. Rennie)

Jones, N. S. 1948. The ecology of the Amphipoda of the south of the Isle of Man. Jour. Marine Biol. Assoc. U.K., 27:400-439.

Most of this paper is on amphipods of strictly marine situations, but pp. 427-431 discuss amphipods of three brackish-water situations. The first two, Spaldrick and Bowery Beach, are freshwater streams running to the sea across intertidal shores, all rocks at Spaldrick and part rocky, part sand, at Bowery Beach. Here the typical species in water which fluctuates from 0-1.5 ppt at low tide to 17-34 ppt at high tide, are Gammarus duebeni, Marinogammarus marinus, and M. stoerensis. Gammarus zaddachi salinus and M. pirloti occur in the sandy part of the beach only. The third brackish-water area is a true estuary, the Silverburn. Here Gammarus pulex, G. duebeni, Melita pellucida, and G. zaddachi zaddachi live in the fresh-to-slightly brackish zone, Corophium volutator and Marinogammarus marinus in the intermediate zone, G. zaddachi salinus in the higher and intermediate zone (overlapping G. z. zaddachi a little), and Hyale prevosti, Melita palmata, Marinogam. pirloti, and Marinogam. stoerensis in the higher salinity zone (15-30 ppt). (S. H. Hopkins)

Jones, N. S. 1950. Marine bottom communities. Biol. Rev., 25:283-313.

Factors affecting the communities are both physical and biological. The former includes temperature, salinity, light, exposure to air and desiccation, oxygen content, nutrient salts, currents and tides, and the nature of the bottom deposit. Salinity can limit organisms to estuaries or other brackish water situations, or it can limit stenohaline forms to below-tide levels. Surface salinities are also somewhat influenced by latitude, therefore limiting the distribution of some forms.

In a proposed classification of the communities salinities are used as well as temperatures. Within the Atlantic boreal region there are communities with salinities of 7-34 ppt, 23-35.5 ppt, and 34-35.5 ppt, and depth, temperature, and substrate requirements. (S. Rennie)

Jones, N. S. and Burbanck, W. D. 1959. Almyracuma proximoculi gen. et sp. nov. (Crustacea, Cumacea) from brackish water of Cape Cod, Massachusetts. Biol. Bull., 116(1):115-124.

This cumacean species was found 1 mile above the mouth of the Pocasset River (Cape Cod, Massachusetts) in a flat, which is almost out of water at low tide, when the water covering it has a salinity of less than 1 ppt. It is the first member of the family Nannustacidae found in such low salinity. At high tide the same flat is covered by 3-4 ft of water, salinity about 30 ppt.

Jørgensen, C. B., and Dales, R. P. 1957. The regulation of volume and osmotic regulation in some Nereid polychaetes. Physiol. Comp., 4:357-374.

Nereis diversicolor and N. pelagica increased in weight when transferred into a dilute medium (from 268 to 201 m equiv. Cl/l). N. virens had nearly regained its original weight after 24 hr, while N. pelagica had not. N. virens gained less weight with the transfer. N. virens gained more weight than N. diversicolor in similar experiments. Weight regulation of N. diversicolor is more efficient than that of N. virens in a hypotonic medium.

Chloride influx is approximately proportional to the concentration of the medium between 225 and 465 m equiv. Cl/l. Below this, uptake is higher than at concentrations where no regulation is found. Maximum uptake was at 65 and 120 m equiv. Cl/l. In fresh water, uptake is only about one-third of that at these concentrations. Influx in N. virens is higher than in N. diversicolor, indicating that the former is probably more permeable to chloride ions.

In N. diversicolor at higher salinities, rate of exchange of chloride is 6%-8% of total body chloride. At 65 m equiv. Cl/l, rate of exchange is maximum in both worms, being 13%-34% in N. diversicolor and 48%-55% in N. virens.

N. virens and N. pelagica were more permeable to water than N. diversicolor. In the latter, permeability to water and chloride ions was independent of the external concentration in sea water and down to 65 m equiv. Cl/l. In fresh water permeability was reduced. (S. Rennie)

Jørgensen, O. M. 1929. The plankton of the Tyne Estuary. Proc. Univ. of Durham Phil. Soc., 8:41-54.

Neomysis integer (Crustacea, Mysidacea) is rare in estuaries where O_2 is low (because of pollution, for instance), especially in warm weather. Mysis relicta in fresh water requires 4 ml/l of oxygen, but in brackish water can live in water with O_2 content as low as 1.6 ml/l. Cited by Green, 1968, p. 94. (S. H. Hopkins)

Joseph, E. B. and Vishnu, P. S. 1966. Determination of salinity tolerances in mummichog (Fundulus heteroclitus) larvae obtained from hormone-induced spawning. Chesapeake Sci., 7(4):193-197.

Spawning was induced by injection of anterior pituitary hormone into adult mummichogs, and eggs were hatched in water of 25.3-ppt salinity. Starting from a control salinity of 26.1 ppt, salinities were raised or lowered at 1-day intervals for 50 days until extremes of 0.16 and 134.3 ppt were reached. In the lowered-salinity group no mortalities occurred until the salinity was reduced to 0.39 ppt. In the high-salinity group the first mortality occurred when salinity reached 102 ppt on the 23d day. Above this level, mortalities occurred at a rapid rate. No larval fish died in the control salinity (26.1 ppt). The results showed tolerance of newly hatched mummichogs for a wide

range (at least 100 ppt) of salinities. (S. H. Hopkins)

Joshi, M. C. 1968. A study on the growth of the clam Katelysia mormorata Lam. Jour. Shivaji Univ. (SCI.), 1(1/2):11-15.

It appears that the growth of K. marmorata, an edible clam, is influenced by salinity and the Ca content of the sea. (From Biol. Abstr.)

Kahler, H. H. 1970. Ueber den Einfluss der Adaptationstemperatur und des Salzgehaltes auf die Hitze-und Gefrierresistenz von Enchytraeus albidus (Oligochaeta). (On the influence of adaptation temperature and salinity on heat and cold resistance of Enchytraeus albidus (Oligochaeta). Mar. Biol. (Berlin), 5(4):315-324. (German with English summary.)

The combined effects of temperature and salinity on resistance adaptation to temperature were investigated in the oligochaete E. albidus Henle. This worm shows reasonable resistance apparation to both cold (-13.2 C) and heat (35.8 C). Acclimation to high salinity increases the degree of resistance to temperature extremes. The effect of salinity on heat resistance, and especially on cold resistance, decreases with rising adaptation temperature. Over the salinity range which allows homeosmotic conditions (2 to 15 ppt), E. albidus does not exhibit a constant resistance level (at least not to heat). (From Biol. Abstr.)

Kajikawa, Toyoaki, Sano, Shigeru, and Soguri, Misao. 1953. Studies on the cause of the abnormal mortality of hanging oysters in the Nakami. On the surface tension of the discontinuous layer. Bull. Jap. Soc. Sci. Fish., 19(4):449-455. (In Japanese/English summary.)

"The authors studied the abnormal mortality of hanging oysters in the Sea of Nakami. The water is of two layers with the upper of lower salinity, and thus shows a very high vertical stability. A distinct discontinuity layer develops between them. Hydrogen sulfide and other sulfides and organic matters were abundant in summer and they were selectively absorbed into the layer. The greatest damage to oysters seems to take place within the moving range of this discontinuity layer and consequently the absorbed substances are supposed to have something to do with the abnormal oyster mortality. The fact that hanging oysters suffer to the greatest degree during the period of water turbulence caused by typhoons or during that of "red-water" in autumn, is explained by rise of the injurious substances from submarine deposits and by diffusion of the surface active substances of the discontinuous layer into the sea water around. G. Gunter."

Kalber, Frederick A. and Costlow, John D., Jr. 1968. Osmoregulation in larvae of the land-crab, Cardisoma guanhumi Latreille. Amer. Zool., 8:411-416.

Larvae of C. guanhumi have the same kinds of adaptations for water intake at the time of molt that were found in Rhithropanopeus harrisii. Land-crab larvae hyperregulated in 10-ppt sea water and hyporegulated in water of 40 ppt for experimental periods for 2 hr during first one-third of their development. During the remainder of larval life, they hyporegulated against 15 ppt in intermolt periods, and became isosmotic with, or hyporegulated against, 10 ppt at the time of molting. From the time of hatching, the osmoregulatory pattern of developing C. guanhumi fits them for deep penetration of estuaries and for crossing steep saline gradients. This pattern is evidence for a stronger and more enduring control of water balance, especially at the time of molting, than found in nonterrestrial species. (S. H. Hopkins)

Karpevich, A. F. 1955a. [Reaction of Azov invertebrates to a change in salinity.] Trudy Vsesoiuznovo N. I., Inst. Morskovo Rybnovo Khoziaistra i Okeanogr., 3(1):240-275. (No abstract; in Russian.)

Karpevich, A. F. 1955b. [The ecological basis for predicting changes in the distribution of fishes and the composition of the ichthyofauna, with increase in salinity of the Sea of Azov.] Trudy Vsesoiuznovo N. I., Inst. Morskovo Rybnovo Khoziaistra i Okeanogr., 31(2):3-84. (No abstract; in Russian.)

Kashiwagi, M. and Sato, R. 1969. Studies on the osmoregulation of the chum salmon, Oncorhynchus keta (Walbaum): I. The tolerance of eyed period eggs, alevins

and fry of the chum salmon to sea water. Iohoku Jour. Agr. Res., 20(1):41-47.

The degree of tolerance of different stages of the eyed period eggs of alevins and fry of the chum salmon, O. keta, to various concentrations of sea water was examined in order to know the outline of the conversion of the mechanisms for osmoregulation in the seaward migration of the fish. The rate of hatching of the eyed period eggs that were abruptly transferred to 100%, 75, 50, and 25% sea water from fresh water were 25%, 50, 75, and 100%, respectively. The days of incubation of the eyed period eggs tended to be more in the experimental salinities. The alevins hatched in these media were not able to live normally. The alevins that were 1 day from hatching were not able to live in the 100%, 75, and 50% sea water, though 95% of the alevins survived in the 25% sea water. The survival rate of the alevins that were 10, 20, and 40 days from hatching were reduced as the concentration of sea water to which the alevins were transferred from fresh water increased. The fry that were more than 60 days from hatching and in which the yolk sac was completely absorbed were able to survive in the 100% sea water when they were transferred abruptly to it from fresh water. (P. Maxwell)

Kasimov, R. Y., Abramov, B. N., and Kyasimov, I. B. 1966. Viliyanie vody raznoi soleniosti na vyzhivanie i rost Kurinskikh osetrovykh na rannikh stadiyakh raz. (Effect of different salinities on the survival and growth of Kura sturgeons during early stages of development.) Tr. Azerb. Otd. Tsentr. Nauchissled Inst. Osetrovogo Khoz, 42:91-125. From: Ref. Zhur., Biol., 1967, No. 3I107.

The most favorable salinity for spermatozoa is 2 ppt for hausen and common sturgeon, 3.5 ppt for sevringa, and Kura water (0.9-1.46 ppt) for spiny sturgeon (Acipenser nudiventris). Ova of each species have different salinity requirements for fertilization and embryonic development, spiny sturgeon and hausen being more sensitive to increased salinity than common sturgeon and sevringa least sensitive. Permissible salinity at Ust-Kura hatchery is 3-3.5 ppt. Kura water (931-1456 mg/l) is favorable for larval development of sevringa and sturgeon; so is 2-3.5 ppt, but the latter increases mortality of spiny sturgeon larvae and hausen larvae, also increasing consumption of food and O_2. Young adapted to salinity outgrow those in river water.

Katayama, T. 1960. Resistance of the guppy, Lebistes reticulatus, to sea water. Physiol. and Ecol., 9(1):32-34. (In Japanese.)

"Adults and young of the guppy, Lebistes reticulatus (Peters), were acclimated to various concentrations of the artificial sea water by raising the concentration of the medium by 10% a day, and their resistance to 100% sea water was tested.

No lethal effect was observed on adult fish when the concentration of the medium was raised up to 100% sea water. The fish which had been kept for 4 weeks at a concentration of 20% or more survived transference to 100% sea water, while the mean anesthesia time of the control (0%) group was 206 minutes.

In young, more or less lethal effects were observed when the medium concentration was raised above 60%. The young which had been kept at 40% tolerated transference to 100%. The mean anesthesia time of the control (0%) group was 85 minutes.

Sudden transference to fresh water of the adults and young acclimatized to sea water brought about no fatal results." (Author's abstract)

Kawaguti, S. 1943. Effect of freshwater on respiration of reef corals. Jour. Nat. Hist. Soc., Taiwan, 33:259-261. (In Japanese.)

Physiological studies of freshwater effects on three species: Goniastrea aspera, Fungia actiniformis, and Pocillopora damicornis. (J. W. Wells)

Kawamura, T. 1966. Distribution of phytoplankton populations in Sandy Hook Bay and adjacent areas in relation to hydrographic conditions in June 1962. Tech. Pap. Bur. Sport Fish. and Wildlife, Washington, 1:1-37.

At the mouth of the Navesink River, New Jersey, Kawamura found a complex succession of phytoplankton, according to Green (1968, pp. 81-82): at the fresh end of the estuary was a zone dominated by euglenoids (salinity below 20 ppt); between salinities of 20 and 22 ppt, Rhizosolenia was dominant; at 22-25 ppt, Cerataulina bergoni was dominant; in lower estuary, an assemblage of dinoflagellates dominated; in open water beyond mouth of the estuary, the diatom Skeletonema costatum became dominant. Kawamura gave a table to show salinity relations of planktonic algae in this estuary, reproduced by Green (1968) on p. 82. (S. H. Hopkins)

Kelley, D. W. and Turner, J. L. 1966. Fisheries protection and enhancement with water development of the Sacramento-San Joaquin Estuary. Pp. 78-82. In: A Symposium on estuarine fisheries. Am. Fish. Soc. Special Publ. No. 3, Washington, D. C., viii + 154 pp.

San Francisco Bay is usually as saline as the ocean. The gradient from sea water to fresh water usually begins in San Pablo Bay and extends 50 miles upstream into the western part of the delta. Water is usually well mixed vertically. The California Water Plan is to collect fresh water in several large northern California reservoirs, transport this water down the Sacramento Valley into a large canal, which will carry it to southern California. This plan threatened anadromous fishes valued at millions of dollars annually. All plans proposed in 1961 seemed harmful to fisheries. For instance, salinity barriers were to be built across lower estuary, eliminating salinity gradient, making San Joaquin River flow backwards, and blocking fish migrations. Best solution seems to be sending water downvalley in peripheral canal instead of in river, which will allow release of fresh water into delta when and where needed. (S. H. Hopkins)

Kellogg, J. L. 1905. Notes on marine food mollusks of Louisiana. Bull. Gulf Biol. Sta., 3:1-43.

In a discussion of the oysters of the Calcasieu Lake, Louisiana, area, mention was made of occasional freshets which made the waters over the oyster beds completely fresh. Nearly all the oysters were destroyed, but some of the deeper beds survived and yielded small numbers of edible adults. In the area, freshets had killed oysters in noticeable numbers only three or four times in two decades. (T. Rennie)

Kellogg, J. L. 1910. Shell-fish industries. Henry Holt & Co., New York, xvi + 361 pp.

Sea farming; the biology of food mollusks (oysters and clams); oyster culture, history, techniques, implements, enemies, and diseases; regional accounts of oystering and oyster culture in the U.S.; the soft clam (Mya arenaria) distribution, biology, future of its culture; the hard clam (Venus mercenaria); scallops. Salinity is mentioned on pp. 97-99 in relation to oysters and oyster culture (e.g., best set of spat occurs in waters of densities between 1.010 and 1.017); in relation to soft clams on pp. 288 and 313; in Gulf of Mexico, pp. 54 and 265; in North Carolina on p. 242. (S. H. Hopkins)

Kendall, A. W. and Schwartz, F. J. 1964. Salinity tolerances of two Maryland crayfishes. Ohio Jour. Sci., 64:403-409.

Orconectes virilis could tolerate salinities up to 33 ppt for short periods (equal to a tidal flush), but longer exposure caused 50% to die after 96 hr. Some lasted as long as 696 hr.

Specimens of Cambarus b. bartonii, with no previous saltwater history, were able to withstand 0, 5.2, 13.6, and 27.5 ppt for 240, 252, 108, and 192 hr, respectively. At 0, 5, 9, 15.4, and 33.6 ppt, 50% survived for 96 hr with longest overall survival at the lower salinities. Salinities of 6-15 ppt were readily tolerated for 27 days, while higher concentrations were detrimental.

Kendall, A. W. and Schwartz, F. J. 1968. Lethal temperature and salinity tolerances of the white catfish, Ictalurus catus, from the Patuxent River, Maryland. Chesapeake Sci., 9(2):103-108.

Temperature tolerances of this freshwater fish were size-related with the smaller individuals surviving longer under stressful conditions. Upper lethal temperatures were 29.2 and 31.0 C for small and large fish, respectively. Salinity tests showed no apparent size-related differences. Upper salinity tolerance limit was estimated at 14 ppt. It is thought that the downriver distribution limit of I. catus in the river follows the 15-ppt isohaline line.

No salinity-temperature combination tests were run although the authors feel these will be of great importance in evaluating the effects of a heated effluent on the river fauna. (S. Rennie)

Kerwin, J. A. 1971. Distribution of the fiddler crab (Uca minax) in relation to marsh plants within a Virginia estuary. Chesapeake Sci., 12(3):180-183.

The marsh area studied was along Poropotank River, a tributary of York River, and had a salinity gradient ranging from 0.33 ppt minimum at upper end to 16.37 ppt maximum at mouth of Poropotank. The fiddler crab studied was found associated with 15 plant species, of which the five most often associated were Spartina alterniflora, Scirpus robustus, Distichlis spicata, Spartina patens, and Spartina cynosuroides. Fiddler crab densities based on counts of burrows ranged 0 to 76 per m^2, averaging 7.88 in brackish (low salinity) marsh and 14.35 in the part of the marsh where salinities averages were higher. No fiddlers were found in freshwater marsh (chlorinity below 0.8 ppt). (S. H. Hopkins)

Kerwin, J. A. and Pedigo, R. A. 1971. Synecology of a Virginia salt marsh. Chesapeake Sci., 12(3):125-130.

Four Point Marsh, a 270-acre tidal marsh in Gloucester County, Virginia, was studied by random quadrant sampling in spring and summer 1964. Salinity of water in adjacent estuary averages 17-22 ppt. There are four plant assemblages, zoned by elevation (1- to 2-in. elevation separates zones); from lowest to highest: (1) edge marsh, dominated by largest Spartina alterniflora, 71%; (2) low meadow dominated by shorter S. alterniflora, 77%; (3) salt-grass meadow, dominated by Distichlis spicata, 64%; and (4) high meadow, dominated by Spartina patens, 54%. Ninety-seven percent of plant coverage was made up of three species, Distichlis spicata (marsh spike grass), Spartina alterniflora (cordgrass, oyster grass), and Spartina patens (couch grass) in order of dominance. Other plants in the marsh include Salicornia europaea, Iva frutescens, Borrichia frutescens, Baccharis halimifolia, Fimbristylis castanea, Juncus roemerianus, and Limonium carolinianum. The small amount of low marsh (which is decreasing by erosion) compared with high marsh indicates a rising sea level. This is a good example of a marsh at salinity of 20 ppt ± 3 ppt. (S. H. Hopkins)

Kessel, H. 1961. [The distribution of Mollusca in the Baltic and its relation to salinity. In Estonian with English abstract.] Limuste levik läänemeres seoses soolsusega. Eesti Loodus, 4:205-211, maps, illus.

From shells in old sediments the Holocene (last 12,000 years) history of the Baltic is reconstructed. The study was made in Estonian waters. Each new stage in the development of the Baltic Sea is marked by immigration of new species incapable of adapting to changed conditions. Contemporary mollusk fauna consists

both of species that have immigrated at the present time and of species that appeared during earlier stages and have become established. Environmental changes have caused alterations in composition of the mollusk fauna and in distribution of individual species. [The only environmental factor specifically stated to have been studied by the author was salinity. (Author's abstract)

Kesteven, G. L. 1947. Biology and cultivation of oysters. Fisheries Newsletter (Australia), 6(3):4, 5, 16.

P. 5: "Losses have occurred because of prolonged periods of very low or very high salinity. Such occurrences are likeliest in lakes such as Wallage. Removal of the stock seems the only answer to this difficulty."

Keup, L. and Bayless, J. 1964. Fish distribution at varying salinities in Neuse River basin, North Carolina. Chesapeake Sci., 5(3):119-123.

In early summer 1960, fish were collected at 18 stations in this tidal river system, from fresh water to water of a salinity of 12.25 ppt. Of the 62 species taken, 39 were considered freshwater forms, 6 brackish-water forms, and 11 marine. The most abundant freshwater fish was the pirate perch, Aphredoderus sayanus (10.4% of total catch), but Centrarchidae was the family best represented. Marine fish predominated in salinity above 3.5 ppt. Freshwater game fish, such as largemouth bass, Micropterus salmoides and other centrarchids, chain pickerel, Esox niger, and yellow perch, Perca flavescens, were more abundant in salinities from 1.75 to 3.5 ppt than in fresh water, and it is suggested that salinities in this range may be beneficial to freshwater game fishes. The predominance of freshwater species in this brackish-water area is attributed to the overlapping of temperate and subtropical faunas in North Carolina. (S. H. Hopkins)

Keys, A. B. 1933. The mechanism of adaptation to varying salinity in the common eel and the general problem of osmotic regulation in fishes. Proc. Roy. Soc. London, B, 112:184-199.

The phenomena observed in the eel are typical of euryhaline teleosts, which act as typical freshwater fish in fresh water, with kidney conservation of salts and elimination of large amounts of water, and as typical marine fish in sea water, with elimination of excess salt and conservation of water by the gills. (S. H. Hopkins)

Khalebovich, V. V. 1962. Osobennosti sostava vodnoi fauny v zavisimosti ot solenosti sredy. [Specific features of the aquatic fauna composition in relation to the salinity of the water.] Zhur. Obshchei. Biol., 23(2):90-97.

"An attempt is made to extend the well known Remane's curve to the region of high salinity. The allochthonous fauna composition of hypersaline lagoons is explained by the geological ephemerality of hypersaline water bodies. The fact that the fauna of hypersaline lagoons consists mainly of elements of brackish or freshwater origin is explained by the development of osmoregulatory mechanisms functioning in both directions in some fresh and brackish water species. The fauna of hypersaline lagoons is being divided into the hypersaline one (sensu stricto) consisting chiefly of marine euryhaline and brackish water elements and into ultrahaline one (sensu stricto) consisting chiefly of species of brackish and freshwater origin. These faunae are separated by the salinities of some 75-80 ppt." (Author's abstract)

Kilby, John D. 1955. The fishes of two Gulf Coastal marsh areas of Florida. Tulane Studies in Zool., 8(2):175-247.

During 1948, monthly collections were made of the fish faunas from Bayport and Cedar Key, Fla., both coastal marshes, but ecologically different. Bayport

had less saline waters due to freshwater influxes from two small rivers (range of 0.0 to 26.1 ppt, mean of 7.1 ppt), while Cedar Key had relatively high salinities, ranging from 0.8 to 37.6 ppt and averaging 20.5 ppt. Seventy-five species were found and recorded, each annotated with data including salinities. Twenty-nine species were common to both areas, with 26 peculiar to Cedar Key (25 marine, 1 fresh water) and 20 peculiar to Bayport (14 fresh water, 5 marine, and 1 catadromous). Of the 29 common species only 5 were restricted to the brackish marshes and the immediately adjacent waters.

On the basis of numbers, the freshwater groups of fish were most abundant in the brackish marshes of both areas. Of 16 species, which contributed 96% of the total catch at Bayport, only 3 were marine; the freshwater fishes contributed 88% of the catch. At Cedar Key, likewise, 14 species made up 96% of the total catch, with only 5 species considered marine. Overall, approximately 85% of the total catch was either freshwater or freshwater-brackish water forms. The above-mentioned marine forms did not breed in the marshes, whereas all the freshwater forms bred and maintained permanent populations there. (T. Rennie)

King, Elizabeth N. 1963. The effects of osmotic changes on respiration in four decapod Crustacea. Ph. D. thesis, Duke University, Durham, N. C., 1963. Dissert. Abs., 24(5):2105.

In the crabs Carcinus mediterraneus, Callinectes sapidus, Maja verrucosa, and Libinia emarginata, compared respiration in different salinities in intact animals, in excised gills, and in isolated mitochondria, according to Tagatz and Hill (1971, p. 40). (S. H. Hopkins)

King, Elizabeth N. 1965. The oxygen consumption of intact crabs and excised gills as a function of decreased salinity. Comp. Biochem. Physioe., 15(2):93-102.

In the intact blue crab, one of the four species studied, the respiratory rate increased when sea water was diluted. In excised blue crab gills, the respiratory rate in diluted sea water increased 10% in crabs caught in sea water and 30% in those from brackish water. In sea water, gill respiration of brackish-water blue crabs was significantly higher than that of sea blue crabs. (Fide Tagatz and Hill, 1971, p. 40.) (S. H. Hopkins)

King, Elizabeth N. 1966. Oxidative activity of crab gill mitochondria as a function of osmotic concentration. Comp. Biochem. Physiol., 17(1):245-258.

In the blue crab, one of four crab species studied, specific activity of gill mitochondrial enzymes increased 200%-300% when medium was diluted from 1.6 to 0.16 osmoles. Oxygen consumption of blue crab gill mitochondria increased 75% in crabs from brackish water and 35% in marine crabs with a similar decrease in osmolarity. An increase in osmolarity of medium reversed this increase in enzyme activity and oxygen use. (Fide Tagatz and Hill, 1971, p. 40.) (S. H. Hopkins)

Kinne, O. 1952. Zur Biologie und Physiologie von Gammarus duebeni Lillj. III. Zahlenverhaltnis der Geschlechter und Geschlechts-bestimmung. (On the biology and physiology of Gammarus duebeni. III. Relative numbers of the sexes and sex determination. Kieler Meeresforsch., 9:126-133.

In this paper and Kinne (1953) the effects of temperature and salinity on the relative numbers of males and females produced are reported, according to Green, 1968, p. 188. (S. H. Hopkins)

Kinne, O. 1953. Zur Biologie und Physiologie von Gammarus duebeni Lillj. VII. Ueber die Temperaturabhangigkeit der Geschlechtsbestimmung. (On the biology and physiology of Gammarus duebeni. VII. On the temperature-dependence of the sex determination.) Biol. Zentralbl., 72:260-270.

In this paper and Kinne (1952) the temperature and salinity effects on sex determination are reported in detail, according to Green, 1968, p. 188. (S. H. Hopkins)

Kinne, O. 1955. Neomysis vulgaris Thompson, eine autoekologisch-biologische Studie. Biol. Zentralbl., 74:160-202.

It is stated that "Neomysis vulgaris is one of the most important representatives of the Mysidacea (Crustacea, Peracardia) in our German brackish-water areas," occurring in dense swarms in summer. This is a thorough review of its ecology and life history based on personal observations and on the literature, including its salinity relations. Several other crustaceans are also discussed, for comparison. Kinne quotes Stammer (1936) as giving the lower limits of salinity in which it occurs as 0.2-2.0 ppt; at the mouth of the Elbe the lower limit for its occurrence is 0.37 ppt. Schlienz (1923) said its principal occurrence was limited to salinities of 0.5-18.0 ppt. Kinne's experiments showed that N. vulgaris could live in pure fresh water for a few weeks at 15-18 C, but it could not reproduce and all finally died. Twenty-eight references are cited. (S. H. Hopkins)

Kinne, O. 1956a. Uber Temperatur und Salzgehalt und ihre physiologisch-biologische Bedeutung. (Concerning temperature and salinity and their physiological significance.) Biol. Zentralbl., 75:314-327.

This review paper includes interesting diagrams; fig. 1, p. 317, compares freezing points of body fluids of land, freshwater, and marine vertebrate and invertebrate groups. Fig. 6, p. 324, compares number of species versus salinity for freshwater, brackish-water, and marine animals in the Baltic and North Seas. The normal course of life processes is a necessary condition of the protoplasm bound to a certain water content. This can be altered by salt content to an extent that depends on temperature change. The optimal water content varies according to species, as does protoplasm itself. In the reactions of organisms to changed temperature and salinity, there should possibly be a distinction between a quickly established regulation of the water economy and a gradual acclimatization based on a recomposition of protoplasmic structure. It is theorized that the quick death of freshwater animals is caused by blocking of biochemical reactions, shrinking, etc., leading to stopping respiration and exchange with the external medium. (S. H. Hopkins)

Kinne, O. 1956b. Ueber den Einfluss des Salzgehaltes und der Temperatur auf Wachstum, Form und Vermehrung bei dem Hydroidpolypen Cordylophora caspia (Pallas), Thecata clavidae. (On the influence of salinity and temperature on the growth, form and reproduction of the hydroid polyp Cordylophora caspia (Pallas), Thecata clavidae.) Zool. Jahrb. (Physiol.), 66:565-638.

Besides differences in growth rate and form (Kinne, 1957), salinity affects reproductive capacity. In fresh water and in high salinity (30 ppt) fewer polyps and fewer gonophores are produced than in salinities of 5-16 ppt, and the gonophores (medusae that remain attached to colony instead of being released) produce fewer eggs than in the optimum (5-16 ppt) salinity range. Fide Green, 1968, pp. 111-113. (S. H. Hopkins)

Kinne, O. 1957. Ueber den Einfluss von Temperatur und Salzgehalt auf die Kopfchenform des Brackwasserpolypen Cordylophora. (On the effect of temperature and salinity on the head form of the brackish-water polyp Cordylophora.) Verh. Deutsch. Zool. Geselsch., 1956:445-449.

At the same temperature, body is shorter and broader in salinities above and below the optimum range of 15-20 ppt. In high salinity (30 ppt) there are fewer ectodermal cells. Fide Green, 1968, pp. 112-113. (S. H. Hopkins)

Kinne, O. 1959. Ecological data on the amphipod Gammarus duebeni. A monograph. Veröff. Inst. Meeresforsch. Bremer., 6:177-202, 96 ref.

This paper presents a review of the present knowledge about the ecology of G. duebeni. In the field, this crustacean is normally found in salinities of between 3 and 12 ppt,, but it is found not uncommonly in fresh water and has been reported alive in salinities up to 73 ppt, although noticeably sluggish. Optimum salinity range in the laboratory was between 5 and 15 ppt. Resistance to heat by adults was prolonged in supraoptimal salinities (30 ppt) and shortened in suboptimal salinites (2.1 ppt). Oxygen consumption increases in suboptimal salinities (5 ppt → fresh water) and decreases in supraoptimal salinities (22 → 30 ppt). The number of eggs laid in brackish water was greater than in fresh water, and eggs from brackish waters were smaller than in fresh water. Incumbation times of eggs were slightly prolonged in suboptimal and supraoptimal salinities. (T. Rennie)

Kinne, O. 1960. Growth, food intake, and food conversion in a euryplastic fish exposed to different temperatures and salinities. Physiol. Zool., 33:288-317.

The fish used was Cyprinodon macularis Baird and Girard. Growth from hatching to maturity is maximal at 30 C and in salinity of 35 ppt. It decreases as follows: 30 > 25 > 35 > 20 > 15 C. Growth rates decrease in salinities in this order: 35 > 15 > 55 ppt > fresh water. In all four salinities the fish grow best at 30 C. At lower temperatures (15, 20 C) fish grow fastest in fresh water; in higher temperatures (25, 30, 35 C) they grow fastest in 35 and 55 ppt. Sexual maturity is reached earliest in 35 ppt, then 15 ppt, and then fresh water. In length-to-weight analyses no significant differences were found in fish of equal length under different conditions. No significant differences were found in percentages of body water content in salinities of 0, 15, and 35 ppt.

On a restricted diet, food intake is greatest at 30 C (35 ppt); with unrestricted diet, intake is greatest at 35 C (35 ppt). At 30 C, intake was greatest in 35 ppt on both restricted and unrestricted diets. At 35 ppt, conversion efficiency on a restricted diet is highest at higher temperatures with young fish and decreases with age. With unrestricted diet, conversion was generally lower and decreased with higher temperatures. At 30 C with restricted diet, efficiency is greatest at 15 ppt.

The author states that his "observations do not permit any conclusions as to the effect of salinity" on rate of conversion. (S. Rennie)

Kinne, O. 1961a. Die Geschlechtsbestimmung des Flohkrebses Gammarus duebeni Lillj. (Amphipoda) ist temperaturabhangig-eine Entegnung. (The sex determination of the flea crab Gammarus duebeni (Amphipoda) is temperature dependent--an answer.) Crustaceana, 3:56-69.

Perhaps at high temperatures the few males will be sexually active enough to fertilize eggs of a larger number of females, but at low temperatures the chance of a male finding a female in breeding condition is less, so more males are needed. The critical temperature for sex determination is changed if the amphipods are in water of higher salinity. Fide Green, 1968, p. 188.
(S. H. Hopkins)

Kinne, O. 1961b. Growth, molting frequency, heartbeat, number of eggs, and incubation time in Gammarus zaddachi exposed to different environments. Crustaceana, 2:26-36.

No differences in molting frequency of this amphipod crustacean were observed in salinities of 5, 10, and 30 ppt. Rate of heartbeat may have been slightly retarded in 30 ppt, but was the same in 5 and 10 ppt. Similarly, the number of eggs per female in 30 ppt was less than in 5 and 10 ppt. There was also a greater mortality of young and mature specimens in 30 ppt, in addition to the

fact that no eggs were observed to hatch in that salinity. (S. Rennie)

Kinne, O. 1963. The effects of temperature and salinity on marine and brackish water animals. I. Temperature. Oceanogr. Mar. Biol. Ann. Rev., 1:301-340, 385 ref.

In this first part he considers some effects of temperature at constant salinity conditions or where it appears that salinity has little effect on the situation. In Part II he discusses salinity at constant temperatures and the combined effects of temperature and salinity.

Temperatures in the open ocean range from about -2 to +30 C while in brackish waters next to continents the range is from about -3 to +43 C. Generally, the total range of tolerance is smallest in marine forms, larger in brackish and freshwater forms, and greatest in terrestrial organisms.

(P. 311) "The capacity to osmoregulate in salinities, hypo- or hyperosmotic to body fluids, may increase or decrease in various marine and brackish water animals as a function of temperature. A number of euryhaline crustaceans maintain their internal osmo-concentration more successfully near the lower end of their temperature range, when under hypo- or hyperosmotic stress...Rhithropanopeus harrisii...Eriocheir sinensis...Gammarus duebeni...Crangon crangon...close to the lower or upper limits of the tolerated temperature range, osmo-regulation breaks down completely. (S. Rennie)

Kinne, O. 1964a. Non-genetic adaptation to temperature and salinity. Helgolaneder wiss. Meeresunters., 9:433-458, 148 ref.

A review of nongenetic adaptations to salinity discusses the literature on the subject in relation to immediate responses to sudden changes in salinity, the process of stabilization, and the new steady state of performance. (S. Rennie)

Kinne, O. 1964b. Physiological and ecological aspects of life in the estuaries. Helgolaender wiss. Meeresunters., 11(3/4):131-156.

Information indicates compensations of organisms for adverse salinity are quicker and better developed than those for adverse temperature. This is a review article discussing many aspects of effects of environmental factors, including salinity, on organisms in estuaries. (S. H. Hopkins)

Kinne, O. 1964c. The effects of temperature and salinity on marine and brackish water animals. II. Salinity and temperature--salinity combinations. Oceanogr. Mar. Biol. Ann. Rev., 2:281-339, 372 ref.

Information obtained in nature should include the fluctuation patterns of salinity, its extremes and gradients, as well as corresponding patterns of other important environmental factors. Information obtained in the lab should include long-term experiments under adequate conditions to give clues to responses of healthy individuals in normal situations as well as various kinds and degrees of environmental stress.

Salinity may affect function and structure of organisms through changes in total osmoconcentration, relative proportions of solutes, coefficients of absorption and saturation of dissolved gases, density and viscosity, and possibly absorption of radiation, transmission of sound, and electrical conductivity. Salinity may also modify species composition of an ecosystem.

Range of salinity tolerance is larger in animals living in brackish, hypersaline, or brine water than in those in sea or fresh water. Salinity tolerances may be different at different ages, life cycle stages, and sexes. It is often narrow during early ontogeny and senile adulthood. The causes of death in low or high salinities appear to be related to osmotic phenomena such as changes in water and mineral balance of body fluids and cells, and changes in absorption and saturation coefficients of dissolved gases at both extremes.

Changes in total osmoconcentration may cause increase or decrease in metabolic rate. Salinities beyond the tolerated range always result in reduced metabolism. Changes will also affect the efficiency of metabolic processes.

Minor changes in relative proportions of solutes are unimportant. Significant changes cause reduced capacities for reproduction, growth, stress compensation, and thermal stability. Extreme changes produce shock reactions and severe metabolic disturbances, and increase mortality noticeably. Euryhaline organisms tend to be less affected by variations in ionic ratios than stenohaline forms.

Absorption and saturation coefficients are functions of salinity and temperature. Solubility of dissolved gases decreases with increased salinity.

Responses to salinity changes may result in escape by migration to more suitable conditions; reduction of contact with the environment by secretion of mucus; production of jelly or other protective substances; reduction of permeability; closure of shells; body contraction; withdrawal of sensitive parts; retreat into holes; transformation into a more resistant stage; exhibit passive tolerances; show active regulation; adapt by adjusting functional and structural properties.

Changes in density and viscosity are important in relation to movement, suspension, and floating. Thus they may affect the amount of energy that has to be spent for progression or maintaining a certain depth.

Ion regulation occurs essentially at two levels: (1) between medium and blood, and (2) between blood and tissues. Cell fluids are somewhat isosmotic with body fluids. Often inorganic ions are bound to organic molecules. The molecular mechanisms involved in active ionic transport are not known.

Differential permeability and diffusion do not seem to play a decisive role in ionic regulation. Active uptake (metabolically controlled transport) of salt has been suggested or demonstrated for several crustaceans. Active excretion (secretion, reabsorption, and filtration) is accomplished in antennal and maxillary glands, gills, or gut. Ion storage in tissues and its potential for maintenance of a given ionic blood concentration have been demonstrated in Eriocheir sinensis (mitten crab) in fresh water. Regulation by changes in behavior has been reported for several crabs in different habitats.

Volume regulation involves enduring changes by regulating body volume. Most euryhaline species seem to possess this capacity. The regulatory mechanism involves membrane permeability controlled by calcium content in the external medium. Removal of excess water by the gut epithelium is known. Contractile vacuoles are used when present.

The capacity for osmoregulation may vary with temperature, season, physiological condition of the organism, age, sex, or genotypes of geographically separated populations. Osmoconformers exhibit no or very little capacity for osmoregulation, but they can regulate ions. Most are stenohaline. Osmoregulators exhibit a tendency toward homeosmosis leading to some degree of osmostability. With respect to their regulatory capacities, osmoregulators may be subdivided into eurysaline (regulate in a variety of salinities but require more salt than that available in fresh water), holeurysaline (regulate from fresh to sea water or higher), and oligosaline (regulate only in fresh waters).

Salinity affects reproduction less obviously than temperature. Although diurnal and annual salinity variations are not as pronounced as those of temperature, areas with considerable salinity gradients may have sterility or reduced reproductive potential due to low salinities (e.g. the Baltic). Laboratory experiments dealing with salinity and reproduction have shown alterations from the asexual to sexual type of reproduction or vice versa, prolonged or reduced periods of development leading to the addition or omission of developmental stages, and alteration between ovipary or ovovivipary.

Structural consequences of salinity variations appear to be based on differences in rates of metabolism affecting development, differentiation, and relative growth of cells and organs. Functional and structural modifications due to salinity seem to be interrelated. Marine organisms show a reduction in final size where salinity is significantly reduced. Salinity may modify meristic characters, dermal differentiations, pigmentation, allometry of body parts and

organs, dimensions of individual cells, size of nuclei, and possibly secondary protoplasmic structures.

Nongenetic adaptation to salinity is presumably overall tissue adaptation in osmoconformers. Immediate responses may often overcompensate or undercompensate for a change. The phase of stabilization varies in length of time to reach the new steady state. Acclimation to low salinities tends to shift the lower lethal limit downward, and to higher salinities shifts the upper limit upward. Nongenetic adaptations to salinity acquired during very early ontogeny tend to be more stable and complete than those acquired in older individuals.

Genetic adaptations to low salinities and fresh water involve evolutionary development of more effective mechanisms of water elimination, salt uptake, reduced surface permeability to water, and increased capacity for salt retention. In hypersaline and brine waters, organisms require the ability to hyporegulate by intensive salt excretion and water uptake and resorption.

Temperature-salinity combinations can affect both function and structure. Lethal temperature limits may be raised or lowered by altering the salinity. Similarly, lethal salinity tolerances may be affected by changes in temperature. Different combinations will also produce different metabolic rates in the same individuals, by altering oxygen consumption and capacity for ion regulation. Little is known of the combined effects of temperature and salinity on reproduction. In coastal areas, combinations play a greater role in determining distributions than in the open oceans.

A correlation between the biological effects of temperature and salinity is quite apparent with respect to body size and shape, meristic characters, and other structural properties. In general, the modifying effects of salinity are augmented by a rise in temperature.

Acclimation to one factor proceeds at different rates and efficiences under different levels of other simultaneous acclimations. Maximum acclimation to temperature may only be possible at near optimum salinities, and conversely. (S. Rennie)

Kinne, O. 1966. Physiological aspects of animal life in estuaries with special reference to salinity. Neth. Jour. Sea Res., 3(2):222-244.

This paper reviews 88 other works pertaining to the subject. Salinity tolerances are discussed with reference to age of organisms, temperatures, and ionic concentrations of the media. Salinity is shown to modify rate and efficiency of metabolism, activity, growth, and reproduction. Limiting and modifying effects of salinity can be handled with several compensatory devices employed by the organism. These include escape, reduction of contact, regulation, and adaptation (genetic and nongenetic). The condition of permanent environmental variation is stressed as being not only the most pronounced feature of the estuary, but also its most ancient and conservative characteristic. (S. Rennie)

Kinne, O. 1967. Physiology of estuarine organisms with special reference to salinity and temperature: general aspects. Pp. 525-540. In: Lauff, G. H., ed. Estuaries. Am. Assoc. Adv. of Sci. Publ. 83, Washington, D. C., xv + 757 pp.

A general review of knowledge on the subject, with 221 references. Physiological compensations for extreme conditions of salinity and temperature are considered under four subheadings: escape, reduction of contact, regulation, and acclimation, the last three of which may occur simultaneously in one individual. "With respect to salinity, regulation (ion, volume, osmoregulation) and reduction of contact appear to be most important." In future studies more attention should be paid to environmental fluctuations and to polyfactorial analyses. Experiments comparing constant intensities of a single environmental factor are insufficient. Experiments should be long-term to include growth, food conversion efficiency, and rate of reproduction. (S. H. Hopkins)

Kinne, O. and Kinne, E. M. 1962a. Effects of salinity and oxygen on developmental rates in a Cyprinodont fish. Nature, 193(4820):1097-1098.

Rates of development of Cyprinodon macularis Baird decrease slightly with increasing salinity. In salinities above 35 ppt at 70% air saturation, development decreases, and at 300% air saturation development increases with salinity.

Lethal temperatures are lowest in all salinities (0-70 ppt) at 70% and highest at 300% air saturation. They decrease with increasing salinity. A salinity of 85 ppt was lethal with all combinations tested. (S. Rennie)

Kinne, O. and Kinne, E. M. 1962b. Rates of development in embryos of a cyprinodont fish exposed to different temperature-salinity-oxygen combinations. Canadian Jour. Zool., 40:231-253.

The studies were done on Cyprinodon macularis. Temperature experiments were run at 48 temperatures between 10-37 C, 35-ppt salinity, and 100% air saturation. Salinity experiments were run at 100% air saturation, in distilled and one-half fresh water, 35%, 45, 55, 70, and 85% salinity, and at 14 temperatures between 19-37 C. At higher temperatures, progressive retardation of development was noticed at 35 ppt. Incubation periods increased with increased salinity. Decrease of developmental rates at higher salinities was obvious at higher temperatures with a maximum at 32-35 C. Hatching was delayed or inhibited at higher salinities. The upper lethal temperature of incubation is lower at higher salinity. At 35 ppt no hatching occurred and structural abnormalities were seen. At high temperatures total hatching length decreased with increased salinity.

Incubation time increases as saturation decreases and temperature increases. At lower saturation the upper lethal temperature of incubation is higher in fresh water. The main cause for the observed retardation of developmental rates and narrowing of temperature and salinity tolerances is the reduced level of ambient dissolved oxygen. Development at 300% air saturation is accelerated at higher salinities. Embryos tend to be more transparent, and above 35 ppt there is an increase in body length at hatching.

Mortality increased at temperatures greater than 34 C, at salinities above and below 35 ppt, and with low air saturation. Mortality was highest in the first few days after fertilization. (S. Rennie)

Kinne, O. and Paffenhofer, G. A. 1965. Hydranth structure and digestion rate as a function of temperature and salinity in Clava multicornis (Cnidaria, Hydrozoa). Helgolaender wiss. Meeresunters., 12:329-341.

Hydroids were tested in temperature-salinity combinations using 12, 17, and 22 C, and 16, 24, 32, and 40 ppt. Survival was good in all salinities at 12 and 17 C. At 22 C and 16 and 40 ppt, Clava survived only 5-7 days.

In 16, 24, and 32 ppt, hydranths are longest at 12 C and are shorter at higher temperatures. There is a decline in hydranth length with increasing salinity at 12 C, no change at 17 C, and an increase in length from 24 to 32 ppt at 22 C. Hydranth width decreases with increasing temperature. At 12 and 17 C, width decreases with increasing salinity. At 22 C, however, width increases from 24 to 32 ppt.

Tentacle number per hydranth varies with temperature. Most tentacles are present at 12 C in 16 ppt, 17 C in 24 ppt, and 22 C in 32 ppt. Tentacle length follows the same pattern as tentacle number with highest values at 17 C in 24 ppt.

Digestion time decreases with increasing temperature. Irrespective of temperature, the shortest digestion time is in 32 ppt. Longest periods were at 12 and 17 C in 16 ppt, and at 24 and 40 ppt at all temperatures. (S. Rennie)

Kinne, O. and Paffenhofer, G. A. 1966. Growth and reproduction as a function of temperature and salinity in Clava multicornis (Cnidaria, Hydrozoa). Helgolaender wiss. Meeresunters., 13:62-72.

Hydroid individuals were tested in combinations of 12, 17, and 22 C and 16, 24, 32, and 40 ppt. Maximum stolon length was attained in all salinities at 17 C, followed by 12 and 22 C. At 12 and 17 C, average stolon length decreased in the order 24, 32, 16, and 40 ppt. At 22 C higher values were reached in 32 ppt than 24 ppt. Faster growth was attained at 32 ppt, followed by 24, 16, and 40 ppt.

The highest number of new polyps per colony occurred at 17 C and 24 ppt. The rate of sexual reproduction is affected by temperature-salinity combinations similarly to stolon length, except at 22 C where the number of hydranths drops from 7.2 to 6.4.

At 12 and 17 C gonophores are formed in all salinities. At 22 C no sexual reproduction was observed. (S. Rennie)

Kinne, O., Shirley, E. K., and Meen, H. E. 1963. Osmotic responses of hermit crabs (Pagurus longicarpus Say) exposed to various constant temperatures and salinities. Crustaceana, 5:317.

The hemolymph is practically isosmotic to the external medium over the salinity range tested, 18-48 ppt. There were some indications of hypertonicity at 15 ppt and 22 C. Crabs conform readily to new external concentrations. No significant differences in hemolymph concentration were found at the test temperatures 11, 22, and 30 C, respectively. (S. Rennie)

Klavestad, Nils. 1957. An ecological study of the vegetation in Hunnebunnen, an old oyster poll in South-eastern Norway. Nytt Mag. Bot., 5:63-100.

The water in the poll (a type of landlocked fjord) is highly stratified. Surface salinities average 10-12 ppt, but vary 2-26 ppt over the year. Bottom salinities average 30 ppt with a yearly variation of 26-31 ppt. Bottom water is stagnant and contains H_2S.

The saline meadows showed the typical floral zonation with Scirpus parvulus, Puccinellia maritima, Juncus gerardi, and Agrostis stolonifera ascending from the water's edge. In Hunnebunnen algae extend down to 5.5 m, while outside they extend to 10-11 m. Fucus serratus and Cladophora rupestris grow only in the outermost area. Ascophyllum nodosum is found only to the inside of the entrance to the poll. Fucus vesiculosus occurs throughout the whole region. Occasional Polyides rotundus, Furcellaria fastigiata, and Phyllophora brodiaei drifted into the poll from the outer areas where they were very common and abundant.

The number of species increased slightly from the inner poll to the outer, along with a slight increase in salinity. In addition to salinity, substratum, temperature, transparency, water exchange, and H_2S content of the water influence the distribution of algae in the area. (S. Rennie)

Klekowski, R. Z. 1963. The influence of low salinity and desiccation on the survival, osmoregulation and water balance of Littorina littorea (L.) (Prosobranchia). Polsk. Arch. Hydrobiol., 11(2):241-250.

The reaction to lowering salinity of water of snails, Littorina littorea, from Kieler Forde ($S \approx 12$ ppt) differs according to the degree of its dilution. The highest mortality occurs in medium degrees around a critical level of ≈ 5 ppt. In salinity of 75 ppt there are efforts at adaptation shown by the opening of the operculum; in salinities <5 ppt the animal isolates itself from the external medium by closing its operculum. This species can live for several days out of water.

Klesch, W. L. 1970. The reproductive biology and larval development of Laeonereis culveri Webster (Polychaeta; Nereidae). Contr. Mar. Sci., Univ. of Texas, 15:71-85.

L. culveri burrows in mud-sand bottoms, forming extensive beds with population densities reaching 203 worms per square meter (average 86/m^2). These beds are

subject to temperature variations of 8 to 30.5 C and salinity variations of 2 to 64 ppt. Spawning was observed in water of 44-ppt salinity and 27 C, when substrate temperature was 24 C. Collections made weekly from a flat on the southwest side of Harbor Island near Port Aransas, Tex., did not show any significant correlation between salinity and population density (table 1, p. 73). At the highest salinity, 36.9 ppt, the number of worms per square meter was 68 (compared with the 86 average), but below-average densities were found also at 24, 29, 32, and other salinities; the highest density, 203/m^2, was at a salinity of 28 ppt. (S. H. Hopkins)

Knight, James M. 1966. Some biochemical aspects of osmoregulation in Crassostrea virginica (Gmelin). Preliminary report. Jour. Mississippi Acad. Sci., 12:208-212.

Oysters were acclimated to salinities from 5 to 30 ppt for 7 days. Whole body homogenates were analyzed for ninhydrin-positive material. Absorbance readings showed that as salinity increased the amount of ninhydrin-positive material increased, except at 30 ppt where a slight decrease was noted. Results suggest the oysters concentrated amino acids for the purpose of osmoregulation. (S. Rennie)

Knight, L. 1965. Some physical and chemical characteristics of coastal soils underlying mosquito breeding areas. Mosquito News, 25(2):154-159.

The characteristic larval habitat of the salt-marsh mosquitos Aedes sollicitans and A. taeniorhynchus is in the limited coastal area between mean high tide level and the extreme inland edge of the zone of brackish water. Soluble inorganic soils contents were determined for aqueous extracts taken from salts underlying breeding areas of these two species and compared with data from other species.

Knipovich, N. M. 1938. (Hydrography of seas and brackwaters, in application to the fishery.) (Title and text in Russian.) Sci. Inst. of Mar. Fish. and Oceanog. of USSR, Moscow-Leningrad. 513 pp.

Hydrography of the world, but especially of seas bordering the Soviet Union, as related to biological problems of fisheries. Detailed information on the brackish waters. According to Hedgpeth (1957, p. 1014) this, Zenkevich (1951), and Zernov (1049) are the "big three" of Russian hydrobiology. (S. H. Hopkins)

Koch, G. J. and Heuts, M. J. 1943. Regulation osmotique, cycle sexual et migration de reproduction chez les epinoches. Arch. Internat. Physiol., 53(3):253-266.

Two subspecies of fishes, the sticklebacks Gasterosteus aculeatus gymnurus and G. aculeatus trachurus, were studied by the Hill-Baldes thermoelectric micro method and the Wigglesworth method of ultramicrodosage of chlorides. The states of dynamic equilibrium between internal and external fluids were determined for all salinities tolerated at 10 ± 0.5 C, in the period of sexual maturity and outside of this period. The osmoregulatory ability of both forms was reduced in sexual maturity. This is correlated with migrations. (S. H. Hopkins)

Koch, H. J., Evans, J., and Schicks. 1954. The active absorption of ions by the isolated gills of the crab Eriocheir sinensis (M. Edw.). Meded. Vlaamsche Acad. Kl. Wet., 16:3-16.

The gills of this crab (Chinese mitten crab) can actively take up Na and Cl ions from the surrounding medium, a vital part of the adaptation to living in fresh water. The body surface of E. sinensis is much less permeable to salts than that of marine crabs also. Cited by Green, 1968, p. 198. (S. H. Hopkins)

Kofoid, C. A., Miller, R. C., Lazier, E. A., Dore, W. H., Blum, H. F., and Van Slyke, E. 1927. Biological section. Pp. 188-343. In: Marine borers and their

relation to marine construction on the Pacific coast, Hill, C. L. and Kofoid, C. A., eds. Univ. of Calif. Press, Berkeley, ix + 357 pp.

This section includes a key to Pacific coast shipworms and a brief account of each, a history, a morphological account of shipworms, a chapter on boring of Teredo, two on the biology of T. navalis including (pp. 257-265) salinity relations; a chapter on the biology of other Pacific shipworms, especially Bankia setacea the "Northwest Shipworm," a short section on the wood-boring clam Martesia striata, a chapter on the clams that bore into rock and concrete structures in Pacific harbors (especially Pholadidea penita), a chapter on the crustacean wood-borers Limnoria lignorum, Sphaeroma pentodon (said to occur from sea water to water that is only faintly brackish), and Chelura spp. (said not to occur on Pacific coast of North America, but on Pacific islands). Any salinity below 5 ppt is lethal to Teredo navalis; any below 10 ppt is lethal and 16 ppt retards activity of Limnoria lignorum. (S. H. Hopkins)

Kohout, F. A. and Kolipinski, M. C. 1967. Biological zonation related to groundwater discharge along the shore of Biscayne Bay, Miami, Fla. Pp. 488-499. In: Lauff, G. H., ed. Estuaries. Am. Assoc. Adv. of Sci. Publ. 83, Washington, D. C., xv + 757 pp.

A study of the effects on marine organisms of fresh water emerging from submarine springs and artesian wells in Biscayne Bay. Siderastrea sideria, a coral, disappeared from the fauna in the zone in which salinity was 21-30 ppt, Spheciospongia vesparia (loggerhead sponge) dropped out in salinity of 13-28 ppt, and the snail Columbella rusticoides extended shoreward into salinity of 22 ppt but became more abundant farther out, in higher salinities. Some brackish-water species (Neritina virginea, Taphromysis bowmani, Palaemonetes intermedius) were abundant toward shore, in low salinities, but did not occur offshore in higher salinities. Distributions and abundance of other species are shown in tables and diagrams. (S. H. Hopkins)

Kolbe, R. W. 1927. Zur Oekologie, Morphologie und Systematik der Brackwasser-Diatomen. Die Kiesselalgen des Sperenberger Salzgebiets. Pflanzenforschung, Heft 7:vi + 146 pp.

Critical systematic studies with notes on cytology, ecology, physiology, and chemistry. It lists diatoms of six or seven bodies of salt water, including marshes and canals. Part I: description of locations of collections and chemical analyses of the water. Part II: technique, and study and classification of the 304 kinds of diatoms. (S. H. Hopkins)

Koroleva, N. V. 1960. Ustoichivost' molodi semgi k razlichnoi solenosti vody. [Tolerance of young salmon (Salmo salar) to various degrees of water salinity.] Nauchn. Tekh. Byul. Gos. Nauchn-Issled. Inst. Ozernogo i Rechnogo Rybn Khoz. 12:33-34. Ref. Zhur., Biol., 1963. No. 2I84 (Transl.).

"Salmon fingerlings and year-olds of various sizes were placed in 10, 15, 20, and 25 ppt salt solutions and kept for 15 days. With the increase in size of the young fish, the tolerance of salinity increased. Fingerlings weighing about 1 g survived in 10 ppt but not 15 ppt. Yearlings weighing 6-10 g survived in 15 ppt salinity."

Korringa, P. 1952. Recent advances in oyster biology. Quart. Rev. Biol., 27:266-308, 339-365.

A review of the world literature on the biology (not including commercial culture) of all species of oysters from 1940 to 1951. Salinity is mentioned at least 30 times as a significant factor in various aspects of oyster biology--survival of adult oysters, reproduction, survival and development of larvae,

setting, growth, predation, parasitism, etc. (S. H. Hopkins)

Korringa, P. 1957. On the supposed compulsory relation between oviparous oysters and waters of reduced salinity. Année Biologique (Colloque International de Biologie Marine, Station Biologique de Roscoff, 27 Juin-4 juillet 1956), 33(3-4):109-116(1957).

P. 114: "The low salinities as such do not bring any advantages, but it is the biological richness of estuarine waters and the escape from many parasites and predators which render many estuarine bodies of water so excellently suited to the oviparous oysters." (S. H. Hopkins)

Korringa, P. 1967. Estuarine fisheries in Europe as affected by man's multiple activities. Pp. 658-663. In: Lauff, G. H., ed. Estuaries. Am. Assoc. Adv. of Sci. Publ. 83, Washington, D. C., xv + 757 pp.

Emphasis is on the Zuider Zee, cut off from the sea by a dam in 1932 and still being drained for conversion to farmland and fresh water, with consequent changes in fish and other fauna; the neighboring Wadden Zee which is still a tremendously productive estuarine area; the North Sea, which has reduced salinity in its southern end and might be called a giant estuary; the Oosterschelde (East Scheldt) of Holland with salinity of about 28 ppt, a highly productive oyster and mussel farming area which is scheduled to be cut off from the sea and drained for agriculture, like the Zuider Zee; Lake Patria in Italy, the estuary of the Volturno River with salinity of about 8 ppt, which receives phosphate from a freshwater source and is therefore highly productive; and the bays of Galicia, Spain, where the sea is enriched by upwelling and raft culture of mussels adds tremendously to the natural production of seafood. (S. H. Hopkins)

Krakatitsa, T. F. 1968. Vyzhivanie i smertnost Chernomorskikh Ustrits (Ostrea taurica Kryn.) v vode razlichnoi solenosti. (Viability and death of the Black Sea oyster (Ostrea taurica Kryn.) in water of different salinity.) Zool. Zh., 47(1):125-127.

The Black Sea oyster can endure sharp changes in salinity--from 34.33 to 14.70 ppt and vice versa--with insignificant mortality, but its growth is strongly slowed as a result. Oysters of the Black Sea have not lost capacity to endure salinity up to 34.33 ppt but they need the salinity of 15.18 ppt for normal life. (P. Maxwell)

Kreps, E. 1929. Untersuchungen uber den respiratorischen Gaswechsel bei Balanus crenatus bei verschiedenem Salzgehalt des Aussenmilieus. I. Mitteilung. Über den Sauerstoffverbrauch im Wassermilieu bei verschiedenem Salzgehalt. Pflüger's Arch. Ges. Physiol., 222:215-233.

Respiratory exchange of gases and O_2 use are determined by intensity of rhythmic respiratory state. With normal intensity, which is found in salinity of 12-35 ppt, gas exchange is practically independent of salinity of outside medium. In salinity below 10 ppt, gas exchange and O_2 use are three to four times less, apparently because of muscle rest. In strongly diluted media (0-10 ppt) the O_2 use is completely dependent on salinity of external medium. When salinity is below 6 ppt, it is the same as fresh water--gas exchange reaches lowest level. At 7-8-9 ppt, gas exchange is 25 %-30% above minimal. In 6 ppt, barnacle remains in "salt sleep," from which it awakens when salinity is raised. Coming out of "salt sleep," O_2 use at first is above normal. On second day, O_2 consumption falls to normal level. (S. H. Hopkins)

Krishnamoorthi, B. and Krishnaswamy, S. 1966. Physiological studies on Marphysa gravelyi Southern: I. Salinity tolerance. Proc. Indian Acad. Sci., B63(1):26-34.

Rates of mortality were greatest in 5 ppt after 96 hr. At 10 ppt mortality was high the first 24 hr but dropped off right away. At 16 and 28 ppt, rates were low throughout the experiments. The limits of salinity tolerance for Marphysa are suggested to be 5 and 28 ppt. (S. Rennie)

Krogh, A. 1939. Osmotic regulation in aquatic animals. Cambridge University Press. (Reprinted 1965 by Dover Publications, Inc., New York; 242 pp.)

This textboook based on lectures given in 1935 is a classic in the field. The organization is as follows (pages as in reprint edition). Introduction and definitions, pp. 1-9; each animal group discussed separately (Protozoa, Coelenterata, Echinodermata, Scolecida (lower worms), Annelida, Mollusca, Crustacea, Arachnomorpha, Insecta, Cyclostomata, Elasmobranchii, Teleostomi, Amphibia, and Reptilia, Aves and Mammalia), pp. 10-169; osmotic conditions in eggs and embryos, pp. 170-190; comments, conclusions, and suggestions, pp. 191-208; appendix (notes on methods), pp. 209-217; list of references, pp. 219-233; index to genera discussed, pp. 235-237; general index, pp. 239-242. There are 54 text-figures, mainly diagrams and graphs; and 42 tables of data. This is perhaps the best introduction to the problems animals encounter in different salinities and how they respond to these problems. (S. H. Hopkins)

Kromhout, G. A. 1943. A comparison of the protonephridia of fresh-water, brackish-water and marine specimens of Gyratrix hermaphroditus. Jour. Morphol., 72:167-181.

"In the fresh-water form [of this flatworm]...the protonephridial system is most extensive and complex. The tubules, ampullae, and paranephrocytes are all present and well developed. In the brackish-water form the tubules are less distinct, but plainly seen in the living animal. The ampullae and paranephrocytes are absent. In the marine form, the tubules and paranephrocytes and ampullae are all lacking. The variations in the protonephridial systems of these forms is correlated with the variation in the salinity of the water in which they live." (Author's summary)

Kudinova-Pasternak, R. K. 1960. Vyzhivanie chernomorskogo Korabel'nogo chervya (Teredo navalis L.) v morskoi vode razlichnoi solenosti i temperatury. [The survival of the Black Sea shipworm (Teredo navalis L.) in sea water of different salinity and temperature.] Zool. Zhur., 39(7):1003-1011.

It was shown experimentally that under favorable temperature conditions T. navalis can tolerate fluctuations in salinity over a very wide range...from 9-35 ppt. A temperature of 10-20 C can be considered optimal for mature forms of T. navalis. A reduction in temperature below 5 C or an increase to 30 C or above causes a marked decrease in the activity of the borers, and later even their death. Especially unfavorable for T. navalis is the combination of low salinity and high temperature. The following salinity zones can be distinguished for the Black Sea T. navalis: optimal--from 12 to 25 ppt; favorable--from 9-35 ppt; sublethal--from 7-9 ppt; and lethal--from 0.7 ppt.

Kudinova-Pasternak, R. K. 1962. Vliyanie na lichinok Korabel'nogo chervya (Teredo navalis L.) morskoi rody ponizhennoi solenosti i razlichnoi temperatur. [Effect of marine water of a decreased salinity and of various temperature upon the larvae of Teredo navalis L.] Zool. Zhur., 41(1):49-57, illus.

For normal development larvae of Teredo navalis L. require salinity not lower than 12 ppt. On the basis of the experiments presented in a 1958 paper the penetration of Teredinids into the Sea of Azov was predicted. As shown by recent papers, Teredinids have actually penetrated into the southern part of the Sea of Azov. Of many existing projects to change the regime of the Sea of Azov with the aim of creating more favorable conditions for commercial fish, a decrease in

the salinity of the waters in the Sea of Azov is most advisable since this will prevent the existence of Teredinids in this sea. (Author's abstract)

Kudinova-Pasternak, R. K. 1963. Sozrevanie polovykh produktov i formirovanie lichinok u Teredo navalis L. v usloviyakh ponizhennoi solenosti. [The maturation of sexual products and the development of larvae in Teredo navalis L. under conditions of reduced salinity.] Nauchn. Dokl. Vysshei Shkoly. Biol. Nauk, 2:28-31. Ref. Zhur., Biol., 1963, No. 1D96. (Transl.)

Eighteen pine beams which had been in the sea for 10 days and contained sexually immature Teredo and 18 pine beams which had been placed in the sea for 1-1/2 months and contained animals already sexually mature were placed in aquaria containing sea water with salinities of 5, 8, 10, 14, and 17.6 ppt. (Control.) The experiments lasted for more than 4 months after which time the gonads of animals fixed in Bouin's mixture were recovered from the wood. Slices from the gonads, 5-6μ thick, were stained with iron hematoxylin according to method of Weigert and Yasuoin. A study of the slices showed that the sexual products of T. navalis matured normally when the salinity of the sea water was 14 and 12 ppt and also in control containers. The gonads appear immature in animals kept at salinities of 10, 8, and 5 ppt. When the sexually mature mollusks were placed in water with a salinity of 8 and 5 ppt, mature egg cells began to resolve. Neither solution nor further development of sexual products occurred at a salinity of 10 ppt. At salinities of less than 10 ppt, larvae located in the mantle cavity of the mothers' bodies also died.

Kuenzler, E. J. 1961. Structure and energy flow of a mussel population in a Georgia salt marsh. Limnol. and Oceanogr., 6:191-204.

Modiolus demissus was studied near Sapelo Island, Georgia. Maximum numbers were in dry weight classes 0-24 mg and 400-599 mg, with less than 2% of total weight less than 200 mg. Population density was 7.8 mussels/m^2 for entire inhabited marsh, 32 mussels/m^2 in densest populations. Organic biomass was 11.5 mg/m^2, 0.3 body and 0.7 shell conchiolin. Net annual population growth was estimated to be 445 mg/m^2 (dry wt.) with annual net mortality loss of 1200 mg/m^2. Population growth and gamete production accounted for energy flux of 13.9 and 2.8 kg-cal/m^2/yr, respectively. Respiration accounted for approximately 39 kg-cal/m^2/yr, over two-thirds of which was in air during low tide. Total assimilation amounted to 56 kg-cal/m^2/yr. The reader is referred to Ragotzkie and Bryson (1955, Bull. Mar. Sci. Gulf and Caribbean, 5:297-314) for salinities and other hydrographic data. (Condensation of author's abstract, S. H. Hopkins)

Kurz, H. and Wagner, W. 1957. Tidal marshes of the Gulf and Atlantic coasts of northern Florida and Charleston, S. C. Florida State University Studies No. 24, 1-168.

The purpose of the investigation was to study the effects of an encroaching sea on a salt marsh, as yet untouched by man. Much of the study is descriptive, but in several places salinity range tolerances of common salt-marsh vegetation are included. The study is concerned solely with the vegetation, and no mention is made of the associated fauna. (S. Rennie)

Kutkuhn, J. H. 1966. The role of estuaries in the development and perpetuation of commercial shrimp resources. Pp. 16-36. In: A symposium on estuarine fisheries. Am. Fish. Soc. Publ. No. 3, Washington, D. C., viii + 154 pp.

P. 20: Most commercial penaeid shrimps have a life history with a particular period passed in an estuary or comparable brackish environment. White shrimp young spend more time in estuaries and penetrate them farther than other species.

P. 22: Majority opinion is that the fertile estuary is irreplaceable and that shrimp cannot be maintained at commercial levels without it.

Pp. 23-24: Penaeid shrimps are adapted to wide ranges of salinity, so they can take advantgage, at appropriate stages, of the high-nutrient reservoir represented by many estuaries. At one stage or another, they have been observed in salinities from less than 1 to more than 60 ppt. Salinity optima are believed to vary from about 5 to 20 ppt.

Pp. 25-27: Physiological adaptation to salinity changes.

Pp. 29-33: One of two ways man-made changes affect shrimp is by changing the salinity.

LaBarbera, M. and Chanley, P. 1970. Larval development of Chione cancellata Linne (Veneridae, Bivalvia). Chesapeake Sci., 11(1):42-49.

Clams from North Carolina were acclimated to the lower salintiy (20 ppt) of the running saltwater system at Virginia Institute of Marine Science, induced to spawn by rapidly fluctuating temperature between 17 and 32 C, and larvae were reared in water of 20-ppt salinity at approximately 25 C. (S. H. Hopkins)

Labat, R. and Serfaty, A. 1961. Modifications électrocardiographiques chez la carpe (Cyprinus carpio L.) au cours des changements de salinité. Hydrobiologia, 18(3):185-193.

When carp is changed suddenly from fresh water to water of salinity near 10 ppt, at temperature near 18 C, electrocargiograph shows tachycardia followed 36-48 hr later by bradycardia. Theorize that contact of gills with salty water results in anoxia, and a reaction probably released by an increase in the quantity of blood. (S. H. Hopkins)

Lackey, J. B. 1938. A study of some ecological factors affecting the distribution of protozoa. Ecol. Monogr., 8(4):501-527.

Transfer of Cyclidium glaucoma from fresh water directly to sea water is reported on p. 503. Table 1, pp. 506-512, lists occurrence of 351 species in seven freshwater habitats and in the harbor at Woods Hole. Seventy-eight species which occurred in fresh water were also found in the harbor in nearly oceanic salinities. This was less than in any of the other habitats, however. (S. H. Hopkins)

Lackey, J. B. 1967. The microbiota of estuaries and their roles. Pp. 291-310. In: Lauff, G. H., ed. Estuaries. Am. Assoc. Adv. of Sci. Publ. No. 83, Washington, D. C., xv + 757 pp.

Gives six lists of microorganisms (bacteria, diatoms and other algae, rhizopods, flagellates (including a list of 135 species of dinoflagellates), and 181 ciliates found in estuaries. P. 310: "The mixing of fresh and salt waters in estuaries has marked effects. Just as water hyacinths die on drifting downstream into salt water, so do many microbiotic species. There is too short a time for adaptation. And just as mangroves push upstream into brackish water, so do many oceanic species. There is some evidence that a real estuarine microbiota exists, and that its members attain greatest numbers there."

Ladd, H. S. 1951. Brackish-water and marine assemblages of the Texas coast, with special reference to mollusks. Publ. Instit. Mar. Sci., Univ. of Texas, 2(1):125-163.

The area studied was from San Antonio Bay south into Laguna Madre. In this area the salinity gradient is fairly stable from the river-mouth areas, where the waters are practically fresh, through the bays and passes to the gulf. Salinities in the different bay systems increased slightly from northeast to southwest. Data from other sources indicated that the faunal assemblages from river mouths to the gulf were closely correlated with changes in the salinity gradient. (Ecology was not comprehensively investigated.) He does characterize the closed bay facies by the fauna present, discussing especially the distribution and size of Rangia cuneata in relation to salinity. (S. Rennie)

Lafon, M., Durchon, M., and Saundray, Y. 1955. Recherches sur les cycles saisonniers du plankton. (Researches on seasonal cycles of plankton.) Ann. Inst. Oceanogr., 31(3):126-230.

Collected plankton throughout the year at two stations in a canal from Caen to

the sea, salinity 2.6 to 8.1 ppt. Cited by Green (1968, pp. 97-98) as example of a study distinguishing between permanent and temporary plankton in waters of low and stable salinity, where more larval forms occur than in highly variable estuaries. (S. H. Hopkins)

Lagerspetz, K. and Mattila, M. 1961. Salinity reactions of some fresh- and brackish-water crustaceans. Biol. Bull., 120:44-53.

Asellus aquaticus from fresh and brackish (Baltic) water, the brackish-water Idotea baltica, and Gammarus spp. (88% G. oceanicus) were tested for reactions (movements in relation) to water of various salinities (0 to 15 ppt). None had enough reaction to brackish water to allow selection of salinities under natural conditions. The reaction threshold for NaCl was higher in brackish-water than in freshwater Asellus. Asellus always preferred the lower salinity. Idotea and Gammarus preferred brackish water; Gammarus preferred even 6-ppt NaCl to fresh water. Chemoreceptors were investigated. (S. H. Hopkins)

Lamb, K. P. 1961. Note on the distribution of larvae of Chironomus novaezealandia Hudson relative to salinity of the environment. New Zealand Jour. of Sci., 4(2):248-249.

Sewage-treatment plant site, under construction, had been reclaimed from Manukan Harbour and was covered with brackish ponds, in some of which midges were developing. Ponds ranged from 0.014 to 2.7% in total salinity, but midge larvae were most abundant in lowest salinities and were not found in water of over 0.54% total salinity. [If he really meant "percent" as printed, this highest salinity in which midge larvae lived would be 5.4 ppt.] (S. H. Hopkins)

Lambert, J. M. and Davies, M. R. 1940. A sandy area in the Dovey Estuary. Jour. Ecology, 28:453-464.

The area described is one in which dunes are developing and salt-marsh vegetation is being replaced by a dune flora. High spring tides cover the lower areas, otherwise this study has no relation to salinity. Rainfall keeps groundwater salinity low. (S. H. Hopkins)

Lance, Joan. 1962. Effects of water of reduced salinity on the vertical migration of zooplankton. Jour. Marine Biol. Assoc. U.K., 42(2):131-154.

Effects of water of reduced salinity on the vertical migration of zooplankton of Southampton water were investigated in the laboratory using the adult of Acartia tonsa, A. bifilosa, A. discaudata, A. clausi, Centropages hamatus, Temora longicornis, and the larvae of Porcellana longicornis. Additional observations were made of Centropages typicus adults taken off Plymouth.

Salinity discontinuity layers had a marked effect on the vertical migration of zooplankton. A single discontinuity layer formed by placing less dense diluted sea water over full-strength sea water acted as a barrier to animals attempting to swim to the surface of an experimental water column, with increased effect as dilutions increased. Comparison of the behavior of various species and of different sexes or developmental stages of a particular species suggests that vertical distribution was partly dependent on salinity tolerances of species. Upward migration was also restricted by a vertical series of discontinuity layers.

The swimming activity of copepods was depressed in homogeneous water columns of reduced salinity. Activity depended both on degree of dilution and period of immersion. There were indications that behavior varied according to the salinity tolerances of the different species. Following is an order of resistance to dilution of the experimental animals: Acartia tonsa > A. bifilosa > A. discaudata > A. clausi = Porcellana longicornis > Centropages hamatus > C. typicus. (S. Rennie)

Lance, Joan. 1963. The salinity tolerance of some estuarine planktonic copepods. Limnol. and Oceanogr., 8(4):440-449.

The salinity tolerance of three species of Acartia was investigated in the laboratory by recording the survival of female copepods at various salinities. The salinity tolerance of A. tonsa, A. discaudata, and A. bifilosa captured during the autumn, winter, and spring, respectively (from Southampton waters), depended on the temperature. Thermal prehistory of copepods affected their survival in diluted sea water, all species being most tolerant when experimental and environmental temperatures were close and least tolerant when experimental and field temperatures differed markedly. The following order of salinity tolerance was established: A. tonsa > A. bifilosa > A. discaudata.

Temperature acclimation increased salinity tolerance. This implies that cooling of the environment might not necessarily lower the tolerance of the autumn, warm-water species, provided the change was gradual, and that slow warming might not cause the decline of the spring, cold-water species. Salinity acclimation increased the salinity tolerance of A. bifilosa. The recovery of A. bifilosa in full-strength sea water after short exposure to low salinity increased with decreased exposure time. (S. Rennie)

Lance, Joan. 1964. Feeding of zooplankton in diluted sea-water. Nature, 201(4914):100-101.

Dunaliella was fed to the copepod crustaceans Acartia bifilosa (Giesbrecht) and A. discaudata (Giesbrecht). Rate of feeding was determined by counting fecal pellets. All pellets were approximately the same size except those from the greatest dilution (28% sea water) which were shorter. In dilutions from 90%-60% the rate of fecal pellet production approximated that in 100% sea water. Below 60%, fewer pellets were produced even after a 12-hr period of acclimation. She proposes that depressed feeding rate may result in insufficient metabolic supply, tending to exclude certain forms from brackish waters. The success of Acartia in estuaries is attributed to the fact that it has higher respiratory and lower feeding rates in marine waters. By acclimatization to estuarine conditions, Acartia may be less affected metabolically by salinity changes. (S. Rennie)

Lance, Joan. 1965. Respiration and osmotic behavior of the copepod Acartia tonsa in diluted sea water. Comp. Biochem. Physiol., 14(1):155-165.

Adult females increase O_2 requirements when salinity is lowered, the rise during an 8-hr exposure to low salinity being from 0.077 µl oxygen/mg dry weight/hour in 90% sea water (0.7% increase) to 16.061 µl/mg/hr in 30% sea water (101.4% increase). The increase rate can persist over 24 hr. The internal osmotic concentration of copepods changed from 100% to 50% sea water falls rapidly due to entry of water. After 1 hr no further osmotic change can be detected. (S. H. Hopkins)

Landers, W. S. and Rhodes, E. W., Jr. 1970. Some factors influencing predation by the flatworm, Stylochus ellipticus (Girard), on oysters. Chesapeake Sci., 11(1):55-60(March 1970).

Lowering temperatures below 10 C caused progressive decrease in predation, but lowering salinity did not. At 5 ppt, approximately the lower limit which oysters tolerate, there was only a temporary pause but no lasting decrease in predation of flatworms on small oysters. S. ellipticus primarily attacked spat and small seed oysters, but large (20 mm) worms killed oysters as long as 61 mm. Worms from higher salinities preferred barnacles, while those from lower salinities preferred oysters. (S. H. Hopkins)

Landers, W. S. and Toner, R. C. 1962. Survival and movements of the flatworm, Stylochus ellipticus, in different salinities and temperatures. Biol. Bull., 123(1):146-153.

Adult flatworms, Stylochus ellipticus (10-18 mm long), an oyster predator, collected from Milford Harbor, Connecticut, were placed immediately in pans having one of 10 salinity groups, ranging from fresh water to 25 ppt. Worms transferred abruptly survived salinities of 25 to 7.5 ppt, but those worms at 7.5 ppt lost color, secreted more mucus than was normal, and were sluggish. Worms at 10 ppt showed no distress at any time. Those transferred directly to 5 ppt suffered 20% mortality, and all worms died when placed directly in 2.5 ppt and fresh water. However, when acclimated to 5 ppt and then transferred to 2.5 ppt, worms showed no signs of distress and were active.

Righting times after being turned ventral side up, were recorded at various salinities. The average righting time ranged from 10 to 13 sec in all salinities (7.5-27 ppt), but increased to 22 sec at 5 ppt and 37 sec at 2.5 ppt.

Survival of worms in salinities below 5 ppt was determined after they had been conditioned to 15-, 10-, and 5-ppt salinities for 2 weeks. Conditioning had little effect on the ability of the worms to survive in low salinities, especially when held at the higher salinities. All worms conditioned at 15 ppt and placed in 2.5 ppt and lower died by end of the fourth day. Worms at 10 ppt had died by the end of the seventh day after transfer. Those held at 5 ppt and transferred to 1.5 ppt, 0.5 ppt, and fresh water died by the end of the seventh day; 40% of the worms conditioned at 5 ppt and transferred to 2.5 ppt survived. The worms were not able to survive below 2.5 ppt even with conditioning at intermediate salinities.

When the combined effects of temperature and salinity were studied, the righting times of S. ellipticus were frequently longer than the combined times obtained when the two factors were observed separately. Lowered salinity and temperatures increased the righting time. (T. Rennie)

Lane, E. D. 1967. A study of the Atlantic Midshipman, Porichthys porosissimus, in the vicinity of Port Aransas, Texas. Contr. to Mar. Sci., Univ. of Texas, 12:1-53.

Trawl, beach seine, and tide trap samples were collected. The Midshipman was found to tolerate a wide range of salinities. Others have found it in salinities ranging from 1.2 to 44.5 ppt. Lane never found it outside the above-cited salinity range, and it seemed to be most abundant between 20 and 37 ppt. It has never been reported in fresh water or in the Laguna Madre. In one experiment, when the water in a tank was lowered suddenly from 35 to 24 ppt, there was no effect on behavior or survival.

The distribution of the fish was affected by a complex of salinity, temperature, bottom type, depth, and other unmeasured factors; but within the tolerances of the species, it was most common on mud bottoms and at moderate depths (3-55 m) where sudden external environmental changes were buffered. (T. Rennie)

Lang, Rolf. (Inst. Mar. Biol., Univ. of Oslo, Norway). 1968. The relationship between the oxygen consumption of isolated gill tissue of the common mussel, Mytilus edulis L. and salinity. Jour. Exp. Mar. Biol. Ecol., 2(1):37-45.

Gills isolated from mussels adapted to salinity ranges from 20 to 28 ppt showed optimum O_2 consumption ability. Evaluation of the gills' capability for volume regulation shows that the volume of the gill tissue in osmotically adapted animals is the same at different salinities. (S. H. Hopkins)

Lange, R. 1963. The osmotic function of amino acids and taurine in the mussel, Mytilus edulis. Comp. Biochem. Physiol., 10:173-179.

Mytilus from different geographic locations with different salinities were analyzed for the amount of amino acids and taurine present in different parts of the body. Over the range of salinities from 5-35 ppt the amount of ninhydrin-positive substances (NPS) and taurine increased correspondingly. Most of the taurine is found in the intracellular fluid. Taurine does not constitute a

constant fraction of the NPS, suggesting that it has a particular function with regard to the maintenance of the intracellular osmotic pressue. (S. Rennie)

Lasker, R. and Theilacker, G. H. 1962. Oxygen consumption and osmoregulation by single Pacific sardine eggs and larvae (Sardinops caerulea Girard). Jour. Cons. Perm. Int. Explor. Mer, 27:25-33.

The oxygen consumption of 42 single Pacific sardine (Sardinops caerulea) eggs and larvae was measured at 14 C in relation to several factors including osmoregulation. Although sardine embryos and larvae had none of the adult organs for osmoregulation, they maintained a hypotonic internal concentration averaging 0.24 M in 0.56 M sea water. Early posthatched larvae and eggs stripped of their chorions swelled and burst in distilled water, while older larvae did not swell and appeared to regulate water flow efficiently. In measuring oxygen consumption in 50% and 100% sea water (35 ppt) of developmental stages of eggs and posthatch larvae, no consistent differences between eggs at the same stage in the two salinities was seen. Larvae and stage IV embryos actually seemed to have a slightly higher oxygen requirement in 50% sea water. (T. Rennie)

Lassere, P. 1970. Action des variations de salinité sur le métabolisme respiratoire d'Oligochètes euryhalins du genre Marionina Michaelsen. (The effect of salinity variation on the respiratory metabolism of euryhaline oligochaetes of the genus Marionina Michaelsen). Jour. Exp. Mar. Biol. Ecol., 4(2):150-155.

Oxygen consumption was measured in two species of meiobenthic and euryhaline oligochaetes as a function of weight and salinity, using the Cartesian diver method. Regression analysis showed the same uptake at salt concentrations between 3-25 ppt for M. achaeta, and between 3-30 ppt for M. spicula. Outside these limits O_2 uptake/h/unit weight first increased then decreased, indicating a metabolic disturbance. (Biol. Abstr.)

Laubenfels, M. W. de. 1947. Ecology of the sponges of a brackish water environment at Beaufort, N.C. Duke University Marine Station Bull. No. 4, 31-46.

Haliclonas and Hymeniacidons, when subjected to summer freshets, turned dark or dull, drab colors, appearing to be dead. Recovery followed later in the summer. Extreme, high salinities are not fatal to the sponges of the Beaufort area. Iotrochota can survive in 38 ppt, but soon dies at less than 20 ppt. Craniella dactyloidea, Cliona vastifica, Haliclona permollis, and Hircinia variabilis are among the brackish-water sponges of the area.

It appears that sponges exposed to low salinities through tidal fluctuation also require exposure to air in order to survive. The boring habit of Cliona might account for its partial success in brackish waters. (S. Rennie)

Laubenfels, M. W. de 1949. The sponges of Woods Hole and adjacent waters. Bull. Mus. Comp. Zool., 103(1):1-55; 3 plates.

Lists only one member of Clionidae, Cliona celata Grant (pp. 23-24). Repeats 1947 statement that dousing in fresh water kills, and that boring habit may be protection for low salinity.

P. 47--Cliona celata a ubiquitous species. Southern sponge fauna (North Carolina) different from New England; New Jersey may be dividing line.

Pp. 49-50--review and criticism of M. C. Old (1941) paper on boring sponges. Suspects C. lobata is syn. of C. celata. Suspects Old's identification of C. vastifica may be mistaken; it may be confined to the Old World. Apparently accepts C. truitti.

Laubenfels, M. W. de. 1953. A guide to the sponges of eastern North America. University of Miami Press (Special Publication), v + 32 pp., illus.

Visual aids are provided to help students identify species of sponges, the major purpose of this publication. There are many notes on habits and habitats of various species, including references to salinity relations. Salinity is said to modify the size and form of some sponges; for instance, in estuarine waters the boring sponge Cliona celata bores inside shells, but in oceanic salinity, it attains the size of a human head. Most sponges require fairly high salinity; only a few species occur in brackish water, but they are marine species, not related to the freshwater sponges. (S. H. Hopkins)

Lauff, G. H., ed. 1967. Estuaries. Am. Assoc. Adv. of Sci. Publ. No. 83, Washington, D. C., xv + 757 pp.

Includes 71 papers by 77 contributors presented at an International Conference on Estuaries held at Jekyll Island, Georgia, 31 Mar-3 Apr 1964. The major subjects covered, as listed in the Contents, were: basic considerations, physical factors (including salinity), geomorphology, sediments and sedimentation, microbiota, nutrients and biological production, ecology and populations, physiology and evolution, fisheries, human influences, and summary ("the sense of the meeting," presented by J. W. Hedgpeth). Many of the papers dealt in a major or minor way with biological effects of salinity, and these are included in this bibliography with appropriate annotations, under the names of the authors. (S. H. Hopkins)

Lazareva, L. P. 1961. O pogloshchenii kisloroda grebnevikami Pleurobrachia pileus O. F. Müeller, raznykh razmerov v zavisimosti ot temperaturyi solenosti ok ruzhayushchei sredy. [on the O_2 consumption of the ctenophore Pleurobrachia pileus O. F. Müeller of different sizes as related to the temperature and salinity of the environment.] Tr. Karadagsk. Biol. Sta. Akad. Nauk. Uzbeksk. SSR., 17:85-96. Ref. Zhur., Biol., 1963, No. 1D62 (Transl.).

At 18.5 C, the relation between O_2 consumption and dry weight (W) was: O_2 consumption = $0.0032 \times W^{0.625}$ in spring-summer (sea temperature lower) and O_2 consumption = $0.0017 \times W^{0.625}$ in summer-fall (sea temperature higher), 0.0032 and 0.0017 being O_2 consumption in mg/hr for ctenophore weighing 0.1 g. Temperatures 20 C and higher reduce rate of O_2 use. Changes in salinity range of 10-20 ppt do not affect rate of O_2 use; variations outside these limits reduce rate O_2 use. Hypothesis: penetration of P. pileus into Sea of Azov is prevented by high water temperature, not by low salinity.

Lear, Donald W. 1962. Growth of coliform bacteria in estuarine waters. Chesapeake Sci., 3(3):160-165, illus.

The coliform bacteria Escherichia coli, E. freundii, and Aerobacter aerogenes were isolated from soft-shell clams (Mya arenaria) and cultured in distilled water, overlying estuarine water, and water from the sediment-water inferface. All three bacteria grew as well or better in "overlying estuarine water" as in distilled water, but grew less well in interface water than in distilled water, supposedly because of antibiotic substances in the water from the sediment-water interface. Salinity in itself would not prevent multiplication of coliform organisms in commercial mollusks. (S. H. Hopkins)

Lee, Byung Don and McFarland, W. N. 1962. Osmotic and ionic concentrations in the mantis shrimp Squilla empusa Say. Publ. Instit. Mar. Sci., Univ. of Texas, 8:126-142.

Mantis shrimp survived gradual changes in salinity down to 13 ppt, with 6 hr required for isosmotic equilibrium, and rapid changes in salinity between 22 and 47 ppt. In salinities below 21 ppt there was hyperosmotic regulation of serum with Na, Cl, and Ca tending to remain constant. In normal sea water, serum cations and Cl accounted for 95% of osmotic pressure, but in low salinity they

accounted for only 67% because nonprotein nitrogenous compounds increased. (S. H. Hopkins)

Lemmerman, E. 1898. Der gross Waterneverstor fer Binnensee. Eine biologische Studie. (In German.) Forsch.-Ber. Plon., 6(2).

According to Redeke, 1932, "Lemmerman 1896" reported that "certain blue green algae, Microcystis aeruginosa, Aphanizomenon flos aquae, Dactylococcopsis raphidioides, Kirchneriella subsolitaria, etc., produce extremely high populations in the oligohaline zone." Redeke's bibliography lists the reference as above. It has not been located. (S. H. Hopkins)

LeRoy, L. W. 1938. A preliminary study of the microfaunal facies along a traverse across Peper Bay, west coast of Java. De Ingenieur in Nederl. Indie IV, No. 8:130-133.

Three foraminiferal facies were recognized: 1, a semibrackish one characterized by Haplophragmoides-Haplophragium; 2, an open sea one with Operculina-Ozawaia; 3, a protected shoal type with Dendritina-Alveolinella. Salinity, degree of protection, and, to some degree, the type of substratum appeared to be the controls. (E. H. Myers and W. S. Cole, 1957, Geol. Soc. Amer. Mem. 67, Vol. 1, p. 1078.)

Lewis, Robert M. 1966. Effects of salinity and temperature on survival and development of larval Atlantic Menhaden, Brevoortia Tyrannus. Trans. Amer. Fish. Soc., 95:423-426.

Larvae fed Artemia were kept at 15, 20, 25, 30, 35, and 40 ppt. Those put immediately into 35 and 40 ppt died, but they became acclimated when raised, over a week, to 35 and 40 ppt. Effects of low temperature (2, 3, 4, 5, and 6 C) were tested at each salinity--0, 5, 10, 15, 20, 25, and 30 ppt. Combination temperature-salinity experiments indicated that if larvae enter an estuary in winter or early spring, they will have best chance of survival if water temperature does not fall below 4 C and salinity remains between 10 and 20 ppt, although there was some survival at every combination tested. Field observations showed larvae entering Bath Creek (tributary of Pamlico River) when temperature was 9 C and salinity less than 5 ppt. Later rain lowered salinity to 1 ppt or less and temperature rose to 30 C. Pacheco and Grant (1965) in a tributary of Indian River, Delaware, found menhaden larvae at 3-32 C and salinities of less than 1 to 30 ppt. High salinity experiments showed that larvae can survive and transform into juveniles even if forced to remain in more saline waters than in nursery areas, although growth would be retarded. (S. H. Hopkins)

Lewis, Robert M. 1967. Response of juvenile menhaden to temperature and salinity. Report of the Bureau of Commercial Fisheries Biological Laboratory, Beaufort, N.C., Circular 264:16-17.

Salinity in menhaden tidal nursery areas can fluctuate from 0 to 40 ppt. Experiments were run at 77, 86, and 95 F and 4.5 to 5.4 ppt. At 5 ppt and 95 F the juvenile fish became distressed and died within a few hours. (S. Rennie)

Lewis, Robert M. and Hettler, William F., Jr. (Bur. Comm. Fish. Biol. Lab., Beaufort, N.C.) 1968. Effect of temperature and salinity on the survival of young Menhaden, Brevoortia tyrannus. Trans. Amer. Fish. Soc., 97(4):344-349.

"Survival of young Atlantic menhaden at different salinities and temperatures was studied in the laboratory. Fish were tested in the spring and summer, and early fall at high temperatures (25-36 C) and low (5-7 ppt), intermediate (15 ppt), and high salinities (31-34 ppt). In the late fall and early winter, tests were conducted at temperatures of 3 to 7 C and salinities of 10 and 26 to

30 ppt. Temperatures had the greatest effect on survival; acclimation time also affected survival but to a lesser degree. Salinity did not appear to markedly affect survival time at the temperatures studied. Yearlings were more sensitive to high temperatures than were younger fish." (Author's abstract)

Lienemann, Louise Joanne. 1938. The green glands as a mechanism for osmotic and ionic regulation in the crayfish (Cambarus clarkii Girard). Jour. Cell. Comp. Physiol., 11:149-161.

Crayfish collected in Louisiana swamps and maintained in Ithaca tap water had blood concentrations of Δ0.644. The urine averaged Δ0.065 while the tap water was Δ0.08. When placed in salt solutions isotonic with the blood, nearly half died within the first 4 days. Among the survivors, the blood and urine concentrations increased with the blood being hypertonic to the medium. (S. Rennie)

Limz, Yvette. 1969. Salinity preference and salinity tolerance of the catadromous teleost Pomatoschistus (Gobius) microps Krøyer. Proc. Roy. Irish Acad. Sect. B, 68(5):77-88.

Distribution and migration of P. microps were studied over a 2-yr period in the salt marsh, North Bull Island, Dublin, and salinity tolerance of the fish was tested. "When the salinity was gradually increased to 80 ppt no fish died. When the salinity was gradually decreased fish taken in water of 6-8 ppt succumbed only in water of very low salinity or in distilled water. Some fish survived in distilled water for a period of 2 weeks. The majority of the fish caught nearer the sea (16-33 ppt) died in distilled water. The remainder succumbed in salinities below 8 ppt. An experiment on abrupt changes in salinity showed no ill effects in the fish. Experiments comparing survival rate during a long period at constant high salinity (25 ppt) and low salinity (8 ppt) did not give a clear-cut pattern." (Biol. Abstr.)

Lindner, Milton J. and Anderson, William W. 1956. Growth, migrations, spawning and size distribution of shrimp Penaeus setiferus. U.S. Fish and Wildlife Service, Fish. Bull. No. 106, 56:555-645.

Young shrimp seek low salinities of bays and estuaries. Adult shrimp move toward more saline water to spawn. Larger sized shrimp are found in the more saline waters due to migration and spawning behavior. Migration out of bays in midsummer appears to be related to salinity as well as maturity (although no specific experiment was conducted to verify this statement). (S. Rennie)

Lindquist, A. 1959. Studien neber das Zooplankton der Bottensee. II. Zur Verbreitung und Zusammensetzung des Zooplanktons. (Studies on the zooplankton of the Gulf of Bothnia. II. On the distribution and concentration of the zooplankton organisms.) Rep. Inst. Mar. Res. Lysekil (Biol.), 11:1-136.

Green (1968, pp. 101-102) cites this as a detailed study which also includes a review of other work on Baltic zooplankton. The Gulf of Bothnia, between Sweden and Finland, is the innermost end of the Baltic Sea, with salinities between 2 and 6 ppt. The fauna is similar to that described by Valikangas in southern Finland. (S. H. Hopkins)

Lint, G. M. de. 1924. De Copepoden, Cladoceren en Ostracoden van het zoete en brakke water van Nederland en haar beteekenis als visch voedsel. Verh. Rapp. Rijksinst. Visscherijond., 1(3).

Used Cl spectrum (chlorinity) as index of salinity in studies of brackish waters, according to Redeke, 1932. Reported that in summer and autumn, as chlorinity (salinity) of inland waters increases, oligohalinophilic copepod Eurytemora affinis is replaced by mesohalinophilic Eurytemora hirundoides (de Lint 1924.).

Little, C. 1969. A note on salinity tolerance in Siboglinum ekmani (Pogonophora). Sarsia, 38:87-90.

S. ekmani cannot survive salinity below 30 ppt but can live at 50 ppt. The osmotic pressure of the blood equals that of the external medium at all concentrations. These data are discussed in relation to possible amino acid pools within the body. (P. Maxwell)

Little, F. J., Jr. 1963. An experimental or tentative revision of the genus Cliona utilizing the principles of numerical taxonomy. Dissert. Abs. 24:904.

Analysis of variance studies showed that megasclere dimensions varied directly with salinity and microsclere dimensions varied inversely or not at all. In Cliona truitti tylostyle diameter appeared to be directly related to salinity while in C. lobata the inverse relation is true. Plots of area cell means versus salinity zone for each spicule type and dimension show data for Louisiana specimens of C. truitti give anomalous results, as compared with the Virginia specimens. This was thought to be caused by the frequently changing salinities of the Louisiana group. He assumes that wide fluctuations in salinity are inhibitory to spicule growth. (S. Rennie)

Livingstone, Robert, Jr. 1965. A preliminary bibliography with KWIC index on the ecology of estuaries and coastal areas of the eastern United States. U.S. Dept. of Interior, Fish and Wildlife Service, Special Sci. Rept. No. 507, iii + 352 pp.

According to the abstract, p. 1, this bibliography contains "more than 5470 references." It "stresses the period 1900-60." The so-called "KWIC index" is a computerized listing by key words in title, each item listed having a number which directs you to the alphabetical listing, by author, of the publication with title and journal, volume, page, etc. The actual bibliography occupies pp. 205-352, or 147 pp, while the "KWIC index," which is difficult and frustrating to use, takes 194 pp. This preliminary bibliography is quite incomplete. (S. H. Hopkins)

Lloyd, A. J. and Yonge, C. M. 1947. The biology of Crangon vulgaris L. in the Bristol Channel and Severn Estuary. Jour. Marine Biol. Assoc., 26:626.

The shrimp C. vulgaris can live in water of very low salinity so long as temperature is not too low--during summer it extends far into estuaries but retreats seaward in winter, and also before the eggs hatch. (Fide Yonge, 1953 "Aspects of Life on Muddy Shores," in: Essays in Marine Biology, pub. Oliver & Boyd, Edinburgh-London). (S. H. Hopkins)

Lochhead, Margaret S. and Newcombe, C. L. 1942. Methods of hatching eggs of the blue crab. Virginia Jour. Sci., 3(2-3):76-86.

Environmental conditions affecting percentage of hatching, and for development of first zoeal stage to second zoea, are stated. Salinity is one of the factors affecting success. Best results were obtained in shallow pans of York River water, salinity 19-21 ppt, water temperature usually 24-27 C, occasionally as high as 31 C. (S. H. Hopkins)

Lockwood, A. P. M. 1960. Some effects of temperature and concentration of the medium on the ionic regulation of the isopod Asellus aquaticus (L.). Jour. Exptl. Biol., 37:614-630.

In this freshwater crustacean, the haemolymph concentration rises with temperature in the range 5-24 C, but only a few mM/l. Osmotic pressure and Na concentration of haemolymph also rise at temperatures below 4-5 C. Rate of Na loss is not affected by temperature. Uptake rises as Na concentration in haemolymph

falls, and also as temperatures rises. Na in haemolymph stays at normal level in media containing more than 90 µM/l NaCl, and also can be maintained at lower "steady state" levels in less concentrated media. It is suggested that: as temperature falls, uptake slows more than loss rate and hence Na concentration of haemolymph falls. This results in a rise in rate of uptake. Thus a new but lower steady state is reached. "It is tentatively suggested that high temperatures may assist some brackish-water species in the invasion of more dilute media." (S. H. Hopkins)

Lockwood, A. P. M. 1961. The urine of Gammarus duebeni and G. pulex. Jour. Exptl. Biol., 38:647-658.

When acclimated to concentrations of more than 50% sea water, the urine of amphipod crustacean G. duebeni is isotonic with the blood. In concentrations of less than 50%, the urine is hypotonic. For G. pulex acclimated to dilutions of sea water in the range of 90-140 mM/l, the urine produced is only slightly more concentrated than it is in fresh water, consequently being less concentrated than the medium. A urine flow of 71% of the body weight per day is estimated for G. duebeni and discussed. Two hours after G. duebeni is transferred from 110% and 160% sea water to fresh water, hypotonic urine is being produced even though the blood concentration is still twice as high as it would be if the animal were fully adapted. (S. Rennie)

Lockwood, A. P. M. 1962. The osmoregulation of Crustacea. Biol. Rev., 37:257-305.

This physiological review paper has few references to ecological applications, but on p. 292 it is stated that "animals for which the temperature coefficients of active uptake are greater than those for ion loss may be expected to penetrate into more dilute media when the temperature is high than when it is low," and that genera confined to brackish water in temperate regions have apparently given rise to freshwater species in warmer areas. The general topics reviewed are: blood concentration in relation to concentration of medium, osmotic and ionic regulation at the cellular level, active uptake of ions, excretion, and energetics of osmoregulation. In the introduction, p. 258, it is stated that adaptation to lower salinity has arisen independently in different groups of crustaceans, these groups relying in varying degrees on one or more of five principal methods of osmoregulation: restricting permeability of skin, active uptake or extrusion of ions, regulation of volume of water in body, conservation of water or salts by excretory organs, and regulation of cellular osmotic concentration. Besides salinity, temperature, pH, and ratios of ions influence osmoregulation. On p. 293 it is pointed out that more work must be performed per unit of mass to maintain salt concentration of blood in small than in large animals, and that in equal salinities small crustaceans tend to maintain lower blood concentrations than larger ones. Shrimps, lobsters, crabs, isopods, amphipods, hermit crabs, cladocerans, crayfish, and fairy shrimps are discussed in some detail, but no attention is given to other important groups such as copepods and barnacles. There are references to 163 publications, the majority European; 41 references are recognizably American, 6 Asian, 2 African, and 2 Australian, the rest being in English but without clues to geographic origin. (S. H. Hopkins)

Lockwood, A. P. M. 1964a. Activation of the sodium uptake system at high blood concentrations in the amphipod Gammarus duebeni. Jour. Exptl. Biol., 41:447-458.

On the basis of experiments on freshwater animals it has come to be accepted that the rate at which Na is actively taken up from the medium is related to the concentration of the blood. The present work shows that, in a brackish-water amphipod, transfer from a high salinity to deionized water results in a large increase in the rate of uptake on subsequent transfer to dilute NaCl, even if the blood concentration has not been lowered to a level at which even a small increase in the rate of uptake would be expected. Transfer from high salinity to

50% sea water does not stimulate increased uptake on subsequent loading in dilute NaCl. Rate of uptake of Na is therefore not determined solely by blood concentration. (Author's abstract in part)

Lockwood, A. P. M. 1964b. The relative losses of sodium in the urine and across the body surface in the amphipod Gammarus duebeni. Jour. Exptl. Biol., 42:59-69.

One of a series of papers by this author on the details of the osmotic and ionic regulatory processes of this euryhaline crustacean in different salinities. (S. H. Hopkins)

Lockwood, A. P. M. 1967. Aspects of the physiology of Crustacea. W. H. Freeman and Co., San Francisco, x + 328 pp.

Osmotic and ionic regulation, Chap. 2, pp. 10-63. For marine forms the subjects considered include ionic composition of blood (table I, p. 11) and its maintenance (pp. 11-12), cell sap (pp. 12-18), osmoregulation in dilute media (p. 18), blood concentration of euryhaline forms in relation to concentration of the medium and its maintenance by reduction of surface permeability (pp. 21-23), cellular adaptation to reduction (pp. 23-26), cellular osmotic adjustment (pp. 27-30), active uptake of inorganic ions (pp. 30-32), excretion (pp. 38-53). For land forms (pp. 53-63) the various mechanisms for retaining water or resisting desiccation of respiratory surfaces are discussed. (S. H. Hopkins)

Lockwood, A. P. M. and Croghan, P. C. 1957. The chloride regulation of the brackish and freshwater races of Mesidotea entomon (L.). Jour. Exptl. Biol., 34:253-258.

Specimens of this isopod taken from freshwater lakes were acclimatized by gradual stages to live in full strength sea water. Specimens from Lake Vattern, Switzerland, had mean chloride content in haemolymph of 239 mM/l, compared with 0.2 mM/l in Lake Vattern water. Specimens of the same species from the Baltic Sea had haemolymph chloride content of 335 mM/l and were found to be incapable of surviving in fresh water. There seem to be two physiological races, with slight morphological differences; Ekman (1919) called the Lake Vattern race M. entomon f. vetterensis. Fide Green, 1968, pp. 182-183. (S. H. Hopkins)

Loeb, J. 1903. Ueber die relative Giftigkeit von destilliertem Wasser, Zuckerlosungen und Losungen einzelner Bestandteile des Seewassers fur Seewassertiere. (Concerning the relative toxicity of distilled water, sugar solutions and solutions of individual constituents of sea water, for marine animals.) Pflüger's Arch. Ges. Physiol., 97:394-409.

The research animal was un unnamed species of "Gammarus" according to the author, but may well have been some other crustacean, Loeb being Loeb. The "sea water" was San Francisco Bay water, salinity 22 ppt. Distilled water and sugar solutions isosmotic with the "sea water" both killed the crustaceans in half an hour at summer temperature. Hypertonic sugar solutions were less toxic. Duration of life decreased as sea water was diluted. Dilution with an isosmotic or weaker sugar solution did not change the curve (of quicker death as sea water was diluted). Tests were made with solutions of NaCl, KCl, $CaCl_2$, and $MgCl_2$. Results led to the theory that death was caused by electrolytes or ions leaving the animal at different rates, causing disturbance of relations in the tissues. (S. H. Hopkins)

Lofts, B. 1956. The effects of salinity changes on the respiratory rate of the prawn Palaemonetes varians (Leach). Jour. Exptl. Biol., 33:730-736.

Higher-salinity-adapted prawns survived a range of 1.7-66 ppt, while the low-salinity-adapted prawns could survive only 0-45 ppt. Respiratory rate for the

sluice-pool population (low salinity) was lowest at 6 ppt, while for the marsh-pool population (higher salinity) the rate was lowest at 26 ppt. It is suggested that the sluice-pool population represents a stage in the physiological adaptation of this species to fresh water. (S. Rennie)

Logvinovich, D. N. and Semyachko, G. Ya. 1963. Vyzhivanie i rost molodi Azovskogo rybtsa v vode razlichnoi solenosti. [Survival and growth of young Azov "vimba" (Vimba vimba carinata) in water of varying salinity.] In: Vosproizvodstovo rybnykh zapasov Azovskogo morya. Tr. Azovsk Nauchn-Issled Inst. Rybn. Khoz., 5:60-63. Ref. Zhur., Biol., 1963, No. 14I39. (Transl.)

Six- and eight-day-old larval Azov vimbas were placed in water of varying salinity (2.5-14.5 ppt) while larvae were kept in fresh Don water. The larvae lived from 3-7 hr to 3-5 days in water of lethal salinity (11-14.5 ppt), and a longer period of time at a salinity of 8-10 ppt, and then died. Threshold salinity was 7-7.5 ppt. Physiological adaptation to water of higher salinity was followed by a greater salt tolerance, thereby enabling the larvae to withstand 8-ppt salinity. Salt tolerance of vimba increased with age. Water with a salinity of 12.5-13.6 ppt was lethal to fingerlings 21-24 mm long and 110-194 mg wt. Gradual increase of salinity to 4-5 ppt caused retardation of growth of larvae; salinity above 5 ppt inhibited the growth of fingerlings. Physiological adaptation of fingerling vimbas to water of higher salinity led to wider salinity optimum without increasing salinity range. Threshold salinity of yearling vimba was 13-14 ppt, their salinity optimum being wider than that of underyearlings. A salinity of 6.5 ppt stimulated and that above 6.5 ppt retarded growth of fingerlings. Only part of Taganrog Bay has optimum salinity. In years of higher salinity, concentration of stenohaline fishes may create strained feeding relations among species utilizing the same types of food.

Loosanoff, Victor L. 1942. Observations on starfish, Asterias forbesi, exposed to sea water of reduced salinities. Anat. Rec., 84:536. (Abstract of paper presented to Amer. Soc. Zool.)

All starfish exposed to less than 18 ppt died whether the exposure was brief or gradual. He declares this to be the lower threshold for starfish survival which agrees with his field studies on distribution. (S. Rennie)

Loosanoff, V. L. 1945. Effects of sea water of reduced salinities upon starfish, A. forbesi, of Long Island Sound. Trans. Conn. Acad. Arts and Sci., 36:813-833.

Starfish placed in hypotonic salinities of 7.5, 10.0, 12.0, 14.0, 16.0, and 20.0 ppt survived indefinitely only at 18.0 and 20.0 ppt. In the lower salinities, their bodies swelled up and they eventually died. Extreme changes in salinity were tolerated if exposures at low salinities were for short periods. Gradual acclimation to lower salinities was attempted, but below 18 ppt, starfish failed to adjust. (S. Rennie)

Loosanoff, V. L. 1948. Gonad development and spawning of oysters. (O. virginica) in low salinities. Anat. Rec., 101-705 [Abs.].

Oysters taken from Long Island Sound soon after the end of hibernation were kept in running fresh water and in water of salinities of 3.5, 7.5, 10, and 12 ppt until spawning temperatures were reached. Histological studies show that gonads did not develop in 0-5 ppt. In 7.5 ppt, functional sperm and eggs formed but embryos soon disintegrated. In 10 and 12 ppt, oysters spawned and fertilization occurred, but development of gametes was not as good as at higher salinities, and development of embryos was usually abnormal. When oysters nearing spawning condition in the sound were placed in low salinities, spawning was profuse in 10 and 12 ppt, medium heavy in 7.5 ppt, and there was no spawning in 0-5 ppt. In 10, 12, and 7.5 ppt, eggs were fertilizable. Oysters kept in

0-5 ppt for 60 days at 8-12 C and then put in sea water in April developed gonads and spawned, producing normal larvae. (S. H. Hopkins)

Loosanoff, V. L. and Engle, J. B. 1943. Polydora in oysters suspended in the water. Biol. Bull., 85(1):69-78.

Experiments at Milford, Connecticut, showed that mudworms, Polydora websteri Hartman, were much more numerous in shells of oysters suspended in trays from a float, 4 ft above the bottom at low tide, for 2-1/2 yr, than in shell oysters living on the muddy bottom. It was theorized that P. websteri grows best in low salinity, and salinity was known to be lower (as low as 1-5 ppt at surface during rainy periods) at the higher level than on bottom (always above 25 ppt). This theory was said to be substantiated by scarcity of Polydora in oysters in Long Island Sound, where salinity is usually above 26 ppt. (S. H. Hopkins)

Loosanoff, V. L. and Smith, P. B. 1949. Some aspects of behavior of oysters accustomed to different salinities (Abs.). Anat. Rec., 105(3):147.

Apparatus imitates changes of salinity during tidal cycles. Oysters directly from Long Island Sound (salinity 27.0 ppt) stopped pumping at 12 ppt, often closed before salinity was reduced to 8 ppt, opened again at 12 ppt, and began pumping at 13.5 ppt. Long Island Sound oysters conditioned 3 months to 10 ppt stopped pumping at 4 ppt, closed at 2.1 ppt, opened at 4.5 ppt, began pumping at 5 ppt. Oysters conditioned at 7.5 ppt stopped pumping at 3 ppt, closed at 1.1 ppt, opened at 2.5 ppt, began pumping at 3.5 ppt.

"These experiments showed that oysters can get accustomed to a much lower salinity than the one in which they were grown."

"As long as the oysters remaimed open, the changes in the salinity of their shell and body fluids closely followed the changes in the salinity of the surrounding water. In general, the salinity of the sea water always remained somewhat higher than the shell fluid, while the body fluid showed the lowest salt content." (S. H. Hopkins)

Losina-Losinsky, L. K. 1948. The influence of salts on infusoria cold-stability and the reasons of death due to cooling. (In Russian.) Zh. Obshchestvo. Biol., 9:441-453.

Not located. (S. H. H.)

Losovskaya, G. V. 1961. Otnoshenie nekotorykh chernomorskikh polikhet K izmeneniyu colenosti, gasovogo rezhima i grynta. [The relationship of some Black Sea polychetes to change of salinity, gas regime and bottom.] In: Voprosy ekologii Vysshaya Shkola: Moscow 5:115-117. Ref. Zhur., Biol., 1962, No. 19Zh47. (Transl.)

Nereis zonata, Melinna palmata, and Platynereis dumerilii were studied. At temperatures of 12-17° and 18-24°, Nereis zonata withstood a fluctuation of salinity (S) from 10-30 ppt. At an S of 40 and 45 ppt there was 3% destruction. For P. dumerilii, optimum S was from 15 to 30 ppt at a temperature of 20-24°. For M. palmata, 9-30 ppt at 7-13° and 17-21° temperature. As a result of experiments on that relation of polychaetes to a deficiency of O_2, it was found that 100% destruction of N. zonata under conditions of a total absence of O_2 occurs within 48 hr; P. dumerilii specimens perished within 8 hr and 25% of the M. palmata within 48 hr. The relation of the first two experimental species to various groups (gravel, sand, and mud) was also studied. Both species quickly penetrated into the gravel and traveled freely in it, the maximum depths that the N. zonata buried themselves was 6 cm in coarse sand, 1.5 cm in fine sand, and 2.5 cm in mud. In coarse and fine sands, as well as in mud, the P. dumerilii were completed unburied.

Lozovik, V. I. 1964. Effect of water salinity on the development of the glomerular apparatus in the kidneys of marine teleostei. Dokl. Akad. Nauk SSSR, Biol. Sci. Sect., 153:1655-1659.

The kidneys of 23 species of Black Sea fish, along with kidneys of fish from the Khadzhibeiskii liman (33 ppt), Mediterranean and Barents Seas. No other salinities were given. The degree of development and number of glomeruli reflected the adaptation to the environment. Black Sea fish (low salinity) had well-developed glomerular apparatus. Mediterranean and Barents Seas fish (normal ocean salinities) show a reduced number of glomeruli and some degeneration. Those fish which had migrated from the Black Sea to the Khadzibeiskii liman showed development similar to Mediterranean and Barents Sea fish. (S. Rennie)

Lucas, J. S. 1970. Breeding experiments to distinguish two sibling species of Halicarcinus (Crustacea, Barachyura). Jour. Zool. (London), 160(2):267-278.

Hybridization experiments and various salinities were used in investigating the status of two Halicarcinus lacustris-like forms, one of which has normal larval stages (indirect development) and the other of which has no free larval stages (direct development). There were no intergrades between the two modes of development in F_1 and F_2 hydrids or as response to salinity. (P. Maxwell, from Biol. Abstr.)

Lucas, J. S. 1971. The larval stages of some Australian species of Halicarcinus (Crustacea, Brachyura, Hymenosomatidae). I. Morphology. Bull. Mar. Sci. (Univ. of Miami), 21(2):471-490.

Five species of this crab genus were studied. Halicarcinus lacustris lives in fresh water and has no free larval stages; hatching occurs just before the first crab instar, which is reached by a molt among maternal pleopods. H. paralacustris and H. australis are estuarine, H. rostratus and H. ovatus are marine, littoral, and coastal sublittoral; these four species all have free-swimming larval stages with three zoeal instars and develop directly from third zoea to first crab instar without an intervening megalopa stage. Estuarine zoeae differ from marine zoeae by having well-developed carapacial spines which are found also in the other three estuarine species of the family Hymenosomatidae, but not in the marine species. (S. H. Hopkins)

Luche, Balduin and Ricca, R. A. 1941. Osmotic properties of the egg cells of the oyster (Ostrea virginica). Jour. Gen. Physiol., 25(2):215-227.

Unfertilized oyster eggs increase in volume when placed in diluted sea water according to the law of Boyle-van't Hoff. The volume of osmotically inactive cell contents is 44%. Osmotic volume changes of these cells are reversible, and semipermeability remains intact. The rate at which oyster eggs attain osmotic equilibria is relatively rapid (5 min). Permeability during endosmosis and exosmosis is about the same. Permeability to solutes is high in oyster eggs with diethylene glycol being taken up faster than glycerol. The oyster egg is a natural osmometer because of its high degree of permeability. (S. Rennie)

Lunz, G. R., Jr. 1938. The effects of the flooding of the Santee River in April 1936 on oysters in the Cape Romain area of South Carolina. (Part II.) War Dept., Corps of Engineers, U. S. Engineer Office, Charleston, S.C., 33 pp.; 14 figs.

Oyster mortality was studied before and after the flood. Normally the southwest corner of the study area had a salinity of 30 ppt, the northwest corner 16 ppt, the southeast corner 26 ppt, and the northeast corner was fresh. During the flood, 3/5 of the area was covered with fresh water. The southwest corner had minimum salinities of 10-11 ppt. A close correlation between low salinity

and high mortality was found. Oysters of the Cape Romain area were able to withstand 5 ppt for only 20 days. The flood had no noticeable effect on the spawning of the oysters. (S. Rennie)

Lunz, G. R. 1958. Notes on a non-commercial crab of the genus Callinectes in trawl catches in South Carolina. Contrib. from Bears Bluff Lab. No. 27. Bears Bluff Laboratories, Wadmalaw Island, S.C., 17 pp.

A small swimming crab of the genus Callinectes, presumed to be C. ornatus but possibly C. danae, made up 62% of the crabs caught in trawls, 30% being the commercial blue crab, C. sapidus. This includes offshore and inshore stations, salinities 15-33 ppt. All stations had salinity as high as 32 ppt at some time during the study period. Catches of the small Callinectes were least at a low-salinity station 8 miles up Ashepoo River, salinity 9.8-26.4 ppt (mean 15.5 ppt); catch per unit of effort here was only 0.4 while all stations averaged 23.1, 25.6, 28.7, and 29.5 in 1953, 1954, 1955, and 1956, respectively. The small Callinectes seems to be more abundant than in former years, and to be increasing. (It is not mentioned here, but these were drought years in South Carolina and the salinity was increasing each year.) (S. H. Hopkins)

Lynch, Maruice P. and Wood, Langley. 1966. Effects of environmental salinity on free amino acids of Crassostrea virginica Gmelin. Comp. Biochem. Physiol., 19:783-790.

Oysters were collected from salinities of 3.4, 9.0, 12.5, 16.5, 19.7, and 26.7 ppt. Portions of adductor muscle were analyzed for free amino acids (FAA). Total FAA concentrations increased proportionately with increasing salinity. Taurine, glycine, alanine, and proline accounted for most of the increase. Glutamic acid decreased sharply at 3.4 ppt. Histidine was more concentrated between 3.4 and 9 ppt. Cysteric acid, aspartic acid, threonine, serine, cystine, tyrosine, phenylalanine, ornithine, lysine, arginine, and ammonia did not show significant change over the salinity range. The remaining amino acids did show change but were present in amounts less than 0.25 µM/mg of total Kjeldahl nitrogen. (S. Rennie)

Lyster, I. H. J. 1955. The salinity tolerance of polychaete larvae. Jour. Animal Ecol., 34:517-527.

When swimming Phyllodoce maculata larvae were placed in a vertical salinity gradient they tended to congregate at a salinity of about 12 ppt, being unable to swim higher because lower salinity reduced swimming ability. This mechanism tends to keep larvae within an estuary; by staying in lower, saltier layers they avoid being carried out by the low-salinity water above, which flows outward while lower, denser layers flow inward in estuary, according to Green (1968), pp. 85-86. (S. H. Hopkins)

MacGinitie, G. E. 1939. Some effects of fresh water on the fauna of a marine harbor. Am. Midland Naturalist, 21:681-686.

In March 1938, the Santa Ana River, which formerly used Newport Bay as an outlet, broke through a levee and fresh water again passed through the bay. A list is given of approximately 20 species (there were probably others unidentified) that were killed by the lowering of salinity, and a list of approximately 37 species that were not killed. Both lists include multicellular invertebrates only. Most of those not killed were able either to close a shell and exclude fresh water, or to withdraw to a safe depth in a tube or burrow. The flood practically wiped out many animals down to 4.5-6 ft below mean low water, but in the long run it was advantageous, for many of the animals reestablished themselves in greater abundance than before, and the fresh water increased food production in the bay after depositing rich sediment. (The area studied was in southern California.) (S. H. Hopkins)

MacGregor, J. S. 1950. Some hydrographic conditions found in winter in lower Chesapeake Bay and their possible effects on the blue crab (Callinectes sapidus) population. M.A. Thesis, College of William and Mary, Williamsburg, Va., 56 pp.

Describes experiments on the effect of low temperature with low salinity on activity and survival of blue crabs. (Fide Tagatz and Hill, 1971, p. 46.) (S. H. Hopkins)

Mackin, J. G. 1951. Histopathology of infection Crassostrea virginica (Gmelin) by Dermocystidium marinum Mackin, Owen, and Collier. Bull. Mar. Sci. Gulf and Caribbean, 1:72-87.

Infections of oysters during conditions of high temperature and salinity are massive. Although all tissues are involved, most damage is done to connective tissues, adductor muscle, digestive epithelium, and blood vessels. (S. Rennie)

Mackin, J. G. 1962. Oyster disease caused by Dermocystidium marinum and other microorganisms in Louisiana. Publ. Instit. Mar. Sci., Univ. of Texas, 7:132-229.

According to author's abstract, "Dermocystidium marinum Mackin, Owen, and Collier, 1950, is discontinuously distributed in the estuaries of the Gulf of Mexico and Atlantic coast from the vicinity of Tampico, Mexico, to Delaware Bay. In Louisiana the fungus is reported from more than 100 bays and bayous, in salinities from about 9 ppt up to oceanic level. The distribution in Louisiana is about coincident with that of the oyster host. Experimental studies show that infection by D. marinum is usually lethal to the host oyster in high temperature periods...under natural conditions...temperature directly controls the development of epizootics which reach their apex in the summer or early fall.... Low salinity areas (under 9 ppt) usually have few or no infections. Above S [salinity of] 10 ppt, incidence of infection of populations increases. It is believed that flushing of estuaries may be more effective in decreasing infection rates than is low salinity per se." Salinity effects are discussed further on pp. 155, 178, 180, 183, 186, 195-198, 201, and 202, also in connection with other parasites and diseases. (S. H. Hopkins)

Mackin, J. G. and Hopkins, S. H. 1962. Studies on oyster mortality in relation to natural environments and to oil fields in Louisiana. Publ. Instit. Mar. Sci., Univ. of Texas, 7:1-131.

From abstract (p. 3): "Field studies showed that oysters had a consistently high mortality rate throughout the warmer half of the year in the study area, and that mortality rate increased with salinity increase within this area. There was no such correlation with proximity of oil fields.... A discharge of

6600 barrels of bleedwater (brine) per day at Lake Barre increased mortality of oysters as far as 50 to 75 ft from the point of discharge, and apparently caused decrease of shell growth and glycogen storage in oysters as far as 150 ft away, but had no detectable effect at greater distances.... The widespread mortalities that did occur during the study period were correlated with high temperature and high salinity, but not with proximity to oil operations." (S. H. Hopkins)

MacMillan, N. F. 1948a. Possible biological races in Hydrobia ulvae (Pennant) and their varying resistance to lowered salinity. Jour. Conch., 23(1):14-16.

Numerous Hydrobia ulvae (sea lettuce snails) were collected from three Great Britain localities and subjected in the laboratory to water containing a diminishing proportion of sea water which was changed regularly for up to 6 weeks. Holywood specimens died in 22% sea water (approximately 7.7-ppt salinity) after 5 days. West Kirby specimens became inactive but stayed alive in 22% sea water. Burton Marsh specimens behaved normally in 22% sea water down to 7.5% sea water. They died in 5% sea water. The difference in resistance to lowered salinity was correlated with the different conditions under which the animals lived in their normal habitat. The least adaptable of the "races" lived in the most stable environment (Holywood), while the most adaptable specimens to lowered salinity came from Burton Marsh, where widely varying conditions were the norm. (T. Rennie)

MacMillan, N. F. 1948b. The resistance of Hydrobia ventrosa (Montagu) to low salinities. Jour. Conch., 23(1):16.

Sixty living specimens of the snail H. ventrosa were obtained from a salt-marsh gutter in Larne Lough, England. In the lab the snails were divided into groups of 30, and each placed in a glass dish. One control group had sea water in the dish while the other had a mixture of 90% sea water and 10% fresh water. In 25 days the solution had been reduced to 70% sea water by 5% stages. In 70% sea water all snails were active. In 65% sea water, all specimens became inactive and died within 2 days. Only two deaths occurred in the control dish. Thus, in the laboratory, H. ventrosa required a minimum salinity of 24.5 ppt. (T. Rennie)

Macnae, William. 1957a. The ecology of plants and animals in the intertidal regions of the Zwartkops Estuary, near Port Elizabeth, South Africa, Pt. I. Jour. Ecol., 45(1):113-130.

The Zwartkops River becomes brackish before it reaches tidal level, because of salt from underlying Cretaceous beds. Over most of the estuary the salinity is high, only slightly less than that of sea water. Halfway between mouth and tidal limit salinity was 33.92-34.76 ppt. Four days after a flood, salinity was 31.86-33.62 ppt. Temperature of water was 12-26 C. At tidal limit there is a sudden transition from freshwater flora to a halophilous one. Above, there are large clumps of Cyperus textilis, Potamogeton sp., Phragmites communis, and Juncus kraussii. These disappear when salinity reaches 5-6 ppt. Next come Cotula coronopifolia, Arthrocnemum perenne var. radicans and A. australasicum, with Spirobolus virginicus at higher level. Farther down there are Zostera capensis beds, submerged in upper estuary and intertidal in lower estuary. Spartina stricta forms large meadows on extensive mud banks in lower estuary, replaced by Arthrocnemum perenne on sand banks and A. australasicum at higher levels on mud banks. At spring high tide level Limonium linifolium is most conspicuous plant, and above it, Salicornia megeriana. Creeks in lower reaches collect drifted algae such as Gracilaria verrucosa and Colpomenia sinuosa. (No animals, except Modiolus, are mentioned in this Part I.) (S. H. Hopkins)

Macnae, William. 1957b. The ecology of plants and animals in the intertidal regions of the Zwartkops Estuary, near Port Elizabeth, South Africa, Pt. II. Jour. Ecol., 45(2):361-387.

The estuary, its salinity, and its flora were described in Part I (Jour. Ecol., 45(1):113-130). The fauna and its ecology are discussed in Part II. On pp. 381 and 385 it is stated that there is no definite horizontal zonation of fauna from mouth to tidal limit because there is no salinity gradient in this high-salinity estuary. (S. H. Hopkins)

Maddox, N. T. 1949. Studies on the biology of the edible oyster, Ostrea rhizophorae Gmelin, in Puerto Rico. Ecol. Monogr., 19(4):339-356; 14 text figs.

In Bay of Boqueron, average of 15 readings was 37.2 ppt; lowest, after spring rains, 35 ppt; highest after hot, dry summer season (22 Aug 1947), 38 ppt. In Laguna Rincon average all stations, 15 readings each, was 37.6 ppt, lowest 32.9 ppt, highest 40.2 ppt. In a small canal-like ditch where there is no circulation except after heavy rains, a salinity of 44.02 ppt was recorded; large mature oysters grew here but no young oysters or spat were found. Normally, when rainfall is sufficient fresh water enters lagoon from freshwater lagoon 4 miles east, but in recent years water from this lagoon has been diverted for irrigation thus reducing flow to Laguna Rincon.

Average pH in lagoon 7.75, average for four stations varying from 7.4 to 8.2; pH higher during rainy season when salinity lower, and higher (nearly 8) in open bay than in lagoon.

Dissolved oxygen lowest when temperature averages were 30 C: 3.9 ppm 30 Sep 1947 and 3.5 ppm 25 May 1948 after long spell of hot, dry weather. Highest after cool spell, 2 Mar 1948 when concentration was 7.0 ppm. Bay water consistently had higher O_2 content than the lagoon: about 4.8 to 8.5 ppm. (S. H. Hopkins)

Maetz, I. 1971. Fish gills: mechanisms of salt transfer in fresh water and sea water. Philos. Trans. Roy. Soc., London, Ser. B, 262(842):209-249.

This paper was presented at a symposium on "active transport of salts and water in living tissues." It reviews results of 116 publications, including 18 by Maetz. The changes that occur in euryhaline fish adapting to changed salinity are thought to be controlled by endocrines. It is stressed that many questions remain unanswered. (S. H. Hopkins)

Maksimova, L. P. 1964. Vyzhivanil i razmnozhenie Monodacna colorata (Eichw.) v. tanaisiana Mil. v. vode razlichnoi solechnosti. [Survival and reproduction of Monodacna colorata (Eichw.) v. tanaisiana Mil. in waters of different salinities.] (Contribution to the problem of introducing Monodacna into the Caspian Sea and bodies of freshwater.) In: Ekalogiya bespozvonochnykh yuzhnykh morei SSSR. [Invertebrate ecology Southern Seas of the USSR.] Nauka: Moscow, 61-79.

Observations were made on the sexual maturation, breeding time, gonad structure, fertility, spawning, and embryo and larval development of Monodacna from the Gulf of Taganrog. Laboratory experiments showed that Monodacna sperm retained its mobility in fresh water and in water from the Sea of Azov and the Caspian Sea with salt concentrations of 7-8 ppt and, for a short time, 10 ppt. Development of embryos and larvae occurs normally in waters with salt concentrations of 1-5 ppt. A further increase in salinity results in a decrease in the percentage of developing eggs and, among the developing eggs, in an increase in the number of deformed larvae. Normal development is impossible in fresh water. If the salt concentration does not exceed 7 ppt, adult Monodacna can be taken from the water with a 2-ppt concentration and placed suddenly in water from the Sea of Azov or the Caspian Sea. With 10-ppt salt concentrations, Monodacna survives in water from the Sea of Azov but dies in Caspian water. With a 12.5-ppt salt concentration these mollusks also die in water from the Sea of Azov. When salt concentrations are gradually changed, Monodacna can survive in water from the Sea of Azov with a 10-ppt salt concentration, and some of the mollusks survive an increase to salt concentrations of 12-19 ppt. Monodacna is better able to withstand high salt concentrations when the temperature is lowered. Under

these conditions the survival rate in the Caspian Sea with a 10-ppt salt concentration is also improved. When salt concentration of water is decreased below 1 ppt adult Monodacna die suddenly, but some individuals can survive for a long time even in fresh water. The author concludes that it would be possible to introduce Monodacna into the same zone in the northern Caspian where the salt concentration ranges from 1-5 ppt. This mollusk cannot be introduced into bodies of fresh water.

Maloeuf, N. S. 1938. Echanges d'eau et d'electrolytes chez un Pagure (P. longicarpus). Arch. Internat. Physiol., 47(1):1-23.

The osmotic behavior of P. longicarpus in sea waters of various concentrations was investigated. The weight of these animals increased rapidly for the first 2 hr after being placed in 50% sea water, and might thereafter fall even below the initial value. When the maximum weight was attained, the blood of the organism was isotonic with the environment. The subsequent loss of weight took place by elimination of an isotonic liquid comparable to urine. The loss of salts occurred most rapidly at the beginning when the animal was gaining water. Animals weighing less than 0.5 g were not able to eliminate "urine" and died in 50% sea water after maintaining the weight approximately constant for some time. The kidneys were found to have no urinary canal, and it was considered that the exchange of water and salts took place through body surface. The O_2 consumption was decreased in hypotonic sea water, but the cardiac rate was not appreciably reduced in those animals that returned to their initial weight in hypotonic sea water.

Maloeuf, N. S. R. 1938. Studies on the respiration and osmoregulation of animals. Zeitschr. f. vergleich. Physiol., 25:1-28.

"If the valves are open, Mytilus gains weight in a hypotonic medium and shows no tendency to return to its original volume during 50 hours;...if the valves are closed the weight is unchanged," according to Prosser et al. 1950, p. 13.

Malone, P. G. and Dodd, J. R. 1967. Temperature and salinity effects on calcification rate in Mytilus edulis and its paleoecological implications. Limnol. and Oceanogr., 12(3):432-436.

Calcification occurred over the experimental range of salinity, 20-37 ppt at 18.5 C, the rate increasing with increase in salinity.

Mandelli, E. F. 1972. A study on the effects of desalination effluents on the life cycle of the American oyster Crassostrea virginica (Gmelin) (Abs.). Abstracts of papers submitted for the 35th Annual Meeting, Amer. Soc. of Limnology and Oceanography, Tallahassee, Fla., March 19-22, 1972.

Tests were made on combined effects of increased temperatures, salinities, and heavy metal concentrations. Limiting conditions for growth and survival of juvenile and adult oysters were found at 32.5 C and 35-ppt salinity, which also enhanced incidence of the lethal fungus Labyrinthomyxa marina. (S. H. Hopkins)

Mangum, C. P. 1964. Activity patterns in metabolism and ecology of polychaetes. Comp. Biochem. Physiol., 11:239-256.

None of the experimental work was related to salinity, but she records an observation in which the environmental salinity of Clymenella torquata dropped below the lethal level of 15 ppt to 13 ppt from the mid 30's in a 24-hr period. While the worms remained in their tubes, mortality was negligible and the worms were not greatly swollen. She suggests the worm can sense the dilution, stop irrigating its tube under these conditions, and maintain a higher salinity. (S. Rennie)

Manning, J. H. and Whaley, H. H. 1955. Distribution of oyster larvae and spat in relation to some environmental factors in a tidal estuary. Proc. Nat. Shellfish. Assoc., 1954, 45:56-65.

Salinities in the St. Mary's River, Maryland, ranged from 8.55 to 15.43 ppt over the sampling area. Due to the longitudinal circulation pattern of the river, which is influenced by tidal activity of the Potomac, the net flow is upstream. Therefore, although more oyster larvae are produced in the lower river, more spat are found upriver due to the slow upstream transport of the larvae. It was suggested, but not pursued, that denisity of the water may be a controlling factor in the vertical distribution of oyster larvae. (S. Rennie)

Mansueti, Romeo J. 1961. Movements, reproduction, and mortality of the white perch, Roccus americanus, in the Patuxent Estuary, Maryland. Chesapeake Sci., 2(3/4):142-205, illus.

Tagging has shown that the white perch tagged in spring moved upstream before spawning, and afterward moved downstream. In summer, movements were random and local. In fall, fish moved downriver to deep water where they stayed through winter, and in spring migrated upriver to spawn again. Sex made no difference in movements. White perch is classified as "semianadromous." There was a negative correlation between first-year growth and rainfall; i.e., lowering the salinity caused decrease in growth. No work was done in correlating salinity to mortality. (T. Rennie)

Mansueti, Romeo J. 1962. Eggs, larvae and young of the hickory shad Alosa mediocris with comments on its ecology in the estuary. Chesapeake Sci., 3(3):173-205, illus., map.

This anadromous clupeoid fish had been thought by many to spawn at sea. "Running-ripe" adult females caught in tidal fresh water of Patuxent River, Maryland, were stripped and mixed with milt from males caught with them, then returned to the laboratory. The fertilized eggs hatched sucessfully in fresh water. Planktonic eggs and larvae caught at the same location in the freshwater part of Patuxent River were thought to belong to A. mediocris.

Mansueti, Romeo J. 1964. Eggs, larvae and young of the white perch, Roccus americanus, with comments on its ecology in the estuary. Chesapeake Sci., 5(1/2):3-45.

Early developmental stages and transforming postlarvae, and very young fish, were identified in plankton samples taken in tidal fresh water and brackish water up to a salinity of 8 ppt in Chesapeake Bay "rivers" or estuaries (in Maryland). (S. H. Hopkins)

Mantel, Linda H. 1967. Asymmetry potentials, metabolism and sodium fluxes in gills of the blue crab, Callinectes sapidus. Comp. Biochem. Physiol., 20(3):743-753.

Measured blood sodium concentrations at various medium salinities, oxygen consumption of gill pieces, potential differences between blood or isolated gills and medium, and sodium fluxes across the gills. (Fide Tagatz and Hill, 1971, p. 47.) (S. H. Hopkins)

Manzi, J. J. 1970. Combined effects of salinity and temperature on the feeding, reproductive, and survival rates of Eupleura caudata (Say) and Urosalpinx cinerea (Say) (Prosobranchia: Muricidae). Biol. Bull., 138(1):35-46(Feb 1970).

Tests were made on these two oyster-boring predacious snails at 12 combinations of salinity (12.5, 15, 20, and 26.5 ppt) and temperature (15, 20, and 25 C). Feeding rates increased with each increase in salinity and temperature, maximum

feeding occurring at 25 C and 26.5 ppt. Mortality rates of both species increased with increasing temperature and decreasing salinity, and were highest at 25 C and 12.5 ppt, lowest at 15 C, 26.5 ppt. E. caudata was less tolerant than U. cinerea to low salinities at all temperatures. Number of eggs per capsule was not affected by temperature or salinity, but number of egg capsules deposited increased with each increase in temperature and salinity, for both species; maximum capsule deposition was in 26.5 ppt at all temperatures. E. caudata oviposited at all three temperatures but not in salinities below 20 ppt. U. cinerea did not oviposit at 15 C or in salinities below 20 ppt. (S. H. Hopkins)

Marchal, P. 1892. Recherches anatomiques et physiologiques sur l'appareil excreteur des Crustacées Decapodes. Arch. Zool. Exp. Gen., Ser. 2, 10:57-275, plus 9 plates in back of volume.

Introduction, pp. 57-61; bibliography, pp. 61-63; anatomy and histology, pp. 63-215; physiology and physiological chemistry, pp. 215-247; appendix, anomalies, pp. 247-248; résumé and conclusions, pp. 248-266; explanation of plates, pp. 267-275; 9 plates on anatomy and histology in back of volume. This monograph gives a wide coverage of all principal types of Decapoda, and includes freshwater, estuarine, and marine species. It is stated that the secretion of urine is not simple dialysis, but that there is a separation of substances by the cells. The urine of the marine crab Maia has almost the same salinity as sea water. It contains neither urea nor uric acid, but does contain an organic acid that Marchal calls "carcinuric," which seems to be one of the "carbopyridic acids." The crayfish urine likewise contains no uric acid, but an acid probably the same as that of Maia. (S. H. Hopkins)

Marcus, Amelie. 1970. La liste des especes de copepods trouvées dans les eaux du littoral roumain de la Mer Noire et dans la Lagune Sinoe. (The list of copepod species found in the waters of the Romanian littoral of the Black Sea and in Sinoe Lagoon.) Trav. Mus. Hist. Natur. Grigore Antipa, 10:7-17. (Russian and Romanian summary.)

An account of the various studies conducted on the copepods of the Romanian littoral of the Black Sea and of Sinoe Lagoon is given, as is a list of the known species.... Two freshwater cyclopoids, Acanthocyclops vernalis (Fischer) and A. americanus (Marsch) appeared sporadically and only under conditions of reduced salinity. (From Biol. Abstr.)

Marine Biological Association of the United Kingdom. 1949. Report of the Council for 1948-49. Jour. Marine Biol. Assoc. U.K., 28(2):533-554.

P. 544: "Some attention has been given to the distribution of Corophium volutator as an estuarine species, with the immediate result that a new species, hitherto confused with volutator, has come to light. The new species occurs at the top ends of estuaries in low salinities, in a variety of situations, such as amongst clumps of Cordylophora, in the debris of reed beds, and in brackish ditches; but apparently not often in bare flat ground or open saltings pools as does Corophium volutator. So far it has been found in the Rivers Plym and Tamar. Immatures can be recognized from those of C. volutator.

"Samples of Corophium arenarium, collected by Mr. N. A. Holme on the Exe Estuary, have been examined and additional characters distinguishing this species from C. volutator have been noted. The two species are confirmed as distinct, and all individuals can be separated, a point which the existing description leaves open to doubt." (S. H. Hopkins)

Mars, P. 1950. Euryhalinité de quelques mollusques Mediterranéens. Vie et Milieu. Bull. Lab. Arago, Univ. of Paris, 1(4):441-448.

Euryhalinity is expressed in 10 deg, 0 being 100% stenohaline, unable to stand any change from pure sea water, and 9 (theoretical) being able to stand total absence of salt or saturation. Muricopsis blainvillei typifies deg 1 (37 ± 4); Cardium tuberculatum and Murex trunculus deg 3 (32 ± 6); Chalamys glabra, Ostrea edulis, and Ocinebra erinaceus deg 4 (30 ± 9); Tapes aureus and Gibbula adansoni deg 5 (27 ± 12); Rissoa labiosa, Mytilus galloprovincialis, and Loripes lacteus deg 6 (23 ± 13 to 25 ± 25 ± 15); Brachydontes marioni deg 7 (24 ± 18); and Cardium edule deg 8 (32 ± 28). (S. H. Hopkins)

Marshall, Nelson. 1954. Factors controlling the distribution of oysters in a neutral estuary. Ecology, 35(3):322-327, 4 figs. (1 map, 3 graphs of salinity and temperature).

In Alligator Harbor, a bay with high salinity, oysters occur only above low tide level. Attributed to depletion by predators below low tide level. (S. H. Hopkins)

Marshall, N. and Wheeler, B. M. 1965. Role of the coastal and upper estuarine waters contributing phytoplankton to the shoals of the Niantic Estuary. Ecology, 46:665-673.

Dinoflagellates were found to dominate the phytoplankton in this estuary, which has fairly clear water and a fairly long flushing period, according to Green (1968). (S. H. Hopkins)

Marshall, S. M., Nicholls, A. G., and Orr, A. P. 1935. On the biology of Calanus finmarchicus. VI. Oxygen consumption in relation to environmental conditions. Jour. Marine Biol. Assoc., U.K., 20:1-28.

In laboratory experiments, as the salinity was reduced the copepods became less active. The death rate was irregular and not very high until 40% (14 ppt) seawater dilutions were obtained (decreased by 5% each day). Respiration studies showed that copepods in 80% (27.2 ppt) had an oxygen consumption as high as the Calanus in normal sea water (0.37-0.38 ml/1000/hr). Those in 50% (17.0 ppt) showed reduced oxygen consumption (0.25 ml/1000/hr).

In the field Calanus is found in waters having salinities of 35.3 ppt or less. It is absent in the low salinities of the Baltic Sea. The lower limit that Calanus can tolerate in the laboratory is about 17 ppt, a value lower than is found in the open ocean. (S. Rennie)

Martin, F. D. 1968. (Actually Feb 1969.) Intraspecific variation in osmotic abilities of Cyprinodon variegatus from the Texas coast. Ecology, 49(6):1186-1188.

Populations of this fish from San Jacinto River at Highlands, Harris County (salinity over 6-month period 6.9-17.4 ppt), from the South Jetty tide pool at Port Aransas (salinity 9.1-63.1 ppt with daily fluctuation of 5 ppt) and from Nine-Mile Pond east of Fulton Beach (salinity 20.1-33.2 ppt) were compared in ability to withstand sudden osmotic shocks. The population from the tide pool, which had the largest daily and seasonal changes in salinity, showed much greater ability to survive large and sudden lowering of salinity. (S. H. Hopkins)

Martin, R. C. 1926. Ecological relations of marine wood-boring organisms in San Francisco Bay. Ecology, 7(3):247-254.

The crustacean (isopod) Sphaeroma pentodon adapts to salt, brackish, and almost fresh water. The isopod Limnoria lignorum and the shipworm (boring mollusk) Bankia setacea are limited to areas in which salinity is not much below 16 ppt. The shipworm (mollusk) Teredo navalis (recently introduced) will thrive in salinities as low as 9 ppt, and can survive long periods in practically fresh

water, providing a salinity of 5 ppt or above is attained at least once a month. The shipworm Teredo diegensis is limited in San Francisco Bay to one shallow inlet, the limiting factor being apparently the low summer temperatures of other bay waters. (S. H. Hopkins)

Massmann, W. H. 1954. Marine fishes in fresh and brackish waters of Virginia rivers. Ecology, 35:75-78.

Samples were taken from five major rivers in Virginia. An annotated list of 18 marine fish species collected is given, citing the greatest distance upriver from the average boundary of brackish and fresh waters for each. Massmann speculates that small amounts of salt (less than 1 ppt) were responsible for survival of marine fish in "fresh" water. (S. Rennie)

Massmann, W. H. 1971. The significance of an estuary on the biology of aquatic organisms of the Middle Atlantic regions. Pp. 96-109. In: A significance of estuaries. Ed: Douglas, P. A. and Stroud, R. H. Sport Fishing Institute, Washington, D. C., xi + 111 pp.

The Middle Atlantic region is interpreted to include the coast from Cape Cod to Cape Hatteras, with special emphasis on Chesapeake Bay. Salinity and its biological importance is mentioned on almost every page. In the conclusion, it is stated that the circulation, with salty water running inland along the bottom and water of lower salinity running seaward on the surface, is an important aspect of the biological effect of salinity, making the upper part of the estuary a nursery area for young fishes and crustaceans. "The most productive nursery areas are those in low salinity waters, near the head of the bay, or upriver in tidal tributaries." Reducing freshwater inflow influences estuarine animals in a variety of ways. (S. H. Hopkins)

Mastenbroek, N., van. 1927. Eenige opmerkingen aangaande Membranipora crustulenta (Pallas). (In Dutch.) Zool. Meded. Leiden, 10(1):50-53.

According to Redeke 1932, Mastenbroek (1927) said that "Membranipora crustulenta Baster" is "frequently still listed as M. membranacea var. erecta Loppens." This is a characteristic mesohalinophilic species, Redeke says. Not seen. (S. H. Hopkins)

Mathiesen, H. and Nielsen, J. 1956. Botaniske underøgelser i Randers Fjord og Grund Fjord. Bot. Tidsskr., 53:1-34 (In Danish.).

The distribution of rooted plants in a Danish brackish waterway, Randers Fjord, with a salinity gradient of 0.5 to 18 ppt. Abstracted in some detail, with three map diagrams showing distribution of salinity, marine and brackish-water plants, and freshwater plants, by Green, 1968, pp. 53-55. (S. H. Hopkins)

Mathieson, A. C. and Burns, R. L. 1971. Ecological studies of economic red algae. I. Photosynthesis and respiration of Chondrus crispus Stackhouse and Gigartina stellata (Stackhouse) Batters. Jour. Exp. Mar. Biol. Ecol., 7(2):197-206.

The photosynthesis and respiration of C. crispus and G. stellata are recorded under a variety of light intensities, temperatures, salinities, and degrees of desiccation. C. crispus showed its maximum photosynthesis and minimum respiration at a salinity of 24 ppt; G. stellata exhibited maximum photosynthetic and reduced respiration rates at 40 ppt. (From Biol. Abstr.)

Matthiessen, George C. 1960. Observations on the ecology of the soft clam, Mya arenaria, in a salt pond. Limnol. and Oceanogr., 5:291-300.

Field observations supplemented by laboratory experimentation indicated that

Mya longer than 2 mm can tolerate salinities less than 1 ppt for at least 24 hr and can withstand sudden salinity fluctuations of an order of 18 ppt. Tolerance of clams 2-25 mm long to low salinities was proportional to their size. Growth rate varied directly with salinity, in range 3.5-15 ppt. Pumping rate varied directly with salinity in range 0-31 ppt. The clams studied lived in a "salt water pond" at Martha's Vineyard, Mass. (S. H. Hopkins)

Maturo, Frank J. S., Jr. 1959. Seasonal distribution and settling rates of estuarine Bryozoa. Ecology, 40:116-127.

This study was made at three estuarine stations around Beaufort, North Carolina, including one in Newport River; salinity at the river station varied from 24 to 35 ppt, but salinity was mentioned in the text only on p. 123, as a cause for scarcity of the stenohaline Aetea anguina at the low salinity (river) station, and on pp. 119-120 and 126 where low salinity was mentioned as a cause of attachment of Bugula neritina at greater depths, and less attachment near the surface during low salinity periods. (S. H. Hopkins)

Matutani, Kozi. 1962. Studies on the temperature and salinity resistance of Tigriopus japonicus. IV. Heat resistance in relation to salinity of Tigriopus japonicus acclimated to dilute and concentrated sea waters. Physiol. and Ecol. [Japan], 10(2):63-67.

This marine copepod was reared in 100% sea water at 20 C for 30 days, then adults were acclimated to 25% and 150% sea water for 0, 4, 12, 24, and 48 hr after which they were tested for their heat resistance at 38.6 C in concentrations of sea water from 25% to 200%. The heat resistance of 100% sea-water-acclimated animals is the highest in 150% sea water and declines gradually as the concentration of test sea water decreases or increases. In 25% sea-water-acclimated animals, heat resistance decreases rapidly with acclimation time. The concentration of sea water in which they are most resistant to heat moves toward lower concentrations till it reaches 50%-75% after 48 hr of acclimation. In 150% sea-water-acclimated animals, heat resistance increases significantly within 24 hr and the peak appears to be shifted, though slightly, toward higher concentration. (Author)

McErlean, A. J. 1964. Characteristics of Macoma balthica populations in the middle Patuxent Estuary. Chesapeake Sci., 5:200-208.

Populations of the small estuarine clam Macoma balthica were sampled by hydraulic dredge (which caught individuals over 11 mm long) at 18 stations. The general trend was for average size to decrease downriver where salinities were higher. Density varied from 0 to 466 clams per square meter. Reduction in numbers occurred both upriver and downriver in the Patuxent Estuary, but was thought not to be due to salinity. Much variation in density of populations occurred both from place to place and from time to time, suggesting "spottiness" in distribution. Bottom salinities at the stations sampled ranged from 0-8 ppt (average 4 ppt) at the station farthest upriver to 9-19 ppt (average 16 ppt) at the station farthest downriver. (S. H. Hopkins)

[Ed. note: Contrary to the author's opinion, decrease in size and density of clams in higher salinity was probably due to increased mortality in higher salinity. SHH]

McFarland, W. N. and Pickens, P. E. 1965. The effects of season, temperature, and salinity on standard and active oxygen consumption of the grass shrimp, Palaemonetes vulgaris (Say). Canadian Jour. Zool., 43(3):571-585.

Nine temperature-salinity combinations were tested: 3.0, 12.5, and 24.5 ppt, and 10, 20, and 30 C. Statistical treatment of the data indicates that it is

most likely that acclimation to neither various salinities nor to different temperatures greatly affects the standard oxygen consumption of grass shrimp. The 20 C-acclimated groups of shrimps gave a slightly and significantly higher mean oxygen rate in all salinities than those acclimated at the other temperatures. (S. Rennie)

McGahee, Cheryl F. and Davis, G. J. 1971. Photosynthesis and respiration in Myriophyllum spicatum L. as related to salinity. Limnol. and Oceanogr., 16(5):826-829 (Sep 1971).

This seed-bearing vascular plant, common name Eurasian water milfoil, has become a pest in some Atlantic coast estuaries. It has recently become established in Albermarle Sound, North Carolina, near the mouth of Alligator River, in a salinity of 1 ppt. Previous reports indicated that plants were stunted or killed in salinities over 13-14 ppt, so that sea-water intrusion can wipe out a population. Plants from 1 ppt were tested at 16 and 32 ppt under low and moderate light intensities. Under low-intensity light, photosynthesis was depressed in 32 ppt but not in 16 ppt, and respiration was not affected by salinity. At moderate light intensity (10-14 hr light-dark cycles) photosynthesis was depressed in 16-ppt as well as in 32-ppt salinity, but respiration remained high. (S. H. Hopkins)

McHugh, J. L. 1966. Management of estuarine fisheries. Pp. 133-154. In: A symposium on estuarine fisheries. Am. Fish. Soc. Special Publ. No. 3, viii + 154 pp., Washington, D. C.

Only oysters and some clams, among major fishery resources, are completely estuarine--other species need also the offshore zone affected by land drainage. But almost 66% by value of the U.S. commercial catch is composed of species that spend at least part of their lives within landbound estuaries, especially along Atlantic and Gulf of Mexico coasts. Invertebrates that require estuaries make up more than 50% of value of fisheries from Chesapeake Bay south. Estuarine species inhabit a rich but rigorous environment, and detailed ecological knowledge is required for management. P. 140: Relatively large variations in salinity and temperature occur in short time intervals in estuaries. Salinity is mentioned also on p. 141 as an important factor. (S. H. Hopkins)

McHugh, J. L. 1967. Estuarine nekton. Pp. 581-620. In: Lauff, G. H., ed. Estuaries. Am. Assoc. Adv. of Sci. Publ. 83, Washington, D. C., xv + 757 pp.

This long paper covers a lot of ground, as "nekton" includes all of the actively swimming animals caught in fishermen's nets. The effects of salinity are referred to throughout as a major factor. Attempts are made to quantitate productivity of estuaries for plankton, benthic animals, and fishes. (S. H. Hopkins)

McInerney, J. E. 1961. An experimental study of salinity preference and related migratory behavior of juvenile Pacific salmon. M. Sc. thesis, Dept. Zool., Univ. of British Columbia.

The seasonal salinity preference of four species of Pacific salmon was investigated. Young salmon were placed in a compartmentalized box. One compartment had fresh water and the other some concentration of salt water. (Controls had fresh water in each compartment.) After raising the water level in the boxes after introduction of the fish, the fish were allowed to choose between the two connected compartments. Records of activity, group behavior, and agonistic behavior were made periodically. Most tests involved comparisons of 9- and 25-ppt salinities; a few were tested for reaction and preference to 2, 4, 5, 6, 10, and 15 ppt. Each of the four species showed a strong preference for hypertonic sea water during the normal period of migration. Pink fry (Onocorphnchus gorbuscha) and Coho

yearlings (O. kisutch) lost this preference during the summer in contrast to chum fry (O. keta) and sockeye yearlings (O. nerka). A preference for hypertonic sea water was associated with high levels of activity, strong schooling tendencies, and depressed aggressive "migration disposition." Subsequent seasonal changes showed a marked increase in aggressive behavior accompanied by decreased levels of activity and group behavior. A long daily photoperiod (16 hr) prolonged the behavior complex (seaward migration). A short daily photoperiod (8 hr) delayed but did not totally inhibit the development of a hypertonic salinity preference. The preference of chum salmon fry for a series of sea-water concentrations indicated an all-or-none type response. No preference was shown for hypotonic sea water. Preference for salt water depended on the concentration of sodium chloride. The swiftness of response (chum and sockeye) indicated stimulation of a peripheral salinity receptor. (T. Rennie)

McInerney, John E. 1964. Salinity preference: An orientation mechanism in salmon migration. Jour. Fish. Res. Bd., Canada, 21(5):995-1018.

"An examination of the modal salinity preferences of five Pacific salmon species showed the following pattern of temporal changes. The sequence began with a preference for fresh water, then changed gradually, in the direction of increasing sea water concentration. The terminal pattern indicated a preference for water of open ocean concentration. This temporal progressing of salinity preference changes was shown to parallel closely the salinity gradients typical of river outflows through which young salmon pass on their way to the ocean. On the basis of this evidence the following orientation mechanism was proposed: that juvenile Pacific salmon are able to use estuarial salinity gradients as one of the directive cues in their seaward migration." (Author's abstract)

McKenzie, R. A. 1959. Marine and freshwater fishes of the Miramichi River and Estuary, New Brunswick. Jour. Fish. Res. Bd., Canada, 16(6):807-833.

The Miramichi, the largest river in northeastern New Brunswick, extends inland 150 miles; commercial fisheries are in tidal waters, lower 50 miles. Water temperatures range from -1.6 C to 25 C and salinities from 0 to 30 ppt. Thirty-eight families, 78 species, of fishes occur; 53 species are marine, 7 anadromous, 1 catadromous, and 17 freshwater. (Author's abstract in part)

McLachlan, Jack. 1961. The effect of salinity on growth and chlorophyll content in representative classes of unicellular marine algae. Canadian Jour. Microbiol., 7(3):399-406.

The growth and relative chlorophyll content per cell of nine different unicellular marine algae were determined at various salinities (2.5 to 35 ppt) in enriched sea-water medium. All nine algal types grew well in a wide range of salinities, and when growth was completely suppressed, it was at the lower levels. Monochrysis lutheri, Syracosphaera carterae, Cyclotella sp., Thalassiosira decipiens, and Cryptomonas sp. did not show a distinct salinity optimum with regard to growth, and there was no significant difference in the concentration of chlorophyll per cell at the various salinities. Growth of Monochrysis was low at 2.5 ppt. Syracosphaera failed to grow in 2.5 ppt, but growth and chlorophyll concentration in the other salinities were essentially the same. Thalassiosira did not grow below 15 ppt while Cryptomonas grew about equally well at all salinities. Growth of Olisthodiscus was completely suppressed in 2.5 and 5.0 ppt, above which growth steadily increased to a maximum at 15 ppt. From 20 to 35 ppt, growth was essentially the same. Chlorophyll cell content followed the same trend. For Amphidinium carteri, maximum growth and chlorophyll concentration occurred in 25 ppt. No growth occurred from 2.5 to 10 ppt. Growth of Porphyridium sp. was slightly depressed at 2.5 ppt, and was essentially equal in from 5- to 35-ppt salinity. Chlorophyll concentration showed a maximum at 25 ppt with greatest decreases from 2.5 to 25 ppt. Platymonas sp. also showed chlorophyll

content per cell affected by changes in salinity. Maximum chlorophyll concentrations occurred in 2.5 and 35 ppt, with minimums in 10 to 15 ppt. Growth in 15 to 35 ppt was approximately equal with the maximum at 35 ppt. Growth at 2.5 ppt was greatly reduced, with a general rise occurring with increase of salinity to 15 ppt. (T. Rennie)

McLeese, D. W. 1956. Effects of temperature, salinity and oxygen on the survival of the American lobster. Jour. Fish. Res. Bd., Canada, 13(2):247-272.

Salinity acclimation experiments (to 7.5, 3.7, and 11.4 ppt) were inconclusive, but it appeared that substantial acclimation had occurred in 4-7 days.

In relation to size, small lobsters were more resistant to reduced salinities than large lobsters in the 16- to 34-cm range. Moulting lobsters were less resistant to reduced salinities.

Upper lethal temperatures are raised when acclimation temperature is raised, and lowered when salinity and oxygen acclimation are decreased. The lower lethal salinity level is raised by an increase in thermal acclimation level. A decrease in salinity acclimation level lowers the lethal salinity. The lethal oxygen level is raised by an increase in the level of temperature acclimation and by a decrease in salinity acclimation level.

Maximum upper lethal levels of temperature and minimum lower lethal levels of salinity and oxygen at 27 combinations of temperature (5, 15, and 25 C), salinity (20, 25, and 30 ppt), and oxygen (2.9, 4.3, and 6.4 mg/1) are given. The only "ultimate" level that could be estimated is for temperature, which is 32 C with 30-ppt salinity and 6.4-mg/1 oxygen.

A three-dimensional diagram is presented that defines a segment of the complete zone of tolerance for the lobster to combinations of temperature, salinity, and oxygen. The diagram provides a method for assessing the lethal effects of any one factor with respect to the other two. (S. Rennie)

McLeese, D. W. 1959. Temperature, salinity and oxygen relationships of the lobster. (Abs.) Anat. Rec., 134:603.

The interaction of these three factors on the ultimate lethal temperature, salinity, and oxygen was demonstrated with lobsters acclimated simultaneously to various levels of temperature, salinity, and oxygen. Lobsters were inactive at some temperatures within the zone of temperature tolerance, hence could not feed and would not survive indefinitely. Reduction in salinity may lead to physiological stress which will lower the lethal temperature. Reduction in dissolved oxygen also lowers the lethal temperature. Each factor affects limits of the other factors that animals can tolerate. (S. H. Hopkins)

McLusky, Donald S. 1967. Some effects of salinity on the survival, molting and growth of Corophium volutator (Amphipoda). Jour. Marine Biol. Assoc. U.K., 43(3):607-617.

If supplied with mud this crustacean will survive 20-50 ppt and without mud 7.5-47.5 ppt. Molting occurs in 2.6-46 ppt but most frequently 5-20 ppt. Growth occurred at a maximum rate in 15.4 ppt and at a slightly slower rate in 4 and 30.6 ppt. Below 4.4 ppt the growth rate was progressively reduced. (From Biol. Abstr.)

McLusky, Donald S. 1968. Some effects of salinity of the distribution and abundance of Corophium volutator in the Ythan estuary. Jour. Marine Biol. Assoc. U.K., 48(2):443-454.

The author concludes that 2 ppt is the critical minimum salinity controlling the distribution of this amphipod (crustacean). Between 2 and 5 ppt, C. volutator occurred in reduced numbers. Breeding occurred only above 7.5 ppt. Above 5 ppt the substrate controlled the distribution and abundance, but below 5 ppt

the salinity overrode effects of substrate. (S. H. Hopkins)

McLusky, D. S. and Heard, V. E. J. 1971. Some effects of salinity on the mysid Praunus flexuosus. Jour. Marine Biol. Assoc. U.K., 51:709-715.

Mysid shrimps, Praunus flexuosus, collected at 2-18 ppt were put in salinities of 0-50 ppt at 5 C. LD_{50}'s showed this mysid could tolerate salinities of 2-33 ppt. Above and below this, survival times were considerably lowered (10.75 hr at 0.5 and 50 ppt).

Blood concentration studies showed that P. flexuosus is isotonic at 25 ppt. Above this it is hypo-osmotic and below this, it is hyperosmotic to the medium. Similar studies with Neomysis integer show it is iso-osmotic at 19 ppt with the same patterns as Praunus, above and below this point. Salinity tolerance is less for N. integer over the same range.

Concentration of the marsupial fluid in P. flexuosus is hypo-osmotic to concentrated media and hyperosmotic to dilute media. The amount of regulation in the brood pouch is less than the haemolymph. Thus the developing embryos must tolerate a wider range of salinity than the adult tissues. (S. Rennie)

McMahan, Craig A. 1968. Biomass and salinity tolerance of shoalgrass and manateegrass in lower Laguna Madre, Texas. Jour. Wildlife Management, 32(3):501-506.

Salinity tolerance of shoalgrass (Diplanthera wrightii) and manateegrass (Syringodium filiforme) was studied in laboratory. Shoalgrass had a salinity tolerance ranging from above 3.5 ppt to a level less than 70 ppt. Salinity optimum appeared to be about 44 ppt. Plants in 3.5 ppt and a tap water lived up to 3 weeks. Sprigs in 70 and 87.5 ppt remained in good to fair condition for 3 weeks before degrading and dying. Manateegrass had a lower level of tolerance to hypersaline water than shoalgrass. Rhizomes survived in water of 35 ppt better than at 44 ppt. Rhizomes in 52.5-ppt salinity died within 21 days of being planted. (T. Rennie)

McMillan, Calvin. 1971. Environmental factors affecting seedling establishment of the black mangrove on the central Texas coast. Ecology, 52(5):927-930.

Some factor prevents seedlings of Avicennia germinans L. (A. nitida Jacq.) from rooting on the gulf (outside) beaches. It is not salinity, for experiments show that seedlings will root in all salinities from 0 to nearly double sea-water concentration. Tumbling, as in surf, prevents rooting, but seedlings root as soon as they are stabilized following 12 weeks of tumbling. High temperature (39-40 C) is lethal to stemless seedlings but not to those with stems and roots. (Avicennia, though called black or honey mangrove, is not related to true mangrove, Rhizophora mangle.) (S. H. Hopkins)

McMillan, Calvin and Moseley, F. N. 1967. Salinity tolerance of five marine spermatophytes of Redfish Bay, Texas. Ecology, 48(3):503-506, illus.

Considers the major plants of the higher productive estuaries along the coast: Thalassia testudinum, Halophila engelmanni, Diplanthera wrightii, Ruppia maritima, and Syringodium filiforme. D. wrightii tolerated highest salinity; S. filiforme was least tolerant of high salinity. In Laguna Madre, Diplanthera and Ruppia were reported by Simmons to occur above and below 45 ppt, respectively. In test tanks, Diplanthera survived in 74 ppt; Thalassia in 67 ppt, or even 74 ppt; Ruppia did not completely die in 74 ppt, but did not grow in salinities above 46 ppt; Syringodium did not live above 60 ppt, and did not grow in salinity above 45 ppt; Halophila survived, or died and reappeared, in 74 ppt. Lower than oceanic salinities were not tested.

Medcof, J. C. 1944. How relaying and transferring at different seasons affect the fatness of oysters. Atlantic Biol. Stat., St. Andrews, N.B., Res. Bd. Canada Progr. Reports, 35:11-14.

Salinities may entirely prevent fattening. Oysters moved downriver increase in fatness, those moved upriver decrease in fatness. (S. H. Hopkins)

Medcof, J. C. 1961. Oyster farming in the Maritimes. Fish. Res. Bd. Canada, Ottawa, Bull. No. 131, xi + 158 pp., illus.

The only mention of salinity is on p. 30, where it is stated, "Unless they are too fresh (less than 2% salt as compared with open sea which is 3% salt) the waters in the middle reaches of inlets are better for oyster farming than those right at the mouths." The 2% of course equals 20 ppt, which would be considered almost too high for oyster farming in southern states. (S. H. Hopkins)

Medcof, J. C. and Needler, A. W. H. 1941. The influence of temperature and salinity on the condition of oysters (Ostrea virginica). Jour. Fish. Res. Bd., Canada, 5(3):253-257, 1 fig.

An index of condition is influenced by temperature and salinity. Between 15 and 20 C the index rises as the spawn develops. However, if the salinity drops below 20%, no fattening takes place even between those temperatures. The index is figured by multiplying the quotient of the dry weight of the meat divided by the volume of space between the valves in ml by 1000. [Although critical salinity was printed here as 20%, authors state elsewhere it is 20 ppt. SHH] (S. Rennie)

Menzel, R. W. 1954. Some phases of the biology of Ostrea equestris Say and a comparison with Crassostrea virginica (Gmelin). Ph. D. Dissert., Department of Biology, Agricultural and Mechanical College of Texas, College Station, x + 176 pp., typed, double spaced; bound. (See Menzel, 1955.)

Menzel, R. W. 1955. Some phases of the biology of Ostrea equestris Say and a comparison with Crassostrea virginica (Gmelin). Publ. Instit. Mar. Sci., Univ. of Texas, 4(1):69-153.

On p. 73 the two genera of oysters are compare in 13 aspects. In salinity relations, Ostrea species are "inhabitants of sea water, high salinity and clear," while Crassostrea species are "inhabitants of estuaries and brackish waters of high turbidity." On p. 93 it is stated that Ostrea equestris and O. frons do not occur in salinity below 25 ppt. At Port Aransas (salinity 35 ppt) and at Pensacola (salinity 19.5-26 ppt) Ostrea spat set near the bottom only, while C. virginica set most profusely at upper levels and least (usually not at all) at bottom levels. The behavior of larvae results in each species setting in the salinity most suitable for the growth and reproduction of adults. C. virginica will grow on the bottom only in lower salinities of estuaries; in higher salinities it will be found in intertidal zone because larvae set as near the surface as possible.

[This paper is a condensation of the Ph. D. dissertation of the same title, which should be consulted for fuller details.] (S. H. Hopkins)

Menzel, R. W. 1956. Annotated check-list of the marine fauna and flora of the St. George's Sound-Apalachee Bay region, Florida Gulf Coast. Oceanographic Institute, Florida State University, Tallahassee, Fla., Contrib. No. 61, mimeo., 78 pp.

Lists plants and animals recorded from this region. For most species gives identifier, representative area where it occurs, substrate, seasonal occurrence, abundance, and salinity range indicated as "F," 0-5 ppt; "B," 5-25 ppt; and

"S," 25-37 ppt. Includes fishes and other vertebrates as well as invertebrates, seed plants, algae, etc. (S. H. Hopkins)

Menzel, R. W., ed. 1971. Checklist of the marine fauna and flora of the Apalachee Bay and the St. George's Sound area. 3rd edition. Department of Oceanography, Florida State University, Tallahassee, Fla., vi + 126 pp.

This revision includes many species added since the 1956 revision (Menzel, 1956): 130 ciliate Protozoa (none were recorded in 1956), 3 Mesozoa, 59 Porifera (12 in 1956), 56 Coelenterata (compared with 28 in 1956), etc. As in earlier editions, distribution of species in relation to salinity (0-5 ppt, 5-25 ppt, or 25-37 ppt) is given for some groups but not for others. Identifiers are designated and a list of references on the fauna and flora of the region is included. (S. H. Hopkins)

Menzel, R. W., Hulings, N. C. and Hathaway, R. R. 1958. Causes of depletion of oysters in St. Vincent Bar, Apalachicola Bay, Florida. Proc. Nat. Shellfish. Assoc. (1957), 48:66-71.

This study was made June 1955 through May 1957. Salinity over the reef had been high and enemies of oysters, including Thais haemastoma and Menippe mercenaria, had consequently become established here. It was shown by experiment that oysters protected from these predators would survive and grow rapidly, but those not protected did not live to be more than 40-50 mm long. Reproduction was good. (From author's abstract)

Menzies, R. J. and Frankenbury, D. 1966. Handbook on the common marine isopod Crustacea of Georgia. Univ. of Georgia Press, Athens, viii + 93 pp., illus.

Only 30 species are recorded from Georgia, some for the first time, but 105 should occur since they are known just north and/or south of Georgia. No attempt was made to collect from other than marine (offshore or on Sapelo Island) habitats. No information on distribution in relation to salinity is given, but some can be inferred from notes on locations outside of Georgia (e.g., Chesapeake Beach, well up the Maryland part of Chesapeake Bay and thus in low salinity). This publication is most useful for its key and list of southeastern species. (S. H. Hopkins)

Meyer, P. F. and Mann, H. 1951. Recherches allemandes relatives au "Mytilicola," copépode parasite de la moule existant dans les watten allemandes 1950-51. Rev. Trav. Off. Peches Marit., 17:63-74.

Mytilicola intestinalis, a maggot-like copepod parasite of the common commercial mussel Mytilus edulis, can tolerate a range of salinity at least as great as its host tolerates so that it extends into estuaries. Its injury to the host is more in places where food for mussels is scarce and less where mussels get a good food supply. Green (1968, pp. 326-327) cites this paper, but may have added information from other sources (Korringa, 1951; Pesta, 1907; Bolster, 1954; Hepper, 1955). (S. H. Hopkins)

Mileikovskii, S. A. 1968. Razmnoz henie morskoi avezdy Asterias rubens L. U belom barentsevom, norveyhskom i drugikh europerskikh moryakh. (Breeding of the starfish Asterias rubens L. in the White, Barents, Norwegian and other European Seas.) Okeanologiya, 8(4):693-704. (Russian with English summary.)

Breeding and larval development of the starfish A. rubens were studied in the White, Barents, and Norwegian seas; two of the races that begin spawning at 3.5-4.5 C and at 6.5-9.0 C, respectively, are the real temperature reproductive "physiological races" similar to those of the oysters Ostrea edulis and Crassostrea virginica. The third one, represented by the Kiel population inhabiting

brackish (S = 15 ppt) waters and spawning at 13-15 C, appears to be influenced not by the temperature, but by low salinity of the habitat. General ecological laws of spawning of A. rubens in European marine waters are analyzed. (From Biol. Abstr.)

Miller, D. N., Jr. 1953. Ecological study of Foraminifera of Mason Inlet, North Carolina. Contr. Cushman Foundation Foram. Res., 4(2):41-62.

At Mason Inlet, a brackish-water environment, substratum conditions seem to be the control of distribution as the largest populations are found on clean, fine sand. A depauperate assemblage was found on a clay bottom, high in organic matter. (E. H. Myers and W. S. Cole, 1957.)

Miller, M. A. and Burbanck, W. D. 1961. Systematics and distribution of an estuarine isopod crustacean, Cyathura polita (Stimpson, 1855), new comb., from the Gulf and Atlantic seaboard of the United States. Biol. Bull., 120:62-84.

Known geographical range extends from Louisiana to Maine, with populations in estuaries, tidal marshes, intertidal areas, etc., where salt and fresh water mix.

Miller, R. C. 1926. Ecological relations of marine wood-boring organisms in San Francisco Bay. Ecology, 7:247-254.

Sphaeroma pentodon adapts to salt, brackish, and nearly freshwater conditions. Limnoria lignorum and Bankia setacea are limited to average annual salinities of 16 ppt and above. Teredo navalis survives down to 9 ppt and can tolerate fresh water if put in 5 ppt once a month. Teredo diegensis is limited to one shallow inlet in the bay, limited by low summer temperatures elsewhere which interfere with breeding. Although T. navalis and B. setacea have overlapping ranges, their breeding seasons do not overlap to any great extent. (S. Rennie)

Milne, A. 1940. The ecology of the Tamar Estuary. IV. The distribution of the fauna and flora on buoys. Jour. Marine Biol. Assoc., 24(1):69.

The buoys studied formed a series extending from open sea to typical estuarine conditions at Neal Point. Only Enteromorpha torta, Callithamnion corymbosum, insect larvae, "Gammarus locusta" (actually a variety of G. zaddachi), and Balanus improvisus, of the 48 forms listed in fig. 1, reached as far upriver as Neal Point. However, salinity was unusually low when the study was made, following a rainy winter; more species were found on Neal Point buoys in previous studies when salinity was higher. Of the 48 plants and animals listed in fig. 1, 22 were confined to the sound and outer waters rather than in the estuary proper. The reader is referred to Milne (1938, Jour. Mar. Biol. Assoc. U.K., 22:529-542) for salinity data, but it is mentioned that organisms on some buoys must stand salinity changes of 5.2, 5.5, and even 12.8 ppt in the 6-hr spring tide cycle. Maximum ranges in one tidal cycle were: 33.7-7.6 ppt at Saltash, 33.7-19.5 ppt at Drake's Island, and 34.9-26.6 ppt at B. (S. H. Hopkins)

Milne, Alec. 1940. Some ecological aspects of the intertidal area of the estuary of the Aberdeenshire Dee. Trans. Roy. Soc. Edinburgh 60, Part 1, 4:117-139.

The Dee Estuary is relatively short with no up-estuary movement of surface water. Both horizontal and vertical salinity gradients are present, which are chiefly responsible for distribution of organisms within the estuary. The number of species present (18) is less than in longer estuaries, due to high salinity fluctuation and absence of mudflats. The number of individuals is enormous. The best penetrators in the estuary are Jaera marina, Gammarus zaddachi, Balanus balanoides, Procerodes ulvae, Nereis diversicolor, and Fucus ceranoides. Experiments showed that Mytilus is sensitive to external salinity even when apparently tightly closed. Mytilus and Patella have shorter feeding periods the higher

upriver and higher into the intertidal zone they live. (S. Rennie)

Mohammad, M. B. M. 1966. Effects of temperature and salinity on the development of Axiothella mucosa (Andrews). Bull. Biol. Res. Cent. (Baghdad), 2:1-20.

The effects of variations in temperature and salinity, apt to be encountered in nature, on the development of A. mucosa in the laboratory were studied, from the fertilized egg to the 11th day of juvenile life. A salinity of 16 ppt proved to be lethal to the eggs. Larvae and juveniles that have been reared in the optimum salinity (32 to 40 ppt) show swellings on transfer to a concentration of 16 ppt and readjust to the dilute medium after approximately 1 week; with respect to rate of development, the low temperature acts as the low salinity in retardation of larval and juvenile growth. The temperature and salinity of the sea water exert their influences on the devlopment of the Maldanid independently, that is to say: the salinity changes undergone do not affect temperature tolerance, and vice versa. (From Biol. Abstr.)

Mohsen, T., Georgin, A., and Amalou, P. 1964. Sur les variations de la teneur globale des ions Na+ chez Lebistes reticulatus maintenus dans de milieux de salinité variée. C. R. Soc. Biol., Paris, 158:153-155.

Sodium content of male fish transferred directly from fresh water to sea water is higher than in fish kept in their natural medium (fresh water). Sodium content of young males almost equals that of fish transferred directly from fresh to salt water, but that of older males corresponds to that of fish in fresh water. This means that young males have a poikilosmotic tendency and that in proportion to their growth they become more and more homo-osmotic. This agrees with results obtained by Boucher-Firly (1935, Ann. Inst. Oceanogr. (Monaco), 15:217) with female eels. (S. H. Hopkins)

Moody, William D. 1949. A study of the natural history of the spotted trout, Cynoscion nebulosus, in the Cedar Key, Florida, area. Quart. Jour. Florida Acad. Sci., 12(3):147-171.

A study on seasonal distribution, movements, spawning, growth, and food habits of young and adult C. nebulosus was conducted at Cedar Key, Florida, in 1948-1949. Beam trawl collections were made. Salinities and air and water temperatures were taken periodically. The difference in salinity in the area was great, ranging from fresh water in the upper portions of the surrounding rivers to almost normal gulf salinity over offshore reefs. The range at any one locality throughout the year was also large. The trout were resident throughout the year being found in waters having salinities ranging from near fresh water to near gulf-strength water and preferring shallow grassy inshore areas. In winter they moved into the rivers and deeper streams along the coast apparently to escape the low water temperatures in shallower areas. Salinity was not apparently a decisive factor in affecting their movements into the rivers, as the fish were "able to tolerate a wide range of salinity. Numerous specimens were taken two miles upstream from the mouth of the Waccasassa in water having a salinity of 1.2 ppt." No specific salinities other than this are given. (T. Rennie)

Moore, H. B. 1935. The biology of Balanus balanoides. IV. Relation to environmental factors. Jour. Marine Biol. Assoc. U.K., 20:279-307.

Pp. 291-292: "Prennant and Teissier (1929) state this species is unable to withstand low salinities, but at la Rance it was found in water with a salinity as low as 0.45 ppt." (S. H. Hopkins)

Moore, H. F. 1898. Some factors in the oyster problem. Bull. U.S. Fish. Comm., 17:275-284.

"Water density, temperature, character of bottom, food, enemies, legislation and environment are discussed." (J. L. Baughman, 1947.) (S. Rennie)

Moore, H. F. 1899. Report on the oyster beds of Louisiana. Rept. U.S. Comm. Fish., 24:45-100.

Spawning begins when the water decreases in salinity. The water is more dense during the summer when the oyster is spawning copiously. There is no relation between the density of the water and the cessation of spawning.

The conch (snail, borer) is located where the prevailing density of the water is higher.

The effects of a crevasse (on oysters) are twofold. It deposits mud and freshens the water. When the oysters are killed by the fresh water the shells are often left in excellent condition to serve as cultch. It is usually false reasoning to believe a crevasse will rehabilitate an exhausted oyster region since there are only a few viable oysters in the region and the cultch has been almost destroyed by boring organisms of several kinds. (S. Rennie)

Moore, H. F. 1911. Condition and extent of the natural oyster beds of Delaware. U.S. Bur. Fish. Doc. No. 745, 30 pp.

Quoted by Federighi, 1931, as saying that in Delaware Bay the oyster drilling snail Urosalpinx cinerea "does not thrive" at specific gravities below 1.012 to 1.013, which Federighi converts to salinities of 15.5-17.0 ppt.

Moore, H. F. and Pope, T. E. B. 1910. Oyster culture experiments and investigations in Louisiana. Report U.S. Comm. Fish. 1908, Doc. 731:1-52; 8 plates.

The danger of oyster drills does not exist where the specific gravity of the water is 1.012 (equal parts of salt and fresh water). In places where the salinity is greater than 20%, seed oysters cannot be produced because the spat are killed by the drills. [No doubt 20 ppt was meant. SHH] (S. Rennie)

More, W. R. 1969. A contribution to the biology of the blue crab (Callinectes sapidus Rathbun) in Texas, with a description of the fishery. Texas Parks and Wildlife Dept. Technical Series No. 1:1-31.

P. 26: "Historically, blue crab production in Texas has been highest in those bays receiving the most fresh water; lowest in areas receiving the least (Copeland, 1966)." The actual figures are shown in table 5, pp. 16-17.

Also, on p. 26, it is stated that blue crab production in the past has dropped during droughts and increased in wet years. Hoese's (1960) study showed low C. sapidus population in Mesquite Bay, Texas, in dry 1950-56 period but sharp increase in 1957, a wet year. In the present study, table 7, pp. 24-25, shows low crab stocks on Texas coast in 1963-65 associated with high salinities. Reappearance of small crabs in 1966 coincided with increase in freshwater inflow. (S. H. Hopkins)

Morishima, Masao. 1944. The accumulation of foraminiferal tests in inlets of Wakasa Bay in the Inland Sea of Japan. Nat. Res. Council, Div. Geol. Geog. Ann. Rep., Appendix H:89-91.

Salinity and character of the bottom control the distribution of the Foraminifera in these bays rather than temperature or depth which are not sufficiently variable to be controlling factors. (E. H. Myers and W. S. Cole, 1957, Geol. Soc. Amer. Mem. 67, Vol. 1, p. 1078.)

Morris, Robert W. 1960. Temperature, salinity and southern limits of three species of Pacific cottid fishes. Limnol. and Oceanogr., 5:175-179.

Oligocottus maculosus, Clinocottus globiceps, and Leptocottus armatus were found tolerant of approximately double strength sea water for up to 14 hr at 12 C. Elevation of temperature resulted in partial failure of osmoregulation at about 16 C in the first two and at about 25 C in L. armatus. The temperature-related reaction to osmotic stress can be related to maximum shore temperatures at the southern extremity of the ranges of O. maculosus and C. globiceps. In intraspecific comparison, tolerance of elevated salinity does not imply tolerance of high temperature and vice versa. (From abstract, p. 175)

Morss, W. L. 1927. Plant colonization of merse lands in the estuary of the River Nith. Jour. Ecology, 15:310-343.

"Merse" is Scottish for "marsh" and refers to salt marsh. Mudflats exposed at low tide are inhabited by cockles, lobworms, and crustaceans such as Corophium longipes, shrimps and crabs; seabird droppings and green algae, with shells, start consolidation of mud. Height is raised by sedimentation so flat is no longer submerged by neap tides, and green seaweed increases. Salicornia first appears, then Glyceria, etc., so that former mudflat becomes a vegetated marsh. Figs. 2, 4, and 6 show salinities in parts per thousand, mostly less than 1 ppt. Salt content of soil is discussed on pp. 337-339. (S. H. Hopkins)

Motais, R., Isala, J., Rankin, J. C., and Maety, J. 1969. Adaptive changes of the water permeability of the teleostean gill epithelium in relation to external salinity. Jour. Exptl. Biol., 51(2):529-546.

Diffusional and osmotic water flows in teleosts probably occur solely across the gills and are lower in sea-water than in freshwater fish. The diffusional and osmotic permeability coefficients are lower than in any other epithelia and appear equal in sea-water fish, suggesting a lack of water-filled pores in the gill epithelium, unless salt fluxes interfere with bulk flow of water. (P. Maxwell, from Biol. Abstr.)

Motwani, M. P. 1955. Experimental and ecological studies on the adaptation of Mytilus edulis L. to salinity fluctuations. Proc. Nat. Inst. Sci. India, B. Biol. Sci., 21(5/6):227-246.

Salinity in the River Blythe in the area of the mussel beds varied by about 4 ppt over a year with the average salinity being about 30 ppt.

Salinity tolerance in the laboratory was 20-50 ppt. As the amount of change in salinity increased, the delay in opening the valves increased. The failure to form a byssus took place at 13.9-10.4 ppt when dilutions were made gradually. Sudden dilutions evoked this at 17.4 ppt, gradual concentrations at 50.8 ppt, and sudden concentrations at 47.8-50.8 ppt.

Below 17.34 ppt and above 53.77 ppt the mussels showed erratic behavior in opening their valves, and mantle water could not be sampled. Below 31 ppt the maximum time for mantle water to reach equilibrium was 50 min with the greatest change. Above 31 ppt, equilibrium was reached in 10 min. The valves cannot be closed tightly enough to insure complete insulation. A slight change of 0.87 ppt was noted after 96 hr in a diluted medium. Permeability of the mantle is sufficiently low to prevent dangerous alteration of the mantle water under normal conditions. Little evaporation takes place between tides.

It seems that osmotic pressure, not ionic concentration, acts as the stimulus to control opening of valves. The minimum salt necessary is equivalent to that in 10% sea water. (S. Rennie)

Mulford, R. A. 1963. Distribution of the Dinoflagellate genus Ceratium in the tidal and offshore waters of Virginia. Chesapeake Sci., 4(2):84-89.

The distribution of 13 species of Ceratium in lower Chesapeake Bay and adjacent offshore waters of the Atlantic Ocean is presented, along with observed

temperature and salinity ranges for each species. Seven species had ranges of over 15-ppt salinity. (T. Rennie)

Mulligan, H. F. 1972. Phytoplankton of Great Bay Estuary (Abs.). Abstracts of papers submitted of the 35th Annual Meeting, Amer. Soc. of Limnology and Oceanography, Tallahassee, Fla., March 19-22, 1972.

Phytoplankton in this New Hampshire estuary were studied Oct 1970-Oct 1971 along a 15-mile transect from most brackish area to Gulf of Maine. Temperature ranged from -2.6 C to 21.8 C. Salinity ranged from 9.5 to 34.4 ppt. Phytoplankton populations were correlated with temperature (and season) and with salinity. Diatoms mentioned as "major bloom formers" were Detonula confervacea and Skeletonema costatum. Ceratium spp. and Peridinium spp. were the most abundant dinoflagellates. (S. H. Hopkins)

Muncy, Robert J. 1962. Life history of the yellow perch, Perca flavescens, in estuarine waters of Severn River, a tributary of Chesapeake Bay, Maryland. Chesapeake Sci., 3(3):143-159, illus., maps.

In 1958, yellow perch spawned in March upriver in fresh and low-salinity (2.5 ppt) brackish water. In experimental floating hatchery boxes, hatching success of eggs seemed to be decreased by increase in turbidity or in salinity. Juveniles, like those in freshwater streams, ate small crustaceans and insects, especially chironomid larvae. However, there was some difference in food in stomachs of fish in different salinities. Yellow perch in the Severn River grew faster than freshwater populations, and adults lived longer (as determined by scale samples and tagging) than in Lake Mendota, Wisconsin. Also, Severn River yellow perch became sexually mature earlier than in Wisconsin, and produced more eggs per female. Juvenile and adult yellow perch were found from fresh water to salinities of 10 ppt in Severn River.

Muthu, M. S. 1955. Unusual lowering of salinity in the Madras coastal area and its effect on the plankton. Current Sci., 24(3):87-89, illus.

With a drop in salinity to 19.45 ppt from a normal of 34 ppt, a considerable increase in volume of plankton occurred, while the composition of the plytoplankton remained nearly the same. Euryhaline zooplankton was unaffected, but a few stenohaline zooplankters were temporarily displaced. (This was in India)

Muus, B. J. 1963. Some Danish Hydrobiidae with the description of a new species, Hydrobia neglecta. Proc. Malacol. Soc. London, 35:131-138.

In Denmark the salinity ranges in which the species of this family of snails live were reported as follows: Potamopyrgus jenkensi, 0-15 ppt; Hydrobia ventrosa, 6-20 ppt; H. neglecta, 10-24 ppt; H. ulvae, 10-33 ppt. H. ventrosa and H. neglecta were equally numerous at 15 ppt, but at lower salinities H. ventrosa was more abundant. Fide Green, 1968, p. 136. (S. H. Hopkins)

Muus, B. J. 1967. Some problems facing the ecologist concerning races and subspecies of brackish-water animals. Pp. 558-563. In: Lauff, G. H., ed. Estuaries. Am. Assoc. Adv. of Sci. Publ. 83, Washington, D. C., xv + 757 pp.

Inconsistent or conflicting findings of authors supposedly working with the same species may be due to the fact that they are actually dealing with genetically different populations. The European cockle, Cardium edule, was found to be two species; C. lamarki Reeve, the low-salinity form, is morphologically distinct (for instance, it has a byssus gland which C. edule lacks). The supposedly wide variation in Hydrobia ulvae and H. ventrosa was due to the presence of a third species, H. neglecta (Muus, 1963) which had confused previous studies on salinity relations. Warwick (1952) found that the variability of the

hydrobiid snail Potamopyrgus jenkensi in fresh and brackish water was due to the existence of three closely related parthenogenetic species. Nereis diversicolor shows a morphological cline, becoming more and more different going from North Sea (high salinity) to Finland (low salinity). The species of the amphipods Gammarus and Corophium are also discussed. (S. H. Hopkins)

Myers, G. S. 1938. Fresh-water fishes and West Indian zoogeography. Smithsonian Report for 1937, pp. 339-364.

In this paper, Myers "made possible a real advance in understanding of fish geography by proposing an ecological classification of freshwater fishes based simply on their ability or inability to tolerate salt water," according to Darlington, 1957, Zoogeogrphy, p. 41. "Fishes that are strictly confined to fresh water Myers put in a primary division. Those that live chiefly in fresh water but have a little (not too much) salt tolerance he put in a secondary division." (S. H. Hopkins)

Myers, G. S. 1949. Salt-tolerance of fresh-water fish groups in relation to zoogeographical problems. Bijdragen Tot de Dierkunde, 28:315-322.

One of at least 10 publications by Myers on this general topic. Further discusses the ecological classification of freshwater fishes in relation to fishes in general. Gives many references. Cited by Darlington, 1957, Zoogeography, pp. 44, 46, 126. Not seen. (S. H. Hopkins)

Nagabhushanam, R. 1956. The rate of water filtration in the marine wood-boring mollusc Martesia striata. Linn. Proc. Indian Acad. Sci. Sect. B, 43(4):223-227, illus.

Boring clams of the species Martesia striata were placed in five beakers, each having a different salinity (11.85 to 34.38 ppt) and a standard amount of neutral red solution. Filtration rates were measured periodically as percentage of neutral red removed from solution. Experiments were allowed to continue for 3 to 7 hr. Slower filtering rates occurred at the lower salinities (16.8 and 11.85 ppt). (T. Rennie)

Nagabhushanam, R. 1961a. Rate of water pumping of Modiolus demissus in relation to salinity and temperature. Jour. Sci. Indust. Res. [New Delhi, India], 20:67-68.

The Atlantic ribbed mussel, Modiolus demissus [at Woods Hole, Massachusetts], has been found to remove about 82% of the neutral red in sea water in 1 hr at 32 C and at a salinity of 3.0% [30 ppt]; the rate of removal of neutral red is directly proportional to the rate of water pumping by the organism. The rate of pumping decreases with the lowering of salinity. The pumping rate varies only slightly between 23 and 35 C, but it is sharply reduced at 15 C. (Author's abstract)

Under equal temperature conditions, mussels removed 82% of neutral red from solution in 60 min at 32 ppt, 58% at 24 ppt, 30% at 16 ppt, and 6% at 10 ppt. (Added by S. H. Hopkins)

Nagabhushanam, R. 1961b. The effect of low salinity on the larvae of Martesia striata. Jour. Sci. Indust. Res., 20(3):102-103. (In Biol. Abstr., 36:7418, Item 79069, Dec 1, 1961--Ecology section) (Martesia striata is a wood-boring clam.)

Sudden change in the salinity of sea water from 3.3 to 1.5% (33 to 15 ppt) has no effect on the larvae of M. striata. In sea water of 0.9% salinity (9 ppt), there is cessation of movement of larvae during the first 24 hr, and in sea water of 0.6% salinity (6 ppt) complete cessation of movement occurs in 20 hr and the larvae die in 36 hr. In sea water of 0.3% salinity (3 ppt), the larvae die in 12 hr. These results show that the larvae can tolerate a fairly wide range of salinity from 0.9 to 3.0% (9 to 30 ppt). (Author's abstract)

This work was done in India at room temperatures of approximately 28 C. Results agreed with previous experiments on adult M. striata except that adults lived longer in water of 6 ppt, but died after a few days. (Jour. Zool. Soc. India, 7:83-86 (1955).) (Added by S. H. Hopkins)

Nagabhushanam, R. 1961c. Tolerance of the prawn, Palaemonetes vulgaris (Say), to waters of low salinity. Sci. and Culture, 27(1):43.

Individuals of the American prawn, Palaemonetes vulgaris, were kept at 14 different salinity concentrations (0-35 ppt). In each experiment, 15 specimens of Palaemonetes were kept in white enamel pans containing 500 ml of the test solution. The water in each pan was changed daily. Temperatures ranged from 20 to 23 C. Animals were kept under observation for 30 days. The lethal level appeared to be 3 ppt. All prawns survived the 30-day observation period above 2 ppt. At 2- and 1-ppt salinity, prawns survived only 2 days; at 0 ppt, survival was for 1 day only. P. vulgaris, although purely marine in habitat, appeared to be better adapted to very low salinities than was reported for P. varians (0.6% sodium chloride was lower tolerance level). [According to the 1952 monograph of Holthuis, P. vulgaris normally lives not only in the edge of the sea but in estuaries, for instance in upper Chesapeake Bay

where salinity is only half that of ocean.-SHH.] (T. Rennie)

Nagabhushanam, R. 1965a. Effects of sea water of reduced salinities upon the amphipod, Ampelisca spinipes Boek (Arthropoda: Crustacea). Sci. and Culture, 31(5):263-264.

Amphipods, Ampelisca spinipes, from York River near Virginia Institute of Marine Science, were tested for survival over a 30-day period in salinities from 19 ppt down to fresh water. The lethal salinity was found to lie between 3 and 4 ppt.

Nagabhushanam, R. 1965b. Tolerance of the pea crab, Pinnotheres ostreum, to waters of low salinity. Current Sci., 34(1):22-23.

The lethal salinity limit appears to be at 0.6%-0.7% of NaCl (sea water = 1.9%). In fresh water the crabs died within 24 hr. At 0.3%-0.6% they survived 3-4 days. This suggests that oysters can be protected from P. ostreum by exposing them to a salinity of 0.6% or below for 4-5 days, which will not kill the oysters. [0.6%, by author's formula, would equal 10 ppt as salinity is usually stated--SHH.] (S. Rennie)

Nagabhushanam, R. 1967. Effect of low salinity on the mud snail, Nassarius obsoletus (Say) (Mollusca: Gastropoda). Sci. and Culture 33(5):243-244.

Nassarius obsoletus in York River, Virginia, were tested in salinities from 17 ppt down to fresh water for 15 days. The lethal salinity was found to lie between 5 and 6 ppt.

Nagabhushanam, R., and Murty, K. Gopalakrishna. 1965. Tolerance of Cirolana fluviatilis to waters of low salinity. Sci. and Culture, 31(8):437-438.

Fouling isopod crustaceans, Cirolana fluviatilis, were collected from wooden jetties in Visakhapatnam harbor, and kept in aquaria at 30-ppt salinity. Twenty individuals were kept in fingerbowls containing 500 ml sea-water solution of varying salinities (fresh water to 30 ppt). Survival rates were noted periodically for 10 days. The lethal salinity level appeared to lie between 4- and 5-ppt salinity. Fourteen Cirolana survived at 5 ppt, but only three at 4 ppt. None survived below 3 ppt. All organisms survived above 5-ppt salinity. (T. Rennie)

Nagabhushanam, R., and Sarojini, R. 1965. Rate of water propulsion of Mulinia lateralis (Say) in relationship to salinity and temperature (Mollusca Lamellibranchiata). Sci. and Culture, 31(8):438-439.

Mulinia filters water slower at low salinities. Similar results with Martesia. (S. H. Hopkins)

Nagahama, Masaho. 1951. Studies on the foraminiferal fauna of small or almost enclosed bays in Japan. Miscell. Reports, Res. Inst. Nat. Resources, Nos. 19-21: 142-148. (Japanese with English abstract.)

Differences in distribution of certain genera (named in paper) are intimately connected with the salinity, temperature, and depth of water. (From author's abstract)

Nagel, H. 1934. Die Aufgaben der Excretionsorgane und der Kiemen bei der Osmoregulation von Carcinus maenas. (The function of the excretory organs and the gills in the osmoregulation of (the crab) Carcinus maenas.) Zeitschr. f. vergleich. Physiol., 21:468-491.

The molar concentration of the body fluids of the crab Carcinus maenas in sea water corresponds closely to that of the outside medium. Brackish-water individuals of Carcinus on the other hand maintain an internal concentration that is hypertonic to the external medium. The cause of this homoiosmotic property was investigated. The excretory organs (antennal glands) produce, in sea-water and brackish-water individuals, a urine nearly isotonic to the blood, also corresponding to chloride content. Salts are eliminated with the urine. Brackish-water crabs take up water faster, but water is also eliminated faster by a higher rate of urine elimination. Antennal glands regulate ion content of body fluids, as by taking iodide from the blood. Gills are permeable to water in both directions. The relatively limited (as compared with stenohaline marine crabs) permeability of Carcinus gills to water helps maintain hypertonicity of the internal medium in brackish water. Gills are also permeable to salts in both directions, but less so than in stenohaline marine crabs; this also helps maintain hypertonicity of body fluids of Carcinus in brackish water. Gill cells can take up salts from an outside medium that is hypotonic to the body fluids, and secrete them into the blood, as fast as salts are lost in urine. The gills are therefore the real osmoregulatory organs of Carcinus maenas. (S. H. Hopkins)

Nash, C. B. 1947. Environmental characteristics of a river estuary. Jour. Marine Res., 6(3):147-174. (Ches. Biol. Lab. Publ. No. 64.)

A study of temperature, salinity, tides, water level, dissolved oxygen, light penetration (by Secchi's disc), H-ion concentration, silicate, nitrite, phytoplankton, and zooplankton in the Patuxent River, at a series of stations, varying from almost nonsaline conditions down to the open waters of Chesapeake Bay; these characteristics were related to one another and to the plankton. (S. H. Hopkins)

National Research Council, Committee on Oceanography and Committee on Ocean Engineering. 1970. Wastes Management Concepts for the Coastal Zone: Requirements for Research and Investigation. National Academy of Sciences, Washington, D. C., vii + 126 pp.

P. 81 - Brine Wastes. Responses of marine organisms to brine, and to large variations in salinity, osmoregulatory problems and osmotic stress, and impact of local increases in salinity should be studied.

P. 81 - Freshwater Discharges to Estuaries. Some biological communities require stable salinity, others must have periodic freshwater pulses. Runoff into an estuary may be "polluting" if it fluctuates enough to cause osmotic stress on the biological system. "There is urgent need for improved comprehension of the effects of alteration of freshwater inflow on the quality and uses of coastal waters. As industrial operations, river storage, and diversions increase, advance predictions of the principal effects of increasing or decreasing freshwater flow, or of modifying the seasonal flow patterns, will become essential." (S. H. Hopkins)

Nayar, J. K. 1969. Effects of larval and pupal environmental factors on biological status of adults at emergence in Aedes taeniorhynchus (Wied). Bull. Entomol. Res., 58(4):811-827.

Adult mosquitoes were reared from larvae under five environmental variables--quality of food, density of larvae, salinity of medium, light regime, and temperature--singly and in combination. On emergence these adults were analyzed for morphological characteristics, dry body weights, energy reserves, and autogeny. The minimal expression of adult characteristics and autogeny was affected by lack of food, crowding of larvae, and higher salinity, singly and in combination, at a constant temperature at 27 C. These three factors in turn showed a distinct relation with delay in onset and prolongation of pupal ecdysis. The maximal expression of adult characteristics and autogeny was found when 75 to

100 larvae were reared on 2X- or 4X-basic ration in 10% to 25% sea water at 27 C under alternating 12-hr light-dark cycles. Adults reared on 4X-basic ration in 10% sea water under alternating 12-hr light-dark cycles and temperatures from 24 to 34 C showed that though largest mosquitoes were obtained at 24 C, the heaviest mosquitoes with maximal lipid and glycogen contents and maximal expression of autogeny were found at 28 and 30 C. Temperature and light regimes show complex effects on adults at emergence, but food quantity, density of larvae, and salinity of the rearing medium are more important factors. (P. Maxwell)

Naylor, E. and Haahtela, I. 1966. Habitat preferences and interspersions of species within the superspecies Jaera albifrons Leach (Crustacea: Isopoda). Jour. Animal Ecol., 35:209-216.

What was formerly considered the single species J. albifrons is now recognized, following Bocquet (1953), as four species, distinguished by small morphological and larger ecological and behavioral differences, including different salinity preferences. Fide Green (1968), pp. 174-175. (S. H. Hopkins)

Naylor, E., Slinn, D. J., and Spooner, G. M. 1960. Observations on the British species of Jaera (Isopoda:Asellota). Jour. Marine Biol. Assoc. U.K., 41:817-828.

J. albifrons (= J. marina) is recognized as four ecologically different species with small morphological differences. J. nordmanni, which has always been considered distinct from J. albifrons, is more euryhaline and penetrates farther into estuaries and higher up shores. Fide Green, 1968, pp. 174-175. (S. H. Hopkins)

Nazarov, V. M. and Chepurnova, L. V. 1969. Pris posobitel'nye osobennosti ekologie raymnozheniya i polovogo tsikla glossy severozapadnoi chasti chernogo morya i prilegayvschikh limanov. (Adaptive characteristics of the breeding ecology and sex cycle of flounder in the northwest Black Sea.) Vop Ikhtiol, 9(6):1133-1135.

Two populations of flounder are found in the northwest portion of the Black Sea--those living in the open sea and those living in estuaries. The estuary group reaches sexual maturity and spawns earlier--probably because the temperature and salinity are less favorable. "This early spawning is accomplished through a shift in gametogenesis phase; the oocytes are smaller at all stages because of early maturation and higher water salinity. The estuary flounder is characterized by greater fecundity, which increases its ability to proliferate under less favorable conditions." (P. Maxwell, from Biol. Abstr.)

Needham, J. 1930. On the penetration of marine organisms into freshwater. Biol. Zentralbl., 50:504-509.

Two theories have been offered to explain why so few marine animals have invaded fresh water. Sollas (1883) pointed out that forms with free-swimming or floating larvae (or eggs) would be excluded because larvae or eggs would be swept to sea by river currents. But this does not explain exclusion of marine forms without such stages, like cephalopods, or presence in fresh water of a few forms with weakly motile larvae (Gurney, 1913). Von Martens (1858) pointed out that freshwater "climate" with extremes of temperature, desiccation, etc. is too severe for most marine animals, and that diversity of freshwater fauna increases toward equator. Needham suggests a third reason. Echinoderm larvae increase in ash content as they develop; so do cephalopod larvae. Phosphorus content especially rises. Sea water contains ample phosphorus to permit this, but most fresh water does not. In English Channel, surface water has 0.0162 mg of phosphorus per liter, winter maximum, and 0.0032 as summer minimum when plankton blooms. Most fresh water has less than 0.003 mg/l, though some may rise to 0.012. To penetrate fresh water, marine species must have mutation to provide enough ash (e.g. phosphorus) in egg to provide for its development,

since environment cannot provide it. (S. H. Hopkins)

Negus, Michael R. S. 1968. Oxygen consumption and amino acid level in Hydrobia ulvae (Pennant) in relation to salinity and behavior. Comp. Biochem. Physiol., 24(2):317-325.

Acclimatized specimens of H. ulvae show a linear increase in oxygen consumption with decreasing salinity. The quantity of amino acid tends to decrease with decreasing salinities. Specimens transferred to different salinities may show a temporary increase in oxygen consumption and α alanine concentration. The temporary increase in oxygen consumption appears to be a standard increment. The increase of α alanine presumably reflects the quantity of pyruvate, the respiratory substrate. The linear relation of oxygen consumption to salinity in acclimatized animals is related to osmoregulation. The temporary increment increase in oxygen consumption may be related to the cyclical behavioral activity of the prosobranch mollusk, H. ulvae, under estuarine conditions.

Neily, R. M., Kirkbride, W. H., Mattos, F. D., Squire, H. E., and Hill, C. L. 1927. Engineering section. Pp. 48-162. In: Marine borers and their relation to marine construction on the Pacific coast, ed. by Hill, C. L. and Kofoid, C. A., Univ. of Calif. Press, Berkeley, ix + 357 pp.

P. 55: "Salinity is particularly important where marine borers are concerned. The danger point is about 15 ppt. If this salinity, or greater, can occur and borers are present, their attack on unprotected timber can be expected.... Teredo navalis is particularly destructive in the lower salinities, from 10 to 20 ppt, a condition to be found in river estuaries. River discharge may vary so that the salinity is reduced below 15 ppt for a period of time, but if it rises again to this amount during the breeding season of Teredo and so remains for a few succeeding months, unprotected timber will be destroyed. This borer will survive in nearly fresh water if a salinity of 5 ppt occurs every 30 days or oftener (see p. 261). Limnoria and Bankia seem to require higher salinities, 20 ppt or more (see pp. 292 and 327). Hence all borers are found active in water of 20 ppt or more." The temptation to use untreated timber in rivers is dangerous because low river flow may allow Teredo to enter. Man-made changes are expected to increase danger.

Nelson, T. C. 1921. Aids to successful oyster culture. I. Procuring the seed. N. J. Agric. Exp. Sta. Bull., 351:37-38, 53-56.

In oyster culture it is necessary to keep salinity records accurately. Suggestions on methods and apparatus for taking density readings are included, as well as a brief discussion of the salinity effect on the setting of oysters, and of its effect on the various stages of oyster growth. (P. Maxwell)

Nelson, T. C. 1923. Report of the Department of Biology. N. J. Agric. Coll. Exper. Sta., 1922:321-343; 4 plates; 6 tables; 3 text-figs.

Destruction caused by Urosalpinx and Eupleura.

P. 334: "A rough estimate of the annual loss to oyster growers in New Jersey through the activities of oyster drills...gives a figure in excess of $1,000,000. As shown in section I of this report, the higher salinities of the water on most of the beds as a result of the decreased rainfall since January 1921 have permitted increased activity on the part of the drills and in an extension of their range. The common oyster drill, Urosalpinx cinereus, has been found as far up on the natural beds of Delaware Bay as New Beds, whereas in 1920 no evidence of its work was found above Egg Island beds some 5 miles below.

Drills were found also on the Cedar Creek natural beds, Barnegat Bay, where the salinity of the water is usually not sufficiently high to permit the snails to operate. From our, as yet, very limited data it appears that the lowest

average salinity at which Urosalpinx is able to live, reproduce and carry on its work of destruction, is in the neighborhood of 1.014...(planting of month-old Barnegat Bay seed in Little Egg Harbor in summer) when examined on October 22, 1921, parts of the grounds showed a mortality of 65 per cent and over, while the general average was in excess of 50 per cent." Drills eat Mytilus recurvus, "the southern oyster mussel" in preference to oysters; drums do also. (S. H. Hopkins)

Quoted by Federighi, 1931, as saying that the minimum salinity for survival and reproduction of the oyster drilling snail Urosalpinx cinerea in New Jersey is 18.33 ppt, "a figure that has recently (1928) been lowered to 15.00 ppt (private communication)" - Federighi, 1931:346.

Nelson, T. C. 1928. On the formation of saliniclines in Barnegat Bay, New Jersey, with observations of the reactions of oyster larvae to salinity gradients. Anat. Rev., 41:84-85 (Abs.).

Barnegat Bay water in calm weather has a pronounced stratification, increasing at the salinicline from a specific gravity of 1.01000 to 1.01700 (salinity 13 to 22.3 ppt) within 0.3 m, vertically. Oyster larvae are found in thousands at the top of the salinicline, while lower waters contain few or none.

Neumann, D. 1961. Osmotische Resistenz und Osmoregulation aquatischer Chironomiden larven. Biol. Zentralbl., 80(5):693-715.

The strongly homoiosmotic freshwater midge (Insecta, Diptera) larva Chironomus thummi thummi reaches the limit of its salt content potential when the blood salt content of 8 ppt, hypertonic in fresh water, nears isotonicity with the external medium. The somewhat homoiosmotic brackish-water Chironomus halophilus and C. salinarius adopt hypotonic regulation in a hyperhaline medium, C. salinarius being adaptable to a wider range of salinity than C. halophilus. All developmental stages, in each species, have the same salinity tolerance. These three species are compared with other dipteran larvae, including several mosquito species, in regard to salt tolerance and osmoregulation. (S. H. Hopkins)

Newcombe, C. L. 1935. A study of the community relationship of the sea mussel, Mytilus edulis L. Ecology, 16:234-243.

Intertidal mussel beds were studied near St. Andrews, New Brunswick, Canada. Attention has been focused on Balanus-Mytilus edulis Association of the Balanus-Littorina-Fucus Biome. Associates are listed. True succession has been demonstrated. Unity and interaction of constituents of the integrated biotic community are stressed. Starfishes (Asterias vulgaris and A. forbesi), sea urchins (S. drobrachiensis), and the whelk Purpura lapillus are predators of Mytilus, especially at lower levels. In absence of predators, mussels grow at normal rate below mean low water level where there are now none, so present absence is blamed on predation. Growth rate data are presented; growth is less at higher levels of bottom. The study was done in an area of near-oceanic salinity, and salinity is not mentioned as a factor. (Condensation of author's conclusions)

Newcombe, C. L. 1945. The biology and conservation of the blue crab, Callinectes sapidus Rathbun. Education Ser. No. 4. Virginia Fisheries Laboratory, Glouces-ter Point, Virginia, 39 pp.

Egg-bearing crabs are most abundant in the saltier waters near the mouth of Chesapeake Bay. Laboratory studies showed that salinity and temperature of this part of the bay are most suitable for hatching and larval development. Salinity of 22-28 ppt is needed for normal hatching and development of zoea larvae, but megalops stage and small juvenile crabs may be reared in salinity as low as 5 ppt, similar to that in the upper bay and tributaries (p. 7). (S. H. Hopkins)

Newell, R. 1964. Some factors controlling the upstream distribution of Hydrobia ulvae (Pennant) (Gastropoda, Prosobranchia). Proc. Zool. Soc. London, 142:85-106.

In the River Crouch there is only a slight (less than 2 ppt) vertical salinity gradient. In upper reaches of the estuary H. ulvae is confined to upper level of intertidal zone, where the salinity of the water reaching them will be higher (because it reaches them only at high tide when the sea water influence predominates). Floating H. ulvae close operculum and sink (to higher salinity) if estuary water is diluted, but where these snails are regularly exposed to low salinities they lose the floating habit, thus avoiding risk of being transported to lethally low salinities. Fide Green, 1968, pp. 136-137. (S. H. Hopkins)

Nichols, J. T. 1928. Fishes from the White Nile collected by the Taylor Expedition of 1927. A discussion of the fresh-water fish faunae of Africa. Amer. Mus. Noyitates, No. 319:1-7.

Divided freshwater fishes into "two main faunae, continental and peripheral": continental, dominated by carp-catfish-characin group, occupies Eurasia, Africa, and the Americas, except northern circumpolar area and southern tips of South America and Africa; peripheral, "with better-marked affinities to salt-water groups," occupies northern circumpolar area (trouts and pikes), southern tips of South America and Africa, Australia, and the islands of the world in general. Peripheral fauna is divided into Boreal, Austral, and "Insular and Australian" which in turn is divided into Australian and insular. "Insular" includes two groups: West Indian and Oceanic. The divisions of the "peripheral fresh-water fish fauna" are not discussed further, but from other publications it is known to include many fishes of marine families which can and do adapt to fresh water or even spend their lives in fresh water. (S. H. Hopkins)

Nichy, F. E. and Menzel, R. W. 1962. Mortality of intertidal and subtidal oysters in Alligator Harbor, Florida. Proc. Nat. Shellfish. Assoc. (1960), 51:33-41.

Because of the combined effects of predation and environmental agencies in southern high salinity areas (salinity 32.5-35.5 ppt in Alligator Harbor), there is a vertical restriction of the extent and density of oyster populations. In Alligator Harbor, where the tidal range does not normally exceed 65 cm, oysters are restricted to a band from about 5 cm above mean low water to 45 cm above. Predation eliminates oysters near and below mean low water, and high summer temperatures at low tide, plus lack of spatfall, limit the upper level at which oysters can live. At the lower experimental locations, 15 cm below mean low water, mortality was over 60% per month when oysters were not protected from predators (xanthid crabs and whelks). (S. H. Hopkins)

Nicol, Edith A. T. 1935. The ecology of a salt-marsh. Jour. Marine Biol. Assoc., U.K., 20:203-262.

The salt marsh studied was in Scotland: margin of Aberlady Bay, south shore of Firth of Forth, 15 miles east of Edinburgh, fringing intertidal sand flats. Bottom salinity in marsh pools varied: 20-32, 10-24, 27-38, 24-36, 4-30, 9-21 ppt, etc., in different pools during different seasons of the year. Salinity of mud did not differ much from that of bottom water, at surface, but became more different 1, 2, 3, and 4 in. below surface (sometimes higher, sometimes lower). Accepts classification of estuarine waters by Redeke (1922, 1921): 0-0.2 ppt, fresh; 0.2-1.9, oligohaline; 1.9-18.6, mesohaline; 18.6-31.8, polyhaline; 31.8 up, sea water. Salinity of some pools 8-40 ppt, others 0.5-15 ppt according to summary.

Animals of marsh surface included Enchytraeus albidus, crustaceans Orchestia gammarella, Porcellio scaber, and Philoscia muscorum, three myriopods, seven insects, and one spider. On mud, Sphaeroma rugicauda, O. gammarella, Carcinus maenas, snails Hydrobia ulvae and Littorina saxatilis, etc. Fresher pools

contain freshwater insects, brackish-water crustacea. Saltier pools and estuary have larger fauna. (S. H. Hopkins)

Niemi, Ake. 1971. Itameren planktonista (On the plankton of the Baltic). Luonnon Tulkija 75(3/4):92-105. (English summary.)

The zooplankton of the coastal waters of Southwest Finland is compared with that of other Baltic areas, and the influence of the increasing salinity on the distribution of plankton is discussed. (Biol. Abstr.)

Nienburg, W. and Kolumbe, E. 1931. Zur Oekologie der Flora des Wattenmeeres. II. Das Neufelder Watt im Elbmundungsgebiet. Wiss. Meeresunt. Abt. Kiel, 21:73-114.

Divided true brackish-water zone of lower Elbe into three sections: (1) 0.6-1.5 ppt, (2) 5.3-6.6 ppt, and (3) 11.2-22.3 ppt, and showed that vegetation of Watten flora corresponded with these divisions.

"The region studied is one of the sea flats about 9 km wide and extending from Nordhusen about 15 km to Schuhmacherberg at the mouth of the Elbe River. One of the most important factors affecting the vegetation is the salt content of the water, dependent upon the mingling of tidal waters with those of the Elbe. Three regions were distinguished: (a) Outermost is an association of Festuca rubra and F. thalassica; next one of Scirpus maritimus and S. tabernaemontanus, with the latter dominant; and back from this clumps of Phragmites communis and Aster tripolium; (b) Festuca rubra and F. thalassica advance upon the Scirpus as the level of the flat rises; and (c) A zone in which the plant types show a definite relation to the salt content of the water; Salicornia herbacea grows in water of 5.3-16.4 ppt. Plants such as reeds aid greatly in the building up of the flats by their ability to break the force of the current. The authors' results compare favorably with those of Montfort and Brandrup (1927) and with others on the relations of halophytes." (By Bodenberg.) (S. H. Hopkins)

Nikitin, V. N. and Turpaeva, E. P. 1959. The euryhalinity of some species of the Black Sea benthos and the possibility of their settlement in the Sea of Azov. Pp. 45-66. In: Nikitin, B. N., ed. Marine biology. Trans. Institute of Oceanology, USSR Academy of Sciences Press, Moscow 1957. English translation published by American Institute of Biological Sciences, Washington, D. C., 1959, 302 pp.

Most Mediterranean species cannot live in Black Sea because its salinity is only half that of the Mediterranean. On the other hand, Black Sea salinity is 1.7 times that of the Sea of Azov, and this is the main reason why only 17% of the Black Sea benthic species (which are of Mediterranean origin) became established in its northern embayment, the Sea of Azov. It is expected that salinity of Sea of Azov will be increased by 3-4 ppt because of dams and diversions on rivers, so the more euryhaline Black Sea species may then become part of Azov fauna. This is a study of which species may be expected to establish themselves in Sea of Azov. (S. H. Hopkins)

Nival, P. 1969. Donnes ecologiques sur quelques protozoaires planctonique rares en Mediterranée. (Ecological data on some rare planktonic protozoans in the Mediterranean.) Protistologica, 5(2):215-225.

Western Mediterranean water samples produced the three following rare flagellates: Gymnaster pentasterias Schutt, Achradina pulchra Lohmann, and Scyphosphaera apsteini Lohmann. The probability of encounter of these cells...for different ecological fields (season-depth-temperature-salinity) is defined. Achradina and Scyphosphaera were more abundant than Gymnaster. Temperature and salinity influences on the higher concentrations of these species were found. (Biol. Abstr.)

Noor-Vodin. 1967. The effects of temperature and salinity on the maturity of gonads and the spawning behavior of oysters of Karachi coast. Sind. Univ. Res. Sci. Ser., 3(1):35-48.

The suitable range of salinity for spawning ranges from 25 to 30.5 ppt. (P. Maxwell)

Norcross, J. J., Massmann, W. H., and Joseph, E. B. 1961. Investigations of Inner Continental Shelf waters off Lower Chesapeake Bay. Part II. Sand Lance larvae, Ammodytes americanus. Chesapeake Sci., 2(1/2):49-59.

Plankton samples were collected monthly from 22 offshore stations in the Atlantic Ocean and 3 in Chesapeake Bay. Numerous Sand Lance larvae were collected, with most (75%) caught in January. Most larvae were caught beyond 25 miles from shore. Only two were found within Chesapeake Bay. Although temperature did not appear to be important in distribution, data showed few larvae taken from waters having less than 30-ppt salinity. (T. Rennie)

Norton, Oswald A. 1947. Some ecological observations on Dosinia discus Reeve at Beaufort, North Carolina. Ecology, 28:199-204.

Salinity in the area ranged from 22 to 27.5 ppt. Experimentally in normal sea water all specimens lived for 16 days; in 3/4 sea water, 15 days; in 1/2 sea water, 12-3/4 days; in 1/4 sea water, 5 days; in fresh water, 2-1/2 days by closing valves. In the Beaufort Estuary Dosinia discus (a venerid clam) readily survives the abnormal salinities caused by heavy rains. Norton doubts that salinities lower than "15 ppm" ever occur for more than a few days in the Beaufort Inlet. [Evidently the author meant "15 ppt" which agrees with my firsthand knowledge of Beaufort Inlet--SHH.] (S. Rennie)

Norton, T. A. and South, G. R. 1969. Influence of reduced salinity on the distribution of two labinarian algae. Oikos, 20(2):320-326.

Chorda filum and Saccorhiza polyschides were cultured in the laboratory in a wide range of salinities from the full salinity of sea water down to that of fresh water. Both species were found to develop from spores at progressively slower rate at lower salinities. The development of S. polyschides was irreversibly inhibited at salinities below 9 ppt whereas C. filum was able to produce sporophytes at salinities as low as 5 ppt. The wide salinity tolerance exhibited by British plants of C. filum suggests that it is unlikely that the plants growing at the limits of the range of these species in the Baltic Sea are a different physiological strain adapted to the extreme environmental conditions prevailing there. (P. Maxwell)

Odum, Howard T. 1953. Factors controlling marine invasion into Florida fresh waters. Bull. Mar. Sci. Gulf and Caribbean, 3:134-156.

The chloride distribution in the fresh waters of Florida is reviewed in some detail. Geochemical analyses of the substrates indicate that the origin of the chloride in fresh waters is the porous substrate itself, being leached out by the groundwater flow.

Mullet (Mugil cephalus), needlefish (Strongylura marina), and sole (Trinectes maculatus) were reported in chlorinities as low as 3-5 ppm. Callinectes sapidus is fairly common in chlorinities of 25-100 ppm, but has also been reported in those of 5-10 ppm.

Several examples in nature are cited as evidence for invasion of fresh waters by marine forms, all clearly related to the chlorinity concentration of the fresh water. Field experiments indicated that crabs can live longer in those fresh waters with higher chlorinities especially in the oligohaline range (0.1 to 1.0 ppt). Good survival in oligohaline waters of low alkalinity suggests that calcium is not a major factor. Laboratory experiments showed that with 1 day of acclimation in brackish water, a blue crab can survive when transferred from full-strength sea water to oligohaline waters.

The distribution of blue crabs and perhaps other marine organisms in Florida fresh water seems to be an ecological manifestation of the physiological phenomenon described and the extensive oligohaline waters. It is suggested that in such environments gradual ranges of chlorinity have always existed without sharp tidal salinity shifts.

The same type of invasion in other parts of the world is postulated. In addition, the idea of freshwater species entering brackish water is furthered by the gradual oligohaline gradients that might make this possible. (S. Rennie)

Odum, H. T. 1967. Biological circuits and the marine systems of Texas. Pp. 99-1957. In: Olson, T. A. and Burgess, F. J., eds. Pollution and Marine Ecology, Interscience Publishers (John Wiley & Sons), New York, xvi + 364 pp.

Attempts an ecological classification of the marine bay systems along the Texas coast: "Flooding Rangia Bays," salinity 0.5-5 ppt, dominated by the clam Rangia cuneata and with relatively few other species; "Blue-Green Mat," shallow saline waters as in Laguna Madre; "Briny Bay," shallow highly saline (50-90 ppt), as in Baffin Bay, with very few species; "Turtle Grass," in waters with 25- to 38-ppt salinity and 0.5- to 1.5-m depth, with currents, Thalassia testudinum (turtle grass) beds; "Hypersaline Thin Grass," upper Laguna Madre, salinity 35-60 ppt, Diplanthera wrightii, a fine sparse grass, covers bottom; "Bay with Consumer Reefs" dominated by cyster reefs with oysters and organisms normally associated with oysters (in very wet or very dry years oyster dies out and oyster reef community changes in composition until conditions return to "normal"); "Brackish Plankton Systems" dominate "several bay systems" (not identified by name) with bracksih waters of 10- to 28-ppt salinity. Some "new systems associated with waste flows" are named and described, including the "Bleedwater Lagoon" containing oil-well brine. (S. H. Hopkins)

Odum, H. T. and Hoskin, C. M. 1958. Comparative studies on the metabolism of marine waters. Publ. Inst. Mar. Sci., 5:16-46.

Neither low nor high salinity appears to limit the plants' ability to photosynthesize. In Texas bays where salinities ranged from 0-79 ppt, primary production was maintained over the range. Some of the highest production values occurred in areas of extreme salinities where consumers were excluded physiologically. (S. Rennie)

Odum, H. T. and Wilson, R. F. 1962. Further studies on reaeration and metabolism of Texas Bay, 1958-1960. Publ. Inst. Mar. Sci., 8:23-55.

Back bays along the Texas coast with their river inflows (among other factors) tend to have lower sustained photosynthesis values. Front bays, in which salinities reach 40-70 ppt, have the highest overall production and respiration. Concentration of nutrients is one of the most important factors here. (S. Rennie)

Oemler, A. (M.D.). 1894. The past, present and future of the oyster industry of Georgia. Bull. U.S. Fish Comm., 1893, XIII:263-276.

Oysters cannot live constantly submerged in water of high salinity in the south. Cliona not mentioned. (S. H. Hopkins)

Ogata, E. and Schramm, W. 1971. Some observations on the influence of salinity on growth and photosynthesis on Porphyra umbilicalis. Mar. Biol. (Berlin), 10(1):70-76.

Notwithstanding the great importance of the salinity factor in the marine environment, the knowledge of influence of salinity on growth of marine benethic algae is very limited. Rate of growth (mg, cm^2) and oxygen output of the intertidal red alga Porphyra umbilicalis from Helgoland, North Sea, were measured during a 3-week culture in three different salinities (1/2X, 1X, and 2X concentrated artificial sea water). Under hypertonic conditions (2X concentrated sea water) growth rate and photosynthesis rate were depressed, compared with values obtained in normal concentrated sea water. Under hypotonic conditions (1/2X concentrated sea water), growth expressed in mg was the same as in normal concentrated sea water, or higher when expressed in cm^2. Rate of oxygen output was almost unaltered in one of the two experiments, lowered in the other. Cell size increased at higher salinity, while swelling of cell walls and intercellular substances as well as the intensity of coloring decreased with salinity. The discrepancies between growth and photosynthesis under hypotonic conditions cannot be completely explained by structures (cell size, swelling of cell substances). Detailed studies on the time course of photosynthesis and respiration rates, and preparation of a metabolic balance for the red algae are necessary. (From Biol. Abstr.)

Ogato, Eizi and Matsui, Toshio. 1965. Photosynthesis in several marine plants of Japan as affected by salinity, drying and pH, with attention to their growth habitats. Bot. Mar., 8(2/4):199-217.

Manometric rates of photosynthesis were measured for four marine algae (Porphyra tenera, Ulva perusa, Gelidium amansii, Zostera nana) placed in three media (filtered sea water and artificial plus and artificial minus $NaHCO_3$) of seven concentrations (chlorinities of 35.3, 25.7,, 18.4, 13.8, 9.2, 4.9, and 0 ppt). For all species, higher rates occurred in the artificial plus $NaHCO_3$ media, with the artificial minus $NaHCO_3$ media completely suppressing rates throughout all salinities. For Porphyra in filtered sea water, photo rate was depressed at low salinities but was enhanced at higher salinity. Maximum rate occurred at 25.7 ppt. For artificial plus $NaHCO_3$ media, both low and high salinities equally depressed the rate. Maximum was at 13.8 ppt. For Ulva, in filtered media, the depressing effect of low salinity was more serious than that of high (max 25.7 ppt). Photosynthesis in the artificial minus $NaHCO_3$ media gradually declined under increasingly hypertonic and hypotonic conditions (max 18.4-ppt chlorinity). For Gelidium in artificial plus $NaHCO_3$ media, both extreme hypotonicity and hypertonicity suppressed photosynthesis (max 13.8 ppt). In filtered media, maximum rate was at 18.4 ppt, with rate dropping proportionally to fall in salinity, but gradually under high salinity. Extreme hypotonicity and the hypertonicity suppressed photosynthesis more in Zostera than in other species in artificial plus $NaHCO_3$ (max 13.8 ppt). Maximum rate in the filtered media was between 13.8- and 18.4-ppt chlorinity. Porphyra and Ulva appeared to be more resistant to increased salinity than Gelidium and Porphyra. Salinity and pH changes were found to affect the plants by their direct effect on the protoplasm, and at the same

time by changing the equilibria in the CO_2 supply system of the surrounding media. (T. Rennie)

Oglesby, L. C. 1965a. Steady state parameters of water and chloride regulation in estuarine nereid polychaetes. Comp. Biochem. Physiol., 14(4):621-640.

Four species differing in salinity requirements were studied, N. limnicola, N. succinea, N. vexillosa, and Laeonereis culveri. Low salinity is a major limiting factor in the distribution of nereids with varying osmoregulatory abilities. High salinity is not proved to be limiting. Lack of water regulation prevents N. vexillosa from living in low salinities.

Oglesby, Larry C. 1965b. Water and chloride fluxes in estuarine nereid polychaetes. Comp. Biochem. Physiol., 16:437-455.

When annelid worms of the species Nereis succinea were transferred from 95% sea water to 50% sea water, chloride decreased and water content increased. Similar results were obtained using N. vexillosa. When N. succinea was transferred from 50% to 100% sea water the opposite happened. N. succinea adapted to 50% were put in 23%. A rapid influx of water was followed by a delayed efflux of chloride. Volume regulation began after 7 hr. When moved from 22% to 51% sea water, N. succinea showed the reverse of the above-mentioned experiment.

At all salinities chloride exchange is lower for N. limnicola than for N. vexillosa or N. succinea. The amount of chloride in all three species is proportional to the external salinity, except for N. limnicola in low salinities. (S. Rennie)

Oglesby, L. C. 1966. Responses of Nereis limnicola to osmotic stress. Amer. Zool., 6:507 (Abs.).

Adjustment after transfer from one salinity to another takes about 8 to 12 hr in this polychaete annelid. It takes longer if animals have been initially acclimated to a salinity in which they can osmoregulate. Movement of chlorides is slower in animals acclimated to lower salinities. N. limnicola is less permeable to salts when acclimated to a low salinity. (S. Rennie)

Oglesby, L. C. 1969. Salinity, stress, and desiccation in intertidal worms. Amer. Zool., 9:319-331.

Worms (oligochaetes, polychaetes, sipunculids) in intertidal zone on beaches and tidal flats, both on sea coast and in estuaries, may be exposed to significant tidal as well as seasonal variations in salinity, to which they may react by irrigation of burrow, vertical movements in burrow, or migrations in salinity gradients. In rapid lowering of salinity, worms gain water and lose salts. Internal dilution is slowest in most euryhaline species. Worms fully adapted to salinities lower than 30% sea water (10.5 ppt) may be hyperosmotic, as shown for six species of Nereidae, thanks to active transport of salts (Nereis diversicolor), reduction of permeability of body surface, and perhaps production of hypo-osmotic urine. Sipunculids can tolerate considerable desiccation. "It is suggested that worms exposed to significant tidal variations in salinity may seldom be in osmotic equilibrium with their external medium." (S. H. Hopkins)

O'Hara, Joseph A. 1930. Oyster survey of Louisiana. Proc. 7th Ann. School Texas Sanitarians. U.S. Publ. Health Eng. Abs. 10, Mi, 20 (May 31, 1930). Chem. Abs., 24:4100.

A survey showed that a reported intestinal disturbance following the ingestion of oysters was due to an abnormally high saline content of the oysters following a drought. (S. H. Hopkins)

O'Heeron, M. K., Jr. 1966. Some aspects of the ecology of Rangia cuneata (Gray). Master's thesis, Texas A&M University, College Station, Tex. (Unpublished manuscript, typed.) 71 pp.

Includes graphs and charts showing average salinity isohalines in various years. Data from Texas Parks and Wildlife Department (formerely Game and Fish Commission) and U.S. Fish and Wildlife Service, Galveston Laboratory. In general, Rangia cuneata (marsh clam) populations are found in zones where salinity averages for the year are below 15 ppt. (S. H. Hopkins)

O'Neil, Ted. 1949. The muskrat in the Louisiana coastal marshes. Louisiana Department of Wildlife and Fisheries, New Orleans, xii + 152 pp., 60 figs. (photographs), foldout maps.

The subtitle describes the book: "A study of the ecological, geographical, biological, tidal, and climatic factors governing the production and management of the muskrat industry in Louisiana." Most of the book is devoted to the vegetation, its importance to the muskrat, and its management for improved muskrat production. Salinity is mentioned frequently as a factor influencing vegetation and muskrats, especially on pp. 84-87. The best muskrat-producing marshes have an abundance of "three-cornered grasses," species of the genus Scirpus, found in the low-salinity brackish and fresh marshes. In the saltier marshes, needlegrass, Juncus roemerianus, salt grass, Distichlis spicata, and oyster grass, Spartina alterniflora, replace Scirpus spp.; such areas are nearly worthless for muskrat production. (S. H. Hopkins)

Ong, Kah-Sin and Costlow, J. D., Jr. 1970. The effect of salinity and temperature on the larval development of the stone crab, Menippe mercenaria (Say), reared in the laboratory. Chesapeake Sci., 11(1):16-29(Mar 1970).

Larvae were reared in salinities of 10, 20, 25, 30, 35, and 40 ppt and temperatures of 20, 25, and 30 C--18 different salinity-temperature combinations. Rate of development was slightly lower in 20 ppt than in 30-40 ppt, and was very markedly retarded with decreasing temperature from 30 to 20 C. All first zoeae died at all temperatures in salinity of 10 ppt. At 20 C (salinities 20-40 ppt) larvae developed to megalopa only, and survival to megalopa was lower in 20-25 ppt than in 30-40 ppt. At 25 and 30 C larvae developed to first crab, but survival to first crab was less in 20 ppt than in higher salinities. Optimum temperature for survival and development of M. mercenaria larvae is approximately 30 C, and optimum salinity 30-35 ppt. (S. H. Hopkins)

Ono, Yuiti. 1959. The ecological studies on Brachyura in the estuary. Bull. Marine Biol. Sta. Asamushi, Tohoku Univ., 9(4):145-148.

The distributions and habits of Brachyura were studied in the estuary of the River Tatara. Nineteen species of crabs, Grapsidae (12 spp., 4 genera) and Ocypodidae (7 spp., 6 genera), were found. The upper limits of the distributional ranges of all species were affected more or less by the chlorinity diminutions, though the limits differed with the species. The distributions of Sesarma globosa, Ocypoda stimpsoni, Hemigrapsus penicillatus, and Galtice depressus were limited within 0.5 km from the river mouth (16-ppt chlorinity), while some species were distributed up to 2 km from the river mouth (2.0-ppt chlorinity). S. haematocheir was often found even in the freshwater zone up to 2.5 km or more. The lower limits of most of the crabs, except for a few ocypoid and grapsoid crabs, extended downward to 0.2-0.5 km from the river mouth. Most of the ocypoid crabs did not live in the stream lower than 0.5 km above the river mouth where the chlorinity in the flow tide exceeded 16 ppt. On the other hand, some grapsoid crabs (S. haematocheir and S. picta) were distributed downward as far as the sea side uninfluenced by the high chlorinity, while a few others (S. intermedia, S. dehaani, S. plicata, and S. bidens) were supposedly more affected by the

absence of suitable edaphic conditions in the lowest stream of the river than by high chlorinity. The distributions of only a few of the grapsoid crabs seemed to be checked by the high chlorinity in the downstream areas. (T. Rennie)

Ono, Y. 1965. On the ecological distribution of ocypoid crabs in the estuary. Mem. Fac. Sci. Kyushu Univ., (E)4(1):1-60.

Upstream penetration of ocypoid crabs in the Tatara-Umi River estuary was governed by chlorinity. Limits for upstream penetration are as follows: Scopinera globosa, 3-5 ppt; Macrophthalmus japonicus, 2-3 ppt; Uca lactea, 2-3 ppt; U. arcuata, Cleistostoma dilatatum, and Paracleistostoma cristatum, 0.05-1.0 ppt; and Ilyoplax pusilla, 0.03-0.05 ppt. In M. japonicus the adult is less tolerant to dilution than the subadult, while in I pusilla the reverse is true.

The lower distribution limit was not determined specifically, but appeared to be restricted to the brackish water zone. (S. Rennie)

Orton, J. H. 1937. Oyster biology and oyster culture. Edward Arnold & Co., London. 211 pp.

The book is mainly on the European oyster Ostrea edulis with only occasional reference to other (Portuguese, Australian, and American) oyster species. On p. 154 differences in salinity are blamed for mortality or failure to fatten when oysters are transplanted from one water body to another. On pp. 174-176, freshets and too rapid fluctuations in salinity are mentioned among "unfavourable environmental conditions," with the statement that slow changes in salinity are less harmful than rapid ones. The beneficial effects of pest-killing low salinities are not mentioned. (S. H. Hopkins)

Otto, J. P. 1927. Een oecologische studie van de fauna der Kagerplassen en omgevende wateren. Bijdrage tot de Kennis der Biologie van het oligohaliene Water van Holland. (An ecological study of the fauna of the Kagerplassen and surrounding waters. Contribution to the knowledge of the biology of the oligohaline waters of Holland.) Dissert., Leiden. Tijdschr. Nederland. Dierk. Ver., 2nd Ser., 20:17-86.

The Kagerplassen, in the lowlands of South Holland, has a higher salinity than most inland waters, the chlorinity varying from 99 to 322 mg/l (0.099-0.322 ppt). The fauna studied most closely included: Porifera, 1 species; Hydrozoa, 3; Bryozoa, 2; Rotatoria (rotifers), 9; Cladocera, 29; Copepoda, 14; Isopoda, 1; Amphipoda, 2; Schizopoda, 1; Caridea, 2; Mollusca, 20; fishes, 14 species. Representatives of other groups also occurred. These waters have a characteristic freshwater fauna, but some species previously encountered only in higher salinities were present: Corophium lacustre, Leander longirostria var. robusta, Cordylophora lacustris, Neomysis vulgaris, and shells of Hydrobia jenkinsi. Among freshwater species, those especially studied were Daphnia pulex, Scapholeberis aurita, Leptodora kindtii, Cyclops vernalis, Cyclops serrulatus, and Culex larvae, which can live in higher salinities. It was concluded that in nature many freshwater species can become acclimated to life in higher salinities. (S. H. Hopkins)

Otto, R. G. and McInerney, John E. 1970. Development of salinity preference in pre-smolt coho salmon, Oncorhynchus kisutch. Jour. Fish. Res. Bd., Canada, 27(4):793-800.

When tested in a horizontal salinity gradient, freshwater-adapted coho salmon exhibited a bimodal preference response throughout most of the presmolt period. Preference modes were located at fresh water and at a salinity intermediate between fresh and sea water. Fish tested in a gradient that originated at 4 ppt exhibited a single preferred salinity at 7 ppt in June, which increased gradually to 13 ppt in February. The same fish tested in a gradient originating at

fresh water showed a corresponding preference for an intermediate salinity in addition to their preference for fresh water. However, this second preferendum was at a somewhat lower salinity than that observed in tests in which fresh water was excluded from the gradient. With the approach of the smolt transformation, preference for fresh water was greatly reduced and the response distribution became unimodal. At no time during the period prior to the smolt transformation did the preferred salinity exceed 14 ppt. (From Biol. Abstr.)

Owen, H. Malcolm. 1953. Growth and mortality of oysters in Louisiana. Bull. Mar. Sci. Gulf and Caribbean, 3:44-54.

Experimental plantings of seed oysters in five locations were analyzed for growth rate and mortality. During the optimum growing period, the rate of mortality and rate of growth were greater in Bastian Bay and Lower Barataria Bay (higher salinity) than at Grand Pass or Sister Lake (lower salinity). Since no environmental data are presented, no conclusions can be drawn about the high mortalities in those particular areas. [Salinity comparisons added by me on basis of firsthand knowledge of the areas and contemporary oral communication with Owen--SHH.] (S. Rennie)

Oye, P. Van. 1920. Note sur les micro-organismes de l'eau saumatre del Vieux - Port de Batavia (Java). Ann. Biol. Lac., 10.

"It is appropriate to speak of <u>oligohyphalmyroplankton</u> when the salt content does not exceed 15 parts per 1000 and of <u>polyhyphalmyroplankton</u> when the concentration varies from 15 to 30 parts per 1000; above this, it is necessary to consider the medium as belonging to the <u>haliplankton</u> properly speaking." Quoted by Redeke 1932.

Packard, E. L. 1918. A quantitative analysis of the Molluscan fauna of San Francisco Bay. Univ. of Calif. Publ. in Zool., 18:299-336.

According to Pearse, 1926, Animal Ecology, p. 154: "Packard (1918) investigated 23 species of lamellibranchs and 12 species of snails in San Francisco Bay. He concluded that depth had little influence on distribution, but the character of the bottom was of great significance. Low salinity and wide ranges in salinity were unfavorable."

Painter, Richard E. 1966. Ecological studies of the Sacramento-San Joaquin Estuary. Zooplankton of San Pablo and Suisun Bays. Calif. Dept. Fish and Game Fish. Bull., 133:18-39.

Highest concentrations of plankton were found in salinities equivalent to 7- to 10-ppt chlorides. Chlorinity was the prime factor that determined the longitudinal distribution of zooplankton. (S. H. Hopkins)

Panikkar, N. K. 1940a. Influence of temperature on osmotic behaviour of some Crustacea and its bearing on problems of animal distribution. Nature, London, 146:366-367.

Leander serratus and Palaemonetes varians have slightly higher osmotic values in winter than in summer, like other Crustacea. From experiments he concludes that (1) the optimum osmotic pressure of homoiosmotic species falls with rise in temperature of the medium; (2) in diluted media the minimum osmotic pressure of blood compatible with life is lower the higher the temperature, reducing osmotic work required in maintaining hypertonicity at higher temperatures. This, then, would seem to be a physiological reason for adaptation to brackish and fresh water taking place more actively in warm seas than in cold. (S. Rennie)

Panikkar, N. K. 1940b. Osmotic properties of the common prawn. Nature, London, 145:108.

This reports that Leander serratus (Pennant) is hypotonic in normal sea water. Compared with Palaemonetes, Leander's ability to maintain optimum osmotic pressure of the blood is less developed. The rate of change of osmotic pressure is different in different sizes, with smaller ones responding faster. The smaller individuals are also more tolerant to low osmotic pressure of the internal medium. (S. Rennie)

Panikkar, N. K. 1941a. Osmoregulation in some palaemonid prawns. Jour. Marine Biol. Assoc. U.K., 25:317-359.

The animals examined were Palaemonetes varians (Leach), Leander serratus (Pennant), and L. squilla (L.). All have blood hypotonic to natural sea water. P. varians had a relatively high tolerance to changes in the medium, followed by L. squilla and L. serratus, which had the lowest tolerance to changes in salinity. In all three the urine was isotonic to the blood indicating that there is no mechanism for the production of urine hypotonic to the blood. L. serratus has a higher osmotic pressure than normal immediately after molting, but the concentration returns to normal in about 10 days. P. varians shows a slight rise in osmotic pressure after molting, with a small amount of water being absorbed. When put in dilute media, both Palaemonetes and Leander showed gains in weight. In general, more than 6% gain was fatal. In concentrated media both lost weight. In both, the permeability of the gills is very low. Water drinking does not seem to be an essential part of the osmoregulatory mechanism. Osmoregulatory mechanisms are discussed, although no real conclusions are made. The evolutionary significance of osmoregulation in these species is considered, suggesting that both species of Leander have probably taken secondarily to marine life. (S. Rennie)

Panikkar, N. K. 1941b. Osmotic behavior of the fairy shrimp Chirocephalus diaphanus Prevost. Jour. Exptl. Biol., 18:110-114.

The blood of Chirocephalus has a normal osmotic concentration equivalent to 0.44%-0.5% NaCl in an external medium of 0.002% NaCl. The osmotic pressure falls rapidly when the animal is kept in glass-distilled water, but is fairly well maintained in tap water. There is an initial rise and a later return to normal in hypotonic saline media, which indicates active absorption of ions. The bracts are presumably the organs concerned in salt absorption. The animal is unable to live in tap water or distilled water for more than 2-3 days without food, which supplies a few necessary ions. [This is a freshwater crustacean--SHH.] (S. Rennie)

Panikkar, N. K. 1951. Physiological aspects of adaptation to estuarine conditions. Proc. Indo-Pacific Fisheries Council, Second Meeting, Sec. 3:168-175.

The marine teleost Chanos chanos can live in waters that are nearly fresh and up to 50 ppt. It is able to be successfully transferred from one salinity to another without acclimatization. Within a 5% NaCl range in the external medium, variations in the blood are within 0.5% NaCl, showing a great ability to regulate chloride in the blood. (S. Rennie)

Panikkar, N. K. and Viswanathan, R. 1948. Active regulation of chloride in Metapenaeus monoceros Fabricus. Nature, 161:137-138.

The average blood chloride of 12 individuals kept at identical conditions was 2.16% NaCl (370 mM) while the external medium was 2.92% NaCl (500 mM). When the external medium is 1.8%-1.9% (20 ppt) the blood chloride is similar. At lower salinities of 5-6 ppt the blood chloride remains at 250 mM. This indicates a hypotonic osmoregulation in dilute media. (S. Rennie)

Pantin, C. F. A. 1931a. The adaptation of Gunda ulvae to salinity: I. The environment. Jour. Exptl. Biol., 8:63-72.

This triclad turbellarian (flatworm) lives under stones too heavy to be moved about by waves in the beds of streams that run over intertidal beach or flat to the sea, and only in this environment where salinity changes from fresh to oceanic at each change of tide. Stream water at Wembury is rich in Ca and CO_3. Its environment varies from one in which it is subjected to sea water for about 1 hr at high tide to one in which sea water is diluted to about one-tenth of its normal strength for a few hours during low tide. (S. H. Hopkins)

Pantin, C. F. A. 1931b. The adaptation of Gunda ulvae to salinity. III. The electrolyte exchange. Jour. Exptl. Biol., 8:82-94.

Rate of loss of salts when worms were tranferrred from sea water to various dilute solutions was studied. They lose salts from the moment of immersion. The worms lose 25% of their salts while imbibing a volume of water equal to their initial volume. The limiting internal salt concentration of worms surviving in waters containing Ca is about 6%-10% of normal sea-water concentration. In distilled water, salts are lost continuously until cytolysis occurs. The effects of osmotic pressure, pH, dilute solutions of NaCl, $NaHCO_3$, glycerol, $CaCl_2$, and $CaCO_3$ were studied. Ca reduces the rate of loss of salts; other factors do not seem to influence this rate. The relation of Ca to maintenance of normal permeability to water and salts, and the significance of this to migration into fresh water, are discussed. (S. H. Hopkins)

Pantin, C. F. A. 1931c. The origin of the composition of body fluids in animals. Biol. Rev., 6:459-482.

"In some marine animals the body fluid closely approximates sea water in composition. In the majority there is a tendency to increased H^+ and K^+ concentrations in the body fluid and diminished Mg^{++} and SO_4.... Osmotic differences between body fluid and external medium are actively maintained as a steady state in which work is done.... Ionic compositions of body fluid and development of osmotic equilibrium may be physical results of increasing impermeability of surface membranes. Composition of body fluid is not direct evidence of former composition of environment. Ion concentrations are dynamically maintained. Composition of body fluid cannot evolve--it is the surface membrane that evolved. Similarity of body fluids to sea water is significant. Probably the fact that sea water by chance had right composition for easy maintenance of protoplasmic systems made their evolution possible, an example of fitness of environment.... In this sense alone can the composition of the body fluid be said to reflect the marine ancestry of the animal." (S. H. Hopkins)

Parker, Frances L. 1952. Foraminiferal distribution in Long Island-Buzzards Bay area. Bull. Mus. Comp. Zool., 106(10):425-473.

Three facies of which one is estuarine are defined by a statistical and graphical treatment of the species present. Temperature and salinity as controlling factors are discussed. (E. H. Myers and W. S. Cole, 1957, Geol. Soc. Amer. Mem. 67, Vol. 1, p. 1079.)

Parker, J. C. 1970. Distribution of juvenile brown shrimp (Penaeus aztecus Ives) in Galveston Bay, Texas, as related to certain hydrographic features and salinity. Contr. to Mar. Sci., Univ. of Texas, 15:1-12.

Table 1, p. 8, and charts of relative abundance, pp. 6 and 7, seem to show a correlation of abundance to salinity with the greatest average "small trawl" catches in salinity below 5 ppt and average catches consistently decreasing as salinity increases from <5 to >30 ppt. However, Parker says this pattern is not consistent and some catches in high salinities indicate as great an abundance of juvenile shrimp as in low salinities. This is supported by table 2, p. 10. He concludes, therefore, that "juvenile brown shrimp were abundant throughout the salinity range 0.9 to 30.8 ppt, and it was concluded that salinity per se had no detectable effect on their distribution." (S. H. Hopkins)

Parker, Robert H. 1955. Changes in the invertebrate fauna, apparently attributable to salinity changes in the bays of central Texas. Jour. Paleont., 29(2):193-211.

Previous studies on the invertebrate fauna of the bays of central Texas have been undertaken during periods of very low or highly variable salinity conditions. From 1948 to 1953 an extended drought with accompanying low river runoff caused salinities in these bays to increase to record highs, with little variation between maximum and minimum. Coincident with this extended high salinity period, the biotic communities within the bays changed considerably. Not only was there an invasion of many marine or open-gulf species of invertebrates, but also a change was observed in the growth and appearance of the oyster reefs, one of the principal biotic assemblages. Another probable result of increased salinities was the disappearance of low-salinity mollusks which previous workers had found to be extremely abundant during the periods of low salinity. (Author's abstract, in part)

According to Collier and Hedgpeth (1950), mean annual salinity for Aransas Bay is approximately 19-20 ppt. After September 1947 mean monthly salinities remained above 20 ppt, and they were above 30 ppt from June 1950 to September 1952; in August 1952 salinity was 42 ppt. Salinity gradient partly disappeared. Ostrea equestris became abundant in bays, along with echinoderms. Rangia and Littoridina died out. (Added by S. H. Hopkins)

Parker, Robert H. 1956. Macro-invertebrate assemblages as indicators of sedimentary environments in east Mississippi Delta Region. Bull. Amer. Assoc. Petrol. Geol., 40(2):295-376.

Seven different assemblages are recognized on the basis of several facts. The assemblages are: (I) The delta marshes; (II) Delta front and lower distributaries, 2-10 ppt; (III) Lower sound and prodelta slopes; (IV) Upper Breton Sound and Chandeleur Sound, 10-19 ppt; (V) Inlets or passes; (VI) Shallow continental shelf of Gulf of Mexico from 0-13 fathoms, off barrier islands, greater than 14-17 ppt; and (VII) Deeper Continental Shelf of Gulf of Mexico, from approximately 13-50 fathoms. Lists of the bottom fauna characteristic of each assemblage are given along with notes on relative abundance of living and fossil specimens. (S. Rennie)

Parker, Robert H. 1959. Macro-invertebrate assemblages of central Texas coastal bays and Laguna Madre. Bull. Amer. Assoc. Petrol. Geol., 43:2100-2166.

Salinity measurements in the Rockport area ranged from less than 1 to more than 42 ppt. When Laguna Madre is included, the upper range is 114 ppt. Salinity in the bays varies from year to year depending on the rainfall.

Assemblages of the Rockport region are classified as follows: (1) River-influenced, low-salinity assemblages characterized by Rangia; (2) Enclosed bays of variable low to intermediate salinities, characterized by oyster reefs, (3) Open high-salinity bays and sounds characterized by Chione and Pandora; and (4) Inlets and inlet-influenced assemblages, including shallow, grassy hypersaline lagoons and bays.

Assemblages of Laguna Madre are similar to those of the shallow hypersaline lagoons and bays of the Rockport region. These are classified as follows: (1) Inlet-influenced, hypersaline lagoon (Chione cancellata, Anachis avara semiplicata) (southern Laguna Madre); (2) Open shallow hypersaline lagoon (from inlet to tidal flat), (Amygdalum papyria, Laevicardium mortoni); (3) Enclosed hypersaline lagoon (Anomalocardia cuneimeris, Tellina tampaensis) (shallow, central northern Laguna Madre, 40-79 ppt); (4) Deep, hypersaline bay, clayey substrate (Mulinia lateralis) (Baffin and Alazan Bays, 2-80 ppt); and (5) Hypersaline lagoon, influenced by adjacent low-salinity bay (no characteristic fauna), (extreme northern end of Corpus Christi Bay).

A checklist from both areas show relative abundance and distribution in the characteristic environments. (S. Rennie)

Parker, Robert H. 1960. Ecology and distributional patterns of marine macro-invertebrates, northern Gulf of Mexico. In: Recent Sediments, Northwest Gulf of Mexico. Amer. Assoc. Petrol. Geol., Tulsa, Okla., pp. 302-381.

The region sampled extended from Port Isabel, Texas, to Mobile Bay, Alabama, along the coast, and to approximately 100 fathoms offshore. The faunal assemblages are classified as follows: (I) Freshwater and low-salinity marshes; (II) River-influenced, low-salinity assemblage (less than 10 ppt); (III) Delta-front distributary and interdistributary assemblage; (IV) low-salinity oyster reef (10-30 ppt); (V) Enclosed lagoon or interreef assemblage; (VI) Open sound or open lagoon margin; (VII) Open sound or open lagoon center assemblage (20-35 ppt in humid zone and 25-39 ppt in dryer climatic zones); (VIII) High salinity oyster or mollusk reef assemblage (34-36 ppt); (IX) Open shallow hypersaline lagoon near inlet (32-45 ppt); (X) Enclosed hypersaline lagoon (43-80 ppt); and (XI) Inlet and deep channel assemblage. In addition eight continental shelf and upper continental slope faunal assemblages are designated. For each assemblage a species list is given along with comparative abundance and size of the individuals. (S. Rennie)

Parker, R. H. and Blanton, W. G. 1970. Final Report: Environmental factors affecting bay and estuarine ecosystems of the Texas coast. Prepared for Texas

Railroad Commission "Show Cause" Hearings on Brine Disposal, Nov 4 and 19, 1970. Coastal Ecosystems Management, Inc., xii + 182 pp. (Processed.)

Using data from their own past researches and from published and unpublished reports of other workers, the authors review what is known about the ecology of a series of Texas estuaries ranging from nearly fresh Sabine Lake to hypersaline Laguna Madre, with special reference to salinity factors. They conclude that all Texas estuaries have extremely variable salinities and that "ionic balance," specifically the Mg/Ca ratio, is also very different according to salinity and to nature of inflowing waters. Also that most organisms living in Texas bays can adapt to a wide range of salinities, in some cases from nearly zero to 40 ppt. Therefore oil-field brine flowing into Texas estuaries does not have significant ecological effects. (S. H. Hopkins)

Parry, G. 1953. Osmotic and ionic regulation in the isopod crustacean Ligia oceanica. Jour Exptl. Biol., 30:567-574.

Ligia can survive for some time immersed at various salinities, although this is not its normal habitat. In well-aerated sea water of 50%-100% concentration, animals could survive indefinitely. In 25% sea water, survival lasted up to 17 days. Freezing point depressions of the blood decreased with decreased salinity. (S. Rennie)

Parry, G. 1954. Ionic regulation in the palaemonid prawn Palaemon (=Leander) serratus. Jour. Exptl. Biol., 31:601-613.

In various concentrations of sea water the ions in blood show the following concentrations:

Concentration, %	Concentration in Medium, %					
	Na	K	Cl	Ca	Mg	SO_4
100	85	85	85	105	20	10
50	105	120	105	200	20	10
120	85	85	85	115	30	20

Concentrations of Na, K, and Ca in urine are always about 20% less than their concentration in the blood. The concentration of Cl is 10%-20% greater in urine than in blood. Concentrations of Mg and SO_4 are very much greater in urine than in blood, up to seven times greater. Relative concentrations of ions in blood and urine do not change substantially with changes in the external medium. The antennal gland plays no part in purely osmotic regulation but is no doubt partly responsible for maintaining the low blood concentrations of Mg and SO_4. (S. H. Hopkins)

Parry, G. 1957. Osmoregulation in some freshwater prawns. Jour. Exptl. Biol., 34:417-423.

Studied osmoregulation of the European species Palaemonetes varians, abundant in brackish ponds and ditches with salinity as low as 0.5 ppt, and Palaemonetes antennarius, which in southern Europe occurs in true freshwater conditions, according to Green, 1968, p. 194. (S. H. Hopkins)

Parry, Gwyneth. 1960. The development of salinity tolerance in the salmon, Salmo salar (L.) and some related species. Jour. Exptl. Biol., 37:425-434.

When young salmonid fishes are transferred from fresh water to various dilutions of sea water, survival is in the order: Salmo salar > S. gairdneri > S. trutta, and is generally better the larger the fish. The survival pattern of alevins (1-6 weeks old) differs from that of older stages. Hypo-osmotic regulation

is first seen in parr (7 months old) and becomes fully effective in smolts (2 yr old). (S. H. Hopkins)

Parry, G. 1961. Osmoregulation of the fresh water prawn Palaemonetes antennarius. Mem. Inst. Ital. Idrobiol., 13:139-149.

The shrimp genus Palaemonetes contains marine, brackish, and freshwater species. P. antennarius in southern Europe lives in true fresh water, so its osmoregulation is of special interest. See Green (1968), pp. 194-195. (S. H. Hopkins)

Parry, G. 1966. Osmotic adaptation in fishes. Biol. Rev., 41:392-444.

According to Green (1968, p. 274) in this review Parry distinguished the following: (a) species that survive in conditions of isosmotic constancy only, and quickly die in a differnt salinity; stenohaline fishes, like marine hagfish Myxine; (b) species that tolerate some change by changing and tolerating changes in concentration of body fluids, e.g. some elasmobranchs; (c) species, or stages, that are semipermeable and allow water to move freely in or out, tolerating resultant changes in body volume or cell volume, e.g. some fish eggs; (d) species that reduce permeability of surface, as the eel does with its thick coating of mucus, limited by the fact that gills must be permeable for respiration; (e) species able to compensate actively for movements of water or solutes caused by external changes. This regulation is often accomplished by a combination of mechanisms: selective excretion, swallowing water, selective absorption of ions or water from gut, and active absorption or excretion of ions from skin or gills. (S. H. Hopkins)

Parvatheswararao, Vipparti. 1965. Influence of different temperature-salinity combinations on the oxygen consumption in the freshwater fish Etroplus maculatus (Teleostei). Helgolaender wiss. Meeresunters., 12(3):302-314.

Salinity used: Freshwater, 9.7, 19.4, and 32.4 ppt
Temperature, °C: 25, 30, and 35

In larger fish: temperature increase augments oxygen consumption in all salinities. These changes are a function of the salinity and in addition are size dependent. In higher salinity levels, sudden temperature increase tends to result in lower rates of oxygen consumption in the smaller fish, but in higher rates in the larger ones. The effects of salinity on oxygen consumption were modified by temperature.

Parvatheswararao, V. 1967. Some mechanisms of salinity acclimation in the euryhaline teleost, Etroplus maculatus. Mar. Biol., 1:97-101.

Etroplus from fresh water were acclimated to 30% sea water (9.7 ppt), 60% (19.4 ppt), and 100% (32.4 ppt). Brain water decreased with increased salinity. Liver water increased initially and then decreased to values near the fresh water control at 100% sea water. The trend in muscle tissue was the same as in the liver. Osmotic pressure increased with the salinity. K and Mg decreased initially before increasing; Na decreased and Ca increased with the concentration of the medium. Cl content was slightly higher in 100% sea water while amino acids and ascorbic acid were slightly lower. (S. Rennie)

Patrick, Ruth. 1967. Diatom communities in estuaries. Pp. 311-315. In: Lauff, G. H., ed. Estuaries. Am. Assoc. Adv. of Sci. Publ. No. 83, Washington, D. C., xv + 757 pp.

Salinity is important factor, affects the number of species and the kinds of species present. Uyeno (1957) found in Osaka Bay that in summer the quantity of diatoms could be expressed as a function of salinity and temperature. In

Chesapeake Bay, Patten et al. (1963) found lowest diversity where salinity was highest. There are many kinds of species in estuaries because water is so variable, especially at mouths of rivers. When river flow is high, river species predominate, and in low-flow periods brackish-water species predominate, with a few marine species. This is because of high reproductive rate of diatoms. There are relatively few euryhaline species, living in wide range of salinities.

Paulus, Marcel. 1942. Contributions a l'etude biologique de la Camargue. Zoologie II. Etude sur la faunule malacologique de l'embouchure du Petit Rhone. Bull. Mus. Hist. Nat. Marseille, 2(3):171-190.

The estuary of a small branch of the Rhone presents a changing topography, as submersion of the banks varies with the season or the direction of the wind. The depth is 2-4 m, never more than 9 m. The water is brackish, and varies in density and salinity at different times, according to the weather. A table is given showing the difference in surface density at different stations and under different conditions. In general, the mollusks of this region are smaller than individuals of the same species living on the seashore away from brackish water. Most species are found to be blackish in color, probably due to being in mud. Even species normally white are affected. Ninety-two species and varieties are listed, with data for each as to habitat and size.

Pearcy, W. G. 1962. Ecology of an estuarine population of winter flounder, Pseudopleuronectes americanus (Walbaum). III. Distribution, abundance, growth and production of juveniles; survival of larvae and juveniles. Bull. Bingham Oceanogr. Coll., 18:39-64.

Age groups 0 and 1 are euryhaline and eurythermal. Both were found throughout the estuary at all seasons and at 4- to 30-ppt salinity. Temperatures were 0 to over 25 C. Laboratory experiments show the lower lethal limit of salinity to be between 1 and 5 ppt after acclimation. This included small (7-10 mm) fish. Lower lethal temperature was between -1.0 and -1.5 C. Maximum temperature tolerance was 30 C. (S. Rennie)

Pearcy, W. G. and Richards, S. W. 1962. Distribution and ecology of fishes of the Mystic River Estuary, Connecticut. Ecology, 43:248-259.

Salinity at the station farthest upriver ranged from 3 ppt at surface to 18 ppt 2 m below surface. At the station near the mouth of the estuary the salinity range from surface to bottom was 29-30 ppt. Fifty-nine species of fishes were caught, including eggs of 13 species, larvae of 26, and juveniles and adults of 51. More kinds of eggs were collected in the lower estuary, but the variety of larvae was about the same in upper and lower estuary. The greatest number of larvae were found in the brackish upper estuary, especially Pseudopleuronectes americanus and Microgadus tomcod. A greater number of species had demersal eggs than in the adjacent neritic areas. It is postulated that demersal eggs are important in reducing offshore dispersal by currents, and that the vertical distribution of larvae from this egg type may enhance retention within the estuary. (S. H. Hopkins)

Pearse, A. S. 1928. On the ability of certain marine invertebrates to live in diluted sea water. Biol. Bull., 54:405-409.

Various marine annelids were tested in different dilutions of sea water. Nereis virens, Laonice viridis, and Limulus polyphemus showed considerable tolerance to 25% sea water. Arabella opalina, Glycera dibranchiata, and Lepidonotus squamatus did well for several days in 50% sea water. Most worms were able to tolerate 75% sea water. In low salt concentrations all animals showed a tendency to swell and become turgid and extended. Worms removed from tubes survived better than those not removed. (S. Rennie)

Pearse, A. S. 1929a. Observations on certain littoral and terrestrial animals at Tortugas, Florida, with special reference to migrations from marine to terrestrial habitats. Carnegie Instit. Wash. Publ. No. 391:205-223, 1 table, 3 text-figs.

Pp. 207-208: Discussion of invasion of land and fresh water by marine animals. Pp. 208-210: Ability of certain littoral and land animals to live in fresh water (account of experiments and discussion of literature). Pp. 210-214: Ability of certain littoral and land animals to resist desiccation (experiments on Tortugas crabs, some discussion of literature). Pp. 219-220: Discussion, conclusions, and summary. (S. H. Hopkins)

Pearse, A. S. 1929b. The ecology of certain estuarine crabs at Beaufort, N. C. Jour. Elisha Mitchell Sci. Soc., 44:230-237.

The following crabs were studied: Callinectes sapidus, Libinia dubia, Menippe mercenaria, Panopeus herbstii, Eurypanopeus depressus, Uca minax, U. pugnax, U. pugilator, Sesarma cinerea, and Ocypode albicans.

Survival in fresh water took place in the following order: Sesarma, the fiddlers, mud crabs, and the spider crab Libinia. In dilutions of sea water to 25% all species except Ocypode showed survival. From the data it appears that survival for Ocypode was better at 75% and 50% sea water than at 100%.

In air, survival was best in Ocypode, followed by U. minax, Callinectes, Eurypanopeus, Sesarma, U. pugnax, U. pugilator, Panopeus, and Libinia, in that order.

An analysis of the relation of the number and size of gills to habitat shows that "in general the number and volume of gills is reduced as crabs migrate from the ocean to the land." (S. Rennie)

Pearse, A. S. 1932a. Animals in brackish water ponds and pools at Dry Tortugas. Papers Tortugas Lab., 28:125-141.

The flora and fauna of five pools with different salinities ranging from 6.60 to 73.32 ppt were studied. Lists of organisms from each pool are given with temperature and salinity data. As the pools became increasingly fresh, the number of insects found increased. (S. Rennie)

Pearse, A. S. 1932b. Freezing points of bloods of certain littoral and estuarine animals. Papers Tortugas Lab., 28:93-102.

Freezing-point depressions for the following animals from sea water at 36.05 ppt (-2.04°) are given: Gecarcinus lateralis (-1.65°), Cardisoma guanhumi (-1.66°), Ocypode albicans (-1.70°), Grapsus grapsus (-1.92°), Mithrax verrucosus (-2.07°), Coenobita clypeatus (-2.09°), Petrochirus bahamensis (-2.09°), and Panulirus argus (-2.20°).

Freezing-point depressions for three species of air-breathing fish from Siam were also determined. They were found to be near those of freshwater fish (Ophiocephalus striatus Bloch, -0.57°; Clarias meloderma Bleeker, -0.58°; and Anabas testudineus, -0.64°). (S. Rennie)

Pearse, A. S. 1936. Estuarine animals at Beaufort, North Carolina. Jour. Elisha Mitchell Sci. Soc., 52:174-222.

Collections of marine animals of the Beaufort area were made in 1934. A list of the animals found is given along with additional data on salinity or place of collection for some of the organisms.

Experiments were also made on 45 species, testing survival at salinities of full-strength sea water, 75%, 50%, and 25% sea water, and fresh water. Those organisms that lived longer in brackish water than in undiluted sea water are Bankia (75%), Modiolus (25%-100%), and Ostrea (100%) (typically brackish

inhabitants); Orchestia (50%) and Sesarma (50%) (terrestrial); Fundulus heteroclitus (fresh) (a migrator); and Emerita (75%) (a burrower). (S. Rennie)

Pearse, A. S. and Gunter G. 1957. Salinity. Pp. 129-157. In: Marine ecology and paleoecology. Geol. Soc. Amer. Memoir. 67, Vol. 1, viii + 1296 pp.

Composition of sea water, pp. 129-131, tables 1, 2, and 3, and fig. 1. Composition of sea water in past, pp. 13-133. Osmosis, pp. 133-135, and fig. 2. Osmoregulation in invertebrates, pp. 135-140, figs. 3, 4, 5, and 6, and table 4. Marine algae, p. 140. Ionic balances, pp. 140-143. Osmoregulation in vertebrates, pp. 143-145, table 4, and fig. 6. The origin of vertebrates, pp. 145-146. Salinity, distribution, and emigration from the sea, pp. 146-150. Salinity as related to structure and size, pp. 150-153 and table 5. Bibliography, 5 pp.

Pearse, A. S. and Wharton, G. W. 1938. The oyster "leech," Stylochus inimicus Palombi, associated with oysters on the coasts of Florida. Ecol. Monogr., 8:605-655.

Pp. 625-634: Ecology. S. inimicus, salinity always above 6 ppt, above 15 at least 2 weeks for egg laying, temperature above 10 C; E. meridianalis tolerates salinity down to 0.6 ppt and lower temperature. Graphs of distribution and abundance in Apalachicola Bay show inimicus most abundant in autumn, meridianalis in winter, both least abundant in spring. In 1935-36, inimicus most abundant in October when salinity was 17-27 ppt, decreased in winter as salinity dropped, none after February; meridianalis increased as salinity went down, peaked in January-February (salinity 5-8) and May (salinity below 10). S. inimicus observed killed and entered oysters in laboratory, and meridianalis did not but were found in gaping oysters in field. S. inimicus found in live, closed oysters; often sealed off by partition. Blenny eats Stylochus.

Other agents causing mortality of oysters listed. "High mortality on an oyster bed is probably never due to one single cause, but to a number of contributing unfavorable circumstances." But Stylochus is "a dark villain on oyster beds, and at times when circumstances make a favorable season does much damage. (S. H. Hopkins)

Pearson, John C. 1948. Fluctuations in the abundance of the blue crab in Chesapeake Bay. Res. Rep., U.S. Fish and Wildlife Service, 14:1-26.

Most spawning blue crabs move toward the ocean to waters of higher salinity prior to hatching of eggs. Optimum hatching was observed to be in salinities between 23 and 30 ppt. The percentage of hatch increased with rising salinity. Less than 50% hatched below 18 ppt. Most larvae were hatched prematurely at these low salinities. Optimum salinity for molting and growth of the first three larval stages was 21-28 ppt. High river discharge into the lower bay during spring and early summer has a limiting effect on the population abundance of the crabs. (Pearson did not do the salinity experiments. He was quoting literature.) (S. Rennie)

Penfound, W. T. and Earle, T. T. 1948. The biology of the water hyacinth. Ecol. Monogr., 18(4):447-472.

Salinity effects on pp. 460-461: Some have suggested that water hyacinth is adapting to salt water, but authors find that it is still a freshwater plant, as previously found by Penfound and Hathaway (1938). Laboratory experiments using water of 12-, 6-, 3-, 1.5- and 0.8-ppt salt content resulted in death of plants in 12- and 6-ppt salinity in 8 days. In another experiment using water of 20-, 10-. 5-, 2.5-, 1.2-, and 0.6-ppt salt content, discontinued after 28 days, plants died quickly in a few days in higher salinities. It was evident from condition of plants that all would have died in a few more days in all salinities except the lowest one (0.6 ppt). "These experiments prove, beyond question,

that the water hyacinth is a freshwater plant and cannot tolerate more than faintly brackish water."

Penfound, W. T. and Hathaway, E. S. 1938. Plant communities in the marshlands of southeastern Louisiana. Ecol. Monogr., 8(1):1-56.

Marsh types are closely correlated with the salinity. The types are fresh water (Typhascirpus), saw grass (Mariscus, salinity less than 0.5%), brackish (Spartina-Distichlis-Juncus, salinity 0.5%-2.0%), and saline marsh (Spartina alterniflora, salinity 2.0%-5.0%). Salt tolerances for 43 species of marsh plants are listed. (S. Rennie)

Pequignot, J. and Serfaty, A. 1965. Influence de la salinité sur la respiration tissulaire chez les Teleosteens. Experientia, 21:227-228. (English summary.)

Respiratory measurements were made on hepatic, renal, and branchial tissues from tench (Tinca tinca L.) and eel (Anguilla anguilla L.). Oxygen consumption of hepatic tissue in both fish increased when the fish were transferred from fresh to salt water (12 g/l). No difference was seen for the renal and branchial tissue. (S. Rennie)

Pequignot, J. and Serfaty A. 1968. Variations de salinite et osmoregulation chez la Tanche (Tinca tinca L.): effet de la vagatomie sur l'excretion des cations (Na^+ aud K^+). (Variations in salinity and osmoregulation in the tench (Tinca tinca L.): Effect of vagatomy on the excretion of cations (Na^+ and K^+). Experientia, 24(6):567.

The excretion of Na^+ by the tench decreases after bilateral section of parasympathetic system; this is observed both in normal and saltwater treated subjects. The mechanism induces the increase of Na^+ concentrations in tissue and is responsible for the short survival of vagatomized fish in salt water. (P. Maxwell)

Percival, E. 1929. A report on the fauna of the estuaries of the River Tamar and the River Lynher. Jour. Marine Biol. Assoc. U.K. (N.S.), 16(1):81-108.

Cited by Redeke, 1932, as evidence of difficulty of zoning estuaries of small rivers "discharging themselves in a channel," but having "distinct traces of a mesohaline facies." (S. H. Hopkins)

Pesta, O. 1935. Ein Mysidaceen-Nachweis auf der Insel Korfu (Griechenland). Zool. Anz., 111:332-333.

The marine mysid (crustacean) Mesopodopsis slabberi was found in a lake on the island of Corfu where the salinity was only 1.3 ppt. Cited by Green, 1968, p. 95, as an example of coastal mysids living in lagoons cut off from the sea. (S. H. Hopkins)

Peterson, G. H. 1958. Notes on the growth and biology of the different Cardium species in Danish brackish water areas. Medd. Danm. Fisk. Havunders., N.S., 2(22):1-31.

Found that C. edule did not occur in salinities below 20 ppt, while C lamarki was found over a range from 5 to 25 ppt. A third species, C. exiguum, was found where the salinity was about 10 ppt. Fide Green, 1968, pp. 155-156. (These are bivalve mollusks, called "cockles.") (S. H. Hopkins)

Peterson, Wiebke. 1967. Zur oekologie von Bernsteinchenecken (Succinea) in Salzwiesen. (Ecology of two Succinea species in salt marshes.) Kieler Meeresforch., 23(2):165-171, illus. (German with English summary.)

S. pfeifferi and S. sarsi live in salt marshes along Schlei, a firth with decreasing salinity from the mouth (about 18 ppt) to the innermost tip (about 4 ppt). Their salinity tolerance was tested experimentally. Egg laying, development, feeding, and growth are normal in fresh water and in salinities of the substratum up to almost 10 ppt. Higher salinity causes migration to the lid of petri dishes (in situ to the upper parts of the vegetation). Development, feeding, and growth stop. The animals lose water because of desiccation and die after about 1 month. The osmotic pressure of the blood is normal for a terrestrial gastropod in fresh water with lettuce as food; it rises with a high salinity in the food (Enteromorpha) or in the substratum or because of desiccation up to maximum values corresponding to a salinity of 14 ppt. In life, Succinea seems to keep its blood slightly hyperosmotic against the substratum. (From Biol. Abstr.)

Pfitzenmeyer, H. T. 1961. Benthic shoal water invertebrates from tidewaters of Somerset County, Maryland. Chesapeake Sci., 2(1/2):89-94.

Quantitative samples were taken in 12 Somerset County water areas of the Chesapeake Bay area. Forty-one invertebrate species were collected. When compared with areas of the upper bay, the most significant difference in the invertebrates found was the appearance of organisms associated with higher salinities of the lower bay. Polychaete annelids, especially the ornate worm Amphitrite ornata, and a holothurian, Leptosynapta inhaerens, were very abundant and widely distributed in areas sampled. This association was often present in soft bottoms near drainage from surrounding marshes where usually other organisms were not collected. Other forms present that are usually associated with higher salinity areas of the bay were: Aligena elevata, Tagelus divisus, Cyrtopleura costata, Lyonsia hyalina, Mercenaria mercenaria, Urosalpinx cinerea, Eupleura caudata, Barnea truncata, Diopatra, and Cerebratulus sp. (T. Rennie)

Pfitzenmeyer, Hayes T. 1962. Periods of spawning and setting of the soft-shelled clam, Mya arenaria, at Solomons, Maryland. Chesapeake Sci., 3(2):114-120.

Periods of abundance of clam larvae and spat taken weekly from end of a pier at lower Patuxent River indicated two annual periods of spawning and setting. Early umbo larvae first appeared in May (mean surface temperature was 16.7C, range 15.0-18.5 C; mean salinity was 10.1 ppt, range 8.2-11.5 ppt) and the second spawning began in September or October when water temperatures decreased to mean of 21.7 C (range 19.0-24.8 C) and salinity increased to a mean of 15.5 ppt (range 14.2-16.9 ppt). Setting occurred usually 1 to 2 weeks after appearance of larvae. (T. Rennie)

Pfitzenmeyer, H. T. 1969. Effects of spoil disposal of the benthos of the upper Chesapeake Bay. (Abs.) Proc. Nat. Shellfish. Assoc., 60(1969).

Effects of spoil disposal from approach channel at Maryland end of Chesapeake and Delaware Canal were studied in the field. Salinity in area is too low for commercial shellfish, 0 ppt in spring to about 8 ppt in autumn, with temperatures from 2 to 29 C. Sixty-five species were found in the area. Dominant animals were the isopod Cyathura polita, the polychaete Scolecolepides viridis, and the amphipod Leptochierus plumulosus. The brackish-water clam Rangia cuneata suddenly appeared and became a dominant form, though new to the area. Most invertebrates showed considerable variation in number and species related to seasonal changes in salinity. Data were obtained on number of individuals, species diversity index, and dry weight. All indices showed a marked reduction immediately after channel dredging followed by nearly complete recovery in 12 to 18 months. (S. H. Hopkins)

Pfitzenmeyer, H. T. and Drobeck, K. G. 1963. Benthic survey for populations of soft-shelled clams, Mya arenaria, in the lower Potomac River, Maryland. Chesapeake Sci., 4(2):67-74.

During January, August, and September 1961, bottom samples were taken with a hydraulic escalator clam dredge at 189 stations, from the mouth of Potomac River up to Popes Creek. Clam densities varied considerably, probably due to differences in bottom type. Densest populations were between Sandy Point and Hollis Marsh, Virginia, and between Piney Point and Swan Point, Maryland. The clams farthest upriver were in an area having spring salinities of less than 5 ppt for extended periods. This is near the minimum salinity limit of Mya arenaria. Sixteen other benthic macroinvertebrates were taken with M. arenaria, the largest number of species being found downriver in the highest salinities. No new species appeared upriver as marine species dropped out. Increase in sedimentation upriver has decreased "salt wedge" and restricted penetration of marine species.

Phibbs, F. D. 1971. Temperature, salinity and clam larvae. (Abs.) Proc. Nat. Shellfish. Assoc., 61:12.

Two-day-old larvae of the native littleneck clam (Protothaca staminea), the Manila littleneck clam (Tapes semidecussata), and the gaper or horseneck clam (Tresus capax) were put in different combinations of salinity and temperature and reared to setting size. The native littleneck showed narrow range of tolerance, with optimum at 10-15 C and 27-32 ppt. At 21 C Manila littleneck larvae survived and grew in salinities from 12 to 32 ppt with optimum at 20-28 ppt. Gaper (horseneck) clam larvae had optimum growth and survival at 10-15 C and 21-28 ppt, but 20 C was lethal to them. Gaper larvae grew very little at 5 C and 28 ppt, but at 10 C they grew to metamorphosis.

Philippson, M., Hannevart, G. , and Thieren, J. 1910. Sur l'adaptation d'Anodonta cygnea à l'eau de mer. Arch. Internat. Physiol., 9:460-472.

These freshwater clams (unionidae) are more resistant to sea water than to NaCl solutions. Temperature or season is important. They can stand a 20-ppt solution of sea salt, with a freezing point of 1.22 C. Salts penetrate the interior of the clam and help relieve osmotic pressure. The internal salt concentration is always lower than the concentration outside. Internal osmotic pressure is caused partly by organic substances, which become modified in the course of adaptation to sea water. Clams adapted to 20-ppt salinity can be readapted to fresh water. (Many clams died during the adaptation process, and the statement that they tolerated 20 ppt is based on a very few survivors, which lived one week at this salinity, after having been brought up through a course of changing each 8 days from 2 to 4 to 8 to 12 to 16 and finally to 20 ppt.) (S. H. Hopkins)

Phillips, R. C. and Fleenor, B. 1970. Investigation of the benthic marine flora of Hood Canal. Washington Pac. Sci., 24(2):275-281.

Hood Canal is a fjord connected to Puget Sound. An assessment of the marine plants has revealed a dearth of littoral growth and a marked sublittoral zonation. It is likely that runoff from snowmelt in spring, which results in greatly diluted surface salinity, limits littoral algal growth. Light is the controlling factor in sublittoral zonation. The list of plants includes 1 sea grass, Zostera marina, 1 blue-green alga, 16 species of green algae (over half are ulvoids), 20 species of brown algae, and 87 species of red algae. (From Biol. Abstr.)

Phleger, C. F. 1971. Effect of salinity on growth of a salt marsh grass. Ecology, 52(5):908-911.

Coastal salt-marsh grass, California cordgrass (Spartina foliosa Trin.), was grown in nutrient solutions at a series of salinities equivalent to 0-125 percent of ocean salinity (which was 33 ppt), i.e. in salinities of 0-41.25 ppt, for 8 weeks. Growth and survival were best in fresh water, although the species

naturally inhabits sea water. (S. H. Hopkins)

Phleger, F. B., Jr. 1952. Foraminifera ecology off Portsmouth, New Hampshire. Bull. Mus. Comp. Zool., 106(8,9):315-390.

The modern foraminiferal fauna of the Portsmouth area is most nearly related to the Arctic fauna with minor elements from south of Cape Cod intermingled. The two principal facies are on sandy bottoms and offshore in 75 m and deeper waters on mud or mud-sand bottoms. The chief control of facies distribution appears to be seasonal temperature ranges although salinity and other factors are important. (E. H. Myers and W. S. Cole, 1957)

Phleger, F. B., Jr., and Walton, W. R. 1950. Ecology of Marsh Bay foraminifera, Barnstable, Mass. Amer. Jour. Sci., 248(4):274-294.

Foraminiferal populations along three traverses in Barnstable Harbor and adjacent Cape Cod Bay are plotted and their distributional patterns analyzed. A major biozone in Barnstable Harbor is distinct from the one in Cap Cod Bay because of differences in temperature and salinity. Subfacies in Cape Cod Bay are related to bottom types, sandy near shore and mud or mud and sand offshore. Subfacies in Barnstable Bay are on high marsh, on intertidal flats, and in the channel. The largest population is in the high marsh, which also had the highest total organic production. (E. H. Myers and W. S. Cole, 1957, Geol. Soc. Amer. Memoir. 67, Vol. 1, pp. 1079-1080)

Pieh, Sylvia. 1936. Ueber die Beziehungen zwischen Atmung, Osmoregulation und Hydration der Gewebe bei euryhalinen Meeresevertebraten. Zool. Jahrb., Abt. allg. Zool. Physiol., 56:129-160.

"She found that the gills of M. edulis and of C. maenas undergo swelling in hypotonic sea water or in an isotonic NaCl solution and that in each of these solutions an increase in respiration occurs (Carcinas). When the gill tissue of Carcinas was exposed to cyanide in either solution, the respiration was inhibited but not the swelling. In another species of crab, Eriocheir sinensis, which has the same rate of respiration in fresh water as in sea water (Schuabe, 1933), she found that the gills from freshwater animals did not contain any more water than did those from marine animals." According to H. S. Hopkins, 1949, p. 297.

Pierce, E. L. 1962. Chaetognatha from the Texas coast. Publ. Instit. Mar. Sci., Univ. of Texas, 8:147-152.

Samples collected in bay, pass, and coastal waters in salinities from several parts per thousand below to several parts above 35 ppt did not show any clear pattern of salinity effect, but no chaetognaths (arrow worms) were found in the four plankton samples collected in the Laguna Madre, where salinity was 45-51 ppt. (S. H. Hopkins)

Pierce, S. K. 1970. The water balance of Modiolus (Mollusca: Bivalvia: Mytilidae): Osmotic concentrations in changing salinities. Comp. Biochem. Physiol., 36:521-533.

"Comparative measurements of the osmotic concentrations in three fluid compartments of species of Modiolus from different regions of the marine environment show that the animals are osmotic conformers. However, the body fluids remain hyperosmotic to the environment by a constant amount over the nonlethal salinity range (about 18-41 ppt). The hyperosmotic condition appears to be the result of a passive equilibrium rather than active regulation and is probably characteristic of all osmoconformers.

"The osmotic difference between the blood and the pericardial fluid precludes the possibility of ultrafiltration from the blood into the pericardial cavity...."

Pericardial fluid does not come in contact with many cells and is probably not useful as a measure of internal osmotic concentration. (S. Rennie)

Pilgrim, R. L. C. 1953a. Osmotic relations in Molluscan contractile tissues. I. Isolated Ventricle-strip preparations from Lamellibranchs (Mytilus edulis L., Ostrea edulis L., Anodonta cygnea L.). Jour. Exptl. Biol., 30:297-317.

Tests with sea mussels Mytilus edulis showed that the tissue was normally capable of contracting in the range of 40%-160% sea water. Beyond this range frequency but not amplitude was lessened. The limits of activity were 10%-200% sea water.

For the oyster Ostrea edulis both frequency and amplitude were affected by dilute sea water. Accommodation of heart muscle took place over the range 50%-120% sea water.

In the freshwater clam Anodonta cygnea accommodation took place in up to 40% sea water, with an increase in frequency, and sometimes a decrease in amplitude. Tap water did not support heartbeat. Diluted frog Ringer's solution gave irregular results, while an artificial blood mixture produced a similar heartbeat which was slightly faster than that produced by the normal 4% sea water standard. (S. Rennie)

Pilgrim, R. L. C. 1953b. Osmotic relations in Molluscan contractile tissues. II. Isolated gill preparations from Lamellibranchs (Mytilus edulis L., Ostrea edulis L., Anodonta cygnea L.). Jour. Exptl. Biol., 30:318-330.

In the sea mussel Mytilus the most resistant cilia are the frontals which accommodated salinities of 30%-225% sea water. Most sensitive were the laterals which could only tolerate salinities of 40%-150% sea water. In extreme concentrations and dilutions, disintegration of the tissue takes place and cells dissociate from the epithelium.

The pattern for the European oyster Ostrea edulis was the same with most tolerance for the frontals over the range 40%-150%. Laterals tolerated 60%-125%. In 10% and 20% dilutions swelling occurred, followed by disintegration. Disintegration also occurred at 200%.

In the freshwater clam Anodonta, terminal cilia beat in sea water concentrations up to 32% and in tap water. Laterals managed only in 1%-20%. Swelling and disintegration occurred in distilled water. Disintegration also occurred in hypertonic sea water. (S. Rennie)

Pillay, T. V. R. 1966a. A bibliography of brackish-water fish culture. F. A. O. Fisheries Division, Rome. (Mimeo.)

A list of 291 references on the culture of fish, prawns, and shrimp is presented. Oyster culture papers and papers on the culture of euryhaline fish in fresh water are omitted. (T. Rennie)

Pillay, T. V. R. 1966b. Brackish-water culture of grey mullet in the Pacific region. Proc. 11th Pacific Science Congress, Tokyo, 1966:16-17.

In a general discussion of brackish-water fish culturing in the Pacific, the author mentioned that the growth of mullet was faster in ponds than under natural conditions and that growth rates were higher in fresh water than in salty water. (T. Rennie)

Pillay, T. V. R. 1967a. Estuarine fisheries of the Indian Ocean coastal zone. Pp. 647-657. In: Lauff, G. H., ed. Estuaries. Am. Assoc. Adv. of Sci. Publ. 83, Washington, D. C., xv + 757 pp.

The largest estuarine area is the Ganges-Brahmaputra Delta, "the Sunderbans," an area of over 3000 square miles with estuarine conditions extending 100 miles

upstream. No clear zonation is evident, but salinities range from fresh to marine. The Irrawaddy Delta in Burma is also large and has important fisheries, and there are several smaller estuaries at the mouths of rivers in India and Pakistan. Mahanadi Estuary in Orissa, east coast of India, is especially important for fish production. On the east coast of Africa the Zambesi has the largest estuary. Lagoons or brackish lakes such as Chilka and Pulicat Lakes, east coast of India, are also important. Such waters, also called "backwaters," have narrow or temporary connections to the sea and variable salinity. A list of common estuarine fish is given, pp. 649-652. Crabs, shrimps and prawns, oysters, and clams are also abundant. (S. H. Hopkins)

Pillay, T. V. R. 1967b. Estuarine fisheries of West Africa. Pp. 639-646. In: Lauff, G. H., ed. Estuaries. Am. Assoc. Adv. of Sci. Publ. 83, Washington, D. C., xv + 757 pp.

The West African coastal waters, especially off the Liberia-Sierra Leone, Biafra, and Niger Delta shores, are diluted from land runoff from many streams and rivers, so much so that the entire Gulf of Guinea has estuarine conditions at least during the rainy season, and off Cape Sierra Leone the salinity is 24.8 ppt 10 miles offshore, 27.5 ppt 30 miles offshore, 30.2 ppt 50 miles offshore, and 32.8 ppt at the edge of the Continental Shelf 75 miles offshore. Many fish are caught by crude native methods (dugout canoes and homemade traps) in the estuaries, of which the Volta and Niger estuaries are largest. A list of the fish species caught is given in table 1, pp. 641-642. Though salinity in estuaries is low, marine species predominate in catches, even in the rainy season. Crabs, prawns and shrimps, oysters, periwinkles, and cockles are also caught for food. (S. H. Hopkins)

Pillay, T. V. R., Vijayaraghavan, M. R., and Thakurta, S. C. 1963. An ecological study of benthic flora in brackish water bheris. Proc. Nat. Inst. Sci. India, Pt. B. Biol. Sci., 28(5):416-431, illus.

Three types of bheris were characterized according to soil fertility, salinity, and productivity. The most productive had the most fertile soil and the highest average salinity (24.3 ppt). The least productive bheri had poor soil and the lowest salinity (10.9 ppt). The other type was intermediate with 18.76 ppt. Data on fluctuations in salinity are not sufficient to show any close relation with the abundance of each species. Floral composition of the three types was about the same. The more saline bheris had more Myxophyceae and Chlorophyceae. The less saline ones had more Ruppia. (S. Rennie)

Pilsbry, H. A. 1916. The sessile barnacles (Cirripedia) contained in the collections of the U.S. National Museum; including a monograph of the American species. U.S. Nat. Mus. Bull. 93, xi + 366 pp.; 76 plates.

Pp. 80-84, plate 24, and figs. 1-1c and 2: Balanus eburneus Gould 1841. P. 83: "Balanus eburneus often lives in brackish water. I found small ones on the piles at Betterton, near the head of Chesapeake Bay, where the water is but slightly brackish, the freshwater snails Goniobasis and Amnicola living in it. Professor Wyman found it living about 50 miles up the St. Johns River, Florida, where the water was fresh enough to drink, and the specimens lived well when transferred to a vessel of perfectly fresh water." P. 80: Distribution of B. eburneus: "Massachusetts to the Caribbean coast of South America, low water to about 20 fathoms." P. 84: Locality list. The only Gulf of Mexico locations listed are Tarpon Springs, Fla., and Pass Christian, Miss. (S. H. Hopkins)

Plateau, F. 1883. Influence de l'eau de mer sur les animaux d'eau douce, et de l'eau douce sur les animaux marins. Compt. Rend. Acad. Sci., Paris, 97:467-469.

This, like Bert (1883) is in answer to Varigny (1883). Claims to have reported in 1870 similar results, which he repeats here. Sea water has little effect on

adult freshwater Coleoptera (beetles) and Hemiptera (bugs), but has more effect on larvae of these insects, which absorb NaCl through thin skin of thin covering of gills. It is NaCl and MgCl that poison insects that absorb these salts, while insects with skins impermeable to these salts can live in sea water. Sulfates have no effect. Density of salt water is not a factor. When insects gradually adapted to salt water reproduce, the new generation resists death in sea water longer than other individuals of the species. Marine Crustacea differ in resistance to death when placed in fresh water, but none lives more than 9 hr. They die because they lose salts from tissues. NaCl is the only necessary sea salt, to prevent death. Density itself is not a factor. Small individuals are less resistant because of thinner integuments. These results are explainable by endosmosis, diffusion, and dialysis. (S. H. Hopkins)

Pogrebnyak, I. I. 1962. Genesis of the bottom flora of the estuaries of the Northwestern Prichernomor'e. Tr. Odessk Univ. Ser. Geol. Geog. Nauk., 152(9):173-170. 1962: Ref. Zhur., Biol., 1963, No. 15V217.

The estuaries of the Northwestern Prichernomor'e arose during the Novoesinian period as a result of depression of land causing restoration of the straits of Bosporus and the Dardanelles. The Novoevsinian Basin then increased in salinity and became the Black Sea. With increase in salinity the freshwater flora gave way to saltwater forms. However, subsequent isolation of the estuaries facilitated their freshening, causing a gradual change to freshwater vegetation, although now under entirely different conditions. The large estuaries of large rivers have a varied freshwater flora, including associations of Potamogeton perfoliatus (Dnepr Estuary), P. pectinatus, and eel grass (Berezansk Estuary). In closed estuaries, the increase in salinity of the water has led to the development of poor benthic vegetation of the marine type and then to vegetation of the salt lake type. (S. H. Hopkins)

Polunina, O. A. 1965. (Murmansk Mar. Biol. Inst. Acad. Sci. USSR, Murmansk, USSR.) O Spasobnosti morskoi swezdy Asterias rubens (L.) differentsirovat's olenost' morskoi vody. (On the capacity of the starfish Asterias rubens (L.) to differentiate the salinities of sea water.) Dokl. Akad. Nauk. SSSR, 165(2):451-453.

The reactions of starfish, Asterias rubens L., to changes of the chemical nature of the external medium normally, and in the presence of disturbances of the integrity of the nervous system, were studied. The threshold of the motor-defensive reactions of the starfish to NaCl solution in normal sea water lies between 4.5 and 5 g/l, to KCl and $CaCl_2$ solutions between 1.5 and 1 g/l, and to $MgCl_2$ solution between 0.5 and 1 g/l. (D. Franklin)

Popham, Edward J. 1966. The littoral fauna of the Ribble Estuary, Lancashire, England. Oikos, 17:19-32.

The changing salinity of the Ribble Estuary during tidal rhythm not only limits the penetration of marine forms in a horizontal direction, but also in a vertical dimension. Since sea water is more dense that fresh water, the penetration of the barnacles (Balanus balanoides) is farther upstream at the bottom of the estuary than it is higher up. Most of the marine forms are limited at 75% sea water with others being limited at 50% sea water. (S. Rennie)

Por, F. D. 1971. One hundred years of Suez Canal--a century of Lessepsian migration: retrospect and viewpoints. Syst. Zool., 20(2):138-159.

Many Red Sea species have migrated through the Suez Canal into the Mediterranean. Very few, nearly all fishes, have passed in the opposite direction. The Red Sea in past times has had various degrees of extension toward the Mediterranean, of which the Bitter Lakes and other small water bodies on the Isthmus of Suez are relicts. These water bodies contained species that were acclimated to

salinity extremes and thus "preadapted" for passage through the canal to the Mediterranean. Some species made this passage step by step; others that were active swimmers or able to attach to ship bottoms probably made the entire passage as individuals. The Levant Basin of the Mediterranean was also "preadapted" to receive immigrants from the Red Sea because of its high salinity and high temperature, and consequent biological undersaturation with temperate fauna. Red Sea species, from highly saline warm waters, were better adapted to the Levant Basin than the indigenous species. (S. H. Hopkins)

Porter, H. J. 1955. Variation in morphometry of the adult female blue crab, Callinectes sapidus Rathbun. M.S. Thesis, Univ. of Delaware, Newark, Del., 69 pp.

Postulated that low-salinity waters permit crabs to attain a larger mature size than do waters of higher salinity. (Fide Tagatz and Hill, 1971, p. 56.) (S. H. Hopkins)

Porter, H. J. 1956. Delaware blue crab. Estuarine bulletin (Univ. of Delaware), 2(2):3-5.

Size variation between crabs may be due to salinity differences in their environments. Based on study of blue crabs of Chesapeake, Chincoteague, and Delaware Bays, which are separate populations. (S. H. Hopkins)

Porter, H. J. 1960. Zoeal stages of the stone crab, Menippe mercenaria Say. Chesapeake Sci., 1:168-177.

Zoeae were raised at the following salinities and temperatures: 23, 27, and 33 ppt and 27-29 C and 23-25 C. Mortalities increased at lower salinities and temperatures. A few zoeae are capable of attaining a fifth stage in salinities as low as 23 ppt at 27-30 C. (S. Rennie)

Post, Rita J. 1951a. Ecology of foraminifera. The Micropaleontologist, 5(3):12-14.

In aerated basins food and the texture of the substratum control distribution, while in stagnant basins oxygen is the limiting factor. The role of temperature in zonation is not as important as is generally claimed. Lowering of salinity reduces the number of species that may be present, but the number of individuals may increase. (E. H. Myers and W. S. Cole, 1957, Geol. Soc. Amer. Mem. 67, Vol. 1, p. 1080)

Post, Rita J. 1951b. Foraminifera of the south Texas coast. Publ. Inst. Mar. Sci., Univ. of Texas, 2(1):165-176.

Foraminifera from several environments from nearly fresh water to the open sea are recorded. Species distribution is controlled by the differences in salinity. (E. H. Myers and W. S. Cole, 1957, Geol. Soc. Amer. Mem. 67, Vol. 1, p. 1080)

Potts, W. T. W. 1954a. The energetics of osmotic regulation in brackish- and freshwater animals. Jour. Exptl. Biol., 31:618-630.

He presents a theoretical model that expresses total osmotic work in terms of the animal's permeability, surface area, blood and urine concentrations, and the concentration of the external medium. Hypothetical calculations are made for the freshwater clam Anodonta in a hypotonic medium.

With equations he shows that when a marine animal enters brackish water, it can reduce strain on osmoregulatory mechanisms by lowering its blood concentration. In brackish water, production of dilute urine has only a small effect on osmotic work. In fresh water, production of urine hypotonic to the blood is compatible with high osmoregulatory efficiency. (S. Rennie)

Potts, W. T. W. 1954b. The inorganic composition of the blood of Mytilus edulis and Anodonta cygnea. Jour. Exptl. Biol., 31:376-385.

Mytilus (sea mussel) blood resembles sea water in total concentration and composition, but has greater concentrations of calcium, potassium, and total carbon dioxide. Anodonta (freshwater clam) blood has a very low concentration of solutes, but the concentrations of calcium and carbon dioxide are of the same order of magnitude as the concentrations in Mytilus blood. It is concluded that the bloods of both animals are saturated with aragonite, after considering the solubility of calcium carbonate in ionic solutions. (S. Rennie)

Potts, W. T. W. 1958. The inorganic and amino acid compositon of some lamellibranch muscles. Jour. Exptl. Biol., 35:749-764.

The percentage dry weight of muscles of bivalve mollusks from 50% sea water is less than that of muscles from normal sea water. Also the inulin spaces are reduced at this dilution. Sodium and chloride concentrations are considerably less in muscles from 50% sea water. Amino acid content is also lower. (S. Rennie)

Potts, W. T. W. 1968. Osmotic and ionic regulation. Ann. Rev. Physiol., 30:73-104.

A review of the literature of the 10 years prior to May 1967. In certain Protozoa, K is accumulated while the contractile vacuole excretes Na. In Coelenterata and Ctenophora ionic regulation aids buoyancy, especially by reducing sulfates. Osmoregulation in estuarine Polychaeta is reviewed, and Na-Cl regulation in earthworms. In Mollusca, the problems and mechanisms of land, freshwater, estuarine, and marine forms are discussed. In Arthropoda, the merostomate Limulus is a euryhaline osmoconformer. Osmoregulation in Crustacea is given lengthly treatment including internal transport of ions and intracellular as well as intercellular osmotic regulation. In Insecta, water balance is controlled by a hormone. In fishes, osmoregulation is discussed in hagfishes, lampreys, elasmobranchs, holocephali, and coelacanths as well as in the more advanced teleosts. In teleosts, the treatment covers osmoregulation in hyperosmotic media (sea water and saltier), fresh water, and adaptation to changes in salinity. Amphibia are given brief treatment. Marine reptiles and sea birds have salt-excreting glands in nose and eye regions. Desert birds and mammals have special mechanisms, which are discussed.

Potts, W. T. W. and Parry, G. 1964. Sodium and chloride balance in the prawn, Palaemonetes varians. Jour. Exptl. Biol., 41:591-601.

The exchanges of Na and Br (for Cl) ions between the brackish-water prawn and its environment are described. In an isosmotic medium, exchange is by passive diffusion. In 100% sea water Na is actively removed extrarenally and Cl ions are kept in passive equilibrium. There may be increased flux of ions in hyperosmotic sea water, associated with water swallowing as in marine teleosts. In 2% sea water Cl ions are actively absorbed, but some active Na uptake also occurs. In salinities below 2%, uptake of ions declines and the animals can no longer maintain equilibrium. (Author's abstract in part)

Precht, Herbert and Linder, Elke. 1966. Reaktionen, Regulationen, und Adaptationen der Tiere nach Veranderung von Temperatur und Salzgehalt: Versuche mit Zoothamnium hiketes (Ciliata, Peritricha). Helgolaender wiss. Meeresunters., 13(4):354-367.

Responses, regulation, and adaptation to salinity are discussed in general. Research on these aspects of the life of the mosslike colonial protozoan Zoothamnium is described. (S. H. Hopkins)

Price, Kent S. 1961. Sand shrimp. Cross-link in an estuarine food web. Estuarine Bull., 6(3/4):12-14.

The sand shrimp (Crangon septemspinosa) can live in salinities from fresh water to full strength sea water. It is distributed at least from Delaware Bay to Florida to Baffin Bay (Texas) on the east coast of the U.S. and in Alaskan waters on the west coast. Its position in a food web is shown. (S. Rennie)

Price, K. S., Jr. 1962. Biology of the sand shrimp Crangon semptemspinosa in the shore zone of the Delaware Bay Region. Chesapeake Sci., 3(4):244-255.

Length-frequency distribution, growth, reproduction, and food analysis studies were made of the sand shrimp between October 1958 and December 1960. They were collected in salinities ranging from 4.4 to 31.4 ppt. Females with eggs were collected in salinities ranging from 17.7 to 29.3 ppt. The author suggests that distribution of ovigerous females may be strongly influenced by salinity; that penetration of berried females into the bay is limited by salinity. (R. Rennie)

Pritchard, A. W. and Yuen, Rosalind. 1963. Respiration of selected tissues from crayfish acclimated to different ssalinities. Amer. Zool., 3:530-531 (abs.).

Pacifastacus leniusculus were acclimated at 20%, 40, 60, 80, and 100% sea water. Respiration was measured on excised tissues. Green gland and gill tissue showed maximum rates at 60%. Gut tissue did not differ. Pacifastacus is a hypo-osmotic regulator at high salinities. (S. Rennie)

Privol'nev, T. I. 1959. Opredelenie ustoichivosti ryb k solenosti sredy po temperature zamerzaniya Krovi. (Determination of the resistance of fish to salinity of the medium in relation to the freezing point of the blood.) Nauchn. Tekhn. Byul. Gos. Nauch.-Issled. Inst. Ozern. Rechn. Rybn Khoz., 9:46-49. Ref. Zhur., Biol., 1962, No. 15I65.

Instead of a Beckmann thermometer, a semiconductor microelectro-thermometer was used, permitting the rapid measurement of the freezing point of the blood (Δ) with an accuracy of 0.012 C. The fish to be investigated were divided into two groups. Carp, pike, perch, crucian carp, orfe, and tench live at a maximum salinity of 12 ppt and have a Δ of the blood of about 0.500 C. Whitefish, trout, sticklebacks, salmon, and eels live at salinities higher than 20 ppt and have a Δ of about 0.650 C. With growth from the larval to the adult stage, the resistance to salinity of the first group increased 1.5-2 times and that of the second group 4-5 times. Knowing the Δ of the blood of the adult fish one can determine approximately the limiting salinity for different stages of growth of each fish. The method described is more satisfactory than the generally used determination of resistance by keeping fish at different salinities for long periods.

Privol'nev, T. I. 1964. Relation of freshwater and diadromous fishes to different salinities. Izv. Gos. Nauch.-Issled. Inst. Ozern. Rechn. Rybn Khoz., 58:58-83

Seventeen species of fish were kept in aquaria in different salinities 15-20 days. Based on salinity tolerance, they were in two groups: Group I, capable of standing salinity not higher than 10-12 ppt (carp, crucian carp, roach, tench, orfe, pike, perch, and burbot), and Group II, standing salinities up to 20 ppt (whitefish, trout, salmon, three-spine stickleback, and eel). Only large fish have such tolerance; larval fish do not survive in more than 7 ppt. Salt concentration of blood is higher in Group II, approaching that of marine fish. In Group II blood osmotic pressure was low, and even a slight salinity rise caused rise in blood plasma salts, and death. In Group II blood osmotic pressure rises only in salinity above 10 ppt. The higher the blood plasma freezing point, the greater the tolerance to salinity. Only slight acclimation is

possible, increasing lethal salinity limit by 3-5 ppt. (S. H. Hopkins, from English summary)

Privol'nev, T. I., Koroleva, N. V., and Shterman, L. Ya. 1960. The relationship of the offspring of salmon (Salmo salar) to the salinity of water. Dokl. Akad. Nauk. USSR. (Biol. Sci. Sect. Trans.) 130(1/6):172-173.

With increasing age, resistance of salmon offspring to the effect of raised salinity increases. At age of 14 months, salmon can stand salinity of 20 ppt, and if salinity is raised gradually, 25 ppt. In sea near river mouth, in salinity of 20-25 ppt, young salmon find more food and fewer predators than offshore. (S. H. Hopkins)

Prosser, C. L. 1955. Physiological variation in animals. Biol. Rev., 30:229-262.

This paper reviews the subject in very general terms for both vertebrates and invertebrates, aquatic, and terrestrial animals. Short sections on water balance and inorganic ions contain specific examples to illustrate the generalities. Most examples are typical aquatic organisms. Through these examples he tries to indicate the adaptive nature of physiological variation and show where such variation may be genotypic, ontogenetic, or adult phenotypic. He concludes that "physiological adaptation is important at three points in speciation: (1) phenotypically in the initial variations which establish populations at range limits, (2) genetically as one mechanism of reproductive isolation, and (3) ecologically in habitat selection" (p. 253). (S. Rennie)

Prosser, C. L. and Brown, F. A., Jr. 1961. Comparative animal physiology, 2d. ed. W. B. Saunders Co., Philadelphia, ix + 688 pp.

The animals compared run the entire gamut from protozoans to mammals. Chap. 2, "Water: osmotic balance," pp. 5-56, covers problems of adapting to different salinities from the physiological standpoint, explaining terms such as stenohaline, euryhaline, osmoconformers, osmoregulators, poikilosmotic, homoiosmotic, isosmotic, hyperosmotic, and hypo-osmotic. Morphological, physiological, and behavioral modifications for life in different salinities are described. Responses to changes in ionic medium and mechanisms of ionic regulation are discussed on pp. 64-70. On p. 166 the effects of salinity on metabolism are summarized: freshwater species use more oxygen than related marine species, euryhaline animals use more oxygen as salinity is lowered, and stenohaline marine animals use less oxygen in lower salinity. Rao (1958) found that marine prawns used maximum oxygen in 25% sea water while prawns from brackish water used the most oxygen in tap water. (S. H. Hopkins)

Prosser, C. L., Green, J. W., and Chow, T. J. 1955. Ionic and osmotic concentrations in blood and urine of Pachygrapsus crassipes acclimated to different salinities. Biol. Bull., 109:99-107.

P. crassipes is a Pacific shore crab that lives in intertidal zone mostly. When crabs were acclimated to 50%, 100%, and 170% sea water, blood concentrations were equivalent to 0.46, 0.57, and 0.89 normal NaCl while medium equaled 0.29, 0.58, and 0.99. Urine concentrations were equivalent to 0.39, 0.53, and 0.90 normal NaCl. Thus, crabs were hyperosmotic in dilute media and hypo-osmotic in concentrated media. Antennary glands may function in hyperosmotic but not in hypo-osmotic regulation. In environmental concentrations of sodium of 229, 459, and 790 mm (50%, 100%, and 170% sea water), serum Na concentrations were 313, 465, and 668 mm, respectively, urine sodium 356, 318, and 264, respectively. As blood sodium increases, urine Na decreases. The osmotic deficit in the urine is accounted for in part by Mg. In artificial sea water urinary Na decreased in high salinities but in the absence of $MgSO_4$ urinary Na increased. Excretion of Mg by antennary glands somehow reduces Na excretion. K in blood is well

regulated in dilute; less well in concentrated sea water. Ca in blood is more concentrated than in dilute; less than in higher salinity. (S. H. Hopkins)

Prost, M. 1959. Badania nad wplywen zasolenia wody na faune Monogenoidea ryb. Acta Parasitol. Polonica, 7(23/35):615-630, map.

The author studied Monogenoidea infection in fishes in Martwa, Wisla (Vistula), salinity 1-4 ppt, Lake Ptasi Raj, salinity about 2 ppt, Lake Karaski, salinity about 2 ppt, the coastal zone of the Baltic Sea, salinity 6-7 ppt, and Vistula Bay, salinity 2.5-4 ppt. In general, increasing salt concentrations were unfavorable to parasitism by the Monogenoidea; however, this was not true for Vistula Bay. The effect of salinity was considered an individual species characteristic of the parasite. The species tolerating the narrowest range of salinity were Dactylogyrus vistulae, D. formosus, D. vastator, and D. intermedius, and those tolerating the greatest range were D. difformis, Diplozoon paradoxum, and to a lesser degree, Dactylogyrus criufer. In support of Dubinin (1948) the author thought that the high sulfate level in Martwa Wisla adversely affected fish parasites there.

Prytherch, H. F. 1934. The role of copper in the setting, metamorphosis and distribution of the American oyster, Ostrea virginica. Ecol. Monogr., 4:47-107.

Duration of the setting process varies according to salinity. Setting occurs most rapidly in salinities of 16-18.6 ppt, when setting was most pronounced at the stage of tide when Cu content of water was highest, 0.05-0.60 mg/l, and within this range was directly proportional to amount of copper. The vertical level at which heaviest setting occurs corresponds with the stage of tide when salinity is lowest and content of copper and river water highest; e.g., in one case (Charleston, S. C.) one-half way between high and low water marks, in another (Milford, Conn.) from 1 ft above to 1 ft below low water level.

Puffer, E. L. and Emerson, W. K. 1953. The molluscan community of the oyster-reef biotype on the central Texas coast. Jour. Paleont., 27:537-544.

The molluscan fauna of oyster reefs from Aransas, Copano, and San Antonio Bays is characterized. Surface salinities range from 2.90 in San Antonio to 42.11 in Aransas, while bottom salinities range from 23.90 in San Antonio Bay to 41.56 in Aransas Bay. (S. Rennie)

Puzanov, I. I. 1967. Mediterranizatsiya faunty chernogo morya i perspektivy ee usileniya. (Mediterranization of the Black Sea fauna and prospectives of its increase.) Zool. Zhur., 46(9):1287-1297. (Russian; English summary.)

Evolution of the Black Sea, with salinity changes, is given and modern changes are discussed. An increase in salinity due to "Mediterranization" leading to an influx of new organisms, including radiolarians and siphonopores, has been noted. More change is expected with the use of incoming fresh water for industry and irrigation. (From Biol. Abstr.)

Pyefinch, K. A. 1950. Notes on the ecology of ship-fouling organisms. Jour. Animal Ecol., 19(1):29-35.

Salinity is only one of several factors that might cause the death of a fouling organism. Balanus balanoides can remain for at least 3-1/2 days in fresh water and resume normal behavior in 5 hr. For B. crenatus only individuals larger in diameter than 8 mm were able to survive in fresh water for 3 days. Other evidence (uncited in the article) suggests that populations of barnacles could survive in diluted sea water for short periods. (S. Rennie)

Quinton R. 1900. Perméabilité de la paroi exterieure de l'Invertébré marin, non seulement à l'eau, mais encore aux sels. C. R. Acad. Sci., 131:952-955.

Experiments were made with sea hares, Aplysia punctata (Mollusca, Gastropoda), and with Carcinus maenas (European edible crabs). The results are shown in tables, demonstrating that salts as well as water can pass through the skins of these marine invertebrates. "It (skin) is therefore a dyalizing membrane." (S. H. Hopkins)

Raffy, A. and Fontaine, M. 1930. De l'influence des variations de salinité sur la respiration des civelles. C. R. Soc. Biol., Paris, 104:466-468.

"Civelles," the young eels that go up rivers, were caught in the Loire River near Nantes. Oxygen consumption was measured in fresh water (consumption 0.270 cc/g/hr), in half fresh-half sea water (0.255 cc/g/hr), and in sea water (0.180 cc/g/hr). Individuals differed greatly; completeness of mucus coating is a major factor. Civelles kept some time in sea water, then returned to fresh, showed increase in oxygen consumption; those changed from fresh to sea water showed decrease. (S. H. Hopkins)

Ragotzkie, R. A. 1959. Plankton preductivity in estuarine waters of Georgia. Publ. Instit. Mar. Sci., Univ. of Texas, 6:146-158.

In the region studied a 5- to 7-mile-wide complex of water and salt marsh lies between mainland and sea islands, with tides having mean range of 6.8 ft (spring range 8 ft) and salinity varying with nearness of rivers and with rainfall but in most of region 20-30 ppt. Average gross plankton production was calculated to be +0.68 gm C/m^2/day, net plankton production -0.038 at lower and -0.16 gm C/m^2/day at upper end of Duplin River. The plankton community tended to be heterotrophic in summer and autotrophic in winter. The primary factor limiting production was light. Analysis shows that under observed conditions of light and vertical mixing, net production by the plankton community must be near zero regardless of the standing crop. An outside source of organic matter is necessary to account for support of animals in estuary with negative production from plankton. The most likely source is the Spartina alternifolia marsh which covers about three-fourths of total area and has net production rate estimated to be on order of 1 gm C/m^2/day, higher than the loss cited above. (S. H. Hopkins)

Rahm, Urs. 1964. Zur Oekologie des Zooplanktons der Lagune Ebrié, Elfenbeinküste. (The ecology of the zooplankton of the Ebrie Lagoon, Ivory Coast). Acta Trop., 21(1):1-47, illus.

An ecological survey of the zooplankton of the Lagoon Ebrié was made during 1953 and 1954. At two places the lagoon is connected with the sea where during the dry season salt water penetrates into the lagoon. Quantitative samples were taken regularly each month at eight different stations and were correlated with rainfall, saltwater concentrations, water temperature, and number of plankton species present at Abidjan.

Rajyalakshmi, T. 1961. Studies on maturation and breeding in some estuarine palaemonid prawns. Proc. Nat. Inst. Sci. India, B. Biol. Sci., 27(4):179-188, illus, map.

Members of the species Palaemon carcinus congregate in the Kolaghat and Uluberia-Fuleshwar areas of the Roopnarain and Hooghly Rivers during the period December to June for purposes of spawning. Salinities ranged from 0.04% to 1.7%. During the peak spawning period the salinity was 0.61%-1.65% in the Fuleshwar-Uluberia region. Temperatures were 22.0-32.6 C for the entire season, and 27.2-31.5 C for the peak. Eggs also hatched in this region. (S. Rennie)

Rämamurthi, R. 1965. Salinity tolerance and chloride ion regulation in a holeury-saline teleost, Tilapia mossambica. Current Sci., 34:694-695.

Tilapia from fresh water were tested at additional salinities of 50%, 100, 150, and 200% sea water (32.5 ppt). The fish were able to withstand direct transfer to 50% and 100% without noticeable effect. Adaptation to salinities above 100% is necessary with survival limited at 200% sea water.

Analysis of extracellular body fluid showed that Tilapia can maintain concentrations below that of the medium. Although the chloride concentration increases

with the salinity, it is maintained at approximately one-third that of the medium. (S. Rennie)

Rämamurthi, R. 1966. Succinic dehydrogenase activity in a fresh-water crab in relation to salinity stress. Comp. Biochem. Physiol., 19:645-648.

Paratelphusa hydrodromous from fresh water were acclimated to 50% sea water for 45 min, and then some were put into 100% sea water for 45 min. Comparing the amount of succinic dehydrogenase activities at these salinities and in fresh water, it is apparent that the greatest activity occurs in 100% sea water. Minimal activity of this enzyme was in fresh water. (S. Rennie)

Rämamurthi, R. 1967a. Influence of salinity and temperature on the metabolism of a fresh-water crab. Current Sci., 36(18):489-490.

The crab was Paratelphusa hydrodromus. Metabolism was measured by oxygen consumption. Combinations of four temperatures (20, 25, 30, and 35 C) and different salinities (tap water, 25%, 50, 75, and 100% sea water) were used.

Generally, the oxygen consumption increased with increased temperatures at all salinities except 100% sea water. The amount of increase was different for each salinity. The author's other conclusions do not seem obvious from the data. (S. Rennie)

Rämamurthi, R. 1967b. Oxygen consumption of a fresh water crab, Paratelphusa hydrodromous in relation to salinity stress. Comp. Biochem. Physiol., 23:599-605 (1967).

This freshwater crab showed good tolerance to salinity up to 100% that of sea water. Oxygen consumption at 27 ± 1 C was lowest in 50% sea water, highest in tap water, and almost as high in 100% sea water as in tap water. (S. H. Hopkins).

Rämamurthi, R. 1968. Oxygen consumption of the common Indian cattle leech Poecilobdella granulosa in relation to osmotic stress. Comp. Biochem. Physiol., 24:283-287.

Leeches were able to survive well in salinities up to 37.5% sea water when gradually acclimated although survival was obtained in salinities up to 75% sea water. Survival upon direct transfer was possible in up to 25% sea water. The leeches had minimal oxygen consumption at 25% and maximum in 50% sea water. They are isotonic at 25%. (S. Rennie)

Ranade, M. R. 1957. Observations on the resistance of Tigriopus fulvus (Fischer) to changes in temperature and salinity. Jour. Marine Biol. Assoc. U.K., 36:115-119.

This copepod can live normally in salinities from 4.2 to 90 ppt. Above 90 ppt, it "falls into a state of apparent death" but recovers if transferred to lower salinity. Lethal temperatures vary from 32 to 41.8 C, being higher in higher salinities. The tide pools at or above normal high tide level where I. fulvus lives are well within its tolerance limits. (S. H. Hopkins)

Randall, J. E. 1958. A review of Ciguatera tropical fish poisoning, with a tentative explanation of its cause. Bull. Mar. Sci. Gulf and Caribbean, 8(3):236-267.

Suggested that the peculiar discontinuous distribution, in space and time, of toxicity of reef fishes was caused by toxic benthic algae growing on coral reef "new surfaces" after freshwater flooding had killed corals, these algae then being ingested by fishes feeding on the reef. So only at such times would people be poisoned by "ciguatera" after eating reef fishes or their predators. (S. H. Hopkins)

Ranson, G. 1943. La vie des huitres. Histoires Naturelles. I. Collection dirigée par Jean Rostand. Gallimard. 3d ed., 261 pp; 17 plates.

P. 34: "Salinity, temperature, nature of the bottom rule the mode of local distribution of the different species. I am going to examine successively these factors and show how their action explains the vertical distribution of oysters.

Most live near the coast, in the mouths of rivers or in the immediate vicinity, in certain lagoons communicating more or less with the sea. They prosper in waters whose salinity is tempered by the addition of fresh water. The development of the egg and of the larva requires a density of 1.010 to 1.024. Some may be able to exist in waters very brackish; this is the case of the Gryphaeas; they maintain themselves some hours in water absolutely fresh, provided their valves are hermetically closed. No species however can live there in a permanent manner. Oysters are marine molluscs...."

P. 35: "Each species of oyster requires a special proportion of mixture of fresh water and sea water; the development of its egg and its larva takes place between rather narrow limits of salinity. The adult tolerates a little wider limits.... Amemiya has studied the action of salinity on the first stages of development of the egg of some species." He gives the following figures for the optimum of salinity favorable (in parts per thousand):

O. virginica	25-29
O. angulata	28-35
O. edulis	31-35
O. gigas at 25°	20-26
O. gigas at 16°	17-26
O. spinosa	31-38
O. circumpicta	29-35
O. denselamellosa	29-33
O. rivularis	18-26
O. sikamea	19-25

P. 36: However, there are exceptions. The species of the genus Pycnodonta and certain of the genus Ostrea live in the zone of corals, where the salinity is elevated. Most of the species of the fossil genera Liogryphaea, Exogyra, and Arctostrea likewise grew in waters of high salinity.

P. 36: "The species requiring, for their reproduction, a mixture of fresh water and sea water can find this only quite near the shores...."

P. 38: "The species of this group are distributed between 0 and 40 meters. The Gryphaeas, requiring a low salinity, are found very near the shore or extend up more or less far into the mouths of rivers, according to their flow. They may accidentally be found lower, below the level of low tide, but only in the mouth of rivers with large flow where, at this depth, the water of the open sea does not have a very high salinity. Among the Gryphaeas themselves, there are differences; G. virginica requires waters a little more brackish than G. angulata. It lives therefore in the estuaries of rivers with very large flow. The species of the genus Ostrea prosper more toward the open sea, in the zone of the algae Laminaria; they extend into the rivers of weak flow in which the waters of the sea predominate."

Pp. 42-44: "The Portuguese oyster lives in the mouths of rivers or in the immediate vicinity, where it finds the salinity suitable for development of the egg, that is to say a density of 1.015-1.020. In the Charente and the Gironde, it develops several kilometers from the coast, toward the interior where, twice each day, at the time of low tide, it finds itself in water absolutely fresh. It resists this excessive variation by hermetically closing its valves. It may live nevertheless in very brackish waters; it supports very well a density of 1.005 for some time. It extends farther upstream in proportion as the flow of the river is weaker.... In saltier waters it grows with more difficulty...."

P. 45: "The reefs of Portuguese oysters develop on rocky or shell bottoms of the shores uncovered by tides of 80-85. However one finds them in the Charente

and Gironde below the level of the lowest tides; they are never uncovered. These are exceptional cases on our coasts. At these points, the mixture of fresh water and sea water is still suitable. They are rare, for, usually, the sea water predominates on the bottom in the mouths of rivers. It is only in those which have a larger flow that one may find them more frequently."

P. 50: "The flat oyster and the Portuguese oyster therefore do not live at the same height in the mouths of rivers or the immediate environs. There is always an appreciable distance between the natural banks of the one and of the other....

Let us consider, schematically, a river entirely hypothetical, for the present time at least, which would present the conditions favorable to the development of natural beds of the above two species, to which we will add the American oyster to make the picture more striking. We would have, very far upstream, the beds of G. virginica; a little below, those of G. angulata; and, at the mouth, those of Ostrea edulis."

P. 50: "Gryphaea gigas, of the coasts of China and Japan, behaves very much like our Portuguese oyster."

Pp. 50-51: Quotes Lamy 1936 on Gryphaea cucullata in Australia. "One recognizes here the mode of distribution of the Portuguese oyster." Quotes Roughley: "This oyster prospers best in the estuaries and the rivers emptying on the east coast of New South Wales, which are filled with an abundance of fresh water from their source. The optimum density of the water ranges from 1.015 to 1.020.... It rarely prospers where the salinity is too high. Roughley obtained in the laboratory the development of eggs and larvae in waters of density 1.011 to 1.021."

P. 51: "Gryphaea gasar, another tropical species, forms considerable masses on the roots of mangroves in the estuaries of rivers of west Africa, especially in the Gambia and the rivers of Portuguese Guinea...likewise in the marigots or brackish lagoons of that coast. It formerly lived in the Senegal River, but disappeared following modifications in the course of that river."

P. 79: Cultivated flat oysters in France are fat all the year if the summer is rainy, thin if the summer is dry. "For a favorable temperature, the quantity of glycogen in the connective tissue is a function of salinity."

P. 152: "If the density of the water attains 1.022-1.025, the Portuguese oyster experiences great difficulties in liberating its genital products. They retain them a long time. They suffer a great deal, become very poor, and the 'maladie du pied' may make them die suddenly or leave them in a physiologically weakened condition. The period of emission of the eggs constitutes for the oyster, a critical phase of its life. In order to pass through it without inconvenience, the salinity must be low, food abundant and variations of the temperature very slight." (S. H. Hopkins)

Ranwell, D. S. 1961. Spartina salt marshes in southern England. 1. The effect of sheep grazing at the upper limits of Spartina marsh in Bridgwater Bay. Jour. Ecology, 49:325-340.

"Where salinity is reduced by seepage of fresh water from the land, Spartina tends to be replaced by a tall marsh of Phragmites communis and Scirpus maritimus," both of which are important plants at the head of estuaries, according to Green, 1968, p. 56, citing Ranwell as authority. (S. H. Hopkins)

Ranwell, D. S., Bird, E. C. F., Hubbard, J. C. E., and Stebbings, R. E. 1964. (Nat. Furzebrook Res. Sta., Wareham, Dorset, England.) Spartina salt marshes in southern England. V. Tidal submergence and chlorinity in Poole Harbour. Jour. Ecology, 52(3):627-641.

Chlorinity gradient decreases gradually in lower and middle reaches and more steeply in estuarine reaches. Seasonal changes in chlorinity in the marsh were correlated with rainfall.

Phragmites seedlings germinated, but did not establish at 1% Cl (10 ppt) and mature plants were confined to areas of 1.2% Cl (12 ppt) or less.

Rao, G. M. M. 1968. Oxygen consumption of rainbow trout (Salmo gairdneri) in relation to activity and salinity. Canadian Jour. Zool., 46:781-786.

Fish were acclimated to fresh water and to dilutions of artificial sea water at 7.5, 15, and 30 ppt. They showed lowest rates of oxygen consumption, at all levels of activity, in salinity of 7.5 ppt. In fresh water and in 15 ppt, the rates were approximately equal. Oxygen consumption was highest in 30 ppt, at all levels of activity. It was concluded that, at a given rate of activity, the differences in metabolic rates in various salinities can be ascribed to the cost of osmoregulation. (S. Rennie)

Rao, K. P. 1958. Oxygen consumption as a function of size and salinity in Metapenaeus monoceros Fab. from marine and brackish water environments. Jour. Exptl. Biol., 35:307-313.

Oxygen consumption increases with size in all salinities. Maximum respiration for marine prawns was obtained in 25% sea water (8.4 ppt). Brackish water prawns exhibit a minimum rate at 50% sea water and a maximum rate in tap water with no noticeable adverse effects. (S. Rennie)

Rao, K. V. 1951. Observations on the probable effects of salinity on spawning, development and setting of the Indian backwater oyster Ostrea madrasensis. Proc. Indian Acad. Sci., 33:231-256.

Between March 1948 and August 1949, a survey of the salinity effect on the gonadal development, egg fertilization, larval growth, shell formation, and spat setting of Ostrea madrasensis was made on oysters in the Adyar River and Madras Harbor. Laboratory control groups were maintained at various salinities, and salinity and temperature charts of the area were made. Results show spawning is induced by the length of time the salinity is stable but that fertilization is inhibited if salinity is too high. Larval development occurs at salinities from 26.0 ppt to 21.83 ppt with incomplete and defective development above and below this range; optimum for setting is between 29.0 and 31.09 ppt. Therefore, although breeding seems to be continuous, the development of Ostrea madrasensis appears to be salinity dependent. (P. Maxwell).

Rathbun, Richard. 1895. Report on the inquiry respecting food-fishes and the fishing grounds. Rept. U.S. Comm. Fish., 19:23-26.

Reports investigation of a mortality of planted oysters in Galveston Bay by John D. Battle which was extended to entire bay, in August 1892, From 1 mile NW of Red Bluff Buoy upbay water was practically fresh, top and bottom. "It would be the height of folly to plant oysters north of Redfish Bar, where empty shells are much more numerous than living oysters." Except for soft bottom, "conditions seem favorable for oyster-culture south of Redfish Bar."

(This report is interesting because at that time Redfish Bar ran right across the narrow "waist" of Galveston Bay, dividing it into a low-salinity upper bay and a high-salinity lower bay. Since then the bar has been pierced by two dredged channels and much of the shell has been removed by dredgers, allowing more mixing of the water. The upper bay has produced most of the oysters in recent years.--S.H.H.)

Rawson, D. S. 1946. Successful introduction of fish in a large saline lake. Canadian Fish. Culturist., 1946:1-4

In 1939, Redberry Lake, Saskatchewan, had an area of 27 square miles and a salinity of 15,000 ppm (15 ppt). As the lake had no outflow, continued increase in salinity was expected. A preliminary test was made to determine the suitability of the water for hatching whitefish eggs. Lab culturing showed the lake water to have no deleterious effect on fertilization, and the eggs developed to

produce normal fry. Planting began in 1940-1941 with the introduction of numerous whitefish (Coregonus clupeaformis) and pike-perch (Stizostedion vitreum). Both species survived and made rapid growth. (T. Rennie)

Ray, S. M. 1965. Notes on the occurrence of Dermocystidium marinum on the Gulf of Mexico coast during 1961 and 1962. Proc. Nat. Shellfish. Assoc. (1963), 54:45-54.

During 1961 the author heard reports of very low incidences of this oyster parasite along the gulf coast, suggesting that it had practically disappeared from areas previously heavily infected. Salinities had been low, especially in Louisiana, in 1959, 1960, and 1961, so there should have been reduction but not disappearance. During October 1961-May 1962, D. marinum was found by the author in 8 of 9 Florida oyster samples, 12 of 12 from Louisiana, and 15 of 18 from 10 stations in the Galveston, Tex., area. The only uninfected samples were 1 from St. Vincent's Reef in Apalachicola Bay and 3 from a low-salinity station near Smith's Point in Galveston Bay. (S. H. Hopkins)

Redeke, H. C. 1922. Zur Biologie der Niederlandischen Brackwassertypen. Ein Beitrag zur regionalen Limnologie. Bijdr. Bierk., Amsterdam (Feest-Num., M. Weber), 22:329-335.

Classified brackish waters on the basis of chlorinity:

Cl less than 0.1 g/l	= fresh	S
Cl 0.1-1.0 g/l	= oligohaline	0.2-1.8
Cl 1.0-10.0 g/l	= mesohaline	1.8-18.1
Cl 10.0-17.0 g/l	= polyhaline	18.1-30.7
Cl more than 17.0 g/l	= sea water	

According to Sverdrup, et al. (Oceans), p. 166: Cl of ocean water = 19.0 and p. 51: $S = 0.03 + 1.805 \times Cl$. (S. H. Hopkins)

Redeke, H. C. 1932a. Auf der regionalen Limnologie der Niederlande. Publ. Hydrob. Club Amsterdam, 1. (In German.) (Publicaties Hydrobiologische Club now Publicaties Hydrobiologische vereeniging.)

"I have given on pages 33 and 34 an inventory of our native mesohalinophilic organisms, 81 species in all." (Redeke, 1932.) Not found by me. (S. H. Hopkins)

Redeke, H. C. 1932b. Ueber den jetzigen Stand unserer Kenntnisse der Flora und Fauna des Brackwassers. Verh. Internat. Verein. Theor. angew. Limnol., 6th Mitgl., Amsterdam, 4-11 Sept., 1932. (On the present condition of our knowledge of the flora and fauna of brackish waters. Translation by S. H. Hopkins, March 29, 1949. Texas A&M Res. Found. Mimeo., 14 pp.)

In this convention address, Redeke reviewed the whole subject of classification of brackish waters from the biological standpoint. In a table he listed 26 typical brackish-water animals and their occurrence or absence in 10 of the most studied brackish-water regions of northwestern Europe, and the next page is devoted to a discussion of these and other brackish-water invertebrates. A list of 55 references is given, including the best of the publications on ecology of European brackish waters up to 1932. This little paper (Redeke, 1932) is much cited and quoted but seldom read in its entirety, as it is difficult to find in this country. (S. H. Hopkins)

Redeke, H. C. 1939. The effect of the closure of the Zuiderzee on fish and fisheries. Jour. Cons. Perm. Int. Explor. Mer, 14(3):337-346.

Zuiderzee was formed by inundation of lake by sea in 15th century; since, it has been a shallow brackish estuary; closed 1932 by dike, now becoming low-salinity almost fresh lagoon. Salinities compared. Changes in fauna and fisheries described. Before closure fauna included: Corophium volutator and lacustre, Mya arenaria, Cardium edule, Macoma baltica, and Polydora redekei ("a genuine brackish-water species"). Flounder fed almost exclusively on Corophium and Nereis.

Pike-perch Stizostedium lucioperca is now most valuable fish in Ijsselmeer (remnant of Zuiderzee). (S. H. Hopkins)

Rees, George H. 1959. Larval development of the sand crab Emerita talpoida (Say) in the laboratory. Biol. Bull., 117:356-370.

Larvae were raised at 30 C and salinity ranging from 28.2 to 35.1 ppt with a mean of 32.2 ppt. Six zoeal stages and one megalops are drawn and described. A seventh zoeal stage is also described. There is not a fixed number of larval stages since diet, trophic conditions, or other environmental factors may shorten or lengthen larval life during the breeding season, although they show no direct evidence of this. (S. Rennie)

Rees, George H. 1967. Blue crab program. Report of the Bureau of Commercial Fisheries Biological Laboratory, Beaufort, N. C., Circular 264:8.

Development of megalops of blue crabs to the first crab stage depends on temperature over the range 68-86 F with a wide range of salinity. At 60 F the time required for molt is dependent on salinity, with higher salinities delaying development. (S. Rennie)

Rees, Gwendolen. 1941. The resistance of the flatworm Monocelis fusca to changes in temperature and salinity under natural and experimental conditions. Jour. Animal Ecol., 10:121-145.

This rhabdocoele turbellarian lives in rock pools with Littorina rudis, Patella vulgata, and, in summer, the copepod Tigriopus fulvus. Except the last, these animals live through salinity changes from 26 to 64 ppt and temperature changes from -1 to 28 C. Experimentally, M. fusca can stand direct transfer from sea water to solutions of various salinities from 5.6 to 76.8 ppt. When salinity is gradually increased by evaporation the flatworms survive up to 120.28 ppt, and when encysted up to 298.1 ppt. When temperature is raised, heat coma sets in at 41-44 C and death occurs at 44.5 C. (S. H. Hopkins)

Reeve, M. R., Raymont, J. E., and Raymont, J. K. B. 1970. Seasonal biochemical composition and energy sources of Sagitta hispida. Mar. Biol. (Borlia), 6(4): 357-364.

Biochemical analyses of Sagitta hispida were made and a lack of fluctuation in protein content in experimentally starved and fed animals was atrributed to environmental parameters, e.g., salinity. (From Biol. Abstr.)

Regan, C. T. 1912. Discussion on Wallaces Line. Rept. British Assoc. Adv. Sci., 1911:433-435.

According to Darlington (1957, Zoogeography, p. 41), Regan, in this report, tried to account for some details of the zoogeographic distribution of fresh-water fish by the passage of salt-tolerant species through the sea. (S. H. Hopkins)

Reid, D. M. 1930. Salinity interchange between sea-water in sand and overflowing fresh-water at low tide. Jour. Marine Biol. Assoc., U.K., 16:609-614.

Field observations showed that a stream of fresh water passing over intertidal sand had little effect on the salinity of water in the sand. Therefore, organisms that burrow in the sand may easily resist tidal changes due to the tolerably constant substrate salinities. (S. Rennie)

Reid, D. M. 1932. Salinity interchange between salt water in sand and overflowing fresh water at low tide. II. Jour. Marine Biol. Assoc. U.K., 18(1):299-306.

Marine burrowing animals living in estuaries are not affected by fresh water flowing over them at low tide provided they can burrow down to a depth of about 12 in. Only animals that live on surface have to adapt to varying conditions. The faster the fresh water runs over the sand the faster it leaches out salt, but a very short time under the tide brings water in the sand back to high salinity. It is more difficult to reduce the salinity of water in the sand than to increase it. (S. H. Hopkins)

Reid, G. K., Jr. 1954. An ecological study of the Gulf of Mexico fishes in the vicinity of Cedar Key, Florida. Bull. Mar. Sci. Gulf and Caribbean, 4:1-94.

From June 1950 to May 1951, an investigation of the fishes inhabiting various areas near Cedar Key, Florida was made utilizing mainly the otter trawl and seine. Collections were made in shallow flats, deep flats, channels, shallow beach zones, and offshore areas. Salinity, rainfall, current, and water and air temperature measurements were made. Salinities ranged between 9.7 and 33.8 ppt, averaging 25.7 ppt. Stomach contents, gonadal development, and morphological characteristics were noted. He collected 122 species representing 100 genera and 58 families, and gave salinity notations for each species. Conspicuous correlation of changes in the total fish population with abrupt salinity fluctuations was not observed; and as the general population integrity was maintained during periods of prolonged low salinity, Reid felt that salinity was not a critical factor. Most of the species listed were considered to be euryhaline. (T. Rennie)

Reid, George K. 1955. A summer study of the biology and ecology of East Bay, Texas. Part I. Introduction, description of area, methods, some aspects of the fish community, the invertebrate fauna. Texas Jour. Sci., 7:316-343.

This study was made to determine conditions prior to dredging of a pass to connect East Bay with the gulf, to permit passage of fish, so special attention was paid to salinity. Salinity isohalines are shown in maps. Most attention was paid to fishes, of which 50 species were collected. The croaker, Micropogon undulatus, was the most abundant fish. The abundance of various species is discussed in relation to salinity and bottom composition. Fish catches in East Bay are compared with those reported by Gunter in Aransas and Copano Bays. Most species found are considered to be euryhaline throughout their life span. Relatively few invertebrates are reported, evidently because no real effort was made to get a complete census of invertebrate species. (S. H. Hopkins)

Reid, G. K. 1956. Ecological investigations in a disturbed Texas estuary. Texas Jour. Sci., 8(3)296-327.

Previous study had been made in summer of 1954. In January 1955 Rollover Pass was completed through Bolivar Peninsula, 80 ft wide and 3-8 ft deep, subsequently widened by waves and currents to nearly 300 ft by June 1955. Present study was made in summer 1955.

In June 1954 there was a typical estuarine salinity gradient from approximately 4 ppt at upper end of bay to around 18 ppt in lower end. In June 1955 salinities ranged from 30 ppt at bay end of Rollover Pass to 20 ppt in midbay nearby, then sloped off in both directions to 12 ppt at upper end of bay and about same (11-14 ppt) in lower end or mouth where East Bay joins Galveston Bay. About the same number of species of fish (50) were found as in 1954 study, but there were

10 new species and 9 species caught in 1954 were not seen in 1955. Most of the catch was made up of same species as in 1954. Menhaden and anchovy were more abundant, croaker and spot less so. Brown shrimp was less and white shrimp more abundant in 1955 than in 1954. Sea bob, not taken in 1954, were taken in 1955. (S. H. Hopkins)

Reid, G. K. 1957. Biologic and hydrographic adjustment in a disturbed Gulf Coast estuary. Limnol. and Oceanogr., 2(3):198-212.

East Bay (of Galveston Bay system) was studied in summers of 1954 (before Rollover Pass was cut), 1955 (with Rollover Pass open), and 1956 (after pass was partially closed). The salinity pattern in 1956 was similar to that in 1954 except for a high-salinity (22 ppt) pocket just inside the pass, and populations of dominant fish and shrimp species suggested that there had been a rapid reversion toward the natural (prepass) condition. A chart of isohalines based on average salinities in 1956 shows a gradient from 13 in upper end of East Bay to 21 near south shore just inside Hanna Reef, with lower salinities along north than south shore, and pocket of 17-22 ppt water near the pass, at Gilchrist. Excluding the extreme upper end of the bay, 1954 salinity ranged from 10 to 20 ppt, 1956 from 14 to 21 ppt, with lowest salinities at upper end and highest near mouth of bay. In 1955 the pattern was reversed, with salinity in upper part averaging near 18 ppt and approximately 15 ppt in lower end of bay. (S. H. Hopkins)

Reid, G. K. 1961. Ecology of inland waters and estuaries. Reinhold, New York. xvi + 375 pp.

Estuaries, pp. 69-80 (Chap. 4); definitions p. 69: "a body of water in which river water mixes with and measurably dilutes sea water" or "the wide mouth of a river or arm of the sea where the tide meets the river currents, or flows and ebbs." Lagoons, p. 73, fjords, p. 74. Parameters of estuarine basins, pp. 76-78. Shores, substrates, zonation, pp. 78-80. Dissolved solids in natural waters (Chap. 10), pp. 176-207. Salinity, pp. 203-207; defined pp. 203-204; "Venice System" of classification of waters according to salinity, p. 204; distribution of salinity in estuaries, pp. 205-207. Salinity effects on populations of organisms, pp. 265-267. (S. H. Hopkins)

Reid, G. K. and Hoese, H. D. 1958. Size distribution of fishes in a Texas estuary. Copeia, 1958(3):225-231.

Analyzes by histograms size distribution of croakers (Micropogon undulatus) and spot (Leiostomus xanthurus) caught by trawl in summers of 1954 (before Rollover Pass was cut through at upper end), 1955 (with pass open), and 1956 (with pass partly closed), in East Bay, Texas. As pointed out by Gunter (1945), sizes decrease going from high to low salinity, as a rule. This may be due to abundance of food or to later juveniles entering a bay "leapfrogging" over earlier entrants and, thus, younger individuals being farther up the bay. Three charts in fig. 1 show salinity patterns in East Bay in 1954, 1955, and 1956. (S. H. Hopkins)

Reintjes, J. W. and Pacheco, A. L. 1966. The relation of menhaden to estuaries. Pp. 50-58. In: A symposium on estuarine fisheries. Am. Fish. Soc. Special Publ. No. 3, viii + 154 pp. Washington, D.C.

Atlantic menhanden, Brevoortia tyrannus, and gulf menhaden, B. patronus, support the largest fishery in North America. They spawn in gulf and Atlantic Ocean; larvae move into estuaries and upstream to near limits of saline water. Larvae and juveniles occur in salinities as low as 1 ppt or less. In south Texas juveniles survive salinities up to 60 ppt but are killed by 80 ppt (in Laguna Madre). Juveniles landlocked in a South Carolina reservoir survived several years and grew to large size but never spawned. Larvae metamorphosed in

laboratory at salinities of 25 to 40 ppt, so the low salinity in which they live in nature is not a physiological requirement. "Food is probably the principal biological factor affecting the well-being of menhaden in an estuary." Zooplankton is the principal food of larval menhaden. (S. H. Hopkins)

Remane, A. 1958. Oekologie des Brackwassers. Pp. 1-213. In: Die Biologie des Brackwassers. Schweizerbartsche Verlag, Stuttgart.

Classifies the euryhaline component of estuarine faunas into four grades based on the lowest salinities to which they penetrate. Grade 1 penetrates to salinity of 15 ppt and includes 100 polychaete species, 300 nematodes, 200 copepods, etc. (in Europe). Grade 2 penetrates to 8-15 ppt: The snail Littorina littorea, the sea anemone Halcampa duodecimcirrata, etc. Grade 3 penetrates to 3-8 ppt and includes, for example, many tintinnid protozoans and the moon jellyfish Aurelia aurita. Grade 4 penetrates to salinities below 3 ppt; e.g., the cladoceran Evadne nordmanni penetrates to 1.3 ppt, but also occurs in full sea water. The "euryhaline component" thus classified includes only animals that live both in sea and in brackish water, excluding those that live only in low salinities, such as certain species of the isopod genus Sphaeroma and of the isopod genus Asellus. Remane (1958) also divided the freshwater component of brackish-water faunas into three grades. (Cited from Green, 1968, pp. 65-67.) (S. H. Hopkins)

Remane, A. and Schlieper, C. 1971. Biology of brackish water. 2d revised ed. (Band XXV of Die Binnengewasser, E. Schweizerbart'she Verlagsbuchhandlung, Stuttgart, West Germany.) Interscience Div., John Wiley & Sons, New York, vii + 372 pp.

Part I, Ecology of brackish water, pp. 1-210, by Remane, starts with 15 pages on salinity as a factor in distribution of animals. Part II, Physiology of brackish water, by Schlieper (139 pages), includes a 17-page section on limits of salinity tolerance of many representative plants and animals. Both sections emphasize European examples, but American literature is also covered to some extent. There are approximately 800 references on ecology and 550 on physiology. (This book was received too late for use in preparation of the bibliography.) (S. H. Hopkins)

Renfro, W. C. 1959. Survival and migration of fresh-water fishes in salt water. Texas Jour. Sci., 11(2):172-180.

In experiments Notropsis lutrensis lived 9 days in salinity of 11.5 ppt, Pimephales vigilax lived "more than a week" in 11 ppt, Gambusia affinis by gradual steps was acclimated to salinities as high as 24 ppt and back to fresh water, Gambusia hurtadoi from Mexico was found to live indefinitely in salinities up to 15 ppt but not above 17 ppt, salinities above 9 ppt were slowly lethal to Micropterus salmoides, Lepomis punctatus tolerated salinities below but not above 15 ppt for "fairly long" periods, and Etheostoma fonticola lived more than 6 days in 11.6 ppt but survived only a "short" time in salinities above 13 ppt. In addition Carpoides carpio was caught in Galveston Bay in salinity of 6 ppt, Ictalurus furcatus was caught in Trinity Bay in 4.8 ppt, Roccus mississippiensis was caught in Galveston Bay in 7.5 ppt, and Pomoxis annularis was caught in Trinity Bay in a salinity of 2.9 ppt. (S. H. Hopkins)

Reshoft, K. 1961. Untersuchungen zur zellularen osmotischen und thermischen Resistenz verschiedener Lamellibranchier der deutschen Kustengewasser. Kieler Meeresforsch., 17:65-84.

Experiments were made on isolated gill tissue of eight German coastal bivalves: Spisula solida, Modiolus modiolus, Mya arenaria, Mytilus edulis, Cyprina islandica, Astarte borealis, Congeria cochleata, and Dreissena polymorpha. Results agree with natural horizontal and vertical distributions of these mollusks.

The most resistant was Congeria cochleata, a brackish-water mussel introduced into Kiel canal from southwest Africa; its gill cilia remained active after 72 hr, in salinities of 30 and 0.5 ppt. The freshwater and brackish-water Dreissena polymorpha gill tissue tolerated best salinities of 3-9 ppt (the salinity of the canal, from which it was taken, was about 6 ppt); its gill cilia became inactive after 48 hr in 15 ppt. Congeria cochleata was also the most resistant of the eight species to high temperature, the gill cilia remaining active 18 min at 42 C, and being killed in 2 min only by 45 C. (S. H. Hopkins)

Reyment, R. A. 1964. Note on an upper salinity tolerance level for Cypridopsis (Ostracoda). Crustaceana, 7:75-76.

P. 76..."Cypridopsis vidua and C. obesa are able to survive in a concentration of freshwater salts up to 1.6 ppt, which is twice the figure available for C. vidua with respect to marine salts." Higher concentrations of marine salts may possibly be tolerated in the laboratory. (S. Rennie)

Ricci, E. 1939, L'adaptation de la Moule commune (Mytilus galloprovincialis) aux changements de salinité. Recherches biologiques et physico-chimiques. Ann. Fac. Sci. Marseille, (2)12(1):47-80; 9 plates of tables and graphs.

In experiments carried out at 17-18 C, Mediterranean mussels easily tolerated dilution of sea water to 70% of the concentration of sea water, but adapted with greater difficulty to 40% sea-water solutions and not at all to fresh water. Power of adaptation was lessened by making the sea-water solution acid or alkaline. Dilution of sea water causes the mussel first to gain weight rapidly, then lose weight, the weight at the end of the experiment being less than at the beginning. Weight changes are lessened by making the sea-water solution acid or alkaline. Salt concentration within the mussel is kept higher than that of the external medium (diluted sea water). Tables show measurements 5, 10, 15, 20, 30, 40, 45, 60, 75, and 120 min after start of experiment. The longest experiment was only 72 hr. (S. H. Hopkins)

Rice, T. R. 1963. Accumulation of radionuclides by aquatic organisms. In: Studies of the Fate of Certain Radionuclides in Estuarine and Other Aquatic Environments, Sabo, J. J. and Bedrosian, P. H., eds. U.S. Public Health Serv. Publ. No. 999-R-3:35-50.

Accumulation of Cs^{137} by phytoplankton in fresh water is 52 to 1530 times its concentration in the medium. Marine species concentrate it at not more than 3.1 times the amount in the medium. This difference is probably due to the higher concentration of potassium in sea water. (S. Rennie)

Riech, Fr. 1926. Beitrage zur Kenntnis der litoralen Lebensgemein-schaften in der poly-and mesohalinen Region der Frischen Haffs. (Contribution to knowledge of the littoral communities of living organisms in the polyhaline and mesohaline regions of the Frischen Haffs.) Schr. Phys.-oekon. Gesellschaft. Konigsberg i. Pr., 65(1).

Used Cl spectrum (chlorinity) as index of salinity in zoning brackish-water flora and fauna in Baltic "Haffes," according to Redeke, 1932. The Frischen Haffs is a brackish-water lagoon connected to the Baltic Sea by a narrow pass. This reference, cited as in Redeke (1932), has not been located. (S. H. Hopkins)

Riemann, F. 1966. Die interstitielle Fauna im Elbe-Aestaur. Verbreitung und Systematik. (The interstitial fauna in the Elbe Estuary, distribution and systematics.) Arch. Hydrobiol. Suppl., 31(1-2):1-279.

In this long paper on the small animals that live between soil particles in the bottom sediments, the salinities of various parts of the brackish-water zone

(0.5 ppt at Gluckstadt to 13.1 at Altenbruch at ebbtide, 1.0 ppt at Gluckstadt to 31.5 at "Elbe 1" in flood tide), and of the "so-called limnetic zone" (0.06- to 0.67-ppt chlorinity), are discussed on pp. 9-12. The animals covered include ciliates, Protohydra, Turbellaria, Gastrotricha (Chaetonotoidea and Macrodasyoidea), rotifers, nematodes (which make up most of this fauna with numerous species), nemerteans, Opisthobranchia (Pseudovermis aff. paradoxus only), Archiannelida (Protodilus), small polychaetes, Oligochaetes, tardigrades, harpacticoid copepods, Cladocera (Iliocryptus sordidus) ostracods, Collembola, and mites. The species found are grouped according to their salinity relations. There is a long English summary, pp. 268-270. (S. H. Hopkins)

Riggs, Carl D. 1957. Mugil cephalus in Oklahoma and northern Texas. Copeia, 1957:158-159.

A specimen of the striped mullet was collected from the draft tubes of small generators of the Denison Dam, Lake Texoma, in June 1956. Other specimens were caught below the dam previously in 1956 and 1955. The dam is located in Bryan County, Oklahoma, and Grayson County, Texas, and impounds the Red River. [This is 800 miles upriver from gulf.--SHH.] (S. Rennie)

Riley, G. A. 1937. The significance of the Mississippi River drainage for biological conditions in the northern Gulf of Mexico. Jour. Marine Res. (Sears Found.), 1(1):60-74.

In this paper, which has come to be considered something of a classic, it is pointed out that chlorophyll, an index of phytoplankton abundance, is found in largest quantities in the lowest salinity (water with largest percentage of river water), which also has the highest content of phosphate and copper; the area of low salinity and high phytoplankton abundance in a narrow zone near shore from Mobile Bay to western Louisiana, or perhaps as far as Galveston Bay, with a projection into the gulf off the mouths of the Mississippi River. However, the quantity of chlorophyll (hence phytoplankton) does not correlate all the way with salinity and nutrient content of water, but shows a dip to a minimum in salinity of about 10 ppt, so there are two peaks, one in fresh water and one in water with salinity of 25-30 ppt. It is suggested that the depressing factor in 10-ppt salinity is salinity itself, limiting growth of algae that require low salinity. (S. H. Hopkins)

Riley, Gordon A. 1967. The plankton of estuaries. Pp. 316-326. In: Lauff, G. H., ed. Estuaries. Am. Assoc. Adv. of Sci. Publ. No. 83, Washington, D. C., xv, 757 pp.

Discusses phytoplankton and zooplankton of shallow estuaries (i.e. not fjords). Reduced salinity of estuaries probably limits the population, at least in cases of freshening. However, field and laboratory observations on effects of salinity do not always agree, and the normal salinity range of a species may vary from one estuary to another. Probably salinity operates in an indirect way, affecting the delicate balance of interspecific competition at ranges that are well within the limits of absolute tolerance. The phytoplankton species mentioned are mostly diatoms, and the animals mentioned are mostly copepods, with emphasis on Acartia clausi in the north and Acartia tonsa in the south. (S. H. Hopkins)

Ristanovic, B. and Miller, C. E. 1969. Salinity tolerances and ecological aspects of some fungi collected from fresh-water, estuarine and marine habitats. Mycopathol. Mycol. Appl., 37(3):273-280.

Twenty species of Fungi Imperfecti, including strains from fresh water, estuarine, and marine habitats in the environs of the middle and lower Neretve River, Yugoslavia, were collected, purified, and identified. Strains of nine species from fresh, brackish, and sea water were grown on various NaCl concentrations.

These fungi exhibited a wide amplitude of salt tolerance. Brackish-water strains were found to be more like strains isolated from fresh water than from sea water. Brackish-water strains were able to grow well in zero or low concentrations of NaCl but they could not do as well at the higher NaCl concentrations. The results of the laboratory experiments with NaCl concentrations support the findings in nature. (P. Maxwell)

Ritchie, Don. 1957. Salinity optima for marine fungi affected by temperature. Amer. Jour. Bot., 44(10):870-874.

In Phoma sp. from sea water, optimum temperature 25 C, no growth occurred at 6-7 C or at 37 C in any medium, or was slow, depending on salinity. At intermediate temperatures growth rate varied with salinity. At 16 C optimum salinity was 19 ppt; at 25 C, 23 ppt; at 30 C, 34 ppt, and at 37 C growth was slow in all salinities but best at 47 ppt. In marine Pestalotia sp., optimum temperature 25 C, range 7-37 C, intermediate temperatures followed Phoma pattern. At 16 C, optimum salinity was below 8 ppt; at 25 C, it was 15 ppt; at 30 C, up to 44 ppt. A species of Lulworthia had a narrow range of temperature tolerance and no temperature-salinity relations like those of Phoma. The salinity-temperature relations shown here could help to explain geographic and seasonal distribution of some facultative halophiles. (S. H. Hopkins)

Ritchie, Don. 1959. The effect of salinity and temperature on marine and other fungi from various climates. Bull. Torrey Bot. Club., 86(6):367-373.

Five species of fungi were cultured in salinities of 10, 25, 34, 55, 80, and 102 ppt at temperatures of 6, 16, 25, 30, and 37 C with special tests at 7, 20, 33, and 42 C. The organisms were Aspergillus flavus (a tropical species), Curvvularia and Chaetophoma (from Delaware Bay, 13 C), Helicoma (Nanaimo, B. C., 12.5 C), and Mucor Spinescens (Pennsylvania). Only Curvularia showed clearly a pattern of good growth with low salinities at low temperatures and high salinities at high temperatures. Growth patterns of the others showed them to be best adapted to the habitats from which they were collected. (S. Rennie)

Ritchie, Don. 1960. The evolution of salinity tolerance in fungi. Trans. New York Acad. Sci., 23(2):138-140.

In the discussion of salinity tolerance in fungi, Ritchie says there are many fungi that are able to grow and reproduce under marine conditions. He considers a fungus marine, if it is obtained from marine or brackish water and if it can grow and reproduce on media containing 35 ppt of such salts as occur in ocean water. Every major division of fungi includes sea-dwelling members. The Basidiomycetes, however, are poorly represented, but even some of them can occasionally grow in places where salinity is a considerable factor. Some fungus groups show intermediate tolerance, i.e., marine slime molds, Phycomycetes, and the Ascomycetes. Transitional forms have been demonstrated in the Fungi Imperfecti. They exhibit a diversity of reaction to salinity ranging from a grudging tolerance in some Alternarias to a positive "preference" for a marine degree of salinity in marine Curvularias. By and large, fungi that live in salt water do not differ markedly in structure from fresh water or terrestrial fungi. He speculates that those fungi that now inhabit salt water are derived from freshwater forms either directly or indirectly by way of terrestrial intermediate ancestors. Marine Phycomycetes are an example of the former, and marine Ascomycetes, the latter. (T. Rennie)

Ritter, H. P. 1896. Report of a reconnaissance of the oyster beds of Mobile Bay and Mississippi Sound, Alabama. Bull. U.S. Fish. Comm., 1895, XV:325-338; plates 57-63; 1 map.

Survey was made 7 Feb-24 Mar, 1894, during a freshet. Preceding 1894 there had

been several successive years without freshets, so salinity had been higher than usual until 1894. "Borers, conchs, whelks, or drills" were found by Ritter even near the upper limit of oyster beds in Mobile Bay, and impressive destruction of oysters by "drills" was reported from beds in the more saline waters. Evidence that oysters do not "thrive so well" in the higher salinities was noted. (S. H. Hopkins)

Robertson, J. D. 1939. The ionorganic composition of the body fluids of three marine invertebrates. Jour. Exptl. Biol., 16:387-397.

Inorganic composition of the perivisceral fluid of Echinus esculentus was identical with sea water. The blood of Homarus vulgaris had higher concentrations of Na, K, and Ca ions, and lower concentrations than sea water of Mg and SO_4. In Cancer pagurus the blood contained more Na, K, and Ca and less Mg, Cl, and SO_4. Antennary gland fluid was high in Mg and SO_4 and low in other ions. (S. Rennie)

Robertson, J. D. 1949. Ionic regulation in some marine invertebrates. Jour. Exptl. Biol., 26(2):182-200.

This work was done at Millport, Scotland. Analyses were made of the ionic composition of body fluids of some 20 marine invertebrates of 5 phyla: 1 coelenterate (Aurelia), 2 echinoderms (Echinus and Marthasterias), 2 polychaetes (Arenicola and Aphrodite), 9 Mollusca including Pecten, Mya, Ensis, Buccinium, Sepia, and Loligo, and 6 crustaceans including Cancer, Carcinus, Palinurus, Nephrops, and Homarus. Some ionic regulation is found in all; most pronounced in the cephalopods and the decapod Crustacea. In echinoderms only potassium is regulated. Polychaetes regulated K and sulfate. Decapods regulated all ions. Lamellibranchs and gastropods accumulate K and Ca, eliminate some sulfate. In cephalopods, differential excretion by renal organs is an important factor in the strong ionic regulation. The ratio of Na + K to Ca + Mg in body fluid remains at sea-water value of 3.8 in Aurelia, echinoderms, annelids, and lamellibranchs, but decreases in gastropods and cephalopods to 3.5; in Crustacea, because of reduction of Mg, it increases from 3.8 in Lithodes to 9 and 12 in the palinurans and astacurans. (S. H. Hopkins)

Robertson, J. D. 1953. Further studies on ionic regulation in marine invertebrates. Jour. Exptl. Biol., 30:277-296.

Little regulation is shown by Holothuria and the bivalves Ostrea and Mytilus. The bivalves accumulate potassium and M. galloprovincialis accumulates sulfate. The nudibranch Archidoris accumulates K, Ca, and Mg, while the sipunculid Phascolosoma has lower Mg and SO_4 but higher Na^+. Sepia regulates all its ion except Mg. Fluid from the renal sacs contained high concentrations of NH_4^+ ions. The vitreous humor in the cephalopod eye is a protein-free fluid, isosmotic with the plasma. Among the decapod and stomatopod Crustacea examined, regulation of all ions existed. Species of Portunus and Eupagurus show more regulation than Dromia, Maia, and Hyas. Regulation in Squilla resembles that in the portunids. In Pachygrapsus each ion in the plasma is maintained below its equilibrium value. In 16 crustaceans the more active ones have lower values of Mg in the blood than the inactive ones. (S. Rennie)

Robertson, J. D. 1960. Osmotic and ionic regulation. Pp. 317-339. In: Waterman, T. H., ed. The physiology of Crustacea, Vol. I, Metabolism and growth. Academic Press, New York, xvii + 670 pp.

A review of the subject by one of the best known authorities. Marine and brackish-water forms, pp. 323-327; freshwater forms, pp. 327-331; other cases, pp. 331-333. (S. H. Hopkins)

Robson, E. A. 1957. A sea anemone from brackish water. Nature (London), 179:787-788.

The small sea anemone Nematostella vectensis is reported from brackish lagoons near the mouth of the River Ore. It had been found in brackish pools on Isle of Wight by Stephenson (1935, British Sea Anemones, Ray Society, London, Vol. II). Salinity of pools in which this species was found ranged from 8.7 to 37.7 ppt. Fide Green (1968, pp. 115-116). (S. H. Hopkins)

Robson, G. C. 1920. Observations of the succession of the gastropods Paludestrina ulvae and ventrosa in brackish water. Ann. Mag. Nat. Hist., Ser. 9, 6:525-529.

The snails Paludestrina ulvae and P. ventrosa were collected from a series of tidal ditches, in Essex, with salinities of 2.47%-2.95% NaCl. P. ulvae was found associated only with the alga Ulva lactuca, while P. ventrosa was found on a variety of plants. Artificial salinities of 0.5% NaCl caused P. ulvae to permanently contract into its shell, while concentrations of 1% NaCl had no apparent effect. (S. Rennie)

Roch, F. 1924. Experimentelle Untersuchungen an Cordylophora caspia (Pallas) (=Lacustris Allman) ueber die Abhaengigkeit ihrer geographischen Verbreitung und ihrer Wuchsform von den physikalisch-chemischen Bedingung des umgehenden Mediums. (Experiments on Cordylophora caspia (Coelenterata, Hydrozoa) concerning the dependence of their geographic distribution and their growth form on the physiochemical condition of the surrounding medium.) Z. Morph. Oekol. Tiere, 2:350-426.

Reviewed in some detail by Green (1968, pp. 111-114), along with work by Kinne (1956, 1957) on the effects of salinity and other factors on this freshwater and brackish-water hydroid. Roch found that it would survive in fresh water only if well aerated, while in brackish water it can live under low oxygen conditions, showing that brackish water is a more favorable medium for this species.
(S. H. Hopkins)

Rodriguez, Gilberto. 1963. The intertidal estuarine communities of Lake Maracaibo, Venezuela. Bull. Mar. Sci. Gulf and Caribbean, 13:197-218.

A short list of plants and animals is given, plus chemical and physical data. a table showing salinity ranges of the invertebrates found in the estuary is also given. No general conclusions relating to salinity are drawn. (S. Rennie)

Rogers, H. M. 1940. Occurrence and retention of plankton within the estuary. Jour. Fish. Res. Bd., Canada, 5:164-171.

This study on the Margaree River, flowing into the Gulf of St. Lawrence, was cited by Green (1968) as a good example of temporary plankton in an estuary so small that plankton stays in estuary only a single tide; freshwater organisms are carried downstream and out of estuary into sea water where high salinity kills them. At high tide the plankton is marine. (S. H. Hopkins)

Rogers-Talbert, R. 1948. the fungus Lagenidium callinectes Couch, 1942, on eggs of the blue crab in Chesapeake Bay. Biol. Bull., 95(2):214-218.

This fungus kills about 25% of the eggs in infected egg masses, which are about 80%-90% of all blue crab egg masses in Virginia waters. In nature almost all fungus infections are found in the area of lower Chesapeake Bay (and tributaries) from Buckroe Beach to Cape Henry, which is the area where most egg-bearing crabs are concentrated for spawning. In the laboratory, however, the fungus can develop in all salinities from 5 to 30 ppt, but not in fresh water.
(S. H. Hopkins)

Ross, Sheena S. and Morris, E. O. 1962. Effect of sodium chloride on the growth of certain yeasts of marine origin. Jour. Sci. Food Agric., 13:467-475.

The effect of varying concentrations of sodium chloride on the growth rates and cell production of yeasts isolated from marine fish from Scottish coastal waters was studied. Yeast strains of terrestrial origin were also examined. All strains of Debaryomyces kloeckeri gave a similar growth pattern having maximum cell production after 48 hr in 1.0%-3% sodium chloride w/v. Cell production decreased with increasing sodium chloride content in the medium. Several strains had maximum cell production in medium containing no sodium chloride, and had sharp falls with increased salt content. One strain grown in 1.0, 4.0, and 8.0 sodium chloride w/v, showed that at lower salt concentrations, the rate of growth during the exponential phase was unaffected, but the duration of the exponential growth was decreased slightly in 4.0% and significantly in 8.0% medium. Further investigations revealed that a complex nitrogen source could stimulate yeast growth and increase the maximum salt tolerance. Yeasts of marine origin were usually more salt tolerant than corresponding species of terrestrial origin. (T. Rennie)

Roughley, T. C. 1922. Oyster culture on the George's River, New South Wales. Government of New South Wales, Sydney. 69 pp.

Salinity is not mentioned in this otherwise complete and detailed account. On p. 17 it is mentioned that in 1887 heavy freshets smothered "a large proportion of the oysters" under a 3-in. deposit of mud. On p. 24, it is stated that in 1913 continued freshets again killed many oysters by mud deposits, but the fresh water proved beneficial because it killed the two greatest enemies of oysters, "wafers" and "borers," "the endurance of the oyster in fresh water being greater than that of either of these pests." On p. 23 the "wafer" is identified as the flatworm Leptoplana australis and the "borer" as the marine snail Xymene hanleyi. (S. H. Hopkins)

Roughley, T. C. 1925. The perils of an oyster. Australian Museum Magazine, 2:277-285. (Also: Mid-Pacific Mag., 1925:117-122.)

Pp. 278-279: Borers or Drills. "Probably the worst pest young oysters have to contend with is the boring whelk, a shellfish provided with a tongue-like rasp, or radula, by means of which a hole is bored through the oyster's shell, the flesh then being extracted piecemeal through the opening.... The mechanical drilling action is assisted by the secretion of sulphuric acid which converts the carbonate of lime of the oyster's shell into sulphate of lime and thereby greatly reduces its resistance.... Oyster borers are most common where the salinity of the water is fairly high; they cannot withstand water of low salinity.... There are three species of boring whelks found on the coast of New South Wales: (1) The common borer (Xymene hanleyi) which grows to a length of about an inch, and deposits its eggs in dome-shaped capsules about one-eighth of an inch in diameter.... (2) the black borer (Drupa marginalba) of about the same size as the preceding, but characterized by blunt protuberances, black in colour; and (3) the hairy borer (Cymatium parthenopeum), a larger species which attains a length of four inches and deposits its eggs in a parchment-like case held firmly against the under surface of the shell." (Legends of photos indicate Xymene hanleyi has over 100 larvae in egg case, held until well developed, and Cymatium, which is capable of penetrating the shells of adult oysters" has egg capsules concentrated in one large case.) (S. H. Hopkins)

Roughley, T. C. 1933. The life history of the Australian oyster, Ostrea commercialis. Proc. Linn. Soc. N. S. W., 58(314):279-333; 18 plates, 2 figs.

As part of a life history study of the Australian oyster (Ostrea commercialis), artificially fertilized eggs were placed in four tanks each having different

density sea water (1.021 to 1.005). It was found that the rate of development decreased in the lower densities. The free-swimming stage was reached in 8 hr in water of 1.021 density, while it took 10-3/4 hr in 1.015 density water. No free-swimming embryos developed at 1.005 density, and an examination 21 hr after the eggs and sperm were mixed showed 50% of the eggs were unfertilized, and those that were fertilized had not developed past the morula stage.

The author mentioned that the best spatting grounds in New South Wales were found in estuaries near the entrances of rivers. There the salinity was consistently high but had low suspensions of sediments. However, the growth of spat was much slower than it was upstream, where the salinity was lower on account of the fresh water continually received from the head of the river. In a tributary of the Hawkesbury River, near the entrance into Broken Bay, oysters occurred in large numbers but remained stunted and rarely grew to commercial size. If the oysters were moved to lower salinity areas upstream, they usually thrived and grew rapidly. (T. Rennie)

Rounsefell, George A. 1964. Preconstruction study of the fisheries of the estuarine areas transversed by the Mississippi River-Gulf Outlet Project. U.S. Fish and Wildlife Service Fish. Bull., 63(2):373-393.

Hydrographical and biological data collected from April 1959 through March 1961 at selected stations in marsh and bayou areas traversed by Mississippi River-Gulf Outlet Channel between New Orleans and Breton Sound to provide preconstruction data needed for later assessment of the effects on the fauna of such a wide and deep channel connected at the gulf end with water of high salinity. This channel will raise salinities over most of the project area. This should not greatly affect the fishes of the areas which are preponderately euryhaline. It should have an adverse effect on abundance of the blue crab. The possible effect on the white shrimp is obscured by their avoidance of the open waters of Lake Borgne and their preference for the shoal-protected marshes. (Author)

Rounsefell, G. A. and Dragovich, A. 1966. Correlation between oceanographic factors and abundance of the Florida red-tide (Gymnodinium breve Davis), 1954-61. Bull. Mar. Sci., 16(3):404-422.

Pp. 410-411: The range of salinity tolerated by G. breve in nature, as shown by surface samples taken off west coast of Florida, was 21 to 37 ppt. The upper limit at which "appreciable numbers" occurred was 35 ppt. The peak abundance was at 33 ppt, in the period of study (graph, fig. 4, p. 411).

Rucker, J. B. and Valentine, J. W. 1961. Salinity response of trace element concentration in Crassostrea virginica. Nature, 190:1099-1100.

Concentrations of trace elements were measured from sections of shells collected from West Chatham, Massachusetts to Port Aransas, Texas. Significant correlations were found between salinity and manganese and sodium. Correlation for combined strontium and magnesium is significant. The combined correlation of magnesium, magnesium plus strontium, and manganese and sodium with salinity is higher than for a single element. Negative correlation was found for elements that are presumably diadochic with calcium. (S. Rennie)

Runnegar, B. and Newell, N. D. 1971. Caspian-like relict molluscan fauna in the South American Permian. Bull. An. Mus. Nat. Hist., 146(1):5-66.

Fossiliferous sediments of Permian age occupy an area in the Parana Basin of Brazil, Uruguary, Paraguay, and Argentina, equivalent to about 1-1/2 times the size of the Gulf of Mexico. The remarkable endemicity of the Estrada Nova fauna and carbon isotope paleosalinities suggest intrabasinal evolutionary radiation under conditions of brackish water and extreme isolation. The taxonomy of 24 generic and 57 specific names employed for the Permian bivalves is revised

and their biologic and ecologic significance is analyzed. (From Biol. Abstr.)

Runyan, Suzanne. 1961. Early development of the Clingfish, Gobiesox strumosus Cope. Chesapeake Sci., 2(3/4):113-141.

The clingfish, G. strumosus, is an estuarine and marine species. It is usually taken in shallow, brackish waters and particularly around oyster bars, as it lays eggs inside empty oyster shells. Development was studied in the natural waters of Solomons, Maryland; salinity 11-16 ppt. The species has been found in tide-pool salinity of 27.2 ppt in Florida. (T. Rennie and S. H. Hopkins)

Russell, H. D. 1941. The recent mollusks of the family Neritidae in the Western Atlantic. Bull. Mus. Comp. Zool., Harvard, 88(4):345-404.

Moore, 1958, Marine Ecology, cites on pp. 404-405: Smaragdia viridis fully marine. Nerita peloronta, N. versicolor, and N. tessellata marine but tolerate lowering salinity in order named. Puperita pupa and P. tristis tide-pool species. Nerita fulgurans increases from marine to brackish. Neritina virginea found in brackish water; N. meleagris and N. piratica brackish forms. Neritina zebra and N. reclivata range from brackish to fresh water. Fluvinerita tenebricosa, Neritina clenchi and N. punctulata, and Neretilia succinea are all freshwater forms. In tropical western Pacific there is a terrestrial species, Neritina cornea. (S. H. Hopkins)

Ryan, E. P. 1956. Observations on the life histories and the distribution of the Xanthidae (mud crabs) of Chesapeake Bay. Am. Midland Naturalist, 56:138.

The following crabs were collected from Chesapeake Bay in the salinity range indicated: Neopanope texana sayi (Smith), 14.66-18.30 ppt; Panopeus herbsti, 13.95-19.04 ppt; Hexapanopeus angustiferons, 18-32 ppt; Eurypanopeus depressus, 4.5-20.4 ppt; and Rhithropanopeus harrisi, 2.8-18.6 ppt. The author draws no conclusions about salinity since the organisms were collected by others over a series of years. (S. Rennie)

Ryder, John A. 1883. Rearing oysters from artificially fertilized eggs, together with notes on pond culture. Bull. U.S. Fish. Comm., 3:281-294.

Found that oysters thrive best in a specific gravity ranging from 1.007 to 1.020. Also described the effects of brackish water on saltwater oysters and of salt water on brackish-water oysters. (P. Maxwell)

Rykova, T. I. 1964. On the salinity tolerance of Chinese herbivorous fishes in early stages of development. Tr. Vses. Nauch-Issled. Inst. Morskogo. Ryon Khoz Okeanogr., 55:195-196. From Ref. Zhur., Biol., 1965, No. 10170.

The salinity tolerance of sperm, eggs, and larvae of grass and silver carp in Caspian and Black Sea waters of varying salinity was studied. Sperm of grass carp retained their mobility in Black Sea water having a salinity of up to 7.5 ppt. Egg development was disturbed at 6.3 ppt salinity and hatching at this salt concentration was very slight. Larvae of grass carp survived a salinity of up to 7.6 ppt and those of silver carp a salinity of up to 6 ppt. In Caspian waters both grass and silver carp withstood higher concentrations. Variation of volume of the perivitelline space with increase in salinity was investigated.

Ryther, John H. 1954. The ecology of phytoplankton blooms in Moriches Bay and Great South Bay, Long Island, New York. Biol. Bull., 106:198-209.

Nitzschia closterium, Nannochloris atomus, and Stichococcus cylindricus were cultured at 34.51, 25.91, 17.44, 8.91, and 3.80 ppt. Nitzchia showed an optimum growth at or near full strength sea water. The other two forms had optima

at about 50% sea water and so are considered brackish-water species.

In the field Nannochloris and Stichococcus normally occurred in Moriches Bay at 15 ppt. It occurs over the entire range of salinity as long as nutrients are present. Nitzchia, on the other hand, is limited by salinity, not being able to grow at the two lower salinities tested, and may be succeeded by other forms in the field. (S. Rennie)

Sacchi, C. F. 1961. L'évolution recente du milieu dans l'étang saumatre dit "Lago di Patria" (Naples analysée par sa macrofaune invertébrée. Vie et Milieu, 12(1)37-65.

An ecological survey of this brackish Italian lagoon; includes salinity (usually 13-14 ppt) of lagoon and neighboring waters, some fresher and some saltier; dissolved oxygen; H_2S; nitrates, nitrites, and phosphates; pH; temperature; and history of man-made changes. Then a discussion of the history of each common species in the area, shown in more compact form in a foldout table between pp. 62 and 63. Forty-three species of benthic macroinvertebrates are listed in the table with distribution in time and place and comparative abundance. This includes 2 Hydrozoa, 3 Bryozoa, 2 Polychaeta, 1 leech, 1 barnacle (B. eburneus), 1 isopod, 2 amphipods, 7 decapods, 5 insects, 6 prosobranch snails and 1 pulmonate snail, and 12 Lamellibranch mollusks including Ostrea edulis (very rare and localized) and Mytilus galloprovincialis, more common. (S. H. Hopkins)

Saha, K., Chakraborty, D., De, B., and Chakraborty S., Jr. 1969. Studies on the salinity tolerance of fry of major Indian carps in captivity. Indian Jour. Fish. A, 11:247-248.

Five nursery tanks, each having 500 sq ft and varying from 3 to 4 ft in depth, contained one of five different salinities ranging from 500 to 3000 ppm (0.5 to 3 ppt). Five hundred carp fry were released into each tank and the percentage survival was recorded for two consecutive fry seasons. Eighty percent survived in a salinity range of 500 to 1000 ppm; while survival decreased to 66 percent at a range of 2500 to 3000 ppm. Growth rates increased with increased salinity. (T. Rennie)

Sanders, H. L., Mangelsdorf, P. C., Jr., and Hampson, G. R. 1965. Salinity and faunal distribution in the Pocasset River, Massachusetts. Limnol. and Oceanogr., 10(Suppl.):R216-R229.

Salinities from sediments and bottom water from seven stations on the Pocasset River (a fluctuating estuary) were taken along with benthic invertebrate fauna samples in 1963. Bottom water showed the most fluctuation highest up in the estuary. Sediment water was relatively stable over tidal changes, but increased in salinity seaward. Epifauna was poorly represented at the upper four stations. Infauna was three times more abundant at the upper three stations (mean sediment salinity 7-20.9 ppt) than at the lower stations.

Station 3 was considered a transitional zone (sediment salinities 19-22 ppt), and was studied again in 1965. Infauna samples were separated by depth in the substrate. Each group was subjected to high (23.3 ppt), low (3.19 ppt), and control salinity (19.9 ppt) water. Those animals which avoid the topmost region of sediment died in the low salinity water. Those organisms which inhabit the topmost centimeters either acted normally or closed up (in the case of the mollusks Hydrobia and Gemma) in the low salinity. In the field, Hydrobia was also found to hide in places which can retain high salinity water, such as algal mats, at low tide. (S. Rennie)

Sandison, E. E. and Hill, M. B. 1966. The distribution of Balanus pallidus stutsburi Darwin, Gryphaea gasar ((Adanson) Dautzenberg), Mercierella enigmatica Fauvel and Hydroides uncinata (Philippi) in relation to salinity in Lagos Harbour and adjacent creeks. Jour. Animal Ecol., 35(1)235-250.

Tidal influence and seasonal rainfall cause salinities to vary in Lagos Harbour as much as 20 ppt daily and 34 ppt annually. Salinity measurements in Kuramo Water were from 26.5 to 6.9 ppt. Salinities along Kuramo Creek ranged between 5.8 and 1.1 ppt at the fresher end and 9.4 to 4.8 ppt near Kuramo Water.

Balanus, Gryphaea, Mercierella, and Hydroides are all abundant in the harbor during the early part of the high salinity season from January to March. With

heavy rainfall in April and May they suffer a high mortality. At the end of the low-salinity season, few are found alive. In the Kuramo area, all are found alive throughout the year.

In addition to a seasonal distribution in the harbor, a spatial distribution is seen in Kuramo Creek. At the fresher end of the creek (2.0-26 ppt) a few barnacles, Chthamalus and Balanus, are found about one-fourth of the way. The oysters (Gryphaea) dominate near the middle of the creek (1.7-23 ppt). At the saline end (7.0-23 ppt) the serpulids (Hydroides) are the dominant organisms. (S. Rennie)

Sandoz, Mildred. 1943. Steps toward crab conservation in Chesapeake Bay. Commonwealth, 10(7):1-6.

Experiments indicated that the optimum salinity for hatching of eggs was 23-30 ppt at 19-29 C. (S. H. Hopkins)

Sandoz, Mildred and Hopkins, S. H. 1944. Zoeal larvae of the blue crab Callinectes sapidus Rathbun. Jour. Wash. Acad. Sci., 34(4):132-133.

Favorable conditions were established as a salinity range of 23-30 ppt and a temperature range of 19-29 C. Outside these ranges, eggs failed to hatch or the larvae hatched as prezoeae (which did not survive). The first three zoeal stages were reared under the same conditions favorable for hatching. (S. H. Hopkins)

Sandoz, Mildred and Rogers, Rosalie. 1944. The effect of environmental factors on hatching, moulting, and survival of zoea larvae of the blue crab, Callinectes sapidus Rathbun. Ecology, 25(2):216-228.

Methods used are described and results given in detail (7 tables, 2 graphs; also 1 map, 1 diagram; 3 drawings taken from thesis of R. L. Robertson). In lower salinities like those in Maryland part of Chesapeake Bay, eggs hatch abnormally as prezoeae. Hatching of normal first zoea larvae and their development into second zoea stages is optimum at salinities of 23-28 ppt, and temperatures of 19-29 C. Bright orange (newly laid) eggs hatch under these conditions in 11-14 days, the first zoea molts to become second zoea in 6-7 days more, and the few second zoeae that molted to become third zoeae did so in another 5-7 days. The conditions of salinity and temperature found to be favorable correspond closely to those found near the mouth of Chesapeake Bay, which is the area in which plankton tows show the largest numbers of blue crab zoeae. (S. H. Hopkins)

Sarkka, J. 1969. The bottom fauna at the mouth of the River Kokemaenjokio, southwestern Finland. Ann. Zool. Fenn., 6(3).

The qualitative and quantitative composition of the macroscopic bottom fauna in a brackish-water area off the mouth of the River Kokemaenjokio, southwestern Finland, is described. The local distribution of the species and their relation to some environmental factors such as salinity, oxygen content of the water, and the amount of deposited or precipitated organic matter, are discussed. Of these factors, the salinity and the amount of organic matter have the greatest effect upon the species composition and the bottom animal communities. (P. Maxwell)

Sato, T. and Craig, L. T. 1948. Oyster culture at Matoya Bay. (Australian) Fisheries Newsletter, April 1948, 7(2):10-11.

P. 11: For Ostrea laperousei, the "Hiroshima" oyster cultured at Matoya Bay, an estuary on Shima Peninsula, Japan, "The optimum specific gravity of water ranges from 1.020 to 1.024 for the best set, and in water below 1.015 and over 1.245 larvae do not live. This is probably due to the salinity content, because larvae which settle in water less than 1 m deep survive but others found in deeper water die."

P. 10: In December the salinity at surface and bottom is practically the same,

the typical winter feature. Highest salinity occurs January-February. In March salinity falls due to spring rains and surface and bottom waters show significant difference. Rainy season ends in late summer. "Generally speaking, the small bay of Matoya fed by Isobe River shows a significant oceanographic change between rainy and nonrainy days and seasons." (S. H. Hopkins)

Say, Thomas. 1817. An account of the Crustacea of the United States. Jour. Acad. Nat. Sci., Philadelphia, 1(5):65-444.

Callinectes sapidus (the blue crab, under the synonymous name Lupa hastata) is reported occurring 100 miles upstream in the St. Johns River, Florida (Fide Tagatz and Hall, 1971, p. 62). (S. H. Hopkins)

Scarratt, D. J. and Raine, G. E. 1967. Avoidance of low salinity by newly hatched lobster larvae. Jour. Fish. Res. Bd., Canada, 24:1403-1406.

Larvae were hatched at 30.6-32.3 ppt. When placed in layered water columns they avoided passing through the interface into fresh water. When offered layers of different salinities, the newly hatched lobsters did not pass readily into water of salinity of 21.4 ppt, suggesting that the avoidance reaction begins to take effect at a salinity higher than the lower limit for survival. (S. Rennie)

Schauman, Karsten. 1968. Higher marine fungi (Ascomycetes and Fungi Imperfecti) from the Weser-estuary. Veroff. Inst. Meeresforsch. Bremer., 11(1):93-117. (English.)

Based on salinity tolerance in situ most of the species were grouped into four different types: the haleuryhaline species (Cerrenalia macrocephala); the euryhaline species (Piricauda pelagica, Speira pelagica, Halosphaeria appendiculata, H. metiostligera, Leptosphaeria oraemairs, Lingnicola laevis, Marinospora calyptrata, Remispora hamata, and R. maritima); genuine brackish-water species (Humocola alopallonella, Leptosphalria discors, and Remispora pellenta); and the stenohaline species (Corollospora maritima and Zalerion maritima.

Schechter, Victor. 1942. Tolerance of the gulf coast snail Thais floridana, to waters of low salinity. Anat. Rec., 84:505-506.

Lethal effects set in rapidly when dilution drops below about 10 ppt of salt. Below 7 ppm, due apparently to the secondary effects of causing closure of the operculum, the lethal effect is somewhat lessened. In all dilutions small snails were more susceptible than large ones. (No doubt "ppm" is error; parts per thousand is meant). (S. H. Hopkins)

Scheltema, R. S. 1962. Environmental factors affecting length of pelagic larval development in the gastropod, Nassarius obsoletus. (Abs.) Zool. Rec., 2(3):445 (Abs. 15).

Larvae of N. obsoletus may have a long planktotrophic life. Duration is modified by circumstances under which larvae develop and by the environment at the time larvae are prepared to metamorphose. Length of pelagic period determines extent of dispersion and degree of attrition by predators. The main factors considered are temperature, salinity, and nature of substratum. Snails begin laying egg capsules at water temperatures between 13 and 17 C. Within the range at which larvae normally occur, 17-30 C, temperature markedly affects length of larval life. Within the salnity range at which larvae are normally found, salinity differences make no substantial difference in growth rate nor in time required for metamorphosis. Salinity affects growth and mortality only at lower limits of tolerance, approximately the same for larvae and adults, about 15-20 ppt.

Scheltema, R. S. 1965. The relationship of salinity to larval survival and development in Nassarius obsoletus (Gastropoda). Biol. Bull., 129(2):340-354.

Region of stress in adults 12.5 to 13.5 ppt
Region of stress in larvae 14.0 to 15.5 ppt

Net result of reduced salinity within the lower third of the range at which the larval development of N. obsoletus is completed is an increase in the length of time to reach the creeping-swimming stage which precedes metamorphosis and an increased mortality of larvae as the limit of saline tolerance is reached.

Scheltema, R. S. and Truitt, R. V. 1954. Ecological factors related to the distribution of Bankia gouldi Bartsch in Chesapeake Bay. Chesapeake Biological Laboratory, Solomons, Md., Publ. No. 100, 31 pp., illus.

P. 20 and fig. 6 on p. 21, "strike" (settling of larvae and penetration of wood) in Chesapeake Bay in relation to salinity. Pp. 22-25, discussion of salinity relations of shipworms in Chesapeake Bay and elsewhere based on literature and on own work. The graph, fig. 6, shows that the lowest mean salinity at which any strike occurred (two animals per test panel) was 8 ppt at Annapolis. Strike occurs farther upbay than adult shipworms live because larvae are carried upbay by higher salinity currents running upbay along the bottom. The next lowest salinity at which strike occurred, 20 per panel, was in a mean salinity of 9 ppt at Kent Narrows. Bankia gouldi was the only shipworm found in the upper bay. Teredo navalis has never been recorded north of the York River, salinity range 15-26 ppt. Strike of Bankia gouldi decreases with decrease in salinity upbay and increases logarithmically going downbay with increasing salinity. (S. H. Hopkins)

Scheltema, R. S. and Truitt, R. V. 1956. The shipworm Teredo navalis in Maryland coastal waters. Ecology, 37(4):841-843.

Test panels for these wood borers at Ocean City on the Atlantic Ocean and at Rattlesnake Landing and Snow Hill Public Landing on the western shore of the bay distant from both inlets, gave different results. The Ocean City panels showed 30 to 373 Teredo burrows, those at Rattlesnake Landing 4 to 30, and those at Public Landing none. The salinity at Ocean City was about 25 to 32 ppt, that at the other two stations lower but consistently well above the lower lethal limits, 9 ppt, which Miller (1926) reported for Teredo navalis. The reason for the low incidence of T. navalis at the two midbay stations is unknown. (S. H. Hopkins)

Schiltz, Mary E. and Trainer, Frances R. 1970. Production of male gametes and auxospores in a polymorphic clone of the centric diatom Cyclotella. Canadian Jour. Bot., 48(5):947-951.

Vegetative cells of a Cyclotella clone (03A) form male gametes and auxospores in response to salinity changes in the medium. (From Biol. Abstr.)

Schlieper, Carl. 1928. Die biologische Bedeutung de Salzkonzentration de Gewasser. Naturwissenschaften, 16(14):229-237.

The presence in sea water of monocarbonates, which occur in reduced amounts in brackish water and are frequently absent in fresh water, makes respiration easier for animals in the sea, particularly in the absorption of CO_2 by the sea water both in a physical solution and in chemical combination. This factor, rather than the increased osmotic pressure of fresh water with respect to the body fluids of animals, keeps marine animals from migrating into brackish water unless, like vertebrates and crustaceans, they have some mechanical means for increasing the rate of respiration. Thus among the bivalve mollusks, only those organisms with the largest gills are able to endure the reduction of alkalinity

of brackish waters. The occurrence of marine animals abundantly in brackish waters of the tropics in contrast with their scarcity in brackish waters of temperate regions is explained by the greater amount of monocarbonates which are present in the warm water, thus increasing the capacity for absorption of CO_2.

Schlieper, C. 1929. Uber die Einwirkung niederer Salzkonzentrationen auf mariner Organismen. (On the influence of lower salt concentrations on marine organisms.) Zeitschr. f. vergleich. Physiol., 9:478-513.

In the first section of this important paper Schlieper describes results of measurements of freezing points of blood or other internal fluids of several marine invertebrates, taken from or held for various periods in diluted and full-strength sea water, or in fresh water. On the basis of these results the animals studied were classified as poikilosmotic in diluted sea water (osmoconformers, as later workers would say): Nereis pelagica, Arenicola marina, Mytilus edulis, Hyas aranea, and Cancer pagurus); or as homoiosmotic (osmoregulators): Nereis diversicolor, Eriocheir sinensis, and Carcinus maenas. The first group have internal salinity closely following external salinity down as sea water is diluted (and are therefore usually not able to penetrate so far into estuaries), and the latter group keep the salinity of blood or other internal fluids much higher than that of the external medium as the surrounding sea water is diluted; Eriocheir sinensis is the best regulator of internal salinity and is therefore able to live even in fresh water, but most "homoiosmotic" or euryhaline marine invertebrates are intermediate between the homoiosmotic freshwater animals and the stenohaline or poikilosmotic marine invertebrates.

In the second section the author reports results of measurements of oxygen consumption in higher and lower salinities. In the crab Carcinus maenas, rate of respiration increases as salinity of the surrounding water decreases, over a period of several days, presumably because work must be performed to counteract the osmotic inflow of water, and this requires more oxidation in the cells. In the worm Nereis diversicolor, respiration likewise increases on transfer to a more dilute sea-water solution, but after some hours rate of respiration falls to the initial level. In Mytilus edulis, whole mussels of equal shell length show a decreasing rate of respiration (oxygen consumption) per 100 mg dry weight as the dry weight of meat increases, and a decreased rate of oxygen use per 100 mg dry weight in lower salinity (8 ppt compared with 16 ppt, or 8 ppt compared with 18 ppt, at 10 C). On the other hand, isolated gills of Mytilus had a higher oxygen consumption in lower (6 ppt) salinity than in 16 ppt, and a lower oxygen consumption in 29 ppt, at 17 C. Experiments were made also of oxygen use in different salinities of starfish, long-necked clams (Mya arenaria), and Carcinus maenas. It is concluded that oxygen demand is higher in lower salinities. "Whether still other factors act in the same direction--raising the oxygen demand or making respiration more difficult--with decrease of salt concentration in the external medium, must for the present remain uncertain."

The kinds of permeability of external surfaces are discussed in a third section. (S. H. Hopkins)

Schlieper, C. 1930. Die Osmoregulation wasserlebender Tiere. Biol. Rev., 5:309-356.

Aquatic animals that use dissolved O_2 have outer membranes permeable to water, and therefore all freshwater animals and marine teleosts must have mechanisms to control water content. In contrast, most stenohaline marine invertebrates are poikilosmotic--having osmotic pressure inside the same as that outside. However, even these have some osmotic control; body fluids of various mollusks and decapod crustacea and tunicates are frequently hypertonic to sea water. Euryhaline marine invertebrates undoubtedly have mechanisms for osmotic control. But marine teleosts have blood hypotonic to sea water, and their osmotic control must work oppositely. Certain invertebrates (Artemia, Pachygrapsus) also have hypotonic internal medium. It has been supposed that freshwater animals constantly

absorb water and pass it out through excretory organs, but osmotic control frequently takes place in a different way. Kidneys of marine teleosts are not concerned in osmotic control either--urine is hypotonic to blood. Still unknown how osmotic control in this group is accomplished. "Numerous...observations and experiments show that O_2 requirements and O_2 consumption increase in euryhaline invertebrates as the salt concentration of the external medium decreases. It is assumed that this increased respiration is required for the work done against an osmotic intake of water from the outside (Schlieper, 1929, Zeitschr. f. vergleich. Physiol., 9:478-513)." (S. H. Hopkins)

Schlieper, C. 1932. Die Brackwassertiere und ihre Lebensbedingungen vom Physiologischen Standpunkt aus betrachet. (The brackish-water animals and their living conditions, considered from the physiological standpoint.) Verhandl. Intern. Ver. Limnol., 6:113-146.

In this review paper the following topics are discussed: (1) experimental researches on the osmotic capability of freshwater and marine animals in brackish water; (2) the osmoregulatory abilities of dwellers in brackish water; (3) analysis of the osmoregulatory mechanisms of a few brackish-water animals; (4) metabolism and energy demand of brackish-water animals. The bibliography lists 51 references. (S. H. Hopkins)

Schlieper, C. 1935. Neuere Ergebnisse und Probleme aus dem Gebiet des Osmoregulation wasserlebender Tiere. Biol. Rev., 10:334-360.

Osmoregulatory organs assure constancy of the normal colloidal state of protoplasm. All freshwater and many brackish-water animals, elasmobranchs, and marine teleosts have such powers. No freshwater invertebrates or stenohaline freshwater fishes can maintain normal concentration of internal medium in sea water, nor can stenohaline marine animals in fresh water. But euryhaline marine invertebrates are homoiosmotic in brackish and some in fresh water. Euryhaline teleosts are homoisomotic in sea water and in fresh water. Excretory organs of many freshwater animals act as osmoregulators. Permeability of body surfaces is correlated with osmoregulatory powers. Gills or body surfaces of homoiosmotic brackish-water invertebrates carry salts against osmotic gradient from outside to inside, so excretory organs can form urine isotonic with blood. Marine teleosts drink sea water; gills secrete concentrated salt solution, kidneys excrete almost isotonic urine. Marine elasmobranchs may also excrete salts extrarenally. Development of osmoregulatory mechanisms made possible colonization of brackish and fresh waters from the sea. Most freshwater animals cannot live even in isotonic brackish water because tissues and kidneys need osmotic stream of water. Without this, turgor of tissues falls and excretory organs can no longer excrete nitrogenous wastes. (S. H. Hopkins)

Schlieper, C. 1964. Ionale und osmotische regulation bei ästuarlebenden Tieren. Kieler Meeresforsch., 20(2):169-178.

English summary, p. 169: "Ionic and osmotic regulation in estuarine animals: The constancy of the cellular ionic medium, especially the maintenance of the original cellular potassium level, is an essential condition for the unharmed survival of invertebrates and fishes in estuarine waters." The animals mentioned in text (this is a review paper) are Nereis diversicolor, Potamon fluviatilis, Palaemonetes varians, Arenicola marina, Asterias rubens, Mytilus edulis, Carcinus maenas, and the fish Cottus bubalis. Approximately 40 papers are cited, of which 9 are the author's own. (S. H. Hopkins)

Schlieper, C., Flügel, H., and Rudolph J. 1960. Temperature and salinity relationship in marine bottom invertebrates. Experimentia, 16:470-472.

All tests were done on excised gill tissue of bivalve mollusks. Tapes

decussatus showed the greatest resistance to increased temperatures, followed by Cardium edule, Mytilus galloprovincialis, and Pinna nobilis. Avicula hirundo and P. pectinata were sensitive to high temperatures. In Cardium individual thermal resistance decreased with lowered salinity. Acclimatization at a higher temperature produced greater thermal resistance. Cellular osmotic resistance of A. hirundo and P. pectinata was low in diluted media, while the others showed greater resistance. Acclimatization to a more dilute medium produces greater osmotic resistance in lower salinities.

Osmoregulatory performance depends on acclimatization temperature. Euryhaline shrimp are osmotically more resistant to salinity extremes at low temperatures. For Crangon osmoregulatory performance was observed to be strongest at 5 C. Below that, performance decreases. They believe that "...one cannot explain the heavy immigration of marine invertebrates into tropical warm brackish waters simply by the hypothesis that osmoregulation is, on the whole, easier in a warmer medium" (p. 472). (S. Rennie)

Schlieper, C., Flügel, H., and Theede, H. 1967. Experimental investigations of the cellular resistance ranges of marine temperate and tropical bivalves: results of the Indian Ocean Expedition of the German Research Association. Physiol. Zool., 40:345-360.

Four temperate species (obtained in the Baltic and North Seas) and five tropical species (from the Red Sea) were investigated. Chama cornucopia has a small dilution resistance, but a high concentration resistance. Modiolus auriculatus has a similar high concentration resistance but a greater dilution resistance than Chama or M. modiolus. Ostrea edulis proved to be stenohaline within its distribution range, while Mytilus edulis has a greater dilution resistance. Baltic Sea forms had low concentration resistances while those from the North Sea could stand higher concentrations, suggesting that population differences are environmentally induced by nongenetic adaptation.

Resistance range is always greatest at optimum temperature of the species investigated. Osmotic resistance of M. auriculatus is less at 10 C than at 24 C.

Dilution and concentration resistances of the temperate and tropical species correspond to their respective natural environmental conditions. The tropical (Red Sea) species are subjected to little if any dilution by fresh water, and much evaporation by direct solar radiation. The opposite is true of the temperate forms. (S. Rennie)

Schmidt, H. 1970. Anthopleura stellula (Actiniaria, Actinidae) and its reproduction by transverse fission. Mar. Biol. (Berlin), 5(3):245-255.

It is thought that fission and regeneration are induced by stimulating substances produced by the anemones (Bunodactis verrucosa and A. stellula) during low salinity conditions. (From Biol. Abstr.)

Schmidt, R. A. 1966. Needed--a coastwise comprehensive program for development of estuaries. Pp. 102-109. In: A symposium on estuarine fisheries. Am. Fish. Soc. Special Publ. No. 3, viii + 154 pp. Washington, D. C.

In the 10-year period 1952-1961, commercial finfish and shellfish landings on North Atlantic coast of U.S. averaged annually values to fishermen of $50 million and $39 million, respectively. For entire Atlantic coast in 1960, 3.4 million sports fishermen spent an estimated $350 million. "Most shellfish and, to a notable but undetermined degree, finfish depend upon ecological conditions attributable to the presence of shallow inshore waters, coastal bays and marshes, and estuaries." A comprehensive program is needed to coordinate necessary changes in estuaries so as to keep damage to fisheries to a minimum. Emphasis is on New England and New York areas. (S. H. Hopkins)

Schmidt-Nielsen, B., Gertz, K. H., and Davis, L. E. 1968. Excretion and ultrastructure of the antennal gland of the fiddler crab Uca mordax. Jour. Morphol., 125:473-496.

Crabs were maintained at 50%, 100%, and 200% sea water. In all cases the urine was found to be slightly hypo-osmotic to the hemolymph. The urine sodium concentration decreased with increasing salinity. The labyrinth efficiently resorbs sodium from the filtrate. The intercellular spaces between the labyrinth cells were found to be closed regardless of the salinity, offering further supportive evidence that no water resorption takes place in the labyrinth. (S. Rennie)

Schmitz, W., Besch, W., and Kneissl, Ingrid. 1967. Die Salzgehaltstoleranz von Gammarus pulex pulex (L.), Gammarus tigrinus Sexton und Asellus aquaticus (L.) in Abhangigkeit von der relativen Konzentration der Kationen Na, Mg, K, und Ca. (The salinity tolerance of Gammarus pulex, G. tigrinus and Asellus aquaticus, and its dependence on relative concentrations of Na, Mg, K, and Ca.) Int. Rev. Ges. Hydrobiol., 52(4):589-616.

In salt solutions that differ from sea-water proportions, higher Mg in relation to Na reduces salinity tolerance. Higher potassium (K) strongly reduces salt tolerance; even 5-10 mMol K/l reduces salt tolerance in A. aquaticus and G. pulex, while G. tigrinus first reaches optimum tolerance in this range. Calcium ions raise salinity tolerance. The maximum detoxifying effect is, in general, at 0.5 mMol Ca/l, which many fresh waters have. The tolerance-heightening effect is not increased by higher concentrations of Ca, except that G. tigrinus has higher salinity tolerance when Ca is 10 mMol/l. Observed distribution of G. tigrinus, G. pulex, and A. aquaticus in the brackish-water rivers Werra, Weser, and Inn agree with the experimental findings. (S. H. Hopkins)

Schodduyn, René. 1931. Observations sur la flore et la faune des coquilles des huîtres. Bull. Inst. Oceanogr., 28-29(568):1-20.

Oysters were studied in an oyster "parc" at Ambleteuse, where many foreign oysters were planted (from such English localities as Falmouth, Colchester, and Stanraer), adding some new species to the local fauna. For study, oysters were kept in sea water of a density of 1.026 to 1.036 and the pH was kept alkaline (pH = 7.8). A long list of species of plants (bacteria and molds, algae, and diatoms), protozoans, sponges (mostly Cliona celata), Coelenterates, polychaetes (including Polydora ciliata), one echinoderid (E. dujardini), bryozoans, mollusks, "rhabdocoelians," nematodes, mites, crustaceans, and sea squirts are reported as associates of oysters under these conditions. No reference to salinity, other than the laboratory culture conditions. (S. H. Hopkins)

Scholander, P. F., van Dam, L., Kanwisher, J. W., Hammel, H. J., and Gordon, M. S. 1957. Supercooling and osmoregulation in Arctic fish. Jour. Cell. Comp. Physiol., 49:5-24.

Bottom water fish in Hebron Fjord, Labrador, are permanently supercooled by almost 1 C. Ice can never reach them at the bottom, so in the absence of seeding their state is stable enough to permit them to maintain hypotonicity. A greater concentration of chlorides in the blood accounts for part of their lower freezing point depression. Other components are not known. Shallow-water fish increase their osmoconcentration in the winter to protect them from freezing. (S. Rennie)

Schroeder, William C. 1924. Fisheries of Key West and the clam industry of Southern Florida. Report U.S. Comm. Fish. 1923, App. XII, Doc. 962: 1-74; 29 figs. (Clams, pp. 59-68.)

Ten Thousand Islands' clam bed of southwestern Florida, 40 miles long and

5 miles wide. Venus mercenaria mortoni, larger than northern clams, average 1 lb and often exceed 2 lb. Shells of dead clams everywhere on the bed, more abundant some places than others. Sudden changes in salinity may have caused part of the mortality, but the brackish condition of the water during the rainy season is especially suitable for growth by clams. High salinity during the winter dry season is believed to have a deleterious effect on the clams. (S. H. Hopkins)

Schultz, Mary E. 1971. Salinity-related polymorphism in the brackish-water diatom Cyclotella cryptica. Canadian Jour. Bot., 49(8):1285-1289.

The brackish-water diatom C. cryptica is a polymorphic species. Nine clones are capable of producing the valve pattern characteristic of C. meneghiniana, as well as the C. cryptica pattern. A study of the effects of salinity and fresh-water conditions on the morphology of the valve shows that the "cryptica" pattern is produced in salinities of about 4.3 ppt to full-strength sea water, 28.7 ppt. The "meneghiniana" pattern is the freshwater or low-salinity (1.4 ppt) form. Characteristics of the valve morphology and life history stages which distinguish C. cryptica from C. meneghiniana and Cyclotella sp., clone 03A, are presented and discussed. (From Biol. Abstr.)

Schuurmans Stekhoven, J. G., Jr. 1936. De Oekologie der Zuiderzee Nematoden (The ecology of nematodes in the Zuiderzee). Biol. Zuiderzee, 4:29-38.

The number of species found, marine, brackish, and freshwater, has reached 108. In places the number of nematodes per square meter reaches 4 to 6 million. The fauna is "an impoverished marine fauna," with a comparatively small number of freshwater species. The distribution and abundance of certain species in relation to salinity, and other factors, are discussed. The boundary between freshwater and brackish-water nematodes is at a salinity of about 1000 mg Cl/l (i.e. chlorinity of 1 ppt. It is to be expected that the number of species of nematodes in the Zuiderzee will decrease as salinity is decreased by the engineering work now in progress (damming the mouth of this estuary to exclude sea water in order to reclaim land for farming, so that the remaining water becomes fresher). (S. H. Hopkins)

Schwartz, Frank J. 1964. Natural salinity tolerances of some freshwater fishes. Underwater Naturalist., 2(2):13-15.

Lists 29 freshwater species known to survive brackish salinities of the Chesapeake and Delaware Bays along with their observed salinity tolerance. The author states that most of these species will tolerate brackish salinities for extended periods, but spawning usually occurs after movement to fresh water. One example mentioned was the white catfish Ictalurus catus which lives year round in salinities up to 14.5 ppt, but spawns in June in fresh water. He mentions that many species are accidentally displaced into higher saline waters by spring freshets and may survive for short periods. Others could utilize the reduced salinities to make extended migrations between tributaries (carp, catfish, sunfish, and gizzard shad). He discusses the physiological problems of adjustment of freshwater fish to saline waters. (T. Rennie)

Seck, C. 1958. Untersuchungen zur Frage der Ionenregulation bei in Brackwasser lebenden Evertebraten. Kieler Meeresforsch., 13:220-243.

Marine invertebrates (Mytilus edulis, Asterias rubens, and Carcinus maenas) were taken from "brackish" western Baltic water of 16-ppt salinity and "normal sea water" of 32 ppt. Internal fluids and the external medium (brackish or sea water) were compared for content of water, albumin, sodium, potassium, calcium, magnesium, chloride, and sulfate. Asterias rubens (starfish) from 16 ppt showed apparent regulation of potassium, while other ions were the same in internal fluids as in the surrounding water. The body fluids of Mytilus edulis (sea

mussel) had distinctly higher potassium content than surrounding water, whether sea or brackish. Carcinus maenas (crab) from North Sea had Na, Ca, and Cl in body fluid higher than in sea, but Mg and sulfate lower than in sea water. C. maenas from 16 ppt had higher potassium in body fluid than in water, other ions the same as in outer medium; but potassium was relatively less in winter. Other details are also given. (S. H. Hopkins)

Segal, Earl. 1967. Physiological response of estuarine animals from different latitudes. Pp. 548-553. In: Lauff, G. H., ed. Estuaries. Am. Assoc. Adv. of Sci. Publ. 83, Washington, D. C., xv + 757 pp.

Reviews work by various authors on physiological differences in members of the same species from warm and colder regions; some species included are the mussel Mytilus edulis, the starfish Asterias rubens, the amphipod Dikerogrmmarus haemobaphes, the flatworm Stylochus ellipticus, the fiddler crab Uca pugilator, the snails Littorina littorea and Patella vulgata, the barnacle Balanus balanoides, the polychaeta worms Nereis diversicolor and N. limnicola, the shrimp Crangon crangon, the amphipod Gammarus duebeni, and the brackish-water crab Rhithropanopeus harrisii, but most emphasis is placed on the amphipod Cyathura polita on which the author has worked (along with Burbanck). The gist of it is that individuals from separate populations, especially those adapted in their native habitat to different temperatures and salinities, respond differently to the same salinity at the same temperature. (S. H. Hopkins)

Segal, Earl and Burbanck, W. D. 1963. Effects of salinity and temperature on osmoregulation in two latitudinally separated populations of an estuarine isopod, Cyathura polita (Stimpson). Physiol. Zool., 36:250-263.

Animals were collected from the Pocasset River on Cape Cod at 0.5-1.0 ppt and 22-23 C, and from Silver Glen Springs, Fla., at 1.0 ppt and 21 C. Both populations were maintained in 25% sea water (100% = 32 ppt) at 22 C. Experimental salinities for the northern group were distilled water, river water, 1.5%, 3.5, 25, 50, 75, 100, 125, and 150% sea water. For the southern group test salinities were distilled water, spring water, 3%, 25, 50, 75, 100, and 125% sea water.

The northern population can maintain blood concentrations higher than the medium at concentrations of sea water of 50% and below. Their regulatory abilities are not impaired at 5 and 32 C, although some difficulty is encountered at high temperatures with river water and 50% sea water. In 125% sea water at 5 C the blood is hypo-osmotic to the medium. No changes in weight were found at the different salinities.

The southern population shows slight hyperosmotic regulation in 75% sea water and above, and a low level of hypo-osmotic regulation in 25% sea water and below. These animals could not survive well in less than 3% sea water. Also, at 32 C, in the ones which survived, blood concentrations were isosmotic with the medium at 125%, hyperosmotic in 50% and 3% sea water. Animals at 5 C showed no differences from those kept at 22 C. (S. Rennie)

Segal, E. and Dehnel, P. A. 1962. Osmotic behavior in an intertidal limpet, Acmaea limatula. Biol. Bull., Woods Hole, 122:417-430.

Osmotic and air desiccation experiments showed that A. limatula does not osmoregulate over a range of salinities (25% to 150% sea water). Blood concentration changes in different external salinities are caused by salt and water movements. Body water as percent body weight decreased 28% in 150% sea water and increased 28% in 50% sea water in 24 hr. Isotonicity is reached within 3 hr in hypertonic media, less time than that in hypotonic media. Exposed animals on lava had more rapid rise of blood concentrations and extravisceral water concentration, and reached a higher concentration than animals on sandstone. Removal of extravisceral water caused increased concentration of both extravisceral water and blood. Populations exposed were different, one having faster increase in extravisceral

water and blood concentrations than the other. In exposed limpets the extravisceral water seems to act both in an osmotic and temperature buffering capacity. (S. H. Hopkins)

Segerstråle, S. G. 1947. New observations on the distribution and morphology of the amphipod, Gammarus zaddachi Sexton, with notes on related species. Jour. Marine Biol. Assoc. U.K., 27(1):219-244.

Divides species into three subspecies: G. z. oceanicus subspecies nov. in northern Atlantic, North Sea, Arctic, and Baltic down to salinity of 2.5 ppt. G. z. zaddachi Spooner 1947, highest salinity recorded 14-18 ppt, in estuaries of northern and western Europe and in Baltic, also locally in fresh water. G. z. subspecies salinus Spooner 1947, in Baltic and Danish waters. G. locusta is also found in Baltic, to minimum salinity of 5-6 ppt, but is not as abundant as G. zaddachi. Only other Baltic species is G. duebeni, confined to very shallow water and tide pools. (S. H. Hopkins)

Segerstråle, S. G. 1949. The brackish-water fauna of Finland. Oikos, 1:127-141.

He characterizes the area of the Baltic around Finland pointing out that it is one of the largest brackish-water areas in the world. It contains many relict animals of Arctic origin which are lacking on oceanic coasts. Tidal movements are nearly lacking, maintaining salinities at constant values as opposed to fluctuations in most oceanic brackish waters. The highest salinity in the Baltic is only 8 ppt. The salinity gradient in the Gulf of Finland illustrates the decrease in numbers of marine species with decreasing salinity as one approaches the inner parts of the Baltic. Actiniaria, echinoderms, cephalopods, and brachiopods are entirely lacking in the Baltic.

The bottom fauna of the Finnish coast is an unusual mixture of marine, freshwater, and brackish-water forms, ranging from Chironimid and trichopteran (insect) larvae to Cardium and Corophium all in one place. Species numbers are small but individuals are many. (S. Rennie)

Segerstråle, Sven G. 1951a. The recent increase in salinity off the coasts of Finland and its influence upon the fauna. Jour. Cons. Int. Explor. Mer, 17(2):103-110.

Data are presented for four stations from 1927 to 1949. The increase on the Finnish coast averages about 1/2 to 3/4 ppt. Biologically this is enough to allow the spread of moon jellyfish, Aurelia aurita, into the waters under consideration. Reports of Aurelia at Tvärminne for the first time, correspond to the first year of noticeably higher salinity, 1938, 6.28 ppt. The reason for the increase is not entirely clear, but more predominantly western winds blowing saltier water eastward have been hypothesized as the major cause. (S. Rennie)

Segerstråle, S. G. 1951b. The seasonal fluctuations in the salinity off the coast of Finland and their biological significance. Soc. Sci. Fennica, Commentat. Biol., 8(3):1-27.

Dilution of the Gulf of Finland has taken place in two ways, widening of the dilution range toward the east and approaching the coast from the open sea. Western parts average 5.98 ppt while eastern parts average 2.19 ppt. A clear zonation of the salt concentration corresponds to the distribution of Mytilus edulis and Gammarus zaddachi. An increase in the range, frequency, and duration of salinity minima has gradually excluded marine animals from the eastern gulf. The marine species Gammarus locusta is able to survive at Tvärminne, where salinities are extremely low in the spring, because it reproduces in the summer when the salinities are higher (4.70 ppt in August). (S. Rennie)

Segerstråle, Sven G. 1953. Further notes on the increase in salinity of the inner Baltic and its influence on the fauna. Soc. Sci. Fennica, Commentat. Biol., 13:1-7.

Reproduction of the jellyfish Aurelia aurita was still going on in Tvärminne waters (6.33 ppt) in 1952. The recent increase in the number of Calliopius laeviusculus (usually found in salinities of 6-6.5 ppt) in the Tvärminne area inhabiting the Fucus vegetation is further evidence of the increase in salinity taking place in the inner Baltic during 1952. (S. Rennie)

Segerstråle, S. G. 1957. Baltic Sea. Pp. 751-800. Chap. 24. In: Hedgpeth, J. W., ed. Treatise on marine ecology and paleoecology. Geol. Soc. Amer. Memoir, 67, Vol. I, Ecology, viii + 1296 pp.

A detailed account of the geology, geography, history, hydrography, and ecology of the Baltic Sea, in which the plants and animals are discussed by species. Salinity, the governing factor in this hugh estuary, on pp. 754-764 and on many other pages. There are 115 references cited. (S. H. Hopkins)

Seno, H., Ebina, K., and Okada, T. 1926. Effects of temperature and salinity on the development of the ova of a marine fish (Calotomus japonicus). Jour. Imp. Fish. Inst., Tokyo, 21:41-47.

Fertilized eggs of the fish Calotomus japonicus were placed in 200-ml beakers, each containing sea water of a different salinity. Ten different salinities were used ranging from 1.03614 to 1.01493 specific gravity (calculated at 10 C). Temperature was held constant at 24 C. Egg development and hatching percentages were noted. Eggs in 1.03009 to 1.02557 specific gravity water showed very healthy development and 95% hatched. Only 70% of eggs at 1.02321 specific gravity hatched. All the eggs between 1.02121 and 1.01493 specific gravity died after 2, 3, or 4 divisions. In water of specific gravity less than 1.01934, all cleavage cells collapsed; 40% of the eggs hatched at 1.0361 specific gravity while only 20% hatched at 1.0221. Eggs in denser water than normal salinity sea water developed more slowly up to the fourth cleavage, but after the morula stage development proceeded as fast as in normal sea water. Hatching and formation of the internal organs took place more rapidly in waters of greater salinity. (T. Rennie)

Seno, H., Hori, J., and Kusakabe, D. 1926. Effects of temperature and salinity on the development of the eggs of the common Japanese oyster, Ostrea gigas Thunberg. (Japanese and English text.) Jour. Imp. Fish. Inst., Tokyo, 22(3):41-47, 169-176.

The optimum salinity for development lies between specific gravity 1.017 and 1.021 at 15 C. Formation of shelled stage larva is retarded by lowered salinity, at 15 C, as follows: 1.0184, 22 hr; 1.0155, 34 hr; and 1.0119, 83 hr after fertilization. (S. H. Hopkins)

Seoane, J. 1960. [Algal communities of the estuary of the Vigo]. Bol. R. Soc. Expanola Hist. Nat. Biol., 58(2):371-374.

Tables are given by which it is possible to see how often a particular species is associated with each of the other species. Six groups of species are considered to be natural nuclei for six natural associations.

Serfaty, A. and Labat, R. 1960. Accidents cardiaques et variations brusques de salinite chez les poissons teleosteens marins. Hydrobiologia, 15(4):293-308.

The effect on cardiac and respiratory movements of Mugil capito, M. aratus, and Cantharus cantharus following a sudden change from sea water to fresh water is described. At first both respiratory and cardiac rates increase, then both

decrease, until abnormalities appear in the cardiac rate which precede arrest of respiratory movements and death. Mugil capito survives for only about 7 hr in fresh water, M. auratus for 4, and Cantharus for only 2.

Serventy, D. L. 1935. Observations on Gammarus zaddachi Sexton, an estuarine amphipod, and associated forms. Intern. Rev. ges Hydrobiol., 32:285-294.

In a survey of the estuary of the River Deben in Suffolk, Gammarus zaddachi was found to be one of the most common organisms in the brackish part of the estuary. It occupied a definite zone between the area of distribution of G. pulex in fresh water upstream and G. locusta on the seaward side. At low water it occurred in a salinity gradient of 0-24 ppt and at high water in 0-28 ppt. The area occupied by G. zaddachi is characterized by a very rapid fall in salinity gradient in a distance of 5 miles and has a great fluctuation in salinity between high and low water. This amphipod survives quite well in full strength sea water in aquaria, but is apparently unable to compete with G. locusta. The transition from G. pulex to G. zaddachi takes place rapidly. (T. Rennie)

Sexton, E. W. and Spooner, G. M. 1940. An account of Marinogammarus (Schellenberg) gen. nov. (Amphipoda), with a description of a new species, M. pirloti. Jour. Marine Biol. Assoc. U.K., 24:633-682.

The genus includes half-a-dozen species. M. marinus is the commonest species in British estuaries. The others penetrate little if any into estuaries, but several occur on rocky shores where a stream of fresh water crosses the intertidal zone, M. pirloti living under stones with the euryhaline flatworm Procerodes ulvae (-Gunda ulvae), according to Green, 1968, p. 188, citing this paper. (S. H. Hopkins)

Shatoury, H. H. A. 1958. A freshwater mutant of Balanus amphitrite. Nature, 181:790-791.

The barnacle B. amphitrite var. denticulata Broch was collected in fresh water from an irrigation tank on the Nile Delta. The originally described specimens of the variety came from the very salty Suez Canal. No live specimens were taken from the tank since. It is believed to be of seasonal occurrence, existing only in favorable conditions (presently unknown). During unfavorable conditions, it dies leaving "resting embryos" which remain dormant until favorable conditions return. (S. Rennie)

Shaw, J. 1959. Salt and water balance in the East African fresh water crab Potamon niloticus (M. Edw.). Jour. Exptl. Biol., 36:157-176.

Animals were tested in 25%, 50, 75, and 100% sea-water solutions. Survival was best (more than 3 weeks) in 25% and 50%. At 75%, survival was variable (from 1 to 3 weeks). In 100%, survival was from 1 to 4 days. Although blood concentrations of Potamon is greater than in freshwater crayfish, the blood concentration remained higher than the external medium at all concentrations. Concentration of the urine is isosmotic with the blood, but may be slightly lower. (S. Rennie)

Shaw, J. and Sutcliffe, D. W. 1961. Studies on sodium balance in Gammarus duebeni Lilljeborg and G. pulex pulex (L.) Jour. Exptl. Biol., 38:1-15.

The euryhaline crustacean G. duebeni can be adapted in the laboratory to salinities from 0.2 mM/l to over twice sea-water concentration. G. pulex can live in concentrations as low as 0.006 mM/l; in very low salinities it takes in sodium faster than G. duebeni but quickly becomes saturated and cannot take in more. G. pulex is a freshwater amphipod, and G. duebeni is better adapted to brackish water. See Green (1968, pp. 186-187), Lockwood (1961, 1964, 1965), Werntz

(1962), and Kinne's papers and books. (S. H. Hopkins)

Shaw, W. N. 1966. The growth and mortality of seed oysters, Crassostrea virginica, from Broad Creek, Chesapeake Bay, Maryland, in high- and low-salinity waters. Proc. Nat. Shellfish. Assoc. (1965), 56:59-63.

"Seed oysters from low-salinity water of Broad Creek were transferred and suspended off bottom in the low-salinity water of Tred Avon River and high-salinity water of Chincoteague Bay. Growth and mortality were measured and compared for two years. The rate of shell growth was similar in both areas. A high second-year mortality was observed in Chincoteague Bay which apparently was not caused by high salinity." On p. 62 it is mentioned that the haplosporidians Minchinia nelsoni and Minchinia costalis occur in the high-salinity waters of Chincoteague Bay, and "it is possible that some of the mortality was due to these parasites." Since these are known to be highly lethal pathogens, this explanation seems more than a possibility. (Author's abstract with addition by S. H. Hopkins)

Shehadeh, Z. H. and Gordon, M. S. 1969. The role of the intestine in salinity adaptation of the rainbow trout, Salmo gairdneri. Comp. Biochem. Physiol., 30(3):397-418.

Steady-state drinking rates and intestinal absorption of H_2O and electrolytes in vivo were studied by means of in-dwelling Foley catheters and a volume indicator (polyethylene glycol). Drinking rates of 47, 95, and 129 ml/kg body weight/day were measured in 1/3, 1/2, and full-strength sea water, and 66%, 78%, and 80% of these loads were absorbed from the intestine, respectively. Freshwater fish did not drink. Net intestinal salt absorption rates (mm/kg body weight/day) in 1/3, 1/2, and full-strength sea water, respectively, were: Na, 4, 19.1, and 56; Cl, 5.5, 23.8, and 67.6; K, 0.1, 0.4, and 1.3; Ca, 0.08, 0.11, and 0.43; mg, 0.06, 0.37, and 3.13; and sulfate, 0.0, 0.0, and 1.0. Relative absorption rates from ingested loads for Na and Cl were: Na 66%, 91%, and 99% and Cl 85%, 94%, and 98%, respectively. In the intestine, ingested media were gradually depleted of monovalent ions and H_2O and enriched in Mg and sulfate. In plasma-hyperosmotic media, relative absorption of H_2O and monovalent ions were significantly higher ($P < 0.01$). Integumentary H_2O permeability appears to decrease in such media. (P. Maxwell)

Shelbourne, J. E. 1963. Marine fish culture in Britain. IV. High survivals of metamorphosed plaice during salinity experiments in open circulation at Port Erin, Isle of Man, 1961. Jour. Cons. Int. Explor. Mer, 28:246-261.

Eggs of plaice (a marine flatfish) were hatched at 34 ppt. Between hatching and "first feeding" the salinity was gradually lowered by 1.5 ppt. Mortality was great due to some unknown factor. When salinities were decreased from 34 to 28 ppt at a rate of 0.5 ppt/day, no marked effect on mortality of larval survivors at this later stage of pelagic development was observed. When salinities were raised from 28 to 34 ppt at the same rate of change, metamorphosed fish showed similar toleration. The author concludes that salinity stabilization may not be a major consideration during later stages of larval development in the hatchery. (S. Rennie)

Shelbourne, J. E. 1966. Influence of temperature, salinity, and photoperiod on the aggregations of chum salmon fry (Oncorhynchus keta). Jour. Fish. Res. Bd., Canada, 23(2):293-304.

Fish were acclimated in the following combinations of conditions: temperatures 9-12 C and 7 C, salinities 25 to 29 ppt and fresh water, and photoperiod 8 hr and 16-17.5 hr per day. Salt water seemed to increase the tendency for aggregation. Cold water fish schooled more strongly than the warm water fish, but the data are not biologically valid since all tests were run at 9-12 C. Photoperiod

had no effect on aggregation. (S. Rennie)

Shelford, V. E. 1930. Geographic extent and succession in Pacific North American intertidal (Balanus) communities. Publ. Pacific Sound Biol. Sta., 7:217-223.

From Alaska to Lower California, the following associations probably can be recognized: (1) Mitella-Mytilus association, dominated by Mitella polymerus and Mytilus californianus, probably on most exposed ocean shores; (2) Balanus-Californianus association, dominated by Balanus hespersus or B. cariosus and Mytilus californianus, usually on moderately exposed shores in waters of salinity from 29 to 33 ppt; (3) Balanus-edulis association, dominated by Balanus-cariosus, B. hespersus, or B. glandula and Mytilus edulis with Littorina sitchana nearly always present, and Fucus a local dominant in enclosed waters of lower salinity. Based on Thompson (1927) and Worley (1930) a summer salinity chart of San Juan Archipelago is shown (p. 223); the isohalines were drawn with help of intertidal fauna as indicators. Gradient is from 26 to 31 ppt. (S. H. Hopkins)

Shelford, V. E., Weese, A. O., Rice, Lucile A., Rasmussen, D. I., and Maclean, Archie. 1935. Some marine biotic communities of the Pacific coast of North America, Part I. General survey of the communities. Ecol. Monogr., 5(3):249-332.

Two subtidal communities of major rank (biome) occur in the area of the western San Juan Islands in Puget Sound: a large gastropod-echinoderm (Strongylocentrotus-Argobuccinium) biome associated with the more rapidly circulating waters, higher salinity, greater light penetration, and less plankton, the other an annelid-bivalve (Pandora-Yoldia) biome in lower salinity, less circulation, slow fine silt deposition, and much bottom detritus. These general hydrographic conditions overshadow the type of bottom in determining the character of the community. (S. H. Hopkins)

Shidler, J. K. 1960a. Job report. Project No. MO-1-R-2. Oyster investigations, Area MO-1. 1 July 1959 to 30 June 1960. Job. No. B-2-C. Interim shrimp study. 19 pp. Texas Game and Fish Commission, Marine Fisheries Division, Project Reports 1959-1960. Mimeo.

This report lists the swimming organisms, including fishes, and the incidental organisms (mostly bottom invertebrates) taken in 71 otter trawl hauls made for the shrimp investigation. Rank of frequency and percentage of total catch are given for the 13 most common species, Penaeus setiferus ranking No. 1 in all areas and P. aztecus No. 3; No. 2 was Galeichthys felis in upper bay and Micropogon undulatus in lower bay. The "incidental organisms" were tabulated according to their occurrence in areas: A, salinity 0-10 ppt; B, salinity 10-15 ppt; C, salinity 15-20 ppt; D, salinity 20-25 ppt; and E, salinity 25 ppt and up. Typical species were: A, Rangia cuneata and Macoma mitchelli; B, Rangia flexuosa and Tagelus plebius; C, Crassostrea virginica and Brachidontes recurvus; D, same plus Clibanarius vittatus, Pagurus pollicaris, Squilla empusa; E, Mulinia lateralis, Ostrea equestris, etc. (S. H. Hopkins)

Shidler, J. K. 1960b. Job report. Project No. MO-1-R-2. Oyster investigations, Area MO-1. 1 July 1959 to June 1960. Job. No. 3-2b. Preliminary survey of invertebrate species. 15 pp. Texas Game and Fish Commission, Marine Fisheries Division, Project Reports 1959-1960. Mimeo.

Gives horizontal zonation of 189 Galveston Bay invertebrates in three salinity zones: low salinity (LS), 0-15 ppt; medium salinity (MS), 15-25 ppt; high salinity (HS), 25-35 ppt. All upper Galveston Bay and Trinity Bay, plus an area in east end of East Bay, is LS; all lower Galveston Bay and West Bay except for a relatively small MS area is HS, with a tongue of high salinity running up Houston

Ship Channel into upper bay. HS also includes gulf, and some species included in HS list are gulf forms that seldom if ever come into the bay. (Many other species collected and packed for shipment to specialists for identification were destroyed along with records and the Seabrook laboratory itself in Hurricane Carla. Shidler was a good naturalist but an undergraduate with little experience at the time of this report.) (S. H. Hopkins)

Shields, Norman. 1972. Studies on the inter-relationships of pressure, temperature and salinity on the respiratory rate of the arctic calanoid copepod, Calanus hyperboreas (Abs.). Abstracts of Papers Submitted for the 35th Annual Meeting, American Society of Limnology and Oceanography, Tallahassee, Fla., March 19-22, 1972.

Only salinities of 30.6 and 35 ppt were compared. High pressure reduced O_2 consumption 80%-90% at all temperatures in salinity of 30.6 ppt, while at pressures of 500-2000 psi no reduction of O_2 consumption was seen at -1.5 C and 35-ppt salinity. (S. H. Hopkins)

Shinkawa, Hideaki. 1959. Physiological considerations concerned with the distribution patterns of oysters. Bull. Marine Biol. Sta. Asamushi, Tohoku Univ., 9(4):193-196.

Six species of oysters were compared. Heartbeat rate and gill cilia activity were recorded for each species in various dilutions of sea water. Gill cilia activity (measured by "the fatty particle method") decreased in sea-water dilutions from 25% to 9% sea water, and 44%-59% sea water, but increased in from 45% to 28% sea water. Gill cilia activity decreased in diluted sea water at different rates in the following order: Crassostrea rivularis least, then Crassostrea gigas, C. nippona, C. echinata, Ostrea circumpicta, and Ostrea denselamellosa (decreased most). This parallels their horizontal distribution from upper estuary to open sea, C. rivularis living in lowest salinities and O. denselamellosa in the highest (oceanic). Gill activity and heartbeat come to a stop earlier in diluted than in 100% sea water. Heartbeats were more irregular in diluted when in concentrated sea water. (T. Rennie)

Shomura, R. and Nakamura, E. L. 1970. Variations in marine zooplankton from a single locality in Hawaiian waters. U.S. Fish and Wildlife Service, Fish. Bull., 68(1):87-100.

Data on marine zooplankton and hydrography were obtained off Oahu, Hawaii, at monthly intervals from June 1957 through December 1958. The 19 months were divided into nine successive periods, each with a temperature-salinity curve differing from that of the preceding and following periods. Volumes of zooplankton and the abundance of Siphonophora, Chaetognatha, Euphausiacea, Decapod Crustacea, and Pteropoda increased when portions of the temperature-salinity curves greater than 35.0 ppt increased during the nine periods; and, conversely, the volumes of zooplankton and the abundance of these groups of zooplankters decreased as the amount of water with salinity greater than 35.0 ppt decreased. (P. Maxwell)

Shoup, C. S. 1932. Salinity of the medium and its effect on respiration in the sea anemone. Ecology, 13:81-85.

A single Metridium marginatum was placed in the respiratory chamber of a Thunberg-Winterstein microrespirometer, covered with normal sea water (30 ppt). Its respiration was then measured as being the "normal" condition. The normal sea water was then replaced by dilute (15 and 10 ppt) or concentrated (45 and 60 ppt) sea water, or M/2 or M/4 concentrations of NaCl, KCl, or $CaCl_2$ and then the respiration was remeasured. Rate of oxygen consumption decreased for all salt solutions and for the sea-water solutions; the greatest decreases were at 10- and 60-ppt salinities. In all hypotonic solutions the anemone remained

extended until the salinity had decreased to about 10 ppt, it then contracted to about one-third or one-fourth its normal length and had partially withdrawn its tentacles. When it was brought in contact with hypertonic sea water, a marked contraction occurred depending on how hypertonic the medium was. At 60 ppt, the Metridium contracted completely to a flat plate, withdrew its tentacles completely, secreted mucus, and discharged nematocysts. All specimens returned to "normalcy" after 4 hr when removed and placed in normal sea water. (T. Rennie)

Shuster, Carl N., Jr. 1960. On the ecology of estuarine zooparasites. Trans. New York Acad. Sci., 23(2):133-137.

He only mentions salinity on p. 134 where he states, "The ability of free-swimming larvae of marine trematodes to survive wide ranges of salinity and to remain infective...will undoubtedly be found to be the case for other species found in estuaries." (T. Rennie)

Sieling, F. W. 1971. Economic value of research in resources management; an exposition of direct economic benefits to management from research. Proc. Nat. Shellfish. Assoc., 61:15-19.

Reviews the history of MSX disease caused by the protozoan parasite Minchinia nelsoni in oysters, discovered in Delaware Bay in 1957, found in Chesapeake Bay in 1961-62, and causing mortalities in Maryland waters wherever salinity was above 15 ppt by 1965. By concentrating the planting of seed oysters in waters farther upbay where salinity is below 15 ppt, and planting only cultch in the higher salinities, Maryland oyster production has been increased since the low period of 1962-65. In the higher salinity area of Maryland in Dorchester, Wicomico, and Somerset Counties, oyster production dropped from 307,000 bushels in 1963-64 to a low of 14,000 bushels in 1966-67 following a period of drouth, then rose to 208,000 bushels in 1969-70. It was estimated that approximately 2.5 million bushels of oysters worth $10 million died at the height of the epizootic, which was also a period of high salinity in Maryland. (S. H. Hopkins)

Sieling, F. W., Otto, Sara V., Rosenfield, A. 1969. Distribution of some microparasites in oysters from Chesapeake Bay (Abs.). Proc. Nat. Shellfish. Assoc. (1968), 59:8-9.

Over the 6-year period 1963-1968 an incursion of Minchinia nelsoni was observed into Maryland water as far as Eastern Bay on the Eastern Shore and Governor's Run on the Western Shore. Highest prevalences were recorded in 1965, accompanying high oyster mortality. In the fall of 1966 a southward retreat of the parasite began and by spring 1968 it was found only in Holland Straits and the Potomac River, and there were few oyster mortalities after 1965. The northward intrusion followed by the southward retreat seemed to follow the fluctuations in salinity in the bay during the period. (S. H. Hopkins)

Simmons, E. G. 1957. An ecological survey of the Upper Laguna Madre of Texas. Publ. Instit. Mar. Sci., Univ. of Texas, 4(2):156-200.

The study area is described as "a long narrow lagoon characterized by shallow flats, noted for hypersalinity, heavy fish populations, and discolored water." Salinity prior to the dredging of the Intracoastal Canal reached 113.9 ppt at times, with consequent fish mortality; since completion of the waterway in 1948, the highest salinity recorded was 79.0 ppt. Relations of fauna to salinity are summarized thus: The higher the salinity, the fewer the species, the greater the number of individuals of each species, the larger the average individual of each fish species, and the smaller the average individual of many invertebrate species (blue crabs, barnacles). Salinity of 40-50 ppt seemed to be optimum for many species; 51 species lived within the 40- to 50-ppt range, 21 only below this range, and 40 above it. Because of the shallow water, animals in the Laguna are

especially subject to "winter kill" from severe northers such as those that occurred in 1940, 1945, 1947, and 1951, when millions of pounds of fish died. In spite of the harsh conditions the Laguna Madre is the most productive bay on the Texas coast and produces over 60% of the bay fish caught in Texas. (S. H. Hopkins)

Simmons, E. G. 1959. Resurvey of the macroscopic flora and fauna of the Upper Laguna Madre. Job Reports, Marine Fisheries Division, Texas Game and Fish Commission, Austin. Mimeo.

Upper Laguna Madre was hypersaline 1951-1956 due to drouth, but salinity was lowered by heavy rains in 1957 and 1958. The present study was to determine what changes occurred. The mean annual salinity for all stations had been reduced from 51 ppt in 1953 to 33 ppt in 1958. Water temperature varied from 2 to 35 C and minor fish kills (due to cold) occurred. During the low-salinity period few additional fish species appeared but about 15 new invertebrates were found. There was a sharp increase in the numbers of flounder, pinfish, small trout, and blue crabs and equally sharp decreases in numbers of black drum, larger trout, and small redfish. Ruppia maritima increased, but in general there was little increase in vegetation, except that red and green algae became very abundant. Overall, plant biomass and invertebrates increased, but fish biomass probably decreased. (S. H. Hopkins)

Simmons, E. G. and Breuer, J. P. 1962. A study of redfish, Sciaenops ocellata Linnaeus, and black drum, Pogonias cromis Linnaeus. Publ. Instit. Mar. Sci., Univ. of Texas, 8:184-211.

Redfish are euryhaline and are found in fresh water and in salinities as high at 50 ppt (15 ppt in text, p. 192, but this paper and Simmons (1957) cited as authority give 50 ppt as approximate maximum). In Upper Laguna Madre they were scarce above 50 ppt and most abundant in salinities of 30-35 ppt. They have been successfully transplanted from salt water to freshwater ponds and rivers in Texas but so far have not been known to reproduce in fresh water.

Black drum are also euryhaline and frequently inhabit brackish or even fresh water, but in Laguna Madre adults have been found in salinities as high as 80 ppt although many had glazed eyes; some were blind and had lesions on the body. Most move out of Laguna Madre when high salinity and high temperature kill the mollusks on which they usually feed. Parasites of both drums include the parasitic copepod Caligus, which is lost when salinity rises above 45 ppt. (S. H. Hopkins)

Simpson, John W., Allen, Kenneth, and Awapara, Jorge. 1959. Free amino acids in some aquatic invertebrates. Biol. Bull., 117:371-381.

When analyzing a variety of invertebrates for the kinds and amounts of amino acids present, it was found that taurine was characteristic of many mollusks. Further investigation of four terrestrial, seven freshwater, three brackish-water, and seven marine species of mollusks revealed that taurine was present in only the brackish-water and marine forms. When present it was always in large quantities. It is suggested that this amino acid plays a part in osmoregulation. (S. Rennie)

Sin, Ong Kah. 1966. The early developmental stages of Scylla serrata Forskal (Crustacea Portunidae), reared in the laboratory. Proc. Indo-Pacific Fisheries Council, 11(II):135-146.

In salinities of 31 ± 2 ppt, development from zoea I to megalops takes at least 18 days. Each zoeal stage requires at least 3-4 days between molts. Sin assumes this to be the normal rate. The molt from megalops to first crab at the salinity above takes 11-12 days. At lower salinities (21-27 ppt), this molt

takes only 7-8 days. This indicates that in nature the megalopa move shoreward into brackish water. (S. Rennie)

Sizer, I. W. 1936. Observations on the oyster drill with special reference to its movement and to the permeability of its egg case membrane. Unpublished typed report. U.S. Bureau of Fisheries, Washington, D. C.

Claimed that Delaware Bay drilling snails, Urosalpinx cinerea, become inactive at salinities below 20 ppt or above 30 ppt, and crawl fastest at a salinity of about 25 ppt. Also reported that low-salinity water penetrates egg cases and kills eggs or embryos. Cited by Stauber, unpublished report. (S. H. Hopkins)

Slack-Smith, R. J. 1960. An investigation of coral deaths at Peel Island, Moreton Bay, in early 1956. Univ. of Queensland Papers, Dept. Zool., 1(7):211-222.

Reef corals were killed on an inshore reef near Brisbane, Australia, after a period of heavy rains and flooding (Fidé Banner 1968, which see).

Smirnov, A. N. 1969. Vliyanie ekologicheskikh faktorou na effektivnost razmnozhen-iya nekoloykh vidou ryb v. Taganrogskom zalive Azovskogo morya. (Ecological factors influencing the effectiveness of reproduction of some species of fish in the Taganrog Gulf of the Azov Sea.) Vop. Ikhtiol., 9(4):651-656.

The size of offspring of a new generation of Clupeonella genus and Acerina cernua (L.) depends mainly on the salinity of the water, the size of the biomass of food organisms, and the water temperature in the Taganrog Gulf. During a great runoff of the Don and significantly decreasing salinity of the Taganrog Gulf, a portion of the herring and siches, Pelecus cultratus (L.), will spawn in the eastern portion of the gulf. With increased salinity of water, these fish will not spawn in the gulf. For the survival of Clupeonella larvae, a salinity of from 0.5-5 ppt is favorable while 0-2 ppt is favorable for herring and siches. (P. Maxwell)

Smith, A. and Vail, J. W. 1959. Relationship between salinity and breeding of Anopheles gambiae in North-eastern Tanganyika. Nature, 183:1203-1204.

The chloride content of waters in which the mosquito A. gambiae was found breeding was 0.13% to 8.95% that of sea water. When tested over a range of salinities, recently hatched larvae survived up to 30% sea water for 8 hr, but died in 7-1/2 hr at 34%. It was thought that the low sporozoite rate in the Pare area where the tests were made was due to saline soils. This was not found to be the case since the A. gambiae in the Pare area were found to be typically fresh water. (S. Rennie)

Smith, G. F. M. 1940. Factors limiting distribution and size in the starfish. Jour. Fish. Res. Bd., Canada, 5(1):84-103.

The minimum salinity tolerated by the starfish Asterias vulgaris in the Bideford River, Prince Edward Island, is 14 ppt. In the laboratory the starfish survived 7 ppt for periods of 1 hr after which they were returned to 25-27 ppt.
Starfish in the mouth of the River Denys, Cape Breton, lived at 20 ppt.
(S. Rennie)

Smith, H. W. 1930. The absorption and excretion of water and salts by marine teleosts. Amer. Jour. Physiol., 93:480-505.

Marine teleosts excrete urine isotonic or hypotonic to blood, and of much lower osmotic pressure to sea water, expending energy in osmotic work. They swallow sea water, absorb water, Na, K, and Cl from intestine, leaving residue of Mg and SO_4 isotonic to blood. Urine salts consist mostly of Mg and SO_4

absorbed from gut. Osmotic work is done elsewhere than kidneys and gut; probably gills excrete solution of NaCl and KCl hypertonic to sea water. Water for formation of urine in freshwater fish is absorbed through oral membranes. Marine fish excrete small fraction of water excreted by freshwater fish. This is probably why glomeruli tend to disappear in strictly marine teleosts.

The experiments were done on the marine sculpin Myoxocephalus octodecimcarpio, the eel Anguilla rostrata, the freshwater carp Cyprinus carpio, and goldfish Carassius auratas. Eel is especially recommended for such experiments, standing easily transfer from fresh to salt water and vice versa. (S. H. Hopkins)

Smith, H. W. 1932. Water regulation and its evolution in the fishes. Quart. Rev. Biol., 7:1-26.

In freshwater teleosts and elasmobranchs water absorption by body is offset by excretion of abundant hypotonic urine, along with waste. In sea water body tends to lose water by osmosis, but kidney needs to separate water from salts in order to form dilute urine to excrete waste. Marine teleost drinks sea water and absorbs most of water and salt from gut, then excretes salt extrarenally (probably through gills) so that water is left free for urine formation. Marine elasmobranch can also excrete salts extrarenally, but also has physiological uremia which enables it to absorb water directly. Urea is conserved at kidneys, and outer membranes become less permeable to urea so it accumulates in blood to 2%-2.5%, until osmotic pressure rises above that of external medium, allowing water to be absorbed directly by external membranes. Essential features in evolution of body-fluid regulation are maintenance of (1) constant water content and (2) constant salt content in body. "It is suggested here that the hypotonic limitations of the kidney in lower vertebrates, the glomerular nature of the renal unit in the primitive fishes, and the physiological similarity between the elasmobranchs and the teleosts when in fresh water" mean that the early vertebrates evolved in fresh water, for which kidney adapted. (S. H. Hopkins)

Smith, Ralph I. 1953. The distribution of the polychaete Neanthes lighti in the Salinas River Estuary, California, in relation to salinity, 1948-1952. Biol. Bull., 105:335-347.

Worms near river mouth are exposed to variable but high salinities, 40% to over 100% of sea water. Worms in upper reaches live in 2%-3% of sea water for most of year. Either area is more favorable than lower estuary where there are full tidal exchanges part of year. Over its range, N. lighti is associated with such typically brackish-water species as Neosphaeroma oregonensis, an isopod, and the amphipods Anisogammarus confervicolus and Corophium spinicorne. Its range slightly overlaps that of the freshwater forms Dugesia sp. leeches, and odonata larvae. Corophium spinicorne extends into even fresher water. Populations of N. lighti in upper reaches are ecologically and reproductively isolated from those in lower reaches; these populations may be physiologically distinct. N. lighti is self-fertilizing viviparous hermaphorodite without planktonic larvae, so physiological races in same estuary seem possible. (S. H. Hopkins)

Smith, R. I. 1955a. Comparison of the level of chloride regulation by Nereis diversicolor in different parts of its geographical range. Biol. Bull., 109:453-474.

Collections were made of Nereis populations living under three types of natural salinity conditions: (1) marine dominated--relatively stable high salinity at Millport, Scotland, and Plymouth, England, (2) relatively stable low salinity--Tvärminne, Finland, where summer salinities are 6 ppt or less, and Isefjord, Denmark, having a stable upper salinity of 2 ppt, and (3) varying salinity (estuarine conditions)--River Tamar, near Phymouth. Constant sized (150-250 mg) animals were placed in pans containing sand for burrowing, having salinities

varying in chloride content from <0.1 g/l to 20.3 g/l (full sea water down to fresh water). Coelomic fluid was taken from individuals in the different salinities and its chloride content determined and compared with the chloride content of the external media. N. diversicolor was a typical adjustor in higher salinities (above 5 g/l) but was a regulator in lower salinities. As a species, it showed a uniform pattern and level of chloride regulation regardless of the region in which it was collected. The "plateau" of regulation for the marine-dominated worms was at about 6 g/l. Over an external chloride range up to 4-6 g/l, worms from the Tvärminne regulated chloride in media of chloride concentrations below 5 g/l (equivalent to 9 ppt). These experiments did not demonstrate physiological races differing in respect to salinity tolerance, but some other response (response to fresh water, emergency response to changes in salinity) may be diagnostic of physiological races. (T. Rennie)

Smith, Ralph I. 1955b. On the distribution of Nereis diversicolor in relation to salinity in the vicinity of Tvärminne, Finland, and the Isefjord, Denmark. Biol. Bull., Woods Hole, 108:326-345.

In the area around Tvärminne, Nereis was not found when the salinity was below 4 ppt. In the Isefjord, Denmark, Nereis was concentrated at the head of the bay and near the mouth of a small stream, with salinities as low as 1.25 and 1.63 ppt. In other areas in the bay it was found in salinities up to 18.40 ppt. (S. Rennie)

Smith, Ralph I. 1955c. Salinity variation in interstitial water of sand at Kames Bay, Millport, with reference to the distribution of Nereis diversicolor. Jour. Marine Biol. Assoc. U.K., 34:33-46.

This study describes a relatively stable zone of brackish interstitial water from the upper midtide area of the Kames Bay beach. Lowered salinities (9-29 ppt) persisted in the sand even during periods of high tide. Distribution on this beach of Nereis diversicolor seems to be correlated with the zone of lowered salinity. Present data do not show whether the brackish conditions are actually favorable to the organisms or if they serve to limit competition from other species. (S. Rennie)

Smith, Ralph I. 1956. The ecology of the Tamar Estuary. VII. Observations on the interstitial salinity of intertidal muds in the estuarine habitat of Nereis diversicolor. Jour. Marine Biol. Assoc. U.K., 35(1):81-104, map.

As previously found by Spooner and Moore (1940) in the same estuary, the number of these worms increases up the estuary into lower salinities as far as North Hooe (S&M, 1715/sq m, Smith, 436/sq m). Smith continued upstream and found 204/sq m at the next station, Cotehele Quay, and only occasional worms above that, at Calstock. The maximum population density is found in that part of the estuary where the greatest variation in salinity is the rule. At its upstream limit Nereis diversicolor regularly endures salinities of less than 0.5 ppt. At its seaward limit salinities below 30 ppt are not found, but few worms occur. None are found in true marine situations. At Salt Mill (28 worms per sq m according to Smith) interstitial salinity is about 25-29 ppt, and at Calstock 0-1 ppt. At North Hooe, where population is at maximum, interstitial salinity is 0.5-2.5 ppt in December and 5-10.5 ppt in June. Where population is maximum, worms are much smaller than at places where they are fewer, but no data on biomass are available. (S. H. Hopkins)

Smith, R. I. 1963a. A comparison of salt loss rate in three species of brackish water nereid polychaetes. Biol. Bull., 125:332-343.

Worms were adapted in salinity equivalent to 55% of sea water, then tested in distilled water for 1 hr, which did not kill them. Nereis (Neanthes) succinea,

which is widespread in European and American brackish waters, shows a higher rate of salt loss than Nereis diversicolor and its close relative N. limnicola, which penetrate into estuarine waters of lower salinity than that N. succinea inhabits. (S. H. Hopkins)

Smith, Ralph I. 1963b. Larval development of Nereis diversicolor in relation to regional salinity. In: 16th Int. Congr. Zool., 1963. Proc. Int. Congr. Zool., 16(1):101.

Larval development of this polychaete annelid was studied at Kristineberg Zoological Station, Sweden (salinity 19 ppt, chlorinity 10-11 g/l), and at Tvärminne Zoological Station, Finland (salinity 5.4 ppt, chlorinity 3 g/l). At each station there is a "bottleneck" in development in the cleavage stages due to chlorinity conditions. At Kristineberg it is at chlorinity of 5-15 g/l, and at Tvärminne, 3-7.5 g/l. Chlorinity tolerances increase, beginning at the trochophore stage. Optimum salinities for development at both stations are the environmental salinities given for each. Development at the extremes is slowed, but normal in outcome. (S. Rennie)

Smith, Ralph I. 1964a. D_2O uptake rate in two brackish-water nereid polychaetes. Biol. Bull., 126:142-149.

The purpose of the study was to determine the difference, if any, in the water-permeability of Nereis (Neanthes) succinea and N. limnicola. N. succinea loses salt at a much higher rate than N. limnicola in 50% sea water. Both worms show an equal water influx at a wet weight of 100 mg. As in the case of salt loss, N. limnicola follows the "surface rule" in its D_2O uptake; N. succinea does not. No increased entry of D_2O with an increase in osmotic gradient has been demonstrated. (S. Rennie)

Smith, Ralph I. 1964b. On the early development of Nereis diversicolor in different salinities. Jour. Morphol., 114:437-464.

Larval development was studied at two geographic locations: Kristineberg Zoological Station, Sweden (salinity 50 ppt) and Tvärminne Zoological Station, Finland (salinity 5.4-6.3 ppt). At Kristineberg fertilization and normal development took place at 5-15 g Cl/l. Near the extremes, rate of development was slower up through development of the monotrochophore. Optimal development was at 10-11 g Cl/l, the same as the environmental salinity.

Nereis at Tvärminne developed at 3 to 7.5-10 g Cl/l. Optimal development was at 7.5 g Cl/l. (S. Rennie)

Smith, S. H. 1966. Effects of water use activities in Gulf of Mexico and South Atlantic estuarine areas. Pp. 93-101. In: A symposium on estuarine fisheries. Am. Fish. Soc. Special Publ. No. 3, viii + 154 pp., Washington, D. C.

Discusses effects of engineering projects for navigation, alteration of land-water source, dredge and fill, and hurricane protection, on estuarine fisheries. Freshwater discharge and salinity intrusion, p. 94; on same page, changes in dispersal and flushing of pollutants. Savannah Harbor project, pp. 95-96; salinity effects, p. 96. Shoaling of Charleston Harbor as result of Santee-Cooper diversion, pp. 96-97. Central and South Florida flood control project, p. 97. Lake Pontchartrain hurricane protection project and Mississippi River-Gulf outlet navigation project, pp. 99-101, including effects on salinity. (S. H. Hopkins)

Smith, W. G. 1970. Spartina "die-back" in Louisiana marshlands, pp. 89-96. In: Louisiana State University Coastal Studies Bull. No. 5, Special Sea Grant Issue, xvii + 184 pp.

The term "die-back" was originally applied to degeneration and death of large

areas of Spartina townsendii marshes in England. What seems to be the same condition in S. alterniflora marshes is described in Louisiana. Six possible causes are discussed, one of which is excessive increase in salinity, as suggested by Rudolfs (1926) for bald spots in New Jersey marshes. (S. H. Hopkins)

Snelling, Barbara. 1959. The distribution of intertidal crabs in the Brisbane River. Austral. Jour. Mar. Freshw. Res., 10:67-81.

Twenty-three species in the following families of crabs were collected along 37 miles of the Brisbane River Estuary: Ocypodidae, Mictyridae, Grapsidae, Xanthidae, Portunidae, and Hymenostomatidae. Distribution in the river was vertical as well as horizontal. The following vertical zones were extablished: (1) sesarmine zone, high water neap and upwards, (2) ocypodine zone, high water neap to mean sea level, (3) upper macrophthalmine zone, mean sea level to low water neap, (4) lower macrophthalmine zone, low water neap to low water spring tide. Sesarma sp. and Halicarcinus australis penetrated farthest upstream.

During drought conditions some bay forms were found 2 miles upstream, including anemones, ascidians, and some gastropods. The penetration of Cleistostoma meneilli was extended from 20 to 29 miles upstream. After flooding, distribution was normal with the bay species disappearing from the river.

At least horizontal distribution appears to be dependent on salinity, but no salinity data were taken to determine these correlations. (S. Rennie)

Soldatova, I. N. 1961. Vliyanie uslovii razlichnoi solenosti na drustvorchatogo mollyuska Teredo navalis L. (Effect of varying salinity conditions on the bivalve mollusk Teredo navalis L.) Trudy Inst. Okeanol. Akad. Nauk SSSR, 49:162-179. Ref. Zhur., Biol., 1962 No. 10 2b 100. (Transl.)

It is shown experimentally that T. navalis from the Black Sea can maintain normal vital activities at levels of salinity from 10 to 35 ppt. T. navalis survived under such conditions for a period of a year, grew normally, their sex products matured, larvae formed, and spawning proceeded normally. Three ranges of salinity levels are identified: the favorable range (12-28 ppt), the sublethal range (8-12 ppt and 28-40 ppt), and the lethal range (<8 and >40 ppt).

Soldatova, I. N. 1963. Effect of water of varying salinities on several physiological processes of the Black Sea bivalve mollusk Teredo pedicellata Quatretages. Tr. Inst. Okeanol. Akad. Nauk. SSR, 70:186-196.

Research done 1957-1961 on effect of salinity on the survival, the rate of oxygen consumption, and growth of Teredo pedicellata. In Black Sea, Teredo can live about 1 yr in 8- to 35-ppt salinity. In 10-ppt salinity--intense and prolonged disturbance of respiration. In 8-ppt salinity--most died. Development of sexual products, fertilization and development of larvae in maternal organism with salinity from 12 to 35 ppt proceeded normally.

Sonnery and Tchang-si. 1931. De la resistance de quelques blenniidées marins à la vàriation de salinité. C. R. Soc. Biol., Paris, 108:1236-1238.

Blennius pavo Riss. at Tamaris is completely adapted to fresh water immediately. Blennius tentacularis Brunn. dies quickly in fresh water, as do Clinus argentatus Riss. and Blennius gottorugine L. Blennius pholis adapts perfectly to brackish water, and in fresh water shows variation of pigmentation. The paper deals with experiments of B. pholis in different salinities. All of these fish belong to the marine family Blennidae, commonly known as "blennies" in English. (S. H. Hopkins)

Spaargaren, D. H. 1971. Aspects of the osmotic regulation in the shrimps Crangon crangon and Crangon allmanni. Neth. Jour. Sea Res., 5(3):275-333.

On two species of shrimps, C. crangon and C. allmanni, data were obtained on internal osmotic concentration after adaptation to various salinities and temperatures. The exchange between the environment and two components of osmotic concentration, viz. water and electrolytes, was investigated. Osmotic concentration, electrolyte concentration, and nonelectrolyte concentrations were related to tissues and blood separately. The differences obtained for the two species can be related to their habitats. (From Biol. Abstr.)

Sparck, R. 1933. Investigations on the biology of the oyster. X. Some preliminary investigations on the power of filtration in Ostrea edulis. Report Dan. Biol. Stat., 38:31-32.

Oysters were placed in water of 30 ppt which was overlaid with water of 27 ppt and fresh water. The oysters were not able to disrupt the stratification with their water currents. (S. Rennie)

Spektorova, L. V. 1970. Morkaya flagellata Platymonas viridius Rouch sp. n. kak ob··ekt dlya massovogo kul'tivirovaniya. (The marine flagellate Platymonas viridius Rouch sp. n. as an object for mass cultivation.) Dokl. Akad. Nauk. SSSR, 192(3):662-664.

Platymonas viridius (Chlamydomonadacea) has considerable ability with respect to environmental conditions (temperature, light, and salinity). This alga is a promising object for mass cultivation for obtaining algal biomass for feeding edible marine invertebrates. (From Biol. Abstr.)

Spinner, G. P. 1969a. A plan for the marine resources of the Atlantic coastal zone. American Geographical Society, New York, v + 80 pp.

This little paperback book is included in the package sent to purchasers of Folio 18 (Spinner 1969b). It reports the researches, discussions, and conclusions of the Marine Resources Committee of the Atlantic Wildfowl Council, chaired by Charles Banks Belt, and is concerned primarily with preservation or conservation of natural areas. Tables of data on various past and present uses of the coastal zone are included. Appendices present recent bills or acts of various state legislatures dealing with conservation of wetlands. (S. H. Hopkins)

Spinner, G. P. 1969b. Serial atlas of the marine environment. Folio 18. The wildlife wetlands and shellfish areas of the Atlantic coastal zone. American Geographical Society, New York.

Consists of 12 large folding maps which together cover the Atlantic coast from the U.S.-Canadian border to the tip of Florida, and a folio 4-page introduction including 4 tables of various acreages. The maps show areas of commercial production of shellfish--clams, oysters, crabs, etc.--and "land" or water-bottom ownership, federal, state or private, plus "proposed aquisition ares." The mapping of these areas is not as accurate as available data would permit, judging from the localities of which I have firsthand knowledge. (S. H. Hopkins)

Spooner, G. M. 1947. The distribution of Gammarus species in estuaries. Part I. Jour. Marine Biol. Assoc. U.K., 27(1):1-52.

Marinogammarus is essentially marine, M. marinus is high-salinity species extending into midestuary, M. olivii in fresh to slightly brackish part of Avon River.

Gammarus locusta (L.) G. O. Sars, sens. stricta, is abundant marine species, but in estuaries it has been often confused with G. zaddachi salinus. Northern populations of G. locusta tend to resemble zaddachi more and to occur in lower salinities than those of Atlantic and Mediterranean.

G. zaddachi is important estuarine species. Has two subspecies, G. z. zaddachi

in brackish waters of low salinity and to limited extent in fresh waters, and G. z. salinus, characteristic estuarine form which does not tolerate oceanic or fresh water, or even very weakly brackish water. These differ in a number of morphological characteristics (setation, etc.). In same water, e.g. 14 ppt, these subspecies are intersterile. (S. H. Hopkins)

Spooner, G. M. and Moore, H. B. 1940. The ecology of the Tamar Estuary. VI. An account of the macrofauna of the intertidal muds. Jour. Marine Biol. Assoc. U.K., 24(1):283-330.

Moore, 1958, Marine Ecology, pp. 402-404 and table 11-9 on p. 403, shows and discusses results. Both vertical and horizontal distribution studied; more marine species tend to concentrate at lower vertical levels as well as farther down estuary; more euryhaline species tend to concentrate at higher vertical levels as well as farther inland. (S. H. Hopkins)

Sprague, V., Dunnington, E. A., Jr., and Drobeck, Elaine. 1969. Decrease in incidence of Minchinia nelsoni in oysters accompanying reduction of salinity in the laboratory. Proc. Nat. Shellfish. Assoc. (1968), 59:23-26.

"Sick oysters, selected from a population with high incidence of Minchinia nelsoni infection, were held in aquaria at different salinities for about 6 months. Salinities were about 7-8 ppt (running water), about 14-16 ppt (running water), and 19-22 ppt (recirculating water). Section preparations for microscopic examination were made from preserved gapers and survivors. The incidences of infection in the three salinities were found to be, respectively, 5.5%, 63.1%, and 88.8%, indicating recovering of some oysters at the low salinity. These results agree with field observations which suggest that the parasite does not thrive at low salinities, although some of the other factors which could have influenced the results were not controlled." (Authors' abstract)

Stafford, Joseph. 1913. The Canadian oyster, its development, environment and culture. Commission of Conservation, Canada. The Mortimer Co., Ltd., Ottawa, Canada. 159 pp.

Wherever "salinity" is mentioned, it is actually specific gravity that is stated. On p. 90, in discussion of physical conditions of natural oyster-producing areas, it is stated that: "The salinity generally lies between 1.012 and 1.020 (distilled water being 1.000) but varies a few degrees with the ebb and flow of the tide and with the amount of river water." Specific gravities for various oyster-growing waters are mentioned on pp. 24, 91, 92, 93, and 128. (S. H. Hopkins)

St. Amant, Lyle S. 1961. Oyster conditions in 1961...an unusual year. Louisiana Conservationist, 13(11):10-11 (November 1961).

Because of high spring and summer rainfall and high river stages, salinity was below normal in Louisiana oyster-growing waters including Sister Lake, Black Bay, Louisiana marshes, Barataria Bay, etc. Salinity and temperature graphs are shown for Barataria Bay. Thais is expected to be affected, and D. marinum is almost "nil." Low salinities are expected to benefit the oyster industry in the long run. Shrimp production was adversely affected. (S. H. Hopkins)

Stammer, H. J. 1928. Die Fauna der Ryckmundung, eine Brackwasserstudie. Zeitschr. Morph. Oekol. Tiere, 11(1/2):36-101.

Listed by Redeke, 1932, as one of five most important monographs on fauna of brackish-water regions.

"The macroscopic fauna and flora, the net plankton, and the bottom organisms were studied at 23 stations in the river and in the various bays and sidewaters

between Greefswald and Wieck on the Baltic Sea. The salt content varied from 0.5 ppt at Greefswald to nearly 7 ppt at Wieck. Roughly 1/3 of typical freshwater forms of the upper Ryck were able to maintain themselves in the brackish water of the lower stretches. Most of the littoral organisms of the Baltic coast near Wieck were met with also in the brackish waters of the Ryck, and some even in the fresh waters of the upper part of the river, their distribution being influenced apparently as much by the character of the bottom and the vegetation as by the salinity. The results of the study are compared with similar studies in other parts of the world."

Stauber, L. A. No date (Circa 1943). Ecological studies on the oyster drill, Urosalpinx cinerea, in Delaware Bay, with notes on the associated drill, Eupleura caudata, and with special consideration of control methods. Unpublished typed report. Rutgers, The State University of New Jersey, New Brunswick, N. J., 180 pp.

Salinity, pp. 67-79. Distribution in Delaware Bay, pp. 167-169. Previous studies were not continued until 100% of the snails were dead and did not give killing times or temperatures with lethal low salinities. This work emphasizes importance of survival of resistant few which could repopulate the area after a killing freshet. A few individuals of U. cinerea remained active after 19 months in salinity of 10 ppt, in laboratory. There was longer survival in experiments started at low temperatures (below 20 C) than in those started at higher temperatures. At 10.7 C, drills lived 60 days or longer in 8 ppt. Distilled water killed 50% in 9 days, but took 10 days to kill 100% (and 1 ppt took 11 days, 2 ppt took 13 days, 6 ppt took 14 days, etc.). Crawling was observed after 7 days in 8 ppt, and one snail laid eggs after 5 days in 9 ppt, but no eggs or larvae survived in salinity below 15 ppt. Drills have not been found regularly below the natural beds farthest downbay. It is on planted beds in more saline waters that they prey on young oysters. (S. H. Hopkins)

Stead, David G. 1907. Preliminary note on the wafer (Leptoplana australis), a species of dendrocoelous turbellarian worm, destructive to oysters. Dept. Fisheries New South Wales (Australia), November 1907:1-6.

(Worm known to oyster farmers of Georges River under local name "wafer." Also occurs Hawkesbury River, Bar Island, and Pelican Island. Stead visited Bar Island and Pelican Island, saw large numbers recently killed oysters and large numbers "wafer," some actually at work inside oysters. Oysters very poor at the time because of lack of a freshet. Polydora occurs at same locality but not found in the recently dead oysters.)

Stenzel, H. B. 1971. Oysters. In: Moore, R. C., ed. Treatise on invertebrate paleontology, Part N (Bivalvia), Vol 3 (of 3), Mollusca 6. University of Kansas and Geological Society of America, Inc., Boulder, Colo., iv + 271 pp. (N953-N1224.)

Salinity tolerances, pp. N1038-N1040; salinity (high and low salinity) barriers, pp. 1040-1041. References to salinity on other pages. Pycnodonteinae now living are restricted to oceanic waters, and so were the many species of extinct Gryphaeidae. Modern oysters (other than Pycnodontinae) belong to the family Ostreidae, some of which live in oceanic waters and others in estuaries where salinities may be low at times, or may be higher than oceanic in the case of Crassostrea virginica and Ostrea equestris in South Bay, Lower Laguna Madre, Texas, according to Breuer (1962). (S. H. Hopkins)

Stephens, G. C. 1963. The influence of salinity on the uptake of glycine by euryhaline annelids. Proc. Int. Congr. Zool., 16(2):41.

In the polychaete worms Nereis limnicola and N. succinea, uptake of glycine declines rapidly as concentrations of the medium fall below 200 mm chloride/l

(12.72 ppt). At 100 mm uptake has ceased. Higher salinities produce slightly higher rates of uptake. (S. Rennie)

Stephens, G. C. 1964. Uptake of organic material by aquatic invertebrates. III. Uptake of glycine by brackish-water annelids. Biol. Bull., 126:150-162.

Nereis limnicola Johnson, collected at 0.216 ppt, and Nereis succinea Frey and Leuckart, collected at 18.00-25.5 ppt, were used. After acclimating at various chloride concentrations for 2 days, N. limnicola showed an increase in uptake of glycine with increased chloride content (from 0-543 meg. Cl^-/1). By increasing the acclimation period to 2 weeks or longer, uptake was increased amost 10 times.

With 2 days of acclimation at various salinities, N. succinea showed a greater overall uptake as well as an increase over the same salinity range as N. limnicola.

In both species, uptake declines rapidly between 200 and 150 meg. Cl^-/1. Data from others show this to be close to the point at which osmoregulation begins, pointing up the incompatibility of the two processes. (S. Rennie)

Stephens, G. C. 1967. Dissolved organic material as a nutritional source for marine and estuarine invertebrates. Pp. 367-373. In: Lauff, G. H., ed. Estuaries. Am. Assoc. Adv. of Sci. Publ. 83, Washington, D. C., xv + 757 pp.

On the basis of his previous work (Stephens, 1964; Stephens and Virkar, 1966) the author suggests that accumulation of amino acids, such as glycine, which takes place at higher salinities, is incompatible with osmotic regulatory activities, so that no amino acid is taken in below the critical salinity at which osmoregulation becomes necessary. Ability to accumulate amino acids may give an adaptive advantage to marine and estuarine animals. No freshwater animal has this ability. (S. H. Hopkins)

Stephens, G. C. and Virkar, R. A. 1966. Uptake of organic material by aquatic invertebrates. IV. The influence of salinity on the uptake of amino acids by the brittle star Ophiactis arenosa. Biol. Bull., 131:172-185.

When acclimated slowly to reduced salinities (50% sea water; 100% is 33.08 ppt), Ophiactis increases its water content and decreses its free amino acid pool. When animals which are acclimated at various salinities from 100% to 50% sea water are exposed to radioactive glycine for 30 min, uptake of amino acids is greater from 90%-70% sea water, but then decreases at the lower salinities. The amount of alchol-insoluble material increases with reduced salinity.

In response to transfer from 100% to 60% sea water directly, there is a rapid decrease of the free amino acid pool at about 2 days with a further gradual decrease thereafter. The amount of alchol-insoluble radioactivity increases rapidly the first day, fluctuates until day 3, and then drops off steadily over the next week. (S. Rennie)

Stephens, W. M. 1968. Southern seashores. Holiday House, New York. 192 pp.

This popular-style book for amateur naturalists is mainly on Florida shore or shallow water flora and fauna. Chap. 5, the World of Estuaries and Harbors, contains several pages (74-79) on the Everglades in which it is stated that the fresh and brackish waters that serve as nursery grounds for the pink shrimp, Penaeus duorarum are necessary for this species and if the supply of fresh water is cut off (because of engineering works, previous paragraphs imply), "the Tortugas shrimp fishery will die." (S. H. Hopkins)

Stephenson, W., Endean, R., and Bennett, Isobel. 1958. An ecological survey of the marine fauna of Low Isles, Queensland. Austral. Jour. Mar. Freshw. Res., 9(2):261-318.

These coral islands lie just off the mouth of Daintree River. Floods of this river kill many corals, make the water turbid, and cover some corals with mud, but the reefs soon recover. In the 5 years preceding the 1928-29 expedition 10 floods were recorded but the coral growth was still luxuriant. (S. H. Hopkins)

Stickney, Alden P. 1964. Salinity, temperature, and food requirements of soft-shell clam larvae in laboratory culture. Ecology, 45(2):283-291.

"Larvae [of Mya arenaria] were reared through metamorphosis and their tolerance to various levels of temperature and salinity were determined. The optimum temperature range was between about 17 C and 23 C, although slow development took place as low as 10 C. Optimum salinity was from about 16 ppt to 32 ppt (the highest value tested). Some differences in response to temperature and salinity between larvae from parents of different origins were observed."

Tables I (p. 286) and II (p. 287) show no differences in survival and growth of Chesapeake Bay Mya larvae at 16 and 32 ppt, and only a slightly lower growth at 10 ppt, but table IV (p. 287) shows less survival of New England Mya larvae at 16 ppt than at 22-23 or 31-32 ppt, and no survival of larvae at 10 ppt. (From abstract, p. 283)

Stock, J. H. 1952. Some notes on the taxonomy, the distribution and the ecology of four species of the Amphipod genus Corophium (Crustacea: Malacostraca). Beaufortia, 21:1-10.

At the seaward end of an estuary C. volutator tends to be replaced by other species of Corophium. In the canal from Amsterdam to the sea, C. sextoni and C. insidiosum occur near the mouth. C. insidiosum, like C. volutator, a mud burrower, often occurs with it in large numbers. Fide Green (1968, p. 192). (S. H. Hopkins)

Stokke, Knut. 1958. The red alga Gracilaria verrucosa in Norway. Nytt. Mag. Bot., 6:101-111.

The distribution of G. verrucosa along the coast of south Norway was determined during summer surveys in 1953 and 1954. Field and laboratory observations were made on the alga's morphology, growth, sexual and vegetative reproduction, tolerance to H_2S, and salinity and temperature dependence. Gracilaria was found in waters having salinities between 10 and 30 ppt, and commonly in 20 ppt. Plants taken from the field survived at salinity values between 5 and 35 ppt. Growth was poor when the plants were kept at salinities lower than 10 ppt and higher than 30 ppt. (T. Rennie)

Strawn, Kirk and Dunn, James E. 1967. Resistance of Texas salt- and fresh-water-marsh fishes to heat death at various salinities. Texas Jour. Sci., 19:57-76.

All fish were acclimated at 35.0 C and 5 ppt except the freshwater specimens which were kept in tap water at the same temperature (3-5 days). Fish were subjected to lethal temperatures in tap water and in salinities of 5, 10, and 20 ppt. They were transferred directly from acclimation to lethal temperatures.

Excluding the freshwater fish, the most resistant to heat shock in decreasing order are Cyprinodon variegatus, Fundulus pulvereus, Adinia xenica, Fundulus similis, and Fundulus grandis. These all are found during low tide in open shallow waters of the salt marsh. The least resistant fish tested were Poecilia latipinna, Gambusia affinis, Lucania parva, and Lepomis symmetricus, which are associated with submerged vegetation. Fundulus chrysotus is one of the most resistant to heat death, and is associated with aquatic vegetation.

In general the salinity optimum for survival decreased with a decrease in temperature for the freshwater fishes and increased for salt-marsh fishes. Survival

at any specific salinity increases as temperature decreases for most salt-marsh fish. (S. Rennie)

Stroud, R. H. 1971. Introduction to symposium. Pp. 3-8. In: A symposium on the biological significance of estuaries, sponsored by the Sport Fishing Institute, etc. Feb 13, 1970, Houston, Tex. Douglas, P. A., Stroud, R. H., ed. Sport Fishing Institute, Washington, D. C., xi + 111 pp.

Estuary, definitions. Transition between fresh and salt water. Estuaries of U.S. total 26,364,800 acres, of which at least 564,500 acres has been lost by filling, mostly in last 50 years. Long list of "estuarine-dependent marine fishes" is presented, pp. 5-7. Approximately 63% of commercial catch on Atlantic coast "is made up of species believed to be estuarine-dependent (McHugh 1966)." For each acre of estuary lost, "there could be a corresponding annual loss in yield...of about 535 pounds of fisheries products on the Continental Shelf." (S. H. Hopkins)

Struhsaker, Jeannette W. and Costlow, J. D., Jr. 1969. Some environmental effects on the larval development of Littorina picta (Mesogastropoda) reared in the laboratory. Malacologia, 9(2):403-419.

The results described are from a general study on population ecology and intraspecific shell variation of Hawaiian L. picta. The major environmental factors studied were the effects of antibiotics, food, salinity, temperature, and substrate on larval growth and mortality. The highest growth and survival are obtained when larvae are reared in sea water within a salinity range of 30-40 ppt and temperature range of 24-25 C, treated with 20-25 ppm of Polymixin B sulfate and fed Phaeodactylum tricornutum. There are variations in the growth and mortality of different sculpture types at the salinity-temperature extremes. These are correlated with the distribution of sculpture types in the natural environment. Heavily sculptured shell forms occurring on drier, low wave action substrata have larvae which are more resistant to high salinity and less resistant to low temperature than the larvae of smooth shell forms which occur on wet substrata with strong horizontal wave force. (From Biol. Abstr.)

Stuart, T. A. 1941. Chironomid larvae of the Millport shore pools. Trans. Roy. Soc. Edinburgh, 60:475-502.

Chironomid larvae were collected from rock pools around the Isle of Cumbrae, Buteshire, monthly from April 1940 to April 1941, and reared at the Marine Station, Millport, Scotland, in shallow covered petri dishes. The salinities of the pool series where the larvae were collected showed a definite gradation from fresh water to a salinity exceeding that of sea water (no exact salinities were given). Ten species of larvae belonging to three Chironomidae subfamilies were identified, a few existing only in fresh water pools, several being able to withstand waters up to 50% sea water, and a few that could withstand the entire freshwater to sea-water range. Each pool in the series contained a different dominant species. The ability of those larvae to withstand high degrees of salinity was felt to be probably due to differences in the permeability of the cuticle and the constitution of the body fluids. The author noted the reduction in size of the anal papillae as the salinity increased. He then carried out experiments, placing different larval types in varying salt solutions, and noted that the size of the papillae did not vary in the different solutions, but remained constant for each type. (T. Rennie)

Stunkard, H. W. and Shaw, Ruth C. 1931. The effect of dilution of sea water on the activity and longevity of certain marine cercariae, with descriptions of two new species. Biol. Bull., 61(2):242-271.

Six species of cercariae (larval trematodes) which emerged from marine snails

at Woods Hole, Mass., were tested for survival and vigor of locomotion in six solutions: I, undiluted sea water; II, 75:25% sea and tap water; III, 50:50% sea and tap water; IV, 25:75% sea and tap water; V, 12.5:87.5% sea-tap water; VI, tap water only. Stunkard interpreted the results to mean that these marine parasites could complete their life cycles in brackish water as dilute as 1/8 to 1/4 sea water (equivalent to about 8.5- to 4-ppt salinity). (S. H. Hopkins)

Styczynska-Jurewick, Ewa. 1971. Tolerance to salinity in some marine and freshwater cercariae. Acta. Parasitol. Pol., 19(19-28):257-268. (Polish summary.)

The life span and behavior of cercariae of three marine species from an Atlantic tidal region and a freshwater species in relation to the environment salinity were studied experimentally. Cercariae from brackish waters survived a very wide range of salinity. Freshwater species showed full tolerance up to 18 ppt. The role of osmosis in the process of encystment in freshwater cercariae is discussed. (From Biol. Abstr.)

Subramanian, A. 1967. Oxygen consumption in the worm eel Moringua linearis (Gray) in relation to size and salinity. Proc. Indian Acad. Sci., Sec. B., 66(6):273-278.

For all sizes, oxygen consumption minimum in 18.8-ppt salinity and increased in higher salinity as well as lower salinity. The changes in metabolic rate in relation to salinity are ascribed to osmotic stress.

Sukumaran, Sukunda (Miss). 1961. Osmoregulation in Clibanarius padavensis De Man, under heterosmotic conditions. Proc. Indian Acad. Sci., Sec. B, 54(3):145-151.

This hermit crab at Madras tolerates salinity of 1.2 to 24 ppt. Survival rate is maximum in 75%-25% sea water. Hypotonic in sea water, hypertonic in 25% sea water, isotonic in 50% sea water. Cl level constant in body fluid in all dilutions of sea water. Means of osmoregulation not yet known. (S. H. Hopkins)

Sumner, Francis B. 1907. Further studies of the physical and chemical relations between fishes and their surrounding medium. Amer. Jour. Physiol., 19:61-96.

Survival of the estuarine killifish Fundulus heteroclitus was obtained in 1% and 150% and 200% sea water. Fish put in sugar solutions survived no better than those in fresh water (in which survival was poor). Sumner found that solutions of NaCl (0.3-30 g/l) counteracted the fatal influence of fresh water on Fundulus. In testing some poisons it was found with Umbra limi, a freshwater fish, that $CuCl_2$ was more toxic to the fish in fresh water than in brackish water. This is suggested for other fish but he draws no conclusion. Concerning salt content of the body, he finds that for the estuarine Fundulus diaphanus the salt content increases with increased salinity (fresh water to 200% sea water). For the marine fish Tautoga onitis in 50% sea water, bathing the gills with fresh water caused death within 2-3 hr, while putting the body of the fish in fresh water and running 50% sea water over the gills had no ill effects, pointing out the relation of the gills to osmosis and diffusion. (S. Rennie)

Sutcliffe, D. W. 1967. A re-examination of observations on the distribution of Gammarus duebeni Lilljeborg in relation to the salt content in fresh water. Jour. Animal Ecol., 36:579-597.

Excluding Ireland (where this amphipod is found in waters with Na as low as 6 mg/l and Cl as low as 10.3 mg/l), G. duebeni in northwest European fresh waters is found only where there is some influence from sea and Na is over 23 mg/l (Cl 35 mg/l). The Irish populations may be a distinct race. It is suggested that this species is in process of invading fresh water from the sea. (S. H. Hopkins)

Sweet, J. G. and Kinne, O. 1964. The effects of various temperature-salinity combinations on the body form of newly hatched Cyprinodon macularius (Teleostei). Helgoleänder wiss. Meeresunters., 11:49-69.

Four hours after being laid in 35 ppt and 28 C, eggs of Cyprinodon macularius were transferred to the following temperature-salinity combinations: fresh water, 35 and 70 ppt; 26, 28, 31-36 C. At 36 C total mortality was observed. In fresh water and 35-ppt salinity, mortality increased with temperature. In 70-ppt salinity, average mortality was the same between 26 C and 31 C.

After hatching, 13 body dimensions were measured. All dimensions were found to be a function of temperature and salinity. In fresh water, body length decreases above and below 32-33 C. The various depth and width measurements increase. In 35 ppt, body length decreases with increasing temperature, and all other measurements tend to decrease in proportion to the length. In 70 ppt, body length decreases rapidly between 26 and 28 C. All other measurements change proportionately, but not as well as in 35 ppt. In general, body width and depth increase with decreasing salinity, with the freshwater fish having less surface area per unit volume. Body dimensions are smaller in 70 ppt. Changes in body dimension may also be related to oxygen content of the water. (S. Rennie)

Swift, Franklin. 1897. Report of a survey of the oyster regions of St. Vincent Sound, Appalachicola Bay, and St. George Sound, Florida. Report U.S. Comm. Fish., 22:187-221; 1 chart.

Data of hydrographic survey were taken to determine the positions, outlines, characteristics, and productivity of all the oyster beds in the area. Additional data were taken in areas suitable for planting oysters, including salinity (density). (S. Rennie)

Symposium on the Classification of Brackish Waters. 1958. The Venice system for the classification of marine waters according to salinity. Oikos, 9(2):311-312.

The Symposium adopted the system below:

Zone	Salinity Range, ppt
Hyperhaline	> ±40
Euhaline	±40 to ±30
Mixohaline	(±40) ±30 to ±0.5
Mixoeuhaline	> ±30 but < euhaline sea
(Mixo-) polyhaline	±30 to ±18
(Mixo-) mesohaline	±18 to ±5
(Mixo-) oligohaline	±5 to ±0.5
Limnetic (fresh water)	< ±0.5

New terms defined are "poikilohalinity" (waters of unstable or variable salinity) and "homoiohalinity" (the condition of stable or constant salinity).

In the Balitc Sea the following subdivisions are important biologically:

Zone	Salinity Range, ppt	Zone	Salinity Range, ppt
(Mixo-) mesohaline		(Mixo-) oligohaline	
α - mesohaline	±18 to ±10	α - oligohaline	±5 to ±3
β - mesohaline	±10 to ±5	β - oligohaline	±3 to ±0.5

Classification of inland saline waters was left up to the International Association of Limnology. (S. Rennie)

Tabb, Durbin. 1958. Differences in the estuarine ecology of Florida waters and their effect on populations of the spotted weakfish, Cynoscion nebulosus (Cuvier and Valenciennes). Trans. N. American Wildlife Conf., 23:392-401.

The author discusses the distribution and ecology of the spotted weakfish along the Florida Atlantic and Gulf coasts. This fish shows some affinity to a truly marine environment, but is essentially an estuarine species. It is found in "greatest numbers in the confines of semi-landlocked lagoons and quiet estuaries." The fish is "sensitive to changes in temperature and to a lesser degree to salinity, so that it reacts quickly to extreme changes in its environment." The author lists seven factors that greatly contribute to the abundance and "success" of this species, one of which is "large areas of shallow, quiet, brackish water (bays and lagoons)." He feels that, "perhaps, in addition, such hydrographic conditions as salinity, turbidity or others may have even greater influence on the species than temperature...." No specific salinities are mentioned. (T. Rennie)

Tabb, D. C. 1966. The estuary as a habitat for spotted seatrout, Cynoscion nebulosus. Pp. 59-67. In: A symposium on estuarine fisheries. Am. Fish. Soc. Special Publ. No. 3., viii + 154 pp., Washington, D. C.

This is one of the most valuable fish of the southeastern United States. It depends on the changeable estuaries and lagoons, even spawning in them. Both young and adults tolerate the extremes found in estuaries, which are too rigorous for most marine fish, freeing the seatrout from most predation and competition. They live in fresh water and in hypersaline Laguna Madre waters with salinity of 77 ppt, but are most abundant in salinities between 15 and 35 ppt, and rare in salinities as high as 55 ppt. Fast drops in salinity, e.g., 35-50 ppt to 10-15 ppt in 3-5 days, cause C. nebulosus to move to more stable salinity, but no mortality due to low salinity in estuaries has been reported. It is suspected, on circumstantial evidence, that freshets do kill postlarval and small juvenile fish unable to swim fast enough to escape. (S. H. Hopkins)

Tabb, D. C. and Manning, R. B. 1961. A checklist of the flora and fauna of northern Forida Bay and adjacent brackish waters of the Florida mainland collected during the period July 1957 through September 1960. Bull. Mar. Sci. Gulf and Caribbean, 11(4):552-649.

Over 400 species of plants, invertebrates, and fish are recorded, listing the scientific name, common name, a short discussion, and temperature and salinity data for each. Collecting areas are described, but no overall discussion of the data is included. (S. Rennie)

Tagatz, M. E. 1961. Tolerance of striped bass and American shad to changes of temperature and salinity. Spec. Sci. Rept. U.S. Fish and Wildlife Service, 388:1-8.

Adults and juveniles of striped bass, Roccus saxatilis, and of American shad, Alosa sapidissima, were tested. Adult bass were tolerant to abrupt changes between salt and fresh water over the range 45-80 F. Juvenile bass survived similarly up to 70 F, but were not tolerant to transfers from fresh water to salt water at 45 F.

Adult shad survived changes from fresh to salt water at the same temperatures and at 16-deg differences. They showed some tolerance with changes from salt to fresh water at the same temperatures and 10-deg differences, but no tolerance with a 25-deg change. Juvenile shad tolerated the change from salt to fresh water in the 45-70 F range, but not the reverse in the same temperature range.

While juveniles of both species tolerated transfers within fresh water over the range 45-70 F, bass mortalities occurred with a decrease to 45 F and all shad died in fresh water with a decrease of 7 F or more in temperature. Where

mortality occurred when abrupt changes were made, no mortality occurred when the same changes were made gradually. (S. Rennie)

Tagatz, Marlin E. 1967. Growth of blue crabs. Report of the Bureau of Commercial Fisheries Biological Laboratory, Beaufort, N. C., Circular 264:11-13.

Blue crabs were kept in the St. Johns River at salinities of 6.9-25.8 ppt and less than 1 ppt over a 12-month period. The greatest increase in size per molt was found in the more saline environment. (S. Rennie)

Tagatz, M. E. 1968a. Biology of the blue crab, Callinectes sapidus Rathbun, in the St. Johns River, Florida. U.S. Fish and Wildlife Service, Fishery Bulletin, Vol. 67, No. 1, pp. 17-33.

In this long estuary with very gradual salinity gradient, blue crabs are widely distributed in fresh water. Tags from crabs tagged here were returned from places as distant as Jekyll Island, Ga., and New Smyrna Beach, Fla. Many females from ocean returned to estuary, some twice. Postlarval crabs entered estuary in numbers 6 months after hatching had begun. Cited by Tagatz and Hall, 1971, p. 68. (S. H. Hopkins)

Tagatz, M. E. 1968b. Growth of juvenile blue crabs, Callinectes sapidus Rathbun, in the St. Johns River, Florida. U.S. Fish and Wildlife Service, Fishery Bulletin, Vol. 67, No. 2, pp. 281-288.

Juveniles were held in floats in saltwater and in freshwater parts of St. Johns River (estuary), and effects of salinity and season on length-width ratios, molt intervals, relative growth, and estimated absolute growth were studied, according to Tagatz and Hall, 1971, p. 68. (S. H. Hopkins)

Tagatz, Marlin E. 1969. Some relations of temperature acclimation and salinity to thermal tolerance of the blue crab, Callinectes sapidus. Trans. Amer. Fish. Soc., 98:713-716.

Adult and juvenile crabs collected at 20-30 ppt and 4-30 C were acclimated to temperatures of 6, 14, 22, or 30 C and salinities of 6.8 or 34 ppt. Crabs were less tolerant to temperature extremes at 6.8 ppt. At both low and high salinities, the upper and lower thermal tolerance limits increased as the acclimation temperature increased. Although limits for adult and juvenile crabs were similar (usually within 0.5 C), juveniles were slightly more tolerant to heat and less tolerant to cold than adults. (S. Rennie)

Tagatz, M. E. 1971. Osmoregulatory ability of blue crabs in different temperature-salinity combinations. Chesapeake Sci., 12(1):14-17.

Total osmotic concentrations were measured periodically for blood samples from adult male and immature, mature, and ovigerous female blue crabs (Callinectes sapidus) taken from Core Sound, N. C., and held in solutions of 5%, 50%, and 100% sea water (100% = 34 ppt) at 10, 20, and 30 C for 72 hr. Blood was hypo-osmotic to medium in sea water, but hyperosmotic in 5% and 50%. Analysis of variance showed effects of salinity, life stage, and all interactions of these factors to be significant, while temperature was not significant. Some differences in osmotic concentration of blood were related to distribution of blue crabs in nature. Ovigerous females (in nature, confined to higher salinities) did not regulate as well as mature nonovigerous females or adult males in 5% or 50% sea water at any temperature, and at 10 C had osmoregulation markedly impaired in 5% sea water. In 50% or 100% sea water, osmotic concentration of blood was lower in immature than in mature females. Only in 5% sea water at 10 C was there significant difference between males and females. (T. Rennie)

Tagatz, M. E. and Hill, Ann B. 1971. Annotated bibliography on the fishing industry and biology of the blue crab, Callinectes sapidus. NOAA Tech. Rept. NMFS SSRF-640. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Seattle, Washington. (For sale by Supt. of Documents, U.S. Govt. Printing Off., Washington, D. C.) 94 pp.

Quoting the abstract: "References are given on 742 publications, published before 1970, on classification, distribution, abundance, life history, morphology, physiology, ecology, fishery, and industry. Annotations and a subject index also are provided." The annotations, which average 6-7 lines, are pertinent and helpful. The bibliography of publications listed alphabetically by author occupies 75 pages and is followed by "Categories of Subject Index," p. 79, then a "Subject Index" of 14 pages with items listed under each subject subheading by author and date. (S. H. Hopkins)

Talbot, G. B. 1966. Estuarine environmental requirements and limiting factors for striped bass. Pp. 37-49. In: A symposium on estuarine fisheries. Am. Fish. Soc. Special Publ. No. 3, viii + 154 pp., Washington, D. C.

P. 43: "Except during spawning, salinity does not seem to be a critical factor." [Low salinity is necessary for spawning, p. 39.] Man-made changes, which change an area of gradual change in salinity into one of abrupt change from high to low, are adverse to striped bass.

Tan, Eng-Chow. 1962. Studies on osmotic and ionic regulation in the blue crab, Callinectes sapidus Rathbun. M.A. thesis, College of William and Mary, Williamsburg, Virginia. 66 pp.

Osmotic concentrations of the blood, Na and K content, and Na to K ratio in serum of adult blue crabs exposed to different salinities. See also Tan and Van Engel (1966). From Tagatz and Hall (1971, bibliography). (S. H. Hopkins)

Tan, Eng-Chow and Van Engel, W. A. 1966. Osmoregulation in the adult blue crab, Callinectes sapidus Rathbun. Chesapeake Sci., 7:30-35.

Blue crabs of both sexes taken from lower Chesapeake Bay were acclimated to 10, 20, and 30 ppt at 20 C for 2 days. Freezing points of blood samples were determined for each crab. All were hyperosmotic to the medium in which they were kept. Females showed significantly different blood osmoconcentrations in the three test salinities: 0.95 osmoles/l in 10 ppt, 1.01 osmoles/l in 20 ppt, and 1.18 osmoles/l in 30 ppt. Males showed no significant differences in blood osmoconcentration in 10 and 20 ppt (1.08 and 1.07 osmoles/l, respectively), but males kept in 30 ppt had 1.14 osmoles/l; significantly higher.

The results suggest that difference in osmoregulatory ability of adult males and females is one of the major factors causing the sexes to live in different salinities, and is further correlated to their differential abilities to regulate sodium in their blood. (S. H. Hopkins)

Tash, Jerry C. and Armitage, Kenneth B. 1967. Ecology of zooplankton of the Cape Thompson area, Alaska. Ecology, 48:129-138.

They examined some aspects of the species associations of crustacean zooplankton from a series of lagoons, coastal and inland pools, and lakes. No specific salinity data are given but they are referred to in Tash's 1964 Ph. D. thesis. Habitat preferences for Cladocera and Copepoda are given for the bodies of water studied. Types of life cycles are analyzed and species affinity have been computed. There is some speculation on food storage in the Cladocera and Copepoda. (S. Rennie)

Tattersall, W. M. 1932. Contributions to a knowledge of the Mysidacea of California. II. The Mysidacea collected during the survey of San Francisco Bay by the U.S.S. "Albatross" in 1914. Univ. Calif. Publ. in Zool., 37:315-347.

The following species are described: Neomysis mercedis, N. franciscorum, N. kadiakensis, N. costata, N. macropsis n. sp. N. mercedis was found in the upper bay where salinities were lower (11.42-28.00 ppt). N. kadiakensis, N. franciscorum, and N. costata were most abundant in the lower and middle part of the bay where salinities were higher (22.96-29.72 ppt, 16.90-30.97 ppt, and 24.85-30.28 ppt, respectively, for the three). N. macropsis was distributed all over the bay rather uniformly.

A key to the genus Neomysis is included. (S. Rennie)

Taylor, N. 1939. Salt tolerance of Long Island salt marsh plants. New York State Museum, Circular 23:1-42.

Grew Spartina alterniflora, Spartina patens, and Distichlis spicata in pots with subirrigation with water of various salinities. All species grew best in fresh water, though Distichlis tolerated sea-strength salinity. Taylor was unable to get good growth in the salinities in which these plants are found in nature (in salt marshes). He found that S. alterniflora in salt solutions became yellow; this species is known to be "chlorosis-prone" even in nature. Cited by Adams (1963), who adds that the chlorosis is caused by iron deficiency, Spartina alterniflora having high iron requirement which causes it to be restricted to low marsh in nature. (S. H. Hopkins)

Taysi, I. and van Uden, N. 1964. Occurrence and population densities of yeast species in an estuarine-marine area. Limnol. and Oceanogr., 9(1):42-45.

Samples were taken from two temperate estuaries, Tagus and Sado Rivers, Portugal, and compared with adjacent Atlantic Ocean areas. No salinity data are given. The greatest numbers of yeast species and individuals are recorded from the estuarine stations, where the most organic pollution occurs. Primary pollution enriches the water with nutrients. Yeasts may be brought in by a number of mechanisms, but those that survive must tolerate the marine or estuarine condition and the particular water temperature. Warmer water species from the Gulf of Mexico and the Indian Ocean (41-46 C) were not found in the cooler Portugal estuaries (32-38 C). (S. Rennie)

Teal, John M. 1958. Distribution of fiddler crabs in Georgia salt marshes. Ecology, 39(2):145-193.

Adult fiddler crabs collected from the Sapelo Island area were placed in fingerbowls containing water of salinities of 0, 7, 15, 30, 43, 49, and 58 ppt and survival was noted. At salinities higher than 7 ppt, all species (Uca minax, U. pugilator, and U. pugnax) survived more than 3 weeks. At 0 salinity, 50% of U. minax died at end of 3 weeks, 50% of U. pugilator died in 3-1/2 days, and 50% of U. pugnax died within 1-1/2 days. At 7 ppt, 50% of U. pugnax died after 3 days, while over 50% of the other two species lived the entire 10-day test period. The author also gave the three species a saltwater/freshwater choice (salinity of salt water 30 ppt) by placing both males and females in an aquarium having a low partition down the center. Crabs could move freely over the partition to the different salinity. Crabs' positions were noted after 24 hr. Both males and females of U. minax showed a statistically significant preference for fresh water over salt. U. pugilator and U. pugnax showed a significant preference for salt water over fresh. The preference shown by the females (in all cases) was less strong than that of the males. These data supported the general distribution of the animals. U. minax is able to stand long immersion in fresh water and can penetrate up streams and rivers. U. pugilator is less resistant but can survive soakings with rainwater, while U. pugnax is least resistant to

dilution and is restricted to tidal marsh areas of comparatively high salinity. (T. Rennie)

Teal, J. M. 1962. Energy flow in the salt marsh ecosystem of Georgia. Ecology, 42(4):614-624.

"The only higher plant of importance on the salt marsh is Spartina alterniflora. It grows over the entire marsh, is eaten by insects, then dies, decomposes and as detritus furnishes the food for much of the remaining fauna of the marsh." Salinity of the water flooding the marshes varies from 20 to 30 ppt, and is as low as 12 ppt in heads of creeks just after heavy rains. Extremes are 5 ppt where there is much freshwater drainage from land and 70 ppt in isolated low areas during rainless summers. Only a few animals can adapt to the great changes in salinity, temperature, and exposure, and these are relatively free from competitors and enemies and can become very abundant. Data are given on productivity of Spartina, respiration rates, rate of decomposition, consumption, etc. The abundant animals in the estuaries live on production exported from the marsh (45% of marsh production is carried from marsh to estuary by tides) and not on phytoplankton, whose net production (because of turbidity and mixing) is zero. (S. H. Hopkins)

Tebble, N. 1966. British bivalve seashells. British Museum (Natural History), London, 212 pp.

Placed Cardium edule in the genus Cerastoderma, and put the closely allied Cardium lamarki in the same genus. According to Green (1968, p. 155), "it seems likely that in the past these two species have been confused, and records of C. edule from salinities below 20 ppt probably refer to C. lamarki." See Peterson (1958). (S. H. Hopkins)

Templeman, W. 1936. The influence of temperature, salinity, light and food conditions on the survival and growth of the larvae of the lobster (Homarus americanus). Jour. Biol. Bd. Canada, 2:485-497.

Normal salinity for the St. Andrews area, 31 ppt, was the most suitable for survival of lobster larvae. Salinities down to 21 ppt were slightly less favorable for survival. At 19.4 ppt few larvae reached the fourth stage of development, while at 16.7 ppt few reached the second stage. At 11.6 ppt none molted to the second stage, and most survived less than 1 day.

In salinities above 31 ppt several larvae reached the third and fourth stages at 34.9 and 35.3 ppt. At 42.5 ppt no larvae reached the second stage since the few that molted died while molting and the others died without molting after 4 to 8 days.

It was found that growth at salinities between 31.4 and 19.4 ppt was not affected by the differing salinities. (S. Rennie)

Teplova, E. P. 1961. Opyt vyraschcchivaniya tolstolobika v kubanskikh limanakh. (Experimental rearing of silver carp, Hypophthalmichthys molitrix, in the Kuban River Estuary.) Rhybnoe, Khoz., 12:28-30.

The common and mottled varieties of silver carp from the Sinyukhinsk fish nursery were introduced into the Kuban Estuary in May 1960. The average monthly biomass of zooplankton fluctuated from 4.2 to 13.4 g/m^2 between May and September, while the zoobenthos fluctuated between 0.6 and 49.9 g/m^2. The phytoplankton of the Kuban Estuary is poor. During one season, the weight of H. molitrix increased tenfold, the average weight at the end of September being over 1 kg. An examination of the food eaten (38 specimens) showed that in the estuary H. molitrix feeds on rotifers, copepods, Cladocera, the larvae of Tendipediae, and blue-green algae. The principal bulk consists of detritus, silt, and bacteria. The common variety H. molitrix is recommended for cultivation in

ponds and in estuaries as a supplementary fish.

Tesch, F. W. 1968. Salinitatstoleranz des parasitischen Ciliaten *Icthyophthirius multifiliis* (Salinity tolerance of the parasitic ciliate *Icthyophthirius multifiliis*). Helgolaender wiss. Meeresunters., 18(1/2):130-135.

The eels *Anguilla anguilla* infested with the ciliate were subjected to various salinities. Parasite lived in eels at 15 C in 8 ppt, but at 15 ppt the parasite disappeared after 4 weeks. (S. H. Hopkins)

Te Strake, Diane. 1959. Estuarine distribution and saline tolerance of some Saprolegniaceae. Phyton Int. Jour. Exper. Bot., 12(2):147-152.

Fungi were collected over a 1-year period from four stations on the upper Neuse River, N. C. Salinities range from 0 to 13.3 ppt, but Saprolegniaceous fungi were found only in waters of 0- to 2.8-ppt salinity. Higher salinities rather than temperature appeared to limit the estuarine distribution of water molds. In the laboratory, mycelial growth was measured and the development of sporangia in water was noted at different temperatures and in various concentrations of raw seawater-agar (0-89.4 ppt) for three water mold forms, *Achlya diffusa*, *Dictyuchus monosporus*, and *Saprolegnia diclina*. The three test species responded in essentially the same manner. Laboratory salinity tolerance (as shown by vegetative growth or spore production) far exceeded the observed tolerance noted under natural conditions. Growth occurred in salinities up to 89.4 ppt, but as the concentration of sea water increased, there was a general decrease of total growth. It also appeared that as temperatures increased, salinity tolerance also increased. The author postulated that nutrition, fundamentally, and not hydrographic factors (as salinity) limit the estuarine distribution of the saprolegniaceous fungi. (T. Rennie)

Thomas, L. P. 1961. Distribution and salinity tolerance in the amphiurid brittle-star, *Ophiophragmus filograneus* (Lyman, 1875). Bull. Marine Sci. Gulf and Caribbean, 11(1):158-160.

In the Everglades this species was found to tolerate salinity of 7.7 ppt, lowest recorded for any echinoderm. Other species of echinoderms tolerating low salinity are reviewed. (S. H. Hopkins)

Thompson, Seton H. 1961. What is happening to our estuaries? Trans. N. American Wildlife and Nat'l. Res. Conf., 26:318-322.

In this paper, Thompson speaks in a general way about the role of the estuary in the overall concern of commercial and sport fishing. He explains how the numerous dredge-and-fill operations are destroying natural breeding and feeding grounds by eliminating salt-marsh areas. In addition, currents and tidal interchanges, salinity, and temperature are affected. These, plus addition of much silt, affect the fish and fishing along the coastline. (S. Rennie)

Thomson, J. M. 1966. The grey mullets. Oceanogr. Mar. Biol. Ann. Rev., 4:301-335.

This paper discusses taxonomy, distribution, habitat, morphology, the scales, head and mouth parts, osteology, alimentary tract, respiratory system, circulatory system, air bladder, nervous system, reproduction, age and growth, population structure, schooling and behavior, food and feeding, predators, parasites and mortality, tolerance to the environment, hormones and neurosecretions, movements and migration, the fisheries, transplantation experiments, mullet farming, and mullet as food.

The majority of mullets are tropical and subtropical. They are usually regarded as estuarine fish, although different species are found in fresh and salt

water also. Mugil cephalus is one of the most tolerant, found in salinities of from 0 to 75 ppt. Lower limits for other species are: Liza ramada 5 ppt, L. provensalis 10 ppt, L. saliens 16 ppt, and L. aurata 24 ppt. Temperature tolerances are mostly unknown, but Mugil cephalus does not inhabit waters where winter temperatures fall below 16 C and summer temperatures fail to reach 18 C. The ability of mullet to obtain oxygen from waters with low oxygen concentration has been demonstrated by others. Spawning temperatures for Liza aurata and L. saliens are 16-24.8 C and 18-24 C, respectively. (S. Rennie)

Tietjen, J. H. and Lee, J. J. 1972. Life cycles of marine nematodes. Influence of temperature and salinity on Monhystera denticulata Timm. (Abs.). Abstracts of Papers Submitted for the 35th Annual Meeting, American Society of Limnology and Oceanography, Inc., Tallahassee, Florida, March 19-22, 1972.

M. denticulata has a generation time of 10-12 days at 25 C and 26-ppt salinity, the optimum conditions. At 25 C and 13 ppt, generation time is 20 days; at 25 C and 39 ppt, generation time is 17 days; at 15 C and 13 ppt, it is 36 days; at 15 C and 39 ppt, it is 32 days. Varying from the optimum 25 C and 26 ppt, a decrease of 10 C in temperature and an increase or decrease of 13-ppt salinity doubles the generation time. At 5 C generation time is almost 100 days. (S. H. Hopkins)

Timm, R. W. 1952. A survey of the marine nematodes of Chesapeake Bay, Maryland. Chesapeake Biological Laboratory, Solomons Island, Maryland, Publication No. 95, 70 pp.

From the Maryland (upper) portion of Chesapeake Bay, 78 species of 44 genera are described; many are new records for North America. Locality records make it possible to find salinity in which each "eelworm" was found living, from a table of salinity by locality in front of the paper. Salinities ranged from 8 ppt at Gibson Island inner harbor and Rock Creek on lower Patapsco River to 16.9 ppt in the bottom of the channel near Solomons Island. Although most species are marine, some are known elsewhere from fresh water. No quantitative data are given, only statements like "scarce" or "abundant," but estuarine nematodes are known to make up a considerable biomass in some localities. (S. H. Hopkins)

Todd, Mary E. 1963. Osmoregulation in Ligia oceanica and Idotea granulosa. Jour. Exptl. Biol., 40:381-392.

The blood of L. oceanica was hyperosmotic to the medium over the salinity range 100%-25% sea water. Internal concentration increased with salinity. Differences caused by temperature and season were relatively marked.

Similarly the blood of I. granulosa remains hypertonic to the medium over the salinity range tested, but only marginally so. Temperature and seasonal effects were also noted, but they were relatively small when compared with those of Ligia.

Neither size nor sex had any apparent effect on the concentration of the blood in these isopod crustaceans. (S. Rennie)

Todd, M. E. 1964a. Osmotic balance in Hydrobia ulvae and Potamopyrgus jenkinsi (Gastropoda: Hydrobiidae). Jour. Exptl. Biol., 41:665-677.

For estuarine Hydrobia ulvae concentration of the urine was slightly hyperosmotic in 100% to 25% sea water. In fresh water, when animals withdrew into their shells, the urine was considerably hyperosmotic. In fresh water, more survived at 5 than at 15 C. Osmotic concentration of the urine of winter animals was significantly higher than that of summer animals.

Identical tests with salt-marsh Hydrobia ulvae yielded similar results except at 25% and 5 C where the urine was much more concentrated. In addition, the salt-marsh animals took longer to adapt to low salinity/low temperature

conditions than the estuarine group. At all salinities the concentration at 5 C was greater than at 15 C.

For P. jenkinsii type A (fresh water) the urine was hyperosmotic relative to the medium over the whole range of salinities including fresh water. At 50% and 15 C both summer and winter animals survived well, but at 5 C summer animals died in 19 days. There was a markedly higher concentration of urine in winter animals than in summer ones in fresh water at 5 C.

For type A (brackish water) the urine was hyperosmotic relative to the medium over the whole range of salinities. Brackish-water animals showed greater tolerance in 75% and 100% sea water. Survival at 5 C lasted at least 10 days.

Types B and C survived indefinitely at 75% and lower salinities. Over the whole range of salinities the urine was hyperosmotic to the medium. It was hypoosmotic to the blood in fresh water indicating a mechanism for maintaining osmotic balance. (S. Rennie)

Todd, Mary E. 1964b. Osmotic balance in Littorina littorea, L. littoralis, and L. saxatilis (Littorinidae). Physiol. Zool., 37:33-44.

These three marine snails or "periwinkles" have different habitats: L. saxatilis lives up to 7 ft above high water and is active during rains. L. littorea ranges farther down the shore, to subtidal zone, as well as on intertidal rocks; it also lives in estuaries where water at low tide is less than 25% sea water. L. littoralis is intertidal in seaweed zone of midtidal and lower tidal stretches, living mainly on Fucus, and is least adapted to environmental changes. In experiments, L. littorea was essentially isosmotic from 150% to 50% sea water, and increasingly hyperosmotic in 50% to 25% sea water. L. littoralis and L. saxatilis were essentially isosmotic from 125% to 50% sea water, and markedly hyperosmotic in 25% sea water. Osmotic concentration of blood in 25% sea water was highest in L. saxatilis and lowest in L. littoralis. In 50% and 25% sea water L. littorea was most and L. littoralis least tolerant. (S. H. Hopkins)

Todd, Mary-Elizabeth and Dehnel, P. A. 1960. Effect of temperature and salinity on heat tolerance in two grapsoid crabs, Hemigrapsus nudus and Hemigrapsus oregonensis. Biol. Bull., 118:150-172.

The influence of seasonal change on heat tolerance was determined for the two crabs along with laboratory acclimation to various temperature-salinity combinations. Average summer temperatures and salinities were 20 C and 35% sea water. Holding experiments with these conditions showed H. oregonensis was more resistant to temperature extremes than H. nudus. Both showed an increase in tolerance after acclimation to 20 C and 75% sea water, although H. oregonensis was still more tolerant than H. nudus. Low temperature (5 C) and low salinity (35% of sea water) combined appeared to be slightly less favorable during the acclimation in both species, although H. nudus had fewer deaths. Acclimation to 5 C and 75% sea water did not show results much different from those of the holding experiment. Summer animals when acclimated to both high and low temperatures with high salinity showed a reduction of thermal tolerance with the low temperature acclimation.

Holding experiments on winter animals (5 C, 75% sea water) showed H. oregonensis tolerated slightly higher temperatures than H. nudus. When acclimated to summer conditions survival was the same. Much higher temperature tolerances were obtained when animals were acclimated first at 20 C and 75% sea water. The greatest difference in tolerances was obtained when acclimated to 5 C and 35% sea water. H. oregonensis could tolerate only 2.5-3 C less than its winter and summer base line tolerances. Regardless of temperature, low-salinity acclimation resulted in more variable survival at test tolerance temperatures than those acclimated at high salinity.

Smaller animals were slightly more tolerant than larger ones. Sex had no influence on tolerance. Crowding caused a lowered resistance to high temperatures. Molting lowered resistance.

Acclimation to a high temperature generally increased resistance to lethal temperatures, whereas acclimation to low salinity generally decreased it. High

temperature-high salinity was the most favorable combination to withstand high test tolerance temperatures. (S. Rennie)

Topping, Francis L. and Fuller, John L. 1942. The accommodation of some marine invertebrates to reduced osmotic pressures. Biol. Bull., 82:372-384.

The Narraguagus River Estuary at Millbridge, Maine, was the site of the study. A survey of the distribution of marine invertebrates in the estuary was conducted along with the freezing points of surface and interstitial waters at each station. There was a noticeable absence of Porifera, Coelenterata, and Echinodermata at the lower salinity stations. Animals at lower salinities were also smaller than those from higher salinities.

In the experimental acclimatization to low salinities it was shown that Nereis virens was able to survive in fresh water for longer periods of time as the acclimatization process was made more gradual. Increased body size and turgidity were less noticeable as the dilution interval became smaller. With intervals of 1% Nereis did not show this condition until 10% sea water was reached, indicating it can accommodate to reduced osmotic pressure when the change is gradual.

Fourteen species from several phyla were selected to show comparative susceptibility to reduced osmotic pressure. The order from greatest to least ability of survival is: Arthropoda > Annelida > Mollusca > Nemertea > Echinodermata > Coelenterata. This corresponds roughly to the degree to which these phyla have succeeded in colonizing fresh water.

Open-sea individuals were less resistant to changes in the concentration of sea water than the brackish-water forms.

Nereis virens was used to show the effect of reduced osmotic pressure on the weight and oxygen consumption. The average weight showed a slight, but consistent decrease down to 50% sea water. At 28% there is a marked increase in weight, but further dilutions reduced the weight. An increase at 16% was due to the failure of the osmoregulatory mechanism. Oxygen consumption increased in dilutions of sea water. A decrease in consumption at 28%-16% was not adequately explained. When returning the animals to natural sea water, oxygen consumption increased to 28%, and then decreased, corresponding to the amount of energy required for osmoregulation. (S. Rennie)

Tortonese, E. and Demir, M. 1960. The echinoderm fauna of the Sea of Marmara and the Bosphorus. Hidrobiol. Instanbul, 5B:5-16.

The asteroid Marthasterias glacialis, the ophiuroids Amphiura chiajei and Amphipholis squamata, and the echinoid Echinus acutus are reported from the entrance to the Black Sea, all in salinity of 18 ppt. (Fidé Binyon 1966, which see.)

Townsley, Sidney J. 1962. The effects of salinity on the accumulation and excretion of Cr-51 by three coral reef organisms. In: Summer Meeting of Amer. Soc. of Zool., Oreg. St. Univ., Corvalis, Oreg., August 1962. Amer. Zool., 2(3):454.

The radionuclide chromium-51 was added to sea water aquaria containing 100%, 75%, and 50% sea-water concentrations (salinity of 100% sea water not stated). Individuals of the brachiopod Lingula reevi, the sipunculid Physcosoma pelma, and the solitary ascidian Ciona intestinalis were added to each aquarium. Specimens were removed and their amount of radioactivity measured (whole animal and dissected parts). A third group of organisms were allowed to reach isotopic equilibrium and then placed in fresh sea-water solutions. Measurements were then made of the movement of Cr-51 out of the animals. Large quantities of Cr-51 were found in all three organism types at the reduced salinities. (T. Rennie)

Trahms, Otto-Karl. 1939. Die Grossen-und Kalkreduktion bei Mytilus edulis L. in Rügenschen Binnengewässern. Z. Morph. Oekol. Tiere, 35(2):246-250.

In the group of brackish bays of the Rügen region, the size of the bivalves varies directly with the salt content of the water. Mytilus is very scarce and very small (10-16 mm) in the Grossen Jasmunder Bodden with 6.5-ppt salt content. However, this mussel is considerably larger in other localities of the same salt content, so that its greatest reduction here seems to depend upon poor nutrition. The lime content of the reduced shell is 57%, organic constituents, 43%, as compared with 82% lime and 18% organic content in Mytilus from outside waters.

Truitt, R. V. 1946. Maryland oyster situation. Maryland Tidewater News, Sept. 1946.

Mortality of estimated 1,500,000 bushels of oysters caused by freshets of Susquehanna River, in upper Chesapeake Bay. (S. H. Hopkins)

Tundisi, J. and T. M. 1968. Plankton studies in a mangrove environment. V. Salinity tolerances of some planktonic crustaceans. Bol. Inst. Oceanogr., 17(1):57-65.

The salinity tolerances of adult females of some species of planktonic copepods were studied in a mangrove region of the estuarine type, at 25° south latitude. Results showed a wide range in the salinity tolerances for the adult females of all species studied. Based on these experiments the following order of salinity tolerance can be proposed: Pseudodiaptomus acutus > Enterpina acutiferons > Acartia lilljeborgi > Oithona ovalis > Centropages furcatus > Temora stylifera. A mechanism for the maintenance of P. acutus at certain regions of the area studied as proposed, based on experimental and field results. Salinity is probably an important factor in the distribution of some members of the zooplankton of this region. (P. Maxwell)

Turner, H. J., Jr. 1954a. A review of the biology of some commercial molluscs of the east coast of North America. Pp. 39-74. In: Sixth Report on Investigations of the Shellfisheries of Massachusetts, Woods Hole Oceanographic Institution, 1953. Commonwealth of Massachusetts, Dept. of Natural Resources, Division of Marine Fisheries. (Contrib. No. 715, Woods Hole Oceanographic Institution.)

P. 55: "Salinity and Growth." Claims that salinity effect on growth "has been for the most part completely neglected," a statement that could at least be challenged. (S. H. Hopkins)

Turner, H. J., Jr. 1954b. Growth of molluscs in tanks. Pp. 35-38. In: Sixth Report on Investigations of the Shellfisheries of Massachusetts, Woods Hole Oceanographic Institution. Commonwealth of Massachusetts, Dept. of Natural Resources, Division of Marine Fisheries. (Contrib. No. 715 from Woods Hole Oceanographic Inst.)

Tanks contained salinities as follows: 1, 31-32 ppt; 2, 31-32 ppt; 3, 25-28 ppt; 4, 19-21 ppt. Soft clams (Mya), mussels (Mytilus), oysters, and scallops all died in tanks 3 and 4. Oysters and scallops died and mussels became weak in tank 2 during 3d and 4th weeks. All species survived in tank 1, which was supplied with running water without any addition while tanks 2, 3, and 4 were stagnant and fertilized. Quahaugs (Mercenaria) survived in all tanks. Salinity in tank 4 was then raised to 23-25 ppt and the experiment continued for 2 more months. Growth averaging 5.5, 8.6, and 6.7 mm in shell size occurred in tanks 2, 3, and 4, respectively; no growth occurred in tank 1, presumably due to lack of food. Salinity of 19-21 ppt was too low for growth, it was found.
(S. H. Hopkins)

Ulken, Annemarie. 1969. Ueber das Vorkommen niederer saprophytischer Phycomycetin (Chytridiales) in Bassin d'Arcachon (Frankreich). (On the occurrence of saprophytic Phycomycetes (Chytridiales) in the Bassin d'Arcachon (France).) Veroff. Inst. Meeresforsch. Bremer; 11(2):303-308, maps. (In German with English and French summaries.)

During April and May 1968, there were many different saprophytic chytrids in the Basin d'Arcachon. They disappeared at the end of May, and no chytrid was found in October. The reason of their disappearance is probably an increase in temperature and salinity during the summer. The infection with uniflagellate fungi occurs in early spring, when large quantities of fresh water reach the basin. (From Biol. Abstr.)

Umpgrove, J. H. F. 1928. De Koraalriffen in de Baai van Batavia. Dienstv. d. Mijnb. Ned.-Ind., Wetens. Meded., No. 7:1-62; 33 plates, 17 figs.

Morphology, geology, and ecology of island reefs in Bay of Batavia, Java. Data on physical environment: temperatures, salinity, and silt. Development of reefs, etc. (J. W. Wells)

Ungar, Irwin A. 1962. Influence of salinity on seed germination in succulent halophytes. Ecology, 43:763-764.

Seeds of Sueda depressa from Big Salt Marsh, Kan., and of Sueda linearis, Spergularia marina, and Salicornia europaea from a coastal saltwater pond shore in Rhode Island were tested for germination in water of salinities of 0%, 0.25, 0.50, 0.75, 1, 2, 3, 4, and 5% NaCl. Germination percentage did not decrease gradually with increased salinity, but dropped sharply when limit was reached, 4 for S. depressa, 2 for S. linearis and S. marina, 5 for S. europaea (which, however, had best germination in distilled water). There was a slight tendency for optimum germination in 0.50% in all but S. europaea. Salinity did not slow germination; seeds germinated or failed to germinate. Seeds that failed to germinate in high salinities were put in distilled water and high germination rates were obtained, indicating that the limiting factor was chiefly an osmotic one. [These plants are species found on high salt marsh, i.e. at or above high tide level. The percentage NaCl used would be equivalent to 2.5-50 ppt.] (S. H. Hopkins)

Ungar, I. A. 1970. Salinity and temperature effects on Iva annua L. establishment. (Abs.) Bull. Ecol. Soc. America, 51(2):25 (June 1970 Program of 1970 meeting at Indiana University).

This plant grows in saline and nonsaline prairie soils. It occurs in soils with 0.0% to 1.3% total salts in surface 0-10 cm. Seed germination percentages and rate of germination decrease as salinity increases. Tests showed that the chief effects of salts were osmotic. Soaking in up to 23% NaCl solutions did not permanently inhibit germination percentages. Temperature extremes reduced percentage germination and reduced salt tolerance of the plant. Ability to withstand high salinities has high survival value in saline marsh environment, especially in drought periods. (S. H. Hopkins)

Ursin, Erik. 1956. Distribution and growth of the queen, Chlamys opercularis (Lamellibranchiata) in Danish and Faroese waters. Medd. Danm. Fisk. Havunders., N. S. 1(13):3-32, illus.

"Within the trasitional area between the Skagerrak and the Baltic, the queen Chlamys opercularis is confined to relatively saline bottom layers of the Kattegat and the northern part of the sound. The shoreward limit of distribution follows approximately the 30 ppt isohaline for the year." The mean depth at which it was found in the southern Kattegat decreased in recent years, probably

due to the increased inflow of saline Atlantic waters. Salinity was a limiting factor, but only in brackish waters, where salinities below 25 ppt were hardly tolerated. (T. Rennie)

U.S. Congress, 1947. Hearings of the House Committee on Merchant Marine and Fisheries, Subcommittee on Salt Water Fish and Shellfish Problems. Rehabilitation of oyster beds destroyed by the opening of the Bonnet Carre Spillway. Hearings, 80th Congress, 1st Session, on H.R. 572 and H.R. 1763. Washington, 81 pp., illus.

The opening of the spillway is evaluated in terms of dollars and cents with respect to the damage done to the oyster beds of Louisiana and Mississippi. An estimate of 5 years was made for full recovery of the damaged beds. Rehabilitation of the grounds is also discussed as an additional expense. (S. Rennie)

Valikangas, I. 1926. Planktologische Untersuchungen im Hafengebiet von Helsingfors. I. Ueber das plankton insbesondere das Netzplankton des Sommer halbjahres. (Researches on plankton in Helsinki Harbor. I. On the plankton especially the net plankton of the summer half-year). Acta Zool. Fennica, 1:1-298.

This extensive and intensive study in an area where salinity is 0.25-4.96 ppt was reviewed at length by Green, 1968, including tables showing numbers of species of various animal groups found in the harbor, and names of many species, at Helsinki and at Tvärminne 60 miles west of Helsinki, on pp. 99-101. (S. H. Hopkins)

Valikangas, I. 1933. Ueber die Biologie der Ostsee als Brackwassergebiet. (Concerning the biology of the Baltic Sea as a brackish-water region.) Verhandl. Intern. Ver. Limnol., 6:62-112.

This is an important and often cited review of the ecology of this, the largest brackish-water body in the world. It includes a discussion of the salinity, with an isohaline chart, and the distribution of plants and animals in this giant estuary, with special reference to salinity relations. There is a bibliography of 63 references. (S. H. Hopkins)

Van Engel, W. A. 1958. The blue crab and its fishery in Chesapeake Bay. Part I. Reproduction, early development, growth and migration. Comm. Fish. Rev., U.S. Fish and Wildlife Service, 20(6):6-17.

A review of what was known at the time, by a specialist on the group. Salinity is mentioned as a factor in distribution, migrations, laying and hatching of eggs, survival and development of early larvae (zoeae), and growth of juveniles to maturity.

Migration of adult females to the spawning grounds at the mouth of the bay, egg laying, hatching, growth and survival of larval stages, and migration of young crab upbay are all controlled or influenced by salinity. (S. H. Hopkins)

Van Uden, N. 1967. Occurrence and origin of yeasts in estuaries. Pp. 306-310. In: Lauff, G. H., ed. Estuaries. Am. Assoc. Adv. of Sci. Publ. No. 83., Washington, D. C., xv + 757 pp.

There is evidence that estuarine waters contain more species and greater densities of yeasts than the adjacent sea. Eight tables show population densities (tables 1 and 2) and lists of species of yeast in estuaries, rivers, and sea. Table 5, salt tolerance of estuarine and marine yeasts.

Van Weil, P. B. 1957. Observations on the osmoregulation in Aplysia juliana Pease (Aplysiidae, Mollusca). Z. Vergl. Physiol., 39:492-506.

When Aplysia is put in 80% sea water, oxygen consumption increases by 438% in 6 hr. Recovery does not occur upon return to 100% sea water. In 95% sea water Aplysia shows weak osmoregulation. Body volume increases. Some water is mechanically extruded by tonic contractions from the intestine. Higher salt concentration in the blood and increased oxygen consumption are evidence that some regulation is taking place. When returned to 100% sea water, oxygen consumption goes down and the water extruding mechanism stops operating. Weight loss occurs over that caused by osmotic water exchange. Sudden increase in salinity of the blood may cause tonic contraction of the intestine, resulting in greater weight loss than expected. (S. Rennie)

Van Winkle, Webster, Jr. 1968. The effects of season, temperature and salinity on the oxygen consumption of bivalve gill tissue. Comp. Biochem. Physiol., 26:69-80.

Oxygen consumption of gill tissue from Crassostrea virginica, Mercenaria mercenaria, Modiolus demissus, and Mytilus edulis was measured at salinities of 5, 10, 15, 20, 25, and 30 ppt and at temperatures of 10, 18, and 26 C during winter and summer. Oxygen consumption was greater at higher temperatures. Seasons and experimental temperature modified only slightly the effects of experimental salinity. Oxygen consumption was relatively constant from 5 to 30 ppt for Crassostrea and Mytilus, but was greater at low salinities for Mercenaria and Modiolus. The efffect of salinity on oxygen consumption of isolated gill does not appear to be correlated with the lower salinity boundaries of the whole animals. (S. H. Hopkins)

Varigny, H. de. 1883. Influence exercée par les principes contenus dans l'eau de mer sur le développement d'animaux d'eau douce. Compt. Rend. Acad. Sci., Paris, 97:54-56.

Experiments on development of frog and toad eggs to tadpoles show that of the constituents of sea water, amphibian development is not affected by calcium sulfate, calcium carbonate, magnesium sulfate, potassium chloride, and magnesium chloride in the concentration found in sea water. But the eggs are killed by NaCl, even in half that concentration. (S. H. Hopkins)

Vasantha, T. V. 1963. Changes in the inter-lamellar and basi-lamellar portions of the gills of Therapon jarbus when exposed to varying salinities. Current Sci., 32(5):214-215.

The number of nuclei in the epithelial cells from the interlamellar and basi-lamellar portions of the gills of the brackish-water fish Therapon increases when put in distilled water (0.5 ppt) and decreases in sea water (32.2 ppt). Therapon naturally lives at 16.05 ppt. Presence of vesicles in the interlamellar areas is found for both conditions other than natural. In sea water they are at the surface and in distilled water they are located deep in the interlamellar areas. (S. Rennie)

Vatova, A. 1962. Salt water fish farms of the north Adriatic. Jour. Cons. Perm. Int. Explor. Mer, 27(1):109-115.

Along the west coast of the north Adriatic are numerous saltwater farms where eels, mullet, goldfish, and bass are raised. Salinities range from 5 to 47 ppt. The numerous benthic communities of the beds are characterized as to salinity range. These communities consist of few species but include large numbers of individuals. Pelecypods make up 90% of the total wet weight; their numbers depending on salinity. Cardium lamarckii and Loripes lacteus are in high salinities (20-35 ppt) while both Cardium (can withstand 12-50 ppt salinity) and Alira ovata are rich in lower salinity areas (less than 20 ppt). A freshwater flood in the farm areas killed most of the benthic animals, these only reappearing 5 to 8 months later when the salinity had gradually increased. Polyhaline (20-35 ppt) and hyperhaline (35 ppt) beds were richest in benthic fauna and had the highest fish productivity. (T. Rennie)

Vaughan, T. W. 1915. Reef corals of the Bahamas and southern Florida. Carnegie Institit. Wash., Yearbook No. 13:222-226.

Experiments indicate that most Floridian reef corals cannot endure 50% sea water for more than 24 hr, but 80% sea water has little immediate effect. Corals run little risk of being affected by dilution due to rain. (J. W. Wells, 1957, Corals, Annotated Bibliography; in Geol. Soc. Amer. Mem. 67, Vol. 1, p. 1102.)

Vaughan, T. W. 1916. Results of investigations of the ecology of the Floridian and Bahaman shoal-water corals. Proc. Nat. Acad. Sci., 2:95-100.

Summary of results of experiments on relations of reef-corals to salinity, duration of larval stages, growth rates, nutrition, light, and temperatures. (J. W. Wells)

Vaughan, T. W. 1919. Corals and the formation of coral reefs. Annual Report, Smithsonian Instit. (1917):189-276.

[According to Pearse, 1926, Animal Ecology, p. 39: "Corals live in water that has only 80 percent of the salt content of sea water. Vaughan (1919) believes that this fact indicates that the ocean is growing more salty, and that its salinity is now supraoptimum for marine animals."] Read by S. H. Hopkins, Oct. 1, 1969: On p. 206 it is reported that none of the 16 species of Tortugas corals tested was killed by exposure to salinity of 27.87 ppt for 48 hr, although all were damaged or killed in 24 hr in 18.28 ppt, except 3 species (of 17): Maeandra areolata, Siderastrea radians, and Porites astreoides, which were not harmed by 24 hr in 18.28 ppt. Vaughan concluded: "Apparently corals would not be hurt if the salinity of the ocean were reduced to about 80 percent of its present salinity," and added that Mayer got similar results with corals of Murray Island, Australia. Then he says it appears that the ocean is becoming more salty and marine organisms are now living in an environment below their optimum condition for existence.

Venkateswarlu, T. (Zool. Sur. India, Patna, Bihar, India.) 1967. Gobioid fauna of Veller Estuary, Portonovo, South India. Hydrobiologia, 30(3/4):411-416, map.

Thirty species were recorded and one specie, Glossogobius giruris fresh water, was found in pools of low salinity only. The other species were all marine. Their distribution is given with brief ecological notes.

Vernberg, F. J. 1967. Some future problems in the physiological ecology of estuarine animals. Pp. 554-557. In: Lauff, G. H., ed. Estuaries. Am. Assoc. Adv. of Sci. Publ. 83, Washington, D. C., xv + 757 pp.

Salinity is mentioned briefly, but the author is mainly concerned with various aspects of temperature effects. The title subject is very poorly covered, considering what it could have included. (S. H. Hopkins)

Vernberg, F. J., Schlieper, C., and Schneider, D. E. 1963. The influences of temperature and salinity on ciliary activity of excised gill tissue of molluscs from North Carolina. Comp. Biochem. Physiol., 8:271-285.

Gill pieces were exposed to the following salinities: 2, 3, 4, 5, 6, 9, 12, 15, 18, 21, 24, 27, and 30 ppt with the upper ones acting as controls. The scallop Aequipecten irradians was least resistant to lower salinity, while the oyster Crassostrea virginica and the mussel Modiolus demissus follow in order. Cold-acclimated Aequipecten were more resistant to low salinities than warm-acclimated ones, while warm-acclimated Modiolus and Crassostrea were better able to tolerate low salinities than were cold-acclimated individuals. Modiolus modiolus from Germany responded similarly to Aequipecten. Response does not appear to be correlated with taxonomic affinities but with habitat requirements. (S. Rennie)

Vernberg, F. J. and W. B. 1970. Lethal limits and the zoogeography of the faunal assemblages of coastal Carolina waters. Mar. Biol. (Berlin), 6(1):26-32.

The offshore of Cape Hatteras, N. C., is an area of dynamic encounter between the Gulf Stream and the Virginia coastal current. To assess the zoogeographical significance of temperature, high and low thermal limits of both adult and larvae of species from these two regions were determined. Lethal salinity limits of the first-stage zoeae of a few crustacea were determined. Zoeae of reef species are the least resistant to both low temperature and low salinity. (From Biol. Abstr.)

Verschaffelt, F. 1929. Bijdrage tot de Kennis der Nederlandsche Zoet - en Brakwaterprotozoen. (Contribution to the knowledge of the fresh- and brackish-water protozoa of the Netherlands.) (Dissert., Amsterdam). N. V. Drukkerij Erasmus, Ledenberg/Gent. 198 pp., 2 foldout plates.

Pp. 7-60, classification and systematic list of all freshwater and brackish-water protozoans found in Holland. Pp. 61-77, descriptions of morphology and biology of the most common species. Pp. 78-104, species found in centrifuged water samples from various specific locations with different environmental conditions near Amsterdam. P. 80, classification of waters following Redeke (1922), based on chlorinity: 7 categories, from fresh with less than 100 mg Cl/l through oligohaline (100-1000 mg), mesohaline (1-10 g/l), alpha mesohaline (1-5 g), beta mesohaline (5-10 g), polyhaline (10-16 g), to sea water (over 16 g Cl/l). Pp. 105-183, ecological-physiological discussion. Pp. 183-185, summary. Pp. 186-195, literature cited. P. 196, list of habitats. Pp. 196-198, list of genera with index. (S. H. Hopkins)

Verwey, J. 1952. On the ecology and distribution of cockle and mussel in the Dutch Wadden Sea, their role in sedimentation and the source of their food supply. Arch. Neerl. Zool., 10:171-239.

Along the Dutch side of the North Sea, the lower and outer limits of distribution of the cockle Cardium edule seemed to be caused by the absence of sufficient light, while their upper and inner limits may have been caused by the level of the sands or by salinity. They withstood less than 10 ppt salinity in the Zuydersea, but they remained very small and conditions must have been adverse. When the Zuydersea was closed, reproduction of the cockle still took place at 9-10 ppt, but they all died when the salinity fell between 5.5 and 1.5 ppt. In the Zuydersea, the mussel Mytilus edulis decreased rapidly in numbers at the entrance to the southern part, where the salinity fell below 15-20 ppt. Mytilus was killed after closure when the salinity fell to 9 ppt and all animals died when the salinity had fallen to 6 ppt. The extreme lower limit seemed to be 5 ppt. The mussel cannot stand low salinities as does the cockle. (T. Rennie)

Villadolid, D. V. and Villaluz, D. K. 1938. Animals destructive to oysters in Bacoor Bay, Luzon. Philippine Jour. Sci., 67:393-399; 4 plates.

[Polyclad turbellarian, Pseudoceros sp. (plate 2, figs. 3-5) finds its way between the open valves of the oyster and feeds on the meat. It appears in the oyster farms in Bacoor Bay during March and April, when the salinity of the water is quite high.

Ref: Kaburaki, T. 1923. The polyclad turbellarians from the Philippine Islands. Smithson. Inst. U.S. Nat. Mus. Bull. No. 100 (Pt. 10):635-649.]

Viosca, Percy, Jr. 1937. Effect of the Bonnet Carré Spillway on fisheries. Louisiana Conservation Review, Winter 1937-38:51-53.

Only an insignificant number of oysters died in the area affected first by Pearl River floods, winter (January-February) 1937, then by spillway opening. The general effect was beneficial. (S. H. Hopkins)

Virkar, R. A. 1963. Amino acids in the economy of the sipunculid worm, Golfingia gouldii. Biol. Bull., 125:396-397.

In this abstract he outlines the general pattern of amino acid uptake by Golfingia from sea water. The rate of uptake is a function of ambient concentration, where a double reciprocal plot of uptake against sea water concentration gives a straight line. When animals are subjected to a small osmotic stress (80% sea water), the body wall tissue water concentration drops from 0.6 to

0.3 M/l. Further stress (50%) does not produce additional loss. (S. Rennie)

Virkar, R. A. (Univ. Calif. Irvine, Calif.). 1966. The role of free amino acids in the adaptation to reduced salinity in the sipunculid Golfingia gouldii. Comp. Biochem. Physiol., 18(3):617-625.

The regulation of intracellular amino acid. Concentration appears to be the only mechanism employed by Golfingia to counteract a decrease in external salinity. This mechanism is thoroughly adequate when the salinity change is modest, but compensates only partly for a wide variation in salinity.

Virkar, R. and Webb, K. L. 1970. Free amino acid composition of the soft-shell clam Mya arenaria in relation to salinity of the medium. Comp. Biochem. Physiol., 32(4):774-783.

Individuals of the soft-shell clam M. arenaria were transferred from a salinity of 20 ppt to a graded series of salinities from 2 to 30 ppt. Total ninhydrin positive substances (NPS) in adductor muscle extracts determined periodically with time after transfer to a 5% medium indicated a 48-hr acclimation period. NPS measurements after 48 hr in each respective medium showed a linear relation between NPS in adductor muscle and salinity. Ion exchange chromatography of muscle extracts of animals kept in the respective media for 5 days indicated that changes in glycine and alanine are largely responsible for the linear relation between NPS and salinity. (From Biol. Abstr.)

Visher, Stephen S. 1925. Tropical cyclones from an ecological viewpoint. Ecology, 6:117-122.

P. 121. "Changes in salinity are produced in three ways, by the salt spray thrown into the air by the waves breaking upon the shore, and carried far inland by the gales, by the vast volume of fresh rainwater falling upon the sea, and by mixing of fresh and salt water along the coast where flooded rivers and elevated sea level meet. Such changes of salinity may well affect the development of various eggs, larvae and seeds not killed.... The sudden changes of temperature, humidity, salinity, evaporation, etc., which [cyclones] cause sometimes... lead eggs, seeds, or larvae not killed to yield mutants." (S. Rennie)

Vishniac, Helen S. 1960. Salt requirements of marine phycomycetes. Limnol. Oceanogr., 5:362-365.

"All 49 isolates of nonfilamentous phycomycetes of marine origin were found to require NaCl for optimum growth. Thraustochytrium globosum gave parallel responses, which were not qualitatively affected by temperature, to salinity and to NaCl concentration. The NaCl optimum was unchanged after 5 serial cultures, using large inocula, in low (1%) and high (4%) NaCl." (Abstract, p. 362)

Vlassblom, A. G., and Bolier, Gerda. 1971. Tolerance of embryos of Marinogammarus marinus and Orchestia gammarella (Amphipoda) to lower salinities. Netherlands Jour. Sea Res., 5(3):334-341.

Investigation was made into the tolerance to lowered chlorinities (4 and 7 ppt) of embryos of M. marinus and O. gammarella. The rate of development remained constant, but the number of hatched juveniles declined with chlorinity. The egg membrane of both species provides only slight protection against dilution of the medium, since isotonicity of the extra-embryonic fluid with the membrane is reached fairly rapidly. The brood production of a population of M. marinus living in 4 ppt Cl is considerably reduced. (From Biol. Abstr.)

Von Wachenfeldt, T. 1969. Aktuella problemstatellningar II. 2. Sympunkter pa algfloran I Orersund. (Current problems II. Some aspects of algal vegetation

in the Oresund.) Bot. Notis., 122(3):427-434.

In the Oresund (sound) between the Baltic and the North Sea (Kattegatt) there is a salinity gradient, due to the outflow of low-salinity water from the Baltic. The surface water in Kattegatt has a salinity of approximately 18-24 ppt. In the northern part of the Oresund the salinity varies from 8 to 26 ppt (the mean value approximately 14 ppt) and in the southern part of the Oresund from 7 to 10 ppt (the mean value 8 ppt). Near the bottom the salinity in the northern part varies between 20 and 34 ppt (25-30 m) and in the southern part between 8 and 10 ppt (8-10 m). There is also a difference in salinity between the western and eastern side of the Oresund. The reduction in salinity from the northern to the southern part of the Oresund has a marked influence on the composition of the benthic algal vegetation. The decreasing salinity influences the algal vegetation in other ways. Reduction both in total size and cell sizes, e.g., Delesseria sanguinea and Callithamnion hookeri; reduction of life cycles. Several species lose their sexuality, some lose their ability to produce tetraspores. Callithamnion corymbosum is completely sterile south of the line Helsingor-Helsingborg. Most of the Baltic Rhodophyceae have lost the sexual part of their life cycle. Meiosis in the tetrasporangium is disturbed and the border between specimens with normal and disturbed meiosis lies evidently somewhere in the southern part of the Oresund. Vertical distribution tends toward greater depth. Trailliella intricata and Corallina officinalis, e.g., appear below a depth of 18-20 m. Four distribution groups may be distinguished according to the lower salinity.
(P. Maxwell)

Wakiya, Yojiro. 1929. Japanese food oysters. Jap. Jour. Zool. Trans. 2(3):359-367; 3 plates.

Gives salinity requirements and tolerances. Ostrea laperousi Schrenck (= O. gigas Thunberg preoccupied) thrives in turbid water, salinity 18.3-31.4; O. ariakensis Fujita, next in value, grows faster, also thrives in low salinities. O. multistriata Hanley (= O. circumpicta Pils.) and O. denselamellosa Lischke are marine oysters, require high salinity. (S. H. Hopkins)

Walker, K. 1969. The ecology and distribution of Halicarcinus lacustris (Brachyura: Hymenosonatidae) in Australian inland waters. Austral. Jour. Mar. Freshw. Res., 20(2):163-173.

Halicarcinus lacustris is a small crab inhabiting inland waters in southeastern Australia, New Zealand, and Lord Howe and Norfolk Islands. The Victorian distribution was investigated with reference to salinity. In the field the species occurs over a salinity range of 0.1-9.6 ppt (although scarce in fresh waters), despite a tolerance of 0.00-36.3 ppt shown by adults in the laboratory. This restriction is attributed to physiological and ecological factors. (P. Maxwell)

Wallace, D. H. 1966. Oysters in the estuarine environment. Pp. 68-73. In: A symposium on estuarine fisheries. Am. Fish. Soc. Special Publ. No. 3, viii + 154 pp., Washington, D. C.

Among man-made changes that affect oysters, "alteration of current and salinity patterns" is mentioned in the abstract, but there is little mention of salinity in the text, which emphasizes pollution. P. 71, the adverse effects of too much fertility caused by duck farms on Long Island were relieved by reopening a closed pass into Great South Bay, allowing ocean water to enter bay. P. 72, in pond culture of oysters it is possible to allow fresh water to enter and drop salinity below 15 ppt, thus killing starfish and oyster drills that would otherwise kill seed oysters, while keeping salinity above 8 ppt, the minimum tolerated by oysters (according to Wallace). (S. H. Hopkins)

Wallace, D. H. 1971. The biological effects of estuaries on shellfish of the Middle Atlantic. Pp. 76-85. In: A symposium on the biological significance of estuaries. Douglas, P. A. and Stroud, R. H., ed. Sport Fishing Institute, Washington, D. C., xi + 111 pp.

The area discussed includes New York, New Jersey, and Delaware coasts. Main emphasis is on pollution and destruction of estuarine habitats by dredging and filling. On p. 77 it is mentioned that the natural habitat of the American Atlantic oyster is in estuaries where the salinity ranges from 7 to 30 ppt, and cities have developed in precisely these areas, causing the early oyster industries in such places as Raritan Bay to move away. (S. H. Hopkins)

Walne, P. R. 1956a. Experimental rearing of the larvae of Ostrea edulis L. in the laboratory. Min. Agric. Fish and Food (Gt. Brit.) Fish. Invest., 20(9):1-23.

During a study on the feeding and growth of oyster Ostrea edulis larvae in 1-liter beakers, some experiments were made on rearing larvae under different salinity conditions. Water was not changed during these experiments and the larvae were fed on Isochrysis galbana. Salinities tested ranged from 21 to 36.7 ppt. Larvae survived and grew in all salinities, but spatfall occurred only above 26 ppt. Larvae in the lowest salinity tested grew to a curious globular shape; larvae in the other salinities appeared normal. (T. Rennie)

Walne, P. R. 1956b. The biology and distribution of the slipper limpet, Crepidula fornicata, in Essex Rivers with notes on the distribution of the larger

epi-benthic invertebrates. Min. Agric. Fish and Food (Gt. Brit.) Fish. Invest., 20(6):1-50.

An investigation was made on the distribution, growth, breeding, spatfall, and effects of temperature and salinity on the American Slipper limpet, Crepidula fornicata, in four Essex Rivers. In one laboratory study, five different salinities ranging from 25 to 34 ppt were established in 15-1 containers, each holding a few chains of slipper limpets. After 2 months, no limpets in any container were dead, but the chains in 25.2 ppt were easily pulled apart, indicating that the limpets at this salinity were distinctly weaker. In another experiment, the feeding current activity was observed under different salinity conditions. C. fornicata showed sensitivity to moderate changes in salinity. A marked current reduction occurred when salinities were lowered from 33 to 29 ppt, and at 24 ppt a very considerable current reduction occurred. Notes are also presented on the distribution and general salinity tolerance of larger epibenthic invertebrates. (T. Rennie)

Walsh, G. E. 1967. An ecological study of a Hawaiian mangrove swamp. Pp. 420-431. In: Lauff, G. H., ed. Estuaries. Am. Assoc. Adv. of Sci. Publ., Washington, D. C., xv + 757 pp.

The mangroves were Rhizophora mangle and Bruguiera sexangula. At the landward edge of the swamp salinity was 0.10-0.19 ppt. At the ocean edge of the swamp, salinity changed with the tides, ranging from 1.0 to 43.3 ppt. All of the animals of the mangrove swamp showed a high degree of tolerance to different salinities in the laboratory, some from 0 to 35.1 ppt and all from 9.2 to 35.1 ppt. The number of animal species increased from the inland to the seaward edge of the swamp, 27 species and a large primary productivity being found at the ocean edge of the swamp. (S. H. Hopkins)

Warburg, O. 1910. Ueber die Oxydationen in lebenden Zellen nach Versuchen am Seeigelei. Hoppe-Seyler's Zeitschr. Physiol. Chem., 66:305-340.

This is a classic paper on the physiology of respiration. The animal studied was the sea urchin Strongylocentrotus lividens, and especially its eggs, varying the salinity and other environmental factors. (S. H. Hopkins)

Warburton, F. E. 1958. Control of the boring sponge on oyster beds. Fish. Res. Bd. Canada, Progr. Repts. Atlantic Coast Stations, 69:7-11.

Recommends overnight soaking in fresh water, soaking in poisons such as potassium permanganate, floating in creeks, exposure on beaches to kill sponge. Removing infested shell from beds. Repeated treatments to prevent reinfestation from larvae. (S. H. Hopkins)

Ward, R. W., Vreeland, Valerie, Southwick, C. H., and Reading, A. J. 1965. Ecological studies related to plankton productivity in two Chesapeake Bay estuaries. Chesapeake Sci., 6(4):214-255.

Middle and Back Rivers (Maryland) with observations on salinity included; mean salinity lower in Back River, and net plankton counts higher. Zooplankton was less abundant than phytoplankton in Back River, while the opposite condition existed in Middle River. The same plankton genera were found in both rivers.

Warme, J. E. 1971. Paleoecological aspects of a modern coastal lagoon. Univ. of Calif. Publ. in Geol. Sci., 87:1-131; incl. 10 plates, plus foldouts in back.

P. 11: Heavy rains in southern California, winter 1968-69, caused mortality of Dendraster excentricus and some molluscan populations in Muga Lagoon (the one described in this paper) which will be described by Charles Peterson, University

of California at Santa Barbara. (S. H. Hopkins)

Warren, C. E. and Doudoroff, P. 1971. Biology and water pollution control. W. B. Saunders Co., Philadelphia, xvi + 434 pp.

Salinity effects on pp. 60 (changes in salinity caused by man's activities put stress on natural fauna), 98-103 (excretion, osmoregulation, and ionic regulation in fish, crustaceans, and oysters). (S. H. Hopkins)

Wass, M. L. 1963. Check list of the marine invertebrates of Virginia. Virginia Institute of Marine Science, Special Scientific Report No. 24 (Revised). Mimeo, 56 pp.

Lists all invertebrates so far reported from Virginia marine and brackish waters, with localities, ecological notes including salinity limits in many cases, population densities in a few cases. Bibliography. (S. H. Hopkins)

Waugh, G. Duncan. 1953. Effect of floods on the oyster grounds of eastern Britain. Nature, 173:68-69.

Floods of January 1953 caused serious losses of oysters, especially in Essex (Colne, Blackwater, Crouch, and Roach Estuaries). Two main causes of loss were burying oysters under debris from land, and choking by silt suspended in the water. Portuguese oysters survived unless actually buried, while O. edulis were choked by silt. Apparently the freshening of the water was not considered a major cause of mortality. (S. H. Hopkins)

Webb, D. A. 1940. Ionic regulation in Carcinus maenas. Proc. Roy. Soc. London, Series B, 129:107-136.

This paper contains a lot of review material on the ionic regulation of the shore crab Carcinus and other Crustacea. Analysis of blood from Carcinus held at 18-19 mg Cl/g water show that the chloride content of the blood is almost identical with that of the medium. Carcinus is also able to raise the concentration of potassium, sodium, calcium, and chloride in its blood, and lower the concentrations of magnesium and sulfate with respect to equilibrium. Webb has also shown that "under conditions which are approximately physiological the crustacean cuticle gives no evidence of irreciprocal permeability...." Salt absorption by the gills is a necessity of osmotic and ionic regulation. The urine of Carcinus is isotonic with the blood. Excretion of magnesium and sulfate is another important function of the antennary gland. He estimates that the antennary gland has a daily output of 14% of the blood volume.

In 67% sea water increased absorption of salts and excretion take place with a net decrease in magnesium and sulfate. (S. Rennie)

Webb, J. E. 1956. The effects of salinity and different sands on the distribution of a tropical Amphioxus. Proc. Zool. Soc. London, 126(1):160-161.

Rainfall at Lagos is concentrated in period March-October, when waters of lagoon and harbor become mostly fresh, killing Amphioxus. During dry season larvae from ocean enter, and populations develop to maturity and spawn. Both larvae and adults tolerate salinities as low as 13 ppt. Larvae swim upward until they reach surface water of 20 ppt, then stop swimming and sink, until they reach deep water of 24 C, which stimulates them to swim upward again. This keeps larvae off Nigerian coast in high salinity water not more than 30-40 m deep, and permits limited invasion of brackish waters during dry season.

Fine sand and silt keep Amphioxus from building up large adult populations. Most are found on bottoms with sands of mixed grain size but all above a certain size (passing sieve of 90 meshes to inch). (S. H. Hopkins)

Webb, J. E. 1958. The ecology of Lagos Lagoon. V. Some physiological properties of lagoon deposits. Phil. Trans. Roy. Soc., B, 241:393-419.

Green (1968, p. 96) cites this paper as authority for an account of larvae of Branchiostoma nigeriense entering lagoon when salinity is below 13 ppt, remaining in lagoon plankton a month or two, settling to bottom, becoming mature and spawning, then all dying when rains begin and salinity falls. (S. H. Hopkins)

Weil, E. and Pantin, C. F. A. 1931. The adaptation of Gunda ulvae to salinity. II. The water exchange. Jour. Exptl. Biol., 8:73-81.

In Plymouth tap water, which is very pure, the majority of worms die in 48 hr; they swell rapidly during first hour to about double volume, then the volume falls slightly; this is reversible. In dilute sea water, the more dilute the more the worms swell. In water from the beach stream, their natural habitat, the worms swell much less than in Plymouth tap water or distilled water; the stream water is rich in $CaCO_3$. Testing distilled water, solutions of NaCl, $NaHCO_3$, glycerol, Cambridge tap water, and Plymouth tap water, it was found that only calcium-containing solutions imitated the beneficial effects of the beach stream water. It is suggested that Ca lowers the permeability of the worms to water. (S. H. Hopkins)

Weisbart, M. 1968. Osmotic and ionic regulation in embryos, alevins, and fry of the five species of Pacific salmon. Canadian Jour. Zool., 46(3):385-397.

Fish in all three stages of development were transferred directly from fresh water into salt water (31.8 ppt). Intermediate acclimation periods of 10 and 20 ppt had no effect. At all three ages pink and chum are more resistant to sea water than coho and sockeye. Resistance of chinook is intermediate. Embryos and fry of all species were more resistant than the alevins. Pink and chum fry survived longer in sea water than their respective embryos and alevins. Chinook fry also survived longer than their embryos.

For all species blood osmotic concentrations of alevins are higher than those of fry or embryos at all exposures from 0-12 hr (except pink salmon in fresh water). Embryos and fry probably can survive longer in sea water than their alevins because of greater osmoregulatory ability. (S. Rennie)

Wells, G. P. and Ledingham, I. C. 1940. Physiological effects of a hypotonic environment. I. The action of hypotonic salines on isolated rhythmic preparations from polychaete worms (Arenicola marina, Nereis diversicolor, Perinereis cultrifera). Jour. Exptl. Biol., 17:337-352.

Preparations used were (1) isolated introvert and (2) ventral body-wall longitudinal strips. When suddenly changed from sea water to hypotonic fluid, there is first brief excitement, then inhibition, then (if not below salinity tolerance) gradual return of activity. From results of decreasing salinity at different speeds it is inferred that shock effects are not likely to be evoked in nature. The lower salinity limits for spontaneous activity in the tissues are: for Perinereis cultrifera, 20%-25% sea water, Arenicola marina, 15%-20%, and Nereis diversicolor, 5%-10%. Except in Arenicola, these results agree with salinity tolerance of natural populations. On suddenly returning from a hypotonic solution to 100% sea water, there may be slight excitation (Arenicola extrovert) or a cycle of excitation-inhibition-accommodation (Nereis body wall). (S. H. Hopkins)

Wells, G. P., Ledingham, I. C., and Gregory, M. 1940. Physiological effects of a hypotonic environment. II. Shock effects and accommodation in cilia (Pleurobrachia, Mytilus, Arenicola) following sudden salinity change. Jour. Exptl. Biol., 17:378-385.

Cilia of ctenophore Pleurobrachia pileus, bivalve mollusk Mytilus edulis, and polychaete annelid Arenicola marina show inhibition, followed by accommodation, as result of sudden downward or upward changes in the salinity of the medium. Variations in sensitivity occur between species and between different types of cilia in the same species. Mytilus gills suddenly changed from 100% to 30% sea water take up water very rapidly. Accommodation, as indicated by mechanical activity, continues long after osmotic equilibrium has been reached, and is not an adjustment of water content of cell. The results are compared with those on other types of contractile tissues. (S. H. Hopkins)

Wells, H. W. 1957. Abundance of the hard clam Mercenaria mercenaria in relation to environmental factors. Ecology, 38(1):123-128.

The exclusion of hard clams in the tributary creeks and rivers on the western and northern margins of the Chincoteague Bay (Maryland) area is attributed to low salinity, 13-20 ppt, in the spring, January through June. Most stations in the Chincoteague Bay area show no such prolonged period when salinity values range below 21 ppt, and hard clam populations in most parts of the bay have a density of 5-68 clams per 100 sq ft. Low density or complete absence of clams can be correlated with a low salinity regime during winter and spring, as well as with bottom type (clams are scarcest on mud bottom, most abundant on shell and sand bottoms) and current volocity (the more current the more clams). The areas with the low salinities also have mud bottoms and few or no clams. (S. H. Hopkins)

Wells, Harry W. 1958. Predation of pelecypods and gastropods by Fasciolaria hunteria (Perry). Bull. Mar. Sci. Gulf and Caribbean, 8:152-166.

In laboratory experiments (salinity 34.5-36.5 ppt, temperature 24-31 C), the predacious snail Fasciolaria showed a preference for Urosalpinx cinerea over Crassostrea virginica. Of gastropods presented the preference was Nassarius obsoletus, Urosalpinx, and N. vibex. Thais haemastoma was not eaten at all, and Cantharus tinctus and other Fasciolaria were only slightly preyed upon. Given a choice of pelecypods, preference was for C. virginica, Modiolus demissus, Aequipecten irradiens, and Mercenaria mercenaria, in that order. Although Fasciolaria were found concentrated on oyster bottoms, the major portion of their diet consisted of other small gastropods which also lived there, particularly drills. [Of interest to us because the penetration of Fasciolaria hunteria is limited by its lack of tolerance of low salinity, thus allowing prey to live.--SHH.] (S. Rennie)

Wells, H. W. 1959a. Boring sponges (Clionidae) of Newport River, North Carolina. Jour. Elisha Mitchell Sci. Soc., 75:168-173.

The species collected were Cliona celata, C. spirilla, C. vastifica, C. lobata, and C. truitti. During the early part of the study period the salinity was high (11.1-35.4 ppt at station farthest upriver), but a thunderstorm and three hurricanes in rapid succession dropped salinity below 10 ppt at six of the nine stations in August and September (below 1 ppt at two stations farthest upriver). Prior to this low-salinity period Cliona species had occurred at all stations. (Even including August-September, the mean salinity at the farthest upriver station was 19 ppt.) The low salinity of August-September killed all species of Cliona at all but the two stations at the mouth of the river, where salinity never dropped below 10 ppt and soon returned to the normal 30-34 ppt. The study was continued 13 months longer, but no Cliona species recolonized the stations upriver, above these two high-salinity stations, during this period. (S. H. Hopkins)

Wells, Harry W. 1959b. The influence of salinity on the fauna of oyster beds. (Abs.) Anat. Rec., 134:652.

Monthly collections were made at five stations on oyster beds near Beaufort, N. C., yielding 295 species whose distribution was correlated with salinity. Number of species was greatest at most seaward station and least at most inland station, and at each station decreased with salinity. Hurricanes Connie, Diane, and Ione in 1955 caused very low salinities and mortality among oysters and associated species. Salinity tolerance of 20 species was tested in the laboratory, and they were ranked in order of their tolerance to lowered salinity. Gastropods (8 species) showed a broad intermediate range of salinity death points, pelecypods (5 species) showed a very broad range from very low to very high death points, decapods (4 species) very low death points, and echinoderms (3 species) very high salinity death points. With only two exceptions, salinity death points were closely correlated with distribution limits in the estuary. Salinity is probably the most important factor in limiting the upstream penetration of most oyster associates. (S. H. Hopkins)

Wells, H. W. 1961. The fauna of oyster beds, with special reference to the salinity factor. Ecol. Monogr., 31:239-266.

Hydrographic data were collected at nine stations and oyster associates were collected at five stations along the length (and salinity gradient) of Newport River, N. C., a short estuary limited to the Coastal Plain, with normally little freshwater flow. From 31 January 1955 to 2 August 1955, salinity at the nine stations varied only from 11-35 ppt at Cross Rock (farthest upriver station) to 34.8-36.6 ppt at Shark Shoal, farthest downriver (in Beaufort Inlet). Then three hurricanes hit in rapid succession with heavy rains: Connie, 12 August; Diane, 17 August; and Ione, 19 September. From 13 August to 11 September salinities were below 1 ppt at the two upper stations, 5 ppt or lower at the next three stations, and below 10 at station 4. Even at the lowest station (Shark Shoal) salinity was 15-22 ppt. By October, salinities had reached their former levels. Altogether 303 species of oyster associates were collected. The number of species declined upstream and bore a direct relation to salinity conditions. Mortalities due to hurricanes and the subsequent recovery of oyster beds were followed. Some species found on upriver beds before the hurricanes never reestablished themselves upriver during the relatively high salinity period October 1955-October 1956. Twenty species tested in the laboratory showed good correlation of low-salinity tolerance and distribution, only two of them showing discrepancies. (S. H. Hopkins)

Wells, Harry W. and Gray, I. E. 1960. Some oceanic sub-tidal oyster populations. Nautilus, 73(4):139-147.

Oysters were found on five of six wrecks examined on the outer "banks" of North Carolina, north and south of Cape Hatteras, and were especially numerous on the northern ones. Salinity was oceanic. Mytilus edulis and Brachidontes exustus, and the barnacles Balanus sp. and Chthamalus sp. were attached at higher levels. Ostrea equestris was competing with Crassostrea virginica on wrecks south of Cape Hatteras. Thais haemastoma also occurred on wrecks south of Cape Hatteras, where C. virginica was scarce at subtidal levels. The one wreck where Urosalpinx cinerea was found had no subtidal oysters. Occurrence and abundance of subtidal oysters was correlated with absence or scarcity of drilling snails, which in estuaries is determined by salinity. (S. H. Hopkins)

Wells, J. W. 1932. Study of the reef corals of the Tortugas. Carnegie Inst. Wash. Yearbook No. 31:290-291.

Investigation of the upper limits of salinity endurable by reef corals: species most closely adjusted to temperature are similarly closely limited by salinity. (J. W. Wells, 1957, Geol. Soc. Amer. Mem. 67, Vol. 1, p. 1103.)

Werntz, H. O. 1963. Osmotic regulation in marine and fresh-water gammarids (Amphipoda). Biol. Bull., 124(2):225-239.

New England specimens of four amphipod species were tested: Gammarus oceanicus, marine and brackish (down to 2.5 ppt); G. tigrinus, brackish water; G. fasciatus, fresh water; and Marionogammarus finmarchicus, littoral marine and estuarine. The two marine species regulate blood concentration at highest level, G. tigrinus at a lower level, and G. fasciatus at the lowest level. The two marine species die in fresh water, G. fasciatus dies in sea water, but G. tigrinus survives in both freshwater and sea-water solutions up to at least 1.5 molal. Data on urine production correspond. (S. H. Hopkins)

Weyland, Horst. 1967. On the distribution of Escherichia coli in sediments of the Weser Estuary. Veroff. Inst. Meeresforsch. Bremer., 10(3):173-182.

Found no correlation between presence of E. coli and type of sediment, the concentration of organic matter, or bottom salinity. (S. H. Hopkins)

Weymouth, F. W., Lindner, M. J., and Anderson, W. W. 1933. Preliminary report on the life history of the common shrimp Penaeus setiferus (Linn.). Bull. Bur. Fish., 48:1-25.

Although no specific salinity data are given, the life history of the shrimp is described. Spawning takes place in gulf waters. Postlarval young are first found in bays, bayous, and "lakes" in warm, shallow, brackish waters. As the young grow they seek deeper, more saline water. (S. Rennie)

Whatley, E. C. 1969. A study of Syngnathus scovelli in fresh waters of Louisiana and salt waters of Mississippi. Gulf Research Reports, 2(4):437-474.

"A breeding population of Syngnathus scovelli [pipefish] was discovered in 1960 in Lake St. John near Ferriday, Louisiana, which is over 300 river miles from the Gulf of Mexico by the shortest possible route. Although S scovelli has been known to be euryhaline, this constitutes the first record of a breeding population in fresh water."

"The fresh water population from Lake St. John showed less variation in meristic characters than did the fish from Mississippi Sound." (From author's abstract)

Widdowson, Thomas B. 1965. A survey of the distribution of intertidal algae along a coast transitional in respect to salinity and tidal factors. Jour. Fish. Res. Bd., Canada, 22:1425-1454.

The study area was on Juan de Fuca Strait from Port Renfrew to Victoria. At Port Renfrew the onshore salinity was 32 ppt. This was the location for the inner limits of Postelsia, Pelvetiopsis, and Dictyoneurum. At this point vertical limits were high, but variable. In the Sooke area (intermediate) the salinity was 30 ppt and sometimes 32 ppt. Here was the inner limit for Cystoseira, Macrocystis, Lessoniopsis, Alaria nana, and Laminaria setchellii. Around Victoria on the eastern end of the study area, salinity was 30 ppt and occasionally 27 ppt. This formed the inner limit for Mytilus californianus, Alaria marginata, Egregia, Mitella, Phyllospadix and Hedophyllum. At Victoria the vertical distribution was not so high and less variable. The author felt that the data did not justify using salinity as the controlling factor in geographical distribution of the species in the study area. (S. Rennie)

Wiesepape, L. M. and Aldrich, D. V. 1970. Effects of temperature and salinity on thermal death in postlarval brown shrimp, Penaeus aztecus. Texas A&M University Sea Grant Program, TAMU-SG-71-201, October 1970, x + 70 pp., processed.

Shrimp were acclimated to 24, 29, and 34 C and each lot was tested for mortality at nine temperatures, 36 to 40.2 C. Those acclimated at 29 and 34 C were not killed at any temperature. The "upper incipient lethal temperature" for shrimp acclimated at 24 C was 36.6-36.8 C. It took longer to acclimate shrimp to higher temperature when salinity was lowered (4 days instead of 3). Shrimp acclimated at the nine combinations of three temperatures (24, 29, and 34 C) and three salinities (5, 15, and 25 ppt) were tested for thermal resistance time at three test salinities (5, 15, and 25 ppt) and two lethal high temperatures for each lot. Resistance time increased with increasing acclimation temperatures and decreased with increasing lethal temperature. Longer resistance time occurred at 25 ppt than at the two lower salinities (5 and 15 ppt). Shrimp acclimated at 5 ppt resisted lethal high temperatures longer than those acclimated to higher salinities, at all three test salinities. Reduction in work needed for osmoregulation is thought to explain higher thermal resistance at higher test salinities. Ecological implications are discussed. (S. H. Hopkins)

Wigglesworth, V. B. 1938. The regulation of osmotic pressure and chloride concentration in the haemolymph of mosquito larvae. Jour. Exptl. Biol., 15:235-247.

Haemolymph concentration remains normal until the external medium contains 0.75% NaCl. From that point to 0.9%, regulation of chloride begins to break down. Above 1.6% NaCl, chloride regulation is not possible and the animals die.

When adapted to different concentrations of chloride (0-0.95% NaCl), and transferred to chloride-free media, the animals adapted to high concentrations lose chloride faster than those from low concentrations. Larvae of Aedes are better at retaining chloride than larvae of Culex. Culex also loses chloride more rapidly.

In more dilute media the anal papillae are enlarged for the purpose of uptake of salts. In concentrated media the papillae are small with less surface area for absorption of salts. (S. Rennie)

Wilbur, K. M. and Yonge, C. M., eds. 1964-1966. Physiology of Mollusca. Academic Press, New York. 2 volumes. Vol. I (xiii + 473 pp.) has many references to salinity: p. 73 in article by G. E. Newell, "Physiological aspects of the ecology of intertidal molluscs," the entire article by J. D. Robertson (pp. 283-311), "Osmotic and ionic regulation," pp. 84-85 on estuarine molluscs in W. R. Hunter's article, "Ecology in non-marine molluscs," and elsewhere. (S. H. Hopkins)

Wilce, R. T., Webber, E. E., and Sears, J. R. 1970. Petroderma and Porterinema in the New World. Mar. Biol. (Berlin), 5(2):119-135.

Two species of crustose brown algae (Ralfsiaceae) (Petroderma maculiforme and Porterinema fluviatile) are discussed. The wide range of salinities from which plants of these species have been collected indicate that they are both euryhaline. (From Biol. Abstr.)

Willer, A. 1931. Vergleichende Untersuchungen an Strandgewassern. Verhandl. Intern. Ver. Limnol. 5:197-231.

P. 197, "Strandgewassern" (seaside waters) defined--waters in immediate vicinity of sea, permanently or intermittently connected and more or less dependent on it, hydrographically and biologically. The examples studied were Frischen Haff and Kurischen Haff near eastern end of Baltic Sea, both separated from Baltic by long sandbar, with very narrow pass at one end connecting with sea. Hydrography and bottom types are discussed, the bottom fauna is described and shown in diagrams of typical quadrats, and plankton production and grazing are considered. Frischen Haff has salinity varying from 0.06 to 7.48 ppt, Kurischen Haff 0.03 to 5.94 ppt. Frischen Haff has a richer bottom fauna and poorer plankton, while Kurischen Haff has a relatively limited bottom fauna and a greater plankton development. (S. H. Hopkins)

Williams, A. B. 1955. A contribution to the life histories of commercial shrimps (Penaeidae) in North Carolina. Bull. Mar. Sci. Gulf and Caribbean, 5(2):116-146.

After larval migrations from spawning places at sea, the young (postlarvae) of Penaeus setiferus, P. duorarum, and P. aztecus (the three species of commercial penaeid shrimp) enter estuaries and grow up in brackish nursery areas. There is a tendency for the smallest juvenile shrimp to be found in the lowest salinities, but there are much denser concentrations in creek heads near the ocean than in low-salinity areas far from the ocean. Shallow areas with soft bottoms attract most young shrimp, and vegetated areas (covered with Diplanthera wrightii or Zostera marina) most of all. The two major requirements are availability of food for these omnivorous bottom feeders, and availability of cover or, in other words, safety from predators. However, there is some indication that P. setiferus juveniles prefer or tolerate lower salinities than the other two species. (S. H. Hopkins)

Williams, A. B. 1960. The influence of temperature on osmotic regulation in two species of estuarine shrimps (Penaeus). Biol. Bull., 119:560-571.

Penaeus aztecus and P. duorarum are hypotonic to sea water and hypertonic to dilutions of sea water below 30 ppt, at room temperature (25-32 C). They regulate moderately well in experimental dilutions (10.06, 15.11, 20.17, 25.09, and 30.5 ppt) at room temperature, though blood is diluted some in lowered salinity. At 8.75-8.8 C, regulatory ability is impaired and blood tends toward isotonicity. P. duorarum is a better regulator at low temperatures than P. aztecus. Survival of both shrimps is better in higher salinities at low temperatures. (S. H. Hopkins)

Williams, A. B. 1964. Marine decapod crustaceans of the Carolinas. U.S. Fish and Wildlife Service Fishery Bulletin, 65(1):xi + 298 pp., illus.

Includes "remarks" on most species (all of the common ones); habits, life history, and ecology, including salinity relations.

Williams, Austin B. and Deubler, Earl E. 1968. A ten-year study of meroplankton in North Carolina estuaries: Assessment of environmental factors and sampling success among bothid flounders and penaeid shrimps. Chesapeake Sci., 9(1):27-41, illus.

Environmental factors: salinity, temperature, current velocity, wind direction, mechanical clogging of nets, and lunar phase were considered. Bogue Sound, Drum Inlet, Pamlico Sound, and the Neuse and Pamlico Rivers were sampled, making up a salinity gradient from 25-35 ppt in the sounds to 0.20 ppt in the rivers. The annual cycle of salinity has a low in February-May and a gradual increase to highest point in September-October. Postlarvae of Paralichthys dentatus and P. lethostigma (flounders) were collected in salinities from 0.02 to 35.0 ppt. Postlarvae of P. albiguttus (another flounder) were taken only near inlets at salinities of 22-35 ppt. Postlarvae of Penaeus aztecus (brown shrimp) and P. duorarum (pink shrimp) were taken in salinities from 0.1 to 34.88 ppt for former and 0.5 to 36.73 ppt for latter. Greatest number shrimp postlarvae taken per unit time occurs near inlets. (S. H. Hopkins)

Williams, I. V. 1969. Implications of water quality and salinity in the survival of Fraser River sockeye smolts. Internat. Pacific Salmon Fish. Comm. Progr. Rep., 22:1-46.

Salinity tolerance tests on sockeye (Oncorhynchus nerka) smolts showed ability of all to tolerate 30 ppt. Preference tests on a salinity gradient showed "a definite time period, distinct from the onset of migration, when the preference of sockeye smolts changed from fresh water to sea water. The time interval prior

to sea-water acceptance appeared to be related to the travel time from the lake to salt water. After sea-water acceptance smolts naturally select 30 ppt so that a period of acclimation is not required. It is possible that "a delay in salinity preference and tolerance...might be indirectly responsible for some of the variations in smolt survival occurring in sea water." (From Biol. Abstr.)

Williams, Louis G. 1948. Seasonal alternation of marine floras at Cape Lookout, North Carolina. Amer. Jour. Bot., 35:682-695.

Salinities at Cape Lookout are rather stable, averaging 32 ppt for the 13-month study. Temperature plays the major role in controlling the seasonal alternation between northern and tropical elements. The fact that several species of marine algae are present at Cape Lookout and not present from the nearby Beaufort Estuary accentuates this alternation. The investigation revealed 137 species and varieties found attached to the jetty; 60 were new to North Carolina, 14 new to the continental United States, 5 new to the western Atlantic Ocean, and 2 new to science. The following range limits were extended: 15 northern extensions of southern species and 19 southern extensions of northern species. (S. Rennie)

Williams, R. B. 1964. Division rates of salt marsh diatoms in relation to salinity and cell size. Ecology, 45(4):877-880.

Fourteen species of motile pennate diatoms; all grew well in salinities from 10 to 30 ppt. Several grew well over entire range (1-68 ppt); 20% division rate maximal or very close. 0.6-3.2 divisions/day = max.

Williams, R. J. 1970. Freezing tolerance in Mytilus edulis. Comp. Biochem. Physiol., 35(1):145-161.

M. edulis tolerates freezing to a tissue temperature of -10 C, while Venus mercenaria tolerates only -6 C. Adapting Mytilus to 150% ocean salinity increases freezing tolerance to -15 C, but does not change the amount of osmotically inactive water or the dehydration limit. Lower salinities reduce freezing tolerance. The adaptations permitting tolerance of varying salinities and of freezing appear to be independently evolved. (From Biol. Abstr.)

Wilson, B. R. 1968. Survival and reproduction of the mussel Xenostrobus securis (Lamark) (Mollusca; Bivalvia; Mytilidae) in a Western Australia estuary. I. Salinity tolerance. Jour. Nat. Hist., 2(3):307-328.

The Swan Estuary is subject to extreme temporal and spatial variations in salinity. Downstream populations of the mussel X. securis are exposed to a seasonal range from 1.5 to 20.0 ppt Cl. The physiography and hydrology of the Swan Estuary are described. Experiments are reported on the salinity tolerance and behavioral responses to salinity stress of adult mussels and larval stages. Adult mussels show no ability to osmoregulate except possibly at very low salinities. They can tolerate environmental chlorinities at least as high as 31 ppt and can withstand sudden dilutions from at least 18 down to 10 ppt. They are capable of survival at 18 ppt for many months. Closure of the shell valves in response to sudden dilutions of the medium is a behavioral mechanism minimizing physiological shock. Adult mussels remain inactive with valves closed indefinitely at chlorinities below 2 ppt. However, the internal body fluids become isoionic with the medium after a few days. Adult salinity tolerance and behavioral responses are sufficient to meet the conditions occurring in the estuary and adult salinity tolerance is unlikely to limit distribution of the species. In laboratory dishes, eggs may be successfully fertilized. Normal cleavage occurs in water between about 8 to 9 ppt and 17.5 ppt Cl. This tolerance range of developing larvae imposes unstream limits on the distribution of the mussel and precludes any possibility of larval dispersal between adjacent estuaries by way of the sea. (P. Maxwell)

Wilson, B. R. 1969. Survival and reproduction of the mussel Xenostrobus sederis (Lamark) (Mollusca; Bivalvia; Mytilidae) in a Western Australian estuary. II. Reproduction, growth, longevity. Jour. Nat. Hist., 3(1):93-120.

The extreme temporal and spatial variation in salinity that occurs in the Swan Estuary is the dominating factor in the growth, longevity, and reproduction of this mussel there. Data on populations from different localities are given. Activities including growth are inhibited at chlorinities below 2%. This occurs each year during the discharge period. The species is physiologically well adapted for persistence in an estuarine environment characterized by variable and unstable salinity conditions. (From Biol. Abstr.)

Wilson, William B. 1967. Forms of the Dinoflagellate, Gymnodinium breve Davis in cultures. Contr. to Mar. Sci., 12:120-134.

Morphological variations of G. breve were noted in different cultures. "Cells subjected to low salinity, high temperature or other adverse conditions became less motile and sloughed the flagella. Later, they became spherical or ellipsoidal and their external features disappeared. The cell membrane then became distended at one or more places. This distended portion was filled with an opaque fluid and continued to enlarge until the cell membrane ruptured." (T. Rennie)

Winslow, Francis. 1886. Report on the waters of North Carolina with reference to their possibilities for oyster culture. Raleigh (P. M. Hale), vii + 151 pp., chart.

A description of the area along various sections of the coast includes depth, characteristics of the bottom, specific gravity of the water, oyster beds and currents. (S. Rennie)

Wohlschlag, D. E. 1957. Differences in metabolic rates of migratory and resident freshwater forms of an arctic white fish. Ecology, 38:502-510.

Field studies on Coregonus sardinella in Elson Lagoon near Point Barrow and Ikroavik Lake, Alaska, showed that weight for weight the marine forms consumed more oxygen than the freshwater fish. The marine fish had higher metabolic rates, associated with greater observed activity in migration and summer wandering. Lake fish were seen to be sluggish. No effect of salinity on metabolism is indicated. Temperatures in both areas were the same. (S. Rennie)

Wohlschlag, D. E. 1972. Seasonal patterns of respiratory metabolism of the striped mullet (Abs.). Abstracts of Papers Submitted for the 35th Annual Meeting, American Society of Limnology and Oceanography, Tallahassee, Florida, March 19-22, 1972.

Metabolic levels of Mugil cephalus are at least slightly lower in brackish than in marine waters, in all seasons. Autumn spawning migrants to marine waters have metabolic rates 2.5 times those of mullets in brackish waters. (S. H. Hopkins)

Wolfe, D. A. 1971. Fallout Cesium-137 in clams (Rangia cuneata) from the Neuse Estuary, North Carolina. Limnol. and Oceanogr., 16(5):797-805 (September 1971).

The concentration of ^{137}Cs was determined in soft tissues of Rangia cuneata at points along the length of the Trent-Neuse Estuary, N. C., during 1965-1967. The ^{137}Cs concentration in Rangia varied inversely in the estuary, but with a lesser salinity dependence than reported previously for ^{137}Cs concentration factors in Rangia. The ^{137}Cs concentration in the water of the estuary also increases with increasing salinity. It is proposed that ^{137}Cs from fallout is transported on sediments down the estuary, and at higher salinities there is ion-exchange

displacement of ^{137}Cs from the sediments, thus explaining the higher concentration in the saltier water of the lower estuary. The salinity in which Rangia was studied ranged from 0 to 15 ppt. (S. H. Hopkins)

Wolfe, D. A. and Coburn, C. B., Jr. 1970. Influence of salinity and temperature on the accumulation of cesium-137 by an estuarine clam under laboratory conditions. Health Phys., 18:499-505.

In laboratory experiments, showed that the accumulation of ^{137}Cs by Rangia cuneata was related directly to temperature and inversely to salinity. On the basis of this study one would expect to find a greater range of ^{137}Cs concentration in Rangia than was actually found over the salinity gradient in the Trent-Neuse Estuary by Wolfe (1967), Wolfe, Lewis, and Brooks (1969), and Wolfe and Schelske (1969). (S. H. Hopkins)

Wood, Carl E. 1967. Physioecology of the grass shrimp, Palaemonetes pugio, in the Galveston Bay estuarine system. Contr. to Mar. Sci., 12:54-79.

A 12-month field study in Galveston Bay and a controlled laboratory experiment were conducted to determine the seasonal distribution, growth rate, and reproductive potential of P. pugio. In the field 11 trips were made to 13 shore stations where pushnet samples of the grass shrimp were collected along with water temperature and water samples for salinity determinations. Moderate salinity habitats were nearer the optimum conditions for P. pugio than either lower of higher salinity habitats, the greatest abundance of grass shrimp being found in mesohaline (10-15 ppt) waters and the lowest in fresh water (<1.0 ppt). Large numbers were at times taken in higher salinity waters (>15 ppt). The numbers of males and ovigerous females increased significantly with increases in salinity, but the nonovigerous females decreased. Plots of the effect of field salinities on the size distribution of P. pugio showed no statistical significance, although there were more large (30-34 mm) ovigerous females in high-salinity water than were present in lower salinities. Salinity, likewise, had no statistically significant effect on the mean total length of males, nonovigerous females, or ovigerous females. However, length of males at low salinity were found to be significantly different from those at moderate and high salinities, and the lengths of the ovigerous females at <10 ppt were significantly larger than those at >22 ppt. There was no significant length difference in the ovigerous females.

Salinity had little effect on the ratios of males to females. The ratio of nonovigerous females to ovigerous females at low salinity was 4:1, and about 2.5:2.0 at high salinities.

Effect of salinity of spawning was included in a temperature-salinity interaction effect. When they spawned, in early summer, temperature was high (30 C) and salinity moderate (15-22 ppt), while in the fall, temperature was moderate (15-25 C) and salinity was high (>22 ppt).

In the laboratory 16 groups of young grass shrimp were reared from eggs and held in aquaria for 30 days at all combinations of four salinities (4-10, 10-16, 16-22, and 22-28 ppt) and four temperatures (11, 18, 25, and 32 C). Length and weight measurements were made periodically. Interactions of temperature and salinity on total survival indicated that water with temperatures of 18 C or above and salinities of 4-16 ppt were best suited for survival and waters of lower (11 C and below) temperatures and higher salinities (22-28 ppt) resulted in lowest survival. In a growth study, increases in both length and weight were greatest in waters having 25-32 C and 16-22 ppt salinity, and lowest at 15 C or lower and 22-28 ppt. Growth was negligible at all salinity interactions involving 11 C temperature. (T. Rennie)

Wood, E. J. Ferguson. 1948. The Japanese oyster industry. (Australian) Fisheries Newsletter, April 1948, Vol. 7, No. 2, pp. 8-9.

P. 8. "In Kumamoto Prefecture...at times, where predators are numerous, the

horizontal stick method similar to that used in Port Stephens is employed (instead of vertical stakes stuck in mud)."

P. 9. "The commonest pests are the oyster drill (a tingle whelk) and starfish. The drill attaches to the young oyster and was imported into the United States along with it in the early days. The hanging method and careful inspection have efficiently controlled this pest. Dr. Imai has found that the drill is killed by immersing the oysters in a 30 percent solution of sea water in fresh water for 24-30 hours, while the oyster is not affected. (Chlorinity about 5 parts per 1000.)"

"The starfish is found to paralyze the oyster by means of a toxin which it excretes and which attacks the oyster's adductor muscle. The oyster naturally opens and is eaten by the starfish. This discovery is also Dr. Imai's work." (S. H. Hopkins)

Wood, E. J. F. 1963. A study of the diatom flora of fresh sediments of the south Texas bays and adjacent waters. Publ. Instit. Mar. Sci., Univ. of Texas, 9:237-310.

This paper includes a list of all species found plus photographs of representative examples. Samples were taken from Laguna Madre to Galveston Bay. No salinity data are given, but assuming an increase in overall yearly salinity from north to south, the following data on distribution are useful. Lower Laguna Madre is characterized by Cocconeis. Rhopalodia, a freshwater species, was also abundant. In upper Laguna Madre Amphora was dominant along with Rhopalodia again. Baffin Bay had a few diatoms but resembled upper Laguna Madre. Corpus Christi Bay, including Redfish and Aransas Bays, had a lot in common, with Rhopalodia and Amphora dominant. Mastogloia was abundant in Redfish and Aransas Bays. Most important in San Antonio and Espiritu Santo Bays were Coscinodiscus and Cyclotella. Matagorda Bay had Actinoptychus, Achnanthes, Diploneis, and Cyclotella. Galveston Bay had Diploneis, Coscinodiscus, and Cyclotella. (S. Rennie)

Wood, E. J. F. 1964. Studies in microbial ecology of the Australasian Region. V. Microbiology of some Australian estuaries. Nova Hedwig., 8:461-527.

Wood's "microbiology" dealt with dinoflagellates and diatoms, which he studied in a number of estuaries. In Lake Macquarie (normally salty) after heavy rain, upper layers of lake with salinity of 25 ppt, middle layers with 29 ppt, and bottom layers with 30 ppt, each had a distinct association of phytoplankton organisms. The bottom layer included diatoms usually found in sediments rather than in water, and these sometimes dominated, according to the review of this paper in Green (1968), pp. 82-83. (S. H. Hopkins)

Wood, E. J. F. 1965. Marine microbial ecology. Reinhold, New York, xii + 243 pp.

"Microbial" is used in a very broad sense, including yeast, fungi, viruses, single-celled algae, and protozoans as well as bacteria. Salinity is discussed as an environmental factor on pp. 126-128, but is mentioned in many other places: pp. 9, 20, and 163, for instance. On p. 9 it is mentioned that Disulphovibrio species, sulphur-reducing bacteria, can adapt to various salinities. On p. 20 salinity is defined, and factors affecting it are discussed; it is also stated that trace elements may be as important as the major ones in microbial ecology; p. 21 continues discussion of salintiy. On p. 163 salinity is mentioned with temperature in ecology of dinoflagellates and the "red tides" they cause when they "bloom." (S. H. Hopkins)

Wood, Langley. 1971. Behavior of bivalve mollusk larvae in a tidal estuary (Abs.). Amer. Zool., 11(4):641-642.

Field studies have shown that bivalve larvae control their distribution in estuaries, but laboratory work has failed to explain the mechanism by which this

is done. Laboratory experiments with Crassostrea virginica (east coast oyster) larvae failed to show that either salinity or any of the other parameters studied (light, pressure, temperature, or tide-linked endogenous periodicity) was clearly or predictably associated with changes in swimming activity. (S. H. Hopkins)

Woodmansee, R. A. 1958. The seasonal distribution of the zooplankton off Chicken Key in Biscayne Bay, Florida. Ecology, 39(2):247-262.

Weekly, daytime plankton samples were made at one station off Chicken Key from October 1947 to December 1948. Detailed information is given for each copepod species and other major plankters found, including salinity range. Water salinities varied between 14.8 ppt in October and 35.1 ppt in May and March. Correlations were made between plankton volumes-rainfall and plankton volumes-salinity. The author concluded that except for a very heavy rainfall in the last part of September that preceded an October plankton maximum by 2 or 3 weeks, rainfall and consequent land drainage into Biscayne Bay had no effect upon the zooplankton volume. The correlation between zooplankton volume and salinity was negative but significant only for the 3 weeks of the October zooplankton maximum. (T. Rennie)

Worsnop, Edith and Orton, J. H. 1923. The causes of chambering in oysters and other lamellibranchs. Nature, 111:14-15.

Chambering in oysters and other lamellibranchs caused much financial loss to some oyster planters, as when opened, the brittle walls of the chamber on the inside of the shell may be opened, releasing an "evil-smelling" liquid (H_2S-producing bacteria are the cause) on the meat, rendering it inedible.

These chambered oysters occurred most commonly on beds in high estuarine or riverine situations, where the salinity variation were great. Towards May or June (around Plymouth), higher salinities were generally found together with the onset of oyster breeding; both factors tend to reduce the volume of the oyster body ("oysters will...shrink in water of high salinity...probably through the readiness of the bladder-tissue in lamellibranchs to respond and accommodate itself to changes in osmotic pressure.").

In good conditions, shell growth occurs automatically, so as the volume of oyster is shrinking, shell material is produced, laying down a shell lamina which is not adjacent to the existing body and a chamber results. Water probably formed in the chamber by percolation along the outside of the body of the oyster between the body and the shell, which also brings in various organisms that produce the "evil-smelling" liquid. (T. Rennie)

Worth, R. H. 1903. The foraminifera of the Exe Estuary. Jour. Marine Biol. Assoc. U.K., 6:336-343.

Twenty species are listed from bottom sediments of several areas in the Exe Estuary, of which the most abundant were Rotalia beccarii, Nonionina depressula, and Polystomella striato-punctata.

Wright, Mike. 1943. A comparison of the dragonfly fauna of the lower delta of the Mississippi River with that of the marshes of the central Gulf Coast. Ecol. Monogr., 13:481-497.

The lower deltaic marshes are fresh for half the year. During the months of July through December saltwater inundation takes place due to storms and less freshwater runoff from the north. Salinities can get as high as 30%-40% sea water. Ten Anisoptera and 13 Odonata species were collected in this habitat. Of the Odonata, 1 was restricted to wooded areas, 4 to fresh water, 1 to saline, and 7 species were found in both fresh and saline areas. In the deltaic marshes 5 species composed 90% of the individuals observed or captured.

The coastal marshes can be zoned into strictly fresh areas (0% sea water), slightly brackish areas (0%-14%), brackish areas (14%-57%), and saline areas (57%-143%). In the coastal marsh 30 Anisoptera and 51 Odonata species were

identified. Of the Odonata 16 were restricted to wooded areas, 15 to fresh water, 1 to saline, and 19 were found in both areas. Most of the species listed for the saline areas bred in the freshwater areas.

Erythrodiplax berenice was the only species restricted to the saline areas (although no nymphs were found). It appeared to increase in numbers with an increase in salinity. According to the data it was found at least in 20%-60% seawater areas.

The five species common in the lower delta were among the most common in the coastal marsh. The author concluded that these were able to become acclimated to a great variation in salinity and breed in strongly brackish areas. (S. Rennie)

Wright, R. L., Sperry, J. J., and Huss, D. L. 1960. (Unpublished.) Vegetation type mapping studies of the marshes of Southeastern Louisiana. Report to U.S. Bureau of Sport Fisheries and Wildlife by Texas A&M Research Foundation, Proj. 191. 42 pp., foldout map.

The study area consists primarily of fresh- and saltwater marsh, transitional types of marsh, and smaller wooded areas. The total area is approximately 1,440,000 acres. O'Neill (1949) said there were 4 million acres of Gulf coast marsh in Louisiana, which Viosca (1928) had classified as 1.75 million acres of freshwater marsh and 2.5 million acres of sea marsh. The salt marsh occurs generally within the 20-ppt "salinity contour" established by the Dept. of Oceanography of Texas A&M (1959). It consists of three vegetation types: saltcane, black mangrove, and salt rim. Spartina alterniflora dominates saltcane marsh, with seashore saltgrass, Distichlis spicata, as a subdominant; burning causes an increase in blackrush, Juncus roemerianus. The black mangrove vegetation type is a border or zonal type dominated by the black or honey mangrove, Avicennia nitida where the substrate is frequently covered with salt water. Salt rim, on higher islands, has a dominance of halophytes such as saltwort, Batis maritima; seaoxeye, Borrschia frutescens, and glassworts, Salicornia bigelovi and S. ambigua. The transitional and freshwater marshes, and smaller areas of other types, have an increasing number of species as frequency of flooding with salt water decreases. (S. H. Hopkins)

Yamamoto, Gotaro. 1959. Behavior and mucus secretion of Japanese marsh clam, Corbicula japonica Prime. Bull. Mar. Biol. Sta. Asamushi, Tohoku Univ., 9(4):141-144.

C. japonica is commonly found in brackish-water areas in Japan. Young clams were immersed for 4 hr singly or in groups in various sea-water concentrations and then their body fluid freezing point depressions were measured and compared with that of adults. Δ values for isolated young corresponded to the concentrations of the rearing media, while aggregated organisms osmoregulated to some degree. Adults and young clams studied in the field maintained a characteristic osmotic concentration of their body fluid with all concentrations of environmental waters in nature. Viscous mucus was secreted by the young individuals reared in high densities in the aquaria. It was suggested that the mucus might play a role to temporarily check perfusion of water from or into the body through its surface. This correlates to a body weight increase of about 1% in hypertonic sea water in 3 hr after which it decreased slowly. Mucus secretion could be activiated by hypotonic and hypertonic sea-water conditions, but was at a minimum in isotonic medium. (T. Rennie)

Yamazaki, Masayasu. 1929. On some physiochemical properties of the pericardial fluid and of the blood of the Japanese oyster, Ostrea circumpicta Pils., with reference to the change of milieu exterieur. Sci. Report Tohoku Imp. Univ., 4th Ser., Biol., 4(1, fasc. 2):286-314.

Blood and pericardial fluid follow closely fluctuations in specific gravity of the surrounding water. In sea water diluted 1/2, specific gravity of blood reaches equilibrium in 4-5 days; returned to sea water, regains normal in 10-13 hrs. (S. H. Hopkins)

Yamazaki, Masayasu. 1932. On the osmoregulation of the blood of several marine and fresh water molluscs. I. The Japanese oyster, Ostrea circumpicta Pils. Sci. Report Tohoku Imp. Univ., 4th Ser., Biol., 7(2):229-238; 3 figs.

Most oysters survive 20 days in fresh water at 19-20 C., keeping their shells closed. In fresh water the blood concentration falls in about 12 hr to 65% of original and maintains this for days. Depression of freezing point to 1.123 required 480 hr in fresh water, while recovery to 1.995 occurred within 15 hr after return to sea water. Threshold for freezing point below which this oyster cannot live lies between 1.00 and 1.20. (S. H. Hopkins)

Yonge, C. M. 1960. Oysters. (New Naturalist Series.) Collins, London, xiv + 209 pp.

Pp. 92-93: "Species of both Ostrea and Crassostrea are euryhaline, i.e., can withstand wide variations in salinity, and this tolerance of much dilution by fresh water has enabled them to colonize rich inshore waters. Again both adults and larvae have to be considered. Oysters of the genus Crassostrea can certainly withstand a much wider range of salinity than can those of Ostrea, indeed some species, such as C. virginica, appear to live for long periods in what is effectively almost fresh water. It has even been maintained that oysters of this type can live only in water of low salinity and, although this statement is open to question, it remains true that they flourish in water of as low as one-third normal salinity (12 parts as compared with 35 parts per 1000). Flat oysters (O. edulis) do not appear able to withstand lowering of salinity below some 23 ppt...the larvae of different species of oysters vary considerably in their ability to grow in water of reduced salinity, in all cases reflecting the tolerance of the adults. But they cannot live in such low salinities as the adults...." (S. H. Hopkins)

Young, R. T. 1938. The effect of balanced versus unbalanced solutions, of pH and distilled water on fish. Ecology, 19:126-140.

The fish studied included the surf perches Embiotoca jacksoni, Cymatogaster aggregatus, and Abeona minima, the California killifish Fundulus parvipinnis, and the freshwater sunfish Apomotis cyanellus.

Distilled water is fatal to Fundulus and Apomotis. Concentrations of NaCl in distilled water are immediately fatal to the marine Embiotocidae (surf perches). Addition of NaCl to sea water in increasing amounts up to 39.63 ppm Cl were accommodated. When gradually acclimatized, Fundulus showed resistance to chloride concentrations up to 65.070 ppm. The freshwater Apomotis could tolerate concentrations of 10.080 ppm made with lake water and sea water for up to 5 days. (S. Rennie)

Zalumi, S. G. 1967. Izmeneniya v ikhtiofaune nizov'ev Dnepra i Dneprovsko-Bugskogo limana v svyazi s gidrostroilel'stvom. (Ichthyofauna changes in the Low Dnieper and Dnieper-Bug Estuary in connection with hydroconstruction.) Vestn. Zool., 3:66-69. (English summary.)

Mentions list of fish that have appeared and disappeared with a substantial rise in estuarine salinity.

Zein-Eldin, Zoula P. 1963. Effect of salinity on growth of post larval penaeids. Biol. Bull., 125(3):188-196, illus.

Experiments testing the effect of salinity on growth and survival of post-larval shrimps Penaeus setiferus (white shrimp) and P. aztecus or P. duorarum (grooved shrimps) showed no significant difference in growth rate in salinities of 2, 5, 10, 25, or 40 ppt. Survival was generally excellent in all of these salinities. Results suggest that salinity per se does not limit growth of young shrimp. (S. H. Hopkins)

Zein-Eldin, Z. P. and Aldrich, D. V. 1964. Laboratory studies of shrimp tolerances to salinity and temperature. Proc. Gulf Carib. Fish. Inst., 16:121. (Abs.)

Postlarvae of pink and brown shrimp survived (for 24 hr) the following temperature and salinity combinations: 2-40 ppt at 45-98 F and 5-37 ppt at 68-90 F. They could not survive in 5 ppt or less at 95 F or above and 60 F and below.

Zein-Eldin, Zoula P. and Aldrich, D. V. 1965. Growth and survival of postlarval Penaeus aztecus under controlled conditions of temperature and salinity. Biol. Bull., 129(1):199-216.

24-hr survival and 30-day growth studies. 24-hr survival indicated wide tolerance limits to both factors. 100% survival - all combinations of 20-32 C with 5-37 ppt. 100% mortality at salinities below 5 ppt or with temperatures above 34 C or below 15 C. Greatest observed growth at 32 C.

Zenkevitch, L. A. 1957. Caspian and Aral Seas. Pp. 891-916 (Chap. 26). In: Hedgpeth. J. W., ed. Treatise on marine ecology and paleoecology. Geol. Soc. Amer. Memoir 67, Vol. I, Ecology, viii + 1296 pp.

After a brief physicogeographical and hydrological section, the ecology of these two isolated inland seas (which in past geological times have had oceanic connections) is described in detail, with much attention to the ecological effects of salinity differences. The Caspian has surface salinities of 12-13 ppt in the south and 5-10 ppt in parts of the north. In lagoons with narrow connections to the sea, along the eastern side of the Caspian, salinity may reach 200 ppt at times (Karabugaz Gulf). Caspian fauna and flora is partly of marine and partly of freshwater origin with few species, some of which are not found elsewhere. The Aral Sea, with a salinity of 10 ppt and ion ratios differing considerably from the ocean, has even fewer species, mainly of freshwater origin, but including some Caspian and Mediterranean forms. Salinity is increasing in both seas as a result of engineering works, and part of the northern Caspian has been drained. (S. H. Hopkins)

Zenkevitch, L. 1963. Biology of the seas of the U.S.S.R. (English translation from Russian by S. Botcharskaya.) Interscience (John Wiley & Sons), New York, 955 pp.

Describes the geography, history (of exploration), physical features, hydrology, hydrochemistry, geology, fauna and flora, and ecology of the Barents Sea,

White Sea, Kara Sea, Laptev Sea, Chukotsk Sea, Baltic Sea, Black Sea, Sea of Azov, Caspian Sea, Aral Sea, Sea of Japan, Sea of Okhotsk, and Bering Sea. Many of these seas or parts of them are especially interesting from the standpoint of biological effects of salinity; for instance, the Baltic Sea, Sea of Azov, Caspian Sea, and Aral Sea are water bodies of naturally reduced salinity which have developed faunas adapted to low salinity. The Sivash or Putrid Sea, on the other hand, is hypersaline much of the time. Some seas, especially the Azov, Arae, and Caspian Seas, have recently had large changes in salinity regimes due to engineering works, with consequent changes in ecology. (S. H. Hopkins)

Zernov, S. A. 1949. (General hydrobiology.) (Title and text in Russian.) Academy of Sciences, USSR, Moscow-Leningrad, 587 pp. (2d ed.)

According to Hedgpeth (1957, p. 1014), this with Zenkevich's "Seas of the U.S.S.R." and Knipovich (1938) make up the "big three" of Russian hydrobiology. Covers a great range and variety of saline to freshwater biotopes. (S. H. Hopkins)

Zhirmunskii, A. V. 1962. Reaktsiya Kletok mertsatel'nogo epiteliya midii i aktinii na povyshenie solenosti. [The reaction of the ciliated epithelium cells of Mytilus galloprovincialis and Actinia equina to increased salinity.] Zhur. Obshchei. Biol., 23(2):119-126. (English summary.)

The resistance to the action of high salinity was studied on the ciliated epithelial cells in Mytilus galloprovincialis and Actinia equina from Black Sea water (17 ppt) and on cells of the animals accustomed to increased salinity (35 ppt during 2 weeks). The dependence of time of ciliary movement on the action of several high salinities (salinity narcosis time) is expressed in a logarithmic graph as a second order parabola which asymptotically approaches a certain limit of salinity. By conditioning the animals to 35-ppt salinity, the resistance of their ciliated epithelial cells to the action of high salinity is shown to rise considerably. Some evidence obtained suggests that compensation processes play a great part in the response of the epithelial cells to the action of high salinity.

Zhirmunsky, A. V. and Kiseleva, M. I. 1957. Adaptation of Black Sea sea anemones to increased salt concentration. Dokl. Akad. Nauk. SSSR [Biol. Sci. Sect. Transl.] 117(1/6):1065-1068, 1957. (Translated from Dokl. Akad. Nauk. SSSR, 117(3):517 ff. 1957.)

Anemones, Actinia equina L., live in Black and Barents Seas, in very different salinities. Black Sea anemones were kept in Black Sea water to which NaCl was added, increasing salinity from 14.4 ppt of Black Sea to the 27 ppt of Barents Sea. Direct change caused death in several hours. When salinity was increased each day by 3 ppt the anemones mostly closed, but survived and remained active for 10 days after 27 ppt was reached. When salinity was raised 1.5 ppt per day, anemones remained open and were normally active 10 days after 27 ppt was reached. Adaptation in this way to 27 ppt lowered sensitivity to anesthetic effect of 54 ppt by 23 times. (S. H. Hopkins)

Zilberberg, M. H. 1966. Seasonal occurrence of fishes in a coastal marsh of northwest Florida. Publ. Inst. Mar. Sci., Univ. of Texas, 11:126-134.

Monthly collections of water samples for salinity determination, water and air temperature measurements, and seine drags were taken from nine stations between December 1963 and January 1965, in a 700-acre estuarine water and marsh area located on the northwest Florida coast near Perry, Fla. Twenty-six species of fish and one crab, Callinectes sapidus, were found. Salinities ranged from 0 to 32 ppt. In general the salinities were lower during the winter than during the summer. Most of the species found were considered euryhaline and a

few were characteristic of fresh water. Elops saurus and Galeichthys felis reached a peak during the months of highest temperatures and highest salinities. Sciaenops ocellata appeared in the area only after salinity had increased to a summer high and, along with Cynoscion nebulosus, had their maximum abundance during late fall when both temperature and salinity were at moderate levels (salinity 15-20 ppt). C. sapidus was euryhaline and was found throughout the entire survey period. The author concluded, however, that temperature variations had a greater influence on fish population variations than did salinity changes. (T. Rennie)

CATEGORIES OF SUBJECT INDEX

1. General Publications and Reports

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2. Laboratory Studies (culture, physiology, tolerance limits)

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5. Original reports on experiments, by subjects
    1. Adaptation
    2. Biochemical studies
    3. Combinations (temperature-salinity, salinity-oxygen, etc.)
    4. Growth (effects on, etc.)
    5. Ion exchange, internal and surface
    6. Limits for survival and lethal thresholds
    7. Locomotion (effects on)
    8. Orientation (to salinity difference)
    9. Osmoregulation
    10. Physiological effects (heartbeat rate, rate of oxygen consumption, rate of feeding, etc.)
    11. Reproduction (effects on)
    12. Survival and development of young stages, effects on

6. Original reports on research, by organisms studied
    0. All organisms, or not specified
    1. Bacteria
    2. Yeasts
    3. Fungi (other)
    4. Algae, single-celled (or single rows of cells)
    5. Seaweeds, large multicellular algae
    6. Seed plants
    7. Protozoa, single-celled animals
    8. Porifera, sponges
    9. Coelenterates
        1. Hydroids, hydrozoan medusae
        2. Jellyfish (Scyphozoa)
        3. Sea anemones
        4. Corals
        5. Comb jellyfish (Ctenophora)
    10. Vermes ("worms")
        1. Free-living flatworms
        2. Parasitic flatworms (flukes, tapeworms)
        3. Ribbon worms (Nemertea, Rhynochocoela)
        4. Roundworms or eelworms (Nematoda)
        5. Wheelworms (Rotifera)

6. Arrow worms (Chaetognatha)
7. Worms, other unsegmented (Nectonema, Priapulida, Gastrotricha, Kinorhyncha, Acanthocephala, Echiurida, Sipunculida, Pogonophora, Hemichordata-Enteropneusta)
8. Annelida, segmented worms
    1. Earthworms and allies (Oligochaeta)
    2. Marine annelid worms (Polychaeta)
    3. Leeches (Hirudinea)

11. Moss animals (Bryozoa)
12. Lamp shells (Brachiopoda)
13. Mollusca
    0. Molluscs in general
    1. Chitons and allies (Amphineura)
    2. Snails and allies (Gastropoda)
    3. Bivalve molluscs (Pelecypoda; clams, mussels, scallops, oysters)
    4. Elephant tusks (Scaphopoda)
    5. Cephalopods (squid, cuttlefish, octopus)
14. Crustacea
    0. Crustaceans in general, or kinds not specified
    1. Brine shrimp, fairy shrimp (Branchiopoda, Phyllopoda, Anostraca)
    2. Water fleas (Cladocera)
    3. Copepods (Copepoda and allies)
    4. Seed shrimps (Ostracoda)
    5. Barnacles and allies (Cirripedia)
    6. Mysid shrimps (Mysidacea)
    7. Isopods (Isopoda)
    8. Amphipods (Amphipoda)
    9. Mantis shrimps (Stomatopoda)
    10. True shrimps and prawns (Decapoda, Natantia)
    11. Lobsters, crayfish, and allies (Decapoda, Reptantia, Macrura)
    12. Crabs, true (Brachyura)
    13. Crabs, hermit and allies (Anomura)
15. Insecta
    1. Flies, gnats, mosquitos (Diptera)
    2. True bugs (Hemiptera)
    3. Dragonflies (Odonata)
    4. Beetles (Coleoptera)
    5. Insects, other
16. Chelicerata (horseshoe crabs, sea spiders, mites, etc.)
17. Echinodermata
    0. General
    1. Starfishes (Asteroidea)
    2. Serpent stars, brittle stars (Ophiuroidea)
    3. Sea urchins, sand dollars (Echinoidea)
    4. Sea cucumbers (Holothuroidea)
    5. Sea lilies (Crinoidea)
18. Chordata (vertebrates and allies)
    0. General
    1. Urochordata, sea squirts and allies
    2. Cephalochordata, lancet fish or toothpick fish (Amphioxus)
    3. Vertebrata - backboned animals
        1. Cyclostomes, lampreys, hagfish
        2. Elasmobranchs and allies, fishes with cartilage skeletons (sharks, skates, etc.)

3. Teleosts or bony fishes
4. Amphibians (salamanders, frogs)
5. Reptiles (turtles, snakes, crocodiles)
6. Birds
7. Mammals, including whale group

3. Field Studies (ecology, limnology, oceanography, hydrobiology)

0. News reports, magazine stories
1. Books and monographs
2. Expedition reports, general
3. Summary reports and literature review articles
4. Bibliographies
5. Original reports on research, by regions

1. Intercontinental or worldwide
2. North America

    0. Continentwide or not specified
    1. Atlantic
    2. West Indian
    3. Gulf of Mexico, including Mexico
    4. Pacific, including Central American west coast
    5. Arctic
    6. Inland

3. South America

    1. Caribbean, including Central America
    2. Atlantic
    3. Pacific

4. Europe

    0. All Europe or not specified
    1. North, including North Sea, Baltic Sea, northern Russia and Finland, and British Isles
    2. Atlantic
    3. Mediterranean, including North African and Asiatic coasts
    4. Black, Caspian, and Aral Seas
    5. Inland

5. Africa

    1. North (Mediterranean coast) - see Europe
    2. West Africa (Atlantic coast)
    3. South Africa
    4. East Africa (Indian Ocean coast, Red Sea, Suez and Nile delta)

6. Asia

    0. Continentwide or not specified
    1. Near East (Arabian Peninsula, Persian Gulf, Iran)
    2. Southern Asia (Pakistan, India, Ceylon, Bangladesh, Burma)
    3. Southeastern Asia (Cambodia, Vietnam, Malaya, Singapore)
    4. Indonesia (East Indies)
    5. Far East (China, Japan, Korea, Taiwan, Philippine Islands, eastern Siberia)

7. Oceania

    1. Papua and Melanesian Islands
    2. Polynesia, Micronesia, Hawaii
    3. Australia, including Tasmania
    4. New Zealand

8. Antarctica

6. Original reports on research, by subjects

   1. Mortality (caused by salinity change)
   2. Distribution (limited by salinity)
   3. Penetration into inland waters
   4. Diversity (of species, related to salinity)
   5. Competition (between related species)
   6. Movements (migrations, locomotion)
   7. Abundance, population density, or biomass
   8. Productivity or annual yield (life produced per year)
   9. Growth of individuals
   10. Feeding (rate of feeding affected)
   11. Parasites and diseases (increased or decreased by salinity)
   12. Enemies of desirable species (distribution or abundance of pests and predators affected by salinity)
   13. Quality (commercial quality of useful species affected by salinity)
   14. Reproduction, affected by salinity
   15. Survival and growth of young

7. Research reports, by types of water bodies studied

   1. Fresh waters
   2. Rivers running into sea
   3. Positive estuaries (bays with rivers, more outflow than inflow)
   4. Neutral estuaries (bays without rivers, inflow and outflow equal)
   5. Negative estuaries (bays or lagoons with more inflow than outflow; excess lost by evaporation so that hypersaline conditions exist)
   6. Coastal lagoons or salt ponds permanently or intermittently cut off from sea
   7. Small estuaries that ebb nearly dry, except channel
   8. Tidal marshlands
   9. Deltas of rivers
   10. Fjords
   11. Sounds and inshore waters of ocean
   12. Salt lakes and inland "seas"
   13. Canals
   14. Lake estuaries

8. Original reports on research, by organisms classified ecologically

   0. All organisms, or several categories, or not specified; general ecology
   1. Decomposers (most bacteria, yeasts, fungi)
   2. Phytoplankton (physosynthetic single-celled or small and floating organisms)
   3. Zooplankton (animals small enough or weak enough swimmers to be caught in plankton nets)
   4. Nekton (swimming animals such as are caught in trawls and other fish nets)
   5. Benthos (mostly invertebrate bottom-dwelling animals, some of which burrow into substrates or are attached to substrates, while others move freely)
   6. Attached seaweeds and seed plants

9. Research reports by organisms classified taxonomically (that is, according to degrees of similarity that supposedly indicate degrees of kinship)

   0. Communities, or many kinds of organisms
   1. Bacteria
   2. Yeasts
   3. Fungi (other)
   4. Algae, single-celled (or filaments of single rows of cells) floating or attached
   5. Seaweeds, large multicellular algae

6. Seed plants or flowering plants, Spermatophyta
7. Protozoa, single-celled animals
8. Porifera, sponges
9. Coelenterata, jelly animals
    1. Hydrozoans (polyps, small medusae, floating colonies)
    2. Scyphozoans, larger jellyfish
    3. Sea anemones and allies
    4. Corals and allies
    5. Ctenophora, comb jellyfish
10. Platyhelminthes, flatworms
    1. Free-living flatworms
    2. Trematoda, external and internal parasites, flukes
    3. Cestoda, tapeworms (internal parasites)
11. Nemertea Rhynchocoela, ribbon worms
12. Gnathostomulida
13. Rotifera, wheelworms
14. Nematoda, roundworms or eelworms
    1. Free-living
    2. Parasitic
15. Nematomorpha, Nectonematoidea
16. Gastrotricha, Macrodasyoidea
17. Kinorhyncha, Echinodera
18. Acanthocephala, thorny-headed parasitic worms
19. Entoprocta or Calyssozoa
20. Priapulida
21. Echiurida
22. Sipunculida
23. Annelida, segmented worms
    1. Oligochaeta, earthworms and allies
    2. Polychaeta, marine annelids
    3. Leeches, Hirudinea
24. Ectoprocta or Bryozoa, moss animals
25. Phoronida
26. Brachiopoda, lamp shells
27. Mollusca
    0. Molluscs in general
    1. Amphineura, chitons and allies
    2. Gastropoda, snails, conchs, whelks, drills, limpets, sea slugs, etc.
    3. Pelecypoda, bivalve molluscs: clams, mussels, scallops, oysters, etc.
    4. Scaphopoda, elephant tusk shells
    5. Cephalopoda, squids, cuttlefish, octopuses
28. Arthropoda, Crustacea
    0. Crustacea in general
    1. Anostraca, fairy shrimps, brine shrimp
    2. Cladocera, water fleas
    3. Copepoda (including Branchiura)
        1. Free-living copepods
        2. Parasitic or symbiotic copepods
    4. Ostracoda, seed shrimps
    5. Cirripedia, barnacles and allies, including parasitic sacculinids
    6. Nebaliacea

7. Mysidacea and Cumacea
    1. Mysids or opossum shrimps
    2. Cumacea, burrowing shrimps
8. Isopoda, isopods
    1. Free-living
    2. Parasitic
9. Amphipoda, amphipods, side-swimmers, beach fleas, etc.
10. Stomatopoda, mantis shrimps, squills
11. Decapoda, 10-legged higher Crustaceans
    0. Decapoda in general
    1. Natantia, true shrimps, prawns
    2. Reptantia (crawlers)
        1. Macrura, Astacura, lobsters, crayfish
        2. Macrura, Palinura, spiny lobsters, rock lobsters
        3. Brachyura, true crabs
        4. Anomura, hermit crabs and allies

29. Arthropoda, Insecta
    1. Diptera, flies, gnats, mosquitos
    2. Hemiptera, true bugs
    3. Coleoptera, beetles
    4. Odonata, dragonflies
    5. Insects, other
30. Arthropoda, Chelicerata
    1. Arachnida (8 jointed legs); Acarina, mites (free-living and parasitic)
    2. Xiphosura, horseshoe crabs
    3. Pycnogonida, sea spiders
31. Tardigrada, water bears
32. Echinodermata
    0. Echinoderms in general
    1. Asteroidea, starfishes
    2. Ophiuroidea, serpent stars, brittle stars
    3. Echinoidea, sea urchins, sand dollars, pin cushions, sea biscuits
    4. Holothuroidea, sea cucumbers
    5. Crinoidea, sea lilies and comatulids
33. Chaetognatha, arrow worms
34. Pogonophora, bearded worms
35. Hemichordata, Enteropneusta, acorn worms
36. Chordata
    1. Urochordata, sea squirts and allies
    2. Cephalochordata, lancet fish, toothpick fish, amphioxus
    3. Vertebrata - animals with backbones
        1. Cyclostomes, lampreys, hagfish
        2. Elasmobranchs, sharks, skates, rays, sawfish, torpedo fish
        3. Holocephala or Chimaeroida, elephant fishes
        4. Osteichthyes or Teleostei, bony fishes
        5. Amphibia, salamanders, frogs, toads
        6. Reptilia, snakes, lizards, turtles, crocodiles (including alligators)
        7. Aves, birds
        8. Mammalia, mammals, including whales and allies, seals, etc.

SUBJECT INDEX

1. General Publications and Reports

1. Books and monographs

Bauchau, A. 1966
Boulenger, E. G. 1936
Dales, R. P. 1967
Darlington, P. J., Jr. 1957
Galtsoff, P. S. 1964
Green, James 1961
Green, J. S. 1968
Hesse, Allee & Schmidt 1937
Knipovich, N. M. 1938
Krogh, A. 1939
Lauff, G. H., ed. 1967
Orton, J. H. 1937
Ranson, G. 1943
Stafford, J. 1913
Stenzel, H. B. 1971
Warren & Doudoroff 1971
Williams, A. B. 1964
Yonge, C. M. 1960

2. Review articles

Beadle, L. C. 1943
Bookhout & Costlow 1959
Kinne, O. 1964a; 1966
Pearse & Gunter 1957

3. Summary reports

Symposium on the classification of brackish waters (Venice) 1958

4. Bibliographies

Cronin, Van Engel, Cargo & Wajcik 1957
Livingstone, R., Jr. 1965
Tagatz & Hill 1971

2. Laboratory Studies (culture, physiology, tolerance limits)

1. Books and monographs

Brown, M. E. 1957
Dales, R. P. 1967
Lockwood, A. P. M. 1967
Orton, J. H. 1937
Prosser & Brown 1961
Stenzel, H. B. 1971
Wilbur & Yonge, eds. 1964-66
Yonge, C. M. 1960

2. Review articles

Bahl, K. N. 1947
Bauchau, A. 1966
Beadle, L. C. 1957
Dakin, W. J. 1931
Florkin, M. 1960
Florkin & Shoffeniels 1965
Huggins & Munday 1968
Kinne, O. 1956a; 1963; 1964a,b; 1966; 1967
Lockwood, A. P. M. 1962
Pantin, C. F. A. 1931c
Pearse & Gunter 1957
Potts, W. T. W. 1968
Prosser, C. L. 1955
Robertson, J. D. 1960
Schlieper, C. 1928, 1930, 1932, 1935
Segal, E. 1967
Smith, H. W. 1930
Turner, H. J., Jr. 1954
Vernberg, F. J. 1967

3. Summary reports

4. Bibliographies

5. Original reports on experiments

1. Adaptation

Ahuja, S. K. 1963
Allen & Avault 1970, 1971
Baggerman, B. 1960
Beadle, L. C. 1934, 1937
Beadle & Cragg 1940
Beudant, F. S. 1816
Black, V. S. 1948, 1951
Colgan, N. 1910
Duchateau-Bosson, Florkin & Jeuniaux 1961
Ebbs & Staiger 1965
Federighi, H. 1931
Foster, B. A. 1970
Fukusho, K. 1969
Fustec-Mathon, Neuville & Daste 1969
Ganapati & Alikunhi 1952
Ganning, B. 1970
Gifford, C. A. 1962
Gross, W. 1961
Habas & Prosser 1966
Hickling, C. F. 1970
Hickman, C. P., Jr. 1959
Hopkins, A. E. 1936

Houston, A. H. 1959
Jackson, C. R. 1952
Jeuniaux & Florkin 1961
Jorgensen & Dales 1957
Joseph & Vishnu 1966
Kahler, H. H. 1970
Kalber & Costlow 1968
Katayama, T. 1960
Keys, A. B. 1933
Kinne, O. 1964
Klekowski, R. Z. 1963
Knight, J. M. 1966
Kudinova-Pasternak, R. K. 1960
Lee & McFarland 1962
Lewis, R. M. 1966
Lewis & Hettler 1968
Lienemann, L. J. 1938
Lockwood & Croghan 1957
Lofts, B. 1956
Logvinovich & Semyachko 1963
Loosanoff, V. L. 1945
Losina-Losinsky, L. K. 1948
Maetz, I. 1971
Maksimova, L. P. 1964
Mangum, C. P. 1964
Martin, F. D. 1968
Matutani, K. 1962
McFarland & Pickens 1965
McInerney, J. E. 1961
McLeese, D. W. 1956
Motais, Isala, Rankin & Maety 1969
Motwani, M. P. 1955
Oglesby, L. C. 1966, 1969
Otto & McInerney 1970
Panikkar, N. K. 1940, 1941, 1951
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Pantin, C. F. A. 1931a,b
Parry, G. 1953, 1960
Parvatheswararao, V. 1967
Pearcy, W. G. 1962
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Penfound & Earle 1948
Philippson, Hannevart & Thieren 1910
Pierce, S. K. 1970
Plateau, F. 1883
Precht & Linder 1966
Pritchard & Yuen 1963
Privol'nev, T. I. 1959
Prosser, Green & Chow 1955
Rämamurthi, R. 1965, 1966, 1967, 1968
Rao, G. M. M. 1968
Rao, K. P. 1958
Rees, G. 1941
Ricci, E. 1939
Roch, F. 1924
Rykova, T. I. 1964
Schechter, V. 1942
Schlieper, C. 1929
Schmidt-Nielsen, Gertz & Davis 1968
Schmitz, Besch & Kneissl 1967
Schultz, M. E. 1971
Segal & Burbanck 1963
Shaw & Sutcliffe 1961
Shehadeh & Gordon 1969
Shelbourne, J. E. 1966
Smith, R. I. 1955
Soldatova, I. N. 1961
Sonnery & Tchang-si 1931
Spaargaren, D. H. 1971
Spektorova, L. V. 1970
Struhsaker & Costlow 1969
Sukumaran, S. 1961
Tagatz, M. E. 1961, 1969, 1971
Todd, M. E. 1963
Topping & Fuller 1942
Ungar, I. A. 1970
Virkar, R. A. 1966
Weil & Pantin 1931
Wells & Ledingham 1940
Wells, Ledingham & Gregory 1940
Wiesepape & Aldrich 1970
Wigglesworth, V. B. 1938
Williams, I. V. 1969
Young, R. T. 1938
Zhirmunsky & Kiseleva 1957

2. Biochemical studies

Bateman, J. B. 1933
Berger, E. 1931
Bethe, A. 1920
Bialaszewicz, K. 1931
Binyon, J. 1962
Bryan, G. W. 1963, 1964
Cole, W. H. 1940
Craigie, J. S. 1969
Duchateau-Bosson, Florkin & Jeuniaux 1961
Dupaul & Webb 1970
Felton & Aiello 1971
Firly & Fontaine 1932
Florkin & Schoffeniels 1965
Fox, D. 1941
Fredericq, L. 1922
Gordon, M. 1963
Green, Harsch, Barr & Prosser 1959
Haefner, P. 1964

Henri & Lalou 1903
Huggins & Munday 1968
Jeuniaux, Duchateau-Bosson & Florkin 1961
Lange, R. 1963
Lockwood, A. P. M. 1960
Lockwood & Croghan 1957
Lynch & Wood 1966
Marchal, P. 1892
Pantin, C. F. A. 1931b,c
Parry, G. 1954
Parvatheswararao, V. 1967
Potts, W. T. W. 1958
Potts & Parry 1964
Prosser, Green & Chow 1955
Rämamurthi, R. 1966
Reeve, Raymont & Raymont 1970
Simpson, Allen & Awapara 1959
Stephens, G. C. 1963, 1964, 1967
Stephens & Virkar 1966
Virkar, R. A. 1963
Virkar & Webb 1970

3. Combinations (temperature-salinity, etc.)

Alabaster, J. S. 1967
Alderdice, D. F. 1963
Alderdice & Forrester 1968, 1971
Bourne, N. 1971
Brenko & Calabrese 1969
Broekema, M. M. M. 1961
Calabrese, A. 1969a,b
Costlow, J. D. 1967
Costlow & Bookhout 1959, 1968
Costlow, Bookhout & Monroe 1960, 1962, 1966
Courtright & Bond 1969
Crisp & Costlow 1963
Davies, T. T. 1965
Davis, H. C. 1963
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Daugherty & Altman 1925
Dehnel & McCaughran 1964
Dupaul & Webb 1970
Eisler, R. 1969
Engel & Angelovic 1968
Farmer & Beamish 1969
Felton & Aiello 1971
Fingerman, M. 1959
Flugel, H. 1959, 1966
Forrester & Alderdice 1966
Gegelius, G. 1965
Gibson & Hirst 1955
Gifford, C. A. 1962
Gopalakrishna-Murtie & Nagabhushanam 1968
Goyacheva, N. V. 1969
Haefner, P. A., Jr. 1969, 1970
Hagerman, L. 1970
Hand, Collard & Davenport 1965
Harrington, R. W., Jr. 1971
Hazel, Thomsen & Meith 1971
Henry, K. A. 1967
Herbert, D. W. M. 1965
Holland, Aldrich & Strawn 1971
Jackson, C. R. 1952
Job, S. V. 1969
Kahler, H. H. 1970
Kendall & Schwartz 1968
Kinne, O. 1952; 1953; 1956a,b; 1957; 1961; 1963; 1964a,b; 1967
Kinne & Kinne 1962
Kinne & Paffenhofer 1965, 1966
Kinne, Shirley & Meen 1963
Kudinova-Pasternak, R. K. 1960, 1962
LaBarbera & Chanley 1970
Lance, J. 1963
Landers & Rhodes 1970
Landers & Toner 1962
Lazareva, L. P. 1961
Lewis, R. M. 1966
Lewis & Hettler 1968
Lockwood, A. P. M. 1960
Loeb, J. 1903
Losina-Losinsky, L. K. 1948
Losovskaya, G. V. 1961
MacGregor, J. S. 1950
Mandelli, E. F. 1972
Manzi, J. J. 1970
Matutani, K. 1962
McFarland & Pickens 1965
McGahee & Davis 1971
McLeese, D. W. 1956, 1959
McLusky & Heard 1971
Menzel, R. W. 1954, 1955
Mohammad, M. B. M. 1966
Morris, R. W. 1960
Nagabhushanam, R. 1961
Nagabhushanam & Sarojini 1965
Nayar, J. K. 1969
Ogato & Matsui 1965
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Panikkar, N. K. 1940a,b
Parvatheswararao, V. 1965
Phillipson, Hannevart & Thieren 1910
Porter, H. J. 1960

Precht & Linder 1966
Rämamurthi, R. 1967
Ranade, M. R. 1957
Rees, G. 1941
Ritchie, D. 1957, 1959
Roch, F. 1924
Sandoz, M. 1943
Sandoz & Hopkins 1944
Sandoz & Rogers 1944
Scheltema, R. S. 1962
Schlieper, Flügel & Rudolph 1960
Segal & Burbanck 1963
Seno, Ebina & Okada 1926
Shelbourne, J. E. 1966
Shields, N. 1972
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Spektorova, L. V. 1970
Stickney, A. P. 1964
Stokke, K. 1958
Strawn & Dunn 1967
Struhsaker & Costlow 1969
Sumner, F. B. 1907
Sweet & Kinne 1964
Tagatz, M. E. 1961, 1969, 1971
Templeman, W. 1936
Tietjen & Lee 1972
Todd, M. E. 1963, 1964
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Ungar, I. A. 1970
Van Winkle, W., Jr. 1968
Vaughan, T. W. 1916
Vernberg & Vernberg 1970
Wiesepape & Aldrich 1970
Williams, A. B. 1960
Williams, R. J. 1970
Wilson, W. B. 1967
Wolfe & Coburn 1970
Wood, C. E. 1967
Wood, L. 1971
Zein-Eldin & Aldrich 1964

4. Growth (effects on, etc.)

Aldrich & Wilson 1960
Aleem, A. A. 1961
Allen & Avault 1970
Baid, I. C. 1963
Bose, B. B. 1959
Bullivant, J. S. 1961
Canagaratnam, P. 1959, 1966
Causey, Prytherch, McCaskill, Humm & Wolf 1946
Davies, T. T. 1965
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Deubler & White 1962
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Kinne, O. 1956, 1957, 1960, 1961
Kinne & Paffenhofer 1965, 1966
Lear, D. W. 1962
Matthiessen, G. C. 1960
McLachlan, J. 1961
McLusky, D. S. 1967
McMahan, C. A. 1968
Norton & South 1969
Ogata & Schramm 1971
Phleger, C. F. 1971
Ritchie, D. 1957, 1959
Roch, F. 1924
Ross & Morris 1962
Ryther, J. H. 1954
Schlieper, C. 1932
Schmidt, H. 1970
Schultz, M. E. 1971
Sin, Ong Kah 1966
Smith, G. F. M. 1940
Soldatova, I. N. 1963
Stokke, K. 1958
Sweet & Kinne 1964
Tagatz, M. E. 1967
Taylor, N. 1939
Templeman, W. 1936
Turner, H. J., Jr. 1954a,b
Vaughan, T. W. 1916
Vishniac, H. S. 1960
Williams, R. B. 1964
Wilson, B. R. 1969
Wilson, W. B. 1967
Wood, C. E. 1967
Zein-Eldin, Z. P. 1963
Zein-Eldin & Aldrich 1965

5. Ion exchange (internal and surface)

Bethe, A. 1908, 1928
Bricteux-Grégoire, Duchateau-Bosson, Jeuniaux & Florkin 1962
Burger, J. W. 1957
Cole, W. H. 1941
Croghan, P. C. 1958a,b
Cuénot, L. 1895
Dailey, Fremont-Smith & Carroll 1931
Dehnel, P. A. 1963, 1967

Denne, L. B. 1968
Duval & Prenant 1926
Fange & Fugelli 1963
Fingerman & Fairbanks 1956
Flemister & Flemister 1951
Fretter, V. 1955
Fulton, C. 1962
Gessner, F. 1969
Gifford, C. A. 1962
Gosselink, J. G. 1970
Greenwald & Kirschner 1971
Henri & Lalou 1903
Hukuda, K. 1932
Koch, Evans & Schicks 1954
Lee & McFarland 1962
Lockwood, A. P. M. 1961, 1964
Lockwood & Croghan 1957
Maetz, I. 1971
Mantel, L. H. 1967
Marchal, P. 1892
Oglesby, L. C. 1965a,b; 1966
Panikkar, N. K. 1941
Panikkar & Viswanathan 1948
Parry, G. 1953
Parvatheswararao, V. 1967
Pearse, A. S. 1932
Pequignot & Serfaty 1968
Pierce, S. K. 1970
Plateau, F. 1883
Potts, W. T. W. 1954a,b; 1958; 1968
Prosser, C. L. 1955
Quinton, R. 1900
Rämamurthi, R. 1965
Rice, T. R. 1963
Robertson, J. D. 1939, 1949, 1953, 1960
Rucker & Valentine 1961
Schlieper, C. 1932, 1935, 1964
Schmitz, Besch & Kneissl 1967
Seck, C. 1958
Shaw, J. 1959
Shaw & Sutcliffe 1961
Shehadeh & Gordon 1969
Smith, H. W. 1930, 1932
Smith, R. I. 1955, 1963
Spaargaren, D. H. 1971
Sukumaran, S. 1961
Tan, E.-C. 1962
Todd, M. E. 1964
Townsley, S. J. 1962
Varigny, H. de 1883
Vishniac, H. S. 1960
Warren & Doudoroff 1971
Webb, D. A. 1940
Weisbart, M. 1968
Wigglesworth, V. B. 1938
Wolfe & Coburn 1970
Yamazaki, M. 1929
Young, R. T. 1938

6. Lethality limits

Ahuja, S. K. 1963
Allen & Avault 1970, 1971
Andrews, F. B. 1925
Barnes, R. S. K. 1967
Becker, G. 1959
Bernard, Braci, Lalami & Moueza 1969
Bert, P. 1883
Bethe, A. 1928
Biebl, R. 1956
Bishai, H. M. 1961
Carriker, M. R. 1957, 1961
Coche, A. G. 1967
Conte, Wagner, Fessler & Gnose 1966
Courtright & Bond 1969
Croghan, P. C. 1958
Davis, H. C. 1963
Dice, J. F., Jr. 1969
Doroshev, S. I. 1965
Eltringham, S. 1961
Federighi, H. 1931b,c
Firly, S. 1932
Flugel, H. 1959, 1966
Fontaine, M. 1930a
Fox, D. 1941
Fukusho, K. 1969
Fustec-Mathon, Neuville & Daste 1969
Galtsoff, Prytherch & Engle 1937
Ganning, B. 1970
Garry, W. C. 1916
Gowanloch & Hayes 1927
Haefner, P. A., Jr. 1969, 1970
Hagerman, L. 1970
Hazel, Thomsen & Meith 1971
Henry, A. 1967
Hill, M. B. 1967
Holland, Aldrich & Strawn 1971
Holliday & Blaxter 1960, 1961
Holliday & Jones 1967
Hopper, A. F. 1960
Huf, E. 1934
Huntsman & Hoar 1939
Ivanov, A. I. 1965
Jackson, C. R. 1952
Jansen, K. P. 1970
Jansson, B.-O. 1962

Joseph & Vishnu 1966
Kahler, H. H. 1970
Kasimov, Abramov & Kyasimov 1966
Katayama, T. 1960
Kendall & Schwartz 1964, 1968
Kinne, O. 1964
Klekowski, R. Z. 1963
Koroleva, N. V. 1960
Krishnamoorthi & Krishnaswamy 1966
Kudinova-Pasternak 1963
Lance, J. 1963
Landers & Toner 1962
Lewis, R. M. 1966
Lewis & Hettler 1968
Lienemann, L. J. 1938
Little, C. 1969
Lofts, B. 1956
Logvinovich & Semyachko 1963
Loosanoff, V. L. 1942, 1945
Losovskaya, G. V. 1961
MacGregor, J. S. 1950
Maksimova, L. P. 1964
Mandelli, E. F. 1972
Mangum, C. P. 1964
Manzi, J. J. 1970
Martin, F. D. 1968
Matthiessen, G. C. 1960
McLeese, D. W. 1956
McLusky, D. S. 1967
McLusky & Heard 1971
McMahan, C. A. 1968
McMillan & Moseley 1967
Morris, R. W. 1960
Motwani, M. P. 1955
Nagabhushanam, R. 1961; 1965a,b; 1967
Nagabhushanam & Gopalakrishna-Murtie 1965
Neumann, D. 1961
Norton, O. A. 1947
Oglesby, D. C. 1965
Pantin, C. F. A. 1931b
Parry, G. 1953, 1960
Pearcy, W. G. 1962
Pearse, A. S. 1928; 1929; 1936
Pequignot & Serfaty 1968
Phibbs, F. D. 1971
Privol'nev, T. I. 1959, 1964
Privol'nev, Koroleva & Shterman 1960
Rämamurthi, R. 1965, 1967, 1968
Ranade, M. R. 1957
Rees, G. 1941
Renfro, W. C. 1959
Reshoft, K. 1961
Reyment, R. A. 1964
Ricci, E. 1939
Ritchie, D. 1957
Rykova, T. I. 1964
Ryther, J. H. 1954
Saha, Chakraborty, De & Chakraborty 1969
Schechter, V. 1942
Schlieper, Flügel & Theede 1967
Segal & Burbanck 1963
Shaw, J. 1959
Shinkawa, H. 1959
Shoup, C. S. 1932
Smith & Vail 1959
Smith, G. F. M. 1940
Soldatova, I. N. 1961, 1963
Sonnery & Tchang-si 1931
Stokke, K. 1958
Strawn & Dunn 1967
Stuart, T. A. 1941
Stunkard & Shaw 1931
Styczynska-Jurewick, E. 1971
Sukumaran, S. 1961
Tagatz, M. E. 1961, 1969, 1971
Taylor, N. 1939
Todd, M. E. 1964
Todd & Dehnel 1960
Topping & Fuller 1942
Tundisi & Tundisi 1968
Turner, H. J., Jr. 1954
Ungar, I. A. 1970
Varigny, H. de 1883
Vasantha, T. V. 1963
Vaughan, T. W. 1915, 1916, 1919
Vernberg, Schlieper & Schneider 1963
Vernberg & Vernberg 1970
Walker, K. 1969
Warren & Doudoroff 1971
Wells, J. W. 1932
Wells & Ledingham 1940
Werntz, H. O. 1963
Wiesepape & Aldrich 1970
Wilson, B. R. 1968, 1969
Wolfe, D. A. 1971
Young, R. T. 1938
Zein-Eldin & Aldrich 1964

7. Locomotion (effects on)

Carriker, M. R. 1961
Costa, H. H. 1966
Creutzberg, F. 1961
Daugherty & Altman 1925

Farmer & Beamish 1969
Hand, Collard & Davenport 1965
Hill & Holland 1971
Houston, A. H. 1957, 1959
Jansson, B.-O. 1962
Koch & Heuts 1943
Lagerspetz & Mattila 1961
Lance, J. 1962
Landers & Toner 1962
Lucas, J. S. 1970
MacGregor, J. S. 1950
McInerney, J. E. 1961, 1964
Oglesby, L. C. 1969
Otto & McInerney 1970
Polunina, O. A. 1965
Scarratt & Raine 1967
Sizer, I. W. 1936
Stunkard & Shaw 1931
Styczynska-Jurewick, E. 1971
Williams, I. V. 1969
Wood, L. 1971

8. Orientation (to salinity difference)

Costa, H. H. 1966
Creutzberg, F. 1961
Daugherty & Altman 1925
Hill & Holland 1971
Houston, A. H. 1957
Jansson, B.-O. 1962
Lagerspetz & Mattila 1961
Lance, J. 1962
Limz, Y. 1969
Lucas, J. S. 1970
Lyster, I. H. J. 1955
Mangum, C. P. 1964
McInerney, J. E. 1961, 1964
Oglesby, L. C. 1969
Otto & McInerney 1970
Polunina, O. A. 1965
Scarratt & Raine 1967
Williams, I. V. 1969

9. Osmoregulation

Anderson & Prosser 1953
Bailey, J. E. 1971
Ballard, B. S. 1968
Ballard & Abbott 1969
Barnes, R. S. K. 1967
Bateman, J. B. 1933
Baumberger & Olmsted 1928
Beadle, L. C. 1931, 1934, 1937
Beadle & Cragg 1940
Bethe, A. 1930
Binns, R. 1969
Black, V. S. 1951
Boguckl, M. 1932
Boon & Tatro 1971
Broekema, M. M. M. 1941
Bull & Morris 1967
Burger, J. W. 1957
Calabrese & Davis 1970
Coche, A. G. 1967
Cole, W. H. 1940
Colgan, N. 1910
Conte & Wagner 1965
Croghan, P. C. 1958a,b,c
Dall, W. 1967, 1970
Dehnel, P. 1962, 1963, 1966, 1967
Dehnel & Stone 1964
Dekhuyzen, M. C. 1920
Denne, L. B. 1968
Denton, E. J. 1971
Dice, F. J., Jr. 1969
Duchateau-Bosson, Florkin & Jeuniaux 1961
Duval & Prenant 1926
Ebbs & Staiger 1965
Ellis, W. G. 1933, 1939
Eltringham, S. K. 1964
Fange & Fugelli 1963
Fingerman & Fairbanks 1956a,b
Firly, S. 1932
Florkin & Schoffeniels 1965
Flugel, M. 1959, 1966
Fontaine, M. 1930a,b
Frankenberg, D. 1963
Fredericq, L. 1922
Freeman, P. J. 1966
Freeman & Rigler 1957
Fukusho, K. 1969
Gifford, C. A. 1962
Ginetsinskii, Vasileva & Natochin 1962
Gnanamulhru, C. 1965
Gordon, M. S. 1957, 1963, 1965
Green, Harsch, Barr & Prosser 1959
Gross, W. J. 1957, 1960, 1961
Haefner, P. 1964
Henri & Lalou 1903
Hickman, C. P., Jr. 1959
Hiscock, I. D. 1953a,b
Houston, A. H. 1964
Huf, E. 1934
Hukuda, K. 1932
Jeuniaux, Duchateau-Bosson & Florkin 1961
Jones, L. L. 1941

Jorgensen & Dalls 1957
Kalber & Costlow 1968
Kashiwagi & Sato 1969
Keys, A. B. 1933
King, E. N. 1963, 1966
Kinne, O. 1963, 1964
Kinne, Shirley & Meen 1963
Klebowsky, R. Z. 1963
Koch & Heuts 1943
Krogh, A. 1939
Kromhout, G. A. 1943
Lance, J. 1965
Lange, R. 1963
Lasker & Theilacker 1962
Lee & McFarland 1962
Lienemann, L. J. 1938
Limz, Y. 1969
Lockwood, A. P. M. 1960, 1962, 1964
Lockwood & Croghan 1957
Lozovik, V. I. 1964
Luche & Ricca 1941
Lyster, I. H. J. 1955
Maetz, I. 1971
Mantel, L. H. 1967
Marchal, P. 1892
McLusky & Heard 1971
Morris, R. W. 1960
Motais, Isala, Rankin & Maety 1969
Nagel, H. 1934
Oglesby, L. C. 1965a,b; 1966
Panikkar, N. K. 1940, 1941, 1951
Panikkar & Viswanathan 1948
Pantin, C. F. A. 1931
Parry, G. 1953, 1957, 1961
Parvatheswararao, V. 1967
Pearse, A. S. 1932
Pequignot & Serfaty 1968
Pieh, S. 1936
Pierce, S. K. 1970
Pilgrim, R. L. C. 1953a,b
Plateau, F. 1883
Potts, W. T. W. 1954, 1968
Pritchard & Yuen 1963
Prosser, C. L. 1955
Prosser, Green & Chow 1955
Rämamurthi, R. 1965
Ricci, E. 1939
Robertson, J. D. 1960
Schlieper, C. 1930, 1935
Schlieper, Flügel & Rudolph 1960
Schmidt-Nielsen, Gertz & Davis 1968
Segal & Burbanck 1963
Segal & Dehnel 1962
Simpson, Allen & Awapara 1959
Smith, H. W. 1930, 1932
Smith, R. I. 1955, 1963
Spaargaren, D. H. 1971
Stephens, G. C. 1967
Styczynska-Jurewick, E. 1971
Subramanian, A. 1967
Sukumaran, S. 1961
Sumner, F. B. 1907
Tan, E.-C. 1962
Tan & Van Engel 1966
Todd, M. E. 1963, 1964
Topping & Fuller 1942
Van Weil, P. B. 1957
Virkar, R. A. 1966
Warren & Doudoroff 1971
Webb, D. A. 1940
Weisbart, M. 1968
Werntz, H. O. 1963
Wigglesworth, V. B. 1938
Williams, A. B. 1960
Yamazaki, M. 1929, 1932

10. Physiological effects (on respiration, etc.)

Alderdice, D. F. 1963
Allen & Avault 1971
Barnes, H. 1953
Barnes & Barnes 1958
Bateman & Keys 1933
Beadle, L. C. 1931
Berrier & Julien 1934
Bethe, A. 1908, 1920
Black, V. S. 1948
Blanc-Livini & Abraham 1970
Borsuk, Vera & Kreps 1929
Bouxin, H. 1931
Bullivant, J. S. 1961
Collier, Ray, Magnitzky & Bell 1953
Courtright & Bond 1969
Eltringham, S. K. 1961, 1965
Engel & Angelovic 1968
Farmer & Beamish 1969
Fearnhead & Fabian 1971
Felton & Aiello 1971
Fingerman, M. 1959
Flemister & Flemister 1951
Florkin, M. 1960
Fox & Simmonds 1933
Frankenberg, D. 1963
Gavard 1927
Gessner, F. 1969
Goyacheva, N. V. 1969

Habas & Prosser 1966
Hagerman, L. 1970
Hammer, L. 1968
Herbert, D. W. M. 1965
Herbert & Shurben 1965
Hickman, C. P., Jr. 1962
Hiscock, I. D. 1953b
Holtzman & Schreibman 1971
Hopkins, A. E. 1936
Hopkins, H. S. 1949
Huggins & Munday 1968
Job, S. V. 1969
Kawaguti, S. 1943
King, E. N. 1963, 1965, 1966
Kinne O. 1952, 1953, 1956, 1957, 1960, 1961, 1964, 1967
Kinne & Kinne 1962
Kinne & Paffenhofer 1965
Kreps, E. 1929
Labat & Serfaty 1961
Lance, J. 1964
Landers & Rhodes 1970
Lasker & Theilacker 1962
Lassere, P. 1970
Lazareva, L. P. 1961
Lofts, B. 1956
Loosanoff & Smith 1949
Losovskaya, G. V. 1961
Lozovik, V. I. 1964
Malone & Dodd 1967
Mantel, L. H. 1967
Manzi, J. J. 1970
Marshall, Nicholls & Orr 1935
Mathieson & Burns 1971
Matthiessen, G. C. 1960
McFarland & Pickens 1965
McGahee & Davis 1971
McLachlon, J. 1961
Menzel, R. W. 1954, 1955
Motais, Isala, Rankin & Maety 1969
Motwani, M. P. 1955
Nagabhushanam, R. 1956, 1961
Nagabhushanam & Sarojini 1965
Ogata & Schramm 1971
Ogato & Matsui 1965
Parvatheswararao, V. 1965
Pequignot & Serfaty 1965
Pieh, S. 1936
Pilgrim, R. L. C. 1953a,b
Potts, W. T. W. 1954, 1958
Precht & Linder 1966
Raffy & Fontaine 1930
Rämamurthi, R. 1967a,b; 1968
Rao, G. M. M. 1968
Rao, K. P. 1958
Reshoft, K. 1961
Roch, F. 1924
Schiltz & Trainer 1970
Schlieper, C. 1928, 1929, 1930, 1932
Schmidt, H. 1970
Segal, E. 1967
Serfaty & Labat 1960
Shelbourne, J. E. 1966
Shields, N. 1972
Shinkawa, H. 1959
Smith, R. I. 1964
Soldatova, I. N. 1963
Sonnery & Tchang-si 1931
Sparck, R. 1933
Stephens, G. C. 1963, 1964, 1967
Stickney, A. P. 1964
Subramanian, A. 1967
Sumner, F. B. 1907
Todd & Dehnel 1960
Topping & Fuller 1942
Townsley, S. J. 1962
Van Weil, P. B. 1957
Van Winkle, W., Jr. 1968
Vasantha, T. V. 1963
Vernberg, Schlieper & Schneider 1963
Walne, P. R. 1956a,b
Warburg, O. 1910
Weil & Pantin 1931
Wells & Ledingham 1940
Wells, Ledingham & Gregory 1940
Wilson, B. R. 1968, 1969
Wohlschlag, D. E. 1957, 1972
Zhirmunskii, A. V. 1962

11. Reproduction (effects on)

Aleem, A. A. 1961
Broekema, M. M. M. 1941
Davis, H. C. 1957
DeLeersnyder, M. 1967
Drabkina, B. M. 1962
Ford, E. 1929
Fox, D. 1941
Gopalakrishna-Murtie & Nagabhushanam 1968
Goyacheva, N. V. 1969
Hagerman, L. 1970
Harrington, R. W., Jr. 1971
Huxley, J. S. 1930

Jansen, K. P. 1970
Kinne, O. 1952; 1953; 1961a,b; 1964c
Kinne & Paffenhofer 1966
Klesch, W. L. 1970
Koch & Heuts 1943
Kudinova-Pasternak, R. K. 1963
Loosanoff, V. L. 1948
Maksimova, L. P. 1964
Manzi, J. J. 1970
Norton & South 1969
Rao, K. V. 1951
Rawson, D. S. 1946
Rees, G. H. 1967
Ryder, J. A. 1883
Rykova, T. I. 1964
Sandoz, M. 1943
Sandoz & Hopkins 1944
Sandoz & Rogers 1944
Scheltema, R. S. 1962
Schiltz & Trainer 1970
Schmidt, H. 1970
Seno, Ebina & Okada 1926
Seno, Hori & Kusakabe 1926
Soldatova, I. N. 1961
Stickney, A. P. 1964
Tietjen & Lee 1972
Ungar, I. A. 1962, 1970
Van Engel, W. A. 1958
Vaughan, T. W. 1916
Vlassblom & Bolier 1971
Williams, R. B. 1964
Wilson, B. R. 1969

12. Survival and development of young

Alderdice & Forrester 1971
Amemiya, I. 1926
Bailey, J. E. 1971
Barnes, H. 1953
Berger & Lebskii 1969
Bernard, Braci, Lalami & Moueza 1969
Bhatnager & Crisp 1965
Bookhout, C. G. 1964
Bookhout & Costlow 1959, 1962
Bourne, N. 1971
Brenko & Calabrese 1969
Broekema, M. M. M. 1941
Buchanan & Billemann 1969
Calabrese, A. 1969a,b
Carriker, M. R. 1957, 1961
Chanley, P. E. 1958
Choe, S. 1966
Coche, A. C. 1967
Costlow, J. D., Jr. 1965, 1967
Costlow & Bookhout 1959; 1962a,b; 1968
Costlow, Bookhout & Monroe 1960, 1966
Culliney, J. L. 1971
Davis, H. C. 1957, 1958, 1962
Davis & Calabrese 1964
Ford, E. 1929
Forrester & Alderdice 1966
Gegelius, G. 1965
Hagerman, L. 1970
Harrington, R. W., Jr. 1971
Hidu & Haskin 1971
Holiday, F. G. T. 1967
Holiday & Blaxter 1960, 1961
Ivanov, A. I. 1965
Jansen, K. P. 1970
Joseph & Vishnu 1966
Kashiwagi & Sato 1969
Kasimov, Abramov & Kyasimov 1966
Kinne & Kinne 1962a,b
Klesch, W. L. 1970
Koroleva, N. V. 1960
Kudinova-Pasternak, R. K. 1962, 1963
Lang, R. 1968
Lewis, R. M. 1966
Lewis & Hettler 1968
Lockhead & Newcombe 1942
Logvinovich & Semyachko 1963
Lucas, J. S. 1970
Matthiessen, G. 1960
Mohammad, M. B. M. 1966
Nagabhushanam, R. 1961
Nayar, J. K. 1969
Ong & Costlow 1970
Phibbs, F. D. 1971
Porter, H. J. 1960
Privol'nev, T. I. 1959, 1964
Privol'nev, Korobena & Shterman 1960
Rao, K. V. 1951
Rawson, D. S. 1946
Rees, G. H. 1959, 1967
Runyan, S. 1961
Ryder, J. A. 1883
Rykova, T. I. 1964
Sandoz, M. 1943
Sandoz & Hopkins 1944
Sandoz & Rogers 1944

Scarratt & Raine 1967
Scheltema, R. S. 1962, 1965
Schultz, M. E. 1971
Seno, Hori & Kusakabe 1926
Shelbourne, J. E. 1963
Sin, O. K. 1966
Sizer, I. W. 1936
Smith & Vail 1959
Smith, R. I. 1963
Soldatova, I. N. 1963
Stickney, A. P. 1964
Struhsaker & Costlow 1969
Sweet & Kinne 1964
Templeman, W. 1936
Tietjen & Lee 1972
Ungar, I. A. 1962
Van Engel, W. A. 1958
Varigny, H. de 1883
Vaughan, T. W. 1916
Vernberg & Vernberg 1970
Vlassblom & Bolier 1971
Walne, P. R. 1956a,b
Weisbart, M. 1968
Wilson, B. R. 1968
Wood, C. E. 1967
Wood, L. 1971
Zein-Eldin, Z. P. 1963
Zein-Eldin & Aldrich 1964, 1965

6. Organisms studied

0. All organisms, or not specified

Fredericq, L. 1922
Kinne, O. 1964, 1967
Pantin, C. F. A. 1931
Pearse, A. S. 1929
Potts, W. T. W. 1968
Schlieper, C. 1929, 1932
Stephens, G. C. 1967
Warren & Doudoroff 1971

1. Bacteria

Fustec-Mathon, Neuville & Daste 1969
Lear, D. W. 1962
Ritchie, D. 1959
Ross & Morris 1962

2. Yeasts

Ritchie, D. 1957
Ross & Morris 1962

3. Fungi

Vishniac, H. S. 1960

4. Algae (small, floating)

Aldrich & Wilson 1960
Aleem, A. A. 1961
Bose, B. B. 1959
Craigie, J. S. 1969
Hammer, L. 1968
Hand, Collard & Davenport 1965
McLachlan, J. 1961
Rice, T. R. 1963
Ritchie, D. 1957
Ryther, J. H. 1954
Schiltz & Trainer 1970
Schultz, M. E. 1971
Spektorova, L. V. 1970
Williams, R. B. 1964
Wilson, W. B. 1967

5. Seaweeds (large attached algae)

Biebl, R. 1956
Causey, Prytherch, McCaskill, Humm & Wolf 1946
Dubois, A. 1968
Gessner, F. 1969
Hammer, L. 1968
Mathieson & Burns 1971
Norton & South 1969
Ogata & Schramm 1971
Ogato & Matsui 1965

6. Seed plants

Gosselink, J. G. 1970
Hammer, L. 1968
McGahee & Davis 1971
McMahan, C. A. 1968
McMillan & Moseley 1967
Ogato & Matsui 1965
Penfound & Earle 1948
Phleger, C. F. 1971
Taylor, N. 1939
Ungar, I. A. 1962

7. Protozoa (single-celled animals)

Aldrich & Wilson 1960
Hand, Collard & Davenport 1965
Goyacheva, N. V. 1969
Klesch, W. L. 1970
Losina-Losinsky, L. K. 1948
Precht & Linder 1966
Spektorova, L. V. 1970
Wilson, W. B. 1967

8. Porifera (sponges)

9. Coelenterata (jellyfish and allies)

1. Hydrozoa (hydroid polyps and hydrozoan medusae)

Fulton, C. 1962, 1963
Kinne, O. 1956, 1957
Kinne & Paffenhofer 1965, 1966

2. Scyphozoa (large, jellyfishes)

Bethe, A. 1908
Robertson, J. D. 1949

3. Sea anemones

Dregol'Skaya, I. N. 1961
Roch, F. 1924
Schmidt, H. 1970
Shoup, C. S. 1932
Zhirmunskii, A. V. 1962
Zhirmunsky & Kiseleva 1957

4. Corals

Kawaguti, S. 1943
Vaughan, T. W. 1915, 1919
Wells, J. W. 1932

5. Ctenophora (comb-jellyfish, sea walnuts)

Lazareva, L. P. 1961
Wells, Ledingham & Gregory 1940

10. Vermes (the old phylum which used to include all "worms")

1. Flatworms, free-living (turbellaria)

Beadle, L. C. 1931, 1934
Kromhout, G. A. 1943
Landers & Rhodes 1970
Landers & Toner 1962
Pantin, C. F. H. 1931a,b
Rees, G. 1941
Weil & Pantin 1931

2. Flatworms, parasitic (flukes and tapeworms)

Stunkard & Shaw 1931
Styczynska-Jurewick, E. 1971

3. Nemertea, Rhynchocoela (ribbon worms)

4. Nematoda (roundworms, eelworms)

Tietjen & Lee 1972

5. Rotifera (wheelworms)

6. Chaetognatha (arrow worms)

Hopper, A. F. 1960
Reeve, Raymont & Raymont 1970

7. Other unsegmented worms

Dekhuyzen, M. C. 1920
Little, C. 1969
Oglesby, L. C. 1969
Robertson, J. D. 1953
Townsley, S. J. 1962
Virkar, R. A. 1963, 1966

8. Annelida (segmented worms)

1. Oligochaeta (earthworms and allies)

Janssons, B.-O. 1962
Kahler, H. H. 1970
Lassere, P. 1970

2. Polychaeta (marine annelids)

Beadle, L. C. 1931, 1937
Berger & Lebskii 1969
Dales, R. P. 1967
Dice, J. F. 1969

Duchateau-Bosson, Florkin & Jeuniaux 1961
Ebbs & Staiger 1965
Ellis, W. G. 1933, 1939
Fretter, V. 1955
Hill, M. B. 1967
Hopper, A. F. 1960
Jeuniaux, Duchateau-Bosson & Florkin 1961
Losovskaya, G. V. 1961
Lyster, I. H. J. 1955
Mangum, C. P. 1964
Mohammad, M. B. M. 1966
Oglesby, L. C. 1965a,b; 1966; 1969
Pearse, A. S. 1928
Robertson, J. D. 1949
Schlieper, C. 1964
Smith, R. I. 1964
Topping & Fuller 1942
Wells & Ledingham 1940
Wells, Ledingham & Gregory 1940

3. Hirudinea (leeches)

Rämamurthi, R. 1968

11. Bryozoa (moss animals)

12. Brachiopoda (lamp shells)

Townsley, S. J. 1962

13. Mollusca

0. Mollusca in general

Andrews, F. B. 1925

1. Amphineura (chitons and allies)

Gopalakrishna-Murtie & Nagabhushanam 1968

2. Gastropoda (snails and allies)

Bethe, A. 1920, 1928, 1930
Bryan, G. W. 1963, 1964
Carriker, M. R. 1957
Colgan, N. 1910
Federighi, H. 1931a,b,c
Galtsoff, Prytherch & Engle 1937
Gowanloch & Hayes 1927
Hagerman, L. 1970
Huf, E. 1934
Klekowski, R. Z. 1963
Manzi, J. J. 1970
Nagabhushanam, R. 1967
Robertson, J. D. 1949, 1953
Schechter, V. 1942
Scheltema, R. S. 1962, 1965
Segal & Dehnel 1962
Simpson, Allen & Awapara 1959
Sizer, I. W. 1936
Struhsaker & Costlow 1969
Todd, M. E. 1964a,b
Van Weil, P. B. 1957

3. Pelecypoda (bivalves)

Allen, K. 1961
Amemiya, I. 1926
Anderson & Prosser 1953
Berrier & Jullien 1934
Boon & Tatro 1971
Bourne, N. 1971
Bouxin, H. 1931
Brenko & Calabrese 1969
Calabrese, A. 1969a,b
Calabrese & Davis 1970
Carriker, M. R. 1961
Chanley, P. E. 1958
Cole, W. H. 1940
Collier, Ray, Magnitzky & Bell 1953
Courtright & Bond 1969
Culliney, J. L. 1971
Davies, T. T. 1965
Davis, H. C. 1957, 1958, 1962, 1963
Davis & Calabrese 1964
Dupaul & Webb 1970
Felton & Aiello 1971

Fingerman, M. 1959
Fingerman & Fairbanks 1956a,b
Fox, D. 1941
Freeman & Rigler 1957
Gavard 1924
Hidu & Haskin 1971
Hiscock, I. D. 1953a,b
Hoop, M. 1940
Hopkins, A. E. 1936
Hopkins, H. S. 1949
Ivanov, A. I. 1965
Joshi, M. I. 1968
Knight, J. M. 1966
Kudinova-Pasternak, R. K. 1960, 1962, 1963
LaBarbera & Chanley 1970
Lange, R. 1963
Lear, D. 1962
Loosanoff, V. L. 1948
Loosanoff & Smith 1949
Luche & Ricca 1941
Lynch & Wood 1966
Maksimova, L. P. 1964
Mandelli, E. F. 1972
Matthiessen, G. C. 1960
Menzel, R. W. 1954, 1955
Motwani, M. P. 1955
Nagabhushanam, R. 1956, 1961, 1965
Norton, O. A. 1947
Orton, J. H. 1937
Pearse, A. S. 1936
Phibbs, F. D. 1971
Philippson, Hannevart & Thieren 1910
Pieh, S. 1936
Pierce, S. K. 1970
Pilgrim, R. L. C. 1953a,b
Potts, W. T. W. 1954a,b; 1958
Rao, K. V. 1951
Reshoft, K. 1961
Ricci, E. 1939
Robertson, J. D. 1949
Rucker & Valentine 1961
Ryder, J. A. 1883
Schlieper, C. 1964
Schlieper, Flugel & Rudolph 1960
Schlieper, Flugel & Theede 1967
Seck, C. 1958
Seno, Hori & Kusakabe 1926
Shinkawa, H. 1959
Simpson, Allen & Awapara 1959
Soldatova, I. N. 1961, 1963
Sparck, R. 1933
Stenzel, H. B. 1971
Stickney, A. P. 1964
Turner, H. J., Jr. 1954a,b
Van Winkle, W., Jr. 1968
Vernberg, Schlieper & Schneider 1963
Virkar & Webb 1970
Walne, P. R. 1956a,b
Wells, Ledingham & Gregory 1940
Williams, R. J. 1970
Wilson, B. R. 1968
Wolfe, D. A. 1971
Wolfe & Coburn 1970
Wood, L. 1971
Yamamoto, G. 1959
Yamazaki, M. 1929, 1932
Yonge, C. M. 1960
Zhirmunskii, A. V. 1962

4. Scaphopoda (elephant tusk shells)

5. Cephalopoda (squid, octopus, cuttlefish)

Denton, E. J. 1971

14. Crustacea

0. Crustacea in general, or kinds not specified

Andrews, F. B. 1925
Anonymous 1947
Archer, A. F. 1947
Bert, P. 1883
Bryan, G. W. 1964
Crisp & Costlow 1963
Fox & Simmonds 1933
Huggins & Munday 1968
Lockwood, A. P. M. 1962, 1967
Robertson, J. D. 1960

1. Branchiopoda, Phyllopoda (fairy shrimps)

Baid, I. C. 1963
Croghan, P. C. 1958a,b,c
Engel & Angelovic 1968
Lockwood, A. P. M. 1967
Panikkar, N. K. 1941

2. Cladocera (water fleas)

3. Copepoda (copepods)

Bernard, Braci, Lalami & Moueza 1969
Hopper, A. F. 1960
Lance, J. 1962, 1963, 1964, 1965
Marshall, Nicholls & Orr 1935
Matutani, K. 1962
Ranade, M. R. 1957
Shields, N. 1972
Tundisi & Tundisi 1968

4. Ostracoda (seed shrimps)

Lockwood, A. P. M. 1967
Reyment, R. A. 1964

5. Cirripedia (barnacles and allies)

Barnes, H. 1953
Barnes & Barnes 1958
Bhatnager & Crisp 1965
Borsuk & Kreps 1929
Crisp & Costlow 1963
Foster, B. A. 1970
Lockwood, A. P. M. 1967

6. Mysidacea (mysid shrimps)

Lockwood, A. P. M. 1967
McLusky & Heard 1971

7. Isopoda (isopods, pill bugs)

Bateman, J. B. 1933
Becker, G. 1959
Boguckl, M. 1932
Eltringham, S. K. 1961, 1964, 1965
Frankenberg, D. 1963
Frankenberg & Burbanck 1963
Hopper, A. F. 1960
Jansen, K. P. 1970
Kreps, E. 1929
Lagerspetz & Mattila 1961
Lockwood, A. P. M. 1960, 1967
Lockwood & Croghan 1957
Nagabhushanam & Gopalakrishna-Murtie 1965
Parry, G. 1953
Schmitz, Besch & Kneissl 1967
Segal & Burbanck 1963
Todd, M. E. 1963

8. Amphipoda (amphipods)

Bateman, J. B. 1933
Beadle & Cragg 1940
Bryan, G. W. 1963
Flugel, H. 1959
Hopper, A. F. 1960
Lagerspetz & Mattila 1961
Lockwood, A. P. M. 1961, 1962, 1967
Loeb, J. 1903
McLusky, D. S. 1967
Nagabhushanam, R. 1965
Pearse, A. S. 1936
Schmitz, Besch & Kneissl 1967
Shaw & Sutcliffe 1961
Vlassblom & Bolier 1971
Werntz, H. O. 1963

9. Stomatopoda (mantis shrimps)

Lee & McFarland 1962
Lockwood, A. P. M. 1967
Robertson, J. D. 1953

10. Decapoda Natantia (prawns, shrimps)

Broekema, M. M. M. 1941
Costa, H. H. 1966

Cuénot, L. 1895
Dall, W. 1967
Denne, L. B. 1968
Eisler, R. 1969
Flugel, H. 1959, 1966
Gnanamulhru, C. P. 1965
Haefner, P. A., Jr. 1969, 1970
Hagerman, L. 1970
Hopper, A. F. 1960
Lockwood, A. P. M. 1967
Lofts, B. 1956
McFarland & Pickens 1965
Nagabhushanam, R. 1961
Panikkar, N. K. 1940a,b; 1941a,b
Panikkar & Viswanathan 1948
Parry, G. 1954, 1957, 1961
Potts & Parry 1964
Rao, K. P. 1958
Schlieper, C. 1964
Schlieper, Flügel & Rudolph 1960
Wiesepape & Aldrich 1970
Williams, A. B. 1960
Zein-Eldin, Z. P. 1963
Zein-Eldin & Aldrich 1965

11. Decapoda Reptantia (crawling decapods). Lobsters and crayfishes (Macrura)

Berger, E. 1931
Burger, J. W. 1957
Cole, W. H. 1941
Cuénot, L. 1895
Dall, W. 1970
Eisler, R. 1969
Kendall & Schwartz 1964
Lienemann, L. J. 1938
Lockwood, A. P. M. 1967
McLeese, D. W. 1956, 1959
Pearse, A. S. 1932
Pritchard & Yuen 1963
Robertson, J. D. 1939, 1949
Scarratt & Raine 1967
Templeman, W. 1936

12. Brachyura (true crabs)

Anderson & Prosser 1953
Ballard, B. S. 1968
Ballard & Abbott 1969
Barnes, R. S. K. 1967
Bateman, J. B. 1933
Bauchau, A. 1966
Berger, E. 1931
Bethe, A. 1920, 1928, 1930
Bialaszewicz, K. 1931
Binns, R. 1969a,b
Bookhout & Costlow 1959
Bricteux-Gregoire, Duchateau-Bosson, Jeuniaux & Florkin 1962
Buchanan & Billemann 1969
Costlow, J. D. 1965; 1967a,b
Costlow & Bookhout 1959a,b; 1962a,b; 1968
Costlow, Bookhout & Monroe 1960, 1962, 1966
Cuénot, L. 1895
Dall, W. 1967
Daugherty, F. M., Jr. 1952
Dehnel, P. 1959, 1960, 1962, 1963, 1966, 1967
Dehnel & McCaughran 1964
Dehnel & Stone 1964
DeLeersnyder, M. 1967
Eisler, R. 1969
Flemister & Flemister 1951
Florkin & Schoffeniels 1965
Flugel, H. 1959
Gifford, C. A. 1962
Green, Harsch, Barr & Prosser 1959
Gross, W. J. 1957a,b; 1960; 1961
Habas & Prosser 1966
Haefner, P. 1963, 1964

Haefner & Shuster 1964
Henry, K. A. 1967
Holland, Aldrich & Strawn 1971
Hopper, A. F. 1960
Hukuda, K. 1932
Jeuniaux & Florkin 1961
Jones, L. L. 1941
Kalber & Costlow 1968
King, E. N. 1963, 1965, 1966
Koch, Evans & Schicks 1954
Lance, J. 1962
Lochhead & Newcombe 1942
Lockwood, A. P. M. 1967
Lucas, J. S. 1970
MacGregor, J. S. 1950
Mantel, L. H. 1967
Marchal, P. 1892
Nagabhushanam, R. 1965
Nagel, H. 1934
Ong & Costlow 1970
Pearse, A. S. 1929, 1932, 1936
Pieh, S. 1936
Porter, H. J. 1960
Quinton, R. 1900
Rämamurthi, R. 1966; 1967a,b
Rees, G. H. 1967
Robertson, J. D. 1939, 1949, 1953
Sandoz, M. 1943
Sandoz & Hopkins 1944
Sandoz & Rogers 1944
Schlieper, C. 1964
Schmidt-Nielsen, Gertz & Davis 1968
Seck, C. 1958
Shaw, J. 1959
Sin, O. K. 1966
Tagatz, M. E. 1967, 1969, 1971
Tagatz & Hill 1971
Tan, E.-C. 1962
Tan & Van Engel 1966
Todd & Dehnel 1960
Van Engel, W. A. 1958
Vernberg & Vernberg 1970
Walker, K. 1969
Webb, D. A. 1940

13. Anomura (hermit crabs and allies, shrimp-like and crablike)

Bookhout, C. G. 1964
Kinne, Shirley & Meen 1963
Lockwood, A. P. M. 1967
Pearse, A. S. 1936
Rees, G. H. 1959
Robertson, J. D. 1953
Sukumaran, S. 1961

15. Insects

Anonymous 1945
Fox & Simmonds 1933
Nayar, J. K. 1969
Neumann, D. 1961
Smith & Vail 1959
Stuart, T. A. 1941
Wigglesworth, V. B. 1938

16. Chelicerata (mites, horse-shoe crabs)

Dailey, Fremont-Smith & Carroll 1931
Ganning, B. 1970
Pearse, A. S. 1928

17. Echinodermata

0. General

Andrews, F. B. 1925

1. Asteroidea (starfishes)

Binyon, J. 1962
Loosanoff, V. L. 1942, 1945
Polunina, O. A. 1965
Schlieper, C. 1964
Smith, G. F. M. 1940

2. Ophiuroidea (brittle stars, serpent stars)

Stephens & Virkar 1966

3. Echinoidea (sea urchins, sand dollars)

Gegelius, G. 1965
Henri & Lalou 1903a,b,c
Robertson, J. D. 1939, 1949

Warburg, O. 1910

4. Holothuroidea (sea cucumbers)

Freeman, P. J. 1966
Henri & Lalou 1903b

18. Chordata (vertebrates and allies)

0. General

Bert, P. 1883

1. Urochordata (sea squirts and allies)

Duval & Prenant 1926
Townsley, S. J. 1962

2. Cephalochordata (lancet fish) ("Amphioxus" and allies)

3. Vertebrata (animals with backbones)

1. Cyclostomes (lampreys, hagfish)

Bull & Morris 1967
Fontaine, M. 1930a,b

2. Elasmobranchs (sharks, skates, etc.) and allied fishes with cartilage skeleton

Fange & Fugelli 1963
Ginetsinskii, Vasileva & Natochin 1962
Hukuda, K. 1932

3. Teleostei (bony fishes)

Ahuja, S. K. 1963
Alabaster, J. S. 1967
Alderdice, D. F. 1963
Alderdice & Forrester 1968, 1971
Allen & Avault 1970, 1971
Baggerman, B. 1960
Bailey, J. E. 1971
Bateman & Keys 1933
Bishai, H. M. 1961
Black, V. S. 1948; 1951a,b
Blanc-Livini & Abraham 1970
Brawn, V. M. 1960
Bullivant, J. S. 1961
Canagaratnam, P. 1959, 1966
Coche, A. G. 1967
Conte & Wagner 1965
Conte, Wagner, Fessler & Gnose 1966
Courtright & Bond 1969
Creutzberg, F. 1961
Daugherty & Altman 1925
Doroshev, S. I. 1963, 1965
Drabkena, B. M. 1962
Farmer & Beamish 1969
Fearnhead & Fabian 1971
Firly, S. 1932
Firly & Fontaine 1932
Ford, E. 1929
Forrester & Alderdice 1966
Ganapati & Alikunhi 1952
Garry, W. C. 1916
Genetsinskii, Vasileva & Natochin 1962
Gibson & Hirst 1955
Gordon, M. S. 1957, 1963
Greenwald & Kirschner 1971
Harrington, R. W., Jr. 1971
Hazel, Thomsen & Meith 1971
Henry, K. A. 1967

Herbert, D. W. M. 1965
Herbert & Shurben 1965
Hickling, C. F. 1970
Hickman, C. P., Jr. 1959, 1962
Hill & Holland 1971
Holliday, F. G. T. 1967
Holliday & Blaxter 1960, 1961
Holtzman & Schreibman 1971
Houston, A. H. 1957, 1959, 1964
Huntsman & Hoar 1939
Huxley, J. S. 1930
Job, S. V. 1969
Joseph & Vishnu 1966
Kashiwagi & Sato 1969
Kasimov, Abramov & Kyasimov 1966
Katayama, T. 1960
Kendall & Schwartz 1968
Keys, A. B. 1933
Kinne, O. 1960
Kinne & Kinne 1962a,b
Klesch, W. L. 1970
Koch & Heuts 1943
Koroleva, N. V. 1960
Labat & Serfaty 1961
Lasker & Theilacker 1962
Lewis, R. M. 1966
Lewis & Hettler 1968
Limz, Y. 1969
Logvinovich & Semyachko 1963
Lozovik, V. I. 1964
Maetz, I. 1971
Martin, F. D. 1968
McInerney, J. E. 1961, 1964
Mohsen, Georgin & Amalou 1964
Morris, R. W. 1960
Motais, Isala, Rankin & Maety 1969
Otto & McInerney 1970
Panikkar, N. K. 1951
Parry, G. 1960
Parvatheswararao, V. 1965, 1967
Pearcy, W. G. 1962
Pearse, A. S. 1932, 1936
Pequignot & Serfaty 1965, 1968
Privol'nev, T. I. 1950, 1964
Privol'nev, Koroleva & Shterman 1960
Prosser, Green & Chow 1955
Raffy & Fontaine 1930
Rämamurthi, R. 1965
Rao, G. M. 1968
Rawson, D. S. 1946
Renfro, W. C. 1959
Runyon, S. 1961
Rykova, T. I. 1964
Saha, Chakraborty & Chakraborty 1969
Schlieper, C. 1964
Seck, C. 1958
Seno & Okada 1926
Serfaty & Labat 1960
Shehadeh & Gordon 1969
Shelbourne, J. E. 1963, 1966
Smith, H. W. 1930, 1932
Sonnery & Tchang-si 1931
Strawn & Dunn 1967
Subramanian, A. 1967
Sumner, F. B. 1907
Sweet & Kinne 1964
Tagatz, M. E. 1961
Vasantha, T. V. 1963
Weisbart, M. 1968
Williams, I. V. 1969
Wohlschlag, D. E. 1957, 1972
Young, R. T. 1938

4. Amphibia (salamanders, frogs)

Gordon, M. 1965
Varigny, H. de 1883

3. Field Studies (ecology, limnology, oceanography, hydrobiology)

0. News reports and popular magazine stories

Anonymous 1944, 1945
James, M. C. 1946

1. Books and monographs

Allee, Park, Emerson, Park & Schmidt 1949
Awati & Rai 1931
Barrington, E. J. W. 1965
Collier, A. W. 1970
Dales, R. P. 1967
Douglas & Stroud, eds. 1971
Friedrich, H. 1969
Galtsoff, P. S. 1954, 1964
Green, J. 1961
Hedgpeth, J. W., ed. 1957
Knipovich, N. M. 1938
Lauff, G. H., ed. 1967
National Research Council 1970
Orton, J. H. 1937
Ranson, G. 1943
Reid, G. K. 1961
Remane, A. 1958
Remane & Schlieper 1971
Stafford, J. 1913
Stenzel, H. B. 1971
Stephens, W. M. 1968
Warren and Doudoroff 1971
Yonge, C. M. 1960
Zenkevitch, L. 1963
Zernov, S. A. 1949

2. Expedition reports

3. Literature reviews and summary reports

Anderson, King & Lindner 1949
Annandale, N. 1922
Anonymous 1931, 1959
Aron & Smith 1971
Bauchau, A. 1966
Beadle, L. C. 1943
Binyon, J. 1966
Bookhout & Costlow 1959
Bowman, H. H. M. 1956
Broekhuysen, G. J. 1936
Brongersma-Sanders, M. 1957
Burbanck, W. D. 1967
Butler, P. A. 1953, 1954
Callamand, O. 1943
Carriker, M. R. 1955, 1967
Caspers, H. 1967
Caulfield, H. P., Jr. 1966
Chapman, C. R. 1966, 1971
Chew, F. 1956
Chitwood, B. G. 1951
Churchill, E. P., Jr. 1920
Copeland, B. J. 1966
Crisp, D. J. 1965
Cronin, L. E. 1967
Cronin & Mansueti 1971
Dahl, E. 1956
d'Ancona, U. 1954
Dannevig, A. 1946
Darnell, R. 1954
Day, J. H. 1951
Emery & Stephenson 1957
Ferronniere, G. 1901
Florkin, M. 1960
Frolander, H. 1964
Galtsoff, P. S. 1964
Gosner, K. L. 1971
Gunter, G. 1942; 1947; 1952; 1956a,b; 1957; 1961a,b; 1967
Hardenberg, J. D. F. 1951
Hargis, W. J., Jr. 1961
Hatai, S. 1930
Hedgpeth, J. W. 1957a,b; 1967
Hickling, C. F. 1970
Holthuis, L. B. 1952
Hopkins, S. H. 1967
Ingle, R. M. 1962
Ingle & Smith 1949
Iversen, E. S. 1968
Jansson, B. O. R. 1972
Jefferies, H. P. 1967
Johnson, T. W., Jr. 1967
Jones, N. S. 1950
Kellogg, J. L. 1910
Kinne, O. 1955; 1956a; 1959; 1964a,b,c; 1966; 1967
Korringa, P. 1952, 1957, 1967
Kutkuhn, J. H. 1966
Laubenfels, M. W. de 1953
Mars, P. 1950
Medcof, J. C. 1961
Menzel, R. W. 1971
Moore, H. F. 1898
Myers, G. S. 1938, 1949
National Research Council 1970
Needham, J. 1930
Nichols, J. T. 1928
Panikkar, N. K. 1951
Parry, G. 1966
Patrick, R. 1967
Pearse, A. S. 1929

Pearse & Gunter 1957
Pillay, T. V. R. 1966b
Pogrebnyak, I. I. 1962
Por, F. D. 1971
Post, R. J. 1951
Redeke, H. C. 1932
Regan, C. T. 1912
Ritchie, D. 1960
Roughley, T. C. 1922, 1933
Schlieper, C. 1928
Schmidt, R. A. 1966
Segal, E. 1967
Segerstråle, S. G. 1949
Shuster, C. N., Jr. 1960
Sieling, F. W. 1971
Smith, S. H. 1966
Stroud, R. H. 1971
Tabb, D. C. 1966
Talbot, G. B. 1966
Thomson, J. M. 1966
Valikangas, I. 1926, 1933
Van Uden, N. 1967
Vernberg, F. J. 1967
Visher, S. S. 1925
Wallace, D. H. 1971
Warburton, F. E. 1958
Willer, A. 1931

4. Bibliographies

Baughman, J. L. 1948
Livingstone, R., Jr. 1965
Pillay, T. V. R. 1966a

5. Original research reports, by regions

1. Intercontinental or worldwide

Bookhout & Costlow 1959
Brattstrom, H. 1954
Burbanck, W. D. 1967
Conte & Wagner 1965
Dybern, B. 1967
Gunter, G. 1967
Reid, G. K. 1961

2. North America

0. Continentwide, or not specified

Chitwood, B. G. 1951
Gunter, G. 1942, 1947, 1956
Henry, D. P. 1959
Thompson, H. 1961
Virkar, R. A. 1966
Wilce, Webber & Sears 1970

1. Atlantic

Adams, D. A. 1963
Allen, J. F. 1960
Amos, W. H. 1957
Andrews, J. D. 1964
Andrews, Haven & Quayle 1959
Anonymous, 1944, 1945, 1946
Barans, C. A. 1972
Barlow, J. P. 1955
Barlow, Lorenzen & Myren 1963
Bary, B. M. 1963, 1964
Batchelder, C. H. 1926
Beach, N. W. 1969
Beaven, G. F. 1955
Borut & Johnson 1962
Bourdeau & Adams 1956
Bousfield, E. L. 1955
Bowman, T. E. 1964
Burbanck, W. D. 1959; 1961; 1962a,b; 1967
Burkenholder, P. R. 1933
Burton, R. W. 1963
Butler, P. A. 1949, 1954
Carriker, M. R. 1951, 1955
Castagna & Chanley 1966
Chapman, V. J. 1940
Churchill, E. P., Jr. 1919, 1920
Cones & Haven 1969
Conger, P. S. 1953
Conover, J. T. 1958
Conover, R. J. 1956
Cowles, R. P. 1930
Croker, R. A. 1968
Cronin, Daiber & Hulbert 1962
Cronin, Van Engel, Cargo & Wojcik 1957
Dees, Mrs. 1949
Dovel, Mihursky & McErlean 1969
Dunnington, E. A. 1956
Elliott, Myers & Tressler 1955
Elliott, Ellison & Nichols 1966
Fassett, N. C. 1928
Federighi, H. 1930, 1931
Fraser, J. H. 1931
Frey, D. G. 1946
Frolander, H. 1964
Galtsoff, P. S. 1964

Galtsoff, Chipman, Engle & Calderwood 1947
Galtsoff & Prytherch 1927
Goodwyn, F. 1968
Gosner, K. L. 1971
Gunter & Hall 1963
Haefner, P. A., Jr. 1967
Hanks, R. 1964
Hargis, W. J. 1961
Harshberger, J.W. 1909, 1911
Haskin, H. H. 1936, 1938
Haskin, Krueger & Tweed 1971
Haven, D. 1957, 1961
Heinle, D. R. 1972
Herman, S. S. 1968
Higgins, E. 1931, 1937, 1940
Hopkins, S. H. 1956b, 1962
Hopkins, T. L. 1958
Hughes, G. C. 1961
Hulburt, E. M. 1957, 1963
Huntsman, A. G. 1918
James, M. C. 1946
Jeffries, H. P. 1960; 1962a,b
Jones & Burbanck 1959
Kawamura, T. 1966
Kellogg, J. L. 1910
Kerwin, J. A. 1971
Kerwin & Pedigo 1971
Keup & Bayless 1964
Kuenzler, E. J. 1961
Kurz & Wagner 1957
Lackey, J. B. 1938, 1967
Laubenfels, M. W. de 1949
Lewis, R. M. 1967
Little, F. J., Jr. 1963
Loosanoff & Engle 1943
Lunz, G. R., Jr. 1938 1958
Manning & Whaley 1955
Mansueti, R. J. 1961, 1962, 1964
Marshall & Wheeler 1965
Massmann, W. H. 1954, 1971
Matthiessen, G. C. 1960
Maturo, F. S., Jr. 1959
McErlean, A. J. 1964
McHugh, J. L. 1966, 1967
McKenzie, R. A. 1959
Medcof, J. C. 1944, 1961
Medcof & Needler 1941
Menzies & Frankenbury 1966
Miller, D. N., Jr. 1953
Miller & Burbanck 1961
Moore, H. F. 1911
Mulligan, H. F. 1972
Muncy, R. J. 1962
Nash, C. B. 1947
Nelson, T. C. 1921, 1923, 1928
Newcombe, C. L. 1935, 1945
Norcross, Massmann & Joseph 1961
Norton, O. A. 1947
Odum, H. T. 1953
Oemler, A. 1894
Parker, F. L. 1952
Pearcy, W. G. 1962
Pearcy & Richards 1962
Pearse, A. S. 1929, 1936
Pearson, J. C. 1948
Pfitzenmeyer, H. T. 1961, 1962, 1969
Phleger, F. B., Jr. 1952
Phleger & Walton 1950
Pilsbry, H. A. 1916
Porter, H. J. 1955, 1956
Price, K. S., Jr. 1961, 1962
Prytherch, H. F. 1934
Ragotzkie, R. A. 1959
Reintjes & Pacheco 1966
Rogers, H. M. 1940
Rogers-Talbert, R. 1948
Rucker & Valentine 1961
Russell, H. D. 1941
Ryan, E. P. 1956
Ryther, J. H. 1954
Sanders, Mangelsdorf & Hampson 1965
Say, T. 1817
Scheltema & Truitt 1954, 1956
Schwartz, F. J. 1964
Shaw, W. N. 1966

Shuster, C. N., Jr. 1960
Sieling, F. W. 1971
Sieling, Otto & Rosenfield 1969
Sprague, Dunnington & Drobeck 1969
Stauber, L. A. (Circa 1943)
Stroud, R. H. 1971
Tabb, D. C. 1966
Tagatz, M. E. 1968a,b
Talbot, G. B. 1966
Teal, J. M. 1958, 1962
Te Strake, D. 1959
Timm, R. W. 1952
Truitt, R. V. 1946
Van Engel, W. A. 1958
Vernberg & Vernberg 1970
Wallace, D. H. 1966, 1971
Warburton, F. E. 1958
Wass, M. L. 1963
Wells, H. W. 1957; 1959a,b; 1961
Wells & Gray 1960
Williams, A. B. 1955, 1964
Williams & Deubler 1968
Williams, L. G. 1948
Winslow, F. 1886
Wolfe, D. A. 1971
Woodmansee, R. A. 1958

2. West Indian

Andrews, E. A. 1940
Breder, C. M. 1933, 1934
Brues, C. T. 1917
Goodbody, I. 1961
Goreau, T. F. 1964
Maddox, N. T. 1949
Pilsbry, H. A. 1916
Rahm, Urs. 1964
Randall, J. E. 1958
Vaughn, T. W. 1919

3. Gulf of Mexico

Anderson, J. B. 1968
Anderson, King & Lindner 1949
Anonymous 1931
Archer, A. F. 1947
Arnold & Thompson 1958
Biglane & Lafleur 1967
Breuer, J. P. 1957, 1962
Burbanck, W. D. 1962b
Burkenroad, M. D. 1931
Butler, P. A. 1949, 1953, 1954
Caldwell, D. K. 1955
Carpelan, L. H. 1967
Cary, L. R. 1906a,b; 1907a,b
Chambers & Sparks 1959
Chapman, C. R. 1966, 1971
Chew, F. 1956
Chin, E. 1961
Churchill, E. P., Jr. 1920
Copeland, B. J. 1967
Copeland & Hoese 1966
Cronin, Van Engel, Cargo & Wojcik 1957
Crowell & Darnell 1955
Cuzon du Rest, R. 1963
Danglade, E. 1919
Darnell, R. 1958, 1959, 1962
Daugherty, F. M., Jr. 1952
Davis & Williams 1950
Dawson, C. E. 1955
Delchamps, J. 1896
Engle, J. 1948
Galtsoff, P. S. 1930, 1931, 1954, 1964
Gates, W. 1907
Gillard, R. M. 1969
Glaser, O. C. 1904
Gunter, G. 1937; 1938a,b,c,d; 1942; 1945; 1947a,b; 1950; 1951; 1952; 1953; 1955; 1956; 1957a,b; 1961; 1967
Gunter, Christmas & Killebrew 1964
Gunter & Hildebrand 1954
Gunter & Shell 1958
Gunter, Williams, Davis & Smith 1948
Harper, D. E., Jr. 1968
Hela, I. 1956a,b
Hellier, T. R., Jr. 1962
Henderson, J. C. 1958
Higgins, E. 1931, 1933, 1936, 1937, 1940
Hildebrand, H. H. 1954

Hoese, H. D. 1958; 1959a, b,c; 1960a,b; 1967
Hoese, Copeland, Moseley & Lane 1958
Hopkins, A. E. 1931
Hopkins, S. H. 1956, 1969
Hopkins, T. L. 1963, 1966
Hubbs, C. 1961
Hubby, T. E. 1926
Ingle, R. M. 1950
Ingle & Smith 1949
Ingmanson & Ross 1969
Jaworski, E. 1970
Johnson, L. C. 1891
Johnson, R. B. 1966
Kellogg, J. L. 1905, 1910
Kilby, J. D. 1955
Klesch, W. L. 1970
Kohout & Kolipinski 1967
Kurz & Wagner 1957
Ladd, H. S. 1951
Lane, E. D. 1967
Laubenfenfels, M. W. de 1953
Lindner & Anderson 1956
Little, F. J., Jr. 1963
Mackin, J. G. 1951, 1962
Mackin & Hopkins 1962
Marshall, N. 1954
McHugh, J. L. 1966, 1967
McMillan, C. 1971
McMillan & Moseley 1967
Menzel, R. W. 1954, 1955, 1956
Menzel, R. W., ed. 1971
Menzel, Hulings & Hathaway 1958
Miller & Burbanck 1961
Moody, W. D. 1949
Moore, H. F. 1898
Moore & Pope 1910
More, W. R. 1969
Nichy & Menzel 1962
Odum, H. T. 1953, 1967
Odum & Hoskin 1958
Odum & Wilson 1962
O'Hara, J. A. 1930
O'Heeron, M. K., Jr. 1966
O'Neil, T. 1949
Owen, H. M. 1953
Parker, J. C. 1970
Parker, R. H. 1955, 1959, 1960
Parker & Blanton 1970
Pearse, A. S. 1929, 1932
Pearse & Wharton 1938
Penfound & Hathaway 1938
Pfitzenmeyer & Drobeck 1963
Pierce, E. L. 1962
Pilsbry, H. A. 1916
Post, R. J. 1951
Puffer & Emerson 1953
Rathbun, R. 1895
Ray, S. M. 1965
Reid, G. K. 1955, 1956, 1957
Reid, G. K., Jr. 1954
Reid & Hoese 1958
Reintjes & Pacheco 1966
Renfro, W. C. 1959
Riley, G. A. 1937
Ritter, H. P. 1896
Rounsefell, G. A. 1964
Rounsefell & Dragovich 1966
Rucker & Valentine 1961
Runnegar & Newell 1971
Schroeder, W. C. 1924
Shidler, J. K. 1960a,b
Simmons, E. G. 1957, 1959
Simmons & Breuer 1962
Smith, W. G. 1970
St. Amant, L. S. 1961
Stephens, W. M. 1968
Swift, F. 1897
Tabb, D. 1958, 1966
Thomas, L. P. 1961
U. S. Congress 1947
Viosca, P., Jr. 1937
Ward, Vreeland, Southwick & Reading 1965
Wells, H. W. 1958
Weymouth, Lindner & Anderson 1933
Whatley, E. C. 1969
Wood, E. J. F. 1963
Wright, M. 1943
Wright, Sperry & Huss 1960
Zilberberg, M. H. 1966

4. Pacific

Barlow, J. P. 1958
Barrows, A. L. 1917

Blum, H. F. 1922
Carpelan, L. H. 1964
Chadwick, H. K. 1971
Filice, F. 1954, 1958, 1959
Fox, D. 1936
Frolander, H. 1964
Haertel & Osterberg 1967
Hedgpeth, J. W. 1968
Heubach, W. 1969
Hewatt, W. G. 1937
Hill & Kofoid 1927
Hoese, H. D. 1960
Hopkins, A. E. 1937
Hughes, G. C. 1969
Johnson, M. W. 1939
Johnson, R. G. 1967
Kelley & Turner 1966
Kofoid, Miller, Lazier, Dore, Blum & Van Slyke 1927
MacGinitie, G. E. 1939
Martin, R. C. 1926
McHugh, J. L. 1967
Miller, R. C. 1926
Neily, Kirkbride, Mattos, Squire & Hill 1927
Packard, E. L. 1918
Painter, R. E. 1966
Phillips & Fleenor 1970
Shelford, V. E. 1930
Shelford, Weese, Rice, Rasmussen & Maclean 1935
Smith, R. I. 1953
Tattersall, W. M. 1932
Widdowson, T. B. 1965

5. Arctic

Tash & Armitage 1967

6. Inland

Gillespie, Wirick & Stephens 1971
Hopkins, S. H. 1969
Lackey, J. B. 1938
Rawson, D. S. 1946
Whatley, E. C. 1969

3. South America

1. Caribbean (including Central American Caribbean coast)

Rodriguez, G. 1963

2. Atlantic

Barth & Da Costa 1968

4. Europe

0. All Europe or not specified

Bernstein, L. 1967
Broekhuysen, G. J. 1936
Conrad, W. 1926
Fischer-Piette, E. 1931, 1933

1. North (including northern Russia, Finland, North and Baltic Seas, British Isles)

Alexander, Southgate & Bassindale 1932
Allen & Todd 1903
Baird, R. H. 1966
Barker, D. 1963
Barnes & Barnes 1961
Bassindale, R. 1942; 1943a,b
Battaglia, B. 1967
Bayne, B. L. 1965
Beadle & Cragg 1940
Beanland, F. L. 1940
Becker, G. 1959
Belyaev & Zelikman 1950
Biernacka, I. 1968
Binyon, J. 1961
Boettger, C. R. 1950
Braarud & Føyn 1958
Brady, F. 1943
Brandt, K. 1897
Brattstrom, H. 1941
Brereton, A. J. 1971
Brunberg, L. 1964
Capstick, C. K. 1959
Carriker, M. R. 1959
Carter, N. 1932, 1938
Caspers, H. 1955
Chapman, V. J. 1939, 1940
Chater & Jones 1957
Crawford, G. I. 1937b
Crisp & Southward 1958
Crothers, J. H. 1969
Dales, R. P. 1951
Dekhuyzen, M. C. 1905
Den Hartog, C. 1963
Dybern, B. I. 1969
Ellis, A. E. 1932
Fenchel, T. 1965
Fraser, J. H. 1931, 1932

Gaarder & Sparck 1932
Gee, J. M. 1961
Giere, O. 1968
Gillham, M. 1957
Goodhart, C. B. 1941
Green, J. 1957
Gurney, R. 1923, 1931
Hagerman, L. 1969
Hart, T. 1930
Hartley, P. H. T. 1939
Hartley & Spooner 1938
Havinga, B. 1930
Hempel, C. 1957
Hepper, B. T. 1955
Horst, R. 1919
Hustedt, F. 1939
Hynes, H. B. N. 1954, 1955
Isyban & Shnaidman 1969
Jansson, B. O. R. 1972
Jones, N. S. 1948
Jørgensen, O. 1929
Kessel, H. 1961
Kinne, O. 1955, 1959
Klavestad, N. 1957
Knipovich, N. M. 1938
Kolbe, R. W. 1927
Lafon, Durchon & Saundray 1955
Lambert & Davies 1940
Lemmerman, E. 1898
Lindquist, A. 1959
Lint, G. M. de 1924
Lloyd & Yonge 1947
Marine Biol. Assoc. U. K. 1949
Mastenbroek, N. van 1927
Mathiesen & Nielsen 1956
McLusky, D. S. 1968
Meyer & Mann 1951
Mileikovskii, S. A. 1968
Milne, A. 1940
Moore, H. B. 1935
Morss, W. L. 1927
Muus, B. J. 1963, 1967
Naylor & Haahtela 1966
Naylor, Slinn & Spooner 1960
Newell, R. 1964
Nicol, E. A. T. 1935
Niemi, A. 1971
Nienburg & Kolumbe 1931
Norton & South 1969
Otto, J. P. 1927
Percival, E. 1929
Peterson, G. H. 1958
Peterson, W. 1967
Popham, E. J. 1966
Prost, M. 1959
Pyefinch, K. A. 1950
Ranwell, D. S. 1961
Ranwell, Bird, Hubbard & Stebbings 1964
Redeke, H. C. 1922; 1932a,b; 1939
Reid, D. M. 1930, 1932
Remane, A. 1958
Riemann, F. 1966
Robson, E. A. 1957
Robson, G. C. 1920
Roch, F. 1924
Sarkka, J. 1969
Schauman, K. 1968
Schlieper, C. 1932
Schuurmans Stekhoven, J. G. 1936
Segerstråle, S. G. 1947; 1949; 1951a,b; 1953; 1957
Serventy, D. L. 1935
Sexton & Spooner 1940
Smith, R. I. 1955a,b,c; 1956
Spooner, G. M. 1947
Spooner & Moore 1940
Stammer, H. J. 1928
Stock, J. H. 1952
Stokke, K. 1958
Sutcliffe, D. W. 1967
Tebble, N. 1966
Tesch, F. W. 1968
Trahms, O.-K. 1939
Ursin, E. 1956
Valikangas, I. 1933
Verschaffelt, F. 1929
Verwey, J. 1952
Von Wachenfeldt, T. 1969
Walne, P. R. 1956a,b
Waugh, G. D. 1953
Weyland, H. 1967
Willer, A. 1931
Worsnop & Orton 1923
Worth, R. H. 1903
Zenkevitch, L. 1963
Zernov, S. A. 1949

2. Atlantic (western France, Spain, and Portugal)

Brisou & Doublet 1958
Callamand, O. 1943
Crawford, G. I. 1937a
Dahl, Fr. 1891
Dean, B. 1893
Ferronniere, G. 1901
Fischer, E. 1928

Fischer-Piette, Gaillard & Delmas 1966
Galhano, M. H. 1970
Seoane, J. 1960
Taysi & van Uden 1964
Ulken, A. 1969

3. Mediterranean (including North African coast)

Albertini-Berhaut, J. 1970
Aleem, A. A. 1961
Battaglia, B. 1967
Blanc, Leueau & Stekielda 1969
Caspers, H. 1967
Dietz, G. 1963
Mars, P. 1950
Nival, P. 1969
Parry, G. 1961
Paulus, M. 1942
Pesta, O. 1935
Por, F. D. 1971
Tortonese & Demir 1960
Vatova, A. 1962

4. Black, Caspian, and Aral Seas

Bacesco & Margineanu 1959
Caspers, H. 1957
Cherbonnier, G. 1960
Daribaev, A. K. 1967
D'Iakonov, A. M. 1955
Isyban & Shnaidman 1969
Karpevich, A. F. 1955a,b
Khalebovich, V. 1962
Knipovich, N. M. 1938
Krakatitsa, T. F. 1968
Maksimova, L. P. 1964
Marcus, A. 1970
Nazarov & Chepurnova 1969
Nikitin & Turpaeva 1959
Puzanov, I. I. 1967
Smirnov, A. N. 1969
Teplova, E. P. 1961
Tortonese & Demir 1960
Warme, J. E. 1971
Zalumi, S. G. 1967
Zenkevitch, L. A. 1957, 1963
Zernov, S. A. 1949

5. Africa

1. North (Mediterranean coast)

See Europe (3.5.4.3) and Asia (3.5.6.1)

2. West (Atlantic coast)

Hill, M. B. 1967
Pillay, T. V. R. 1967b
Webb, J. E. 1956, 1958

3. South (South and Southwest Africa)

Broekhuysen, G. J. 1940
Brown, A. C. 1959
Day, J. H. 1951, 1967
Grindley, J. 1964
Macnae, W. 1957a,b

4. East (Indian Ocean coast, Red Sea, Suez and Nile delta)

Bayowmi, A. R. 1969
Nichols, J. T. 1928
Pillay, T. V. M. 1967a
Por, F. D. 1971
Shatoury, H. H. A. 1958
Shaw, J. 1959

6. Asia

0. Continentwide, or not specified

Pillay, T. V. R. 1966b

1. Near East (Asia Minor, Arabian Peninsula, Persian Gulf, Iran)

Gruvel, A. 1934, 1936 (See also 3.5.4.3 and 3.5.5.4)

2. Southern (Pakistan, India, Ceylon, Bangladesh, Burma)

Annandale, N. 1907; 1915a,b; 1922
Balasubrahmanyan, K. 1960
Devanesan & Chacko 1943
Durve & Alagarswami 1964

Dutta, Malhotra & Bose 1954
Muthu, M. S. 1955
Noor-Vodin 1967
Pillay, T. V. R. 1967a
Pillay, Vijayaraghavan & Thakurta 1963
Rajyalakshmi, T. 1961
Zernov, S. A. 1949

3. Southeastern (Cambodia, Vietnam, Malay Peninsula)

Awati & Rai 1931
Burckhardt, G. 1913
Hall, D. N. F. 1962
Hardenberg, J. D. F. 1951
Johnson, D. S. 1965

4. Indonesia (East Indies)

LeRoy, L. W. 1938
Oye, P. Van 1920
Regan, C. T. 1912
Umpgrove, J. H. F. 1928

5. Far East (China, Japan, Korea, Taiwan, Philippine Islands, Eastern Siberia)

Amemiya, I. 1928
Bersamin, S. 1957
Bromhall, J. D. 1954
Burckhardt, G. 1913
Hada, Y. 1936, 1937
Hatai, S. 1930
Herre, A. W. C. T. 1929
Knipovich, N. M. 1938
Morishima, M. 1944
Nagahama, M. 1951
Ono, Y. 1959, 1965
Pillay, T. V. R. 1966b
Sato & Craig 1948
Villadolid & Villaluz 1938
Wakiya, Y. 1929

7. Oceania (Pacific Islands)

1. Papua and Melanesia

Cooper, M. J. 1966
Regan, C. T. 1912

2. Polynesia, Micronesia, Hawaii

Banner, A. H. 1968
Edmondson, C. H. 1928
Shomura & Nakamura 1970
Walsh, G. E. 1967

3. Australia and Tasmania

Anonymous 1945, 1947
Barnes, R. S. K. 1967
Bayly, I. A. E. 1963, 1964, 1965
Clarke & Hannon 1971
Frey, D. G. 1946
Hedley, C. 1925
Hodge, D. 1963
Hodgkin & Rippingale 1971
Kesteven, G. L. 1947
Roughley, T. C. 1922, 1925, 1933
Slack-Smith, R. J. 1960
Snelling, B. 1959
Stead, D. G. 1907
Stephenson, Endean & Bennett 1958
Walker, K. 1969
Wilson, B. R. 1968, 1969
Wood, E. J. F 1948, 1964

4. New Zealand

Bayly, I. A. E. 1967
Cassie, R. M. 1960
Estcourt, I. N. 1967
Fleming, C. A. 1952
Hodge, D. 1964
Lamb, K. P. 1961

8. Antarctica

6. Original research reports, by subjects

1. Mortality (caused by salinity change)

Allen, J. F. 1960
Andrews, Haven & Quayle 1959
Anonymous 1944, 1945, 1946
Banner, A. H. 1968
Beaven, G. F. 1955
Blum, H. F. 1922

Butler, P. A. 1949
Carriker, M. R. 1955
Cary, L. R. 1906, 1907
Cooper, M. J. 1966
Copeland & Hoese 1966
Dawson, C. E. 1955
Durve & Alagarswami 1964
Edmondson, C. H. 1928
Engle, J. 1948
Galtsoff, P. S. 1930, 1931, 1964
Galtsoff & Prytherch 1927
Gates, W. H. 1907
Gillard, R. M. 1969
Glaser, O. 1904
Goodbody, I. 1961
Goreau, T. F. 1964
Gunter, G. 1952, 1953, 1955, 1957, 1967
Hedley, C. 1925
Higgins, E. 1940
Hoese, H. D. 1959a,c; 1960a
Iversen, E. S. 1968
James, M. C. 1946
Kajikawa, Sano & Soguri 1953
Kellogg, J. L. 1905
Kesteven, G. L. 1947
Krakatitsa, T. F. 1968
Laubenfels, M. W. de 1947
Lewis, R. M. 1967
MacGinitie, G. E. 1939
Mackin, J. G. 1962
Mackin & Hopkins 1962
Mansueti, R. J. 1961
Moore, H. F. 1899
Norton, O. A. 1947
Oemler, A. 1894
Owen, H. M. 1953
Pyefinch, K. A. 1950
Randall, J. E. 1958
Rathbun, R. 1895
Ritter, H. P. 1896
Schroeder, W. C. 1924
Shaw, W. N. 1966
Slack-Smith, R. J. 1960
Smith, W. G. 1970
Stauber, L. A. (Circa 1943)
Stead, D. G. 1907
Stephenson, Endean & Bennett 1958
Truitt, R. V. 1946
Villadolid & Villaluz 1938
Viosca, P., Jr. 1937
Warme, J. E. 1971
Waugh, G. D. 1953
Webb, J. E. 1958
Wells, H. W. 1959a,b

2. Distribution (limited by salinity)

Adams, D. A. 1963
Albertini-Berhaut, J. 1970
Alexander, Southgate & Bassindale 1932
Allen & Todd 1903
Amos, W. H. 1957
Anderson, J. B. 1968
Anderson, King & Linder 1949
Annandale, N. 1907; 1915a; 1922
Bacesco & Margineanu 1959
Barans, C. A. 1972
Barlow, J. P. 1955
Barnes, R. S. K. 1967
Barrows, A. L. 1917
Barth & Da Costa 1968
Bary, B. M. 1963, 1964
Balasubrahmanyan, K. 1960
Bassindale, R. 1942; 1943a,b
Batchelder, C. H. 1926
Battaglia, B. 1967
Bayly, I. A. E. 1963, 1964
Bayowmi, A. R. 1969
Beach, N. W. 1969
Beadle & Cragg 1940
Beanland, F. L. 1940
Becker, G. 1959
Belyaev & Zelikman 1950
Bernstein, L. 1967
Biernacka, I. 1968
Biglane & Lafleur
Binyon, J. 1961
Blum, H. F. 1922
Boettger, C. R. 1950
Bookhout & Costlow 1959
Borut & Johnson 1962
Bourdeau & Adams 1956
Bousfield, E. L. 1955
Bowman, H. H. M. 1956
Bowman, T. E. 1964
Brady, F. 1943
Brandt, K. 1897
Brattstrom, H. 1954
Breder, C. M. 1933, 1934
Brereton, A. J. 1971
Breuer, J. P. 1957, 1962
Brisou & Doublet 1958
Broekhuysen, G. J. 1936, 1940
Brown, A. C. 1959
Brunberg, L. 1964
Burbanck, W. D. 1959, 1962, 1967
Burckhardt, G. 1913
Burkenroad, M. D. 1931
Butler, P. A. 1954

Caldwell, D. K. 1955
Capstick, C. K. 1959
Carpelan, L. H. 1964, 1967
Carriker, M. R. 1951, 1967
Carter, N. 1932
Cary, L. R. 1907
Caspers, H. 1955, 1967
Cassie, R. M. 1960
Castagna & Chanley 1966
Chambers & Sparks 1959
Chapman, C. R. 1971
Chapman, V. J. 1939
Cherbonnier, G. 1960
Chin, E. 1961
Chitwood, B. G. 1951
Churchill, E. P. 1919
Clarke & Hannon 1971
Cones & Haven 1969
Conger, P. S. 1953
Conover, J. T. 1958
Conrad, W. 1926
Cowles, R. P. 1930
Crawford, G. I. 1937a,b
Crisp & Southward 1958
Croker, R. A. 1968
Cronin, Daiber & Hulbert 1962
Crothers, J. H. 1969
Crowell & Darnell 1955
Cuzon du Rest, R. 1963
Dahl, Fr. 1891
Dales, R. P. 1951
Darnell, R. M. 1959, 1962
Daugherty, F. M., Jr. 1952
Day, J. H. 1967
Dekhuyzen, M. C. 1905
Den Hartog, C. 1963
D'Iakonov, A. M. 1955
Dietz, G. 1963
Dovel, Mihursky & McErlean 1969
Dunnington, E. A. 1956
Dunson & Ehlert 1972
Dutta, Malhotra & Bose 1954
Dybern, B. 1967, 1969
Elliott, Myers & Tressler 1955
Elliott, Ellison & Nichols 1966
Ellis, A. 1932
Estcourt, I. N. 1967
Fassett, N. C. 1928
Ferronniere, G. 1901
Filice, F. 1954, 1958, 1959
Fischer, E. 1928
Fischer-Piette, E. 1931, 1933
Fischer-Piette, Gaillard & Delmas 1966
Fleming, C. A. 1952
Fox, D. 1936
Fraser, J. 1932
Frey, D. G. 1946
Frolander, H. 1964
Galhano, M. H. 1970
Galtsoff, P. S. 1954
Gee, J. M. 1961
Gillespie, Wirick & Stephens 1971
Gillham, M. 1957
Goodhart, C. B. 1941
Goodwyn, F. 1968
Gosner, K. L. 1971
Gunter, G. 1937; 1938; 1942; 1945; 1947a,b,c,d; 1950; 1951; 1956a; 1961a,b; 1967a,b
Gunter, Christmas & Killebrew 1964
Gunter & Hall 1963
Gunter & Shell 1958
Gurney, R. 1923, 1931
Hada, Y. 1936, 1937
Haefner, P. A., Jr. 1967
Hagerman, L. 1969
Hall, D. N. F. 1962
Hanks, R. 1964
Hardenberg, J. D. F. 1951
Harper, D. E., Jr. 1968
Harshberger, J. W. 1909, 1911
Hart, T. 1930
Hartley & Spooner 1938
Hatai, S. 1930
Haven, D. 1957, 1961
Havinga, B. 1930
Hedgpeth, J. W. 1968
Heinle, D. R. 1972
Hela, I. 1956a,b
Hempel, C. 1957
Henderson, J. C. 1958
Henry, D. P. 1959
Herman, S. S. 1968
Herre, A. W. C. T. 1929
Heubach, W. 1969
Hewatt, W. G. 1937
Hildebrand, H. H. 1954
Hill, M. B. 1967
Hodge, D. 1963, 1964
Hoese, H. D. 1958; 1959a,b,c; 1960a,b; 1967
Hoese, Copeland, Moseley & Lane 1968
Holthuis, L. B. 1952
Hopkins, S. H. 1956a,b; 1962, 1967

Hopkins, T. L. 1958, 1963, 1966
Horst, R. 1919
Hubby, T. E. 1926
Hughes, G. C. 1961, 1969
Hulburt, E. M. 1957
Huntsman, A. G. 1918
Hustedt, F. 1939
Hynes, H. B. N. 1955
Ingmanson & Ross 1969
Jackson, C. R. 1952
Jeffries, H. P. 1960; 1962a,b
Johnson, D. S. 1965
Johnson, L. C. 1891
Johnson, M. W. 1939
Johnson, R. B. 1966
Jones, N. S. 1948
Jones & Burbanck 1959
Jørgensen, O. 1929
Karpevich, D. F. 1955a,b
Kawamura, T. 1966
Kelley & Turner 1966
Kerwin, J. A. 1971
Kerwin & Pedigo 1971
Kessel, H. 1961
Keup & Bayless 1964
Khalebovich, V. 1962
Kilby, J. D. 1955
Kinne, O. 1955, 1959, 1964
Klavestad, N. 1957
Knight, L. 1965
Kofoid, Miller, Lazier, Dore, Blum & Van Slyke 1927
Kohout & Kolipinski 1967
Kolbe, R. W. 1927
Korringa, P. 1957
Kurz & Wagner 1957
Lackey, J. B. 1938, 1967
Ladd, H. S. 1951
Lamb, K. P. 1961
Lane, E. D. 1967
Laubenfels, M. W. de 1947, 1949, 1953
LeRoy, L. W. 1938
Lewis, R. M. 1967
Lindner & Anderson 1956
Lindquist, A. 1959
Lloyd & Yonge 1947
Lucas, J. S. 1971
Lunz, G. R. 1958
Macnae, W. 1957
Manning & Whaley 1955
Mansueti, R. J. 1961
Marcus, A. 1970
Marine Biol. Assoc. of U. K. 1949
Mars, P. 1950
Marshall, N. 1954
Marshall & Wheeler 1965
Martin, R. C. 1926
Massmann, W. H. 1971
Mastenbroek, N. van 1927
Mathiesen & Nielsen 1956
Maturo, F. J. S., Jr. 1959
McErlean, A. J. 1964
McLusky, D. S. 1968
McMillan, C. 1971
McMillan & Moseley 1967
Menzel, R. W. 1956
Menzies & Frankenbury 1966
Miller, D. N., Jr. 1953
Miller & Burbanck 1961
Miller, R. C. 1926
Milne, A. 1940
Moody, W. D. 1949
Moore, H. B. 1935
Moore, H. F. 1899, 1911
Morishima, M. 1944
Morss, W. L. 1927
Mulford, R. A. 1963
Muus, B. J. 1963, 1967
Nagahama, M. 1951
Nash, C. B. 1947
Naylor & Haahtela 1966
Naylor, Slinn & Spooner 1960
Nazarov & Chepurnova 1969
Neily, Kirkbride, Mattos, Squire & Hill 1927
Newcombe, C. L. 1935
Newell, R. 1964
Nichols, J. T. 1968
Nichy & Menzel 1962
Nicol, E. A. T. 1935
Niemi, A. 1971
Nienburg & Kolumbe 1931
Nikitin & Turpaeva 1959
Nival, P. 1969
Norcross, Massmann & Joseph 1961
Norton, O. A. 1947
Norton & South 1969
Odum, H. T. 1967
O'Heeron, M. K., Jr. 1966
O'Neil, T. 1949
Ono, Y. 1959, 1965
Otto, J. P. 1927
Oye, P. Van 1920
Packard, E. L. 1918
Painter, R. E. 1966
Panikkar, N. K. 1951
Parker, F. L. 1952
Parker, J. C. 1970
Parker, R. H. 1955, 1956, 1959, 1960
Parker & Blanton 1970
Parry, G. 1961
Patrick, R. 1967

Paulus, M. 1942
Pearcy, W. G. 1962
Pearcy & Richards 1962
Pearse, A. S. 1929a,b; 1932a; 1936
Penfound & Hathaway 1938
Percival, E. 1929
Pesta, O. 1935
Peterson, G. H. 1958
Peterson, W. 1967
Pfitzenmeyer, H. T. 1961
Pfitzenmeyer & Drobeck 1963
Phleger, F. B., Jr. 1952
Phleger & Walton 1950
Pierce, E. L. 1962
Pillay, T. V. R. 1967a,b
Pillay, Vijayaraghavan & Thakurta 1963
Pilsbry, H. A. 1916
Popham, E. J. 1966
Por, F. D. 1971
Post, R. J. 1951
Price, K. S. 1961
Prost, M. 1959
Prytherch, H. F. 1934
Puffer & Emerson 1953
Puzanov, I. I. 1967
Pyefinch, K. A. 1950
Ranwell, Bird, Hubbard & Stebbings 1964
Redeke, H. C. 1922, 1932, 1939
Reid, D. M. 1930, 1932
Reid, G. K., Jr. 1954, 1957
Renfro, W. C. 1959
Riech, Fr. 1926
Riemann, F. 1966
Ristanovic & Miller 1969
Ritchie, D. 1960
Robson, E. A. 1957
Robson, G. C. 1920
Roch, F. 1924
Rodriguez, G. 1963
Rogers, H. M. 1940
Rogers-Talbert, R. 1948
Rounsefell, G. A. 1964
Rounsefell & Dragovich 1966
Rucker & Valentine 1961
Runnegar & Newell 1971
Russell, H. D. 1941
Ryan, E. P. 1956
Sacchi, C. F. 1961
Sanders, Mangelsdorf & Hampson 1965
Sandison & Hill 1966
Sarkka, J. 1969
Schauman, K. 1968
Scheltema & Truitt 1954, 1956
Schodduyn, R. 1931
Schroeder, W. C. 1924
Schuurmans Stekhoven, J. R., Jr. 1936
Schwartz, F. J. 1964
Segal, E. 1967
Segerstråle, S. G. 1947; 1949; 1951a,b; 1953; 1957
Serventy, D. L. 1935
Sexton & Spooner 1940
Shaw, J. 1959
Shelford, V. E. 1930
Shelford, Weese, Rice, Rasmussen & Maclean 1935
Shidler, J. K. 1960a,b
Simmons, E. G. 1957, 1959
Simmons & Breuer 1962
Smith, R. I. 1953; 1955a,b,c; 1956
Snelling, B. 1959
Spooner, G. M. 1947
Spooner & Moore 1940
Stammer, H. J. 1928
Stauber, L. A. (Circa 1943)
Stock, J. H. 1952
Sutcliffe, D. W. 1967
Swift, F. 1897
Tabb, D. C. 1966
Teal, J. M. 1958
Tebble, N. 1966
Te Strake, D. 1959
Thomas, L. P. 1961
Timm, R. W. 1952
Trahms, O.-K. 1939
Umpgrove, J. H. F. 1928
Ulken, A. 1969
Ursin, E. 1956
Valikangas, I. 1926, 1933
Van Engel, W. A. 1958
Van Uden, N. 1967
Van Wachenfeldt, T. 1969
Vatova, A. 1962
Vaughn, T. W. 1919
Venkateswarlu, T. 1967
Vernberg & Vernberg 1970
Verschaffelt, F. 1929
Verwey, J. 1952
Wakiya, Y. 1929
Walker, K. 1969
Wallace, D. H. 1966
Walne, P. R. 1956b
Walsh, G. E. 1967
Wass, M. L. 1963
Webb, J. E. 1956
Wells & Gray 1960
Wells, H. W. 1957, 1959, 1961

Weyland, H. 1967
Widdowson, T. B. 1965
Wilce, Webber & Sears 1970
Willer, A. 1931
Williams, A. B. 1955, 1964
Williams & Deubler 1968
Williams, L. G. 1948
Wilson, B. R. 1968, 1969
Winslow, F. 1886
Wood, C. E. 1967
Wood, E. J. F. 1963, 1964
Woodmansee, R. A. 1958
Worth, R. H. 1903
Wright, M. 1943
Wright, Sperry & Huss 1960
Zalumi, S. G. 1967
Zenkevitch, L. A. 1957, 1963
Zilberberg, M. H. 1966

3. Penetration into inland waters

Annandale, N. 1922
Bayly, I. A. E. 1967
Brues, C. T. 1917
Burckhardt, G. 1913
Churchill, E. P. 1919
Gunter, G. 1938a,b; 1942; 1947a,b; 1956
Hopkins, S. H. 1969
Hubbs, C. 1961
Hynes, H. B. N. 1954
Johnson, D. S. 1965
Massmann, W. H. 1954
Naylor, Slinn & Spooner, 1960
Needham, J. 1930
Newell, R. 1964
Odum, H. T. 1953
Otto, J. P. 1927
Riggs, C. D. 1957
Say, T. 1817
Schlieper, C. 1928
Stammer, H. J. 1928
Whatley, E. C. 1969

4. Species diversity (related to salinity)

Blanc, Leueau & Stekielda 1969
Braarud & Føyn 1958
Brandt, K. 1897
Breuer, J. P. 1957, 1962
Brunberg, L. 1964
Carriker, M. R. 1967
Caspers, H. 1967
Chambers & Sparks 1959
Chapman, C. R. 1971
Chapman, V. J. 1940
Chitwood, B. G. 1951
Conger, P. S. 1953
Copeland, B. J. 1967
Darnell, R. 1962
Fassett, N. C. 1928
Filice, F. 1958, 1959
Fleming, C. A. 1952
Frey, D. G. 1946
Galhano, M. H. 1970
Galtsoff, P. S. 1954
Giere, O. 1968
Gillard, R. M. 1969
Gillespie, Wirick & Stephens 1971
Gunter, G. 1938a,b; 1945; 1952; 1961a,b; 1967a
Haertel & Osterberg 1967
Hanks, R. 1964
Hardenberg, J. D. F. 1951
Harshberger, J. W. 1909
Hellier, T. R., Jr. 1962
Hewatt, W. G. 1937
Hoese, H. D. 1958, 1959, 1960
Hoese, Copeland, Moseley & Lane 1968
Hopkins, S. H. 1967
Hopkins, T. L. 1966
Hulburt, E. M. 1963
Hulburt & Rodman 1963
Ingmanson & Ross 1969
Isyban & Shnaidman 1969
Jansson, B. O. R. 1972
Johnson, D. S. 1965
Keup & Bayless 1964
Khalebovich, V. V. 1962
Kilby, J. D. 1955
Klavestad, N. 1957
Kurz & Wagner 1957
Lackey, J. B. 1938
Lafon, Durchon & Saundray 1955
Laubenfels, M. W. de 1953
Marcus, A. 1970
Marshall & Wheeler 1965
Matthiessen, G. C. 1960
McKenzie, R. A. 1959
Menzel, R. W. 1956
Milne, A. 1940
Moody, W. D. 1949
Mulligan, H. F. 1972
Nash, C. B. 1947
Newcombe, C. L. 1935
Nicol, E. A. T. 1935
Nienburg & Kolumbe 1931
Nikitin & Turpaeva 1959
Nival, P. 1969
O'Neil, T. 1949
Parker, R. H. 1955, 1956, 1960

Parker & Blanton 1970
Patrick, R. 1967
Pearcy & Richards 1962
Pearse, A. S. 1932
Penfound & Hathaway 1938
Pfitzenmeyer, H. T. 1961, 1969
Pillay, T. V. R. 1967a,b
Prost, M. 1959
Puffer & Emerson 1953
Ranwell, Bird, Hubbard & Stebbings 1964
Redeke, H. C. 1939
Reid, G. K., Jr. 1954, 1955, 1956, 1957
Riech, Fr. 1926
Riley, G. A. 1967
Ristanovic & Miller 1969
Rodriguez, G. 1963
Runnegar & Newell 1971
Sacchi, C. F. 1961
Sarkka, J. 1969
Segerstråle, S. G. 1949; 1951a,b; 1953
Seoane, J. 1960
Shelford, V. E. 1930
Shelford, Weese, Rice, Rasmussen & Maclean 1935
Shidler, J. K. 1960
Shomura & Nakamura 1970
Simmons, E. G. 1957, 1959
Spooner & Moore 1940
Stammer, H. J. 1928
Tabb & Manning 1961
Ulken, A. 1969
Umpgrove, J. H. F. 1928
Valikangas, I. 1926
Van Uden, N. 1967
Vatova, A. 1962
Von Wachenfeldt, T. 1969
Walsh, G. E. 1967
Wells, H. W. 1959a,b; 1960
Widdowson, T. B. 1965
Willer, A. 1931
Williams & Deubler 1968
Williams, L. G. 1948
Wood, E. J. F. 1963, 1964
Worth, R. H. 1903
Wright, M. 1943
Wright, Sperry & Huss 1960
Zalumi, S. G. 1967
Zenkevitch, L. A. 1957, 1963
Zilberberg, M. H. 1966

5. Competition of related species (as affected by salinity)

Chater & Jones 1957
Conover, R. J. 1956
Hynes, H. B. N. 1955
Jeffries, H. P. 1962b,c; 1967
Lambert & Davies 1940
Lucas, J. S. 1971
Morss, W. L. 1927
O'Neil, T. 1949
Ranwell, D. S. 1961
Riley, G. A. 1967
Teal, J. M. 1962

6. Movements, migration, locomotion

Anderson, King & Lindner 1949
Callamand, O. 1943
Carriker, M. R. 1955
Churchill, E. P. 1919
Darnell, R. M. 1959, 1962
Dovel, Mihursky & McErlean 1969
Grindley, J. 1964
Gruvel, A. 1934, 1936
Gunter, G. 1938
Hartley, P. H. T. 1939
Haven, D. 1957
Hoese, Copeland, Moseley & Lane 1968
Hopkins, S. H. 1969
Hopkins, T. L. 1963
Jeffries, H. P. 1960
Kelley & Turner 1966
Kinne, O. 1964
Lindner & Anderson 1956
Lloyd & Yonge 1947
Mansueti, R. J. 1961
McHugh, J. L. 1966
McKenzie, R. A. 1959
Moody, W. D. 1949
Nelson, T. C. 1928
Pearse, A. S. 1929
Reid & Hoese 1958
Renfro, W. C. 1959
Simmons & Breuer 1962
Stauber, L. A. (Circa 1943)
Tabb, D. C. 1966
Tagatz, M. E. 1968a
Van Engel, W. A. 1958
Webb, J. E. 1956
Weymouth, Lindner & Anderson 1933
Williams, A. B. 1955

7. Abundance, population density, or biomass

Albertini-Berhaut, J. 1970

Andrews, E. A. 1940
Barlow, J. P. 1958
Barlow, Lorenzen & Myren 1963
Beanland, F. L. 1940
Bersamin, S. 1957
Blanc, Leueau & Stekielda 1969
Braarud & Føyn 1958
Brady, F. 1943
Breuer, J. P. 1962
Burkholder, P. R. 1933
Butler, P. A. 1954
Carpelan, L. H. 1967
Carriker, M. R. 1967
Cary, L. R. 1906
Caspers, H. 1955, 1967
Chapman, C. R. 1971
Chin, E. 1961
Croker, R. A. 1968
Cronin, Daiber & Hulbert 1962
Cuzon du Rest, R. 1963
Daribaev, A. K. 1967
Dean, B. 1893
Dutta, Malhotra & Bose 1954
Filice, F. P. 1954, 1959
Frey, D. G. 1946
Galhano, M. H. 1970
Giere, O. 1968
Green, J. 1957
Gunter, G. 1938, 1945, 1947, 1952, 1967
Gunter & Hildebrand 1954
Haertel & Osterberg 1967
Hela, I. 1956a,b
Hellier, T. R., Jr. 1962
Heubach, W. 1969
Hewatt, W. G. 1937
Hildebrand, H. H. 1954
Hoese, H. D. 1967
Hopkins, S. H. 1967
Hopkins, T. L. 1963, 1966
Ingmanson & Ross 1969
Isyban & Shnaidman 1969
Jeffries, H. P. 1962
Keup & Bayless 1964
Klesch, W. L. 1970
Kohout & Kolipinski 1967
Kuenzler, E. J. 1961
Lindquist, A. 1959
Lunz, G. R. 1958
McErlean, A. J. 1964
McLusky, D. S. 1968
Milne, A. 1940
Muthu, M. S. 1955
Odum, H. T. 1967
Packard, E. L. 1918
Parker, J. C. 1970
Patrick, R. 1967
Pearcy, W. G. 1962
Pearson, J. C. 1948
Pfitzenmeyer, H. T. 1969
Pfitzenmeyer & Drobeck 1963
Phillips & Fleenor 1970
Rahn, U. 1964
Reintjes & Pacheco 1966
Riley, G. A. 1937
Roughley, T. C. 1925
Rounsefell, G. A. 1964
Rounsefell & Dragovich 1966
Ryther, J. H. 1954
Sarkka, J. 1969
Scheltema & Truitt 1956
Schroeder, W. C. 1924
Schuurmans Stekhoven, J. G., Jr. 1936
Segerstråle, S. G. 1949
Shomura & Nakamura 1970
Simmons & Breuer 1962
Smith, R. I. 1956
St. Amant, L. S. 1961
Stephenson, Endean & Bennett 1958
Swift, F. 1897
Taysi & Van Uden 1964
Timm, R. W. 1952
Van Uden, N. 1967
Vatova, A. 1962
Wells, H. W. 1957
Winslow, F. 1886
Woodmansee, R. A. 1958

8. Productivity or annual yield

Butler, P. A. 1949
Carriker, M. R. 1959
d'Ancona, U. 1954
Galtsoff, P. S. 1954
Gunter, G. 1956, 1967
Gunter & Hildebrand 1954
Hellier, T. R. 1962
Hickling, C. F. 1970
Ingle, R. M. 1962
Ingle & Smith 1949
Iversen, E. S. 1968
Jaworski, E. 1970
Kellogg, J. L. 1910
Korringa, P. 1967
Kuenzler, E. J. 1961
McHugh, J. L. 1966, 1967
More, W. R. 1969
Odum, H. T. 1967
Odum & Hoskin 1958
Odum & Wilson 1962
Pillay, Vijayaraghavan & Thakurta 1963
Ragotzkie, R. A. 1959
Schmidt, R. A. 1966

Simmons, E. G. 1959
Stephens, W. M. 1968
Stroud, R. H. 1971
Teal, J. M. 1962
Thomson, S. H. 1961
Wallace, D. H. 1971
Ward, Vreeland, Southwick & Reading 1965

9. Growth of individuals

Adams, D. A. 1963
Andrews, E. A. 1940
Baird, R. H. 1966
Barans, C. A. 1972
Barnes & Barnes 1961
Bayne, B. L. 1965
Boettger, C. R. 1950
Borut & Johnson 1962
Butler, P. A. 1954
Caldwell, D. K. 1955
Carpelan, L. H. 1964
Carriker, M. R. 1955
Conover, J. T. 1958
Copeland & Hoese 1966
Dawson, C. E. 1955
Dovel, Mihursky & McErlean 1969
Federighi, H. 1930, 1931
Fraser, J. H. 1931
Gaarder & Sparck 1932
Gibb, D. C. 1957
Gillard, R. M. 1969
Green, J. 1957
Gunter, G. 1947a,b; 1957; 1961
Harshberger, J. W. 1911
Haven, D. 1957
Krakatitsa, T. F. 1968
Lindner & Anderson 1956
Little, F. J., Jr. 1963
Maddox, N. T. 1949
Menzel, R. W. 1954, 1955
Owen, H. M. 1953
Paulus, M. 1942
Pearcy, W. G. 1962
Peterson, G. H. 1958
Porter, H. J. 1955, 1956
Price, K. S., Jr. 1962
Reid & Hoese 1958
Roch, F. 1924
Shaw, W. N. 1966
Tagatz, M. E. 1968b
Trahms, O.-K. 1939
Ursin, E. 1956
Van Engel, W. A. 1958
Verwey, J. 1952
Walne, P. R. 1956a,b
Weymouth, Lindner & Anderson 1933
Williams, A. B. 1955

10. Feeding (rate affected by salinity, etc.)

BroLarsen, E. 1951
Carriker, M. R. 1955
Darnell, R. M. 1958
Haskin, H. H. 1936
Menzel, R. W. 1954, 1955
Moody, W. D. 1949
Moore, H. F. 1898
Muncy, R. J. 1962
Peterson, W. 1967
Price, K. S., Jr. 1962
Reid, G. K., Jr. 1954
Williams, A. B. 1955
Wolfe, D. A. 1971

11. Parasites and diseases (increased or decreased by salinity differences)

Andrews, J. D. 1964
Beudant, F. S. 1816
Burton, R. W. 1963
Butler, P. A. 1954
Choe, S. 1966
Dunnington, E. A. 1956
Fenchel, T. 1965
Hepper, B. T. 1955
Higgins, E. 1940
Iversen, E. S. 1968
Mackin, J. G. 1951, 1962
Meyer & Mann 1951
Ray, S. M. 1965
Rogers-Talbert, R. 1948
Shaw, W. N. 1966
Shuster, C. N., Jr. 1960
Sieling, F. W. 1971
Sieling, Otto & Rosenfield 1969
Sprague, Dunnington & Drobeck 1969
St. Amant, L. S. 1961
Tesch, F. W. 1968

12. Enemies of desirable species (pests, predators, etc., as affected by salinity)

Anonymous 1931
Butler, P. A. 1953, 1954
Cary, L. R. 1907
Chew, F. 1956
Danglade, E. 1919
Delchamps, J. 1896
Engle, J. 1948
Galtsoff, P. S. 1964

Galtsoff, Chipman, Engle & Calderwood 1947
Galtsoff & Prytherch 1927
Gunter, G. 1953
Gunter, Williams, Davis & Smith 1948
Haskin, Krueger & Tweed 1971
Hela, I. 1956
Higgins, E. 1933, 1936, 1937
Hill & Kofoid 1927
Ingle, R. M. 1962
Ingle & Smith 1949
Iversen, E. S. 1968
Kellogg, J. L. 1910
Loosanoff & Engle 1943
Marshall, N. 1954
Maturo, F. J. S., Jr. 1959
Menzel, Hulings & Hathaway 1958
Moore, H. F. 1898, 1899, 1911
Moore & Pope 1910
Neily, Kirkbride, Mattos, Squire & Hill 1927
Nelson, T. C. 1923, 1928
Newcombe, C. L. 1935
Nichy & Menzel 1962
Pearse & Wharton 1938
Prost, M. 1959
Ritter, H. P. 1896
Roughley, T. C. 1922, 1925
St. Amant, L. S. 1961
Stead, D. 1907
Villadolid & Villaluz 1938
Viosca, P., Jr. 1937
Warburton, F. E. 1958
Wells, H. W. 1958
Wells & Gray 1960
Wood, E. J. F. 1948

13. Quality, especially commercial quality of economic species

Anonymous 1944
Atwater, W. O. 1888
Butler, P. A. 1954
Dean, B. 1893
Dees, Mrs. 1949
Gaarder & Sparck 1932
Galtsoff, Chipman, Engle & Calderwood 1947
Galtsoff, Chipman, Hasler & Engle 1938
Galtsoff & Prytherch 1927
Gunter, G. 1942
Hubby, T. E. 1926
Ingle, R. M. 1950
Kellogg, J. L. 1910
Medcof, J. C. 1944, 1961
Medcof & Needler 1941
Moore, H. F. 1911
O'Hara, J. A. 1930
Worsnop & Orton 1923

14. Reproduction affected by salinity

Adams, D. A. 1963
Aleem, A. A. 1961
Anderson, King & Lindner 1949
Arnold & Thompson 1958
Barlow, J. 1955
Borut & Johnson 1962
Bromhall, J. D. 1954
Butler, P. A. 1949b; 1954
Caldwell, D. K. 1955
Carriker, M. R. 1955
Chadwick, H. K. 1971
Churchill, E. P. 1919
Daugherty, F. M., Jr. 1952
Dovel, Mihursky & McErlean 1969
Gunter, G. 1937
Haskin, H. H. 1936, 1938
Hopkins, A. E. 1931, 1937
Hopkins, T. L. 1958
Jeffries, H. P. 1962
Kinne, O. 1959, 1964
Kellogg, J. L. 1910
Lindner & Anderson 1956
Lunz, G. R., Jr. 1938
Maksimova, L. P. 1964
Mansueti, R. J. 1961, 1962, 1964
Menzel, R. W. 1954, 1955
Mileikovskii, S. A. 1968
Moody, W. D. 1949
Moore, H. F. 1899
Muncy, R. J. 1962
Newcombe, C. L. 1945
Noor-Vodin 1967
Peterson, W. 1967
Pfitzenmeyer, H. T. 1962
Price, K. S., Jr. 1962
Rajyalakshmi, T. 1961
Ranwell, Bird, Hubbard & Stebbings 1964
Rawson, D. S. 1946
Reid, G. K., Jr. 1954
Rogers-Talbert, R. 1948
Roughley, T. C. 1933
Smirnov, A. N. 1969

Van Engel, W. A. 1958
Von Wachenfeldt, T. 1969
Walne, P. R. 1956b
Weymouth, Lindner & Anderson 1933
Williams, A. B. 1955
Wilson, B. R. 1969
Wood, C. E. 1967

15. Survival and growth of young

Amemiya, I. 1928
Anderson, King & Lindner 1949
Anonymous 1945
Broekhuysen, G. J. 1936
Butler, P. A. 1949, 1954
Carriker, M. R. 1955
Chadwick, H. K. 1971
Churchill, E. P. 1919
Devanesan & Chacko 1943
Gunter, G. 1957
Haskin, H. H. 1936, 1938
Higgins, E. 1931, 1940
Hill, M. B. 1967
Hopkins, A. E. 1931, 1937
Kellogg, J. L. 1910
Kutkuhn, J. H. 1966
Lewis, R. M. 1967
Lucas, J. S. 1971
Maddox, N. T. 1949
Maksimova, L. P. 1964
Manning & Whaley 1955
Mansueti, R. J. 1962, 1964
Menzel, R. W. 1954
Muncy, R. J. 1962
Nelson, T. C. 1921
Newcombe, C. L. 1945
Norcross, Massmann & Joseph 1961
Pearcy, W. G. 1962
Pearson, J. C. 1948
Peterson, W. 1967
Pfitzenmeyer, H. T. 1962
Prytherch, H. F. 1934
Rawson, D. S. 1946
Reintjes & Pacheco 1966
Robertson, J. D. 1949
Rogers-Talbert, R. 1948
Roughley, T. C. 1933
Sato & Craig 1948
Scheltema & Truitt 1954
Smirnov, A. N. 1969
Stauber, L. A. (Circa 1943)
Talbot, G. B. 1966
Teplova, E. P. 1961
Van Engel, W. A. 1958
Webb, J. E. 1956
Weymouth, Lindner & Anderson 1933
Williams, A. B. 1955
Williams & Deubler 1968

7. Research reports, by types of water bodies studied

1. Fresh waters

Bayly, I. A. E. 1967
Brues, C. T. 1917
Burbanck, W. D. 1967
Burckhardt, G. 1913
Den Hartog, C. 1963
Devanesan & Chacko 1943
Gunter, G. 1942; 1947a,b; 1956a,b; 1957; 1967
Hopkins, S. H. 1969
Johnson, D. S. 1965
Lackey, J. B. 1938
Needham, J. 1930
Nichols, J. T. 1928
Odum, H. T. 1953
Otto, J. P. 1927
Parry, G. 1961
Redeke, H. C. 1922
Reid, G. K. 1961
Russell, H. D. 1941
Shatoury, H. H. A. 1958
Shaw, J. 1959
Sutcliffe, D. W. 1967
Verschaffelt, F. 1929
Whatley, E. C. 1969

2. Rivers running into sea

Annandale, N. 1922
Beadle & Cragg 1940
Blanc, Leueau & Stekielda 1969
Bousfield, E. L. 1955
Bromhall, J. D. 1954
Brues, C. T. 1917
Callamand, O. 1943
Cary, L. R. 1906
Darnell, R. M. 1962
Dutta, Malhotra & Bose 1954
Ferronniere, G. 1901
Fischer-Piette, Gaillard & Delmas 1966
Glaser, O. 1904
Gunter, G. 1937; 1938a,b,c; 1947a,b,c; 1956a,b,c; 1957a,b
Haven, D. 1961
Hopkins, S. H. 1969
Hubbs, C. 1961
Hynes, H. B. N. 1954, 1955

Johnson, L. C. 1891
Jones, N. S. 1948
Keup & Bayless 1964
Lint, G. M. de 1924
Massmann, W. H. 1954
Myers, G. S. 1938
Needham, J. 1930
Nichols, J. T. 1928
Odum, H. T. 1953
Paulus, M. 1942
Post, R. J. 1951
Rajyalakshmi, T. 1961
Redeke, H. C. 1922, 1932
Reid, G. K. 1961
Riggs, C. D. 1957
Ristanovic & Miller 1969
Say, T. 1817
Stammer, H. J. 1928
Tagatz, M. E. 1968a,b
Talbot, G. B. 1966
Teplova, E. P. 1961
Walker, K. 1969

3. Positive estuaries (bays with rivers, more outflow than inflow)

Alexander, Southgate & Bassindale 1932
Allen, J. F. 1960
Amemiya, I. 1928
Amos, W. H. 1957
Anderson, King & Lindner 1949
Anonymous 1931, 1944, 1945
Archer, A. F. 1947
Atwater, W. O. 1888
Bacesco & Margineanu 1959
Baird, R. H. 1966
Balasubrahmanyan, K. 1960
Barans, C. A. 1972
Barker, D. 1963
Barlow, Lorenzen & Myren 1963
Barnes & Barnes 1961
Barnes, R. S. K. 1967
Barrows, A. L. 1917
Barth & Da Costa 1968
Bassindale, R. 1942; 1943a,b
Battaglia, B. 1967
Bayly, I. A. E. 1963, 1965
Bayne, B. L. 1965
Beach, N. W. 1969
Beaven, G. F. 1955
Becker, G. 1959
Biernacka, I. 1968
Biglane & Lafleur 1967
Binyon, J. 1961
Blum, H. 1922
Bookhout & Costlow 1959
Borut & Johnson 1962
Bowman, T. E. 1964
Braarud & Føyn 1958
Brady, F. 1943
Brandt, K. 1897
Brattstrom, H. 1941, 1954
Brisou & Doublet 1958
Broekhuysen, G. J. 1936
Brongersma-Sanders, M. 1957
Brunberg, L. 1964
Burbanck, W. D. 1959, 1961, 1962, 1967
Burckhardt, G. 1913
Burkenroad, M. D. 1931
Burkholder, P. R. 1933
Burton, R. W. 1963
Butler, P. A. 1949, 1953, 1954
Capstick, C. K. 1959
Carriker, M. R. 1951, 1955, 1967
Cary, L. R. 1906a,b; 1907a
Caspers, H. 1955, 1967
Cassie, R. M. 1960
Castagna & Chanley 1966
Chadwick, H. K. 1971
Chambers & Sparks 1959
Chapman, C. R. 1971
Cherbonnier, G. 1960
Chew, F. 1956
Chin, E. 1961
Chitwood, B. G. 1951
Churchill, E. P. 1919
Cones & Haven 1969
Conger, P. S. 1953
Conover, J. T. 1958
Conrad, W. 1926
Copeland & Hoese 1966
Cowles, R. P. 1930
Crawford, G. I. 1937a,b
Cronin, L. E. 1967
Cronin, Daiber & Hulbert 1962
Cronin & Mansueti 1971
Crothers, J. H. 1969
Cuzon du Rest, R. 1963
Dahl, F. R. 1891
Dales, R. P. 1951
Danglade, E. 1919
Darnell, R. M. 1962
Daugherty, F. M., Jr. 1952
Davis & Williams 1950
Dawson, C. E. 1955
Day, J. H. 1951, 1967
Dean, B. 1893
Dekhuyzen, M. C. 1905
Delchamps, J. 1896
Douglas & Stroud, eds. 1971
Dunnington, E. A. 1956

Dybern, B. I. 1969
Elliott, Ellison & Nichols 1966
Ellis, A. 1932
Engle, J. 1948
Estcourt, I. N. 1967
Federighi, H. 1930, 1931
Fenchel, T. 1965
Filice, F. P. 1954, 1959
Fischer, E. 1928
Fischer-Piette, E. 1931, 1933
Fox, D. 1936
Fraser, J. H. 1931, 1932
Frey, D. G. 1946
Frolander, H. 1964
Galhano, M. H. 1970
Galtsoff, P. S. 1930, 1931, 1954, 1964
Galtsoff, Chipman, Engle & Calderwood 1947
Galtsoff, Chipman, Hasler & Engle 1938
Galtsoff & Prytherch 1927
Gates, W. H. 1907
Gee, J. M. 1961
Gibb, D. C. 1957
Giere, O. 1968
Gillard, R. M. 1969
Goodbody, I. 1961
Goodhart, C. B. 1941
Goodwyn, F. 1968
Gosner, K. L. 1971
Grindley, J. 1964
Gunter, G. 1938a,b; 1942; 1945; 1947a,b; 1950; 1952; 1953; 1955; 1956a,b,c; 1957; 1961a,b; 1967
Gunter, Christmas & Killebrew 1964
Gunter & Hildebrand 1954
Gurney, R. 1931
Haefner, P. A., Jr. 1967
Hagerman, L. 1969
Hall, D. N. F. 1962
Hanks, R. 1964
Hardenberg, J. D. F. 1951
Harper, D. E., Jr. 1968
Hart, T. 1930
Hartley, P. H. T. 1939, 1938
Hartley & Spooner 1938
Haskin, H. H. 1936, 1938
Haskin, Krueger & Tweed 1971
Hatai, S. 1930
Haven, D. 1957
Hedgpeth, J. W. 1968
Heinle, D. R. 1972
Hela, I. 1956
Hempel, C. 1957
Henry, D. P. 1959
Herman, S. S. 1968
Heubach, W. 1969
Higgins, E. 1931, 1933, 1936, 1937, 1940
Hill & Kofoid 1927
Hill, M. B. 1967
Hodgkin & Rippingale 1971
Hoese, H. D. 1958; 1959a,b,c; 1960a
Hoese, Copeland, Moseley & Lane 1968
Hopkins, A. E. 1931, 1937
Hopkins, S. H. 1956a,b; 1962; 1967
Hopkins, T. L. 1958, 1963, 1966
Hubby, T. E. 1926
Hughes, G. C. 1961, 1969
Hulburt, E. M. 1957, 1963
Hulburt & Rodman 1963
Huntsman, A. G. 1918
Hustedt, F. 1939
Hynes, H. B. N. 1955
Ingle, R. M. 1950, 1962
Ingle & Smith 1949
Iversen, E. S. 1968
James, M. C. 1946
Jansson, B. O. R. 1972
Jaworski, E. 1970
Jeffries, H. P. 1960; 1962a,b,c; 1967
Johnson, D. S. 1965
Johnson, M. W. 1939
Johnson, R. G. 1967
Johnson, T. W., Jr. 1967
Jones, N. S. 1948
Jones & Burbanck 1959
Jørgensen, O. 1929
Karpevich, A. F. 1955a
Kawamura, T. 1966
Kelley & Turner 1966
Kellogg, J. L. 1905, 1910
Kessel, H. 1961
Kesteven, G. L. 1947
Kinne, O. 1955, 1959
Klesch, W. L. 1970
Kofoid, Miller, Lazier, Dore, Blum & Van Slyke 1927
Kohout & Kolipinski 1967
Korringa, P. 1957, 1967
Krakatitsa, T. F. 1968
Kutkuhn, J. H. 1966
Lackey, J. B. 1967
Ladd, H. S. 1951
Lambert & Davies 1940
Lane, E. D. 1967

Laubenfels, M. W. de 1947
Lauff, G. H., ed. 1967
LeRoy, L. W. 1938
Lewis, R. M. 1967
Lindner & Anderson 1956
Lindquist, A. 1959
Little, F. J., Jr. 1963
Livingstone, R., Jr. 1965
Lloyd & Yonge 1947
Loosanoff & Engle 1943
Lucas, J. S. 1971
Lunz, G. R., Jr. 1938, 1958
MacGinitie, G. E. 1939
Mackin, J. G. 1951, 1962
Mackin & Hopkins 1962
Macnae, W. 1957a,b
Maksimova, L. P. 1964
Manning & Whaley 1955
Mansueti, R. J. 1961, 1962, 1964
Marine Biol. Assoc. U. K. 1949
Mars, P. 1950
Martin, R. C. 1926
Maturo, F. J. S., Jr. 1959
Massmann, W. H. 1971
Mastenbroek, N. van 1927
McErlean, A. J. 1964
McHugh, J. L. 1967
McKenzie, R. A. 1959
McLusky, D. S. 1968
McMillan, C. 1971
McMillan & Moseley 1967
Medcof, J. C. 1944, 1961
Medcof & Needler 1941
Menzel, R. W. 1954, 1955, 1956
Menzel, R. W., ed. 1971
Menzies & Frankenbury 1966
Meyer & Mann 1951
Mileikovskii, S. A. 1968
Miller, D. N., Jr. 1953
Miller & Burbanck 1961
Miller, R. C. 1926
Milne, A. 1940
Moody, W. D. 1949
Moore, H. B. 1935
Moore, H. F. 1898, 1899, 1911
Moore & Pope 1910
More, W. R. 1969
Morishima, M. 1944
Mulford, R. A. 1963
Mulligan, H. F. 1972
Muncy, R. J. 1962
Muus, B. J. 1963, 1967
Nash, C. B. 1947
National Research Council 1970
Naylor & Haahtela 1966
Naylor, Slinn & Spooner 1960
Nazarov & Chepurnova 1969
Needham, J. 1930
Neily, Kirkbride, Mattos, Squire & Hill 1927
Nelson, T. C. 1921, 1923, 1928
Newcombe, C. L. 1945
Newell, R. 1964
Niemi, A. 1971
Nikitin & Turpaeva 1959
Noor-Vodin 1967
Norton & South 1969
Odum, H. T. 1953, 1967
Odum & Hoskin 1958
Odum & Wilson 1962
Oemler, A. 1894
O'Hara, J. A. 1930
O'Heeron, M. K., Jr. 1966
Ono, Y. 1959, 1965
Owen, H. M. 1953
Oye, P. Van 1920
Packard, E. L. 1918
Panikkar, N. K. 1951
Parker, F. L. 1952
Parker, J. C. 1970
Parker, R. H. 1955, 1956, 1959, 1960
Parker & Blanton 1970
Parry, G. 1961
Patrick, R. 1967
Pearcy, W. G. 1962
Pearcy & Richards 1962
Pearse, A. S. 1929, 1936
Pearse & Wharton 1938
Pearson, J. C. 1948
Percival, E. 1929
Peterson, G. H. 1958
Pfitzenmeyer, H. T. 1961, 1962, 1969
Pfitzenmeyer & Drobeck 1963
Phleger & Walton 1950
Pierce, E. L. 1962
Pillay, T. V. R. 1967b
Pilsbry, H. A. 1916
Popham, E. J. 1966
Porter, H. J. 1955, 1956
Post, R. J. 1951
Price, K. S. 1961, 1962
Prost, M. 1959
Prytherch, H. F. 1934
Puzanov, I. I. 1967
Pyefinch, K. A. 1950
Ragotzkie, R. A. 1958
Rathbun, R. 1895
Ray, S. M. 1965
Redeke, H. G. 1922, 1932
Reid, D. M. 1930, 1932

Reid, G. K., Jr. 1954, 1955, 1956, 1957, 1961
Reid & Hoese 1958
Reintjes & Pacheco 1966
Renfro, W. C. 1959
Riemann, F. 1966
Riley, G. A. 1967
Roch, F. 1924
Rodriguez, G. 1963
Rogers-Talbert, R. 1948
Roughley, T. C. 1922, 1925, 1933
Rounsefell, G. A. 1964
Rucker & Valentine 1961
Russell, H. D. 1941
Ryan, E. P. 1956
Ryther, J. H. 1954
Sanders, Mangelsdorf & Hampson 1965
Sandison & Hill 1966
Sarkka, J. 1969
Sato & Craig 1948
Schauman, K. 1968
Scheltema & Truitt 1954, 1956
Schmidt, R. A. 1966
Schodduyn, R. 1931
Schwartz, F. J. 1964
Segerstråle, S. G. 1947; 1949; 1951a,b; 1953; 1957
Seoane, J. 1960
Serventy, D. L. 1935
Sexton & Spooner 1940
Shaw, W. N. 1966
Shidler, J. K. 1960a,b
Shuster, C. N., Jr. 1960
Sieling, F. W. 1971
Sieling, Otto & Rosenfield 1969
Smirnov, A. N. 1969
Smith, R. I. 1953; 1955a,b; 1956
Snelling, B. 1959
Spooner, G. M. 1947
Spooner & Moore 1940
Sprague, Dunnington & Drobeck 1969
St. Amant, L. S. 1961
Stammer, H. J. 1928
Stauber, L. A. (Circa 1943)
Stead, D. G. 1907
Stephens, W. M. 1968
Stock, J. H. 1952
Stroud, R. H. 1971
Sutcliffe, D. W. 1967
Swift, F. 1897
Tabb, D. 1958, 1966
Tabb & Manning 1961
Talbot, G. B. 1966
Tattersall, W. M. 1932
Taysi & Van Uden 1964
Tebble, N. 1966
Teplova, E. P. 1961
Tesch, F. W. 1968
Te Strake, D. 1959
Thomas, L. P. 1961
Thomson, S. H. 1961
Timm, R. W. 1952
Tortonese & Demir 1960
Trahms, O.-K. 1939
Truitt, R. V. 1946
Ursin, E. 1956
U. S. Congress 1947
Valikangas, I. 1926, 1933
Van Engel, W. A. 1958
Van Uden, N. 1967
Vernberg, F. J. 1967
Verschaffelt, F. 1929
Verwey, J. 1952
Villadolid & Villaluz 1938
Viosca, P., Jr. 1937
Von Wachenfeldt, T. 1969
Wakiya, Y. 1929
Walker, K. 1969
Wallace, D. H. 1966, 1971
Walne, P. R. 1956b
Warburton, F. E. 1958
Ward, Vreeland, Southwick & Reading 1965
Wass, M. L. 1963
Waugh, G. D. 1953
Webb, J. E. 1956, 1958
Wells, H. W. 1957; 1959a,b; 1961
Weyland, H. 1967
Weymouth, Lindner & Anderson 1933
Wilce, Webber & Sears 1970
Williams, A. B. 1955, 1964
Williams & Deubler 1968
Wilson, B. R. 1968, 1969
Winslow, F. 1886
Wolfe, D. A. 1971
Wood, C. E. 1967
Wood, E. J. F. 1948, 1963, 1965
Woodmansee, R. A. 1958
Worsnop & Orton 1923
Worth, R. H. 1903
Zalumi, S. G. 1967
Zenkevitch, L. 1957, 1963

4. Neutral estuaries (without rivers, inflow and outflow equal)

Day, J. H. 1951
Fox, D. 1936
Hewatt, W. G. 1937

Lauff, G. H., ed. 1967
Livingstone, R., Jr. 1965
Marshall, N. 1954
Nichy & Menzel 1962
Tabb, D. 1958

5. Negative estuaries (lagoons with more inflow from sea than outflow)

Bernstein, L. 1967
Breuer, J. P. 1957, 1962
Brongersma-Sanders, M. 1957
Carpelan, L. H. 1967
Copeland, B. J. 1967
Day, J. H. 1951
Dietz, G. 1963
Fox, D. 1936
Galtsoff, P. S. 1954
Gunter, G. 1967
Hellier, T. R., Jr. 1962
Hempel, C. 1957
Henderson, J. C. 1958
Henry, D. P. 1959
Khalebovich, V. 1962
Lauff, G. H., ed. 1967
Maddox, N. T. 1949
McMillan & Moseley 1967
Odum, H. T. 1967
Odum & Hoskin 1958
Odum & Wilson 1962
Panikkar, N. K. 1951
Parker, R. H. 1959, 1960
Parker & Blanton 1970
Pierce, E. L. 1962
Simmons, E. G. 1957, 1959
Simmons & Breuer 1962
Tabb, D. 1958, 1966
Wood, E. J. F. 1963

6. Coastal lagoons or ponds permanently or intermittently cut off from sea

Aleem, A. A. 1961
Andrews, E. A. 1940
Andrews, J. D. 1964
Annandale, N. 1907, 1915
Anonymous 1945, 1946, 1947
Bernstein, L. 1967
Boettger, C. R. 1950
Bromhall, J. D. 1954
Carpelan, L. H. 1964
Carriker, M. R. 1959
Carter, N. 1938
Copeland, B. J. 1967
d'Ancona, U. 1954
Davis & Williams 1950
Dietz, G. 1963
Dunson & Ehlert 1972
Herre, A. W. C. T. 1929
Hickling, C. F. 1970
Hodge, D. 1964
Iversen, E. S. 1968
Johnson, M. W. 1939
Johnson, R. B. 1966
Kolbe, R. W. 1927
Lamb, K. P. 1961
Marcus, A. 1970
Matthiessen, G. C. 1960
Nagahama, M. 1951
Noor-Vodin 1967
Pearse, A. S. 1932
Pesta, O. 1935
Pillay, Vijayaraghavan & Thakurta 1963
Prost, M. 1959
Rahm, U. 1964
Robson, G. C. 1920
Sacchi, C. F. 1961
Segerstråle, S. G. 1947
Stuart, T. A. 1941
Tabb, D. 1958
Tash & Armitage 1967
Vatova, A. 1962
Venkateswarlu, T. 1967
Wallace, D. H. 1966
Warme, J. E. 1971
Willer, A. 1931

7. Small estuaries that ebb nearly dry, except channel

Allen & Todd 1903
Batchelder, C. H. 1926
Beanland, F. L. 1940
Bowman, H. H. M. 1956
Brown, A. C. 1959
Durve & Alagarswami 1964
Green, J. 1957
Nagahama, M. 1951
Rogers, H. M. 1940
Walsh, G. E. 1967

8. Tidal marshland areas

Adams, D. A. 1963
Biglane & Lafleur 1967
Bourdeau & Adams 1956
Brereton, A. J. 1971
BroLarsen, E. 1951
Carter, N. 1932
Chapman, V. J. 1939, 1940
Chater & Jones 1957
Clarke & Hannon 1971
Darnell, R. M. 1962
Fassett, N. C. 1928
Gilham, M. 1957
Gurney, R. 1923

Harshberger, J. W. 1909, 1911
Hoese, H. D. 1967
Jackson, C. R. 1952
Jaworski, E. 1970
Kerwin, J. A. 1971
Kerwin & Pedigo 1971
Kilby, J. D. 1955
Kolbe, R. W. 1927
Kurz & Wagner 1957
Massmann, W. H. 1971
Nicol, E. A. T. 1935
O'Neil, T. 1949
Parker, R. H. 1956
Penfound & Hathaway 1938
Peterson, W. 1967
Ragotzkie, R. A. 1959
Ranwell, D. S. 1961
Ranwell, Bird, Hubbard & Stebbings 1964
Rounsefell, G. F. 1964
Smith, W. G. 1970
Teal, J. M. 1958, 1962
Thomson, S. H. 1961
Wright, M. 1943
Wright, Sperry & Huss 1960
Zilberberg, M. H. 1966

9. River deltas

Pillay, T. V. R. 1967a

10. Fjords

Barlow, J. 1958
Gaarder & Sparck 1932
Klavestad, N. 1957
Mathiesen & Nielsen 1956
Phillips & Fleenor 1970

11. Sounds and inshore waters of ocean

Albertini-Berhaut, J. 1970
Amemiya, I. 1928
Anderson, J. B. 1968
Anderson, King & Lindner 1949
Annandale, N. 1915
Arnold & Thompson 1958
Banner, A. H. 1968
Bary, B. M. 1963, 1964
Battaglia, B. 1967
Bayne, B. L. 1965
Bayowmi, A. R. 1969
Belyaev & Zelikman 1950
Binyon, J. 1961
Broekhuysen, G. J. 1940
Brunberg, L. 1964
Burbanck, W. D. 1967
Burkholder, P. R. 1933
Caldwell, D. K. 1955
Chitwood, B. G. 1951
Conover, R. J. 1956
Cooper, M. J. 1966
Crawford, G. I. 1937
Crisp & Southward 1958
Croker, R. A. 1968
Daugherty, F. M., Jr. 1952
Dawson, C. E. 1955
Dunson & Ehlert 1972
Dybern, B. 1967
Edmondson, C. H. 1928
Elliott, Myers & Tressler 1955
Ellis, A. 1932
Fenchel, T. 1965
Fleming, C. A. 1952
Fox, D. 1936
Galhano, M. H. 1970
Galtsoff, P. S. 1954
Goreau, T. F. 1964
Gosner, K. L. 1971
Gunter, G. 1938, 1942, 1950, 1951, 1956
Gunter & Hildebrand 1954
Gunter, Williams, Davis & Smith 1948
Hagerman, L. 1969
Harper, D. E., Jr. 1968
Hedley, C. 1925
Hela, I. 1956a,b
Henry, D. P. 1959
Hildebrand, H. H. 1954
Hoese, H. D. 1958, 1960
Hughes, G. C. 1969
Hulburt, E. M. 1963
Hulburt & Rodman 1963
Ingmanson & Ross 1969
Jones, N. S. 1948
Kajikawa, Sano & Soguri 1953
Korringa, P. 1967
Lackey, J. B. 1938
Laubenfels, M. W. de 1949
Lindner & Anderson 1956
Livingstone, R., Jr. 1965
Lloyd & Yonge 1947
Lunz, G. R. 1958
Menzel, R. W. 1956
Menzel, R. W., ed. 1971
Menzies & Frankenbury 1966
Mileikovskii, S. A. 1968
Mulford, R. A. 1963
Muthu, M. S. 1955
Nazarov & Chepurova 1969
Newcombe, C. L. 1935
Nival, P. 1969

Noor-Vodin 1967
Norton, O. A. 1947
Parker, R. H. 1960
Pearse, A. S. 1929, 1936
Phleger, F. B., Jr. 1952
Pillay, T. V. R. 1967b
Pilsbry, H. A. 1916
Post, R. J. 1951
Randall, J. E. 1958
Reid, G. K., Jr. 1954
Reintjes & Pacheco 1966
Riley, G. A. 1937
Rounsefell & Dragovich 1966
Russell, H. D. 1941
Schroeder, W. C. 1924
Sexton & Spooner 1940
Shaw, J. 1959
Shelford, V. E. 1930
Shelford, Weese, Rice, Rasmussen & MacLean 1935
Shomura & Nakamura 1970
Slack-Smith, R. J. 1960
Stephenson, Endean & Bennett 1958
Stokke, K. 1958
Stroud, R. H. 1971
Taysi & Van Uden 1964
Umpgrove, J. H. F. 1928
Ursin, E. 1956
Van Engel, W. A. 1958
Vaughn, T. W. 1919
Vernberg & Vernberg 1970
Von Wachenfeldt, T. 1969
Wakiya, Y. 1929
Wass, M. L. 1963
Wells, H. W. 1958
Wells & Gray 1960
Weymouth, Lindner & Anderson 1933
Widdowson, T. B. 1965
Williams, A. B. 1955, 1964
Williams, L. G. 1948
Wood, E. J. F. 1965
Zenkevitch, L. 1963

12. Salt lakes and inland "seas"

Bowman, H. H. M. 1956
Daribaev, A. K. 1967
Gillespie, Wirick & Stephens 1971
Maksimova, L. P. 1964
Rawson, D. S. 1946
Runnegar & Newell 1971
Zenevitch, L. A. 1957

13. Canals

Den Hartog, C. 1963
Gruvel, A. 1934
Gunter & Hall 1963
Hempel, C. 1957
Kolbe, R. W. 1927
Lafon, Durchon & Saundray 1955
Por, F. D. 1971
Stock, J. H. 1952

14. Lake estuaries

Annandale, N. 1915
Breder, C. M., Jr. 1933, 1934
Conover, J. T. 1958
Crowell & Darnell 1955
Darnell, R. M. 1959, 1962
Gunter & Shell 1958
Hada, Y. 1936, 1937
Horst, R. 1919
Lemmerman, E. 1898
Pillay, T. V. R. 1967a
Redeke, H. C. 1939
Riech, Fr. 1926
Roch, F. 1924
Schuurmans Stekhoven, J. G., Jr. 1936
Willer, A. 1931
Wood, E. J. F. 1964

8. Research reports, by ecological classes of organisms

0. General ecology, all organisms or types not specified

Allen & Todd 1903a,b
Annandale, N. 1922
Biernacka, I. 1968
Biglane & Lafleur 1967
Brandt, K. 1897
Breuer, J. P. 1957, 1962
Brongersma-Sanders, M. 1957
Carpelan, L. H. 1967
Caspers, H. 1967
Chapman, C. R. 1971
Cronin, L. E. 1967
Cronin & Mansueti 1971
Darnell, R. 1962
Day, J. H. 1951, 1967
Dekhuyzen, M. C. 1905
Douglas & Stroud, eds. 1971
Elliott, Myers & Tressler 1955

Ferronniere, G. 1901
Fischer-Piette, E. 1931, 1933
Frey, D. G. 1946
Frolander, H. 1964
Galtsoff, P. S. 1954
Gosner, K. L. 1971
Gruvel, A. 1934, 1936
Gunter, G. 1952, 1957, 1961
Hardenberg, J. D. F. 1951
Hopkins, S. H. 1967
Jansson, B. O. R. 1972
Karpevich, A. F. 1955
Lackey, J. B. 1967
Lauff, G. H., ed. 1967
Livingstone, R., Jr. 1965
Macnae, W. 1957
Menzel, R. W. 1956
Menzel, R. W., ed. 1971
National Research Council 1970
Needham, J. 1930
Nicol, E. A. T. 1935
Odum, H. T. 1967
Otto, J. P. 1927
Parker & Blanton 1970
Pearse, A. S. 1932
Popham, E. J. 1966
Por, F. D. 1971
Puzanov, I. I. 1967
Redeke, H. C. 1922, 1932, 1939
Riech, Fr. 1926
Segerstråle, S. G. 1951, 1953, 1957
Simmons, E. G. 1959
Tabb & Manning 1961
Valikangas, I. 1933
Vernberg & Vernberg 1970
Wass, M. L. 1963
Zenkevitch, L. 1957, 1963

1. Decomposers (bacteria, yeasts, fungi)

Borut & Johnson 1962
Brisou & Doublet 1958
Hughes, G. C. 1961, 1969
Isyban & Shnaidman 1969
Johnson, T. W., Jr. 1967
Lackey, J. B. 1967
Oye, P. Van 1920
Ristanovic & Miller 1969
Ritchie, D. 1960
Schauman, K. 1968
Taysi & Van Uden 1964
Te Strake, D. 1959
Ulken, A. 1969
Van Uden, N. 1967
Weyland, H. 1967
Wood, E. J. F. 1965

2. Phytoplankton (small floating or feebly swimming photosynthetic organisms)

Aleem, A. A. 1961
Barlow, J. P. 1958
Barlow, Lorenzen & Myren 1963
Bernstein, L. 1967
Bersamin, S. 1957
Blanc, Leueau & Stekielda 1969
Bowman, H. H. M. 1956
Braarud & Føyn 1958
Brongersma-Sanders, M. 1957
Burkholder, P. R. 1933
Carpelan, L. H. 1964
Carter, N. 1938
Cassie, R. M. 1960
Chew, F. 1956
Conger, P. S. 1953
Conrad, W. 1926
Dahl, F. 1891
Dutta, Malhotra & Bose 1954
Gillespie, Wirick & Stephens 1971
Goreau, T. F. 1964
Gunter, Williams, Davis & Smith 1948
Hela, I. 1956
Hopkins, T. L. 1966
Hulburt, E. M. 1963
Hulburt & Rodman 1963
Hustedt, F. 1939
Kawamura, T. 1966
Kolbe, R. W. 1927
Lackey, J. B. 1967
Lafon, Durchon & Saundray 1955
Lemmerman, E. 1898
Marshall & Wheeler 1965
Mulford, R. A. 1963
Mulligan, H. F. 1972
Muthu, M. S. 1955
Nash, C. B. 1947
Odum & Hoskin 1958
Odum & Wilson 1962
Oye, P. Van 1920
Patrick, R. 1967
Ragotzkie, R. A. 1959
Riley, G. A. 1937, 1967
Rogers, H. M. 1940
Rounsefell & Dragovich 1966
Ryther, J. H. 1954
Valikangas, I. 1926
Ward, Vreeland, Southwick & Reading 1965

Willer, A. 1931
Wood, E. J. F. 1964, 1965

3. Zooplankton (animals small or weak enough to be caught in plankton nets)

Albertini-Berhaut, J. 1970
Barlow, J. 1955
Bary, B. M. 1963, 1964
Bayly, I. A. E. 1963, 1964, 1965, 1967
Blanc, Leueau & Stekielda 1969
Burckhardt, G. 1913
Carriker, M. 1951
Cassie, R. M. 1960
Cones & Haven 1969
Conover, R. J. 1956
Cronin, Daiber & Hulbert 1962
Cuzon du Rest, R. 1963
Dahl, Fr. 1891
Davis & Williams 1950
Dietz, G. 1963
Dutta, Malhotra & Bose 1954
Giere, O. 1968
Gillespie, Wirick & Stephens 1971
Goodwyn, F. 1968
Grindley, J. 1964
Gurney, R. 1931
Haertel & Osterberg 1967
Harper, D. E., Jr. 1968
Heinle, D. R. 1972
Henderson, J. C. 1958
Herman, S. S. 1968
Heubach, W. 1969
Hodge, D. 1963
Hodgkin & Rippingale 1971
Hopkins, T. L. 1958, 1963, 1966
Jeffries, H. P. 1962a,b,c; 1967
Jørgensen, O. 1929
Kinne, O. 1955
Lackey, J. B. 1938, 1967
Lafon, Durchon & Saundray 1955
Lamb, K. P. 1961
Lindquist, A. 1959
Lint, G. M. de 1924
Marcus, A. 1970
Muthu, M. S. 1955
Nash, C. B. 1947
Niemi, A. 1971
Nival, P. 1969
Norcross, Massmann & Joseph 1961
Oye, P. Van 1920
Painter, R. E. 1966
Parker, J. C. 1970
Pearcy & Richards 1962
Pesta, O. 1935
Pierce, E. L. 1962
Rahm, U. 1964
Riley, G. A. 1967
Rogers, H. M. 1940
Segerstråle, S. G. 1951
Shomura & Nakamura 1970
Shuster, C. N., Jr. 1960
Stammer, H. J. 1928
Stuart, T. A. 1941
Tash & Armitage 1967
Tattersall, W. M. 1932
Valikangas, I. 1926
Verschaffelt, A. 1929
Ward, Vreeland, Southwick & Reading 1965
Willer, A. 1931
Williams, A. B. 1955
Williams & Deubler 1968
Wood, E. J. F. 1965
Woodmansee, R. A. 1958

4. Nekton (swimming animals such as are caught in fish nets)

Anderson, King & Lindner 1949
Anonymous 1944
Arnold & Thompson 1958
Barans, C. A. 1972
Barnes, R. S. K. 1967
Barth & Da Costa 1968
Bassindale, R. 1942
Bayowmi, A. R. 1969
Bowman, T. E. 1964
Breder, C. M., Jr. 1933, 1934
Bromhall, J. D. 1954
Brues, C. T. 1917
Caldwell, D. K. 1955
Callamand, O. 1943
Chadwick, H. K. 1971
Chambers & Sparks 1959
Chin, E. 1961
Churchill, E. P. 1919
Copeland, B. J. 1967
Cowles, R. P. 1930
Crothers, J. H. 1969
d'Ancona, U. 1954
Daribaev, A. K. 1967
Darnell, R. M. 1958, 1959, 1962
Daugherty, F. M., Jr. 1952
Devanesan & Chacko 1943

Dovel, Mihursky & McErlean 1969
Dunson & Ehlert 1972
Durve & Alagarswami 1964
Goodhart, C. B. 1941
Gunter, G. 1937; 1938a,b,c,d; 1942a; 1945; 1947a,b,c; 1950; 1956a,b,c; 1957; 1961; 1967
Gunter, Christmas & Killebrew 1964
Gunter & Hall 1963
Gunter & Hildebrand 1954
Gunter & Shell 1958
Gurney, R. 1923
Haertel & Osterberg 1967
Hall, D. N. F. 1962
Hartley, P. H. T. 1939
Haven, D. S. 1957
Havinga, B. 1930
Hedgpeth, J. W. 1968
Hellier, T. R., Jr. 1962
Herre, A. W. C. T. 1929
Hickling, C. F. 1970
Hildebrand, H. H. 1954
Hoese, H. D. 1958; 1959b; 1960a,b
Hoese, Copeland, Moseley & Lane 1968
Hubbs, C. 1961
Hulburt, E. M. 1957
Huntsman, A. G. 1918
Hynes, H. B. N. 1954
Iversen, E. S. 1968
Jaworski, E. 1970
Jeffries, H. P. 1960
Johnson, D. S. 1965
Jones, N. S. 1948
Karpevich, A. F. 1955
Kelley & Turner 1966
Keup & Bayless 1964
Kilby, J. D. 1955
Kinne, O. 1959
Korringa, P. 1967
Kutkuhn, J. H. 1966
Lane, E. D. 1967
Lewis, R. M. 1967
Lindner & Anderson 1956
Lloyd & Yonge 1947
Lunz, G. R. 1958
Mansueti, R. J. 1961, 1962, 1964
Massmann, W. H. 1954, 1971
McHugh, J. L. 1966, 1967
McKenzie, R. A. 1959
Moody, W. D. 1949
More, W. R. 1969
Muncy, R. J. 1962
Myers, G. S. 1938
Nazarov & Chepurnova 1969
Neily, Kirkbride, Mattos, Squire & Hill 1927
Newcombe, C. L. 1945
Nichols, J. T. 1928
Ono, Y. 1959
Panikkar, N. K. 1951
Parker, J. C. 1970
Parry, G. 1961
Pearcy, W. C. 1962
Pearse, A. S. 1936
Pearson, J. C. 1948
Pillay, T. V. R. 1967a,b
Porter, H. J. 1955, 1956
Price, K. S., Jr. 1961, 1962
Rawson, D. S. 1946
Redeke, H. C. 1939
Reid, G. K. 1954, 1955, 1956, 1957
Reid & Hoese 1958
Reintjes & Pacheco 1966
Renfro, W. C. 1959
Rogers-Talbert, R. 1948
Rounsefell, G. A. 1964
Say, T. 1817
Schwartz, F. J. 1964
Segerstråle, S. G. 1947
Serventy, D. L. 1935
Shidler, J. K. 1960a,b
Simmons, E. G. 1957
Simmons & Breuer 1962
Smirnov, A. N. 1969
Snelling, B. 1959
Spooner, G. M. 1947
St. Amant, L. S. 1961
Stammer, H. J. 1928
Tagatz, M. E. 1968a,b
Talbot, G. B. 1966
Teplova, E. P. 1961
Tesch, F. W. 1968
Thomson, J. M. 1966
Van Engel, W. A. 1958
Vatova, A. 1962
Venkateswarlu, T. 1967
Weymouth, Lindner & Anderson 1933
Whatley, E. C. 1969
Williams, A. B. 1955, 1964
Williams & Deubler 1968
Wood, C. E. 1967
Zalumi, S. G. 1967
Zilberberg, M. H. 1966

5. Benthos (burrowing, attached, and other bottom-dwelling animals)

Alexander, Southgate & Bassindale 1932

Allen & Todd 1903
Allen, J. F. 1960
Amemiya, I. 1928
Amos, W. H. 1957
Anderson, J. B. 1968

Benthos (burrowing, attached, or free-moving bottom-dwelling animals)

Andrews, E. A. 1940
Andrews, J. D. 1964
Andrews, Haven & Quayle 1959
Annandale, N. 1907, 1915
Anonymous 1931, 1945, 1946, 1947
Archer, A. F. 1947
Atwater, W. O. 1888
Bacesco & Margineanu 1959
Baird, R. H. 1966
Balasubrahmanyan, K. 1960
Banner, A. H. 1968
Barker, D. 1963
Barnes & Barnes 1961
Barrows, A. L. 1917
Bassindale, R. 1943
Batchelder, C. H. 1926
Battaglia, B. 1967
Bayne, B. L. 1965
Beach, N. W. 1969
Beanland, F. L. 1940
Beaven, G. F. 1955
Becker, G. 1959
Belyaev & Zelikman 1950
Blum, H. 1922
Boettger, C. R. 1950
Bookhout & Costlow 1959
Bousfield, E. L. 1955
Brady, F. 1943
Brattstrom, H. 1941, 1954
Broekhuysen, G. J. 1936, 1940
Brown, A. C. 1959
Brunberg, L. 1964
Burbanck, W. D. 1959, 1961, 1962, 1967
Burkenroad, M. D. 1931
Burton, R. W. 1963
Butler, P. A. 1949a,b; 1953; 1954
Capstick, C. K. 1959
Carriker, M. R. 1955, 1959, 1967
Cary, L. R. 1906a,b; 1907a,b
Caspers, H. 1955
Cassie, R. M. 1960
Castagna & Chanley 1966
Cherbonnier, G. 1960
Chitwood, B. G. 1951
Conger, P. S. 1953
Cooper, M. J. 1966
Copeland & Hoese 1966
Cowles, R. P. 1930
Crawford, G. I. 1937a,b
Crisp & Southward 1958
Croker, R. A. 1968
Crowell & Darnell 1955
Dales, R. P. 1951
Danglade, E. 1919
Darnell, R. M. 1958
Dawson, C. E. 1955
Dean, B. 1893
Dees, Mrs. 1949
Delchamps, J. 1896
Den Hartog, C. 1963
D'Iakanov, A. M. 1955
Dunnington, E. A. 1956
Dybern, B. 1967, 1969
Edmondson, C. H. 1928
Elliott, Ellison & Nichols 1966
Ellis, A. 1932
Engle, J. B. 1948
Estcourt, I. N. 1967
Federighi, H. 1930, 1931
Fenchel, T. 1965
Filice, F. P. 1954, 1958, 1959
Fischer, E. 1928
Fischer-Piette, Gaillard & Delmas 1966
Fleming, C. A. 1952
Fox, D. 1936
Fraser, J. H. 1931, 1932
Frey, D. G. 1946
Gaarder & Sparck 1932
Galhano, M. H. 1970
Galtsoff, P. S. 1930, 1931, 1964
Galtsoff, Chipman, Engle & Calderwood 1947
Galtsoff, Chipman, Hasler & Engle 1938
Galtsoff & Prytherch 1927
Gates, W. H. 1907
Gee, J. M. 1961
Gillard, R. M. 1969
Glaser, O. 1904
Goodbody, I. 1961
Green, J. 1957
Gunter, G. 1942, 1951, 1953, 1955, 1967
Hada, Y. 1936, 1937
Haefner, P. A., Jr. 1967
Haertel & Osterberg 1967
Hagerman, L. 1969
Hanks, R. 1964

Hart, T. 1930
Haskin, H. H. 1936
Haskin, Krueger & Tweed 1971
Hatai, S. 1930
Hedley, C. 1925
Hempel, C. 1957
Henry, D. P. 1959
Hepper, B. T. 1955
Higgins, E. 1931, 1933, 1936, 1937, 1940
Hill & Kofoid 1927
Hill, M. B. 1967
Hoese, H. D. 1959, 1960
Hopkins, A. E. 1931, 1937
Hopkins, S. H. 1956a,b; 1962
Horst, R. 1919
Hubby, T. E. 1926
Hustedt, F. 1939
Ingle, R. M. 1950
Ingle & Smith 1949
Ingmanson & Ross 1969
Iversen, E. S. 1968.
James, M. C. 1946
Johnson, L. C. 1891
Johnson, R. B. 1966
Johnson, R. G. 1967
Kajikawa, Sano & Soguri 1953
Kellogg, J. L. 1910
Kerwin, J. A. 1971
Kessel, H. 1961
Kesteven, G. L. 1947
Klesch, W. L. 1970
Kofoid, Miller, Lazier, Dore, Blum & Van Slyke 1927
Kohout & Kolipinski 1967
Korringa, P. 1957, 1967
Krakatitsa, T. F. 1968
Kuenzler, E. J. 1961
Ladd, H. S. 1951
Laubenfels, M. W. de 1947, 1949, 1953
LeRoy, L. W. 1938
Little, F. J., Jr. 1963
Loosanoff & Engle 1943
Lunz, G. R., Jr. 1938
MacGinitie, G. E. 1939
Mackin, J. G. 1962
Mackin & Hopkins 1962
Maddox, N. T. 1949
Maksimova, L. P. 1964
Manning & Whaley 1955
Marine Biol. Assoc. U. K. 1949
Mars, P. 1950
Marshall, N. 1954
Martin, R. C. 1926
Massmann, W. H. 1971
Mastenbroek, N. van 1927
Matthiessen, G. C. 1960
Maturo, F. J. S., Jr. 1959
McErlean, A. J. 1964
McLusky, D. S. 1968
Medcof, J. C. 1944, 1961
Medcof & Needler 1941
Menzel, R. W. 1954, 1955
Menzel, Hulings & Hathaway 1958
Menzies & Frankenbury 1966
Meyer & Mann 1951
Miller, D. N., Jr. 1953
Miller & Burbanck 1961
Milne, A. 1940
Moore, H. B. 1935
Moore, H. F. 1898, 1911
Morishima, M. 1944
Muus, B. J. 1963, 1967
Nagahama, M. 1951
Naylor & Haahtela 1966
Nelson, T. C. 1921, 1923, 1928
Newcombe, C. L. 1935
Newell, R. 1964
Nichy & Menzel 1962
Nikitin & Turpaeva 1959
Noor-Vodin 1967
Norton, O. A. 1947
Oemler, A. 1894
O'Hara, J. A. 1930
O'Heeron, M. K., Jr. 1966
Ono, Y. 1959, 1965
Orton, J. H. 1937
Owen, H. M. 1953
Packard, E. L. 1918
Parker, F. L. 1952
Parker, R. H. 1955, 1956, 1959, 1960
Paulus, M. 1942
Pearse, A. S. 1929, 1936
Pearse & Wharton 1938
Percival, E. 1929
Peterson, G. H. 1958
Peterson, W. 1967
Pfitzenmeyer, H. T. 1961, 1962, 1969
Pfitzenmeyer & Drobeck 1963
Phleger, F. B., Jr. 1952
Phleger & Walton 1950
Pilsbry, H. A. 1916
Post, R. J. 1951
Prytherch, H. F. 1934
Pyefinch, K. A. 1950
Randall, J. E. 1958
Rathbun, R. 1895
Ray, S. M. 1965
Reid, D. M. 1930, 1932
Riemann, F. 1966

Ritter, H. P. 1896
Robson, E. A. 1957
Robson, G. C. 1920
Roch, F. 1924
Rodriguez, G. 1963
Roughley, T. C. 1922, 1925, 1933
Rucker & Valentine 1961
Runnegar & Newell 1971
Russell, H. D. 1941
Ryan, E. P. 1956
Sacchi, C. F. 1961
Sanders, Mangelsdorf & Hampson 1965
Sandison & Hill 1966
Sarkka, J. 1969
Sato & Craig 1948
Scheltema & Truitt 1954
Schodduyn, R. 1931
Schroeder, W. C. 1924
Segerstråle, S. G. 1949
Sexton & Spooner 1940
Shatoury, H. H. A. 1958
Shaw, J. 1959
Shaw, W. N. 1966
Shelford, V. E. 1930
Shelford, Weese, Rice, Rasmussen & Maclean 1935
Shidler, J. K. 1960
Shuster, C. N., Jr. 1960
Sieling, F. W. 1971
Sieling, Otto & Rosenfield 1969
Slack-Smith, R. J. 1960
Smith, R. I. 1953; 1955a,b,c; 1956
Snelling, B. 1959
Spooner & Moore 1940
Sprague, Dunnington & Drobeck 1969
St. Amant, L. S. 1961
Stammer, H. J. 1928
Stauber, L. A. (Circa 1943)
Stead, D. G. 1907
Stenzel, H. B. 1971
Stephenson, Endean & Bennett 1958
Stock, J. H. 1952
Teal, J. M. 1958
Tebble, N. 1966
Thomas, L. P. 1961
Timm, R. W. 1952
Tortonese & Demir 1960
Trahms, O.-K. 1939
Truitt, R. V. 1946
Umpgrove, J. H. F. 1928
Ursin, E. 1956
U. S. Congress 1947
Vatova, A. 1962
Vaughn, T. W. 1919
Verwey, J. 1952
Villadolid & Villaluz 1938
Viosca, P., Jr. 1937
Wakiya, Y. 1929
Walker, K. 1969
Wallace, D. H. 1966, 1971
Walne, P. R. 1956a,b
Walsh, G. E. 1967
Warburton, F. E. 1958
Warme, J. E. 1971
Waugh, G. D. 1953
Webb, J. E. 1956, 1958
Wells, H. W. 1957; 1958; 1959a,b; 1961
Wells & Gray 1960
Willer, A. 1931
Williams, A. B. 1964
Wilson, B. R. 1968, 1969
Winslow, F. 1886
Wolfe, D. A. 1971
Wood, E. J. F. 1948, 1963
Worsnop & Orton 1923
Worth, R. H. 1903
Wright, M. 1943
Zenkevitch, L. A. 1963

6. Attached seaweeds and seed plants

Adams, D. A. 1963
Bassindale, R. 1943
Batchelder, C. H. 1926
Bernstein, L. 1967
Bourdeau & Adams 1956
Bowman, H. H. M. 1956
Brereton, A. J. 1971
Carter, N. 1932, 1938
Chapman, V. J. 1939, 1940
Chater & Jones 1957
Conover, J. T. 1958
Cooper, M. J. 1966
Crisp & Southward 1958
Fassett, N. C. 1928
Gibb, D. C. 1957
Gillham, M. 1957
Harshberger, J. W. 1909, 1911
Hoese, H. D. 1967
Kerwin & Pedigo 1971
Klavestad, N. 1957
Kurz & Wagner 1957
Lambert & Davies 1940
Macnae, W. 1957
Mathiesen & Nielsen 1956
McMillan, C. 1971
McMillan & Moseley 1967
Milne, A. 1940
Morss, W. L. 1927
Nicol, E. A. T. 1935

Nienburg & Kolumbe 1931
Odum & Hoskin 1958
Odum & Wilson 1962
O'Neil, T. 1949
Phillips & Fleenor 1970
Pillay, Vijayaraghavan & Thakurta 1963
Ranwell, D. S. 1961
Ranwell, Bird, Hubbard & Stebbings 1964
Seoane, J. 1960
Smith, W. G. 1970
Stokke, K. 1958
Teal, J. M. 1962
Von Wachenfeldt, T. 1969
Widdowson, T. B. 1965
Wilce, Webber & Sears 1970
Williams, L. G. 1948
Wright, Sperry & Huss 1960

9. Research reports, by organisms studied, classified taxonomically

0. Communities, many kinds of organisms, or not specified

Alexander, Southgate & Bassindale 1932
Allen & Todd 1903
Annandale, N. 1915, 1922
Bassindale, R. 1943
Batchelder, C. H. 1926
Beanland, F. L. 1940
Biglane & Lafleur 1967
Brady, F. 1943
Brandt, K. 1897
Breuer, J. P. 1957, 1962
Brongersma-Sanders, M. 1957
Brown, A. C. 1959
Carpelan, L. H. 1967
Carriker, M. R. 1967
Caspers, H. 1967
Cassie, R. M. 1960
Chapman, C. R. 1971
Cowles, R. P. 1930
Crisp & Southward 1958
Cronin, L. E. 1967
Cronin & Mansueti 1971
Dahl, Fr. 1891
Day, J. H. 1951, 1967
Dekhuyzen, M. C. 1905
Douglas & Stroud, eds. 1971
Elliott, Myers & Tressler 1955
Ferronniere, G. 1901
Filice, F. P. 1954, 1958, 1959
Fischer, E. 1928
Fischer-Piette, E. 1931, 1933
Fraser, J. H. 1932
Frey, D. G. 1946
Frolander, H. 1964
Galhano, M. H. 1970
Galtsoff, P. S. 1954
Goodbody, I. 1961
Gosner, K. L. 1971
Gruvel, A. 1934, 1936
Gunter, G. 1947a,b; 1952; 1956a; 1957a; 1961b
Gunter & Shell 1958
Haefner, P. A., Jr. 1967
Haertel & Osterberg 1967
Hanks, R. 1964
Hardenberg, J. D. F. 1951
Hartley & Spooner 1938
Hewatt, W. G. 1937
Hoese, H. D. 1959, 1960
Hoese, Copeland, Moseley & Lane 1968
Hopkins, S. H. 1967
Ingle, R. M. 1962
Jansson, B. O. R. 1972
Johnson, L. C. 1891
Johnson, R. B. 1966
Johnson, R. G. 1967
Karpevich, A. F. 1955
Khalebovich, V. 1962
Kohout & Kolipinski 1967
Lafon, Durchon & Saundray 1955
Lauff, G. H., ed. 1967
Lindquist, A. 1959
Livingstone, R., Jr. 1965
MacGinitie, G. E. 1939
Macnae, W. 1957
McHugh, J. L. 1967
Menzel, R. W. 1956
Menzel, R. W., ed. 1971
Milne, A. 1940
Morss, W. L. 1927
Muthu, M. S. 1955
Nash, C. B. 1947
National Research Council 1970
Needham, J. 1930
Newcombe, C. L. 1935
Nicol, E. A. T. 1935
Nikitin & Turpaeva 1959
Odum, H. T. 1967
Otto, J. P. 1927
Painter, R. E. 1966
Parker, R. H. 1955, 1956, 1959, 1960

Parker & Blanton 1970
Pearse, A. S. 1929, 1932, 1936
Percival, E. 1929
Pfitzenmeyer, H. T. 1969
Popham, E. J. 1966
Por, F. D. 1970
Redeke, H. C. 1922, 1932, 1939
Reid, D. M. 1930, 1932
Riech, Fr. 1926
Riemann, F. 1966
Rodriguez, G. 1963
Rogers, H. M. 1940
Sacchi, C. F. 1961
Sanders, Mangelsdorf & Hampson 1965
Sarkka, J. 1969
Schodduyn, R. 1931
Segerstråle, S. G. 1947; 1951a,b; 1953; 1957
Shomura & Nakamura 1970
Shelford, V. E. 1930
Shelford, Weese, Rice, Rasmussen & Maclean 1935
Shidler, J. K. 1960a,b
Shuster, C. N., Jr. 1960
Simmons, E. G. 1957, 1959
Spooner & Moore 1940
Stammer, H. J. 1928
Tabb & Manning 1961
Valikangas, I. 1926, 1933
Vernberg & Vernberg 1970
Walsh, G. E. 1967
Ward, Vreeland, Southwick & Reading 1965
Wass, M. L. 1963
Wells, H. W. 1959a,b; 1961
Willer, A. 1931
Zenkevitch, L. 1957, 1963

1. Bacteria

Brisou & Doublet 1958
Isyban & Shnaidman 1969
Lackey, J. B. 1967
Oye, P. Van 1920
Weyland, H. 1967
Wood, E. J. F. 1965

2. Yeasts

Oye, P. Van 1920
Ragotzkie, R. A. 1959
Ristanovic & Miller 1969
Ritchie, D. 1960
Schauman, K. 1968
Taysi & Van Uden 1964
Van Uden, N. 1967
Wood, E. J. F. 1965

3. Fungi (other than bacteria and yeasts)

Borut & Johnson 1962
Bowman, H. H. M. 1956
Dunnington, E. A. 1956
Hughes, G. C. 1961, 1969
Johnson, T. W., Jr. 1967
Mackin, J. G. 1951, 1962
Oye, P. Van 1920
Ray, S. M. 1965
Ristanovic & Miller 1969
Ritchie, D. 1960
Rogers-Talbert, R. 1948
Schauman, K. 1968
St. Amant, L. S. 1961
Te Strake, D. 1959
Ulken, A. 1969
Wood, E. J. F. 1965

4. Algae, single-celled or filamentous

Aleem, A. A. 1961
Barlow, J. 1958
Barlow, Lorenzen & Myren 1963
Bernstein, L. 1967
Bersamin, S. 1957
Biernacka, I. 1968
Braarud & Føyn 1958
Brongersma-Sanders, M. 1957
Burkholder, P. R. 1933
Carpelan, L. H. 1964
Carter, N. 1932, 1938
Chew, F. 1956
Conger, P. S. 1953
Conrad, W. 1926
Cooper, M. J. 1966
Dutta, Malhotra & Bose 1954
Gillespie, Wirick & Stephens 1971
Goreau, T. F. 1964
Gunter, Williams, Davis & Smith 1948
Hela, I. 1956
Hulburt, E. M. 1963
Hulburt & Rodman 1963
Hustedt, F. 1939
Kawamura, T. 1966
Kolbe, R. W. 1927
Lackey, J. B. 1967
Lemmerman, E. 1898
Marshall & Wheeler 1965
Mulford, R. A. 1963
Mulligan, H. F. 1972
Odum & Hoskin 1958
Odum & Wilson 1962
Oye, P. Van 1920
Patrick, R. 1967

Riley, G. A. 1937, 1967
Rounsefell & Dragovich 1966
Ryther, J. H. 1954
Valikangas, I. 1926
Ward, Vreeland, Southwick & Reading 1965
Wood, E. J. F. 1963, 1964, 1965

5. Seaweeds (large, multicellular attached algae)

Bernstein, L. 1967
Conover, J. T. 1958
Cooper, M. J. 1966
Gibb, D. C. 1957
Gillham, M. 1957
Klavestad, N. 1957
Kurz & Wagner 1957
Norton & South 1969
Odum & Hoskin 1958
Odum & Wilson 1962
Phillips & Fleenor 1970
Robson, G. C. 1920
Seoane, J. 1960
Stokke, K. 1958
Von Wachenfeldt, T. 1969
Widdowson, T. B. 1965
Wilce, Webber & Sears 1970
Williams, L. G. 1948

6. Spermatophyta, flowering or seed plants

Adams, D. A. 1963
Bourdeau & Adams 1956
Brereton, A. J. 1971
Chapman, V. J. 1939, 1940
Chater & Jones 1957
Clarke & Hannon 1971
Conover, J. T. 1958
Fassett, N. C. 1928
Gillham, M. 1957
Harshberger, J. W. 1909, 1911
Haven, D. 1961
Hoese, H. D. 1967
Jackson, C. R. 1952
Kerwin & Pedigo 1971
Klavestad, N. 1957
Kurz & Wagner 1957
Lambert & Davies 1940
Macnae, W. 1957
Mathiesen & Nielsen 1956
McMillan, C. 1971
McMillan & Moseley 1967
Morss, W. L. 1927
Nicol, E. A. T. 1935
Nienburg & Kolumbe 1931
Odum & Hoskin 1958
Odum & Wilson 1962
O'Neil, T. 1949
Penfound & Hathaway 1938
Pillay, Vijayaraghavan & Thakurta 1963
Pogrebnyak, I. I. 1962
Ranwell, D. S. 1961
Ranwell, Bird, Hubbard & Stebbings 1964
Smith, W. G. 1970
Teal, J. M. 1962
Wright, Sperry & Huss 1960

7. Protozoa, single-celled animals

Anderson, J. B. 1968
Biernacka, I. 1968
Blanc, Leueau & Stekielda 1969
Chew, F. 1956
Dietz, G. 1963
Dutta, Malhotra & Bose 1954
Hada, Y. 1936, 1937
Hela, I. 1956a,b
Ingmanson & Ross 1969
Lackey, J. B. 1938, 1967
Laubenfels, M. V. de 1947
LeRoy, L. W. 1938
Miller, D. N., Jr. 1953
Morishima, M. 1944
Mulford, R. A. 1963
Nagahama, M. 1951
Nival, P. 1969
Oye, P. Van 1920
Parker, F. L. 1952
Phleger, F. B., Jr. 1952
Phleger & Walton 1950
Post, R. J. 1951a,b
Puzanov, I. I. 1967
Riemann, F. 1966
Sieling, F. W. 1971
Sieling, Otto & Rosenfield 1969
Sprague, Dunnington & Drobeck 1969
Tesch, F. W. 1968
Verschaffelt, A. 1929
Worth, R. H. 1903

8. Porifera, sponges

Annandale, N. 1915
Hopkins, S. H. 1956a,b; 1962
Laubenfels, M. W. de 1949, 1953
Little, F. J., Jr. 1963
Warburton, F. E. 1958
Wells, H. W. 1959a,b

9. Coelenterata, jelly animals

1. Hydrozoa, polyps, small medusae, floating colonies

Albertini-Berhaut, J. 1970
Crowell & Darnell 1955
Puzanov, I. I. 1967
Roch, F. 1924

2. Scyphozoa, larger jellyfishes

Cones & Haven 1969
Segerstråle, S. G. 1951

3. Anthozoa, sea anemones

Annandale, N. 1907
Robson, E. A. 1957

4. Anthozoa, corals

Banner, A. H. 1968
Barrows, A. L. 1917
Cooper, M. J. 1966
Edmondson, C. H. 1928
Hedley, C. 1925
Randall, J. E. 1958
Slack-Smith, R. J. 1960
Stephenson, Endean & Bennett 1958
Umpgrove, J. H. F. 1928

10. Platyhelminthes, flatworms

1. Turbellaria, free-living flatworms

Danglade, E. 1919
Pearse & Wharton 1938
Roughley, T. C. 1922
Stead, D. G. 1907
Villadolid & Villaluz 1938

2. Trematoda, flukes, external and internal parasites

Belyaev & Zelikman 1950
Prost, M. 1959
Shuster, C. N., Jr. 1960

11. Nemertea or Rhychocoela, ribbon worms

Brunberg, L. 1964
Pfitzenmeyer, H. T. 1961

12. Gnathostomulida

13. Rotifera, wheelworms

Bayly, I. A. E. 1967

14. Nematoda, roundworms or eelworms (free-living)

Capstick, C. K. 1959
Chitwood, B. G. 1951
Schuurmans Stekhoven, J. G., Jr. 1936
Timm, R. W. 1952

15. Nematomorpha, including Nectonematoidea

16. Gastrotricha, including Macrodasyoidea

17. Kinorhyncha or Echinodera

18. Acanthocephala, thorny-headed parasitic worms

19. Entoprocta or Calyssozoa

20. Priapulida

21. Echiurida

22. Sipunculida

23. Annelida, segmented worms

1. Oligochaeta, earthworms and allies

Bahl, K. N. 1947

2. Polychaeta, marine annelids

Amos, W. H. 1957
Dales, R. P. 1951, 1967
Estcourt, I. N. 1967
Hempel, C. 1957
Hill, M. B. 1967
Klesch, W. L. 1970

Loosanoff & Engle 1943
Muus, B. J. 1967
Pfitzenmeyer, H. T. 1961
Sandison & Hill 1966
Smith, R. I. 1953 1955a,b,c; 1956; 1963a,b; 1964a,b

24. Bryozoa (Ectoprocta)

Brattstrom, H. 1954
Mastenbroek, N. van 1927
Maturo, F. J. S., Jr. 1959

25. Phoronida

26. Brachiopoda, lamp shells

27. Mollusca

0. Mollusca in general

Boettger, C. 1950
Davis & Williams 1950
Kessel, H. 1961
Parker, R. H. 1956, 1960
Warme, J. E. 1971

1. Amphineura, chitons and allies

2. Gastropoda, snails, conchs, whelks, drills, limpets, etc.

Andrews, E. A. 1940
Archer, A. F. 1947
Broekhuysen, G. J. 1940
Burkenroad, M. D. 1931
Butler, P. A. 1953
Carriker, M. R. 1955
Den Hartog, C. 1963
Ellis, A. E. 1932
Federighi, H. 1930, 1931
Fischer-Piette, Gaillard & Delmas 1966
Fraser, J. H. 1931
Haskin, H. H. 1936, 1938
Haskin, Krueger & Tweed 1971
Ladd, H. S. 1951
Mars, P. 1950
Moore, H. F. 1911
Moore & Pope 1910
Muus, B. J. 1963, 1967
Nelson, T. C. 1923
Newell, R. 1964
Packard, E. L. 1918
Paulus, M. 1942
Peterson, W. 1967
Pfitzenmeyer, H. T. 1961
Puffer & Emerson 1953
Ritter, H. P. 1896
Robson, G. C. 1920
Roughley, T. C. 1922, 1925
Russell, H. D. 1941
St. Amant, L. S. 1961
Stauber, L. A. (Circa 1943)
Walne, P. R. 1956b
Wells, H. W. 1958
Wells & Gray 1960
Wood, E. J. F. 1948

3. Pelecypoda, bivalves (oysters, scallops, clams, mussels)

Allen, J. F. 1960
Amemiya, I. 1928
Andrews, J. D. 1964
Andrews, Haven & Quayle 1959
Anonymous 1931, 1945, 1946, 1947
Archer, A. F. 1947
Atwater, W. O. 1888
Awati & Rai 1931
Baird, R. H. 1966
Bayne, B. L. 1965
Beaven, G. F. 1955
Becker, G. 1959
Blum, H. F. 1922
Burton, R. W. 1963
Butler, P. A. 1949a,b; 1953; 1954
Carriker, M. R. 1951, 1959
Cary, L. R. 1906a,b; 1907a,b
Castagna & Chanley 1966
Churchill, E. P. 1920
Conger, P. S. 1953
Copeland & Hoese 1966
Danglade, E. 1919
Dannevig, A. 1946
Darnell, R. M. 1958
Dawson, C. E. 1955
Dean, B. 1893

Dees, Mrs. 1949
Delchamps, J. 1896
Dunnington, E. A. 1956
Engle, J. B. 1948
Fenchel, T. 1965
Fleming, C. A. 1952
Fox, D. 1936
Frey, D. G. 1946
Gaarder & Sparck 1932
Galtsoff, P. S. 1930, 1931, 1964
Galtsoff, Chipman, Engle & Calderwood 1947
Galtsoff, Chipman, Hasler & Engle 1938
Galtsoff & Prytherch 1927
Gates, W. H. 1907
Gillard, R. M. 1969
Glaser, O. 1904
Green, J. 1957
Gunter, G. 1942, 1951, 1953, 1955, 1967
Gunter & Shell 1958
Hatai, S. 1930
Hepper, B. T. 1955
Higgins, E. 1931, 1933, 1936, 1937, 1940
Hill & Kofoid 1927
Hoese, H. D. 1959
Hopkins, A. E. 1931, 1937
Hubby, T. E. 1926
Ingle, R. M. 1950
Ingle & Smith 1949
Iversen, E. S. 1968
James, M. C. 1946
Kajikawa, Sano & Soguri 1953
Kellogg, J. L. 1905, 1910
Kesteven, G. L. 1947
Kofoid, Miller, Lazier, Dore, Blum & Van Slyke 1927
Korringa, P. 1957, 1967
Krakatitsa, T. F. 1968
Kuenzler, E. J. 1961
Ladd, H. S. 1951
Loosanoff & Engle 1943
Lunz, G. R. 1938
Mackin, J. G. 1951, 1962
Mackin & Hopkins 1962
Maddox, N. T. 1949
Maksimova, L. P. 1964
Manning & Whaley 1955
Mars, P. 1950
Marshall, N. 1954
Martin, R. C. 1926
Matthiessen, G. C. 1960
McErlean, A. J. 1964
McHugh, J. L. 1966
Medcof, J. C. 1944, 1961
Medcof & Needler 1941
Menzel, R. W. 1954, 1955
Menzel, Hulings & Hathaway 1958
Meyer & Mann 1951
Miller, R. C. 1926
Moore, H. F. 1898, 1899, 1911
Moore & Pope 1910
Muus, B. J. 1967
Neily, Kirkbride, Mattos, Squire & Hill 1927
Nelson, T. C. 1921, 1923, 1928
Newcombe, C. L. 1935
Nichy & Menzel 1962
Noor-Vodin 1967
Norton, O. A. 1947
Oemler, A. 1894
O'Hara, J. A. 1930
O'Heeron, M. K., Jr. 1966
Orton, J. H. 1937
Owen, H. M. 1953
Packard, E. L. 1918
Paulus, M. 1942
Pearse & Wharton 1938
Peterson, G. H. 1958
Pfitzenmeyer, H. T. 1961, 1962
Pfitzenmeyer & Drobeck 1963
Pillay, T. V. R. 1967b
Prytherch, H. F. 1934
Puffer & Emerson 1953
Ranson, G. 1943
Rathbun, R. 1895
Ray, S. M. 1965
Ritter, H. P. 1896
Roughley, T. C. 1922, 1925, 1933
Rucker & Valentine 1961
Runnegar & Newell 1971
Sandison & Hill 1966

Sato & Craig 1948
Scheltema & Truitt 1954, 1956
Sieling, F. W. 1971
Sieling, Otto & Rosenfield 1969
Sprague, Dunnington & Drobeck 1969
Stafford, J. 1913
St. Amant, L. S. 1961
Stead, D. G. 1907
Stenzel, H. B. 1971
Swift, F. 1897
Tebble, N. 1966
Trahms, O.-K. 1939
Truitt, R. V. 1946
Ursin, E. 1956
U. S. Congress 1947
Vatova, A. 1962
Verwey, J. 1952
Villadolid & Villaluz 1938
Viosca, P., Jr. 1937
Wakiya, Y. 1929
Wallace, D. H. 1966, 1971
Warburton, F. E. 1958
Waugh, G. D. 1953
Wells, H. W. 1957; 1958; 1959b; 1961
Wells & Gray 1960
Wilson, B. R. 1968, 1969
Winslow, F. 1886
Wolfe, D. A. 1971
Wood, E. J. F. 1948
Worsnop & Orton 1923
Yonge, C. M. 1960

28. Crustacea

0. Crustacea in general

Bayly, I. A. E. 1967
Crawford, G. I. 1937b
Cronin, Daiber & Hulbert 1962
Cuzon du Rest, R. 1963
Davis & Williams 1950
Green, J. 1961
Hopkins, T. L. 1966

1. Anostraca, fairy shrimps

Gillespie, Wirick & Stephens 1971

2. Cladocera, water fleas

Barlow, J. P. 1955
Goodwyn, F. 1968
Lint, G. M. de 1924

3. Copepoda, copepods

1. Free-living copepods

Bary, B. M. 1963, 1964
Battaglia, B. 1967
Bayly, I. A. E. 1963, 1964
Conover, R. J. 1956
Galhano, M. H. 1970
Giere, O. 1968
Grindley, J. 1964
Gurney, R. 1931
Heinle, D. R. 1972
Henderson, J. C. 1958
Herman, S. S. 1968
Hodgkin & Rippingale 1971
Jeffries, H. P. 1962a,b,c; 1967
Johnson, M. W. 1939
Lindquist, A. 1959
Lint, G. M. de 1924
Marcus, A. 1970
Niemi, A. 1971
Rahm, W. 1964
Riley, G. A. 1967
Tash & Armitage 1967
Ward, Vreeland, Southwick & Reading 1965
Woodmansee, R. A. 1958

2. Parasitic copepods

Hepper, B. T. 1955
Meyer & Mann 1951

4. Ostracoda, seed shrimps

Barker, D. 1963
Elliott, Ellison & Nichols 1966
Hagerman, L. 1969
Lint, G. M. de 1924

5. Cirripedia, barnacles and allies

Barnes & Barnes 1961
Bookhout & Costlow 1959
Bousfield, E. L. 1955
Henry, D. 1959
Moore, H. B. 1935
Pilsbry, H. A. 1916
Pyefinch, K. A. 1950
Sandison & Hill 1966
Shatoury, H. H. A. 1958

6. Nebaliacea

7. Mysidacea and Cumacea

1. Mysidacea, opossum shrimps

Bowman, T. E. 1964
Heubach, W. 1969
Hodge, D. 1963, 1964
Hopkins, T. L. 1958
Hulburt, E. M. 1957
Jørgensen, O. 1929
Kinne, O. 1955
Kofoid, Miller, Lazier, Dore, Blum & Van Slyke 1927
Martin, R. C. 1926
Pesta, O. 1935
Tattersall, W. M. 1932

2. Cumacea

Jones & Burbanck 1959

8. Isopoda, isopods

Burbanck, W. D. 1959, 1961, 1962, 1967
Hill & Kofoid 1927
Kofoid, Miller, Lazier, Dore, Blum & Van Slyke 1927
Menzies & Frankenbury 1966
Miller, R. C. 1926
Miller & Burbanck 1961
Naylor & Haahtela 1966
Naylor, Slinn & Spooner 1960
Neily, Kirkbride, Mattos, Squire & Hill 1927

9. Amphipoda, amphipods, side-swimmers, beach fleas, etc.

Bassindale, R. 1942
Beadle & Cragg 1940
Crawford, G. I. 1937a,b
Croker, R. A. 1968
Gee, J. M. 1961
Goodhart, C. B. 1941
Hart, T. 1930
Hynes, H. B. N. 1954, 1955
Jones, N. S. 1948
Kinne, O. 1959
Marine Biol. Assoc. U. K. 1949
McLusky, D. S. 1968
Muus, B. J. 1967
Segerstråle, S. G. 1947
Serventy, D. L. 1935
Sexton & Spooner 1940
Spooner, G. M. 1947
Stock, J. H. 1952
Sutcliffe, D. W. 1967

10. Stomatopoda, mantis

11. Decapoda, 10-legged higher crustaceans

0. Decapoda in general

Anonymous 1945
Chin, E. 1961
Gunter, G. 1950
Gunter & Shell 1958
Johnson, D. S. 1965
Massmann, W. H. 1971
McHugh, J. L. 1966
Pillay, T. V. R. 1967b
Williams, A. B. 1964

1. Decapoda Natantia, true shrimps, prawns

Anderson, King & Lindner 1949
Barth & Da Costa 1968
Chambers & Sparks 1959
Darnell, R. M. 1958
Gunter, G. 1937, 1950, 1956, 1967
Gunter, Christmas & Killebrew 1964
Gunter & Hildebrand 1954
Gurney, R. 1923
Hall, D. N. F. 1962
Harper, D. E., Jr. 1968
Havinga, B. 1930
Hedgpeth, J. W. 1968
Hildebrand, H. H. 1954
Hoese, H. D. 1960
Holthuis, L. B. 1952
Kutkuhn, J. H. 1966
Lindner & Anderson 1956
Lloyd & Yonge 1947
Parker, J. C. 1970
Parry, G. 1961
Price, K. S., Jr. 1961, 1962
Rajyalakshmi, T. 1961
Reid, G. K. 1956, 1957
Rounsefell, G. A. 1964
St. Amant, L. S. 1961
Stephens, W. 1968
Weymouth, Lindner & Anderson 1933
Williams, A. B. 1955
Williams & Deubler 1968
Wood, C. E. 1967

2. Decapoda Reptantia, crawling decapods

1. Astacura, lobsters, and crayfishes

2. Palinura, spiny lobsters, rock lobsters, sea crawfish

3. Brachyura, true crabs

Anonymous 1944
Barnes, R. S. 1967
Bauchau, A. 1966
Beach, N. W. 1969
Broekhuysen, G. J. 1936
Brues, C. T. 1917
Chambers & Sparks 1959
Churchill, E. P. 1919
Cronin, Van Engel, Cargo & Wojcik 1957
Crothers, J. H. 1969
Darnell, R. M. 1958, 1959
Daugherty, F. M., Jr. 1952
Gunter, G. 1938
Hildebrand, H. H. 1954
Jaworski, E. 1970
Kerwin, J. A. 1971
Lucas, J. S. 1971
Lunz, G. R. 1958

More, W. R. 1969
Newcombe, C. L. 1945
Ono, Y. 1959, 1965
Pearse, A. S. 1929a,b
Pearson, J. C. 1948
Porter, H. J. 1955, 1956
Rogers-Talbert, R. 1948
Rounsefell, G. A. 1964
Ryan, E. P. 1956
Say, T. 1817
Shaw, J. 1959
Snelling, B. 1959
Tagatz, M. E. 1968a,b
Tagatz & Hill 1971
Teal, J. M. 1958
Van Engel, W. A. 1958
Walker, K. 1969

29. Insecta

0. Insects in general

Bayly, I. A. E. 1967

1. Diptera, flies, gnats, mosquitos

Gillespie, Wirick & Stephens 1971
Knight, L. 1965
Lamb, K. P. 1961
Stuart, T. A. 1941

2. Hemiptera, true bugs

3. Coleoptera, beetles

BroLarsen, E. 1951

4. Odonata, dragonflies

Wright, M. 1943

30. Arthropoda, Arachnida

1. Acarina, mites

31. Tardigrada, water bears

32. Echinodermata, starfishes and allies

0. Echinoderms in general

Binyon, J. 1966

1. Asteroidea, starfishes

Binyon, J. 1961
Brattstrom, H. 1941
D'Iakonov, A. M. 1955
Mileikovskii, S. A. 1968
Tortonese & Demir 1960
Warme, J. E. 1971

2. Ophiuroidea, serpent stars, brittle stars

D'Iakonov, A. M. 1955
Tortonese & Demir 1960
Zenkevitch, L. A. 1957

3. Echinoidea, sea urchins, sand dollars

Tortonese & Demir 1960

4. Holothuroidea, sea cucumbers

Bacesco & Margineanu 1959
Cherbonnier, G. 1960
Pfitzenmeyer, H. T. 1961
Zenkevitch, L. 1963

33. Chaetognatha, arrow worms

Bary, B. M. 1963, 1964
Pierce, E. L. 1962

34. Pogonophora, bearded worms

35. Hemichordata, Enteropneusta, acorn worms

36. Chordata, animals with notochords, gill slits, and dorsal nerve cords

1. Urochordata, sea squirts and allies

Barrington, E. J. W. 1965
Dybern, B. I. 1967, 1969

2. Cephalochordata, lancet fish, toothpick fish, "amphioxus"

Webb, J. E. 1956, 1958

3. Vertebrata, animals with backbones

1. Cyclostomes, lampreys and hagfish

Gunter, G. 1942

2. Elasmobranchs or Salachians, sharks, skates, rays, sawfish

Gunter, G. 1938a,d; 1942a; 1956a; 1967b

3. Holocephalans or chimaeroid fishes

4. Osteichthyes (mostly Teleostei), bony fishes

Arnold & Thompson 1958
Barans, C. A. 1972
Bayowmi, A. R. 1969
Breder, C. M., Jr. 1933, 1934
Bromhall, J. D. 1954
Caldwell, D. K. 1955
Callamand, O. 1943
Chadwick, H. K. 1971
Chambers & Sparks 1959
Chin, E. 1961
Copeland, B. J. 1967
d'Ancona, U. 1954
Daribaev, A. K. 1967
Darlington, P. J., Jr. 1957
Darnell, R. M. 1958, 1962
Devanesan & Chacko 1943
Dovel, Mihursky & McErlean 1969
Durve & Alagarswami 1964
Gunter, G. 1938a,b,d; 1942a; 1945; 1947b; 1956a; 1957; 1961; 1967
Gunter & Hall 1963
Gunter & Shell 1958
Hartley, P. H. T. 1939
Haven, D. S. 1957
Hellier, T. R., Jr. 1962
Herre, A. W. C. T. 1929
Hickling, C. F. 1970
Hoese, H. D. 1958, 1959
Hopkins, S. H. 1969
Hubbs, C. 1961
Huntsman, A. G. 1918
Iversen, E. S. 1968
Jeffries, H. P. 1960
Karpevich, A. F. 1955
Kelly & Turner 1966
Keup & Bayless 1964
Kilby, J. D. 1955
Korringa, P. 1967
Lane, E. D. 1967
Lewis, R. M. 1967
Mansueti, R. J. 1961, 1962, 1964
Massmann, W. H. 1954, 1971
McHugh, J. L. 1966
McKenzie, R. A. 1959
Moody, W. D. 1949
Muncy, R. J. 1962

Myers, G. S. 1938, 1949
Nazarov & Chepurnova 1969
Nichols, J. T. 1928
Norcross, Massmann & Joseph 1961
Panikkar, N. K. 1951
Parry, G. 1966
Pearcy, W. G. 1962
Pearcy & Richards 1962
Pillay, T. V. R. 1966a,b; 1967a,b
Prost, M. 1959
Randall, J. D. 1958
Rawson, D. S. 1946
Redeke, H. C. 1939
Reid, G. K. 1954, 1955, 1956, 1957
Reid & Hoese 1958
Reintjes & Pacheco 1966
Riggs, C. D. 1957
Schwartz, F. J. 1964
Simmons, E. G. 1957
Simmons & Breuer 1962
Smirnov, A. N. 1969
Stroud, R. H. 1971
Tabb, D. C. 1958, 1966
Talbot, G. B. 1966
Teplova, E. P. 1961
Tesch, F. W. 1968
Thomson, J. M. 1961, 1966
Vatova, A. 1962
Venkateswarlu, T. 1967
Whatley, E. C. 1969
Williams & Deubler 1968
Zalumi, S. G. 1967
Zilberberg, M. H. 1966

5. Amphibia, frogs, toads, salamanders

Dunson & Ehlert 1972

6. Reptilia, snakes, lizards, turtles, crocodiles, alligators

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2a. REPORT SECURITY CLASSIFICATION

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References with annotations are given for about 1400 published and unpublished reports, dated 1972 and earlier, on physiological and ecological effects of salinity, salinity differences, and changes in salinity on organisms living in estuaries and other coastal waters. A subject index with cross-indexing is provided.

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