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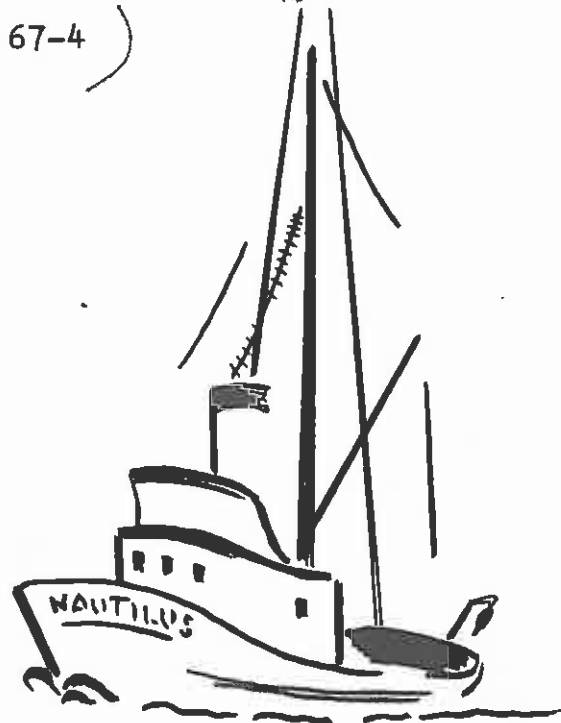
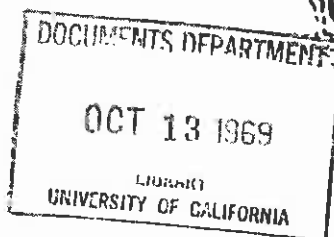
State of California
THE RESOURCES AGENCY
Department of Fish and Game,
Marine Resources Operations

BIOLOGICAL SURVEY
OF
SAN FRANCISCO BAY,
1963-1966

by J. A. Aplin

(MRO Reference No. 67-4)

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Marine Resources Operations Laboratory
411 Burgess Drive, Menlo Park
California
June 15, 1967

State of California
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TABLE OF CONTENTS

	Page
Summary	ii
Acknowledgments	ii
Introduction	1
Procedure	2
Fishes	, 8
Invertebrates	95
Zooplankton	106
Intertidal Sampling	111
Mammals	117
Salinity and Temperature	117
Discussion	123
Selected List of Papers	130

SUMMARY

The Biological Survey of San Francisco Bay for the years 1963, 1964, 1965, and 1966, using special sampling methods, yielded data on organism occurrence. More than 500 trawl net tows were made; temperature and salinity data were recorded; invertebrates at ten selected shore stations were observed; and about 100 bottom substrate samples and 100 plankton tows were studied. A total of 70 species of fish (510,877 individuals) and 80 species of larger invertebrates was collected. Although much of San Francisco Bay is relegated to waste disposal, the variety and abundance of animals occurring over many square miles of the bay indicate an area of high biological productivity.

ACKNOWLEDGMENTS

The author expresses his gratitude to Pauline McMasters, San Jose State College, for work on invertebrates. Thanks are also due to Walter Schneebeil, Steinhart Aquarium, for his assistance in sorting and identification of fish, and to H. G. Orcutt, California Department of Fish and Game, for assistance with the manuscript.

INTRODUCTION

San Francisco Bay stands as a geographical entity and is one of California's major natural resources. The bay is several hundred square miles in area, 75 percent of which is publicly owned, and represents 8 counties and 68 municipalities. As a consequence, conservation planning is extremely complicated. At present, the area around the bay has a population of four million people, and this is rapidly increasing.

The waters of San Francisco Bay in past years have yielded living marine resource harvests of considerable magnitude. The oyster, clam, smelt, herring, shrimp, and sport fisheries each has been, or is now of major consequence (Table 1). When these fisheries are combined, they represent a possible harvest of millions of pounds. The potential for this production still remains, and may be realized through proper management.

TABLE 1
Peak Landings of Selected Species,
San Francisco Bay

Species	Pounds	Year
Clam, soft shell	302,000	1919
Herring, Pacific	4,733,000	1918
Oyster, eastern	2,000,000	1916
Shrimp, bay	3,000,000	1929
Smelt	462,000	1945

Sport fishing in San Francisco Bay is very popular. Anglers frequent the piers at Sausalito, San Francisco, Oakland, and Berkeley; shore fishermen cast from selected sites along both sides of the bay; angling is popular from partyboats and skiffs; and clammers dig at several locations. Much effort is expended for striped bass, salmon, perch, and flounder. In addition, jacksmelt,

rockfish, and shark are available in sufficient numbers to attract many fishermen. The most sought shellfish are littleneck, gaper, and soft shell clams.

In recent years, the Department of Fish and Game has been asked frequently to give economic or biological evaluations concerning extensive dredge, fill, and waste disposal operations that are underway or planned for San Francisco Bay. Any long term management plan for the bay must consider the effects of domestic and industrial wastes from the greater bay area (San Pablo and San Francisco Bays) upon the flora and fauna. Basic to the solution of management problems is a knowledge of the organisms existing in the area.

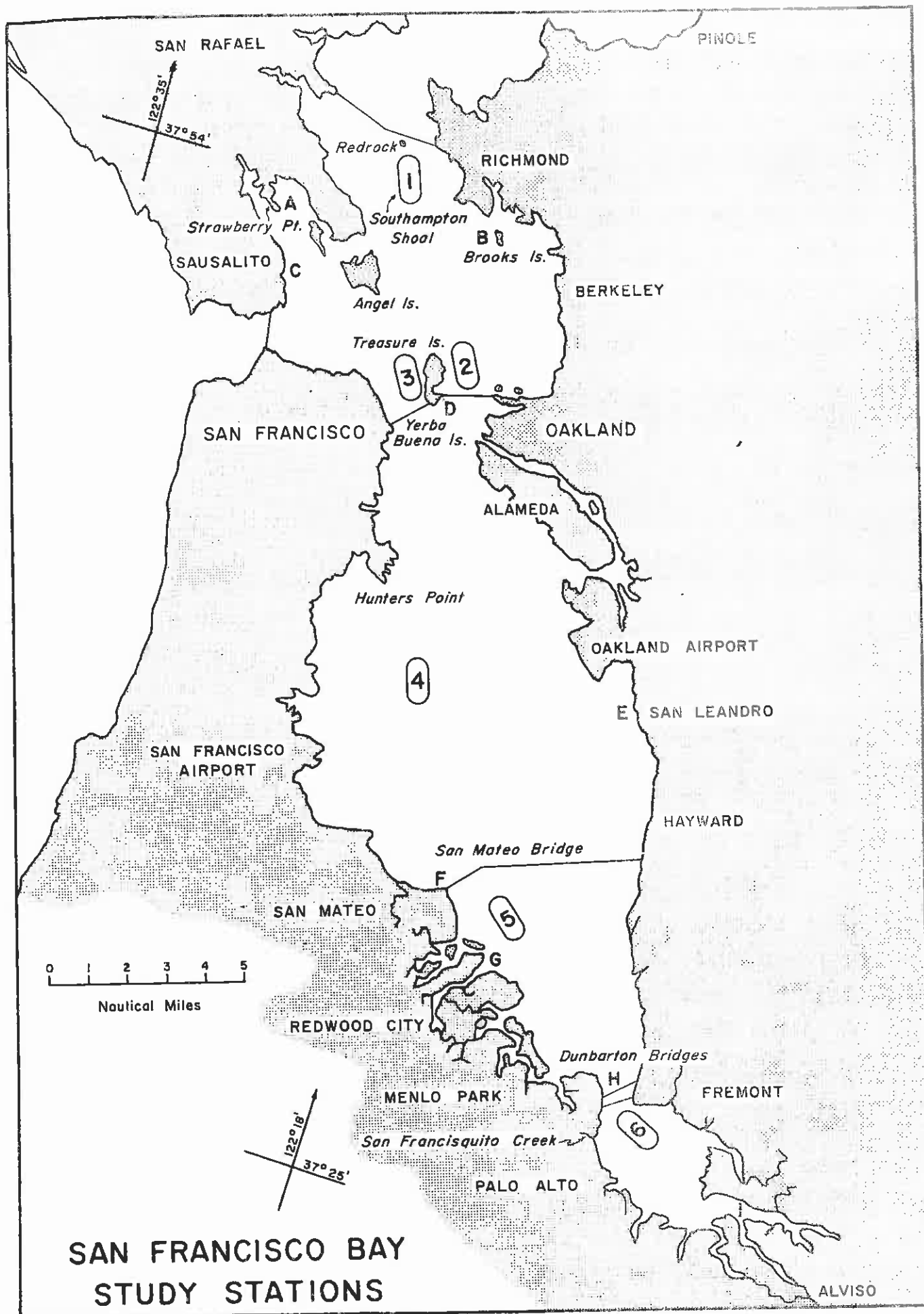
In February 1963, Marine Resources Operations, Menlo Park, initiated a biological study to determine distribution and relative abundance of fish and invertebrates in major ecological zones of the channels of San Francisco Bay.

PROCEDURE

This study established six fish sampling stations which represent a wide variation of environmental conditions ranging from essentially ocean water to brackish water, which in some areas is contaminated from industrial and domestic sources (Figure 1).

The Department of Fish and Game 50 foot research vessel, NAUTILUS, was used to sample each station each month with the following exceptions: January and July 1963, January and July 1964, February 1965, and May and July 1966. At each station we undertook the following activities: (Figures 2 - 3)

1. A ~~25~~-foot square-mouthed midwater trawl was towed for 20 minutes at the surface. The corners of the net were spread by four "doors" each about 18 inches square. This net normally has a 15-foot square fishing spread. The cod end is of 1/2-inch stretched mesh which is capable of catching fish as small as 1 inch long. At the limited depths found



SAN FRANCISCO BAY STUDY STATIONS

Figure 1

in the bay, adequate collections could be made within 20 feet of the surface without the hazard of snagging the net on the bottom. This net is best suited to take schooling pelagic fishes and is not designed for contact with the bottom (Figure 2).

2. A 10-foot beam trawl with a 1 inch stretched mesh net was used in 1963. This net, mounted on a steel frame with sled runners, fished an area 4 feet high and 10 feet wide, and as it slid along the bottom, often collected oyster shells or mud. However, the heavy beam made handling difficult, so the bottom sampling has been done with a 15-foot otter trawl since March 1964. A bottom trawl was towed for 20 minutes, and duplicate tows frequently were made to check consistency of collections. This net was most effective in catching flatfish and other bottom dwellers. Many of the invertebrates were collected with this net (Figure 3):
3. During 1963, bottom samples were collected with a 100 cubic-inch orange peel dredge, frozen aboard the vessel, and later examined for invertebrates by specialists at San Jose State College.
4. Surface plankton tows of 20 minutes duration were made in 1963 with a net of 28 mesh per inch and a 1/2 meter mouth. Plankton samples were submitted to San Jose State College for sorting and identification.
5. Temperatures and salinities at the surface were taken by bucket thermometer and extended-scale hydrometers. Bottom water temperatures and salinities were taken of water collected with Van Dorn type sampler. At the shallow station (No. 6), only surface observations were made. Temperature was determined to 0.1°C and salinities to 0.1 parts per thousand.

In addition to the regular station samples, a series of consecutive bottom trawls was made from one mile south of Carquinez Bridge to the south end of the bay. The species composition of the catches indicated the sampling stations were representative of their respective parts of the bay. Occasionally, tows had to be discarded due to gear malfunction or too many fish to haul aboard. Others were recorded for tests of sample replication, but not included in the totals for comparison. Surface water dwelling species were frequently caught in bottom tows when the net was on the way down or coming up.

Seven daytime sets with a trammel net were also made. This netting produced catches that were not significantly different from those of the bottom-trawl sampling.

Following is a brief description of each station.

Station 1, from Redrock to the Navy's degaussing range pylon at the south end of Southampton Shoal, is roughly three miles long and includes Redrock Shoal, averaging about 25 feet in depth, and Southampton Shoal averaging 17 feet. The substrate is coarse sand and shells, and frequently bottom trawls scoop up large quantities of loose, empty oyster shells. The deeper water of the ship channels on each side of Redrock Shoal cause strong currents which may be as great as 2.0 knots. The Sacramento-San Joaquin drainage passes this station, so of all the stations, it has the greatest amount of fresh water mixing with seawater. As a consequence, such fishes as carp and two species of sturgeon appeared only at this station. Freshwater flows often kill large numbers of salt-water shellfish such as littleneck clams.

Station 2 extends about two miles north and south along the east side of

the channel east of Treasure Island. Both ends of this station are only 12 feet deep, but there is a deep area of over 40 feet in the middle. This deep spot is the result of the removal of sand fill material to build Treasure Island. The fish congregated here, and catches were consistently good. Fish peculiar to this station were white spot greenling, rock greenling, kelp greenling, and cabezon. This station produced the maximum number of species, 17, in 1963. Sea pens were abundant, and some tows brought up dozens caught on the trawl warps. Current velocity here reaches 2.5 knots. Salinity reflects that of the open ocean.

Station 3, on the west side of Treasure Island, receives the largest volume of ocean water and the most rapid flows which reach 3.3 knots. The bottom is sand, and water depth averages 60 feet. There are generally larger fish here. This station produced the largest number of fish in 1964 and 1965.

Station 4 is in the center of the widest part of the bay. The bottom is composed of shell fragments which make good attachment for large numbers of hydroids. The biomass of the hydroid, Obelia dichotoma, amounts to many tons in this area. Native oysters are plentiful and the whelk, Busycon canaliculatum, which was introduced from the Atlantic with oyster seed, is commonly picked up in the otter trawl. Tidal flow at this location reaches a peak of 2.0 knots. This station produced the least fish in 1963 and 1964.

Station 5 is in the central channel with a mile of shallow water on all sides. The bottom is mostly soft mud and frequently several hundred pounds of mud were scooped up by the otter trawl. This station produced the least fish and the fewest species in 1964. Temperatures of this part of the bay are generally several degrees warmer than at the Golden Gate. Flow velocities reach a maximum of 2.0 knots.

At Station 6, at the south end of the bay, the Nautilus operations were limited to the buoyed channel two miles south of the Dumbarton Bridge. Over the extensive mud flats on each side, the shallow layer of water warms quickly and diatoms multiply in great numbers. Considerable waste water from surrounding cities enters the south bay. This combined with the fresh water from Coyote Creek at Alviso and San Francisquito Creek at Menlo Park keeps the salinity at about the mean of the other stations. Tidal flows at the Dumbarton Bridge reach a maximum of 2.0 knots. Maximum temperatures of over 21°C were recorded. Pacific oysters, spawned from plants made in 1958, are still living in the area, which indicates water quality has not fallen to a lethal level since then. Each year sampled, this station produced more fish than either Station 4 or 5 nearer the bay entrance (Tables 4, 5, and 6). Thirty species of fish were taken at this station. A small run of steelhead passes through this area to ascend San Francisquito Creek.

FISHES

A total of 510,877 fish (Table 2), representing 70 species (Table 3), were collected during the four years of sampling. Anchovies were both more numerous and greater in total weight than all other species combined. Several times an anchovy haul was over one thousand pounds and could not be hauled aboard. On April 24, 1964, feeding schools of anchovies south of the Dumbarton Bridge were estimated to contain several hundred tons of fish. The wide variation in total number of fish taken at each station (Table 2) indicates that all are very productive and none is consistently high or low as compared to the others. Comparisons of gross numbers of fish (Tables 4, 5, 6, and 7) give a general productivity measure. A more meaningful comparison of the particular sample areas is the number of species taken at each station (Tables 8, 9, 10, and 11). A variety of fish is an indication of a more desirable

TABLE 2

Total Numbers of Fish Taken at the Six Sampling Stations of the
San Francisco Bay Survey, 1963-1966

Station	1963	1964	1965	1966	Totals
1	6,992	17,293	28,655	6,323	59,263
2	16,206	27,801	36,562	17,127	97,696
3	6,656	29,094	148,430	4,428	188,608
4	5,346	5,402	18,500	15,410	44,658
5	17,015	7,372	13,581	12,677	50,645
6	23,221	12,194	27,488	7,104	70,007
Totals	75,436	99,156	273,216	63,069	510,877

TABLE 3

Species of Fish Taken in San Francisco Bay Study, 1963-1965

<u>Common Name</u>	<u>Scientific Name</u>
Anchovy, northern	<u>Engraulis mordax</u>
Bass, striped	<u>Roccus saxatilis</u>
\ Bocaccio	<u>Sebastes paucispinis</u>
Cabezon	<u>Scorpaenichthys marmoratus</u>
Carp	<u>Cyprinus carpio</u>
Croaker, white	<u>Genyonemus lineatus</u>
\ Flounder, starry	<u>Platichthys stellatus</u>
Goby, bay	<u>Lepidogobius lepidus</u>
Goby, bluespot	<u>Coryphopterus nicholsi</u>
Goby, Japanese	<u>Acanthogobius flavimanus</u>
Greenling, rock	<u>Hexagrammos superciliosus</u>
Greenling, whitespotted	<u>Hexagrammos stelleri</u>
Gunnel, saddleback	<u>Pholis ornata</u>
Halibut, California	<u>Paralichthys californicus</u>
Herring, Pacific	<u>Culpea pallasi</u>
Herring, thread	<u>Opisthonema libertate</u>
Irish lord, red	<u>Hemilepidotus hemilepidotus</u>
Jacksmelt	<u>Atherinopsis californiensis</u>
Lamprey, river	<u>Lampetra ayresii</u>
Lingcod	<u>Ophiodon elongatus</u>
Midshipman, northern	<u>Porichthys notatus</u>
Perch, black	<u>Embiotoca jacksoni</u>
Perch, dwarf	<u>Micrometrus minimus</u>
Perch, pile	<u>Rhacochilus vacca</u>

TABLE 3 (con't)

Perch, rubberlip	<u>Rhacochilus toxotes</u>
Perch, shiner	<u>Cymatogaster aggregata</u>
Pipefish, bay	<u>Syngnathus griseolineatus</u>
Poacher, pricklebreast	<u>Stellerina xyosterna</u>
Poacher, pigmy	<u>Odontogobius trispinosa</u>
Pompano, Pacific	<u>Palometa simillima</u>
Ray, bat	<u>Myliobatis californicus</u>
Ray, Pacific electric	<u>Torpedo californica</u>
Rockfish, brown	<u>Sebastes auriculatus</u>
Salmon, king	<u>Oncorhynchus tshawytscha</u>
Sanddab, speckled	<u>Citharichthys stigmaeus</u>
Sand lance, Pacific	<u>Ammodytes hexapterus</u>
Sardine, Pacific	<u>Sardinops caeruleus</u>
Sculpin, bonehead	<u>Artedius notospilotus</u>
Sculpin, Pacific staghorn	<u>Leptocottus armatus</u>
Sculpin, padded	<u>Artedius fenestralis</u>
Sculpin, smoothhead	<u>Artedius lateralis</u>
Seaperch, rainbow	<u>Hypsurus caryi</u>
Seaperch, striped	<u>Embiotoca lateralis</u>
Seaperch, white	<u>Phanerodon furcatus</u>
Shad, American	<u>Alosa sapidissima</u>
Shad, threadfin	<u>Dorosoma petenense</u>
Shark, brown smoothhound	<u>Triakis henlei</u>
Shark, leopard	<u>Triakis semifasciata</u>
Shark, sevengill	<u>Notorynchus maculatus</u>
Shark, spiny dogfish	<u>Squalus acanthias</u>

TABLE 3 (con't)

Skate, big	<u>Raja binocularata</u>
Smelt, night	<u>Spirinchus starksi</u>
Smelt, longfin	<u>Spirinchus thaleichthys</u>
Smelt, surf	<u>Hypomesus pretiosus</u>
Smelt, whitebait	<u>Allosmerus elongatus</u>
Snailfish, showy	<u>Liparis pulchellus</u>
Sole, English	<u>Parophrys vetulus</u>
Sole, sand	<u>Psettichthys melanostictus</u>
Steelhead	<u>Salmo gairdneri</u>
Stickleback, threespine	<u>Gasterosteus aculeatus</u>
Sturgeon, green	<u>Acipenser medirostris</u>
Sturgeon, white	<u>Acipenser transmontanus</u>
Surfperch, barred	<u>Amphistichus argenteus</u>
Surfperch, walleye	<u>Hyperprosopon argenteum</u>
Tomcod, Pacific	<u>Microgadus proximus</u>
Tonguefish, California	<u>Symphurus atricauda</u>
Topsmelt	<u>Atherinops affinis</u>
Turbot, curlfin	<u>Pleuronichthys decurrens</u>
Turbot, diamond	<u>Hypsopsetta guttulata</u>
Turbot, hornyhead	<u>Pleuronichthys verticalis</u>

The names of fishes used are those of the California Department of Fish and Game and the American Fisheries Society lists.

fishing area. Several varieties in each ecological grouping also constitute a more stable gross population by averaging out fluctuations in individual species of fish. Graphic presentation of the sampling of fish 1963-1965 has revealed seasonal variations in number of species taken (Figure 4). May and June peaks approximately coincide with the maximum plankton production, while the lowest points are scattered through the late fall and winter. Monthly catches by station are shown in Tables 4 - 11.

Twenty fish species occurred at all six stations. Listed in order of magnitude of numbers, they were:

- | | |
|-----------------------------|-----------------------------|
| 1. Northern anchovy | 11. Northern midshipman |
| 2. Shiner perch | 12. Topsmelt |
| 3. English sole | 13. California tonguefish |
| 4. Pacific herring | 14. American shad |
| 5. Bay goby | 15. Pile perch |
| 6. Speckled sanddab | 16. Starry flounder |
| 7. Jacksmelt | 17. Bat ray |
| 8. White croaker | 18. Brown smoothhound shark |
| 9. Pacific staghorn sculpin | 19. Spiny dogfish shark |
| 10. Pacific tomcod | 20. Leopard shark |

Six additional species, having wide distribution in the bay, were taken at five of the six stations. These species are walleye surfperch, bay pipefish, striped bass, white seaperch, big skate, and whitebait smelt. A full presentation of the four-year fish profile for the stations is in tabular form (Tables 12-35).

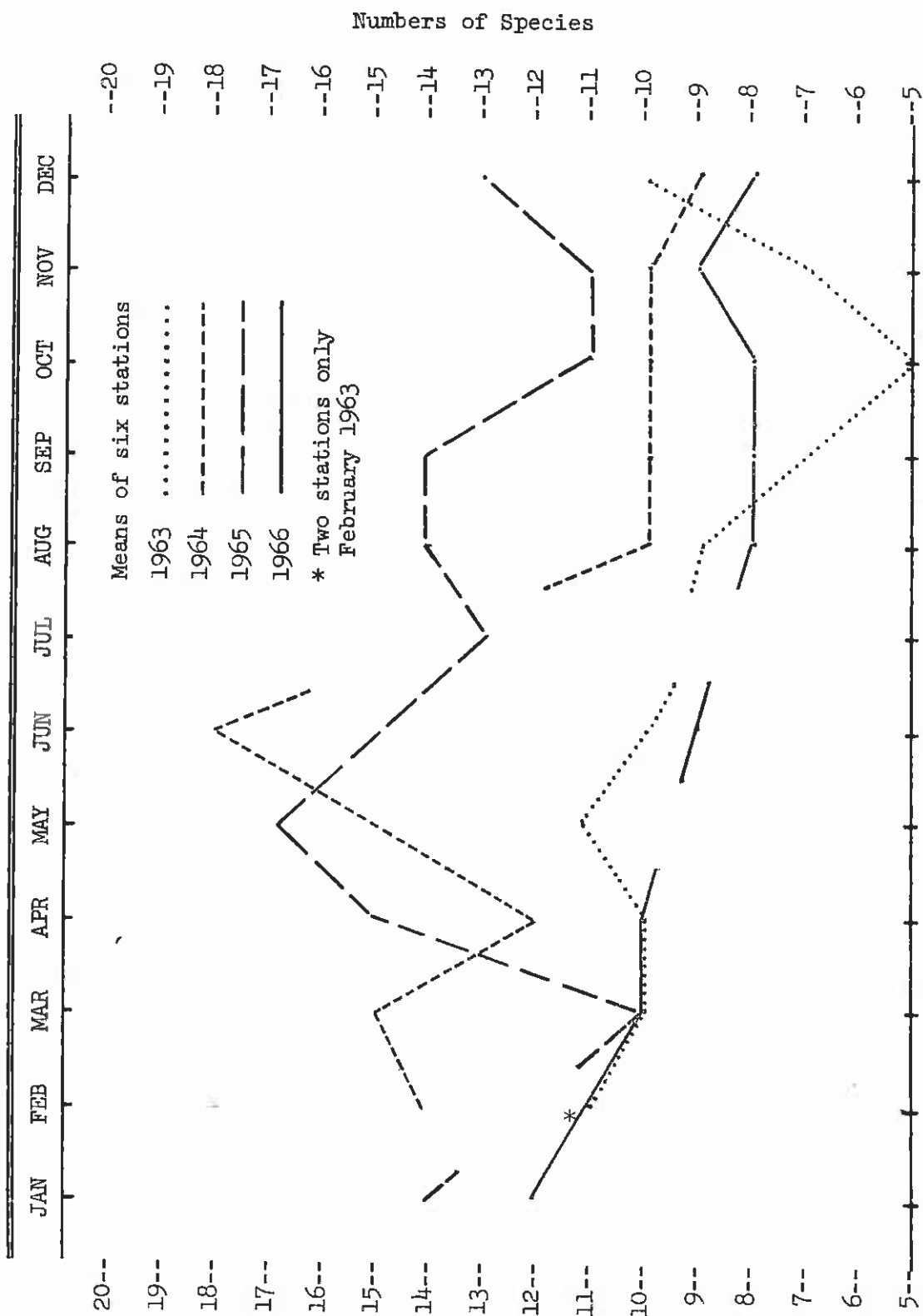


Figure 4. Number of species of fish taken by month, San Francisco Bay Survey, 1963-1966.

TABLE 4
Numbers of Fish Taken at Each Station by Month,
San Francisco Bay Survey, 1963

Stations	Feb	Mar	Apr	May	Jun	Aug	Sep	Oct	Nov	Dec	Mean Per Month
1		584	1558	2270	281	333	147	86	674	1127	772
2		869	1629	2567	1847	1153	2403	239	102	133	1216
3		102	586	2683	332	31	530	599	603	1185	739
4		8	1306	1151	297	1227	1019	71	7	151	582
5	2728	735	309	1632	10187	355	651	48	77	142	1686
6	702	825	3668	914	4185	2091	2530	5004	2025	1291	2324
Mean	1715	521	1509	1876	2855	865	1213	1008	581	672	

TABLE 5

Numbers of Fish Taken at Each Station by Month,
San Francisco Bay Survey, 1964

Stations	Feb	Mar	Apr	May	Jun	Aug	Sep	Oct	Nov	Dec	Mean Per Month
1	540	692	989	1237	9952	455	1495	1561	79	291	1729
2	1079	337	878	1453	11317	1711	5329	1184	712	232	2423
3	1200	642	1028	7004	9599	422	848	5946	2957	22	2966
4	155	491	386	704	780	1470	1139	142	25	148	544
5	206	210	711	1693	296	1584	2029	181	192	226	733
6	139	1054	2360	1272	732	2125	3517	689	188	140	1222
Mean	553	571	1058	2227	5446	1295	2393	1617	692	177	

TABLE 6

Numbers of Fish Taken at Each Station by Month,
San Francisco Bay Survey, 1965

Stations	Jan	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean Per Month
1	435	122	783	1,117	5,496	3,634	635	12,440	3,016	318	659	2,605
2	623	336	1,211	1,338	6,682	11,490	1,777	10,667	276	1,095	1,097	3,327
3	91	257	1,622	101,102	6,658	4,206	10,671	10,837	11,580	175	1,231	13,494
4	246	471	256	10,137	405	578	619	5,304	77	105	302	1,682
5	147	285	260	706	5,226	3,219	2,061	1,055	59	177	386	1,235
6	317	319	616	2,559	467	2,003	10,104	10,114	221	324	444	2,499
Mean	310	298	791	19,493	4,156	4,188	4,311	8,403	2,538	366	687	

TABLE 7

Numbers of Fish Taken at Each Station by Month
San Francisco Bay Survey, 1966

Stations	Jan	Feb	Mar	Apr	Jun	Aug	Sep	Oct	Nov	Dec	Means
1	184	130	340	311	876	2162	1507	315	265	233	632
2	288	59	62	430	1443	23	10169	2308	2112	233	1712
3	329	385	117	103	687	998	1052	471	230	56	443
4	129	52	449	10552	2032	1059	606	250	141	140	1541
5	478	164	534	10423	276	50	303	285	48	116	1268
6	206	62	3027	261	474	269	265	2109	210	221	710
Mean	269	142	755	3680	760	2317	956	501	501	167	

TABLE 8

Numbers of Species Taken at Each Station by Month,
San Francisco Bay Survey, 1963

Stations	Feb	Mar	Apr	May	Jun	Aug	Sep	Oct	Nov	Dec	Mean Per Month
1		11	7	10	10	15	7	4	7	9	9
2		15	5	17	16	17	8	10	7	12	12
3		4	11	16	11	5	10	11	14	12	10
4		7	6	5	11	6	6	4	3	10	6
5	14	8	13	11	7	4	4	1	5	7	7
6	9	14	16	11	5	6	8	3	8	8	9
Mean	11	10	10	11	10	9	7	5	7	10	

TABLE 9
Numbers of Species Taken at Each Station by Month,
San Francisco Bay Survey, 1964

Stations	Feb	Mar	Apr	May	Jun	Aug	Sep	Oct	Nov	Dec	Mean Per Month
1	13	16	18	13	27	7	20	15	9	10	15
2	16	15	12	21	26	16	9	8	6	6	14
3	14	15	6	21	22	10	12	18	18	5	14
4	17	15	12	14	11	11	4	9	6	9	11
5	10	9	14	8	10	3	5	5	11	11	9
6	12	17	12	14	13	13	6	8	11	10	12
Mean	14	15	12	15	18	10	10	10	10	9	

TABLE 10
Numbers of Species Taken at Each Station by Month,
San Francisco Bay Survey, 1965

Stations	Jan	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean Per Month
1	17	15	16	23	21	17	16	22	17	6	8	16
2	11	14	18	17	22	17	14	17	11	18	13	16
3	14	11	17	22	20	15	21	17	20	15	21	18
4	15	5	14	15	17	9	15	8	4	4	14	11
5	14	9	11	11	3	12	7	9	7	12	11	10
6	10	7	11	16	8	6	11	13	9	9	9	10
Mean	14	10	15	17	15	13	14	14	11	11	13	

TABLE 11

Numbers of Species Taken at Each Station by month,
San Francisco Bay Survey, 1956

Station	Jan	Feb	Mar	Apr	Jun	Aug	Sep	Oct	Nov	Dec	Means
1	10	15	15	8	10	7	7	5	11	8	10
2	14	10	10	12	12	10	10	12	11	10	11
3	13	15	10	16	18	13	14	14	8	7	13
4	11	11	8	10	3	7	6	2	7	9	7
5	11	8	7	7	3	7	5	8	9	4	7
6	9	7	8	9	5	5	5	6	7	9	7
Mean	12	11	10	10	9	8	8	8	9	8	

TABLE 12

Numbers of Fish by Species Taken by Month at Station No. 1 During 1963

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Anchovy, northern	✓	✓		500	2000	125	✓	36	11		300	1000
Bass, striped						1						
Bocaccio												
Cabezon												
Carp			1		2							
Croaker, white												
Flounder, starry			2	2		1						
Goby, bay												
Goby, bluespot												
Goby, Japanese												
Greenling, rock												
Greenling, whitespotted												
Gunnel, saddleback					1							
Halibut, California					250	125		4			21	20
Herring, Pacific			19	1001								
Herring, thread												
Irish lord, red			21	42		2		30	40			50
Jacksmelt												
Lamprey, river												
Lingcod												
Midshipman, northern				3	7							
Perch, black												
Perch, dwarf												
Perch, pile								6	2			1

TABLE 12 (con't)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Perch, rubberlip	A	A	16		3		A					45
Perch, shiner												
Pipefish, bay								1				
Poacher, pigny												
Poacher, pricklebreast												
Pompano, Pacific								10				
Ray, bat												
Ray, Pacific electric												
Rockfish, brown												
Salmon, king					1	1		2			2	1
Sanddab, speckled			325	9		10			10	30	50	
Sand lance, Pacific												
Sardine, Pacific												
Sculpin, bonehead						3			8	3	2	
Sculpin, Pacific staghorn												
Sculpin, padded												
Sculpin, smoothhead												
Seaperch, rainbow												
Seaperch, striped												
Seaperch, white						1					1	1
Shad, American												
Shad, threadfin												
Shark, brown smoothhound			2									
Shark, leopard												
Shark, sevengill												
Shark, spiny dogfish												
Skate, big				1							1	

TABLE 13

Numbers of Fish by Species Taken by Month at Station No. 2 During 1963

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Anchovy, northern			67	604	1000	500	A	6			50	2C
Bass, striped			2									
Bocaccio												
Cabazon						2		4				
Carp												
Croaker, white												
Flounder, starry			2		1			5	20	5		
Goby, bay												
Goby, bluespot												
Goby, Japanese					2							2
Greenling, rock												
Greenling, whitespotted												
Gunnel, saddleback												
Halibut, California			56	1000	1000	1000	+	30		1	8	6
Herring, Pacific							+					
Herring, thread												
Irish lord, red			36	23	7	20		50	17	25	37	
Jacksmelt												
Lamprey, river												
Lingcod			1					1	8			1
Midshipman, northern			3		20			1				
Perch, black												
Perch, dwarf					2			2				
Perch, pile				1	2			1				3

TABLE 14

Numbers of Fish by Species Taken by Month at Station No. 3 During 1963

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Anchovy, northern	✓	✓		1	200	5	✓	2	51		110	15
Bass, striped												
Bocaccio												
Cabezon												
Carp						3					2	
Croaker, white												
Flounder, starry					10	1			12	6	3	10
Goby, bay	✓	✓					✓					
Goby, bluespot	✓	✓					✓					
Goby, Japanese	✓	✓					✓					
Greenling, rock	✓	✓					✓					
Greenling, whitespotted	✓	✓					✓					
Gunnel, saddleback	✓	✓					✓					
Halibut, California	✓	✓				250	✓	10				15
Herring, Pacific	✓	✓	1	500	2000		✓					
Herring, thread	✓	✓	57				✓					
Irish lord, red	✓	✓	45	43	4	2	✓	6	66	25	8	75
Jacksmelt	✓	✓					✓					
Lamprey, river	✓	✓					✓					
Lingcod	✓	✓					✓					
Micshipman, northern	✓	✓		1	10	2	✓			2		
Perch, black	✓	✓					✓				1	4
Perch, dwarf	✓	✓					✓					
Perch, pile	✓	✓					✓					

TABLE 14 (con't)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Smelt, night	✓	✓					✓					
Smelt, longfin												
Smelt, surf												
Smelt, whitebait								12				
Snailfish, showy					200	20	✓		300	300	200	1000
Sole, English												
Sole, sand					7		✓				1	
Steelhead												
Stickleback, threespine												
Sturgeon, green												
Sturgeon, white												
Surfperch, barred												
Surfperch, walleye												
Tomcod, Pacific					10	17		1	13	1	2	2
Tonguefish, California					24	6				8	1	3
Topsmelt												
Turbot, curlfin					2	1						
Turbot, diamond												
Turbot, hornyhead	✓	✓					✓					

TABLE 15

Numbers of Fish by Species Taken by Month at Station No. 4 During 1963

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Anchovy, northern	✓		1200	600		1000	✓	1000	51	1	100	30
Bass, striped		1										
Bocaccio												
Cabazon												
Carp					2				1			
Croaker, white												
Flounder, starry				1						1		
Goby, bay	✓						✓					
Goby, bluespot	✓						✓					
Goby, Japanese	✓						✓					
Greenling, rock	✓						✓					
Greenling, whitespotted	✓						✓					
Gunnel, saddleback	✓						✓					
Halibut, California	✓						✓					
Herring, Pacific	✓		19	500		200	✓					30
Herring, thread												
Irish lord, red		1	76	49	32	25			5	4	50	
Jacks, melt												
Lamprey, river												
Lingcod										1		
Midshipman, northern												
Perch, black												2
Perch, dwarf												
Perch, pile	✓						✓					

TABLE 15 (con't)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Perch, rubberlip	✓	1	6		225		✓		1			35
Perch, shiner												
Pipefish, bay												
Poacher, piggy												
Poacher, pricklebreast												
Pompano, Pacific								1		1		
Ray, bat												
Ray, Pacific electric			1									
Rockfish, brown												
Salmon, king				1		1	✓	1				6
Sanddab, speckled												
Sand lance, Pacific												
Sardine, Pacific												
Sculpin, bonehead		1										1
Sculpin, Pacific staghorn												
Sculpin, padded												
Sculpin, smoothhead												
Seaperch, rainbow												
Seaperch, striped												2
Seaperch, white												
Shad, American												
Shad, threadfin												
Shark, brown smoothhound		1			3	1		1				
Shark, leopard					3							
Shark, sevengill												
Shark, spiny dogfish												
Skate, big	✓	1			3		✓					

TABLE 15 (con't)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Smelt, night	✓						✓					
Smelt, longfin		2	1									1
Smelt, surf												
Smelt, whitebait					30			10				
Snailfish, showy												
Sole, English												
Sole, sand									2			
Steelhead												
Stickleback, threespine												
Sturgeon, green												
Sturgeon, white												
Surfperch, barred												
Surfperch, walleye												
Tomcod, Pacific			4		2							5
Tonguefish, California												
Topsmelt												
Turbot, curlfin												4
Turbot, diamond												
Turbot, hornyhead	✓						✓					

TABLE 16 (con't)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Smelt, night	✓	3					✓					
Smelt, longfin		2										
Smelt, surf												
Smelt, whitebait		1			50							
Snailfish, showy												
Sole, English												
Sole, sand												
Steelhead				1		1						
Stickleback, threespine												
Sturgeon, green												
Sturgeon, white												
Surfperch, barred												
Surfperch, walleye												
Tomcod, Pacific		3		1								
Tonguefish, California		1										
Topsmelt												
Turbot, curlfin												
Turbot, diamond												
Turbot, hornyhead	✓						✓					

TABLE 17

Numbers of Fish by Species Taken by Month at Station No. 6 During 1963

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Anchovy, northern Bass, striped Bocaccio	✓	506 4	501 2	2000 6	420 10	4012	✓	2020	2009	5000		30
Cabazon Carp Croaker, white	—											
Flounder, starry Goby, bay Goby, bluespot	— p e r s i s h e d		1 3	2			—	5	5		1	4
Goby, Japanese Greenling, rock Greenling, whitespotted	p e r s i s h e d											
Gunnel, saddleback Halibut, California Herring, Pacific	n o t	34	13	1100								
Herring, thread Irish lord, red Jacksmelt	—	4	8	1	1	84	—	30	500	2000		1004
Lamprey, river Lingcod Midshipman, northern	—			6	2							
Perch, black Perch, dwarf Perch, pile	✓	—					✓					

TABLE 17 (con't)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Smelt, night	✓		1	5			✓					4
Smelt, longfin												
Smelt, surf												
Smelt, whitebait								2				
Snailfish, snow			1	1	250	7	ed					
Sole, English							fish					
Sole, sard												
Steelhead				1								
Stickleback, threespine												
Sturgeon, green												
Sturgeon, white							Not					
Surfperch, barred												
Surfperch, walleye												
Tomcod, Pacific		12	8	5			✓					
Tonguefish, California												
Topsmelt												
Turbot, curlfin												
Turbot, diamond												
Turbot, hornhead	✓						✓					

TABLE 18

Numbers of Fish by Species Taken by Month at Station No. 1 During 1964

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Anchovy, northern	A	25	100	35	500	175	A	373	100	1000	15	8
Bass, striped											1	
Bocaccio												
Cabazon												
Carp				6	11							
Croaker, white												
Flounder, starry				10	2	1		1	25	2		3
Goby, bay												
Goby, bluespot												
Goby, Japanese												
Greenling, rock												
Greenling, whitespotted												
Gunnel, saddleback												
Halibut, California												
Herring, Pacific		119	11	139	1	200		36	1	1		8
Herring, thread												
Irish lord, red		10	54	1		12		37	13	75	50	
Jacksmelt												
Lamprey, river												
Lingcod				3	3	3						
Midshipman, northern		2	2	22	74	12			15	5		
Perch, black												
Perch, dwarf			1									
Perch, pile			1	2				1	40			

TABLE 18 (con't)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Smelt, night	✓							1				
Smelt, longfin												1
Smelt, surf												
Smelt, whitebait												
Snailfish, showy		35	145	250	65	75			1002	300	3	44
Sole, English	✓											
Sole, sand				1								
Steelhead	✓											
Stickleback, threespine	✓											
Sturgeon, green												
Sturgeon, white												
Surfperch, barred	✓											
Surfperch, walleye												
Tomcod, Pacific		1	3	3	51	1			100	8	1	8
Tonguefish, California		5							16	6		
Topsmelt												
Turbot, curlfin		1			1				2	1		
Turbot, diamond										1		
Turbot, hornyhead	✓	1					✓					

TABLE 19

Numbers of Fish by Species Taken by Month at Station No. 2 During 1964

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Anchovy, northern	✓	200	100	500	150	40	✓	350	5150		500	210
Bass, striped												
Bocaccio												
Cabazon								2				
Carp				7	150	1						
Croaker, white												
Flounder, starry		3		2	3	3					2	
Goby, bay		3			16	2						
Goby, bluespot	✓						✓					
Goby, Japanese						2		1				
Greenling, rock	✓											
Greenling, whitespotted	✓											
Gunnel, saddleback												
Halibut, California		9	1	200	136	60	✓	37	10			3
Herring, Pacific												
Herring, thread												
Irish lord, red		15	15		15	3		75	150		101	
Jacksmelt												
Lamprey, river												
Lingcod			1	1	2	14				50		
Midshipman, northern					20	24						
Perch, black		1			3	1						1
Perch, dwarf		1										
Perch, pile	✓		46	1		15	✓	301	5	1		

TABLE 19(con't)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Perch, rubberlip Perch, shiner Pipefish, bay	A	3	3	25	25	4 77	A	13 125	7	50	1	2 15
Poacher, pigmy Poacher, pricklebrest Pompano, Pacific					1	3						
Ray, bat Ray, Pacific electric Rockfish, brown		18		3	110	15		2 2		12		
Salmon, king Sanddab, speckled Sand lance, Pacific		500	156 1	19	1 175	2000		250	2	60	9	
Sardine, Pacific Sculpin, bonehead Sculpin, Pacific staghorn	F S T F	20	3		1	5 47	F S T F		2	10	1 1	
Sculpin, padded Sculpin, smoothhead Seaperch, rainbow	P O N				15		P O N					
Seaperch, striped Seaperch, white Shad, American		2		5				250			1	
Shad, threadfin Shark, brown smoothhound Shark, leopard			1		2 1	8		1				
Shark, sevengill Shark, Spiny dogfish Skate, big	A	1			.		A					

TABLE 20

Numbers of Fish by Species Taken by Month at Station No. 3 During 1964

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Anchovy, northern	✓	50	100		5020	313	✓	75	625	25		
Bass, striped												
Bocaccio												
Cabezon												
Carp			2		75	3		5				
Croaker, white												
Flounder, starry	✓											
Goby, bay	✓	2	2	1	3	4	✓	12	3	7	12	
Goby, bluespot	✓				25	12	✓			12	75	
Goby, Japanese	✓						✓					
Greenling, rock	✓				1		✓					
Greenling, whitespotted	✓						✓					
Gunnel, saddleback	✓						✓					
Halibut, California	✓						✓					
Herring, Pacific	✓	300	15	1015	500	257	✓	145	50		16	1
Herring, thread												
Irish lord, red												
Jacksmelt		2	42	6	100	4		38	20		175	
Lamprey, river												
Lingcod												
Midshipman, northern					15	26				20	10	
Perch, black					75	42						
Perch, dwarf			7							2	3	
Perch, pile	✓		1	1		13	✓		4	20	1	

TABLE 20(cont't)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Perch, rubberlip	A	1	60	4	50	41	A	27	24	50	1	1
Perch, shiner											200	1
Pipefish, bay												
Poacher, pigmy												
Poacher, pricklebrest					25							
Pompano, Pacific												
Ray, bat												
Ray, Pacific electric					5					1	8	
Rockfish, brown		3	1									
Salmon, king												
Sanddab, speckled		500	97	1		500		75	1	201	205	6
Sand lance, Pacific		1							83			
Sardine, Pacific												
Sculpin, bonehead					3							
Sculpin, Pacific staghorn		25	5		25	1			3	201	75	
Sculpin, padded												
Sculpin, smoothhead										1		
Seaperch, rainbow												
Seaperch, striped												
Seaperch, white		12	1					1		2	1	30
Shad, American						1						
Shad, threadfin												
Shark, brown smoothhound					2					1		
Shark, leopard		2										
Shark, sevengill												
Shark, spiny dogfish					2							
Skate, big					1							

TABLE 21

Numbers of Fish by Species Taken by Month at Station No. 4 During 1964

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Anchovy, northern	↗	75	100	12	200	150	↗	1050	1075	60	10	100
Bass, striped				6	13	7						
Bocaccio												
Cabezon												
Carp								100				
Croaker, white												
Flounder, starry		2	1	1	40			41				1
Goby, bay	↗						↗					
Goby, bluespot	↗						↗					
Goby, Japanese	↗						↗					
Greenling, rock	↗						↗					
Greenling, whitespotted	↗						↗					
Gunnel, saddleback	↗						↗					
Halibut, California	↗			252		200	↗					2
Herring, Pacific	↗						↗					
Herring, thread												
Irish lord, red		12	214	94	15	111		14	50		1	
Jacksnelt												
Lamprey, river												
Lingcod												
Midshipman, northern					50	8		100				
Perch, black												
Perch, dwarf												
Perch, pile	↗	4	1				↗					

TABLE 21(con't)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Perch, rubberlip	✓											
Perch, shiner												
Pipefish, bay		5 1	46 9	11	7							
Poacher, pigmy												
Poacher, pricklebrest												
Pompano, Pacific												
Ray, bat												
Ray, Pacific electric				1	2	2		5				
Rockfish, brown												
Salmon, king												
Sanddab, speckled		32	70	1	61	1		150		15		35
Sand lance, Pacific												
Sardine, Pacific												
Sculpin, bonehead		1										
Sculpin, Pacific staghorn		1						5		3		4
Sculpin, padded												
Sculpin, smoothhead												
Seaperch, rainbow												
Seaperch, striped												
Seaperch, white		16	11								1	2
Shad, American												
Shad, threadfin												
Shark, brown smoothhound		1	2	1	1	3		3				
Shark, leopard		1		1								
Shark, sevengill												
Shark, spiny dogfish												
Skate, big		1		2								

TABLE 21 (con't)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Smelt, night	✓						✓					
Smelt, longfin												
Smelt, surf												
Smelt, whitebait			1		11	6				3		
Snailfish, showy		1	3									
Sole, English												
Sole, sand												
Steelhead												
Stickleback, threespine												
Sturgeon, green												
Sturgeon, white												
Surfperch, barred												
Surfperch, walleye												
Tomcod, Pacific		1 3	17	4	1 13			12				
Tonguefish, California								1				
Topsmelt												
Turbot, curlfin												
Turbot, diamond		2	2							10	8	2
Turbot, hornyhead	✓						✓					

TABLE 22

Numbers of Fish by Species Taken by Month at Station No. 5 During 1964

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Anchovy, northern	✓						✓					
Bass, striped											104	25
Bocaccio		100	131	575	415	159				58	1	
Cabazon												
Carp												
Croaker, white										57	21	
Flounder, starry												
Goby, bay	✓		1	27		3	✓			10		
Goby, bluespot	✓						✓					
Goby, Japanese	✓						✓					
Greenling, rock	✓						✓					
Greenling, whitespotted	✓						✓					
Gunnel, saddleback	✓						✓					
Halibut, California	✓	3		52	10	5	✓				1	9
Herring, Pacific	✓						✓					
Herring, thread												
Irish red												
Jacksmelt		58	44	16	111	13						
Lamprey, river			1									
Lingcod			1	13								
Midshipman, northern												
Perch, black												
Perch, dwarf												
Perch, pile	✓			1			✓					

TABLE 22 (con't)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Perch, rubberlip	✓					1	✓					
Perch, shiner				19					2	38	34	16
Pipefish, bay		30 3	22	2								
Poacher, pigmy												
Poacher, pricklebrest				1								
Pompano, Pacific												
Ray, bat								3	5			
Ray, Pacific electric												
Rockfish, brown												
Salmon, king												
Sanddab, speckled		1										
Sand lance, Pacific												
Sardine, Pacific	de											
Sculpin, bonehead	fish			1							1	3
Sculpin, Pacific staghorn	fish	1										
Sculpin, padded												
Sculpin, smoothhead												
Seaperch, rainbow	Not											
Seaperch, striped												
Seaperch, white											2	
Shad, American		8	6	1								
Shad, threadfin												
Shark, brown smoothhound		1		1	1					2	1	6
Shark, leopard				1							1	
Shark, sevengill												
Shark, spiny dogfish				1								3
Skate, big		1	3				✓					

TABLE 22 (con't)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Smelt, night	✓						✓					
Smelt, longfin												
Smelt, surf						1						1
Smelt, whitebait												1
Snailfish, showy												
Sole, English												
Sole, sand												
Steelhead												
Stickleback, threespine												
Sturgeon, green												
Sturgeon, white												
Surfperch, barred												
Surfperch, walleye												2
Tomcod, Pacific										4	1	
Tonguefish, California									1	12	25	50
Topsmelt								6				
Turbot, curlfin												1
Turbot, diamond			1									
Turbot, hornyhead	✓						✓					

TABLE 23

Numbers of Fish by Species Taken by Month at Station No. 6 During 1964

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Anchovy, northern	✓											
Bass, striped				2026	219	230	✓	256	20	50	100	25
Bocaccio		50 2	100 2	1							1	1
Cabezon												
Carp						28		100		2	30	2
Croaker, white												
Flounder, starry		1	10 12	103	85	34	✓	1				
Goby, bay	✓						✓					
Goby, bluespot	✓						✓					
Goby, Japanese	✓						✓					
Greenling, rock	✓						✓					
Greenling, whitespotted	✓						✓					
Gunnel, saddleback	✓						✓					
Halibut, California	✓		8	100	50	4	✓				1	
Herring, Pacific	✓						✓					
Herring, thread												
Irish red		12		10		50						
Jacksmelt												
Lamprey, river												
Lingcod			3	36		1						
Midshipman, northern												
Perch, black	✓						✓	1				
Perch, dwarf								3				
Perch, pile								1				

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Smelt, night	✓						✓					8
Smelt, longfin		✓	1									
Smelt, surf												
Smelt, whitebait												
Snailfish, showy			7	28	84	73						
Sole, English												
Sole, sand												
Steelhead			1			2						
Stickleback, threespine												
Sturgeon, green												
Sturgeon, white												
Surfperch, barred												
Surfperch, walleye			2									1
Tomcod, Pacific		1										
Tonguefish, California												
Topsmelt			8	1				505	208	110	12	
Turbot, curlfin												
Turbot, diamond												
Turbot, hornyhead	✓						✓					

TABLE 24

Numbers of Fish by Species Taken by Month at Station No. 1 During 1965

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.*	Nov.	Dec.
Anchovy, northern	10											
Bass, striped				50	210	5050	3000	500	10,100	200	200	500
Bocaccio				1	1					3		
Cabezon												
Carp	1				150		90		1			2
Croaker, white			1	3								
Flounder, starry	1		1		15	22	10	1	6	8		
Goby, bay					1	5			1			
Goby, bluespot												
Goby, Japanese												
Greenling, rock												
Greenling, whitespotted												
Gunnel, saddleback								1				
Halibut, California								55	100	100	100	100
Herring, Pacific	3		20	500	45							
Herring, thread												
Irish lord, red			16	50	8	3	20	10	1		9	
Jacksnelt												
Lamprey, river												
Lingcod												
Midshipman, northern			2	9	12	43	301					
Perch, black												
Perch, dwarf												
Perch, pile	2				30			3	1			

* Nov. 2

TABLE 24 (con't)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Perch, rubberlip	29	1	24	50	100	32	25	19	1	2000	5	8
Perch, shiner												
Pipefish, bay												
Poacher, pigmy												
Poacher, pricklebreast			1		3	15				1		
Pompano, Pacific												
Ray, bat									1			
Ray, Pacific electric									1			
Rockfish, brown	1				1	8						
Salmon, king												
Sanddab, speckled	22				2	60	100		500	100		
Sand lance, Pacific					100							
Sardine, Pacific												
Sculpin, bonehead												
Sculpin, Pacific staghorn	10		1	8	100	32	5	3	200	50		
Sculpin, padded												
Sculpin, smoothhead												
Seaperch, rainbow												
Seaperch, striped	3											
Seaperch, white	6		1	3	4	8	1		3	8	1	25
Shad, American												
Shad, threadfin	4											
Shark, brown smoothhound			1	1	8	8	2	2	7	2		
Shark, leopard	3								2	3		
Shark, sevengill												
Shark, spiny dogfish			1	8	12			1				2
Skate, big				1	3	6	3	2	1	2		

TABLE 24 (con't)

[illegible]

TABLE 26

Numbers of Fish by Species Taken by Month at Station No. 3 During 1965

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
	25	4	7	200	100,000	5000	3000	10,000	10,050	10,000	100	1000
Anchovy, northern												
Bass, striped												
Bocaccio.												
Cabezon												
Carp												
Croaker, white			1	3	52	210	100	15	20	5	2	2
Flounder, starry												
Goby, bay	1			4	30	56	100	3	15	15	3	22
Goby, bluespot						6	6	1	10			
Goby, Japanese												
Greenling, rock												
Greenling, whitespotted												
Gunnel, saddleback												
Halibut, California												
Herring, Pacific	6		200	1000	126	100		500	220	8	27	25
Herring, thread												
Irish lord, red												
Jacksmelt	15		9	150	3	10	7	15		2		10
Lamprey, river												
Lingcod				1	1							3
Midshipman, northern				20	20	150		2	1			
Perch, black												
Perch, dwarf												
Perch, pile	1			3	3	3	6	1	2		1	5

TABLE 26 (cont.)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Perch, rubberlip		✓	15	108	100	50	250	1	100	150	10	75
Perch, shiner				1				50				
Pipefish, bay												
Poacher, pigmy					10							
Poacher, pricklebreast												
Pompano, Pacific												
Ray, bat						1		1				
Ray, Pacific electric						6		1		8		
Rockfish, brown	13							1				
Salmon, king												
Sanddab, speckled	1			2	100	450	300	12	50	3	2	1
Sand lance, Pacific	6			30						100		20
Sardine, Pacific												
Sculpin, bonehead												
Sculpin, Pacific staghorn			2	6	50	48	20	1	10	35	1	
Sculpin, padded	2						1					
Sculpin, smoothhead												
Seaperch, rainbow												
Seaperch, striped												
Seaperch, white	1				3		1		2	1	7	5
Shad, American	17											8
Shad, threadfin												
Shark, brown smoothhound					3	3	2	1	1	1	1	3
Shark, leopard										3		1
Shark, sevendgill												
Shark, spiny dogfish			1		2						1	1
Skate, big		✓			3	18	5			3	1	1

TABLE 27 (con't)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Perch, rubberlip	35	✓	3	10	13	12	50	190	22			12
Perch, shiner												
Pipefish, bay										1		
Poacher, pigmy												
Poacher, pricklebreast												
Pompano, Pacific												
Ray, bat							1	2				1
Ray, Pacific electric								1				
Rockfish, brown												
Salmon, king												
Sanddab, speckled	35	✓		18	6	1		18	4			
Sand lance, Pacific												
Sardine, Pacific												
Sculpin, bonehead												
Sculpin, Pacific staghorn	32	✓		3	1	1		10				
Sculpin, padded												
Sculpin, smoothhead												
Seaperch, rainbow												
Seaperch, striped												
Seaperch, white	1											
Shad, American	1				3	1					1	25
Shad, threadfin												
Shark, brown smoothhound	1			1		1		2	1			20
Shark, leopard					3	2						3
Shark, sevengill												
Shark, spiny dogfish				1								1
Skate, big		✓		1								

TABLE 28

Numbers of Fish by Species Taken by Month at Station No. 5 During 1965

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Anchovy, northern	50	1	212	1	10,000	5100	3025	2010	1011	30	50	10
Bass, striped	2				3							1
Bocaccio												
Cabazon												
Carp					8		25		11			
Croaker, white							1		10	5	1	
Flounder, starry	1	1										
Goby, bay		10										
Goby, bluespot		10										
Goby, Japanese		10										
Greenling, rock		10										
Greenling, whitespotted		10										
Gunnel, saddleback		10										
Halibut, California	4	10	15	100	50					12	40	110
Herring, Pacific		10										
Herring, thread		10										
Irish lord, red	2	10	50	125	31	100	9	8				
Jacksmelt		10										
Lamprey, river		10										
Lingcod		10	2	2	13				9			1
Midshipman, northern		10										
Perch, black	1	10										
Perch, dwarf		10										
Perch, pile		10					1					

TABLE 28 (con't)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Perch, rubberlip	50			1	10	13	26	80	2	6	7	25
Perch, shiner												1
Pipefish, bay												
Poacher, pigmy												
Poacher, pricklebrest												
Pompano, Pacific												
Ray, bat	3							3	1	6		
Ray, Pacific electric												
Rockfish, brown												
Salmon, king			1	1	8	6						
Sanddab, speckled												
Sand lance, Pacific												
Sardine, Pacific												
Sculpin, bonehead			2	3	1			8	1	1	2	5
Sculpin, Pacific staghorn	1											
Sculpin, padded												
Sculpin, smoothhead												
Seaperch, rainbow												
Seaperch, striped	1											
Seaperch, white	6								1		2	25
Shad, American						3						8
Shad, threadfin	4			1						1		1
Shark, brown smoothhound						3					10	5
Shark, leopard											1	
Shark, sevengill												
Shark, spiny dogfish			1	1								
Skate, big				1								

TABLE 29

Numbers of Fish by Species Taken by Month at Station No. 6 During 1965

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Anchovy, northern	33											
Bass, striped												
Bocaccio												
Cabezon												
Carp									8			
Croaker, white												
Flounder, starry												
Goby, bay				1		1	1		1	2		1
Goby, bluespot									1			
Goby, Japanese												
Greenling, rock												
Greenling, whitespotted												
Gunnel, saddleback												
Halibut, California												
Herring, Pacific				15							4	2
Herring, thread												
Irish lord, red												
Jacksnelt	5		50	26	26	20	1	8	1			
Lamprey, river												
Lingcod												
Midshipman, northern				2	4				6			
Perch, black												
Perch, dwarf												
Perch, pile									1	3		

TABLE 30

Numbers of Fish by Species Taken by Month at Station No. 1 During 1966

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Anchovy, northern	100		200	250	↗	500	↗	2050	1000		208	200
Bass, striped					↗							
Bocaccio					↗							
Cabazon												
Carp	2	15	10									
Croaker, white												
Flounder, starry			3	2	↗	6	↗	2				1
Goby, bay		1	1		↗	12	↗					
Goby, bluespot					↗		↗					
Goby, Japanese					↗		↗					
Greenling, rock					↗		↗					
Greenling, whitespotted					↗		↗					
Gunnel, saddleback					↗		↗					
Halibut, California					↗		↗					
Herring, Pacific	41	25	51	35	↗		↗	50		1	6	18
Herring, thread					↗		↗					
Irish lord, red					↗		↗					
Jacksnelt	3	9	9	15	↗		↗		500	300		
Lamprey, river					↗		↗					
Lingcod					↗	3	↗		1			
Midshipman, northern					↗	203	↗					
Perch, black					↗		↗					
Perch, dwarf	1	1			↗		↗					
Perch, pile					↗		↗	5			5	

TABLE 31

Numbers of Fish by Species Taken by Month at Station No. 2 During 1966

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Anchovy, northern	100			300	✓	500	✓		10,000	2010	5	200
Bass, striped												
Bocaccio										1		
Cabazon												
Carp	1			30								
Croaker, white												
Flounder, starry				1	✓	1	✓		2			
Goby, bay					✓		✓		25			
Goby, bluespot					✓		✓					
Goby, Japanese					✓		✓				1	1
Greenling, rock					✓		✓					
Greenling, whitespotted					✓		✓					
Gunnel, saddleback					✓		✓					
Halibut, California					✓		✓					
Herring, Pacific	100	10	24	50	✓		✓			5	10	1
Herring, thread					✓		✓					
Irish lord, red					✓		✓					
Jacks, melt		2	15	10	✓	2	✓			200	2000	
Lamprey, river					✓		✓					
Lingcod					✓		✓			8		
Midshipman, northern					✓		✓					
Perch, black	2				✓		✓			15		
Perch, dwarf					✓		✓			30	8	8
Perch, pile	4			1	✓	8	✓	3	25			

TABLE 31 (con't)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Perch, rubberlip			7		✓	1	✓	3	35	8	25	5
Perch, shiner						301						
Pipefish, bay												
Poacher, pigmy				1								
Poacher, pricklebrest												
Pompano, Pacific												
Ray, bat												
Ray, Pacific electric				1		1		4				10
Rockfish, brown	3	2										
Salmon, king												
Sanddab, speckled	10	20	1	3	✓	100	✓	5	50	5	1	5
Sand lance, Pacific			2		✓		✓					
Sardine, Pacific					✓		✓					
Sculpin, bonehead					✓		✓					
Sculpin, Pacific staghorn	2				✓	2	✓				12	
Sculpin, padded					✓		✓	1				
Sculpin, smoothhead					✓		✓					
Seaperch, rainbow					✓		✓					
Seaperch, striped												
Seaperch, white			3			10		2	8	10		
Shad, American	50	3										
Shad, threadfin												
Shark, brown smoothhound				1		17		1	1			
Shark, leopard	4											
Shark, sevengill												
Shark, spiny dogfish				1	✓							
Skate, big	3								3			

TABLE 31 (con't)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Smelt, night	5	2	2		↗		↗			13		
Smelt, longfin												
Smelt, surf												
Smelt, whitebait												
Snailfish, showy	1	11		31	↗	500	↗	2	20	3	25	1
Sole, English												
Sole, sand					↗		↗					
Steelhead					↗		↗					
Stickleback, threespine					↗		↗					
Sturgeon, green					↗		↗					
Sturgeon, white					↗		↗					
Surfperch, barred					↗		↗					
Surfperch, walleye					↗		↗					
Tomcod, Pacific	3	5	6		↗		↗	1			5	1
Tonguefish, California		3			↗		↗					
Topsmelt					↗		↗					
Turbot, curlfin					↗		↗					
Turbot, diamond		1	1		↗		↗					1
Turbot, hornyhead					↗		↗					

TABLE 32

Numbers of Fish by Species Taken by Month at Station No. 3 During 1966

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Anchovy, northern		200	75	10	↗	400	↗		1000	110	100	8
Bass, striped					↗							
Bocaccio												
Cabazon						14						1
Carp	18	13	4	1								
Croaker, white												
Flounder, starry	5	3	2	8	↗	7	↗		1	2	2	
Goby, bay				1	↗					6		
Goby, bluespot					↗							
Goby, Japanese					↗							
Greenling, rock					↗							
Greenling, whitespotted					↗							
Gunnel, saddleback					↗							
Halibut, California					↗							
Herring, Pacific	25	59	25	20	↗	100	↗	50			5	32
Herring, thread					↗							
Irish lord, red					↗							
Jacksmelt	10	7		13	↗			30	10	200	100	
Lamprey, river					↗							
Lingcod					↗	22		10	3			
Midshipman, northern		1			↗	30						
Perch, black					↗	1						
Perch, dwarf					↗							
Perch, pile	1	7			↗					12	1	

TABLE 34

Numbers of Fish by Species Taken by Month at Station No. 5 During 1966

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Anchovy, northern Bass, striped Bocaccio	30		502 2	10,015	A	250	A	10	225	200	5	100
Cabazon Carp Croaker, white								18			3	
Flounder, starry Goby, bay Goby, bluespot					deep		deep	3		1		
Goby, Japanese Greenling, rock Greenling, whitespotted					fish		fish	1		1	1	
Gunnel, saddleback Halibut, California Herring, Pacific	96	50			Not		Not				4	7
Herring, thread Irish lord, red Jacksmelt		49	12	200		25						
Lamprey, river Lingcod Midshipman, northern								6				
Perch, black Perch, dwarf Perch, pile					V		V					

TABLE 35

Numbers of Fish by Species Taken by Month at Station No. 6 During 1966

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Anchovy, northern	27		100	203		310	✓	212	225	2000	101	100
Bass, striped	1	1	3	1								
Bocaccio												
Cabazon												
Carp												
Croaker, white												
Flounder, starry										1		
Goby, bay	1	3										
Goby, bluespot												
Goby, Japanese											1	
Greenling, rock												
Greenling, whitespotted												
Gunnel, saddleback												50
Halibut, California												
Herring, Pacific	27	3	100	1								
Herring, thread												
Irish lord, red						10						
Jacksmelt				12								
Lamprey, river												
Lingcod									1			
Midshipman, northern												
Perch, black												
Perch, dwarf												
Perch, pile						2						

TABLE 35 (con't)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Smelt, night	89	6	50	3	A		A					
Smelt, longfin												
Smelt, surf												
Smelt, whitebait												
Snailfish, showy												
Sole, English												
Sole, sand												
Steelhead												
Stickleback, threespine								1				
Sturgeon, green												
Sturgeon, white												
Surfperch, barred												
Surfperch, walleye												
Tomcod, Pacific									1			
Tonguefish, California												
Topsmelt	18	4	50	26				15		1	50	50
Turbot, curlfin												
Turbot, diamond												
Turbot, hornyhead												

INVERTEBRATES

Widespread distribution of bay shrimp and their availability throughout the year was indicated by their presence in 101 of 125 bottom tows. On August 12, 1964, a 20-minute tow of the 15-foot otter trawl caught 400 pounds of shrimp at Station 6. This was the largest catch of shrimp made during the study. During the study occasional examinations of fish stomachs indicated shrimp a major food item.

Benthos

During 1963, a 100 cubic inch orange-peel bottom sampler was used at the six stations established for the study of fishes. One sample was taken at each station each month except July. In a few cases, a second sample was removed and preserved in formalin or alcohol. Most of the animals were carefully measured, with the exception of the very small forms that occurred in great numbers.

In addition to the orange-peel samples, other bottom living animals were obtained from hauls of the beam trawl used for collecting fish. This net sometimes dug into the substrate and brought up many bottom specimens. There were several advantages to this incidental sampling. We obtained crabs which escape orange-peel sampling; we found some species that the bottom sampler did not collect because it failed to penetrate deep enough to reach them, or we found that a species was more numerous in an area than our bottom sample indicated. Some species that appeared to be relatively rare from our samples actually existed in large numbers.

Because of the very small size of our sample in relation to the size of the area which it represented, little can be determined about the total population or density patterns of a species. It is disappointing to be able to take only one sample when many more are needed for adequate statistical analyses. However, within the limitations of the survey, we did secure sufficient information

of a general nature to help determine the relative numbers of animals in several of the bay substrates (Tables 36-37).

Animals representing five different phyla and many species were found in the samples, and are briefly discussed here by phylogenic grouping.

Porifera

Several small encrusting sponges were observed, but no attempt was made to identify them. One globular sponge, believed to be Tetilla mutabilis, was taken in a grab sample at Station 4, and appeared in large numbers in the dredged material from Stations 4 and 5.

Coelenterata

No attempt was made to find and identify all the hydroids that might have been present; however, the most abundant was Obelia dichotoma, particularly in material from Stations 3 and 4.

Stylatula elongata, the slender sea pen, was collected in two samples at Station 1 (3 specimens), in three samples at Station 2 (12 specimens), and in larger numbers in all samples from Station 3 (33 specimens). At Station 3, very small specimens were found in October. The substrate at all these stations is sand mixed with mud.

A small salmon-pink anemone, Diadumene leucolena (an introduced species), was collected in grab samples at Station 5. It was very abundant in dredged material from Stations 4 and 5, and was found fastened to shells, stones, pieces of wood, and even submerged leaves all through the spring months.

Bryozoa

Here again, no attempt was made to find and identify the species of this phylum. Membranipora spp. were seen on shells and stones at all stations except 6. In the dredged material, one species of arborescent bryozoa was common.

TABLE 36

Common and Scientific Names of Invertebrates

Porifera (sponges)

<u>Cliona celata</u>	Yellow sponge
<u>Tetilla mutabilis</u>	

Coelenterates (jellyfish)

<u>Chrysaora melanaster</u>	brown jellyfish
<u>Pelagia panopyra</u>	blue jellyfish
<u>Obelia dichotoma</u>	hydroid
<u>Stylatula elongata</u>	slender sea pen
<u>Diadumene leucolea</u>	salmon pink anemone
<u>Aurellia aurita</u>	

Bryozoa (moss animals)

Membranipora sp.

Echinoderms (starfish)

<u>Patiria miniata</u>	leather starfish
<u>Pisaster ochraceus</u>	ochre starfish
<u>Pisaster brevispinus</u>	shortspine starfish
<u>Ophiopteris papillosa</u>	brittlestar

Annelids (segmented worms)

<u>Axiiothella rubrocincta</u>	bamboo worm
<u>Glycera capitata</u>	
<u>Glycera americana</u>	
<u>Lumbrineris zonata</u>	
<u>Marphysa sanguinea</u>	
<u>Neanthes succinea</u>	
<u>Nereis procera</u>	
<u>Nereis zonata</u>	
<u>Pectinaria californiensis</u>	

Molluscs (shells)

Pelecypods

<u>Modiolus demissa</u>	ribbed horsemussel.
<u>Barnea pacifica</u>	piddock .
<u>Botula falcata</u>	pea-pod borer
<u>Clinocardium nuttallii</u>	basket cockle .
<u>Corbicula fluminea</u>	Asiatic clam

TABLE 36 (con't)

Molluscs

Pelecypods (con't)

<u>Gemma gemma</u>	gem clam
<u>Macoma inconspicua</u>	inconspicuous macoma
<u>Macoma nasuta</u>	bent nosed clam "
<u>Macoma secta</u>	white sand clam
<u>Musculus senhousei</u>	mud mussel "
<u>Mya arenaria</u>	soft shelled clam
<u>Mytilus californianus</u>	California sea-mussel "
<u>Mytilus edulis</u>	bay mussel.
<u>Ostrea lurida</u>	native oyster.
<u>Crassostrea gigas</u>	Pacific oyster
<u>Pododesmus macroschismus</u>	jingle
<u>Protothaca staminea</u>	common littleneck
<u>Solen sicarius</u>	sickle razor clam
<u>Schizothaerus nuttallii</u>	gaper clam
<u>Tapes semidecussata</u>	Japanese littleneck.
<u>Trachycardium</u>	
<u>quadragenarium</u>	spiny cockle

Gastropods

<u>Acmaea sp.</u>	limpet.
<u>Mopalia sp.</u>	chiton
<u>Bittium sp.</u>	horn snail
<u>Hopkinsia rosacea</u>	rosy nudibranch
<u>Epitonium sp.</u>	wentle-trap
<u>Anisodoris noblis</u>	lemon nudibranch
<u>Tethys californica</u>	sea hare
<u>Busycon canaliculatum</u>	channeled whelk
<u>Crepidula nivea</u>	slipper limpet
<u>Nassarius cooperi</u>	
<u>Nassarius fossatus</u>	channeled basket snail
<u>Nassarius mendicus</u>	
<u>Nassarius obsoletus</u>	mud snail.
<u>Oceanebra sp.</u>	
<u>Olivella biplicata</u>	olive snail
<u>Polinices lewisii</u>	moon snail
<u>Urosalpinx cinereus</u>	oyster drill

Arthropods (jointed feet)

<u>Balanus glandula</u>	acorn barnacle
<u>Callianassa sp.</u>	ghost shrimp
<u>Minertia sp.</u>	fish louse
<u>Cancer antennarius</u>	rock crab
<u>Cancer magister</u>	market crab.
<u>Cancer productus</u>	red crab
<u>Cancer gracilis</u>	slender crab

Arthropods (con't)

<u>Caprella</u> sp.	skeleton shrimp
<u>Ligyda occidentalis</u>	isopod
<u>Limoria lignorum</u>	gribble
<u>Hemigrapsus oregonensis</u>	mud crab
<u>Spirontocaris</u> sp.	shrimp
<u>Argeia pugettensis</u>	
<u>Palaemon macrodactylus</u>	Korean shrimp
<u>Pachygrapsus crassipes</u>	shore crab
<u>Pagurus hirsutiusculus</u>	hermit crab
<u>Petrolisthes cinctipes</u>	porcelain crab
<u>Pinnixa franciscana</u>	pea crab
<u>Pugettia grascilis</u>	kelp crab
<u>Pugettia richii</u>	
<u>Pyromaia tuberculata</u>	spider crab
<u>Crago franciscorum</u>	bay shrimp
<u>Crago nigricauda</u>	blacktail shrimp

Ascidians

<u>Molgula</u> sp.	
<u>Styela montereyensis</u>	sea squirt

TABLE 37

Distribution of Species and Specimen Numbers Taken by
Orange-Peel Dredge at Six Stations, San Francisco Bay
April - December, 1963

Station and substrate	Number of Species	Number of Specimens	Species Unique to Station
Station 1 - predominantly sand with some mud and fine shell.	16	39*	2
Station 2 - predominantly sand and shell but with some mud. More varied than Station 1.	16	60*	3
Station 3 - mostly homogeneous sand and mud, usually with empty bamboo worm tubes.	19	123*	1
Station 4 - Predominantly mud with shell fragments.	11	98	2
Station 5 - sticky mud with some sand, little or no shell, more varied than 4 or 6.	13	549	1
Station 6 - uniformly very sticky mud with no sand or shell.	7	93	1

* Gemma gemma, amphipods, and chelifers omitted from the specimen count at three stations. These would add thousands at Stations 1 and 2, and hundreds at Station 3.

Nemertea

Only four specimens were collected and no attempt was made to identify them.

Annelida

All the annelids collected belong to the class Polychaeta.

Glycera americana, one specimen in each of two samples, was found at Station 1 (notably lacking in polychaetes). It also occurred in one sample from Station 3. In all three cases the substrate was sand mixed with mud.

Glycera capitata was found in three samples at Station 2, and it is probable that four very tiny glycerids found at this station in May were G. capitata.

Pectinaria californiensis occurred in one sample from Station 1, three samples from Station 2, and one sample from Station 3. Empty shells were found in several other samples, but no living worms were taken. In all cases except one, the substrate was a mixture of sand, mud, and broken shell. In the exceptional case, the substrate had very little sand, but did contain broken shell.

Axiiothella rubrocincta, the bamboo or joint worm, was the most numerous and wide-spread polychaete. It occurred in one sample from Station 1, one from Station 2, and in 50 percent of the samples from Station 3 and Station 4. While it was not found at Station 5, there were empty tubes, and some living specimens were found in dredged material from this station. This species was not taken at Station 6. The tubes of this worm must be very resistant and long lasting, for they were in extraordinary abundance in many samples. The worm was most abundant in rather sticky pure mud. Since the substrate in Station 6 is of this nature and the worm shows some tolerance (the substrate in Stations 1

and 2 was sandy), its distribution must be limited by some other factor.

Nereis zonata was found in one sample from Station 4, two from Station 5, and two from Station 6. Nineteen specimens were recovered, all from sandy mud.

Neanthes succinea was more widely distributed than N. zonata since it was found at Stations 3, 4, 5, and 6. However, fewer specimens (15) were taken. These polychaets seemed to require the same substrate and were taken in the same sample twice.

Nereis procera was found in dredged material at Station 5.

Marphysa sanguinea was found only at Station 6 in homogeneous sticky mud.

Lumbrineris zonata occurred in one sample at Station 3.

Mollusca

The phylum Mollusca was represented by several species of clams, oysters, mussels, and snails.

Musculus senhousi, the mud mussel, was extremely abundant. This species occurred in large masses fastened together by byssal threads. One mass examined contained 75 individuals. This mussel was taken at all stations except 1 and 3. Stations 2 and 4 had only six specimens while Station 5 had 485. The largest specimen was 36 mm in length. Two size ranges were found at Station 5 in June and October, and at Station 6 in June. This would indicate that there are two peaks of settling, and these occur prior to June and prior to October. This might be explained by spawning occurring earlier in one area of the bay than in another, and individuals from both areas contributing to the sample. Temperature differences could cause such a situation.

A few small bay mussels, Mytilus edulis, were found at scattered locations. Only eight specimens were obtained at Stations 4, 5, and 6. The largest was 20 mm in length, indicating that the areas sampled may not be suitable for the maturing of this species.

Macoma nasuta, the bent-nosed clam, was found at Stations 1, 2, and 3. The maximum size was 30 mm, but most were smaller. They occurred in 50 percent of the samples at both Stations 2, and 3, and in one-third of those at Station 1. In all, 33 specimens were taken, and there was no correlation between season and size.

Macoma inconspicua was taken only at Station 1. It occurred in two samples, in one case with M. nasuta. Both of these clams were found on sandy bottoms where there was some admixture of mud.

Tapes semidecussata, the Japanese littleneck, was abundant. However, it was not found at Station 1 or 2, and only four specimens occurred in two samples at Station 3. At Station 4, 49 specimens were found in four samples. At Station 5, 142 clams were taken and occurred in all but one sample. At Station 6, five specimens were found in three samples. All were very small, and no specimens approached the maximum size for the species, the largest being 31 mm. According to Fitch (1953), the maximum is about 77 mm. There were, however, areas in the channel at Station 5 where large specimens were taken by dredging.

Ostrea lurida, the native oyster, was found only once. Three small specimens were found attached to an old Macoma shell at Station 1.

The three species of oysters, which have been harvested in times past from San Francisco Bay, are Crassostrea virginica, the eastern oyster; C. gigas, the Pacific oyster; and Ostrea lurida, the native oyster. The eastern oyster production was from growth of young oysters brought in from the Atlantic coast by rail for several years after completion of the transcontinental railroad. About 1938, Pacific oyster seed was brought to California from Japan, but few marketable oysters were produced in San Francisco Bay. San Francisco Bay did not prove suitable for the spawning of the eastern or the Pacific oyster. The

most recent planting of Pacific oysters was made in San Pablo Bay in 1958, but the seed was lost in soft mud. The native oysters have never been an important commercial product of San Francisco Bay. For many years, O. lurida shells have been dredged from the deeper waters of south San Francisco Bay for use in poultry feed and the making of cement. Geologists have reported these shell beds indicate that large populations of native oysters existed in the bay over 2,000 years ago. At present, the native oyster occurs in the bay, but is too sparse to support active harvesting activities.

Solen sicarius, the sickle razor clam, was found in two samples from Station 1, and in three samples from Station 3. The substrate in all cases was sand with some mud in homogeneous mixture. One specimen was 75 mm in length while the others were small. Our sampler did not penetrate deep enough to collect large individuals of this species

Clinocardium nuttallii, the basket cockle, occurred in one sample at Station 1, two at Station 2, and one at Station 3. All specimens were small, the largest 20 mm, and occurred in samples taken from September to December. The substrate was muddy sand with fine shell fragments in some cases.

Mya arenaria, the soft-shell clam, was found once at Station 3.

Gemma gemma occurred in almost unbelievable numbers at

Stations 2 and 3. Care was taken to estimate the numbers carefully. The samples containing this minute clam were frozen which caused the shell to gape. In washing the samples, the soft parts were often lost; therefore, a count was made of all shells with the hinge intact. Only 32 specimens of this species were found at Station 3; however, these clams were present in all Station 2 samples except the one taken in December. In two cases, 2,000 or more were present in a single sample. The total number of

intact shells (still hinged) was estimated at 6,500 and those still retaining soft parts at 2,300. Peak numbers seemed to be reached from May to August with a gradual decrease through the fall months. The substrate at Station 2 was quite uniform, consisting of fine sand with some mud and shell fragments.

Schizothaerus nuttallii, the gaper clam, was found only once in fine mud at Station 6. This specimen was 20 mm in length. The presence of siphons in many starry flounder stomachs indicate this clam is quite abundant in some areas.

Nassarius obsoletus, the mud snail, was very common. This introduced species occurred in two samples from Station 1, one sample from Station 3, one from Station 5, and three from Station 6. It was abundant in dredge samples at both Stations 4 and 5 so that our bottom sampling may have been biased. It was usually found in rather heavy mud, but did occur in a sandy substrate as at Station 1. There seemed to be no seasonal peak of size, and large animals were found.

Nassarius fossatus was found in two samples from Station 1, and in three samples from Station 2. It was always on a substrate of sand with some mud.

Nassarius cooperi was found in two samples from Station 2, and in one sample from Station 3. It was found in one sample with N. fossatus.

Nassarius mendicus was found only once at Station 5.

Several other gastropods were found only once: Crepidula nivea at Station 4 in November, Epitonium sp. at Station 4 in November, Ocenebra sp. from Station 5 in October, Olivella biplicata from Station 1, Bittium sp. from Station 2 in June. Urosalpinx cinereus was found at Station 6. In a dredged sample nine large specimens of the introduced conch, Busycon canaliculatum, were taken at Station 4.

Arthropoda

Other than gammarids and chelifers, which were extremely numerous in spring samples from Station 1 and 2, few crustaceans were taken in bottom samples. This is undoubtedly due to the fact that surface dwelling crabs can escape the sampler. Most of our specimens were from material brought up by beam trawl.

Cancer magister was taken only once. This was a very small crab (carapace width 12 mm) obtained at Station 2.

Cancer antennarius was taken once in a grab sample, and two specimens of large size were taken by dredge at Station 4.

Cancer productus was taken at Station 4 by dredge.

Cancer gracilis was taken at Station 4 by dredge.

Hemigrapsus oregonensis was very common in dredged material from Stations 4 and 5, and was found clinging to the trawl net at Station 6.

Pachygrapsus crassipes was found once, in a most unlikely situation, in mud brought up at Station 6.

Pugettia richii was taken at Station 5.

A spider crab, Pyromaia tuberculata, was taken several times in hauls at Stations 4 and 5. The distribution of this crab is reported to extend as far northward as Monterey Bay (Schmitt, 1921; Rathbun, 1930). This presented problems of identification, but we think this is correct. We have more than a dozen specimens.

Zooplankton

The plankton study was made to determine relative abundance and seasonal variations of zooplankton. An exact quantitative analysis was not possible, but the data give us a general picture. The animals collected were at, or

very near, the surface and were 1 mm or larger in size. This limitation excluded protozoans, planulae, trochophores, immature copepods, and possibly some of the smallest mature copepods. The results are biased because of the differing vertical distributions of the various species encountered. Although all tows were twenty minutes in duration, there was considerable variation in the quantity of water that passed through the net depending on whether the vessel was progressing with or against the tidal current.

In this zooplankton study, the volume of the sample was reduced to 50 cc by straining away excess liquid. The larger organisms, which were picked out, included amphipods, mysids, postlarval crabs, and a few isopods and chaetognaths. These were counted for the whole sample. The remainder of the sample was carefully stirred and a 1 cc aliquot removed. The sample was stirred again and another aliquot removed. The process was again repeated. The three aliquots were combined, put into a Petri dish, and the animals identified and counted.

The species of copepods could be distinguished with practice except for Acartia clausii and A. tonsa, which required an examination of minute structures at high magnification. It was decided as impractical to separate these, so they are considered together. Where a great many copepods were found, the sample was estimated by counting random squares.

In treating the larval crustaceans, no attempt was made at specific identification. Brachyuran larvae were identified simply as brachyuran zoea or postlarval stages (mysis and megalops). The zoeal and postlarval stages of the anomuran crabs were separated from those of the brachyurans. Larval stages of the Cragonidae, readily distinguishable because of the long fifth leg, were listed separately.

Our samples were biased for several reasons. Most planktonic animals

migrate vertically in the water, and are near the surface only during the night. For example, Calanus finmarchicus, a member of a carefully studied genus of copepod, tends to go deep in the water and to prefer a depth of a few fathoms even during darkness. A surface haul probably would not sample this species. Species of the genus Acartia show a more varied pattern of movement. Surface sampling does not give an accurate picture of animal distribution with respect to the total vertical water column. In a more comprehensive study, vertical hauls should be made. The data for monthly hauls indicate San Francisco Bay plankton tends to have a shifting distribution. Phytoplankton is concentrated just below the surface except in the darkest winter months, and the members of the food chains dependent directly on phytoplankton or on the primary consumers follow this pattern. In the case of the mysids found in samples during the winter months, we were obtaining "strays," since these are primarily bottom animals. They may swim upward at night and be found in small numbers in the upper zone. Amphipods also tend to be more subsurface in distribution, but are not as definite bottom dwellers as mysids.

The only previous work with which comparisons may be made is that of C. G. Esterly (1924) who studied the copepods collected by the U. S. Bureau of Fisheries' steamer ALBATROSS during the survey of San Francisco Bay, 1912-13. Esterly found 11 species of copepods in the bay, but three were collected only once and in a single sample. Others were rare. The common species were the same three that we found most abundant, but the proportions of their occurrence were very different. In his study, Esterly found Paralabidocera 15 times as numerous as Calanus and 100 times as numerous as Acartia. Our samples indicate Paralabidocera to be 5-1/2 times as numerous as the other genera (Table 38). These differences may be due to the sampling methods or gear used.

TABLE 38

Relative Abundance of Principal Plankton Forms in Aliquot
Parts of Plankton Samples Collected April, 1963-February, 1964

Copepods	1	2	3	4	5	6	Totals
Calanus	92	57	329	196	203	138	1015
Paralabidocera	830	881	1355	856	788	996	5706
Acartia	26	122	285	222	215	215	1085
Totals	948	1060	1969	1274	1206	1349	7806

Undoubtedly the nature of the bay in many respects has been altered radically in fifty years. A rise in water temperature, which has been suggested, might increase the numbers of Acartia. This genus was common off southern California, but rather scarce further north fifty years ago. Salinity changes might be involved, because the more oceanic species that have apparently increased in numbers. Of course, the shift may represent a yearly variation rather than a long term shift of numbers. A possibility exists that the differences in secondary consumer population composition may be the result of different survival rates. It is an interesting question about which one can only speculate.

Crab zoea and postlarval stages were important elements of the plankton. These first appeared in large numbers in April (they might have been there in March - we had no March samples). They continued through June and dropped off sharply by August. A few were present in September. They are a more important element than their numbers indicate, since they contribute considerable biomass. Most of the larvae were brachyuran crabs. A few porcellanid larvae were found. Cragonid larva were very rare in the plankton, and this was surprising because great numbers of gravid female shrimps were found in the areas we sampled. They must spend their larval life in deeper waters, or in some other portion of the bay.

Amphipods occurred in moderate numbers throughout the year. However, a sample from Station 1 in May contained a large number.

Mysids were taken in small numbers during the winter months. There are apparently three closely related species all belonging to the genus Neomysis represented in our samples. In the winter, they exist in large numbers near the bottom.

Fish eggs were numerous throughout the spring and summer, but some were present at other times.

It was rather surprising to find so few of the usual invertebrate predators in the plankton. There were no large jellyfish and only two arrow worms.

During no month was the plankton really depleted. It was quite evenly distributed throughout the year, though a single month might show considerable variation from station to station. There was a definite spring peak with a tapering off through August and September and a new build-up beginning in December. There did not seem to be two peaks. This may have been a special characteristic of the year, and should be assumed so until further data are available.

Intertidal Sampling

A series of widely separated locations (Figure 1, A through I), which included a wide range of water quality and substrate material, was chosen for intertidal observations. Limited collections of intertidal animals were made to reveal what invertebrates were common about the margin of the bay. An examination of each location was made for macrofauna during a minus tide (Table 12). Species identification was not made for all groups of invertebrates collected. Over two dozen species of annelids are known to occur in San Francisco Bay, so are referred to as worms in the following discussion. Japanese and native littleneck clams also have been combined, as have the basket and spiny cockle. The white sandclam, bent-nosed clam, and the inconspicuous macoma are all considered macoma clams. The acorn barnacle is the most common invertebrate in the bay, but there are several barnacle species that are difficult to distinguish which are probably present. A similar situation exists with other groups such as sponges, sea slugs, and anemones.

A thorough study to determine distribution and relative abundance of the invertebrate species in the vast mud flats, sloughs, and channels of San Francisco Bay would require an investigation manifold larger than this biological survey.

Station A, Strawberry Point in Richardson Bay, is an area of coarse gravel eroded from the bluff above the shore. This substrate is ideal for littleneck clams, and many small Japanese littleneck clams are harvested for bait in this area by sport fishermen. Sea lettuce, Ulva sp., is plentiful, and hundreds of northern midshipmen spawn under the flat rocks. The road, built in 1964 along the south shore, provides access to this popular fishing area.

On January 23 and July 9, 1963, the following animals were found at this location:

Northern midshipman	Littleneck clams
Mud crab	Gaper clam
Shore crab	Macoma clams
Rock crab	Lemon nudibranch
Barnacles	Worms
Bay mussel	

The area from the southern limits of Sausalito south to the sewer plant was chosen as Station B. This area has some sandy beach at its southern end, but is composed of large rocks at the north end. This shore is heavily used by fishermen. Numerous gaper clams were found living about 200 feet from the sewer plant. The outfall is several hundred feet offshore, and does not appear to influence marine life along the beach. Hundreds of thousands of Japanese oyster drill egg cases were found on the rocks and pilings at the edge of town.

The invertebrates found July 13, 1964, include the following:

Kelp crab	Basket cockle
Rock crab	Littleneck clams
Porcelain crab	Jingle
Ghost shrimp	Oyster drill
Barnacles	Lemon nudibranch
Isopods	Ochre starfish
California sea mussel	Bat starfish
Bay mussel	Chitons
Gaper clam	Worms

The substrate of Station C, located at the Brooks Island and the Richmond jetty, ranges from rough rocky shore along the south side of the island to very soft mud on the north side. The stone jetty running west from the island does not support as much marine life as the rocky island's southeast point. There are numerous patches of eel grass north of the island but none to the south.

On August 24, 1964, we observed the following invertebrates in the intertidal zone:

Mud crab ✓	Soft-shell clam
Market crab	Littleneck clams
Barnacles	Piddock
Bay mussel	Basket cockle
California sea mussel	Limpets
Bent-nosed clam ✓	Mud snail ✓
Native oyster	Worms 2

10/10/64

Station D, on the east shore of Yerba Buena Island between the Bay Bridge pier and the north end of the Coast Guard Base, has several kinds of bottom. The bridge piers at this station support a fauna that is similar to that of a steep rocky shore. High on the beach is coarse gravel and rocks. However, at about the -2.0 foot elevation, there is an area of almost level sand, over an acre in extent, that supports a good growth of eel grass.

Animals found August 10, 1964:

Northern midshipman	Littleneck clam
Shore crab	Basket cockle
Mud crab	Macoma clam
Hermit crab	Jingle
Market crab	Oyster drill
Rock crab	Sea slug
Ghost shrimp	Ochre starfish
Barnacle	Shortspine starfish
Isopods	Sponge
Bay mussel	Anemone
California sea mussel	Worms

Station E consists of several miles of shore from Alameda south to the mouth of San Lorenzo Creek. A drawbridge leads from Bay Farm Island to Alameda, and a sand and gravel bar follows the south side of the channel westward for about a quarter of a mile. The littleneck clam population along here was the most dense found during our study. At some sandy areas along this spit, worms are dug for fishbait. A mile southeast of the drawbridge many gaper clams occur along the channel by the old airport. Intensive digging has resulted in

harvest of the larger clams. The area around the San Leandro Marina is included in this station. Soft-shell clams are the most abundant form here. Approximately 2 miles southeast of the marina there is a sandspit about one-half a mile long at the mouth of San Lorenzo Creek. The most common marine life found here is ghost shrimp.

Animals found February 5, 1963 and April 5, 1963:

Ghost shrimp	Soft-shell clam
Barnacle	Gaper clam
Ribbed horsemussel	Worms
Littleneck clams	

Station G includes the Port of Redwood City and the adjacent shore. The substrate is soft mud in the deeper water and along the shore, except for the filled location behind the dock. This dock has had trays of living oysters hanging from it since February, 1962. At no time since then has the water quality caused oyster mortality. Near the dock there is enough broken shell on the surface to make walking possible. Soft-shelled and gaper clams are found in these gravelly areas.

Animals found December 6, 1963, March 10, 1964, and May 6, 1964:

Mud crab	Ribbed horsemussel
Skeleton shrimp	Soft-shell clam
Barnacle	Gaper clam
Isopod	Native oyster
Gribble	Sponge
Hydroid	Ascidians
Bay mussel	

Station H includes the Dumbarton Bridge and nearby western shoreline. The bridge piers support Pacific oysters. These were the only ones found in San Francisco Bay, and they were all old individuals which probably originated from spawning of earlier plantings in the south end of the bay.

Animals found January 31, 1962, May 17, 1963, September 20, 1963, and April 18, 1964:

Shore crab	Ribbed horsemussel
Skeleton shrimp	Native oyster
Barnacle	Basket cockle
Gribble	Pacific oyster
Hydroid	Sponge
Bay mussel	Sea anemone

Station I is near the town of Alviso at the railroad bridge over Coyote Creek. The natural flow of fresh water from the creek, as well as the considerable flow of sewage coming into the bay here, limits the variety of organisms. As a result, only three species were found living here. They were acorn barnacles, ribbed horsemussels, and mud snails. However, there were hundreds of snails per square yard. Observations were made January 16, 1963, and April 19, 1964.

The ribbed horsemussel, Modiolus demissa, deserves special mention because it is one of the more abundant shellfish in the bay. This bivalve was introduced from the Atlantic coast with transplants of Eastern oysters, which began in 1879. It lives in the high intertidal zone and prefers areas of cord grass, Spartina foliosa. This mussel, a filter feeder, removes all sorts of suspended matter from water, and a dozen animals in a five-gallon aquarium of murky water will

remove most of the suspended material within a few hours. It is high in vitamin D content and has been harvested commercially on the Atlantic coast. A venture in 1962 to harvest this mussel from San Francisco Bay beds was unsuccessful. This shellfish is common in Napa Slough as well as around the south end of the bay. A single square foot of substrate in the Palo Alto Harbor vicinity contained 387 individuals weighing 7.45 pounds. When this figure is projected for the total area they are known to inhabit, estimates of hundreds of tons are feasible.

MAMMALS

Though not subject to special study in the course of the biological survey of San Francisco Bay, several species of marine mammals were observed. Their occurrence is noted briefly here for they do represent an important part of the bay's population of larger animals.

California sea lions, Zalophus californianus, were frequently seen in the bay within a mile or two of the Golden Gate. South of the Dumbarton Bridge we observed a colony of harbor seals, Phoca vitulina. This non-migrating population has been estimated to be of 50 to 100 individuals. Another group of about 30 harbor seals was found near the Richmond end of the Richmond-San Rafael Bridge. Occasionally harbor porpoises, Phocoena phocoena, were seen between Treasure Island and the Golden Gate.

SALINITY AND TEMPERATURE

Means of surfact water salinities are shown in Figure 5. The measurements at specific stations are given in Tables 39 to 42. Considerable freshwater flows into the bay system from the Sacramento and San Joaquin rivers and lowers the surface salinity in the north end of the bay. November, 1964 shows 14.2 parts per thousand at the surface on Southampton Shoal. This was the lowest

PARTS PER THOUSAND

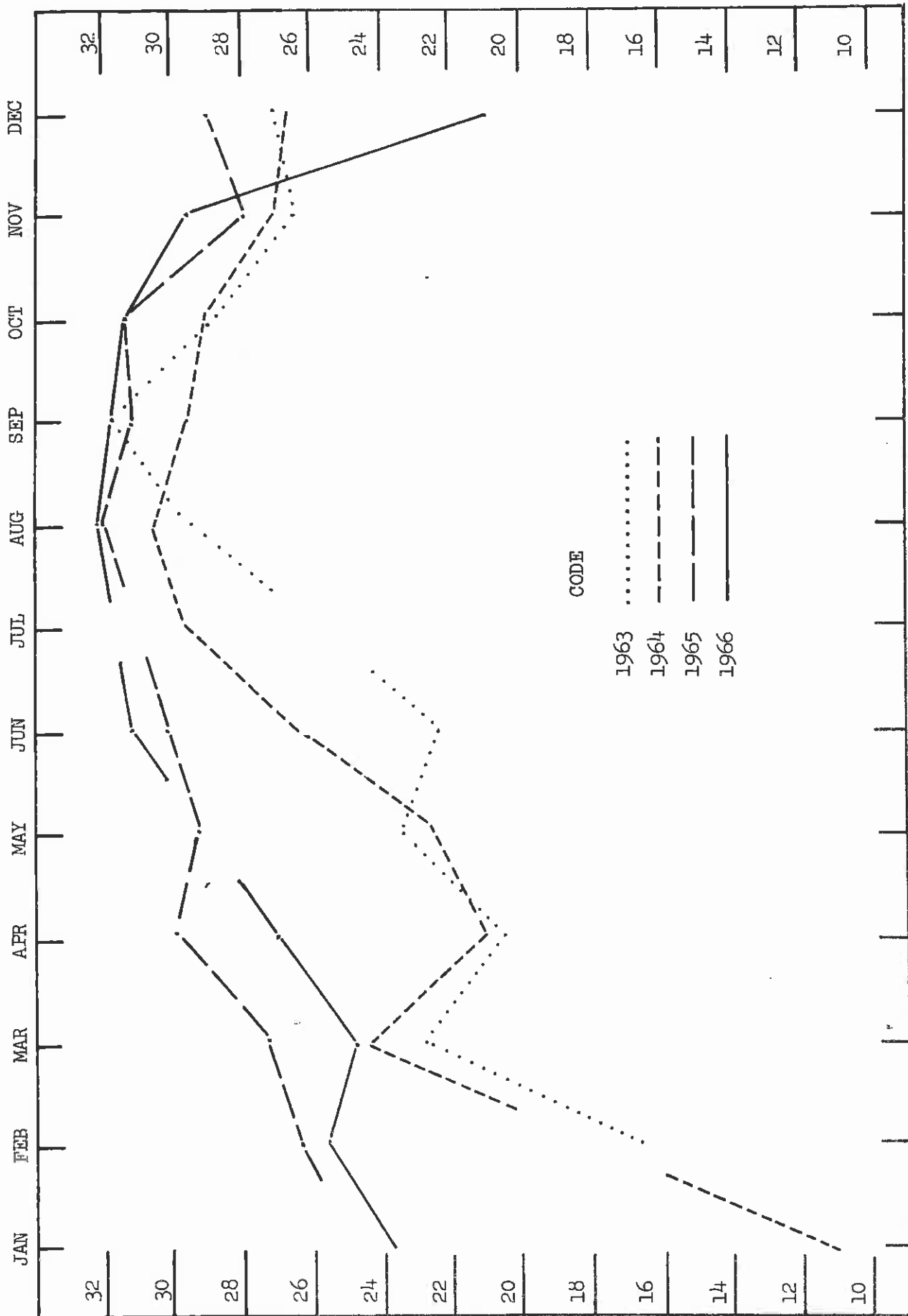


Figure 5. Surface water salinities in San Francisco Bay. Means of six stations.

TABLE 39
Salinities Recorded at Stations of San Francisco Bay Study, 1963

(P a r t s P e r T h o u s a n d)												
Station	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1 surface			21.2	19.0	26.9	15.8		25.8	31.4	24.4	20.5	26.8
bottom					28.1			29.4	31.5	27.4	24.4	29.0
2 surface				20.4	23.5	24.2		31.0	32.8	29.0	23.0	26.1
bottom				20.4	27.6	24.4		31.1	32.7	29.4	29.5	28.1
3 surface			29.8	20.8	24.8	26.1		31.0	32.7	29.3	28.1	26.9
bottom				22.7	26.3	27.2		31.2	32.7	29.8	29.5	27.7
4 surface	19.0	24.7	24.6	24.6	24.3	24.8		34.1	32.7	30.4	32.3	27.2
bottom		24.7	25.1	25.1	23.8	24.1		32.1	31.6		28.5	26.5
5 surface			20.3	23.9	21.8	21.4		28.9	31.1	29.9	29.3	27.2
bottom			21.6	23.1	20.1			28.8	31.2		28.5	27.5
6 surface	14.0	18.7	19.7	19.7	19.2	21.6		26.0	29.8	28.9	25.1	27.2

TABLE 40

Salinities Recorded at Stations of San Francisco Bay Study, 1964

(P a r t s P e r T h o u s a n d)												
Station	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1 surface	26.3	28.5	30.8	30.8	29.5	28.4		30.8	29.8	29.3	14.2	27.5
1 bottom	22.7	26.9	30.7	30.7	33.5	31.2		31.9	31.4	30.7	29.9	29.1
2 surface	27.3	29.0	30.8	30.8	29.9	30.7		31.5	31.1	29.4	28.5	27.3
2 bottom	28.6	29.1	31.0	31.0	30.6	31.5		31.6	31.2	30.7	29.9	29.0
3 surface	27.2	27.3	31.9	31.9	30.3	30.7		32.9	31.2	31.0	29.8	27.7
3 bottom	29.7	29.8	32.0	32.0	30.6	30.6		32.7	31.9	31.5	30.1	29.7
4 surface	26.5	27.1	29.3	29.3	29.4	30.7		32.1	32.3	32.0	31.5	28.9
4 bottom	26.7	27.2	29.7	29.7	30.3	30.6		32.3	32.5	33.2	32.0	29.1
5 surface	25.0	26.0	28.2	28.2	29.1	30.6		32.3	32.1	32.3	31.8	29.4
5 bottom	25.6	25.6	28.6	28.6	30.6	30.7		32.0	32.7	32.5	32.7	29.7
6 surface	24.7	25.0	27.6	27.6	28.0	28.6		32.0	30.8	32.5	32.0	29.7

TABLE 41

Salinities Recorded at Stations of San Francisco Bay Study, 1965

(P a r t s P e r T h o u s a n d)													
Station	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	
1	surface	10.2		21.4	16.7	22.4	27.5	29.8	29.8	27.6	31.0	26.4	25.2
	bottom	12.9		29.1	25.8	27.2	30.7	29.8	30.8	28.1	31.1	29.8	29.3
2	surface	10.7		25.6	21.8	23.3	27.6	29.7	31.0	29.0	28.8	26.1	26.3
	bottom	26.7		28.2	23.3	23.9	27.6	29.7	30.8	29.7	29.5	28.5	28.8
3	surface	9.9		26.7	23.3	21.2	26.8	31.2	31.1	30.3	28.8	28.2	28.8
	bottom	28.4		26.7	24.4	22.9	29.5	31.4	31.6	31.1	30.6	31.0	30.6
4	surface	9.8		25.5	23.4	22.9	27.3	29.4	31.6	30.8	27.2	26.5	27.3
	bottom	13.7		25.5	24.3	21.3	26.9	29.7	33.2	30.8	28.4	27.3	26.9
5	surface	12.0		24.2	25.8	23.8	26.1	28.5	30.3	30.1	30.1	28.6	26.7
	bottom	25.9		24.2	25.8	23.5	26.1	28.8	30.1	30.3	30.1	28.6	26.9
6	surface	12.7		21.8	21.0	21.6	23.1	28.0	29.1	29.8	29.1	27.1	26.4

TABLE 42
Salinities Recorded at Stations of San Francisco Bay Study, 1966

		(P a r t s P e r T h o u s a n d)											
Station		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1	surface	21.8	27.7	23.1	27.6		31.0		32.8	29.7	29.5	28.4	14.4
	bottom	24.1	27.5	27.2	29.1		31.0		31.6	31.6	31.6	30.8	25.2
2	surface	25.2	26.0	23.7	28.4		31.2		33.2	32.1	30.7	28.5	21.2
	bottom	26.0	26.8	27.5	29.1		31.5		33.2	31.6	31.1	29.3	27.1
3	surface	22.9	27.8	26.4	29.1		31.2		31.8	32.1	30.8	28.1	17.4
	bottom	28.9	30.1	27.2	31.4		32.5		32.7	32.7	31.9	29.0	29.7
4	surface	23.7	24.2	25.4	26.5		30.4		33.6	32.5	31.9	30.4	21.8
	bottom	23.8	23.7	25.5	26.5		30.6		32.0	32.4	32.0	31.0	24.3
5	surface	23.8	24.3	26.4	25.8		29.8		31.8	32.7	33.6	31.4	23.7
	bottom	24.3	24.4	26.0	25.4		29.8		31.8	32.8	31.9	32.0	26.5
6	surface	24.8	23.7	23.3	24.2		29.7		29.1	31.9	31.0	31.0	26.8

salinity recorded. The highest was 34.1 in August, 1963 on San Bruno Shoal. The bottom water is generally more saline, but the stirring action of the tides causes the whole body to become of equal density by the time it reaches the Golden Gate. The addition of sewer effluent and irrigation waste waters also reduce the salinity. At times of maximum river flow there are severe dieoffs of certain shellfish. Japanese littleneck clams are killed but soft-shelled clams are unaffected.

Temperature means for surface water are shown in Figure 6. Tables 43 to 45 give readings by station. The highest temperature measured was 23.9° C south of the Dumbarton Bridge in August, 1965. The lowest recorded was 8.6° C on San Bruno Shoal in December, 1963. A series of cold days with strong winds from the central valley will reduce the bay water temperature below that of the open ocean. On windless days in the summer or fall, exceptional highs occur in the shallow south bay waters.

DISCUSSION

The waters of San Francisco Bay from San Rafael to Alviso support a wide variety of vertebrate and invertebrate animals. The biological survey, including several locations in the deeper channels as well as intertidal areas, reveals the assemblage of three species of marine mammals, 71 species of fish, and numerous invertebrates representing as many as eight phyla. The microflora and fauna are rich and support a wide variety of filter feeding animals. The zooplankton consists of the eggs and larvae of many of the resident and migrant species as well as many other small animals of major importance in the food chain of the bay. San Francisco Bay has been, is now, and can be in the future an area capable of supporting large commercial and recreational activities based on utilization of marine resources. The bay is unique in California in

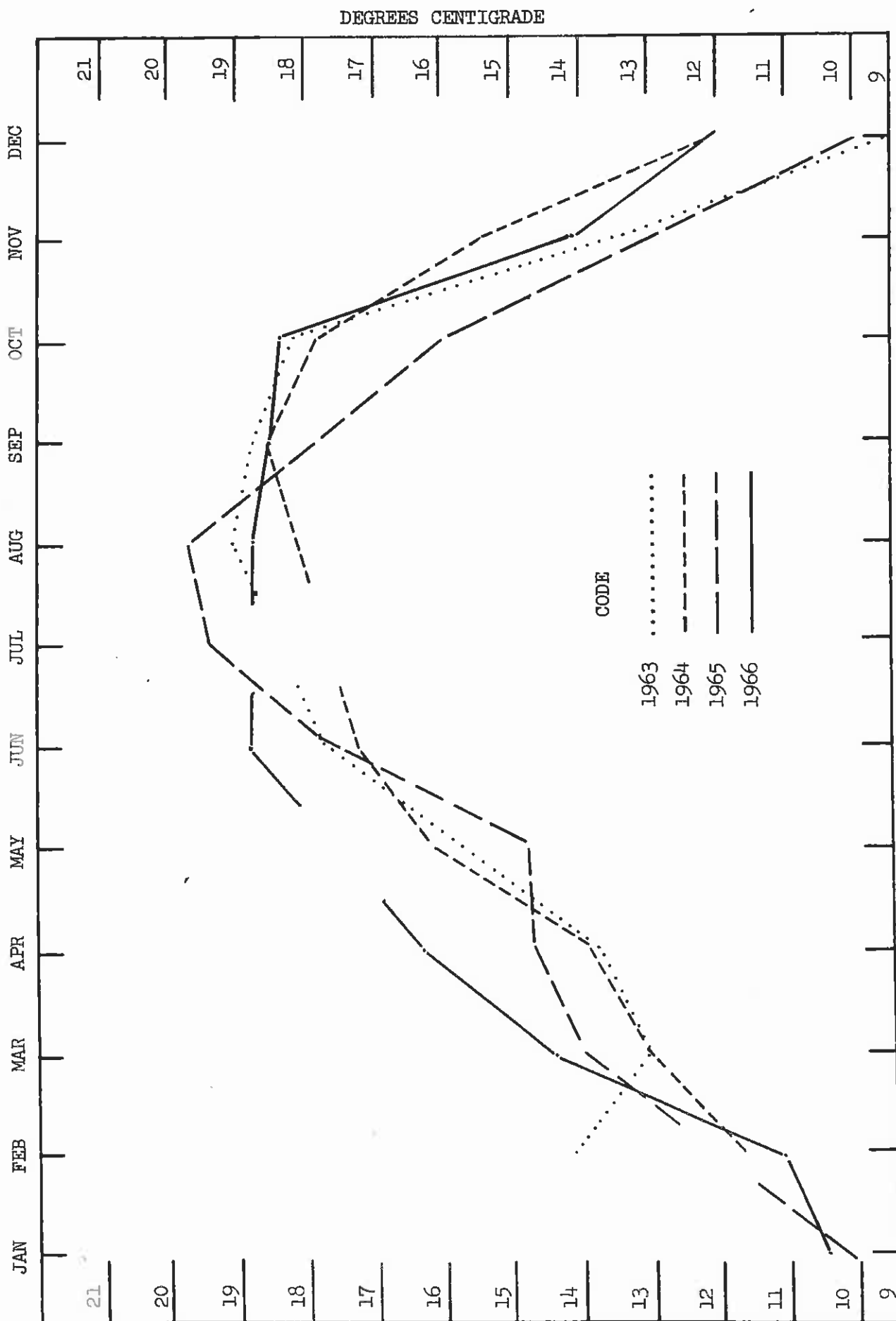


Figure 6. Surface water temperatures in San Francisco Bay. Means of six stations.

TABLE 42

Water Temperatures Recorded at Stations of San Francisco Bay Study, 1963

		(Degrees Centigrade)											
Station		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1	surface			14.4	12.8	14.2	16.4		19.4	18.3	18.6	13.9	9.4
	bottom				12.8	13.1	15.3		18.1	18.1	18.3		10.0
2	surface			13.3	12.8	14.7	15.8		16.9	17.8	18.3	13.9	9.2
	bottom				12.8	14.2	15.0		18.1	18.3	18.1	13.9	9.4
3	surface			11.9	12.8	14.2	16.1		16.9	18.1	17.8	13.9	9.4
	bottom				12.5	14.2	14.7		17.5	17.5	17.5	13.9	9.4
4	surface		12.8	12.8	14.7	15.0	17.2		18.9	18.3	18.1	13.3	8.6
	bottom			12.8	14.2	15.6	18.3		18.9	18.3		13.9	8.3
5	surface		15.1	13.1	14.4	20.3	20.3		21.1	20.0	18.1	13.6	9.7
	bottom			13.1	14.4	16.9			20.6	19.7		13.3	9.4
6	surface		14.7	13.3	15.6	15.0	21.1		21.1	20.6	18.1	11.1	9.2
surface means			14.2	13.1	13.8	15.6	17.8		19.1	18.8	18.2	13.3	9.3

TABLE 43

Water Temperatures Recorded at Stations of San Francisco Bay Study, 1964

(D e g r e e s C e n t i g r a d e)													
Station	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	
1 surface	11.7	12.8	12.8	13.3	14.2	16.9		17.8	18.9	16.7	14.4	11.4	11.4
	bottom	12.2	13.1	13.1	13.9	15.8		17.8	18.9	16.4	14.4	11.1	
2 surface	12.2	12.5	12.5	12.2	15.6	16.1		17.2	18.9	17.2	13.9	11.7	11.7
	bottom	12.2	13.1	12.2	15.0	15.3		17.5	19.4	16.7	14.2	11.7	
3 surface	11.1	12.2	12.2	12.5	16.4	17.2		16.1	17.5	16.7	14.4	11.1	11.1
	bottom	11.7	12.2	12.2	16.2	17.2		16.1	17.8	16.5	14.7	10.8	
4 surface	11.9	13.3	13.3	14.4	16.4	17.2		20.0	18.6	18.5	15.3	12.2	12.2
	bottom	12.2	13.6	13.6	15.3	16.9	17.2	19.4	18.3	19.2	15.3	12.2	
5 surface	11.7	13.6	13.6	14.4	16.7	17.8		19.7	17.8	18.3	16.7	12.2	12.2
	bottom	12.8	13.9	13.9	14.4	16.7	17.5	19.4	18.9	18.3	16.1	12.2	
6 surface	11.7	15.6	15.6	15.3	18.1	18.6		21.1	20.0	19.7	18.1	13.1	13.1
surface means	11.7	13.1	13.1	13.9	16.2	17.3		18.2	18.6	17.9	15.4	12.0	12.0

TABLE 44

Water Temperatures Recorded at Stations of San Francisco Bay Study, 1965

		(D e g r e e s C e n t i g r a d e)											
Station		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1	surface	10.0		12.8	15.8	14.2	15.0	18.3	18.6	16.7	14.2	12.2	10.6
	bottom	11.1		12.2	14.2	12.8	14.2	17.8	17.2	16.7	14.7	12.8	11.1
2	surface	9.7		13.9	15.0	15.0	15.6	18.3	17.8	17.2	15.0	12.2	10.3
	bottom	10.8		13.9	15.6	14.4	15.3	17.8	17.8	16.7	14.7	12.8	11.1
3	surface	10.6		12.8	13.6	13.9	16.1	17.8	17.2	16.1	15.0	12.2	10.8
	bottom	11.1		12.2	13.9	14.4	15.0	17.5	16.7	16.1	15.3	12.8	11.1
4	surface	11.9		13.3	14.4	15.3	18.9	19.4	19.7	19.4	15.8	13.3	9.7
	bottom	11.9		13.3	13.9	15.6	19.4	19.4	20.0	18.9	16.7	13.3	10.0
5	surface	9.2		13.3	13.9	15.0	18.1	21.4	21.7	18.9	17.8	12.8	9.4
	bottom	9.2		13.3	14.4	14.7	18.1	22.2	21.7	18.9	17.2	13.1	10.0
6	surface	10.0		19.2	15.6	15.6	22.2	21.9	23.9	18.9	18.1	13.6	9.4
surface means		10.2		14.0	14.7	14.8	17.6	19.5	19.8	17.9	16.0	12.7	10.0

TABLE 45

Water Temperatures Recorded at Stations of San Francisco Bay Study, 1966

		(Degrees Centigrade)											
Station		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1	surface	10.6	11.1	13.3	15.3		17.2		16.9	18.3	17.5	13.9	11.9
	bottom	11.1	11.7	12.5	13.9		17.8		18.3	18.9	17.2		12.8
2	surface	10.6	11.1	13.9	16.7		18.1		16.7	16.9	17.2	13.6	12.8
	bottom	10.6	11.4	13.9	15.0		16.7		16.7	17.8	17.5		13.3
3	surface	10.0	11.1	13.3	13.9		16.4		17.5	17.5	16.7	13.9	11.7
	bottom	11.1	11.4	12.8	13.3		15.0		17.2	18.9	15.8		12.8
4	surface	11.1	11.4	15.0	18.1		18.6		18.3	19.7	19.7	13.3	12.8
	bottom	10.8	10.3	15.6	17.5		18.6		18.1	20.3	20.0		13.1
5	surface	10.6	10.6	15.3	18.3		20.6		20.8	18.9	20.0	15.0	11.9
	bottom	10.8	10.3	16.1	18.6		20.3		20.8	19.4	19.7		11.9
6	surface	9.4	11.9	15.6	15.6		21.9		22.5	19.7	19.2	15.0	12.2
surface means		10.4	11.2	14.4	16.3		18.8		18.8	18.5	18.4	14.1	12.2

regard to size, fresh water run-off received, and industrial and domestic pollution discharges. Another fact stands out, in addition to their great waste carrying capacity, the waters also support a wealth of marine organisms. Therefore, conditions can be improved or worsened, depending upon the decisions of those governmental agencies, commissions, and legislative bodies controlling the future of the bay.

San Francisco Bay yields to the sport fishermen perch, rockfish, salmon, striped bass, smelt, shark, jacksmelt, and many others. Clam diggers can enjoy littleneck, soft-shell, and gaper clams. Commercial fishermen have shark, shrimp, and bait species for the taking, and there is a tremendous potential for culture of oysters and clams. These uses of the bay are not at established fishing piers and in deep channels alone. They occur along the shore, on the intertidal flats, and along many miles of sloughs.

The California Fish and Wildlife Plan specifically includes bays and estuaries in both its research and management recommendations as well as future planning recommendations. San Francisco Bay in particular received considerable attention in the plan (Vol. III, pages 795-807) which explained the problems of the bay and emphasized the need for a program to meet them.

The need for protection of the fish and wildlife resources and their habitat is well documented. This Marine Resources Operations Biological Survey of San Francisco Bay presents data which

gives an indication of the great need for additional study to gain an understanding of the relationships between the deep and shallow water environments and the marine resources therein.

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