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Division of Salt Water Fisheries

RANDOLPH HODGES, *Director*

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THE FLORIDA SHRIMPING INDUSTRY

by

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PREFACE

The total dockside value of shrimp produced in Florida (bait shrimp included) amounted to \$16,675,635.50 in 1964. Retail value was approximately three times this figure. Because of the vagaries of supply and demand, these figures vary somewhat from year to year. However, shrimp have been the leading seafood produced in Florida in both value and volume for several years.

The amount of money invested in this industry in the form of boats, gear, maintenance, and shore facilities makes this one of Florida's major industrial complexes. Additional value is present in subsidiary businesses dependent to some extent upon shrimp. These include trucking, packaging, freezing, marketing, marine products and supplies, boat construction, and many others. It is only when all of these factors are considered as a whole that one may begin to understand the importance of the shrimp industry to the economy of Florida.

The first Educational Series on the shrimp industry of Florida was written in 1950 by C. P. Idyll under the direction of the Florida Board of Conservation. This publication was expanded and updated in the 1957 re-issue (C. P. Idyll, 1957). Since that time, advances in the understanding of shrimp biology have been made through extensive shrimp research programs.

The demand for the original publications has long since exhausted the supply and it was felt that a reprinting would no longer satisfy the needs of a more enlightened public. Consequently, the following is a revision and re-evaluation of the Florida shrimping industry based on new biological advances.

As should be expected, not all problems have been answered and, in fact, some new ones have presented themselves. Nevertheless, it is hoped that the following will provide many of the answers for the private and commercial person interested in shrimp and shrimping.

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INTRODUCTION

The State of Florida, with over 7,000 miles of coastline, is unique among the major shrimp producing states. This great length of coastline, stretching from almost temperate to almost tropical climates, allows for a great diversity in shrimp populations, and the major producing areas exhibit differences in both major species and the biology of these species. Consequently, sound conservation practices for one area may be useless or detrimental in another area. This factor has necessitated detailed research programs in each productive area.

Under the direction and guidance of Mr. Robert M. Ingle, Director of Research, the Florida Board of Conservation has been instrumental in shrimp research throughout the State. During earlier years the Board contracted this work to the Institute of Marine Science, University of Miami. In 1955, the Board of Conservation established its own Marine Laboratory in St. Petersburg and this organization has conducted many important phases of the state-supported shrimp research.

The U. S. Fish and Wildlife Service has also played an important role in this field. Although not limited to the State of Florida, it has done some valuable exploratory work along both coasts. It has also financed additional research on basic shrimp biology through its own marine facilities and the Institute of Marine Science, University of Miami.

MAJOR COMMERCIAL SPECIES

Three species of shrimp, belonging to the genus *Penaeus*, make up most of the commercial Florida catch. These are the white shrimp (*Penaeus fluvialis* Say), the brown shrimp (*Penaeus aztecus* Ives), and the pink shrimp (*Penaeus duorarum* Burkenroad).

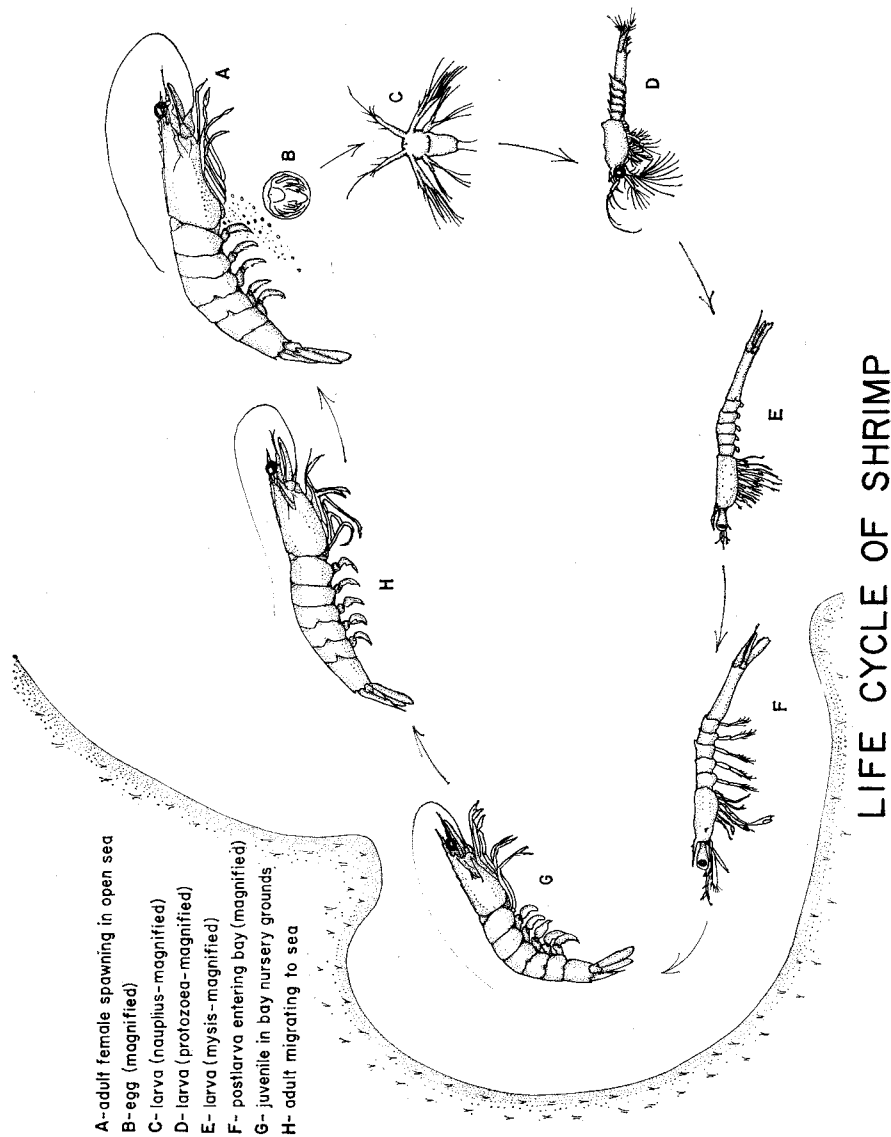


Figure 1. Life history of the shrimp.

Studies by several workers have determined that the life histories of these species are quite similar (Figure 1). The eggs are laid

offshore, hatch in about 24 hours and undergo a complex series of larval stages, during which time these shrimp move slowly toward shore. After reaching the shallow inshore waters, the young shrimp take up a bottom-dwelling existence in the grass flats. Throughout their stay on this "nursery" area, growth is rapid. Studies have shown that there is a definite depth/size relationship. As growth continues, the shrimp move to deeper and deeper water. When around four inches in length, the shrimp make a return migration to offshore waters to complete maturation and ultimately to spawn. The entire cycle is completed in approximately twelve months. The following section discusses each of these species in more detail.

White Shrimp (*Penaeus fluviatilis* Say)

This species, long known as *Penaeus setiferus* (Linn.) occurs in disjunct populations on both coasts of Florida. It has been taken along the Atlantic as far south as the St. Lucie Inlet and on the northwest coast to the Ochlockonee River.

Species of the genus *Penaeus* are easily identified by the presence of two or three ventral spines on the long rostrum or horn. Identification of the white shrimp is quite easy since it is the only *Penaeus* species in Florida which does not have grooves on the cephalothorax or head. It is also characterized by antennae (feelers) which are twice as long as the body.

Spawning on both coasts begins in April and reaches a peak in May and June, although there are slight variations in each area from year to year. Spawning is concentrated offshore in depths between 20 and 80 feet, but there are indications that spawning may also occur at or very near inlets during some years.

Newly spawned shrimp first appear on the nursery grounds in late June and growth is quite rapid, averaging near $1\frac{1}{2}$ inches per month. Shrimp remain on the nursery grounds for approximately three months and some migration up large, freshwater rivers apparently occurs throughout this period. White shrimp have been taken 130 miles upstream in the St. Johns River.

Individual shrimp begin migrating out of the river around the middle of August. This is verified by the fact that commercial catches of this species usually begin in mid-August and September.

It was previously believed that cold weather caused white shrimp to move from the nursery grounds. Later it was found that the movement of white shrimp from the St. Johns River began in mid-August and continued through September, when temperature changes were negligible. Furthermore, these migrating shrimp were approximately the same size (about 5 inches) when leaving the nursery

areas. This indicates that the stage of maturation may determine the start of migration, especially in these early months. For the remainder of the season (October through December), lower temperatures may cause the white shrimp to leave the rivers and bays, at a smaller size.

Among the three major commercial species, white shrimp exhibit the greatest tolerance to low salinities. White shrimp migrated over 100 miles up the St. Johns River from salinities of 1.0 o/oo and higher for a period of two months or more, and were taken in salinities as low as 0.26 o/oo.

By the end of November, most white shrimp have moved from the nursery grounds and only a very few remain in high saline inshore areas.

During the colder winter months, growth is almost negligible. With the advent of warmer weather, a relatively high growth rate is resumed and the female shrimp are soon ready to spawn, thus completing the cycle.

Brown Shrimp (*Penaeus aztecus* Ives)

The brown shrimp occurs in a disjunct range very similar to that of white shrimp. Only a few scattered individuals have been reported from the southwest Florida coast (Costello, 1963).

Identification of the brown shrimp is quite difficult. The presence of an abdominal spot in the pink shrimp has been used to separate this species from the brown shrimp; however, in certain areas this character is invalid.

In the grooved species (pink and brown) there is also a groove on the last segment of the tail next to the telson (fan). If it is possible to insert the thumbnail into the groove, the specimen is *P. aztecus*. If the groove is too narrow for the thumbnail to enter, then it is *P. duorarum*. The groove on another species, *P. brasiliensis*, is also too narrow for the thumbnail to enter but this species is rarely taken outside of the southeast Florida area.

The thumbnail test is very gross and will work only on adult or nearly adult Florida shrimp. Accurate scientific identification requires a microscope and thorough familiarization with each species.

Brown shrimp spawning begins relatively early and inshore recruitment to the nursery grounds apparently reaches a peak sometime in late February and March. Spawning depths appear greater than those of *P. fluvialis*. There are also indications that a second, though much reduced, spawning may occur in early fall.

Brown shrimp nursery areas appear to differ from those of the white shrimp. Whereas white shrimp may perish if they do not reach the lower saline inshore areas, *P. aztecus* utilize low and high saline inshore grounds and appear to use the shallow offshore areas on the northeast coast as nursery grounds.

Small brown shrimp are found inshore and offshore from early May, and by August or September the majority have moved from these nursery grounds. Smaller shrimp again appear on these grounds in small numbers during October and these are believed to be the result of a second spawning. Growth of brown shrimp is fairly rapid (between $1\frac{1}{2}$ to $1\frac{3}{4}$ inches per month) and the shrimp leave the nursery grounds at a smaller average size (around 4 inches) than the white shrimp.

Although *P. aztecus* are found in the St. Johns River in nearly fresh water, it appears that they are not as tolerant to fresh water as are the white shrimp. Brown shrimp migrate up the St. Johns River in June and July but the distance traveled upstream and the length of time spent in the river is much shorter than that for white shrimp.

After September, *P. aztecus* are scarce or absent in both inshore and offshore catches in the Apalachicola and northeast Florida areas. On the northeast coast it appears that they spend the winter in deeper and more southerly waters in a reproductively advanced stage and that spawning may occur with or soon after the first warming of the water. Very recent data indicate that some spawning may occur in November and December and that the postlarvae have the ability to delay their entrance to inshore areas until a suitable time.

Pink Shrimp (*Penaeus duorarum* Burkenroad)

Since the publication of Educational Series No. 6 (Idyll, 1950), most of the shrimp research in Florida has been directed to this species. Basically, this is because of the important and extensive Tortugas pink shrimp grounds (southwest coast of Florida) which produce an average of 18,000,000 pounds per year.

This species occurs throughout the marine waters of Florida and enters the shrimp catches in most areas. Along the northeast coast of Florida, pink shrimp form a small percentage of the commercial catch, but are a major constituent of the live bait industry from Ponce de Leon Inlet south to Biscayne Bay. The offshore grounds north of Tortugas to Sanibel Island is the major productive area. Farther up the coast from the Sarasota to Tarpon Springs area, a tremendous bait industry and some occasional commercial production is based on this species. From the Cedar Keys area northward, minor

bait shrimping operations and sporadic commercial production occur. Since 1961, commercial production of pink shrimp on the northwest coast of Florida has exceeded the production of whites and browns.

Spawning, growth rates, and other biological functions of this species vary more than those of the preceding species, because of its greater geographical range. Spawning, for example, which occurs year-round to some extent in the Tortugas area, does not begin until early spring in the St. Petersburg, St. Augustine latitudes. It appears that a gradual cessation of winter spawning occurs as one proceeds northward.

Growth of *P. duorarum* appears to average about $\frac{3}{4}$ inch per month until the shrimp are 3 inches long, then the growth rate decreases as the shrimp grow larger. Unlike the two other major species, a large number of pink shrimp remain in the high salinity inshore nursery areas during the winter.

Of the three species, the pink shrimp is the least tolerant to low salinity, although a few have been found 50 miles up the St. Johns River in nearly fresh water.

COMMERCIAL SHRIMPING

Commercial shrimping is herein designated as that shrimping done in offshore waters for the production of food shrimp. Bait shrimping is usually done in the shallow, inshore waters.



Figure 2. Commercial shrimp.

—Florida State News Bureau

Historically, the shrimping industry developed similarly at several locations. In the beginning, shrimp were a by-product of seining operations until they finally became an end in themselves with seining still the method of choice.

The first truly commercial shrimping was begun by a Sicilian immigrant, Sollecito Salvador, at Fernandina, Florida, around 1900. By 1902, Mr. Salvador had instituted the first power-driven boat which was used to pull a haul seine in deeper water to increase his shrimp catch.

The industry continued to enlarge and around 1912-1915 the otter trawl designed by Capt. Billy Corkum was first used and is now standard equipment. This net is characterized by two large "doors" which are designed to bounce along the bottom and keep the net open. As the net is pulled, the shrimp and other bottom animals are swept into the closed bag.

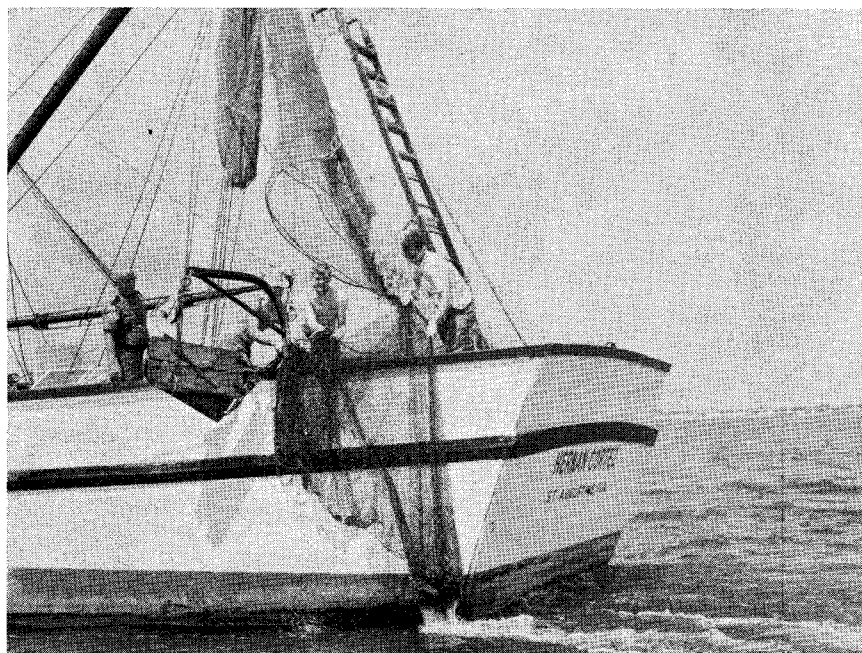


Figure 3. 16 ft. trynet, a small version of the standard otter trawl.

Research on the use of a new electric shrimp trawl to increase catches has proven very interesting (Bullis, 1966). It was theorized that an electric shock immediately preceding the net might cause buried shrimp to jump and thus be taken in the net. Preliminary results have been quite promising. In addition, it appears that this gear will enable shrimpers to work during daylight hours and still catch nocturnal species.

In the early 1920's, most of the shrimpers shifted their operations from Fernandina to St. Augustine which was the shrimping capital until the discovery of the large shrimp grounds off Louisiana, Texas, Campeche, and the Tortugas. It is interesting to note that it was one of Sollecito Salvador's sons who discovered the Tortugas grounds in late 1949.

Today's commercial production in Florida is located in three major areas: the northwest coast from the Georgia line to south of Melbourne; Tortugas to Sanibel; and Apalachicola to Pensacola. A large amount of shrimp taken in the Campeche grounds off the tip of the Yucatan Peninsula are also landed in Florida primarily

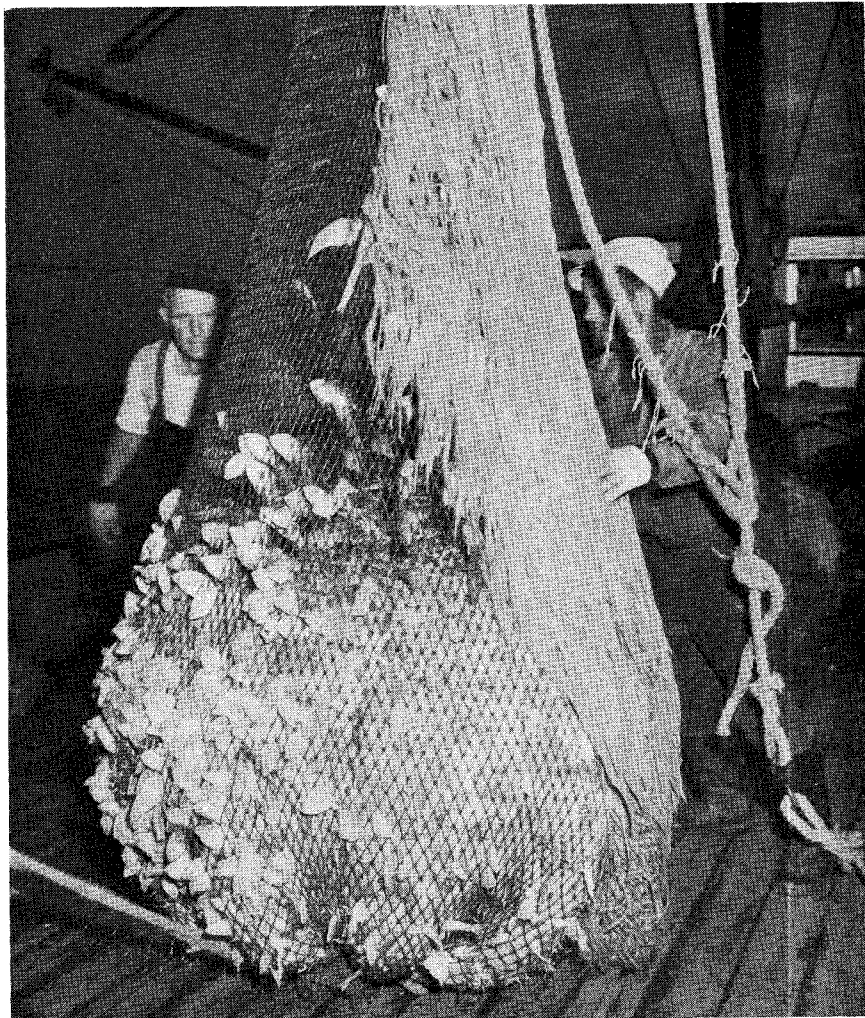


Figure 4. Cod end of net with a full catch.

—Florida State News Bureau

on the lower west coast. In addition, there is a fishery from Sarasota to north of Tarpon Springs, but this fishery is erratic, with production varying from a few thousand pounds to almost a million and a half (Table 1).

SHRIMPING AREAS

Northeast Coast Area

This is the southern end of an almost continuous shrimping area that begins around Beaufort, North Carolina and ends near Melbourne, Florida. Some of the more knowledgeable shrimpers are able to work as far south as Fort Pierce but this requires a great deal of experience and familiarity with the trawlable areas. All trawling along this coast (with the exception of that done for the deep water royal red shrimp) is usually within 6-8 miles of the shore in depths of 20-80 feet.

All three species are recorded from this area (Table 2). The percentage of each species in the catches varies from year to year and it should be mentioned that the records for *P. duorarum* are probably not too accurate. There are a few pink shrimp taken every year but since their numbers are relatively small, they are probably grouped with the other grooved shrimp (brown) since some shrimpers are unable to distinguish between the two species. Another possible reason for small catches of pink shrimp is that night shrimping is illegal during the period of greatest pink shrimp abundance.

Biological habits of these three shrimp differ considerably in spite of their relatively similar appearances and these differences greatly affect shrimping in this area. *P. aztecus* and *P. duorarum* are caught in greater numbers when the trawling is done at night and better catches of white shrimp (*P. fluvialis*) occur during daylight hours. Furthermore, brown shrimp are caught earlier in the year than are white shrimp.

From the shrimper's standpoint, the above factors cause a shrimping year to be broken down into the following seasons: 1) the "off" season, from January through May; 2) the brown shrimp season, from June 1 to August 31; 3) the white shrimp season, from late August to December or January.

The off season is that time of year (January to June) after the white shrimp season and prior to the brown shrimp season. Catches are extremely small and an entire day's dragging may amount to less than 15-20 pounds. Since this is insufficient to cover even operating expenses, most shrimpers in the area switch to snapper fishing or other means of livelihood. When the weather is suitable some

TABLE 1. SHRIMP CATCH BY AREAS (1951-1965)

POUNDS
(Heads On)

	East Coast	Tortugas- Sanibel	Campeche	Central West Coast	Upper West Coast (Apalachicola)	Total
1951	7,312,354	17,716,537	6,949,646	—	1,341,061	33,319,598
1952	6,439,789	11,463,661	22,988,906	—	2,942,124	43,834,480
1953	5,667,711	17,429,049	32,319,184	—	3,055,627	58,471,571
1954	5,077,675	18,273,314	24,880,714	—	2,651,173	50,882,876
1955	4,136,103	20,639,680	24,302,014	—	3,656,193	52,733,990
1956	5,702,465	20,727,091	25,511,685	—	2,868,524	54,809,765
1957	5,182,865	16,746,017	21,786,266	—	3,384,447	47,099,595
1958	5,512,433	24,198,937	13,995,837	1,428,573	3,986,958	49,122,738
1959	4,514,149	13,787,611	15,524,863	141,698	2,179,504	36,147,825
1960	6,809,053	24,662,001	15,591,774	42,883	3,591,838	50,697,549
1961	6,026,528	18,446,965	13,917,126	215,853	3,520,351	42,126,823
1962	5,223,184	14,036,044	14,893,380	140,078	3,015,283	37,307,969
1963	4,509,368	16,720,489	12,564,322	1,209,820	4,123,748	39,127,747
1964	4,493,754	19,351,280	12,708,909	730,014	5,007,275	42,291,232
1965	5,398,943	19,895,955	9,391,511	1,516,614	4,834,459	41,037,482

Ref. U. S. Bureau of Commercial Fisheries

TABLE 2. SHRIMP CATCH — EAST COAST OF FLORIDA (1957-1965)
(Heads Off)

Year	Species		
	Brown	Pink	White
1957	717,936	2,895	2,328,625
1958	654,623	000	2,621,568
1959	477,947	000	2,207,326
1960	344,397	000	3,699,046
1961	73,967	000	3,506,656
1962	901,727	1,355	2,375,382
1963	631,107	000	2,266,457
1964	597,743	000	2,204,688
1965	519,732	000	2,918,427

Ref. U. S. Bureau of Commercial Fisheries

shrimpers go out to the Gulf Stream (200 fathoms) and trawl for the deep water shrimp *Hymenopenaeus robustus* (royal reds) during the off season.

Brown shrimp (*P. aztecus*) are primarily nocturnal. However, on the east coast of Florida, night fishing is illegal except during the months of June, July, and August; consequently, the brown shrimp season begins with the opening of night fishing on June 1. Although the past few years have been somewhat disappointing, according to the shrimpers, this season is a noticeable improvement over the previous five months. Production is usually sufficient to at least cover expenses.

The white shrimp season is the money crop for this area in spite of its relatively slow start in late August. The best months are usually October, November, December, and sometimes January. It is during these months that the shrimper earns enough money to meet expenses incurred during the last off season. Catches of 15-20 boxes of tails (100 lbs. per box) per day have been recorded. However, catches generally average from 2-4 boxes per day with the prices usually ranging between 60 and 85c per pound, depending upon size and abundance of the shrimp.

It should be noted that the law forbidding night shrimping except in June, July, and August, is probably detrimental to the fishery. This law was instituted at the request of the shrimpers who believe that nighttime fishing causes a reduction of daytime catches. Consequently, night fishing is prohibited except for those months of peak brown shrimp catches. However, there are indications that night shrimping, especially in deeper waters during the off season, could be profitable.

One such indication may be seen from the research sampling done by the Board of Conservation in 1962 and 1963. Winter sampling

showed a definite (though not great) increase in catches of *P. aztecus* in the Cape Canaveral area as compared to the Fernandina Beach samples. On the basis of these tendencies, it was suggested (Joyce, 1965) that exploratory night shrimping from January to June in depths of 100 feet or more might yield increased catches of *P. aztecus* and *P. duorarum*. While this paper was in press (January 1965) the U. S. Fish and Wildlife Service (research vessel *Oregon*) reported concentrations of *P. aztecus* South of Canaveral in depths of 120-210 feet. Commercial operations were begun almost immediately and before work was halted because of weather approximately 30,000 pounds of tails had been taken. It is yet to be determined whether or not this may be an annual source of production during the off season. However, it does indicate the practical value of research and the need for more exploratory shrimping under a variety of times and conditions.

Tortugas-Sanibel Area

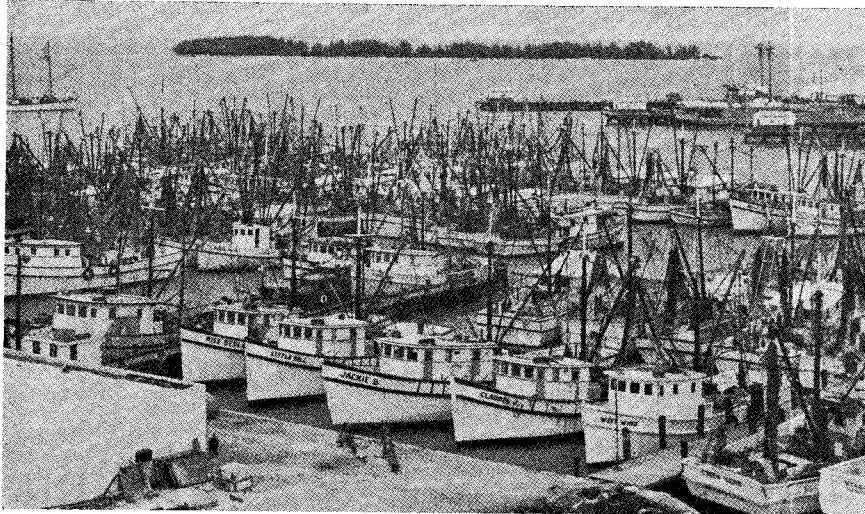


Figure 5. Tortugas shrimp fleet.

—Florida State News Bureau

Shrimp production on these grounds is based almost entirely on the pink shrimp, *P. duorarum*. However, relatively large numbers of the smaller shrimp *Trachypeneus similis* and *Sicyonia dorsalis* appear in the catches but are not of much commercial importance at this time. Although shrimping in these grounds continues the year round, highest production usually occurs from October through May. *P. duorarum* is nocturnal in its habits and consequently, shrimping is done at night. This is the largest shrimp producing area in Florida waters, producing an average yearly catch of approximately 18,000,000 pounds (Table 1).

Lowest catches in the Tortugas grounds are generally recorded in June, July, and August. In recent years it has been learned that hurricanes may greatly affect the monthly catch records. Hurricane Donna in September 1960 so affected the natural shrimp patterns that catches in October and November were several times larger than in previous years but the average size of the shrimp taken was smaller than in previous years.

The main nursery area for this fishery lies in the shallow waters and back rivers of the upper Florida Bay-Everglades Park area. This was verified by several tagging and staining studies in which thousands of young pink shrimp were marked in several shallow areas of Florida Bay. Many of these marked shrimp were later taken by commercial trawlers on the Tortugas grounds. This illustrates the great importance of this huge nursery area to the Tortugas shrimping industry.

Central West Coast Area



Figure 6. Shrimper releasing catch prior to sorting. —Florida State News Bureau

This area, roughly from Sarasota to north of Tarpon Springs, is occasionally of commercial importance (Table 1). The catches, however, are erratic and the offshore bottom contour is not conducive to large scale trawling. Most of the catch usually consists of relatively small shrimp taken in shallower water (30-60 ft.) as they are leaving the inshore nursery areas. Tampa is an important port for Campeche and Tortugas shrimp boats and these boats will occasionally drop their trynets as they enter or leave this area. If trynet samples warrant, some of the boats will remain in the area and shrimp where the substrate will allow it (coral beds and sponges are quite numerous, especially in water over 30 feet deep). The species taken is the pink shrimp, *P. duorarum*, and most fishing is at night. The best catches usually occur in the spring months (March or April through June or July).

Northwest Coast Area

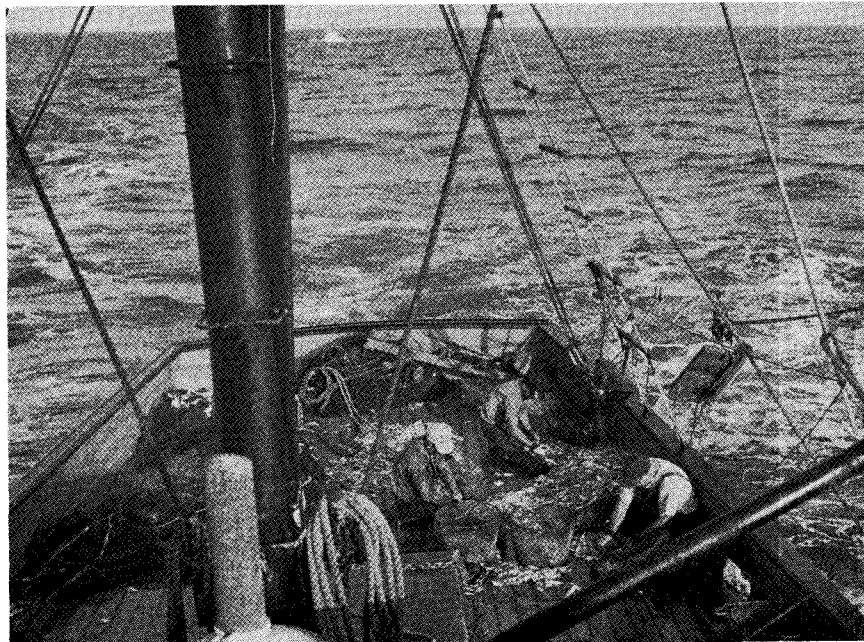


Figure 7. Sorting of shrimp catch.

—Florida State News Bureau

Production in this area is centered around Apalachicola Bay and extends west to Pensacola. All three major species are taken in the area and their respective percentages in the catch vary annually (Table 3). It would appear that the higher production of the last few years was due to increases in the catches of *P. duorarum* (pink shrimp). The yearly catches of this species in the area, however, are erratic, varying from 6,646 pounds to 1,941,180 pounds.

TABLE 3. SHRIMP CATCH—NORTHWEST COAST AREA
(1956-1965)
(Heads Off)

Year	Species		
	Brown	Pink	White
1956	169,938	796,231	507,247
1957	333,504	534,902	763,253
1958	591,002	1,488,774	807,159
1959	738,290	6,646	347,043
1960	373,667	472,569	1,069,728
1961	228,351	1,246,492	509,728
1962	463,869	941,000	404,517
1963	368,628	1,941,180	694,549
1964	402,270	1,621,508	1,096,177
1965	697,231	1,797,882	871,941

Ref. U. S. Bureau of Commercial Fisheries

TABLE 4. SHRIMP CATCH—NORTHWEST COAST AREA (1963)

Month	Species		
	Brown	Pink	White
Jan.	644	1,834	5,368
Feb.	0	2,634	7,584
Mar.	0	45,559	2,159
April	688	448,639	0
May	37,326	752,170	5,144
June	144,296	136,504	3,062
July	73,034	329,785	1,454
Aug.	61,272	103,058	1,706
Sept.	29,132	5,366	188,463
Oct.	18,967	40,188	216,628
Nov.	3,269	22,079	172,785
Dec.	0	4,178	92,196

Ref. U. S. Bureau of Commercial Fisheries

Table 4 gives the monthly catch of each species in the northwest coast area. It is interesting to note that the months of highest catch in this area conform very well with those on the northeast coast area. The only difference is the magnitude of catches for each species.

The percentage composition of the catch by species may vary from year to year and there have been instances where one species may almost replace another as the primary producer. For example, Gunter (1950) and Hildebrand (1954) both discussed a change in Texas catches from a predominance of *P. fluvialis* (white) to *P. aztecus* (brown) since 1947. The reasons behind a change of this magnitude can only be theorized and undoubtedly are quite complex. However, utilization of new areas or fishing techniques and long-range effects of meteorological conditions are possible factors.

Campeche Grounds

These grounds are located in the Gulf of Mexico off the Yucatan Peninsula, in 6 to 18 fathoms. The southern half of the west coast of Florida is strategically located for shrimp boats wishing to use these lucrative grounds. Some of the Campeche shrimp are landed in the United States and the largest percentage is currently landed in Florida (Table 1).

TABLE 5. SHRIMP CATCH—CAMPECHE (1963)
(Heads Off)

Month	Species		
	Brown	Pink	White
Jan.	1,072	509,491	000
Feb.	35,125	1,547,341	1,336
March	54,506	1,336,908	1,440
April	91,347	1,235,866	4,378
May	56,694	1,414,909	530
June	132,860	967,109	1,886
July	126,880	1,052,140	1,751
Aug.	17,649	467,468	000
Sept.	000	359,479	000
Oct.	12,085	847,738	000
Nov.	12,368	131,250	000
Dec.	30,135	891,055	125

Ref. U. S. Bureau of Commercial Fisheries

All three major species are taken in various portions of the area but the most important species is the pink shrimp, *P. duorarum*. Table 5 shows the monthly catches for each species in 1963.

These grounds were first utilized by the Japanese in the late 1930's but were not exploited by U. S. based shrimpers until early in 1950. Since that time the grounds have been an important source of shrimp for Gulf based shrimpers.

MINOR SHRIMP SPECIES

Minor species constitute those shrimp which are not now of major commercial importance. The following discusses the more prominent of these and lists other species which are occasionally taken during shrimping operations.

Sea-Bob *Xiphopenaeus kroyeri* (Heller)

The sea-bob is a small penaeid occurring in the northern Gulf of Mexico and along the northeast coast of Florida. It enters the commercial catches in Louisiana and, in spite of its small size, production ranges from approximately one-half to two million pounds

per year. These shrimp are seined along the Louisiana beaches in the fall. Most of them are sun dried on platforms but a large proportion now goes to canneries.

The sea-bob is easily recognized by its long, upcurved rostrum and four feelers (2 antennae and 2 antennules of equal size). This shrimp seldom reaches 5 inches in length.

Little is known of the life history except that the species is taken in largest numbers in the fall and winter months and apparently does not use inshore areas as nursery grounds.

Royal Red *Hymenopenaeus robustus* Smith

The royal red shrimp is a deep water species taken in 150 to 500 fathoms in the upper Continental Slope Zone. The species is distributed from Cape Hatteras to Brazil with three major areas of commercial concentration near Florida: St. Augustine to Ft. Pierce on the Florida east coast, south and southwest of the Dry Tortugas, and off the Mississippi delta.

The commercial production of this species has been hampered by a number of factors: 1) the extreme depth of the fishery with consequent difficulties in rigging of gear to work these depths; 2) the distance offshore and its effect on travel time and vulnerability to adverse weather; 3) low consumer acceptance because of the bright red (pre-cooked) look of the raw shrimp. Most commercial exploitation is attempted when catches of regular shrimp are poor.

Very little is known of the life history of this shrimp. Bullis and Cummings (1963) found their largest catches associated with temperatures between 9 and 12° C. It is hoped that as this fishery continues, more will be learned of the basic biology of the species, such as spawning seasons, location of spawning and nursery areas, and growth rates.

Rock Shrimp *Sicyonia* spp.

There are six species of rock shrimp (*Sicyonia*) in Florida waters: *S. brevirostris*, *S. dorsalis*, *S. typica*, *S. laevigata*, *S. stimpsoni*, and *S. parri*. *S. laevigata* and *S. parri* are very small, relatively shallow water species, while *S. stimpsoni* is a small, deeper water species, but is rarely taken.

S. typica and *S. dorsalis* are somewhat larger but still too small to be commercially productive at this time. However, these are taken in some areas (Tortugas) and perhaps mechanization of the cleaning and shelling may open the way for exploitation of these two species.

Sicyonia brevirostris is the only species which does occasionally enter the commercial catches. It is found along the southeast coast of the United States, and apparently occurs throughout Florida waters with some areas more heavily populated than others.

Although little is known of the biology of this species, indications are that spawning may begin quite early in the year. The inshore areas are not used as nursery grounds and nothing is known of natural growth rates. This shrimp is best characterized by its heavy shell and short, stocky appearance. It seldom exceeds 5 inches in length but is quite excellent eating. They are taken in relatively deep water, with best catches from 20 to 25 fathoms. Night fishing is more productive for this species.

More information on the occurrence and abundance of *S. brevirostris* might open the way for large scale commercial utilization in certain areas. This should also be accompanied by consumer education of the fine qualities of this shrimp.

***Penaeus brasiliensis* (Latreille)**

This very close relative of *P. duorarum* and *P. aztecus* occurs along the southeast coast of Florida. In Biscayne Bay, this species may form over 40 per cent of the total shrimp population in the summer months. Consequently, it is of some value to the live bait industry during this time. A few specimens have been found as far north as Oak Hill in the Mosquito Lagoon-Hillsborough River area.

***Trachypeneus* spp.**

There are two species of *Trachypeneus* in Florida, *T. constrictus* and *T. similis*. Both species are of a small size and only the largest individuals of *T. similis* occasionally enter the commercial catch in the Tortugas area. Only *T. constrictus* is found on the east coast, but both species occur on the west coast and may be used as live bait in some areas.

Current commercial production is more accidental than intentional. These species are taken in relatively large amounts in certain areas but because of their small size they are usually discarded. As future demands dictate, these species may become commercially important for canning. Many foreign producers are already using species of this size as cocktail shrimp.

Other Shrimp Species

The following species are taken from Voss (1955) and are listed as potentially commercial, although very little is known about them and they rarely enter the present commercial catches.

Solenocera vioscai Burkenroad
Solenocera atlantidis Burkenroad
Solenocera necopina Burkenroad
Aristaeomorpha foliacea (Risso)
Plesiopenaeus edwardsianus (Johnson)
Parapenaeus longirostris (Lucas)
Penaeopsis megalops (Smith)
Penaeopsis goodei (Smith)

There are also several very deep water species (not listed here) which might someday have commercial potential (Springer and Bullis, 1956).

Our knowledge is relatively complete regarding the three major commercial species (pink, white, and brown), due largely to their shallow water existence and their value. The minor shrimp species are very poorly known in comparison. Yet, as our demands upon the sea grow with our population, these species may become increasingly valuable and more research should be directed toward them.

There are several factors which are influential in the shrimpers' present inability to utilize the minor species; small size, high cost of production, and lack of consumer acceptance. However, there are certain biological facets of many of these species which may make them very valuable in the future. The most important of these is slight or non-existent dependence on an inshore nursery area during the juveniles' life stages. Most of these species apparently utilize offshore areas for this purpose. This will undoubtedly become very important in later years as the population explosion continues to encroach upon the estuaries and shallow water areas. Dredging and filling, and the loss of fresh and brackish water estuaries will apparently have little effect on these species, whereas the present commercial species might be effectively eliminated from commercial production.

The major hindrance at this time to commercial utilization of most of these species is small size. However, it should be noted that even today there are many areas of the world where shrimp sizes of 100 or more tails per pound are quite commonly marketed. Furthermore, smaller shrimp are actually preferred for canning purposes. Consequently, it seems that the greatest advances in the use of the "small" species would be through further development of mechanical cleaning devices which would head, peel and devein large quantities in short periods of time.

OTHER FACTORS AFFECTING COMMERCIAL SHRIMPING

There are a large number of other factors which affect commercial shrimping and although a detailed analysis is not within the scope of this paper, the following major ones will be discussed.

Criteria of Conservation Regulations

Shrimping laws, even within the State of Florida, vary from region to region and unfortunately are not always based on sound biological data. These laws are meant to help fulfill the basic concept of conservation; that is, to provide the greatest *continuing* production from a natural resource. It requires a detailed, comprehensive knowledge of the biology of a species to formulate such laws and this type of information has not always been available at the proper time. It is believed that law-making bodies should always be willing to re-examine an old statute in the light of new biological advances.

Contrary to past beliefs, the number of spawning shrimp required to produce a large crop is apparently very small. It is now felt by most biologists that instead of protecting spawning populations, the greatest gain in shrimp production can be made by protecting the young shrimp. The problem then is to determine the length of time these young shrimp should be protected. This is probably one of the most important areas in which further research is needed.

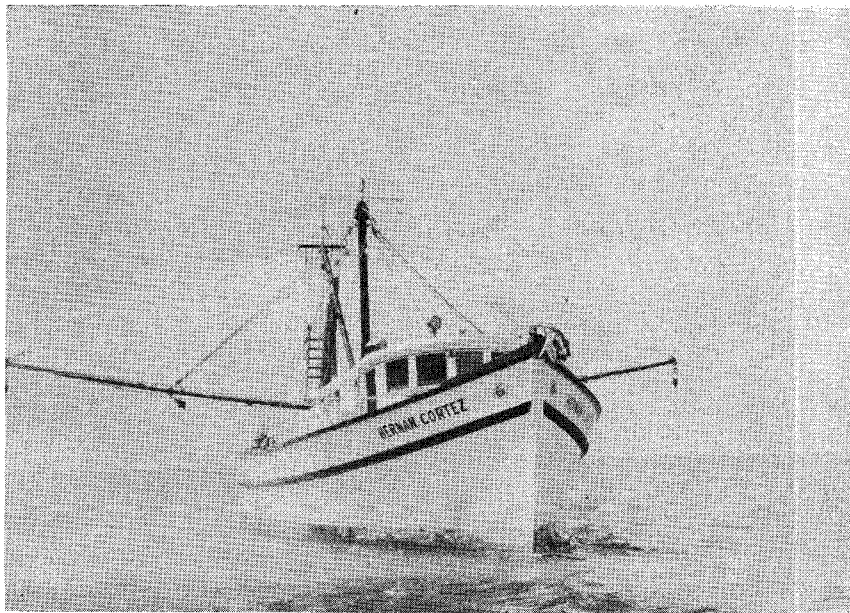


Figure 8. R/V *Hernan Cortez*, a standard St. Augustine shrimp trawler, modified as a research vessel.

Young shrimp are subject to predation by almost everything in the water, including other shrimp. In spite of this loss, the total weight of shrimp populations increases because of the rapid growth of surviving shrimp. However, as time passes, the number of adult shrimp decreases, growth slows, and at some point (probably different for each species) growth and mortality are equal and the total weight of the shrimp biomass is at its highest point. After this time, the total weight of the population decreases as mortality continues. A large shrimp is worth more than a small one and consequently the greatest value of the crop will be reached slightly later than the greatest weight of the population. It is at this point of greatest value that harvesting should be done.

Several studies have been done to determine this period of maximum yield. In a recent report (1964) submitted to the Governor of Texas and its 59th Legislature, Mr. J. W. Watson, Executive Director of the Texas Parks and Wildlife Department states: "From the best information developed to date by the Bureau of Commercial Fisheries from studies conducted in the Gulf of Mexico, the maximum yield by weight can be reached when harvesting is begun at a count size from 100 to 45 headless brown shrimp to the pound and from 75 to 40 headless white shrimp to the pound. The greatest value could be obtained when harvest on brown shrimp is commenced between 100 and 28 tail count."

Two of the most widespread methods to legally protect small shrimp are minimum size regulations and closed seasons or areas. Laws regulating sizes above which shrimp are legal, are probably least effective. These laws inevitably lead to culling to eliminate small, "illegal" shrimp. However, once shrimp are caught and brought on board, they are dead. Consequently, the culled shrimp is a dead shrimp and the laws are not serving the full purpose for which they were designed. An example of this occurred when a count law was put into effect to stop the taking of small pink shrimp from the Tortugas grounds. (It should be mentioned that there was a market for these "undersize" shrimp in the canning industry though at a reduced price.) Because of the law, small shrimp were culled and returned to the water, usually dead. Later it was shown that a large percentage of this "illegal" catch was not young pink shrimp but were full grown adults of *Trachypeneus*.

The other method, that of closing an area to shrimping during certain specified times, is more successful but not without fault, because of the variation in the size of the population of shrimp at any one period from year to year. Consequently, a law opening an area to shrimping on a certain date may be too early one year and too late the next.

It appears that the best protection is derived from a variation of the closed season method. In this method an area is closed until the average size of the shrimp is above a certain limit. The area is then opened to shrimping and all sizes are taken. The size of the shrimp on the grounds is determined by weekly or bi-weekly samples taken by the Law Enforcement Department. This method is extremely advantageous as it allows wide flexibility. According to sampling results, an area may be separated into sections, some of which may be open, some closed to shrimping. Under this system, certain nursery areas always containing small shrimp might never be opened.

This method of small shrimp protection is rather expensive to maintain. Samples should be sufficient to cover most of the main shrimping areas and this requires the use of boats, shrimping gear, and the services of two or three law enforcement officers per area. However, it is believed that this will afford the best protection to the shrimp at a time when growth rates are highest.

The closing of the northeast Florida area to night shrimping from September 1st to May 31st has already been described. It is suggested that this law should be changed so that night shrimping is illegal only during the white shrimp season. This would satisfy the shrimpers, yet would allow night shrimping during the off season which might possibly improve catches. Under this interpretation, night shrimping would be closed from approximately the middle of September until the middle of January.

It is also possible that a general acceptance of the new electric shrimp trawl may have a bearing on this problem. If this trawl allowed the shrimpers to get good catches in daylight hours, then there would be no real need to change the law.

Prediction of Shrimp Crop Size

Because of the annual variation in total shrimp catches for any particular area and the resultant hardships created among the fishermen, it has become desirable to have a means of estimating seasonal catches in advance. One such method predicts the size of the fall and winter crops on the basis of the abundance of postlarvae entering the inshore nursery areas in the spring. It takes several years of sampling to correlate the size of the commercial catch with the numbers of postlarvae; however, once this is accomplished, continued sampling apparently yields good indications of the size of the catches for that year. Research on this method is currently under way in Louisiana and Texas and results have been promising.

Although the method is untried in Florida waters, it appears that it would have easy application in the major shrimping areas. If the

necessary funds become available, this may well be a worthwhile project, depending on its ultimate success in other states.

Weather

There are immediate and long-range weather effects, both of which influence shrimp and the shrimping industry.

Immediate effects fall mainly into two classes; those that affect the ability of shrimp boats to work, and those that affect the behavior of the shrimp themselves.

For the most part, late spring to early fall weather in Florida is rarely a problem for commercial shrimpers. There are a large number of thunderstorms but these are hardly ever a deterrent to fishing. In late summer and fall, hurricanes are an occasional menace but these seldom result in more than a week to ten days loss of fishing unless the boats are damaged. During the winter and early spring, however, weather is a major factor in reducing the number of working days. As cold fronts move in from the north, northeast, or northwest, winds become strong enough to prohibit boats from leaving port. As a general rule, there are three to seven days of this high wind, after which there are several days of good weather until the next front passes.

The immediate effect of weather on shrimp and shrimp behavior is not completely understood. It is known that severe drops in temperature may cause direct mortality (white and brown shrimp), especially in inshore areas. Less severe drops in temperature may cause shrimp to leave low salinity areas, to move to deeper water, or to bury into the substrates (pink shrimp in the Tampa Bay area have been shown to remain buried in the substrate when the temperature is about 12° C or below). High tides and increased tidal currents associated with storms may also modify the normal movement of shrimp. It is easily seen that such changes could alter the commercial shrimping effort. As research produces more exact data on the effects of such weather changes, many of these might be used to the advantage of the shrimping industry.

Hurricanes have also been shown to have a pronounced effect on pink shrimp, especially in the estuarine situations. Pink shrimp mortality was reported in northern Florida Bay, resulting from the direct action of Hurricane Donna in September 1960. Additional mortality was observed after the storm passed and was blamed on oxygen depletion due to decomposition of organic materials churned up by the storm. It was suggested that the storm caused juvenile shrimp to leave the nursery grounds earlier and at a smaller size than usual. This was confirmed by greatly increased commercial catches of small shrimp.

Long-range weather effects are those which are extant for a longer period of time, such as drouths, major floods, abnormally warm or cold seasons, or unusual winds or currents. Although these are the least understood factors affecting the productivity of the shrimp populations a correlation was found between high rainfall and increased catches of white shrimp one and two years later. It is also possible that spawning and growth rates may be affected by above or below normal temperatures during a crucial period. Larval and postlarval recruitment to the nursery grounds could also be altered by unusual winds or currents.

There are many other possible effects of meteorological phenomena and much research work is needed to determine what correlations exist between shrimp biology and weather patterns.

Shrimp Migrations

Inshore and offshore migrations of shrimp entering and leaving the nursery grounds are by far the most important movements and occur in all shrimping areas. However, in some areas there are good indications of coastal migrations at least for the white shrimp *P. fluviatilis*. An apparent southerly migration exists on the Florida east coast through December with a return northerly migration beginning in January. Later findings have indicated that this northerly migration is shorter and of a lesser magnitude.

Little, if anything, is known of the existence of coastal migration in other species. However, some indications of a southerly concentration of *P. aztecus* in the Cape Canaveral area might have resulted from migration, but data is far too scarce to be conclusive. Tagging and staining studies similar to those used in establishing inshore and offshore migrations should be used to further our understanding of coastal migrations when and where they exist.

BAIT SHRIMPING

The use of shrimp as bait for sports fishing has grown considerably since World War II. With the increase in tourism and a steadily rising preference for shrimp for bait, this industry has become increasingly important to the State of Florida.

Bait shrimping, as used in this report, refers to that shrimping done in the inshore or shallow nursery areas. The gear and methods of capture vary from area to area, as do the seasons of highest production. The greatest percentage of the catch is taken with roller frame trawls (Figure 9) and small otter trawls (similar to the larger ones used offshore) but pushnets, dipnets, and castnets are predominant in certain areas.

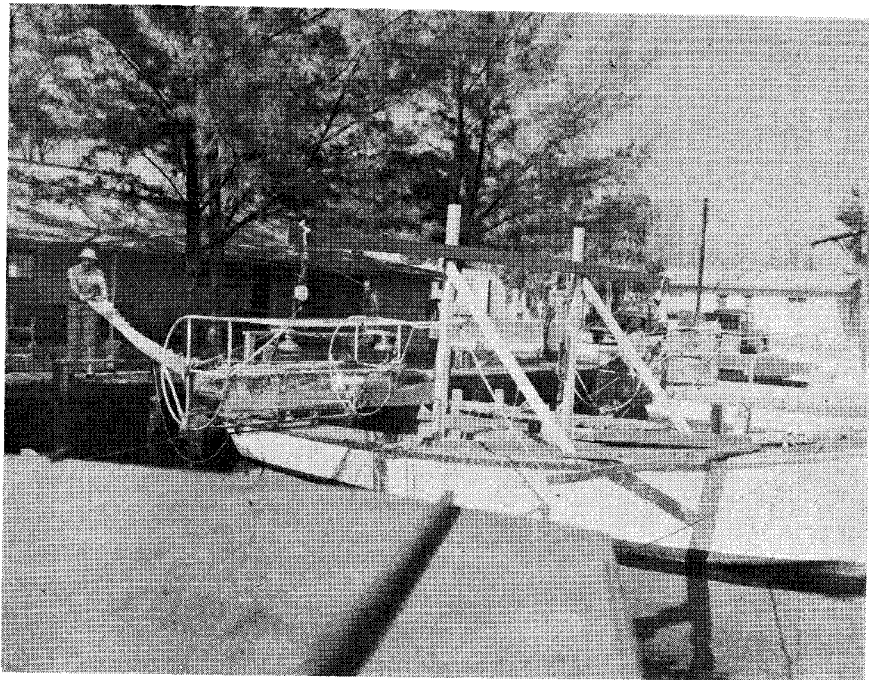


Figure 9. Typical roller frame trawl used in Tampa Bay area.

Both live shrimp and packaged (dead) bait shrimp are produced from Florida waters. Live bait shrimp production is by far the most valuable, yielding over \$1,000,000 per year to the shrimper. Dead bait production is only important in certain counties. Tables 6, 7, and 8 show the live and dead bait production and value by county for 1963, 1964, and 1965.

Most live shrimp are taken in roller frame or otter trawl drags of 10 to 15 minutes duration. This short towing time is necessary to avoid killing the shrimp after they are in the net. The catch is quickly sorted with the small shrimp being kept alive in various types of aerated tanks or recirculated live wells on the boat. The shrimp are then brought to the wholesalers who usually keep them in large concrete tanks in which the water is constantly recirculated and aerated. Depending on the size of the operation, these shrimp can be retailed directly or wholesaled in large numbers and transported in aerated tank trucks to other areas.

The mortality rates of live shrimp vary according to species with the pink shrimp, *Penaeus duorarum*, and brown shrimp, *P. aztecus*, being the most viable and consequently the most valuable. The white shrimp, *P. fluvialis*, the the least valuable and usually makes up the largest percentage of the dead bait in areas where this species

TABLE 6. FLORIDA LANDINGS — WHOLESALE BAIT DEALERS
(JANUARY-DECEMBER, 1963)

County	(Individuals) Live Shrimp	W H O L E S A L E		(\$) Value
		(\$) Value	(Lbs) Dead Shrimp	
Bay	439,453	\$ 9,272.58	203,102	\$ 64,896.06
Charlotte	23,000	399.00	—	—
Citrus	3,113,030	39,241.93	50	15.00
Clay	—	—	142	196.36
Collier	16,500	330.00	—	—
Dade	20,812,557	402,766.02	28,326	11,750.52
Dixie	1,672,150	27,656.50	10,028	4,207.93
Duval	211,000	2,815.00	60,256	18,777.14
Escambia	110,474	2,220.03	16,092	5,250.84
Gulf	106,700	3,856.00	2,640	1,192.85
Hernando	40,100	555.70	75	22.50
Hillsborough	7,500	112.50	—	—
Lee	3,852,595	55,126.38	269	67.00
Levy	6,497,917	86,015.73	843	213.60
Manatee	3,227,780	37,260.11	1,458	728.50
Martin	369,450	6,471.85	841	485.55
Monroe	735,207	18,783.14	52,152	19,869.22
Nassau	285,256	4,268.63	36,771	11,542.83
Okaloosa	33,300	685.80	490	192.00
Pasco	15,612,364	242,674.50	3,500	1,142.90
Pinellas	25,620,897	330,507.85	7,624	4,937.39
Santa Rosa	327,231	6,691.32	4,689	1,699.03
St. Johns	19,500	382.00	3,142	1,682.10
St. Lucie	234,135	4,607.27	2,564	897.40
Sarasota	614,000	9,569.90	—	—
Volusia	5,981,325	82,930.16	2,350	1,323.80
Walton	—	—	915	689.50
Total	89,963,421	\$1,375,199.90	438,319	\$151,780.02

Ref. Florida Board of Conservation

occurs. White shrimp are also considered poorer quality live bait because of the larger size which they attain on the nursery grounds. Smaller to medium sizes are preferred by the average sports fishermen. *P. brasiliensis* enters the bait catches of Biscayne Bay in the summertime, and probably has a survival rate similar to the other two grooved shrimp, the pinks and the browns.

The majority of all live bait shrimp produced in Florida is the pink shrimp, *P. duorarum*. Although there are certain localized areas where *P. duorarum* is not the predominant species, seven out of the top ten producing counties were located on the lower and central west coast of Florida where *P. duorarum* is the only major species. In addition, the industry in the other three counties of the top ten (Volusia, St. Lucie, and Dade) is also based primarily on this

TABLE 7. FLORIDA LANDINGS — WHOLESALE BAIT DEALERS
(JANUARY-DECEMBER, 1964)

County	(Individuals) Live Shrimp	W H O L E S A L E		(\$) Value
		(\$) Value	(Lbs) Dead Shrimp	
Bay	356,999	\$ 7,339.18	279,342 ³ / ₄	\$175,892.69
Citrus	3,826,615	43,055.84	—	—
Dade	24,629,847	362,732.48	30,575	6,843.25
Dixie	795,300	10,661.75	4,445	1,794.75
Duval	276	4.41	107,640	35,641.24
Escambia	171,059	3,423.68	9,522	3,710.04
Franklin	500	10.00	—	—
Gulf	197,553	6,768.15	4,805	1,669.95
Hernando	65,000	780.00	—	—
Lee	2,411,070	31,327.49	160	39.00
Levy	1,938,367	19,172.47	—	—
Manatee	2,419,582	26,961.00	900	272.00
Martin	411,410	7,541.26	25	16.50
Monroe	272,700	4,908.60	42,397	16,170.02
Nassau	585,400	8,781.00	18,359	6,535.26
Okaloosa	22,400	448.00	550	360.00
Pasco	14,912,788	180,398.59	1,740 ¹ / ₂	484.65
Pinellas	26,274,528	327,971.72	1,181	348.30
Sarasota	234,250	3,125.75	—	—
St. Johns	6,000	120.00	2,250	1,087.50
St. Lucie	1,178,667	23,573.34	1,426 ¹ / ₂	286.08
Santa Rosa	159,307	3,449.38	497	200.20
Volusia	3,969,905	50,863.01	13,871	6,025.17
Walton	—	—	1,878	1,568.80
Total	84,839,523	\$1,123,417.10	521,564 ³ / ₄	\$258,945.40

Ref. Florida Board of Conservation

species. Because of the nocturnal habit of *P. duorarum*, most bait shrimping is conducted at night.

The inshore production of dead (packaged) bait shrimp is most prevalent in counties where *P. fluviatilis* occurs. The method of capture is the same as that used offshore, but smaller otter trawls are required by law. In some areas the size of the daily catch is limited and only certain sections may be opened to trawling.

The problem of competition between bait shrimping and commercial shrimping interest has become more acute with the rising demand on all shrimp products. Commercial shrimpers have complained bitterly in the past that bait shrimping, especially shrimping for dead bait, is extremely deleterious to their welfare. They state that the number of shrimp in one pound of bait shrimp taken in July and sold for 35-50¢ would equal 2-3 pounds by late September and would bring 70-85¢ per pound. Furthermore, a certain proportion of the shrimp taken inshore for dead bait are illegally sold to

TABLE 8. FLORIDA LANDINGS — WHOLESALE BAIT DEALERS
(JANUARY-DECEMBER, 1965)

County	(Individuals) Live Shrimp	W H O L E S A L E		(\$) Value
		(\$) Value	(Lbs) Dead Shrimp	
Bay	169,372	\$ 3,445.47	269,608	\$162,745.69
Citrus	944,347	12,407.72	—	—
Dade	26,677,448	393,593.05	780	299.00
Dixie	1,435,000	24,395.10	4,905	1,954.25
Duval	8,312	166.24	118,475	39,822.32
Escambia	232,133	9,808.74	7,021	3,382.20
Gulf	254,772	7,166.10	19,024	6,998.26
Hillsborough	70,000	700.00	—	—
Lee	3,068,277	34,871.17	—	—
Levy	94,950	949.50	—	—
Manatee	2,262,370	24,325.39	—	—
Martin	387,000	7,021.88	—	—
Monroe	347,250	4,634.00	34,132	15,337.69
Nassau	128,700	1,930.50	5,746	2,037.26
Okaloosa	3,000	75.00	100	35.00
Pasco	28,370,133	327,986.81	1,321	396.30
Pinellas	26,680,667	319,599.19	—	—
St. Lucie	209,500	3,651.00	1,800	439.00
St. Johns	12,000	240.00	4,400	1,660.00
Santa Rosa	82,588	1,791.26	585	263.50
Sarasota	90,300	1,083.60	—	—
Volusia	3,170,167	38,989.06	10,218	4,086.05
Walton	—	—	1,640	1,400.25
Total	94,698,386	\$1,218,830.78	479,755	\$240,856.77

Ref. Florida Board of Conservation

restaurants or fish houses for human consumption. According to the commercial shrimper, such a practice not only harvests shrimp before they have reached maturity but also undercuts both their market and their prices.

Another complaint often leveled at the bait shrimper, usually by sports fishermen, is that otter trawls and roller frame trawls destroy the grass beds which act as nursery grounds for small sports fish as well as shrimp. In reality, however, such complaints are not well founded. Several biological studies have shown that trawl damage to such flats is negligible and that the occurrence of sports fish in the catch is very slight. In addition, most of the sports fish which are taken are quickly returned to the water so that survival is relatively high.

In spite of the charges against the bait shrimping industry, its presence in Florida is very important, economically. It should be remembered that the figures listed in Tables 6, 7, and 8 are only wholesale. They do not cover retail values of this industry nor do

they indicate the value to allied or subsidiary industries. Consequently, any regulations affecting shrimping, trawling, or the use of shallow grass flats and other nursery areas should carefully consider the effect of these acts on bait shrimping as well as on other interests. It is also felt that the taking of live bait shrimp should be given priority over the taking of dead bait with the possible exception of those counties where *P. fluviatilis* makes up most of the catch.

SHRIMP FARMING

Pond culture of shrimp or shrimp farming, as it is commonly called, is not presently of commercial importance in Florida.

Probably the most basic problem encountered in the field of mariculture is the securing of sufficient numbers of organisms for stocking purposes. In light of the basic biology of the commercial Florida species there are two major methods of obtaining shrimp stocks to be reared: 1) the use of ripe females as spawners to obtain larvae, or 2) impoundment of postlarvae as they enter these nursery areas.

The first method is apparently the least feasible at this time. We are not yet in a position, biologically, to cope with the many factors involved with captive spawning and rearing of sufficient numbers of shrimp for commercial utilization. However, knowledge is being accumulated which may make this method practical in the future. Pink shrimp, for example, have been raised from eggs at the Institute of Marine Science, University of Miami, but the numbers were very small and each shrimp specimen was handled and fed separately. Another study on the Florida east coast supposedly showed that white shrimp were hatched and reared successfully in enclosed ponds. However, many authorities think that the larvae and postlarvae in the ponds may have entered as part of the regular recruitment rather than hatching in the pond itself. This method of cultivation is currently being used on a similar species (*Penaeus japonicus*) in Japan. There are two factors which make this operation more practical in Japan; 1) cheap labor, and 2) high market price (this shrimp is considered a delicacy and may bring over \$4 per pound).

The postlarval impoundment method has a distinct advantage in that it leaves to nature the difficulties involved in spawning and rearing larvae during the first critical weeks. The postlarvae migrate into shallow grassy bays and estuaries in large numbers during the spring. It is possible by means of dikes and levees to impound these shrimp at this time. Tidal exchange must remain as unhampered as possible while the shrimp are retained and this is easily accomplished

by selective screening. Older postlarvae are prevented from leaving the enclosure by closing the screens during the ebb tide and the population is increased by removing the screens during flood tide to receive new postlarvae into the impoundment. Once the peak recruitment season has passed, the screens may be left in place continuously as long as they are kept clean. Feeding may also be done in the impoundment to enhance growth.

Although this method appears to be the most feasible at this time, there are several important problems. 1) It is not known if a commercial venture can be sufficiently supported by natural recruitment of postlarvae. If not, then some means will have to be found to increase the numbers of postlarvae in the enclosures. 2) There is little or no information available as to the amount of food which could be efficiently utilized by the shrimp. Consequently, spoilage and resultant pollution would be a constant threat. Good circulation in the ponds would tend to alleviate this problem. 3) Control would have to be exercised over natural predators. In addition to consuming young shrimp, they would also utilize the food being added for the shrimp. This is probably one of the most difficult problems, but it should be remembered that a large number of these predators are food fish and hence valuable in their own right. 4) Control must also be exercised as much as possible over sudden fluctuations of temperature and salinity. This is especially important during winter cold periods and the spring rainy season. 5) Location is an important problem; although shrimp occur in all Florida marine waters, certain areas are more favorable as nursery grounds. In addition, suitable pond areas should be nearly surrounded by higher lands to ease the costs involved in impoundment. Such lands are not readily available nor numerous. 6) There are also legal factors involved in setting up a shrimp farming operation. Purchasing or leasing of submerged lands is often difficult and fraught with legal complications. Conservation interests must also be considered and many of these organizations are bound by laws based on the old search-find-harvest techniques which are not always applicable to mariculture methods.

In spite of many difficulties, the impoundment method is being used currently in several Indo-Pacific and oriental countries, but it is usually a type of dual crop system in which the rice paddies are flooded during the unused season for an extra harvest, a portion of which is shrimp.

There is little doubt that at this time shrimp farming in this country by any method has a questionable chance for success. However, previous pond culture attempts have helped define many of the prob-

lems and additional information is being gathered each year. It is hoped that the above discussion will alert prospective shrimp farmers to the problems involved in mariculture.

FUTURE OF THE INDUSTRY

It appears from recent figures that shrimp production in Florida, based on the three major species, is probably near maximum for the areas being exploited. In spite of a relatively extreme variation in annual catches, there has been little indication of continual rise or decline in production over the last several years. Consequently, the best trends in improvement of the industry seem to be along the following lines: 1) intelligent management of the resource based on sound biological facts to secure a continual maximum yield; 2) research on the factors causing yearly variations in catch, followed by attempts to control these factors when possible, to yield a steady yearly production; 3) exploratory shrimping to determine if there may be other areas of possible commercial exploitation in Florida waters which are not now utilized; and 4) utilization of other species by modernization of production, mechanization, and marketing techniques.

A great deal of research is currently in progress along these lines and more is initiated each year. As results are obtained and this information is used to its best application, the industry will gradually approach its goal of maximum utilization of all resources on an annual basis.

PERTINENT REFERENCES

BIOLOGY

- ALDRICH, D. V.
1964. Behavior and tolerances. Annual report. Fishery Research Galveston Biol. Lab. *U. S. Fish and Wildl. Serv.*, Circ. No. 183: 60-64.
- ANDERSON, W. W.
1955. Observations upon the biology, ecology and life history of the common shrimp *Penaeus setiferus* (Linnaeus) along the south Atlantic and Gulf coasts of the United States. Section III. *Proc. Indo-Pacific Fish Council*: 1-5.
- ANDERSON, W. W.
1956. January to April distribution of the common shrimp on the South Atlantic continental shelf. *U. S. Fish and Wildl. Serv.*, Spec. Sci. Rept. No. 171: 1-14.
- ANDERSON, W. W.
1958. Recognizing important shrimp of the south. *U. S. Fish and Wildl. Serv.*, Fish. Leaf. No. 366, revised: 1-7.
- ANDERSON, W. W. and M. J. LINDNER
1943. A provisional key to the shrimps of the family Penaeidae with especial reference to American forms. *Trans. Amer. Fish. Soc.*, 73: 284-319.
- ANDERSON, W. W., J. E. KING, and M. J. LINDNER
1949. Early stages of the life history of the common marine shrimp, *Penaeus setiferus* (Linnaeus). *Biol. Bull.*, 96(2): 168-172.
- BEARDEN, C. M.
1961. Notes on postlarvae of commercial shrimp (*Penaeus*) in South Carolina. *Contrib. Bears Bluff Lab.*, No. 33: 1-8.
- BROAD, C.
1949. Identification of the commercial common shrimp species. *Comm. Fish. Rev.*, 11(12): 1-4.
- BULLIS, H. R., JR.
1966. R/V *George M. Bowers* cruise report No. 66. *U. S. Fish and Wildl. Serv.*, (mimeo): 1-3.
- BURKENROAD, M. D.
1934. The Penaeidae of Louisiana with a discussion of their world relationships. *Bull. Amer. Mus. Nat. Hist.*, 68 (2): 61-143.
- BURKENROAD, M. D.
1934. Littoral Penaeidae chiefly from the Bingham Oceanographic Collection, with a revision of *Penaeopsis* and descriptions of two new genera and eleven new American species. *Bull. Bingham Oceanogr. Coll.*, 4(art. 7): 1-109.
- BURKENROAD, M. D.
1936. The Aristaeinae, Solenocerinae and pelagic Penaeinae of the Bingham Oceanographic Collection. Materials for a revision of the oceanic Penaeidae. *Bull. Bingham Oceanogr. Coll.*, 5(art. 2): 1-151.
- BURKENROAD, M. D.
1936. A new species of *Penaeus* from the American Atlantic. *Ann. Acad. Bras. Sci.*, 8(4): 315-318.
- BURKENROAD, M. D.
1939. Further observations on Penaeidae of the northern Gulf of Mexico. *Bull. Bingham Oceanogr. Coll.*, 6(art. 6): 1-62.
- BURKENROAD, M. D.
1949. Occurrence and life histories of commercial shrimp. *Science*, 110(2869): 688-689.
- CHIN, E. and D. M. ALLEN
1959. List of references on the biology of shrimp. *U. S. Fish and Wildl. Serv.*, Spec. Sci. Rept. No. 276: 1-143.
- COOK, H. L. and M. A. MURPHY
1965. Early developmental stages of the rock shrimp, *Sicyonia brevirostris* Stimpson, reared in the laboratory. *Tulane Stud. Zool.*, 12(4): 109-127.

- COSTELLO, T. J.
1959. Marking shrimp with biological stains. *Proc. Gulf and Carib. Fish Inst.*, 11th Annual Session: 1-6.
- COSTELLO, T. J.
1963. Pink shrimp life history. Annual Report, Fishery Research Galveston Biol. Lab. *U. S. Fish and Wildl. Serv.*, Circ. No. 161: 35-37.
- COSTELLO, T. J. and D. M. ALLEN
1959. Migration and growth of pink shrimp. Annual Report, Fishery Research Galveston Biol. Lab. *U. S. Fish and Wildl. Serv.*, Circ. No. 62: 13-18.
- COSTELLO, T. J. and D. M. ALLEN
1960. Notes on the migration and growth of pink shrimp (*Penaeus duorarum*). *Proc. Gulf and Carib. Fish. Inst.*, 12th Annual Session: 5-9.
- COSTELLO, T. J. and D. M. ALLEN
1961. Survival of stained, tagged, and unmarked shrimp in the presence of predators. *Proc. Gulf and Carib. Fish. Inst.*, 14th Annual Session: 16-20.
- COSTELLO, T. J. and D. M. ALLEN
1964. Pink shrimp life history. *U. S. Fish and Wildl. Serv.*, Circ. No. 183: 30-31.
- COSTELLO, T. J. and A. INGLIS
1960. Field studies. Annual Report, Fishery Research Galveston Biol. Lab. *U. S. Fish and Wildl. Serv.*, Circ. No. 92: 36-38.
- CUMMINGS, W. C.
1961. Maturation and spawning of the pink shrimp, *Penaeus duorarum* Burkenroad. *Trans. Amer. Fish. Soc.*, 90(4): 462-468.
- DAWSON, C. E.
1957. Studies on the marking of commercial shrimp with biological stains. *U. S. Fish and Wildl. Serv.*, Spec. Sci. Rept. No. 231: 1-24.
- DAWSON, C. E.
1957. *Balanus* fouling of shrimp. *Science*, 126(3282): 1068.
- DOBKIN, S. B.
1961. Early developmental stages of pink shrimp, *Penaeus duorarum*, from Florida waters. *U. S. Fish and Wildl. Serv.*, Fish. Bull. 190: 321-349.
- ELDRED, B.
1958. *Meioceras lermondi* as food for *Penaeus duorarum*? *Nautilus*, 71(4): 152.
- ELDRED, B.
1958. Observations on the structural development of the genitalia and the impregnation of the pink shrimp, *Penaeus duorarum* Burkenroad. *Fla. Bd. Conserv. Mar. Lab.*, Tech. Ser. No. 23: 1-26.
- ELDRED, B.
1959. Notes on *Trachypeneus* (*Trachysalambria*) *similis* (Smith) in the Tortugas shrimp fishery. *Quart. Jour. Florida Acad. Sci.*, 22(1): 75-76.
- ELDRED, B.
1959. A report on the shrimps (Penaeidae) collected from the Tortugas Controlled Area. *Fla. Bd. Conserv. Mar. Lab.*, Spec. Sci. Rept. No. 2: 1-6.
- ELDRED, B.
1960. A note on the occurrence of the shrimp, *Penaeus brasiliensis* Latreille, in Biscayne Bay, Florida. *Quart. Jour. Florida Acad. Sci.*, 23(2): 164-165.
- ELDRED, B.
1962. The attachment of the barnacle, *Balanus amphitrite niveus* Darwin, and other fouling organisms to the rock shrimp, *Sicyonia dorsalis* Kingsley, *Crustaceana*, 3(3): 203-204.
- ELDRED, B., R. M. INGLE, K. D. WOODBURN, R. F. HUTTON, and H. JONES
1961. Biological observations on the commercial shrimp, *Penaeus duorarum* Burkenroad, in Florida waters. *Fla. Bd. Conserv. Mar. Lab.*, Prof. Papers Ser. No. 3: 1-139.
- ELDRED, B., J. WILLIAMS, G. T. MARTIN and E. A. JOYCE, JR.
1965. Seasonal distribution of penaeid larvae and postlarvae of the Tampa Bay area, Florida. *Fla. Bd. Conserv. Mar. Lab.*, Tech Ser. No. 44: 1-47.

- EWALD, J. J.
1965. The laboratory rearing of pink shrimp, *Penaeus duorarum* Burkenroad. *Bull. Mar. Sci. Gulf and Carib.*, 15(2): 436-449.
- GULF STATES MARINE FISHERIES COMMISSION
1961. The brown shrimp (*Penaeus aztecus*) pink shrimp (*Penaeus duorarum*) white shrimp (*Penaeus setiferus*) of the Gulf of Mexico. Res. Prospectus No. 1: 1-10.
- GUNTER, G.
1941. Death of fishes due to cold on the Texas coast, January 1940. *Ecology*, 22(2): 203-208.
- GUNTER, G.
1950. Seasonal population changes and distributions as related to salinity, of certain invertebrates of the Texas coast, including the commercial shrimp. *Publ. Inst. Mar. Sci.*, 1(2): 7-51.
- GUNTER, G.
1959. Biological investigations of St. Lucie Estuary in connection with Lake Okeechobee discharges through St. Lucie Canal. Report to Jacksonville District Corps of Engineers, Serial No. 49: 1-75.
- GUNTER, G.
1961. Habitat of juvenile shrimp (family Penaeidae). *Ecology*, 42(3): 598-600.
- GUNTER, G.
1962. Specific names of the Atlantic American white shrimp. *Gulf Research Reports*, 1(1): 107-114.
- GUNTER, G.
1962. Reply to Dr. L. B. Holthuis on the names of white shrimp. *Gulf Research Reports*, 1(3): 118-121.
- GUNTER, G.
1963. The proper zoological name of the North American white shrimp. *Proc. Gulf and Carib. Fish. Inst.*, 15th Annual Session: 6-17.
- GUNTER, G.
1964. Objections to the proposed validation under plenary powers of a neotype for *Cancer setiferus* L. 1767. *Bull. Zoo. Nomen.*, 21(3): 229-232.
- GUNTER, G. and H. H. HILDEBRAND
1951. Destruction of fishes and other organisms on the south Texas coast by the cold wave of January 28-February 3, 1951. *Ecology*, 32(4): 731-736.
- GUNTER, G. and H. H. HILDEBRAND
1954. The relation of total rainfall of the State and catch of marine shrimp (*Penaeus setiferus*) in Texas waters. *Bull. Mar. Sci. Gulf and Carib.*, 4(2): 95-103.
- GUNTER, G., J. Y. CHRISTMAS, and R. KILLBREW
1964. Some relations of salinity to population distributions of motile estuarine organisms, with special reference to penaeid shrimp. *Ecology*, 45 (1): 181-185.
- GUTSELL, J. S.
1936. A study of the ovaries of the commercial shrimp, *Penaeus setiferus* (Linnaeus) with reference to the history. Unpublished manuscript U. S. Fish and Wildl. Serv., Washington, D. C.
- HEEGAARD, P. E.
1953. Observations on spawning and larval history of the shrimp *Penaeus setiferus*. *Publ. Inst. Mar. Sci.*, 3(1): 73-105.
- HIGMAN, J. B.
1956. The behavior of pink grooved shrimp, *Penaeus duorarum* Burkenroad, in a direct current electrical field. *Fla. Bd. Conserv. Mar. Lab.*, Tech. Ser. No. 16: 1-23.
- HILDEBRAND, H. H.
1954. A study of the fauna of the brown shrimp (*Penaeus aztecus* Ives) grounds in the western Gulf of Mexico. *Publ. Inst. Mar. Sci.*, 3(2): 233-366.
- HILDEBRAND, H. H.
1955. Study of the fauna of the pink shrimp (*Penaeus duorarum* Burkenroad) grounds in the Gulf of Campeche. *Publ. Inst. Mar. Sci.*, 4(1): 169-232.

- HILDEBRAND, H. H. and G. GUNTER
1952. Correlation of rainfall with the Texas catch of white shrimp, *Penaeus setiferus* (Linnaeus). *Trans. Amer. Fish. Soc.*, 82: 151-155.
- HOESE, H. D.
1960. Juvenile penaeid shrimp in the shallow Gulf of Mexico. *Ecology*, 41 (3): 592-593.
- HOESE, H. D.
1960. Biotic changes in a bay associated with the end of a drought. *Limnol. Oceanog.*, 5: 326-336.
- HOLTHUIS, L. B.
1962. On the names of *Penaeus setiferus* (L.) and *Penaeus schmitti* Burkenroad. *Gulf Research Reports*, 1(3): 118-121.
- HUDINAGA, M.
1942. Reproduction, development and rearing of *Penaeus japonicus* Bate. *Jap. J. Zool.*, X(2): 305-393.
- HUTTON, R. F. and B. ELDRED
1958. A sarcophagid larva (Diptera) from the terminal ampoule of the pink shrimp, *Penaeus duorarum* Burkenroad. *J. Parasitol.*, 44(1): 27.
- HUTTON, R. F., F. SOGANDARES-BERNAL and B. ELDRED
1959. Another species of *Microphallus* Ward, 1901, from the pink shrimp, *Penaeus duorarum* Burkenroad. *J. Parasitol.*, 45(5): 490.
- HUTTON, R. F., F. SOGANDARES-BERNAL, B. ELDRED, R. M. INGLE, and K. D. WOODBURN
1959. Investigations on the parasites and diseases of saltwater shrimps (Penaeidae) of sports and commercial importance to Florida. *Fla. Bd. Conserv. Mar. Lab.*, Tech. Ser. No. 26: 1-38.
- HUTTON, R. F., T. BALL and B. ELDRED
1962. Immature nematodes of the genus *Contracaecum* Railliet and Henry, 1912, from shrimps. *J. Parasitol.*, 48(2): 327-332.
- IDYLL, C. P., F. F. KOOZY, A. C. JONES, M. D. RINKLE, and D. DIMITRIOU
1961. Identification and distribution of pink shrimp larvae. Annual Report July 1, 1960-June 30, 1961. *U. S. Fish and Wildl. Serv.*, (mimeo): 1-16.
- IDYLL, C. P., A. C. JONES, and D. DIMITRIOU
1962. Production and distribution of pink shrimp larvae and postlarvae. Mar. Lab. Inst. Mar. Sci., Annual Rept., July 1961-June 1962 to *U. S. Fish and Wildl. Serv.*, (mimeo): 1-22.
- INGLE, R. M., B. ELDRED, H. JONES, and R. F. HUTTON
1959. Preliminary analysis of Tortugas shrimp sampling data 1957-58. *Fla. Bd. Conserv. Mar. Lab.*, Tech. Ser. No. 32: 1-45.
- IVERSEN, E. S. and R. B. MANNING
1959. A new microsporidian parasite from the pink shrimp (*Penaeus duorarum*). *Trans. Amer. Fish. Soc.*, 88: 130-132.
- IVERSEN, E. S. and C. P. IDYLL
1960. Aspects of the biology of the Tortugas pink shrimp, *Penaeus duorarum*. *Trans. Amer. Fish. Soc.*, 89(1): 1-8.
- IVERSEN, E. S., A. E. JONES, and C. P. IDYLL
1960. Size distribution of pink shrimp, *Penaeus duorarum*, and fleet concentration on the Tortugas fishing grounds. *U. S. Fish and Wildl. Serv.*, Spec. Sci. Rept. No. 356: 1-62.
- IVERSEN, E. S. and A. C. JONES
1961. Growth and migration of the Tortugas pink shrimp, *Penaeus duorarum*, and changes in the catch per unit of effort of the fishery. *Fla. Bd. Conserv.*, Tech. Ser. No. 34: 1-24.
- IVERSEN, E. S. and N. N. VAN METER
1964. A record of the microsporidian, *Thelohania duorara*, parasitizing the shrimp, *Penaeus brasiliensis*. *Bull. Mar. Sci. Gulf and Carib.*, 14(4): 549-553.

- JONES, A. C., D. DIMITRIOU, and J. EWALD
1963. Abundance and distribution of pink shrimp larvae. Mar. Lab. Inst. Mar. Sci., Annual Rept. July 1962-June 1963 to U. S. Fish and Wildl. Serv., (mimeo): 1-11.
- JONES, A. C., J. B. HIGMAN, D. DIMITRIOU, R. K. ROBINSON, and J. EWALD
1963. Abundance and distribution of pink shrimp larvae. Mar. Lab. Inst. Mar. Sci., Quart. Rept. July-September 1963 to U. S. Fish and Wildl. Serv., (mimeo): 1-11.
- JONES, E. E.
1958. Microsporidiosis in shrimp. *ASB Bull.*, 5(1): 10.
- JOYCE, E. A., JR.
1965. The commercial shrimps of the northeast coast of Florida. *Fla. Bd. Conserv. Mar. Lab.*, Prof. Papers Ser. No. 6: 1-224.
- KING, J. E.
1948. A study of the reproductive organs of the common marine shrimp, *Penaeus setiferus* (Linnaeus). *Biol. Bull.*, 94(3): 244-262.
- KRUSE, D. N.
1959. Parasites of the commercial shrimps, *Penaeus aztecus* Ives, *P. duorarum* Burkenroad, *P. setiferus* (Linnaeus). *Tulane Stud. Zool.*, 7(4): 123-144.
- LINDNER, M. J. and W. W. ANDERSON
1956. Growth, migrations, spawning and size distribution of shrimp *Penaeus setiferus*. U. S. Fish and Wildl. Serv., Fish. Bull. No. 106: 555-645.
- LUNZ, G. R.
1945. Carolina shrimps of the genus *Eusicyonia*. *Charleston Mus.*, Leaf. No. 20: 1-12.
- LUNZ, G. R.
1957. Notes on rock shrimp, *Sicyonia brevirostris* (Stimpson) from exploratory trawling of the South Carolina Coast. *Contr. Bears Bluff Lab.*, No. 25: 1-10.
- LUNZ, G. R.
1959. Annual report 1957-1958. *Contr. Bears Bluff Lab.*, No. 30: 1-15.
- LUNZ, G. R.
1961. Annual report 1959-1960. *Contr. Bears Bluff Lab.*, No. 32: 1-13.
- MENZEL, R. W.
1955. Marking of shrimp. *Science*, 121(3143): 446.
- PEARSON, J. C.
1939. The early life histories of some American Penaeidae, chiefly the commercial shrimp, *Penaeus setiferus* (Linn.). *Bull. U. S. Bur. Fish.*, XLIX(3): 1-73.
- SALOMAN, C. H.
1964. The shrimp, *Trachypeneus similis*, in Tampa Bay. *Quart. Jour. Florida Acad. Sci.*, 27(2): 160-164.
- SOGANDARES-BERNAL, F. and R. F. HUTTON
1959. The identity of Metacercaria B reported from the pink shrimp, *Penaeus duorarum* Burkenroad, by Woodburn *et al.* in 1957. *J. Parasitol.*, 45(4): 362, 378.
- SPRAGUE, V.
1950. Notes on three microsporidian parasites of decapod crustacea of Louisiana coastal waters. *Occ. Pap. Mar. Lab. La. Univ.*, 5: 1-8.
- SPRINGER, S. and H. R. BULLIS, JR.
1956. Collections by the Oregon in the Gulf of Mexico. U. S. Fish and Wildl. Serv., Spec. Sci. Rept. No. 196: 1-134.
- ST. AMANT, L. S., R. C. CORKUM, and J. G. BROOM
1963. Studies on growth dynamics of the brown shrimp, *Penaeus aztecus*, in Louisiana waters. *Proc. Gulf and Carib. Fish. Inst.*, 15th Annual Session: 14-26.
- ST. AMANT, L. S., J. G. BROOM, and T. B. FORD
1966. Studies of the brown shrimp, *Penaeus aztecus*, in Barataria Bay, Louisiana, 1962-1965. *Proc. Gulf and Carib. Fish. Inst.*, 18th Annual Session: 1-17.
- TABB, D. C., D. L. DUBROW, and A. E. JONES
1962. Studies of the biology of the pink shrimp, *Penaeus duorarum* Burkenroad, in Everglades National Park, Florida. *Fla. Bd. Conserv.*, Tech. Ser. No. 37: 1-31.

- VOSS, G. L.
1955. A key to the commercial and potentially commercial shrimp of the family Penaeidae of the western North Atlantic and the Gulf of Mexico. *Fla. Bd. Conserv.*, Tech. Ser. No. 14: 1-23.
- WEYMOUTH, F. W., M. J. LINDNER, and W. W. ANDERSON
1933. Preliminary report on the life history of the common shrimp *Penaeus setiferus* (Linn.). *Bull. U. S. Bur. Fish.*, No. 48 (1940): 1-26.
- WHEELER, R. S.
1960. Experiments in rearing shrimp larvae. *U. S. Fish and Wildl. Serv.*, Circ. No. 92: 7-8.
- WILLIAMS, A. B.
1955. A contribution to the life histories of commercial shrimps (Penaeidae) in North Carolina. *Bull. Mar. Sci. Gulf and Carib.*, 5(2): 116-146.
- WILLIAMS, A. B.
1955. A survey of North Carolina shrimp nursery grounds. *Jour. Elisha Mitchell Sci. Soc.*, 71(2): 200-207.
- WILLIAMS, A. B.
1958. Substrates as a factor in shrimp distribution. *Limnol. Oceanog.*, 3(3): 283-290.
- WILLIAMS, A. B.
1959. Spotted and brown shrimp postlarvae (*Penaeus*) in North Carolina. *Bull. Mar. Sci. Gulf and Carib.*, 9(3): 281-290.
- WOODBURN, K. D.
1961. A summary of Tomoka Marsh sampling for one year (July 1960, October 1960, January 1961, and May 1961). *Fla. Bd. Conserv. Mar. Lab.* (mimeo): 1-13.
- YOUNG, J. H.
1959. Morphology of the white shrimp, *Penaeus setiferus* (Linnaeus 1758). *U. S. Fish and Wildl. Serv.*, 59 Bull. No. 145: 1-168.
- ZEIN-ELDIN, Z. P.
1963. Effect of salinity on growth of postlarval penaeid shrimp. *Biol. Bull.*, 125(1): 188-196.
- ZEIN-ELDIN, Z. P.
1964. Growth and metabolism. Annual Report, Fishery Research Galveston Biol. Lab. *U. S. Fish and Wildl. Serv.*, Circ. No. 183: 65-67.

INDUSTRY

- ANDERSON, W. W.
1958. The shrimp and shrimp industry of the southern United States. *U. S. Fish and Wildl. Serv.*, Fish. Leaflet No. 472: 1-9.
- ANONYMOUS
1951. Fifty years of progress. *Southern Fisherman*, XI(2): 38-39, 119.
- ANONYMOUS
1962. The Versaggi story is the saga of the shrimping industry. *The Fish Boat*. September 1962.
- BULLIS, H. R., JR.
1956. Preliminary results of deep-water exploration for shrimp in the Gulf of Mexico by the M/V *Oregon* (1950-1956). *Comm. Fish. Rev.*, 18(12): 1-12.
- BULLIS, H. R., JR. and W. F. RATHJEN
1959. Shrimp explorations off southeastern coast of the United States. *Comm. Fish. Rev.*, 21(6): 1-20.
- BULLIS, H. R., JR. and R. CUMMINGS, JR.
1963. Another look at the royal red shrimp resource. *Proc. Gulf and Carib. Fish. Inst.*, 15th Annual Session: 9-13.
- CLIFFORD, D. M.
1955. Marketing and utilization of shrimp in the United States. *Proc. Indo-Pacif. Fish. Coun.*, 6th Sess., (Sec. III): 438-443.

- COLLIER, A., R. M. INGLE, G. GUNTER, and P. VIOSCA, JR.
1959. The shrimp fishery of the Gulf of Mexico. *Gulf States Mar. Fish. Comm.* No. 2: 1-5.
- ELDRED, B. and R. F. HUTTON
1960. On the grading and identification of domestic commercial shrimps (Family Penaeidae) with a tentative world list of commercial penaeids. *Quart. Jour. Florida Acad. Sci.*, 23(2): 89-118.
- FLORIDA BOARD OF CONSERVATION
1959. Thirteenth biennial report, 1957-1958. 1-59.
- FLORIDA BOARD OF CONSERVATION
1961. Fourteenth biennial report, 1959-1960. 1-70.
- FLORIDA BOARD OF CONSERVATION
1963. Fifteenth biennial report, 1961-1962. 1-17.
- FLORIDA BOARD OF CONSERVATION
1965. Biennial report, 1963-1964. 1-105.
- FLORIDA BOARD OF CONSERVATION
1961. Salt water fisheries division laws.
- GUNTER, G.
1960. Shrimp landings and production of the State of Texas for the period 1956-1959, with a comparison with other states. In *Shrimp Conservation Act. Texas Game and Fish Comm.*: 1-14.
- HOLTHUIS, L. B. and H. ROSA, JR.
1965. List of species of shrimps and prawns of economic value. *FAO Rome, Fish. Tech. Paper No. 52*: 1-20.
- IDYLL, C. P.
1950. A new fishery for grooved shrimp in southern Florida. *Comm. Fish. Rev.*, 12(3): 10-16.
- IDYLL, C. P.
1950. The commercial shrimp industry of Florida. *Fla. Bd. Conserv. Educ. Ser.* No. 6: 1-31. (Reissued August, 1957)
- INGLE, R. M.
1957. Intermittent shrimp sampling in Apalachicola Bay with biological notes and regulatory applications. *Proc. Gulf and Carib. Fish. Inst.*, 9th Annual Session: 6-17.
- INGLE, R. M.
1961. Synoptic rationale of existing Florida shrimp regulations. *Proc. Gulf and Carib. Fish. Inst.*, 13th Annual Session: 1-8.
- IVERSEN, E. S. and C. P. IDYLL
1959. The Tortugas shrimp fishery: the fishing fleet and its method of operation. *Fla. Bd. Conserv.*, Tech. Ser. No. 29: 1-35.
- KUTKUHN, J. H.
1960. The Sanibel-Tortugas shrimp fishery: 1956-1959. Annual Report, Fishery Research Galveston Biol. Lab. *U. S. Fish and Wildl. Serv.*, Circ. No. 92: 11-15.
- KUTKUHN, J. H.
1962. Gulf of Mexico commercial shrimp population trends and characteristics, 1956-1959. *U. S. Fish and Wildl. Serv. Fish. Bull.* No. 212: 61-69.
- LINDNER, M. J.
1966. What we know about shrimp size and the Tortugas fishery. *Proc. Gulf and Carib. Fish. Inst.*, 18th Annual Session: 18-26.
- NATIONAL SHRIMP CONGRESS, INC.
1961. Statistics concerning shrimp and shrimp products. Submitted to the U. S. Tariff Comm.
- ROSEN, A. and R. K. ROBINSON
1961. Summary of Florida commercial marine landings 1960, and an analysis of the catch and effort of certain species. *Mar. Fish. Research Rept. to Fla. Bd. Conserv.*, 61(2): 1-32.

- ROSEN, A. and R. K. ROBINSON
1962. Summary of Florida commercial marine landings 1961, and an analysis of the catch and effort of certain species. *Mar. Fish. Research Rept. to Fla. Bd. Conserv.*, 62(7): 1-32.
- ROSEN, A. and R. K. ROBINSON
1963. Summary of Florida commercial marine landings 1962, and an analysis of the catch and effort of certain species. *Mar. Fish. Research Rept. to Fla. Bd. Conserv.*, 63(4): 1-32.
- SPRINGER, S.
1957. Shrimp, a new deep-water resource. *Trans. 22nd North American Conference, Wildl. Mar. Inst.*: 425-431.
- TAYLOR, F. B.
1956. Is the shrimp trawl net destructive to marine life? *Bears Bluff Lab.*, 1-43.
- U. S. BUREAU OF COMMERCIAL FISHERIES
1956-1965. Gulf of Mexico shrimp catch. Statistical Branch.
- U. S. BUREAU OF COMMERCIAL FISHERIES
1958. Survey of the United States shrimp industry. Vol. I. *U. S. Fish and Wildl. Serv., Spec. Sci. Rept. No. 277*: 1-311.
- U. S. BUREAU OF COMMERCIAL FISHERIES
1959. Survey of the United States shrimp industry. Vol II. *U. S. Fish and Wildl. Serv., Spec. Sci. Rept. No. 308*: 1-167.
- U. S. TARIFF COMMISSION
1960. Investigation of shrimp under section 332 of the tariff act of 1930. *U. S. Tariff Comm., Natl. Shrimp Cong.*, 1-107.
- WATHNE, F.
1963. Promising leads in fishing gear development. *Proc. Gulf and Carib. Fish. Inst.*, 15th Annual Session: 5-9.
- WATSON, J. W.
1964. The Texas shrimp fishery. A report to the Governor and the 59th Legislature. *Texas Parks and Wildl. Dept.*: 1-11.
- WELCH, E.
1965. Summary of Florida commercial marine landings, 1964. *Fla. Bd. Conserv.*, 1-77.

BAIT SHRIMPING

- BROAD, C.
1950. The shrimp fishery of the Florida Keys. *Univ. N. Carolina Inst. Fish Res.* (mimeo): 1-13.
- CHIN, E.
1960. The bait shrimp fishery of Galveston Bay, Texas. *Trans. Amer. Fish. Soc.*, 89(2): 135-141.
- DE SYLVA, D. P.
1954. The live bait shrimp fishery of the northeast coast of Florida. *Fla. Bd. Conserv., Tech. Ser. No. 11*: 1-35.
- FLORIDA BOARD OF CONSERVATION
Bait shrimp statistics, 1963, 1964, 1965 (mimeo).
- HIGMAN, J. B.
1952. Preliminary investigation of the live bait shrimp fishery of Florida Bay and the Keys. *Mar. Lab. Univ. Miami* (mimeo): 1-8.
- INGLIS, A. and E. CHIN
1959. The bait shrimp industry of the Gulf of Mexico. *U. S. Fish and Wildl. Serv., Fish Leaflet No. 480*: 1-14.
- SALOMAN, C. H.
1965. Bait shrimp (*Penaeus duorarum*) in Tampa Bay, Florida — biology, fishery economics, and changing habitat. *U. S. Fish and Wildl. Serv., Spec. Sci. Rept. No. 520*: 1-16.

- SIEBENALER, J. B.
1953. The Biscayne Bay commercial fishery. *Fla. Bd. Conserv. Tech. Ser. No. 6*: 1-20.
- TABB, D. C.
1958. Report on the bait shrimp fishery of Biscayne Bay, Miami, Florida. *Mar. Lab. Univ. Miami*, Rept. to Fla. Bd. Conserv. (mimeo): 1-12.
- WOODBURN, K. D., B. ELDRED, E. CLARK, R. F. HUTTON, and R. M. INGLE
1957. The live bait shrimp industry of the west coast of Florida (Cedar Key to Naples). *Fla. Bd. Conserv. Mar. Lab.*, Tech. Ser. No. 21: 1-33.

SHRIMP FARMING

- DELMENDO, M. N. and H. R. RABANAL
1955. Cultivation of *Sugpo* (jumbo tiger shrimp), *Penaeus monodon* Fabricius, in the Philippines. *Proc. Indo-Pacif. Fish. Coun.*, 6th Sess., (Sect. III): 424-431.
- GOPINATH, K.
1955. Prawn culture in the rice fields of Travancore-Cochin, India. *Proc. Indo-Pacif. Fish. Coun.*, 6th Sess. (Sect. III): 419-424.
- IDYLL, C. P.
1965. Shrimp nursery. *J. Nat. Geog. Soc.*, 127(5): 636-659.
- JOHNSON, M. C. and J. R. FIELDING
1957. Propagation of the white shrimp, *Penaeus setiferus* (Linnaeus) in captivity. *Tulane Stud. Zool.*, 4(6): 175-190.
- KESTEVEN, G. L. and T. J. JOB
1957. Shrimp cultivation in Asia and the Far East: A preliminary review. *Proc. Gulf Carib. Fish. Inst.*, 10th Annual Session: 49-68.
- LORIO, W. J.
1965. The biology of the brown shrimp, *Penaeus aztecus*, in impoundments. *Proc. 18th Annual Conference Southeastern Assoc. Game and Fish Comm.* (In press)
- LUNZ, G. R.
1958. Pond cultivation of shrimp in South Carolina. *Proc. Gulf and Carib. Fish. Inst.*, 10th Annual Session: 44-48.
- LUNZ, G. R. and C. M. BEARDEN
1963. Control of predaceous fishes in shrimp farming in South Carolina. *Contr. Bears Bluff Lab.*, No. 36: 1-9.
- MENON, M. K.
1954. On the paddy field prawn fishery of Travancore-Cochin and an experiment in prawn culture. *Proc. Indo-Pacif. Fish. Coun.*, 5th Sess. (Sect. 2): 1-5.
- VILLADOLID, D. V. and D. K. VILLALUZ
1951. The cultivation of *Sugpo* (*Penaeus monodon* Fabricius) in the Philippines. *Philipp. J. Fish.*, 1(1): 55-56.

