

COMMERCIAL FISHERIES REVIEW

January 1952

Washington 25, D.C.

Vol. 14, No. 1

THE NORTHERN SHRIMP FISHERY OF MAINE

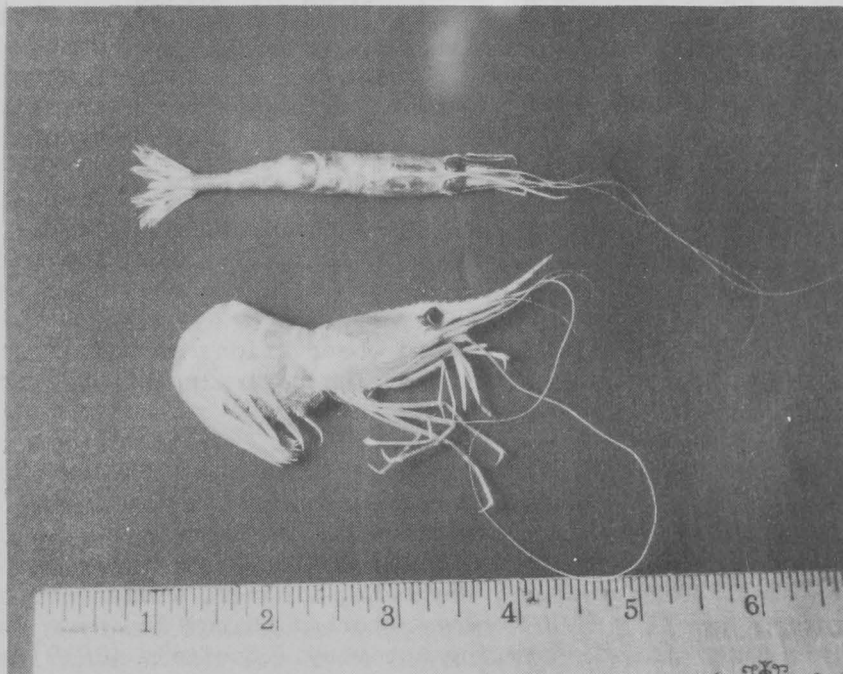
By Leslie W. Scattergood*

ABSTRACT

OBSERVATIONS ON THE RISE AND FALL OF THE NORTHERN SHRIMP (PANDALUS BOREALIS) FISHERY OF MAINE ARE PRESENTED. IN ADDITION TO GIVING PRODUCTION STATISTICS FOR 1928-50, VARIOUS PHASES OF THE NORTHERN SHRIMP FISHERY ARE DISCUSSED. AMONG THE SUBJECTS COVERED ARE BACKGROUND, EXPLORATIONS, DEVELOPMENT, AND FISHING GEAR AND METHODS USED IN THE FISHERY. ANALYSES OF THE FISH AND SHELLFISH CAUGHT IN SHRIMP HAULS AND THE COMPOSITION OF THE SHRIMP CATCH ARE INCLUDED. THE ARTICLE CONCLUDES WITH A DISCUSSION OF THE PROBABLE REASONS FOR THE DECLINE OF THE NORTHERN SHRIMP FISHERY OFF THE NEW ENGLAND COAST.

INTRODUCTION

Among the commercially valuable crustaceans in the United States, the shrimps are now the most important. In both poundage and value, they exceed the lobster, spiny lobster or sea crawfish, and various edible crabs. During the past decade, the shrimp fisheries have gained increasing importance in the United States. In the South Atlantic and Gulf States the production of the Southern shrimps (predominantly Penaeus setiferus, Penaeus aztecus, and Penaeus duorarum) climbed from 118 million pounds in 1936 to 189 million pounds in 1945. The 1950 catch was estimated at 182 million pounds. At the present time, Southern penaeid shrimps probably represent 98 percent of the total catch of shrimps in this country and Alaska.



TWO SPECIMENS OF ATLANTIC COAST NORTHERN SHRIMP (PANDALUS BOREALIS). CHARACTERISTICS OF THIS SPECIES ARE: (1) A TUBERCLE OR SMALL SPINE ON THE DORSAL SURFACE OF THE REAR HALF OF THE THIRD ABDOMINAL SEGMENT; (2) A BIFID ROSTRUM, WITH THE LOWER TIP PROJECTING BEYOND THE UPPER TIP. NOTE THE EGGS ON THE LARGER SPECIMEN--OVIGEROUS FEMALES MAKE UP THE BULK OF THE COMMERCIAL CATCH. (LARGE SPECIMEN DOES NOT HAVE LEGS IN NORMAL POSITION.)

Not all the other species of shrimps have shown the same steady upward trend in production as have the Southern shrimps recently. This is particularly true of the Pacific Coast. The catches of the California shrimps, primarily

* FISHERY RESEARCH BIOLOGIST, BRANCH OF FISHERY BIOLOGY, U.S. FISH AND WILDLIFE SERVICE, BOOTHBAY HARBOR, MAINE.

Crago franciscorum and C. nigricauda, have declined from slightly over 2,240,000 pounds in 1936 to about 437,000 pounds in 1946. However, the California catches climbed to 843,000 pounds in 1947, and still higher to 931,000 pounds in 1948, but dropped to 804,000 pounds in 1949.

The fishery for the Northern shrimps (species of Pandalus and Pandalopsis) along the Pacific Coast declined from 2,817,000 pounds in 1936 to 1,322,000 pounds in 1945 (table 1 and figure 1). These declines during the period were caused largely by various World War II restrictions on fishing and by disruptions in the economic pattern of the fisheries along the Pacific Coast. An upward spurt in production took place in 1948 due mainly to a slight increase in interest in the Alaska shrimp fishery. In 1949, however, the catch almost dropped back to the 1944 and 1945 level.

There are no recent statistics on the minor catches of the fresh-water shrimp, Macrobrachium ohionis, in the Mississippi River drainage.

The fishery along the New England coast for the Northern shrimp, Pandalus borealis, had a remarkable development in Maine from 1933 to 1945 (table 2 and figure 2), but after that year the fishery steadily declined. No catch of shrimp

Year	Alaska ¹	British Columbia ²	Washington ³	Total
	lbs.	lbs.	lbs.	lbs.
1936	2,645,423	69,600	101,600	2,816,623
1937	2,575,795	121,200	46,900	2,743,895
1938	2,428,609	150,400	25,100	2,604,109
1939	2,441,329	83,100	60,700	2,585,129
1940	2,824,103	114,500	55,300	2,993,903
1941	2,473,491	61,000	27,100	2,561,591
1942	1,692,810	39,200	12,300	1,744,310
1943	636,790	52,100	54,300	743,190
1944	784,660	38,800	24,800	848,260
1945	1,198,617	79,900	43,800	1,322,317
1946	346,811	118,500	130,400	595,711
1947	350,375	106,800	44,200	501,375
1948	2,834,803	353,900	42,200	3,230,903
1949	521,703	-	67,100	-

- NOT AVAILABLE.
¹ALASKA FISHERY AND FUR SEAL INDUSTRIES REPORTS, 1936-45.
²ANNUAL FISHERIES STATISTICS OF CANADA REPORTS, 1936-45.
³FISHERIES INDUSTRIES OF THE UNITED STATES OR FISHERY STATISTICS OF THE UNITED STATES REPORTS, 1936-49.

is recorded for Massachusetts in 1928, although we know from Birdseye's account that there were some landed during January of that year. It is possible that the statistics may also err in some of the subsequent years. After 1938, such errors would be of smaller magnitude, particularly in Maine where State and Federal Government fisheries agencies initiated a system in which statistical agents collected monthly figures on the catch of fish and shellfish. After the fishery assumed larger proportions in 1938 and the following years, the statistics improved in accuracy.

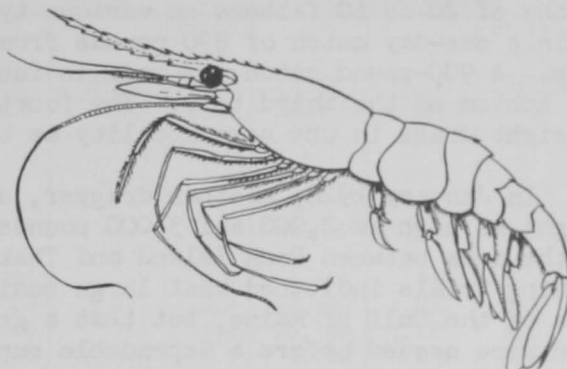
It is my purpose to record observations on this fishery, for one is seldom given the opportunity to witness the beginning and the practical end of a local fishery.

There is less information available about the New England Northern shrimp than for most other commercially-valuable species in the United States, British Columbia, and Alaska. As most edible shrimps have been utilized in North America for many years, some biological and historical notes on these fisheries have been published. Among others, Weymouth, Lindner, and Anderson (1933) and Anderson, Lindner, and King (1949) have reported on the Southern shrimp fishery, which is perhaps our oldest shrimping activity. Scofield (1919) and Bonnot (1932) have provided information on the California shrimps, which have been caught in San Francisco Bay since about 1869. Hynes (1930) has described the Alaska shrimp fishery, which began in 1915, and Smith (1937) has made observations on the Puget Sound shrimps, fished since 1888. Berkeley (1929 and 1930) made important biological findings in her studies on the Pandalidae of British Columbia. Various shrimp reports have also been made by others. Although there is no information about the

New England Northern shrimp fishery comparable to that given in the above reports, some observations are available.

BACKGROUND OF ATLANTIC COAST NORTHERN SHRIMP FISHERY

While the present Pandalus borealis fishery in New England is of recent origin, the potential commercial possibilities of harvesting Northern shrimp have been known for many years. In discussing the possible future importance of New England Pandalidae, Rathbun (1883) stated: "When their haunts, great abundance, and fine flavor, as well as the proper methods of capturing them, become known to the fishermen, it is fair to suppose that they will give rise to an important industry. Such a fishery must necessarily be more difficult than the shrimp and prawn fisheries of the Southern States, and would require more capital, in the start, for the purchase of larger boats and more extensive nets; but there is every reason to believe that it would repay the outlay to, at least, a limited number of fishermen, for many important markets are close to hand." Rathbun (1883, 1884) also mentioned that the distribution of shrimp along the New England coast had been traced by the United States Fish Commission which had constantly come upon immense schools of them.



PANDALUS BOREALIS
LENGTH 70 TO 135 MM. (ABOUT 2.76-5.31 INCHES).

Until the introduction of the otter trawl into the Gulf of Maine in 1905, there was little chance of a fishery developing for the Northern shrimp. These crustaceans commonly live at depths greater than 25 fathoms, but they may dwell as deep as 1,000 meters (547 fathoms), according to Poulsen (1946). Prior to 1905, there was no fishing gear in common use which would efficiently sweep the

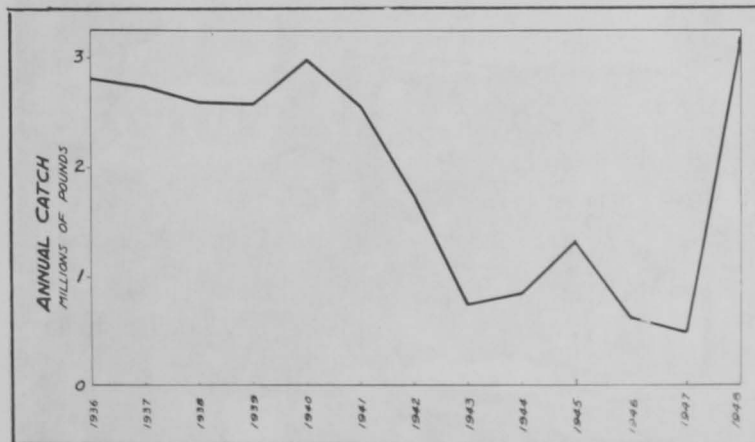


FIG. 1 - PRODUCTION OF PACIFIC COAST PANDALIDAE, 1936-48.

bottom and capture moving fish or shellfish at moderate depths. It is questionable whether shrimp were caught in any quantity by the New England otter-trawl fishery during the early years of operation. Boats using this gear would be seeking groundfish, mainly cod and haddock. These species of fish are not commonly found on the mud bottom frequented by shrimp. Also, the mesh of these groundfish nets would be so large that most shrimp entering the nets would escape between the meshes.

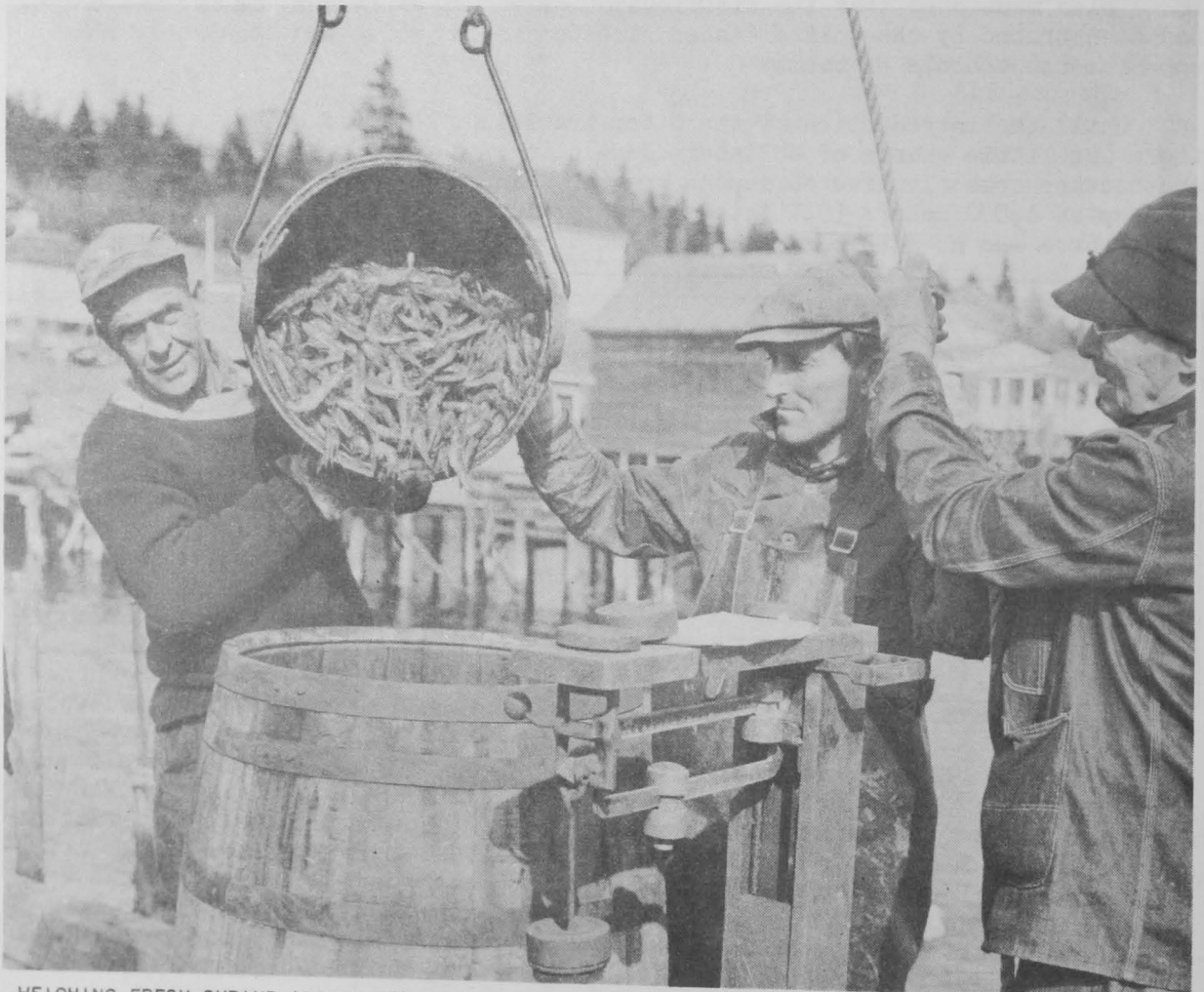
Birdseye (1928) mentioned that Gloucester draggers had brought in small quantities of these New England pink shrimp for several years prior to 1927. Many of them were eaten by fishermen, but some were sold on the Boston market. Officials of the General Seafoods Corporation became interested in the commercial possibilities of the shrimp and conducted experiments to determine the proper methods of cooking, freezing, and storing. They then decided to ascertain whether these crustaceans could be obtained in quantity at a reasonable cost. Thus began the first organized attempt to establish a shrimp fishery in New England--44 years after Rathbun's note of its potentialities.

NORTHERN SHRIMP EXPLORATIONS BY COMMERCIAL FIRM

During June and July 1927, the General Seafoods Corporation chartered successively two 60-foot boats which dragged small mesh otter trawls in the Gulf of Maine off the New Hampshire and southern Maine coasts. The fishery was confined to the region east of Jeffrey's Ledge and between Boon Island and Thatcher Island. Four trips were made. The first one-day trip yielded about 100 pounds of shrimp from depths of 20 to 60 fathoms on various types of bottom. The second voyage resulted in a one-day catch of 890 pounds from six drags on mud bottom 50 to 65 fathoms deep. A 900-pound catch was made in four drags at depths of 85 to 100 fathoms on mud bottom on the third trip. The fourth voyage resulted in a 1,700-pound catch in eight drags in the same locality as the third trip.

In January 1928, another dragger, using General Seafoods Corporation's nets, caught as high as 2,000 and 3,000 pounds per day on mud bottom at 35 to 90 fathoms in the area between Boon Island and Thatcher Island. Birdseye believed that the fishing trials indicated that large bodies of shrimps were to be found over a wide area of the Gulf of Maine, but that a great many months of effort and investigation were needed before a dependable supply of shrimps would be guaranteed. The results of Birdseye's investigation are mentioned by Johnson and Lindner (1934).

No great exploitation of the shrimp fishery followed the General Seafoods' experiments.



WEIGHING FRESH SHRIMP AT NEW HARBOR, MAINE. THE NEW ENGLAND NORTHERN SHRIMP FISHERY HAD A REMARKABLE DEVELOPMENT FROM 1933 TO 1945, BUT AFTER THAT YEAR THE FISHERY STEADILY DECLINED.

OTHER NORTHERN SHRIMP SURVEYS

The next development in the history of this fishery has been given in some detail by Hjort and Ruud (1938) and Bigelow and Schroeder (1939). Johan Hjort, widely known for his founding and promotion of the Norwegian shrimp fishery, was a visitor to this country in 1936. During his stay, he was able to make a brief survey of some of the shrimping areas in the Gulf of Maine. With the cooperation of the Woods Hole Oceanographic Institution, the research ship Atlantis was used for this exploratory investigation in August 1936. According to Hjort and Ruud, "The aim of this cruise was, in particular, to investigate if prawns were to be found in abundance off the Atlantic coasts of North America, and if there corresponded to these occurrences similar conditions to those which we have been able to examine in the Skager Rack and the junction of these waters with the North Sea." The Atlantis found Pandalus to be most abundant in the same general area where the General Seafoods' boats had made their best hauls. Bigelow and Schroeder have made detailed analyses of the 22 trawl-hauls of the Atlantis. These authors have estimated the shrimp catches (adjusted to a 60-minute tow with an 82-foot trawl) to be as high as 168 liters (about 210 pounds) per hour. In the opinion of Hjort and Ruud, such a catch would be a particularly good one in Norway or Sweden.

Table 2 - Yield of the North Atlantic Pandalus borealis Fishery, 1928-50^{1/}

Year	Maine			Massachusetts ^{2/}		
	Catch	Value	Price per Pound	Catch	Value	Price per Pound
	Pounds	Dollars	Cents	Pounds	Dollars	Cents
1928	-	-	-	(3/)	-	-
1929	17	1	5.9	-	-	-
1931	-	-	-	-	-	-
1932	-	-	-	-	-	-
1933	-	-	-	40,900	2,045	5.0
1935	-	-	-	-	-	-
1937	200	3	1.5	6,800	475	7.0
1938	82,500	5,691	6.9	23,200	1,930	8.3
1939	18,300	766	4.2	36,100	1,115	3.1
1940	6,700	303	4.5	2,700	170	6.3
1941	57,717	2,332	4.0	-	-	-
1942	109,100	3,971	3.6	2,000	131	6.6
1943	291,700	14,305	4.9	3,200	277	8.7
1944	457,900	20,841	4.6	3,700	224	6.1
1945	580,900	29,050	5.0	1,100	112	10.9
1946	161,500	8,076	5.0	4,400	561	12.7
1947	193,800	10,571	5.5	500	63	12.6
1948	27,300	3,120	11.4	-	-	-
1949	9,900	1,806	18.2	-	-	-
1950	7,359	1,417	19.3	-	-	-

- NOT AVAILABLE OR NONE REPORTED.
^{1/} FROM ANNUAL STATISTICAL REPORTS OF THE U.S. BUREAU OF FISHERIES AND U.S. FISH AND WILDLIFE SERVICE.
^{2/} ONLY CATCHES OF SHRIMP BY OTTER TRAWL ARE CONSIDERED AS PANDALUS BOREALIS. DIP-NET CATCHES ARE FOR OTHER SMALL SPECIES, USED AS FISH BAIT.
^{3/} AN UNDETERMINED POUNDAGE WAS CAUGHT BY A GLOUCESTER, MASSACHUSETTS, DRAGGER IN JANUARY. SEE BIRDSEYE (1928).

The results of the Atlantis trip were encouraging, and the time seemed propitious for a campaign to stimulate the dormant shrimp fishery. Through the cooperative efforts of Hjort, the United States Bureau of Fisheries, the Fishermen's Relief Corporation of Portland, Maine, and the Federated Fishing Boats of New England and New York, Inc., the boat New Dawn was outfitted and began to catch shrimp as a practical demonstration that shrimp fishing could be profitably conducted in New England. Considerable publicity was given to this project (Anon. 1936). Walford (1936) presented information on the fishing efforts and gave detailed descriptions of the fishing gear and its operation. He also described the methods for preparing the shrimp for market.

Walford prepared a chart of the localities in which the shrimp were caught by the General Seafoods Corporation's boats, the Atlantis, the New Dawn, and other fishing vessels. This revealed that the four exploratory boats had dragged primarily in depths of over 50 fathoms during the summer months. These boats did not operate their fishing gear along the coast in the shallower water. However, according to the chart, winter catches of over 30 pounds per hour were made by other boats in fairly shallow water between Pemaquid Point (Maine) and Gloucester (Mas-

sachusetts). The fishery later developed along these inshore areas rather than in the deeper water regions, which had received the great part of the investigational efforts.

Although it had been demonstrated that commercial quantities of shrimp could be caught and much favorable publicity had been given the new potential fishery, a flourishing business did not evolve immediately. The fishing industry was not yet ready to expand into the new field, and the consuming public was not yet prepared to absorb more than a small production of the Northern shrimp.

FIRST LARGE-SCALE FISHERY FOR NORTHERN SHRIMP

The first large-scale fishery for Northern shrimp began the first quarter of 1938. Shrimp nets were supplied by the Fishermen's Relief Corporation of Portland, Maine (Anon. 1938c), and thirteen boats began dragging for shrimp and landing their

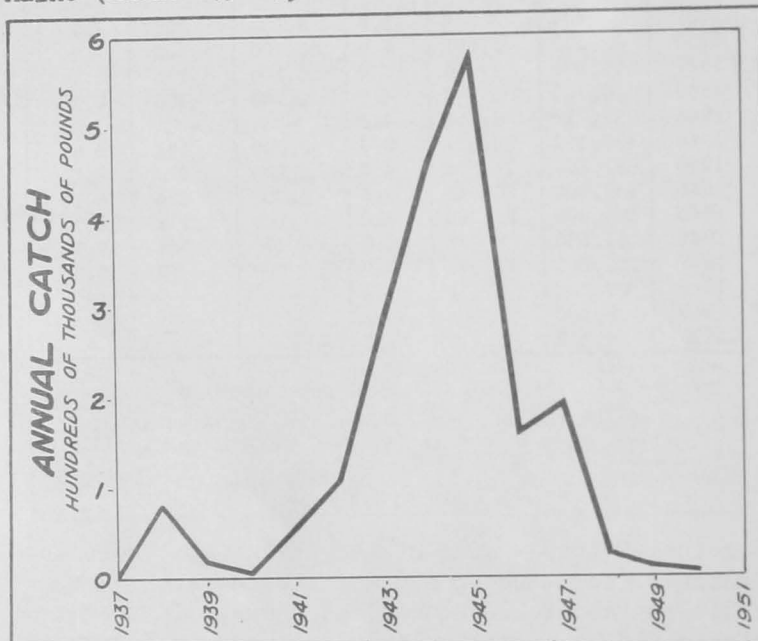


FIG. 2 - PRODUCTION OF NORTHERN SHRIMP IN MAINE, 1937-50.

a 62-foot boat, Elinor and Jean. All trips were of one-day duration and were made primarily off Wood Island, about seven miles southwest of Cape Elizabeth, Maine (figure 3). Several small boats, around 30 feet in length, also operated in Casco Bay, near Mark Island, but we have no records of their catches, which were probably small.

This winter shrimp fishery in the Portland (Maine) region was definitely seasonal. One boat began dragging as early as January 7, but the first shrimp were not brought in until February 11. The last shrimp catch was on April 13, although some dragging was continued until the end of April. The seasonal peak occurred in the middle of March. Fifty-eight percent of the total catch was made in the two-week period March 8-21. This fishery has been dependent upon egg-bearing female shrimp, which accumulated on certain inshore grounds prior to and during the egg-hatching period. As the egg hatching neared completion, the number of shrimp available to the fishermen declined markedly.

Some shrimp were also caught at this time by small boats near Pemaquid Point and New Harbor, Maine (figure 3). From the United States Bureau of Fisheries statistical records, it appears that approximately 1,500 pounds were produced in that region.

catches at Portland. These boats ranged in length from 46 to 73 feet. Incomplete records collected by the local office of the United States Bureau of Fisheries in 1938 show a total poundage of 12,115 in February, 59,181 in March, and 2,150 in April. Apparently the greatest producer was the Annie Louise, a 46-foot boat, which caught 24,890 pounds in 15 shrimp-yielding trips. A few daily catches exceeding 5,000 pounds were taken by this vessel and by the Alice M. Doughty II, a 73-foot ship. Unfortunately, complete records do not exist for the latter vessel. A fairly high production was the 14,875 pounds caught in 12 trips by

In view of the difficulties encountered in initiating an otter-trawl fishery on relatively unfamiliar bottoms, this first organized attempt could be considered fairly successful. An average value of 7.5 cents per pound was obtained by the fishermen. Some of the shrimp were sold fresh locally. However, as the available markets were unable to sell large quantities of the new shrimp (which were much smaller than the popular Southern shrimp), most of the Portland landings were frozen for future use. Furthermore, the New England public was familiar with the

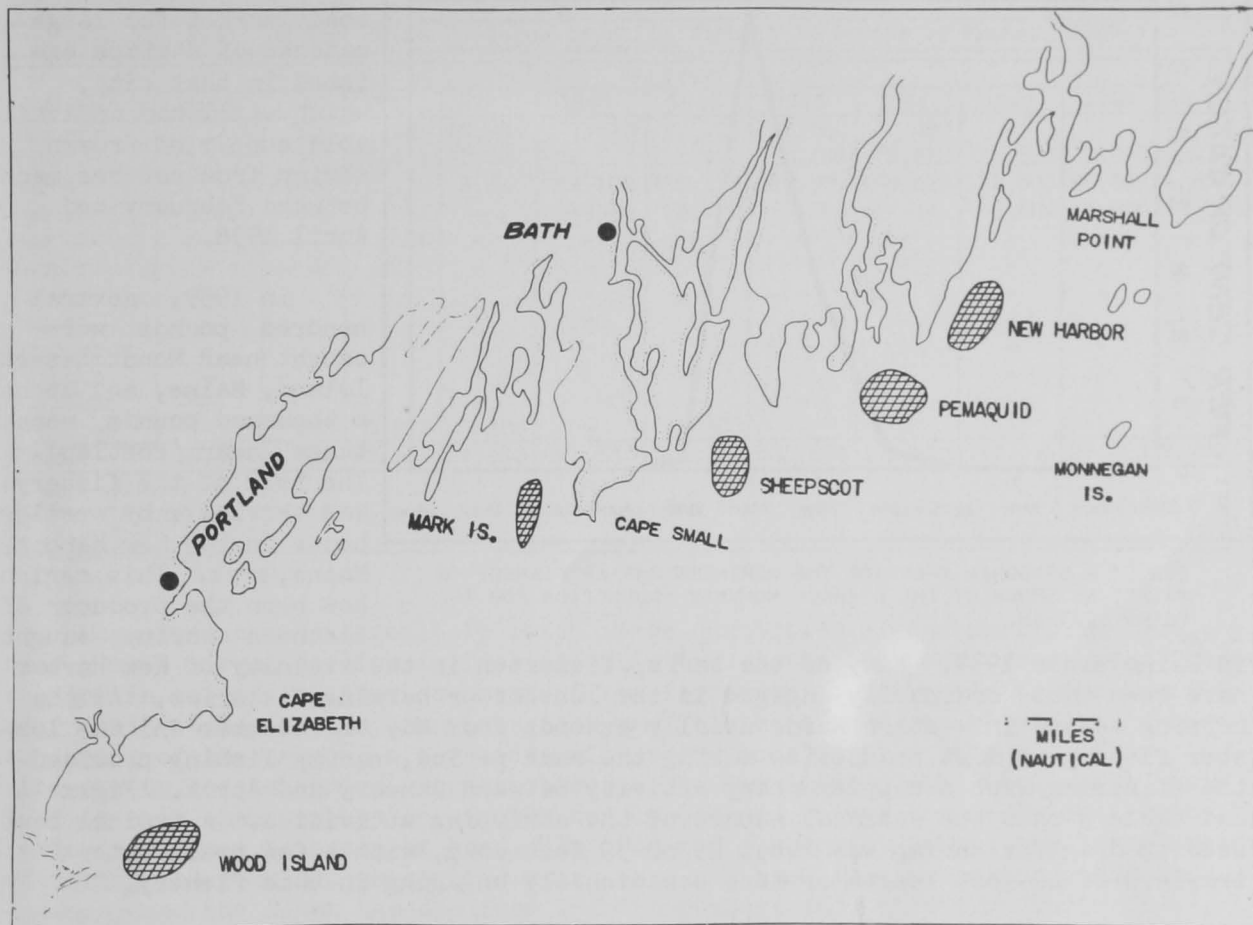


FIG. 3 - PRESENT SHRIMP FISHING GROUNDS OFF THE MAINE COAST.

green-colored Southern shrimp rather than the red-hued Northern species. It seemed evident that during the winter a supply of shrimp could be produced in excess of the local market demand. Consequently, the Maine Department of Sea and Shore Fisheries increased its efforts to publicize the Maine shrimp.

In anticipation of increased utilization in the future, an attempt was made to learn if the fishery could be established on a year around basis. The Maine Department of Sea and Shore Fisheries, in cooperation with the United States Bureau of Fisheries, began further exploratory fishing with two boats during July and August of 1938 to determine whether commercial quantities of shrimp could be located along the Maine coast during the summer (Anon. 1938a, b, c). One small boat, the Flora C., made 55 tows at depths of 43 to 102 fathoms, but was unable to locate any large amounts. The greatest catch was equivalent to 57 pounds of shrimp per hour of dragging and was made at 67 fathoms. The average catch was about eight pounds per hour. The Mina J., another small fishing boat, dragged in depths of less than 55 fathoms along the coast of Maine, but was similarly unsuccessful. From these experiments it was concluded that shrimp fishing did not seem profitable in Maine during the summer months.

DEVELOPMENT OF THE FISHERY

In the following shrimp season, the winter and early spring of 1938-39, the fishery was rather dormant. Portland boats which had dragged for shrimp in 1938 had become engaged in the rosefish (*Sebastes marinus*) fishery. This formerly neglected fish was then beginning its meteoric rise to its present great importance in the New England fisheries. A further deterrent to a Portland shrimp fishery was that no ready market for large catches of shrimps existed in that city, which still had an available supply of frozen shrimp from catches made between February and April 1938.

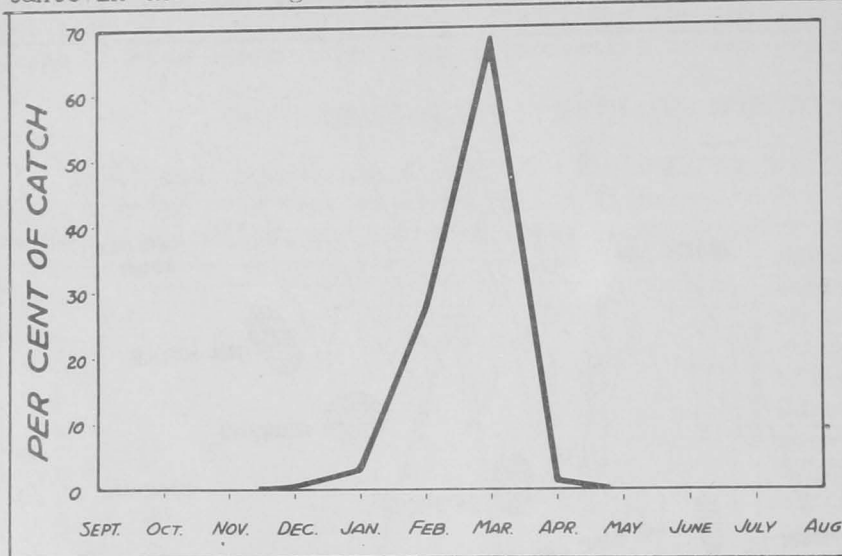


FIG. 4 - SEASONAL TREND OF THE NORTHERN SHRIMP FISHERY IN MAINE, AS SHOWN BY THE AVERAGE MONTHLY PRODUCTION FOR THE YEARS 1937-48.

In 1939, several hundred pounds were caught near Mount Desert Island, Maine, and about a thousand pounds were taken near Portland. The bulk of the fishery was carried on by smaller boats in the New Harbor, Maine, area. This region has been the producer of Northern shrimp caught in Maine since 1939. Many of the shrimp fishermen in the vicinity of New Harbor have been those ordinarily engaged in the lobster or herring fisheries. As the herring season in western Maine usually extends from May to December and the lobster fishery is most productive during the same period, shrimp fishing provided the fishermen with a supplementary activity between January and April. Figure 4 and table 3 show the seasonal nature of the shrimping activities. A typical boat used to drag for shrimp was about 25 or 30 feet long, with a few small otter trawlers of 40-foot length or more occasionally engaging in this fishery.

From 1939 to 1942, the catches of shrimp were largely limited by the demand. For example, a boat might catch 500 pounds of shrimp, but three or four days might elapse before all could be sold and another trip made. Some fishermen would fish for several hours and then peddle their catches for the next few days in the neighboring towns until all of the shrimp were sold. Occasionally, the shrimp would remain unsold until they had to be dumped. By 1941, an increased local demand for Maine shrimp had developed and larger quantities were being home-canned by consumers. While the catch rose to about 58,000 pounds that year, there was still no ready market for all the shrimp which could be caught by the boats intermittently engaged in this fishery between January and April. But in 1942 there was a greater demand for shrimp for fresh consumption and home canning. The fishermen also had another outlet for their catches when a cannery at Friendship, Maine, began to process shrimps.

After 1942, the fishery expanded rapidly for the next few years, as demonstrated by table 2 and figure 2. Several more canneries began processing shrimp, and quantities of whole shrimp and shrimp tails were also quick-frozen. By 1944, the fishery was no longer limited by the demand, but instead was governed by the supply available to the fishermen. This condition has prevailed to the present.

When the market began to absorb all the catches after 1943, fishing activities increased. The fishermen operated longer hours and made larger catches. Daily landings of 2,000 pounds per boat were not rare, and as high as 3,000 pounds were taken on some one-day trips. It was natural that these successful operations would attract more fishermen, and consequently the fleet expanded until 1944, when 25 boats were dragging on the five principal Maine shrimping grounds. In 1945, a further increase occurred and the fleet numbered 31 boats.

Table 3 - Yield of the Maine *Pandalus borealis* Fishery in Pounds by Months, 1939-49^{1/}

Month	Year										
	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949
January	6	156	980	10,056	6,819	12,715	21,760	580	-	-	-
February	1,684	181	39,411	61,306	28,111	111,631	205,566	2,622	28,907	1,600	5,500
March	16,924	6,886	13,198	3,865	239,102	258,676	323,670	158,313	162,503	24,437	4,200
April	1,250	1,032	291	-	17,400	6,210	303	-	2,289	1,288	-
May	-	-	32	-	-	-	-	-	-	-	-
June	-	60	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-	-
August	-	-	-	-	-	-	-	-	-	-	-
September	-	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	81	-	-	-	-	-	-
December	-	295	3,805	196	-	5,485	-	-	-	-	-
Total	19,864	8,610	57,717	75,423	291,513	394,717	551,299	161,515	193,699	27,325	9,700

- NONE REPORTED.
^{1/}YEARLY TOTALS (AS COMPILED BY MAINE DEPARTMENT OF SEA AND SHORE FISHERIES) DO NOT IN ALL CASES AGREE WITH THOSE OF TABLE 2.

When it became difficult to catch large quantities of the shrimp in 1946, there was a marked decline in fishing activity. As is the usual practice of those engaged in seasonal fisheries, most of the fishermen do not begin to use their gear until there is some assurance that profitable catches can be made. At the beginning of the season, a few boats will spend considerable time and effort in attempts to locate shrimp concentrations. The remainder of the fleet will begin to fish only when worthwhile catches are landed and it has become evident that the shrimping season is again at hand. In 1946 and subsequent years, the large masses of shrimp so prevalent in earlier years have not been located on the customary grounds, and the fleet has declined in both numbers and activity. During 1949, another poor year, only about 12 boats fished intermittently during the season. There were, however, at least 25 other boats which would have operated if profitable catches could have been made.

FISHING GEAR AND METHODS

The fishing gear and methods used in the Northern shrimp fishery are not greatly different than those used in otter-trawling operations. The size and power of the boats have governed the size of the net. A net in common usage has been one with a 40-foot footrope. The stretched-mesh size in the cod end and in part of the back and belly of the net is 1½ inches. The remainder of the net, including the wings, has a 2-1/8 inch mesh. There are in operation other sizes and shapes of nets. Some are made by the fishermen according to their own preferences. Many of the nets have been equipped with wooden rollers on the footrope. Others have loops of chain suspended on the footrope. To my knowledge, the sweepnet mentioned by Walford has not been used. Fishing has been carried on during the daylight hours at depths of about 20 to 40 fathoms. Night trawling has not been tried, because the boats are not equipped with flood lights for working at night and the grounds are located with reference to landmarks not visible at night. The towing speed

has been about $1\frac{1}{2}$ to 2 miles per hour. While speeds up to 4 miles per hour capture more fish, they are evidently less efficient in catching shrimps. Ropes, with or without bridles, have been commonly used to tow the nets, although wire towing lines are used by several of the larger boats.

OTHER FISH AND SHELLFISH CAUGHT IN SHRIMP HAULS

The quantities of fish and invertebrates taken incidental to the shrimping operations have never been large or of much importance to the fishermen. Sometimes a few legal-sized lobsters are caught and sold, but this is not a common occurrence. The quantities of fish caught have been relatively small. Table 4 reveals the numbers, sizes, and weights of commercially-important species taken during a total of six hours of dragging during March 1947. Of the 13 edible species, only the smelt, dab, and blackback were large enough to be marketed. The total shrimp catch for the two days was 1,160 pounds, while the commercially-

Table 4 - Commercially-Important Species of Fish Caught March 13 and 20, 1947

Species	Total Catch		Range in Length		Minimum Marketable Length ^{1/}	Marketable Catch		Percent Marketable	
	No.	Lbs.	Inches		Inches	No.	Lbs.	No.	Wgt (lbs.)
Herring (<i>Clupea harengus</i>)	288	5.8	2.6 - 8.8		5	2/	0.0	0.0	0.0
Alewife (<i>Pomolobus pseudoharengus</i>)	166	2.3	2.8 - 4.8		9	0	0.0	0.0	0.0
Smelt (<i>Osmerus mordax</i>)	7	.3	5.6 - 6.2		5	7	0.3	100.0	100.0
Ocean Perch or rosefish (<i>Sebastes marinus</i>)	63	.3	1.9 - 3.2		8	0	0.0	0.0	0.0
Whiting (<i>Merluccius bilinearis</i>)	83	1.4	3.4 - 5.8		8	0	0.0	0.0	0.0
Pollock (<i>Pollachius virens</i>)	24	1.8	5.7 - 7.0		12	0	0.0	0.0	0.0
Cod (<i>Gadus morhua</i>)	1	.2	8.8 - 8.8		12	0	0.0	0.0	0.0
Haddock (<i>Melanogrammus aeglefinus</i>)	2	.1	5.3 - 5.7		12	0	0.0	0.0	0.0
White hake (<i>Urophycis tenuis</i>)	11	1.1	6.7 - 8.6		12	0	0.0	0.0	0.0
Squirrel hake (<i>U. chuss</i>)	26	.6	3.4 - 6.8		12	0	0.0	0.0	0.0
Dab (<i>Hippoglossoides platessoides</i>)	97	9.7	3.0 - 13.9		10	6	2.8	6.2	29.3
Blackback flounder (<i>Pseudopleuronectes americanus</i>) .	207	46.2	2.9 - 14.6		10	35	23.8	16.9	51.5
Grey sole (<i>Glyptocephalus cynoglossus</i>)	94	.5	2.6 - 4.0		10	0	0.0	0.0	0.0
Total	1069	71.3				48	26.9	4.5	37.7

^{1/}THESE LENGTHS VARY WITH THE PREVAILING MARKET. IN TIMES OF SCARCITY, SOME SMALL FISH MAY BE MARKETED. AT THE TIME OF THE OBSERVATIONS, FISH LESS THAN THE MINIMUM SIZE GIVEN WOULD NOT BE MARKETABLE IN NEW ENGLAND.

^{2/}THE HERRING WERE IN SUCH A THIN CONDITION AT THE TIME OF CAPTURE THAT THEY WERE OF NO VALUE COMMERCIALY.

important fish amounted to less than 27 pounds. Figure 5 shows the length frequencies of nine of the species. These data portray the size composition of the average catch fairly well, although I have occasionally seen large specimens of rosefish and whiting landed with the shrimp. It is evident that no great numbers of small commercially-valuable fish have been destroyed in the shrimp fishery. The shrimp and fish are sorted soon after being brought on deck, and the smaller flatfish are generally thrown back into the sea. No fish scales were collected and no attempt was made to deduce the ages from the length frequencies. The relatively small samples and the probable selectivity of the net introduce too great an error for length frequency-age analyses. The trash fish caught during the two days have been listed in table 5. Information on the unusual specimens taken at this time have been recorded by Scattergood (1948). Prior to the summer of 1949, none of the trash species had any value, except occasionally as lobster bait, but now all could be sold to fish-meal producers. The quantities taken in shrimp trawling would be low, however, for the two days' activities caught only 79 pounds. With an increase in the towing speed more fish could be caught, but probably not enough to warrant the probable decrease in the shrimp catch. With the present market of one cent or less per pound there is little incentive for small boats to capture trash fish during the shrimp season.

METHODS OF HANDLING ABOARD THE VESSEL

Since there is generally not a great amount of other invertebrates or fish mixed with the shrimp, the operation of sorting and preparing the shrimp for the

buyer is not a great task. Usually the catch of a one-hour tow can be culled completely before the next tow is finished. Shrimp are fairly free of mud, for when the net is brought to the surface it is towed through the water until most of the mud has been washed out. After removing the shrimp from the catch, the fishermen usually wash them in sea water and remove most of the small or broken shrimp. The size of the catch and the attitude of the buyer influence the thoroughness of the culling activities.

In Maine, the Northern shrimp are not cooked aboard the boats, as is a common custom in many other regions, such as British Columbia (Anon. 1945); Puget Sound, Washington (Smith 1937); and Norway (Walford 1936). The weather is cool, usually below freezing, during the shrimp season, and there is little danger of spoilage

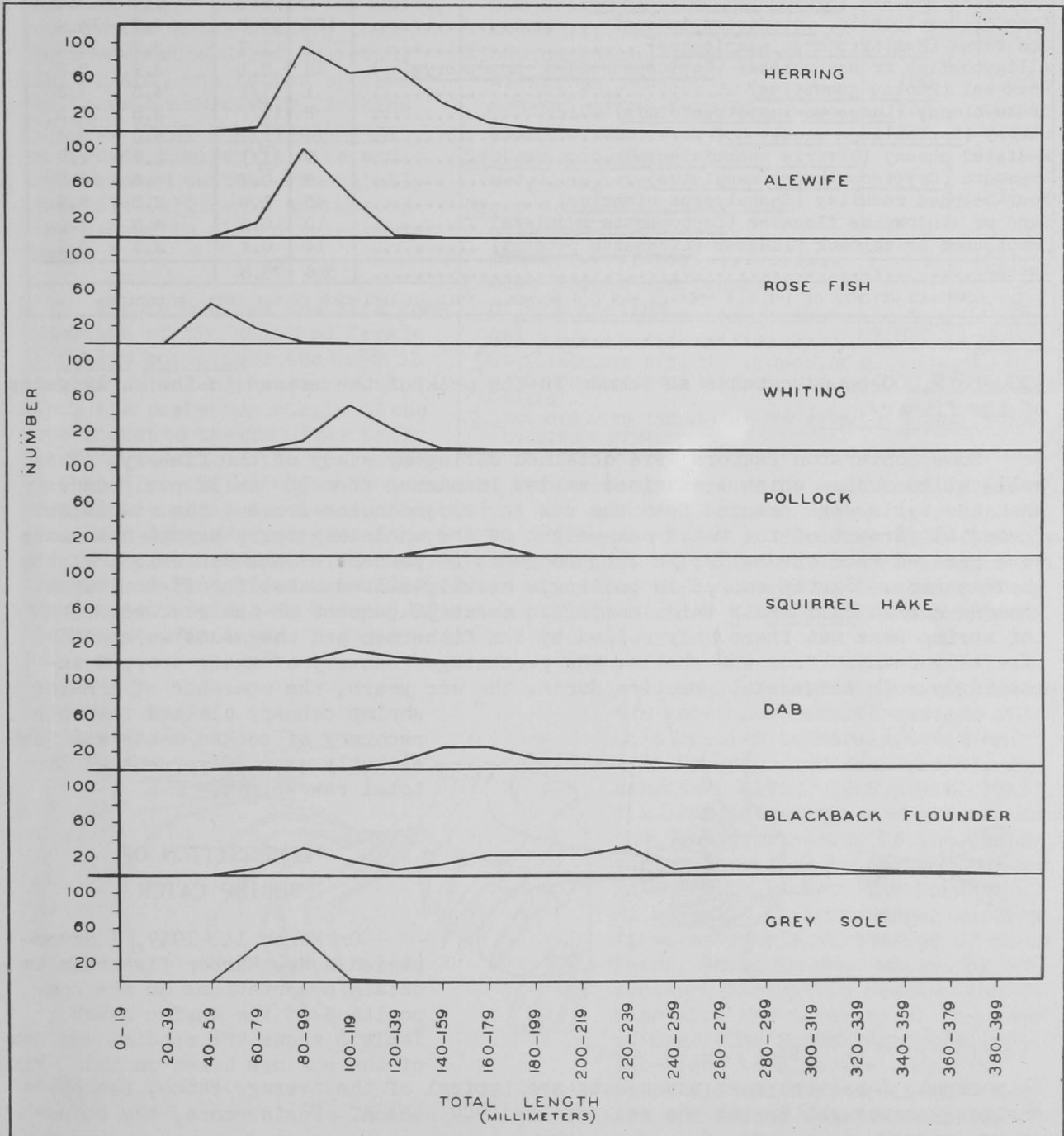


FIG. 5 - SIZE COMPOSITION OF NINE COMMERCIALY-IMPORTANT SPECIES OF FISH TAKEN BY A SHRIMP BOAT IN 6 HOURS OF DRAGGING IN MARCH 1947.

between the catching and landing of these crustaceans. None of the boats have sufficient space in which to install cooking equipment large enough to boil the

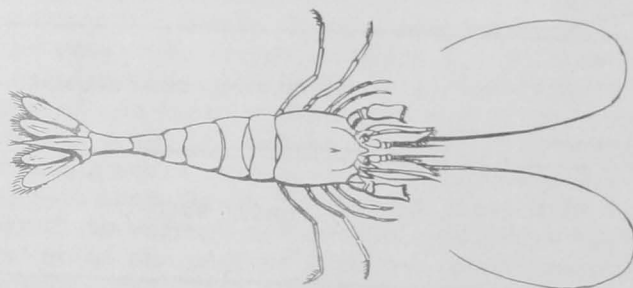
Table 5 - Trash Fish Caught March 13 and 20, 1947

Species	Total	Catch	Range in Length
	No.	Lbs.	Inches
Little skate (<i>Raja erinacea</i>)	21	22.3	7.5 - 21.8
Big skate (<i>R. diaphanes</i>)	11	21.4	14.8 - 23.3
Prickly skate (<i>R. scabrata</i>)	7	2.2	9.2 - 13.5
Pipefish (<i>Syngnathus fuscus</i>)	2	(1/)	7.1 - 8.6
Silverside (<i>Menidia notata</i>)	33	0.4	3.3 - 5.1
Mailed sculpin (<i>Triglops ommatistius</i>)	3	(1/)	2.9 - 3.3
Shorthorn sculpin (<i>Myoxocephalus scorpius</i>)	2	0.9	8.9 - 10.4
Longhorn sculpin (<i>M. octadecimspinosus</i>)	130	26.8	4.2 - 14.4
Sea raven (<i>Hemitripterus americanus</i>)	5	1.7	3.7 - 11.4
Alligatorfish or sea poacher (<i>Aspidophoroides monopterygius</i>)	12	0.1	2.9 - 5.7
Rock eel (<i>Pholis gunnellus</i>)	1	(1/)	4.3 - 4.3
Snake blenny (<i>Lumpenus lampetraeformis</i>)	8	(1/)	3.5 - 11.2
Shanny (<i>Leptoclinus maculatus</i>)	10	(1/)	4.0 - 5.4
Radiated shanny (<i>Ulvaria subbifurcata</i>)	9	(1/)	2.7 - 4.2
Wrymouth (<i>Cryptacanthodes maculatus</i>)	3	0.7	14.6 - 16.3
Four-bearded rockling (<i>Enchelyopus cimbrius</i>)	45	1.2	2.8 - 9.4
Sand or windowpane flounder (<i>Lophopsetta maculata</i>)	10	0.6	4.5 - 6.0
Smoothback or eelback flounder (<i>Liopsetta putnami</i>)	14	0.1	2.0 - 3.1
Total	326	78.8	

1/THE COMBINED WEIGHTS OF THE SIX SPECIES WAS 0.4 POUNDS. THIS IS INCLUDED IN THE TOTAL POUNDAGE.

300- to 2,000-pound catches so common in the peak of the season in the early years of the fishery.

Some conversion factors were obtained during my study of the fishery. The well-culled shrimp which I examined varied in number from 36 to 38 per pound. When the tails were removed from the raw shrimp and quick-frozen, the raw tails formed 61 percent of the total raw weight of the whole shrimp. When the raw meats were removed from the tails, it weighed about 45 percent of the raw weight of the whole shrimp. Shrimp cooked in boiling, heavily-salted water for five minutes yielded cooked tail meats which comprised about 32 percent of the raw weight. If the shrimp were not thoroughly culled by the fishermen and the meats were not carefully removed from the shells, the percentage recovery of meats dropped accordingly. In commercial practice during the war years, the operator of a Maine shrimp cannery claimed that his recovery of cooked meats was just slightly over 20 percent of the total raw weight.



CRAGO SEPTemspinosus
LENGTH 40 TO 70 MM. (ABOUT 1.6-2.8 INCHES).

In general, I believe that these data are typical of the average catch, for these shrimps were caught during the peak of the 1949 season. Furthermore, the compo-

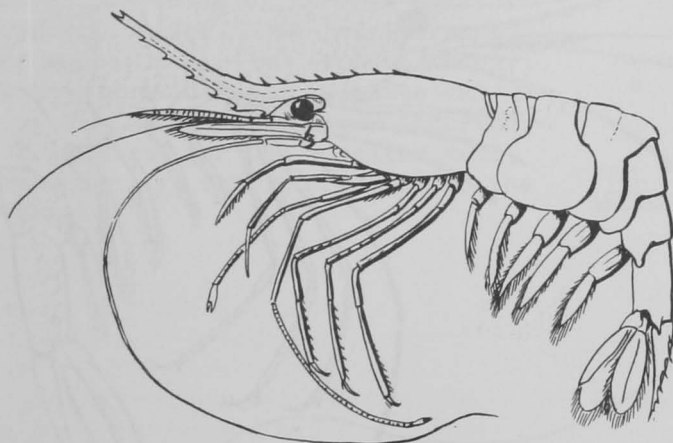
COMPOSITION OF SHRIMP CATCH

On March 14, 1949, I accompanied a New Harbor fisherman to obtain observations on the composition of the shrimp catch. Table 6 shows the species and sex of the shrimps taken on this trip.

sition of this shrimp catch did not seem to vary markedly from my casual observations on numerous trips aboard shrimping boats since 1939. Of the five species only the Pandalus borealis females have been considered as large enough to be sold. Most of the specimens of both Dichelopandalus leptoceros and Pandalus montagui are larger than many shrimp species used for food in other parts of the world, but in the Maine fishery they have been considered as trash. In England, the latter species is taken commercially (Jenkins 1920). Crago septemspinosus, a species similar in size and appearance to the commercially-valuable California shrimps of the genus, is also discarded in Maine.

Figure 6 shows the size composition of the male and female Pandalus borealis in the March 14 sample. The lengths are measured from the posterior margin of the eye socket to the end of the tail. It is evident that the males are distinctly smaller than the females. This size difference is explained by the dominant protandrous hermaphroditism of the species. (These shrimp have both male and female sex organs maturing at different stages.) Berkeley (1929), studying in British Columbia, Canada, discovered that this species of shrimp and other species of Pandalidae matured first as males and then changed to females as they increased in size. In Europe, Jagersten (1936) examined P. borealis and confirmed Berkeley's findings.

Species	No.	Wgt. (lbs.)
<u>Pandalus borealis</u> :		
ovigerous females	6,799	185.00
non-ovigerous females	1	1/0.01
males	261	0.71
<u>P. montagui</u> :		
ovigerous females	23	0.24
non-ovigerous females	1	(2/)
males	2	(2/)
<u>Dichelopandalus leptoceros</u> :		
ovigerous females	180	1.13
non-ovigerous females	236	0.42
males	314	0.62
<u>Lebbeus groenlandicus</u> :		
ovigerous females	1	0.01
<u>Crago septemspinosus</u> :		
ovigerous females	2	0.02
males	7	(2/)
Broken bodies and fragments of all species		
	-	0.36
Total	7,827	188.52
1/THIS INCLUDES ALSO THE WEIGHTS OF <u>P. MONTAGUI</u> MALES AND NON-OVIGEROUS FEMALES, AND <u>CRAGO SEPTEMSPINOSUS</u> MALES.		
2/INCLUDED WITH THE WEIGHT FOR <u>PANDALUS BOREALIS</u> NON-OVIGEROUS FEMALES.		



PANDALUS MONTAGUI
LENGTH 50 TO 110 MM. (ABOUT 2.0-4.3 INCHES).

Other detailed observations on the growth and sexual changes of this species in Norway have been made by Hjort and Ruud (1938), and Rasmussen (1942, 1945, 1946, 1947). The last investigator demonstrated that the growth rate of the shrimp varies according to the environment in which it lives. The Norwegian P. borealis at Spitzbergen matures first as a male at the age of three years, while in some waters of southern Norway it reaches the same size and maturity at one year of age. The Spitzbergen shrimp functions as a female when five years old and some southern Norway shrimps become females when two years old (Rasmussen 1942). It is

not possible at this time to present similar information on the Maine shrimps, for the age and growth of shrimps must be measured by the analysis of length-frequency data collected during the entire year, and our collections have been confined to the month of March. Of the Norwegian regions in which shrimps have been studied, the ecological conditions of the waters of southern Norway are more similar to those of Maine and, therefore, the rates of development may be similar in the two areas.

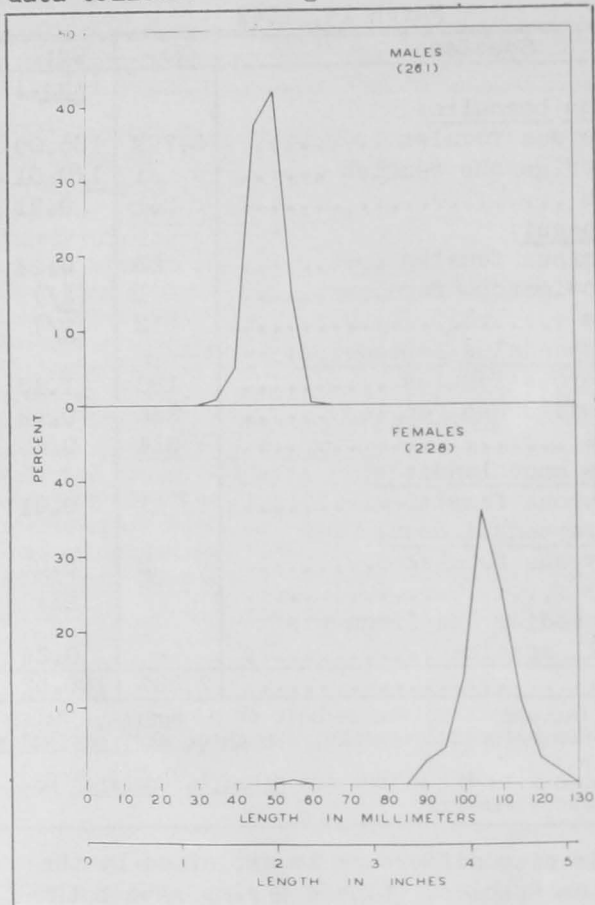
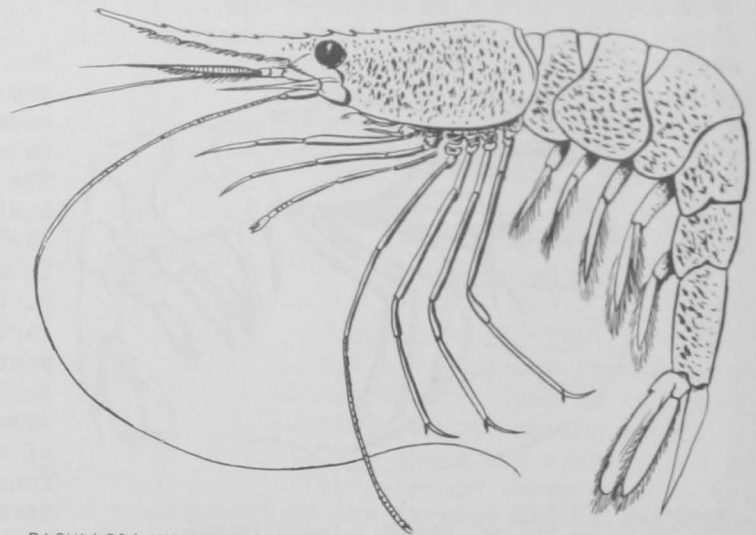


FIG. 6 - SIZE COMPOSITION OF A SAMPLE OF THE PANDALUS BOREALIS CAUGHT MARCH 14, 1949.

PROBABLE REASONS FOR DECLINE OF NORTHERN SHRIMP FISHERY

A most intriguing question is why so few shrimp have been found during the past several years on the formerly productive shrimping grounds. There is not enough information available to evaluate the probable reasons for this phenomenon. However, brief comments are appropriate concerning the factors which may have influenced the availability of these crustaceans. First, it is likely that shrimp populations are subject to cyclic fluctuations, and the bottom of the cycle may now be at hand. This fishery is of such recent origin that evidence of cyclic

The life histories of the other shrimp taken with Pandalus borealis are not as well known. Jägersten (1936) has stated that among P. montagui there are primary females which have never been males, and males which change to females (protandrous hermaphroditism). According to him, P. borealis also has these same classes of individuals, but the primary females are fewer in number than in P. montagui. As shown in table 6, the catch of P. montagui was not large enough to supply adequate information on the relative proportions of these three classes. The length frequencies of male and female Dichelopandalus leptoceros are shown in table 6 and figure 7, and it appears that this species, like the Pandalus propinquus mentioned by Jägersten (1936), may not be hermaphroditic, since both males and females occur at all sizes. However, further study would be necessary to confirm this possibility.



DICHELOPANDALUS LEPTOCEROS
LENGTH FROM 50 TO 98 MM. (ABOUT 2.0-3.9 INCHES).

abundance cannot be substantiated. Second, instead of migrating inshore to the known fishing areas in February to April, the shrimps may now be appearing on other areas not yet exploited. Until extensive experimental fishing operations are carried out along the Maine coast we will know little of the distribution of the shrimp, and therefore, we will have no idea whether or not annual migrations are erratic. Third, there is the possibility that overfishing has occurred. If the decline in the yield of the Maine fishery in the four shrimping areas has been caused by the catching of too many mature shrimp, this would indicate that the shrimp populations in those waters were not a part of a homogeneous Gulf-of-Maine population, but instead represent one or more independent stocks. It would indeed be difficult to imagine that the fishery for shrimp along the Maine coast would seriously affect the abundance of a single, large Gulf-of-Maine population. Fourth, since shrimp are associated with rosefish in deep water for a greater part of the year, it is probable that many of the shrimp, both large and small, are damaged in the rosefish nets before they can escape through the cod ends. This resultant drain on the shrimp population might be much greater than realized. Of course, there are other theoretical explanations, such as possible oceanographic changes adversely affecting the survival of the shrimp, increased natural mortalities through greater competition for food, or increased predation, etc., but unfortunately, we have no evidence to indicate whether or not such conditions have occurred. The reasons for the decline must, consequently, remain obscure for the present.

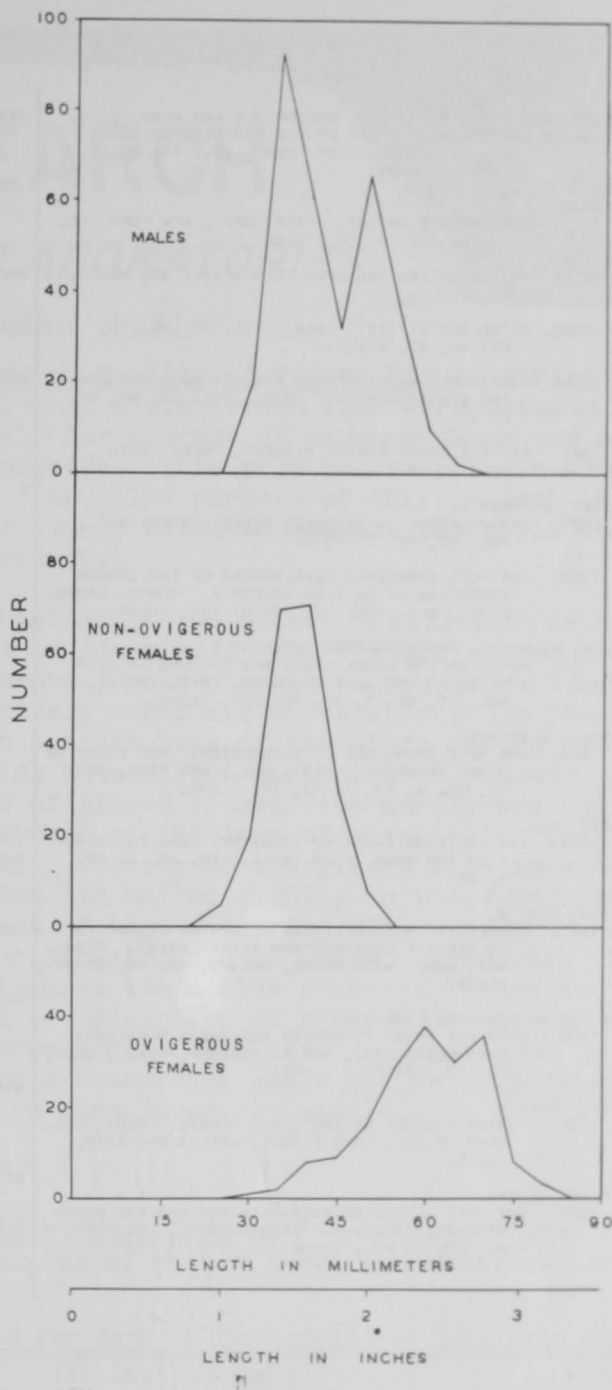


FIG. 7 - SIZE COMPOSITION OF THE DICHELOPANDALUS LEPTOCEROS CAUGHT MARCH 14, 1949.

- ANDERSON, WILLIAM W.; LINDNER, MILTON J.; AND KING, J. E.
1949. THE SHRIMP FISHERY OF THE SOUTHERN UNITED STATES. COMM. FISH. REV., VOL. 11, NO. 2, 17 PP., ILLUS.
- ANONYMOUS.
1936. NEW ENGLAND SHRIMP. FISH. GAZ., NEW YORK, VOL. 53, NO. 12, P. 10, ILLUS.
- 1938A. INVESTIGATING SHRIMP. IBID., VOL. 55, NO. 8, P. 32.
- 1938B. MAINE ACTIVITIES. IBID., VOL. 55, NO. 10, PP. 95, 97, ILLUS.
- 1938C. PROFITABLE MAINE SHRIMP FISHERY POSSIBLE DURING WINTER MONTHS. IBID., VOL. 55, NO. 12, P. 9.
1945. PACIFIC COAST SHRIMP FISHERY. WEST. FISH., VOL. 30, NO. 3, PP. 42, 44, 46.
- BERKELEY, ALFREDA A.
1929. SEX REVERSAL IN PANDALUS DANAE. AMER. NAT., VOL. 63, PP. 571-573.
1930. THE POST-EMBRYONIC DEVELOPMENT OF THE COMMON PANDALIDS OF BRITISH COLUMBIA. CONTR. CANAD. BIOL., N.S., VOL. 6, PP. 81-163, ILLUS.
- BIGELOW, HENRY B., AND SCHROEDER, WILLIAM C.
1939. NOTES ON THE FAUNA ABOVE MUD BOTTOMS IN DEEP WATER IN THE GULF OF MAINE. BIOL. BULL., VOL. 76, NO. 3, PP. 305-324, ILLUS.
- BIRDSEY, CLARENCE.
1928. SHRIMP FISHING OUT OF GLOUCESTER. THE STORY OF A NEW INDUSTRY. FISH. GAZ., NEW YORK, VOL. 45, NO. 4, PP. 12-13, 15, ILLUS.
- BONNOT, PAUL.
1932. THE CALIFORNIA SHRIMP INDUSTRY. CALIF. DIV. FISH AND GAME, FISH. BULL., NO. 38, 22 PP., ILLUS.
- CARLSON, CARL B.
1945. COMMERCIAL POSSIBILITIES OF SHRIMP RESOURCES IN CERTAIN SOUTHEASTERN ALASKA AREAS. FISH. MKT. NEWS, WASHINGTON, VOL. 7, NO. 7A, 25 PP., ILLUS.
- HJORT, JOHAN AND RUUD, JOHAN T.
1938. DEEP-SEA PRAWN FISHERIES AND THEIR PROBLEMS. HVALRODETS SKR., NORSK. VIDENSK.-AKAD., OSLO, NO. 17, 144 PP., ILLUS.
- HAYNES, FRANK W.
1930. SHRIMP FISHERY OF SOUTHEAST ALASKA. REPT. U.S. COMM. FISH., 1929 (1930), APP. 1, PP. 1-18, ILLUS.
- JAGERSTEN, GOSTA.
1936. ÜBER DIE GESCHLECHTSVERHÄLTNISSE UND DAS WACHSTUM BEI PANDALUS. ARCHIV. ZOOL., BD. 28A, NO. 20, 26 PP., ILLUS.
- JENKINS, JAMES T.
1920. THE SEA FISHERIES. LONDON, CONSTABLE AND CO., LTD., XXXI + 299 PP., ILLUS.
- JOHNSON, FRED F., AND LINDNER, MILTON J.
1934. SHRIMP INDUSTRY OF THE SOUTH ATLANTIC AND GULF STATES. INVEST. REPT. U.S. BUR. FISH., NO. 21, 83 PP., ILLUS.
- POULSEN, ERIK M.
1946. INVESTIGATIONS ON THE DANISH FISHERY FOR AND THE BIOLOGY OF THE NORWAY LOBSTER AND THE DEEP-SEA PRAWN. REPT. DAN. BIOL. STA., 1943-1945 (1946), PP. 29-49, ILLUS.
- RASMUSSEN, BIRGER.
1942. OM DYPVANNISREKEN VED SPITSBERGEN. FISKERIDIREKTORATETS SKRIFTER, SERIE HAVUNDERSØKELSE. (REPORT ON NORWEGIAN FISHERY AND MARINE INVESTIGATIONS), VOL. 7, NO. 4, 43 PP., ILLUS.
1945. TREKK FRA DYPVANNISREKENS BIOLOGI I NORSKE KYST-FARVANN. I. VIGRAFJORDEN, MØRE. IBID., VOL. 8, NO. 2, 38 PP., ILLUS.
1946. DYPVANNISREKENS BIOLOGI I NYTT LYS. NATUREN, 1946, NR. 1, PP. 10-17, ILLUS.
1947. NOTES ON THE DEEP SEA PRAWN IN A NORWEGIAN FJORD. ANN. BIOL. INT. EXPLOR. MER., VOL. 2, PP. 10-13, ILLUS.
- RATHBUN, RICHARD.
1883. NOTES ON THE SHRIMP AND PRAWN FISHERIES OF THE UNITED STATES. BULL. U.S. FISH. COMM., VOL. 2, 1882 (1883), PP. 139-152.
1884. PART V. CRUSTACEANS, WORMS, RADIATES AND SPONGES. IN GOODE, GEORGE BROWN, 1884, THE FISHERIES AND FISHERIES INDUSTRIES OF THE UNITED STATES, WASHINGTON, GOV'T PRINT. OFF., SEC. 1, PP. 759-850.
- SCATTERGOOD, LESLIE W.
1948. NOTES ON SOME GULF OF MAINE FISHES. COPEIA, 1948, NO. 2, PP. 142-144.
- SCOFIELD, N. B.
1919. SHRIMP FISHERIES OF CALIFORNIA. CALIF. FISH AND GAME, VOL. 5, NO. 1, PP. 1-12, ILLUS.
- SMITH, RICHARD T.
1937. OBSERVATIONS ON THE SHRIMP FISHERY IN PUGET SOUND. WASH. STATE DEPT. FISH. BIOL. REPT., NO. 36D, 11 PP., ILLUS.
- WALFORD, LIONEL A.
1936. NOTES ON SHRIMP FISHING ALONG THE NEW ENGLAND COAST. U.S. BUR. FISH. MEMO., SER. 1, NO. 57, 5 PP., ILLUS.
- WEYMOUTH, FRANK W.; LINDNER, MILTON J.; AND ANDERSON, WILLIAM W.
1933. PRELIMINARY REPORT ON THE LIFE HISTORY OF THE COMMON SHRIMP PENAEUS SETIFERUS (LINN.). BULL. U.S. BUR. FISH., VOL. 48, PP. 1-26, ILLUS.

