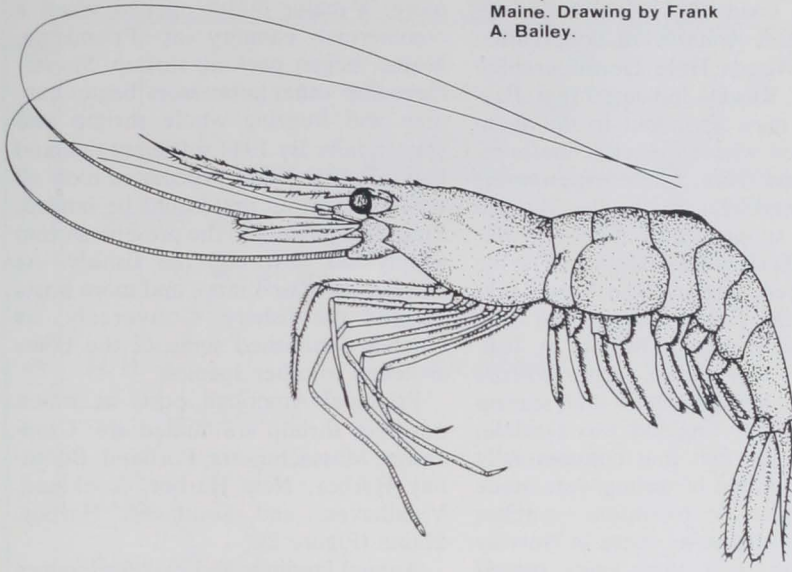


Figure 1.—Adult northern shrimp from the Gulf of Maine. Drawing by Frank A. Bailey.



Biologically, the northern shrimp differs drastically from the southern shrimp which makes up most of the U.S. catch.

Fishery for Northern Shrimp, *Pandalus borealis*, in the Gulf of Maine

ROLAND L. WIGLEY

ABSTRACT

A fishery for northern shrimp in the Gulf of Maine has grown rapidly during the last decade to become one of the most valuable fisheries in New England. American landings of this shrimp in the period 1962 to 1972 increased from 388,000 pounds to 24,295,000 pounds; correspondingly, value increased from \$57,000 to \$4,557,000. Trends in the total catch of northern shrimp in the past few years, plus decreased catch per unit effort during the past year, indicate that maximum utilization of this stock was attained in 1969. This paper briefly reviews the history and development of the fishery, landings, vessel types and gear, processing, and recent development in the fishery.

INTRODUCTION

Northern shrimp, *Pandalus borealis*, (Figure 1) is a medium-sized species that is commercially abundant in North Pacific and North Atlantic waters. This species has supported a small fishery along the southern Maine coast for sev-

eral decades and during the last decade it has developed into one of the most valuable fisheries in New England. Vessels from Maine, New Hampshire, and Massachusetts landed a total of 24 million pounds of northern shrimp in 1969. This fishery started as an off-season fill-in for herring and lobster fisher-

men. Today it is a major species fished throughout the year. Expansion of this fishing occurred at a time when other fisheries in New England were declining. It has generated a need for new processing plants, new boats, and has substantially increased employment. Maine has been the traditional center of this fishery and remains so today.

NOTES ON BIOLOGY

Some of the more important biological characteristics of the northern shrimp's life cycle are diametrically opposite to those of the southern commercial shrimp (genus *Panaeus*).

Southern shrimp (*Panaeus*) spawn in offshore waters; the eggs are broadcast free into the sea where they drift, without parental care until they hatch. Average number of eggs per clutch is 500,000 to 1,000,000. They begin life as male or female and complete their life cycle without change. Young stages migrate to the bayous and other estuarine areas where they pass their early life. When they attain moderately large size they migrate to offshore waters and spawn. Life span of most species of penaeid shrimp is roughly one year.

Northern shrimp spawn in offshore waters and attach the eggs to the pleopods where they are protected until they hatch. Average number of eggs per clutch is 800 to 3,400. They are protandric hermaphrodites, functioning first as males. Larval stages develop in coastal waters. Juvenile and young adult stages move to offshore waters as they grow larger. When they become egg-bearing females they migrate to coastal waters during the egg maturation period. Life span of northern shrimp in the Gulf of Maine is four to five years.

Northern shrimp is a cold-water species that occurs in commercial abundance in northern regions of both the North Pacific and North Atlantic Oceans. In the North Pacific it is fished commercially in continental shelf waters of both the Asiatic and North American continents. In the North Atlantic it is fished in many areas, such as the Barents Sea, off Scandinavia, British Isles, Ice-

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land, southern Greenland, Newfoundland, and the Canadian Maritimes. The Gulf of Maine population is the southernmost stock of this species. This stock also ranks among the first in terms of growth rate for this species.

In the Gulf of Maine it occurs in commercial abundance in the Bay of Fundy region and along much of the western Gulf of Maine southward to Cape Cod, Massachusetts, and the northern margin of Georges Bank. It is less common in the eastern and southeastern sections of the Gulf.

HISTORY

Although fishing for northern shrimp in the Gulf of Maine has produced substantial quantities only in recent years, 1963 to present, this species was known to inhabit Gulf waters since 1873. In those early years most ocean fishing was pursued by hook-and-line and the species sought were groundfishes, such as the cod, haddock, halibut, and hake. Shrimp would normally go unnoticed, except possibly as a food item in stomachs of groundfish. However, with the advent of beam trawls and other trawls, around the turn of the century, shrimp were caught, but only in small quantities, owing to the large size mesh used for groundfish.

Prior to 1927, small draggers operating out of Gloucester, Massachusetts, caught and landed modest quantities of northern shrimp from time to time. General Seafoods Corp. took an interest in the commercial utilization of this species. It sponsored several exploratory cruises in 1927 and one in 1928, with the objective of locating a sufficiently large and dependable supply of shrimp. Mediocre results, combined with more promising prospects in other fisheries, deterred further development in the shrimp industry at that time.

The next major investigation of shrimp in the Gulf of Maine took place in 1936. A Norwegian fishery expert, Johan Hjort, who was instrumental in getting a shrimp fishery started in his homeland, visited the United States at the request of American scientists and supervised a series of exploratory shrimp-trawling cruises in the western Gulf of Maine. Principal area of operation was Jeffrey's Basin and the region

east of Cape Ann, Massachusetts. This work was conducted aboard the research vessel *Atlantis*, in cooperation with the Woods Hole Oceanographic Institution. Results indicated that *Pandalus* was most abundant in the same general area where General Seafoods' vessels found them. These explorations were followed by a cooperative venture financially supported by the U. S. Bureau of Fisheries, the Federated Fishing Boats of New England and New York, Inc., and the Fishermen's Relief Corporation of Portland, Maine. A fishing vessel, *New Dawn*, was outfitted and, again, demonstrated that shrimp fishing off New England was feasible. In spite of the fact that commercially profitable catches of shrimp were made during these explorations—catches equal to or surpassing those in Norway and Sweden—two more years passed before the beginning of a new fishery materialized.

In 1938 the first large-scale fishing for northern shrimp began in southern Maine. That year 13 vessels that ranged in size from 46 to 73 feet began dragging for shrimp and landing their catches at Portland. Fishing was conducted primarily off Wood Island, located southwest of Cape Elizabeth. Catches were made only during the early spring months (February to April); all trips were of 1-day duration. Part of the catch was sold fresh, but most of it was frozen for future use. In the summer of 1938 an attempt was made by the Maine Department of Sea and Shore Fisheries and the U. S. Bureau of Fisheries to learn if a year-round fishery could be established. Two small fishing boats carried out explorations along the Maine coast in July and August. Results were generally unsatisfactory and it was concluded that shrimp fishing during summer months along that part of the Maine coast were unprofitable.

During the years 1939 to 1942 small amounts of shrimp were landed, the supply substantially greater than the demand by local consumers. Customarily fishermen would fish for a few hours or a day and devote the next few days to selling the catch in neighboring towns. Occasionally the shrimp could not be sold and had to be discarded.

In 1942 there was increased demand for fresh shrimp for immediate con-

sumption and home-canning. Furthermore, a major outlet opened when a commercial cannery at Friendship, Maine, began packing shrimp. Shortly thereafter other processors began canning and freezing whole shrimp and shrimp tails. By 1944 sufficient demand had developed that processors took all northern shrimp that could be landed. From that time up to the present, shrimp supply has governed the fishery. As catches increased more and more boats entered the fishery. Conversely, as catches diminished some of the boats switched to other species.

Principal American ports at which northern shrimp are landed are: Gloucester, Massachusetts; Portland, Boothbay Harbor, New Harbor, Rockland, Vinalhaven, and Southwest Harbor, Maine (Figure 2).

Annual landings and ex-vessel values of northern shrimp at U. S. ports since 1938, when this fishery started, are listed in Table 1 and illustrated in Figure 3. The most striking fact revealed by these data is the dramatic increase in

Table 1.—Annual landings and ex-vessel values of northern shrimp at American ports during the years 1938 to 1972. (Weight in thousands of pounds, value in thousands of dollars.)

Year	Weight Landed	Value
1938	106	7
1939	54	2
1940	9	0.5
1941	0	0
1942	111	4
1943	295	15
1944	462	21
1945	582	29
1946	166	9
1947	194	11
1948	27	3
1949	10	2
1950	8	2
1951	58	10
1952	104	18
1953	38	7
1954	0	0
1955	0	0
1956	0	0
1957	0	0
1958	5	2
1959	17	5
1960	90	20
1961	68	14
1962	388	57
1963	561	67
1964	932	113
1965	2,093	245
1966	3,894	550
1967	6,991	872
1968	14,572	1,612
1969	28,271	3,478
1970	23,522	4,697
1971	24,684	4,650
1972	24,295	4,557

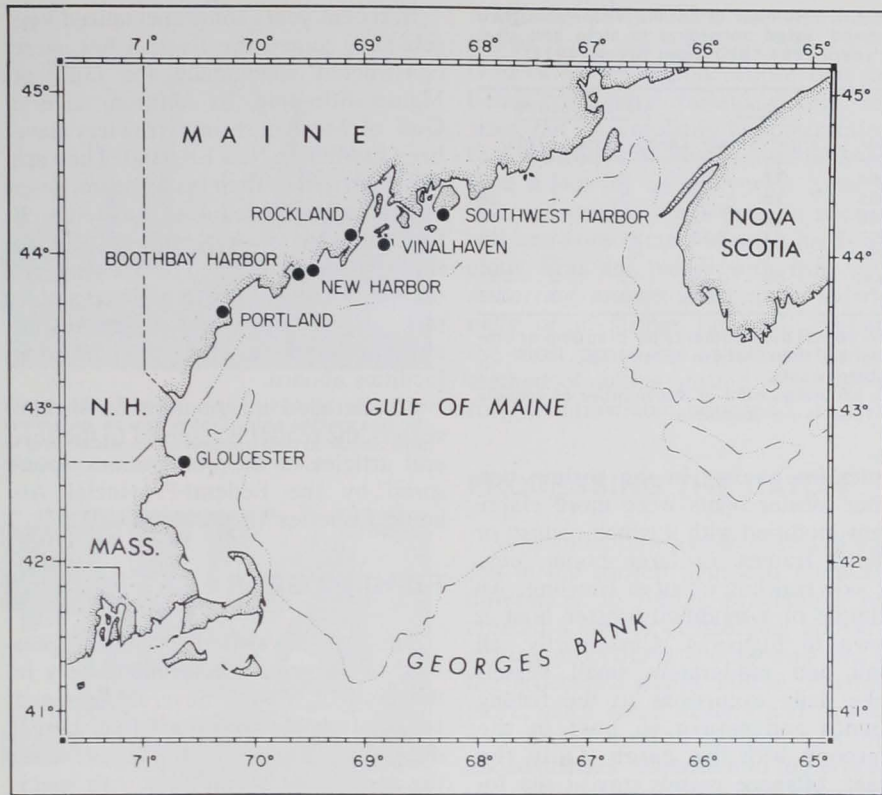


Figure 2.—Gulf of Maine region showing some of the principal shrimp-landing ports of New England.

landings that began in 1962-1965 period and reached a peak of 28 million pounds in 1969. Concurrently several fin fisheries (sea herring, silver hake, haddock) were declining; thus there were vessels and crews available that could quickly convert from finfishing to shrimping. Also noteworthy are the four years 1954-1957 during which no shrimp were landed, even though substantial demand existed throughout the entire period. The smaller total catch during the past three years suggests that the approximate maximum harvest of this stock has been attained. The rapidity with which this fishery was established attests to the demand for shrimp by the consumer.

TRENDS IN ABUNDANCE

Trends in the actual abundance of the Gulf of Maine shrimp stock may be judged from changes in catch per unit of effort. A comparison of the number of pounds of shrimp landed by the same group of vessels on a per-trip basis over a period of years provides an

index of abundance. A "trip" for small or medium shrimp boats operating in coastal Maine waters has traditionally been one day of fishing. In Table 2 are listed the fishing effort and landings for the fleet operating in the vicinity of Portland, Maine. The number of pounds of shrimp caught per trip averaged over a 1-year period is the index of abundance. These data are based on Market

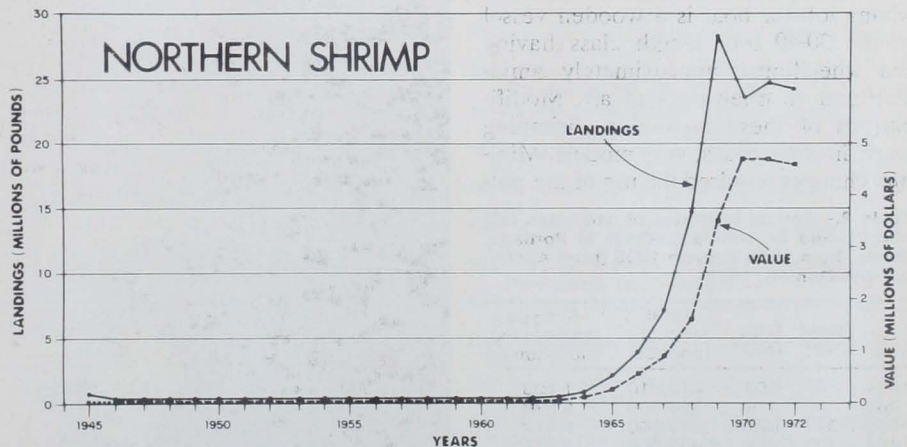


Figure 3.—U.S. landings and value of northern shrimp from the Gulf of Maine, 1945 to 1972.

News Service reports issued by the U. S. Bureau of Commercial Fisheries, as summarized and reported by Apollonio and Dunton (1969). Although there may be some complicating factors negating the validity of these types of data, because of the so-called "learning factor", improvements in fishing gear, etc., it is the best information available that reveals trends in abundance of this stock. Also, the possible complications appear to be minor in comparison to the substantial changes in catch.

Catch rates in 1964 averaged 1,128 pounds per trip, based on 189 fishing trips. During the subsequent four years the fishing effort and catch rate increased rather steadily each year. In 1968 the catch rate averaged 3,661 pounds per trip, based on 914 trips. One of the more interesting aspects of this catch-effort trend is the increased catch rate in the face of enormous increases in total landings. Total landings increased from 213,210 pounds in 1964 to 3,346,500 pounds in 1968. The substantially larger catches per unit effort each year during the time period evaluated, in spite of a continually mounting increase in total effort and removals, is sound evidence of marked increases in abundance of shrimp.

SIZE OF SHRIMP

In the early years of the Gulf of Maine shrimp fishery only the large egg-bearing females were caught. These are the oldest and largest members of the population, usually egg-bearing females that migrate into coastal waters during the

final stages of the egg maturation period. They generally range in size (total length: as measured from the tip of the rostrum to posterior end of the telson) from 4¾ inches to 7½ inches. Average length, which of course varies according to season, location, etc., is approximately 6 inches. Average weight of a whole shrimp is slightly less than ½ an ounce.

Shrimp landed in more recent years are believed to have been significantly smaller than those taken in earlier years of the fishery (as described above). Changes in the geographical areas fished in recent years could account for part of the size change. Smaller shrimp of saleable size, that is the male and transitional-stage shrimp (as well as females) inhabit deeper, offshore parts of the Gulf of Maine. Now that larger vessels are engaged in shrimping there is a strong likelihood that smaller shrimp are caught, some of which are landed. Other changes in fishing practices, such as the use of smaller mesh nets, smaller cull size, year-round fishing, could result in the catching and utilization of smaller shrimp.

VESSELS

Vessels currently engaged in the Gulf of Maine shrimp fishery include a rather wide variety of styles and sizes. Inasmuch as the fishery started as a small off-season enterprise, it is to be expected that the vessels used would be those used in other fisheries. Most vessels engaged in this fishery during its developmental stages (and still in use) were lobster boats. Characteristically, the Maine lobster boat is a wooden vessel in the 30-40 foot length class having the wheelhouse approximately amidship and an open cockpit aft. Modifications of these boats for shrimping were, in some cases, very modest. Minimal changes required the use of the pot-

Table 2.—Annual estimates of catch per unit effort based on shrimp landings at Portland, Maine, from 1964 through 1968 (from Apollo and Dunton, 1969).

Year	Boats (no.)	Trips (no.)	Total landings (pounds)	Average landings per trip (pounds)
1964	12	189	213,210	1,128
1965	20	419	869,800	2,076
1966	31	652	1,572,600	2,412
1967	33	859	2,426,800	2,825
1968	28	914	3,346,500	3,661

Table 3.—Number of shrimp vessels in New England, listed according to state and size, for years 1964-1970 (from Bruce, 1971).

Year	Maine		Massachusetts		Total
	Large ¹	Small ²	Large	Small	
1964	17	12	2	1	32
1965	18	16	3	1	38
1966	16	13	10	1	40
1967	44	23	21	1	89
1968 ³	—	—	—	—	—
1969	89	134	40	2	265
1970	96	191	46	3	336

¹ Any vessel built primarily for dragging or other fishery than inshore lobstering.

² Lobster boats.

³ An accurate count of the number of vessels for 1968 is not available.

hauler for hauling in the shrimp net. Other lobster boats were more elaborately modified with a winch, gantry or gallows frames, or large boom, etc., for side trawling or stern trawling. An example of a modified lobster boat is shown in Figure 4. Customarily, all small and moderately small vessels make daily excursions to the fishing grounds and return to port in the afternoon with the catch. Only the larger, offshore vessels stay at sea for several days at a time.

Another common type of vessel engaged in shrimping is the small or medium-size trawler (dragger), such as those shown in Figure 5. These are side trawlers that were formerly used in the whiting fishery or for other groundfish species. Commonly they are wooden vessels 50 to 75 feet long and operated by a crew of three or four men. They required virtually no modifications for shrimp fishing.

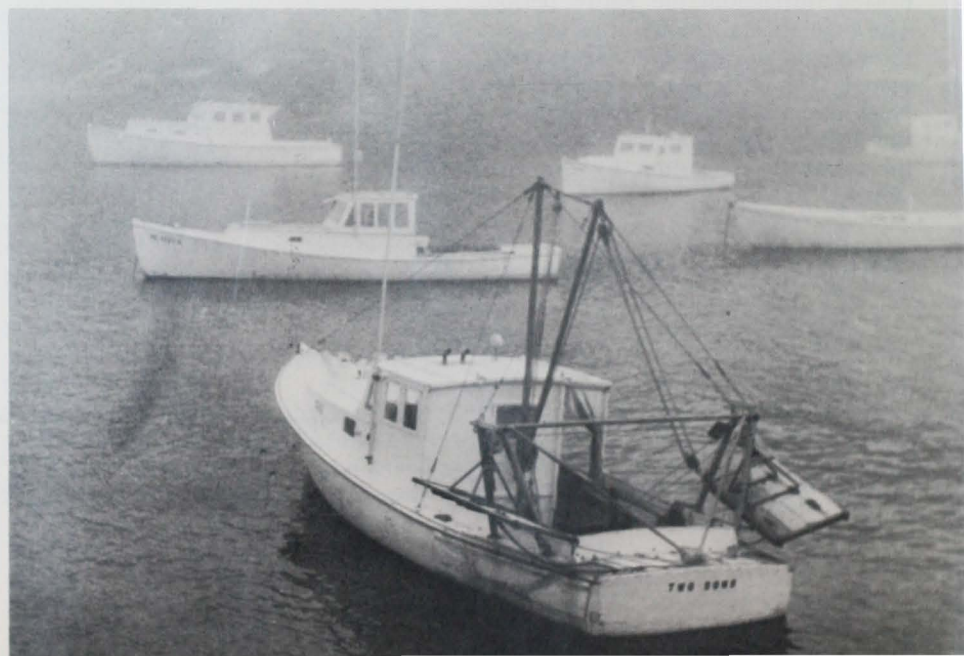
In recent years some specialized vessels have joined the fleet; a few were constructed specifically for Gulf of Maine shrimping. In addition, several Gulf of Mexico shrimp trawlers have been brought to New England. They are characterized by their broad beam, large boom, and a wheelhouse located well forward. One or two Gulf of Mexico shrimpers have retained their outriggers that permit trawling with two nets simultaneously. Some of the newer vessels also have cooking, chilling, or freezing facilities aboard.

For detailed information on shrimp vessels, the reader is referred to the several articles in the publications sponsored by the Federal-Provincial Atlantic Fisheries Committee (1971).

FISHING GEAR

The otter trawl is the standard gear used in the northern shrimp fishery in the Gulf of Maine. Several sizes and styles of trawls are in common usage, depending largely on the vessel size, the experience of the crew with specific nets and their results, type of bottom on the fishing grounds, and other related factors. One of the most commonly used nets is the "50-70 trawl". This is a standard New England 2-seam trawl having a 50-foot headrope and a 70-foot groundrope. Larger or smaller versions of this net are used, but the 20-foot

Figure 4.—Maine lobster boat modified with gallows frames and boom for stern trawling for shrimp. Photograph courtesy of Robert A. Bruce.



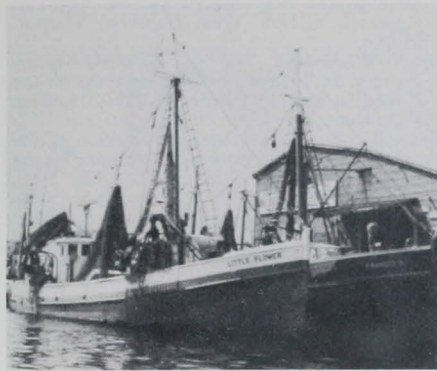


Figure 5.—Typical side trawlers used for shrimping, as well as for fishing whiting and other groundfish, in the western Gulf of Maine. Photography courtesy of Robert Bruce.



Figure 6.—Transferring shrimp from the deck to the storage hold of a medium-size shrimp trawler. Photograph courtesy of Warren J. Rathjen.

difference in headrope-footrope length is usually maintained. Netting is most often made of nylon or polyethylene of 2-inch (stretch measure) in the wings and square, $1\frac{3}{4}$ inch mesh in the cod-end. Rollers on the footrope are employed when fishing rough bottom areas; chain-rigged footropes are used on smooth bottoms. Rectangular otter doors 5-7 feet in length (depending on size of trawl net) and a short ground cable are customarily used.

Small vessels use a rather greater variety of styles of otter trawls. Many are modifications of fish trawls that are on hand, others are specifically designed for shrimp fishing by an individual fisherman for a particular locality or to be accommodated by a particular vessel.

Semi-balloon trawls, used for shrimping in the Gulf of Mexico, have been used. Also, the 4-seam trawl, which has an especially high headrope height, has been used successfully.

Shrimp pots, which are stationary baited traps, are relatively new to the Gulf of Maine region. Those that are being tried have various shapes and sizes, but for simplicity in construction, they are frequently rectangular in shape, have a slot for an entry-way, have an internal weight to serve as an anchor, and are constructed of wire hardware cloth. Pots are baited with fish, such as herring, and set and buoyed individually or in strings (groups). Perhaps the most promising aspect of the pot method of taking shrimp is its use in rocky, untrawlable bottoms.

PROCESSING THE CATCH

Substantial differences in size of vessels in the shrimp fleet and attendant differences in fishing procedures has created a variety of handling and processing procedures aboard ship and in the processing plants ashore. Furthermore, since some dealers and processors prefer cooked shrimp, this has added another dimension to the processing procedure. At present there are four major categories of processed shrimp with a seemingly endless number of combinations. The four categories are:

1. whole or headless
2. cooked or uncooked
3. peeled or unpeeled
4. raw or frozen

Aboard the larger vessels the catch is dumped on a sorting table where finfish, mollusks, other invertebrates, and bottom debris are removed. Generally the catch is fairly clean and does not require a large amount of work obtaining a clearly sorted catch. When the fishery was strictly a winter activity, the low temperature retarded spoilage, which eliminated the need to cook shrimp aboard ship or to pack it in ice for the short time at sea. In more recent years, as the fishing season has extended through the warm season (see Table 4), some vessels have adopted the practice of boiling whole shrimp in a brine solution. Other vessels pack raw, whole shrimp in ice, to be processed (possibly peeled, cooked or frozen) at the facilities in port. Smaller boats store the shrimp on deck without icing, when weather conditions permit.

At other times they pack them in ice in wooden boxes.

Processing firms at the major shrimp ports have automatic cleaning, peeling, cooking, and freezing equipment. Firms that were engaged in processing shrimp in Maine during 1969 are listed in Table 5. For additional information pertaining to shrimp processing and marketing the reader is referred to the reports by Whitaker (1971a and 1971b).

Table 4.—United States annual landings of northern shrimp by months, 1965-1969 (from Whitaker, 1971). (weight in thousands of pounds, whole shrimp).

Month	1965	1966	1967	1968	1969
January	344	360	1,002	1,723	3,694
February	731	1,212	1,647	3,074	6,078
March	905	2,019	3,161	5,074	9,120
April	50	60	571	1,855	2,621
May	—	—	7	103	67
June	—	—	—	—	209
July	—	—	—	—	155
August	—	—	—	36	113
September	—	—	—	102	341
October	—	—	—	303	491
November	—	2	65	563	400
December	45	179	472	1,532	946

Table 5.—List of shrimp processing companies that were operating in Maine in 1969 (from Whitaker 1971).

Bath Canning—Prospect Harbor—Raw meats, raw headless
Belfast Canning Co.—Prospect Harbor—Raw meats
Windjammer Sea Farming Corp.—Eastport—Peeled, raw (canned natural)
A. M. Look Canning Co.—East Machias—Dip (canned, and natural)
Three Rivers Fish Co.—Jonesport—Raw meats
Brown Fish Company—Portland—Raw meats
Central Wharf Fisheries, Inc.—Portland—Raw meats
Eastern Fish Company—Portland—Raw meats
Mid-Central Fish Company—Portland—Raw meats, raw headless
Stinson Canning Co.—Prospect Harbor—Raw meats
F. J. O'Hara and Sons, Inc.—Rockland—Raw meats, raw headless
Royal River Packing Co.—Yarmouth—Raw meats, raw headless
Scandia Seafood Company, Inc.—Bailey Island—Cooked whole
Malpeque Shrimp, Ltd.—Boothbay Harbor—Cooked whole
Maine Biological Supply & Development Corp.—Brunswick—Raw meats
Maine Lobster Company—Portland—Raw meats
Maine Crabmeat Company—Portland—Raw meats
Gulf of Maine, Inc.—Portland—Raw meats, breaded
Paul Bayley Seafoods Company—Scarboro—Raw meats, raw headless
Port Lobster Company—Kennebunkport—Raw meats
Rockland Shrimp Corp.—Rockland—Cooked whole
Mill Cove Lobster Co. (No. 2)—Southport—Cooked whole
Atwood Brothers, Inc.—St. George—Cooked headless, raw meats
Mill Cove Lobster Co. (No. 1)—Trevett—Raw meats

RECENT TRENDS IN THE FISHERY

Some of the more important trends in the northern shrimp fishery in the Gulf of Maine pertain to the fleet and to the shrimp catch. In regard to the fleet, the trend is toward larger vessels, especially designed and equipped for shrimping. Shrimp vessels capable of operating farther offshore and during the warmer seasons of the year are becoming particularly more numerous in the fleet operating out of Gloucester, Massachusetts.

Total landings, as shown in Table 1 and Figure 3, are leveling out at roughly 24 million pounds per year. Correspondingly, the value of shrimp landings is

also leveling out, at \$4.5 million annually. Less well documented are decreases in catch per unit effort and an equally discouraging decrease in the size of shrimp landed.

Although the bulk of each year's landings is caught during the later winter and early spring, there is a trend of increased fishing during the warm seasons of the year (Table 4).

Assuming the future demand for shrimp remains high, it can be anticipated that small shrimp will make up a larger proportion of the catch.

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Gulf Estuaries Studied

The great shrimp nursery grounds in the estuaries of the Gulf of Mexico are being described in unprecedented detail in a series of publications issued at the recommendation of the Gulf States Marine Fisheries Commission. The most recent such publication to appear is "Cooperative Gulf of Mexico Estuarine Inventory and Study, Florida: Phase I, Area Description," by J. Kneeland McNulty, William N. Lindall, Jr., and James E. Sykes. All, at the time the report was prepared, were members of the NMFS Gulf Coastal Fisheries Center Biological Laboratory, St. Petersburg Beach, Fla.

The object of the study was to develop realistic comparable appraisals of estuarine resources along the entire coast. "The planners envisioned a broad study that would include physical descriptions of the estuarine basins and waters within them plus comprehensive

biological studies of plant and animal life. Funding was provided through the Commercial Fisheries Research and Development Act (Public Law 88-309, as amended) with which studies in Alabama, Mississippi, and Louisiana were financed in part." The St. Petersburg Laboratory and the Gulf Coastal Fisheries Center, Galveston, Tex., took on the preparation of the parts of the study dealing with the west coast of Florida and the Texas coast.

Published as NOAA Technical Report NMFS CIRC-368, the Florida study deals with the vegetation of the coast, its geology, stream discharge, water temperature, salinity, oysters and clams, and artificial fishing reefs. Figures and charts trace the rise in population in the area during the past decades, its economic development, and the amounts of pollution and dredging.

Florida's Gulf coast estuaries cover

just over 3 million acres: half unvegetated, and half occupied by mangroves, tidal marshes and submerged vegetation. These estuaries are drowned river valleys, resulting from melting polar ice caps during the current interglacial stage.

The hydrology of the estuaries is discussed from three aspects: stream discharge, water temperature and salinity. The impact of these on commercially important oysters and clams is discussed also.

The economic development of Florida's Gulf coast has resulted in increased human population near its estuaries along with its attendant problems: artificial fishing reefs, pollution and dredging. Although dredging has come under legislative control, pollution legislation has been only partially effective and much remains to be done in this area to preserve the estuarine environment.

The report carries extensive figures and tables. The entire coast is covered by a series of detailed maps (see Figure 1).

NOAA Technical Report NMFS CIRC-368, which consists of 126 pages, is available from the Superintendent of