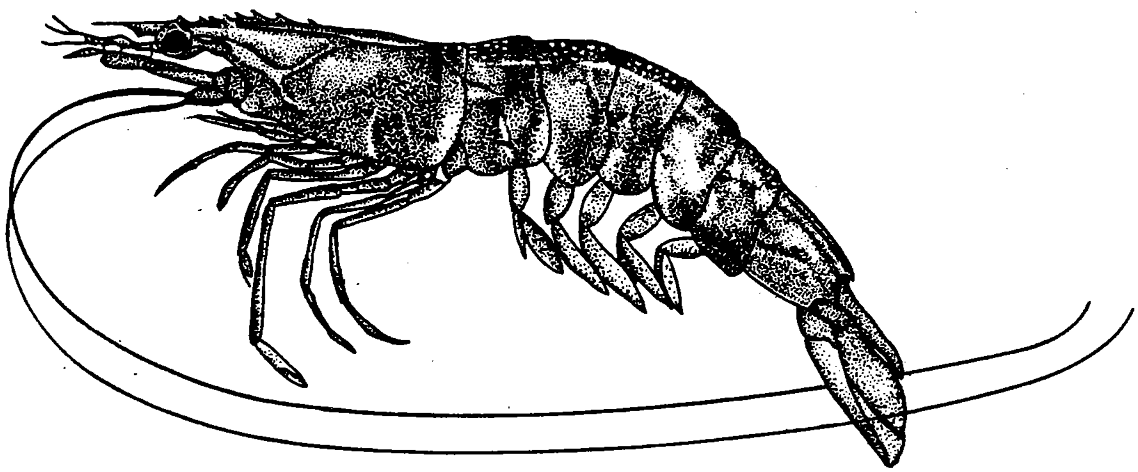
FISHERY MANAGEMENT PLAN FOR THE SHRIMP FISHERY OF THE GULF OF MEXICO, UNITED STATES WATERS



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GULF OF MEXICO FISHERY MANAGEMENT COUNCIL
TAMPA, FLORIDA

DRAFT UPDATE

OF

FISHERY MANAGEMENT PLAN

FOR

SHRIMP

GULF OF MEXICO

NOVEMBER, 1981

THE GULF OF MEXICO FISHERY MANAGEMENT COUNCIL
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2.0 INTRODUCTION

The Magnuson Fishery Conservation and Management Act (Public Law 94-265) provides for exclusive United States management authority over the fishery resources within a fishery conservation zone extending from the seaward boundary to the United States territorial sea (three nautical miles for the Gulf of Mexico states of Louisiana, Mississippi, and Alabama and nine nautical miles for Texas and the west and northwest coasts of Florida) to a point 200 miles from shore. Responsibility for developing a shrimp fishery management plan for the Gulf of Mexico is vested in the Gulf of Mexico Fishery Management Council; and implementation and enforcement of any regulations pertinent to the management of fisheries within the fishery conservation zone are the responsibility of the Secretary of Commerce and Secretary of the Department wherein the U.S. Coast Guard is located.

Successful implementation of the plan will require unity of purpose between federal regulations and those of the five Gulf states (Florida, Alabama, Mississippi, Louisiana, and Texas). Authority for implementing state regulations is vested in the Florida Department of Natural Resources, the Alabama Department of Conservation and Natural Resources, the Mississippi Marine Conservation Commission, the Louisiana Wildlife and Fisheries Commission, and the Texas Parks and Wildlife Commission.

The fishery addressed is composed of six species, occurring in the area of jurisdiction of the Gulf of Mexico Fishery Management Council as well as in the territorial seas adjacent thereto and the associated bays, inlets, wetlands, and upland areas as appropriate. Species include brown shrimp (Penaeus aztecus Ives), white shrimp (Penaeus setiferus Linnaeus), pink shrimp (Penaeus duorarum Burkenroad), and royal red shrimp (Hymenopenaeus robustus Smith[1]), plus seabobs (Xiphopeneus kroyeri Heller) and rock shrimp (Sicyonia brevirostris Stimpton), which are incidental bycatch. The management unit is to be equal to the fishery throughout its range; however, federal implementation will occur only in the fishery conservation zone.

Biological aspects of the shrimp species have been reviewed, and the maximum probable catch is estimated at: (see Sec. 4.7.1.1)

Brown shrimp	--	132 million pounds (tails) per year
White shrimp	--	64 million pounds (tails) per year
Pink shrimp	--	20 million pounds (tails) per year
Royal red shrimp	--	0.392 million pounds (tails) per year

Each year's take of brown, white, and pink shrimp will be heavily influenced by water salinity and temperature during critical periods of estuarine shrimp growth. Maximum sustainable yield (MSY) estimates for the seabobs and rock shrimp cannot be made with any authority because they are caught incidentally by fishermen trawling for the other species.

Seabobs and rock shrimp are caught incidental to the three main species of penaeid shrimp. MSY estimates are weakened because of lack of data.

None of the stocks appear to be biologically overfished.

Major concern for future stocks is related to concern for adequate habitat, particularly for the estuarine-dependent brown, white, and pink shrimp, which account for most of the annual shrimp harvest.

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[1] The genus Hymenopenaeus is the same as Pleoticus according to Isabel Farfante.

The effects of shrimping on sea turtles and incidentally caught finfish are considered in the plan.

The fishery is the most valuable and probably the most diverse in the nation. Harvesters include (1) a large commercial fleet fishing the inshore, nearshore Gulf, and open Gulf waters, (2) an undetermined (but large) number of recreational shrimpers mainly fishing the inshore and nearshore Gulf waters, and (3) a substantial number of bait shrimpers mainly fishing the inshore waters. Processed products include frozen, canned, fresh, and breaded shrimp as well as a host of specialty items. Present management regimes differ in the fishery over the allowable size of shrimp at first harvest as size is related to whom can harvest and process the shrimp.

Unfortunately, socioeconomic data are insufficient for this complex fishery to evaluate fully the relative needs of various user groups for shrimp of different sizes. Care has therefore been taken in making recommendations to reduce the waste of current culling practices so that one user group will not be favored over another. No recommendations are made on limiting fishing effort because the resource is not biologically overfished. There is insufficient socioeconomic data to suggest methods or reasons, consistent with MFCMA, to limit entry at this time.

During a period of public review of the Draft Fishery Management Plan and Environmental Impact Statement, 21 public hearings were held and written comments were received by mail. Public comments and responses are contained in the Final Environmental Impact Statement.

The plan is to be reviewed annually so that management measures can be evaluated for their fairness and effectiveness and so that other methods of optimizing yield can be assessed.

Problems in the Fishery (See Section 8.3)

The Council has identified the following problems associated with the fishery and the present management regime and has prepared the plan objectives to address and alleviate them. In a free access fishery, a management regime to maximize protein yield and economic return to the fisherman is of importance.

1) Conflict among user groups as to area and size at which shrimp are to be harvested.

2) Discard of shrimp through the wasteful practice of culling.

3) The continuing decline in the quality and quantity of estuarine and associated inland habitats.

4) Lack of comprehensive, coordinated and easily ascertainable management authorities over shrimp resources throughout their ranges.

5) Conflicts with other fisheries such as the stone crab fishery in southern Florida, the groundfish fishery of the north central Gulf, and the Gulf's reef fish fishery.

6) Incidental capture of sea turtles.

7) Loss of gear and trawling grounds due to man-made underwater obstructions.

8) Partial lack of basic data needed for management.

2.1 Goal and Objectives

GOAL:

To manage the shrimp fishery of the United States waters of the Gulf of Mexico in order to attain the greatest overall benefit to the nation with particular reference to food production and recreational opportunities on the basis of the maximum sustainable yield as modified by relevant economic, social or ecological factors.

OBJECTIVES:

1. Optimize the yield from shrimp recruited to the fishery.

2. Encourage habitat protection measures to prevent undue loss of shrimp habitat.

3. Coordinate the development of shrimp management measures by the GMFMC with shrimp management programs of the several states, where feasible.

4. Promote consistency with the Endangered Species Act and the Marine Mammal Protection Act.

5. Minimize the incidental capture of finfish by shrimpers, when appropriate.

6. Minimize conflicts between shrimp and stone crab fishermen.

7. Minimize adverse effects of underwater obstructions to shrimp trawling.

8. Provide for a statistical reporting system.

2.2 Management Measures Considered and Adopted (See Sec. 8.5.1.1)

In order to obtain the above objectives, the Council has adopted the following management measures:

Measure 1: Establish a cooperative permanent closure with the State of Florida and the U.S. Department of Commerce of the area delineated in Table 8.3-1 to protect small pink shrimp until they have generally reached a size range larger than 69 tails to the pound.

Measure 2: Establish a cooperative closure of the territorial sea of Texas and the adjacent U.S. FCZ with the State of Texas and the U.S. Department of Commerce during the time when a substantial portion of the brown shrimp in these waters weigh less than a count of 65 tails to the pound (39 heads-on shrimp to the pound).

Measure 3: Recommend that all Gulf states consider establishing shrimp management sanctuaries in important segments of nursery grounds under their sole jurisdiction.

Measure 4: The Gulf of Mexico Fishery Management Council has established an internal committee to review and assess the status of Gulf fishery habitats, with particular attention to those factors which might further stimulate "the downward trends in quality and quantity of fish habitats." (Atlantic States Marine Fisheries Commission, et al., 1977.)

Measure 5: The Gulf states are encouraged to adopt flexible management procedures which would provide regulation by administrative agencies of the shrimp resources in inland waters and territorial seas.

Measure 6: The Gulf states are encouraged to adopt reciprocal internal management decisions flexible enough to allow joint management of shrimp with other states and with the Department of Commerce.

Measure 7: Develop and implement an educational program to inform shrimpers of the current status of sea turtle populations and of proper methods of resuscitation and return to sea of incidentally captured sea turtles.

Measure 8: Encourage research on and development of shrimping gear in order to reduce the incidental catch without decreasing the overall efficiency of shrimping or excessively increasing the cost of gear.

Measure 9: Consistent with the Stone Crab Management Plan, establish a seasonal closure of a portion of the Dry Tortugas shrimp grounds in order to avoid gear conflicts with stone crab fishermen.

Measure 10: The Gulf of Mexico Fishery Management Council will attempt to reduce, where feasible, the loss of offshore trawlable bottom by establishing within GMFMC, a committee to monitor and review construction of offshore reefs, with attention to the needs of the reef fish and shrimp user groups.

Measure 11: All statistical reporting requirements will be mandatory.

2.3 Operational Definitions of Terms Used

Acceptable Biological Catch (ABC) is a seasonally determined catch that may differ from MSY for biological reasons. It may be lower or higher than MSY in some years for species with fluctuating recruitment. It may be set lower than MSY in order to rebuild overfished stocks.

Annual Crop is a species which is harvested essentially as a 0-year class (less than one year of age).

Boats are crafts that displace less than five gross tons.

Catch Per Unit of Effort (CPUE) is the total number or weight of fish harvested by a defined unit of fishing effort.

Commercial Shrimpers are shrimpers who sell any portion of their catch.

Culling is the practice of discarding those shrimp caught which are smaller than a size the fisherman wishes to retain.

Determination for Total Allowable Level of Foreign Fishing (TALFF). The foreign allowable catch is determined by deducting the expected domestic annual harvest from the optimum yield.

Detritus is considered as decaying plant material and its associated community of microscopic plants and animals.

Domestic Annual Fishing Capacity (DAFC) is the total potential physical fishing capacity of the fleet, modified by logistic factors. The components of the concept are:

a. An inventory of total potential physical capacity, defined in terms of appropriate vessel and gear characteristics (that is, size, horsepower, hold capacity, gear design, etc.).

b. Logistic factors determining total annual fishing capacity, (that is, variations in vessel and gear performance, trip length between fishing locations and landing points, weather constraints, etc.).

Domestic Annual Processing Capacity (DAPC) is the amount that can be processed if supplies are available.

Equilibrium Yield (EY) is the annual or seasonal harvest that maintains the resource at approximately the same level of abundance (apart from the effects of environmental variation) in succeeding seasons or years.

Estuarine Dependent Species are those organisms that must complete a portion of their life cycle within an estuary.

Expected Domestic Annual Harvest (EDAH) is the total expected catch of the U.S. shrimp fleet.

Fishery Conservation Zone (FCZ) is the area of federal jurisdiction, beginning at the outer limit of the states' territorial seas and extending 200 miles from shore.

Fishing Effort is the total fishing gear in use for a specified period of time.

Fishing Mortality includes all deaths to the exploited populations associated with the harvesting practices.

Growth Overfishing is a level of effort which prevents the exploited population from providing its maximum yield but does not impare the reproductive capacity of the stock.

Incidental Catch refers to the catch of species other than the target species (bycatch).

Inland Waters (inside waters) are areas of state jurisdiction and include all bays and lagoons inland from the baseline from which the territorial sea is measured.

Maximum Economic Efficiency (MEE) is that level of fishing effort at which the value to society of the last unit of shrimp produced is equal to the cost to society of producing that unit.

Maximum Economic Yield (MEY) is the level of harvest from the common property resource that maximizes the stream of generated net incomes over time.

Maximum Sustainable Yield (MSY) is an average over a reasonable length of time of the largest catch which can be taken continuously from a stock, under current environmental conditions.

Natural Mortality includes deaths from all causes except capture by man.

Omnivore is an animal which eats whatever dead or alive animal or plant material is available.

Optimum Yield (OY) with respect to the yield from a fishery, means the amount of fish:

(a) which will provide the greatest overall benefit to the nation, with particular reference to food production and recreational opportunities; and

(b) which is prescribed as such on the basis of the maximum sustainable yield from such fishing, as modified by any relevant economic, social, or ecological factor.

Recreational Shrimpers are shrimpers who do not sell their catch.

Recruitment Overfishing is used to denote that level of fishing effort which reduces the spawning stock size to the point where there is a reduction in the amount of young recruited to the fishery.

Spawner-Recruit Relationship is the quantifiable relationship between the number of reproducing adults and the resulting number of young recruited to the fishery.

Stock is a group of fish manageable as a unit.

Target Species are the species at which the fishery is directed.

Territorial Sea is the area of state jurisdiction extending from the baseline to three nautical miles seaward for Alabama, Mississippi, and Louisiana, and to nine nautical miles for Texas and the Florida west and northwest coasts.

Total Allowable Level of Foreign Fishing (TALFF) is any surplus in the optimum yield above the expected domestic annual harvest.

Unit Fishing Effort is a measure of harvesting pressure which has been adjusted to account for differences in the ability of boats and vessels of different types to harvest the resource.

Vessels are crafts with displacement greater than or equal to five gross tons.

Year-class is the fish spawned in a given year.

Yield is the amount of a species harvested by man.

3.0 DESCRIPTION OF FISHERY

3.1 Area and Stocks Involved

The fishery being addressed is comprised of the species listed below and occurs in the area of jurisdiction of the Gulf of Mexico Fishery Management Council as well as in the area of jurisdiction of the various Gulf states including their territorial seas, associated bays, inlets, wetlands, and upland areas as appropriate.

Consideration of this large area is necessary because of the migratory natures of the exploited species and fishermen, the critical role of estuaries in the life cycles of the dominant shrimp species, and the impacts upland alterations may have on the quality of shrimp habitat.

Shrimp species within the fishery are:

Brown shrimp (*Penaeus aztecus* Ives)
White shrimp (*Penaeus setiferus* Linnaeus)
Pink shrimp (*Penaeus duorarum* Burkenroad)
Royal red shrimp (*Hymenopenaeus robustus* Smith)
Seabobs (*Xiphopeneus kroyeri* Heller) INCIDENTAL BYCATCH
Rock shrimp (*Sicyonia brevirostris* Stimpton) INCIDENTAL BYCATCH

In addition to these shrimp species, shrimpers also catch sea turtles and other shellfish and finfish. The sea turtle catch is of concern to the development of this plan because all the sea turtles which occur in the Gulf are listed as either endangered or threatened under the U.S. Endangered Species Act which prohibits capture of endangered species. Though primary responsibility for protection of these sea turtle species lies with the National Marine Fisheries Service and the U.S. Fish and Wildlife Service, the plan contains appropriate suggestions to minimize the impact on sea turtle populations. The incidental catch of other shellfish and finfish is also of concern because much of this catch is discarded at sea. Since much of the discarded catch is dead or dies as a result of being caught, this operation largely represents a direct conversion of national resources into food for scavengers. Many of these resources can be used by other national interests. Primary responsibility for managing these resources lies with the GMFMC, NMFS, and the Gulf states. Management plans are currently being prepared by GMFMC for two major bycatch groups--groundfish and reef fish--in which appropriate measures are suggested to reduce this bycatch. In addition, the groundfish management plan contains a thorough treatment of current efforts to develop markets for these discarded species.

Brown shrimp range along the north Atlantic and Gulf of Mexico coasts from Martha's Vineyard, Massachusetts, to the northwestern coast of Yucatan. The range is not continuous but is marked by an apparent absence of brown shrimp along Florida's west coast between the Sanibel and the Apalachicola shrimping grounds (Perez Farfante, 1969). In the U.S. Gulf of Mexico, catches are high along the Texas, Louisiana, and Mississippi coasts.

Mark-recapture experiments indicate a mixing of brown shrimp populations along the north central and northwestern Gulf coast. A southward drift of brown shrimp off the Texas coast towards Mexico has been proposed (Gunter, 1962). There is some speculation that the Mississippi River may act as a barrier to east-west migration.

Brown shrimp are caught out to at least 50 fathoms, though most come from less than 30 fathoms. The season begins in May, peaks in June and July, and gradually declines to an April low.

White shrimp range along the Atlantic coast from Fire Island, New York, to Saint Lucie Inlet, Florida, and along the Gulf coast from the mouth of the Ochlachonee River, Florida, to Campeche. In the Gulf there are two centers of abundance: one along the Louisiana coast and one in the Campeche area (Perez Farfante, 1969).

There appears to be a general mixing of white shrimp west of the Mississippi River to at least the northeast coast of Mexico, with an observed northward migration along the Mexico-Texas shore to at least Aransas Pass, Texas, during the spring (Lindner and Anderson, 1956). A reciprocal southward movement in the fall and winter has been proposed (Gunter, 1962). It has been suggested that again the Mississippi River may act as a barrier in east-west migration (Lindner and Anderson, 1956; Perez Farfante, 1969).

White shrimp are a comparatively shallow-water shrimp, with most of the catch coming from less than 15 fathoms. Annual catch has two peaks: the major one in late summer-early fall, with an October high; the minor one is the "Easter fishery" on over-wintered shrimp which peaks in May. Largest U.S. catches occur west of the Mississippi River to the Freeport, Texas, area, though catch is considerable along the entire north central and western Gulf.

Pink shrimp range along the Atlantic from lower Chesapeake Bay south to around the Florida Keys and up and around the Gulf coast to Isla Mujeres, Mexico. They are also found in the Bermuda Islands and the northern coast of Yucatan. Major concentrations are off southwest Florida and in the southeastern part of Golfo de Campeche (Perez Farfante, 1969).

The two major pink shrimp grounds in the United States are the Tortugas and Sanibel grounds in southwestern Florida. There is little movement of shrimp between these grounds, and they are derived from largely different estuarine areas (Costello and Allen, 1965).

Pink shrimp catch comes mainly from less than 25 fathoms, with a peak catch at 11 to 15 fathoms. Because of continuous recruitment in southeastern Florida, the catch exhibits a broad peak October through May. U.S. catch is mainly restricted to Florida and is greatest in southwestern Florida.

Royal red shrimp are deepwater shrimp occurring as far north as Cape Hatteras, North Carolina, to as far south as the coast of the Guianas, and primarily in depths of 140 to 300 fathoms. Concentrations of royal red are known to exist in three geographical areas: (1) east of St. Augustine, Florida, in the western Atlantic; (2) south-southeast of the Dry Tortugas in the Florida Straits; and (3) southeast of the Mississippi River Delta in the Gulf of Mexico (Roe, 1969).

Seabobs are caught most often in shallow waters at six to seven fathoms or less and almost never in estuaries (Renfro and Cook, 1963). U.S. catch is highest along the Louisiana coast in October through December.

Rock shrimp occur along the Atlantic coast from Virginia to the Florida Keys and up along the Gulf coast to Cabo Catoche, Mexico (Cobb, et al., 1973; Hildebrand, 1954). Major concentrations occur at Cabo Catoche, Mexico, and in the Cape Canaveral, Florida, area (Christmas and Etzold, 1977). Major Gulf catch (1971-1975) comes from the Panhandle area of Florida at depths of 10 to 22 fathoms (Christmas and Etzold, 1977).

3.2 History of Exploitation

3.2.1 Domestic Fishery

3.2.1.1 Description of User Groups

The shrimp fishery of the Gulf can be divided into four general categories of users -- harvesters (directly involved in the taking of shrimp), processors, marketers, and consumers.

The actual taking of shrimp is done by recreational fishermen, commercial bait shrimpers, and commercial (food) shrimpers. The commercial shrimp user category includes employees as well as owners of vessels and may be divided into smaller boat operations, which are restricted to inland bay and shallow offshore activities, and the offshore vessels, which range from the territorial seas out to the limits of the FCZ and into foreign waters.

The structure of the shrimp fishery includes a large number of harvesters, the boatyard and gear industry, and the suppliers of ice and fuel (essential inputs for shrimping operations).

Processors include the shrimper as a first level processor, if he heads the shrimp. Fish houses may perform one or all processing activities such as heading, peeling, grading, packing in ice, and freezing, cooking, or drying. The non-shrimper processors handle the shrimp between the fish house and the purchaser. The three basic types of processors are: (1) producers of "green" (fresh) or frozen shrimp; in 1974 they accounted for 86.25 million pounds valued at $152.6 million, or 59 percent of the total value of shrimp produced in the Gulf that year; (2) "breaders," who in 1974 produced 52.66 million pounds of breaded shrimp (including imports) valued at $75.7 million, or 29 percent of the total value of shrimp processed in the Gulf region (Florida and Texas accounted for 91 percent of the breaded shrimp); (3) canners, who generally use small- to medium-sized shrimp; such canning plants are located primarily in south Louisiana and Mississippi, with the greatest concentration found in the New Orleans area. They accounted for $13.1 million worth of canned shrimp represented by 1.9 million standard cases, or seven percent of the total value of all shrimp processed in the Gulf region. In addition, there is a wide array of specialty items such as dried shrimp, gumbo, etc.

Restaurants are also an important processing entity. It is estimated that more shrimp are consumed in restaurants than used in homes. The role of restaurants as processors ranges from minimal, limited to the actual cooking process, to the handling of shrimp in raw and unpeeled form.

Marketing of shrimp involves every stage of the industry; there also are groups which engage solely in marketing, with their processing function limited to possible repackaging. Transportation of shrimp is usually handled by trucks operated by the wholesale marketing entities.

Consumers are given a choice of several different ways to purchase shrimp, ranging from heads-on to stove-ready status.

3.2.1.2 General Description of Fishery Effort

Prior to the introduction of the otter trawl in 1917, most shrimp were commercially harvested in shallow inshore areas with haul seines. White shrimp were the main shrimp caught and marketed until the early 1950s. Quantities of seabobs and brown shrimp were used for dried products. During these years, fishing efforts were concentrated in areas where white shrimp were abundant. From 1917 to the late 1940s, most shrimp were caught from vessels rigged with single otter trawls which operated within about six miles of shore. However, vessels occasionally went out about ten miles and, in some instances off Louisiana, out fifty miles. Wing or butterfly nets were also used in Louisiana passes. By the early 1950s, increased markets for brown and pink shrimp and the discovery of new fishing grounds initiated a period of rapid expansion of the shrimp industry. As a result, some vessels began to move farther offshore because of the increasing difficulty of making profitable catches on traditional fishing grounds. By the early 1960s, U.S. shrimp vessels were fishing off the coasts of Mexico and South America. A major change in gear methodology took place in the late 1950's with the introduction of double-rig trawling. Two small trawls were pulled instead of a single large net, resulting in a substantial increase in catch efficiency and a reduction of handling problems. Double-rig trawls were used by most vessels fishing for pink and brown shrimp. More recently the twin-trawl has become popular in the offshore Gulf shrimp fleet because of its efficiency (Figure 3.2-11). With this arrangement four small trawls are towed instead of two from a single vessel. The inshore shrimp fishery is primarily confined to the territorial waters of each of the Gulf states. There are numerous small boats rigged with single otter trawls which harvest shrimp commercially from the bays and marshes. Some of the boats may fish in the Gulf during favorable weather conditions, especially for white shrimp.

Fishing efforts for royal red shrimp occur intermittently when shrimping along the coast is poor. Royal red shrimp are harvested from vessels using a single trawl. The deep-water habitat of the species necessitates the use of heavier winches and cables than are used to catch shallow-water shrimp species and, in general, the use of larger vessels.

The live-bait shrimp fishery is generally limited to bays and the shallow inshore waters of the Gulf. Bait shrimp catches on the Florida west coast consist primarily of pink shrimp, which are harvested in shallow grass beds from boats equipped with single or double side-frame trawls. The bait shrimp fishery in the remaining Gulf states is usually dependent upon white and brown shrimp, which are harvested with boats rigged with a single otter trawl. Mortality of the live shrimp is minimized by trawling for short durations during the cooler early morning hours and then rapidly sorting the catch. The limited capacity of live-holding facilities aboard the boat and the perishability of live shrimp probably restrict bait shrimping operations to areas near the dealer where the catch is sold. The dealer in turn, however, may transport live shrimp considerable distances, i.e., 200 or more miles.

Recreational shrimping efforts are generally concentrated in shallow inshore waters, though few individuals may occasionally venture into the territorial sea during favorable weather conditions. It is unlikely, however, that any recreational shrimpers operate in the fishery conservation zone. The boats used in the recreational shrimp fishery are usually outboard or inboard pleasure craft rigged to tow a single otter trawl ranging from about 16 to 40 feet in width. Although most of the recreational catch is harvested with otter trawls, other gear such as cast nets, wing nets, channel nets, and dip nets may account for a substantial amount of the harvest in localized areas.

The actual amount of fishing effort applied in the shrimp fishery and a more descriptive analysis of the gear employed are discussed in detail in several other sections of the management plan. For example, see Sections 3.2.1.4, 3.5.2.1, 3.5.2.4, 3.5.3.2, 4.7 and 5.0. Fishing effort in the shrimp fishery from a physical standpoint increases through more vessels entering the fishery and through more technologically efficient harvesting techniques. More units of effort due these two factors occur due to industry responses to high profit levels and returns on investment. Because of the open access characteristic of the shrimp fishery and some periods of rapidly rising product prices, fishing effort sometimes reaches levels beyond that which yields satisfactory economic returns during certain time periods. The reasons for this occurrence in a fishery and its relation to periodically poor financial years in the shrimp fishery are discussed in detail in Sections 3.5.2.3 and 5.1.2.

3.2.1.3 Catch Trends

Trends in the shrimp fishery discussed here are based on two data sets. The first is the reported commercial catch by species (U.S. Department of Commerce, 1959-1975). The second is the reported commercial landings by state (U.S. Department of Commerce, 1880-1975). These two data sets are not identical. The catch is the amount of shrimp caught in a specific inshore or offshore area. Landings are the total catch, whose origin may not be known, delivered at a port and sold commercially.

3.2.1.3.1 Commercial Catch Trends by Species

Annual Catch Patterns

The average annual reported commercial catch of shrimp ($\pm$ one standard deviation) by species in the U.S. Gulf area:

Brown shrimp [1]	66.5	$\pm$ 16.6	million pounds (tails)
White shrimp [1]	36.9	$\pm$ 7.2	million pounds (tails)
Pink shrimp [1]	13.0	$\pm$ 1.8	million pounds (tails)
Royal Red shrimp *	.83	$\pm$ .091	million pounds (tails)
Seabob shrimp **	1.4	$\pm$ 1.6	million pounds (tails)
Rock shrimp ***	.331	$\pm$ .358	million pounds (tails)

[1] 1963-1977

* 1959-1975

** 1959-1975

*** 1971-1976

The most recent information, 1977, indicates that brown, white and pink shrimp account for 97 percent of the total catch. This reflects essentially no change from the average total catch of 98 percent for the 1959-1975 period.

Shrimpers, processors, consumers, and resource managers recognize the historical annual variation in annual catches of the dominant species (brown, white, pink). The vulnerability of shrimp during the critical estuarine growth phase to environmental pertubations is the basic cause of catch variation (Section 4.1). Griffin and others (1976) calculated a yield function for shrimp using the level of discharge from the Mississippi. Discharge was useful because of its impact on salinity and temperature while the shrimp are in the nursery ground. Two recent incidences of environmentally induced problems with shrimp production resulted in the Small Business Administration (SBA) declaring areas of Louisiana and Texas to have suffered economic disasters. Tropical storms in coastal areas of Texas during 1979 caused heavy rains which SBA found to adversely affect the shrimp catch. Heavy spring rainfalls in Louisiana during 1980 were judged by SBA to have severely impaired brown shrimp catch. Both of these natural events caused unacceptable variation, in the eyes of SBA, in earning potential of small businesses. The variation in catch of the three minor species is more related to the market conditions and the supply of other shrimp than to variation in their abundance. This is particularly evident for seabob shrimp. Primarily a fall-early winter fishery off Louisiana, catch has fallen only once between 1969-1975 compared to the white shrimp fishery decline in catch during five of those years (Fig. 3.2-1 and Fig. 3.2-2).

Catch for a given year appears to be independent of the preceeding year's catch. The absence of any defined spawner-recruit relationship suggests that the shrimp catch can fluctuate widely from year to year. The critical determinant is estuarine environmental conditions which vary annually, often times radically. No apparent or significant linear trends in annual catches of brown, white, or pink shrimp (Fig. 3.2-1 and Table 4.7-1) have yet been determined.

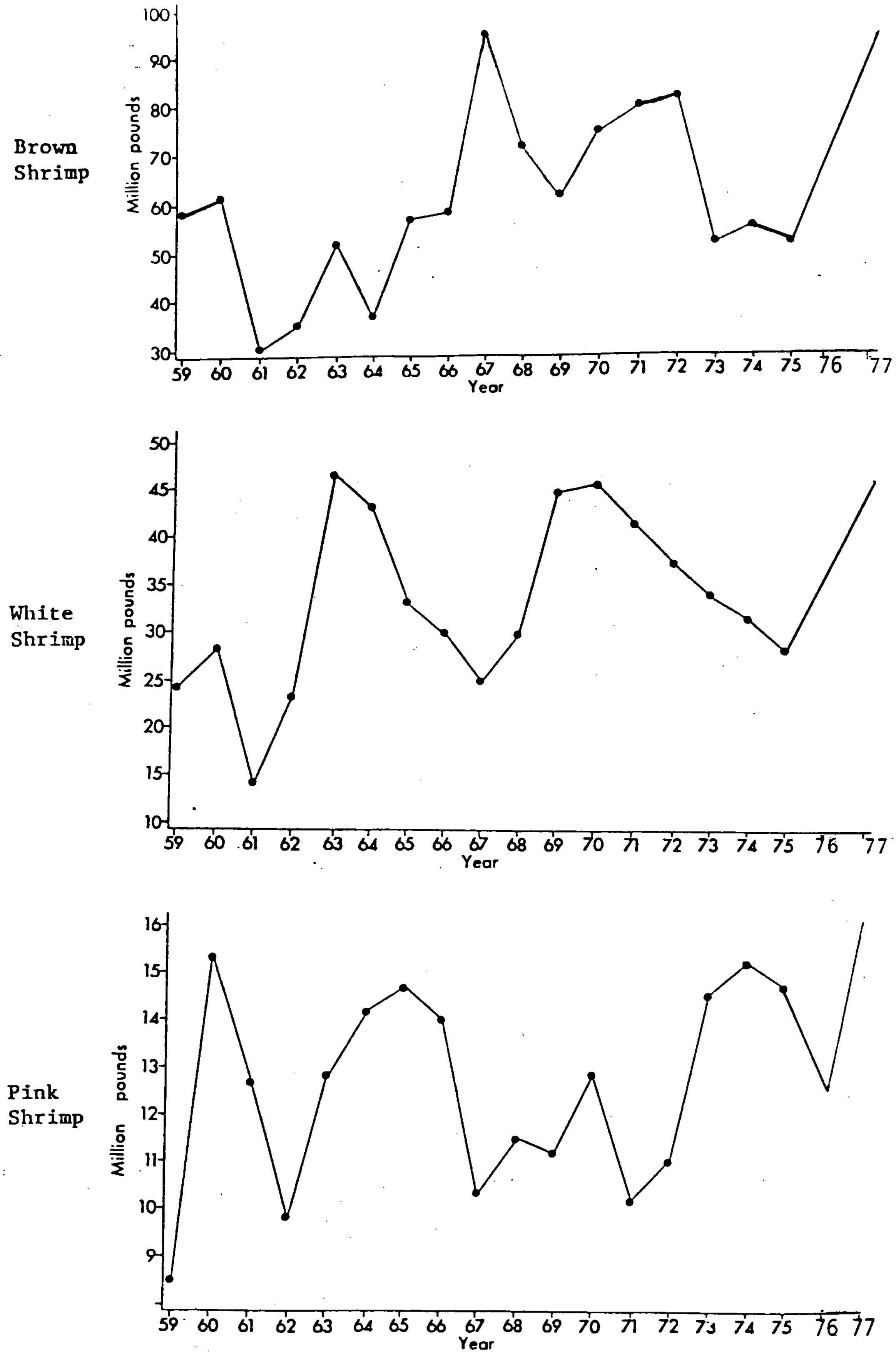
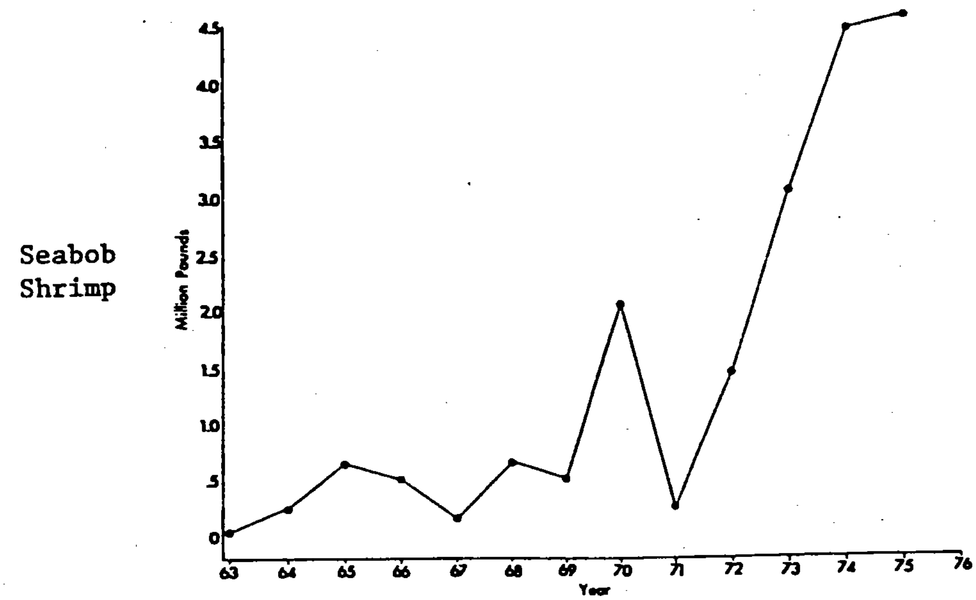


Figure 3.2-1. Annual reported commercial catch of brown, white, and pink shrimp from the US Gulf of Mexico (US Dept. Com., Gulf Coast Shrimp Data, 1959-1977). Weight is in pounds of tails.



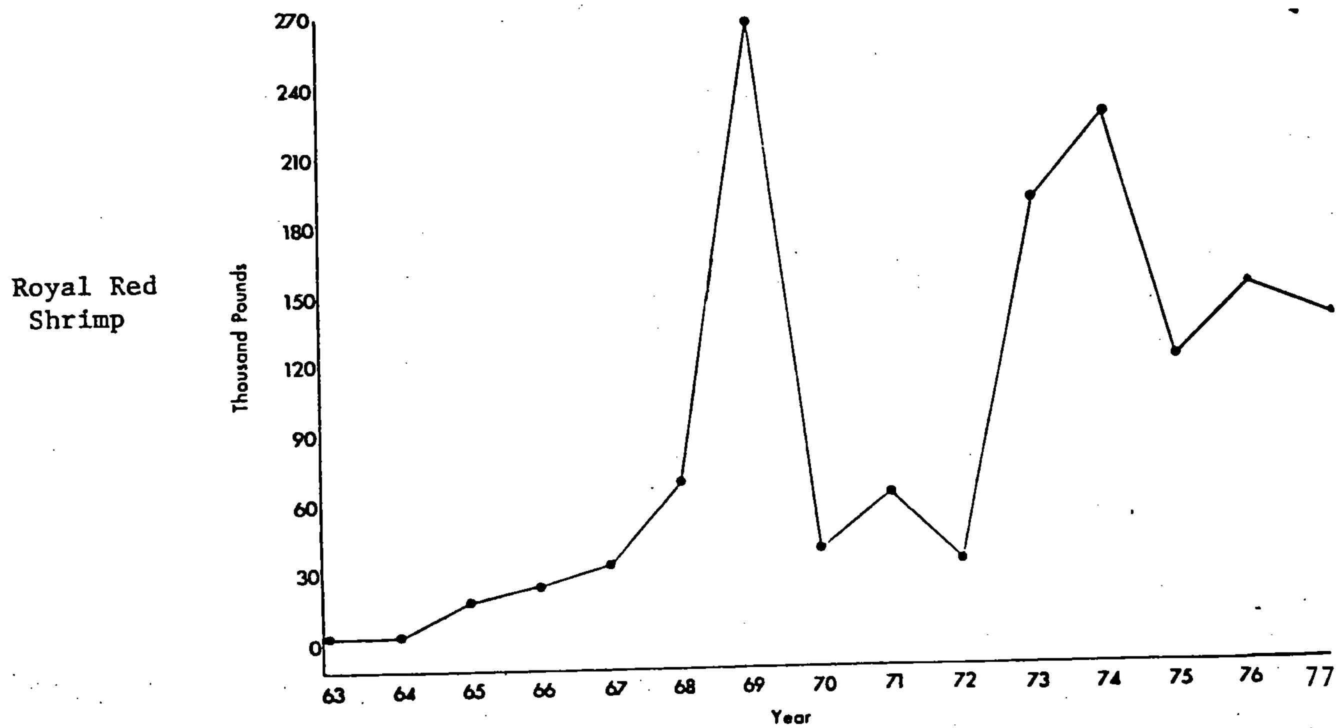


Figure 3.2-2. Annual reported commercial catch of seabob (1963-1975) and royal red shrimp (1963-1977) from the U.S. Gulf of Mexico (U.S. Dept. Com., Gulf Coast Shrimp Data, 1963-1975). Weight is in pounds of tails.

Annual catch of minor species has increased with time (Table 4.7-3). As effort increased to harvest major species, the catch of minor species increased (Table 4.7-1). Annual catch of royal red shrimp ranged between 4,600 and 270,000 pounds of tails with an average increase of 14,000 $\pm$ 5,000 pounds of tails per year (1963-1976).

The acceptability of seabob shrimp in Louisiana by the canning industry was in part responsible for the catch increase over the 1963-1975 period (Fig. 3.2-2). The seabob catch results in part from incidential catch during white shrimping activities (Table 4.7-5), though a targeted fishery develops when price is high and other shrimp are in short supply (P. Juneau, personal communication, 1978).

The reported catch of rock shrimp is relatively recent, with the first report occurring in 1971. Catch for the 1971-76 period is listed in Table 4.7-3. Rock shrimp are mostly caught incidentally with other species, especially pink shrimp (Table 4.7-9), however, a small directed fishery does exist.

Area Distribution of the Catch

The reported commercial catch of shrimp is classified by NMFS into 21 areas along the U.S. Gulf coast (Fig. 3.2-3).

The average annual commercial catch by area is compared for brown, white, and pink shrimp in Fig. 3.2-4 and for royal red, seabob, and rock shrimp in Fig. 3.2-5.

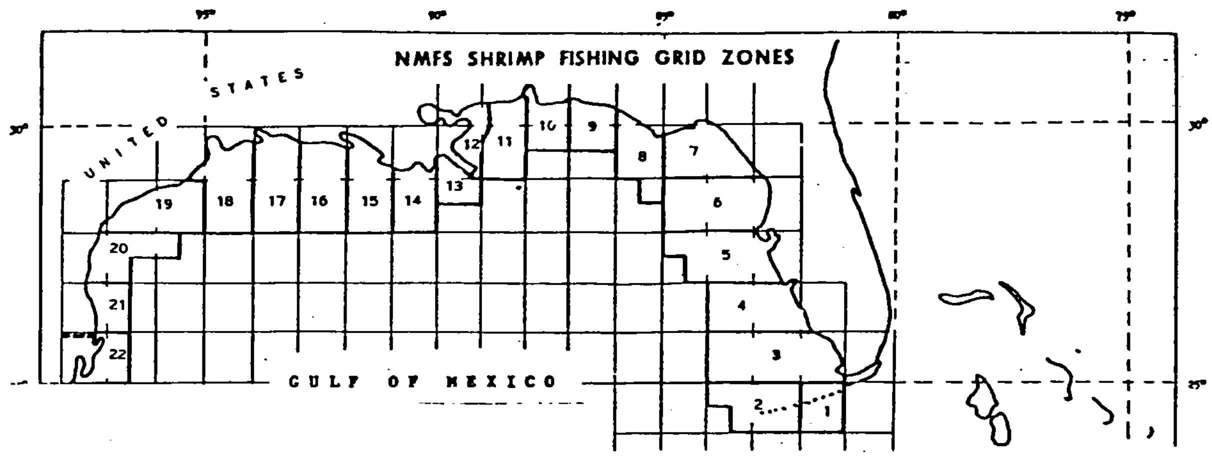
Brown and white shrimp exhibit a similar broad peak in catch from the Apalachee to Brownsville areas. Pink shrimp catch is substantial in the Key West to Apalachee Bay areas. There is little overlap of dominant pink areas with brown or white shrimp.

Brown shrimp catch normally exceeds two million pounds of tails annually in each of the NMFS grid areas in the Biloxi to Brownsville areas. The Freeport area normally has the largest catch, averaging 12 million pounds of tails annually. White shrimp catch normally exceeds four million pounds of tails annually in the Barataria, Terrebonne, and Atchafalaya areas. Catches from the Rockefeller through Freeport areas are also normally high, averaging about 2.5 million pounds of tails annually. Pink shrimp harvest is concentrated in the Dry Tortugas areas with an annual catch of nine million pounds of tails.

There are two main areas for the royal red shrimp catch. One is off the Dry Tortugas areas; the other is off the mouth of the Mississippi River and is reported for the Biloxi and Barataria areas. Catch is highest from January through June and in September and occurs at depths of 100 to 300 fathoms. Seabob catch is normally highest in waters associated with the Louisiana coast, peak catch normally occurring in the Atchafalaya area at 0.5 million pounds annually. Rock shrimp catch (1971 to 1975) is mainly limited to waters associated with Florida. Annual catch is highest in the Panama City and Apalachee areas.

Month, Depth, and Size Patterns in Catch of Brown, White and Pink Shrimp

Brown and white shrimp exhibit distinct annual cycles in their abundance and size at different depths in the shrimping grounds of the U.S. Gulf. Although pink shrimp have an expected size-depth relationship (Section 4.1), their seasonal and size patterns in reported commercial catch are not as dramatic as those of brown and white shrimp; pink shrimp have a more or less continual recruitment in the Dry Tortugas area and Florida has practiced area closures to protect undersized pink shrimp. Pink shrimp catch (Fig. 3.2-8) exhibits a peak from October through May at 11 to 15 fathoms. Seasonal patterns in size or depth of catch are not pronounced because of the fairly continual recruitment of pink shrimp in the Dry Tortugas area and closure of the Tortugas shrimp bed by Florida to protect undersized shrimp.



Area code index to prominant city, bay, or federal game reserve associated with the area:

1. Key West
2. Dry Tortugas
3. Everglades
4. Naples
5. Tampa
6. Tarpon Springs
7. Apalachee
8. Panama City
9. Fort Walton
10. Mobile
11. Biloxi
12. Chandeleur
13. Barataria
14. Terrebonne
15. Atchafalaya
16. Rockerfeller
17. Calcasieu
18. Galveston
19. Freeport
20. Corpus Christi
21. Brownsville

Figure 3.2-3. National Marine Fishery Service Shrimp Fishery Grid Zones in the US Gulf of Mexico (US Department of Commerce, Gulf Coast Shrimp Data, 1959-1975).

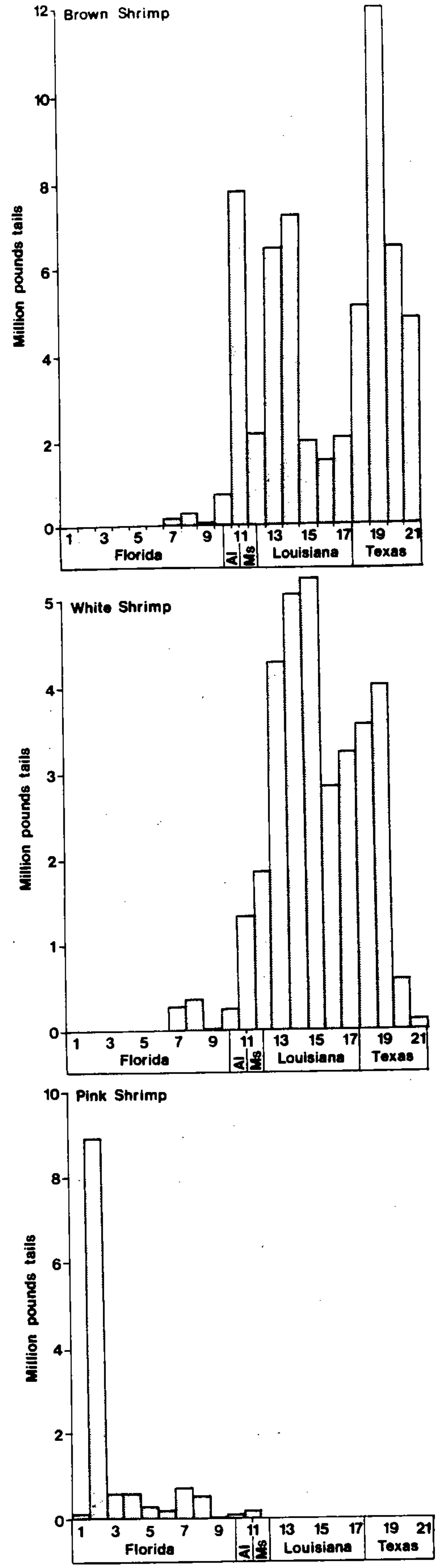


Figure 3.2-4. Average reported commercial catch of brown, white, and pink shrimp along the US Gulf Coast (US Dept. Com., Gulf Coast Shrimp Data, 1959-1975). Catch is represented as averages reported for the 21 NMFS statistical reporting zones along the US Gulf Coast (Fig. 3.2-3).

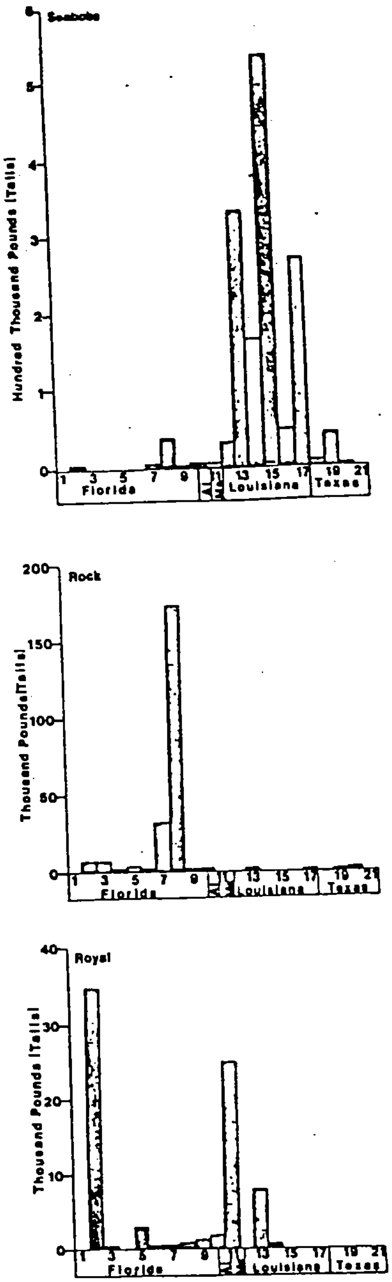


Figure 3.2-5. Average reported commercial catch of seabob (1963-1975), rock (1971-1975), and royal red shrimp (1963-1975) along the US Gulf Coast (US Dept. Com., Gulf Coast Shrimp Data, 1963-1975). Averages are for the 21 NMFS statistical reporting zones (Fig. 3.2-3).

As shown in Fig. 3.2-6, the fishery on 0-year class brown shrimp normally starts in inland waters in May on shrimp of a count greater than 67 tails to the pound. The inshore catch peaks in June at an average catch of 6.6 million pounds of tails. Although it consists mainly of smaller size shrimp, this inshore catch is popular among recreational and small boat commercial shrimpers whose gear does not normally allow them to fish the open waters of the Gulf.

The offshore fishery for brown shrimp peaks in July and August at depths of 11 to 20 fathoms. The dominant size class in the reported commercial catch is 31 to 40 tails to the pound. The actual average size shrimp caught may be much smaller since a considerable number of undersized shrimp are discarded off the Texas coast (Baxter, 1973; Sections 4.7 and 8.3) and the primary brown shrimp catch during this time also occurs off the Texas coast.

The September brown shrimp catch is dominated by 26 to 30 tails-to-the-pound shrimp at 16 to 20 fathoms. The catch becomes further restricted to deeper waters and larger shrimp in October to December. The January to April pattern is relatively constant, with greatest catch in open Gulf waters of 21 to 40 fathoms and of shrimp of a count less than 21 tails to the pound.

The size-depth-month patterns in white shrimp catch are not as simple as those of brown shrimp, but they do reflect the annual nature of the white shrimp's life cycle. The fishery on the 0-year class white shrimp, spawned in the spring and summer, essentially begins in August and September (Fig. 3.2-7). The white shrimp catch in internal waters contains much larger size shrimp than does the brown shrimp catch. This size difference reflects the rapid growth rate of white shrimp and their tendency to leave the estuaries at a larger size than brown shrimp. Catch remains comparatively high from August to November, though it is essentially limited to water shoreward of 11 fathoms. The comparative increase in shrimp catch in the 68 tails and over count group in October through December reflects a decline in the growth rate of white shrimp as well as a migration of shrimp to deeper waters. Both of these phenomena are associated with cold fronts advancing during these months and the accompanying decline in temperature.

Catch declines from December through February. The decline reflects, in part, adverse weather conditions for shrimping but also the dwindling supplies and comparatively small size of white shrimp during this period.

In March through June with the spring warming of the estuaries and shallow Gulf, the overwintered white shrimp are believed to exhibit an increase in their growth rates. This increase is reflected in the commercial catch: peak size classes of white shrimp shift from those greater than 67 tails to the pound to 31 to 40 tails to the pound in March, to shrimp 15 to 20 tails to the pound in June and July. The May and June inshore catch of white shrimp reflects the reentry of overwintering white shrimp into the estuaries for a period of pre-spawning growth.

Catch by Size, State, and Species for Brown, White and Pink Shrimp

Different harvesting strategies have developed among the several Gulf states. These differences largely relate to the evolution of the dominant fisheries at different times (Section 3.2.1.2). The Louisiana-Mississippi fishery developed comparatively early on inshore and nearshore Gulf concentrations of white, brown, and seabob shrimp. The brown shrimp fishery in Texas and the pink shrimp fishery in Florida developed in the 1950s on offshore concentrations of shrimp in comparatively deep water. In large part local management still reflects the needs of the historical fisheries in these areas for shrimp of certain sizes or of their gear restrictions limiting the depth of harvest.

Tables 3.2-1 and 3.2-2 compare estimates of the average commercial (1963 to 1976) catch of brown, white, and pink shrimp in the various reported size categories in terms of pounds and estimated number (see Table 3.2-2 for method in which number of shrimp were estimated).

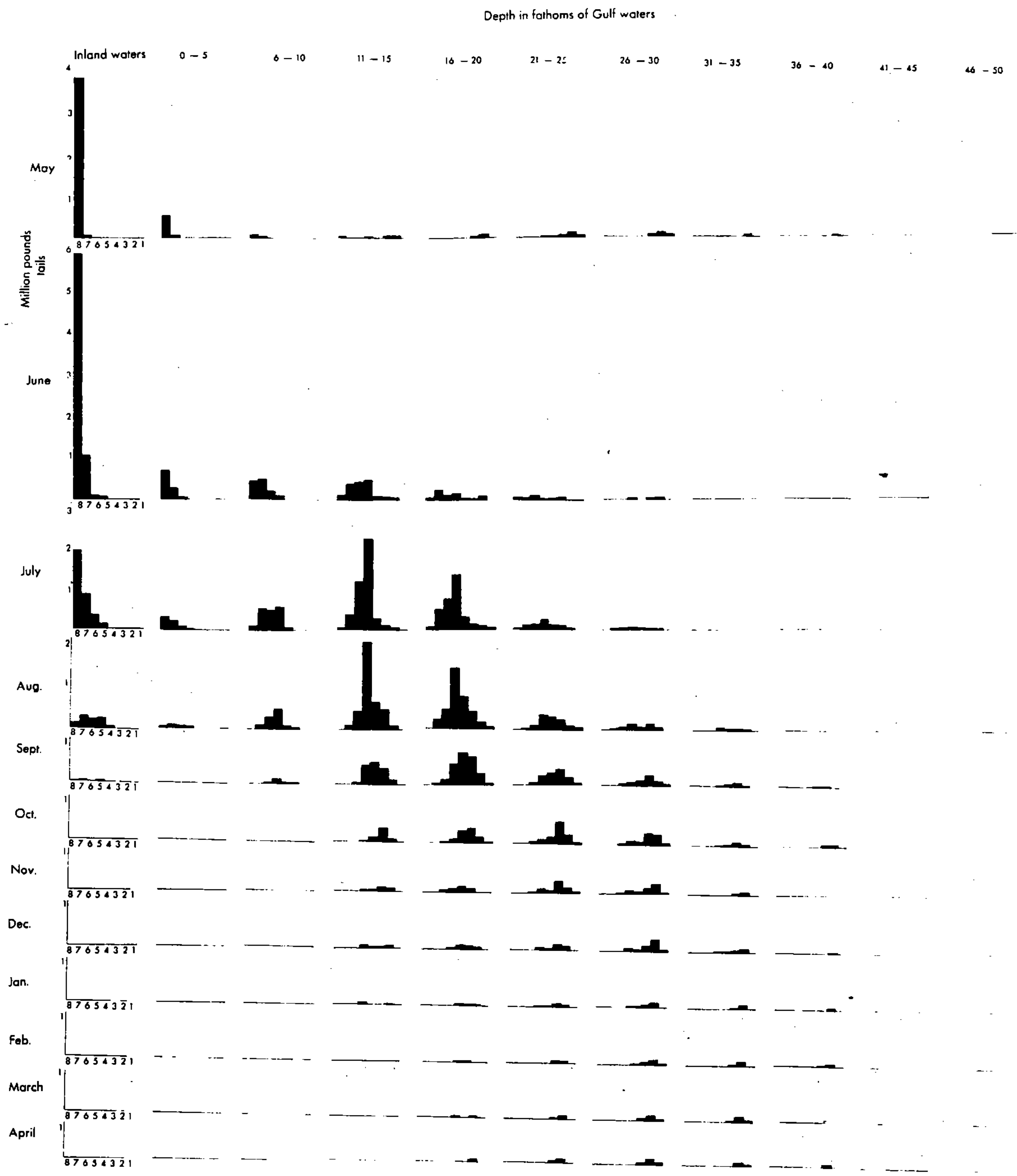


Figure 3.2-6. Brown shrimp average catch in the US Gulf by size, class, depth, month (US Dept. Com., Gulf Coast Shrimp Data, 1959-1975). Code to size of shrimp: 1 = under 15 tails per pound; 2 = 15-20 tails per pound; 3 = 21-25 tails per pound; 4 = 26-30 tails per pound; 5 = 31-40 tails per pound; 6 = 41-50 tails per pound; 7 = 51-67 tails per pound; 8 = 68 and over tails per pound.

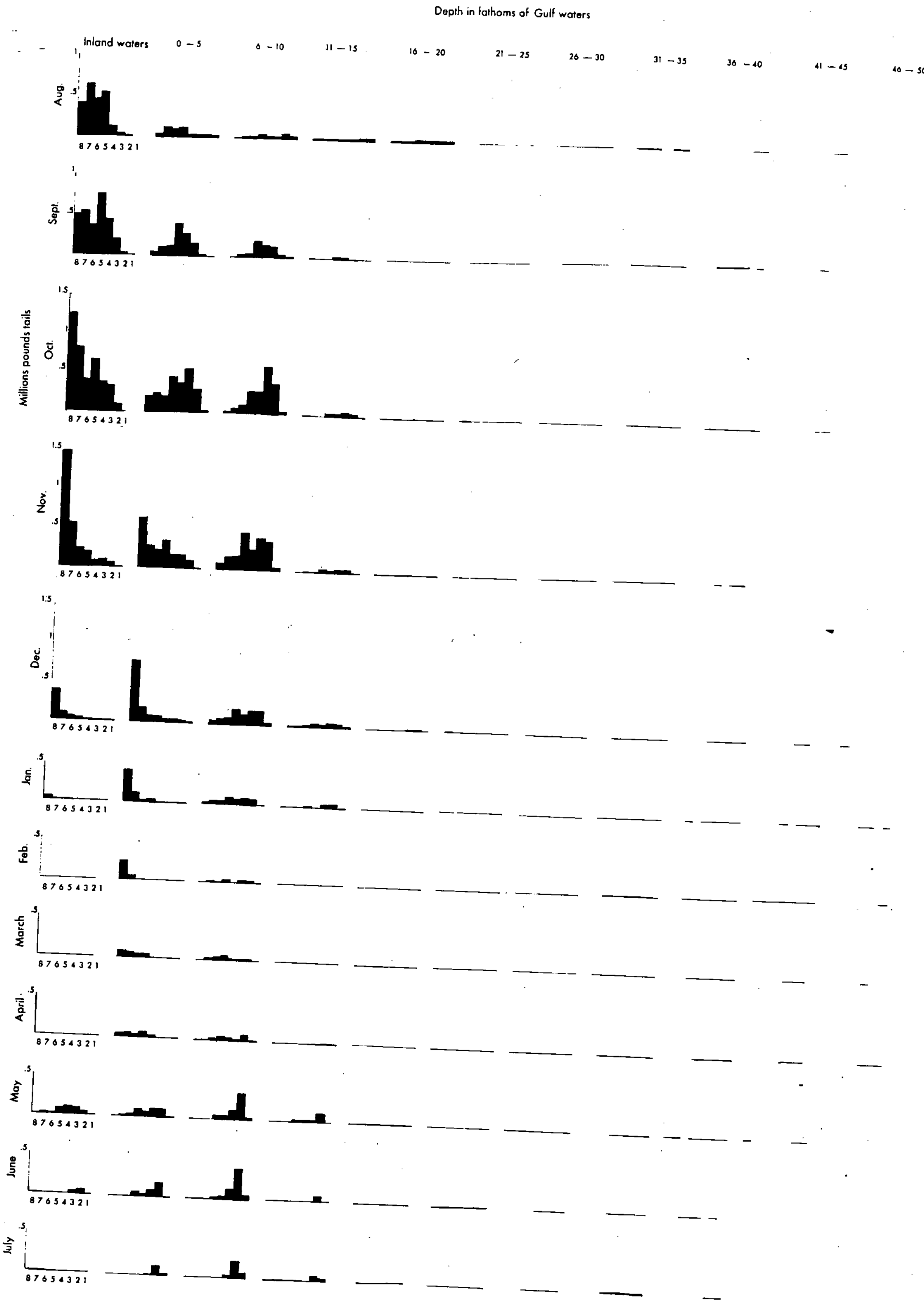


Figure 3.2-7. White shrimp average catch in the US Gulf by size, class, depth, month (US Dept. Com., Gulf Coast Shrimp Data, 1959-1975). Code to size of shrimp: 1 = under 15 tails per pound; 2 = 15-20 tails per pound; 3 = 21-25 tails per pound; 4 = 26-30 tails per pound; 5 = 31-40 tails per pound; 6 = 41-50 tails per pound; 7 = 51-67 tails per pound; 8 = 68 and over tail

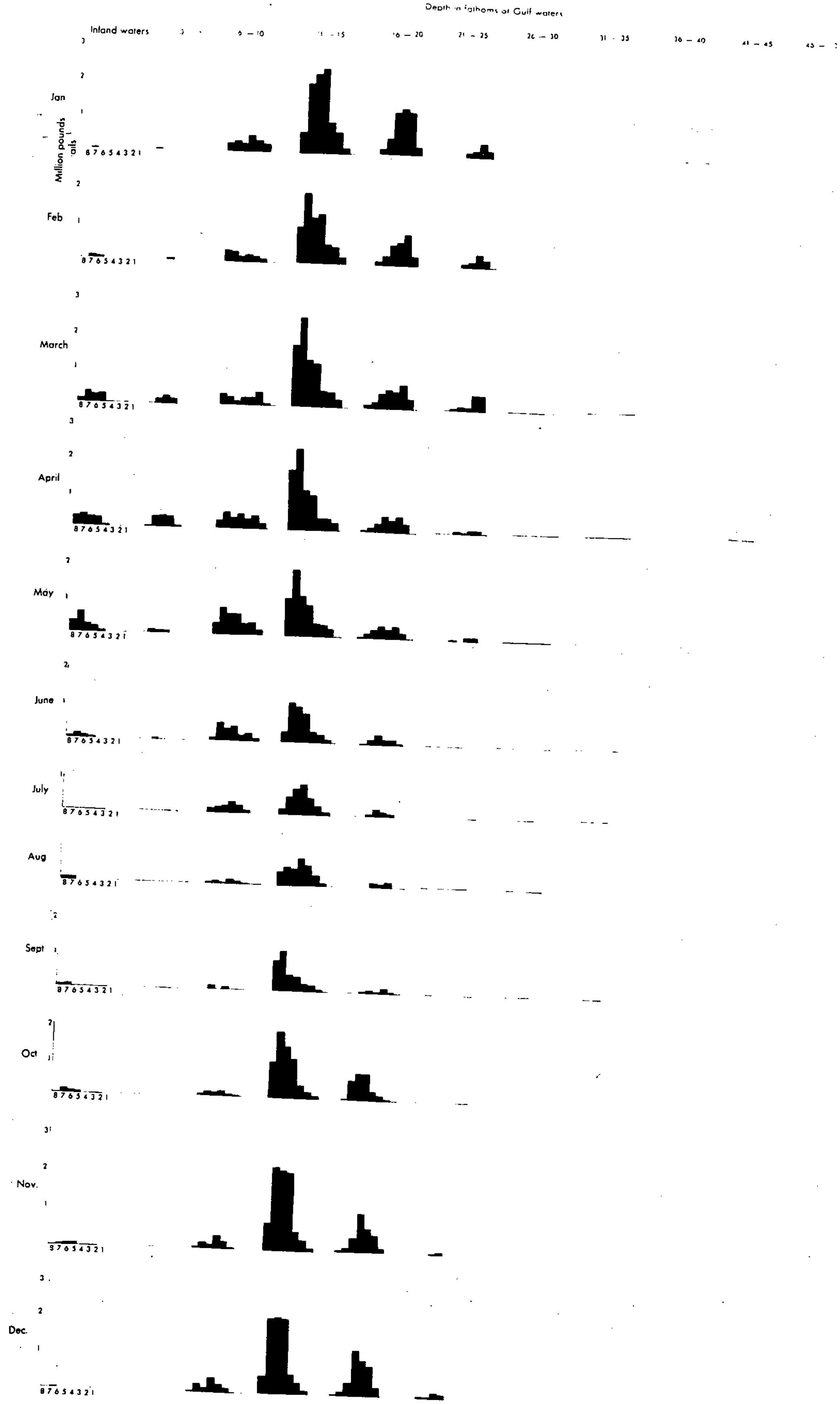


Figure 3.2-8. Pink shrimp average catch in the US Gulf by size class, depth, month (US Dept. Com., Gulf Coast Shrimp Data, 1959-1975). Code to size of shrimp: 1 = under 15 tails per pound; 2 = 15-20 tails per pound; 3 = 21-25 tails per pound; 4 = 26-30 tails per pound; 5 = 31-40 tails per pound; 6 = 41-50 tails per pound; 7 = 51-67 tails per pound; 8 = 68 and over tails per pound.

Catch from the states of Mississippi and Alabama were combined due to similarities in the minimum size of harvest and overlapping areas in the reported catch statistics.

The brown shrimp catch off the Texas coast accounts for 46 percent of the total poundage and 25 percent of the number of brown shrimp caught commercially in the U.S. Gulf of Mexico. The catch associated with Louisiana accounts for 40 percent of the poundage but 64 percent of the number of commercially caught brown shrimp. The apparent discrepancy lies in the fact that Louisiana is estimated to harvest a tremendous number of shrimp in the smallest commercial size category, some 54 percent of average total catch of brown shrimp in the Gulf. Much of these shrimp are utilized in the Louisiana canning industry. Conversely, the reported catch of brown shrimp off Texas, peaks at a larger size, 31 to 40 tails to the pound of shrimp. There are no shrimp canneries in Texas and much of this product is utilized by the fresh-frozen industry. The introduction of several peeling machines has recently allowed utilization of smaller shrimp, however. The Mississippi-Alabama and Florida catches of brown shrimp exhibit a peak catch at 51 to 67 tails to the pound size category.

Louisiana has by far the largest catch of white shrimp, accounting for some 82 percent by number and 77 percent by weight of the average reported catch. As with brown shrimp, the peak in catch occurs in the smallest commercial size group, though there is a comparatively better mix of larger size shrimp than with brown shrimp. The Texas white shrimp catch peaks at a size similar to the brown shrimp catch, or 31 to 40 tails to the pound. Though the Florida white shrimp catch peaks at the same size class as its brown shrimp catch, the Mississippi-Alabama catch of white shrimp peaks at a larger size, 15 to 20 tails to the pound in terms of weight, and 31 to 40 tails to the pound in terms of number.

Florida accounts for 98 percent of the pounds and numbers of pink shrimp caught in the reported commercial fishery of the U.S. Gulf of Mexico. Pounds and numbers both peak at a size of 51 to 67 tails to the pound.

Although the previously mentioned difference in harvesting strategies has resulted in larger shrimp being harvested in Texas vis-a-vis Louisiana-Mississippi, there has been a trend toward landing more small shrimp. Caillouet, et. al. (1979) report that for brown and white shrimp in both Louisiana and Texas there was a significant trend toward increased proportions of small shrimp in the 1959 to 1976 catches. Louisiana catches contain greater proportions of small shrimp than Texas catches. It is important to note that the proportion of Louisiana inshore catch in the 68 count and smaller category increased markedly during 1963 to 1976 with the major change occurring between 1973 to 1976 (Sass, 1979). Sass reports the major change to be in the size composition of the white shrimp catch.

3.2.1.3.2 Landing Trends by State

The historical pattern of landings among states during 1880-1975 is evident in Figure 3.2-9. Landings data differ from the catch data used in the preceding section. Landings are reported in heads-on units and are attributed to the state where off-loaded regardless of catch location. Due to the lengthy historical period portrayed, the data may not have been collected consistently; however, the data are suitable for reflecting long run trends and accurately depict in recent time the frequent fluctuation in landings.

Before about 1920, Louisiana and Mississippi were the dominant shrimp producing states in the Gulf. Between 1920 and 1948 the fisheries off Texas and Alabama began to rival that of Mississippi. At the same time, Louisiana's landings far exceeded any of the other states. During these early years the fishery was mainly an inshore and shallow water fishery predominantly of white shrimp, with minor catches of seabob and brown shrimp used mainly as dried shrimp. After World War II, the fishery began to expand. Sudden increases of landings in Texas and Florida were due to the discovery of concentrations of offshore populations of brown and pink shrimp, respectively, and the successful development

Table 3.2-1. Average weight of catch of brown, white, and pink shrimp by size and state[1] in thousand pounds of tails (US Dept. Comm., 1963-1975).

Shrimp	State	Size (Tails per Pound) 68 & over	51-67	41-50	31-40	26-30	21-25	15-20	Under 15	Total
Brown	FLA	37	84	50	64	18	4	2	---	259
	ALA-MISS	1724	2223	1288	1513	784	674	467	73	8746
	LA	13598	2612	1625	2636	1256	1550	1974	520	25771
	TX	1323	2287	3398	8726	4426	5234	3506	483	29383
	GULF	16682	7206	6361	12939	6484	7462	5949	1076	64159
White	FLA	189	154	81	104	64	34	22	1	649
	ALA-MISS	74	133	164	260	220	345	379	31	1606
	LA	7220	3646	2187	3780	2212	2640	2593	516	24794
	TX	519	587	490	1212	773	793	679	135	5188
	GULF	8002	4520	2922	5356	3269	3812	3673	683	32237
Pink	FLA	1135	3199	2164	2786	1411	1245	547	27	12514
	ALA-MISS	16	79	61	46	23	16	5	1	247
	LA	1	3	3	3	1	1	---	---	12
	TX	---	---	---	3	1	1	1	---	6
	GULF	1152	3281	2228	2838	1436	1263	553	28	12779
Species Combined	GULF	25836	15007	11511	21133	11189	12537	10175	1787	109175

[1]Florida = statistical area 1-9. ALA-MISS = statistical area 10-11. Louisiana = statistical area 12-17. Texas = statistical area 18-21. See Fig. 3.2-3 for location of statistical areas.

Table 3.2-2. Estimated average number[1] of brown, white, and pink shrimp by size and state[2] in thousands of shrimp (US Dept. of Comm., 1963-1975).

Shrimp	State	Size (Tails per Pound) 68 & over	51-67	41-50	31-40	26-30	21-25	15-20	Under 15	Total
Brown	FLA	2536	4954	2253	2270	513	99	31	---	12656
	ALA-MISS	151742	131134	58618	53699	21942	15513	8174	912	441734
	LA	2189355	154116	73920	93597	35159	35640	34554	6496	2622837
	TX	89949	134949	154594	309764	123920	120393	61364	6043	1000976
	GULF	2433582	425153	289385	459330	181534	171645	104123	13451	4078203
White	FLA	12848	9089	3669	3709	1782	789	384	8	32278
	ALA-MISS	6341	7834	7461	9236	6148	7939	6636	389	51984
	LA	620918	215132	99528	134204	61933	60721	45371	6446	1244253
	TX	35298	34634	22283	43020	21638	18240	11886	1690	188689
	GULF	675405	266689	132941	190169	91501	87689	64277	8533	1517204
Pink	FLA	77200	188731	98487	98920	39497	28645	9570	343	541393
	ALA-MISS	1392	4658	2765	1628	640	371	90	11	11555
	LA	241	197	122	122	31	14	7	---	734
	TX	1	18	23	115	29	19	18	1	224
	GULF	78834	193604	101397	100785	40197	29049	9685	355	553906
Species Combined	GULF	3187821	885446	523723	750284	313232	288383	178085	22339	6149313

[1]The number of shrimp caught in each size category was estimated in the following manner:

If size equals	Then number equals pounds times
Under 15	12.5
15-20	17.5
21-25	23
26-30	28
31-40	35.5
41-50	45.5
51-67	59
68 and over in Fla or Tx	68
68 and over brown or pink shrimp Miss-Ala	88
68 and over brown or pink shrimp in La	161
68 and over white shrimp in La or Miss-Ala	86

[2]Florida = statistical area 1-9. ALA-MISS = statistical area 10-11. Louisiana = statistical area 12-17. Texas = statistical area 18-21. See Fig. 3.2-3 for location of statistical area.

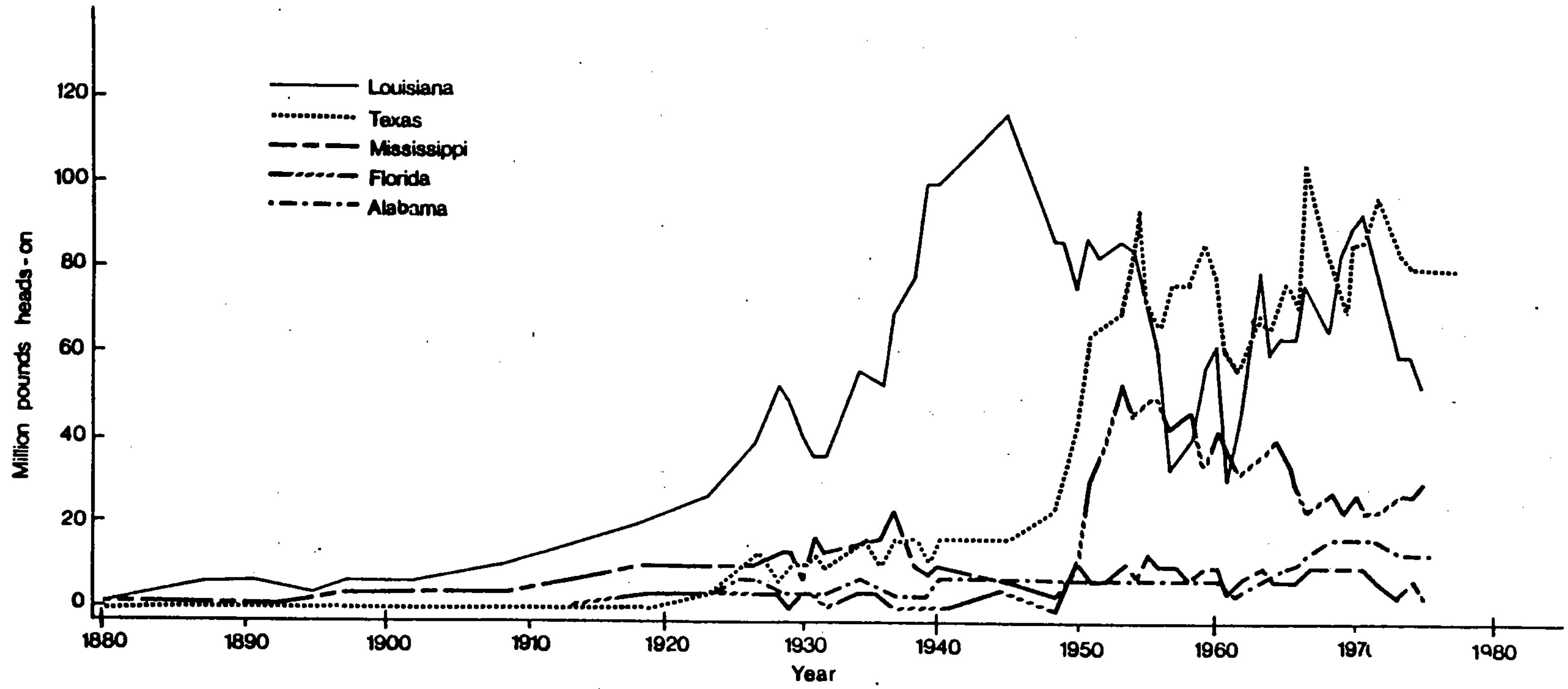


Figure 3.2-9. Annual reported commercial landings of shrimp (heads-on) by Gulf state (US Dept. Com., 1880-1975). Note that landings data are for heads-on shrimp off-loaded within a state regardless of where they were caught. This graph is not directly comparable with catch data used in this report.

of markets for these species. The gradual decline in landings from Florida (west coast) after 1954 may reflect a change in landing patterns of shrimp caught in Central and South America. The dramatic decline in landings in Louisiana from 1945 to about 1961 may reflect a salinity-induced shift in estuarine production of the state from predominantly white shrimp to a mixture of brown and white shrimp. However, data are insufficient to support this hypothesis.

The period from the mid-1950s to 1979 clearly depicts two important features of shrimp landings. First a mature fishery is evident from the standpoint that landings overall are neither increasing nor decreasing over time. The maturity is also visible from the fact that no trend in the share of landings has developed since the mid-1950s. Florida landings may have decreased slightly but Louisiana and Texas have maintained their respective relationships. Figure 3.2-9 also reveals that major fluctuations in landings are common. Peaks and valleys occur frequently and are large in magnitude. Since 1955 the annual landings have reversed the trend set in the preceding year on the average about 50 percent. This is interpreted to mean that landings following a good (bad) year are equally likely to increase or decrease. Shrimp businesses are often financially stressed by the variation in landings. The figure (3.2-9) indicates that shrimp harvesters cannot assure themselves of a stable catch by journeying to adjoining states. Generally, poor (or successful) seasons occur simultaneously in the states.

3.2.1.4 Description of Vessels and Gears Employed

Early Gulf coast shrimp trawlers were generally shallow-draft open skiffs ranging in length from 15 to 25 feet and powered by inboard gasoline engines. These early designs were gradually replaced in the 1920's by trawlers constructed with decks and pilot houses (Christmas and Etzold, 1977). The introduction of the diesel engine in the 1930s was considered a major advancement over gasoline engines in terms of safety, reliability, and reduced maintenance. The limited holding facilities and range of these early trawlers confined shrimping operations to areas relatively near the major shrimping ports. As a result, many coastal areas of the Gulf were inaccessible to the small trawlers (Johnson and Lindner, 1934, cited in Christmas and Etzold, 1977).

Until the late 1940s, commercial shrimp landings in the Gulf of Mexico consisted primarily of white shrimp (Idyll, 1963). By the early 1950s, however, increasing quantities of brown and pink shrimp were being caught and sold in response to a growing public acceptance of these unfamiliarly pigmented species (Idyll, 1963). The strong demand for shrimp and the opening of new fishing grounds off Florida, Alabama, Texas, and Mexico initiated a period of rapid growth in the size of the shrimp fleet. The expansion of offshore fishing grounds dictated the need for larger vessels with greater horsepower capable of remaining at sea for extended periods. Innovations in design and construction, such as steel hulls and onboard freezer units, were incorporated into the newer offshore trawlers of the late 1940s (Christmas and Etzold, 1977).

Captiva (1966) stated that the modern trends in the design and construction of shrimp trawlers were: (1) the increasing use of all-welded steel construction instead of wood; (2) more powerful engines, (3) onboard installation of sorting, packaging, and freezing equipment; (4) more comfortable crew accommodations; (5) development of multipurpose vessels which may be rapidly rerigged with a variety of fishing gears; (6) modern hydraulic equipment; (7) increased use of modern electronic equipment; and (8) increased use of newer hull materials such as aluminum and fiberglass-reinforced plastics.

The shrimp boat design most commonly seen in the offshore waters of the Gulf of Mexico is believed to be a derivation of Greek designs used in the sponge fishery on the Florida west coast (Idyll, 1963). The "Florida-type" vessels are characterized by the forward placement of the wheelhouse and engine room. Current construction trends are toward larger offshore Florida-type vessels ranging from 75 to 80 feet or more in length (Christmas and Etzold, 1977).

The "Biloxi-type" vessel design, with the wheelhouse and engine room aft, is used primarily for shrimping in the inshore waters of the Gulf region (Idyll, 1963). These vessels range from 30 to 45 feet in length and are less common than the Florida-type designs (Idyll, 1963).

The boats used in inshore shrimp fisheries are made of wood or fiberglass and range in length from 16 to 50 feet. Most of the boats use gasoline-powered inboard or outboard motors for propulsion, and some may be equipped with powered winches to retrieve nets. The smaller boats are rigged in a variety of ways and are primarily confined to sheltered inshore waters. The larger boats may occasionally fish offshore if weather conditions are suitable. The "mosquito" fleet of Louisiana is made up of numerous small boats, generally operated by one person, that shrimp commercially in the inshore bays and marshes. These boats are typically shallow-draft, open skiffs.

Deep-water trawling for royal red shrimp in the Mississippi and Tortugas grounds has been steadily increasing in the past few years. Royal reds are fished by wood, steel, and aluminum vessels ranging in length from 56 to 86 feet. Most of the vessels are double-rigged and are capable of shrimping in both the shallow and deep water of the Gulf. Smaller vessels and boats usually do not have the winch capacity or sufficient stability in rough seas to fish for royal reds (Klima and Ford, 1970).

Although the otter trawl is the most common of the gears used in the Gulf shrimp fisheries, other kinds of gear are also used. The star trawl was developed for shallow-water shrimping in the Gulf of Mexico (Marinovich and Whiteleather, 1968, cited in Klima and Ford, 1970). Sideframe trawls, used almost exclusively to harvest bait shrimp on the Florida west coast from Cedar Key to Naples (Woodburn, et al., 1957; Saloman, 1965), are virtually unknown in the other Gulf states. Researchers are conducting experiments with the electric trawl, beam trawl, separator trawl, and excluder panels. Other gear types used by both commercial and recreational shrimp fishermen include haul seines, cast nets, channel nets, wing nets, and push nets.

The haul seine was the primary gear used to harvest shrimp until the introduction of the otter trawl in Beaufort, North Carolina, between 1912 and 1917 (Christmas and Etzold, 1977). Tulian (1920) reports that the otter trawl was introduced into the Louisiana shrimp fisheries in 1917. The use of the otter trawl spread rapidly among shrimp fishermen in Louisiana because of the increase in catch per man-hour possible over haul seines.

An otter trawl consists of a heavy mesh bag with wings on each side designed to funnel the shrimp into the codend or tail. A pair of otter boards or trawl doors positioned at the end of each wing hold the mouth of the net open by exerting a downward and outward force at towing speed.

The two basic otter trawl designs used by the Gulf shrimp fleet are the flat and the semi-balloon trawls (Klima and Ford 1970). The mouth of the flat trawl is rectangular in shape, whereas the mouth of the semi-balloon design forms a pronounced arch when in operation. The basic design of each trawl type is shown in Figure 3.2-10. The semi-balloon designs tend to maintain an efficient shape under repeated towing strains; flat nets require periodic rerigging and rehanging to maintain maximum efficiency (Christmas and Etzold, 1977). The two-seam semi-balloon trawl (Figure 3.2-10) was introduced in the Gulf of Mexico in 1947 (Marinovich and Whiteleather, 1968, cited in Christmas and Etzold, 1977). The two-seam design was followed by the development of the four-seam semi-balloon trawl, which has "a shorter jib with wings on either side between the top and bottom bellies," whereas the "top and bottom bellies were joined directly together" in the two-seam design (Christmas and Etzold, 1977). The four-seam trawl maintains an efficient shape under towing strains and therefore creates less resistance in the water than the two-seam trawl.

About 90 percent of the fishermen in the royal red fishery use 55 to 75-foot flat otter trawls, and the remainder use semi-balloon trawls ranging in width from 45 to 60 feet (Klima and Ford, 1970).

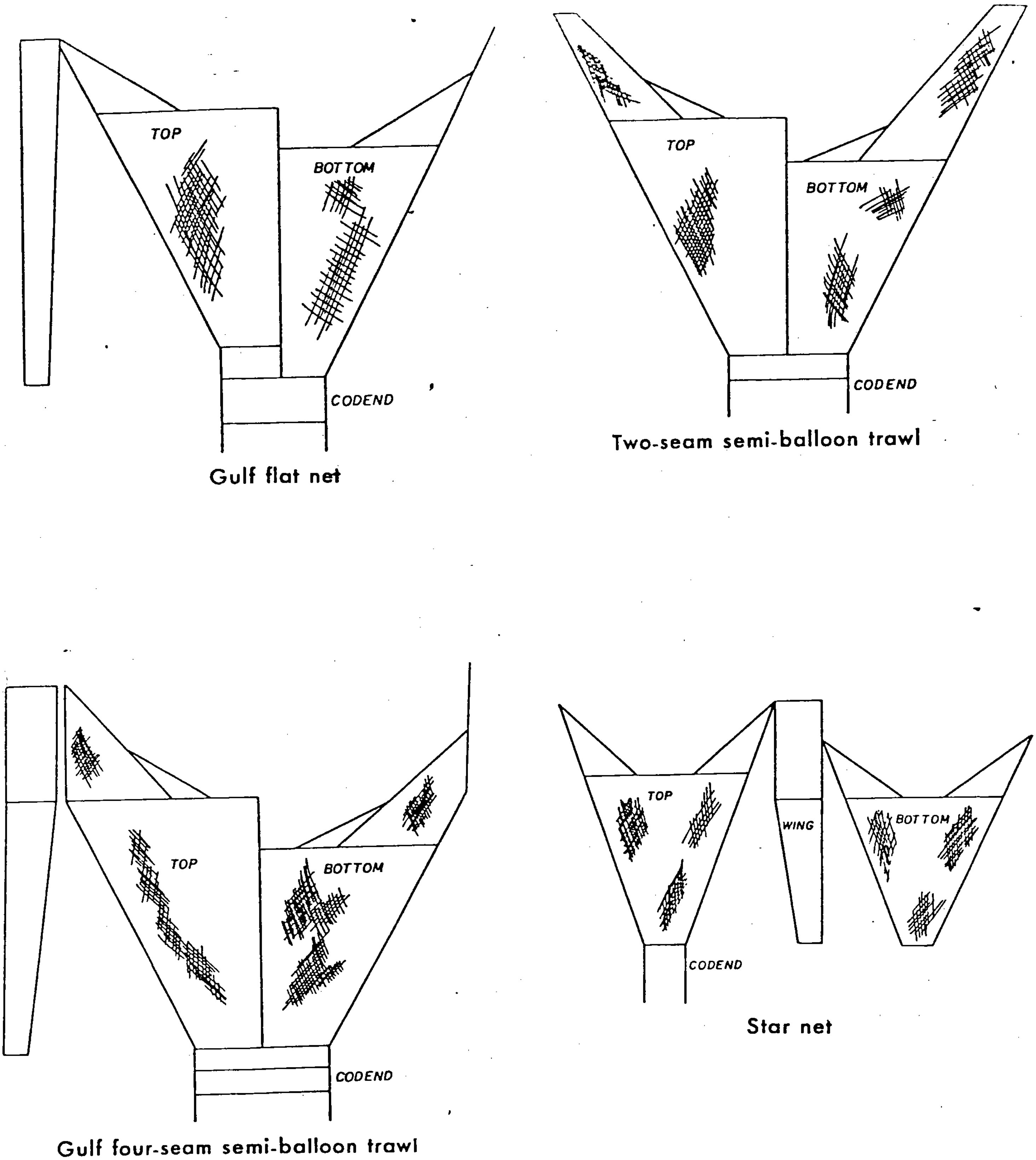


Figure 3.2-10. Diagrams of the four basic designs of otter trawls used by the Gulf of Mexico shrimp fleet (after Christmas and Etzold 1977).

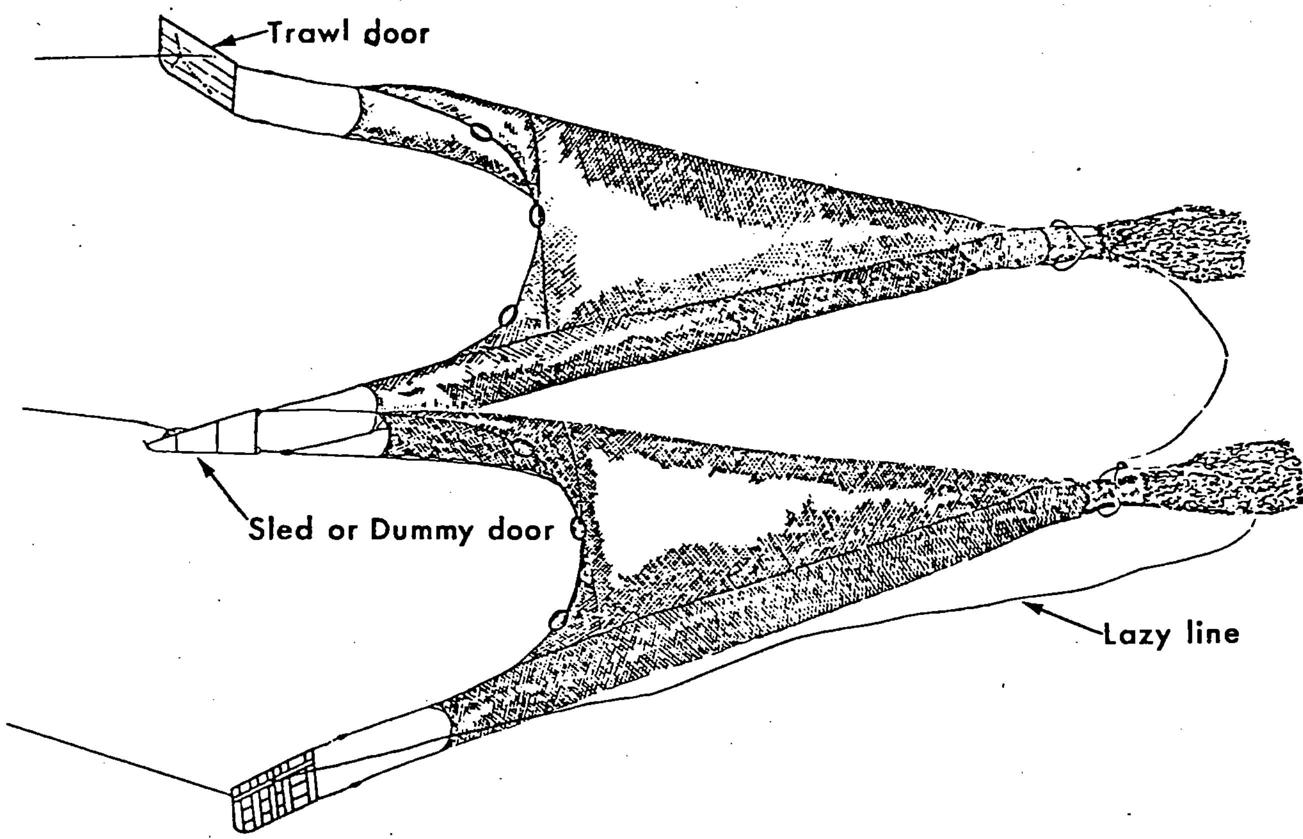


Figure 3.2-11. Diagram of the twin-trawl rig (after Harrington et al. 1972).

Try nets are small otter trawls about 12 to 15 feet in width which are used to test areas for shrimp concentrations. These nets are towed during regular trawling operations and lifted periodically to allow the fishermen to assess the amount of shrimp and other fish and shellfish being caught. These amounts in turn determine the length of time the large trawls will remain set.

Until the late 1950's, most shrimp vessels pulled single otter trawls ranging from 80 to 100 feet in width (Idyll, 1963). Double-rig trawling was introduced into the shrimp fleet during the late 1950's. The single large trawl was replaced by two smaller trawls, each 40 to 50 feet in width, which were towed simultaneously from stoutly constructed outriggers located on the port and starboard sides of the vessels. The port trawl was towed about 150 feet in back of the starboard trawl to prevent fouling. The advantages of double-rig trawling are (1) increased catch per unit of effort, (2) fewer handling problems with the small nets, (3) lower initial gear costs, (4) a reduction in costs associated with damage or loss of the nets, and (5) greater crew safety (Idyll, 1963).

The haul seine consists of a large rectangular panel of webbing ranging up to 1,000 feet in length and 20 feet in depth. It was mainly used before 1917. At that time mesh size ranged from 0.5- to 1.5-inch bar and a large crew was required to set and fish the net. Typically, a corkline buoyed the top of the net and a leadline was attached to the bottom edge. Haul seines were frequently constructed with bags or pockets where the captured shrimp were forced to congregate. Although the haul seine is no longer used to harvest commercial quantities of shrimp, it is still licensed in some states.

Cast nets are used mostly by sportsmen along tidal creeks, bayous, and weirs where shrimp congregate seasonally. Cast nets are circular, usually ranging from six to 12 feet in diameter, with a leadline sewn around the periphery of the net. A cord line passes through a metal or plastic thimble in the center of the net and radiates out to several smaller cords which are attached at even intervals to the leadline. Cast nets are usually constructed of nylon webbing with a 0.25- to 0.75-inch mesh. The nets are thrown in a circular pattern and allowed to sink to the bottom. The cord line is pulled in, causing the leadline to be drawn to the center of the net where the shrimp are trapped.

Channel nets are stationary nets which resemble otter trawls and catch emigrating shrimp in narrow cuts and bayous in areas with large tidal amplitude. The mouth of the net is held open with anchors or poles instead of trawl doors. The contents of the net are periodically dumped into a small skiff or a box located onshore.

Butterfly or wing nets are bags constructed of nylon webbing which are hung on a rectangular frame and attached to the side of a boat. Boats equipped for "butterfly" shrimping anchor themselves heading into the current and lower the nets into the water perpendicular to the gunwales. The tidal currents are then allowed to sweep emigrating shrimp into the mouth of the net. The net can be checked without raising the frame by lifting the codend on board with a lazy line and emptying the contents into a sorting box. The net is then put overboard to resume fishing while the catch is sorted.

Push nets, which are occasionally used to catch shrimp in shallow-water areas of Florida and Texas, are small mesh bags hung on rectangular frames. The operation of a push net usually involves an individual wading and pushing the net before him in shallow water.

Table 3.2-3. Estimates of Foreign Catch (in tails) of Shrimp (1971-1976) in Waters Now Considered as Within the US Fishery Conservation Zone of the Gulf of Mexico (Data from Charles Fuss, NMFS, personal communication 1978).

Bordering state	Year	Foreign country involved: Estimated catch			Total estimated foreign catch
		Cuba	Mexico	Panama	
		Pounds			
Florida	1971	57,440	0	0	57,440
	1972	10,240	0	0	10,240
	1973	20,480	0	0	20,480
	1974	75,000	0		75,000
	1975	135,000	105,000	0	240,000
	1976	0	0	0	0
6-year average		49,693	17,500		67,193
Texas	1971	0	2,783,300	0	2,783,300
	1972	0	83,820	0	83,820
	1973	1,710,000	0	0	1,710,000
	1974	1,110,000	90,000	0	1,200,000
	1975	1,665,000	225,000	0	1,890,000
	1976	722,750	0	126,000	848,750
6-year average		867,958	530,353	21,000	1,419,311

Table 3.2-4. Estimates of Monthly Foreign Effort and Catch Directed Toward Shrimp (1971-1976) in Waters Now Considered as Within the US Fishery Conservation Zone of the Gulf of Mexico (Data from Charles Fuss, NMFS, personal communication 1978). Weight is tail weight.

Bordering states	Year	Principal fishing months	Estimated # vessels	Estimated fishing days per vessel	Estimated number of vessel days	Estimated catch per vessel day	Estimated total catch (pounds)
				Mexico			
Florida	1971	—	—	—	—	—	—
	1972	—	—	—	—	—	—
	1973	—	—	—	—	—	—
	1974	—	—	—	—	—	—
	1975	July	7	30	210	500	105,000
	1976	—	—	—	—	—	—
Texas	1971	June	128	16	2,048	195	
		July	345	16	5,520	418	
		August	11	16	176	435	2,783,300
	1972	June	7	16	112	435	
		July	5	16	80	[439]	83,820
	1973	—	—	—	—	—	—
	1974	July	3	30	90	500	
		October	3	30	90	500	90,000
	1975	July	8	30	240	500	
		August	7	30	210	500	225,000
	1976	—	—	—	—	—	—
				Cuba			
Florida	1971	January	10	16	160	215	
		February	6	16	96	240	57,440
	1972	February	2	16	32	320	10,240
	1973	February	4	16	64	320	20,480
	1974	January	1	30	30	500	
		November	4	30	120	500	75,000
	1975	February	3	30	90	500	
		August	6	30	180	500	135,000
	1976	—	—	—	—	—	—
Texas	1971	September	7	2	14	—	—
	1972	—	—	—	—	—	—
	1973	April	3	30	90	500	
		May	5	30	150	500	
		June	15	30	450	500	
		July	59	30	1,770	500	
		August	32	30	960	500	1,710,000
	1974	April	3	30	90	500	
		May	10	30	300	500	
		June	16	30	480	500	
		July	35	30	1,050	500	
		August	10	30	300	500	1,110,000
	1975	June	25	30	750	500	
		July	46	30	1,380	500	
		August	40	30	1,200	500	1,665,000
	1976	June	25	25	625	350	
		July	31	25	775	350	
		August	19	25	[475]	350	[656,250]
				Panama			
Florida	1971	—	—	—	—	—	—
	1972	—	—	—	—	—	—
	1973	—	—	—	—	—	—
	1974	—	—	—	—	—	—
	1975	—	—	—	—	—	—
	1976	—	—	—	—	—	—
Texas	1971	—	—	—	—	—	—
	1972	—	—	—	—	—	—
	1973	—	—	—	—	—	—
	1974	—	—	—	—	—	—
	1975	—	—	—	—	—	—
	1976	January	1	30	30	350	
		September	5	60	300	350	
		October	1	30	30	350	126,000

3.2.2 History of Foreign Exploitation

3.2.2.1--3.2.2.3 General Description of User Groups, Fishing Effort, Vessels and Gear Employed

Foreign shrimp fishing in the U.S. Gulf of Mexico has been virtually nonexistent in 1977-1978 (Charles Fuss, NMFS, personal communication, 1978) as a result of the passage of the MFCMA. Prior to 1971, Mexican vessels had been shrimping in U.S. waters for many years; Cubans entered the fishery in 1971, and some Panamanian boats shrimped off Texas in 1976 (Table 3.2-3). Annual harvest for the years 1971-1976 ranged from zero to 2.8 million pounds in resources in inland waters and in tails off Florida. Mexican harvest off Texas ranged from zero to 2,783,000 pounds in tails. Cuban boat activities off Texas were concentrated in the months of June, July, and August, the peak brown shrimp season (Table 3.2-4). It is estimated that 30 boats worked 29 days per month and harvested 408,000 pounds in tails per month. Mexican boats, present in the same waters during the same period, in 1971 totaled 345 and took an estimated 2.3 million pounds. The catch fell sharply in ensuing years. Cuban boat activities off Florida occurred mainly during the winter months; from one to ten vessels were involved, and the take was as high as 135,000 pounds in tails annually. Seven Mexican vessels took 105,000 pounds of shrimp tails off Florida in July 1975 (Charles Fuss, NMFS, personal communication, 1978). Foreign vessels are of the same configuration as the U.S. offshore fleet and utilize similar gear.

3.2.3 Fishing in Foreign Waters

The United States and Mexico signed a treaty in November, 1976, concerning U.S. shrimping activity in Mexico's portion of the Gulf of Mexico affected by the 200-mile extended jurisdiction. A three and one-half year phaseout period was negotiated, and all U.S. shrimp fishing within Mexico's 200-mile offshore fishing zone was terminated by January, 1980.

Historical U.S. Shrimping Activity in the Gulf of Mexico

The shrimp grounds in the Gulf of Mexico begin with Area 1 off the southwestern tip of Florida and extend to Area 40 just off Quintana Roo; these areas and depth zones in ten-fathom increments are shown in Figure 3.2-12. Areas 1 to 21 off the U.S. coast, and Areas 22 to 40, off Mexico's coast, conform to those used by the National Marine Fisheries Service (NMFS) in collecting and reporting shrimp landings data.

Landings from Mexican waters decreased from around 18 to 10 million pounds for the period 1962-1974 with the average for the last five years being 9.6 million pounds (Table 3.2.5). The decrease in landings came from regions 31 to 40 off the Yucatan Peninsula where catch dropped from 12 million pounds to four million pounds. Landings from Areas 22 to 30 remained fairly constant at five to six million pounds. During 1970-1974, 90 percent of U.S. shrimp landings came from U.S. waters and 10 percent from Mexican waters. Within the last five years almost two-thirds of the landings from Mexican waters came from Areas 22 to 30 on the Texas side of the Gulf.

Total value of catch (nominal dollars) from Mexican waters (Areas 22-40) remained fairly constant at $13 million. Areas 22 to 30 have become relatively more valuable to Gulf shrimpers in the U.S. than Areas 31 to 40. While Mexican vessels began to fish in U.S. waters in the early 1970s, their catch and associated value was negligible.

Days fished in Mexican waters decreased from around 30,000 to 16,000 between 1962 and 1974. Most noticeable in this shift was between 1965 and 1966 when days fished dropped in Areas 31 to 40 of Mexican waters. Days fished in Areas 22 to 30 of Mexican waters remained nearly constant at about 10,000 days for the 13-year period.

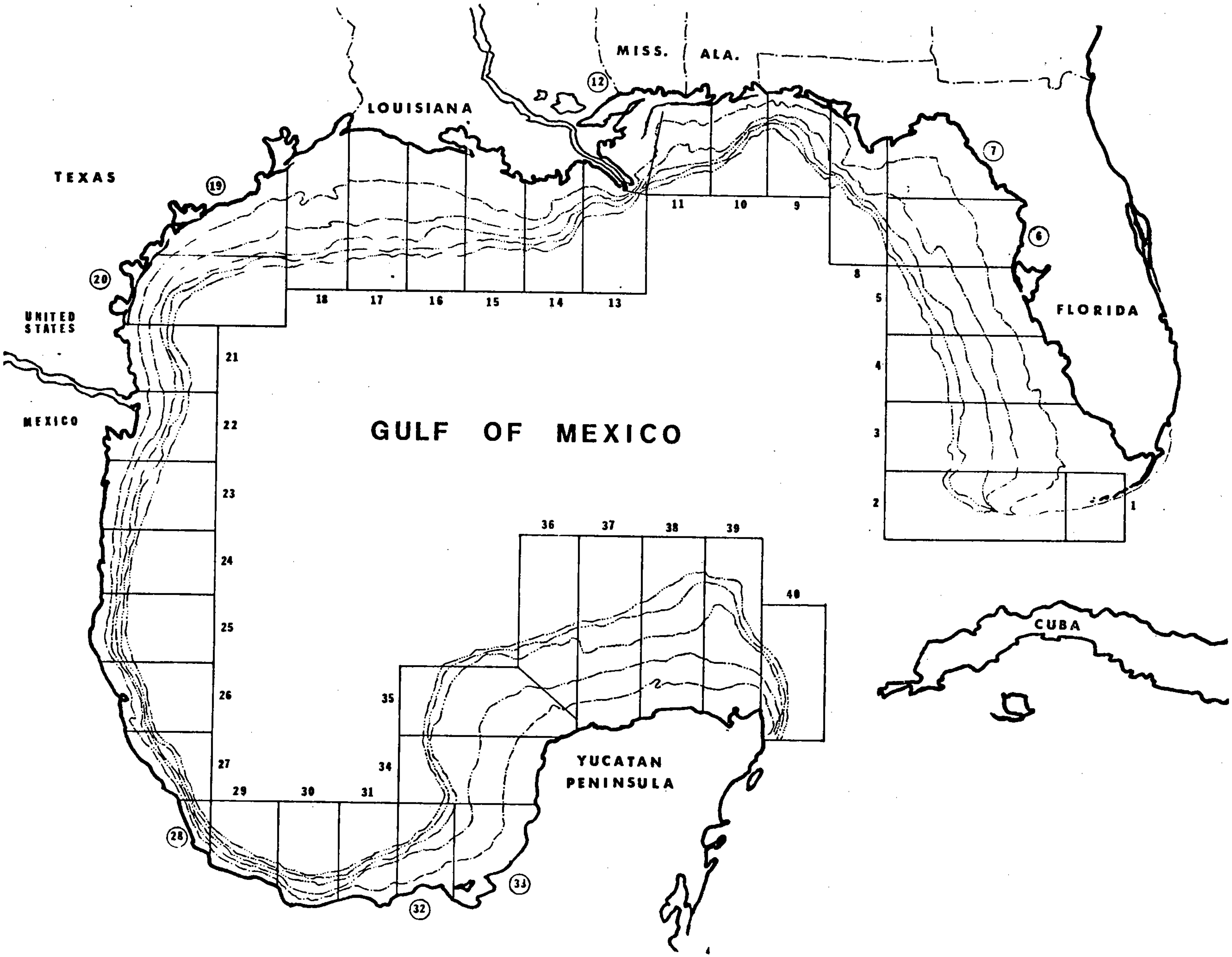


Figure 3.2-12 Gulf of Mexico with ten-fathom depth lines.

Distribution of Landings from Mexican Water

Landings data for the period 1970 to 1974 indicate that more than 99 percent of the catch from Mexican waters was landed in Florida and Texas (Table 3.2.6). For the five Gulf states an average of 85.0 million pounds (90 percent) of the shrimp landed during the 1970-1974 period came from U.S. waters whereas 9.5 million pounds (10 percent) came from Mexican waters. Eighty-nine percent of Florida landings (and revenue) came from U.S. waters and 11 percent from Mexican waters. Texas was somewhat more dependent on Mexican waters since 17 percent of its landings and 19 percent of its revenue came from Mexican waters.

Table 3.2.5. Total landing and value by U.S. vessels and days fished from statistical reporting areas in Mexican waters of the Gulf of Mexico, 1962-1974.

Year	Landings			Value			Days Fished		
	22-30	31-40	22-40	22-30	31-40	22-40	22-30	31-40	22-40
	----million pounds----			-------million $-------			---------(1000)--------		
1962	5.9	13.9	19.8	5.0	10.7	15.7	11.5	26.5	38.0
1963	3.3	10.7	14.0	2.5	7.7	10.2	5.9	20.4	26.3
1964	5.2	12.3	17.4	3.9	7.5	11.4	8.9	22.1	31.0
1965	5.0	11.4	16.3	3.7	8.0	11.7	7.8	20.1	27.9
1966	6.1	4.1	10.1	5.6	3.5	9.1	10.3	7.2	17.5
1967	5.0	5.0	10.0	4.6	4.5	9.1	7.1	7.5	14.6
1968	8.1	6.3	14.4	8.0	5.9	13.9	11.8	11.1	23.0
1969	4.1	4.2	8.3	4.5	4.4	8.9	9.2	7.6	16.8
1970	5.2	3.9	9.1	4.9	4.2	9.1	7.7	7.8	15.5
1971	6.3	2.7	9.1	8.3	3.1	11.5	10.5	4.3	14.8
1972	8.3	3.4	11.7	11.6	4.4	16.0	12.3	4.5	16.8
1973	5.7	4.4	10.1	11.1	7.7	18.8	10.5	7.2	17.7
1974	4.8	3.4	8.2	8.1	4.3	12.4	10.3	4.7	15.0
1970-1975 Average	6.1	3.6	9.6	8.8	4.7	13.6	10.3	5.7	16.0
Percent of Total Gulf	6.4	3.7	10.1	7.5	4.0	11.5	6.7	3.7	10.4

Source: Griffin and Beattie (1978).

Most of the catch taken from Mexican waters and brought to Texas was landed in the ports of Brownsville and Port Isabel. For these two ports, located across the Rio Grande River from Mexico, 58 percent of the landings come from U.S. waters and 42 percent from Mexican waters. Thus, vessels operating out of Brownsville and Port Isabel were very dependent on Mexican waters.

Based on a Griffin and Beattie (1978) article, Table 3.2.7 shows the number of Florida and Texas vessels that were estimated to be directly affected by the 200-mile extended jurisdiction by Mexico before the phase-in of the fishing moratorium was begun. The average number of Texas vessels that fished in Mexican waters for the period 1971-1974 was 565; for Florida, the average was 85. Of the 565 Texas vessels, 464 fished in Areas 22 to 30, 207 fished in Areas 31 to 38 and 59 fished in Areas 39 to 40. The Florida vessels were more dependent on Areas 39 to 40 where 80 of the 85 vessels fished. Only nine of the Florida vessels fished in Areas 31 to 38 and only one fished in Areas 22 to 30.

Economic Consequence of Mexican Extended Jurisdiction

Griffin and Beattie (1978) relied on economic theory and statistical models to estimate the economic consequences of extended Mexican jurisdiction. The nature and extent of the economic losses estimated were highly dependent on assumptions made with respect to shrimp prices, costs, length of adjustment period and alternative uses of shrimp vessels.

Slightly more than 10 percent, 30,600 units, of the total effort (real days fished) expended by U.S. shrimpers on the Gulf shrimp fishery occurred in Mexican waters during the 1970-1974 period (Griffin and Beattie, 1978). In their analysis, Griffin and Beattie (1978), assumed that these 30,600 units of effort (E_m in Figure 3.2-13) would be diverted to U.S. waters when Mexico's extended jurisdiction went into full effect in 1980. Assuming that the U.S. Gulf of Mexico fishery was in open-access equilibrium where total value product (TVP) equals total cost (TC), a temporary disruption of that equilibrium was expected.

Present Value of Negative Rent Stream

When the 30,600 units of effort exerted in Mexican waters were diverted to U.S. waters over a three and one-half year period ending in 1980, the industry as a whole was estimated to incur negative rents temporarily. Since rent is zero at equilibrium in an open-access common property resource, rent (r) was temporarily negative due to the excess effort. The term rent refers to "excess profits." Excess profit may be defined as a return over and above the normal profit return to labor and capital used in the fishery.

The expected increase in effort (E^m = 30,600) resulted in an increase in total value product of shrimp from \$147.6 million to \$156.4 million and in total cost (TC) from \$147.6 million to \$161.4 million (Griffin and Beattie, 1978). At 291,400 units of effort, rent accruing to the fishery would be a negative \$5.1 million per year.

Assuming the industry was no longer in equilibrium after being removed from Mexican waters, it moved toward the equilibrium effort level of 260,800 units if cost-price relationships did not change. The magnitude of the real cost to the industry can be represented by the annual stream of net loss over that period of time until equilibrium is reached. Table 3.2.8 shows the present value of the stream of losses for alternative adjustment periods ranging from one to seven years, and prices per pound of shrimp landed ranging from \$1.70 to \$3.00 assuming a ten percent discount rate over time. Adjustment was assumed to take place in equal increments of effort each year until equilibrium was reestablished (i.e., at 260,800 unit of effort).

At a price of \$1.70 (see Table 3.2-8 for other price and time scenarios) per pound of shrimp landed, and a three-year adjustment period, the present value of the stream of net losses was estimated to be \$8.6 million. Assuming the same price and discount rate but five years to adjust the net

Table 3.2-6. Total pounds and value (and percentages) of shrimp landed in the five Gulf states, Florida, Texas and Brownsville/Port Isabel by areas of the Gulf of Mexico, average over the five years, 1970-1974.

Area	Five Gulf States		Florida		Texas		Brownsville & Port Isabel	
	Pounds (mil)	Dollars (mil)	Pounds (mil)	Dollars (mil)	Pounds (mil)	Dollars (mil)	Pounds (mil)	Dollars (mil)
U.S.:								
1-21	85.0 (90)	103.6 (89)	13.5 (89)	15.1 (89)	38.2 (83)	49.5 (84)	9.9 (58)	12.6 (54)
Mexico:								
22-30	6.0 (6)	8.7 (7)	*	*	5.9 (13)	6.8 (12)	6.0 (34)	8.6 (37)
31-40	3.6 (4)	4.7 (4)	1.7 (11)	1.9 (11)	1.9 (4)	2.8 (5)	1.4 (8)	2.1 (9)
Total Gulf:								
1-40	94.5 (100)	117.0 (100)	15.2 (100)	16.9 (100)	46.0 (100)	59.1 (100)	17.3 (100)	23.3 (100)

* Less than 100,000

Source: Griffin and Beattie (1978), p. 17.

Table 3.2-7. Number of vessels from Texas and Florida fishing in the Gulf of Mexico by areas, 1971-1974.

	----------Texas Vessels----------				----------Florida Vessels----------			
Year	Total* 22-40	22-30	31-38	39-40	Total* 22-40	22-30	31-38	30-40
1971	570	460	158	78	75	4	11	72
1972	632	528	193	74	90	0	7	86
1973	615	480	323	53	96	0	14	86
1974	444	393	153	30	79	1	5	77
Average	565	465	207	59	85	1	9	80

*Exclusive of duplication

Source: Griffin and Beattie (1978).

present value of the stream of losses was estimated to be $12.1 million. Obviously, the longer the adjustment period, the larger the loss.

Also presented in Table 3.2.8 are estimates of the present value of the negative rent stream assuming alternative shrimp prices. Since a change in product price shifts TVP and thus the equilibrium effort level, the estimates presented assume that costs of production shifted simultaneously so that the same (260,800) equilibrium effort level was maintained. Given this assumption, the present value of the stream of losses was estimated to be $12.8 million assuming a $2.50 shrimp price and three years to adjust. At the same shrimp price but assuming a five-year adjustment period, the present value of the loss stream was estimated to be $18.0 million.

Table 3.2-8. Present value of U.S. cost due to Mexico's extended jurisdiction in the Gulf of Mexico for alternative adjustment periods and product prices (assuming equilibrium effort at 260,800 units and a ten percent discount rate.)

Years to adjust	Exvessel Price Per Pound			
	$1.70	$2.00	$2.50	$3.00
	----------million dollars----------			
1	4.6	5.5	6.9	8.3
3	8.6	10.1	12.8	15.4
5	12.1	14.3	18.0	21.8
7	15.2	18.0	22.7	27.4

Source: Griffin and Beattie (1978)

3.3 History of Management

3.3.1. Management Institutions, Policies, Jurisdiction

Inland water management of the Gulf shrimp fishery is based on the laws and regulations of the five states affected. All the states have restrictions on the size of shrimp which may be taken; all have exclusive state authority for the determination of shrimping seasons; all require licensing of or permits for various types of shrimp dealers and vessels; all provide for restricted waters to some degree; all have penalties for violations of laws and regulations; Florida, Alabama, Mississippi, and Louisiana have some administrative authority to negotiate reciprocal shrimp agreements with other states while Texas has none. All Gulf states have agencies concerned with wetlands management; shrimp habitat protection in nursery areas comes within their purview as advisory or rule-making bodies. Florida, Louisiana, Mississippi, and Alabama have federally approved Coastal Zone Management Programs which would embrace all the laws and regulations of the governing bodies, both local and state, affecting the state-controlled shrimp fishery and nursery areas. The five states all have reporting requirements, but the type of information asked for and the diligence with which it is sought vary. Louisiana, Mississippi, and Alabama are authorized to collect taxes based on volume from shrimpers and/or processors. None of the states have a limited entry law.

Alabama: The Department of Conservation and Natural Resources is responsible for shrimp fishery management. Its powers include determination of open and closed seasons, regulation of time, place, and method of taking seafood, and authority to require submission of statistical information from shrimpers and processors. Direct supervision of seafoods is handled by the Department's Division of Marine Resources, headed by a director named by the Commissioner of Conservation and Natural Resources. A thirteen-member advisory board meets at least twice each year to review regulations proposed by the Commissioner and to establish policy on proposed legislation. The advisory board can revise or repeal regulations proposed by the Commissioner, or it can adopt its own regulations by a two-thirds vote and the consent of the Governor. All seafood in state-owned waters is declared to be state property. Wetlands management in Alabama is under the jurisdiction of the Coastal Area Board (appointed by the Governor). Its area of authority begins at the ten-foot contour line and is concerned with habitat protection. A fourteen-member advisory committee of experts in all fields of coastal usage advises the Coastal Area Board. Alabama has entered into reciprocal shrimp agreements with Louisiana, Mississippi, and Florida.

Texas: Overall control of the Texas shrimp fishery is either vested in the six-member Parks and Wildlife Commission appointed by the Governor or controlled by the legislature. The Commission establishes rules and regulations in some coastal counties and may adjust the closed Gulf season; enforcement is handled by the Texas Parks and Wildlife Department. The Texas Shrimp Conservation Act is applicable all along the Texas coast because the Commission has adopted it as a regulatory policy. State jurisdiction extends seaward three leagues (nine nautical miles) from the coastline. The state distinguishes between inside waters--all bays, passes, rivers, or other bodies of water landward from the Gulf--and outside waters, extending from the shoreline seaward to the extent of Texas jurisdiction. The Texas Coastal Coordination Act requires the Texas Natural Resources Council to study problems and issues in connection with coastal natural resources and to submit a biennial study with recommendations for action on identified problems. The Council is also to recommend research and data acquisition priorities. Texas has no reciprocal shrimp agreement with the other Gulf states; legislative approval of any such agreement would be required. The Commission is empowered to coordinate any Texas shrimp management plans with those drafted for the federal fishery zone.

Louisiana: The Wildlife and Fisheries Commission has exclusive control over the shrimp fishery and the shrimp industry. Rules and regulations are promulgated by the seven-member Commission. Its members are named by the Governor to serve overlapping terms and represent various segments of fish- and wildlife-related industries and sportsmen's groups. Administration is handled by the Department of Wildlife and Fisheries. The Department's Office of Coastal and Marine Resources is responsible for enforcing regulations and monitoring the shrimp fishery. A severance tax, payable by the first purchaser and collected by the Department, is levied on shrimp taken from Louisiana waters. Data reporting is required from shrimp processing plants and wholesale dealers. The Department has a limited degree of authority to enter into reciprocal agreements with other states. Louisiana's jurisdiction extends seaward three nautical miles from the coastline. The state differentiates between inside waters, including the large bays, and outside waters. Shrimping seasons are set for inside waters; there is no closed season for outside waters. Regulations proposed by the Commission are subject both to review by the Joint Senate and House Natural Resources Committee and to the Administrative Procedures Act which requires public notice through publication in the Louisiana State Register prior to their adoption by the Commission. The State Department of Transportation and Development is in the process of developing a Coastal Zone Management Program covering coastal marshes and estuaries and extending to Louisiana's seaward boundary. The vast Louisiana shrimp nursery grounds are included in the territorial limits to be covered by the program.

Mississippi: The policy making body of the Mississippi Department of Wildlife Conservation is a five-member Commission on Wildlife Conservation. Executive authority is vested in the Director of Wildlife who is elected by the Commission for a four-year term. A Bureau of Marine Resources is supervised by a director experienced in marine conservation; this Bureau aids the Commission in "formulating policies, discussing problems and considering other matters." The Commission determines seasons, restricted waters, and size of shrimp to be taken. The Commission is authorized to require such reporting as may be needed to meet the needs of any research project, and persons receiving such questionnaires are required to respond factually. Fines are imposed for failure to respond or for falsifying data. A severance tax is imposed on all shrimp processed, transported in or from the state, or caught within state waters. The state has a broadly-worded statute covering reciprocal agreements. The Bureau of Marine Resources is authorized to study "plans, proposals, reports, and recommendations" for development and utilization of coastal and offshore lands, waters, and marine resources.

Florida: The Florida Department of Natural Resources is the state's shrimp fishery regulating agency. It is empowered to adopt rules and regulations governing "method, manner, and equipment" used in taking shrimp and to define areas where shrimp may be caught. Its Division of Marine Resources is charged to "preserve, manage, and protect" fishery resources and to regulate vessels and fishermen "within or without" the boundaries of the state. However, the legislature has adopted numerous local laws (general bills of local application) which regulate shrimping in the particular counties. Special county acts govern shrimping seasons in Apalachicola Bay, St. Vincent Sound, and the area from Cape San Blas to Cape St. George. By legislative act, some nursery areas are permanently closed to all except bait shrimping. Florida has uniform rule-making procedures for all administrative agencies; these procedures require prior notice, an economic impact statement, and an opportunity for "substantially affected" persons to challenge proposed rules on the grounds of invalid exercise of the agency's legal authority. Proposed rules are also to be reviewed by a legislative Administrative Procedures Committee. Florida has no statute specifically taxing the taking or handling of shrimp. The Department of Natural Resources is authorized to enter into reciprocal agreements with other states, giving shrimpers based in such states the same "rights and privileges" that residents of states in which they are fishing have.

3.3.1.1 Regulatory Measures Employed to Regulate the Fishery

The following is summarized from Craig, et al. (1978).

Legal Size of Shrimp; Catch Limits

Texas: In 1981, Texas amended its shrimp regulations to eliminate its minimum size restriction of 39 whole shrimp to the pound on Gulf shrimp so long as there is a Shrimp FMP in place which provides for a closed season in the FCZ which corresponds to the Texas closed Gulf season. Commercial shrimpers are not limited as to amount of shrimp taken in outside waters; 300 pounds per day limit in spring open season for inside waters; no limit on fall catch in major bays; however, August 15 to October 31, minimum count of 50 whole is required; no count restriction November 1 to December 15. Recreational shrimpers may take 100 pounds per day in outside waters, 15 pounds per day from major bays in spring, and 15 pounds per day in fall open season. Commercial bait shrimpers are limited to 200 pounds per day.

Louisiana: Inside waters size limit is 68 whole shrimp to the pound; limit not applicable in outside waters or to any species taken during spring inside waters open season, nor to brown shrimp taken after November 20. There are no catch limits on commercial shrimpers; unlicensed recreational shrimpers are limited to 100 pounds per boat per day. Bait shrimp are excluded from size requirements.

Mississippi: Size limit is 68 whole shrimp to the pound. Bait shrimpers are limited to a maximum of 20 pounds of dead shrimp. In addition, bays are not opened to live bait shrimping until such time as the shrimp are determined by sample catch to be 95 whole shrimp to the pound of larger. No catch limits otherwise.

Alabama: Size limit is 68 whole shrimp to the pound. Bait shrimp are excepted. There are no catch limits for commercial including bait shrimpers. Recreational boats are limited to 25 pounds per boat in areas open to commercial shrimpers and 15 pounds per boat in bait shrimping areas.

Florida: Statewide size limit for shrimp taken in state waters is 47 to the pound, heads on, and 70 tails to the pound; in three Panhandle counties local size limit is 55 to the pound, heads on, in open inside bays and sounds. No catch limits.

Licensing of Vessels and Fishermen

Texas: Commercial Gulf shrimp boat, bay shrimp boat, bait shrimp boat, and sport shrimp trawl must be licensed; "John Doe" licenses are also required for the captain and each crewman of commercial vessel and a personal license for each recreational shrimper.

Louisiana: Commercial boat license based on length; no license needed for recreational boats; license required for all gear except noncommercial 16 feet and under in length.

Mississippi: Vessel license is based on length; bait shrimp boats and interstate vessels pay additional annual fees. No shrimp gear license required.

Alabama: Vessel license for Alabama residents and non-resident shrimpers required unless there is reciprocal agreement with state of their residence; gear license is based on length of trawl.

Florida: Vessels are registered according to size; permits are required for trawling but no charge is assessed. Alien and nonresident commercial fishermen are required to obtain license.

Season

Texas: Inside waters in major bays are open May 15 to July 15 and August 15 to December 15. Outside waters are normally closed June 1 to July 15, subject to 15-day alteration in opening and closing. White shrimp may be caught during the closed season at zero to four fathoms during the day.

Outside waters are also closed December 16 to February 1. During the closed season seabobs may be harvested during the day, but catch can contain no more than ten percent of other species. Zero to seven fathoms at night closed year round.

Louisiana: For inside waters, the spring season opens no later than May 25 and continues for at least 50 days or until technical data indicate a closure is needed to protect newly recruited white shrimp; however, at least one zone must have a 50 day-open season. Fall season opens the third Monday in August and closes December 21. Commission may set special seasons. No closed season in outside waters.

Mississipi: The season opens first Wednesday in June, dependent on shrimp size of sample catch, and usually runs from the second or third week of June until December 1 unless declared otherwise.

Alabama: Closed from late April to mid-June, depending on samples.

Florida: Season varies according to area.

Restricted Waters

Texas: All passes to and from outside waters are closed to trawling. Shrimping in inside waters is limited to major bays and bait bays as defined by law. Other inside waters are classified as nursery areas and no shrimping is allowed.

Louisiana: State and federal wildlife refuges, Bayou Judge Perez, and sanctuaries in Lake Pontchartrain and Lake Catherine are restricted waters.

Mississippi: Commercial shrimping is forbidden within one-half mile of mainland from Mississippi-Alabama line west to Bayou Caddy, off Gulf Island National Seashore, and in all bayous with the exception of two pipeline ditches in Hancock County. (Shrimping within the one-half mile sanctuary is limited to licensed live-bait dealers.)

Alabama: All rivers, streams, bayous, creeks, and portions of bays designated as nursery areas are restricted. No shrimping is allowed within 200 yards of the beach off Dauphin Island and Mobile Point from May 5 to September 15.

Florida: Portions of Santa Rosa Sound, Tortugas shrimp bed in Florida waters, and that portion of the Tortugas shrimp bed in the FCZ are closed to Florida residents. Other areas are subject to local seasonal restrictions. Certain areas designated as state parks or recreational areas are closed to commercial fishing.

3.3.1.2 Consistency Requirements of Coastal Zone Management Act

Consistency provisions of the Coastal Zone Management Act require a Council, in preparation of a fishery management plan, to address and consider the extent of fishing within state waters, on the premise that good management principles "require that the FMP address an individual stock of fish as a unit throughout its range, including its presence within state waters." Councils should "make every effort to coordinate their FMP development activities with the state coastal zone agencies."

3.3.2 Management and Regulation of Foreign Fishery

The present extent of the U.S. fishery conservation zone in the Gulf of Mexico is defined on the basis of two treaties on maritime boundaries, one with Mexico and the other with Cuba. Both treaties are now pending Senate advice and consent to ratification. In the meantime, the maritime boundaries specified in the treaties are being applied provisionally.

Access to the FCZ for foreign shrimp fishermen must be predicated on an available surplus of shrimp in excess of the U.S. harvesting capacity, as well as a Governing International Fishery Agreement (GIFA) with their home country. Likewise, for U.S. shrimp fishermen to gain access to the zones of exclusive fisheries jurisdiction of Mexico or Cuba, there must be a surplus over the harvesting capacity of the domestic fishermen involved. Cuba has a GIFA with the United States effective September 26, 1977. However, the MFCMA does not permit allocations to the fishermen of either country unless a shrimp surplus is determined.

The current U.S.-Mexico Fisheries Agreement as discussed in Section 3.2.3 allows for no access to shrimp by U.S. fishermen in Mexico's fishery zone. The United States continues to negotiate with Mexico in an effort to obtain some form of shrimp access. U.S. fishermen have no access to fish or shrimp in the Cuban fishery zone. The U.S.-Cuba Convention for the Conservation of Shrimp was terminated on April 28, 1978, after being in force twenty years.

3.4 History of Research

Other than the work of Percy Viosca and various annual reports by the Gulf states, little was recorded about Gulf shrimp until the 1930's. During the 1930's, the various Gulf states and the U.S. Bureau of Commercial Fisheries initiated a series of intensive studies on the life history of white shrimp (Lindner and Anderson, 1956). These mark-recapture and associated studies provided the basis for our knowledge of Gulf shrimp as well as providing a model for subsequent studies and an initial group of fishery scientists knowledgeable about Gulf shrimp and their environment.

The history of research since that time is too extensive and diverse to summarize in this section. Indeed, this entire plan attempts to summarize only that portion of the research which is directly relevant to the mandates of MFCMA.

No articles were encountered which would indicate studies on U.S. Gulf shrimp had been supported by foreign countries.

3.5 Socioeconomic Characterization

3.5.1 Output of the Subject Domestic Reported Commercial Fishery

Measured by the value of shrimp at dockside, the shrimp fishery is the most valuable of all domestic fisheries, averaging 23 percent of the value of all fish and shellfish landed in the United States for the period 1964 through 1979. Translated into dollars, the 1979 fish and shellfish landings were worth $2,233,679,000. Shrimp accounted for $471,573,000; salmon, $412,776,000; and tuna, $158,387,000. The Gulf of Mexico commercial shrimp fishery in 1979 accounted for 80 percent of the dockside value of the U.S. shrimp landings and in terms of pounds of shrimp, the relative Gulf contribution is 61 percent of the U.S. shrimp landings.

3.5.1.1 Exvessel Value of the Catch

Exvessel value of Gulf of Mexico shrimp landings increased over six-fold between the late 1950's and the late 1970's (Table 3.5.1 and Figure 3.5.1). Although the overall trend in volume was upward for the twenty-two year period, most of the increase in value of landings was due to increases in exvessel prices. Since 1964 total value of shrimp landings only decreased in 1974. Between 1964 and 1970 total value increased steadily while after 1970 total value of shrimp landings increased dramatically. The overall trend in prices has been upward since 1967 causing most of the increase in total value. Prices generally moved in opposite direction than volume landed, causing the total value trend to be much smoother. Price movements changed direction in twelve of the twenty-two years, declining two years in a row only in 1958 and 1959 while increasing three years in a row during two periods.

Texas, with an average of 46 percent of the value of all Gulf of Mexico shrimp landings, has consistently had the largest exvessel value of all the Gulf states. Louisiana accounts for 28 percent of the average annual value of the landings. Florida ranks third at 15 percent of the total value. Value of shrimp landings increased in all states between 1958 and 1977 (Table 3.5.2). Average annual rate of increase in value of landings ranged from 5.2 percent for the Florida west coast to 16.6 percent for Alabama. Texas and Louisiana, the two most important states, averaged over nine percent per year.

Table 3.5-1. Total volume and value of U.S. Gulf of Mexico shrimp commercial landings, 1958-1980

Year	Heads-on pounds	dollars	Dollars per pound
	----------- 000	------------	
1958	173,354	63,871	.37
1959	193,503	50,348	.26
1960	205,725	57,631	.28
1961	133,795	43,650	.33
1962	141,726	60,557	.43
1963	203,116	63,539	.31
1964	179,032	62,695	.35
1965	195,237	70,907	.36
1966	179,230	82,973	.46
1967	225,731	90,575	.40
1968	204,024	95,829	.47
1969	200,429	101,062	.50
1970	230,474	108,186	.47
1971	227,376	136,274	.60
1972	228,941	164,101	.72
1973	182,206	171,854	.94
1974	186,211	138,042	.74
1975	170,084	178,227	1.05
1976	210,078	275,222	1.31
1977	265,903	296,785	1.12
1978	248,327	319,590	1.29
1979	206,564	377,642	1.82
1980	204,914	295,212	1.44

Source: Fishery Statistics of the United States and Fisheries of the United States.

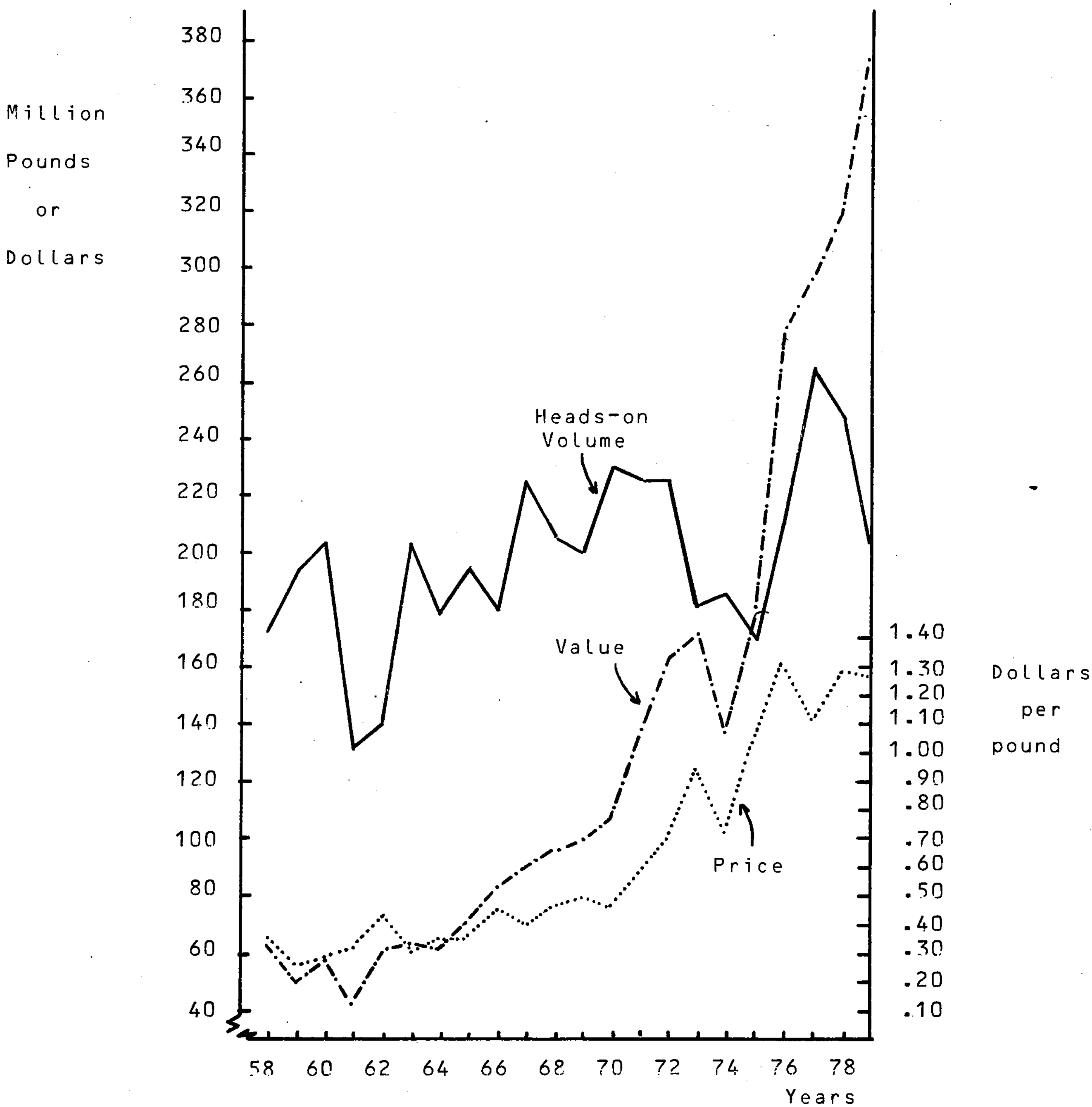


Figure 3.5.1.--Total volume and value of Gulf of Mexico shrimp landings and average ex-vessel prices, 1958-79

Area Distribution of the Value of the Catch

Figure 3.5-2 compares the average value distribution of the combined brown, white and pink shrimp catches from 1959 to 1975. Area 19 (the Freeport, Texas, grid) has the highest ex-vessel value. It has accounted for an average of 19 percent of the total value. Waters adjacent to Texas provide 42 percent of the average shrimp catch value. The value of the catch off Louisiana accounts for 36 percent of the total value; Florida, 11 percent; and Alabama and Mississippi each six percent.

A comparison of the value of landings (Table 3.5-2) and the average percent of the value of catch (Fig. 3.5-2) indicates some apparent differences, for example, Texas and Florida have larger percentage values in landings (see above) than are accounted for in percentage value of catch, whereas Mississippi and Louisiana have smaller values in landings than expected from the reported value of the catch. These differences reflect the mobility of much of the Gulf fleet. For example, until recently many vessels from Florida and Texas, because of their proximity, had shrimped off Mexico and landed a portion of their catch in the United States. Some vessels from Florida often migrate north in the spring and summer to fish off Mississippi and Louisiana and then Texas. Vessels from Louisiana frequent the shallow waters off Galveston, Texas, fishing for white and brown shrimp. Texas boats may fish off Louisiana during the Texas closed season in June and part of July. Alabama's Bayou La Batre vessels have the capability to "roam" the Gulf in search of shrimp, though they are larger than the average sized vessel in the northern Gulf.

Harvesting regimes exert a substantial influence on exvessel value. Texas regulations, for example, result in much greater landings of larger-sized shrimp than do those of Louisiana. A 1958-1975 study showed Texas prices for brown shrimp to be 1.6 times that of Louisiana brown shrimp, and 1.2 times that of white shrimp (Caillouet and Patella, 1978).

Although there have been variations in the relative importance of the exvessel value of brown, white, and pink shrimp, the brown shrimp is the most valuable, accounting for 52 percent of the total value of all species from 1958 to 1967 and for 56 percent of the total value from 1968 to 1977. White shrimp are the second most valuable species. The relative position of white shrimp increased from 25 percent of the total value in the 1958-1967 period to 30 percent of the total value during the 1968-1977 period. The percentage of total value of Gulf shrimp catch attributable to pink shrimp has fallen from 21 percent in the 1958-1967 period to 13 percent for 1968-1977.

Approximately 57 percent of the annual value of the brown shrimp catch is from Texas, 28 percent from Louisiana, and the remaining 15 percent from Mississippi, Alabama, and Florida (Fig. 3.5-3).

Louisiana waters furnish 61 percent of the value of the white shrimp harvest, Texas 30 percent, Mississippi five percent, Alabama three percent, and Florida one percent (Fig. 3.5-4).

The Florida catch accounts for 97 percent of the total pink shrimp value (Fig. 3.5-5). The Dry Tortugas area accounts for 70 percent of this value. Seabob are concentrated in the Atchafalaya River area of Louisiana (Fig. 3.5-6). These waters furnish 92 percent of the value of the catch. Texas adds four percent and the remainder comes from areas east of the mouth of the Mississippi (Fig. 3.5-6). Florida accounts for 98 percent of the rock shrimp exvessel value (Fig. 3.5-7). The royal red fishery is concentrated in two areas (Fig. 3.5-8): the Dry Tortugas catch is 45 percent of the total value, while the catch off the Mississippi Delta is 42 percent of the value.

Price Structure and Sensitivity by Size Distribution of the Catch

The price per pound of shrimp varies in direct proportion to size. There are significant price differences between size groups of shrimp. Price differentials play a key role in the substitution of

Table 3.5-2. Exvessel value of shrimp landings by state

Year	Florida West Coast	Alabama	Mississippi	Louisiana	Texas
	--------------------	--------------------	1,000 dollars	--------------------	--------------------
1958	16,312	1,984	2,377	13,533	29,665
1959	9,752	1,991	2,345	13,067	23,193
1960	12,155	2,090	2,899	15,881	24,606
1961	11,094	1,154	1,281	8,913	21,208
1962	14,556	1,647	2,220	14,985	27,149
1963	12,256	2,419	2,484	19,789	26,591
1964	13,322	2,630	1,805	18,794	26,144
1965	13,905	3,654	2,523	19,584	31,241
1966	12,427	4,920	2,751	24,390	38,485
1967	10,476	6,049	3,122	24,573	46,355
1968	12,695	7,964	3,677	25,623	45,870
1969	12,021	8,788	4,011	33,358	42,884
1970	13,108	8,040	3,810	34,614	48,614
1971	12,985	11,451	4,362	43,285	64,191
1972	17,309	14,661	4,966	47,066	80,099
1973	22,601	14,165	3,698	44,511	86,879
1974	21,445	13,490	3,225	32,203	67,679
1975	27,799	17,843	3,825	40,968	87,902
1976	36,842	30,393	8,418	79,688	119,881
1977	39,971	33,487	10,113	87,183	125,620
	--------------------	--------------------	percent	--------------------	--------------------
Average Annual change for 1958-1977	5.2	16.6	6.5	9.5	9.1

Source: Fishery Statistics of the United States.

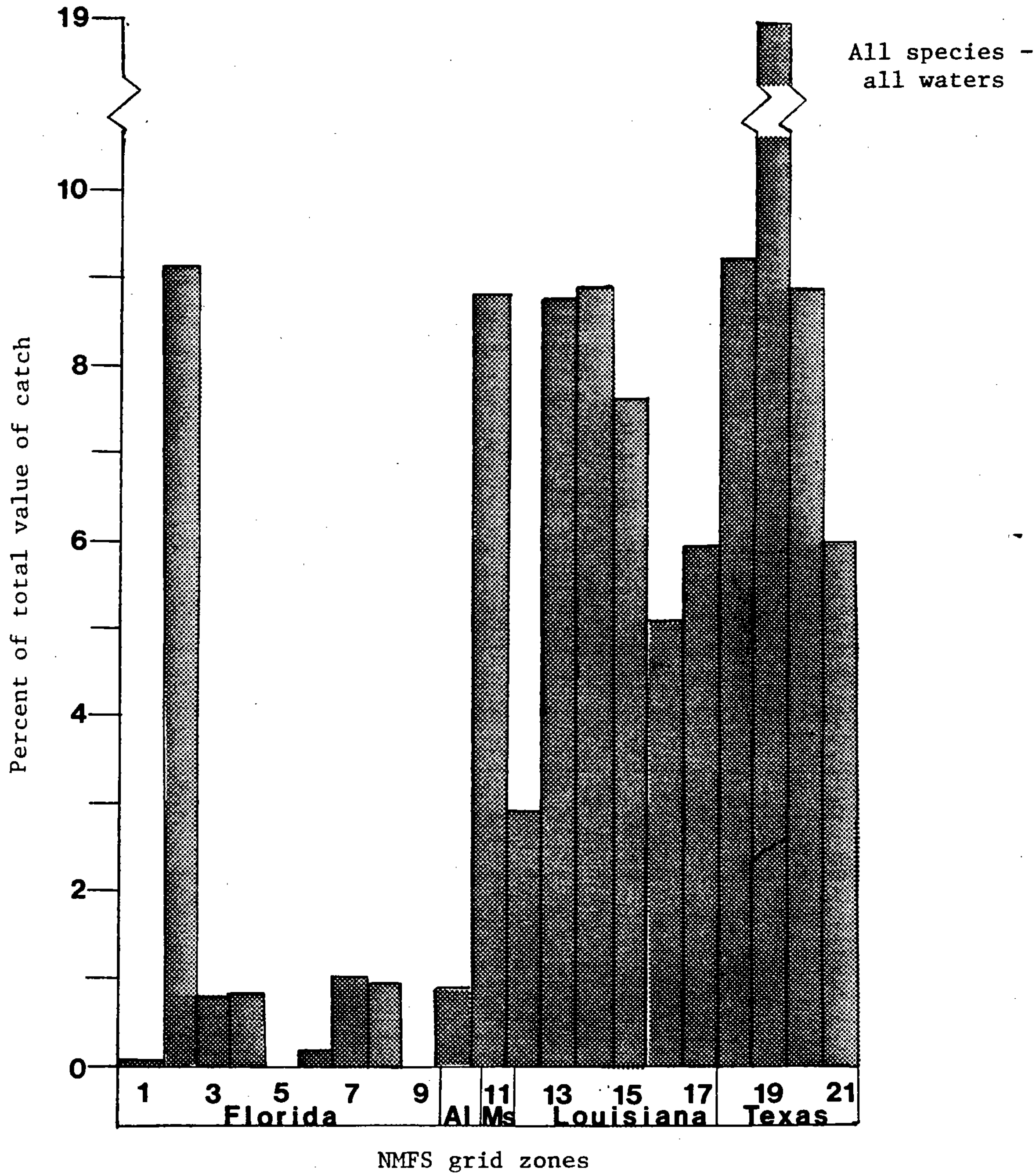


Figure 3.5-2. Average percent of total value of the Gulf catch for all species 1959-1975 by area (US Dept. Com., 1959-1975).

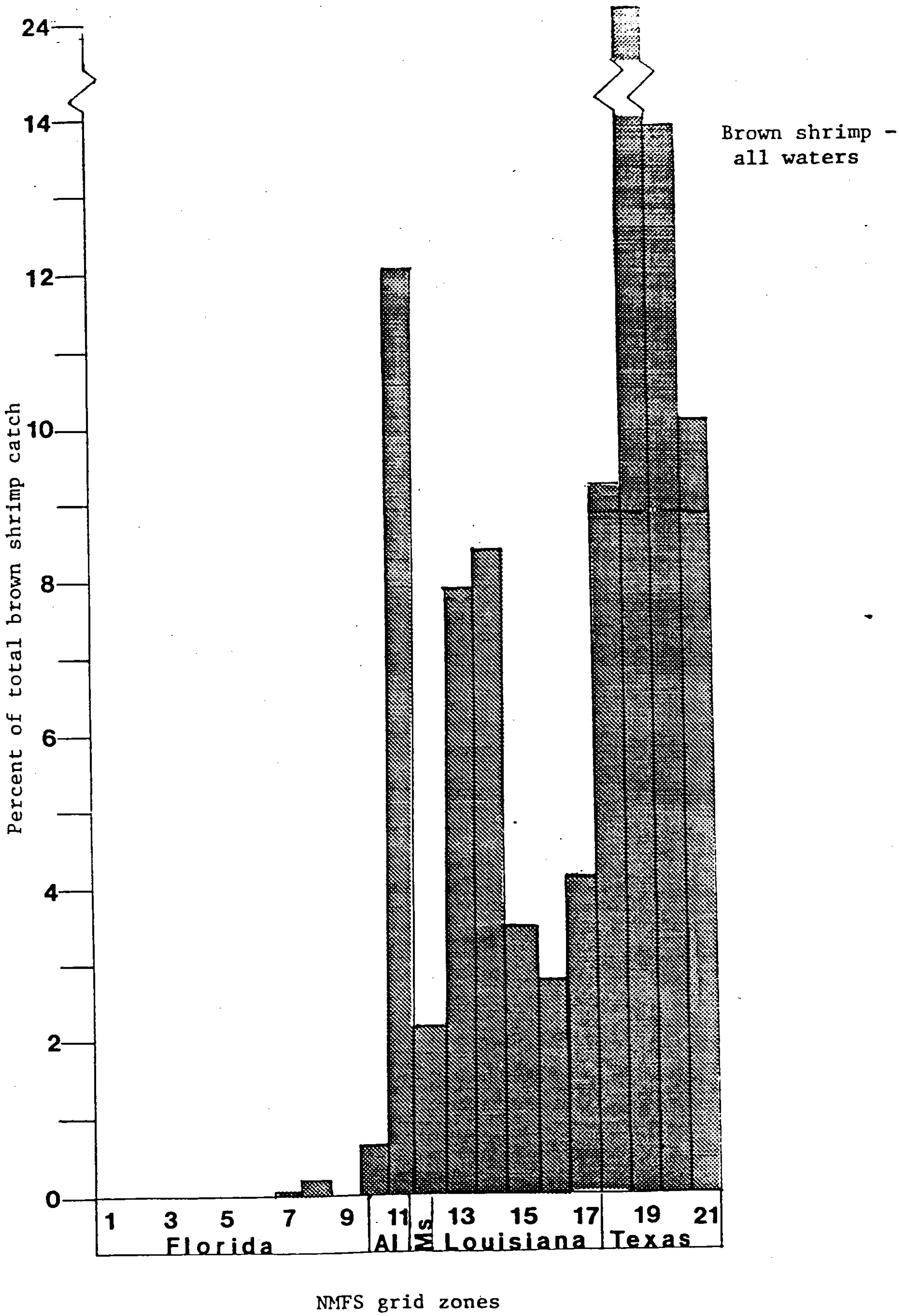


Figure 3.5-3. Average percent of the total value of the brown shrimp catch 1959-1975 by area (US Dept. Com., 1959-1975).

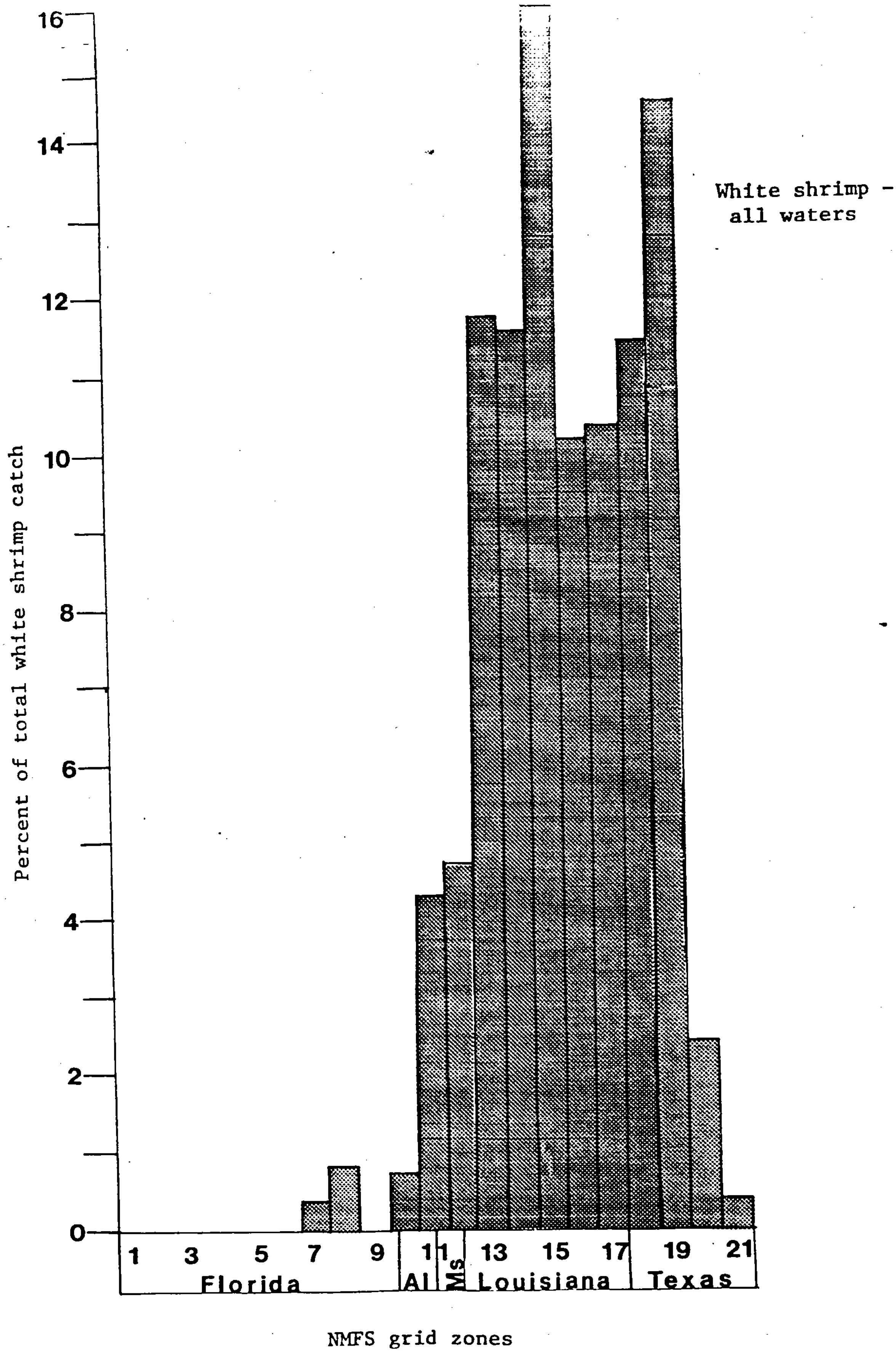


Figure 3.5-4. Average percent of the total value of the white shrimp catch 1959-1975 by area (US Dept. Com., 1959-1975).

certain sizes for others into various products such as breaded shrimp, fresh-frozen, and specialty items. This price structure appears to be partially sensitive to changes in the size distribution of the catch (Toevs and Johnson, 1978).

Larger shrimp are consumed primarily through restaurants, while mediums are sold to breaders, fresh seafood retailers, canners and other processors. Small shrimp are often processed into canned, dryed or specialty products.

A more recent study (Chui, 1980) also indicates an existance of separate markets by size of Gulf shrimp; large (under 30 count), medium (30 to 50 count), and small (over 50 count). Exvessel demand for shrimp was concluded to vary significantly by size of shrimp. Demand is higher for the larger sizes of shrimp and with the exception of small shrimp, the larger the size the greater the price response to changes in supply. Price responsiveness was, however, shown to be small within regions of the Gulf: eastern, northern and western Gulf.

3.5.1.2 Wholesale Value of the Product

Total value of processed shrimp products more than doubled between 1971 and 1977, increasing from \$253.7 million to \$528.9 million (Table 3.5-3). Texas has consistently been the leading state, with Florida's west coast second. In percentage terms, Alabama has had the largest growth rate while the Texas growth rate was the smallest.

Frozen raw headless is by far the most important processed product form accounting for 55.9 percent of processed shrimp products in 1976 (Figure 3.5-9). Breaded shrimp ranks second with 21.0 percent. Percentage production by states by product type is shown in Figure 3.5-10.

Wholesale price of processed products depends on exvessel prices, decrease or increase in product weight through processing, costs of marketing and processing and demand for the processed product. With the exception of exvessel prices, none of these parameters are reported on a consistent and continuous basis in published statistics. Wholesale prices computed by dividing volume of processed product into value of processed products are an estimate of value per unit of product as it leaves the processors establishment.

Wholesale prices increased for all processed products between 1958 and 1978 with the largest percentage increase for raw headless at 7.5 percent annually (Table 3.5-4). Annual wholesale prices vary widely because of exvessel prices, processing costs and demand shifts. Exvessel price variations are probably the most important factor determining variation in wholesale prices. Breaded raw products have consistently been the lowest valued products per pound since 1961. Required pounds of heads-on shrimp per pound of processed product are: 1.58 pounds, raw headless; 2.04 pounds, raw peeled, 1.0 pounds, breaded raw; 3.13 pounds, peeled and cooked; 3.21 pounds, canned; and 7.69 pounds, dried (based on conversion factors in Fishery Statistics of the United States). Multiplying these factors by the exvessel price gives the cost of raw product per unit of processed product and is referred to as the raw product equivalent price. This component is the largest part of the wholesale price. Wholesale price variation is then expected to vary directly with exvessel prices and the amount of variation is directly related to the conversion factor. Percentage of wholesale price variation is greatest for products utilizing a high ratio of shrimp to processed product.

The difference between the raw product equivalent price and the wholesale price is the marketing margin. This imputed marketing margin covers transportation, processing costs and profits to processors. Marketing margins were imputed for raw headless, breaded raw, and cooked and raw peeled processed shrimp products (Table 3.5-5). These margins were estimated by subtracting the imputed raw product equivalent prices from the wholesale prices. The raw product equivalent prices were estimated by multiplying the conversion factors discussed above by average exvessel Gulf of Mexico shrimp prices reported in Table 3.5-1.

Table 3.5-3. Wholesale values of processed shrimp for Gulf of Mexico states

State	1971	1972	1973	1974	1975	1976	1977
	millions of dollars						
Florida, W.C.	70.2	70.9	80.0	69.5	83.3	133.2	150.9
Alabama	11.6	23.2	30.7	20.3	28.9	59.0	68.3
Mississippi	12.7	13.7	15.7	16.9	15.7	26.9	40.0
Louisiana	65.7	64.8	76.9	72.4	64.1	95.6	125.4
Texas	93.6	110.2	120.6	80.7	67.7	141.4	144.2
Gulf Total	253.7	282.6	330.0	259.9	259.8	456.1	528.9

Numbers do not add due to rounding. Totals are correct.

Source: National Marine Fisheries Service, Processed Fishery Products Annual Summary (Washington, D.C.: Dept. of Commerce, various years).

Marketing margins for shrimp increased from $.18 per pound of processed product in 1958 to $1.20 per pound in 1978. The increase was fairly slow through 1972 at which time the margin was $.30. Substantial increases took place between 1973 and 1974 and between 1976 and 1977. A comparison of exvessel price movements from year to year with changes in marketing margins shows no overall negative or positive relationship. Marketing margins for breaded shrimp also increased over time but not as consistently nor as substantially. Marketing margins for breaded raw shrimp increased from $.30 per pound in 1958 to a high of $1.10 in 1977.

Marketing margins for peeled shrimp generally increased until the late 1960's but then declined throughout the 1970's. The negative imputed margins during the late 1970's may reflect the margin estimation procedure for this product. Raw product price equivalents may have been over stated if smaller than average size shrimp were used in the processed product or if lower valued imported shrimp were used for this processed product.

3.5.1.3 Domestic Marketing Channels

The marketing of shrimp from the vessels to consumer may be handled through a variety of channels with as many as 11 components (Figure 3.5-11). The usual participation is more limited, however, involving fishermen, wholesalers, processors, transporters, and retailers. Other seafood products are usually also handled by members of the shrimp marketing system.

Since shrimp may range from five to more than 200 tails per pound, size is the principal factor influencing market channels and use. Larger size shrimp usually go to restaurants; those in the 30 to 65 per pound range go principally to breaders, fresh seafood retailers, canners, and other processors. Smaller shrimp are used by canners, driers, and specialty producers. In recent years there has been a growing trend to use the full range of shrimp sizes for breaded, peeled, and stove-ready products.

Variation in use of marketing channels depends on many factors: shrimp size, processed form, location of processor, degree of industry concentration, source of raw shrimp, amount of imported shrimp used, and amount of foreign labor involved in processing. Area differences prevent extrapolation of the Alvarez, et al. (1976) study of Florida's marketing channels to the entire Gulf coast (Christmas and Etzold, 1977). A telephone survey of shrimp processors and middlemen in each of the Gulf states was conducted in the drafting of this plan. The survey revealed a general pattern of marketing channels, shown in Fig. 3.5-11. The bold lines in the figure indicate major channels.

Dealers

The dealer is the first middleman to take possession of the shrimp. He normally operates docking facilities with allied provisions for service and storage. His relationship with the fisherman is that of purchaser of shrimp and, on occasion, purveyor of fuel, ice, and supplies. But he may also offer financial services ranging from credit extension to maintenance of records for boats based at his dock. In this relationship there is usually an understanding that the shrimper's catch will be handled by the dealer; such a relationship may have a corrolary price impact.

Louisiana dealers surveyed reported purchasing shrimp on a regular basis from 80 to 120 craft, with the median about 110. Dealers may also get shrimp from other craft on a part-time basis; some operate craft of their own.

Among the dealer's functions are processing of shrimp for the market--heading, grading, packing, refrigerating, and storing. Some, especially in Louisiana, have operations for handling of heads-on shrimp for drying. The drying operations reduce loss of shrimp due to spoilage and permit the utilization of shrimp in periods of peak landings.

Table 3.5-4. Wholesale prices of Gulf of Mexico shrimp processed products, 1958-1978

Year	Raw[a] Headless	Raw[a] Peeled	Breaded[a]	Cooked[a] and Peeled	Canned[b]	Dried[a]
1958	.76	1.06	.67	1.89	10.38	1.41
1959	.59	.82	.62	1.54	8.89	.90
1960	.61	.98	.63	1.64	8.29	1.12
1961	.76	1.09	.75	1.63	9.09	1.78
1962	.92	1.24	.81	1.93	10.43	1.61
1963	.72	1.18	.71	1.77	8.59	.84
1964	.82	1.16	.80	1.67	8.63	1.99
1965	.83	1.16	.80	1.67	9.63	1.99
1966	.96	1.32	.90	1.97	10.66	2.02
1967	.88	1.37	.85	1.92	10.21	1.65
1968	1.03	1.55	.94	2.39	10.92	1.90
1969	1.09	1.75	1.00	2.04	10.29	1.74
1970	1.04	1.45	.99	1.57	10.51	no data
1971	1.28	1.69	1.07	2.51	11.14	1.87
1972	1.44	1.90	1.24	1.95	13.28	2.42
1973	2.42	2.25	1.48	3.44	18.91	3.87
1974	1.74	1.80	1.44	3.11	16.25	2.72
1975	2.35	1.77	1.61	3.36	16.74	4.92
1976	2.79	2.67	2.02	3.82	19.74	3.81
1977	2.81	2.41	2.22	3.43	22.66	3.88
1978	3.24	2.32	2.15	3.08	21.92	4.00
	----------	----------	---------- percent	----------	----------	----------
Average annual increase	7.5	5.0	5.7	4.1	4.0	6.7

[a] Price per pound of finished product.

[b] Price per standard case of canned shrimp.

Source: Computed from Fishery Statistics of the United States and Current Fishery Statistics.

Table 3.5-5. Imputed marketing margins for selected Gulf of Mexico processed shrimp products, 1958-1978

Year	Raw Headless	Breaded Raw	Peeled	
			Raw	Cooked
	dollars per pound			
1958	.18	.30	.31	.73
1959	.18	.32	.29	.73
1960	.17	.35	.41	.76
1961	.24	.42	.42	.60
1962	.24	.38	.36	.58
1963	.24	.40	.55	.80
1964	.25	.36	.41	.51
1965	.26	.44	.42	.54
1966	.23	.44	.38	.53
1967	.25	.45	.55	.67
1968	.29	.47	.59	.92
1969	.30	.50	.73	.47
1970	.30	.52	.49	.10
1971	.32	.47	.47	.63
1972	.30	.52	.43	-.31
1973	.93	.54	.33	.50
1974	.57	.70	.29	.79
1975	.69	.56	-.37	.07
1976	.72	.71	0	-.28
1977	1.04	1.10	.13	-.08
1978	1.20	.86	-.31	-.96

Source: Estimated by multiplying conversion factors reported in text by average annual exvessel prices and then subtracting this value from wholesale prices.

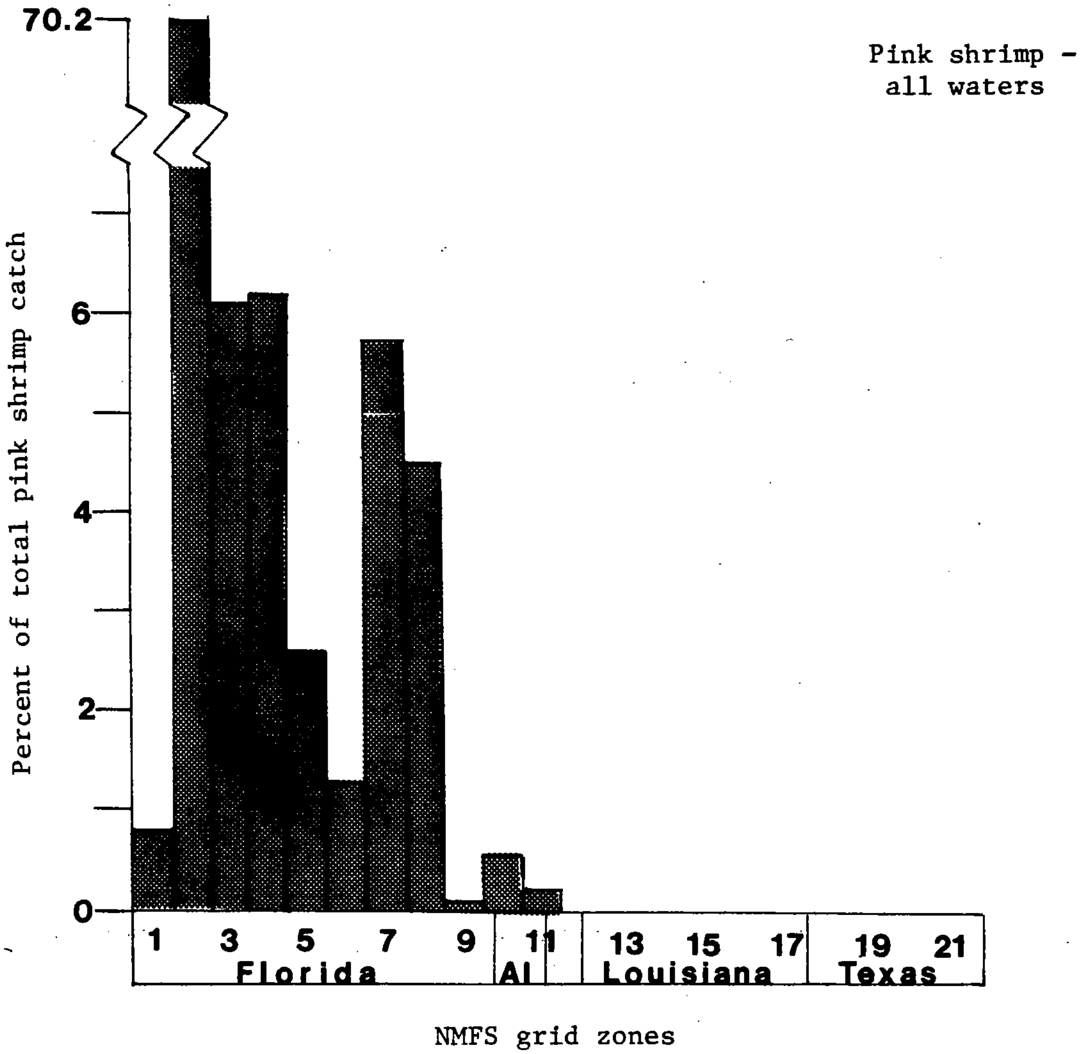


Figure 3.5-5. Average percent of the total value of the pink shrimp catch 1959-1975 by area (US Dept. Com., 1959-1975).

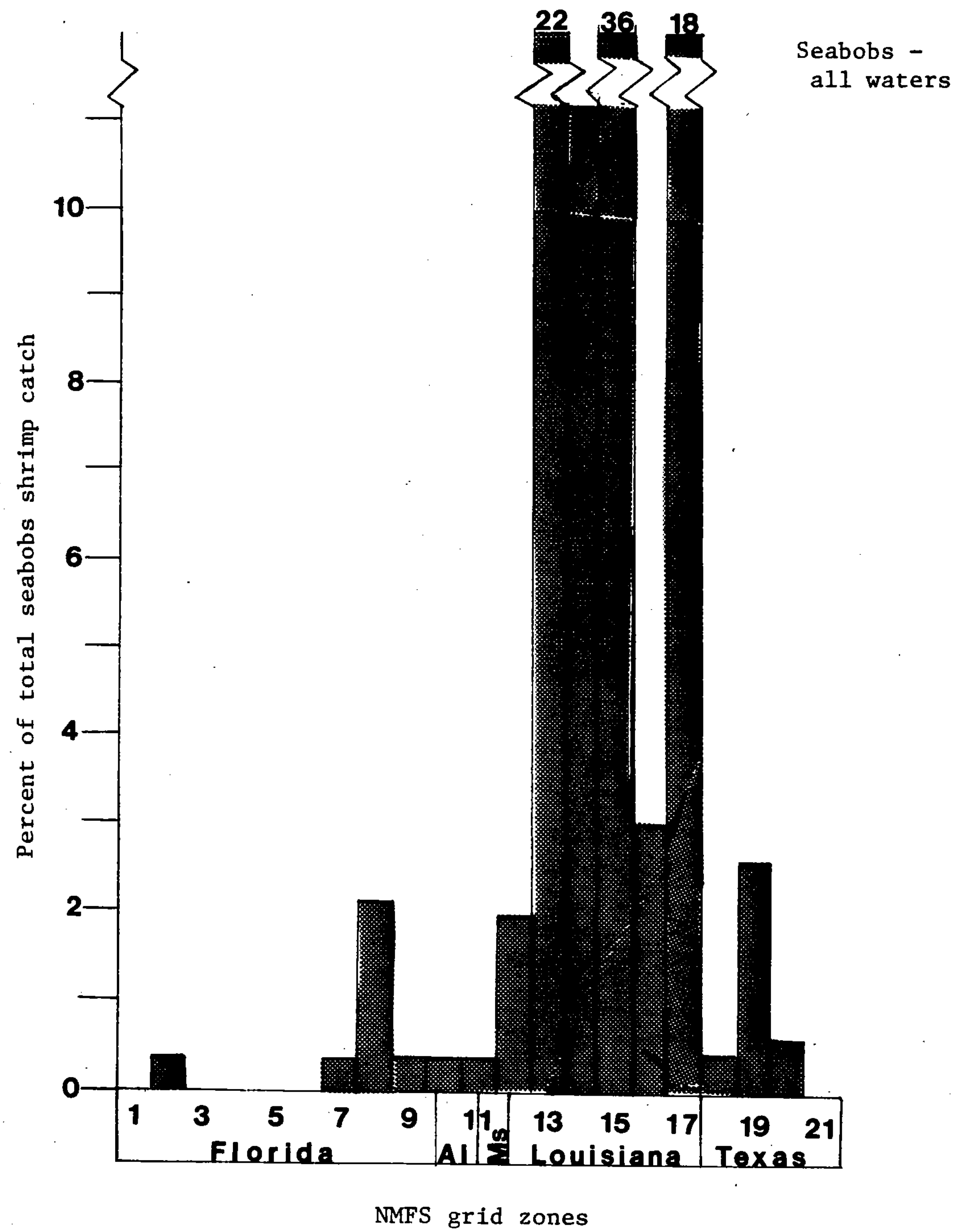


Figure 3.5-6. Average percent of the total value of the seabob shrimp catch 1963-1975 by area (US Dept. Com., 1963-1975).

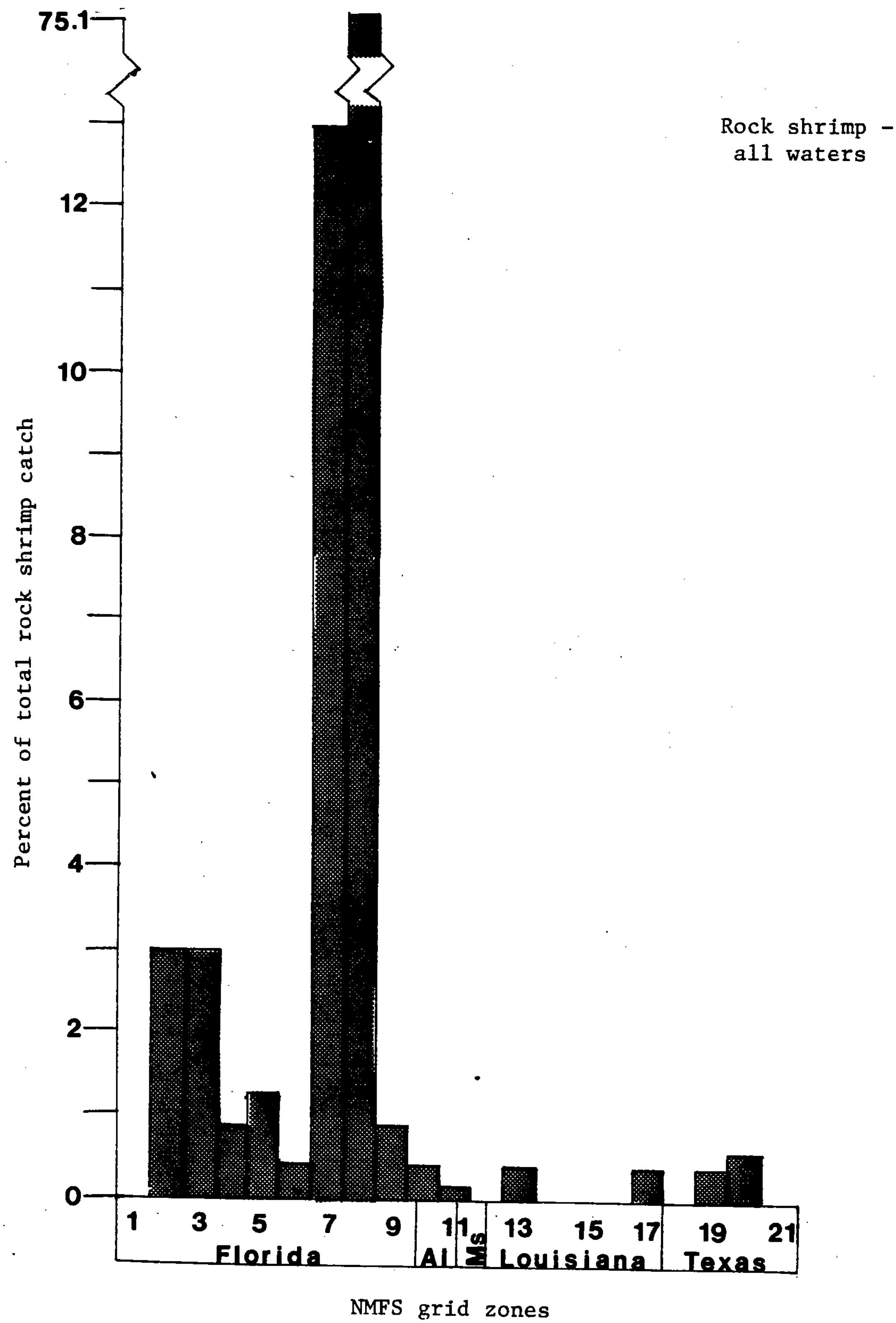


Figure 3.5-7. Average percent of the total value of the rock shrimp catch 1963-1975 by area (US Dept. Com., 1963-1975).

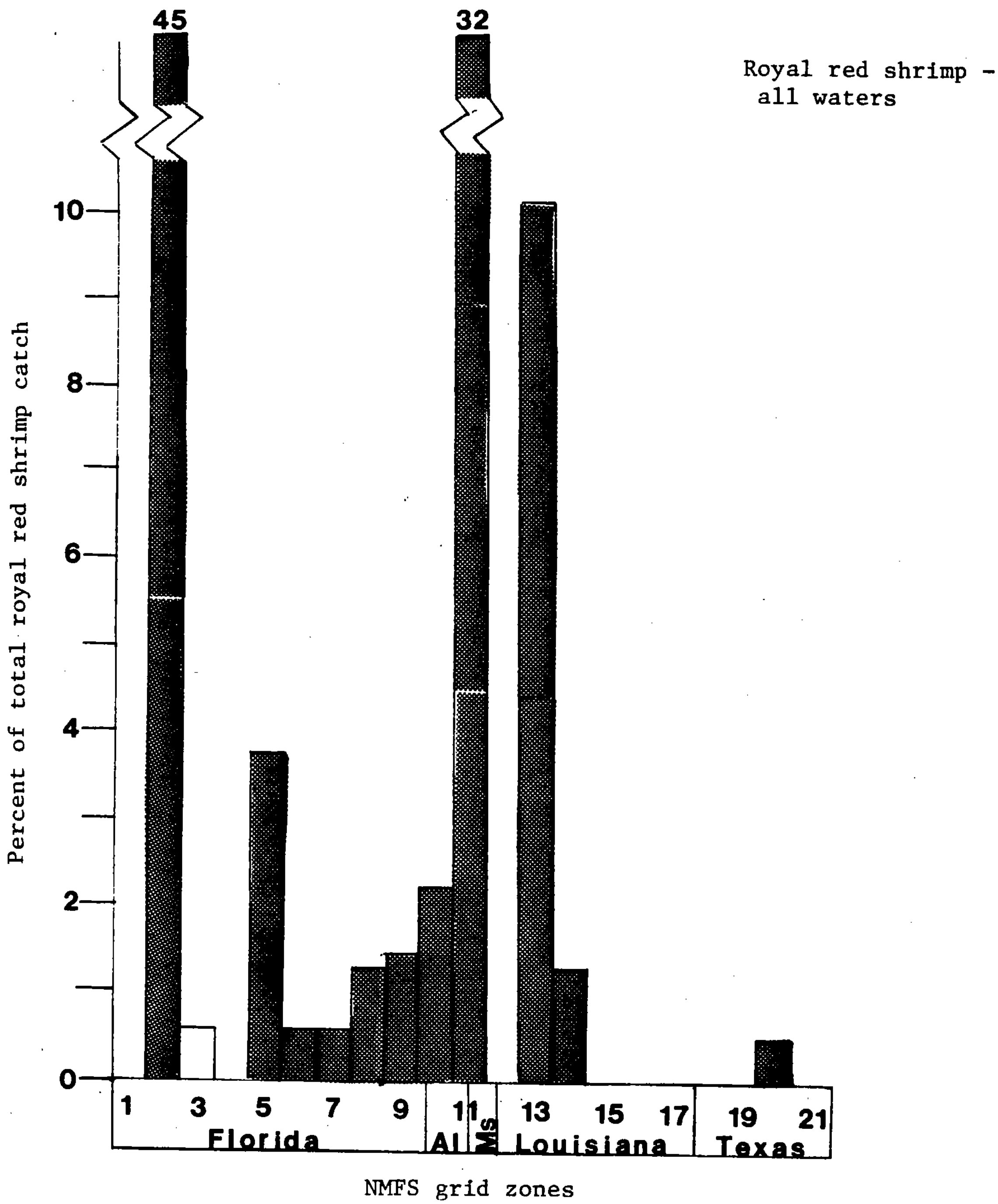
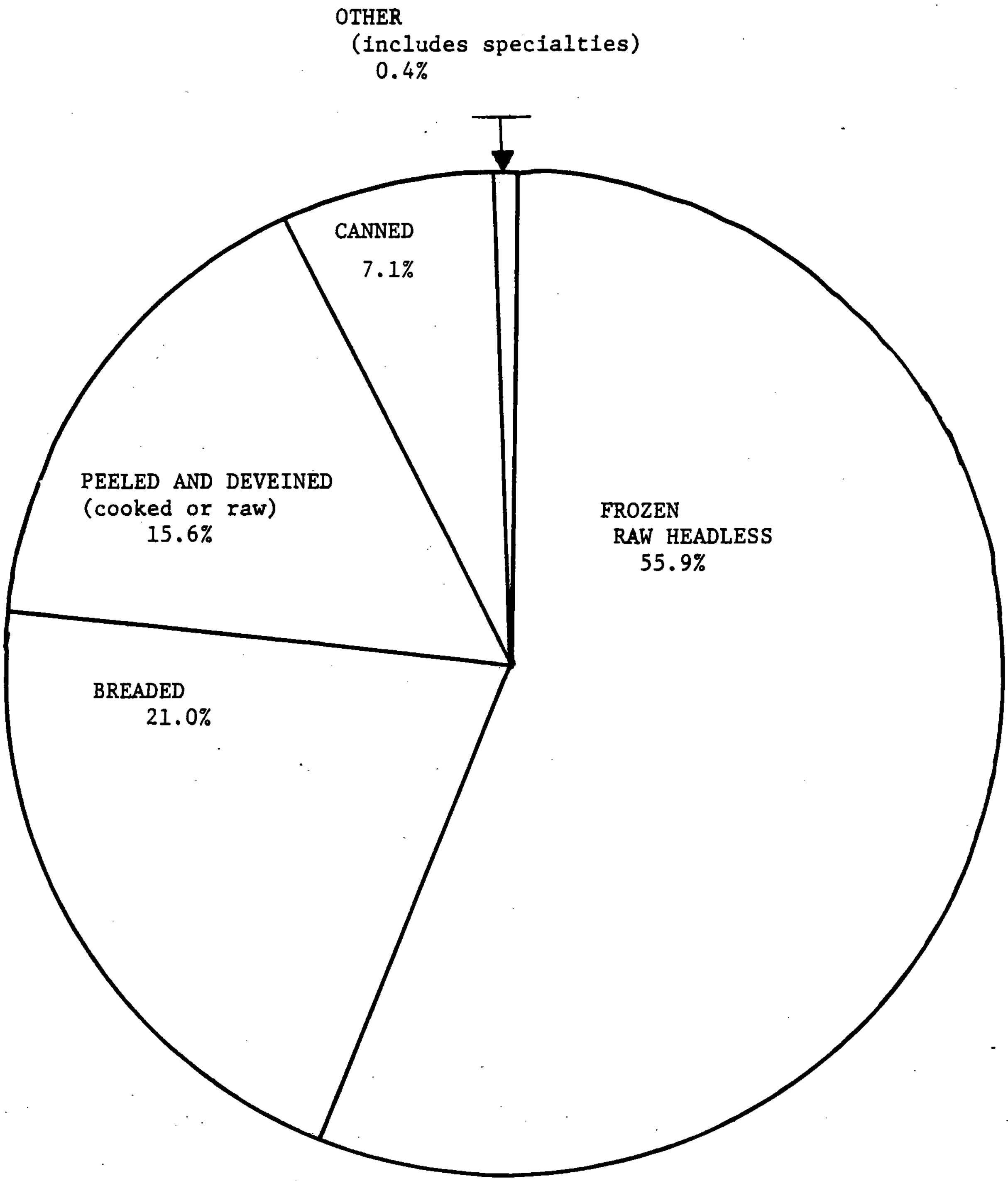


Figure 3.5-8. Average percent of the total value of the royal red shrimp catch 1963-1975 by area (US Dept. Com., 1963-1975).

Figure 3.5-9

Value of Shrimp Products of the Gulf States, 1976



NOTE: Some of the products may have been procesed from raw products imported from other states or from foreign countries.

SOURCE: National Marine Fisheries Service, Processed Fishery Products, Annual Summary, 1976 (Washington D.C.: Dept. of Commerce).

Dealer operations tend to be seasonal in nature. At peak periods the work force is augmented largely by women, teenagers, and members of the fishermen's families. The workweek can vary from three to seven days, and the working day can last from six to fifteen hours.

Most of the dealer's output is sold directly to processors; wholesalers also figure largely in this market. Dealers generally have up to 10 major customers and ship their output in their own trucks or with common carriers.

Processors

Processors are the shrimp companies engaged in peeling and deveining, cooking, freezing, canning, breading, and preparing specialty products. Some also deal in green headless shrimp, requiring no processing.

In the southeast region, including the south Atlantic and the Gulf of Mexico shrimp fisheries, 69 percent of the processors are single facility corporations; 25 percent are either corporations with branches or divisions of parent corporations. Nearly half of the individual corporations are family owned; six percent of all southeastern processors are partnership operations.

The shrimp handling and processing industry is expanding in total volume, but the rate of withdrawal of individual firms exceeds the rate of new entrants. A shortage of domestic landings appears to put a severe constraint on the entrance of new firms and the expansion of existing ones. Major factors contributing to the shrimp shortage are: (1) the decline in U.S. landings of shrimp-caught in Central and South American waters, and (2) the current exploitation of the major domestic Gulf stocks at their MSY levels. An example of the decline in U.S. landings from foreign waters is Florida's landings of Campeche shrimp, which have declined from a high of more than 30 million pounds in 1953 to two to three million pounds annually (1970-1975).

There are an increasing number of processors who maintain their own fleets or dockside facilities. Others continue to depend on dealers for their shrimp supplies. Due to the seasonal nature of the shrimp catch, processors carry large raw product and frozen finished product inventories. Unlike dealers, processors tend to operate their plants throughout the year. Market forms of processed shrimp include breaded, frozen, canned and specialty products (dried, pastes, sauces, and convenience (dishes).

Brokers and Wholesalers

Brokers act as an intermediary between the buyers and sellers of shrimp products at the various marketing levels, usually from the various marketing levels, usually from the processor level on up. The biggest use of brokers is in interstate and international contracts and sales, promotion of new products, and establishment of business contacts for new firms.

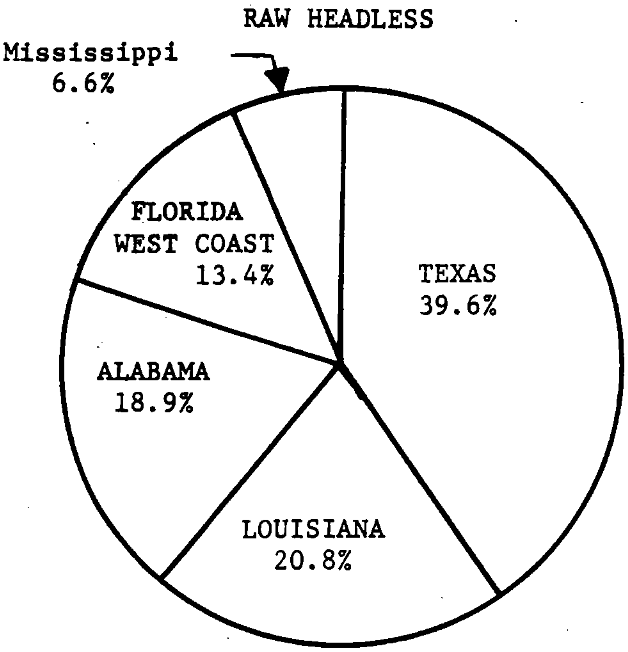
Wholesalers also act as intermediaries in the marketing system. They take possession of shrimp products and provide storage and transportation functions for firms in the industry, thereby creating benefits and economies for all firms.

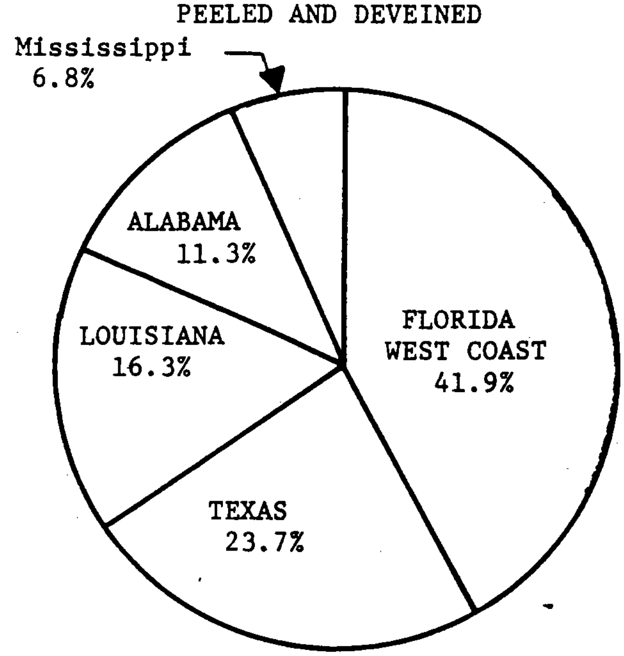
Marketing

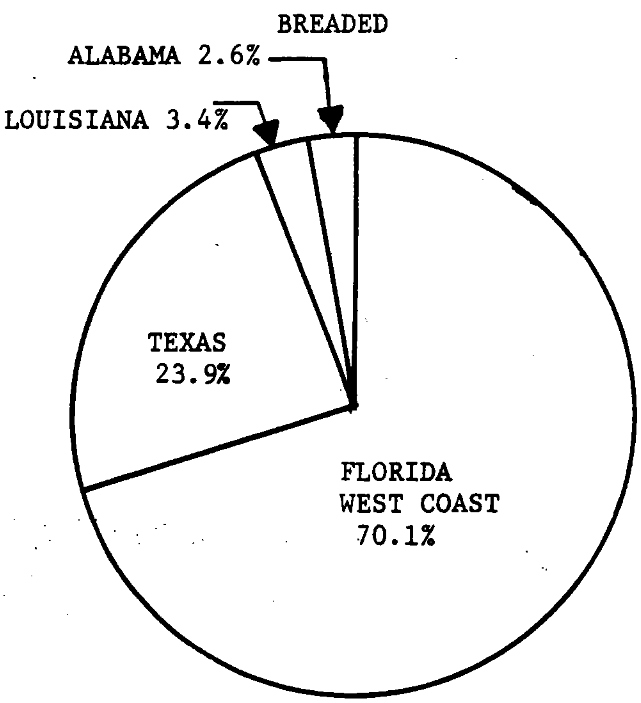
Channels used to market processed shrimp products vary from firm to firm. Some processors have their own distribution channels--such as an organization of sales representatives or a subsidiary seller--while many other firms almost exclusively employ brokers to sell their products. Though net flows cannot be given, most processors do not limit their geographic marketing territories as much as dealers do; indeed, most processors sell on a national or at least regional basis, and many of them export shrimp, primarily to Canada, Mexico, and Japan. Tables 3.5-6 through 3.5-8 provide data on U.S. exports for 1977. Data on exports by Gulf processors are unavailable.

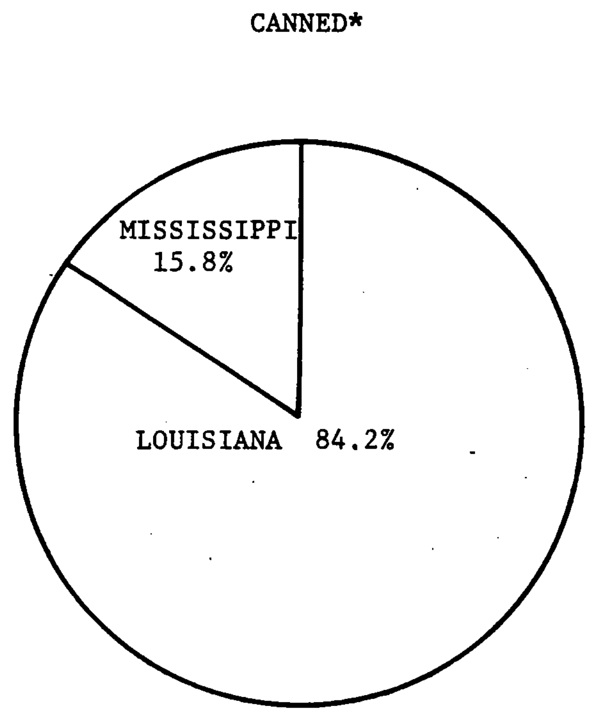
Figure 3.5-10
Percentage of Value Production, by States, of the Major Gulf Shrimp Products

(Percentage figures based on wholesale dollar values)









*All other states combined produce less than one percent.

SOURCE: National Marine Fisheries Service, Processed Fishery Products, Annual Summary, 1976 (Washington D.C.: Dept. of Commerce)

Figure 3.5-11
Major Marketing Channels for Shrimp Products

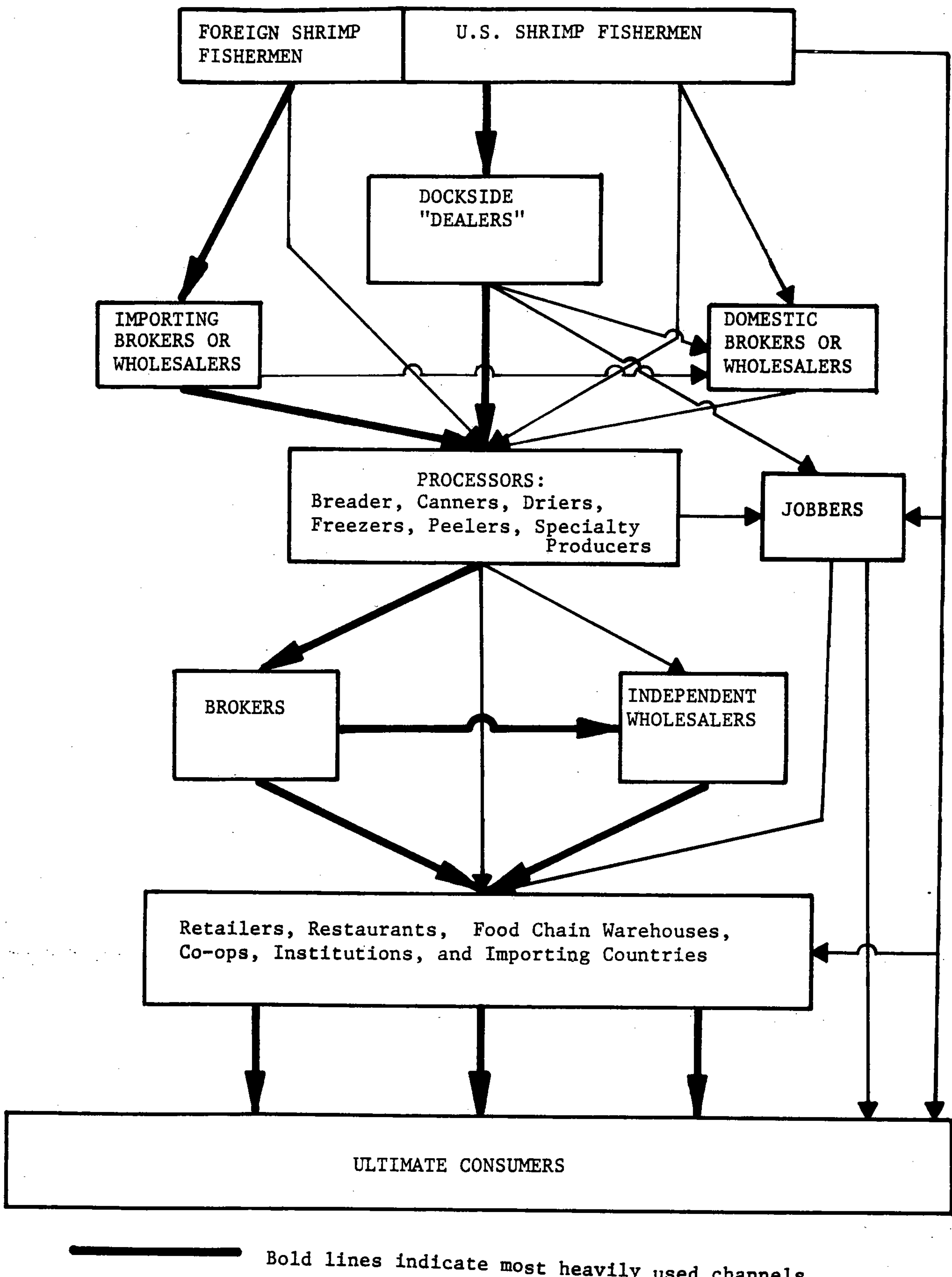


Table 3.5-6. United States Export of Domestic and Foreign shrimp Products (Fishery Statistics of the United States, 1977).

Item	Percent of Total: Pounds	Percent of Total: Dollars	Quantity: Thousand Pounds	Quantity: Thousand Dollars
Fresh and frozen:				
Domestic	74.6	69.5%	26,089	$60,731
Foreign*	25.4	30.5	8,902	26,643
Total	100.0	100.0	34,991	87,374
Canned:				
Domestic	99.5	99.2	8,966	18,066
Foreign*	0.5	0.8	48	144
Total	100.0	100.0	9,014	18,210
Total:				
Domestic	79.7	74.6	35,055	78,797
Foreign	20.3	25.4	8,950	26,787
Total	100.0%	100.0%	44,005	$105,584

* Foreign shrimp exports are shrimp exported out of the United States that were of foreign origin - prior to processing.

Table 3.5-7. Exports of Domestic Fresh and Frozen Shrimp. by Country of Destination (Fishery Statistics of the United States, 1977).

Country	Percent of Total: Pounds	Percent of Total: Dollars	Quantity: Thousand Pounds	Quantity: Thousand Dollars
Canada	33.1%	33.9%	8,634	$20,610
Mexico	33.8	31.3	8,811	19,003
Japan	18.1	19.7	4,718	11,957
Sweden	6.6	6.3	1,734	3,815
United Kingdom	2.4	2.4	630	1,474
Denmark	1.6	1.6	428	941
Bermuda	0.4	0.7	115	412
New Zealand	0.7	0.6	176	363
Netherlands	0.5	0.5	124	312
Other	2.8	3.0	719	1,844
Total	100.0%	100.0%	26.089	$60,731

Domestic per capita consumption of shrimp has increased at a rate of 2.8 percent per year (1960-1977), a remarkable increase given that shrimp prices increased by 600 percent while the Consumer Price Index increased by slightly more than 100 percent. Exceptions to this general increase in shrimp consumption are associated with a slowing in the growth of the U.S. economy (1961-1962, 1966, late 1973-1974) or with extraordinarily high increases in shrimp prices (1971, 1975). In addition, the energy crisis in 1974 was a factor in reducing important consumption in restaurants.

Shrimp is becoming a larger portion of the total seafood products consumed in the nation (1960-1977). A large part of this relative increase has come within the last few years despite a faster growing price for shrimp than for other processed fish products.

The socioeconomic characteristics of domestic consumers of shrimp were assessed in 1969 (U.S. Department of Commerce, 1973). An update of this data is necessary in order to evaluate what effect, if any, management of shrimp decisions may have on different types of consumers.

3.5.1.4 Imports and Utilization

The role of shrimp imports in the U.S. shrimp industry is substantial. This role can be examined from two sources. The first is from an analysis of secondary data that demonstrates how important shrimp imports are to U.S. supply, illustrates the source of imports and outlines the types of products imported. The second source is from past econometric studies that attempted to statistically measure the impact of imports on the domestic industry. These two sources are examined in the next sections.

3.5.1.4.1 Importance, Source and Type

The role of shrimp imports in determining the supply of shrimp is demonstrated in Table 3.5-9. The supply of shrimp in the U.S. annually is determined by beginning stocks, landings, imports, and exports. From 1960 to 1979, the total supply of shrimp in the U.S. has ranged from 289.6 million pounds in 1961 to the high of 618.8 million pounds in 1977. Supplies have always been over 500 million pounds since 1970. Supplies were high in 1974, fell in 1975, increased dramatically in 1976 and 1977 and then fell in 1978 and 1979. Supplies are in part influenced by the amount consumers are willing to take off the market. Another factor of late that has probably influenced supplies has been the high cost of financing inventories due to high interest rates. The ratio of imports to U.S. landings demonstrates the importance of imports. Between 1967 and 1976, the level of imports ranged from 106 to 119 percent of U.S. domestic landings (with the exception of 90 percent in 1971). However, the ratio was 94 percent in both 1977 and 1978 and 129 percent in 1979. Domestic landings were quite high in 1977 and 1978 and low in 1979 and 1980.

Apparent consumption of shrimp in the U.S. was the highest on record in 1977 and 1978. Apparent consumption fell to 407.2 million pounds in 1979, the lowest since 1971. The first-half year apparent consumption for 1980 is two percent below 1979 levels. The ratio of imports to apparent consumption was 65 percent in 1979, the highest ratio ever recorded. Per capita consumption fell to 1.85 pounds in 1979, the lowest recorded since 1969. This represents a decline from the all time high of 2.244 pounds in 1977.

The ratio of total U.S. imports to Gulf of Mexico landings indicates that during 1979, imports were more than double Gulf landings (208 percent). In the two previous years the ratio was 163 and 154 percent. From 1973 to 1976 the ratio had been between 200 and 228 percent. It is clear that imports are an important supply source to the U.S. shrimp industry. Comparing the 1960's to the 1970's, imports, U.S. landings and apparent consumption have all increased.

In the first half of 1980, the supplies, consumption and prices of shrimp were down from 1979 levels according to the U.S. National Marine Fisheries Service (1980). Landings in the Gulf and south

Table 3.5-8. Exports of Domestic Canned Shrimp, by Country of Destination, 1974.

Country	Percent of Total		Quantity	
	Pounds	Dollars	Thousand Pounds	Thousand Dollars
Canada	70.7%	72.4%	6,340	$13,076
Sweden	5.5	6.7	493	1,205
United Kingdom	6.0	4.7	542	845
Switzerland	3.3	3.2	293	582
Australia	4.1	3.0	368	536
Japan	3.9	2.9	345	526
France	1.9	2.3	169	417
New Zealand	0.9	0.8	82	151
Other	3.7	4.0	719	1,844
Total	100.0%	100.0%	8,966	$18,066

From National Marine Fisheries Service, Fisheries of the United States, 1977, (Washington, D.C.: U.S. Department of Commerce, April 1978).

Table 3.5-9. Supply and utilization of all shrimp in the U.S., annual, 1960-1979, with emphasis on imports. Hands-off weight.

	Supply				Utilization				Ratio of Imports to		
Year	Beginning stocks	U.S. Landings	Imports[a]	Total	Ending Stocks	Exports	Apparent Total	Consumption Per Capita	U.S. Landings	Apparent Consumption	Gulf of Mexico Landings
	million pounds							pounds	Percent		
1960	46.0	148.5	119.1	313.6	51.0	11.0	251.0	1.398	80	47	97
1961	51.0	103.9	134.6	289.6	26.2	14.6	248.3	1.357	130	54	169
1962	26.2	119.2	152.5	297.9	37.9	9.9	250.0	1.346	128	61	171
1963	37.9	150.7	167.3	355.9	55.8	20.4	279.6	1.483	111	60	130
1964	55.8	133.1	169.5	354.4	45.5	22.8	290.1	1.518	127	58	150
1965	45.5	152.3	179.0	376.8	38.2	22.0	316.6	1.636	118	57	147
1966	38.2	148.2	194.9	381.4	42.5	25.5	313.4	1.602	132	62	173
1967	42.5	190.0	202.1	434.6	57.6	34.9	342.1	1.732	106	59	143
1968	57.6	184.1	210.1	451.8	55.8	29.6	366.4	1.838	114	57	164
1969	55.8	195.0	218.7	469.5	62.5	47.4	359.5	1.785	112	61	173
1970	62.5	224.3	245.7	532.5	72.2	56.8	403.5	1.980	110	61	169
1971	72.7	238.1	213.9	523.2	69.9	57.5	396.8	1.924	90	54	149
1972	69.9	235.9	253.1	559.0	92.7	52.2	414.1	1.989	107	61	176
1973	92.7	229.4	229.3	551.4	79.0	67.7	404.7	1.924	100	57	200
1974	79.0	224.4	267.5	570.9	76.2	48.0	446.7	2.113	119	60	228
1975	76.2	207.6	231.0	514.8	47.4	47.2	420.2	1.972	111	55	215
1976	47.4	243.0	270.7	561.1	61.0	48.1	452.0	2.106	111	60	205
1977	61.0	287.4	270.4	618.8	80.2	52.9	485.7	2.244	94	56	163
1978	80.2	255.4	239.0	574.6	58.2	60.4	455.7	2.088	94	52	154
1979	56.2	206.9	267.1	530.2	77.5	45.7	407.2	1.85	129	65	208

[a] Almost all is fresh and frozen

Source: Shellfish Market Review, November, 1978. Last three columns calculated. Data for 1978-1979 from the Shellfish Market Review, November, 1980 (in print).

Atlantic were sharply lower. Imports were above first quarter 1979 levels but the lead declined as the quarter progressed and imports were sharply lower in the second quarter. High beginning inventories were drawn down to 1979 levels by the end of June, 1980.

Landings of shrimp in the Gulf and south Atlantic were 43 million pounds (heads-off) in the first half of 1980 which was 23 percent below 1979 levels. However, during later months gains were made that put landings closer to 1979 levels.

Total imports of shrimp were 92 million pounds (product weight) in the first half of 1980. This was eight percent below 1979 levels. The major drop was because of a restriction of imports of peeled raw shrimp from India due to actions by the FDA because of quality problems. Imports from Mexico were up slightly. Imports of shrimp by Japan through July, 1980, were 16 percent lower than in 1979. This decrease in world demand has also been a contribution to price problems in the U.S.

Beginning inventories in 1980 of 78 million pounds were 14 percent above the 1974-1978 average. Inventories on July 1, 1980 were 40 million pounds, seven percent above 1979 same period levels. Inventories normally drop to a seasonal low about July 1 and rise to a seasonal high about January 1. The steeper than normal inventory drop of 49 percent in the first half of 1980 was associated with low landings and imports and an effort to cut inventories to reduce carrying costs.

As discussed in section 3.5.2.3, beginning in late 1979 the price of 21-25 raw headless shrimp fell rapidly to a low of $3.82 in May, 1980. Prices increased again from June through August but fell again in October, 1980, due primarily to good late summer landings. Retail prices have remained high and did not fall to the same degree beginning in late 1979, as did exvessel prices and wholesale prices. This may explain the failure of consumption to improve from 1979 levels in the second half of 1979 and first half of 1980.

The primary type of shrimp imported into the U.S. are raw headless as shown in Table 3.5-10. In terms of product weight, raw headless shrimp represented 123.4 million pounds (55 percent), raw peeled, 86.1 million pounds (38 percent), canned, 4.2 million pounds (two percent) and other forms, 10.6 million pounds (five percent) of the total imports of 224.5 million pounds in 1979. These percentages have been fairly consistent the last few years.

The North American Continent continues to provide slightly over one-half of all shrimp imports into the U.S. as shown in Table 3.5-11. Mexico is the dominant supplier with about 35 percent of all U.S. imports. Panama, El Salvador and Nicaragua are the other major suppliers. The South American Continent supplied about 15 percent of U.S. imports from 1975-1979, down from almost 19 percent from 1970-1974. Ecuador, Columbia and Brazil were the major suppliers the last five years. Guyana, Venezuela, and French Guiana were major suppliers the first half of the decade. Imports from Asia increased from 26 percent of the total from 1970-1974 to 32 percent from 1975-1979. The major supplying country is India at almost 17 percent. Increases were seen for India, Indonesia, Thailand, Taiwan, Hong Kong and Bangledesh. Small amounts of shrimp are imported from the continents of Europe, Africa and Australia and Oceania.

3.5.1.4.2 Measured Impacts of Imports

As stated in the USITC (1976), shrimp imported into the U.S. have historically been free of duty. Under the Tariff Schedules of the U.S., shrimp are provided for under item 114.45. The duty-free status of peeled shrimp in airtight containers and other peeled shrimp if dried or cooked, but not breaded is bound as a result of concessions granted by the U.S. in the sixth round of trade negotiations (Kennedy Round) under the General Agreement on Tariffs and Trade. The duty-free status of shrimp in other forms is not bound. Imports that enter in the forms for which the duty-free treatment is bound account for only a small part of the U.S. imports of shrimp. A particular question to be answered

Table 3.5-10. U.S. imports of shrimp by product type, annual 1960-1979. Product weight.

Year	Raw Headless	Raw Peeled	Canned	Other	Total	Total Heads-off Weight
1960	93.0	18.1	a	2.3	113.4	119.1
1961	101.3	20.3	a	4.7	126.3	134.6
1962	108.6	24.7	a	7.9	141.2	152.5
1963	111.7	29.5	4.1	6.2	151.2	167.3
1964	112.1	27.4	3.0	12.0	154.6	169.5
1965	114.2	32.0	2.2	14.6	162.9	179.0
1966	129.9	37.2	1.5	9.8	178.5	194.9
1967	131.9	39.0	2.2	13.0	186.1	202.1
1968	128.0	47.5	4.3	9.7	189.5	210.1
1969	121.3	63.8	3.6	5.1	193.7	218.7
1970	140.0	69.5	3.9	5.4	218.7	245.7
1971	123.9	60.1	2.7	4.5	191.3	213.9
1972	126.8	90.1	1.1	5.2	223.2	253.1
1973	123.3	71.4	3.0	4.9	202.6	229.3
1974	132.0	83.2	6.1	7.7	228.9	267.5
1975	117.2	76.7	1.1	6.4	201.5	231.0
1976	129.7	86.4	2.3	11.3	229.8	270.7
1977	125.8	87.8	2.8	11.6	228.0	270.4
1978	101.3	83.1	2.7	11.0	198.0	239.0
1979	123.4	86.1	4.2	10.6	224.5	267.1

[a] Included in other

Source: <u>Shellfish Market Review.</u> November, 1978.

Table 3.5-11. Imports of all shrimp into the U.S. by country of origin, 1970-1979. (Product weight)[c].

Country[b]	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1970-1974 Average million pounds	1970-1974 Average percent of total	1975-1979 Average million pounds	1975-1979 Average percent of total
	---------- millions of pounds ----------													
North America														
Mexico	72.0	74.6	80.7	76.1	78.1	75.0	80.4	76.3	72.5	71.9	76.3	35.8	75.2	34.8
Panama	11.6	9.3	10.1	10.4	10.1	9.8	11.6	10.0	9.2	12.2	10.3	4.8	10.6	4.9
El Salvador	6.4	6.7	5.7	5.9	6.1	6.8	5.6	5.4	5.0	6.3	6.2	2.9	5.8	2.7
Nicaragua	6.0	5.6	6.6	6.1	6.4	6.2	6.5	7.4	5.6	5.4	6.1	2.9	6.2	2.9
Guatamala	2.9	2.3	1.3	3.0	2.9	3.6	2.7	3.8	4.2	3.6	2.5	1.1	3.6	1.7
Honduras	2.6	3.9	4.8	3.4	3.4	3.6	3.9	4.7	3.5	3.1	3.6	1.7	3.8	1.8
Others	9.1	5.6	4.9	5.3	5.6	4.3	4.9	10.8	4.3	4.6	6.1	2.9	5.8	2.7
Total[c]	110.6	108.0	114.1	110.2	112.6	109.3	115.6	118.4	104.3	107.1	111.1	52.2	110.9	51.3
South America														
Guyana	10.2	9.0	6.9	10.1	7.3	5.4	4.2	4.6	3.4	3.7	8.7	4.1	4.3	1.2
French Guiana	5.1	3.8	3.6	3.9	2.4	1.9	1.4	1.6	1.7	3.6	3.8	1.8	2.0	.9
Ecuador	6.0	5.3	6.9	7.5	6.2	8.1	9.4	8.6	10.9	13.7	6.4	3.0	10.1	4.7
Venezuela	11.6	10.1	8.0	5.7	6.5	4.9	5.8	2.8	1.3	2.3	8.4	4.0	3.4	1.6
Columbia	4.8	4.8	6.0	6.0	6.2	5.7	6.3	5.7	4.2	4.1	5.6	2.6	5.2	2.4
Surinam	2.6	2.1	2.1	1.9	1.6	3.1	3.8	3.7	2.0	1.5	2.1	1.0	2.8	1.3
Brazil	2.1	4.4	8.9	4.3	3.0	1.4	2.0	3.5	3.9	9.7	4.5	2.1	4.1	1.9
Others	1.2	.6	1.5	1.0	.5	.7	1.0	.9	.8	1.2	1.0	.5	.9	.4
Total[c]	43.6	40.1	43.9	40.4	33.7	31.2	34.0	31.4	28.2	29.8	40.3	18.9	32.9	15.2
Europe	1.0	1.1	1.2	1.1	.9	1.5	1.5	2.2	.7	1.9	1.1	.5	1.6	.7

Table 3.5-11. Imports of all shrimp into the U.S. by country of origin, 1970-1979. (Product weight)[c].

Country[b]	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1970-1974 Average million pounds	1970-1974 Average percent of total	1975-1979 Average million pounds	1975-1979 Average percent of total
	----------	----------	----------	----------	----------	millions of pounds	----------	----------	----------	----------				
Asia														
Indonesia	a	a	2.4	2.5	6.3	1.6	4.6	4.6	3.8	5.5	2.2	1.0	4.0	1.9
India	33.6	22.8	33.5	20.6	31.4	29.6	41.6	41.1	39.2	30.8	28.4	13.3	36.5	16.9
Pakistan	7.1	2.9	2.6	1.4	a	a	a	.8	.8	1.0	2.8	1.3	.5	.2
Thailand	3.6	2.0	4.0	2.9	3.7	2.7	3.2	4.2	3.9	10.6	3.2	1.5	4.9	2.3
China, Taiwan	.9	.9	6.0	5.4	5.3	5.6	5.1	3.6	3.2	7.9	3.7	1.7	5.1	2.4
Hong Kong	a	a	a	a	1.5	2.2	5.1	3.9	3.6	5.3	.3	.1	4.0	1.9
Bangladesh	a	a	.7	1.2	2.0	2.2	3.7	3.4	3.5	2.7	.8	.4	3.1	1.4
Other	12.9	6.5	10.8	12.9	23.9	12.5	11.9	11.0	5.5	9.4	13.4	6.2	10.1	4.7
Total[c]	58.1	35.1	60.0	46.9	74.1	56.4	75.2	72.6	63.5	73.2	54.8	25.7	68.2	31.5
Australia and Oceania	1.6	3.1	1.5	.6	4.8	.9	.8	.8	.2	1.2	2.3	1.1	.8	.4
Africa	3.9	4.0	2.5	3.4	2.8	2.3	2.7	2.5	1.3	1.4	3.3	1.6	2.7	1.3
Grand Total[c]	218.7	191.3	223.2	202.6	228.9	201.5	229.8	228.0	198.2	224.5	212.9	100.0	216.4	100.0

[a] No listed separately in original data source.

[b] The original data source usually lists about 45 countries. A country was listed separately on this table if at any time from 1970 to 1979 annual imports from that country exceeded 3.5 million pounds.

[c] Totals may not add due to rounding.

Source: Fisheries of the United States, Annual Issues.

should a tariff ever be levied on shrimp, is whether shrimp caught by U.S. vessels but landed in foreign ports and then shipped to the U.S. would be taxed. See USITC (1976) for a complete discussion of this point.

On November 17, 1975, the National Shrimp Congress filed a petition with the U.S. International Trade Commission for import relief pursuant to section 201 of the Trade Act of 1974. The USITC instituted an investigation to determine whether shrimp; fresh, chilled, frozen prepared, or preserved (including pastes and sauces), provided for in item 114.45 of the Tariff Schedules of the U.S., were being imported into the U.S. in such increased quantities as to be a substantial cause of serious injury or threat to the domestic industry producing an article like, or directly competitive with, the imported article. The USITC (1976) report indicates that before a cause of injury or threat of injury can be found that:

1. An article is being imported into the U.S. in increasing quantities.

2. That the domestic industry producing an article like or directly competitive with the imported article is being seriously injured or threatened with serious injury.

3. That such increased imports of an article are a substantial cause of the serious injury to the domestic industry.

Five of the six USITC commissioners participated in the finding of the commission. One commissioner found that shrimp; fresh, chilled, frozen prepared, or preserved was being imported in such increased quantities as to be a substantial cause of serious injury to the domestic shrimp fishing industry. The commissioner further found that from the information available that the shrimp items were not being imported in such increased quantities as to be a substantial cause of serious injury, or the threat thereof, to the domestic shrimp processing industry. The "domestic industry" was thus defined as two industries: (1) shrimp boats and (2) shrimp processors. Two other commissioners found that shrimp was being imported into the U.S. in such increased quantities as to be a substantial cause of serious injury to the domestic shrimp catching sector. These two commissioners did not address the impact on the processing sector. The remaining two commissioners found that increased imports of shrimp were not a substantial cause of any serious injury or the threat thereof, which the domestic shrimp fishing industry may be suffering. Further, they found that the domestic shrimp processing industry was not being seriously injured or threatened with serious injury. The overall determination was such that shrimp were being imported into the U.S. in such increased quantities as to be a substantial cause of serious injury to the domestic shrimp catching industry. Adjustment assistance to the industry was recommended.

Miller (1975) also discussed the role of shrimp imports. This discussion focused on the impact of shrimp imports at a time when the overall market for seafoods was declining. Miller (1975) indicates that the need and desirability for the U.S. to purchase substantial imports of shrimp has been amply demonstrated over the long run. Starting in the early 1960's, imports as a rule supplied slightly more than half the quantity of shrimp supplies in the U.S. The growing level of demand required these imports for satisfaction. Imports kept production lines busy in processing plants during the off season for U.S. shrimp fishermen. However, Miller indicated that beginning in 1970, the level of imports fluctuated widely and contributed to the volatility of U.S. domestic shrimp markets. The primary reason for this is reflected primarily through changes in competitive conditions for world shrimp supplies. Japan became a dominant competitor for shrimp during 1973. The Japanese bid away needed U.S. shrimp supplies which caused a sharp price increase. During 1974, Japanese demand softened, and the world shrimp catch was focused on U.S. markets which were soft. Major supplying countries such as Indonesia and Pakistan were forced to adjust accordingly. The impact of the world demand and supply for shrimp on the U.S. industry is never more readily apparent than today. This external factor impact on domestic prices, coupled with much higher energy costs and sluggish consumer demand have led to an unstable economic situation in the shrimp industry.

Doll's (1972) analysis of shrimp exvessel prices from 1950 to 1968 examined the influence of imports on domestic price. Doll points out that imports were about one-third the size of domestic landings in 1950 but began to increase rapidly in 1955 and have exceeded domestic landings in every year between 1961 and 1968 (the last year of data covered in his analysis). Doll's analysis suggested that during the study period imports had a larger direct impact on exvessel price than on wholesale price. Beginning shrimp stocks (first quarter) were found to have a larger effect on wholesale price, than on exvessel price. Imports entered throughout the year but were largest during the fourth quarter. Doll hypothesized that imports are placed in storage and sold during the first and second quarters when domestic landings are seasonally low. The effect of imports on wholesale price is thereby reflected through beginning stocks for the next year. Beginning stocks also have an important effect on exvessel price. Thus, over time, imports were estimated to have a lagged effect on both prices.

The principal objective of import restrictions on shrimp is to reduce supplies and thereby eliminate or lesson the negative price effects of imports. The analysis by Doll (1972) indicates that exvessel price levels are highly inversely sensitive to changes in the level of supplies and positively related to increases in consumer income. Doll (1972) stated specifically that exvessel prices were found to decrease as beginning stocks and landings increase, but to increase as income increases. The study also concluded that imports have a negative impact upon domestic prices. It was estimated that an increase in imports by one million pounds, (heads-off) would, if sustained for five years, reduce exvessel price by six cents per pound. This appears to be underestimated, however, because between the study period of 1950 to 1968, imports increased an average of nine million pounds per year.

Miller (1975) also outlined three questions which must be answered regarding raising domestic exvessel prices. These are (1) how much of a cutback in supplies is needed to bring about a desired change in exvessel prices, (2) how should a cutback be allocated, as between domestic production and imports and (3) what would be the impact of reduced supplies on consumer prices? The second question must be answered by political processes. Miller (1975) performed an analysis using data from 1960-1974 in an attempt to answer the other two questions. According to Miller's analysis, a 12 percent reduction in total supplies in 1975 of shrimp would have been accompanied by a 20 percent increase in average exvessel shrimp prices for the year (assuming "real" per capita disposable income dropped three percent). If, in this case, domestic landings matches 1974 totals, imports would have to be reduced about 63 million pounds, or 23 percent. (Imports in 1974 entered at an average monthly rate of 22.5 million pounds, with a high of 30 million pounds and a low of 18 million pounds.)

For exvessel prices to increase 30 percent, total supplies would have to have dropped about 18 percent. This would mean a 36 percent cutback in imports (96 million pounds) assuming no change in the domestic catch. It needs to be stressed that these are not precise estimates, given the short comings of the statistical techniques applied. The analysis does clearly demonstrate that taking into account the relatively high level of carryover holdings going into 1975, a substantial reduction in imports would have improved the exvessel price situation measurably if domestic production stayed about the same as in 1974.

Restrictions on imports of shrimp offer one avenue of relief for U.S. shrimp fishermen. However, it needs to be recognized that restricted imports may run counter to the interests of some sectors of the shrimp industry and would likely be opposed by these sectors. Processors of breaded shrimp, for example depend in part upon imports for their raw material requirements. A ban on imports could prove disruptive for these processors. Also, U.S. private capital underwrites certain foreign shrimp operations which produce for the U.S. market. Adding to this the international political implications makes it clear that there are perils, as well as benefits, in restricting imports of shrimp, and that caution and thought should precede such action. The importance of outside supplies of raw shrimp to the shrimp processing industry during the mid-1970's was documented by Prochaska and Cato (1975). Based on this article, shrimp landings during 1972 were greater than the amounts processed in that state for only North and South Carolina of all southeastern states. Louisiana, Texas, Alabama, Mississippi, Georgia and Florida shrimpers supplied only about 97, 84, 76, 57, 35 and 18 percent, respectively, of raw product needs of their processors. International trade and imports are thus quite important to these states.

Miller and Marasco (1976) also addressed the question of whether or not some form of governmental control should be imposed on the importation of shrimp into the U.S. This analysis was done because at that time (1974 and 1975) the longest and most severe economic downturn occurred in the U.S. shrimp industry. The principal issues addressed were the justification for government intervention, the potential effectiveness of intervention, and the long term implications.

Beginning in late 1973, and through 1974, the market for shrimp was unfavorable and fishermen became concerned over the large quantities of shrimp imports entering the U.S. markets that were already heavily over supplied. Imports normally are required to satisfy U.S. demand and to keep processing lines open. However, during this period prices were depressed and most people linked the problem to imports. The industry turned to the government for assistance. As Miller and Marasco (1976) point out, government intervention is not always the best answer when the market mechanisms are not effective in bringing order to a chaotic market in a short time period. Nonetheless, there has been precedence for government intervention to assist lagging market forces, particularly in agricultural commodity situations.

Based on past periods, the market mechanism appears to work in the shrimp market, although in a highly volatile fashion. The shrimp market appears to sometimes over react and over correct. After 1975, the rapid price rise and correction of the supply problem makes it appear that if import controls had been implemented, there would have been a more serious shortage problem due to the low level of imports in 1975. If shrimp imports act as the stabilizing factor in the market and government interference increases the volatility of this factor, import controls might not be in the best interest.

Producers through consumers gain from reducing instability in the shrimp market. Income stability among primary food producers has always been a national policy problem. The processing sector depends heavily upon stability of raw material supplies and resources. Consumers benefit from a lesser price swing in the retail market. Retail shrimp prices are slow to move downward during price adjustment periods at the wholesale and exvessel level. Any conditions that move retail prices to inordinately high levels contribute to overall higher price levels and are thus inflationary.

Miller and Marasco (1976) also reported a price analysis of the effects of imports which found that imports in a given month have considerably less effect on exvessel prices than any of the other major price determinants. Current monthly exvessel prices are most affected by domestic landings, and in order of importance, choice beef prices, retail marketing costs and wholesale marketing costs. A ten percent increase in imports was associated with one-tenth of one percent drop in exvessel prices. However, imports move first into cold storage, and these inventory levels influence prices over time in a cumulative fashion. Sustaining the one-month increase in imports of ten percent over three months leads to a 3.4 percent drop in exvessel prices. The influence on price of the other factors, however, still overshadows that of imports. This conclusion is consistant with recent findings by Chui (1980).

Miller and Marasco (1976) concluded that import restrictions benefits would probably be short term and narrowly focused. Domestic shrimp fishermen would probably benefit, but consumers would pay higher prices. Imports appear to be a stabilizing factor in supply and do not exert tremendous influence on domestic prices. Import restrictions did not appear to be the promising cure for market instability in the shrimp industry as analyzed in 1976.

3.5.1.5 Economic Impact of the Domestic Fishery

The harvest, processing, and marketing of shrimp are the readily visible aspects of shrimp utilization. Since each year various user groups generally increase their demand for Gulf shrimp resources, the economic contribution of users should be considered in decisions. The economic impact of the commercial user groups is more easily estimated than that of recreational users. An indication of an industry's impact can be made with the use of multiplier analysis. A multiplier shows the relationship between a primary, readily observable economic event and the total economic activity stimulated by the primary event. The primary event of landing shrimp at a dock results in sales, income, and employment in numerous businesses. Insight to the overall impact of commercial landings is gained by identifying the sales, income and employment multipliers in the shrimp industry.

A few studies of fishery economic impacts have been completed in the Gulf (see Jones, et al., 1974, Morris, et al., 1979; and Nisson, et al., 1978). The most useful analysis was the Jones, et al., study of the shrimp industry in Texas. By making the explicit assumption that their results reflect the general situation in other Gulf states, estimates for the Gulf were obtained. Using a sales multiplier of 3.09 yields an impact of \$1.2 billion in 1979. Included in the \$1.2 billion is the approximate \$377.6 million of landings and \$789.3 million of indirect and induced output by support industries. Direct and indirect income payments to workers in shrimp related businesses were estimated to approximate \$336 million of the \$1.2 billion total. The employment of workers in shrimping and related businesses is often a major element of isolated resource based economics. Using the Texas results of .8 people employed directly in the shrimp industry per \$10,000 of landings, indicates 30,200 individuals employed throughout the Gulf in 1979. When the multiplier effect (1.22) of employment in shrimping was included, the total employment estimate for the Gulf became 36,800 individuals.

3.5.2 Domestic Commercial Fleet Characteristics

3.5.2.1 Income of the Fleet

Gross Income

Reported annual pounds and exvessel value for domestic catch of U.S. Gulf shrimp by vessels and by boats is computed in Table 3.5-12. Annual total income for both vessels and boats increased over this time period 1962-1974.

A 10.3 percent average annual growth rate in gross income of shrimp vessels is due to a 2.3 percent average annual growth rate in pounds of shrimp landed, plus an 8.0 percent increase in exvessel price. A ten percent growth rate in gross income to shrimp boats is due to a 3.2 percent increase in pounds caught and a 6.8 percent increase in exvessel price.

As evident in Tables 3.5-13 and 3.5-15 this average annual growth rate (2.3 percent) in pounds of shrimp landed has occurred from an increasing number of vessels and boats in the fishery. Boats have increased their share of total days fished through their larger growth in numbers and average days fished per boat. Vessels while fishing slightly more days per year through the period, are exerting more effective effort because of their upward trend in vessel size. Larger horsepower and nets are generally correlated with increased vessel size. Thus, the increase in total gross income associated with the small increase in catch results from more vessels and boats, more days fished, and larger vessels. Shrimp vessel and boat information more current than 1975 was not available at this writing.

Insight to the general trend in shrimp vessel numbers is evident from reviewing recent data from state agencies in the two largest producing Gulf states, Louisiana and Texas. The number of licensed shrimp vessels in Texas increased 23 percent between 1975 and 1979 (Swartz, 1980). Approximately half of the growth rate was due to increases in vessels larger than 40 feet. Neighboring Louisiana

Table 3.5-12. Reported annual pounds and value of the domestic catch of US Gulf Shrimp by boats and by vessels, 1962-1974 (Christmas and Etzold 1977).

Vessel Fishery

Year	Million Pounds (Heads-off)	Value (Million $)	Price Per Pound ($)	Total Days Fished (1000)	Effort (1000)	Pounds Per Day Fished
1962	45.4	33.4	0.74	88.5	144.0	513
1963	77.0	41.5	0.54	112.9	181.8	682
1964	71.0	40.7	0.57	114.4	186.3	621
1965	80.1	49.1	0.61	113.7	187.6	704
1966	78.3	61.9	0.79	187.6	190.5	688
1967	99.7	68.5	0.69	116.0	201.7	859
1968	83.7	68.4	0.82	121.5	218.1	688
1969	82.4	74.3	0.90	147.8	273.6	557
1970	96.1	81.4	0.85	134.6	249.1	713
1971	91.3	100.8	1.10	137.0	259.0	566
1972	94.3	120.1	1.27	146.8	282.6	642
1973	71.0	118.6	1.67	140.0	269.7	507
1974	73.9	99.8	1.35	132.4	243.6	558
Annual Growth Rate	2.3%	10.3%	8.0%	3.1%	4.7%	-1.0%

Boat Fishery

Year	Million Pounds (Heads-off)	Value (Million $)	Price Per Pound ($)	Total Days Fished (1000)	Pounds Per Day Fished
1962	25.2	11.9	0.47	58.0	434
1963	33.3	9.4	0.28	38.5	865
1964	23.5	9.6	0.41	55.4	424
1965	25.5	9.5	0.37	56.7	450
1966	24.6	12.2	0.50	62.2	395
1967	30.6	12.1	0.40	66.1	463
1968	29.9	13.2	0.44	70.0	427
1969	35.5	17.8	0.50	52.6	675
1970	40.1	17.6	0.44	65.4	613
1971	42.5	23.7	0.56	67.9	626
1972	37.7	27.5	0.73	82.1	459
1973	33.6	34.3	1.02	98.0	343
1974	33.0	22.7	0.69	90.3	363
Annual Growth Rate	3.2%	10.0%	6.8%	5.1%	-1.7%

From The Shrimp Fishery of the Gulf of Mexico United States: A Regional Management Plan, J.Y. Christmas and D.J. Etzold et al.

Table 3.5-13. Annual estimates of vessels and boats in the U.S. Gulf shrimp fishery

Year	Number of Gulf Shrimping Vessels*	Gross Tons Per Vessel	Otter Trawls Per Vessel	Number of Gulf Shrimping Boats
1960	2,941	41.3	1.76	3,089
1961	2,686	42.6	1.80	2,987
1962	2,600	41.9	1.77	3,927
1963	2,697	41.5	1.76	4,481
1964	2,782	42.0	1.74	4,360
1965	2,849	42.7	1.72	4,785
1966	2,942	44.9	1.74	4,797
1967	3,146	48.9	1.76	4,983
1968	3,430	52.5	1.77	5,109
1969	3,569	53.7	1.76	4,817
1970	3,579	53.8	1.73	4,495
1971	3,487	57.8	1.77	4,828
1972	3,683	59.2	2.20	4,500
1973	4,091	59.9	1.78	4,723
1974	3,785	61.5	1.77	4,589
1975	3,680 (est.)	59.5	1.78	5,054

* This total is exclusive of duplication.

From NMFS data from <u>Fishery Statistics of the United States.</u>

Table 3.5-14. Cost of new U.S. Gulf shrimp vessels by various sizes and types of construction, 1971 to 1977

Year	Vessel Length and Type	Cost
1971:	53 - 65 ft. wood and steel	$ 57,000
	66 - 72 ft. wood and steel	76,000
1973:	63 - 69 ft. wood	93,000
	63 - 69 ft. steel	118,000
	70 - 78 ft. steel	114,000
1975:	68 ft. wood	121,000
	73 ft. wood	134,000
	68 ft. steel	148,000
	73 ft. steel	185,000
1977:	68 ft. wood	147,000
	73 ft. wood	164,000
	68 ft. steel	195,000
	73 ft. steel	220,000

Source: Warren and Griffin (1978)

Table 3.5-15. Annual participation in the subject fishery by vessels and boats

Year	Vessels	Days* fished per vessel	Boats	Days fished per boat
1962	2,600	34.0	3,927	14.8
1963	2,697	41.9	4,481	8.6
1964	2,782	41.1	4,360	12.7
1965	2,849	39.9	4,785	11.8
1966	2,942	38.6	4,797	13.0
1967	3,146	36.9	4,983	13.3
1968	3,430	35.4	5,109	13.7
1969	3,569	41.8	4,817	10.9
1970	3,579	37.6	4,495	14.5
1971	3,487	39.3	4,828	14.1
1972	3,683	39.9	4,500	18.2
1973	4,091	34.2	4,723	20.7
1974	3,785	35.0	4,589	19.7

* Day = 24 hours of fishing time

Source: Fishery Statistics of the U.S.

experienced a 41 percent increase in licensed resident shrimp vessels between 1976 and 1979 (Roberts and Thompson, 1981). Boats licensed in Louisiana increased 47 percent in the same period. Licensed sport shrimpers increased 22 percent. The increase in total Louisiana shrimp licensees (licensed sport, commercial boat, commercial vessel, and nonresident commercial shrimpers) was 37 percent for the period. The recent figures for Louisiana and Texas indicate that the growth in shrimp industry participants continued through 1979. The contribution of these additional vessel and boat participants to the increase in gross fleet income of the period is unknown. Identification of the growth rate in pounds and exvessel price is necessary prior to specifying the productivity of this major increase in people and capital.

Net Income

Gross income is known to fluctuate widely in the shrimp fishery. The fluctuation is due to: (1) variation in shrimp availability arising from uncontrollable environmental forces, and (2) price variation resulting from changes in economic conditions of consuming nations. Gross income will fluctuate sharply when both factors are unfavorable. The major fuel price increases since 1973 have been the most visible long term influence on net income. Fuel is the largest component of operating costs. The inability to change to less fuel intensive technology will make net income heavily dependent on catch, exvessel price, and now cost of effort.

Changes in these factors produce the variation over the 1971-1977 period shown in Tables 3.5-16 and 3.5-17. Comparable cost and return budgets for Louisiana vessels indicate positive returns to owner management and investment in 1978 and 1979, Table 3.5-18. Generalization of results from the studies yielding the budgets conceal that net income varies by vessel size and hull material. Wooden vessels (Warren and Griffin, 1978) and medium size vessels (Roberts, 1979) have earned higher returns to owner management than larger steel hulled vessels in the recent years of major cost and price increases. To get a better picture of increasing cost and revenue for the period 1971 to 1977, Table 3.5-19 shows the index of increasing cost and revenue for vessels. Indexes are calculated to reflect nominal percentage increase in each item. The consumer price index is included for comparison. Fuel and fixed cost stand out as areas where costs have risen the most (increased 208 percent and 149 percent, respectively). Total cost and total revenue have increased approximately the same amount over the seven year period. In 1980 the exvessel price on average fell from the record high levels experienced in 1979. Thus, with fuel prices rising continually over the 1971-1980 period, a major cost-price squeeze occurred in 1980. Information presented to the Gulf States Marine Fisheries Commission annual meeting in October, 1980, forecast negative returns to the average vessel owner's management and investment (Roberts, 1980). The forecast was based on large vessels (greater than 65 ft.) landing on the average 41,000 pounds of tails. This catch level would reflect the average catch level for the vessel class experienced in Louisiana during 1979. The reasonableness of this vessel catch forecast is reflected by comparing the 1979 and 1980 Gulf landings. Through October 1980, Gulf-wide landings were slightly higher than 1979 (Shrimp Statistics, 1980). The Louisiana forecast is thought to reflect the financial situation facing the average offshore shrimper in the Gulf. As cited elsewhere in the plan, the severity of the financial situation is exemplified by the October 28, 1980, U.S.D.C. announcement of a $12.2 million aid program for Gulf shrimpers.

As indicated in Figures 3.6-1 through 3.6-5, the sale of incidentally caught finfish has no potential to relieve the tight net income situation. In the short run, the shrimp vessels are of limited usefulness in other economic endeavors. Therefore, the near term prospects are for vessels to be predominately dependent on the shrimp catch, exvessel prices, and fuel prices to determine their net income.

The fluctuation in net income experienced by shrimpers on an annual basis occurs on top of seasonal variation. Shrimping in the Gulf is very seasonal. Table 3.5-20 shows monthly cash flows for 1971 (a year when profits were made) and 1975 (a year when substantional losses were made). In both years the net flow of cash is negative January through June and positive net flows are incurred July

Table 3.5-16. Average annual costs and returns for Gulf of Mexico shrimp vessels, 50 to 80 feet in length, all types of construction, 1971 to 1977

	1971[a]	1973[b]	1974[c]	1975[c]	1977[a]
	Dollars				
Returns					
Landings (pounds)	50,618	40,073	46,390	44,054	56,576
Price per pound	1.20	1.85	1.70	2.30	2.39
Receipts from sales	60,742	74,135	78,864	101,324	135,216
Variable costs					
Ice	1,387	1,579	1,541	1,766	2,788
Fuel	6,561	9,539	18,976	19,144	20,194
Net, supplies, groceries	2,358	6,747	9,885	11,211	13,131
Repair and maintenance	11,708	9,593	9,337	11,643	11,143
Crew shares	19,437	23,723	26,593	32,422	43,320
Payroll taxes	388	474	1,547	1,815	257
Packing	2,411	1,899	2,428	2,905	3,852
Subtotal	44,250	53,554	70,307	80,876	94,685
Returns above variable costs	16,492	20,581	8,557	20,448	40,531
Fixed Costs					
Insurance	3,532	4,291	4,306	4,840	5,677
Depreciation	6,333	8,177	11,228	12,607	14,623
Overhead	0	2,415	3,201	3,073	3,194
Interest	2,256	2,611	5,604	6,984	6,880
Subtotal	12,221	17,494	24,339	27,504	30,374
Total Operating Costs	56,471	71,048	94,646	108,380	125,059
Profit or loss	4,271	3,087	-15,782	-7,056	10,157
Required return to equity	2,636	3,155	16,590	12,587	5,399
Return to owner management	1,635	-68	-32,372	-19,643	4,758
Vessels in sample	25	103	109	101	81
New cost of vessel	77,949	100,641	138,188	155,168	179,981
Percent financed	67	67	67	67	80
Depreciable life (years)	8	8	8	8	8
Salvage value (percent)	35	35	35	35	35
Required return rate[d] (percent)	10.25	9.50	13.00	14.00	15.00

[a] Florida and Texas vessels in sample

[b] Florida, Mississippi and Texas vessels in sample

[c] Texas vessels only in sample

[d] Reflects a base rate, determined by bond yields, plus a financial risk premium.

Source: (Blomo and Griffin (1978); Griffin (1978); Hayenga, Lacewell and Griffin (1974); amd Wardlaw and Griffin (1974).

Table 3.5-17. Dollars per pound and pounds landed for typical vessel fishing in the Gulf of Mexico shrimp fishery, 1971 to 1977

Year	Fuel	Variable[1] cost	Fixed cost	Total cost	Revenue	Pounds
1971	0.13	0.43	0.24	1.12	1.20	50,618
1973	0.19	0.54	0.35	1.40	1.85	40,073
1974	0.41	0.86	0.52	2.04	1.70	46,391
1975	0.43	0.99	0.62	2.46	2.30	44,054
1977	0.46	0.78	0.54	2.21	2.39	56,576

[1] Does not include crew shares, payroll taxes and packing.

Source: Computed from Table 3.5-16.

Table 3.5-18. Average annual costs and returns for Louisiana shrimp vessels, 1978 and 1979

	1978 size in feet		1979 size in feet	
	51-65[a]	66 and over[b]	51-65	66 and over
	dollars			
Gross income	94,409	166,439	104,586	188,564
Costs:				
Associated with catch	30,482	45,789	33,882	52,163
Associated with effort	20,690	49,231	28,616	74,484
Fixed	8,385	24,949	8,230	24,034
TOTAL	59,557	119,969	70,729	150,682
Captain's pay	18,708	25,003	20,703	28,300
Return to owner's management & investment	16,144	21,467	13,154	9,582

[a] n = 48

[b] n = 44

Source: Roberts & Sass (1979).

Table 3.5-19. Index of increasing total cost and total revenue for vessels operating in the Gulf of Mexico shrimp fishery, 1971 to 1977. (1971 = 100).

	Year				
	1971	1973	1974	1975	1977
Variable Cost					
Not proportional to catch:					
Fuel	100	145	289	292	308
Other	100	116	134	159	175
Proportional to catch	100	121	159	183	213
Fixed cost	100	143	199	225	249
Total cost	100	106	167	191	221
Total Revenue	100	122	129	166	223
Consumer Price Index	100	110	122	133	150

Source: Computed from Table 3.5-16

through December. These monthly flows indicate the need for financial planning within a year by vessel owners in the industry. The annual budgets (Table 3.5-16) indicate the need for financial planning over the life of the vessel.

Fishing Activities Supplemental to Shrimping

The rise of fuel prices has interjected an aspect of uncertainty into the shrimp harvest business. Shrimp vessels are subject to operating with a fuel intensive technology. Operating costs are therefore certain to rise more rapidly than the general price level. This has prompted experimentation with shrimp vessels in other fisheries. Although there is much written on underutilized species, shrimpers are experimenting with the suitability of their vessels in fisheries with established markets. The most prominent examples are the refitting of vessels to harvest swordfish, snapper and grouper, and tunas. Equipping a vessel to mid-water longline for swordfish may cost \$20,000 to \$40,000. Similar costs may be experienced by shrimpers attempting to bottom longline for reef fish or other species such as tilefish. Minimal investment is required to equip a vessel for the pole fishery for blackfin tuna.

Texas shrimpers are more active in refitting vessels for supplemental fisheries. The most promising alternative has been longlining for swordfish, where as many as 40 to 45 vessels attempted to enter this fishery from Texas during 1980 (John Nichols, Texas A&M, personal communication). Not all these vessels participated the entire six month season.

Work in progress has attempted to measure the economic success of this alternative for shrimp vessels during 1980 (John Nichols, personal communication). Vessels normally shrimp in Texas from May through October and have the possibilities of a six-month season for swordfish from November through April. The estimated initial capital cost of first time vessel conversion to go swordfish longlining is \$26,205. This includes structural changes in the vessel, winches and all the longline equipment for a 19 mile longline. Based on preliminary projections for 1980, a shrimp vessel fishing for shrimp during six months and not fishing for six months would have encountered a loss of \$36,309. Returns

Table 3.5-20. Cash flow by months for Gulf of Mexico shrimp vessels 50 to 80 feet in length, 1971 and 1975.

	Jan	Feb	Mar	Apr	May	June
1971[1]						
Total inflow	3,009	3,107	3,107	3,115	3,654	4,667
Total outflow	4,370	4,252	5,043	4,967	4,567	5,617
Net flow	-1,361	1,145	-1,936	-1,852	-913	-950
Accumulated net returns	-1,361	2,506	-4,442	-6,294	-7,207	-7,957
1975[2]						
Total inflow	3,503	4,001	3,956	3,535	4,960	6,653
Total outflow	6,071	6,298	6,501	6,720	7,052	8,437
Net flow	-2,568	2,297	-2,545	-3,185	-2,092	-1,784
Accumulated net returns	-2,568	-4,865	-7,410	-10,595	-12,687	-14,471

	July	Aug	Sep	Oct	Nov	Dec
1971[1]						
Total inflow	7,367	9,356	8,003	9,673	7,916	6,696
Total outflow	6,255	6,715	6,368	7,532	6,845	5,742
Net flow	1,112	2,841	1,635	2,141	1,071	954
Accumulated net returns	-6,845	-4,004	-2,369	-288	-834	1,797
1975[2]						
Total inflow	13,074	11,969	11,929	11,775	12,645	13,319
Total outflow	11,636	10,977	11,246	11,192	10,498	12,398
Net flow	1,438	992	683	583	2,147	921
Accumulated net returns	-13,033	-12,041	-11,358	-10,775	-8,628	-7,707

1 Florida and Texas.

2 Texas only.

Source: Lacewell, Griffin, Smith and Hayenga (1974); Griffin, Nichols, Anderson, Buckner and Adams (1978).

above variable costs would have been $7,743. However, fixed costs over the entire year were great enough to cause the loss. Converting the vessel to longlining during the winter months would have caused a total annual return to the owner's equity and management of $10,477. This results from selling 56,600 pounds of swordfish ($2.60 per pound) and covering both the variable costs of longlining and the fixed costs not covered by shrimping.

The break-even point for the vessel owner would be at 6,500 pounds of swordfish while the crew would break even at 46,000 pounds due to the way in which crewshares are calculated. While these data are preliminary, it is clear that swordfish longlining may be a viable alternative for only a few of the vessels in the shrimp fishery because of the limited swordfish resource.

Two factors in this supplemental activity are especially noteworthy. The supplemental fisheries are not being developed as a year round substitute to shrimping. Rather the majority of conversions are to the supplemental fisheries for brief periods during the year. As shown in Table 3.5-20 shrimping vessels experience negative cash flows in several months. Secondly, the share system on shrimp vessels historically have placed the cost of fuel solely upon the owner. Supplemental fisheries which are not fuel intensive may return more net income to the owner per dollar of gross income than the situation with shrimp. Consequently, the supplemental fisheries do not have to yield the same gross income as shrimping to be competitive.

3.5.2.2 Investment in Vessels, Boats, and Gear

Table 3.5-13 lists annual estimates of the number of vessels and boats in the domestic shrimp fleet, as well as estimated gross tons and otter trawls per vessel. These estimates indicate that since 1970 Gulf shrimp vessels have averaged 76 percent of the number and 83 percent of the gross tonnage of total U.S. shrimp vessels. The average gross tons per vessel in the Gulf is half again as large as that in the South Atlantic fleet. Since 1970, Gulf shrimp boats have averaged 83 percent of the total number of U.S. shrimp boats. The Gulf vessels are comparatively new: in 1975, 23 percent of the vessels had been constructed within the 1970 to 1975 period and 52 percent in the 1965 to 1975 decade.

Investment in vessels and gear is only available for a limited portion of the vessel component of the fleet (Table 3.5-14, from Warren and Griffin, 1978). As indicated, the cost of a vessel has jumped sharply during the 1970's. In addition, data from one manufacturer indicates the basic price of a typical wood vessel has increased by 44 percent from 1977 to 1980. The increase of a fiberglass vessel has been 42 percent. Inflation, the trend to larger vessels, and additional equipment are the principal causes of the increase. Obviously, a larger income is now required to justify investment in the vessels. Larger income has been forthcoming, however. Figure 3.5-12 shows that the value of landings per gross ton of vessel has increased by $150 per ton or more from 1962 to 1974. Notice, however, that catch declined over 300 pounds per ton for the same period.

The 16 year trend shown in Table 3.5-13 shows a significant increase in average gross tons per vessel. This statistic may reflect the larger vessel's ability to fish in inclement weather, its increased range, and its attractiveness to more competent crew members. There are no current studies over a sufficiently long period of time to investigate economic profitability by size of vessel, however, studies that examined this question have been done for several individual years (Lacewell, Griffin, Smith and Hayenga (1974); Wardlaw and Griffin (1974); Griffin, Nichols, Anderson, Buckner and Adams (1978); and Griffin (1978); Roberts and Sass (1979). Figure 3.5-13 shows the results of a regression analysis of average cost based on 1973 data collected from 115 vessels in Florida, Mississippi and Texas. In the regression analysis construction, length and effort (effort is based on horsepower and length of footrope) were used as dummy variables in estimating the average cost equation. All coefficients were significant at the 99 percent level. The estimated cost equation explained 79 percent of the variation of the data. Predicted average cost values for the 115 vessels are plotted with average cost on the vertical axis and pounds landed on the horizontal axis. Vessels

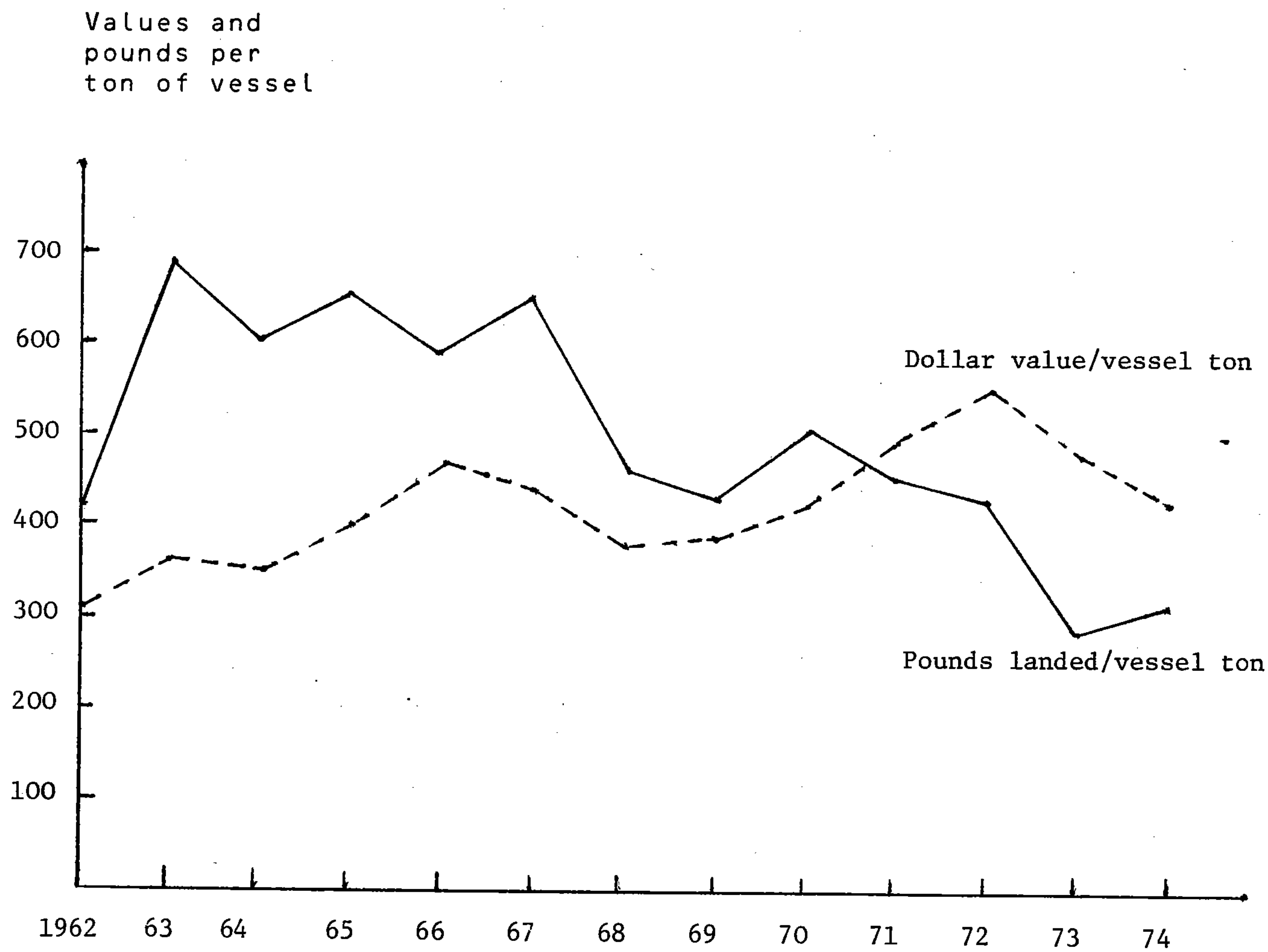
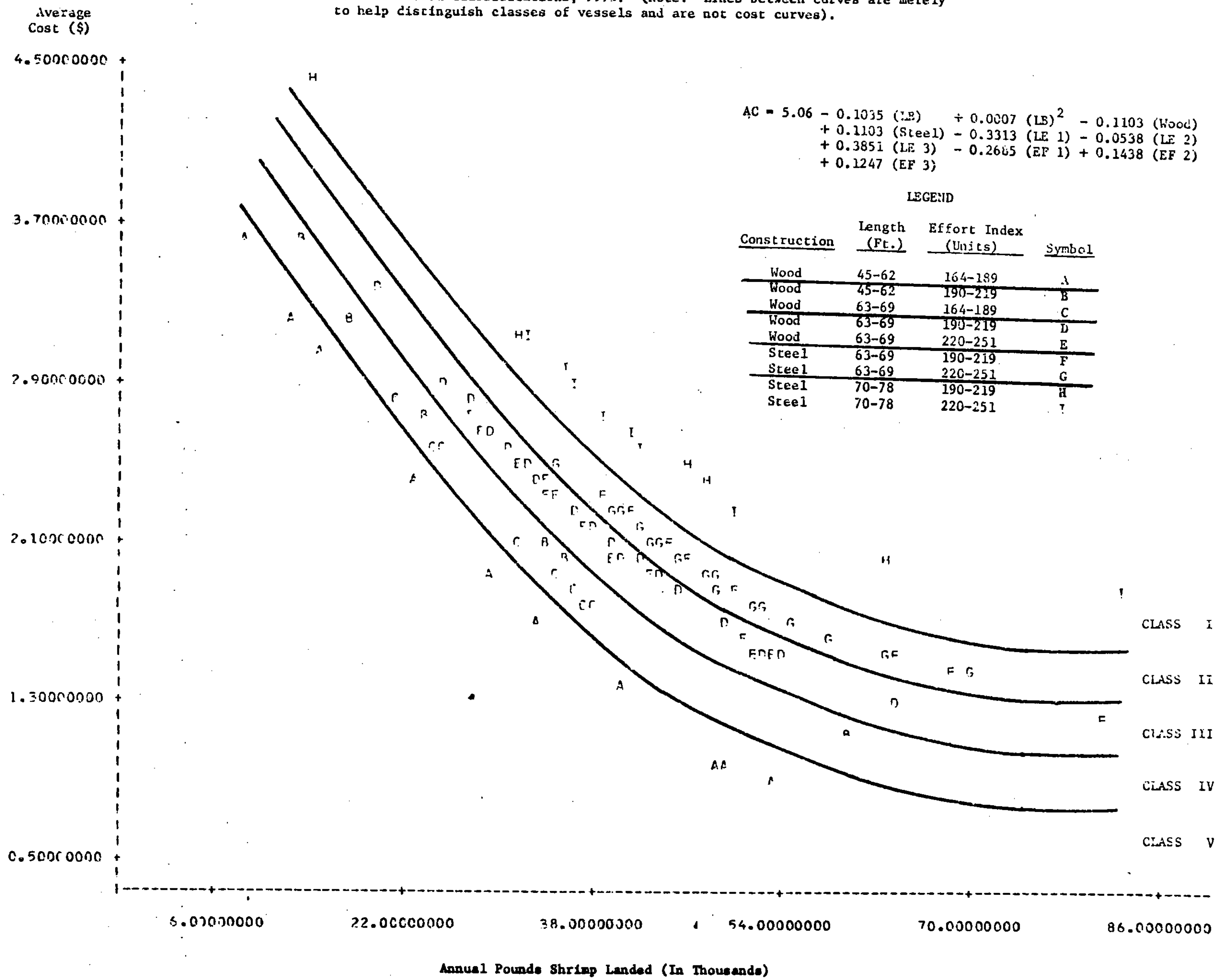


Figure 3.5- 12= Pounds and Value of landings per vessel ton harvested in the Gulf of Mexico shrimp fishery (calculated from Tables 3.5-12 and 3.5-13).

Figure 3.5-13 - Predicted average cost data points for 115 Gulf of Mexico shrimp vessels for various vessel classifications, 1973. (Note: Lines between curves are merely to help distinguish classes of vessels and are not cost curves).



Source: Griffin and Wardlaw (1974)

tend to fall into five general classes. Notice in Figure 3.5-13 that at any given pounds produced that larger vessels have a higher average cost which means they have a higher breakeven price per pound. Conversely, at any given price larger vessels must land more pounds of shrimp to break even. A comparison of wood and steel vessels shows that steel vessels have a higher average cost than wood. Wooden vessels with a higher effort index (larger engines and nets), but of the same length category, have higher average costs per pound. This could be caused by less fuel efficiency and/or larger investment in engines.

The combined influence of high fuel prices and lowered exvessel shrimp prices in 1980 focused attention on the cost-price squeeze in the shrimp industry. Fuel efficiency in trawl fisheries, including shrimp, was a topic frequently discussed by shrimpers when planning vessel construction and operation. Unfortunately, economic budgets developed for vessels in the mid to late 1970's were not sufficiently detailed to make definitive conclusions about vessel fuel efficiency in relation to vessel size. Roberts and Sass (1979) report medium size (51 to 65 feet) shrimp vessels in Louisiana during 1978 had about twice the gross revenue per dollar of fuel as did large vessels (greater than 65 feet). Since the large vessels caught shrimp valued at $3.14 per pound in 1978 compared to $2.47 for medium vessels, it is evident that large vessels are harvesting shrimp of a size not harvestable by the medium vessels. It should also be noted that the Louisiana research indicated small (less than 50 feet) vessels were less efficient in terms of gross revenue per dollar of fuel costs than medium vessels. Thus, caution is advised when attempting to correlate vessel size with fuel efficiency.

Warren and Griffin (1978) in a 1977 survey constructed economic budgets for two shrimp vessel groups. Small wooden vessels (28 to 55 feet) landed $7.74 worth of shrimp per dollar of fuel cost. Wooden vessels in the largest (56 to 80 feet) class landed $7.65 of shrimp per dollar of fuel cost. Another aspect of their study points out the problem of generalizing about fuel efficiency of various vessels. While wooden vessels in the large class landed $7.65 of shrimp per dollar of fuel, steel vessels of the same length class landed $5.88 of shrimp. Thus, specific studies would be necessary to clarify the situation with respect to fuel efficiency of various types of vessel types and sizes. Analyses should explore efficiency by several criteria.

Investment in new vessels appears to be cyclical in nature; several consecutive good shrimping years induce a major increase in new craft construction and several consecutive bad years result in a pronounced reduction. An example of this can be seen in the number of licenses sold for vessels to fish in the Gulf waters of Texas, Table 3.5-21. Economic conditions in the Gulf shrimp industry began to decline in late 1973. Economic conditions were unfavorable through the middle of 1975 when they turned around and were favorable through 1978. In 1979 conditions were near the breakeven point and 1980 is a clear, negative net income situation. As a result of these economic ups and downs, Texas Gulf licenses sold decreased from 1975 to 1976 by 89 vessels, a lag effect of a year to a year and a half. Licenses sold increased through 1979 but are expected to decrease in 1981 because of current economic problems.

The favorable economic conditions from 1976 to 1978 precipitated an expansion in vessel and boat investment in Louisiana. Due to the lag effect, expansion can be more accurately portrayed by viewing the 1976 to 1979 period. Resident shrimp vessels increased 41 percent between 1976 and 1979 (778 to 1,093). Boats in Louisiana increased from 9,692 to 14,217. Using the average market value of Louisiana vessels in 1978, the increase in vessel investment between 1978 and 1979 was estimated to be $7.5 million. Boat investment in Louisiana increased $4.6 million for a combined one year increase of $12.1 million (Roberts, 1980).

3.5.2.3 Capitalization

Biological literature dealing with fishery management is replete with the discussion of "overfishing". The economics profession has developed a similar body of literature which attributes

Table 3.5-21. Number of Texas licenses sold for Gulf shrimping only

Year	Total	Net Change
1975	1,763	
1976	1,674	-89
1977	1,804	130
1978	1,852	48
1979	1,937	85

Source: Swartz (1980).

the eventuality of overfishing to the common property nature of fishery resources. Economic literature also identifies economic waste as an inherent aspect of harvesting common property fishery resources.

Factors Affecting Capitalization

As outlined in some detail in Section 5.1.2, economic capacity in any firm is determined by the level of product prices, the expected marginal productivity of inputs and input prices. Industry expansion or growth takes place when firms in the industry are earning a profit. This expansion, through the entrance of new firms, or through individual firms growing larger, will cause greater demands on resources. The increased demand for resources increases input prices which increases production costs to producers using the resources (inputs). At the same time the increased supply of products reduces final product prices. This growth pattern continues until profits to individual firms in the industry are eliminated.

These same economic forces are at work in the fishing industry. However, one primary resource or input (the stock of fish) into the production process is common property rather than private property. The fish belong to no one person, but to all the people in common. They become private property by institutional arrangement or after they are harvested. Thus, no "price" is paid for the fish resource and the fishery is usually referred to as an "open access" situation. The normal restraints that increased input prices place on industry growth are thus not fully effective in common property industries. That is, inputs into the fishery will continue to be used longer in the growth process than they would in private property industries. This results in total industry fishing effort beyond the level necessary to produce maximum economic yield (MEY). Total industry fishing effort could even expand to the extent that maximum sustainable yield is surpassed. These events occur due to rational economic decisions of fishermen acting as individuals. Increased effort by individual fishermen imposes an unaccounted for cost on all other fishermen. This increased cost due to overfishing eventually curtails production. This situation is sometimes referred to as the "tragedy of the commons". The exception to this occurs when growing consumer demand increases exvessel prices more than the increased costs resulting from overfishing. Since there is no "price" or "cost" put on the raw fish input, its price does not rise as the factor demand for it becomes greater as it becomes more scarce. If the fish resource were "priced", cost would increase and fishermen would be encouraged to decrease fishing effort, and further capitalization into the fishery would be discouraged.

During periods of economic prosperity when shrimp prices are rapidly rising, profits to the owners of shrimp vessels have been over and above the returns their capital could have earned in other alternatives. In economic terms, "excess profits" have been generated. Both existing owners and new entrants into the fishery have been encouraged to make new capital investments in the fishery. When prices declined, vessels continue to fish in the short run even at a loss as long as the return generated covers variable operating (trip) costs. When revenues were not large enough to cover variable costs, vessels have been tied up for periods of time. The normal decision of the owner would be to sell the vessel and use the capital elsewhere. However, as is the case with much agricultural equipment, shrimp vessels represent a classic case of asset fixity (Johnson, 1958). No entrepreneur wants to invest capital in a shrimp vessel that will yield a negative return which makes it difficult to sell vessels. Thus, along with the other problems caused by the open access nature of the shrimp fishery, vessel owners sometime face economic hardships because of investment decisions made during times of rapidly rising prices.

In summary, the argument is that given an open access fishery and rapidly rising prices (more rapidly than costs) for the product, overcapitalization from an economic standpoint is inevitable and will become worse as product price continues to rapidly rise. The only way to slow down the overcapitalization process is to artificially increase costs of fishing to the fishing vessel through fees for the right to fish. Free access and rising demand will result in effort levels beyond that necessary for the maximum economic yield and possibly beyond that required to harvest the maximum sustainable yield. This situation will usually place vessel owners in negative return situations during times of falling demand for shrimp.

Focusing on the economic impact of free access, then, involves deliberation over the quantities harvested and the effort and capital expended. Much debate normally occurs when proponents of MEY management argue that not only less effort but also lower harvests will be beneficial to fishermen, processors, and society at large. As Gulland (1972) indicates, shrimp fisneries exhibit flat-topped yield curves. At high levels of effort, the implication is that reductions in fishing effort are likely to result in proportionally smaller decreases in shrimp landings. Thus, management of fishing effort at some point below MSY must be concerned with the benefits and costs of reducing fishing effort. Economists note that free access to fishery resources leads to overfishing, lower sustained yield, and higher costs. With overfishing and lower sustained yield previously cited as not a valid concept in the Gulf shrimp fishery, the benefits to society from any benefit-cost measurement must mainly come from reductions in harvest costs. Reducing the total harvest cost would involve reducing the number of firms (fishing effort) in the industry. There is evidence that other measures to reduce fishing effort, such as quotas, gear restrictions, shortened seasons, etc., actually increase capitalization and costs (Crutchfield and Zellner, 1962).

Although the annual nature of the shrimp crop provides some biological uniqueness, the Gulf shrimp fishery is subject to the sound scientific argument that all mature free access fisheries become overcapitalized (overcapitalization being the fishing effort or number of firms beyond that necessary to harvest the MEY). Very little analysis is required to show that the ideal world, perhaps MEY for the economist or MSY for the biologist, is better than the laissez-faire real world of free access to fishery resources (Coase, 1968). As pointed out above, however, methods to achieve MEY or even MSY may be more burdensome to the resource users, society, and government. Simply stated, the issue of overcapitalization and limited entry as a means of eliminating it really only require that a proposed shrimp harvest be judged better or worse than the existing harvest when all benefits and costs are considered. The problem of overcapitalization in the shrimp fishery, however, is not as simple as might first appear.

Capitalization In the Shrimp Fishery

The extent of overcapitalization in the Gulf of Mexico shrimp fishery cannot be precisely stated at this time from the standpoint of a specific research study designed to address this question. Griffin, Lacewell and Nichols (1976), estimated the optimum effort level for the Gulf shrimp fishery for 1973. This study indicated that the equilibrium level of effort under open access fishery conditions at 1973 average prices with a normal return to labor, management and investment was 201,800 units of effort or 2,277 vessels. Actual fishing effort during 1973 was estimated at 304,431 units of effort or 3,435 vessels. The optimum effort that maximized economic rent to the fishery was 105,300 units or 1,213 vessels. This generated an economic rent of $22 million dollars, reduced total industry revenue from $136 million to $89 million and reduced shrimp landings from 80 million to 52 million pounds.

It is clear that the management of the shrimp fishery to achieve economic optimums would necessitate a drastic reduction in the amount of effort applied in the fishery, and hence a reduction in the number of vessels allowed to fish. The results of such a management goal would be a lower total industry cost, possibly lower revenues (depending on elasticity of demand for shrimp), fewer vessels, higher profits per vessel and probably higher shrimp prices to consumers. To accomplish this goal a program would have to be implemented that would tax away the economic rent generated and return the rent to society. The central question would be concerned with whether the benefit to society of such a management program would be greater than the cost to society of implementing the program.

There are two other issues, each dealing with the demand for shrimp, that also have an effect on the extent and importance of overcapitalization. The first is that Gates and Norton (1974) clearly demonstrate that the level of fishing effort (capital) yielding MEY is not necessarily the same as that representing maximum economic efficiency (MEE). MEE is that level of fishing effort at which the value to society of the last unit of shrimp produced is equal to the cost to society of producing that unit. MEY is equal to MEE only when the price of shrimp is perfectly elastic, that is, when unlimited quantities can be purchased without the price rising. The demand for shrimp is quite different from this situation, and the result is that MEY and MEE are not identical. In this case, MEE, not the rent maximization associated with MEY, might be the appropriate economic goal for society. Further, the MEE goal would induce an even lower harvest than that of MEY, since the industry generates costs to society by using a common property resource. These costs involve the physical, human and monetary resources used in the fishery which could be better employed in other sectors of the economy. Their use in the fishery bids up their prices thereby creating inflationary pressures.

The second issue is concerned with the impact high levels of consumer demands have on the size of cost savings from decreasing the number of shrimping firms (capitalization). Bell (1972) recognizes that, at high levels of consumer demand, maximum economic yield (MEY) and maximum economic efficiency (MEE) for all practical purposes are identical goals, even in view of the above argument. If MEE is considered the appropriate economic goal, then the degree of overcapitalization would be much less during levels of high demand for shrimp. While there is some evidence of overcapitalization in the shrimp fishery the economic performance of harvesting firms, their owners and employees have at certain times appeared satisfactory. Performances during other times have not been so satisfactory.

Perhaps the most important factor that regulates the economic status of the shrimping industry is consumer demand and the rise and fall of consumers discretionary income. Shrimp are normally thought of as a luxury consumer item with their consumption highly responsive to the availability of consumer discretionary income. Estimates of the amount of shrimp eaten outside the home in restaurant situations range from 60 to 80 percent of all shrimp sold. In fact, according to Quick Frozen Foods (1980), 85 percent of the frozen shrimp consumed in the U.S. during 1979 were consumed in the institutional trade with the remaining sold at retail. Thus, as discretionary income declines the demand for shrimp declines. Processors sometimes have large inventories of shrimp purchased at higher prices which must be sold at a loss or held until price rebounds. Exvessel prices normally drop as the decline in consumer demand reaches the dockside level. The price movement of shrimp as related to historical downturns in the U.S. economy can be vividly illustrated. Miller (1975) indicates that historical downturns in shrimp prices have occurred during 1954 to 1955, 1958, 1963, 1967, 1970 and 1974. Four of these six years (all except 1963 and 1967) were recessionary years as measured by declines in real gross national product while the others were associated with business downturns. The same situation occurred during 1977 and 1979 to 1980. The shrimp industry has also lagged behind the general economy in terms of recovery.

It is during these periods of price declines that the shrimp industry has suffered through periods of economic loss, particularly at the vessel level. As discussed earlier, the industry has operated without apparent problems during periods of rising prices. However, economic success during these periods has led to capital investment and reinvestment in the fishery to such levels that short-term economic losses have occurred during the price decline periods. Further compounding these problems has been the rapid rise in the cost of diesel fuel which is a major input cost item in the harvesting of shrimp.

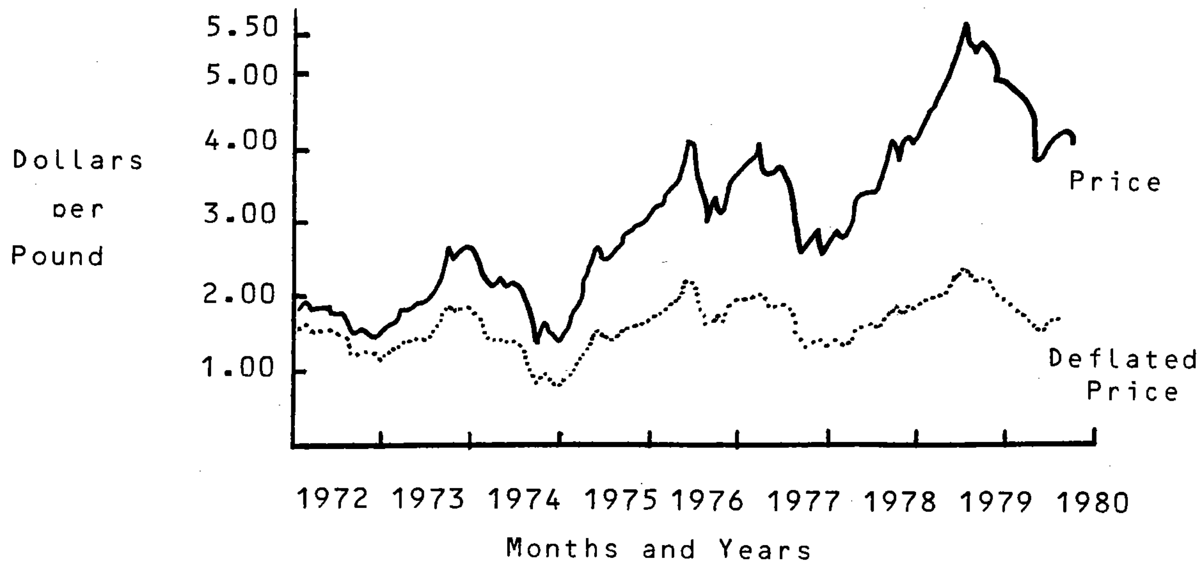
The importance of this rapid increase in fuel prices was masked somewhat by the more rapid increase in shrimp prices. Most shrimp vessels were returning good profits and many owners were using high profits to reinvest in the fishery during this period with replacement and/or new vessels. Many used this profit as leverage capital for new loans to expand fleet sizes. Surdi, et al. (1979) report that a total of 311 shrimp vessels were built or on order for the Gulf of Mexico during 1979, with 271 built or on order for 1980. This represents an approximate 10 percent increase in the fleet size in about a one year period which represents a dramatic increase in capital investment in the fishery.

When the U.S. economy entered into the recessionary period beginning in late 1979, consumer demand slacked and the price of 21-25 raw headless shrimp fell rapidly to a low of $3.82 in May, 1980. This represented a decline of 29 percent in a nine month period.

Fuel prices did not decline. Investment signals misread during 1978 and 1979, when rapidly rising shrimp prices masked the importance of the rapidly rising fuel prices, placed many shrimp vessel owners in severe economic straits, beginning in the early summer of 1980. Between 1971 and 1977, fuel costs represented between 14 and 24 percent of total revenues of most shrimp vessels. Since fuel prices almost doubled between 1977 and 1980, and price (and hence total revenues) fell by almost 30 percent from 1979 highs, it is easy to see that fuel costs could have represented almost half of total revenues. Many shrimp vessel owners have not been able to meet mortgage payments and have attempted to generate support for controls on imports in an attempt to stimulate domestic prices. Representatives of the shrimp industry met with the Secretary of Commerce during October, 1980, to discuss the economic situation in the shrimp industry.

This meeting resulted in a statement issued by the Secretary of Commerce on October 28, 1980. This statement indicated that the shrimp industry was facing a critical economic situation. A cost price squeeze caused by rising fuel costs combined with declining consumer demand and depressed prices had placed a significant portion of shrimp harvesters in jeopardy of bankruptcy and had undermined the long-time viability of the industry. The Secretary offered a program of assistance to help shrimp vessel operators weather the current economic and energy crisis and to promote restructuring the industry to enhance long-term productivity and competitiveness. In summary, the program calls for the formation of a high-level NOAA task force to oversee the implementation of:

1. $11 million of Department of Commerce funds made available for low cost loans with the possibility of an additional $5 million in the future. These monies will result from removing a moritorium on the Fisheries Loan Fund and through EDA funds.



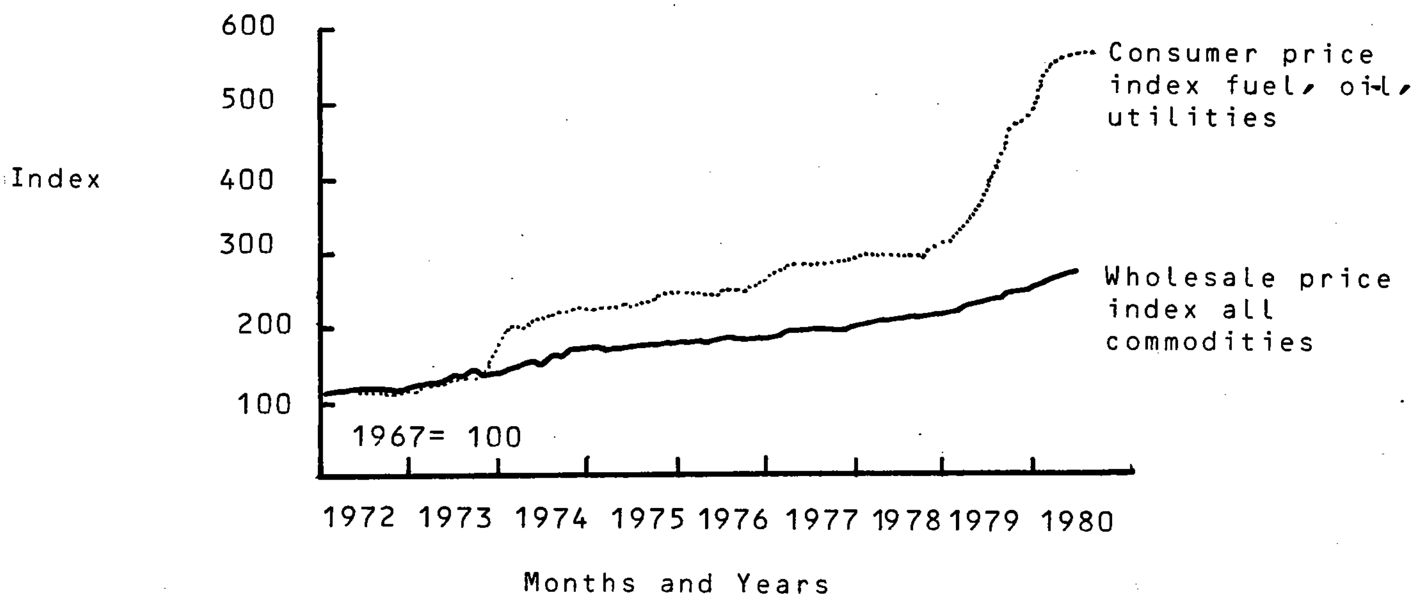


Figure 3.5-14.--Monthly current and deflated price of 21-25 raw headless shrimp in the Gulf and South Atlantic, consumer price index for fuel, oil and utilities and wholesale price index for all commodities, 1972-1980.

2. Encouraging passage of the American Fisheries Promotion Act which will place $20-30 million in foreign fees in the Fisheries Loan Fund by late 1981.

3. Examination of the legislative possibility of a vessel debt consolidation program with possible interest subsidies.

4. Assistance on a case-by-case basis with EDA loans for refitting of vessels for participation in underutilized fisheries and purchase and installation of new energy and other cost-saving equipment for vessels remaining in the shrimp fishery. A direct one-time fuel adjustment grant requested by the industry was not felt to be consistent with the policy of encouraging fuel conservation.

5. Use of $200,000 in S-K money in 1981 to make available fishery production and market services for shrimp operators desiring to sell their vessels into underutilized fisheries.

6. Making available $1 million for a major seafood consumer education and information effort.

7. Support for a shrimp marketing council.

8. Formation of a top-level committee to identify research and development priorities directed at improving vessel productivity and efficiency with first attention given the shrimp production sector.

9. Provide support through S-K money for the establishment of a Shrimp Research Foundation.

10. Direction for the U.S. International Trade Commission to begin the immediate examination of the range of possible remedies under existing law of any harm shrimp imports are causing the domestic shrimp industry to suffer through their effect of a dampening on prices. The U.S. Trade Representative will also be asked to establish an interagency task force to analyze the impact of shrimp imports and to provide recommendations whether temporary import relief measures are necessary and advisable. Talks will also be held with shrimp exporting countries.

Hence, it becomes quite apparent that with an open access fishery and rapidly rising demand, the capitalization level of the shrimp fishery can be dramatically raised. The influence of uncontrollable external factors such as rapidly rising fuel prices and the normal consumer demand related price movements then makes the overcapitalization question apparent during the less satisfactory economic periods. The relevent question becomes do the positive economic benefits enjoyed during periods of rapidly rising price outweigh the negative benefits which become evident during periods of low prices and to what degree would limited access reduce these negative benefits?

3.5.2.4 <u>Annual Participation in the Fishery</u>

Annual participation in the fishery may be measured in terms of total boats and vessels participating in the fishery. A more precise estimate includes consideration of time spent fishing such as vessel and boat days fished and/or man days fished per period of time. These alternative estimates of annual participation are considered in this section.

<u>Vessels and Boats</u>

The number of boats and vessels in the Gulf of Mexico shrimp fishery are available in published form through 1975. Shortcomings, however, exist in the data. Boats and vessels recorded in Fishery Statistics of the United States contain duplication when individual states are reviewed. These data record the number of craft landing shrimp in each state. Due to the mobility of the fleet some boats and vessels are recorded in more than one state. Gulf totals but not state totals are adjusted for duplication.

Total shrimp vessels fishing in the Gulf of Mexico increased from a low of 2,600 in 1962 to a high of 4,091 in 1973 for the 1960 to 1975 period. After 1973 the number of shrimp vessels in the Gulf declined to 3,690 by 1975 (latest year of published data).

The number of vessels landing shrimp has been greatest in Texas each year since 1960 (Table 3.5-22). Overall the number of vessels increased over the 16 year period to a high of 2,294 in 1973. Louisiana is the second most important state for landings by shrimp otter trawl vessels. The Louisiana trend in vessel numbers is similar to the trend for Texas; the number gradually increased and reached a peak in 1973. Florida and Alabama also have had increases in number of shrimp vessels over the period and both also had peak years in 1973. Mississippi is the only state showing an overall decrease in number of shrimp vessels landing in their ports.

The total number of shrimp otter trawl boats gradually increased to 5,109 in the Gulf of Mexico in 1968 and then declined to 4,500 in 1972 (Table 3.5-23). By 1975, the number of shrimp boats increased to 5,054.

Louisiana has the greatest number of shrimp otter trawl boats landing in her ports, accounting for between 60 to 70 percent of all shrimp boats in the Gulf. Texas and Mississippi are the next two states in importance in terms of number of shrimp boats landing in their ports. Both states experienced an increase in number of shrimp boats over the 16 year period. Number of shrimp boats landing catch in Florida and Alabama declined over the same time period.

Trends in number of otter trawl shrimp boats were less consistant by state than were trends in number of shrimp vessels. Year-to-year variation was greater and peak years were usually different for each state. Years of peak shrimp boat activity by state were: 1966, Texas; 1972, Louisiana; 1968, Mississippi, and; 1963 for both the Florida west coast and Alabama.

Comparison of boat and vessel totals with and without duplication (Table 3.5-22 and 3.5-23) gives an indication of participation of vessels and boats in the shrimp fishery in states other than their home state. The number of vessels recorded in more than one state ranged from a low of 1,022 in 1962 to a high of 2,080 in 1973. If each vessel only lands shrimp in one other state in addition to its home state, these estimates represent maximum estimates of vessels participating in the fishery in neighboring states. If each vessel fishing outside of its home state landed shrimp in all Gulf states, a minimum of between 270 and 520 vessels would have participated in fisheries outside of their home states. These minimum and maximum estimates provide a range on the number of vessets participating in fisheries in other states.

Between 1960 and 1967 relatively few boats landed shrimp outside of their home states (Table 3.5-23). After 1967 no boats landed shrimp in Gulf states other than their home states.

In addition to the participation of Gulf of Mexico boats and vessels in several Gulf states there has been recent reports of movement into Gulf waters by the south Atlantic fleet, especially during periods of low production in the south Atlantic states. Studies now under way pinpoint current casual evidence of mobility.

Only unpublished estimates developed from the "code book" used by port agents are available for current indications of the number of vessels and boats participating in the Gulf of Mexico shrimp fishery (personal communications with J. Ernest Snell, NMFS, Miami Center). These estimates are based on the vessel code book through June, 1980. The total number of shrimp otter trawl vessels in the Gulf of Mexico was 4,585 as of June, 1980 (Table 3.5-24). This represents a considerable increase

Table 3.5-22. Number of shrimp otter trawl vessels by state, 1960 to 1975

Year	Florida West Coast	Alabama	Missississippi	Louisiana	Texas
1960	869	222	435	1,235	1,521
1961	875	187	447	962	1,541
1962	823	168	451	905	1,275
1963	847	247	432	1,262	1,356
1964	901	230	405	1,343	1,387
1965	845	295	409	1,299	1,371
1966	886	366	410	1,342	1,409
1967	891	397	351	1,422	1,675
1968	986	467	486	1,447	1,815
1969	932	506	464	1,502	1,806
1970	813	448	452	1,693	1,723
1971	756	456	344	1,517	1,931
1972	849	451	310	1,624	1,900
1973	1,054	550	365	1,908	2,294
1974	913	439	245	1,446	2,006
1975	932	455	237	1,387	1,758

Year	Total exclusive of duplication	Total[a] including duplication	Vessels in more than one state: Maximum[b]	Minimum[c]
1960	2,941	4,282	1,791	448
1961	2,686	4,012	1,326	332
1962	2,600	3,622	1,022	256
1963	2,697	4,144	1,447	362
1964	2,782	4,266	1,484	371
1965	2,849	4,219	1,130	343
1966	2,942	4,413	1,471	368
1967	3,146	4,736	1,590	398
1968	3,430	5,201	1,771	443
1969	3,569	5,210	1,641	410
1970	3,579	5,129	1,550	388
1971	3,487	5,004	1,517	379
1972	3,683	5,134	1,451	363
1973	4,091	6,171	2,080	520
1974	3,785	5,049	1,264	316
1975	3,690	4,769	1,079	270

[a] Computed as the summation of vessels landing in each state.

[b] Maximum number of vessels landing in more than one state. Computed as the difference in totals with and without duplication. Assume each vessel fishes only in one other state.

[c] Minimum number of vessels. Computed by dividing maximum number of vessels by four. Assume each vessel fishes in all states in addition to its homes state.

Source: Fishery Statistics of the United States.

Table 3.5-23. Number of shrimp otter trawl boats by state, 1960 to 1975

Year	Florida West Coast	Alabama	Mississippi	Louisiana	Texas
1960	90	206	385	1,999	421
1961	104	192	346	1,920	429
1962	111	231	356	2,443	803
1963	127	247	357	2,867	919
1964	107	231	360	2,967	695
1965	114	206	396	3,236	845
1966	98	203	380	3,261	861
1967	95	174	594	3,402	724
1968	84	139	634	3,471	781
1969	76	129	615	3,452	545
1970	76	149	600	3,250	420
1971	70	169	618	3,465	506
1972	66	179	540	3,625	438
1973	82	156	452	3,603	430
1974	78	127	416	3,581	387
1975	73	133	455	3,549	844

Year	Total exclusive of duplication	Total[a] including duplication	Boats in more than one state	
			Maximum[b]	Minimum[c]
1960	3,089	3,101	12	3
1961	2,987	2,991	4	1
1962	3,927	3,944	17	4
1963	4,481	4,517	36	9
1964	4,360	4,360	0	0
1965	4,785	4,797	12	3
1966	4,797	4,803	6	2
1967	4,983	4,989	6	2
1968	5,109	5,109	0	0
1969	4,817	4,817	0	0
1970	4,495	4,495	0	0
1971	4,828	4,828	0	0
1972	4,848[d]	4,848	0	0
1973	4,723	4,723	0	0
1974	4,589	4,589	0	0
1975	5,054	5,054	0	0

[a] Computed as the summation of boats landing in each state.

[b] Maximum number of boats landing in more than one state. Computed as the difference in totals with and without duplication. Assume each vessel fishes only in one other state.

[c] Minimum number of boats. Computed by dividing maximum number of boats by four. Assume each vessel fishes in all states in addition to its homes state.

[d] Reported incorrectly as 4,500 in published statistics.

Source: Fishery Statistics of the United States.

from 3,690 vessels in 1975 (Table 3.5-22). The number of boats also increased from 5,054 in 1975 to 5,475 in 1980. The relative importance of individual states in terms of number of boats and vessels is the same as indicated in the previous discussion, however, the numbers recorded by state are lower due to a lack of duplication in the 1980 estimates.

Boat and Vessel Days Fished

Annual participation in the shrimp fishery can be approximated in several ways. Total days (24 hour units) fished represents an estimate based on the number of boats and vessels and number of days fished per craft. Total vessel days fished were 88,400 in 1962 after which time total vessel days increased to a maximum of 149,184 days in 1969 (Table 3.5-25). Overall the number of vessel days fished per year increased 32.8 percent from the 1962 to 1964 period to the 1972 to 1974 period. This increase in annual participation in vessel days per year was mainly a function of the number of vessels which increased over the period while there was no overall trend in number of days fished per year. However, peak number of total vessel days per year were associated with years with high days fished per vessel.

Annual participation in the boat fishery was approximately 50 percent of the participation in the vessel fishery during the 1962 to 1964 period (Table 3.5-25). The large increase in average days fished per boat over the period, however, increased total days fished by boats to approximately 65 percent of total days fished by vessels. Total days fished per boat increased from approximately 50,000 days at the beginning of the period to approximately 90,000 days per year during 1972 to 1974. Overall the total days fished by both boats and vessels was 229,802 days annually during the 1972 to 1974 period.

The level of annual participation is a function of profits in the fishery which depend on catch, costs and prices. Data are not available on all of these variables over time. Catch per day fished generally declined for both boat days and vessel days over the 1962 to 1974 period (Table 3.5-12). However, increases in prices were sufficient that total annual revenue per boat and per vessel more than doubled over this period. (Table 3.5-26). The total number of boats and vessels participating in the fishery was positively related with exvessel prices (compare Tables 3.5-2 and 3.5-13).

Man-Days Fished Per Season

Total man-days fished per season on vessels was estimated as the number of vessel fishermen (from Table 3.5-26) multiplied by the number of days fished per vessel per year. These were computed on a 24 hour day basis. Man-days on boats were computed in the same way (from Table 3.5-27).

Total man-days on vessels varied widely from year to year with an overall increase of approximately 30 percent between the 1962 to 1964 period and the 1972 to 1974 period. (Table 3.5-28). Total number of days fished on boats remained relatively stable between 1964 and 1971 but then increased considerably. Total days fished on boats and vessels averaged 326,181 days during the 1962 to 1964 period and then increased 34 percent to an average of 437,894 days per season during the 1972 to 1974 period.

Table 3.5-24. Number of commercial vessels and boats participating in Gulf of Mexico shrimp fishing by state exclusive of duplication, 1980

State and Region	Vessels[a]	Boats[a]
Florida West Coast	690	175
Alabama	465	150
Mississippi	280	450
Louisiana	1,300	4,000
Texas	1,850	700
Total Gulf	4,585	5,475

[a] Recorded vessels and boats landing through an identified dealer.

Source: Code book used by port agents of the NMFS. Personal communication with J. Ernest Snell.

Table 3.5-25. Annual participation in the shrimp fishery by vessels and boats, 1962 to 1974

	Vessels			Boats		
Year	Number	Days[a] fished per vessel	Total days fished	Number	Total days fished	Days fished per boat
1962	2,600	34.0	88,400	3,927	58,120	14.8
1963	2,697	41.9	113,004	4,481	38,537	8.6
1964	2,782	41.1	114,340	4,360	55,372	12.7
1965	2,849	39.9	113,675	4,785	56,463	11.8
1966	2,942	38.6	113,561	4,797	62,361	13.0
1967	3,146	36.9	116,087	4,983	66,274	13.3
1968	3,430	35.4	121,422	5,109	69,993	13.7
1969	3,569	41.8	149,184	4,817	52,505	10.9
1970	3,579	37.6	134,570	4,495	65,178	14.5
1971	3,487	39.3	137,039	4,828	68,075	14.1
1972	3,683	39.9	146,952	4,848	88,234	18.2
1973	4,091	34.2	139,912	4,723	97,766	20.7
1974	3,785	35.0	132,475	4,589	90,403	19.7

[a] Day = 24 hours of fishing time.

Source: Fishery Statistics of the U.S.

Table 3.5-26. Gross sales per vessel and per boat, 1962 to 1975

Year	Total boats and vessels	Gross sales per vessel	Gross sales per vessel (catch statistics)	Gross sales per boat (catch statistics)
	dollars			
1962	6,527	9,278	12,846	3,030
1963	7,178	8,852	15,387	2,098
1964	7,142	8,778	14,630	2,202
1965	7,634	9,288	17,234	1,985
1966	7,739	10,721	21,040	2,545
1967	8,129	11,142	21,774	2,428
1968	8,539	11,222	19,942	2,584
1969	8,386	12,051	20,818	3,695
1970	8,074	13,399	22,744	3,915
1971	8,315	16,389	28,907	4,909
1972	8,183	19,234	32,609	5,672
1973	8,814	19,498	28,990	7,262
1974	8,374	16,485	26,367	4,947
1975	8,834	20,188		

Computed from Tables 3.5-12, 3.5-13 and 3.5-2.

Table 3.5-27(a). Resident vessel shrimp fishermen for the Gulf and Gulf states (1958 to 1975)

Year	Total Gulf*	Florida West Coast	Alabama	Mississippi	Louisiana	Texas
1958	8,171	2,669	518	1,221	2,749	4,592
1959	8,225	2,520	577	1,261	3,235	4,222
1960	7,849	2,119	564	1,106	3,432	4,142
1961	7,186	2,091	462	1,152	2,613	4,268
1962	6,661	1,955	428	1,174	2,348	3,406
1963	7,252	2,601	659	1,157	3,380	3,824
1964	7,121	2,254	582	1,000	3,503	3,749
1965	7,223	2,105	706	1,010	3,341	3,657
1966	7,466	2,140	882	1,020	3,524	3,787
1967	8,219	2,161	961	972	3,782	4,723
1968	8,851	2,412	1,164	1,195	3,824	4,932
1969	9,266	2,350	1,283	1,166	3,987	4,975
1970	9,386	2,033	1,143	1,127	4,450	4,737
1971	9,042	1,897	1,160	851	4,063	5,247
1972	9,534	2,159	1,166	766	4,170	5,264
1973	10,573	2,710	1,438	904	4,948	6,312
1974	9,733	2,377	1,175	615	3,675	5,415
1975	9,507	2,425	1,179	573	3,552	4,751

Source: Fishery Statistics of the United States

* exclusive of duplication between states

** estimates for 1975 are all the latest available

Table 3.5-27(b). Resident full-time boat shrimp fishermen for the U.S. Gulf, by states (1958 to 1975)

Year	Total Gulf*	Florida West Coast	Alabama	Mississippi	Louisiana	Texas
1958	4,358	219	348	322	2,824	645
1959	4,280	149	340	270	2,789	768
1960	4,116	140	346	248	2,836	570
1961	3,903	147	315	208	2,668	573
1962	4,108	172	371	216	2,815	565
1963	4,443	203	395	220	3,098	594
1964	4,451	160	380	232	2,974	705
1965	4,457	178	335	235	2,997	735
1966	4,312	142	311	178	2,919	772
1967	4,195	110	279	168	2,949	699
1968	3,988	104	227	146	2,910	601
1969	3,771	88	188	150	2,914	431
1970	3,774	97	174	200	2,791	512
1971	3,879	93	171	254	2,808	553
1972	3,794	75	177	218	3,188	475
1973	4,078	94	158	200	3,152	474
1974	3,937	94	125	222	3,130	366
1975	4,159	75	147	216	3,168	553

Source: <u>Fishery Statistics of the United States</u>

Table 3.5-28. Man-days fished per season, 1962 to 1974

Year	Man-Days Fished (24 Hours)		
	On Vessels	On Boats	Total
1962	226,474	60,798	287,272
1963	303,859	38,210	342,069
1964	292,673	56,528	349,201
1965	288,198	52,593	340,791
1966	288,188	56,056	344,244
1967	303,281	55,794	359,075
1968	313,325	54,636	367,961
1969	387,319	41,104	428,423
1970	352,914	54,723	407,637
1971	355,351	54,694	410,045
1972	380,407	69,051	449,458
1973	361,597	84,415	446,012
1974	340,655	77,559	418,214

Computed from Tables 3.5-15, 3.5-26 and 3.5-27.

3.5.3 Domestic Commercial Processing Characteristics

3.5.3.1 Total Gross Income from the Shrimp and All Related Fisheries

Annual production for the Gulf region by product type of shrimp is shown in Table 3.5-29. Raw headless shrimp appear to generate the most revenue for Gulf processors: they constitute 45 percent of gross income in the 1967 to 1976 time period. Raw peeled shrimp make up 26 percent of the total, and breaded shrimp 17 percent. Although it involves a substantial amount of poundage processed, canning accounts for only ten percent of revenue, and the remaining two percent is split between dried shrimp and cooked and peeled shrimp.

3.5.3.2 Investment in Plant and Equipment

The number of seafood processing plants in the Gulf totaled 356 in 1976 (Table 3.5-30). No data are available for the capital assets or the yearly investment in shrimp processing either at national or at Gulf-wide levels. Data are available at the national level to construct an accurate capital series for all canned and cured seafood processing plants and for all fresh and frozen seafood processing plants. These data will be useful for comparative purposes if, at some future time, a shrimp processing capital series can be constructed.

3.5.3.3 Total Employment and Labor Income

Statistics for the Gulf shrimp processing industry cannot be isolated from the total fish processing data. Table 3.5-31 gives the pattern of employment and Table 3.5-32 shows the average hourly wage, for the nation and for the Gulf region. The annual rate of increase in fish processing employment has exceeded the national average for all manufacturing industries. Employment, reflected in both yearly average and seasonal high, declined for Louisiana and Texas in the 1970 to 1976 interval, while the other three states in the Gulf fishery all registered increases.

3.5.4 Recreational Fishing Characteristics

From 1955 to 1970, the number of marine recreational fishermen in the U.S. Gulf of Mexico more than doubled, from 1.1 million to 2.3 million, and expenditures by recreational fishermen more than quadrupled, from about $98 million to $405 million. A 1975 marine recreational survey conducted by the National Marine Fisheries Service suggested that the total poundage of shellfish, in terms of live weight, taken by recreational fishermen amounted to more than 56 million pounds, or about 25 percent of the finfish catch. Brown, 1981, estimated in excess of 239,000 recreational participants in shrimping in the Gulf exclusive of Florida in 1979. He estimated the Gulf recreational catch exclusive of Florida to be about 10.5 million pounds in 1979 and 6 million pounds in 1980.

Most of the shrimp caught by recreational fishermen are taken with otter trawls ranging from 16 to 40 feet in width. Seines, cast nets, dip nets, butterfly nets, and push nets are also used in some areas. It is not possible from available data to determine what portion of the total recreational shrimp catch is used for home consumption and what may be sold commercially.

State-by-state summaries of the recreational shrimp fishery are:

Florida west coast: No permit is required; total catch and effort are not quantified. The number of boats is estimated at 500 to 650 (Charles R. Futch, Florida Department of Natural Resources, personal communication).

Table 3.5-29. Volume and value from Gulf of Mexico shrimp processing plants, 1958 to 1978

Year	Breaded cooked and raw		Cooked and peeled		Raw headless shrimp	
	Dollars	Pounds	Dollars	Pounds	Dollars	Pounds
	----------	----------	---------- thousand	----------	----------	----------
1958	20,854	19,392	2,265	2,368	43,474	57,284
1959	18,094	18,156	1,739	2,227	32,914	55,486
1960	25,608	25,530	2,379	2,851	45,263	74,730
1961	32,016	26,941	2,354	2,839	31,993	42,297
1962	33,399	25,870	1,925	1,965	43,743	47,646
1963	30,437	27,092	2,465	2,745	44,748	62,143
1964	35,459	31,661	2,243	2,745	44,271	55,295
1965	45,211	35,605	3,580	4,216	48,689	58,928
1966	52,001	36,349	3,707	3,705	54,207	56,242
1967	43,494	32,319	3,922	4,039	81,121	91,860
1968	53,257	35,687	4,327	3,569	76,448	74,205
1969	59,545	37,396	5,510	5,318	88,031	80,452
1970	55,900	35,462	4,586	5,751	91,342	88,061
1971	61,085	36,048	6,378	5,013	112,342	87,860
1972	76,451	38,763	4,004	4,038	125,159	86,824
1973	95,767	40,680	4,927	2,819	149,473	43,642
1974	75,173	32,888	4,788	3,032	114,077	65,537
1975	68,066	26,716	4,319	2,535	132,084	56,183
1976	92,835	28,935	3,549	1,832	255,877	85,459
1977	118,016	53,178	4,162	1,213	308,635	109,984
1978	136,735	63,667	7,333	2,378	355,521	109,848

Year	Raw Peeled		Canned		Dried	
	Dollars	Pounds	Dollars	Pounds	Dollars	Pounds
	----------	----------	---------- thousand	----------	----------	----------
1958	4,402	5,309	16,759	22,034	493	1,688
1959	6,056	9,437	13,259	21,207	291	1,555
1960	19,519	13,702	14,853	24,428	796	3,430
1961	13,058	15,402	8,760	13,142	745	2,019
1962	14,360	14,825	16,502	21,584	598	1,796
1963	17,258	18,676	17,503	27,765	380	2,194
1964	19,155	21,957	11,929	17,812	461	1,092
1965	21,286	23,430	19,560	27,724	547	1,329
1966	26,443	25,664	20,383	26,057	685	1,640
1967	33,033	30,842	19,833	26,489	582	1,701
1968	37,715	31,068	22,079	27,527	1,066	2,707
1969	42,260	30,852	20,898	27,663	1,135	3,141
1970	45,540	40,228	26,730	34,664	n.a.	n.a.
1971	48,934	36,893	23,787	29,130	1,356	3,498
1972	47,380	31,917	29,160	29,937	1,439	2,876
1973	43,371	24,671	38,024	27,420	1,250	1,558
1974	33,937	24,145	31,137	26,131	1,401	2,482
1975	34,824	25,249	17,486	14,235	2,931	2,879
1976	67,685	32,437	32,606	22,511	1,748	2,217
1977	62,683	25,967	48,271		2,073	
1978	83,839	83,314	33,563		2,042	

Source: Processed Fishery Products.

Table 3.5-30. Number of processing plants in the Gulf coast states, 1970 to 1978

Year	Total	Florida West Coast	Alabama	Mississippi	Louisiana	Texas
1970	435	438	44	43	122	88
1971	428	127	48	44	128	81
1972	417	118	51	42	124	82
1973	407	118	51	40	118	80
1974	360	103	44	37	112	64
1975	350	106	43	37	104	60
1976	356	113	43	36	109	55
1977	388	107	50	38	139	54
1978	425	139	50	40	136	60

Source: Fishery Statistics of the United States and Processed Fishery Products, Annual Summary.

Table 3.5-31. Yearly average and seasonal high employment in seafood processing

Year	Total Gulf		Florida West Coast		Alabama	
	Yearly Avg.	Sea. High	Yearly Avg.	Sea. High	Yearly Avg.	Sea. High
1970	11,527	15,659	3,507	4,137	875	1,383
1971	11,488	15,912	3,562	4,321	1,018	1,590
1972	11,477	15,372	3,409	3,971	1,158	1,732
1973	11,405	15,440	3,477	3,951	1,196	1,786
1974	9,316	13,245	2,953	3,473	1,040	1,496
1975	9,058	12,028	2,860	3,319	1,005	1,419
1976	10,399	13,590	3,393	4,014	1,297	1,839
1977	11,146	15,481	3,482	4,228	1,488	2,298
1978	11,164	15,159	3,717	4,487	1,284	1,869

Year	Mississippi		Louisiana		Texas	
	Yearly Avg.	Sea. High	Yearly Avg.	Sea. High	Yearly Avg.	Sea. High
1970	990	1,458	3,177	4,612	2,978	4,069
1971	1,025	1,604	3,122	4,699	2,771	3,698
1972	1,087	1,564	3,262	4,775	2,561	3,328
1973	1,016	1,466	3,233	4,807	2,483	3,430
1974	1,088	1,516	2,953	4,242	1,282	2,518
1975	1,035	1,468	2,733	3,780	1,425	2,042
1976	1,124	1,530	2,865	3,958	1,720	2,249
1977	1,295	1,782	3,103	4,676	1,778	2,497
1978	1,290	1,788	3,140	4,611	1,733	2,404

Source: Fishery Statistics of the United States and Current Fisheries Statistics.

Table 3.5-32. Hourly wage rates for seafood processing 1958 to 1976

Year	Canned and Cured		Fresh and Frozen	
	Nation	Gulf	Nation	Gulf
1958	$1.57	$1.10	$1.17	$ .82
1959	1.68	1.18	1.19	.83
1960	1.79	1.25	1.20	.84
1961	1.79	1.25	1.28	.90
1962	1.88	1.32	1.41	.98
1963	1.91	1.34	1.41	.98
1964	1.94	1.36	1.46	1.02
1965	2.07	1.56	1.65	1.24
1966	2.12	1.59	1.71	1.28
1967	2.19	1.64	1.80	1.35
1968	2.28	1.72	1.90	1.42
1969	2.34	1.86	2.04	1.62
1970	2.74	2.19	2.00	1.60
1971	2.86	2.29	2.17	1.73
1972	3.09	2.81	2.59	2.36
1973	3.34	3.04	2.72	2.48
1974	3.60	3.27	3.07	2.79
1975	3.87	3.52	3.32	3.02
1976	4.50	4.10	3.65	3.31

Source: Census of Manufacturers and Annual Survey of Manufacturers, U.S. Department of Commerce.

Alabama: About a third of the owners of boats in the coastal counties less than 26 feet in length owned 16-foot trawls, for which no licenses are required (Swingle, et al., 1976). There are more than 6,000 such boats. Swingle, et al. (1976) estimate that recreational shrimpers harvested 15 to 25 percent of the total catch in the inland waters (Table 3.5-33). Brown, 1981, estimated 20,423 recreational participants took 785,242 pounds of whole shrimp in 1979, and 29,194 took 710,492 pounds in 1980. Because of catch limitations, some recreational shrimpers often purchase commercial licenses during open commercial seasons to avoid poundage restrictions imposed on sport shrimpers.

Mississippi: Weaver and Christmas (n.d.) estimate that recreational shrimpers constituted an average of 67 percent of the licensed shrimpers in 1974-1976 and took more than a half million pounds of shrimp or about one-eighth of the reported inshore commercial catch during the three-year period (Table 3.5-33). Brown, 1981, estimated 8,929 participants in 1979 catching about 900 thousand pounds.

There is no distinction between commercial and recreational shrimpers under the law. In their study, Weaver and Christmas classified recreational shrimpers as those who reportedly did not sell their catches.

Louisiana: More recreational shrimpers are located in Louisiana than in any other state. It is estimated that in 1973 sport shrimpers in Louisiana equipped some 30,000 boats with otter trawls and harvested some 23.6 million pounds (heads-on) of shrimp, Table 3.5-33 (U.S. Army Corps of Engineers n.d.). At the present time, both the number of boats equipped with trawls and the total catch are probably much higher. Brown, 1981, reports 173,948 participants catching 7.8 million pounds in 1979 and 122,522 participants catching 3.8 million pounds in 1980. No license is required for recreational trawls up to 16 feet. Licenses are required for trawls in the 17- to 50-foot range. The smaller trawl operators may take up to 100 pounds of shrimp, heads-on, per day with no size limitations. A sport trawling license permits the shrimper to take as many shrimp each day as he can, provided the shrimp are not sold. Recreational shrimpers often purchase commercial licenses which permit them to shrimp on a part-time basis and sell all or part of the catch. Most of the shrimp sold go to outlets which are not statistically monitored, so the magnitude of this commercial catch cannot be defined.

Texas: King (1975) estimated that 1.1 percent of the Texas shrimp harvest was caught by recreational shrimpers in 1973. Recreational shrimpers harvested about 846,000 pounds from Texas' bays and about 55,000 pounds from the Gulf waters adjacent to Texas (Table 3.5-33). Brown, 1981, reported 49,853 participants taking 1.4 million pounds in 1980. Licenses are required of Texas recreational fishermen. An additional license is required for trawls. Cast nets, dip nets, traps, and minnow seines do not require licenses. Catch limits are two quarts per person during any inland waters closed season. Up to 100 pounds may be taken in major bays during the open season, August 15 to December 15 and from Gulf waters under state jurisdiction during the July 16 to May 31 season. The limit is 15 pounds in major bays during the May 15 to July 15 season. Recreational shrimpers are prohibited from selling any portion of their catch and are subject to the same size restrictions as commercial fishermen.

Personal Communications from Fishery Managers

The following information on recreational shrimping was collected by means of personal communications with fishery management personnel from each of the five Gulf states.

Florida west coast: Most of the interest in recreational shrimping appears to be centered in the Apalachicola Bay region. The boats used in the fishery range in size from about 15 feet to large cabin cruisers, and include a number of small (20-25 feet) fully-rigged shrimp boats. Most of the recreational effort is expended on weekends during summer and autumn by residents of the coastal counties and adjacent inland counties. Trawls range in size from 14 to 18 feet with an average size of 16 feet. Other gear types are seldom used to harvest shrimp for home consumption. The popularity of recreational shrimping in Florida appears to be related to the retail price of shrimp rather than to the availability of the resource. The number of participants in the recreational shrimp fishery may increase if shrimp prices continue to rise. (Charles R. Futch, Assistant Chief, Bureau of Marine Science and Technology, Florida Department of Natural Resources, Tallahassee, 9 May 1978).

Comparatively little recreational shrimping occurs on the Florida west coast. Some recreational effort may occur out of the Cedar Key area by inland county residents traveling to the coast for the weekend. There may have been a decline in the number of participants in the recreational shrimp fishery in the past few years because of the rising prices of fuel, nets, and equipment. Also, obtaining the necessary information on how to shrimp may be more difficult here than in other areas (Jeffrey A. Fisher, Marine Advisory Agent, Panama City, 10 May 1978).

Alabama: Enforcement officers have observed an apparent increase in the number of recreational shrimp boats in the past few years which is believed to be mainly due to the rising retail price of shrimp. The number of participants will probably increase if shrimp prices continue to rise. Most of the recreational effort is expended in the Mississippi Sound and lower Mobile Bay where the greatest concentrations of brown shrimp occur. Some recreational effort may occur in Wolf and Perdido Bays but is small by comparison. Recreational shrimpers reside primarily in Baldwin and Mobile counties, although some live in the inland counties and travel to the coast to shrimp. Residents of other

Tab .5-33. Gulf of Mexico recreational shrimp fishery: the sur methods, number of sport trawls, estimated total effort (m.h man hours, a.d. = angler-days, m.d. = man-days, and T = trips), estimated total catch and data source by state and year.

State	Year	Survey Method	Number of Sport Trawls[1]	Estimated Total Effort	Estimated Total Catch (lbs. heads-on)	Data Source
Florida West Coast			2/	2/	2/	2/
Alabama	1972	Postal and Telephone Survey	5,727 3/	4/	277,051	Swingle et al., 1976
	1973	Personal Interview	5,727	309,644 m.h.	204,577	Swingle et al., 1976
	1974	Personal Interview	5,727	189,944 m.h.	290,541	Swingle et al., 1976
	1979	Interview and Telephone	4/	53,330 T	785,242	Brown, 1981
	1980	Interview and Telephone	4/	88,556 T	710,492	Brown, 1981
Mississippi	1974	Personal Interview	1,535	19,958 a.d.	166,667	Weaver and Christmas n.d.
	1975	Postal and Telephone	1,770	15,410 a.d.	176,353	Weaver and Christmas n.d.
	1976	Survey	1,874	16,571 a.d.	182,111	Weaver and Christmas n.d.
	1979	Interview and Telephone	4/	31,642 T	901,343	Brown, 1981
	1980 5/	Interview and Telephone	4/	11,464 T	70,528	Brown, 1981
Louisiana	1968	Telephone Survey	14,000	378,000 m.d. 6/	19,000,000	U.S. Fish and Wildlife Service, 1972
	1973	7/	30,000	472,000 m.d.	23,600,000	U.S. Army Corps of Engineers n.d.
	1979	Interview and Telephone	4/	482,414 T	7,795,024	Brown, 1981
	1980	Interview and Telephone	4/	189,329 T	3,838,740	Brown, 1981
Texas 8/	1973	Postal and Telephone Survey	10,117	4/-5/	900,823 ±118,080	King, 1975
	1979	Interview and Telephone	4/	95,315 T	979,004	Brown, 1981
	1980	Interview and Telephone	4/	107,486 T	1,363,770	Brown, 1981

1/ The number of recreational trawls (≤ 16 feet in length) in Baldwin and Mobile Counties, Alabama, was estimated for 1972 based on the assumptions that all recreational trawls were owned by boat owners and that all recreational shrimping was conducted from boats ≤ 26 feet in length. The estimated number of recreational trawls in Louisiana during 1973 was based on the assumption that 25 percent of the licensed sport boats were equipped with trawls to harvest shrimp. The total number of trawls in Mississippi was based on the results of a survey of licensed trawl holders who reported no sale of catch. In Texas, the total number of recreational trawls was determined from direct counts of the number of "Individual Bait-Shrimp Trawl" licenses sold during 1973.

2/ No data available.

3/ Catch estimates for 1973 and 1974 were based on the assumption that there was no change in the number of trawls owned since 1972.

4/ Not determined.

5/ Incomplete.

6/ Based on the assumption that 14,000 shrimpers fished an average of 27 man-days each in 1968.

7/ The estimated total catch and effort for 1973 were projections based upon the result of the 1968 survey.

8/ Does not include data for May/June.

states have been periodically observed trawling recreationally in Alabama. Most of the recreational effort occurs on the weekends, and to a lesser extent, after work on weekdays. The boats generally range from 14 to 30 feet in length, with the majority in the 14 to 20 foot class. Most of the recreational catch is harvested with 16-foot otter trawls. Owners of 16-foot trawls sometimes purchase commercial licenses to avoid the poundage limitations imposed on recreational shrimpers. (Steven R. Heath, Marine Biologist, Alabama Department of Conservation and Natural Resources, Dauphin Island, 11 May 1978.)

Mississippi: Recreational shrimping occurs primarily in Mississippi Sound between Biloxi and Pascagoula, with a comparatively small effort in the vicinity of Waveland. Most recreational shrimping is conducted using a small boat (30 feet long or less) outfitted with a single 16-foot trawl with one to two people aboard. The majority of the recreational shrimpers reside in Harrison and Jackson counties; relatively few live in Hancock county. The number of licensed trawls in Mississippi has increased sharply in the last three years. (Tom Van Devender, Fishery Biologist, Gulf Coast Research Lab, Ocean Springs, 8 May 1978.)

Louisiana: There are a large number of participants in the recreational shrimp fishery. About 25 percent of the estimated 200,000 recreational boats registered in Louisiana are equipped with otter trawls. Although the majority of the recreational catch is taken in otter trawls, some effort occurs with wing nets and cast nets. Wing nets may be attached to fixed platforms or boats; cast nets are used in the Rockefeller Refuge, Lake Pontchartrain vicinity, and other accessible marsh areas. The boats used for recreational shrimping range in length from about 14 feet and up. Most of the residents of the coastal parishes who own boats 16 feet in length have otter trawls. Many recreational shrimpers are residents of larger cities and choose to shrimp in the wetland areas nearby. However, on a typical trip, recreational shrimpers travel 50 to 80 miles to shrimp in coastal areas. Comparatively few people from the northern part of the state above Baton Rouge travel to the coast to shrimp. There is no known recreational shrimping by residents of other states. (Harry Schafer, Chief; William S. Perret, Federal Aid Coordinator; Judd Pollard, Biologist, Division of Oysters, Water Bottoms and Seafoods, Louisiana Wildlife and Fisheries Commission, New Orleans, 6 June 1978.)

Texas: The general increase in the number of "Individual Bait-Shrimp Trawl" licenses sold in recent years suggests that the number of participants in the Texas recreational shrimp fishery has shown the same growth trends as the other Gulf states. The growth of the recreational shrimp fishery in Texas may be attributed to (1) population growth in the coastal areas, (2) an increase in leisure time, and (3) the rising retail price of shrimp. The boats used by recreational shrimpers average about 16 to 21 feet in length. Most of the shrimpers reside in coastal counties or adjacent inland counties. There is no known recreational shrimping effort by residents of other states. The majority of the recreational catch is taken with otter trawls. (Roy B. Johnson, Regional Director, Coastal Fisheries, Texas Parks and Wildlife Department, La Porte, 13 June 1978.)

3.5.5 Subsistence Shrimping

Accepting the definition of a subsistence shrimp fisherman as one who catches just enough shrimp to provide for immediate sustenance of his family, no individuals, communities, or societies fitting into this category could be identified as part of the Gulf of Mexico shrimp fishery. There are apparently some fishermen who partially subsist on shrimp. In a broader sense, there are substantial numbers of south Louisiana residents who alternate their subsistence activity from shrimping to crabbing, trapping, and hunting and who have little or no income other than that derived from these activities.

3.5.6 Indian Treaty Fishing Characteristics

No treaties or Congressional actions with Indians (Native Americans) which would affect a Gulf of Mexico fishery management plan have been located. One lawsuit, pending in Federal District Court for the Eastern District of Louisiana, seeks to enjoin enforcement of all Louisiana wildlife and fishery laws "unsupported by legitimate conservation considerations" as applied to three tribes domiciled in Louisiana. It seeks to overturn Louisiana laws regulating gill nets and seines, defining the line of demarcation between inside and outside waters for shrimping, and regulating nets and gear used for taking shrimp, by having them declared unconstitutional as applied to Houmas, Chittimacha, and Choctaw Indians on the grounds that treaties entered into between France and Spain and various Indian tribes were carried over in full force by the terms of the Louisiana Purchase.

3.5.7 Output of Domestic Commercial Bait-Shrimp Fishery

A bait-shrimp industry of considerable economic importance has arisen in some areas of the Gulf of Mexico due to the popularity of shrimp, live or dead, as bait for numerous varieties of saltwater game fish (Section 4.1, Predation). Each of the Gulf states has laws regulating the bait-shrimp industry. Generally there are no restrictions as to season, count size, or closed areas. The bait fishery is based primarily on the juveniles of brown, pink, and white shrimp, with pink shrimp dominant for Florida and brown and white shrimp dominant in the other states.

Otter trawls, side-frame trawls, cast nets, seines, and baited traps are used to harvest bait. The catch is sorted rapidly, and shrimp are placed in aerated live-bait wells. Live-bait shrimping operations are conducted primarily at night.

A state-by-state summary:

Florida: An average of 74.75 million shrimp, valued at $1.42 million, was produced in the 1968-1975 period (Table 3.5-34). The number of permits issued increased from a 1968-1969 low of 182 to 761 in 1974 (Table 3.5-34). A decline in the total catch has accompanied the increase in permits (Table 3.5-34).

Alabama: Swingle (1972) reports that 24 bonafide bait dealers in Baldwin and Mobile counties sold 1,544,000 live shrimp with a retail value of $64,500 during 1968. In addition to the live bait sales, a total of 22,200 pounds of dead shrimp was sold for bait with a retail value of $12,040. Bait-shrimping is a part-time occupation, primarily during the May-September period, for most of the bait dealers; 40 licenses were issued for 1977-1978 fiscal year (Steven R. Heath, Alabama Department of Conservation and Natural Resources, personal communication.)

Mississippi: Christmas, et al. (1976) estimate that bait-shrimpers in the coastal counties of Mississippi harvested a total of 60,317 pounds of live shrimp with a retail value of $96,804 during May to November, 1971. In addition, they estimate that 44,860 pounds of shrimp valued at $25,875 were used as dead bait during the same period.

Louisiana: Saltwater finfishermen in Louisiana used an estimated 1,529,000 pounds of bait-shrimp during 1973 (U.S. Fish and Wildlife Service data 1976, cited in U.S. Army Corps of Engineers n.d.). Live bait-shrimping in Louisiana comes under strict regulation, and a $1,000 property, cash, or performance bond must be posted by the dealer as surety for observance of regulations. The number of licenses issued during 1971-1978 varied between 11 and 28 per year; a recent high was 28 in 1974, and the 1978 total was 12 (W.S. Perret, LDWF personal communication).

Texas: Chin (1960) estimates that a total of 460,995 pounds of live bait-shrimp and 206,624 pounds of dead bait-shrimp were harvested from Galveston Bay from June 1957 to May 1959. The total retail value of the catches were $653,520 and $112,761 for live and dead bait-shrimp, respectively.

Stokes (1974) estimates that a total of 53,181 quarts of live bait-shrimp with a retail value of $265,905 were harvested in the Lower Laguna Madre area from November 1970 through October 1972. NMFS estimates that a total of 2,340,000 pounds of live and dead bait shrimp valued at $6,790,000 were harvested on the Texas coast in 1978. There were approximately 1,500 commercial bait-shrimp boat licenses issued that year.

3.5.8 Area Community Characteristics

3.5.8.1 Total Population

A very substantial settlement of the coastal area has occurred during the twentieth century, resulting in substantial changes to the estuarine habitat of the Gulf shrimp populations (Lindall and Saloman, 1977).

The most recent population trends in the coastal area are presented in Figure 3.5-15. The coastal parishes/counties display no uniform pattern of recent population change. However, on a state-by-state comparison the coastal parishes/counties that have been experiencing the most rapid growth tend to be situated along the Florida coast. Several Louisiana, Alabama, Mississippi, and Texas counties that show moderately strong growth appear to do so in conjunction with the spread of population in and around metropolitan areas. Rapid growth of Florida counties has long been associated with retirement.

Table 3.5-34. Total number of bait-shrimp permits issued, total live shrimp production and value of the catch in Florida for the years 1968 through 1975 (after Christmas and Etzold 1977).

Year	Permits	Live shrimp production (x 10^6 individuals)	Value (x 10^6 dollars)
1968	182	87.02	1.49
1969	182	88.55	1.76
1970	399	78.72	1.40
1971	401	67.04	1.23
1972	544	73.64	1.32
1973	361	70.31	1.34
1974	761	61.30	1.29
1975	699	71.43	1.55

The shrimp industry makes its presence felt in virtually all ports that lie on or near the Gulf of Mexico. However, in only a handful of ports could it be considered the dominant industry. The ports tend also to be sites of shipbuilding, petrochemical manufacture, and marine transport.

3.5.8.2 Total Employment in Shrimp Fishery

Average total employment in the shrimp fishery can only be estimated. A maximum estimate would be to assume all seafood wholesaling and processing employees were associated with processing and marketing of shrimp products. Under this assumption and with 1978 seafood processing and wholesaling data and 1975 numbers of full time fishermen, it is estimated that total employment in the Gulf is 31,440 at seasonal peaks and 26,692 on an annual basis (Table 3.5-35). Florida and Louisiana are leading states in the employment of processing employees while Texas is the leading state for employment in seafood wholesaling. Louisiana is the leading state for total employment.

An alternative, more conservative, estimation is to proportion processing and wholesaling employment in the same proportion as value of processed shrimp products is to total processed products. In 1978 processed shrimp products were 69 percent of total processed seafood products in the Gulf. With this proportion, total Gulf seasonal shrimp related employment is estimated to be 25,884 employees while the yearly average is estimated to be 22,608.

Table 3.5-35. Employment on shrimp boats and vessels and in seafood processing and wholesaling, 1975 and 1978, respectively[a]

State	Seafood Processing Averages		Seafood Wholesaling Averages	
	Seasonal	Yearly	Seasonal	Yearly
Florida West Coast	4,487	3,717	546	501
Alabama	1,869	1,284	181	101
Mississippi	1,788	1,290	151	95
Louisiana	4,611	3,140	617	498
Texas	2,404	1,733	1,268	815
Total Gulf	15,159	11,164	2,763	2,010

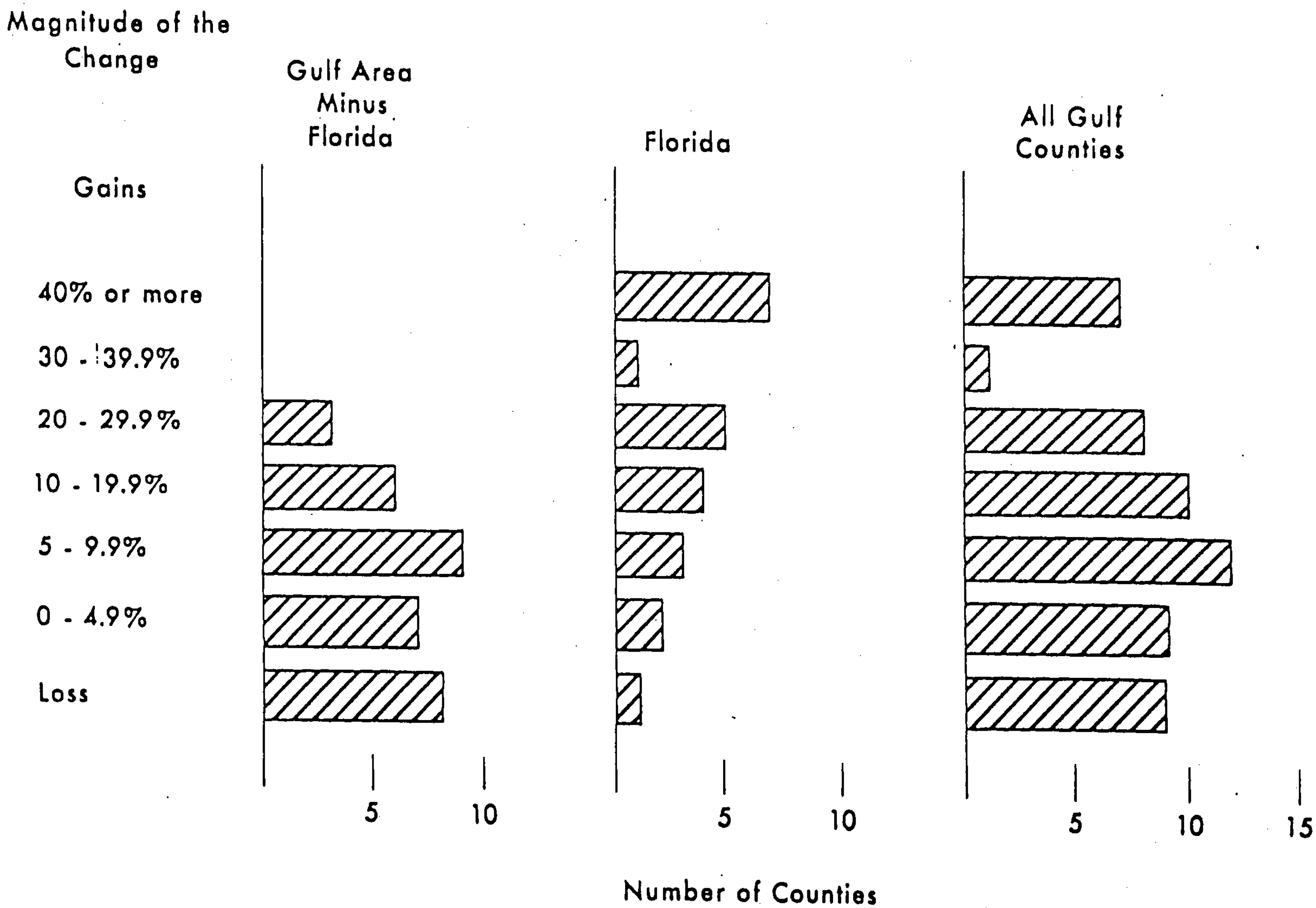
State	Full time Fishermen		Total Employment	
	Vessels	Boats	Seasonal	Yearly
Florida West Coast	2,425	75	7,533	6,718
Alabama	1,179	147	3,376	2,711
Mississippi	573	216	2,728	2,174
Louisiana	3,522	3,168	11,918	10,328
Texas	4,751	553	8,976	7,852
Total Gulf	9,359[b]	4,159[b]	31,440	26,692

[a] Latest years available. For total employment it is assumed 1975 level of fishermen represent 1978 levels.

[b] Total exclusive of duplication.

Souce: Fisheries of the United States, 1979, and Tables 3.5-26 and 3.5-27.

Figure 3.5-15. Estimated Change in Population, 1970-75



3.5.8.3 Relationship of Shrimp Fisheries to Total Work Force

Census information about numbers of shrimp fishermen is unavailable as it is masked among counts of people employed in agriculture, forestry, and fisheries. A frequency distribution of Gulf counties, in terms of the percent of the labor force that was employed, is given in Figure 3.5-16. It does not appear that shrimp fishing is a major contributor to overall employment in most of Gulf counties. The highest proportion employed in agriculture, forestry, and fisheries combined was 30 percent.

Table 3.5-36 compares, by county, the number of people identified as employed in the fisheries, mining, contract construction, and petrochemical manufacturing industries (county business patterns) for Texas and Louisiana counties identified as major centers of shrimp industry activity. The data indicate that the shrimp industry is overshadowed in all these units by other marine-oriented industries alone. The data suggest that the shrimp industry could not contribute, even at its peak, much more than 25 percent to the employment profile of any of these Gulf counties. In most cases, the peak contribution very likely is far less than 25 percent.

The presence of other industries in the shrimp ports is a mixed blessing to the shrimpers. Offshore oil, in particular, can provide off-season employment. However, in a number of ports shrimpers have had to relinquish berthing space to offshore oil or oceanic transshipment, both of which provide more revenue to port authorities.

3.6 Interaction Between and Among User Groups

3.6.1 Shrimpers Interactions

Recreational, bait, and commercial offshore and inshore shrimpers are the major direct users of the shrimp resource. Though easily grouped in this manner, there are differences within groups that occasionally result in disputes. There are differences on the size of shrimp preferred for harvest as well as varied techniques used by the groups to harvest. The migrating nature of shrimp make them initially susceptible to capture in shallow areas where gear alternatives are greater as opposed to the single technology of trawling by offshore shrimpers.

The inshore commercial shrimper, particularly in Louisiana, also has more business alternatives than the offshore shrimper. A survey of Louisiana shrimpers using undocumented boats in 1978 revealed that approximately 90 percent retained full-time employment other than shrimping (Sass and Roberts, 1979). The high incidence of casual shrimpers in inshore areas of Gulf states signifies the supplemental income approach to shrimping. The large number of participants in the Louisiana inshore fishery, as well as fisheries in other states, can occasionally stress the ability of shoreside facilities to adequately handle the catch. The then record season in 1977 stressed canning and ice facilities to the point where some shrimp spoiled prior to utilization. This occurred only during the initial week of the May-June inshore season. Subsequent seasons have not resulted in a shortage of ice. Louisiana facilities are adequate to support the processing and marketing of the Louisiana catch. Inshore shrimpers whether full-time or part-time generally operate their boats alone with a few occasionally using one or two crewmen when catch rates are high. Vessels operating a portion of their time inshore typically have one or two crewmen on board. This difference between inshore boats and vessels is marked by a preponderence of family members or friends serving as crew on the boats while the traditional crew relationship of sharing the value of the catch prevails on inshore vessels.

Offshore vessels operated by the owners are characterized by several methods of sharing the proceeds from the catch. Basically all the share systems call for the vessel and captain with crew to receive a share of the value of the catch after certain expenses are deducted. The expenses deducted

Figure 3.5-16. The percent of all county residents employed who were active in Agriculture, Forestry, and Fisheries.

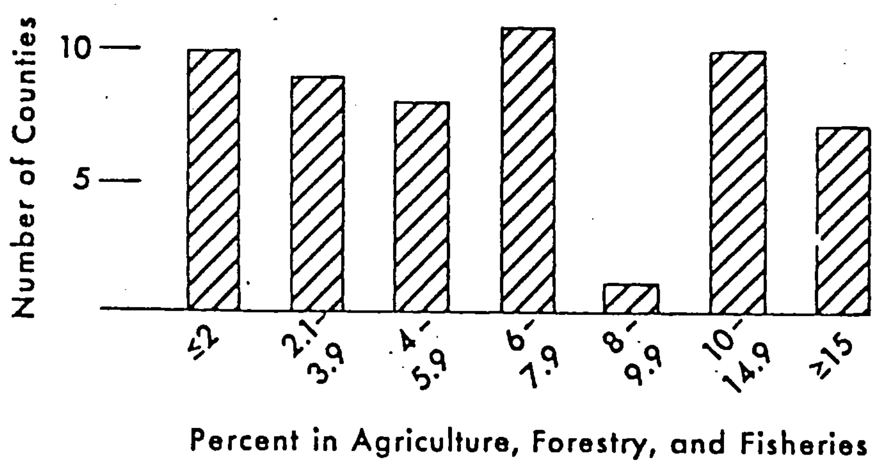


Table 3.5-36

Employment Patterns in Major Shrimp Counties
of Texas and Louisiana, 1976

Number of employees	Seafood				Other		
	Fishing Hunting Trapping	Whole-salers	Canned Cured Seafood	Fresh or Frozen Shrimp	Contract Construction	Mining	Petrochemical Manufacturing
Louisiana							
Calcasieu					3531	612	1816
Jefferson	86	157	160	289	13288	7052	509
LaFourche	316				981	956	
Terrebonne	191	93	113	(100-249)	1886	7312	(100-249)
Texas							
Brazoria	128	60			6432	675	(5000-9999) +(2500-4999)
Cameron	1075	59		(500-999)	7770	89	(100-249)
Galveston	108	50			3125	505	6532
San Patricio [1]	300				457	1048	(500-999)

[1] Note that no establishments are reported in any of the seafood trade or processing categories. This is despite the fact the Aransas Pass, in San Patricio County, touts itself the world's shrimp capital. Aransas Pass does have a sizeable shrimp wholesaling and processing industry. Again, this time for county business patterns, the data are not very adequate even for our modest purposes.

may vary as do the percentages going to the captain and crew. When seven complex methods of determining shares to captain and crew were analyzed by converting to a common denominator, they were shown to range from 21 to 28 percent of gross revenue (Sass and Roberts, 1979).

If the vessel operator is not the owner, a different relationship exists. The captain and crew share from 42 to 33 percent of the "take" -- the net value of shrimp less a portion of such operating expenses as fuel, ice, processing charges, and gear repair. Although crewmen have traditionally resisted sharing the cost of fuel (Griffin, et al., 1976) the large fuel increases of the 1970's has resulted in some shift to sharing fuel expenses (Roberts, personal communication).

There is another complex set of relationships -- between the owner and the dealer where the shrimp are unloaded. In some areas there is no apparent bond; in others, with such fluctuations as periodic ice shortages or marked shrimp supply-demand fluctuations, a fairly permanent relationship may develop. The relationship seems to work to the benefit of both dealer and owner in some cases, for example, when ice, fuel or shrimp supplies are scarce. This kind of relationship, in which both parties are mutually interdependent, appears to be an amicable one with few signs of antagonism or conflict. In other areas, where it is customary for a dealer rather than a banker to advance operating capital to the shrimper, the lack of independence in business transactions apparently can lead to antagonism.

Ethnic interactions have provided few conflicts until Vietnamese fishermen became increasingly involved in the bay shrimp fishery of the Gulf coast after 1975. By using aggressive and often more efficient fishing strategies, this group has become economically competitive with the established fishermen. The Vietnamese generally fish longer hours on shorter trips, may use smaller crews (often family members), and are equally skilled as compared with their American counterparts. Because of their lower operating costs, thrift, willingness to experience more hardship and risk, and reinvestment into better equipment and facilities, the Vietnamese fishermen have become well established in the fishery (Gulf and South Atlantic Fisheries Development Foundation, Inc., 1981).

This same report estimates the numbers of Vietnamese owned bay shrimp boats on the Gulf coast as follows:

Port Area	Number of Boats
Panama City	35 - 37
Pensacola	20
Biloxi	75
Placquemines Parish	30 - 35
Galveston Bay	70
Palacios	45 - 50
Rockport-Fulton	35 - 38
Approximate Total Gulf Coast	315 - 375

Conflicts have occurred between the Vietnamese and the local fishermen, with the latter accusing the former of violation of fishing regulations and customs. Action programs by state and other agencies have improved the understanding of language, regulations, and local customs by the Vietnamese fishermen.

Other ethnic groups making up the ownership of boats and vessels in the Gulf shrimp fishery include Anglos, Mexican-Americans, Hondurans, eastern Europeans, and persons of French descent. These groups have been well assimilated into the Gulf fishery, and their problems tend to be the problems of the industry as a whole (Gulf and South Atlantic Fisheries Development Foundation, Inc., 1981).

3.6.2 Prevalent Conflicts with Shrimpers and Other National Interest

Gulf shrimp are harvested by one of the largest and most diverse group of fishermen in the nation. Harvest occurs from the shallow-water estuarine areas out to open Gulf waters of 300 fathoms. The reported commercial fleet averaged 8,300 boats and vessels trawling an average of some 5.2 million hours annually during the 1970 to 1974 period. All information indicates a general increase in these figures. In addition, there is growth in the number of recreational users (3.5.2.1). Conflicts of these groups with other national interests may involve:

1) Capture of finfish and shellfish, which are harvested and then discarded.

2) Incidental capture of sea turtles.

3) Loss of estuarine habitat necessary for growth and survival of brown, white and pink shrimp.

4) Gear conflicts with stone crab fishermen in southern Florida.

5) Accidental or intentional creation of underwater obstructions to shrimp trawling.

The danger to boats and vessels from underwater obstructions relates to safe navigation as well as hazards to trawl gear. Significant problems caused by underwater obstructions in Louisiana waters and the Gulf are being rectified by two government programs. Fishermen can apply to the federal government for compensation to cover damage to gear, vessels, and lost income resulting from underwater obstructions in the FCZ (U.S.D.C. 1979). A comprehensive program established in 1980 enables Louisiana shrimpers to receive compensation for damage to gear and vessels from obstructions in state waters (Dept. Natural Resources, Louisiana, 1980).

Measures are suggested in Section 8.3 to alleviate these conflicts through consideration of the needs both of shrimpers and other national interests. Two of these conflicts (those over sea turtles and finfish) are treated in more detail in this section.

3.6.2.1 Incidental Catch of Finfish by Shrimpers and Shrimp by Groundfish Fishermen

The discard of the incidental catch of finfish during commercial shrimping operations in the Gulf of Mexico is a matter of concern to fishery managers. During the process of sorting shrimp from the remainder of the catch brought in by a trawl, most of the incidental catch die from trawling, handling, and exposure before they are discarded. In recent years this problem has become accentuated by the movement of shrimp trawlers into offshore areas traditionally used by the groundfish fleet.

Seidel (1975) estimated that four to 12 pounds of finfish are taken for each pound of shrimp harvested. The annual finfish discard was approximated in Table 3.6-1 by multiplying the low and high estimates (four and 12 pounds, respectively), by the total yearly shrimp catch in the Gulf of Mexico. The analysis of experimental tows taken in the north central Gulf by the National Marine Fisheries Service, Pascagoula Laboratory, indicates that fish-to-shrimp ratios vary widely by season, locality, year, and fishing strategy. The fish-to-shrimp ratios presented in Table 3.6-2 are composite figures computed from many tows taken in the inshore and offshore areas of the north central Gulf. Up to 70 percent (by weight) of the discard are species usuable by the groundfish industry.

During the period of concentrated shrimping effort in estuarine areas, shrimp trawls capture and kill large numbers of juvenile groundfish and other species. At present it is not known if current levels of trawl-induced mortality of juvenile fishes in estuaries have a detrimental effect on offshore groundfish populations.

Gulf-wide the income from sale of incidental catch taken in shrimp trawls is low. Statistics reported to NMFS in 1974 indicated (by states): Florida, 1.7 percent of the value of the shrimp landings; Alabama, 13 percent; Mississippi, 7 percent; Louisiana, 0.8 percent; and Texas, 0.5 percent (Figures 3.6-1 through 3.6-5). Specifically, only 19 percent of Louisiana shrimp vessel captains sold a portion of the incidental catch (Sass and Roberts, 1979). The income potential was further constrained by markets, quality, and fish size. Sixty percent of those selling some of the incidental catch responded that they were not able to sell all of the food fish harvested. The conclusion is that shrimp vessels are highly specialized units dependent almost entirely on income from the sale of shrimp.

There is no information currently available on the magnitude of the incidental catch discarded by recreational shrimpers. Most of the recreational catch and effort occurs in estuarine areas. The total amount of finfish discards, based on the estimated number of participants in the recreational shrimp fishery, may be substantial in some states. Louisiana has by far the largest number of participants in the recreational shrimp fishery, followed by Texas, Alabama, Mississippi, and Florida.

No quantitative data are available on the mortality of the incidental catch taken during live bait-shrimping operations. Bait shrimpers operate primarily at night in the estuaries. The mortality of the incidental catch is probably minimized by: (1) the short duration of the tows; (2) the speed at which the catch is sorted; and (3) cooler, humid conditions at night.

Juhl (1974) estimates that the average incidental catch of shrimp was eight pounds and seven and a half pounds (heads-on) per hour of fishing effort by industrial and foodfish trawlers, respectively. Although quantities of shrimp are caught and marketed by the industrial and foodfish fleet (Gutherz, et al., 1975) these catches are not specifically listed in the annual summaries of landing statistics published by the National Marine Fisheries Service.

3.6.2.2 Habits, Distribution, and Incidental Capture of Sea Turtles in the Gulf of Mexico (See Appendix FEIS for detail information)

Six of the seven species of sea turtles in existence are found in the U.S. Gulf of Mexico. These sea turtles are sometimes accidentally caught during trawling operations for shrimp and groundfish. The listing of the Kemp's ridley, hawksbill, leatherback, and Florida populations of the green turtle as endangered species, and of the green, loggerhead, and olive ridley turtles as threatened species, necessitated a careful consideration of the effect of shrimping on these species. A considerable effort was made to document what was known about the life history and factors affecting the decline in their numbers, and shrimping operation measures which would alleviate these problems. (See Appendix FEIS.)

Exploitation and habitat loss are two major causes of the drastic decline in sea turtle numbers. Incidental capture by shrimp and groundfish fishing operations is increasingly important as populations decline. Preservation measures are aimed at reducing adult and subadult mortality and increasing juvenile recruitment.

The accidental capture of sea turtles during shrimp and groundfish fishing activities is a major problem along the southern Atlantic and Gulf coasts (Ogren, et al., 1977). An estimated 800 to 1,000 sea turtles are caught each year off the south Atlantic coast (based on Hillestad, et al., 1977; Ulrich, 1978). Similar estimates for incidental turtle catch in the Gulf of Mexico are not available.

All of the Gulf states have laws aimed at conservation of sea turtles. At the federal level, designation of critical habitat areas is under consideration. Headstarting -- protection during incubation and the first year of life -- still is in the experimental stage. Predator control, primarily for raccoons, can protect nests from destruction.

Table 3.6-1. Annual Gulf of Mexico shrimp catch and estimated finfish discards using fish:shrimp ratios of 4:1 and 12:1, 1959-1975. Shrimp catches were converted to heads-on poundages from headless data furnished by the U.S. Department of Commerce, 1959-1975. Discard ratios encompass the range reported by Seidel (1975) and are presumably based on round (live) weight.

Year	Shrimp catch (heads-on)[1] (million pounds)	Estimated discard 4:1 ratio (million pounds)	Estimated discard 12:1 ratio (million pounds)
1959	143.4	573.6	1,720.8
1960	166.1	664.4	1,993.2
1961	90.7	362.8	1,088.4
1962	106.6	426.4	1,279.2
1963	176.5	706.0	2,118.0
1964	150.1	600.4	1,801.2
1965	167.7	670.8	2,012.4
1966	163.4	653.6	1,960.8
1967	207.7	830.8	2,492.4
1968	180.4	721.6	2,164.8
1969	187.8	751.2	2,253.6
1970	215.6	862.4	2,587.2
1971	211.4	845.6	2,536.8
1972	208.2	832.8	2,498.4
1973	165.3	661.2	1,983.6
1974	169.1	676.4	2,029.2
1975	157.9	631.6	1,894.8

1/ Heads-on poundages were estimated from headless data using conversion factors for each species and average percent species composition of Gulf catches from 1959-1975: brown shrimp -- 1.61, 55%; white shrimp -- 1.54, 32%; pink shrimp -- 1.60, 11%; sea bobs -- 1.53, 1%; royal red shrimp -- 1.80, 0.8%; rock shrimp -- 1.67, 0.2%. The conversion factors for all species except rock shrimp are from the U.S. Department of Commerce (1959-1975). The conversion factor for rock shrimp was computed from data published by Cobb et. al. (1973).

Table 3.6-2. Comparison of fish discard ratios derived from trawl data collected in the inshore and offshore areas of the Gulf of Mexico between 87° 30' and 91° 31', 1973-1977 (data collected and summarized by the National Marine Fisheries Service, Pascagoula, Mississippi).

Year	Inshore		Offshore	
	Sample size	Ratio	Sample size	Ratio
1973	52	4.9	(1)	(1)
1974	19	1.0	15	4.3
1975	47	5.9	52	20.3
1976	27	3.6	53	12.6
1977	24	2.7	19	6.0

(1) No data.

Table 3.6-3. Estimated annual discard (metric tons) of the six major species of finfishes taken during inshore and offshore shrimping operations in the Gulf of Mexico from 87° 30' to 90° 30', 1969-1976. Percentages in parentheses refer to the percent composition of the total catch for each species and are composite figures derived from data collected during 1973-1977 (data collected and summarized by the National Marine Fisheries Service, Pascagoula, Mississippi).

Year	Inshore						Offshore					
	Atlantic Croaker (32.8%)	Sand Seatrout (10.6%)	Spot (10.6%)	Sea Catfish (7.5%)	Atlantic Cutlassfish (6.0%)	Silver Seatrout (1.7%)	Atlantic Croaker (55.1%)	Sand Seatrout (6.1%)	Atlantic Cutlassfish (5.0%)	Spot (3.3%)	Silver Seatrout (2.0%)	Sea Catfish (1.7%)
1969	28,854	9,325	9,325	6,598	5,278	1,495	133,298	14,759	12,096	7,983	4,838	4,113
1970	29,890	9,659	9,659	6,834	5,468	1,549	140,576	15,563	12,756	8,419	5,102	4,337
1971	33,196	10,728	10,728	7,590	6,072	1,720	153,543	16,998	13,933	9,196	5,573	4,737
1972	26,274	8,491	8,491	6,008	4,806	1,362	142,417	15,767	12,924	8,530	5,169	4,394
1973	18,369	5,936	5,936	4,200	3,360	952	89,939	9,957	8,161	5,386	3,264	2,775
1974	19,504	6,303	6,303	4,460	3,568	1,011	92,583	10,250	8,401	5,545	3,360	2,856
1975	16,183	5,230	5,230	3,700	2,960	839	96,713	10,707	8,776	5,792	3,510	2,984
1976	29,430	9,511	9,511	6,730	5,384	1,525	134,188	14,856	12,177	8,037	4,871	4,140

Table 3.6-4. Estimated percent species composition of the total catch of finfishes taken in shrimp trawls for each of the six major species discarded in the inshore and offshore waters of the Gulf of Mexico between 87° 30' and 91° 30', 1973-1977 (data collected and summarized by the National Marine Fisheries Service, Pascagoula, Mississippi).

Year	Inshore						Offshore					
	Atlantic Croaker	Sand Seatrout	Spot	Sea Catfish	Atlantic Cutlassfish	Silver Seatrout	Atlantic Croaker	Sand Seatrout	Atlantic Cutlassfish	Spot	Silver Seatrout	Sea Catfish
1973	17.3	4.6	21.4	8.5	7.6	0.6	(2)	(2)	(2)	(2)	(2)	(2)
1974	46.2	2.6[1]	19.7	13.2	7.0	---	80.9	1.1	(3)	(3)	2.2	6.0
1975	36.2	12.9	7.7	7.0	6.3	2.1	56.2	6.3	6.2	1.9	1.6	0.8
1976	24.1	4.6	15.4	8.2	2.5	0.3	45.1	6.9	2.0	9.6	3.8	3.2
1977	16.9	9.8	16.7	5.0	5.1	0.3	23.5	6.1	5.1	14.1	(3)	6.3

[1] Includes Silver Seatrout.

[2] No data coverage.

[3] No records of having been captured.

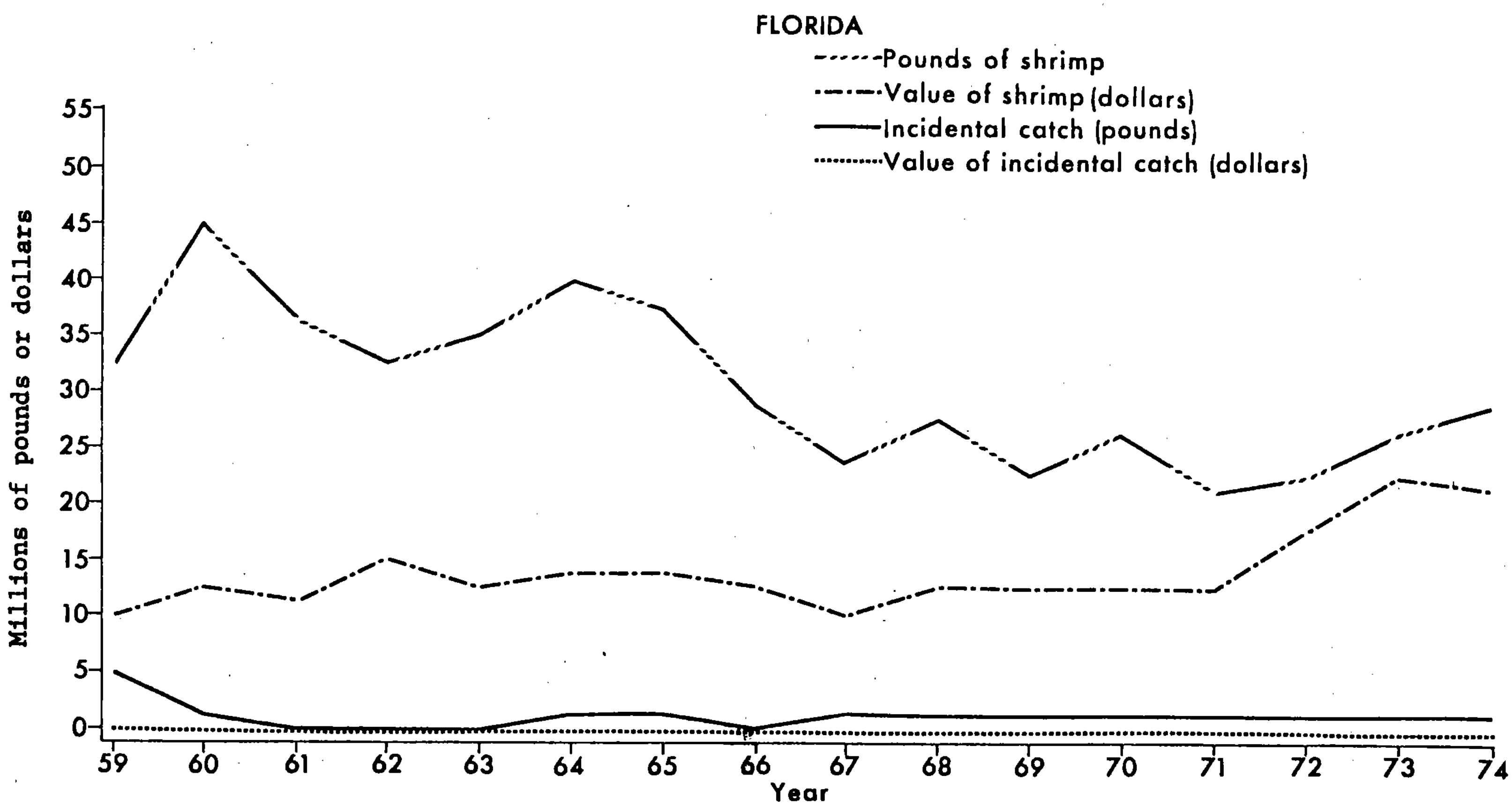


Figure 3.6-1. Annual Florida landings and value of shrimp and marketable incidental catch, 1959-1974. Poundages are in round (live) weight. Source: Fishery Statistics of the United States, 1959-1974.

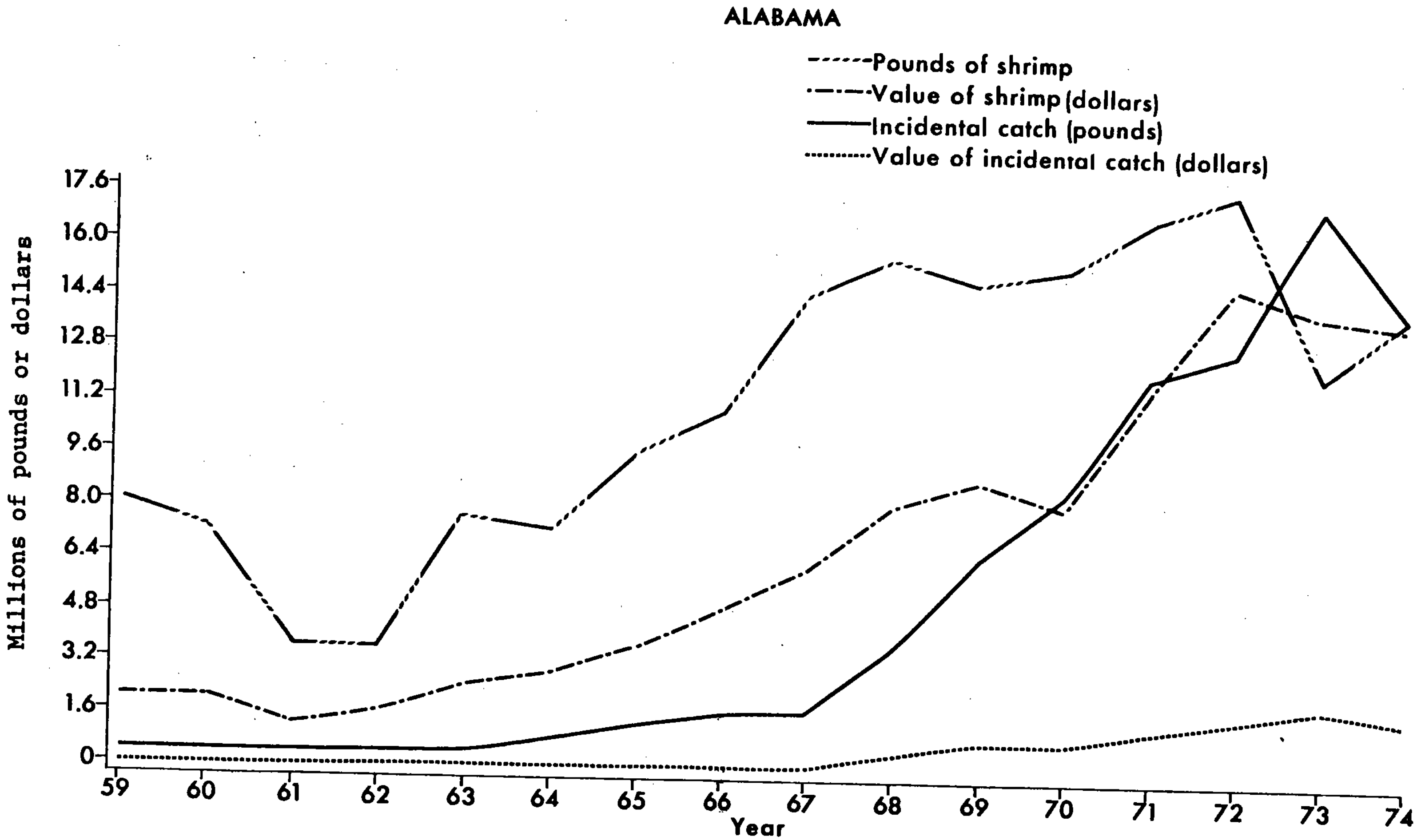


Figure 3.6-2. Annual Alabama landings and value of shrimp and marketable incidental catch, 1959-1974. Poundages are in round (live) weight. Source: Fishery Statistics of the United States, 1959-1974.

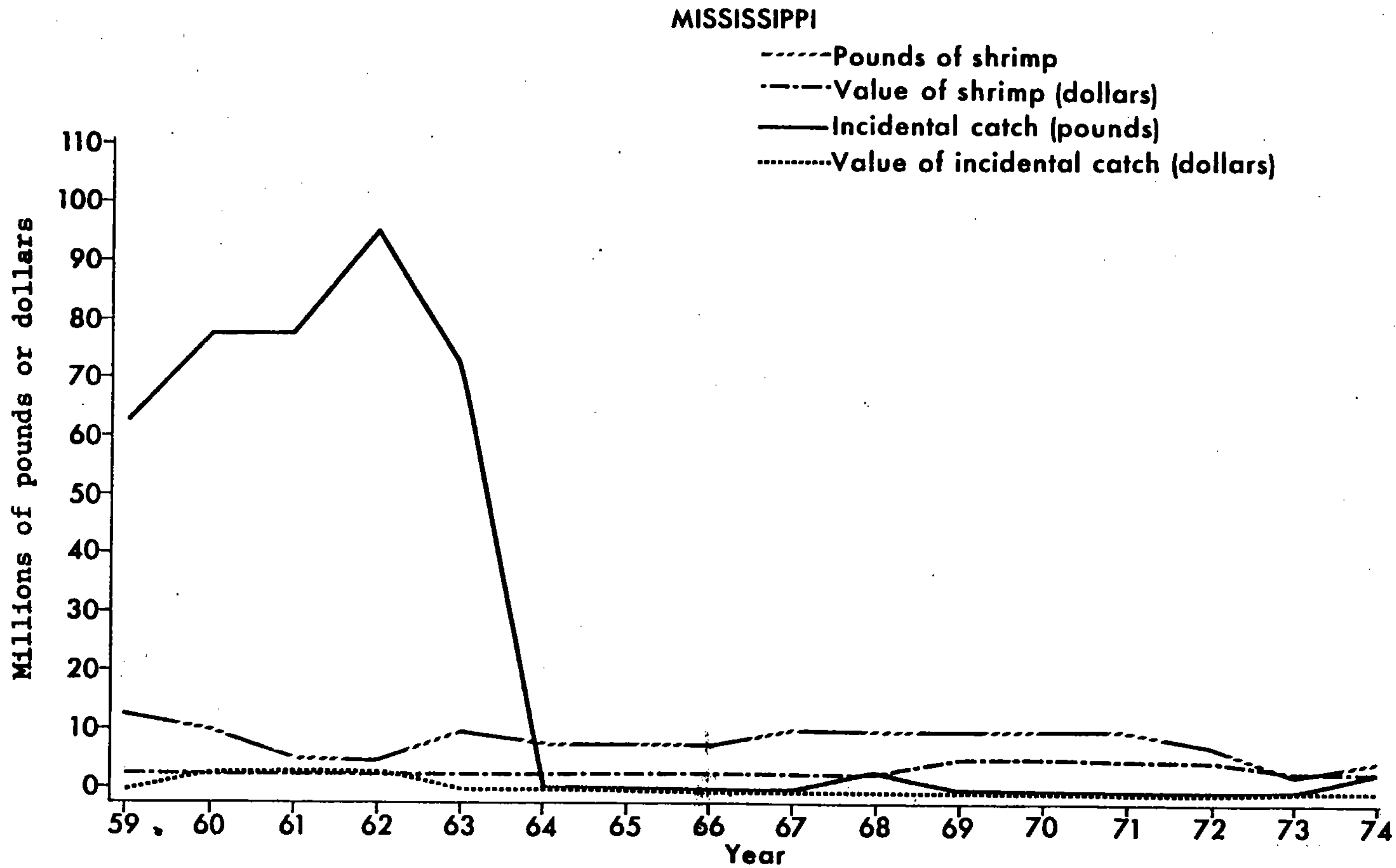


Figure 3.6-3. Annual Mississippi landings and value of shrimp and marketable incidental catch, 1959-1974. Poundages are in round (live) weight. Source: Fishery Statistics of the United States, 1959-1974.

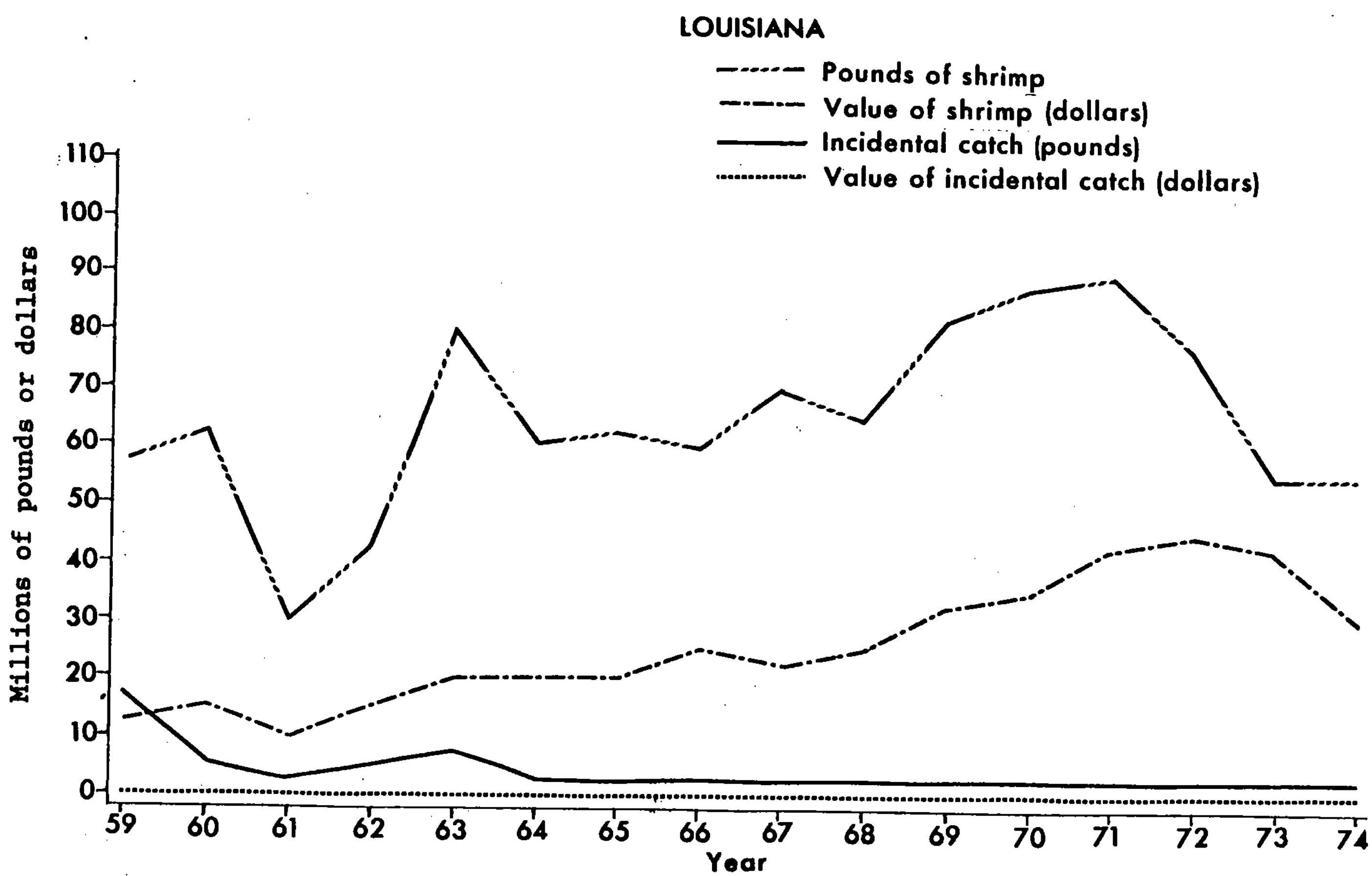


Figure 3.6-4. Annual Louisiana landings and value of shrimp and marketable incidental catch, 1959-1974. Poundages are in round (live) weight. Source: Fishery Statistics of the United States, 1959-1974.

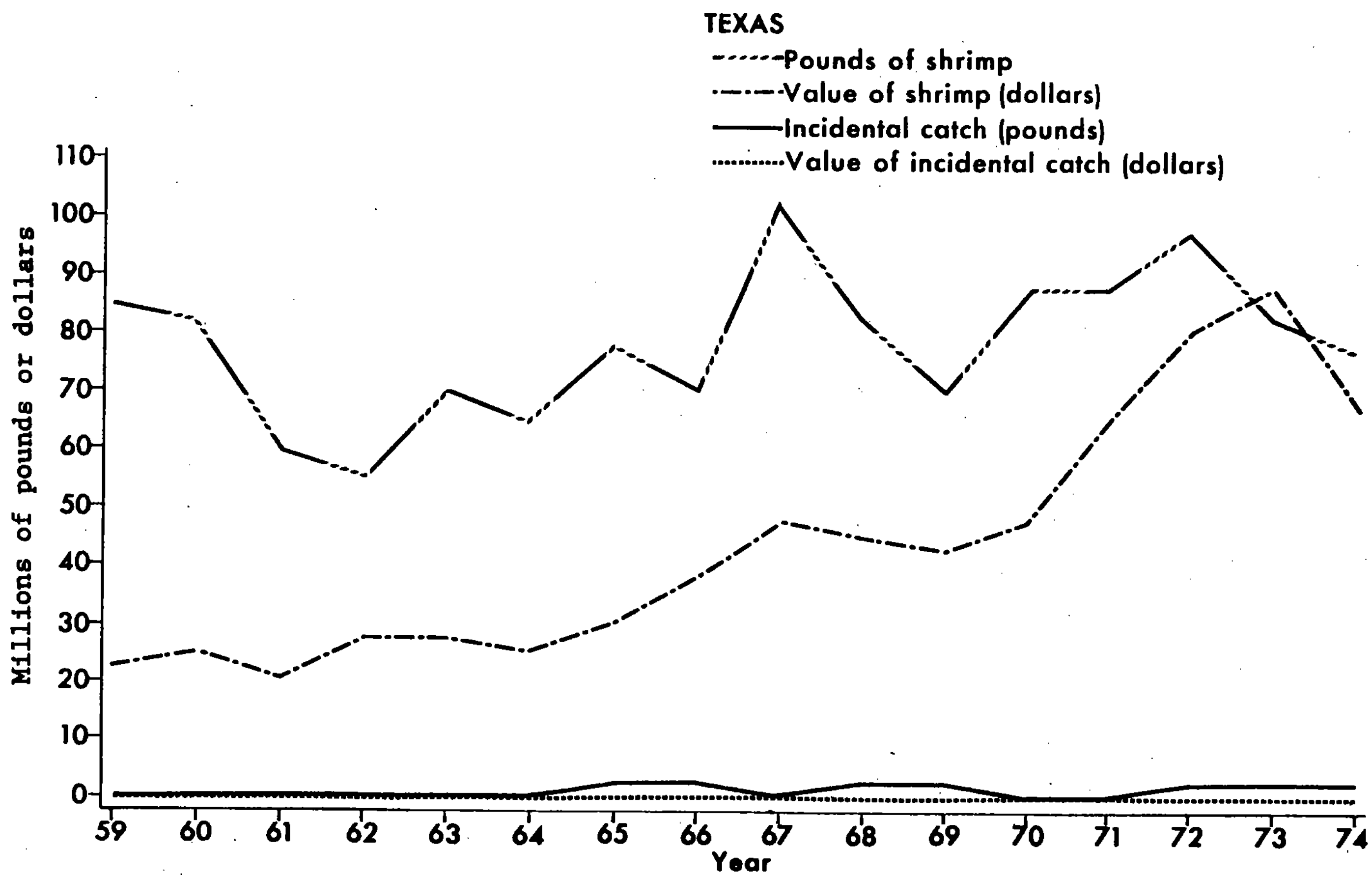


Figure 3.6-5. Annual Texas landings and value of shrimp and marketable incidental catch, 1959-1974. Poundages are in round (live) weight. Source: Fishery Statistics of the United States, 1959-1974.

Of the sea turtles in the Gulf, the Kemp's ridley is in the greatest danger of extinction. Almost all of Kemp's ridley nesting is restricted to a small stretch of beach near Rancho Nuevo, Tamaulipas, Mexico, although nestings are also recorded for Padre Island on the Texas coast. Seventeen recaptures of tagged nesting females show that these ridleys are distributed throughout most of the Gulf. Eight -- all taken by shrimp trawlers -- occurred in 1969 between Brownsville, Texas, and the mouth of the Mississippi. Captures of Kemp's ridleys through the years are recorded from Brownsville to the Dry Tortugas off Florida; it is believed that these turtles migrate along the shores back to Mexico for nesting. One of the smallest sea turtles with a primary range in the Gulf of Mexico, the ridley is a turtle of coastal areas -- primarily a carnivore and a bottom feeder.

The National Marine Fisheries Service and the U.S. Fish and Wildlife Service are currently involved in research and public workshops whose goal is to restore those sea turtle populations in a manner consistent with the requirements of the Endangered Species Act. Three approaches to reducing the incidental catch are most prominent: first, delineation of critical habitats and restriction of trawling in these areas; second, an education program to inform shrimpers and groundfish fishermen of the methods of, and reasons for, adequately handling incidentally captured sea turtles in order to reduce mortality; and third, development of gear such as the excluder panel, which reduces the capture of sea turtles during trawling operations. Currently work is underway on all three approaches.

3.7 State and Federal Revenues Derived From Shrimp Fishery

State and federal revenue figures from the shrimp fishery are not isolated by data processing systems of the state agencies in the Gulf; these data are included, however, at the federal level with non-related activities.

The only available documentation applies to licenses and severance taxes imposed by the states. Revenues by states are listed below:

State	1977	1976	1975	1974	1973
Texas	$881,084	$845,556	$887,768	$969,899	$644,781
Louisiana	645,867	517,877	405,651	405,152	405,507
Mississippi	54,696	43,889	37,912	42,483	37,842
Alabama	46,285	25,846	19,017	17,099	16.218
Florida west coast	470,109	450,431	439,439	431,078	398,062

Such items as taxes paid for fuels, income, social security, and employment security by participants in the shrimp fishing effort do not appear in any statistical breakdown, nor is there any pinpointed material on government income derived from the onshore processing and distributing segment.

4.0 BIOLOGY DESCRIPTORS

4.1 Life History Features

General Features of the Species

The general life cycles of brown, white, and pink species of shrimp are similar. Adults spawn in the Gulf. Fertile eggs hatch into free-swimming larvae, and the larvae pass through a series of molts. During the postlarvae stage, the shrimp enter an estuary and become bottom feeders.

Within the estuary the juvenile shrimp feed mainly at the marshwater or mangrove-water interface or in submerged grass beds. These areas apparently offer both a concentrated food supply of detritus, algae and microfauna and some protection from predators. Growth and survival in the estuary are largely dependent upon local salinity and temperature regimes. As they grow larger the shrimp shift to deeper waters and become more predacious. At a variable size 2.75-4.7 in (70 to 120 mm) they emigrate to the Gulf. This emigration is a function of size, tide, and temperature. Growth continues at a rapid rate in the Gulf under optimum temperatures, though it declines as shrimp approach their maximum size. Spawning probably occurs before the shrimp are 12 months old.

Major differences in the life cycles of the brown, white, and pink shrimp are due to shifts in the time and space at which various life stages reach their maximum abundance. These shifts apparently allow the species to avoid direct competition even when one species predominates in the same general geographical area. In areas where shrimp stocks co-occur, management has built its harvest strategies around these shifts. For example, the Louisiana estuaries are closed in winter and early spring in order to protect juvenile brown shrimp. The inshore brown season is closed when appreciable numbers of juvenile whites appear in trawls for brown shrimp.

There are five overriding biological factors which seem to account for the resiliency of the shrimp resources:

1) The migration of the life stages through several environments.

2) The food habits of juveniles and subadults in the estuary provide access to rich, widely-based food supply.

3) The apparent rapid growth rate of shrimp under favorable conditions results in a harvestable size shrimp within a short time.

4) High fecundity and extended spawning seasons help to prevent recruitment overfishing in spite of intense fishing pressure.

5) A large portion of the Gulf is inaccessible to harvesting, e.g., rocky bottom, loggerheads, etc.

The other three shrimp species exploited in the Gulf (royal red, seabob, and rock shrimp) are not estuarine-dependent and apparently spend their life cycles within the open waters of the Gulf. Royal red shrimp differ considerably from other species in that they: 1) are harvested from depths of 100 to 300 fathoms, 2) have an estimated five year classes occupying the same fishing grounds, 3) exist in a relatively stable environment, and 4) do not reach sexual maturity as a zero-year class shrimp. Seabob shrimp are harvested, along with white shrimp, October through December when they migrate towards the Gulf beaches from deeper water, in response to advancing cold fronts. Rock shrimp are harvested mainly from Florida's sandy bottoms. They are taken primarily as bycatch.

Sexual Maturity

The minimum size at which shrimp become sexually mature (males--fully developed spermatophores; females--ripe ovaries) are listed in Table 4.1-1.

Spawning, Larval Development, Recruitment of Postlarvae to Either Estuaries or Fishing Grounds

Brown Shrimp

Renfro and Brusher (1965) found brown shrimp spawned in Gulf waters of greater than ten fathoms from spring to early summer and continuously at 25 to 60 fathoms. Two peaks were noted, a major one in September to November and a minor one April to June (Renfro and Brusher, 1965). A February to March spawning peak has been proposed (Gunter, 1950; Kutkuhn, 1962), based on juvenile abundance in estuaries; however, no direct evidence was presented. Temple and Fisher (1967) note that off the Texas coast planktonic stages of Penaeus species were greatest at 14.8 fathoms from August to November and in 25.2 fathoms and 44.8 fathoms from September to November. They suggest that as these peaks corresponded to peaks in the occurrence of adult brown shrimp at these depths, the larvae were those of brown shrimp. The reported commercial catch peaks in July on the zero-year class; and spawning reaches its height after this July peak and occurs during the intense fall offshore fishing season for brown shrimp.

Baxter and Renfro (1967) found that postlarval brown shrimp recruitment to Galveston Bay peaks in March and mid-April. Second and third peaks are sometimes noted June through September. Estuarine recruitment may occur slightly earlier in Louisiana. White and Boudreaux (1977) and Gaidry and White (1973) report that postlarval brown shrimp recruitment normally peaks in Louisiana in February to March. Thus peak recruitment of postlarval brown shrimp to the estuaries occurs months after the peak in spawning.

Basing their claim on a comparison of their work with Baxter and Renfro (1967), Temple and Fisher (1967) proposed an overwintering of postlarval brown shrimp in the Gulf. They suggest that the postlarvae burrow in the offshore bottom and await the advent of warmer temperatures before entering the estuaries. In support of this theory they note the laboratory work of Aldrich, et al. (1967) which showed that postlarval brown shrimp burrowed at low temperatures.

White Shrimp

A single female white shrimp releases between 500,000 and 1,000,000 eggs in a spawn (Burkenroad 1934, Anderson, et al., 1949). Spawning occurs in Gulf waters at four to seventeen fathoms, spring through fall (Lindner and Anderson, 1956; Renfro and Brusher, 1964; Joyce, 1965; Bryan and Cody, 1975). The spring spawn is believed to be accomplished by females which have overwintered, while the fall spawn is largely attributed to females spawned in the early spring (Lindner and Anderson, 1956).

Multiple spawning of white shrimp in a single season is believed to occur (King, 1948; Lindner and Anderson, 1956; and Renfro and Temple, personal communication in Perez Farfante, 1969).

Off the Texas coast the greatest abundance of planktonic stage Penaeus species occurred from May to August at 7.6 fathoms (14 m) (Temple and Fisher, 1967). They suggest that this peak was composed of white shrimp and note that the time corresponded to the reported spawning peak for white shrimp.

Larval development requires between ten to twelve days (Johnson and Fielding, 1956) and two to three weeks (Anderson, et al., 1949). By the time the postlarval stage is reached, the shrimp have normally entered the estuarine nursery areas (Anderson, et al., 1949). However, Anderson, et al. (1949) reported that "schools of adult white shrimp have been known to approach the coast and spawn

Table 4.1.1 Estimate of the Minimum Sizes at Which Shrimp Reach Sexual Maturity (Fully Developed (Fully Developed Spermatophores for Males and Ripe Ovaries for Females)

Species/Sex	Size (Total Length)	Source
	mm	
Brown shrimp		
males	140 (assumed)	Renfro (1964)
females	140	Renfro (1964)
White shrimp		
males	155	(Perez Farfante's [1969] conversion of Burkenroad's [1934] estimate)
females	135	(Perez Farfante's [1969] conversion of Burkenroad's [1934] estimate)
Pink shrimp		
males	34	Perez Farfante (1969)
females	92	Eldred et al. (1961)
Royal red		
males	125	Anderson and Lindner (1971)
females	155	Anderson and Lindner (1971)
Rock shrimp		
males	34	Cobb et al. (1973)
	42	Kennedy et al. (1977)
females	49	Cobb et al. (1973)
	64	Kennedy et al. (1977)
Seabob		
males	n.a.	
females	63	Anderson (1970)

close to inlets. When such a spawning occurs, the eggs may be swept through the passes on incoming currents, and larvae (nauplii) may reach the nursery grounds within a few hours."

Postlarval white shrimp recruitment to the estuaries of the northern Gulf occurs over a fairly uniform time period. In Mississippi it extends from May through October (Christmas, et al., 1966). In Louisiana, postlarvae are primarily recruited to the estuaries from July to August though recruitment begins in June (Gaidry and White, 1973; White and Boudreaux, 1977). In Texas, postlarval white shrimp recruitment to the estuary extends from May through October (Baxter and Renfro, 1967).

Pink Shrimp

Pink shrimp in the Dry Tortugas area spawn year round at 12 to 26 fathoms, with a more intense spawn in spring through fall (Ingle, et al., 1959; Cummings, 1961; Tabb, et al., 1962; Jones, et al., 1964, in Perez Farfante, 1969). In the Tampa and Apalachicola areas, spawning occurs in summer, and juveniles overwinter in the bays (Christmas and Etzold, 1977). Matosubrato (1974) estimates fecundity at about 500,000 eggs per female.

Minimal larval development time is 15 days (Ewald, 1965; Jones, et al., 1964). In the Dry Tortugas, estuarine recruitment is continuous, with peaks in abundance reported for April to June (Tabb, et al., 1962) and July through October (Jones, et al., 1964). A May through December recruitment of pink shrimp in Mississippi is reported (Christmas, et al., 1966). In Texas, Copeland and Truitt (1966) report an August to September peak in recruitment.

With the three major species, copulation is not directly associated with spawning. Indeed, Perez Farfante (1969) suggests multiple copulation for white and pink shrimp, since female white shrimp often lose the attached spermatophore and female pink shrimp shed the spermatophore upon molting.

Royal Red Shrimp

Anderson and Lindner (1971) observe that the St. Augustine population of royal red shrimp have a major spawning peak during the winter and spring, with some spawning occurring throughout the year. Their analysis of length-frequency distributions by sex for all sample periods combined suggests that recruitment to the fishery begins at one year of age but is not complete until the shrimp reach maturity at about three years of age. They note that the majority of shrimp taken in their samples were fully mature. Even though this population is outside of the management area, this information is thought to be true of the Gulf of Mexico stock.

Rock Shrimp

Spawning of rock shrimp in Gulf waters off Tampa to Fort Myers, Florida, is continuous, with a peak in October through January (Cobb, et al., 1973). Development time to postlarvae requires 29 days in the laboratory at 70° to 76° F (21° to 24.5° C) and 24 to 27 ppt (Cook and Murphy, 1965).

Cobb, et al., (1973) note that rock shrimp less than 1.2 in. (30 mm) total length appeared in their samples in March, May to July, and November, whereas slightly larger individuals occurred in all other months except December. They therefore suggest recruitment to the fishing grounds occurs year round.

Rock shrimp are not believed to be estuarine dependent (Eldred, 1959; Joyce, 1965; Cobb, et al., 1973). Cobb, et al., (1973) suggest that the shrimp found by Rouse (1969) in Chatham River, Florida, were other species of Sicyonia and not rock shrimp. The life cycle of rock shrimp is apparently passed in offshore waters and mainly at depths of 10 to 45 f (18 to 82 m) (Cobb, et al., 1973).

Seabob Shrimp

Juneau (1977) reports gravid seabob females were taken in peak numbers along the Louisiana beaches in July and August, while smaller non-gravid females were taken in large numbers between December and March. He concludes that spawning most likely occurs in the Gulf between July and December.

Renfro and Cook (1963) observe that early larval development from spawning to first protozoeal stage requires 58 hours in the laboratory at 73-75° F (23°to 24° C) and 27 ppt.

Juneau (1977) reviews current information available on seabob shrimp and concludes with Renfro and Cook (1963) that the species is probably not estuarine dependent and is found most commonly from the beach line to Gulf waters of five fathoms (9 m) and are primarily caught in one to two fathoms (1.8 to 3.6 m) along the Louisiana coast (within the Territorial Sea).

Emigration of Brown, White, and Pink Shrimp From Estuaries

The time, size, and causes of emigration have important management implications for brown, white, and pink shrimp. The specific reasons for their importance may vary from area to area. In Louisiana, with its large inshore harvester group, the setting of opening dates must include a recognition that a portion of the catch may be lost for smaller boats if the shrimp emigrate before the inshore season is opened. Conversely, in Texas and southern Florida where estuarine and near-shore Gulf harvest is restricted, the expected emigration time is needed in order to close offshore waters to protect the emigrating crop.

In general, emigration is keyed to environmental conditions such as tides, temperature, or salinity. Fishermen take advantage of this knowledge and fish the surface waters of channels and passes with a butterfly, or wing net used at night, although efforts during the day are sometimes rewarded.

Brown Shrimp

Copeland (1965) sampled ebb tide March to December in Aransas Pass, Texas. He found that brown shrimp emigration peaked in association with full moons in May through August, the high tides and faster currents of full moons being a stimulus to emigration.

Trent (1967) sampled the main tidal pass to Galveston Bay, day and night on the ebbing tides (May to August) with a bottom trawl as well as from June to August with a surface trawl. Catch per unit effort was greater on the bottom during the day and at the top during the night, though the difference was not significant.

Trent (1967) found two peaks in abundance of emigrating shrimp: one in mid-May and another in mid-June. The mean size of emigrating shrimp increased linearly from 400 tail count (58 mm) on May 18 to 40 tail count (108 mm) on July 28 or 0.14 in. (3.6 mm) per week. (See Table 4.1.5 for length-weight conversions).

Gaidry and White (1973) observed that emigration of brown shrimp from the Louisiana nursery grounds occurs in two stages. The first movement normally begins at a size of 264 to 415 tail count (60 to 70 mm) when juveniles leave the shallow marsh areas for the open bays. These bays serve as a "staging area" where the shrimp continue to grow and feed until they begin a second movement--the migration to offshore waters--at a size of 3.5 to 4.3 in (90 to 110 mm). This offshore movement begins in middle to late May, increases in intensity in June and July, and continues in diminished magnitude until November when essentially all the shrimp have left the bays.

Blackmon (1974) sampled a small tidal pass in Caminada Bay, Louisiana, from May to November on the full and new moons. He found that the mean length of emigrating shrimp generally increased from 3 in. (79 mm) in May to 3.8 in. (98 mm) in September and then declined to 3.3 in. (84 mm) in November. Mean lengths of emigrating shrimp were always greater than those in the bay: during the May to September period, the average emigrating shrimp was at least 0.39 in. (10 mm) larger than its average counterpart in the bay.

The highest percentage of emigrating brown shrimp occurred during or just after twilight. No correlation was found between the percentage of emigrating shrimp and current speed, temperature, or salinity. Distribution of emigrating shrimp in the three-meter water column changed with time of day. During the day, peak density of emigrating shrimp was greatest on the bottom; at twilight, the peak occurred in the middle; and at night, the peak occurred in the top meter (Blackmon, 1974).

White Shrimp

White shrimp that enter the Louisiana estuaries as postlarvae in the spring and early summer emigrate to the Gulf in September through November (Gaidry and White, 1973). Those white shrimp postlarvae recruited to the estuary later in the summer and early fall may be forced offshore by advancing cold fronts in October to December at a size much smaller than that of shrimp emigrating in the summer. These "later-recruited" white shrimp overwinter in the nearshore Gulf and reenter the estuaries at an average size of 100 mm during the spring warming. After a second period of growth, they emigrate to the Gulf to spawn in the spring and early summer (Lindner and Anderson, 1956; Gaidry and White, 1973).

Pink Shrimp

In the Everglades nursery areas, Yokel, et al., (1969) observed that juvenile pink shrimp emigrate almost exclusively at night, and on night ebb rather than night flood tides. Catch per unit effort of emigrating was 37 shrimp per minute as during new and full moons opposed to 20 shrimp per minute during the first and third lunar quarter. The effect of moon phase was directly dependent upon the relative abundance.

They observed that the size of emigrating shrimp ranges from 2 to 45 mm (carapace length), and averaged 14 mm (carapace length). Using Kutkuhn's (1966, Fig. 7) carapace length vs. weight plot for pink shrimp, the size range equates to a weight range of up to 80 g for male shrimp and an average of 2.0 to 2.5 g for male and female shrimp. The average shrimp leaving the Everglades is in the 300 to 200 tails to the pound range.

Migration Patterns in Offshore Waters

Brown Shrimp

Brown shrimp released off the Mississippi coast in June (Klima and Benigno, 1965) traveled less than an average of one mile per day from the release site. An offshore movement was not apparent since less than one percent of returns came from waters deeper than 16 fathoms. The longest distance traveled was 85 miles--from the release site off Horn Island to the Mississippi River's Southwest Pass. This information indicates that the Mississippi River may not be an absolute barrier to brown shrimp migration.

Most of the brown shrimp released off Grand Isle, Louisiana, in July (Klima, 1964) were recaptured near the release site. A slight seaward and westward movement was noted.

Movement of brown shrimp released off Galveston, Texas, in July led Klima (1964) to suggest that brown shrimp from the Galveston estuary were recruited to the fishery all along the Texas coast.

Brown shrimp released off the central Texas coast at 21 to 24 fathoms in April (Klima, 1964) showed little coastwide movement. No major offshore movement was apparent from April to June because 99 percent of the returns were within 25 fathoms and none were beyond 30 fathoms.

From an examination of commercial catch trends, Gunter (1962) suggested a southward drift of brown shrimp off the Texas coast in the fall.

The commercial catch statistics indicate that brown shrimp migrate out to the deeper waters of the Gulf. The inshore catch peaks in May to July on shrimp smaller than those measuring 67 tails to the pound. After Texas opens its Territorial Sea, offshore brown shrimp catch in the Gulf as a whole peaks in July and August at depths of 11 to 20 fathoms, with most of the landed shrimp being 31 to 40 tails to the pound. By December, the largest catch comes from 26 to 30 fathoms, and the 15 to 20 tails to the pound shrimp predominate. Generally, the data indicate a four to five fathom per month depth migration of the catch. However, the relationship of the shift in the catch to the actual depth migration of the shrimp is somewhat obscured by the Texas closure in June and mid-July and by the multiple waves of shrimp emigrating from the estuaries.

White Shrimp

White shrimp east of the Mississippi River to Mobile Bay tend to migrate from the estuaries to deeper waters along the barrier islands and towards the Mississippi River Delta during the summer to fall (Lindner and Anderson, 1956). The Mississippi River may act as a barrier to east-west movement (Lindner and Anderson, 1956; Perez Farfante, 1969).

Other than the offshore-onshore migrations and a tendency to concentrate between Ship and Trinity Shoals, Lindner and Anderson (1956) observed no definite migration patterns of white shrimp along the Louisiana coast west of the Mississippi River during the fall and winter.

Klima (1964) noted a coastwide movement or dispersion of tagged white shrimp along the Louisiana coast between Cameron and Vermillion Bay. Perret, et al. (1978) observed that movement along the western portion of the Louisiana coast was mainly westerly, though the majority of the tagged shrimp were returned within 60 nautical miles of the release area.

Lindner and Anderson (1956) observed a migration of white shrimp from off the coast of Mexico to Aransas Pass, Texas, during the spring. There also appears to be a reciprocal southward movement from central and southern Texas into northern Mexico during the fall and winter. From an analysis of reported commercial catch patterns, Gunter (1962) suggested a similar southward movement of white shrimp.

Pink Shrimp

Juvenile pink shrimp emigrate from the estuaries of southern Florida into the deeper waters of the Gulf. Costello and Allen (1965) found that the nursery grounds of pink shrimp on the Tortugas grounds were estuaries from Florida Bay and from as far north as Indian Key, whereas the nursery grounds of shrimp on the Sanibel grounds were estuaries from Indian Key north to Pine Island Sound. They observed little movement of shrimp between the Tortugas and Sanibel grounds. Iverson, et al. (1960) observed that larger pink shrimp tended to occur at deeper depths on the Tortugas grounds.

Royal Red and Rock Shrimp

Apparently nothing is recorded about migration patterns of royal red or rock shrimp.

Seabob Shrimp

Immediately following passage of a cold front, seabob shrimp along the Louisiana coast migrate toward the beach from offshore areas. In July and August, gravid females also move close to shore (C.J. Juneau, personal communication in Christmas and Etzold, 1977).

Substrate

The substrate preferences of shrimp appear to be important to their distribution patterns along the Gulf coast. In general, pink and rock shrimp prefer calcareous sediments and are found mainly along the Florida coast. Brown, white, and seabob shrimp prefer soft mud or peat bottoms and are found mainly along the coast from Texas to Alabama.

The juvenile brown and white shrimp prefer a soft mud or peat bottom with large quantities of decaying organic matter or vegetation (Williams, 1955, 1959; Mock, 1967; Jones, 1973). Sand or clay substrates are sometimes satisfactory for young brown shrimp, unless these substrates are bare clay, sand, or shell (Williams, 1959). Adult brown shrimp are found on mud or silt and also on mud, sand, and shell (Perez Farfante, 1969). In the Gulf, white shrimp are also found on muddy or silty bottoms and on clay or sand with fragments of shell (Springer and Bullis, 1954; Hildebrand, 1954, 1955).

Pink shrimp apparently prefer firm mud or silt bottoms with coral sand containing a mixture of mollusk shells (Springer and Bullis, 1954; Hildebrand, 1954, 1955; Williams, 1958) and firm sand bottoms (Farfante, 1969).

Royal red shrimp show no apparent preference for a particular sediment type; they occur on sand, silty sand, terrigenous, and calcareous sediments (Roe, 1969).

Rock shrimp occur most frequently on sandy bottoms (either terrigenous or biogenic) and only sporadically on mud bottoms (Hildebrand, 1954, 1955; Cobb, et al., 1973). Hildebrand (1955) suggests bottoms were "strays" from areas of hard sand. In South Carolina, the rock shrimp is called the coral shrimp because it is occasionally taken from coral banks (Lunz, 1957).

Seabob shrimp are taken from bottoms of mud, silt, or silt mixed with sand (Neiva, 1967; Christmas and Etzold, 1977).

Food

Larval Stages

Larval stages are planktonic and eat algae and zooplankton (Pearson, 1939; Ewald, 1965). Nutrient levels of Gulf waters may be a necessary environment for larval stages because a high density of food causes poor survival due to entanglement.

The postlarval stage is not strictly planktonic but is capable of deposit feeding (Pearson, 1939). Zien-Elden and Griffith (1969) have fed this stage on algae, *Artemia salina* nauplii, and groundfish or shrimp in the laboratory.

Juveniles to Adults

Juvenile and adult brown, white, and pink shrimp ingest whatever is available, including decaying organic matter, animals, and plants (Vicosa, 1920; Weymouth, et al., 1955; Flint, 1956; Darnell, 1958; Broad, 1965; Perez Farfante, 1969; Odum, 1971; Jones, 1973).

Jones (1973) intensively studied the food habitats and absorption efficiency of brown shrimp 1 to 4 in. (25 to 104 mm) in a Louisiana marsh. He observed a shift in diet and habitat as shrimp grew larger. Juveniles 1 to 1.75 in. (25 to 44 mm) were concentrated in the nearshore environment. Here they indiscriminately ingest the top layer of sediment containing detritus and microorganisms. Jones classified this stage as omnivores or encounter-feeders. At 1.8 to 2.5 in. (45 to 64 mm) they selected the organic fraction of the sediment and were classified as opportunistic omnivores. At 2.6 to 4 in. (65 to 104 mm) shrimp had dispersed from the nearshore environment to the deeper waters of the marsh and became active predators feeding intensively on polychaetes, amphipods, nematodes, and chironomid larvae. However, they continued to ingest detritus and algae and were classified as omnivore predators (Jones, 1973).

Darnell (1958) found the foreguts of white shrimp 3.6 to 5.6 in. (91 to 142 mm) contained sand, detritus and ground organic matter, and fragments of mollusks, ostracods, copepods, insect larvae, and forams.

Eldred, et al., (1961) found pink shrimp in the Tampa Bay contained both animal and plant remains. These included aquatic macrophytes, red and blue-green algae, diatoms, dinoflagellates, polychaetes, nematodes, shrimp, mysids, copepods, isopods, amphipods, mollusks, forams, and fish.

Rock shrimp are apparently nocturnal, generalized carnivores (Cobb, et al., 1973). Small bivalve mollusks, decopod crustaceans, gastropods, and other crustaceans are an important part of the diet which also includes foraminifera, nematodes, polychaetes, ectoprocts, echinoderms, and finfish (Cobb, et al., 1973; Kennedy, et al., 1977).

Nothing is apparently recorded on the food habits of seabob or royal red shrimp.

Predation

Penaeid shrimp, in general, are ingested by many carnivorous fish (Gunter, 1945; Darnell, 1958; Farfante, 1969). Table 4.1-2 lists some fish known to ingest brown, white, or pink shrimp. Included in this list are speckled trout, black drum, redfish, Atlantic croaker, southern flounder, bass, and several varieties of catfish. Many of these prey species are an important component of the bycatch discarded by shrimpers.

Growth Rates

General Considerations

As in most fisheries, growth rates are estimated from changes in the length of the species with time. Growth in weight is estimated by converting growth in length estimates to weight. Table 4.1-3 lists length-weight estimates for shrimp.

The method of measuring growth varies with the size of shrimp. Growth (in length) of "smaller" shrimp 1 to 3.5 in. (25 to 90 mm) is normally estimated from length frequency measurements of trawl samples taken in estuarine nursery areas over a period of time. Growth is expressed as the increase either in the mean size of the trawl sample or in each of the peaks in the polymodal length-frequency data with increasing time. Growth estimates range from 0.003 to 0.13 in. (0.1 to 3.3 mm) per day. Variability has been attributed to temperature, salinity, recruitment, density, and emigration.

Growth of "large" shrimp greater than 2.75 in. (70 mm) has normally been estimated from mark and recapture experiments. A simple linear relationship of length (or weight) to time is not applicable. The shrimp enter a self-limiting period of growth.

Table 4.1-2. Fish identified by Gunter (1945) or Darnell (1958) as feeding on penaeid shrimp

Species	Common Names
Carcharhinus leucas (Miller and Henle)	Bull shark
Dasyatis sabina (LeSueur) [1]	Stingaree
Lepisosteus spatula (Lacepede)	Alligator Gar
Elops saurus (Linnaeus)	Bonefish, Shipjack, Bigeye Herring, Ten-pounder
Ictalurus furcatus (LeSueur)	Blue catfish
Bagre marina (Mitchell)	Gafftopsail catfish
Galeichthys felis (Linnaeus)	Hardhead or sea cat
Morone interrupta (Gill)	Yellow bass
Micropterus s. salmoides (Lacepede) [1]	Northern largemouth bass
Sciaenops ocellata (Linnaeus)	Redfish, channel drum
Micropogon undulatus (Linnaeus)	Atlantic croaker
Pogonias cromis (Linnaeus) [2]	Black drum
Cynoscion nebulosus (Cuvier and Valenciennes) [3, 4]	Speckled trout
Paralichthys lethostigma (Jordan and Gilbert)	Southern flounder

[1] Assumed to ingest shrimp by Darnell (1958).

[2] Darnell (1958) states that when black drum are in the marine waters Gulf penaeid shrimp are a significant portion of its diet.

[3] Gunter (1945) states that in Texas shrimp are the predominant food of speckled trout during the summer. However, when shrimp are scarce, as in January, speckled trout shift to fish (Mugil species).

[4] Darnell (1958) states that pink shrimp are the stable diet of speckled trout in Florida.

Table 4.1-3. Length-weight relationships for brown, white, pink, royal red, and rock shrimp (after Christmas and Etzold 1977).

Species/Sex	Total Length to Total Weight: $W=aL^b$ a	b	Size Range (mm)	No. measured	Carapace Length to Total Weight: $W=a'c^b$ a'	b	Size Range (mm)	No. measured	Carapace Length to Total Length: $L=a''c^b$ a''	b	Size Range (mm)	No. measured	Source
Brown shrimp	$\times 10^{-6}$												
Combined	12.3	3.02	65-165	2104									McCoy (1968)[1]
Male	11.61	2.911	45-204	1396									Fontaine and Neal (1971)
Female	9.53	2.966	55-240	2016									Fontaine and Neal (1971)
Combined	10.52	2.938	45-240	3412									Fontaine and Neal (1971)
Male					0.000819	2.94	10-42	259	(2)				McCoy (1972)[1]
Female					0.00113	2.84	10-42	243	(2)				McCoy (1972)[1]
White shrimp													
Combined	7.69	2.976	55-160	100									Perret (1966)
Male	2.02	3.261	70-200	970									Fontaine and Neal (1971)
Female	2.32	3.234	70-214	1120									Fontaine and Neal (1971)
Combined	2.16	3.247	70-214	2090									Fontaine and Neal (1971)
Pink shrimp[3]													
Male	4.49	3.13	35-175	729	0.001*	3.04	8-40	729	5.27	0.96	35-175	729	Kutkuhn (1966)
Female	5.06	3.12	35-215	888	0.002*	2.79	8-55	888	6.14	0.90	35-215	888	Kutkuhn (1966)
Combined	9.79	2.98	65-165	2641									McCoy (1968)[1]
Male	10.02	2.967	70-175	1173									Fontaine and Neal (1971)
Female	5.93	3.92	60-114	2125									Fontaine and Neal (1971)
Combined	7.71	3.029	60-175	3298									Fontaine and Neal (1971)
Combined					0.0062	3.03443	6-22						Tabb, et al. (1962a)
Male					0.00148	2.77	10-42	297	(2)				McCoy (1972)[1]
Female					0.00209	2.66	10-42	503	(2)				McCoy (1972)[1]
Royal red shrimp: Dry Tortugas Area													
Male	2.129	3.22	113-154	109									Klima (1969)
Female	16.134	2.82	95-209	118									Klima (1969)
Combined	7.860	2.96	95-209	227									Klima (1969)
Mississippi River Delta Area													
Male	4.325	3.06	125-174	90									Klima (1969)
Female	13.306	2.83	135-229	114									Klima (1969)
Combined	5.853	3.00	125-229	204									Klima (1969)
Rock shrimp[4]													
Male					0.000601	3.122	n.a.	n.a.					Cobb et al. (1973)
Female					0.000589	3.144	n.a.	n.a.					Cobb et al. (1973)
Combined					0.000604	3.128	3-37	973					Cobb et al. (1973)

[1] For shrimp from North Carolina.

[2] McCoy (1972) derived the following equations for converting carapace length (CL) to total length (TL) in mm for North Carolina populations of:

Brown shrimp	Male	$TL = 3.50 + 4.16\ CL$
	Female	$TL = 10.50 + 3.83\ CL$
Pink shrimp	Male	$TL = 12.37 + 3.81\ CL$
	Female	$TL = 21.90 + 3.40\ CL$

[3] Iverson and Idyll (1960) provide conversion tables for pink shrimp in terms of total length, carapace length, and tails to the pound.

[4] Kennedy, et al. (1977) give the following relations for rock shrimp off the east coast of Florida:

	Carapace length versus weight: <23 mm CL	≥23 mm CL	Carapace length versus total length: <20 mm CL	≥20 mm CL
Males:	$W = 4.104 \times 10^{-4} CL^{3.303}$	$W = 1.886\ CL - 30.922$	$TL = 3.803\ CL + 0.249$	$TL = 3.448\ CL + 7.523$
Females:	$W = 3.398 \times 10^{-4} CL^{3.364}$	$W = 1.818\ CL - 30.475$	$TL = 3.786\ CL + 0.118$	$TL = 2.881\ CL + 18.498$

where CL and TL are carapace and total length in mm and W is weight in gms.

*Kutkuhn's carapace-weight equations do not fit his published data, evidently due to rounding error. It is suggested that figures published in Kutkuhn (1966) be used instead of these equations to convert carapace length to weight.

Brown Shrimp

Growth in length is slow 0.019 in. (0.5 mm per day) during January and February, increases in March, and reaches a maximum .02-.13 in. (0.5-3.3 mm per day) in April and June (Loesh, 1965; Ringo, 1965; St. Amant, et al., 1966; Broom, 1968; Ford and St. Amant, 1971; Jacob, 1971; Swingle, 1971). This monthly variation in growth rate has been associated with the spring warming of the estuaries (St. Amant, et al., 1962; Ford and St. Amant, 1971).

Parrack (1978) estimates growth rate of brown shrimp from mark and recapture experiments conducted in the northern Gulf of Mexico in 1967, 1968, and 1969 (Clark, Emiliani, and Neal, 1974). His discussion indicates that females grow more rapidly than males, weigh more than males of the same age, and attain a larger final length and weight than males.

White Shrimp

Growth rates of white shrimp estimated from trawl samples range from .02-.08 in. (0.6 to 2.2 mm) per day in the summer (Williams, 1955; Gunter, 1955; Loesch, 1965).

Growth rates of white shrimp have been estimated by a number of workers from mark and recapture experiments. Lindner and Anderson (1956) marked white shrimp 200 to 18 tail count (5 to 180 mm) in the south Atlantic and northern Gulf and calculated formulae for growth in length and weight. The results indicated that growth in length was a function of size and month, growth being faster for the smaller than the larger shrimp, and faster in April to June and September to December than from December to March. Klima (1964, 1974) calculated formulae for growth in length and weight. In comparing growth rates for two time periods, he notes that growth was faster in August to October than in September to November. He suggests that the difference is due to differences in water temperature.

Pink Shrimp

Higman, et al. (n.d.) determined the growth of postlarval-juvenile pink shrimp held in enclosures in the estuarine area of Everglades National Park. Multivariant regression analysis was used to determine significant relationships between weekly growth rate estimates and weekly estimates of bottom salinity, temperature, and dissolved oxygen. Salinity appeared to be the most important factor. Since the salinity regime of this area is dependent upon drainage through southern Florida into the Everglades, pink shrimp success in the Dry Tortugas may be related to local rainfall in the Everglades drainage basin as well as to man-made alterations which block the normal waterflow patterns.

Several growth estimates from tagging experiments are available. Iverson and Idyll (1960) tagged pink shrimp in the Dry Tortugas in December, 1957, and recovered them through April, 1958. Females increased in weight from 39 to 31 tails per pound in 45 days, whereas males increased from 60 to 50 tails per pound in the same time. This approximates a growth rate of .07 oz. (0.75 g) per week for female shrimp and of .013 oz. (0.38 g) per week for male shrimp. The authors caution that these estimates were made in the "unusually cold winter of 1957-1958 and may be slower than the growth in a more normal winter." Kutkuhn (1966, Table 4) estimates that pink shrimp tagged in the Dry Tortugas area September to December 1961 grew from 5.9 g to 19.5 g in 12 weeks. Lindner (1966) also derived growth curves for pink shrimp in the Dry Tortugas.

Royal Red and Seabobs

Apparently nothing is recorded about the growth rates of seabobs and royal red shrimp.

Mortality Rates

The death of fish in a population is due either to natural causes or to harvest by man. Coefficients of fishing (F), natural (M), and total (Z) mortality are defined as instantaneous death rates for a cohort of N individual fish over a short time, noted as dt. The rate of decline of the population numbers over time is presented as a function of these observed values.

The reported estimates of natural (M), fishing (F), and total (Z) mortality of shrimp are compared in Table 4.1-4. Values of the weekly natural mortality coefficient range from .01 to .55 or a loss of from 1 to 42 percent of the population from the beginning to the end of the week. Estimates of fishing mortality range from .02 to .96. Based on recently developed data by NMFS the weekly instantaneous natural mortality rate of brown shrimp in offshore regions is believed to be approximately 0.025 to 0.075 (Fox, 1981, personal communication). The variations in mortality estimates make it difficult to construct yield per recruit models.

Yield Per Recruit

The pounds of brown, white, or pink shrimp which can be harvested from a given number of postlarval shrimp reaching an estuarine system is a function of the population's rates of growth and mortality, age at which harvest begins, and the rate of fishing mortality once the shrimp are subject to harvest. The age at which yield will be maximized will be dependent on the trade-off between growth and natural and fishing mortality.

Brown shrimp

There are no published yield per recruit estimates available on brown shrimp. M. Parrack (NMFS, Galveston Lab) prepared a preliminary yield per recruit analysis using his sex specific growth rate equations for brown shrimp (Parrack, 1978) and two levels of monthly instantaneous natural mortality rate, M = .05 and M = .10 (Annon, 1978). (These levels of M on a monthly basis compare to estimates of M = .011 and .023 on a weekly basis.) If M = .05, yield was maximized when harvesting began on shrimp six months of age, or 21 tails to the pound (assuming a sex ration of 50:50). If M = .10, yield was maximized when harvesting began on shrimp five months of age, or 24 tails to the pound (assuming a sex ratio of 50:50).

He points out that these sizes are much larger than size limits currently imposed in the U.S. Gulf. His analyses indicate that if the above estimates of M approximate reality and if F is at the level estimated by Berry (1971), then current harvesting strategies employed in the Gulf result in a harvest considerably below the theoretical maximum. Klima and Parrack (1978) review the question of the size of shrimp at harvest which will maximize yield and state that "data on hand indicates that these two rates (growth and natural mortality) balance at 6-9 months of age or at a size of 20-30 shrimp tails per pound." If their analyses are correct, then a reduction in the size at first harvest of brown shrimp in the U.S. Gulf of Mexico would result in a decrease in protein yield. Further, an increase in yield is expected if the size at first harvest of brown shrimp is increased in any of the areas of the U.S. Gulf.

White shrimp

Data are insufficient at this time to estimate the expected yield per recruit for white shrimp in the U.S. Gulf.

Pink Shrimp

The most extensive published yield per recruit estimates of Gulf shrimp are for pink shrimp off southeastern Florida (Kutkuhn, 1966; Lindner, 1966; Berry, 1971). Although there is some disagreement

Table 4.1-4. Comparison of instantaneous rates of mortality (in weekly values) for shrimp in the U.S. Gulf of Mexico (Modified from Berry, 1970)

Species	Natural Mortality M	Fish Mortality F	Total Mortality Z	
Brown shrimp	.21	.06	.27	Klima (1964)
(Offshore)	.025 - .075	-	-	Fox (1981) pers. comm.
White shrimp	.08	.06 - .91	.14 - .27	Klima & Benigno (1965)
	.04 - .12	.10 - .13	.16 - .22	Klima (1974)
(Lake)	.214 - .556	.027 - .020	.241 - .576	Phares (1980)
Pink shrimp	.27	.09	.36	Iversen (1962)
	.55	.96	.76 - 1.51	Kutkuhn (1966)
	.08 - .12	.12 - .18	.25	Lindner (1966)
	.02 - .06	.16 - .23	.22 - .27	Berry (1967)
	.08 - .11	.03 - .07	.11 - .18	Costello & Allen (1968)
	.01 - .03	.02 - .16	.07 - .16	Berry (1970)

between authors, the data indicate that a reduction in yield will be expected if pink shrimp are harvested before they reach a size of 70 tails to the pound.

Temperature and Salinity

Temperature and salinity are important driving forces in the life cycles of brown, white, and pink shrimp, affecting growth, mortality, migration, and spawning. These factors can be incorporated in models used to predict annual yield (see Section 4.7.1.2).

The major influx of postlarval brown shrimp to the estuaries of the northern Gulf occurs February to March (Baxter, 1963; Baxter and Renfro, 1967; Gaidry and White, 1973; Christmas and Etzold, 1977). Little growth is expected until water temperature exceeds 20° C (St. Amant, et al., 1963; Ford and St. Amant, 1971).

Table 4.1-5

Length-weight Conversion Table for Brown, White, Pink, and Royal Red Shrimp (Sexes Combined). (Equations are listed in Table 4.1-3.)

Total length	Count							
	Brown shrimp[1]		White shrimp[2]		Pink shrimp[1]		Royal red shrimp[3]	
	Shrimp per pound	Tails per pound	Shrimp per pound	Tails per pound	Shrimp per pound	Tails per pound	Shrimp per pound	Tails per pound
mm								
50	440	708	519*	799*	420*	673*	*	*
60	258	415	301	464	242	387	*	*
70	164	264	227	349	152	243	*	*
80	111	178	147	227	101	162	137	247
90	78	126	100	155	71	113	97	174
100	57	92	72	110	52	82	71	128
110	43	70	52	81	39	62	53	96
120	34	54	40	61	30	47	41	74
130	26	43	31	47	23	37	32	58
140	21	34	24	37	18	30	26	47
150	17	28	19	30	15	24	21	38
160	14	23	16	24	12	20	18	32
170	12	19	13	20	10	16	15	26
180	10	16	11	16	9*	14*	12	22
190	9	14	9	14	*	*	10	19
200	7	12	8	12	*	*	9	16
210	6	10	6	10	*	*	8	14

[1]From Fontaine and Neal (1971).

[2]50-60 mm estimates from Perret (1966) and 70-210 mm estimates from Fontaine and Neal (1971).

[3]Klima (1969).

*Outside of data range.

Postlarval white shrimp normally enter the major bays of the Gulf when temperatures are above 25° C (Baxter and Renfro, 1967) and are apparently optimum for growth and survival. As the temperatures decline in the fall with advancing cold fronts, growth apparently also declines (Lindner and Anderson, 1956; Klima, 1974). Annual production in the northern Gulf has been associated with estuarine salinity regimes. A similar salinity effect, caused by different weather patterns seems to operate in Texas and Louisiana. Gunter and Edwards (1969) observed a positive correlation between the annual successes (1922-1964) of white shrimp in Texas with the rainfall in the state for that year and the two previous years. They suggest that the lag effect of rainfall was a result of the arid conditions of the state. In Louisiana, an inverse relationship between annual white shrimp catch and the annual discharge of the Mississippi and Atchafalaya Rivers has been noted (Barrett and Gillespie, 1973). White and Boudreaux (1977) obtained statistically significant linear regressions of catch against river discharge by dividing the data into two periods, 1958-1968 and 1969-1974.

Gunter and Edwards (1969) suggest that high rainfall is necessary in Texas to dilute the estuaries for optimum white shrimp production, while lower than normal river discharge is necessary in Louisiana for optimum white shrimp production, since these estuaries were less saline than those in Texas.

Growth of postlarval and juvenile pink shrimp in Florida appears to decline as salinity increases from 10 to 28 ppt and may increase as tempera-ture increases from 15° C to 32° C (Higman, et al., n.d.). This apparent relationship between growth and salinity is in contrast to the observation that juvenile pink shrimp normally occupy a higher salinity area on nursery grounds than do brown or white shrimp (Gunter, et al., 1964).

Highest densities of royal red shrimp are found at 9° to 10° C and most occur within 8° to 12° C (Roe, 1969).

Migration and Spawning

Spawning of white shrimp has been associated with the sudden warming in the spring of the offshore waters of the northern Gulf (Lindner and Anderson, 1956).

Both white and pink shrimp apparently seek deeper water as water temperatures fall in the fall and winter and will reenter shallow water if temperatures rise (Lindner and Anderson, 1956; Tabb, et al., 1962).

Bioeconomic Models

Grant and Griffin (in press) and Blomo, et al. (1978) have developed a bioeconomic simulation model of the brown shrimp fishery of Galveston Bay, Texas, and its associated offshore waters. The model is designed to assess the change in yield and revenue recruited to the fishery if various restrictions are imposed on either area of catch or fishery effort. Work is currently underway to adapt this model to the Dry Tortugas pink shrimp fishery (Griffin, personal communication, 1979).

4.2 Stock Unit

A stock is defined as a group of fish manageable as a unit. This definition differs from the biological concept of a stock as a more or less freely interbreeding population of a species.

The effects that strategies for increasing the yield for one of these species may have on other species of national interest as well as other multipurpose uses of the area involved must be considered (Section 3.6). Management and conservation of Gulf shrimp has been carried out mainly by the several Gulf states. Management policies employed by these states differ (Section 3.3.1); these differences largely reflect differences in the history of exploitation (Section 3.2).

Given this apparent genetic continuity, the need for a multipurpose approach to management, and the partial lack of data necessary to evaluate potential benefits derived by modifying current management practices, the GMFMC, realizing that management must consider other multipurpose uses for national resources and may have to consider area differences in harvesting strategies, has adopted the FMP group of species as the management unit for the Gulf shrimp fishery.

4.3 Catch-Effort Data

The National Marine Fisheries Service has collected data on shrimp landed by commercial fishermen. Griffin (1978) has prepared estimates for the 1963-1975 period on unit fishery effort for brown, white, and pink shrimp.

Published accounts of recreational and bait-shrimp catch and effort are comparatively sparce. The few published estimates of discarded catch are summarized in Section 4.7.

4.4 Survey and Sampling Data

Christmas and Etzold (1977) reviewed the major survey and sampling programs which exist in order to monitor the shrimp resource and predict yields.

Texas: Texas has sampled its key bay areas from March to May for brown shrimp and from June to September for white shrimp. In addition Texas Parks and Wildlife Department also monitors the size, distribution, and abundance of shrimp in the open Gulf.

Louisiana: Louisiana has an ongoing shrimp monitoring program in the estuaries March through October. The program provides the data needed to set the opening date and predict the success of the brown shrimp season.

Mississippi: There is a year-round monitoring of all of Mississippi's marine resources. In addition, an intensive sampling of juvenile shrimp occurs from mid-April through summer to provide growth and size data for opening of the inshore brown shrimp season.

Alabama: An ongoing shrimp monitoring program extends from April through September of each year to provide background data as well as to set seasons.

Florida: Florida surveys for age information, and for the life cycle and population dynamics of rock and pink shrimp in offshore waters.

NMFS: NMFS surveys provide the number, weight, and species composition.

4.5 Habitat

Brown, white, and pink shrimp use a variety of habitats as they grow from planktonic larvae to spawning adults. In part, this migration tends to separate the various life stages so that they are not in direct competition for the same resources. As planktonic larvae the shrimp feed on phytoplankton and zooplankton and exist mainly in the open Gulf. As postlarvae they enter the estuaries and adopt a benthic existence at the marsh-water, mangrove-water interface, or within grassbeds. The estuarine phase is considered a critical stage because local fluctuations in temperature and salinity have a dramatic affect on both the acres of marsh available for growth and the actual growth rate of the shrimp. As the shrimp grow, they move away from the marsh-water or mangrove-water interface into deeper, more open waters. At some point they begin an offshore migration to the Gulf. The major species tend to be partly separated in the Gulf. Brown and white shrimp predominate on the mud and sandy mud bottoms of the northwestern and northern Gulf; pink shrimp predominate on the coral sand bottoms of the southeastern Gulf. Adult brown shrimp tend to migrate to deeper waters (30 to 50 fathoms) than adult white shrimp (10 to 20 fathoms).

The weakest link in the life cycle chain is the estuarine phase of growth. Man's alteration of the fragile environment has removed much of the area that would be considered suitable shrimp habitat. Some of these alterations are easily assessed. These include:

- impoundments that prevent influx of shrimp.
- bulkheading that removes the critical marsh-water or mangrove-water interface.
- alterations in freshwater discharge that create an unfavorable salinity regime.

The immediate effects of other alterations are not as easily assessed. These include:

- stimulation of saltwater intrusion.
- the continuing encroachment of polluted waters on the estuarine waters.

Despite any uncertainty about the effects of these alterations, we do have indications of the kind of environment necessary for shrimp survival. Turner (1977) observed that the yield of shrimp in Louisiana's estuaries is directly related to the acreage of marsh, while that from the northeastern Gulf of Mexico is directly related to the acreage of marsh and submerged grassbeds. He found no relationship between yields and estuarine water surface, average water depth, or volume. His findings concur with the observations of Barrett and Gillespie (1973) that annual brown shrimp production in Louisiana is correlated with the acreage of marsh with waters above 10 ppt salinity, but not with acres of estuarine water above 10 ppt salinity. These findings suggest that the brown, white, and pink shrimp yields in the U.S. Gulf of Mexico depend on the survival of the estuarine marshes, mangrove areas, and grassbeds in their natural state. These areas not only provide postlarval, juvenile, and subadult shrimp with food and protection from predation, but they help to maintain an essential gradient between fresh and salt water.

4.5.1 Physical Description of the Habitats

The following parameters are used in characterizing shrimp habitats around the Gulf Coast:

1. Bottom types
   a. Offshore
   b. Inshore

2. Surface water discharge into estuaries

3. Estuarine salinities

4. Areal extent of estuaries

5. Estuarine availability (access from open Gulf)

6. Water quality (with emphasis on low salinity)

All of these factors vary over space and time.

Habitats can change from one type to another, and the changes can be either culturally induced (i.e., filling or dredging of wetlands) or naturally induced (i.e., subsidence of wetlands resulting in its conversion to open water). These changes are critically important to the Gulf's estuarine-dependent species. Documented evidence of the effect of permanent changes in essential habitats is severely limited, except for the change in wetland area.

An important component in the habitat of the estuarine dependent shrimp is the wetland zone along the Gulf coast. Salinity regimes critically needed for shrimp occur in these areas, and their primary production (vegetation) is the basis for the shrimp's detritus food web.

The wetlands along the Gulf coast have formed during approximately the past 5,000 years, when alluvial sediment supplied to the coast exceeded that removed through erosion and subsidence. The general physiography of the Gulf coast has favored extensive wetland formation. Some 60 percent of the coastal wetland area of the conterminous United States occurs along the Gulf coast. Tidal marsh, mangroves, and submerged aquatics that comprise this area amount to some 6.2 million acres. An additional 8.4 million acres are classified as unvegetated estuarine open water (Crance, 1971; Chabreck, 1972; McNulty, Lindall, and Sykes, 1972; Christmas, 1973; Diener, 1975).

Wetlands are not evenly distributed along the Gulf coast. Some 63 percent of the emergent wetlands along the Gulf are found in Louisiana as the result of an abundant sediment supply transported by the Mississippi River. Some 395,000 acres of mangrove are found almost exclusively along the Florida coast. While substrate and currents (to carry germinated seeds) are generally favorable along the entire Gulf coast, mangrove distribution is limited to areas where hard freezes do not occur. Submerged vegetation is found along most of the Gulf coast but is particularly abundant and diverse along the shores of central and southern Florida. Information on submerged vegetation is generally lacking for other states.

The relative abundance and type of submerged vegetation depends mainly on bottom type, turbidity, salinity, water temperature, bottom slope, and tidal range (McNulty, Lindall, and Sykes, 1972). Along the Gulf coast of southern Florida nearly 50 percent of the estuarine bottoms are covered by submerged vegetation. Cover density generally decreases as one moves northward, with bays along the panhandle having only five percent of their bottoms vegetated. Reports for isolated study sites indicate that the five percent figure would hold for the remainder of the Gulf coast, except for portions of Louisiana where the percentage would be less, and the lower Texas coast where abundance is greater. Lindall and Saloman (1977) report 796,806 acres of submerged vegetation in estuaries along the Gulf, of which 63 percent are found in Florida and 31 percent are found in the Laguna Madre and Copano-Aransas Bays in Texas.

4.5.1.1 Bottom Types

4.5.1.1.1 Offshore Bottom Types

There are three general offshore bottom type regions extending to the 200 m isobath in the Gulf of Mexico. One occurs from the Texas-Mexico border to just west of the Texas-Louisiana border. Here the offshore zone consists mainly of sand and finer grain sediments. Occasional pockets of sand and shell are found from the 11 to 109 fms (20 m to 200 m) isobath. The second zone extends eastward to a point approximately even with Pascagoula Bay, Mississippi, and is mainly a complex of fine grain sediments with occasional surface deposits of sand and shell. The dominance of muddy bottoms in this zone is attributed to the deposition by the Mississippi River. The third region encompasses the remaining area offshore Alabama and Florida, which is almost exclusively comprised of sand, shell, and coral. Coral becomes more prevalent along the central and southern Florida coast.

The first two zones are primarily associated with brown and white shrimp, while the third zone is primarily associated with pink shrimp.

4.5.1.1.2 Estuarine Bottom Types

Many of the estuaries found along the Gulf of Mexico represent drowned river valleys, which have subsequently undergone some degree of fill. Generally those estuaries that still have considerable freshwater flow coming in at the head contain bottom sediments that reflect the stream load. Those with little or no stream flow are generally dominated by marine sediments and are usually coarser. Estuaries formed by deltaic progradation and subsequent deterioration are dominated by muddy bottoms.

4.5.1.2 Surface Water Discharge

Freshwater flow into the estuaries of the northern Gulf of Mexico is variable in space and time (Fig. 4.5-1) largely because of differences in drainage basin area, lithology, climate, and land use.

Two aspects of surface water flow are considered in terms of their effect on shrimp habitat: 1) the volume entering the estuaries and 2) the seasonal variability of the hydrography. Four regions of surface water flow are identified:

1. Lower Texas coast

2. Upper Texas coast through the Panhandle of Florida, except for the Deltaic plain of Louisiana.

3. Deltaic plain of Louisiana

4. Central and lower Florida coast

Lower Texas Coast

Rivers of the lower Texas coast have relatively low discharges, with peaks occurring in the spring and fall. Low discharge is due to the semi-arid conditions and relatively small drainage areas of the rivers. More to the south, the fall peak is first noticeable on the hydrographs of streams entering the Matagorda Bay system. In the San Antonio Bay system, the fall peak is very pronounced, and, from Aransas Bay through Laguna Madre, the fall peak exceeds the spring peak. In Laguna Madre, however, the total volume of discharge is extremely low, 9 to 200 cfs (1950-1977).

Occasional heavy rains (often associated with tropical disturbances) can have a substantial short term effect on the estuaries and may affect shrimp yields if the resulting flood waters enter the estuaries during critical growth periods of shrimp.

Upper Texas coast through the Panhandle of Florida, except for the Deltaic plain of Louisiana

Most of the rivers from the panhandle of Florida west to Galveston Bay, Texas, have a peak discharge in early spring, followed by low discharge during the summer and early fall months. Mean monthly precipitation is generally similar throughout the year; however, a high degree of variability exists from year to year. The differences in seasonal distributions of precipitation and discharge are primarily attributed to the seasonal differences in evapotranspiration rates and to the spring release of precipitation stored in winter as soil moisture and snow.

Deltaic Plain of Louisiana

The Mississippi and the Atchafalaya are by far the largest suppliers of fresh water to the Gulf of Mexico (Fig. 4.5-1). Peak discharge usually occurs in April through May; low flow typically occurs in September through October. During periods of flood, fresh water, carried by the Gulf into the mouths of neighboring estuaries, results in lower salinities.

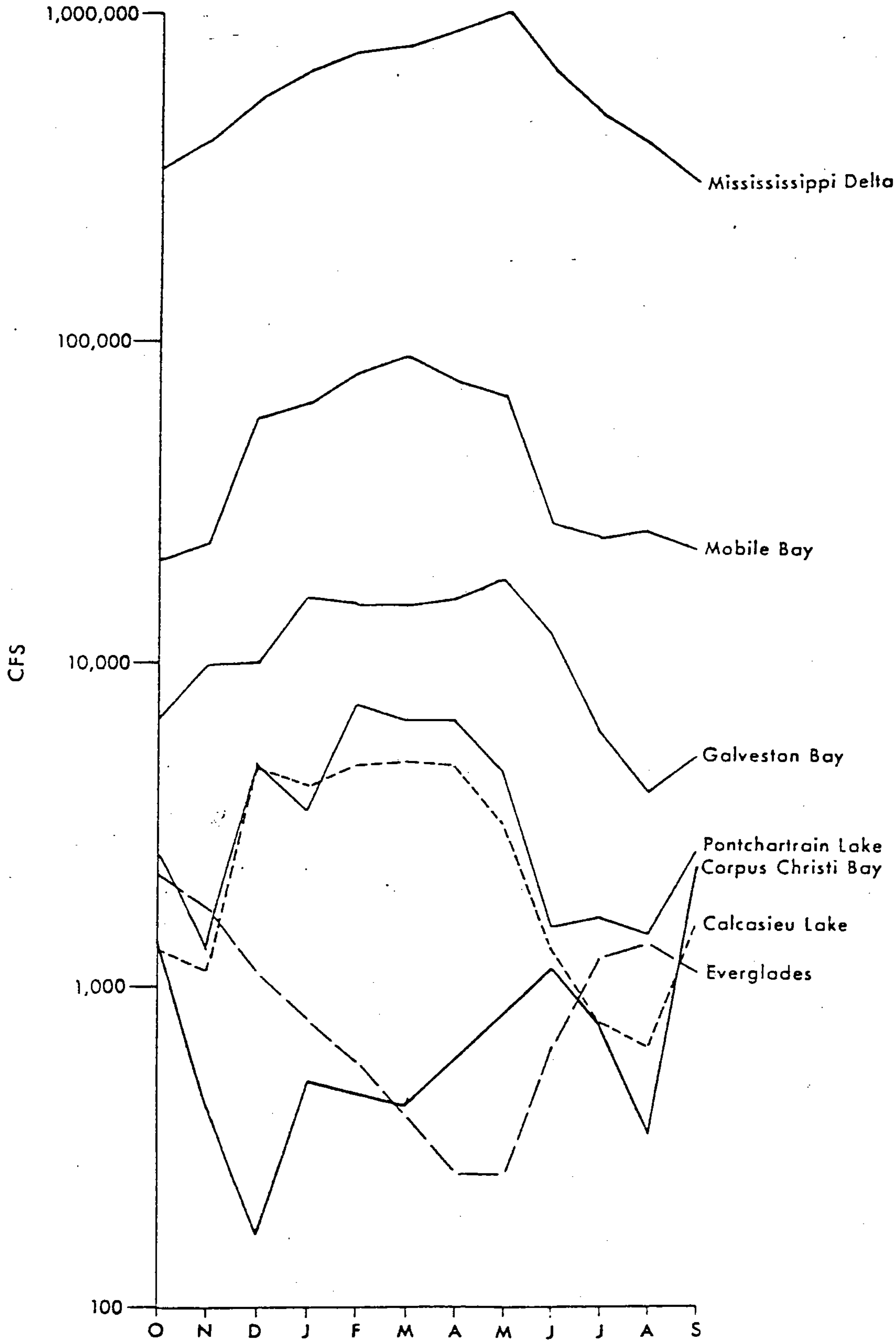


Figure 4.5-1 Ten Year Mean Freshwater Discharge Into Selected Gulf Coast Estuaries (U.S. ACOE and USGS Water Resource Data).

Though extremely variable in magnitude, the monthly flow of the Mississippi River is less variable in relation to average flow than any other gauged rivers entering the Gulf. Its variance in flow, however, has a notice-able effect on the yield of brown shrimp in the Gulf (Section 4.1) and on white shrimp in Louisiana (White and Boudreaux, 1977).

Central and Lower Florida Coast

Stream flow entering the Everglades is lower than most areas of the Gulf, largely because of the small contributing drainage area. The additional input of groundwater is recognized, but its significance cannot be determined.

The seasonal flood cycle is asymmetrical. The peak rises rapidly in early summer, continues into the fall, and then drops slowly to a low stage during the months of April and May (Fig. 4.5-1). The summer maximum differs from most other Gulf rivers in that the latter are typically at low stage during the summer. This difference reflects the greater influence of tropical climate in the Everglades where summer showers are typically intense and result in higher stream flow despite evapotranspiration rates. From Charlotte Harbor north to Suwannee Sound, the seasonal hydrograph is in transition between the summer-fall peak of the south and the late winter-spring peak common along the northern Gulf coast. South of Suwannee Sound the total volume of stream flow is small.

4.5.1.3 Estuarine Salinity

Throughout the Gulf of Mexico estuarine salinity is highly variable in both time and space. Salinity ranges from 0 ppt to a high of 113.9 ppt recorded in Laguna Madre (Hedgepeth, 1953, in Diener, 1975).

Because of severe data inadequacies, it is rather difficult to make a Gulf-wide comparison of salinity in the various estuaries. There are few estuaries in which salinity is continually monitored. In those which are monitored by public agencies, station locations are such (for example, along major dredged waterways) that data often do not reflect general conditions of the estuary.

This section is limited to presentation of averages and extremes; these values, however, are generally based on limited data and present a superficial picture. As a result, many of the estuaries appear quite similar with respect to salinity. The ensuing description of salinity in various estuaries is based largely on secondary reference material, and all values are for surface salinities unless otherwise noted.

Laguna Madre: The only estuary in the Gulf which is almost continually hypersaline had average annual isohalines ranging from 35 to 55 ppt (1963-1966), with lower salinities occurring at tidal passes rather than inland (Diener, 1975).

Corpus Christi Bay: The Nueces River helps to maintain salinities lower than those of average seawater. Most of Corpus Christi Bay averaged between 30 to 35 ppt (1963-1966). Hypersaline conditions can be expected during low discharge periods.

Copano-Aransas Bays: Salinity ranged from 6 ppt in Copano Bay and 12 ppt in Aransas Bay near the Gulf Intracoastal Waterway (GIWW) during flood periods, to 32 ppt in Copano Bay and 35 ppt in Aransas Bay during low discharge periods of the Mission River (1965-1967, McGowen, et al., 1976).

San Antonio Bay: The Guadalupe River strongly influences the salinity in San Antonio Bay. During periods of flood, the entire bay above the Gulf Intercoastal Waterway may be fresh; during low flow, slightly hypersaline conditions occur in some parts of the bay (1965-1967, McGowen, et al., 1976). Average salinities range from 6 ppt at the head to 20 to 25 ppt at the GIWW and decrease slightly on the lee side of Matagorda Island.

Matagorda Bay Complex: The Lavaca River and several streams affect salinity. Salinities range from 0 ppt at the head of Lavaca and Tres Palacios Bays and 20 ppt near Port O'Connor during flood periods, to 30 ppt at the head of the bays and slightly hypersaline conditions near Port O'Connor during low discharge (1965-1967, McGowen, et al., 1976). East Matagorda Bay is separated from Matagorda Bay proper by the Colorado River Delta. Several streams flow into East Matagorda Bay, and its opening to the Gulf consists of a single narrow cut. Salinities here are generally lower, averaging 10 to 15 ppt and ranging from a reported low of 8 ppt to a high of 24 ppt at Brown Cedar Cut (1965-1967).

Galveston Bay Complex: Considerable surface flow enters via the Trinity and San Jacinto Rivers and several small streams and bayous. These are the westernmost estuaries influenced by a humid climate, and hypersaline conditions are rare. Highest salinities are recorded in West Bay, averaging 25 to 30 ppt (1965-1967, Fisher, et al., 1972). Galveston and Trinity Bays average from 10 to 15 ppt near the head to 20 to 25 ppt in the lower portions. During high discharge, surface salinity ranges from 2 ppt to 14 ppt, and during low discharge periods the range is from 20 to 32 ppt (Fisher, et al., 1972).

Circulation between East Bay and Galveston Bay is rather poor (Gosselink, in press) perhaps because of numerous oyster reefs, and salinities are somewhat higher. The reopening of Rollover Fish Pass in 1955 improved circulation in the eastern half of East Bay.

Sabine Lake: Dredging of the Sabine-Neches Ship Channel and the construction of the Toledo Bend Reservoir are classic examples of how man has altered the natural salinity regime of Gulf estuaries. The dam stores winter surplus water, which is released in mid-May for hydroelectric generator demands (White and Perret, 1973). The mid-May release corresponds to the peak period of brown shrimp estuarine production. Alteration in this discharge pattern means the loss of the lake as a shrimp habitat (White and Perrett, 1973).

The natural opening of Sabine Lake to the Gulf was narrow and approxi-mately 4 m deep (Gosselink, in press). This narrowness, combined with the large discharge into the estuary, probably resulted in low salinities throughout the area. The Sabine-Neches Ship Channel 46 ft. (14 m in depth) has resulted in unusual hydrographic changes. Spoil from the channel is continuous until the mouth of the Neches River, at which point an increase in lake salinity is noted. The ship channel acts as a corridor facilitating saltwater intrusion during low discharge periods and allows for more rapid runoff of high discharge.

Combined effects of the natural physiography and of these perturbations have resulted in relatively low and monotonous annual salinity regimes. Salinities at the estuary's head range from 2 to 10 ppt (wet and dry years) and from 16 to 20 ppt (wet and dry years) at the south end of Sabine Lake (Fisher, et al., 1973).

Calcasieu Lake: This estuary is similar to Sabine Lake in its size, its orientation, and in that its constricted opening to the Gulf has been dredged. Salinity in the ship channel has increased since its construction (Gosselink, in press). Historic changes in oyster distribution and in marsh acreage and vegetation indicate that salinity has increased in the lake. Means and extremes are not known for the lake, but it seems that salinity here is somewhat higher than in Sabine Lake (Barrett, 1971).

Atchafalaya-Vermilion Bays Complex: Salinities are generally low due to the Atchafalaya River as well as to other lesser sources of fresh water. A significant decrease in salinity has occurred in the Vermilion Bay area since 1950, and the expected continued growth of the Atchafalaya Delta will result in continued high turbidity levels and lower salinities. If the Delta grows out to the present coastline it may act as a barrier decreasing water exchange with the Gulf. The immediate estuarine area will probably deteriorate in terms of shrimp habitat over the foreseeable future. Over the long term, if the normal sequence of deltaic processes is not inhibited, the result will be a significant increase in estuarine habitat area (Gosselink, in press).

Terrebonne and Barataria Estuaries: Since artificial levies block the normal flow of the Mississippi River, these estuaries are no longer greatly influenced by freshwater runoff. During flood periods, Mississippi waters can enter into the mouths of these estuaries via the Gulf of Mexico and create a reversal in the salinity gradient (Barrett, 1971). While salinity data is extremely sparse, the extensive salt and brackish marshes indicate favorable conditions for shrimp habitat.

Mississippi Delta: The Delta marshes are generally too fresh to be significant shrimp habitats. Surface salinities are usually near zero ppt; however, a well-developed salt wedge moves upriver at low stage.

Pontchartrain-Breton Sound: Marshes in Breton Sound have salinities similar to those of the lower portions of the Barataria and Terrebonne estuaries (20 to 25 ppt, 1967-1968, Barrett, 1971).

Mississippi Sound Complex: Salinities in Mississippi Sound, despite its numerous wide passes, are considerably less than those of the Gulf. Freshwater discharge is considerable both directly (via the Pascagoula system and weirs entering into St. Louis and Biloxi Bays) and indirectly (via Mobile Bay to the east and the Pearl River and Pontchartrain-Borgne system to the west). At the western end, surface salinity ranged from 6 to 20 ppt, while at the east end it ranged from 14 to 30 ppt (1962-1964, 1966-1969, Christmas, 1973). The east-west gradient reflects differences in surface water inputs.

In the landward estuaries, such as Biloxi and St. Louis Bays, surface salinities range from less than eight ppt to 20 ppt. A fairly strong salinity gradient is present from the mouths of the estuaries seaward to the offshore barrier islands. This gradient is most evident from Biloxi Bay to Dog Keys Pass where surface salinities differ by about 12 ppt, with a range of 10 to 20 ppt over the 131 m distance.

Mobile Bay: Mobile Bay is another example of a shallow-water estuary modified by a deep-water channel that allows for saltwater intrusion. Mobile Bay receives more freshwater flow than any other U.S. Gulf estuary except for the Mississippi River and its tributary, the Atchafalaya. Consequently, salinity has a strong inverse relationship to stream flow.

Florida Estuaries: In the panhandle area and south to Suwannee Sound, salinity patterns are similar to those of the estuaries to the west. Salinities are highly variable and are related to stream flow, which is substantial for these areas. Choctawhatchee Bay is a glaring exception because of a well-defined persistent salt wedge (McNulty, et al., 1972).

Despite the lack of major freshwater surface flow, the coastline south of Waccassa Bay and north of Tampa Bay has salinities similar to those of the large-discharge panhandle estuaries. These lower-than-normal Gulf salinities have been a factor in the presence of offshore oyster reefs and submerged aquatics, suggesting the strong possibility of springs emerging in the offshore zone (McNulty, et al., 1972).

Relatively high salinities from Tampa Bay south through Florida Bay are due to the absence of major stream flow and high evapotranspiration rates. The frequency and degree of hypersalinity generally increases in a southerly direction, except for the Charlotte Harbor area where stream flow is normally sufficient to mitigate hypersalinity. Hypersalinity, a normal and frequent occurrence in Florida Bay, is brought about by natural drought periods and is intensified by man's diversion of normal freshwater flow (McNulty, et al., 1972). Higman (n.d.) discusses the possible inverse relationship between growth rate of postlarval and juvenile pink shrimp and salinity in Florida Bay estuaries.

4.5.1.4 Estuarine Access

The area becomes closed as a nursery ground if wetlands are impounded. Indirect effects may be considerable and may cause changes in water flow patterns. Control gates can close off nursery grounds landward of the structures.

Weirs constructed along the Sabine Navigation Channel and the Gulf Intracoastal Waterway in the Keith Lake area of southeast Texas to protect the neighboring marshes from saltwater intrusion were removed in 1977 reopening the Keith Lake area as a shrimp nursery ground (R. Fish, personal communication).

4.5.1.5 Non-Salinity Water Quality

The effects of pollutants on Gulf shrimp is still relatively unknown. Pollutants can reduce the available estuarine habitat area and result in high concentrations of substances harmful for human consumption.

4.5.1.6 Currents

The most important process in producing currents in the Gulf of Mexico is the stress of the wind upon the water surface. While the loop current in the eastern Gulf has been documented for some time, a major current in the western Gulf has only recently been firmly established (Sturges and Blaha, 1976). The loop current may serve as an eastern boundary to the Mexican current (Sturges and Blaha, 1976), especially during summer months.

Tidal currents are of particular importance in the nearshore area and affect movement into and out of estuaries. Despite the small tidal range throughout the Gulf, tidal current velocities are relatively high. In the estuaries high velocity is due to constricted outlets that characterize many of the lagoons and bays. In the nearshore area, water level changes occur over a shallow continental shelf. Wind can have a pronounced effect on the overall water level change. Two of the most dramatic examples are cold fronts that push water out of the northern Gulf estuaries and tropical disturbances that raise water levels in these same estuaries. Shrimp migration, from these estuarine areas is associated in part with the relative magnitude of the tidal exchange (Section 4.1).

4.5.2 Habitat Concerns

See introduction to Section 4.5, Habitat, and Section 4.8, Estimates of Future Stock Conditions.

4.6 Quality of Data

Despite the importance of the Gulf shrimp fishery, there are some significant data deficiencies which limit the selection of management measures. Some of these deficiencies include:

- lack of a clear understanding of natural mortality rates, of temperature and salinity effects on growth rates, and of migration patterns.
- lack of data on utilization of the shrimp resources.
- lack of cost-earnings and catch-effort data.

4.7 Current Status of the Stocks

4.7.1 Maximum Sustainable Yield

4.7.1.1 Explanation and Specification of MSY

The biological characteristics which affect sustainable yields for penaeid shrimp are unusual. They are an annual crop. Very few individuals live a year and the majority harvested are less than six months old. There is no demonstrable stock-recruitment relation and recruitment overfishing, given present technology, is essentially impossible. That is, it is not economically or technically feasible to take so many shrimp that there are too few survivors to provide an adequate supply for the following year. Because of these characteristics, fishing mortality and yield in one year do not affect yield in the following year. The maximum yield in number for a given year is essentially all the shrimp available to harvest, using current technology.

Growth overfishing is caused by taking the available recruits at too small a size. If growth overfishing is occurring, allowing additional time for growth will result in a greater total yield in weight, although the total number of individuals will be less. The rapid growth rate of penaeid shrimp makes them resistant to growth overfishing until high levels of effort are reached. Effort in the fishery has been increasing rapidly, and it is probable that the total yield of penaeid shrimp could be increased if the average size taken were larger. However, the poor quality and small amount of available data makes it difficult to precisely estimate the magnitude of any increase (see Section 4.1).

The abundance (number of recruits) and therefore yield and catch per unit effort, vary greatly from year to year depending on the temperature and salinity in the estuarine nursery areas. This is evident when regression coefficients for the different models are compared. For example, linear regressions of catch on effort showed that effort alone explained only 38 percent of the variation in catch of Louisiana white shrimp and 57 percent of the variation in Gulf brown shrimp catch. Multiple regressions including environmental parameters explained 89 percent and 88 percent respectively. For brown shrimp, the environmental model predicts that at a fishing effort of 100,000 units (essentially the record until 1976), annual catch would vary from 57 to 88 million pounds provided temperature and salinity ranged within 1963-1975 levels. If environmental conditions were more favorable, a greater yield would be expected. Given environmental conditions slightly better than previously observed and high levels of effort, the maximum probable catch is estimated at 116.4 million pounds tails, 37.6 percent greater than the point estimate of MSY from a Schaefer surplus production model.

Surplus production models utilize trends in catch and fishing effort over a series of years. They were designed for, and are usually applied to, species with multiple year classes, (i.e., individual animals live longer than one year). They do not consider fluctuations in recruitment controlled by environment, but assume that environmental effects are constant. The predictive ability of these models, particularly in the range of fishing effort which might produce overfishing, is at its best for long-lived species and/or those which are not subject to large, environmentally produced fluctuations in recruitment. Because penaeid shrimp meet neither of these criteria, application of surplus production models must be made with caution and with an understanding of what is being predicted by the model. Estimates of MSY produced should be considered as long-term averages which are greatly affected by environmental conditions. They should not be considered a maximum allowable catch for a given year.

The Schaefer version of the surplus production model was chosen to estimate MSY in all three species because: sufficient data were available; it fit the data as well as other models which gave similar estimates of MSY, and was mathematically easier to use. The estimate was calculated using only reported catch and effort from the commercial fishery. Estimates of the recreational catch, bait catch, and discarded undersized shrimp are added.

	Schaefer Commercial*	Recreational	Bait	Discard	Total
Brown shrimp	85	8	2	5	100
White shrimp	38	8	1	3	50
Pink shrimp	14	-	1	-	15

for a total MSY of 165 million pounds of tails annually for the three species.

For royal red shrimp, MSY was estimated as 392,000 lbs. of tails using a Schaefer model.

For rock shrimp, MSY was estimated as 1.1 million pounds of tails using a Schaefer model. This estimate is a very poor one because most landings are incidental catch, making effort estimates unreliable.

For seabob shrimp, no accurate MSY could be calculated due to lack of effort data. Seabobs are treated as an incidental catch, to the white shrimp fishery where they account for an average of 4.3 percent of the total catch or 1.4 million pounds (tails) for the years 1959-1975. This must serve as the best available MSY. The catch of seabobs is almost entirely within the Territorial Sea (Sec. 4.1).

For the three penaeid species, surplus production models indicate only a long term average yield, and not an allowable maximum. The catch in any given year can only be estimated using environmental factors and expected effort for that particular year.

A reasonable estimate of the maximum probable catch of white and pink shrimp can be estimated by applying the percentage by which the maximum probable catch of brown shrimp exceeds the Schaefer MSY estimate to all species. Estimates of bait catch, recreational catch and discards are then added to give a total maximum probable catch (see Sec. 4.7.1.2). These estimated are:

	Schaefer Commercial Estimate	Maximum Commercial Yield Considering Environmental Factors (137.6%)	Recreational	Bait	Discard	Total
Brown shrimp	85	117	8	2	5	132
White shrimp	38	52	8	1	3	64
Pink shrimp	14	19	-	1	-	20
Total	137	188	16	4	8	216

for a total of 216 million pounds of tails

4.7.1.2 Technical Description of MSY Calculations

Yield Models Incorporating Environmental Driving Forces

To achieve reasonable accuracy, the calculation of specific yields for penaeid shrimp must be made for specific points in time and must include environmental driving forces, since yield is dependent on those forces and not on abundance in previous years. Such models are much more appropriate and useful for penaeid shrimps because of the overriding impact of the environment on yield.

* All weights are in millions of pounds, tail weight

The environmental models presented below do not estimate MSY in the classical sense, rather they provide a yield estimate for any year under given conditions. They fit empirical relationships to observed data but are not directly tied to biological parameters of the species such as growth rate or mortality rates. The estimates from these models become invalid if extreme and unrealistic values are used for fishing effort and/or environmental parameters. At average levels of river discharge and effort, these models produce yield estimates which approximate MSY estimates from surplus production models.

Griffin and Beattie (1978) attempted to do this using freshwater discharge from the Mississippi River as a proxy for estuarine salinity conditions. Their formula, a modified Spillman production equation (Heady and Dillon, 1961) estimates yield for that portion of Gulf shrimp resources of all species caught by vessels (i.e., five gross tons or larger). It predicts maximum yield will be attained only at infinite fishing pressure, although the rate of increase in yield decreases rapidly with increasing effort.

To estimate average yield, equivalent to MSY, Mississippi River discharge was used as an index of environmental driving forces, and the predictive equation derived is

$$Y = 6593D^{-0.60134}(1-0.995701^{E}) \qquad \text{Eq. 4.7-1}$$

where Y is yield in million pounds of tails, D is Mississippi River discharge in thousand cubic feet per second, and E is fishing effort in thousand units. For a year with an average river discharge pattern, their equation predicts an average yield for Gulf shrimp vessels of 128.7 million pounds of tails. Within rounding error, 90 percent of this catch would be achieved at an expenditure of 314,300 effort units. The current range is 100,000 to 300,000 units.

For the purposes of this plan, it was necessary to consider each species individually. For white shrimp, the data was available only for Louisiana (Fig. 4.7-1).

The association of Louisiana's reported commercial catch of white shrimp (on a year-class basis) to unit fishing effort and Mississippi River discharge was investigated. It was found that the log of average river discharge for the May through August period (LMJJA) could be used as a forecaster for the success of the coming year's harvest (Y) if an estimate of commercial fishing effort (E) could be made (Figure 4.7-4),

$$Y = 127.8 + .6411\ E - 49.4\ \text{LMJJA} \quad (R^2 = .84) \qquad \text{Eq. 4.7-2}$$

where Y is in million pounds tails of white shrimp, LMJJA is the log of river discharge in 1,000 cfs and E is in 1,000 units. This time period encompasses the early phase of estuarine growth. It was also noted that the relationship in Eq. 2 was improved (increased R^2) if the time period over which river discharge was averaged was increased from the May through August period to May through December.

$$Y = 129.1 + .6411\ E - 51.48\ \text{LMD} \quad (R^2 = .89) \qquad \text{Eq. 4.7-3}$$

where LMD is the log of the average river discharge in 1,000 cfs for the May through December period. This longer time period essentially encompasses the first growing season for white shrimp.

These models could not be applied to the entire Gulf white shrimp catch because shrimp production from estuarine areas not connected to the Mississippi River are substantial and do not always correlate well with Louisiana production.

For pink shrimp no data was available to fit these types of models.

For brown shrimp in Louisiana, a correlation has been drawn between the annual success of the brown shrimp harvest and the temperature of both the estuarine water during mid-April and the acres of marsh above 10 ppt. (Barrett and Gillespie, 1973, 1975, 1976; Barrett and Ralph, 1977). In general, good production is expected if the spring is dry and warm, whereas poor production is expected for a wet, cold spring. A similar phenomenon has been observed in Texas (T. Leary, GMFMC, personal communication, 1978).

After the success of the Louisiana Department of Wildlife & Fisheries in predicting its brown shrimp harvest with these environmental variables, and given the fact that the successes of many of the major brown shrimp fishery areas in the Gulf are correlated with the Louisiana catch, "Barrett's" indicators were then tested for their ability to predict the annual Gulf brown shrimp catch. Results of the multiple regression equation generated are shown in Figure 4.7-2. The equation,

$$\text{Catch} = -51.73 + 3.664\,(\text{Temp}) - 0.01496\,(\text{River}) + 0.5061\,(\text{Effort}) \qquad \text{Eq. 4.1-4}$$

predicts 88 percent of the annual variance in catch, where "Catch" is annual brown shrimp catch in million pounds, "Temp" is average water temperature in degrees Centigrade at Grande Terre, Louisiana, April 16 to 22, "River" is Mississippi River discharge in 1,000 cfs March to May, and "Effort" is unit fishing effort in 1,000 units (Griffin, 1978).

In general, low freshwater discharge and high temperatures mean large yields (temperature is the most important factor). The estimated yield for the most favorable recorded combination of temperature (26.3° C in 1967), river discharge (480,000 in 1963) and effort (113,569 in 1972) is 94.9 million pounds. This compares with the best reported catch of 91.5 million pounds in 1967. To calculate a maximum probable yield, it is reasonable to assume slightly better environmental conditions and higher levels of effort. Using 27° C, 480,000 cfs and 150,000 effort units, the yield estimate is 116.4 million pounds of tails. This estimate is 37.6 percent greater than the estimate of MSY from the Schaefer surplus production model and more nearly resembles true conditions.

This model is an adequate predictor of reported annual Gulf brown shrimp harvest, although there is considerable room for refinement and improvement. When the necessary data becomes available, this type of model should be used for all penaeid shrimp.

As shown by the calculations above, surplus production models which do not incorporate environmental forces are inappropriate for these species. They are only used because of a lack of the required environmental data.

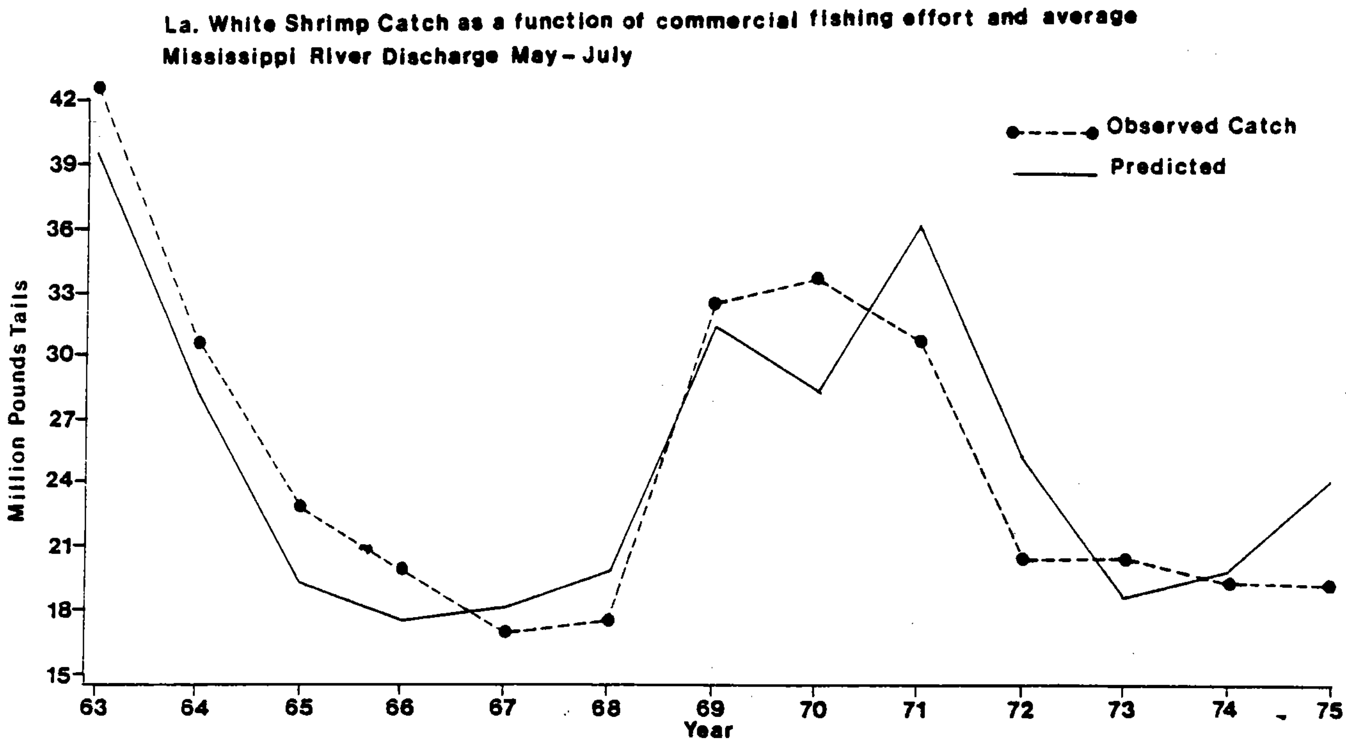
Surplus Production Models

Klima and Parrack (1978) used the Schaefer form of the Generalized Stock Production (GSP) model to predict a MSY for the shallow-water catch of Gulf shrimp (brown, white, pink, seabob, and rock shrimp). They used estimates of reported commercial catch and days fished for the period 1956-1975, excluding 1957, 1961, and 1962 as years of major hurricane activities and therefore not indicative of normal fishing activity. Their equation,

$$Y = E\,(.45528 - 9.3870396 \times 10^{-7} E) \qquad \text{Eq. 4.7-4}$$

(where Y = yield in metric tons and E is effort in days fished) predicts an annual MSY for these shallow-water shrimp of 55 thousand metric tons (121 million pounds) of tails harvested by 225,000 days fished. They noted that annual catch has fluctuated around this maximum since 1970 and conclude that the shallow-water shrimp "have been fully exploited in recent years."

In developing this plan an attempt was made to find the most predictive model relating catch to fishing effort for each of the shrimp species harvested in the U.S. Gulf. Models used were the



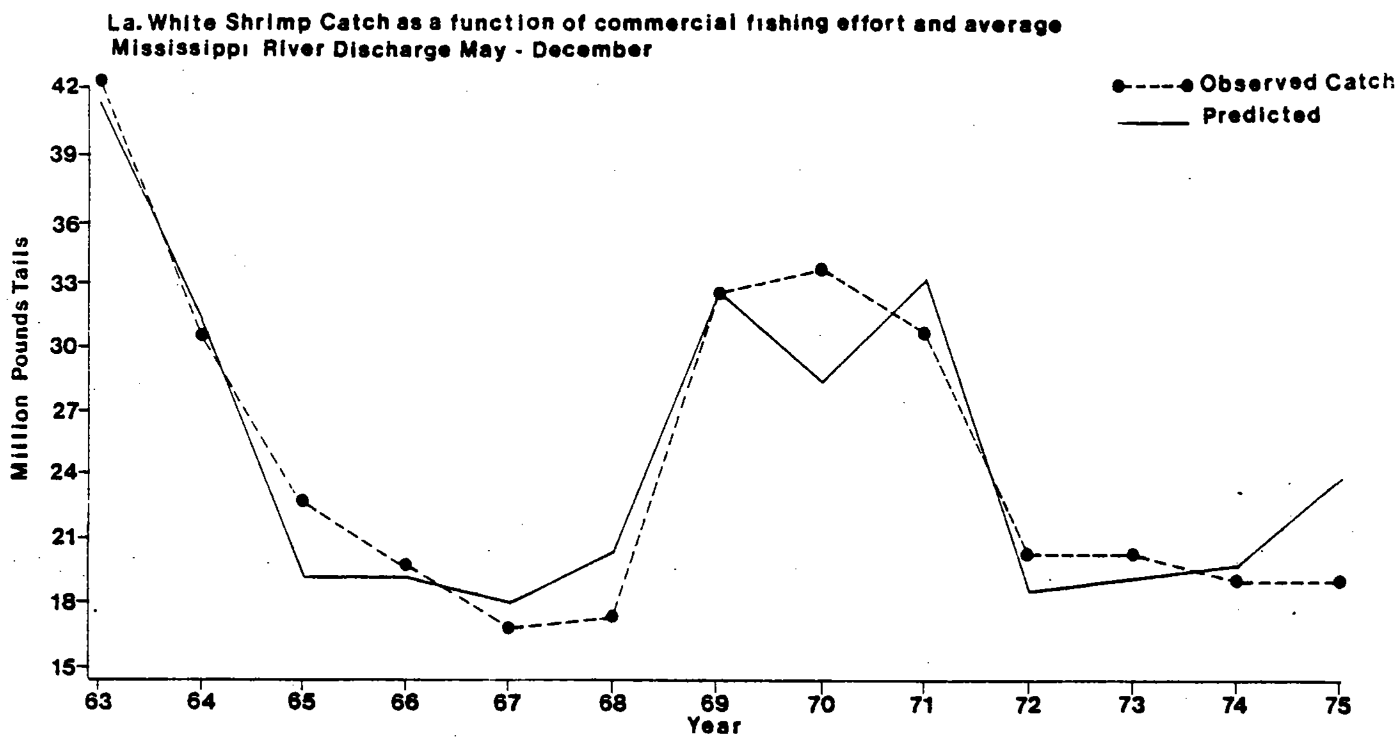


Figure 4.7-1. Louisiana white shrimp commercial reported catch as a function of commercial fishing effort and average Mississippi River discharge.

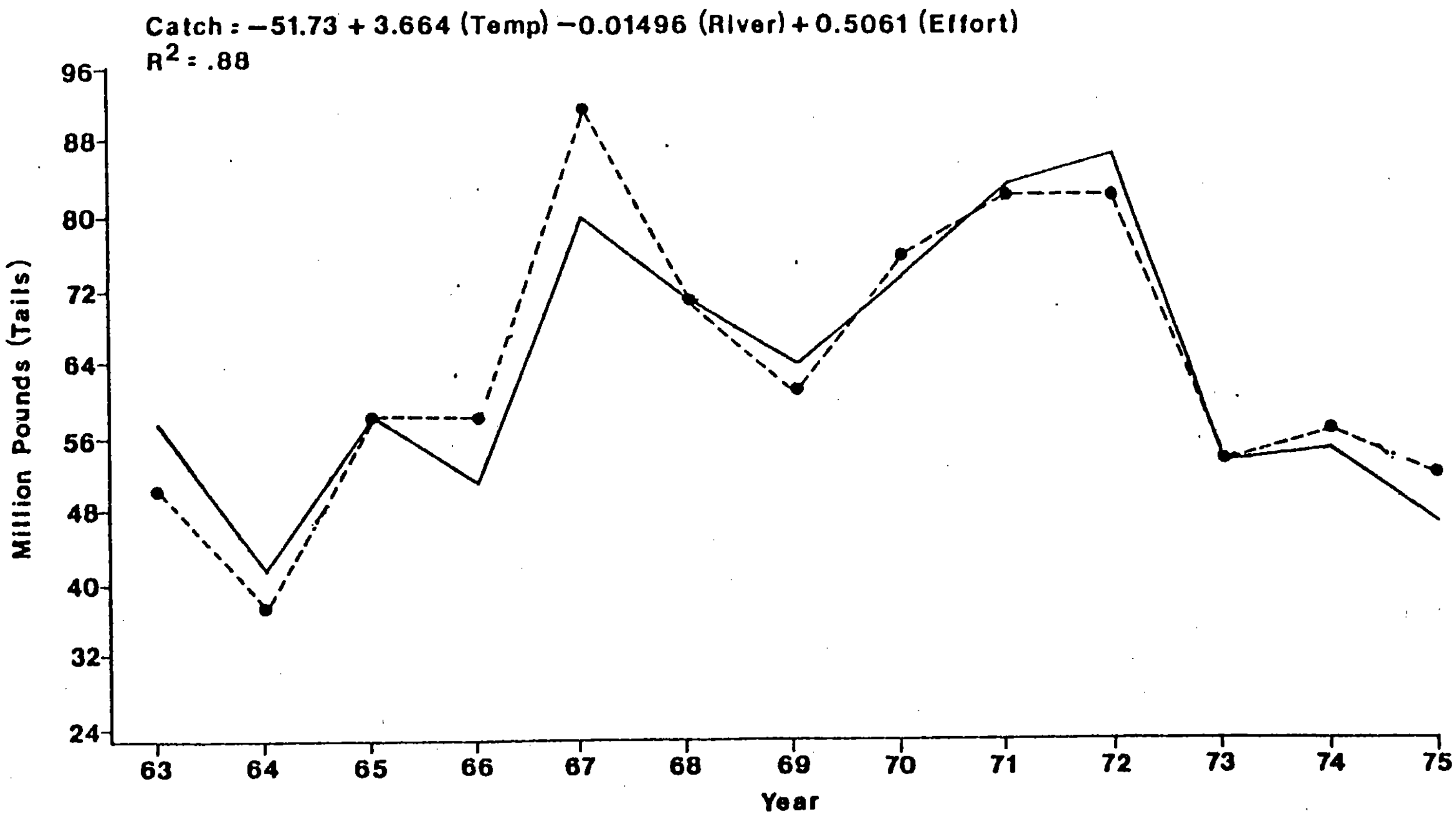


Figure 4.7-2. Predicting the annual US Gulf of Mexico harvest of brown shrimp by the commercial fleet. TEMP is the temperature at Grand Terre, Louisiana, April 16-22 in °C, RIVER is the average Mississippi River Discharge in 1000 cfs for March through May, and EFFORT is 1000 units of unit fishing effort. The solid line represents the solution to the predictive equation and the points represent the actual reported commercial harvest.

Spillman production equation (Dillon and Heady, 1966) (for brown, white, and pink shrimp) and the Generalized Stock Production model (GSP) (Pella and Tomlinson, 1969; Fox, 1975). Four levels of m were used in fitting the GSP model: m = 0.5, 1.5, 2.0, 3.0. The parameter m is a measure of how a stock reacts to increasing fishing effort and overfishing.

The available catch data include the reported commercial catch-effort data published in the Gulf Coast Shrimp Data (U.S. Department of Commerce, 1963-1975) as well as point estimates of recreational, bait, and discarded catch and (in some cases) effort. To test the fit of the models to available data, only the reported commercial catch and effort data were used, since these were the only data with reliable time-series, catch-effort estimates.

Brown, white, and pink shrimp commercial catch-effort data (U.S. Department of Commerce, 1963-1975; Griffin, 1978) are listed in Table 4.7-1. Yield curves were fitted to this reported commercial catch and are compared in Figure 4.7-3 and Table 4.7.2. Essentially, all the models suggest that brown, white, and pink shrimp are being harvested within their respective MSY ranges. With each species, the fit (compare the residual sum of squares) is generally better with the GSP models than with the Spillman equation, and within the GSP models the fit becomes better with increasing m.

Choosing one of these models over another because of the apparent fit of the data is questionable. The fit of the data points to any of the surplus production models is relatively poor because of fluctuations in abundance caused by environmental factors. Although the GSP model where m = 3 appears to give the best fit, this level of m is usually associated with species which are very susceptible to recruitment overfishing. Penaeid shrimp are very resistant to this type of overfishing.

There are other factors which may be affecting the fit of the data. Most of the points lie near the peak of the yield curve. This makes prediction of the effects of higher levels of effort unreliable. A fraction of the catch is unreported. If this fraction is increasing and is large, it would cause the reported catch effort data to fit the curve where m = 3 more closely. Environmentally induced fluctuations in abundance cause great scatter in the points. In the case of white shrimp the shape of the curve is greatly affected by one point, 1975. Removal of this point would result in a large change in the right half of the curve.

The Schaefer model, which is equivalent to the GSP where m = 2, was chosen as representative of the current commercial catch-effort relationships of brown, white, and pink shrimp. The Schaefer model appears to fit the data well, is mathematically easier to use, and generates MSY estimates comparable to those of other models giving similarly good fits. The MSY estimates excluding unreported bait, recreational, and discards, were 85 million pounds of brown shrimp, 38 million pounds of white shrimp, and 14 million pounds of pink shrimp.

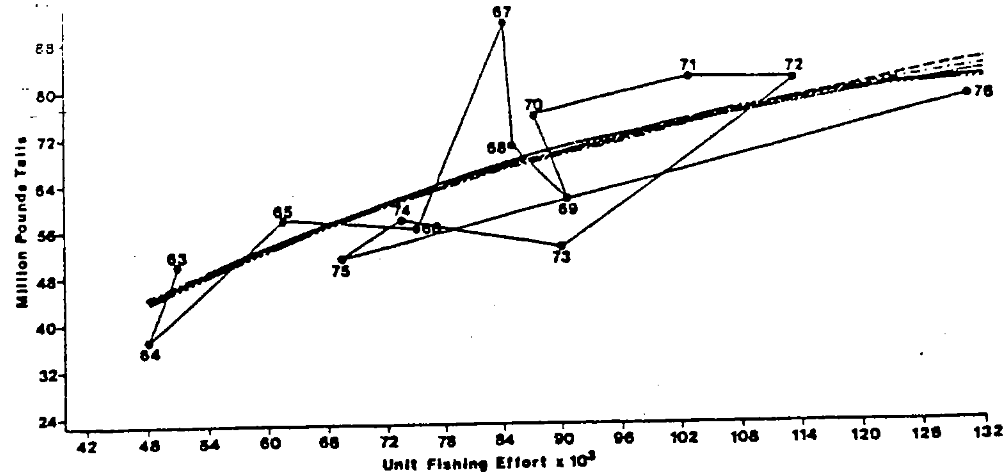
Catch and effort data for royal red shrimp are shown in Table 4.7-3; the data are compared to the Generalized Stock Production model in Table 4.7-4, for m equal to 0.5, 1.5, 2.0, and 3.0. As with brown, white, and pink shrimp, all models have fairly similar fits to the data. Despite the similarity, however, the Schaefer model is suggested as representative of the royal red shrimp since they exist in a relatively constant environment in which at least three year classes occupy the same feeding grounds (Anderson, 1971). A MSY of 392,000 pounds of tails annually is predicted. This result is compatible with Roe's estimate of a potential royal red shrimp yield of 425,000 pounds (in Klima, 1976).

Catch and effort estimates for seabob and rock shrimp are shown in Table 4.7-3. An attempt was made to fit the data to the GSP model despite the fact that the reported commercial catch data for seabob and rock shrimp indicate that they are caught and landed incidentally with other shrimp (Tables 4.7-5 and 4.7-6).

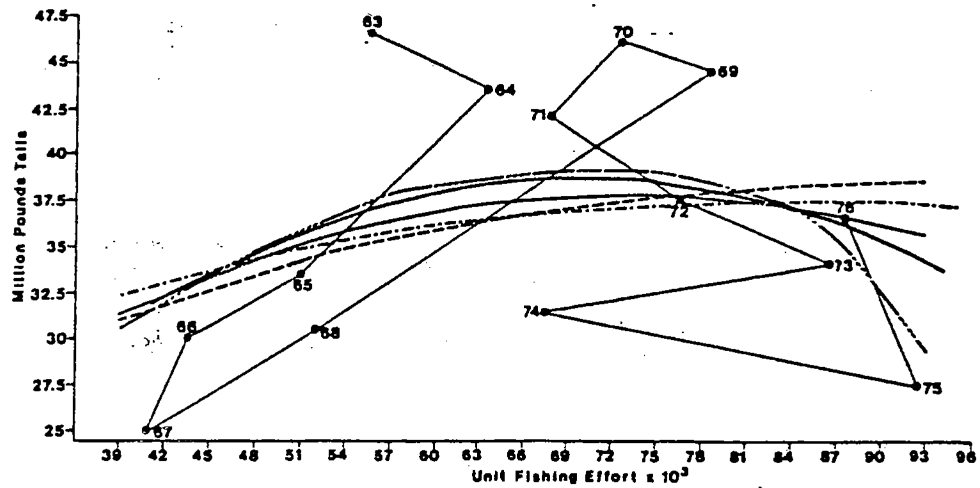
Table 4.7-1. Reported commercial catch and effort data for brown, white, and pink shrimp for 1963-1976 (data from Griffin 1978). Weight is tail weight.

Year	Brown shrimp			White shrimp			Pink shrimp		
	Catch	Days fished	Unit effort	Catch	Days fished	Unit effort	Catch	Days fished	Unit effort
	Million pounds	Thousand days	Thousand units	Million pounds	Thousand days	Thousand units	Million pounds	Thousand days	Thousand units
1963	50.2	82.0	51.3	46.6	80.0	55.7	12.4	21.9	15.3
1964	36.4	74.1	48.0	43.6	95.3	63.3	14.2	25.0	18.5
1965	57.0	102.4	61.6	33.2	74.5	51.2	14.6	23.3	17.4
1966	57.7	111.9	73.6	29.8	72.1	43.6	13.9	23.1	17.5
1967	91.5	116.6	84.2	24.2	61.6	40.9	10.2	21.7	16.7
1968	71.1	117.8	84.9	30.3	77.4	52.0	11.4	22.4	17.5
1969	61.5	114.6	90.6	44.5	115.1	78.4	11.1	21.5	17.8
1970	75.3	117.4	86.7	45.8	91.3	72.6	12.7	20.2	16.8
1971	81.1	126.2	102.6	42.0	88.7	68.2	10.3	17.8	15.1
1972	81.4	144.0	113.6	37.7	91.8	76.3	10.9	21.5	18.7
1973	52.8	115.3	90.0	34.0	115.6	86.5	14.5	25.4	22.4
1974	55.8	103.8	74.9	31.3	96.1	67.5	15.1	27.1	23.9
1975	50.6	86.6	67.8	27.6	121.8	92.3	14.6	31.3	28.6
1976	77.8	181.9	130.3	36.5	111.4	87.7	13.0	29.4	26.2

BROWN



WHITE



PINK

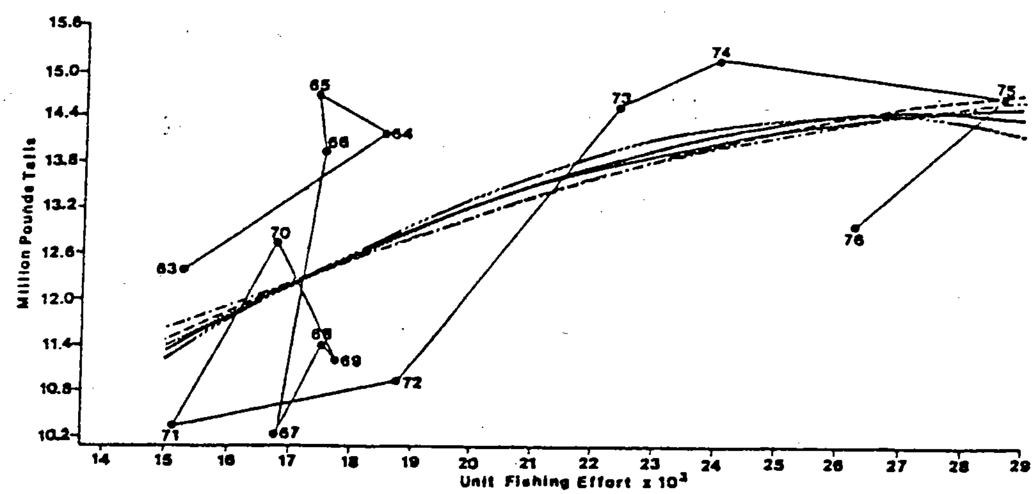


Fig. 4.7- 3. Comparison of the fit of various surplus yield modes to the reported commercial catch of brown, white, and pink shrimp in the US Gulf of Mexico. Equations and estimates of MSY and f opt are listed in Table 4.7-2. Spillman — — — — ; GSP, m = 0.5 -·—·—··; GSP, m = 1.5 ············ ; GSP, m = 2.0 ———— ; GSP, m = 3.0 ——⁄⁄⁄⁄—;

Table 4.7-2. Comparison of point estimates of MSY generated by fitting[1] various surplus yield models to the reported commercial catch data for brown, white, and pink shrimp as reported in Table 4.7-1.

Species	Model	Equation Predicted	Residual Sum of Squares***	Predicted MSY	Predicted f_{opt}
				million pounds tails	unit fishing effort (thousand units)
Brown Shrimp	Spillman*	$Y = 113.5\ (1 - .9896^{E})$	1315	113.5	-
	CSP**, m = 0.5	$Y = .5268\ E\ (.6513 + .001970\ E)^{-2}$	1320	102.6	331
	m = 1.5	$Y = .5431\ E\ (1.448 - .002846\ E)^{2}$	1296	85.8	170
	m = 2.0	$Y = 1.087\ E - .003491\ E^{2}$	1283	84.6	156
	m = 3.0	$Y = .3\ E\ (12 - .059\ E)^{.5}$	1265	81.4	136
White Shrimp	Spillman	$Y = 39.92\ (1 - .9272^{E})$	582	39.9	-
	CSP, m = 0.5	$Y = .9626\ E\ (.7821 + .008144\ E)^{-2}$	573	37.8	96.0
	m = 1.5	$Y = .7073\ E\ (1.299 - .006041\ E)^{2}$	487	38.0	71.7
	m = 2.0	$Y = 1.102\ E - .007885\ E^{2}$	447	38.5	69.9
	m = 3.0	$Y = .6039\ E\ (2.702 - .02604\ E)^{.5}$	377	39.6	69.2
Pink Shrimp	Spillman	$Y = 16.23\ (1 - .9211^{E})$	25.7	16.2	-
	CSP, m = 0.5	$Y = .9102\ E\ (.8224 + .01782\ E)^{-2}$	25.7	15.5	46.1
	m = 1.5	$Y = .8851\ E\ (1.115 - .01255\ E)^{2}$	25.3		29.6
	m = 2.0	$Y = 1.036\ E - .01866\ E^{2}$	25.1	14.4	27.8
	m = 3.0	$Y = .3043\ E\ (9.794 - .2494\ E)^{.5}$	25.0	14.4	26.2

[1] The NLIN procedure in Barr et al. (1976) was used to fit the data to the curvilinear models. All three iterative procedures provided in the NLIN program were used. Only the solution with the lowest residual sum of squares is presented in the "Equation Predicted" column for each species-model combination.

*$Y = M\ (1-A^{E})$

where Y is yield in million pounds tails, M is the maximum yield, A is a constant, and E is thousand units of fishing effort.

**Equation 4.7-1 where catch in million pounds and effort is in 1000 units of effort.

***Corrected total sum of squares for brown shrimp data is 3138, for white shrimp data is 692, and for pink shrimp data is 39.3.

The MSY's predicted for rock shrimp are compared in Table 4.7-4. The Schaefer model (GSP, m = 2) was chosen because the predicted relation between catch and effort was similar to other GSP models and because it is mathematically easy to use. The MSY predicted for rock shrimp is 1.1 million pounds of tails annually. This figure cannot be compared to published reports of rock shrimp density; rather it should be viewed with skepticism because the effort estimates for 1971 to 1976 are poor (since the species is an incidental bycatch) and new fishing grounds for these shrimp may be found, as a market for them continues to develop.

Solutions predicting a MSY were not obtained for seabob shrimp. This inability to predict a MSY is due to unreliable effort estimates since seabob shrimp are usually landed incidentally with other shrimp.

<u>Modification of Surplus Yield Estimates for Penaeid Shrimp</u>

The estimates of MSY from surplus production models for penaeid shrimp must be modified to include unreported catch, bait, recreational, and discards. The demonstrated influence of environmental driving forces must also be included. These considerations have much less impact on other species in this plan and need not be considered for them.

Estimates of recreational and bait catches of brown, white, and pink shrimp are listed in Tables 4.7-7 and 4.7-8. In addition, there are important harvesting areas in the Gulf where shrimp are caught and discarded. Some estimates of these discarded catches on an average annual basis are:

- five million pounds (tails) of brown and white shrimp along the Texas coast, June through August (Terry Leary, GMFMC, personal communication, 1978).
- two to four million pounds (tails) of brown and white shrimp along the Louisiana coast (Charles White, LDWF, personal communication, 1978).
- 316,000 pounds (tails) of pink shrimp in the Dry Tortugas for the 1963-1966 period (Berry and Benton, 1969).

The lack of sufficient data series prevented the development of MSY figures for the recreational, bait, and discard catch. Because estimates of these catches are low in comparison with the commercial MSY figure, they have been rounded off and added to it in the case of each of these three species. This "add-on" is a reasonable approach when, as in this case, the amount to be added is a small fraction of the total. An alternate approach would assume trends in annual CPUE for recreational, bait, and discarded catch to be similar to observed commercial CPUE, adjust the point estimates of the catches accordingly, and add them to the commercial catch and effort in each year. While this might be more technically correct, the estimated MSY would be unchanged. The "add-on" approach was only necessary with brown, white, and pink shrimp because estimates for royal red shrimp are not believed to be significant.

The impact of environmental factors on the Gulf brown shrimp catch has been demonstrated. Although the available data for whites and pinks does not allow individual calculation, it is reasonable to expect a very similar impact. This is supported by visual inspection of the figures for Gulf brown shrimp catch and for Louisiana white shrimp catch. Both show a very similar amount of variation in yield, slightly greater than 100 percent between the lowest and highest yields.

In order to estimate a maximum probable yield for all three species, the percentage by which the maximum probable yield estimate for brown shrimp exceeded the surplus production model estimate (137.6 percent) was applied to all three penaeid species. The point estimates for bait, recreational, and discards were then added on. The estimates for the "add-on" do not consider environmental factors

Table 4.7-3. Reported commercial catch and effort[1] for royal red, sea bob, and rock shrimp in the U.S. Gulf of Mexico (U.S. Dept. of Commerce, 1963-1976).

Year	Royal Red Shrimp		Sea Bob Shrimp		Rock Shrimp	
	CATCH	EFFORT	CATCH	EFFORT	CATCH	EFFORT
	thousand pounds tails	days fished	million pounds tails	days fished	thousand pounds tails	days fished
1963	5.0	8.4	1.14	709	--	--
1964	4.6	6.1	.33	778	--	--
1965	17.0	27.3	.71	790	--	--
1966	23.5	36.5	.48	737	--	--
1967	37.7	88.4	.21	575	--	--
1968	73.5	88.7	.69	2,420	--	--
1969	271.3	506.2	.52	817	--	--
1970	40.9	65.8	2.13	1,905	--	--
1971	64.1	90.7	.32	344	.1	.4
1972	36.6	34.8	1.43	1,635	198.5	167.4
1973	230.8	410.3	2.97	3,548	177.6	299.2
1974	226.9	503.8	4.36	4,350	60.9	58.4
1975	112.6	229.7	4.58	4,580	673.9	463.1
1976	164.2	382.1	.74	1,641	880.0	981.5

[1] Days fished for sea bob and rock shrimp (1963-1975) was calculated by assuming that the fishing effort for a given trip was proportioned directly as the weight of the various species caught and landed. Interviewed days fished estimates were converted to total days fished estimates by using the ratio of interviewed days fished to interviewed trips on an annual basis for royal red, sea bob, and rock shrimp, 1963-1975. Estimates of 1976 days fished for each species were taken directly from NMFS estimates on the Gulf Coast Shrimp Data tapes.

Table 4.7-4 Comparison of point estimates of MSY generated by fitting[1] various forms of the GSP model[2] to the reported commercial catch date for royal red, sea bob, and rock shrimp as reported in Table .

Species	Model	Equation Predicted	Residual Sum of Squares[3]	Predicted MSY	Predicted f_{opt}
				thousand pounds tails	days fished
Royal Red Shrimp	GSP, m = 0.5	$Y = .7048\ E\ (1.0723 + .0002529\ E)^{-2}$	3547	650	4240
	m = 1.5	$Y = .6063\ E\ (.9974 - .0001960\ E)^{2}$	3577	455	1696
	m = 2.0	$Y = .6068\ E - .0002347\ E^{2}$	3588	392	1290
	m = 3.0	$Y = .1976\ E\ (9.150 - .00598\ E)^{.5}$	3613	352	1020
Sea Bob Shrimp	GSP, m = 0.5	$Y = 1.182\ E\ (.2604 + .000969\ E)^{-2}$	*	*	*
	m = 1.5	$Y = 0.002538\ E\ (5.086 - .01600\ E)^{2}$	*	*	*
	m = 2.0	$Y = .5077\ E + .0001039\ E^{2}$	**	**	**
	m = 3.0	(no points produced a valid sum of squares)			
Rock Shrimp	GSP, m = 0.5	$Y = .6465\ E\ (.6909 + .0001528\ E)^{-2}$	57621	1531	4522
	m = 1.5	$Y = .2054\ E\ (2.525 - .0004214\ E)^{2}$	56446	1162	1997
	m = 2.0	$Y = 1.297\ E - .0003889\ E^{2}$	55970	1081	1668
	m = 3.0	$Y = .2087\ E\ (37.24 - .01853\ E)^{.5}$	55131	985	1339

[1] The NLIN procedure in Barr et al. (1976) was used to fit the data to the curvilinear models. All three iterative procedures provided in the NLIN program were used. Only the solution with the lowest residual sum of squares is presented in the "Equation Predicted" column for each species-model combination.

[2] Equation 4.7-1 where catch in thousand pounds and effort is in days fished.

[3] Corrected total sum of squares for royal red shrimp data is 110949 and for rock shrimp data is 642499.

[4] Equations predicted for sea bob shrimp data are not theoretically expected and do not predict a MSY.

*Although equations yield solutions, the estimates appear meaningless and plots of residuals indicate that the equations are biased.

**Equation generated is not theoretically expected.

Table 4.7-5. Comparison of sea bob shrimp caught with and without other shrimp in the U.S. Gulf of Mexico (GCSD, 1970-1975).

Year	Sea bob shrimp catch reported as not occurring with other shrimp (million pounds)	Sea bob shrimp catch reported as occurring with other shrimp (million pounds)	Percent total sea bob shrimp catch occurring without other shrimp (%)	Catch of other shrimp reported with sea bob shrimp catch (million pounds)	Ratio sea bob shrimp catch to other shrimp caught
1970	.073	2.06	3.4	11.8	1:5.7
1971	.003	0.25	1.3	11.0	1:43.7
1972	.073	1.36	5.1	17.6	1:12.3
1973	.782	2.19	26.3	8.8	1:4.0
1974	.740	3.62	17.0	13.8	1:3.8
1975	.344	4.24	7.5	19.2	1:4.5

Table 4.7-6 Comparison of the catch of rock shrimp caught with and without other species of shrimp in the U.S. Gulf of Mexico (GCSD, 1971-1975).

Year	Rock shrimp catch reported as not occurring with other shrimp (pounds)	Rock shrimp catch reported as occurring with other shrimp (pounds)	Percent total rock shrimp catch occurring without other shrimp (%)	Catch of other shrimp reported with rock shrimp catch (pounds)	Ratio rock shrimp catch to other shrimp caught
1971	0	113	0	253	1:2.2
1972	3,039	195,461	1.5	349,305	1:1.8
1973	2,915	174,734	1.6	651,469	1:3.7
1974	7,813	53,064	12.8	270,293	1:4.4
1975	11,199	662,723	1.7	828,149	1:1.2

Table 4.7-7 Estimates of annual recreational shrimp catch by waters associated with the five gulf states.

State	Reported estimate of annual commercial recreational shrimp	Assumptions made to convert reported estimates to species catch in	Estimated annual brown shrimp	Estimated annual white shrimp	Estimated annual pink shrimp
	Thousand pounds of tails (heads-on)		Thousand pounds of tails	Thousand pounds of tails	Thousand pounds of tails
Florida	5/		-	-	5/
Alabama[1]	257 ± 46	Assume catch is 78% brown shrimp and 22% white shrimp[6]	125	37	-
Mississippi[2]	175 ± 9	Assume catch is 86% brown shrimp and 14% white shrimp[6]	94	16	-
Louisiana[3]	23,600	Assume catch is 50% brown shrimp and 50% white shrimp[6]	7,329	7,662	-
Texas[4]	901 ± 118	Assume catch is 77% brown shrimp and 23% white shrimp[6]	431	134	-

[1]Average 1972-1974 (Swingle et al. 1976).

[2]Average 1973-1975 (Weaver and Christmas n.d.).

[3]1973 estimate (U.S. Army Corps of Engineers n.d.).

[4]1973 estimate (King 1975).

[5]No data available.

[6]Computed from ratio of annual average reported commercial catch of brown shrimp to white shrimp from the area.

Table 4.7-8 Estimates of annual commercial bait shrimp catch by waters associated with the five gulf states.

State	Reported estimate of annual commercial bait shrimp catch	Assumptions made to convert reported estimates to species catch in tail weight	Estimated annual brown shrimp catch	Estimated annual white shrimp catch	Estimated annual pink shrimp catch
			Thousand pounds of tails	Thousand pounds of tails	Thousand pounds of tails
Florida	74.75 ± 9.5 million shrimp[1]	Assume all shrimp are pink shrimp and 68 tails per pound	-	-	1,099
Alabama	1,544,000 shrimp[2], plus 22,000 pounds shrimp	Assume all shrimp are 68 tails per pound. Assume catch is 78% brown shrimp and 22% white shrimp[6]	28	8	-
Mississippi	43,407 pounds shrimp[3]	Assume catch is 86% brown shrimp and 14% white shrimp[6]	23	4	-
Louisiana	1,529,000 pounds shrimp[4]	Assume catch is 50% brown shrimp and 50% white shrimp[6]	475	496	-
Texas	2,340,000 pounds shrimp[5]	Assume catch is 77% brown shrimp and 23% white shrimp[6]	1,119	349	-
ESTIMATED TOTAL			1,645	857	1,099

[1] Average 1969-1975, Christmas and Etzold (1977).

[2] Estimate for the 1968 period, from Swingle (1972).

[3] Estimate for 1971, from Christmas et al. (1976).

[4] Estimate for 1973, from U.S. Army Corps of Engineers (n.d.) citing a manuscript from the U.S. Fish and Wildlife Service.

[5] Estimate for 1978 from O. H. Farley (NMFS, personal communication 1979).

[6] Computed from ratio of annual average reported commercial catch of brown to white shrimp from the area.

and are probably conservative for that reason. The maximum probable catches in millions of pounds of tails for the three penaeid species are:

	Schaefer Estimate	Maximum Yield Considering Environmental Factors (137.6%)	Recreational	Bait	Discard	Total
Brown Shrimp	85	117	8	2	5	132
White Shrimp	38	52	8	1	3	64
Pink Shrimp	14	19	-	1	-	20
Total	137	188	16	4	8	216

These estimates of probable maximum catch, particularly for white and pink shrimp are subject to considerable uncertainty, and are only achievable under optimum environmental conditions with high levels of effort.

The Council will monitor data points throughout the life of the plan in order to obtain data which will allow the derivation of specific formula for species other than brown shrimp.

4.8 Estimates of Future Stock Conditions

Although effort is expected to increase, there is no reason to believe that recruitment overfishing will occur. Growth overfishing could occur and decrease the total yield if effort in inshore areas continues to increase. Management measures in the plan should prevent this from occurring and increase yield beyond present levels.

5.0 CATCH AND CAPACITY DESCRIPTORS

5.1 Annual Capacity

The capacity of any firm or industry can be measured and/or expressed in both physical and economic terms. These expressions will usually lead to widely divergent conclusions regarding the empirical measure of capacity. Both are valid and the use of each depends upon the objectives which are to be satisfied. The differences in physical and economic capacity as applied to the shrimp fishery are discussed in the following sections.

5.1.1 Physical Domestic Annual Capacity (DAC)

The capacity of a production unit or plant such as a shrimp vessel or shrimp breading plant usually refers to an engineering input-output ratio. For each input level there is a certain level of output that can be expected to be produced. In the case of a shrimp vessel, inputs as measured through units of effort, result in shrimp being caught. For a given vessel and a given stock of shrimp, more shrimp will be caught with each added unit of effort until at some point, total output will decline with more effort. Maximum physical capacity occurs at the point of absolute diminishing returns for the individual vessel. The same capacity relationship exists throughout the shrimp landing and processing system.

Maximum capacity in fishery management plans is usually estimated for the purpose of determining the total allowable level of foreign fishing (TALFF). A demonstrated capacity and intent to use that capacity equal to or greater than the optimum yield estimate from the fishery indicates that no foreign fishing would be allowed. In this plan, capacity was estimated to be the highest catch per day per vessel during a specified period, times total days fished for all vessels in the fishery. Measuring highest catch per day per vessel also provides an indirect measure of the amount that was landed and processed through the entire production and marketing system.

Domestic Annual Capacity is considered to be the total physical capacity of the fleet and the processing sector. The basic physical indicators of the U.S. commercial Gulf fleet and its estimated annual capacity to harvest Gulf shrimp are given in Table 5.2-1 for the 1962 to 1975 period. The number of commercial boats increased from 1962 to 1968, declining in the early 1970's then increased to 1968 levels in 1975. The number of commercial vessels, average gross tons, average effort index, and total days fished by vessels and boats increased generally over the 1962 to 1975 period. The increases in days fished by boats and by vessels were similar over this period (Christmas and Etzold, 1977, Fig. 17).

In estimating the DAC of the Gulf shrimp fishery, the intent should be to use the largest annual catch per day experienced during the 1963 to 1975 analysis period. This figure when multiplied by the number of days fished each year will estimate DAC in pounds. Note in Table 5.2-1 that the catch per day fished in 1963 and 1967 was 731.1 and 717.7 pounds, respectively. Although the average catch per day was slightly higher in 1963, the DAC calculation was based on 1967 for two reasons. Several economic variables reflecting prices and costs are indexed by using 1967 as the base year. Selection of 1967 as the base for the DAC calculation will facilitate wider use of the estimate. The second factor is evident from viewing the days fished column of Table 5.2-1. The record daily catch in 1963 resulted in large part from a 18 percent decrease in days fished from the previous year. An obvious trend over the fourteen year period covered in Table 5.2-1 is the major increase in days fished. Rather than ignore this trend by making the DAC calculation on an atypical base, the similar figure experienced in 1967 was utilized. Thus, the commercial domestic annual capacity in the following years was computed by using 718 pounds per day as an estimate of M_c in Eq. 5.2-2 in the following section. The actual reported days fished in each year through 1975 were used to estimate the nation's capacity to fish commercially for shrimp in the U.S. Gulf during that year. These estimates are given in Table 5.2-1.

Table 5.2-1. Basic Catch and Capacity Indicators of the Reported Commercial U.S. Gulf Fleet and Estimates of Domestic Annual Capacity[3] to Harvest Shrimp.

Year	Number of reported commercial boats[1]	Number of reported commercial vessels[1]	Average vessel gross tons[1]	Average effort index of vessels[2]	Reported commercial catch[2]	Reported days fished[2]	Reported catch per days fished[2]	Domestic annual capacity (DAC)[3]	Difference between DAC and observed harvest	Percent DAC not attained
			Tons		Million pounds	Thousand days	Pounds per day	Million pounds	Million pounds	Percent
1962	3927	2600	41.9	1.63	69.9	146.5	477.1	----	----	----
1963	4481	2697	41.5	1.61	110.7	121.4	731.1	----	----	----
1964	4360	2782	42.0	1.63	95.9	169.8	546.7	----	----	----
1965	4785	2849	42.7	1.65	107.1	170.4	628.5	----	----	----
1966	4797	2942	44.9	1.67	103.7	175.9	589.5	----	----	----
1967	4983	3146	48.9	1.74	130.7	182.1	717.7	----	----	----
1968	5109	3430	52.5	1.80	113.9	191.5	594.7	137.4	23.5	17
1969	4817	3569	53.7	1.85	118.3	200.4	550.3	143.8	25.5	18
1970	4495	3579	53.8	1.85	136.3	200.0	681.5	143.5	7.2	5
1971	4828	3487	57.8	1.89	134.1	204.9	654.4	147.0	13.1	9
1972	4500	3683	59.2	1.93	132.1	228.9	577.1	164.3	32.2	20
1973	4723	4091	59.9	1.93	104.7	238.0	539.9	170.8	66.1	39
1974	4589	3785	61.5	1.84	106.9	222.7	480.0	159.8	52.9	33
1975	5054	3780	64.0	----	99.5	266.5	466.0	191.3	91.8	48

[1]Griffin (1978).

[2]Christmas and Etzold 1977.

[3]Computed as DAC = E x M_c where DAC equals domestic annual capacity, E is the observed days fished, and M_c is the maximum observed catch per day fished for a peak catch year during the period of observation.

In general, the annual U.S. capacity to harvest shrimp commercially increased over the 1968 to 1975 period from an estimated 138 to 191 million pounds of tails annually. This increase in Domestic Annual Capacity reflects a general increase in the desire and physical facilities to harvest Gulf shrimp. In addition, recreational and bait shrimp catches are expected to remain at least at current levels. These levels have been estimated as 16 and four million pounds of tails, respectively.

The estimated total Domestic Annual Capacity to harvest U.S. Gulf brown, white and pink shrimp is 211 million pounds of tails annually, as of 1975. Estimated capacity at the present time (1981) is 240 million pounds. The DAC for royal red shrimp is estimated to be 270,000 pounds.

5.1.2 Economic Capacity

In general, economic capacity is addressed from the viewpoint of the individual firm (or vessel). However, it is also important to examine the economic capacity of the industry and the implications of these capacity levels on society. In extending the discussion to economic capacity, not only is physical capacity important but the rate at which the physical capacity is utilized is important. Four factors are important in determining physical capacity and the rate of capacity utilization. These are (1) prices of the inputs employed in catching shrimp and the actual catch per unit of effort, (2) product or shrimp prices throughout the market system, (3) the available quantities and associated prices of products that substitute for shrimp in the market and (4) physical input constraints such as ice, fuel, etc.

The determination of economic capacity in fisheries is complicated by a number of factors. Fisheries are common property resources and the problem of open access with no charge for the raw fish (or shrimp) input into the production process along with the fact that one person's action or entrance into the fishery affects the production of other producers and causes unrealized costs on them complicates the capacity question (see Section 3.5.2.3). The fact that shrimp boats can be to a limited degree converted and used for other fisheries on a seasonal basis means that the same vessel or production unit can have excess economic capacity for one fishery and limited capacity for another. Seasonal gluts and fishing patterns may strain the capacity of dockside facilities and in fisheries there may be "good" and "bad" production years due to external factors such as the environment which makes the estimation of economic capacity difficult.

The rational optimum economic capacity of the firm must be determined subject to both short run and long run considerations. In the short run, the vessel owner tries to maximize net profit for the given vessel. Only in the long run is the owner afforded the opportunity to try to change vessel size and design to take advantage of economies of scale and thereby change the net profit situation. The rational firm's optimum economic capacity level of output is that point where the marginal revenue (addition to total revenue) for each new unit of effort is just equal to the marginal cost (addition to total cost) of that unit of effort. If the cost of an added effort unit is greater than the added revenue produced by that unit, the vessel will reduce effort until marginal revenue equals marginal cost. This is the optimum economic capacity of the firm.

Marginal revenue for each unit of effort is affected by both the price of shrimp and the additional shrimp caught for each added unit of effort. Shrimp prices affect the long run industry capacity in terms of investment in vessels and equipment and price also affects the rate of utilization of existing vessels. Additional units of shrimp caught are affected by the available stock of shrimp and the number of vessels seeking to harvest from that stock. The catch per unit of effort for a vessel decreases as each additional unit of effort is applied and the catch per unit of effort is also affected as more vessels enter the fishery. Additional vessels entering the fishery cause existing vessels as well as the new vessels to fish harder (more effort) to maintain the same level of catch as before.

Marginal cost or the cost of each added unit of effort is affected by the cost of inputs such as ice and fuel. However, since there is no charge or "cost" on the raw shrimp as an input into the production process, their cost does not change as they become more scarce due to the added effort of more vessels. A real cost is not felt but the entrance of new vessels puts an unrealized cost on others by effectively making their cost per unit of effort higher: more vessels means each vessel catches fewer shrimp at the same cost or incurs higher costs for the same level of catch.

External factors also affect the economic capacity of the firm through the effect of these factors on marginal revenue and marginal cost. The price of shrimp is affected by consumer demand which in turn is affected by the price of substitute products and income. Imports also affect the price of domestically caught shrimp. The stock of shrimp, and hence the amount caught for each unit of effort, is affected by the environmental factors affecting shrimp growth, mortality and availability. The cost of inputs faced by shrimp producers is also affected by the demand by other industries competing for these same factors of production.

Economic capacity of a fishery industry (rather than individual firms) can also be examined from the viewpoint of society. This approach estimates a return to all resources employed in the fishery and determines the most efficient allocation of these resources from society's viewpoint. This level of input use is usually called the maximum economic yield level of effort. In an open access fishery (see Section 3.5.2.3) fishing effort usually is beyond that level of optimum economic capacity from the standpoint of maximum economic yield. This level of effort generates economic rent that accrues to the producing sector unless taxed away and returned to society.

In summary, physical capacity is the maximum amount of shrimp that the industry can catch, process, and market. Economic capacity is determined by physical capacity, shrimp price plus total cost of production.

5.2 Data and Analytical Approach

Catch (Y) can be viewed as

$$Y = f(P) \cdot E \qquad \text{Eq. 5.2-1}$$

where f is the catchability coefficient; P, the population density and E, the fishing effort. The population density will depend in large part upon prevalent environmental conditions. The expected fishing effort will be the summation of physical and economic parameters limiting fishing effort, as well as physical and economic parameters limiting the landing, storage, and consumption of shrimp.*

Domestic annual capacity (DAC) can be defined as

$$DAC = E \times M_c \qquad \text{Eq. 5.2-2}$$

where E is annual days fished and M_c is the average maximum catch per day fished that could be harvested, landed, processed, and later consumed, for that annual period of fishing effort.

In estimating the DAC of the Gulf shrimp fishery, the largest annual catch per day (during a peak year) for the 1963 to 1975 period and the actual number of days fished in each year was used.

After 1975 the annual number of days fished (E) was estimated by a linear regression of days fished on year for 1968-1975.

$$E=(-17958.6) + 9.22\ (\text{year}) \quad r^2 = .81$$

The shrimp catch of the Gulf vessel fleet in any year can be expressed by the following identity:

$$Yv = V\ (Dv/V)\ (E/Dv)\ (Yv/E) \qquad \text{Eq. 5.2-3}$$

where Yv indicates the pounds caught by vessels, V represents the number of vessels, Dv is the total number of days fished by the vessel fleet, and E is total fishing effort of the vessel fleet.

Similarly, the shrimp catch by Gulf boats in any year can be expressed as

$$Yb = B\ (Db/B)\ (E/Db)\ (Yb/Db) \qquad \text{Eq. 5.2-4}$$

where Yb represents the pounds landed by boats, B the number of boats, and Db the number of days fished by all shrimp boats.

5.3 Expected Domestic Annual Harvest (DAH)

The Domestic Annual Harvest is the record and projections of actual shrimp harvest.

5.3.1 Expected DAH for the Combined Species

DAH was estimated from trends in the reported commercial harvest and from point estimates derived for recreational, bait, and discarded catches. Trends in commercial harvest and effort were examined by boat data and vessel data separately.

The number of commercial vessels (V) and the unit effort per day fished (E/Dv) of these vessels have had statistically significant linear increases from 1962 to 1974 that are represented by the relationships

$$V = 2461 + 117\ YR\ (R^2 = .93) \qquad \text{Eq. 5.3-1}$$

$$E/Dv = 1.57 + .029\ YR\ (R^2 = .86) \qquad \text{Eq. 5.3-2}$$

where YR is the calendar year minus 1961.

The catch and effort statistics for commercial vessels are listed in Table 5.3-1. Although statistically significant linear increases in number of vessels and effort per day fished existed for the period, no significant trend was found in days fished per vessel (Dv/V) or catch per unit of fishing effort (Yv/E). Rather these seemed to have exhibited averages of

38.1 days fished per vessel, and
367.1 pounds (tails) per unit effort.

The conclusion that catch per unit of fishing effort showed no significant trend during the period needs periodic reassessment. Choice of the base period is obviously important. Basing the calculation in 1967 when the number of vessels was showing a major trend upward when combined with the major increase in effective effort per day fished would likely lead to a different conclusion. Since 1974 the number of vessels has increased along with average vessel tonnage. The implication is that when comparable data for the post 1974 period are available, these calculations should be repeated.

The practice of calculating DAH with equations including calendar years as variables (see 5.3-1 and 5.3-2) needs improvement. Though a high R^2 is obtained it must be recognized that use of the equations ignores arguments made in the biological sections of the plan. That is, production in a

Table 5.3-1. Parameters used to estimate expected domestic annual harvest for the reported commercial shrimp fishery.

YEAR	VESSEL CHARACTERISTICS				BOATS		
	number[1] of vessels	days fished[2] per vessel	ratio unit[3] effort to days fished	pounds[3] per unit effort	number[1] of boats	days fished[2] per boat	pounds per[3] days fished
62	2600	34.0	1.63	315	3927	14.8	434
63	2697	41.9	1.61	423	4481	8.6	865
64	2782	41.1	1.63	381	4360	12.7	424
65	2849	39.9	1.65	427	4785	11.8	450
66	2942	38.6	1.67	411	4797	13.0	395
67	3146	36.9	1.74	494	4983	13.3	463
68	3430	35.4	1.80	383	5109	13.7	427
69	3569	41.8	1.85	301	4817	10.9	675
70	3579	37.6	1.85	386	4495	14.5	613
71	3487	39.3	1.89	352	4828	14.1	626
72	3683	39.9	1.93	333	4500	18.2	459
73	4091	34.2	1.93	263	4723	20.7	343
74	3785	35.0	1.84	303	4589	19.7	363

[1] From Table 3.5-8.

[2] Data on days fished from Table 3.5-7.

[3] From Christmas and Etzold (1977).

year is not dependent on catch, production, or mature shrimp in the previous year. The weakness of using the equations to predict DAH for 1980 and 1981 is evident from viewing the 1980 prediction (139 million pounds) and 1981 prediction (144 million pounds) in relation to historical vessel landings.

Catch and days fished statistics for commercial boats are listed in Table 5.3-1. The commercial boat fleet has not exhibited statistically significant linear trends in number of boats (B) or catch per day fished (Yb/Db). The averages over the 1962 to 1974 period have been 4,645 boats and 503 pounds per day fished. The number of days fished per boat (Db/B) has increased significantly (1962 to 1974).

$$Db/B = 9.72 + .66\ (\text{Time}) \quad (R^2 = .55) \qquad \text{Eq. 5.3-3}$$

The expected commercial boat catch in 1981 is estimated (by substituting the estimated values for B, Yb/Db, and Db/B into Eq. 5.1-4) to be 54 million pounds of tails.

The expected reported commercial catch for 1981 is 198 million pounds. Bait and recreational catches are not expected to decline from 1963 to 1967 levels. A conservative estimate of expected recreational catch is 16 million pounds (tails) and four million pounds (tails) for the expected bait shrimp. The total expected domestic catch is 218 million pounds.

These estimates of expected harvest must be viewed with considerable caution because of limitations inherent in the formulas or model being used. The periods for which catch is estimated are six or more years beyond the limits of the available data series. Such a large time extension increases the risk that the observed trends may change. The model assumes constant CPUE and increases in catch with increasing effort. Catch per unit effort was assumed constant because the trend between 1962 and 1974 was not statistically significant. However, the data does indicate a downward trend as effort has increased. Because the catch is approaching the maximum available in a given year, further increases in effort must, inherently, decrease CPUE. When the data becomes available, the estimate of expected harvest may be reduced if CPUE is declining. The Council will closely monitor the fishery to establish the reliability of these estimates.

5.3.2 Expected DAH of Royal Red Shrimp

Royal red shrimp deserve special attention because these deep-water shrimp were subject to a directed fishery. Available data indicated they were underexploited.

In this case annual catch was regressed against year by simple linear regression. The relationship implies that as time progresses, catch will increase. This has some validity in that

- catch has tended to increase with time (1963-1976);
- the major shrimp resources of the Gulf are being harvested at levels approximating MSY; and
- there has been a general increase in effort in the U.S. Gulf shrimp fishery despite the fact that the major stocks are being harvested at levels approximating MSY.

A simple linear increase is not expected to continue as catch of this limited resource approaches its MSY. The relationship derived is

$$\text{DAH of royal red shrimp} = -890 + 14.2\ (\text{year}) \qquad \text{Eq. 5.3-4}$$

$$(R^2 = .41,\ \text{H.S.})$$

where year is in the form 63, 64, etc. The expected domestic annual harvest of royal red shrimp is 260,000 pounds. Eq. 5.3-4 is considered a crude estimator and should be reevaluated as new data are available.

5.4 Domestic Annual Processing Capacity (DAP)

Cato (1975) reported that 1970 shrimp landings in Louisiana, Texas, Alabama, Mississippi, and Florida represented 97, 84, 76, 57, and 35 percent respectively of the raw shrimp processed in each state. There have been no subsequent studies to identify more recent conditions. If similar figures apply after 1970, then the capacity to process domestic landings exceeds domestic landings. The deficit is overcome with shrimp imported from other states and foreign nations.

A 1972 (Alvarez) survey of fifteen Florida shrimp processors who accounted for 85 percent of the state's production revealed that the industry was utilizing only 55 percent of total plant capacity. This poor utilization of plant capacity occurred despite the use of significant imports from other states and countries. On the average, firms in the "small" class used more of their capacity than did firms in the "medium" and "large" classes. The same relationship held true between the "medium" class and the "large" class. A shortage of raw shrimp for processing was responsible for the excess capacity.

Prochaska and Andrew (1974) point out that the entire southeast is deficient in raw shrimp supplies in comparison with processing capacity. A detailed analysis of the situation in Florida reveals that shortages of raw shrimp result in an increasing share of processed shrimp being produced by a few firms.

While excess capacity is frequently found in an industry, the available information here clearly leads to the conclusion that Gulf shrimp processing capacity is far in excess of the region's domestic landings.

The Florida studies adequately addressed shrimp processing functions similar to those in most Gulf states. However, the absence of information on shrimp canning operations means that the results cannot completely describe the major Gulf shrimp canning industry. Capacity measures for the canning industry located in Louisiana and Mississippi were developed from key machinery capacities and a specified number of operating days per year; the production year was based on 147 operating days during the approximate 180 days of the inshore seasons. Average daily plant capacity was estimated to be 4,400 standard cases containing 24 cans, each four and one-half ounces. When these figures are applied to the 14 shrimp canners reporting production in 1978, a maximum capacity of 9,055,20 standard cases is derived. In the three most recent years Gulf shrimp canners produced 1,618,322 (1976), 2,104,625 (1977), and 1,464,722 (1978) standard cases (U.S. Department of Commerce 1979). Excess capacity in shrimp canning operations exists for a number of reasons, among which are the necessity of designing plants to handle peak volumes of fresh shrimp, recent high ex-vessel prices, and cash-flow problems related to the difficulty of financing inventories.

5.5 Additions to DAH to Account for Joint Ventures

The domestic market for shrimp and shrimp products has been sufficiently strong historically to attract significant quantities of imported shrimp. The economic climate has been such that no incentive exists for the transfer at sea of U.S. shrimp caught in the FCZ to flag vessels of other nations. In fact, domestically based shrimpers have sought harvesting arrangements in foreign waters to secure increased supplies of shrimp. The catch by U.S. flag vessels off Central and South America was reported to be 14 million pounds annually worth about $18 million (G.A.O., 1976). However, there is information available which indicates that the practice as relates to Mexican waters decreased significantly between 1962 and 1974 (Griffin, 1976).

The shrimping activities of foreign nations in the FCZ have been quite limited. From 1971 to 1975 harvest by Cuba and Mexico in the FCZ averaged slightly more than one million pounds (G.A.O., 1976). Thus, there has been little spatial interaction in the FCZ between major shrimp harvesting nations on which a transfer business could be based.

The lack of historical occurrence of the transfer of shrimp to foreign vessels and a domestic market strong enough to attract approximately 50 percent (Sec. 3.5.1.3) of domestic needs from imported shrimp lead to the conclusion that transfers are unlikely to occur. The market conditions are such that this conclusion should have merit over the next five years. While this conclusion relates to shrimp it is possible that the transfer of incidental catch could be arranged. The domestic market condition for the bulk of the incidental catch is essentially the antithesis of that for shrimp. Transfer of some or all of the incidental catch of cooperating vessels to foreign vessels may become an avenue to improve the utilization of incidental catch.

6.0 OPTIMUM YIELD

A program of improved management as specified in this plan is expected to increase the yield from the fishery which is not operating at optimum harvest levels. Basic factors limiting the attainment of optimum harvest include:

1) Conflict between user groups as to area and size of shrimp to be harvested.

2) Discarding of shrimp through the wasteful process of culling.

3) Continuing decline in quality and quantity of estuarine habitat.

4) Lack of comprehensive, coordinated, and easily ascertainable management authorities over shrimp resources throughout their ranges.

5) Conflicts with other fisheries such as the stone crab fishery in southern Florida, groundfish fishery in the north central Gulf, and the Gulf's reef fish fishery.

6) Incidental capture of sea turtles.

7) Loss of gear and trawling grounds due to man-made underwater obstructions.

8) Partial lack of the basic data needed for management.

Specific objectives and measures to alleviate these problems and to attain OY levels are suggested in Section 8.0. None of these measures are likely to result in a reduction in present catch levels; some are likely to increase yield in a manner consistent with the National Standards for Fishery Conservation and Management.

6.1 Determination of Optimum Yield (OY)

Optimum yield is defined as "the amount of fish

(A) which will provide the greatest overall benefit to the nation, with particular reference to food production and recreational opportunities; and

(B) which is prescribed as such on the basis of the maximum sustainable yield from such fishery, as modified by any relevant economic, social, or ecological factor."

It is the intent of this plan in conformance with the first of the national standards to prevent overfishing while achieving, on a continuing basis, the optimum yield. The shrimp fishery, however, is unique for several reasons. Most shrimp harvested are about six months old, and few survive beyond a year. They are prolific spawners, and the quantity of one year's brood stock has no apparent relationship to the abundance of the next year's population.

Natural environmental forces have a dramatic and overriding effect on the annual yields of brown, white, and pink shrimp (Section 4.1). Because of their great fluctuation and the high spawning ability of shrimp, a predetermined classical MSY is not a good indicator to use in determining if overfishing will occur. For example, the classical MSY levels were exceeded in four years from 1966 to 1975, years of favorable environmental conditions.

For these species of shrimp the optimum yield essentially is all of the shrimp that can be harvested from the stock given certain management conditions. Recruitment overfishing has not and will not occur with the use of present technology and fishing gear. Management measures proposed in Section 8 are intended to prevent growth overfishing where it may presently occur, thus achieving a higher yield from a same level of recruitment.

For the purpose of this plan OY should be regarded as a goal to be achieved and exceeded under favorable environmental conditions without fear of damage to future stocks. It should not be considered to be a ceiling above which recruitment overfishing occurs.

6.2 Specification of Optimum Yield

In deriving OY from MSY as adjusted by environmental conditions, the Council paid close attention to the following criteria:

1. Provide each associated processing industry with the count size of the shrimp resource most suited to the several needs.

2. Prevent discrimination among fishermen based on boat/vessel size.

3. Eliminate conditions wherein boat/vessels would shrimp in the FCZ and claim the landings came from the territorial sea for inland waters and vice versa, depending on location of open and/or closed waters.

4. Protect the resource during specific periods to improve yield.

6.2.1 Shrimp Other Than Royal Red Shrimp

OY is determined to be: All the shrimp that can be taken during open seasons in permissible areas in a given fishing year with existing gear and technology. The Council has determined that, because of the annual nature of the resource, a numerical value for OY cannot be calculated for any given year until the environmental factors can be determined and evaluated. However, under optimum environmental conditions and maximum effort, the maximum probable catch for brown, white and pink shrimp is estimated to be 216 million pounds of tails. Fishing, however, will not be stopped when this numerical estimate is reached.

The Council has also determined that adjustments to OY need not be made yearly as economic, biological, and technological factors prevent the taking of sufficient shrimp during a single year to harm the next year's resource size. The Council will monitor closely the appropriate factors of the management regime established by the plan and, in particular, the environmental factors surrounding the determination of MSY. Should conditions warrant, the Council will provide the information to the Secretary of Commerce and a new MSY/OY relationship will be established through rule making.

6.2.2 Royal Red Shrimp

Royal red shrimp differ from brown, white, and pink shrimp in that they are not estuarine dependent but exist in a relatively constant environment in the deeper waters of the Gulf (100 to 300 fathoms). They are not an annual crop but are harvested from grounds believed to contain at least five year classes. Thus, they conform more closely to a classical Schaefer-type fishery. For this reason, the optimum yield of royal red shrimp should be the total pounds of royal red shrimp which can be harvested without biologically overfishing this resource. An estimate of the allowable catch is 392,000 pounds (tails). These figures should be reassessed as new annual catch-effort data become available. OY is set at this figure and fishing will stop when it is reached.

6.3 Alternatives to Optimum Yield Considered and Rejected

6.3.1 Optimum Yield for Brown, White, and Pink Shrimp to be Set at MSY

Setting OY for these three species at MSY or 165 million pounds of tails annually would have reduced the 1977 catch by 27 million pounds. Because this fishery can support a yield of all that can be harvested with present gear and technology, setting a lower level of harvest would result in a wasted resource in an annual crop. The loss of 27 million pounds of shrimp at 1976 wholesale prices would have resulted in a loss of $75.3 million to the industry. No benefit from stockpiled shrimp nor an increased number of recruits the following season would result from taking less than is available.

6.3.2 Fishing to Stop When Optimum Yield is Reached for Brown, White, and Pink Shrimp

The intent of the first National Standard is to achieve OY while preventing overfishing the stocks. If the stocks cannot be overfished, any reduction of catch from the available, harvestable stock is a direct loss to the fishing industry.

6.3.3 Optimum Yield for Royal Red Shrimp to be Set Above MSY

The fishery for royal red shrimp differs substantially from that for brown, white and pink shrimp. It is composed of a slower growing species with up to five year classes in the catch. Little is known about the population dynamics of royal red shrimp, and recruitment overfishing may be possible. The establishment of OY above MSY could result in overfishing and stock damage.

6.3.4 Optimum Yield for Royal Red Shrimp to be Set at MSY With Fishing to be Permitted to Exceed OY

Exceeding the catch of OY equal to MSY (as in alternative 6.3.3) could result in biological overfishing. This alternative was rejected for a more conservative approach in an area of limited data.

6.3.5 Optimum Yield for Royal Red Shrimp to be Set Below MSY

This alternative for a multiyear class fishery would have the result of rebuilding the stock. Royal red shrimp have, however, been fished well below MSY and may be considered to be an underutilized resource. No rebuilding is necessary at this time.

6.3.6 Optimum Yield Set at Higher Estimate of ABC

An expected range of the seasonally determined estimates for Acceptable Biological Catch when the upper range of variation in catch data was considered as an ABC for each fishery; the following ranges were proposed:

brown shrimp--51 to 107 million pounds of tails annually.

white shrimp--37 to 59 million pounds of tails annually.

pink shrimp--11 to 16 million pounds of tails annually.

The Council considered determining that OY for these species should be at the upper level of the expected ABC ranges:

brown shrimp--107 million pounds of tails annually.

white shrimp--59 million pounds of tails annually.

pink shrimp--16 million pounds of tails annually.

for a total of 182 million pounds of tails annually. This option was rejected for two reasons. It was based only on past recorded landings with little basis in the biology of the stocks. This OY can be and has been (1977, 1978) exceeded when environmental conditions are favorable and effort is high. There is no evidence that exceeding this OY option had an adverse impact on recruitment in subsequent years.

7.0 TOTAL ALLOWABLE LEVEL OF FOREIGN FISHING (TALFF)

7.1 Brown, White, and Pink Shrimp

There is no surplus available for a TALFF in the fisheries for brown, white, and pink shrimp. Domestic Annual Harvesting Capacity for brown, white and pink shrimp is estimated to be 234 million pounds in 1980 and 240 million pounds in 1981. Expected Domestic Annual Harvest for 1980 and 1981 is estimated at 211 and 218 million pounds of tails; OY is designated to be all the shrimp that can be harvested in allowable times and areas under present conditions. Major stocks are currently being harvested at optimum yield levels by the U.S. shrimp fleet.

7.2 Royal Red Shrimp

It is generally believed that royal red shrimp are not being harvested at their OY level of 392,000 pounds of tails annually. Annual reported commercial catch has never exceeded 270,000 pounds of tails (1963-1975); expected domestic harvest for 1980 and 1981 are 246,000 and 260,000 pounds of tails. A foreign TALFF of some 146,000 pounds in 1980 and 132,000 pounds in 1981 is, therefore, estimated to be available. Catch trends should be reinvestigated, however, as new data become available.

Further domestic development of this fishery is hampered by the great depth at which the resource exists and the specialized gear required to fish it, high production costs, and shrinkage of the product during processing.

7.3 Seabob and Rock Shrimp

Data available on seabob and rock shrimp indicate that

- o they are caught incidentally to other shrimp--seabob shrimp mainly with white shrimp and rock shrimp with pink shrimp;
- o they are not being harvested at MSY levels (1963-1976);
- o the catch has increased markedly in recent years (1971-1976).

Seabobs and rock shrimp are caught incidentally with white and pink shrimp respectively. There is no surplus of white and pink shrimp from the domestic fishery available for foreign fishing. Therefore, in order to prevent foreign harvest of nonsurplus species, no TALFF for seabobs or rock shrimp is provided.

8.0 MANAGEMENT REGIME

8.1 Areas and Stocks Involved

The fishery being addressed is comprised of the species listed below and occurs in the area of jurisdiction of the Gulf of Mexico Fishery Management Council as well as in the territorial seas adjacent thereto and the associated bays, inlets, wetlands, and upland areas as appropriate:

Brown shrimp (*Penaeus aztecus* Ives)	
White shrimp (*Penaeus setiferus* Linnaeus)	
Pink shrimp (*Penaeus duorarum* Burkenroad)	
Royal red shrimp (*Hymenopenaeus robustus* Smith)	
Seabobs (*Xiphopeneus kroyeri* Heller)	Incidental bycatch
Rock shrimp (*Sicyonia brevirostris* Stimpton)	Incidental bycatch

The Council recognizes that the stock and the fishery extend across political and international boundaries. While it is the intent to manage the stock as a unit, the authority of the Council is restricted to the development of plans and proposal of management measures in the United States' FCZ in the Gulf of Mexico.

An arrangement for joint management of common stocks with Mexico would require a bilateral agreement. Negotiations with Mexico to renew the U.S./Mexico bilateral are underway; however, a mechanism for joint management does not seem likely for the near future. With the present lack of such an international management mechanism this plan addresses only the stock in U.S. waters and makes the assumption that shrimp movement across the border flows equally in both directions.

8.2 Management Unit and Period

8.2.1 Management Unit

This management unit is comprised of brown, white, pink, royal red, seabobs and rock shrimps in the area of jurisdiction of the Gulf of Mexico Fishery Management Council as well as the territorial seas adjacent thereto and the associated bays, inlets, wetlands and upland areas as appropriate. Federal implementation of regulations will occur only in the FCZ. On the east coast of the United States a natural biological break in fauna is found on the southeast coast of Florida. On the western edge the international boundary between Mexico and the U.S. serves as a political break.

8.2.2 Management Period

The Council has specified that the management year for all species except royal red should begin May 1 and extend through April 30 annually. The beginning of the period coincides with a time of low harvest in all of the major species of the management unit. The fishery year for royal red shrimp will be the calendar year because of the TALFF associated with the fishery.

8.3 Problems in the Fishery

The Council has identified the following problems associated with the fishery and the present management regime and has prepared the plan objectives to address and alleviate them. In a free access fishery a management regime to maximize protein yield and economic return of the fisherman is of importance.

1) Conflict among user groups as to area and size at which shrimp are to be harvested.

2) Discard of shrimp through the wasteful practice of culling.

3) The continuing decline in the quality and quantity of estuarine and associated inland habitats.

4) Lack of comprehensive, coordinated and easily ascertainable management authorities over shrimp resources throughout their ranges.

5) Conflicts with other fisheries such as the stone crab fishery in southern Florida, the groundfish fishery of the north central Gulf, and the Gulf's reef fish fishery.

6) Incidental capture of sea turtles.

7) Loss of gear and trawling grounds due to man-made underwater obstructions.

8) Partial lack of basic data needed for management.

8.4 Objectives

8.4.1 Specific Management Objectives

The following are the specific management objectives of this plan and are proposed to the appropriate authorities in charge of Gulf of Mexico shrimp resources. These objectives are to:

1) Optimize the yield from shrimp recruited to the fishery.

2) Encourage habitat protection measures to prevent undue loss of shrimp habitat.

3) Coordinate the development of shrimp management measures by the Gulf of Mexico Fishery Management Council with the shrimp management programs of the several states, where feasible.

4) Promote consistency with the Endangered Species Act and Marine Mammal Protection Act.

5) Minimize the incidental capture of finfish by shrimpers, when appropriate.

6) Minimize conflicts between shrimp and stone crab fishermen.

7) Minimize adverse effects of underwater obstructions to shrimp trawling.

8) Provide for a statistical reporting system.

8.4.2 Alternative Objectives

Alternative management objectives were considered by the Council and rejected for the reasons indicated:

Alternative 1.

Establish the preferred size at which shrimp will be harvested. In establishing this size provide a reasonable accommodation for the conflicting interests of the various groups which concurrently compete for the shrimp resources in order to prevent the economic dislocation of particular groups as a result of measures adopted.

Rationale: The Council did not establish one preferred size for harvest because, based on economic and sociological factors, this size varies regionally. The variation is due to the local vessel size composition of the fleet and prevailing methods of processing shrimp. The establishment of one preferred size throughout the Gulf and the regulation of catch to that size would have severely disrupted the economy and work force of those areas where the fishery is directed to a different size.

Alternative 2.

Define and restrict shrimping in areas where preferred size shrimp are not normally taken on a seasonal or yearly basis.

Rationale: This alternative was rejected as a specific management objective because its scope was narrow. Its goal is included under the selected objective number 1.

Alternative 3.

Minimize the incidental catch and the adverse effects of the incidental catch of sea turtles by shrimpers.

Rationale: The wording of this alternative was revised to become objective number 4.

Alternative 4.

Establish a preferred level of capitalization.

Rationale: There is no economic evidence to suggest that the shrimp fishery differs from the classic example of a fishery near open access equilibrium. (Open access equilibrium refers to firms having free access to the fishery, generating just enough revenue to cover total costs over a long period of time, and entering or exiting the fishery in the short run with prevailing economic conditions.) Reductions in fishing effort are unlikely to result in anything other than small decreases in shrimp landings and a loss of jobs to fishermen and shore support personnel.

Alternative 5.

Insure continuance of the resource.

Rationale: Objective number 1 includes this option. Recruitment overfishing is not a problem in this fishery.

8.5 Management Measures and Rationale

8.5.1 Management Measures Considered and Adopted

Management measures considered by the Gulf of Mexico Fishery Management Council and suggested for incorporation into a shrimp management plan are discussed below. Some of these management measures are recommended for federal implementation by the U.S. Department of Commerce. Other measures are either administrative policies adopted by the GMFMC or are recommended for consideration by the various states and other agencies. Other measures considered, but not recommended, are documented in Section 8.5.2 and in the notes of the various meetings conducted to develop and evaluate the draft plan. The recommended measures are grouped with the objective addressed.

8.5.1.1 Objective 1: Optimize the Yield of Shrimp Recruited to the Fishery

Measure 1: Establish a cooperative permanent closure in conjunction with the State of Florida and the U.S. Department of Commerce of the area delineated in Table 8.5-1 to protect small pink shrimp until they have generally reached a size larger than 69 tails to the pound. The area to be closed is to be denoted as the "Tortugas Shrimp Sanctuary" and is generally represented by the line drawn in Figure 8.3-1.

The historic Tortugas Shrimp Sanctuary as established by the State of Florida has been modified slightly as the result of public hearings to reduce its size. This modification will allow shrimping in some deeper areas containing larger shrimp north of Smith and New Ground Shoals north of Key West.

The U.S. Department of Commerce will close that portion of the FCZ within the area defined as the Tortugas Shrimp Sanctuary to all shrimping. All shrimp which are caught in open waters of the FCZ may be retained. In 1981 Florida amended its shrimp regulations to allow the landing of shrimp of any size taken outside Florida waters.

NMFS will monitor biological, economic, ecological, and sociological data collected through implementation of the plan and provided by other surveys and research. NMFS will annually assess both the adverse impacts and benefits derived from closure of the sanctuary in the FCZ and advise the Regional Director and Council of the findings by July 15 of each year. The Council may utilize its Scientific and Statistical Committee and Advisory Panel to review and advise on the findings.

The Regional Director shall have the authority, after consultation with the Council, to implement action to revise this management measure through the Regulatory Amendment process. Criteria to be considered in reaching the decision to amend the regulations include:

1. Benefits in increased pounds of shrimp caught and/or dollars derived resulting from the closure.

2. Adverse effects from an increase in fishing pressure in other areas as a result of the closure which causes a decrease in catch per unit of effort.

3. Identification of areas (a) within the sanctuary containing an abundance of shrimp of harvestable size, or (b) outside the sanctuary containing shrimp populations too small for harvest.

4. Adverse effects from stress on support facilities for the shrimp fleet because of fleet migration resulting from the closure.

5. Any other information determined by the Regional Director to be relevant.

The Regional Director may, after determining that benefits may be increased or adverse impacts be decreased, take either of the following actions to achieve the goals and objectives of the Shrimp Fishery Management Plan consistent with the National Standards and other applicable federal laws. The first action is considered to be less drastic and may be employed where a lesser degree of change is required.

1. Modify by no more than ten percent the geographical scope of the extent of the Tortugas Shrimp Sanctuary in the FCZ of the Gulf of Mexico south of latitude 26° North.

2. Eliminate the closure of the FCZ off Florida for one season.

Table 8.5-1. Delineation of suggested Tortugas Shrimp Sanctuary

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The Tortugas Shrimp Sanctuary is described as follows:

That part of the fishery conservation zone shoreward of the following line (see Figure 8.5-1):

Begin at the intersection of the Florida territorial sea with a line drawn between point N (Coon Key Light, 25° 52.9' north latitude, 81° 37.95' west longitude) and point F (24° 50.7' north latitude, 81° 51.3' west longitude); thence proceed on a straight line to point F; thence proceed on a straight line to point G (New Grounds Shoals Light, 24° 40.1' north latitude, 82° 26.7' west longitude); thence proceed on a straight line to point H (Rebecca Shoals Light, 24° 34.7' north latitude, 82° 35.1' west longitude); thence proceed on a straight line to the intersection of the Florida territorial sea with a line drawn from point H to point P (Marquesas Keys, 24° 35' north latitude, 82° 08' west longitude).

The Regional Director shall by August 15th of that year publish in the Federal Register his intent to take action as provided in 1 and 2 above or not to take action.

If the proposed action is believed to be a substantial federal action likely to have a significant effect on the human environment, a supplemental environmental impact statement and regulatory impact analysis shall be prepared. The Regional Director may hold public hearings on the proposed action.

The State of Florida is encouraged to continue its present restrictions on shrimping in the area and to continue to allow the retention of all shrimp which are caught in open waters of the FCZ, as well as establishing a sampling program to evaluate the effectiveness of the closed area.

Rationale: This measure would essentially re-establish most of the old Tortugas shrimp nursery area which until recently has served as a sanctuary for pink shrimp recruited to the Tortugas and Sanibel shrimping grounds. (The area within the FCZ can currently be shrimped by non-Floridians because Florida does not have jurisdiction.) Currently, the minimum legal size in Florida is 70 tails to the pound. No more than five percent of the catch can be of smaller-sized shrimp.

This proposal is based on available biological data and on the fact that a mature fishery appears to be dependent on it. Lindner (1966) and Berry (1970) report growth and mortality data which indicate that pink shrimp yield will be maximized if harvest begins after shrimp reach a size of about 70 tails to the pound.

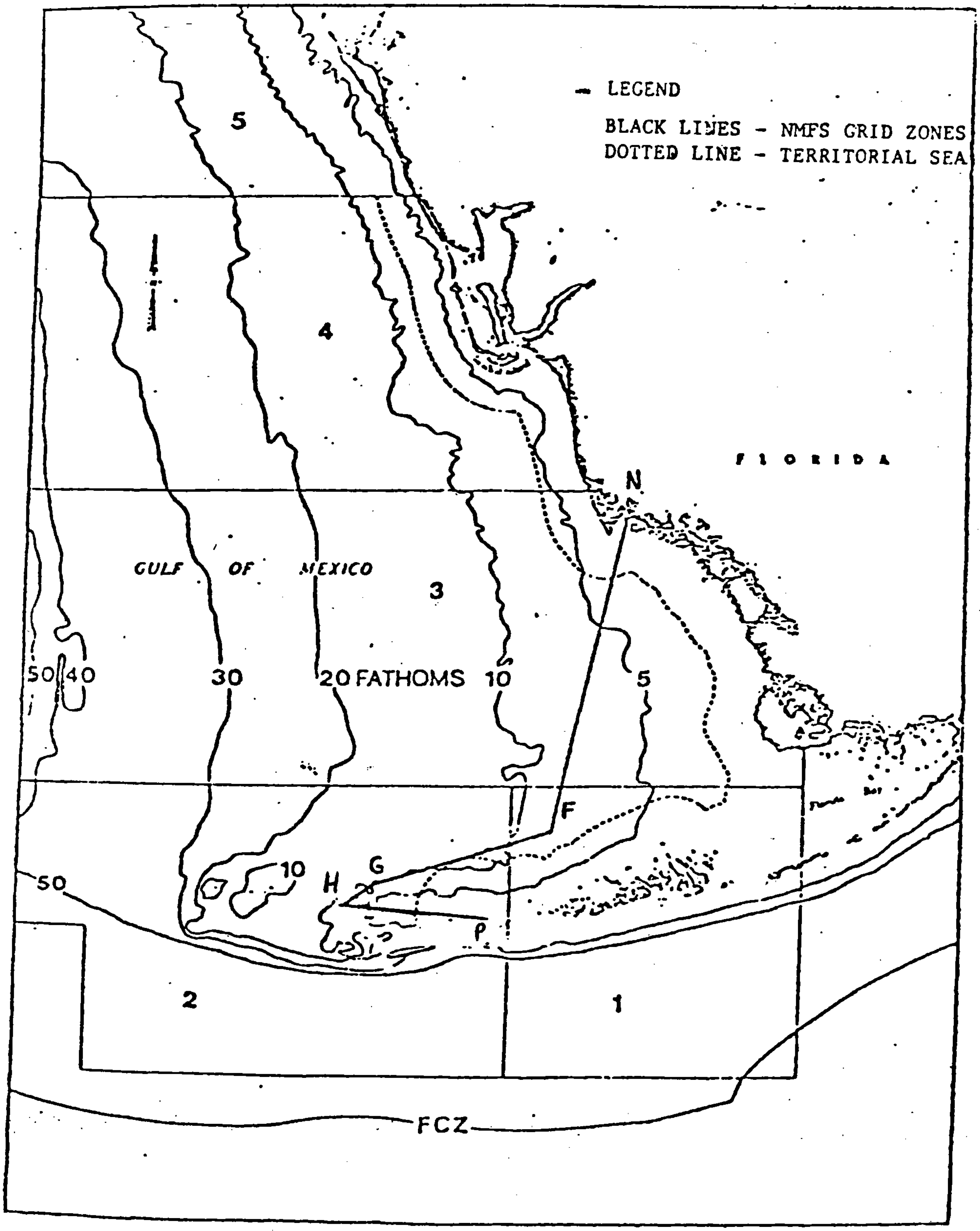

Figure 8.5-1. Location of proposed Tortugas Shrimp Sanctuary. Between line N F G H P and the territorial sea.

Table 8.5-2. Expected average weight of male and female pink shrimp in the Dry Tortugas area as a function of depth[1].

Depth	Shrimp Weight: Males (heads-on)	Shrimp Weight: Females (heads-on)	Count[2] of a 1.1 mixture males to females
fm	g	g	tails per pound
7	6.6	9.8	89
8	7.1	10.8	81
9	7.7	11.8	74
10	8.3	12.9	68
11	9.0	14.0	63
12	9.6	15.2	58
13	10.3	16.5	54
14	11.1	17.8	50
15	11.9	19.3	47

1 Expected average weight was calculated from carapace length-depth relationships derived by Iversen et al. (1960) (See Eq. 4.1-1, 4.1-2) and the carapace length-weight relationships of Mc Coy (1972) (See Table 4.1-3). The formulas used are:

Males: $W = 0.00148 \; (16.394 + 0.618\,D)2.77$

Females: $W = 0.00209 \; (17.914 + 0.868\,D)2.66$

where W is weight of shrimp in grams and D is depth in fathoms.

2 Currently the minimum legal size in Florida for shrimp caught in state waters is 70 tails to the pound which cannot exceed five percent of the catch. the table estimates that at a given depth the entire catch will average a given count. It does not denote the depth at which the minimum legal size mix currently in effect in Florida will occur.

Costello and Allen (1965) summarized extensive sampling and mark and recapture data which indicate that estuaries within the Tortugas Shrimp Sanctuary are important nursery areas for post-larval and juvenile pink shrimp eventually recruited to the Tortugas and Sanibel beds. Yokel, et al. (1969) observed that the average shrimp leaving the Everglades nursery area is in the 300 to 200 tails to the pound range. Iversen, et al. (1960), sampling extensively in the southern portion of the Tortugas Shrimp Sanctuary area and in the southern portion of the Tortugas shrimping grounds, observed a relationship between size of shrimp and depth of water.

Table 8.5-2 was constructed using these observed relationships and McCoy's (1972) carapace length-weight relationships. The table indicates that at 10 fathoms shrimp will average 68 tails to the pound, and at 13 fathoms they will average 54 tails to the pound. Essentially, none of the proposed sanctuary area is deeper than 13 fathoms, and most of it is shallower than ten fathoms. Thus the closure should protect shrimp until they have reached an average count of around 70 tails to the pound. However, given the variation in size of shrimp according to depth reported in Iversen, et al. (1960), it does not seem likely that the sanctuary will protect shrimp until they have reached a size of no more than five percent of the catch consisting of shrimp 70 or more tails to the pound. For example, Table 8.5-2 indicates that at 13 fathoms the catch will average around 54 tails to the pound. A spot check of the reported commercial catch (U.S. Department of Commerce, Gulf Coast Shrimp Data, Annual Summaries for 1972 and 1974) shows that catch in the 11 to 15 fathom interval of the Dry Tortugas does have a peak in the 51 to 57 tails to the pound range. However, although considerable pounds of shrimp larger than this count were reported, only minor quantities of smaller shrimp were reported as landed. This apparent discrepancy in size distribution may relate to a possible discard of large quantities of undersized pink shrimp.

Florida law presently prohibits all shrimping (except for live bait fishing under permit) in its nine-mile territorial sea within the sanctuary (Figure 8.3-1). Florida prohibited Florida vessels from shrimping in the sanctuary beyond its territorial sea. Thus, the vessels displaced by this measure were non-Florida vessels fishing the sanctuary beyond the territorial sea and Florida vessels that fished the area contrary to state law. No estimates on the number of these vessels is available.

No special provision is made for live bait shrimping in the sanctuary in the FCZ because none is presently conducted there. It is limited to the nearshore waters of the territorial sea.

No allocation or redistribution among user groups is expected to result from this action.

Although the Dry Tortugas shrimp nursery area has been defined by the best available data, at times pink shrimp smaller than the size preferred for local harvest may be taken beyond the closed area. Similarly, large shrimp may also be found within the nursery area. The present delineation provides for the best conservation and use of the resource according to known information, but the Council recognizes the need for better data and recommends a program of sampling in order to identify more precisely the actual range of small shrimp in this area. When the area can be better defined, it can be adjusted accordingly.

Although the concept and rationale for the sanctuary was well established by Costello, Allen, Iversen, and Yokel in the 1960s, more recent researchers have attempted to evaluate variations of the extent of the closure both by area and time. Grant, et al. (1980), Blomo (1979), Khilmani and Tse (1980), and Costello, et al., estimated effects of these variations.

Grant, Isakson and Griffin (1980) evaluated the closing of the Tortugas shrimp sanctuary. The basic model used was developed at Texas A&M University by Grant and Griffin (in press) and is called the general bioeconomic fishery simulation model (GBFSM). The analysis characterizes the fishery as having two depths (0-10 and 11 fathoms and greater), four size classes of shrimp and NMFS statistical areas 1-3 as the study area. In a previous study (Blomo, 1979), Florida shrimp prices were shown to have varied negligibly with changes in Florida landings; therefore, prices in the model remained constant.

The model allowed five important biological variables to vary randomly. These variables were rate of recruitment, natural mortality, growth, movement from depth 1 to depth 2 and the proportion of organisms harvested during one real day fished. Simulations were run on two specific options of (1) the baseline situation during 1963-1975 of the traditional nursery area in depth 1 closed year-round, and (2) depth 1 open May through October. The model allows policy options to be tested for significant differences from the baseline situation.

Since the baseline situation reflects the traditional Tortugas (closed) nursery area, deviations from the baseline will indicate the effectiveness of the permanent closure. Opening the nursery grounds from May through October results in the harvest of significantly more biomass of shrimp in the two smallest legal size classes from depth 1 but has a negligible effect on the harvest from depth 2. Total harvest, revenue and rent (profit) were all greater than the baseline but within ten percent (Table 8.5-3).

Blomo (1979) also evaluated the Tortugas Shrimp Sanctuary in conjunction with the stone crab-shrimp separation line (Measure 9) by using the GBFSM cited above. As in Grant, et al. (1980), the baseline situation reflects the traditional fishery during 1963-1975 with a permanently closed nursery area. This study included NMFS statistical areas 1-5, three depth levels in fathoms (1-5, 6-10 and 11 and greater) and three size classes of shrimp by tail count (51-70/pound, 31-50/pound and under 30 per pound). A regional demand model by size class of shrimp was included.

Although the study analyzed an early version of Measure 1 which was combined with Measure 9, it does point out the effectiveness of the permanent closure when deviations are made from it. The first deviation was opening the nursery area year-round as a result of several court cases testing Florida's jurisdiction (U.S. v. Florida; Allen et al. v. Tingley; Tingley v. Allen et al.). An open fishery resulted in slightly greater landings, lower prices and greater revenue and rent for harvesters Table (8.5-4). The second deviation was the institution of a seasonal closure of the nursery area in conjunction with the stone crab-shrimp separation line. Here the results in terms of landings, prices, revenue and rent lie between the baseline and the open fishery case. In both deviations, there was a greater percentage of smaller shrimp in the landings.

Khilmani and Tse (1980) used the Fisheries System Management Model (FISYS) developed at Stanford University to evaluate closure of the Tortugas Shrimp Sanctuary. This study analyzed two grounds by fathom levels (up to nine and ten and greater), and two sizes of shrimp by tails to the pound (72 to 35, and under 35). The study evaluated the fishery over a six-month period (peak activity) by modeling separately the fall and winter months. The study's results are influenced by a demand model wherein prices are affected by Florida landings; the effect of shrimp landings elsewhere in the Gulf was not considered. Three different closures of the shallower grounds are evaluated: a six-month closure (November-April) and two closures of a three-month duration (November-January and February-April), none of which conform to the management measure as proposed and implemented.

In all three closures landings decrease but at magnitudes no more than 150,000 pounds (Table 8.5-5). Decreased supplies increase consumer prices in two cases and harvester revenue increases in two cases due to reduction of operating costs. In a sensitivity analysis of the basic model when the catchability coefficient of shrimp by the fleet in the shallower ground was greatly reduced, the catch in the offshore ground increased by almost three million pounds. Decreasing the catchability coefficient is analogous to closing the shallower ground as this management measure actually does.

In another review of the Tortugas nursery area, Costello, Raulerson and Lyons (NMFS, personal communication) indicated that total shrimp landings would increase by one million pounds. In addition the average size of shrimp landed would increase, thus increasing the per unit value of the increase in landings as well as the protein yield of the managed fishery. The total exvessel value of the increased landings would increase by $2.78 million, using a price of $2.78 per pound (first quarter 1980, eastern Gulf ports for 41-50 count shrimp). The contribution of these increased landings to the nation's Gross National Product would be $9.4 million based on the regional multiplier of 3.37 for south Florida (U.S. Water Resources Council, 1977) for fresh or frozen packaged fish.

In all of these estimates, the variation in the biological parameters which would influence changes in catch is quite large. However, all the studies indicate increased size of shrimp caught (more weight per individual), greater harvester revenue and profit, decreased operating costs and increased vessel efficiency. It should be noted that the economic impacts described are for the first year only. Where industry experiences profits over the baseline, these cannot be maintained. Under open access common property resources, additional vessels will move into the shrimp fishery until first round excess profits are dissipated. The industry will become more capitalized unless some mechanism for removing excess profits or effort is applied.

Table 8.5-3. Harvest of pink shrimp and associated revenue and rent to the fishery predicted under the baseling situation and two management policies.

Item	Baseline Situation	Lower Size Count to 90 Heads Off	Open Nursery Grounds May-Oct.
Total Harvest (metric tons)	5,551	6,678	5,989
(Percent difference)		(21)	(9)
Total Revenue (million dollars)	33.1	37.1	35.1
(Percent difference)		(12)	(6)
Total Rent (million dollars)	13.0	15.6	14.2
(Percent difference)		(20)	(9)

Source: Grant, Isakson and Griffin (1980)

Table 8.5-4. Changes in producers and consumer surplus for selected management alternatives for the pink shrimp fishery, Statistical Areas 1-5.

Option	Change in				
	Price	Quantity	Consumer[1] Surplus	Producer Surplus	Net Surplus
	$/lb.	Mil.lbs.	Mil. $		
Fishery open[2] year round	-0.12	1.6	1.43	0.9	2.33
(Percent difference)	(5.8)	(14.4)			
1-8Fms closed[2] Jan 1 - Apr 15	-0.09	1.4	1.06	1.00	2.06
(Percent difference)	(4.0)	(12.6)			

1 A slope of -1 was assumed for the demand curve. Therefore, in computing the change in consumer surplus the change in price was multiplied by the average of the quantity consumer under the alternative and the quantity consumed under the original situation.

2 Compared with baseline simulation.

Source: Blomo (1979).

Table 8.5-5. Changes in net revenue and consumer surplus for selected management alternatives for the pink shrimp fishery.

Item	Close Ground 1		
	November - April	November - January	February - April
Change in Price (dollars per pound)	0.43	-0.07	0.30
Change in Processor Consumption (10^6 kg)	-0.15	-0.03	-0.12
Change in Net Revenue/Vessel (dollars)	6,887	-838	5,396
Change in Consumer Surplus (10^6 dollars)	-2.28	0.38	-1.78

Source: Khilmani and Tse (1980)

Measure 2: Establish a cooperative closure of the territorial sea of Texas and the adjacent U.S. FCZ with the State of Texas and the U.S. Department of Commerce during the time when a substantial portion of the brown shrimp in these waters weigh less than a count of 65 tails to the pound (39 heads-on shrimp to the pound). The U.S. Department of Commerce will close the FCZ, and the time of closing should correspond to the closure by Texas of its territorial sea. Closure normally occurs June 1 to July 15; however, the effects of climatic variation on shrimp growth may necessitate flexibility in the closing and opening dates to provide for a closure of no more than 60 days. Provision is to be made to allow taking of royal red shrimp beyond the 100 fathom contour (where brown shrimp do not occur).

NMFS will monitor biological, economic, ecological, and sociological data collected through implementation of the plan and provided by other surveys and research. NMFS will assess both the adverse impacts and benefits derived from the seasonal closure in the FCZ and advise the Regional Director and the Council of the findings by December 1. The Council may use its Scientific and Statistical Committee and Advisory Panel to review and advise on the findings.

The Regional Director shall have the authority, after consultation with the Council, to implement action to revise this management measure through the Regulatory Amendment process. Criteria to be considered in reaching the decision to amend the regulations include:

1. Benefits in increased pounds of shrimp caught and/or dollars derived resulting from the closure.

2. Adverse effects from an increase in fishing pressure in other areas as a result of the closure which causes a decrease in catch per unit of effort.

3. Adverse effects from stress on support facilities for the shrimp fleet in other areas because of fleet migration resulting from the closure.

4. Any other information determined by the Regional Director to be relevant.

The Regional Director may, after determining that benefits may be increased or adverse impacts be decreased, take either of the following actions to achieve the goals and objectives of the Shrimp Fishery Management Plan consistent with the National Standards and other applicable federal laws. The first action is considered to be less drastic and may be employed where a lesser degree of change is required.

1. Modify the geographical scope of the extent of the seasonal closure of the FCZ off Texas west of a line beginning at latitude 29° 32' 06.784" North, longitude 93° 47' 41.699" West, drawn in the general direction of 166.6° true and ending at the seaward limit of the FCZ at latitude 26° 11' 24" North, longitude 92° 53' 00" West. (This line is an extension of the boundary of Texas and Louisiana through the territorial sea into the FCZ.)

2. Eliminate the closure of the FCZ off Texas for one season.

The Regional Director shall by January 15 of the following year publish his intent to take action as provided in 1 and 2 above or not to take action.

If the proposed action is believed to be a substantial federal action likely to have a significant effect on the human environment, a supplemental environmental impact statement and regulatory impact analysis shall be prepared. The Regional Director may hold public hearings on the proposed action.

The State of Texas is encouraged to continue the present seasonal closure of its territorial sea, to continue to allow the landing of shrimp of any size, and to evaluate the effect of its allowing fishing for white shrimp in the Gulf inside of four fathoms.

Rationale: In general, the measure is recommended to increase the yield of shrimp and to eliminate waste by discard of undersized brown shrimp in the FCZ. Data indicate that closure would protect the shrimp until they have reached a greater biomass and generally reached a more valuable size. The elimination of the Texas count restriction in May of 1981 allows all the shrimp that are caught to be landed. This Act is contingent on there being an FMP in place which provides for a closed season in the FCZ contiguous to Texas and which conforms to the Texas territorial sea closure. A Texas study of the benefits of its white shrimp fishery in the territorial sea within four fathoms during the closed season seems necessary because of the incidental catch of considerable numbers of small brown shrimp.

The brown shrimp discard off the Texas coast was estimated to average 33 percent by number of the May-through-August catch (Berry and Benton, 1969; Baxter, 1973). Bryan (1980) estimated a June-July discard of 5.8 million pounds (whole shrimp) in 1973 and 4.3 million pounds in 1974. This amounted to 77 and 63 percent of the probable discards off Texas for those years. The discard apparently occurred not only because of the former legal count restriction in Texas but also because price and market favor larger sizes in the Texas area (Baxter, 1973). In Texas there are relatively less landings of smaller-sized shrimp than in Louisiana. There are no shrimp canneries in Texas, and most of the shrimp are processed by freezing. The economy of the industry in the western Gulf is tied to the harvest of shrimp larger than 65 tails to the pound.

Bryan, et al. (1978) found relatively large numbers of small brown shrimp in waters beyond the state's territorial sea out to 20 fathoms off the central Texas coast during June and July and in the open area inside 4 fathoms during June. They recommended that a seasonal closure of these waters based on biological sampling would protect the brown shrimp until they had reached a useful size for the area's fishery and would eliminate the need for a forced discard of undersized shrimp under Texas law.

Unpublished data from the Texas Parks and Wildlife Department indicate that shrimp beyond 20 fathoms, approximately 20 miles, off the central Texas coast generally are larger than 65 tail count. Because of the variability of distance of the 20 fathom isobath from shore, a zone 30 miles from shore was considered for protection of small brown shrimp. However, only seven percent of the shrimp landed from Gulf waters off Texas in June and July came from beyond 30 miles offshore.

In July of 1981, NMFS studies found small brown shrimp well below the former Texas minimum count size off the lower Texas coast to 28 fa or 25 nmi offshore (K. N. Baxter, personal communication).

The Council, with support from its Advisory Panel, has made the determination that the entire FCZ off Texas should be closed to increase total yield (weight and value), catch per unit of effort, and to facilitate effective law enforcement.

This action is presently limited to the FCZ off Texas as a measure which would enhance an existing management regime in the territorial sea. It is expected to be immediately beneficial to the majority of present users in the area. The Council, however, recognizes that the seasonal closure could result in displacement and shift of effort in an already highly migratory shrimp fleet. It is the intent of the Council that the biological, ecological, social and economic impact of this measure be monitored so that revisions of the management measure may be made when warranted.

An attempt has been made to assess the possible change in yield associated with this measure. The most recent data indicate that the closure could result in the availability of an additional four million pounds of shrimp tails with an exvessel value of $6.8 million to $12.7 million. This would contribute between $13.6 million and $25.4 million to the Gross National Product (GNP). The increase in landings results from a gain of 3.5 million pounds of tails (expected size 36 to 50 count) from survival and growth of shrimp previously discarded during the closed period based on discard data from Bryan (1980) and an instantaneous weekly natural mortality rate of 0.05 (Fox, 1981, personal communication). Growth was calculated using the monomolecular model described by Parrack (1978). On reopening of the season in mid-July these shrimp will have reached at least 65 tail count (the minimum size previously required by Texas law). Another 0.5 million pounds (expected size 40 count) becomes available from the additional growth of shrimp formerly caught and landed from the area during June/July.

The dollar value at dockside associated with these increased landings can vary between $6.8 million and $12.7 million. The value will fluctuate from year to year because the price per pound will be influenced by more than just the effects of the management measure itself. Prices will vary due to the size of the total catch, the level of shrimp inventories, the flow of imports, and the state of the economy. All these factors, including the management measure which is intended to increase individual shrimp size as well as total harvest yield, will cause exvessel prices to vary. The extent of this variation can be seen from a July-August price swing from a high of $3.17 per pound in 1979 to a low of $1.70 per pound in 1977 (for the expected size range of 41 to 50 count). These prices from the five-year 1977 through 1981 period were used to estimate the increased gross benefits from this measure.

The $13.6 million to $25.4 million contribution these landings make to the GNP from additional economic activity was derived by multiplying the exvessel values by an economic-activity multiplier of 3.0 (average for the Texas coast for fresh or frozen packaged fish; from U.S. Water Resources Council, 1977) and subtracting the exvessel values.

An extension of the closure to offshore Louisiana could have a major impact on the fishery in that area. The measure would not be compatible with present territorial sea management and may have a negative impact on the industry presently geared to the processing of smaller shrimp.

The Texas closure may affect other areas by causing a dislocation of effort. Some vessels will tie up, but others will likely fish off other states such as Louisiana, as many do now.

The Gulf shrimp fleet is presently migratory. In 1978, Louisiana sold over 2,300 non-resident shrimp trawl/vessel licenses even though many of the larger Texas vessels did not fish within Louisiana's territorial sea or land in Louisiana.

In 1976, about 20 percent of the volume and 25 percent of the value of Louisiana's Gulf shrimp catch was landed in Texas (Gulf Coast Shrimp Data).

In 1979 the Texas-based shrimp fleet capable of fishing in the FCZ consisted of approximately 1,269 vessels over 55 feet long. Another 218 similar vessels from other states, including Louisiana, were licensed to fish in Texas during a portion of the year. (Warren and Bryan, 1981.)

In 1980, of the 2,302 vessels landing shrimp in Texas, 1,912 were based in Texas; 127 in Louisiana; 204 in Florida; 38 in Alabama and five in Mississippi. Sixteen were unidentified (Farley, 1981, personal communication).

An estimate of numbers of vessels by state is presented in Table 3.5-24.

Because of higher operating costs mostly due to fuel prices, the Texas shrimp fleet is remaining in port during periods of low productivity (National Marine Fisheries Service, 1980a). The extent to which these vessels make longer trips to offshore Louisiana during the seasonal Texas closure cannot be predicted.

In determining that the closure should extend through the entire FCZ off the Texas coast the Council made the following determinations in conformance with the National Standards:

1. Management Objectives 1 and 3 will be met by increasing the opportunity for greater yield in product and value and by enhancing the existing management regime of the adjacent state. In this measure the brown shrimp stock will be managed in its range from the estuary and territorial sea through the FCZ.

2. There will be no discrimination against any group by this measure. All vessels will have the same opportunity to catch the larger, more valuable shrimp during open season. Small boats restricted to near-shore operation are already excluded from fishing during this period by the nine-mile Texas territorial sea closure and may resume fishing when the season reopens for all boats and vessels. No allocation is made among fishermen.

3. The low yield of large shrimp offshore and beyond 20 fathoms during this period does not provide for an efficient fishery according to the advisory panel and landing statistics.

4. Enforcement difficulties presently encountered by the state with vessels moving from the FCZ to the closed territorial sea would be greatly reduced. Closure of the FCZ to 200 miles would prevent a similar enforcement problem in the FCZ.

5. The measure takes into account the variation in the brown shrimp fishery in Texas directed toward a larger size product.

6. The measure would minimize costs by enhancing an existing management regime.

7. The measure conforms to best data available from state and other researchers concerning this fishery.

8. Most importantly, this measure is directed toward achieving optimum yield in the fishery while preventing growth overfishing.

9. This measure is parallel with the establishment of the Tortugas Shrimp Sanctuary for pink shrimp. Pink shrimp emigrate from inshore nursery grounds over a long period while brown shrimp move in a major migration in late May or early June.

During public hearings some comments included concern that this management measure would be ineffective and could adversely affect other areas by diverting excessive fishing effort to them during the closed periods. Louisiana shrimp fishermen and processors were particularly concerned because all fishermen were to be excluded seasonally from shrimping the FCZ off Texas and because they feared increased shrimping effort off Louisiana would result during that same period.

The Council, through the Southeast Fisheries Center of National Marine Fisheries Service (NMFS), is monitoring to identify the effect of the closures which became effective in 1981. A number of studies will monitor the conditions and yield of the Gulf shrimp fishery. The scientists have been careful to point out, however, that because of the natural, ecologically based fluctuations in the abundance of shrimp, no clear-cut measurement of cause and effect will be produced from any one study. Economic factors such as fuel cost will also affect the production of shrimp. An analysis of the effect of this management measure must consider many factors and the variables which influence them.

If an analysis of the study results indicates that the plan objectives can best be met with a revision of the management measure, the Council wishes that the plan provide a mechanism for such action. This measure directs the Regional Director of NMFS to review research findings each year and authorizes him to adjust the regulations in accordance with findings and plan objectives. He is to publish annually his intent to take action or not to take action as provided. Regulation change would allow correction of any undue hardship to participants in the fishery before the following season. This provision is included for both Management Measures 1 and 2.

Measure 3: Recommend that all states consider establishing shrimp management sanctuaries in important segments of nursery grounds under their sole jurisdiction. Within these areas shrimp would be protected from harvest until they have reached an optimum size for harvest by the user groups dependent upon them. In all open areas shrimpers would be allowed to keep all shrimp they harvest--that is, there should be no laws which would force the culling of shrimp caught.

All states are encouraged to continue their monitoring of these areas in order to provide basic data for management--especially data on habitat quality, yield predictions, and variations in the area distribution of shrimp.

Rationale: There are diverse user groups dependent on shrimp of differing sizes in the Gulf area. In fact, the conflict between interest groups is often acute in the states' internal waters. Currently, the Gulf states are attempting to provide accommodation for the various groups dependent upon these resources while protecting shrimp smaller than useful size. This problem will not be easy to solve since the number of recreational and commercial shrimpers is apparently increasing.

The most vulnerable area appears to be shallow water estuaries. These areas, critical for growth and development of brown, white, and pink shrimp, are also fragile ecosystems which are being affected by man (Lindall and Saloman, 1977).

It is conceivable that shrimp within these areas could be harvested and used at an extremely small size, say 300 tails to the pound, particularly by recreationists. On the other hand, basic biological data reviewed in the development of this plan indicate that yield would be maximized if shrimp were harvested at sizes larger than minimum count laws currently enforced in the Gulf area. These viewpoints provide the Gulf states biological flexibility in deciding which size ranges of shrimp would give the best yields.

The respective Gulf states can protect critical habitat areas, reduce the waste of shrimp from culling, and probably increase the yield of shrimp by identifying the areas where shrimp smaller than useful size exist and closing those areas to shrimping on a seasonal or permanent basis. Without such closures it is likely that these areas will be subject to increased fishing effort as competition for the resource intensifies. Increased effort will likely reduce the overall yield of shrimp. This measure is consistent with the groundfish plan and would afford protection to juvenile recreational and commercial fisheries which utilize the same nursery areas as shrimp.

Where feasible, area closures based on biological sampling are preferred to count laws which force discarding of undersized shrimp and directly waste the resources. The effect of such closures might be to shift fishing areas several miles or more to the larger lakes and bays. The Council will work toward a common management regime throughout the area on a state-by-state basis.

8.5.1.2 Objective 2: Encourage Adequate Habitat Protection Measures

Measure 4: The Gulf of Mexico Fishery Management Council has established an internal committee to review and assess the status of Gulf fishery habitats, with particular attention to those factors which might further stimulate "the downward trends in quality and quantity of fish habitats." (Atlantic States Marine Fisheries Commission, et al., 1977). The committee interacts where appropriate, with federal and state agencies to insure that adequate consideration is given to possible impacts of the agencies' actions on these renewable resources. The agencies include, but are not limited to, the states' wildlife management agencies, the U.S. Corps of Engineers, the U.S. Fish and Wildlife Service, the National Marine Fisheries Service, the Environmental Protection Agency, and coastal zone management agencies (in those states which have them).

The Council will adopt the policies set forth in the National Plan for Marine Fisheries and the Eastland Fisheries Survey (Atlantic States Marine Fisheries Commission, et al., 1977) regarding habitat protection and pollution control to:

1) "Reverse the downward trends in quantity and quality of fish habitats by minimizing further losses and degradation of these habitats, restoring and enhancing them where possible, and establishing protected areas where necessary, while recognizing other compatible essential uses of fish habitat areas.

   a) Improve the consideration given to fish habitats in key decision-making processes.

   b) Where possible, mitigate losses of habitats, restore habitats lost or degraded, and develop economically feasible enhancement opportunities.

   c) Establish sanctuaries, resources, or other systems when necessary to protect critical fish habitats and maintain fish production.

   d) Improve the quality and increase the dissemination of information required for effective fish habitat conservation.

2) Prevent rapid development of coastal and marine areas including those of the Continental Shelf, where development is based on hastily gathered and often critically incomplete data.

3) Take stronger action to insure abatement and control of pollution that contaminates fish or adversely influences fish environment and prevent development of new environmental degradation or fish contamination."

Rationale: Man's alteration of the Gulf estuarine and offshore fish habitats appear to pose the greatest threat to viability of fish resources. This is especially true for estuarine areas, since about 90 percent of the commercial and 70 percent of the recreational catches are estuarine-dependent (Lindall and Saloman, 1971). The shrimp fishery depends on acreage of suitable marsh or estuarine habitat not merely on acreage of inland waters. The Council encourages the Secretary of Commerce to aid in achieving wetland conservation. Quantitative studies are needed both to assess potential impacts on fishery habitats by man-made alterations and to support recommendations for workable alternatives. Some direct action is needed now; a Council committee working with the appropriate state and federal agencies appears to be not only a logical extension of the review and advice role of the Council but also a mechanism to insure adequate consideration of the habitat needs of fishery resources addressed in its fishery management plans. This committee is concerned with fishery habitats in general, because of the similarities in species requirements, and because it is necessary to approach these impacts with a multispecies understanding and to carry out the mandate of FCMA (reducing, where possible, duplication of effort). The committee makes recommendations to the Council as needed.

This measure particularly addresses National Standard Number 3 which requires management of the stock throughout its range. Because authority in the estuaries and marshes lies with the various states, the Council recommends coordinated efforts for habitat protection for the shrimp resource.

8.5.1.3 Objective 3: Coordinate, Where Feasible, the Gulf Shrimp Management Programs

Measure 5: The Gulf states are encouraged to adopt flexible management procedures which would provide regulation by administrative agencies of the shrimp resources in inland waters and territorial seas. These agencies would operate within legislative parameters but would have sufficient flexibility to perform such essential tasks as setting the seasons, based on environmental monitoring.

- The State of Florida is encouraged to consider setting its regulations by general law rather than by special laws of local application and to codify all such laws.

- The State of Louisiana is encouraged to enact laws which would authorize LDWF to regulate shrimping activities in its territorial sea.

Rationale: The yield of the dominant shrimp stocks is related to prevalent environmental conditions during the estuarine phase of growth. This dependency results in yearly variations in the times at which shrimp reach a minimum useful size and begin their offshore emigrations.

In order to increase the yield of shrimp, various minimum useful sizes have been established in the Gulf region. Appropriate state agencies are responsible for monitoring the resource and opening and closing seasons based on evaluations of their monitoring. To accomplish this essential task, the agencies must have sufficient flexibility to be able to establish seasons based on interpretations of current, relevant data. Without this flexibility, shrimp are wasted through culling because statutory seasons open on shrimp smaller than a useful size.

If the Gulf states adopt such flexible management where it does not already occur in conjunction with allowing all shrimp caught to be landed, wasteful culling of shrimp should be eliminated; the opening and closing of seasons will then be based on interpretation of current data on the shrimp populations. This management should not drastically affect present seasons because the flexibility required would not normally adjust the seasons more than a few weeks. Also, programs can be devised to provide shrimpers with suitable lead time. Nor will this management measure result in a drastic increase in the monitoring responsibilities of the various states, since programs are currently in effect to assess the majority of needed parameters.

Measure 6: The Gulf states are encouraged to adopt reciprocal internal management decisions flexible enough to allow joint management of shrimp with other states and with the Department of Commerce.

Rationale: Shrimp and shrimpers in the Gulf states are not limited by state or federal jurisdictional boundaries. Migrations of these populations from one area to another require coordinated flexible management to better protect the biological basis of the resource, to reduce conflicts among shrimpers and the waste of resources, and to ease enforcement problems.

The usefulness of such interaction was evidenced in the preparation of this management plan. The measures recommended herein are, in large part, results of the interaction of state and federal personnel who suggested and assessed measures to reduce the waste of resources and to enhance the industry's vitality. As is appropriate, the final plan will reflect the open public review of these measures to insure that they are sound, acceptable, and designed to promote conservation of our resources. The continued interaction of the appropriate state agencies with the GMFMC is essential if the shrimp resources in the area are to be harvested at optimum levels.

If management measures were coordinated wherever feasible, the likely result would:

1) provide a stronger base for protecting the environmental basis of the resource;

2) reduce waste of shrimp resources through the cooperative protection of shrimp smaller than a minimum size for an area;

3) reduce conflicts between fishermen by coordinating, where feasible, such regulation measures as opening and closing dates;

4) ease enforcement problems; and

5) reduce the cost of management by coordinating the monitoring, enforcement, and environmental assessment programs.

8.5.1.4 Objective 4: Promote Consistency with the Endangered Species Act and Marine Mammals Protection Act.

Measure 7: Develop and implement an educational program to inform shrimpers of the current status of sea turtle populations and of proper methods of resuscitation and return to sea of incidentally-captured sea turtles.

Rationale: All of the sea turtles that inhabit the U.S. Gulf of Mexico are listed either as threatened or endangered and must be protected. The shrimp fishermen, therefore, need to be informed of the necessity of following good conservation practices in relation to this species.

Informed shrimpers would be prepared both to take adequate measures in releasing turtles in a viable state and to give reliable information on incidental sea turtle capture.

8.5.1.5 Objective 5: When Appropriate, Minimize the Incidental Capture of Finfish by Shrimpers.

Measure 8: Encourage research on and development of shrimping gear which reduces incidental catch without decreasing the overall efficiency of shrimping or excessively increasing the cost of gear. This program would include current efforts on an excluder panel to prevent accidental catch of sea turtles; examination of the feasibility of reducing the harvest of shrimp smaller than a given size through adjustments in trawl mesh size and configuration; and development of a trawl to reduce incidental capture of finfishes (includes efforts on excluder panel, beam trawl, separator trawl). However, the emphasis on gear development should not rule out consideration of alternatives such as seasonal area closures and shortened "drags" as cost effective methods of achieving desired results. Implementation of measures to reduce incidental catch should be phased in as means of assuring compliance and allowing orderly disposition of unsuitable gear.

Rationale: This option would generally reduce the waste not only of marine resources but also of labor efforts, gear damage, and conflicts with other users. Development and use of an excluder panel would greatly reduce the incidental capture of sea turtles and facilitate compliance with the Endangered Species Act.

A shrimp trawl that is size selective for shrimp would allow protection of undersized shrimp without area closures. Reduction in incidental catch of finfish would reduce waste of these resources and conflicts with the groundfish and reef fish fisheries. However, efforts to reduce incidental catch will negate the sale of bycatch to the human food and pet food processors in 1979 (Mavar, personal communication).

The indirect impact of this option includes the possibility of (1) a reduction in finfish bycatch (usually discarded), (2) increases in predation on shrimp by escaping finfish predators, (3) increased competition for food and shelter between shrimp and escaping finfish which occupy ecological niches similar to those of shrimp, (4) a reduction in the amount of food available to scavengers, (5) a reduction in finfish growth rate through stocks not being thinned out, (6) shrimpers might be able to shrimp in areas not previously used, (7) stimulate the development of fisheries utilizing escaping finfish, and (8) the effect of discarding the bycatch on the fertility of the area may be ascertained. The ecosystems should be monitored to determine the best mix of benefits.

8.5.1.6 Objective 6: Minimize Conflicts between Shrimp and Stone Crab Fishermen.

Stone crab traps are placed on the bottom where they are inadvertently destroyed by shrimp trawlers. Trawling for pink shrimp is done at night when buoys are not visible. The loss to the stone crab fishery is estimated to be $80,000 per year (Table 1, Stone Crab EIS).

Measure 9: Consistent with the Stone Crab Management Plan, establish a seasonal closure of a portion of the Dry Tortugas shrimp grounds in order to avoid gear conflicts with stone crab fishermen. The area to be closed is outlined in Table 8.5-10 and is generally shown in Fig. 8.5-7 and 8.5-8. The seasonal opening of this area will not affect the "Tortugas Shrimp Sanctuary."

As a result of adopting this line from the Stone Crab FMP, the seasonal exclusion of shrimp vessels from this inshore area would allow for a longer growth period for these generally smaller shrimp. The increase in pounds of shrimp landed has been estimated at 60 thousand. The increase in value due to growth from delay in harvest has been estimated to be $46.2 thousand.

Rationale: The Stone Crab Fishery Management Plan contained a measure to avoid gear conflicts between shrimpers and stone crab fishermen. The seasonal closure developed in that plan is a reasonable compromise between the requirements of these two groups and is incorporated into the plan in order to provide consistency. However, the seasonal opening of the area outlined in the Stone Crab Management Plan will not affect that area closed as the "Tortugas Shrimp Sanctuary"; this area is closed to provide for conservation of shrimp recruited to the Tortugas and Sanibel shrimping grounds.

8.5.1.7 Objective 7: Minimize Adverse Effects of Underwater Obstructions to Shrimp Trawling.

Measure 10: The Gulf of Mexico Fishery Management Council will attempt to reduce, where feasible, the loss of offshore trawlable bottom by establishing within GMFMC, a committee to monitor and review construction of offshore reefs, with attention to the needs of the reef fish and shrimp user groups.

Rationale: In the Gulf shrimp fishery, there is a considerable loss of gear and time associated with trawls becoming entangled on artificial underwater obstructions. The adverse effect of these obstructions must be minimized in a way consistent with other national interests.

8.5.1.8 Objective 8: Provide for a Statistical Reporting System

Data Which Shrimp Processors Must Submit to the Secretary of Commerce to Calculate DAP

Shrimp processors in the Gulf of Mexico participate in data collection programs of varied natures. Most states have some reporting requirements of processors; these requirements must be recognized prior to the development of mandatory data systems for the Gulf Shrimp Management Plan. The comparability of the requirements among the states and the information collected through the voluntary programs of the National Marine Fisheries Service must also be considered.

Reporting requirements of the Gulf states are identified in section 3.3.1, Management Institutions, Policies, and Jurisdictions. A brief summary for each state follows:

Alabama--Seafood dealers are required to make monthly reports of the names and addresses of persons from or to whom fish, seafood, or other saltwater products of the state are purchased or sold, the quantity purchased from or sold to each vendor or buyer, and the date of each transaction. The data reporting requirements are not well accepted.

Florida--Individuals harvesting or buying shrimp for canning, drying, or shipping must state the number of barrels of shrimp caught or sold each month and any other information FDNR may require. Wholesale dealers make quarterly reports on the number of pounds purchased from commercial fishermen but this is not applied or enforced as to purchases of shrimp.

Mississippi--Processing or landing firms are the points at which data on harvesting activities are reported.

Louisiana--All shrimp processing plants and dealers must keep records of the date, quantity, and point of origin of each lot of shrimp received. Retailers must complete a quarterly report on the amount of shrimp purchased and the name and license number of the seller.

Texas--No reporting on processing activities is required. Anyone who purchases shrimp from the fisherman for resale must report monthly.

Shrimp processors, ranging from dealers to canners, frequently provide information to the National Marine Fisheries Service on a variety of topics. The amount of product handled, its value, frozen shrimp holdings, and the number of seasonal and full-time employees are all reported to the public through the NMFS Current Fisheries Statistics publication series and Market News Reports. The information collection procedure involves voluntary contribution of statistics. Although there may be previously unmeasured problems with the representativeness of the statistics, they do identify poundage, locations, disposition, and prices. In the majority of instances species identification is not maintained beyond the dealer level.

The NMFS information collection effort, other U.S. government surveys on economic activities of businesses, and the reporting requirements of some states do not make for a climate conducive to the successful addition of another information system. Thus, the management objectives concerning the processing sector that are proposed here require no additional information collecting programs. Then too, many shrimp processors are involved in the processing of other species, and, until a systematic program of information collection on processing activities is developed, a species approach to data collection could create a chaotic situation. Instead, emphasis should be placed on improving the coverage, frequency, and currency of the existing voluntary system. When developed, comprehensive information systems on processing activities should show their consideration of the statistics that reflect processing capacity.

Measure 11: All statistical reporting requirements will be mandatory. As a unit, the Gulf shrimp fishery is the most valuable one in the nation. It is also complex and supports a large recreational effort mainly limited to inside state waters, as well as a diverse commercial effort which ranges out to Gulf waters of 200 to 300 fathoms. Data useful for wise management of these resources includes the following (however, not all is to be included in the statistical reporting program):

A. Harvesting sector--all harvesters, recreational and commercial

1. Number of fishermen and mailing addresses.

2. Boat or vessel: home port, length of hull, construction of hull, year built, number in crew, type, make and model number of engine, type, size, and number of gear, presence or absence of salt box, and, when developed and deployed, type of excluder panel used (if required).

3. Catch data by boat or vessel including: date left port; date returned to port; date shrimp landed; catch and value by species, size, area, and depth; shrimping time by species area and depth; size distribution of catch including discards; species composition of catch (including discards).

B. Processing sector

Number and locations of processing plants identified by type of product, seasonal production of types and species processed, and number of employees and seasonality of employment.

Because of the high cost of gathering all the data listed in A and B above, the following alternative system is recommended. The NMFS will be responsible for the design for Council review, implementation and management of surveys to obtain the necessary information to manage the fishery including, but not limited to the following guidelines:

Statistical reporting requirements recommended:

1. Maintain at least the existing commercial statistical reporting system with more timely publication.

2. Require the collection of minimum data on catch, effort, biological and socioeconomic information needed to manage this fishery under MFCMA.

3. Require mandatory reporting of all selected shrimp fishermen and all selected shrimp dealers and processors. Selection of respondents to be made by NMFS.

4. Utilize the vessel enumeration system to identify saltwater shrimp fishermen.

5. The Fisheries Survey Task Force of Southeast Fisheries Center will be responsible for the design, implementation and management of this survey and will spell out details on what is to be collected based on resources provided.

6. Consideration should be given to improvement of the data base on boat catch and the bait harvest in state waters.

Rationale: Basic statistical data are needed in monitoring the fishery in order to insure the viability of the stocks, to evaluate reasonable solutions to conflicts, and to provide for the management of the fishery.

8.5.2 Alternative Management Measures Considered But Not Adopted

8.5.2.1 No Action

The Council has determined in the plan that management of shrimp stocks in the FCZ can provide a higher yield of shrimp in both weight and value. Management measures, therefore, were developed to provide this optimum yield from the fishery. Taking no action would result in continuing waste from culling and discard of small shrimp, degradation of shrimp habitat, conflicts among users, and inadequate statistics to monitor the fishery. Implementation of management measures will serve to address and meet the objectives of the plan.

The anticipated benefits and costs presented earlier from management measures in this plan provide a comparison with a "no action" alternative. Without these measures, either the status quo would prevail, as in the case of shrimping in the Texas FCZ, or the Tortugas area would continue to experience a lower total yield than when the traditional nursery area was closed by Florida.

8.5.2.2 Size and/or Season Regulations

1. Modify Any of the Minimum Size Ranges of White Shrimp Seasonally Imposed by the Gulf States and/or Establish Minimum Size Ranges for White Shrimp in the Fishery Conservation Zone (FCZ).

Minimum size limits require culling and discarding of small shrimp, a wasteful and self-defeating practice. The purpose, to direct fishing effort toward larger, more valuable shrimp, can more constructively be attained. This plan uses closed areas and seasonal closures on small shrimp to accomplish the objective.

No size restrictions are proposed in the FCZ but the management regime selected should encourage harvesting in the FCZ of the optimum weight and value, and the plan encourages states to permit the landing of any size shrimp from open areas.

Because the fishery for white shrimp is inshore, the plan suggests that states identify and close to trawling those areas in their internal waters and territorial seas where shrimp are too small for best local use.

The existing minimum size patterns as currently outlined by the states do not appear to threaten the biological basis of the resource. As the size of shrimp is frequently associated with the area and depth of harvest, the ability of the fleet to harvest the resource would be affected if the minimum size were changed; boats could be dislocated or excluded from the fishery. Additionally, as most states currently impose size regulations based on local industry demands, local processors in the Gulf could be disrupted.

2. No Size Regulation

No size regulation with no area closures to protect undersized shrimp would likely result in a harvest with a wider range of sizes. The mix would consist of more smaller size shrimp and consequently less large shrimp. Because there are few sufficiently developed markets for the smaller ranges of shrimp except in Louisiana, discard could be expected to increase, resulting in greater biological waste. It could also be expected to result in a greater concentration of fishing effort in nearshore and inland waters on juvenile shrimp. This could result in a decreased harvest for deepwater vessels. More shrimp would be harvested, but with less total poundage and lower total value.

3. Determine Preferred Minimum Size and Regulate Area and Season for That Size. Allow Retention of All Catch Regardless of Size

This approach has been proposed in those measures which establish seasonal closures for areas off of Texas and Florida as an extension of present state management schemes, as well as in Option 3, Section 8.3.1.1, where it is suggested that the Gulf states consider such delineations and closures.

Adopting a no size regulation will take state action by Mississippi and Alabama since presently state laws prohibit catching small shrimp.

The shrimp fishery has a number of processing entities (e.g., fresh, frozen, canned, etc.), each of which contributes to the economy of the nation, and each of which has preferred sizes. If this alternative were implemented, it would provide protection for the resource until the preferred minimum size for the area were attained thus delaying the harvest. Some processors might be disrupted temporarily due to the loss of fresh shrimp during the time of closure. The congestion of boats and vessels within open waters could increase, intensifying conflicts over trawlable space. The elimination of forced discard would reduce biological and economic waste.

Those shrimpers who have traditionally fished in an area of closure would be displaced. Boats smaller than 47 feet in length would not be entirely displaced as a closure of an area in the FCZ would still permit shrimping within a state's inland and territorial waters. Those using deepwater vessels would move to further fishing grounds that were not within the area of closure with an attendant increase in fuel consumption. The extent of the dislocation would depend on the area closed.

4. Establish a Minimum Shrimp Count Size in the FCZ, Under Which White Shrimp May Not Be Retained

White shrimp which reach the FCZ are large enough to comply with the landing laws of the adjacent area. There is no need to protect undersized white shrimp in the FCZ because recruitment or growth overfishing is not evident there.

The imposition of a minimum size count with a forced discard is unnecessary and would result in increased biological waste due to the culling of shrimp smaller than permitted, if and when they should occur there.

5. Establish a Cooperative Seasonal Closure to Shrimping in the FCZ off Texas within 20 fathoms in June and July to Protect Undersized Brown Shrimp

Currently, the Texas territorial sea is usually closed from June 1 through July 15. There is a variable, but often substantial discard of small brown shrimp in the territorial sea and FCZ associated with Texas during the May-August period. This closure reduces the biological waste that presently occurs when large quantities of undersized shrimp are discarded.

The extension of the closed season to 20 fathoms in the FCZ was considered because Texas researchers found that small shrimp usually do not extend beyond 20 fathoms. Shrimp of the preferred size do occur beyond that depth off the central Texas coast with infrequent mixing of smaller sizes. The 20 fathom isobath is about 20 miles from shore in the study area but is much closer on the lower Texas coast and more than 50 miles offshore near Louisiana. Size distribution offshore is as much a function of distance as depth. Shrimp fishermen document occasions when small shrimp are taken beyond this depth.

Because a meandering depth contour was not practical as a line of closure, various distances from shore were suggested as alternatives.

Closure of only a portion of the FCZ would cause substantial enforcement problems in monitoring the area of limited closure. Because the line of closure is based on a depth delineation, there may result some hardship to fishermen attempting to stay just beyond the 20 fathom range. Texas' present terrtorial sea closure is difficult to enforce because vessels move inshore under cover of darkness when shrimping occurs. The enforcement costs requiring full at-sea patrols were estimated by NMFS to be $202,400.

6. Establish a Cooperative Seasonal Closure of the Territorial Sea off of Texas and the Associated FCZ within 30 Nautical Miles to Protect Undersized Brown Shrimp

This alternative is similar to the previous measure. It is an extension of present Texas management policies. Currently, the Texas territorial sea is usually closed from June 1 through July 15. There is a variable, but often substantial discard of brown shrimp in the territorial sea and FCZ associated with Texas during the May-August period. This closure would reduce the biological waste that presently occurs when large quantities of undersized shrimp move beyond the state's closure of the territorial sea. The 30-mile line was considered to provide a zone beyond which most shrimp would provide an optimum yield in weight and value.

With support from its advisory panel, the Council has determined that a partial closure of the FCZ in this instance would be ineffective. Shrimping is done at night and vessels can move into the closed area to fish. Small shrimp do move far offshore on occasion. Only seven percent of shrimp landed from Gulf waters off Texas during this period came from beyond 30 miles. The alternative of expanding the closure to encompass the entire FCZ associated with Texas was adopted. The enforcement costs requiring full at-sea patrols were estimated by NMFS to be $136,000.

8.5.2.3 Spawning Area Closures

1. Protect Spawning White Shrimp From Harvest in April Through July

Although white shrimp have the shallowest depth range of the three major species and are fished extensively throughout their range, catch-effort data do not indicate a decline as a result of recruitment overfishing. Data also indicate multiple spawning of white shrimp in a season with wide ranging spawning areas which are difficult to delineate.

No scientific data exist to show an advantage from protecting spawning shrimp. There is no relationship between the number of spawners and recruits.

2. Establish a Trial Sanctuary in April and May in the FCZ South of Mississippi to Protect Spawning White Shrimp and Assess Spawner Recruit Relationship

In recent years there has been a decline in the white shrimp fishery off Mississippi and Alabama. Because white shrimp live in the bays, sounds, and inshore Gulf, they are heavily fished throughout their range. Some fishermen have suggested that heavy fishing on spawning adults off Mississippi may be a factor in the decline of stocks in that area. Best available scientific data, however, show no relationship between the number of spawners and subsequent number of recruits to the fishery.

Establishment of a seasonal sanctuary for the spawners would result in the loss of the spring catch in that area with no evidence of justification.

3. Close the Offshore Waters of the Northern Gulf (Fishery Conservation Zone and Territorial Sea) to All Shrimping from Approximately April 15 to Approximately June 15 Each Year (At Least East of the Mississippi River).

4. Area Closures to Protect Spawning Populations of Brown Shrimp

5. Area Closures to Protect Spawning Populations of Pink Shrimp

The same rationale for rejection was established for measures 3, 4, and 5 as for all other proposals for protection of spawning shrimp. There are no scientific data to support a measure to protect spawning shrimp because no relationship between number of spawners and subsequent number of recruits to the fishery has been found.

6. Area Closures to Protect Spawning Populations of Royal Red, Rock and Seabob

Royal reds (off St. Augustine, Florida) are believed to spawn during the winter. Unlike other species of shrimp, they are harvested over several year classes.

The area of spawning for rock shrimp has not been determined as they are not believed to be estuarine dependent.

Seabobs spawn in the Gulf off of Louisiana during July-December. They are not estuarine dependent.

Present data on all three species is incomplete. Rock and seabob shrimp have been harvested mainly as an incidental bycatch. Spawning area closures would be difficult to identify and might conflict with peak harvesting for the major species, thus restricting shrimpers in those areas so closed, and disrupting local processors. This could be an unnecessary disruption as there is no apparent spawner-recruit relationship.

8.5.2.4 Licensing and Data Collection

1. A No-Cost Permit Be Issued to "Recreational" Shrimpers (Trawlers Only)

This measure would permit identification and determination of the effort by recreational shrimpers in the FCZ. Substantial costs would occur in the governmental sector. These costs appear unjustified because most recreational shrimping occurs within inland and nearshore waters. Recreational shrimpers will be identified by a vessel enumeration system through state boat registration.

2. Numerous Recommendations Were Considered Dealing With the Licensing of Different Types of Trawls

Costs of implementing this type of regulation would be substantial to fishermen with no benefits to be derived from such regulation. Identification of users is to be obtained through a vessel enumeration program.

8.5.2.5 Limited Entry and Gear Restrictions

Management schemes designed to prevent biological overfishing or restore a fishery stock are usually formulated around gear restrictions, size or catch limits, and closed seasons or areas. These type schemes do not address effectively the common property resource problem. Limited entry is a tool that attempts in part or total to deal with the common property problem by: (1) selecting those that may have access and (2) allowing people to qualify for access by using economic criteria such as taxes, auctions, leases or outright endowments for the right to fish.

Three basic approaches exist for accomplishing limited entry. The first is to license all users of the fishery and then issue no more future licenses. This essentially freezes effort, limits expansion, transfers property rights from the public sector to the fishermen, and allows technology to increase. Since licenses are usually transferable, entry is not actually limited, just effort to a degree. The second method is to institute landing quotas per craft through the issuance of stock certificates which can be bought and sold among fishermen. This method is not attractive from a purely economic standpoint since the capital invested in vessels remains idle after quotas are reached. The third method is the use of direct taxes, license fees and/or auctions for the right to fish. This method can control the amount of fishing effort and is effective in taxing away the economic rent generated in the fishery during periods of prosperity. If the primary management objective is maximizing the return to society as a whole from the fishery, this method provides the most efficient techniques from the standpoint of economics to accomplish this objective.

Several provisions of the MFCMA are important to limited access systems. Section 303(b)(6) establishes the authority to establish limited access systems subject to the consideration of a number of considerations. Section 303(B)(1) establishes the right to obtain vessel permits and charge fees for the permit. However, Section 304(d) established that the level of the fees shall not exceed the administrative costs incurred in issuing such permits. Section 301(a)(5) indicates that management measures where practical, shall promote efficiency in the utilization of fishery resources; except that no such measure shall have economic allocation as its sole purpose.

These stipulations of the act thus allow the implementation of limited access systems. However, the restrictive qualifications are such that any limited access system designed only to accomplish pure economic efficiency from the standpoint of society as a whole (such as allowing only the maximum economic yield level of effort) would not be allowed. One of the necessary options in a purely economic limited entry system is the ability to levy a tax or fee at a high enough rate to tax away economic rent generated in the fishery. Section 304(d) would probably not allow high enough fees to be charged to permit this. Management measures designed to achieve the maximum economic yield in the fishery could be interpreted as measures with economic allocation as the sole criteria. Section 301(a)(5) probably would not permit this. Essentially the implementation of a limited access system could be implemented which would in effect create property rights in the fishery to the fishermen. Then since high enough fees could not be charged to tax away economic rents generated, the benefits of the common property resource would be given to the fishermen, rather than to society for the publicly owned resource.

1. Impose Limited Entry in the Fishery Conservation Zone

Provided there was no increase in effort in the states' waters, the imposition of limited entry in the FCZ would have substantial economic impact. The catch per unit of effort could be expected to increase and provide stable incomes for those permitted to participate in the fishery. There would be reduction in the amount of disturbance to the benthic habitat as well as possible reduction in the incidental capture of associated fisheries. There would be an overall decrease in consumption of fuel within the industry as well as reduced conflicts over space for trawling in the FCZ. Incidental factors such as lack of ice supplies could be expected to improve.

Without a limit on entry in the states' waters, this measure could also be expected to result in intensified effort in waters within state jurisdiction. The increased pressure on juvenile shrimp in these areas may decrease the poundage of yield harvested by deepwater vessels. Additionally, it might be difficult for people not presently in the fishery in the FCZ to participate, particularly young people. Excessive economic rent may accrue to industry members because of the current limitations provided by the MFCMA.

The measure was not recommended because there is insufficient data on who is using the resource, on what the benefits (if any) to society at large would be, and on how methods to limit entry would be made consistent with the mandates of MFCMA. The only study examining maximum economic yield in the fishery was for the year 1973 and is not consistent with current effort levels and the industry situation. A complete discussion of overcapitalization is presented in Section 3.5.2.3.

2. Various Limitations on the Width, Mesh, and Type of Trawl

Regulation of the width, mesh, and type of trawls might reduce disturbance of the benthic habitat, reduce conflicts over trawling space, and reduce the incidental catch of associated fisheries. As the industry is presently using the most efficient gear economically available, changes rendering current gear useless could result in increased costs to the fishermen as well as the consumer. Additionally, such restrictions could reduce the catch per unit of effort and possibly result in lay-offs in the processing industry. There is evidence that gear restrictions actually increase capitalization and costs (Johnson and Toevs, 1979).

8.5.2.6 Recommend Consideration to Change Endangered Species Act to Permit Incidental Catch and Release of Sea Turtles

Sea turtles protected by the Endangered Species Act may be captured unwittingly. Even though shrimpers may release the turtles unharmed, they are in technical violation of the Act when they capture an endangered turtle. The suggestion was made to recommend that the Act be changed to provide for incidental capture and release of endangered and threatened turtles.

This proposal was rejected as being beyond the authority of the Council's planning responsibility.

8.5.3 Management Measures for Foreign Fishing

Currently there is no foreign fishing for shrimp in the U.S. Gulf of Mexico, nor are there applications for the only stock (royal red shrimp) which has an estimated surplus in 1980 and 1981 for total allowable level of foreign fishing (TALFF). Measures to provide catch data and area/depth restrictions to eliminate non-surplus bycatch will be specified in the permits or in the regulations as may be appropriate. In addition, the Secretary is requested to place the following three restrictions on any foreign nation fishing for royal red shrimp were adopted by the Council.

1. Foreign fishing for royal red shrimp is to be accomplished by trawl; however, gear other than standard shrimp trawl may be used after approval by the Secretary after consultation with the Council.

2. Foreign fishing for royal red shrimp is to be permitted only in depths beyond 100 fathoms.

3. Bycatch of foreign vessels fishing for royal red shrimp is to be monitored and the Secretary, after consultation with the Council, may require appropriate conservation measures.

8.5.4 Relationship of Recommended Measures to Existing Laws and Policies

8.5.4.1 Other Fishery Management Plans Prepared by a Council or the Secretary

The plan is consistent with the Stone Crab Management Plan, the Draft Reef Fish Management Plan, and the current status of the Groundfish Plan.

8.5.4.2 Federal Laws and Policies

The plan attempts to be consistent with the Endangered Species Act and Marine Mammals Protection Act. Section 7 consultations have been requested from appropriate federal agencies to assure conformance (EIS Appendix B, Exhibits 1 and 2).

8.5.4.3 State Laws and Policies

The following section contains a discussion of the relationship between the shrimp plan and the existing state laws and policies. Where discrepancies are apparent, they are pointed out for consideration by the appropriate state.

Texas Laws and Policies:

Relationship to 8.5.1.1, Measure 2:

The Texas territorial sea is closed from June 1 to July 15 to protect small brown shrimp during the major emigration period. Based on sound biological data, the season may be extended to no more than 60 days by the Texas Parks and Wildlife Commission changing the opening or closing dates. Currently, white shrimp within four fathoms may be harvested during the closed season.

Texas, in 1981, eliminated its minimum size restriction on Gulf shrimp contingent on there being a shrimp FMP in place which provides for a cooperative seasonal closure of Gulf waters adjacent to that state's territorial sea.

Relationship to 8.5.1.1, Measure 3:

The Texas Parks and Wildlife Department currently has the flexibility to determine opening and closing of the summer season in outside waters. However, the department has no flexibility in determining the time of the winter closed season.

Section 77:062 might be amended to provide the Commission the authority to change the opening and closing of both the summer and winter season (or areas), the decision to be based on sound biological data acquired through sampling. Conceivably the seasons (or areas) could then be opened when shrimp have reached the size desired.

A 1979 amendment to the Texas Shrimp Conservation Act provides for some bays to serve as shrimp sanctuaries in which no shrimp trawling is permitted.

Relationship to 8.5.1.3, Measure 5:

The Parks and Wildlife Commission is vested with control of the Texas shrimp fishery and is authorized to establish rules and regulations for the conservation and management of shrimp. At present, the Commission has only minimal flexibility in determining the seasons. Texas might amend the statutes and clearly establish that the Commission has full flexibility to set seasons based on their environmental monitoring.

Relationship to 8.5.1.3, Measure 6:

The Texas statutory scheme provides the Department the authority to negotiate reciprocal agreements with other states. However, agreements are limited to the application in Texas' contiguous zone of another state's shrimping regulations to citizens of that state. The Department also has limited authority to cooperate with the Gulf Council in developing a fishery management program.

Texas might broaden the Department's authority to allow it to enter into any reciprocal agreements necessary to insure coordinated management with other interested states. Additionally, the limitation on the Department's authority to cooperate with the Gulf Council puts the state in a difficult position. Texas might make cooperative management easier by repealing Sec. 79:002, which limits the authority granted in Sec. 79:001.

Relationship to 8.5.1.5. Measure 8:

There is a Special Game and Fish Fund (Sec. 11:031-11:033) available for varied uses approved by the Legislature. Since the Department is authorized to conduct research on the use of trawls, nets, and other devices for taking shrimp, there are funds to carry out this measure if required by the state agency and appropriated by the Legislature.

Relationship to 8.5.1.8, Measure 11:

The Department of Parks and Wildlife is authorized to acquire certain data from all licenses, and dealers purchasing seafood from fishermen for resale are required to report quantity and value of products.

Other measures would have little or no effect on existing Texas law and policies.

Louisiana Laws and Policies:

Relationship to 8.5.1.1, Measure 3:

Louisiana has designated certain areas as "sanctuaries," closed to most forms of shrimping (R.S. 56:801); these areas, however, are limited in scope. If Louisiana adopts the sanctuary concept (Management Measure No. 3), legislative action would be needed to implement this provision: the Louisiana legislature might amend R.S. 56:493, authorizing the Department of Wildlife and Fisheries to designate areas as needed, or it could create sanctuary areas by special provision. (It is noteworthy that, during 1975, a series of public hearings on the feasibility of establishing additional sanctuaries was held throughout the state. A renewal of these efforts appears justified.)

Louisiana's present management procedures divide the waters in which shrimp are found into inside and outside waters. Because of the indefinite nature of Louisiana's water/land interface, the definitions are quite precise, and the statute draws the line delineating these waters. If a sanctuary area is designated, Louisiana might create these divisions: the sanctuary waters, inside waters (which would refer to open bays), and outside waters as already defined. The exact delineation of the sanctuary areas may be difficult and perhaps likely to result in legal challenges and enforcement problems. The state might grant this authority to the LDWF by amending R.S. 56:495 to provide for the designation of the protected areas in the same manner that inside and outside waters are determined; however, it may be more feasible to permit LDWF to open and close areas as appropriate (R.S. 56:497).

Relationship to 8.5.1.3, Measure 5:

The Wildlife and Fisheries Commission does not have exclusive control of the shrimp fishery or shrimp industry. Although the Commission is authorized to open or close seasons occasionally at times other than the regular seasons and may set special seasons for all or part of the inside waters, the two major seasons are set by statute. These seasons apply only to inside waters and are determined by sampling data; the Commission has only minimal flexibility in setting the spring season and none in setting the fall season.

To provide the flexibility necessary for the best yield, Louisiana might amend R.S. 56:497, giving the Commission the authority to establish open and closed seasons within both inside and outside waters. These seasons should be determined on the basis of biological data acquired through sampling, such as are currently used to determine the opening of the spring season.

Relationship to 8.5.1.3, Measure 6:

The Department of Wildlife and Fisheries is authorized to enter into reciprocal agreements with Mississippi and Texas for the protection of aquatic life found within common waters. While this provides part of the framework for reciprocal agreements, Louisiana might consider legislation authorizing the Department of Wildlife and Fisheries to enter into appropriate agreements with Alabama, Florida, and the Gulf Council, as well as with Texas and Mississippi.

Relationship to 8.5.1.5, Measure 8:

Louisiana currently has sufficient authority to implement this measure and does in fact conduct such research.

Relationship to 8.5.1.8, Measure 11:

The Department of Wildlife and Fisheries is authorized to acquire certain data from commercial shrimpers and processors, but enforcement is limited. Louisiana has no provisions for collecting data from recreational shrimpers.

Other measures would have little or no effect on Louisiana's existing laws and policies.

Mississippi Laws and Policies:

Relationship to 8.5.1.1, Measure 3:

The Mississippi Marine Conservation Commission is authorized to enact all regulations necessary for the "protection, conservation, or propagation of all shrimp..." (Sec. 49-15-15 3 k). The Commission has previously enacted ordinances closing certain areas to shrimping in order to protect juvenile stage shrimp. For example, the Commission has closed to all but bait shrimpers that portion of the state's waters lying one-half mile from the coastline from July 15 to August 15 (Sec. 8100).

If Mississippi adopts the policy, it may have to denote and close other areas or eliminate its count restriction on catch.

Relationship to 8.5.1.3, Measure 5:

Supervision of matters concerning marine aquatic life is vested in the Mississippi Marine Conservation Commission. The Commission has broad authority to adopt and supervise appropriate management plans for marine fisheries. If it adopts the suggestions of the Shrimp Management Plan, the Commission has the mechanism to carry them out.

Relationship to 8.5.1.3, Measure 6:

Mississippi is a member of the Gulf States Marine Fisheries Commission, which was developed to foster cooperation between the states in matters of fish management. The Commission is authorized (49-15-15 j) to enter into agreements with officials of other states for the protection, propagation, and conservation of seafood.

Relationship to 8.5.1.5, Measure 8:

Mississippi has no specific authorization to conduct research on shrimping gear but is authorized to contract the services and facilities of the Gulf Coast Research Laboratory, or of state higher education facilities, for research it deems necessary to foster the seafood industry.

Relationship to 8.5.1.8, Measure 11:

The Commission is authorized to collect limited data from various sources.

Other measures would have little or no effect on Mississippi's existing laws and policies.

Alabama Laws and Policies:

Relationship to 8.5.1.1, Measure 3:

Alabama closes its season on about April 30 and does not open it again until sampling shows an average shrimp count of 68 or less per pound. Undersized shrimp are supposed to be discarded. If Alabama adopts this measure, current laws might be amended to allow possession of all shrimp caught in open areas.

Alabama already designates certain sanctuary areas as closed to shrimping for any purpose (Sec. 9-12-48). Supplemental legislation might be needed to the extent that Alabama finds the sanctuaries inadequate for producing the best yield.

Relationship to 8.5.1.3, Measure 5:

The Division of Marine Resources, under the Department of Conservation and Natural Resources, has been established to develop and administer management schemes for conservation and use of seafoods. It presently has fairly wide latitude in carrying out its programs and could adapt these programs to suggested guidelines if the Division so desired.

Relationship to 8.5.1.3, Measure 6:

Alabama is a member of the Gulf States Marine Fisheries Commission which was designed to promote this type of cooperation. The Commissioner of Conservation and Natural Resources is authorized by Sec. 9-12-160 to enter into agreements of reciprocity with other states for the taking of seafood.

Relationship to 8.5.1.5, Measure 8:

Alabama has no specific authorization for the study and development of improved shrimping gear. However, the state has established a Seafoods Fund (9-2-87), which can be used by the Commissioner of Conservation and Natural Resources (9-2-89) in any way deemed appropriate for the benefit of the seafood industry. The governor's approval is necessary for such expenditures.

Relationship to 8.5.1.8, Measure 11:

The Department of Conservation and Natural Resources is authorized to acquire certain data within the realm of commercial seafood production, but enforcement is limited. Alabama has no provisions for collecting data from recreational shrimpers.

Other measures would have little or no effect on Alabama's existing laws and policies.

Florida Laws and Policies:

Relationship to 8.5.1.1, Measure 1:

Closure of the portion of the Tortugas Shrimp Sanctuary in the FCZ will, in large part, reimplement what Florida has done in the past. As noted previously, part of the Tortugas area was reopened to shrimping as a result of a U.S. Supreme Court decision delimiting Florida's Submerged Lands Act jurisdiction. While under Skiriortes, Florida law was still applicable in those waters beyond state waters but had no jurisdiction in the area over out-of-state fishermen.

The Supreme Court decision led to a heated controversy between shrimp fishermen and stone crabbers, because shrimpers began moving into areas of the Tortugas from which they had been excluded under previous law. Enactment of this recommendation by the Council decreased conflicts between the shrimpers and crabbers.

In accord with the establishment of the Tortugas Shrimp Sanctuary in the FCZ, Florida in 1981 amended its law to allow possession of any size shrimp not taken in Florida waters.

Relationship to 8.5.1.1, Measure 3:

In Florida waters, however, it is unlawful to catch and keep shrimp with more than five percent "small shrimp" -- that is, those smaller than 47 with heads or 70 without heads.

Relationship to 8.5.1.3, Measure 5:

There is presently some flexibility in the administration of fisheries in Florida. The Division of Marine Resources within the Department of Natural Resources apparently has authority to open and close areas (based on biological data), but the authority has not been exercised to the fullest extent. The Florida legislature might consider the enactment of a clearly written statute authorizing the Division of Marine Resources to use biological data in opening and closing areas to shrimping during the year.

Relationship to 8.5.1.3, Measure 6:

Florida has a reciprocal agreement with Alabama concerning access to shrimping waters. However, there have been no agreements adopted that would provide for joint management, and it is questionable whether the Department of Natural Resources has statutory authority to make such an agreement. If Florida adopts the option, its legislature might provide the Department with this authority.

Relationship to 8.5.1.5, Measure 8:

Florida's Department of Natural Resources presently has authority to regulate "the method, manner, and equipment used in the taking of shrimp," but there is no indication that ongoing research to develop gear is being conducted.

Relationship to 8.5.1.6, Measure 9:

If Florida adopts seasonal closure of a portion of the Dry Tortugas Shrimp Grounds, it will require legislative action. Presently, Sec. 370.151 closes an area designated as the Tortugas Shrimp Bed. Florida might find it useful to amend this law so that it also differentiates the seasonal closure of a delineated portion of the Dry Tortugas Shrimp Ground. Alternatively, the Division of Marine Resources is authorized by Sec. 370.15 to control the method, manner, and equipment used in the taking of shrimp, as well as limiting and defining the areas where shrimp can be taken. There appears to be sufficient authority to regulate a seasonal closure of the Tortugas Shrimp Grounds, which could be accomplished with a specific subsection for this area.

Relationship to 8.5.1.8, Measure 11:

Florida has legislation authorizing the acquisition of the various data listed in the recommendation, but the provision is not enforced.

Other measures would have little or no effect on Florida's existing laws and policies.

8.6 Enforcement Requirements

Enforcement agents of NMFS will be required.

Coast Guard aircraft and patrol vessels are needed for patrol.

8.7 Cooperative Research Requirements

Data needs in the fishery have been identified by the interdisciplinary team which prepared Christmas and Etzold (1977).

These data are also needed under FCMA and are therefore adopted here. However, priorities may differ; for example, adequate socioeconomic data are critically needed.

8.8 Permit Requirements

No permits are required except as may be required of foreign vessels.

8.9 Financing Requirements

8.9.1 Management and Enforcement Costs

8.9.1.1 Tortugas Closure (year round) Measure No. 1:

Estimated vessel population = 1,000
50 percent at-sea enforcement mode
Patrol days required = 83
Cost of patrol days = $232,400
Aircraft hours required = 83
Cost of aircraft hours = $83,000
Enforcement officers required = 1.4
Cost of officers = $35,000

Subtotal - Tortugas closure = $350,400

8.9.1.2 Texas Closure (45 days) Measure No. 2:

Estimated vessel population = 1,500
50 percent at-sea enforcement mode
Patrol days required = 125 (annual)
Forty-five day patrol requirement = 16
Cost of patrol days = $44,800
Aircraft hours required = 16
Cost of aircraft hours = $16,000
Enforcement officers required = 0.3
Cost of officers = $7,500

Subtotal - Texas closure = $68,300

8.9.1.3 Shore-side enforcement for inspections relative to mandatory reporting, etc., Measure No. 11:

Estimated vessel population - 4,000
50 percent shore-side enforcement
Inspection days required = 667
Inspectors required = 3.0
Cost of inspectors = $75,000

8.9.1.4 Investigations to support sea and shore enforcement:

Total sea and shore staff required = 4.7
Investigators figured at 30 percent of (a) above
Agents required = 1.4
Cost of agents = $35,000

8.9.1.5 Support for all enforcement efforts:

Total sea, shore and investigative = 6.1
Support figured at 10 percent of (a) above

Support staff required = 0.6
Cost of support = $15,000

8.9.1.6 Total staff years of effort required and total cost of vessel and aircraft patrols, inspections, investigations and support:

Staff years required = 6.7
Total cost = $543,700

8.9.2 Expected State and Federal Revenues, Taxes, and Fees

No changes in existing revenues are expected other than those which would be required to obtain basic catch-effort data to manage the stocks.

9.0 STATEMENT OF COUNCIL INTENTION TO REVIEW THE PLAN AFTER APPROVAL BY THE SECRETARY

It is the intention of the Gulf of Mexico Fishery Management Council to monitor and review the plan and implementing regulations on a continuing basis, after its approval by the Secretary. The Council intends that the Secretary of Commerce, after consultation with the Council, develop annual estimates of MSY, DAH, DAP, OY and TALFF using the methodology developed by the Council and specified in Section 4.7. The Secretary will develop the data necessary to derive the specifications according to the equation(s) in the plan. The Secretary will publish the yearly figures as a notice for public review. The Council will monitor the management regime closely to assure that it attains the desired objectives of the management plan.

10.0 SELECTED BIBLIOGRAPHY

Abramson, N. J. 1963. Distribution of California angling effort in 1961. Calif. Fish and Game 49:174-182.

Acheson, J. M. 1977. Social and cultural aspects of the south Atlantic shrimp industry--a pilot study. University of Maine, Orono, Maine.

Aldrich, D. V., C. E. Wood, and K. N. Baxter. 1967. Burrowing as a temperature response in postlarval shrimp. Bull. Ecol. Soc. Am. 48:80.

Alvarez, J., C. O. Andrew, and F. J. Prochaska. 1976. Dual structure equilibrium in the Florida shrimp processing industry. Florida Sea Grant Program. University of Florida, Gainesville, Fla. 16 pp.

Alvarez, J., C. O. Andrew, and F. J. Prochaska. 1976. Economic structure of the Florida shrimp processing industry. Florida Sea Grant Program, University of Florida, Gainesville, Fla. Rep. 9. 46 pp.

Alvarez, J., C. O. Andrew, and F. J. Prochaska. 1975. Florida shrimp: from the sea through the market. Florida Sea Grant Program. University of Florida, Gainesville, Fla. 15 pp.

Alverson, D. L. 1975. Management of the ocean's living resources: an essay review. Ocean Dev. and Intern. Law J. 3:99.

Anderson, L. G. 1977. A classification of fishery management problems to aid in the analysis and proper formulation of management problems. Ocean Dev. and Intern. Law J. 4:113.

Anderson, W. W. 1970. Contributions to the life histories of several penaeid shrimps (Penaeidae) along the south Atlantic coast of the United States. U.S. Fish. Wildl. Serv., SSR-F. 605. 24 pp.

Anderson, W. W., M. J. Lindner, and J. E. King. 1949. The shrimp fishery of the southern United States. Comm. Fish. Rev. 11:1-17.

Anderson, W. W., and M. J. Lindner. 1971. Contributions to the biology of the royal red shrimp, Hymenopenaeus robustus Smith. Fish. Bull. 69: 313-336.

Andrew, C. O., and F. J. Prochaska. 1974. Shrimp processing in the southeast: supply problems and structural change. S. J. of Ag. Eco. (1974):247-252.

Anon. 1977. Review of the shallow water shrimp fishery management unit, Gulf of Mexico Fishery Management Council Area. Compiled by staff of the NMFS Galveston Lab. 165 pp.

Association of Village Council Presidents of the Yukon-Kuskokwin Delta Region in Southwestern Alaska. 1977. Recommendations on lands that support Alaska's subsistence living Eskimo and Indian. Unpublished manuscript.

Atlantic States Marine Fishery Commission, Gulf States Marine Fishery Commission, and Pacific States Marine Fishery Commission. 1977. Eastland Fisheries Survey: A report to the congress. 91 pp.

Barr, A. J., J. H. Goodnight, J. P. Sall, and J. T. Helwig. 1976. A user's guide to SAS 76. SAS Institute, Inc. Raleigh, N.C. 329 pp.

Barrett, B. B. 1971. Cooperative Gulf of Mexico estuarine inventory and study, Louisiana. Phase II, Hydrology, and phase III, Sedimentology. La. Wildlife and Fish. Comm., New Orleans, La. 191 pp.

Barrett, B. B., and M. C. Gillespie. 1975. 1975 environmental conditions relative to shrimp production in coastal Louisiana. La. Dept. Wildlife and Fish., Tech. Bull. No. 15:22 pp.

Barrett, B. B., M. C. Gillespie. 1973. Primary factors which influence commercial shrimp production in coastal Louisiana. La. Dept. Wildlife and Fish., Tech. Bull. No. 9:28 pp.

Barrett, B. B., and E. J. Ralph. 1976. 1976 environmental conditions relative to shrimp production in coastal Louisiana. La. Dept. Wildlife and Fish., Tech. Bull. No. 21:20 pp.

Baxter, K. N. 1973. Shrimp discarding by the commercial fishery in the Western Gulf of Mexico. Marine Fisheries Rev. 35:26.

Baxter, K. N., and W. C. Renfro. 1967. Seasonal occurrence and size distribution of postlarval brown and white shrimp near Galveston, Texas, with notes on species identification. U.S. Fish. Wildl. Serv., Fishery Bull. 66:149-158.

Beardsley, G. L. 1970. Distribution of migrating juvenile pink shrimp, Penaeus duorarum, Burkenroad, in Buttonwood Canal, Everglades National Park, Florida. Trans. Am. Fish. Soc. 99:401-408.

Bell, F. W. 1972. Technological externalities and common-property resources: an empirical study of the US northern lobster fishery. J. Political Eco. 80:148-158.

Bell, F. W., et al. 1970. The future of the world's fishery resources: forecasts of demand, supply, and prices to the year 2000 with a discussion of implications for public policy, Washington, D.C.: NMFS, Division of Economic Research, Working Paper No. 65-1, December 1970.

Berry, R. J., and R. C. Benton. 1969. Discarding practices in the Gulf of Mexico shrimp fishery. FAO Fish. Rep. 3:983-999.

Berry, R. J. 1970. Shrimp mortality rates derived from fishery statistics. Pages 66-78 in Proc. Gulf Carib. Fish. Inst., 22d Ann. Ses.

Beverton, R. J. H., and S. J. Holt. 1957. On the dynamics of exploited fish populations. Fishery Investigation, London, 19:533 pp.

Biennial Report - Louisiana Dept. of Conservation. 1918. Miscellaneous comments in biennial report of April 1, 1916-April 1, 1918. 151 pp.

Blackmon, J. H., Jr. 1974. Observation on the immigration of the brown shrimp, Penaeus aztecus, through a tidal pass in the Caminada Bay, Louisiana area. Master's thesis, Louisiana State University, Baton Rouge, La. 58 pp.

Blomo, V., K. Stokes, W. Griffin, W. Grant, and J. Nichols. 1978. Bioeconomic simulation model for the management of the Gulf of Mexico Shrimp Fishery. So. J. Ag. Eco. 10:119-125.

Blomo, V. J., and W. L. Griffin. 1978. Cost and Returns Data: Florida-Based Gulf of Mexico Shrimp Trawlers, 1977. TAMU-SG79-604.

Blomo, V. J., 1979. Bioeconomic analysis and management of the shrimp fishery of the eastern Gulf of Mexico. Ph.D. diss., Texas A&M University. 150 pp.

Blomo, V. J., and J. P. Nichols. 1974. Utilization of finfishes caught incidental to shrimp trawling in the Western Gulf of Mexico. Part I: Evaluation of markets. Texas A&M Univ., College Sta., Tex. Sea Grant Publ. TAMU-SG-74-212. 85 pp.

Bromley, D. W. 1969. Economic efficiency in common property natural resource use: a case study of the ocean fishery. Ph.D. diss., Oregon State University. 162 pp.

Brood, A. C. 1965. Environmental requirements of shrimp. In Clarence M. Tarzwell, ed. Biological problems in water pollution. U.S. Div. Water Supply Pollution Control, 3d Seminar, 1962.

Broom, J. G. 1968. Pond culture of shrimp on Grand Terre Island, Louisiana, 1962-1968. La. Wildl. and Fish. Comm., Mar. Lab., Grand Terre Island, La. 15 pp.

Brown, G. L. 1981. A survey of recreational shrimping in the bay and sound systems of the Gulf coast for 1980. Final Report, Gulf States Marine Fisheries Commission, Ocean Springs, Miss. 147 pp.

Bryan, C. E. 1980. Organisms captured by the commercial shrimp fleet on the Texas brown shrimp (Penaeus aztecus Ives) grounds. Masters' thesis, Corpus Christi State University, Corpus Christi, Texas.

Bryan, C. E., and T. J. Cody. 1975. A study of commercial shrimp, rock shrimp, and potentially commercial finfish 1973-1975. Part I. White shrimp, Penaeus setiferus (Linnaeus), spawning in the Gulf of Mexico off Texas. Coast. Fish. Branch, Texas Parks and Wildl. Dept. P. L. 88-309 Proj. 2-202-R:1-29.

Bryan, C. E., T. J. Cody, and K. W. Rice. 1978. Monitoring of shrimp populations and an evaluation of the Texas shrimp laws in the Gulf of Mexico. Pages 1-29 in Completion Report for Texas Parks and Wildlife Project 2-276-R with U.S. Dept. of Commerce.

Bullis, H. R. 1951. Gulf of Mexico shrimp trawl designs. U.S. Fish. Wildl. Serv. Fish. Leafl. 394, 16 pp.

Burkenroad, M. D. 1934. The Penaeidae of Louisiana with a discussion of their world relationships. Bull. Am. Mus. Nat. Hist. 68:61-143.

Burkenroad, M. D. 1939. Further observations on Penaeidae of the Northern Gulf of Mexico. Bull. Bingham Ocean. Collect. 6:1-62.

Burnett, W. E. 1979. Prototype 'tongue trawl' outshrimps flat nets nearly 20 percent. National Fisherman 59(11):53.

Butlin, J. A. 1974. The role of economics in fisheries management research. Maritime Policy and Management 2:56.

Caillouet, C. W., and F. J. Patella. 1978. Relationship between size composition and ex-vessel value of reported shrimp catches from two Gulf coast states with different harvesting strategies. Marine Fisheries Rev. 40:14-18.

Caillouet, C. W., F. J. Patella, and W. B. Jackson. 1980. Trends toward decreasing size of brown shrimp (Penaeus aztecus) and white shrimp (P. setiferus) in reported annual catches from Texas and Louisiana. Fish. Bull.: Vol. 77, No. 4.

Captiva, F. J. 1966. Trends in shrimp trawler design and construction over the past five decades. Pages 23-30 in Proc. Gulf Carib. Fish. Inst., 19th Ann. Ses.

Cato, J. 1975. Shrimp supplies in the southeast and their effect on processing firm size. Paper presented to the Annual Conference on Marine Resources of the Coastal Plains States. 7 pp.

Cato, J., and F. J. Prochaska. 1975. Economic growth aspects of the Florida shrimp industry. Fishing Gazette 18:10.

Cato, J. C., and F. J. Prochaska. 1977. Primary economic impact of shrimp landings on the Tampa Bay economy. University of Florida, Gainesville, Fla.

Chabreck, R. H. 1972. Vegetation, water and soil characteristics of the Louisiana coastal region. Louisiana State Univ. Agri. Exper. Sta., Baton Rouge, LA. Bull. #664, 72 pp.

Chavez, E. A. 1973. A study on the growth rate of brown shrimp (Penaeus aztecus Ives, 1891) from the coasts of Veracruz and Tampaulipas, Mexico. Gulf Res. Rep. 4:278-299.

Chin, E. 1960. The bait shrimp fishery of Galveston Bay, Texas. Trans. Am. Fish. Soc. 89:135-141.

Chieborowicz, A. G. 1974. Evaluation of twin-trawl shrimp fishing gear. Sea Grant Pub. UNC-SG-74-10 (Addendum), North Carolina State Univ. 14 pp.

Christmas, J. Y. 1973. Cooperative Gulf of Mexico estuarine inventory and study, Mississippi. Phase I: Area description. Phase II: Hydrology. Phase III: Sedimentology. Phase IV: Biology. Gulf Coast Res. Lab., Ocean Springs, Miss. 434 pp.

Christmas, J. Y., and D. J. Etzold. 1977. The shrimp fishery of the Gulf of Mexico United States: a regional management plan. Gulf Coast Res. Lab., Ocean Springs, Miss., Tech. Report Ser. No. 2:128 pp.

Christmas, J. Y., G. Gunter, and P. Musgrave. 1966. Studies on annual abundance of postlarval penaeid shrimp in the estuarine waters of Mississippi as related to subsequent commercial catches. Gulf Res. Rep. 2:117-212.

Christmas, J. Y., W. Langley, and T. Van Devender. 1976. Investigations of commercially important penaeid shrimp in Mississippi. Gulf Coast Res. Lab., Ocean Springs, Miss. 66 pp.

Chui, M. K. 1980. Exvessel demand by size for the Gulf shrimp. Masters Thesis. Texas A&M Universith, College Station, Texas.

Clark, S. H., P. A. Emiliani, and R. A. Neal. 1974. Release and recovery data from brown and white shrimp mark-recapture studies in the northern Gulf of Mexico May 1967-November 1969. NMFS Data Rept. 85. 152 pp.

Cleary, D. P. 1975. Demand and prices for shrimp. Bureau of Commercial Fisheries, Division of Economic Research, Washington, D.C. Working Paper No. 15.

Coase, R. H. 1968. The problem of social cost. Pages 423-456 in Readings in microeconomics, ed. William Briet and H. M. Hochman. Holt, Rinehart and Winston, New York.

Cobb, S. P., C. R. Futch, and D. K. Camp. 1973. Memoirs of the Hourglass cruises: the rock shrimp, Sicyonia brevirostris Stimpson, 1871 (Decapoda, Penaeidae). Fla. Dept. Nat. Res. Mar. Res. Lab. 38 pp.

Cohen, Y. A., ed. 1968. Man in adaptation: the cultural present. Aldine Publishing Co., Chicago, Ill.

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. 12:109-127.

Copeland, B. J. 1965. Fauna of the Aransas Pass Inlet, Texas. I. Emigration as shown by tide trap collections. Publ. Inst. Mar. Sci., Univ. of Texas. 10:9-21.

Copeland, B. J., and M. V. Truitt. 1966. Fauna of the Aransas Pass Inlet, Texas. II. Penaeid shrimp postlarvae. Texas J. Sci. 18:65-74.

Cordell, J. 1974. The lunar-tide fishing cycle in northeastern Brazil. Ethnology 13:379-392.

Costello, T. J. 1964. Pink shrimp life history. Pages 30-31 in U.S. Fish. and Wildl. Cir. 183.

Costello, T. J., and D. M. Allen. 1960. Notes on the migration and growth of pink shrimp (Penaeus duorarum). Proc. Gulf Carib. Fish. Inst. 12:5-9.

Costello, T. J., and D. M. Allen. 1961. Migrations, mortality, and growth of pink shrimp. Pages 18-21 in U.S. Fish. Wildl. Serv. Cir. 129.

Costello, T. J. and D. M. Allen. 1965. Migrations and geographic distribution of pink shrimp, Penaeus duorarum, of the Tortugas and Sanibel Grounds, Florida. Fish. Bull. 65:449-459.

Costello, T.J. and D. M. Allen. 1968. Mortality rates in populations of pink shrimp, Penaeus duorarum, on the Sanibel and Tortugas grounds, Florida. Fish. Bull. 66:491-502.

Costello, T. J., and D. M. Allen. 1970. Synopsis of biological data on the pink shrimp Penaeus duorarum Burkenroad, 1939. FAO Fish. Rep. 57:1499-1537.

Craig, F. J. III, J. T. Bockrath, and K. D. Marcel. 1978. Management institutions, policies and jurisdiction of the Gulf of Mexico shrimp fisheries. Unpublished manuscript. Louisiana State University Center for Wetland Resources, Baton Rouge, La. Unpublished manuscript. 210 pp.

Crance, J. H. 1971. Description of Alabama estuarine area--cooperative Gulf of Mexico Inventory. Ala. Mar. Res. Bull. 6. 85 pp.

Critchfield, R. 1973. The golden bowl is broken: peasant life in four cultures. Indiana Univ. Press, Bloomington, Ind. 312 pp.

Crutchfield, J. A. 1973. Fisherman quotas: A tentative suggestion for domestic management. Unpublished manuscript. 7 pp.

Crutchfield, J. A., and A. Zellner. 1962. Economic aspects of the Pacific Halibut Fishery. Fish. Indus. Res. 1:41-77.

Cummings, W. C. 1961. Maturation and spawning of pink shrimp, Penaeus duorarum Burkenroad. Trans. Am. Fish. Soc. 90:462-468.

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

Davis, H. H. Jr. 1940. The ecology and geologic role of mangroves in Florida. Carnegie Inst. Washington Pub. No. 517. Papers Tortugas Lab. 32:303-412.

Department of Natural Resources, Louisiana. 1980. Regulations for the fishermen's gear compensation fund.

Diener, R. A. 1975. Cooperative Gulf of Mexico estuarine inventory and study, Texas: Area description. U.S. Dept. Comm., NOAA Tech. Rep. NMFS CIRC-393. 129 pp.

Doll, J. P. 1972. An econometric analysis of shrimp exvessel prices, 1950-1968. Am. J. of Ag. Eco. 54:431-440.

Eldred, B. 1959. Notes of Trachypeneus (Trachysalambris) similis (Smith) in the Tortugas shrimp fishery. Quar. J. Florida Acad. Sci. 22:75-76.

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. Florida St. Board Conserv., Prof. Paper Series 3:1-139.

Everhart, W. H., A. W. Eipper, and W. D. Young. 1975. Principles of fishery science. Cornell University Press, Ithaca, N.Y. 288 pp.

Ewald, J. J. 1965. The laboratory rearing of pink shrimp, Penaeus duorarum Burkenroad. Pages 436-449 in Contrib. no. 615 from Mar. Lab., Inst. of Mar. Sci., University of Miami.

Farfante, Isabel Perez. 1969. Western Atlantic shrimps of the genus Penaeus. Fish. Bull. 67:461-591.

Farfante, Isabel Perez. 1977. American solenocerid shrimps of the genera Hymenopenaeus, Haliporoides, Pleoticus, Hadropenaeus, new genus, and Mesopenaeus, new genus. Fish. Bull. 75: 261-346.

Farley, Orman. 1981. Personal communication. National Marine Fisheries Service, Galveston, Texas.

Firth, R. 1946. Malay fishermen: their peasant economy. Kegan Paul, Trench, Trubner & Co., London.

Fisher, W. L., L. F. Brown Jr., J. H. McGowen, and C. G. Groat. 1973. Environmental geologic atlas of the Texas Coastal Zone: Beaumont-Port Arthur Area. Bur. Eco. Geol., University of Texas, Austin, Texas. 93 pp. and 9 plates.

Fisher, W. L., J. H. McGowen, L. F. Brown Jr., and C. G. Groat. 1972. Environmental geologic atlas of the Texas coastal zone: Galveston-Houston area. Bur. Eco. Geol., University of Texas, Austin, Texas. 91 pp. and 9 plates.

Flint, L. H. 1956. Notes on the algal food of shrimp and oysters. Proc. La. Acad. Sci. 19:11-14.

Ford, T. B., and L. S. St. Amant. 1971. Management guidelines for predicting brown shrimp, Penaeus aztecus, production in Louisiana. Pages 149-161 in Proc. Gulf Carib. Fish. Inst., 23d Ann. Ses.

Forman, S. 1970. The raft fishermen: tradition and change in the Brazilian peasant economy. Indiana University Press, Bloomington, Ind. 158 pp.

Fontaine, C. T., and R. A. Neal. 1971. Length-weight relations for three commercially important penaeid shrimp of the Gulf of Mexico. Trans. Am. Fish. Soc. 100:584-586.

Fox, W. W. Jr. 1975. Fitting the generalized stock production model by least-squares and equilibrium approximation. Fish. Bull. 73:23-36.

Fox, W. W. Jr. 1981. Personal communication. National Marine Fisheries Service, Southeast Fisheries Center, Miami, Florida.

Fuller, D. A. 1978. The habits, distribution and incidental capture of sea turtles in the Gulf of Mexico. Louisiana State University Center for Wetland Resources, Baton Rouge, La. Unpublished manuscript. 46 pp.

Futch, C. R., and D. S. Beaumariage. 1965. A report on the bait shrimp fishery of Lee County, Florida. Fla. St. Board Conserv. Mar. Lab., St. Petersburg, FL, FBCML No. 65-1. 22 pp.

Gaidry, W. J. III, and C. J. White. 1973. Investigations of commercially important penaeid shrimp in Louisiana estuaries. La. Wildlife and Fish. Comm., Tech. Bull. 8. 154 pp.

Gates, J. M., and V. J. Norton. 1974. The benefits of fisheries regulation: A case study of the New England yellowtail flounder fishery. University of Rhode Island Mar. Tech. Rep. 21. 35 pp.

Gillespie, W. C., J. C. Hite, and J. S. Lytle. 1969. An econometric analysis of the U.S. shrimp industry. Clemson University Agricultural Experiment Station, Clemson, S.C. Economics of Marine Resources No. 2, AE330.

Gosselink, J. G., ed. In Press. A characterization of the Chenier Plain coastal ecosystem of Louisiana and Texas. USFWS, FWS/OBS-78/11.

Gosselink, J. G., and R. H. Baumann. 1978. Wetland inventories: wetland loss along the United States coast. Paper presented at the Coastal Symposium of the joint Assoc. of Amer. Geog/Intern. Geog. Union meetings. New Orleans, La. 1978. Unpublished manuscript from Louisiana State University Center for Wetland Resources, Baton Rouge, La. 25 pp.

Grant, W. E., and W. L. Griffin. In Press. A bioeconomic model of the Gulf of Mexico shrimp fishery. Trans. Am. Fish. Soc.

Grant, W., K. Isakson and W. Griffin. 1980. A General bio-economic simulation model for annual-crop marine fisheries. Manuscript submitted to Journal of Ecological Modeling. Department of Wildlife and Fisheries Sciences and Department of Agricultural Economics. Texas A&M University, College Station, Texas.

Griffin, W. L. 1978. Estimation of relative fishing power from interviewed landings to total landings. Texas A&M University, College Station, Texas. Unpublished manuscript. 23 pp.

Griffin, W. and B. Beattie. 1977. Mexico's 200-Mile offshore fishing zone: Its economic impact on the U.S. Gulf of Mexico shrimp fishery. Sea Grant Publication TAMU-SG-77-210. Department of Agriculture Economics. Texas A&M University, College Station, Texas.

Griffin, W. L., and B. R. Beattie. 1978. Economic impact of Mexico's 200-mile offshore fishing zone on the U.S. Gulf of Mexico shrimp fishery. Land Economics. 54:27-38.

Griffin, W. L., and J. R. Nichols. 1975. Trends in catch-effort relationships with economic implications: Gulf of Mexico Shrimp Fishery. Marine Fisheries Rev. 37:1-4.

Griffin, W. L., D. Smith, R. D. Lacewell, and J. P. Nichols. 1973. National Marine Fisheries Service shrimp landings: Description of data availability. Texas A&M University Ag. Exp. Station, Dept. Int. Rept. No. 73-3:17 pp.

Griffin, W. L., R. D. Lacewell and J. P. Nichols. 1976. Optimum effort and rent distribution in the Gulf of Mexico shrimp fishery. Amer. J. Agr. Econ. Vol. 58, No. 4. pp. 644-652.

Griffin, W., J. Nichols, R. Anderson, J. Buckner and C. Adams. 1978. Cost and returns data: Texas shrimp trawlers Gulf of Mexico, 1974-75. Sea Grant Publication TAMU-SG-79-601. Department of Agriculture Economics. Texas A&M University, College Station, Texas.

Griffin, W., W. Grant, J. Warren, and J. Nichols. (In press). Analysis of suggested policies for the Texas shrimp fishery. Department of Agriculture Economics. Texas Agricultural Experiment Station. Texas A&M University. Staff Paper Series.

Gulf of Mexico Fishery Management Council. 1980. Portion of June, 1980 minutes relating to shrimp industry economic condition and conditional fishery. Naples, Florida.

Gulf and South Atlantic Fisheries Development Foundation, Inc. 1981. Minority participation in the fisheries of the Gulf and south Atlantic. Interim Report prepared by Frank Orth & Associates, Inc.

Gulland, J. A. 1972. Some introductory guidelines to management of shrimp fisheries, FAO, Rome. J. Cons. Perm. Int. Explor. Mer. 33:471-477.

Gulland, J. A. 1974. The management of marine fisheries. University of Washington Press. Seattle, Wash. 198 pp.

Gunter, G. 1945. Studies on marine fishes of Texas. Publ. Inst. Mar. Sci. University of Texas 1:1-190.

Gunter, G. 1950. Seasonal population changes and distribution as related to salinity, of certain invertebrates of the Texas coast, including the commercial shrimp. Publ. Inst. Mar. Sci., University of Texas. 1:7-51.

Gunter, G. 1955. Principles of fishery management. Pages 99-106 in Proc. Gulf Carib. Fish. Inst. 8th Ann. Ses.

Gunter, G. 1962. Shrimp landings and production of the state of Texas for the period 1956-1959 with comparison with other Gulf States. Publ. Inst. Mar. Sci., University of Texas. 8:216-226.

Gunter, G., ard J. C. Edwards. 1969. The relation of rainfall and fresh water drainage to the production of penaeid shrimp (Penaeus fluviatilis Say and Penaeus aztecus Ives) in Texas and Louisiana waters. FAO. Fish Rep. 57:875-892.

Gunter, G., and W. E. Snell. 1958. A study of an estuarine area with water-level control in the Louisiana marsh. Proc. La. Acad. Sci. 21:5-34.

Gutherz, E. J., G. M. Russell, A. F. Serra, and B. A. Rohr. 1975. Synopsis of the northern Gulf of Mexico industrial and foodfish industries. Marine Fisheries Rev. 37:1-11.

Harrington, D. L. 1975. Four nets, more shrimp. NOAA magazine, Vol. 15, No. 3.

Harrington, D. L., M. R. Bartlett, and J. Higgins. 1972. Shrimp fishing with twin trawls (Addendum). University of Georgia, Marine Ext. Bull. No. 1.

Hayenga, W. A., R. D. Lacewell, and W. L. Griffin. 1974. An economic and financial analysis of Gulf of Mexico shrimp vessels. U.S. Dept. of Commerce, NOAA, National Marine Fisheries Service, Contract No. 03-3-042-19. Texas A&M University Ag. Exp. Sta. MP No. 1138.

Heady, E. O., and J. L. Dillon. 1961. Agriculture production functions. Iowa State University Press, Ames, Iowa. 667 pp.

Hedgpeth, J. W. 1953. An introduction to the zoogeography of the northwest Gulf of Mexico with reference to invertebrate fauna. Publ. Inst. Mar. Sci., University of Texas 3:107-224.

Higman, J. B. 1952. Preliminary investigation of the live bait shrimp fishery of Florida Bay and the Keys. Fla. St. Board Conserv., Mar. Lab., Univ. Miami, 52-20, 8 pp.

Higman, J. B. 1955. Observations on the live bait shrimp industry of Pasco and Pinellas Counties, Florida. Fla. St. Board Conserv., Mar. Lab., Univ. Miami, 55-16, 4 pp.

Higman, J. B., and R. Ellis. 1955. Investigation of sport and commercial fishery activities in Old Tampa Bay north of Gandy Bridge. Fla. State Bd. Conserv. Mar. Lab., Univ. Miami, 55-20:5 pp.

Higman, J. B., B. J. Yokel, and M. A. Roessler. n.d. Growth of pink shrimp in the Everglades estuary, 1968-1971. Final report to NMFS on contract UM-RSMAS-72007. Univ. of Miami, Rosenstiel School of Mar. and Atmos. Sci. 55 pp.

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., Univ. of Texas 3:234-366.

Hildebrand, H. H. 1955. A study of the fauna of the pink shrimp (Penaeus duorarum Burkenroad) grounds in the Gulf of Campeche. Publ. Inst. Mar. Sci., Univ. of Texas 4:169-232.

Hillestad, H. O., J. I. Richardson, and G. K. Williamson. 1977. Incidental capture of sea turtles by shrimp trawlermen in Georgia. A report to NMFS, Miami, Florida by Southeast Wildl. Services, Inc., Athens, Ga. 106 pp.

Holloway, S. 1981. Personal communication, National Marine Fisheries Service, Galveston Laboratory, Galveston, Texas.

Hutton, R. F., B. Eldred, K. D. Woodburn, and R. M. Ingle. 1956. The ecology of Boca Ciega Bay with special reference to dredging and filling operations. Fla. St. Board Conserv. Tech. Ser. 17. 87 pp.

Hydraulic Laboratory, Department of Civil Engineering, University of Florida. 1978. Shrimp beam trawl--design, construction and operation. Report 7804. 42 pp.

Idyll, C. P. 1963. The shrimp fishery. Pages 160-182 in M. E. Stansby, ed. Industrial fishery technology. Reinhold Publishing Co., New York. 393 pp.

Ingle, R. M. 1960. Synoptic rationale of existing Florida shrimp regulations. Pages 22-27 in Proc. Gulf Carib. Fish. Inst. 13th Annual Session.

Ingle, R. M., B. Eldred, H. Jones, and R. F. Hutton. 1959. Preliminary analysis of Tortugas shrimp sampling data 1957-1958. Fla. St. Board Conserv. Tech. Series 32. 45 pp.

Inglis, A., and E. Chin. 1966. The bait shrimp fishery of the Gulf of Mexico. Bur. Comm. Fisheries Biol. Lab., Galveston, Texas, Fish. Leaflet 582. 10 pp.

Iversen, E. S., and C. P. Idyll. 1960. Aspects of the biology of the Tortugas pink shrimp, Penaeus duorarum. Trans. Am. Fish. Soc. 89:1-8.

Iversen, E. S., A. E. Jones, C. P. Idyll. 1960. Size distribution of pink shrimp, Penaeus duorarum, and fleet concentrations on the Tortugas grounds. U.S. Fish. Wildl. Serv. Special Scientific Report 356. 62 pp.

Jacob, J. W. Jr. 1971. Observations on the distribution, growth, survival, and biomass of juvenile and subadult Penaeus aztecus in southern Louisiana. Master's thesis, Louisiana State University, Baton Rouge. 68 pp.

Johnson, D.G. 1958. "Supply function-some facts and notions." Agricultural Adjustments Problems in a Growing Economy. Ames: Iowa State College Press.

Johnson, F., and M. Lindner. 1934. Shrimp industry of the South Atlantic and Gulf States with notes on other domestic and foreign areas. U.S. Bur. Comm. Fisheries Investigational Rep. 21:1-34.

Johnson, M. C., and J. R. Fielding. 1956. Propagation of the white shrimp, Penaeus setiferus (Linnaeus) in captivity. Tulane Studies in Zoology. Vol. 4:173-190.

Jones, A. C., D. E. Dimitriou, J. J. Ewald, and J. H. Tweedy. 1964. Distribution of pink shrimp larvae (Penaeus duorarum Burkenroad) in waters of the Tortugas Shelf, Gulf of Mexico. Inst. Mar. Sci., Univ. of Miami. 105 pp.

Jones, L. L., J. W. Adams, W. L. Griffin, and J. Allen. 1974. Impact of commercial shrimp landings on the economy of Texas and coastal regions. TAMU-SG-75-204.

Jones, R. R. Jr. 1973. Utilization of Louisiana estuarine sediments as a source of nutrition for the brown shrimp, Penaeus aztecus. Ph.D. diss., Louisiana State University. 125 pp.

Joyce, E. A. Jr. 1965. The commercial shrimps of the northeast coast of Florida. Fla. St. Board Conserv., Prof. Paper Series 6. 224 pp.

Juhl, R. 1974. Economics of Gulf of Mexico industrial and foodfish trawlers. Marine Fisheries Rev. 36:39-42.

Juhl, R., S. B. Drummond, E. J. Gutherz, C. H. Roithmayer, J. A. Benigno, and J. A. Butler. 1976. Oceanic resource surveys and assessment task, status report. NMFS, SEFC, Pascagoula, Miss. 50 pp.

Juneau, C. L. 1977. A study of the seabob, Xiphopeneus kroyeri (Heller) in Louisiana. La. Dept. Wildlife and Fish. Tech. Bull. 24. 24 pp.

Kennedy, F. S., J. J. Crane, R. A. Schleider, and D. G. Barber. 1977. Studies of the rock shrimp, Sicyonia brevirostris Stimpson, 1871, a new fishery resource on Florida's Atlantic shelf. Florida Mar. Res. Publ. No. 27. 69 pp.

Khilmani, A. and E. T. S. Tse. 1980. Integrated approaches to fisheries policy analysis: A case study of the Tortugas shrimp fishery. Unpublished report to the Southeast Fisheries Center, NMFS, NOAA. Dept. of Engineering and Economic Systems. Stanford University. Stanford, California.

King, B. D. III. [1975]. Harvest of shrimp by Texas sport fishermen 1973. Pages 22-36 in Coastal Fisheries Project Report 1973, Texas Parks and Wildl. Dept., Austin, Tex.

King, J. E. 1948. A study of the reproductive organs of the common marine shrimp, Penaeus setiferus (Linnaeus). Biol. Bull. (Woods Hole). 94:244-262.

Klima, E. F. 1964. Mark-recapture experiments with brown and white shrimp in the northern Gulf of Mexico. Pages 52-64 in Proc. Gulf Carib. Fish. Inst., 17th Ann. Ses.

Klima, E. F. 1974. A white shrimp mark-recapture study. Trans. Am. Fish. Soc. 103:107-113.

Klima, E. F. 1976. A review of the fishery resources in the western central Atlantic. FAO WECAF Studies No. 3. 77 pp.

Klima, E. F., and J. A. Benigno. 1965. Mark-recapture experiments. Pages 38-40 in U.S. Fish. Wildl. Cir. No. 230.

Klima, E. F., and R. S. Ford. 1970. Gear and techniques employed in the Gulf of Mexico shrimp fishery. Conf. on Canadian Shrimp Fishery. 26 pp.

Klima, E. F., and M. Parrack. 1978. Constraints on food production from wild Penaeid shrimp stocks in the Gulf of Mexico. Pages 317-330 in P. N. Kaul and C. J. Sinderman, eds. Drugs and food from the sea: myth or reality? University Oklahoma Press, Norman, Okla.

Knight, C. E. 1966. Mark-recapture experiments. Pages 21-23 in U.S. Fish Wildl. Serv. Cir. No. 246.

Kreitler, C. W. 1977. Faulting and land subsidence from ground-water and hydrocarbon production, Houston-Galveston, Texas. Pages 435-446 in Proc. Second International Symposium on Land Subsidence, Internat. Assoc. of Hydrol. Sci. Publ. No. 121.

Kutkuhn, J. H. 1962. Recent trends in white shrimp catch of the northern Gulf. Pages 3-19 in Proc. Gulf and Carib. Fish Inst., 14th Ann. Ses.

Kutkuhn, J. H. 1966. Dynamics of a penaeid shrimp population and management implications. U.S. Fish. Wildl. Serv. Fish. Bull. 65:313-338

Lacewell, R. D., W. L. Griffin, J. E. Smith, and W. A. Hayenga. 1974. Estimated costs and returns for Gulf of Mexico shrimp vessels: 1971. Texas A&M University System Agri. Exp. Sta. Tech. Rept.

Lapin, L. L. 1973. Statistics for modern business decisions. Harcourt Brace Jovanovich, Inc. San Francisco, California.

Lee, E. 1979. Progress report on shrimp population dynamics and management. Dept. of Energy, SPRMO, 900 E. Commerce, Harrahan, La. Unpublished manuscript. 10 pp.

Leipper, D. F. 1954. Physical oceanography of the Gulf of Mexico. Pages 117-137 in D. S. Galtsoff, ed. Gulf of Mexico, its origin, waters and marine life. U.S. Fish Wildl. Serv. Bull. No. 55.

Lindall, W. N., and C. H. Saloman. 1977. Alteration and destruction of estuaries affecting fishery resources of the Gulf of Mexico. Marine Fisheries Rev. 39:1-7.

Lindner, M. J. 1966. What we know about shrimp size and the Tortugas fishery. Pages 18-26 in Proc. Gulf Carib. Fish. Inst. 18th Ann. Ses., 1965.

Lindner, M. J., and W. W. Anderson. 1956. Growth, migrations, spawning and size distribution of shrimp, Penaeus setiferus. Fish. Bull. 56:555-645.

Loesch, H. 1957. Observations on bait shrimping activities in rivers north of Mobile Bay Causeway. J. Ala. Acad. Sci. 29:36-43.

Loesch, H. 1965. Distribution and growth of penaeid shrimp in Mobile Bay, Alabama. Publ. Inst. Mar. Sci., Univ. of Texas 10:41-58.

Lunz, G. R. Jr. 1957. Notes on rock shrimp, Sicyonia brevirostris Stimpson from exploratory trawling off the South Carolina coast. Contrib. Bears Bluff Lab. 25. 10 pp.

Marinovich, S., and R. T. Whiteleather. 1968. Gulf of Mexico shrimp trawls, current trends in design, and prospective developments. The future of the fishing industry of the United States. University of Washington Fisheries Publ. Vol. 4 N.S.

Martosubrato, P. 1974. Fecundity of pink shrimp, Penaeus duorarum Burkenroad. Bull. Mar. Sci., Gulf and Carib. 24:606-627.

McCoy, E. G. 1972. Dynamics of North Carolina commercial shrimp populations. North Carolina Dept. of Nat. and Eco. Resources, Div. Comm. and Sports Fish. Special Sci. Rep. No. 21.

McGowen, J. H., C. V. Proctor Jr., L. F. Brown Jr., T. J. Evans, W. L. Fisher, and C. G. Groat. 1976. Environmental geologic atlas of the Texas coastal zone-Port Lavaca Area. Bur. Eco. Geol., Univ. of Texas, Austin. 107 pp. and 9 plates.

McGowen, J. H., L. F. Brown Jr., T. J. Evans, W. L. Fisher, and C. G. Groat. 1976. Environmental geologic atlas of the Texas coastal zone-Bay City-Freeport Area. Bur. Eco. Geol., Univ. of Texas, Austin. 97 pp. and 9 plates.

McHugh, J. L. 1966. Management of estuarine fisheries. Pages 133-154 in Am. Fish. Soc. Spec. Pub. No. 3.

McNulty, J. K., W. N. Lindall Jr., and J. E. Sykes. 1972. Cooperative Gulf of Mexico estuarine inventory and study, Florida: Phase I, area description. U.S. Dept. Commerce, NOAA Tech. Rep. NMFS CIRC-368. 126 pp.

Miller, M. M. 1975. The role of shrimp imports in a declining seafoods market - A background paper. Division of Economic and Marketing Research. U.S. Dept. of Commerce, NOAA. NMFS mimeo.

Miller, M. and R. Marasco. 1976. Statement on applying import controls on shrimp products entering the United States. Unpublished National Marine Fisheries Service Draft Report. Washington, D.C.

Mock, C. R. 1967. Natural and altered estuarine habitats of penaeid shrimp. Pages 86-98 in Proc. Gulf Carib. Fish. Inst., 19th Ann. Ses.

Moraney, J. R., and A. L. Toevs. 1977. Factor costs and factor use: An analysis of labor, capital and natural resource inputs. S. Eco. J. Vol. 44.

Morris, R. A. and F. Prochaska. 1979. Economic impact of the processing and marketing of commercial Florida marine landings. Florida Sea Grant Report No. 26.

National Marine Fisheries Service. 1980. Shellfish Market Review. Washington, D.C. November.

National Marine Fisheries Service. 1980a. Trends and Conditions of the Fisheries of Texas. Galveston, Texas. December.

Neiva, G. de S. 1967. Observations on the shrimp fisheries of the central and southern coast of Brazil. FAO Fish. Rep. 57:847-858.

Nelson, R. K. 1969. Hunters of the northern ice. Univ. of Chicago Press, Chicago, Ill. 429 pp.

Neter, J., and W. Wasserman. 1974. Applied linear statistical models. Richard D. Irwin, Inc., Homewood, Ill. 842 pp.

Nietschmann, B. 1973. Between land and water: the subsistence ecology of the Miskito Indians, Eastern Nicaragua. Seminar Press, New York. 279 pp.

Nissan, E., D.C. Williams, Jr., and T. Green. 1978. An economic input-output analysis for Mississippi-Alabama coastal counties. Ms.-Al. Sea Grant Program MAS-GP-78-029.

Odum, W. E. 1971. Pathways of energy flow in a south Florida estuary--Univ. of Miami Sea Grant Program Tech. Bull. 7. 161 pp.

Ogren, L. H. 1977. Survey and reconnaissance of sea turtles in the northern Gulf of Mexico. NMFS, Panama City, Fla. 8 pp. (mimeo).

Olson, F. L. 1975. Fisheries management with landing fees and subsidies, presented at the Northeast Fish and Wildlife Conference, Northeast Division, American Fisheries Society.

Orbach, M. K. 1978. Social and cultural aspects of limited entry. Unpublished paper prepared for the workshop and conference on limitation of entry into fisheries, Institute for Marine Studies, Univ. of Washington.

Owers, J. 1975. Limitation of entry in the United States fishing industry, a comment. Land Economics 51:177-178.

Parrack, M. L. 1978. Aspects of brown shrimp in the northern Gulf of Mexico. Prepublication manuscript, NMFS, Galveston Lab. 26 pp.

Pearson, J. C. 1939. The early life histories of some American Penaeidae, chiefly the commercial shrimp, Penaeus setiferus (Linnaeus). U.S. Bur. Fish. Bull. Vol. 49. 73 pp.

Pella, J. J., and P. K. Tomlinson. 1969. A generalized stock production model. Inter-Am. Trop. Tuna Comm. Bull. 13:419-496.

Perez, L. O., and P. G. Groth. 1978. Interaction among user groups of the U.S. Gulf shrimp fishery. Unpublished manuscript. Louisiana State University Center for Wetland Resources, Baton Rouge, La. 10 pp.

Perrett, W. S. 1966. Occurrence, abundance, and size distribution of fishes and crustaceans collected with otter trawl in Vermilion Bay, Louisiana. Master's thesis, University of Southwestern Louisiana, Lafayette, La.

Perrett, W. S., B. B. Barrett, W. R. Latapie, J. F. Pollard, W. R. Mock, G. B. Adkins, W. J. Gaidry, and C. J. White. 1971. Cooperative Gulf of Mexico estuarine inventory and study, Louisiana. Phase I, Area Description and Phase IV, Biology. Louisiana Wildlife and Fish. Comm., New Orleans, La. 175 pp.

Perrett, W. S., S. T. Kuzenski, and J. M. Lyon. 1978. Dollars in your shrimp trawl? Louisiana Conservationist 30:22-23.

Phares, P.L. 1978. An analysis of some shrimp trawl mesh size selection data. Mimeographed report prepared for the Gulf of Mexico Fishery Management Council, Tampa, Florida. 33 pp.

Phares, P.L. 1980. Estimates of natural fishing mortality for white shrimp in the Gulf of Mexico. NOAA Tech. Memo. NMFS-SEFC-58. 21 pp.

Price, W. A. 1954. Shorelines and coasts of the Gulf of Mexico. Pages 39-65 in D. S. Galtsoff, ed. Gulf of Mexico: its origin, waters, and marine life. U.S. Fish Wildl. Serv. Bull. No. 55.

Prochaska, F. J. and J. C. Cato. 1975. Economic Growth Aspects of the Florida shrimp industry. Fishing Gazette. October. New York. pp. 18-20.

Quick Frozen Foods. 1980. 1979 Retail and institutional frozen fish and seafood poundage and estimated dollar value. October.

Renfro, W. C., and H. A. Brusher. 1964. Population distribution and spawning. Pages 13-15 in U.S. Fish Wildl. Cir. No. 183.

Renfro, W. C., and H. A. Brusher. 1965. Distribution and intensity of shrimp spawning activity. Pages 68-70 in U.S. Fish Wildl. Cir. 230.

Renfro, W. C., and H. L. Cook. 1963. Early larval stages of the seabob, Xiphopenaeus kroyeri (Heller). U.S. Fish Wildl. Fish. Bull. 63:165177.

Ricker, W. E. 1958. Handbook of computations for biological statistics of fish populations. Bull. Fish. Res. Board Canada. No. 119. 300 pp.

Ringo, R. D. 1965. Dispersion and growth of young brown shrimp. Pages 68-70 in U.S. Fish Wildl. Cir. No. 230.

Roberts, K. J. 1980. Current economic condition and forecasts for Louisiana shrimp vessels. Speech to Gulf States Marine Fisheries Commission Annual Meeting. Orlando, October, 1980.

Roberts, K. J. and M. Thompson. 1981. Commercial fishing licensees in Louisiana 1976-1980. Sea Grant Publ.

Roberts, K. J. and M. E. Sass. 1979. Financial aspects of Louisiana shrimp vessels, 1978. Sea Grant Publ. No. LSU-TL-79-007.

Roberts, K. J. and M. E. Sass. 1980. Louisiana's inshore shrimp fishery. Sea Grant Publication No. LSU-TL80-003.

Roe, R. 1969. Distribution of royal red shrimp, Hymenopenaeus robustus, on three potential commercial grounds off the southeastern United States. U.S. Fish. Wildl. Serv., Fish Ind. Res. 5:161-174.

Roedel, P. M., ed. 1975. Optimum sustainable yield as a concept in fisheries management. J. Am. Fish. Soc. 89 pp.

Rouse, W. L. 1969. Littoral crustacea from southwest Florida. Quart. J. Florida Acad. Sci. 32:127-152.

Russell, E. S. 1931. Some theoretical considerations on the 'overfishing' problem. J. Cons. Perm. Int. Explor. Mer. 6:3-27.

Ryan, J. J. 1969. A sedimentologic study of Mobile Bay, Alabama. Florida State Univ. Dept. Geology, Sedimentological Res. Lab. Contrib. 30. 110 pp.

Saloman, C. H. 1965. Bait shrimp (Penaeus duorarum) in Tampa Bay, Florida--biology, fishery economics, and changing habitat. U.S. Fish Wildl. Serv., Spec. Sci. Rep. No. 520. 16 pp.

Saloman, C. H., D. M. Allen and T. J. Costello. 1968. Distribution of three species of shrimp (genus Penaeus) in waters contiguous to south Florida. Bull. of Marine Science. 18: 343-350.

Sarkar, S. R. 1974. Socioeconomic aspects of sponge fishing. Anthropos. 69:569-589.

Sass, M. E. 1979. Descriptive annual statistics for brown and white shrimp in Louisiana waters. 1963-76. Sea Grant Publ. No. LSU-TL-79-004.

Sass, M. E. and K. J. Roberts. 1979. Characteristics of the Louisiana shrimp fleet, 1978. Sea Grant Publ. No. LSU-TL-79-006.

Schaefer, M. B. 1954. Some aspects of the dynamics of populations important to the management of the commercial marine fisheries. Bulletin Inter.-Am. Trop. Tuna Comm. 1:25-56.

Schaefer, M. B., and R. J. H. Beverton. 1963. Fishery dynamics: Their analysis and interpretation. Pages 464-479 in M. N. Hill, ed. The Sea. 2 vols. Interscience Publishers.

Seidel, W. R. 1975. A shrimp separator trawl for southeast fisheries. Pages 66-76 in Proc. Gulf Carib. Fish. Inst., 27th Ann. Ses.

Siegel, S. 1956. Nonparametric statistics for the behavioral sciences. McGraw-Hill Book Co., New York. 312 pp.

Sinclair, W. F., and R. W. Morley. 1975. Statistical bias problem in on-site surveys: The severity of the problem and its potential for solution. J. Fish. Res. Board Can. 32:2520-2524.

Snedecor, G. W., and W. G. Cochran. 1978. Statistical methods. Iowa State Univ. Press. Ames, Iowa. 593 pp.

Springer, S., and H. R. Bullis. 1954. Exploratory shrimp fishing in the Gulf of Mexico, summary report for 1952-1954. Comm. Fish. Rev. 16:1-16.

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. Pages 1-17 Proc. Gulf and Carib. Fish. Inst., 18th Ann. Ses.

St. Amant, L. S., K. C. Corkum, and J. G. Broom. 1962. Studies of growth dynamics of the brown shrimp, Penaeus aztecus, in Louisiana waters. Bull. Mar. Sci., Gulf and Carib. 15:14-26.

Stokes, G. M. 1974. The distribution and abundance of penaeid shrimp in the Lower Laguna Madre of Texas, with a description of the live bait shrimp fishery. Texas Parks and Wildl. Dept. Tech. Series No. 15. 32 pp.

Sturges, W., and J. P. Blaha. 1976. A western boundary current in the Gulf of Mexico. Science 192:367-369.

Surdi, R., M. Miller, R. Morasco. 1979. Report on 1979 survey of commercial fishing vessel construction in the U.S. Unpublished National Marine Fisheries Service Report. Washington, D.C.

Swartz, A. N. 1980. The characteristics of the Texas shrimp fleet. TAMU, Dept. of Ag. Econ. Staff Papers, Oir. 80-1, SP-2.

Swingle, H. A. 1971. Biology of Alabama estuarine areas. Cooperative Gulf of Mexico estuarine inventory. Ala. Mar. Res. Bull. 5:123 pp.

Swingle, H. A., D. G. Bland, and W. M. Tatum. 1976. Survey of the 16-foot trawl fishery of Alabama. Ala. Mar. Res. Bull. 11:51-57.

Swingle, W. E. 1972. Survey of the live bait shrimp industry of Alabama. Ala. Mar. Res. Bull. 8:1-8.

Tabb, D. C., D. L. Dubrow, and A. E. Jones. 1962. Studies on the biology of the pink shrimp, Penaeus duorarum Burkenroad, in Everglades National Park, Florida. Florida St. Board Conserv. Tech. Ser. 30 pp.

Taylor, C. C., et al. 1949. Rural life in the United States. Alfred A. Knopf, New York. 549 pp.

Temple, R. F., and C. C. Fisher. 1967. Seasonal distribution and relative abundance of planktonic-stage shrimp (Penaeus sp.) in the northwestern Gulf of Mexico, 1961. Pages 323-334 in U.S. Fish. Wildl. Fish. Bull. No. 66.

Texas Parks and Wildlife Department. 1977. Digest of shrimp laws. TPWD Leaflet 2000-1.

Titcomb, M. 1972. Native use of fish in Hawaii. University of Hawaii Press, Honolulu. 175 pp.

Toevs, A. L., and D. B. Johnson. 1978. Economic characterization of the U.S. Gulf of Mexico shrimp fishery. Louisiana State University Center for Wetland Resources, Baton Rouge, La. 168 pp.

Trent, L. 1967. Size of brown shrimp and time of emigration from Galveston Bay system, Texas. Pages 7-16 in Proc. Gulf and Carib. Fish. Inst., 19th Ann. Ses.

Tulian, E. A. 1920. Louisiana--greatest in the production of shrimp--Penaeus setiferus. Pages 106-114 in 4th Biennial Report, Louisiana State Department of Conservation, New Orleans.

Turner, R. E. 1977. Intertidal vegetation and commercial yields of penaeid shrimp. Trans. Am. Fish. Soc. 106:411-416.

Ulrich, G. F. 1978. Incidental catch of loggerhead turtles by South Carolina commercial fisheries. A report to NMFS. 36 pp. and 11 tables.

Upshaw, C. F., W. B. Creath, and F. L. Brooks. 1966. Sediments and microfauna off the coasts of Mississippi and adjacent states. Miss. Geol. Eco. Topograph. Bull. No. 106.

U.S. Army Corps of Engineers. n.d. Fish and wildlife study of the Louisiana coastal area and the Atchafalaya basin floodway. USACE, New Orleans District. Unpublished manuscript, App. D.

U.S.D.C. 1979. Fishermen's Contingency Fund. Federal Register. Vol. 44, No. 102:30292-30304.

U.S.D.C. 1980. NMFS NEWS: Commerce Secretary Klutznick announces $12.2 million in aid to shrimp industry. Press release Oct. 18, 1980.

U.S. Department of Commerce. Various years. Fisheries of the United States. Shrimp landings in the South Atlantic and Gulf: Annual summary. NMFS. Washington, D.C.

U.S. Department of Commerce. Various years. Statistical abstract of the United States. Washington, D.C.

U.S. Department of Commerce. Various years. Fisheries of the United States. Current Fish Statistics. NMFS. Washington, D.C.

U.S. Department of Commerce. Various years. Fisheries of the United States. Fishery statistics of the United States. NMFS. Washington, D.C.

U.S. Department of Commerce. Various years. Fisheries of the United States. Shellfish market review and outlook. NMFS. Washington, D.C.

U.S. Department of Commerce. 1958-1976. Bureau of Census. Annual Survey of Manufacturers. Washington, D.C.

U.S. Department of Commerce. 1958, 1963, 1967, 1973. Census of Manufacturers. Washington, D.C.

U.S. Department of Commerce. 1959-1975. Gulf coast shrimp data. Annual issues 1959-1975. NOAA, NMFS.

U.S. Department of Commerce. 1976. Processed fishery products annual summary. NMFS. Washington, D.C.

U.S. Fish and Wildlife Service. 1972. Sportfish and wildlife work unit report. Field Office, Vicksburg, MS. Unpublished manuscript.

U.S. International Trade Commission Report to the President. 1976. Shrimp. USITC Publication, No. 773. Washington, D.C.

U.S. International Trade Commission. 1976. Shrimp: Report to the President on investigation No. TA-20112 under Section 201 of the Trade Act of 1974. USITC Publication 773. Washington, D.C.

U.S. Water Resources Council. 1977. Regional Multipliers: Guideline 5. Washington, D.C. 135 pp.

Vanstone, J. W. 1962. Point Hope: an eskimo village in transition. Univ. of Washington Press, Seattle. 177 pp.

Viosca, P. 1928. Louisiana wetlands and the value of their wildlife and fishery resources. Ecology 9:216-229.

von Bertalanffy, L. 1938. A quantitative theory of organic growth (Inquiries on Growth Laws II). Human Biol. 10:181-213.

Walford, L. A. 1946. A new graphic method of describing the growth of animals. Biological Bull. 90:141-147.

Walford, L. A. 1965. Research needs for salt-water sport fisheries: experience in the United States. Pages 81-90 in Canadian Fisheries Report No. 4, Special Issue on a Symposium on the Economic Aspects of Sport Fishing.

Wardlaw, N. J., and W. L. Griffin. 1974. Economic analysis of costs and returns for the Gulf of Mexico shrimp vessels: 1973. Texas A&M Ag. Exp. Sta. Tech. Rep. No. 74-3.

Warren, J. P., and C. E. Bryan. 1981. The Texas shrimp fleet: a description. Texas Parks and Wildlife Department, Austin, Texas. Management Data Series No. 18. 8 pp.

Warren, J. P., and W. L. Griffin. 1978. Costs and return trends in the 1970s for the Gulf of Mexico shrimp vessels. Texas A&M Ag. Eco. Dept., College Sta., Texas. 20 pp.

Watson, J. W. Jr. 1976. Electrical shrimp trawl catch efficiency for *Penaeus duorarum* and *Penaeus aztecus*. Trans. Amer. Fish. Soc. 105:135-148.

Watson, J. W. Jr., and C. McVea Jr. 1977. Development of a selective shrimp trawl for the southeastern United States shrimp fisheries. Mar. Fish. Rev. 39:18-24.

Weaver, T., and J. Y. Christmas. n.d. Statistics on subsistence fishing in Mississippi. Gulf Coast Res. Lab., Ocean Springs, MS. Unpublished manuscript. 16 pp.

Weymouth, F. W., M. J. Lindner, and W. W. Anderson. 1955. Preliminary report on the life history of the common shrimp, *Penaeus setiferus* (Linnaeus). Bur. Fish. Bull. 48:1-26.

Wheeland, H. A., and B. G. Thompson. 1975. Fisheries of the United States, 1974. U.S. Dept. Commer. NMFS. Curr. Fish. Stat. 6700. 98 pp.

White, C. J., and C. J. Boudreaux. 1977. Development of an areal management concept for Gulf penaeid shrimp. Louisiana Wildl. and Fish. Comm., Tech. Bull. No. 22. 77 pp.

White, C. J., and W. S. Perret. 1973. Short-term effects of the Toledo Bend Project on Sabine Lake, La. Pages 710-721 in Proc. 27th Annual Conference, Southeastern Association of Game and Fish Commissioners.

Williams, A. B. 1955. Contribution to the life histories of commercial shrimp (Penaeidae) in North Carolina. Bull. Mar. Sci. Gulf and Carib. 5:116-146.

Williams, A. B. 1958. Substrates as a factor in shrimp distribution. Limnol. and Oceanogr. 3:283-290.

Williams, A. B. 1959. Spotted and brown shrimp postlarvae (*Penaeus*) in North Carolina. Bull. Mar. Sci. Gulf and Carib. 9:381-390.

Wise, J. P., and B. G. Thompson. 1978. Fisheries of the United States, 1977. U.S. Dept. Commer. NMFS. Curr. Fish. Stat. 7500. 112 pp.

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. St. Board Conserv. Mar. Lab., St. Petersburg, Tech. Series No. 21. 33 pp.

Yokel, B. J., E. S. Iverson, and C. P. Idyll. 1969. Prediction of the success of commercial shrimp fishing on the Tortugas Grounds based on enumeration of emigrants from the Everglades National Park Estuary. Pages 1027-1039 in FAO Fish. Rep. 57-3.

Zein-Eldin, Z. P., and G. W. Griffith. 1969. An appraisal of the effects of salinity and temperature on growth and survival of postlarval penaeids. Pages 1015-1026 in FAO Fish. Rep. 57-3.