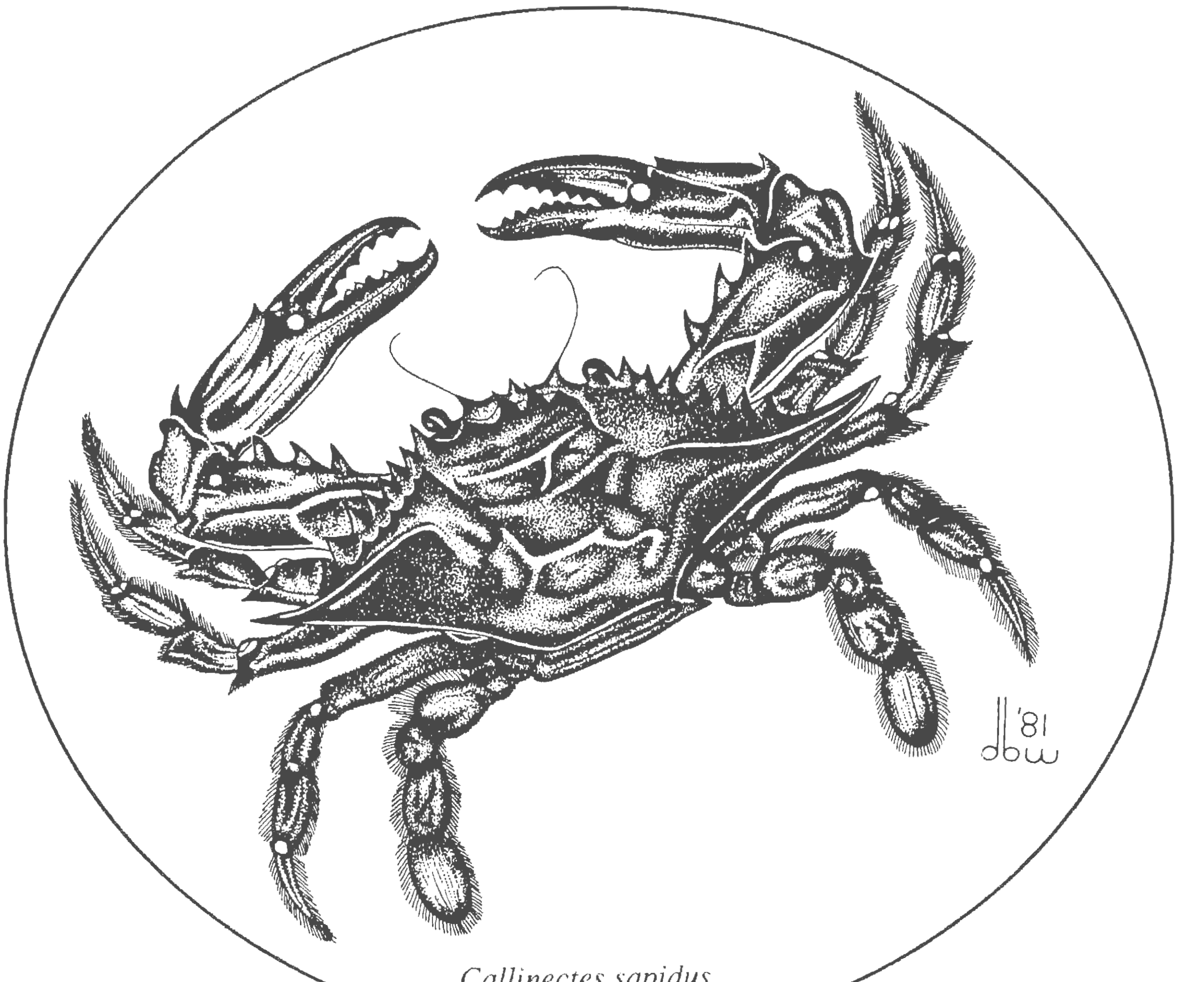
THE BLUE CRAB FISHERY OF THE GULF OF MEXICO UNITED STATES:

A Regional Management Plan



Callinectes sapidus

GULF STATES MARINE FISHERIES COMMISSION
P.O. Box 726
Ocean Springs, Mississippi 39564

No. 21 **April 1990**

THE BLUE CRAB FISHERY OF THE GULF OF MEXICO UNITED STATES:

A REGIONAL MANAGEMENT PLAN

edited by

Philip Steele and Harriet M. Perry

published by

Gulf States Marine Fisheries Commission
P.O. Box 726
Ocean Springs, Mississippi

April 1990
Number 21

This study was supported in part by the National Oceanic and Atmospheric Administration, National Marine Fisheries Service under Cooperative Agreements NA88WC-D-IJ096 (2-IJ-8-1), NA89WC-D-IJ074 (2-IJ-8-2), and NA90AA-D-IJ202 2-IJ-8-3.

GULF STATES MARINE FISHERIES COMMISSION

Interjurisdictional Fisheries Management Program

Blue Crab Technical Task Force

Philip Steele, Chairman
Florida Department of Natural Resources
Florida Marine Research Institute
100 8th Avenue. S.E.
St. Petersburg, Florida 33701

Vince Guillory
Louisiana Department of Wildlife
and Fisheries
P.O. Box 189
Bourg, Louisiana 70343

Stevens R. Heath
Alabama Marine Resources Division
P.O. Box 189
Dauphin Island, Alabama 36528

Walter R. Keithly
Coastal Fisheries Institute
Louisiana State University
Baton Rouge, Louisiana 70803

Charles Moss
Sea Grant Advisory Service
Route 2, 1800, C.R. #171
Angleton, Texas 77515

Harriet M. Perry
Gulf Coast Research Laboratory
P.O. Box 7000
Ocean Springs, Mississippi 39564-7000

Steve Thomas
University of South Alabama
BMSB Room #8
Mobile, Alabama 36688

Tom Wagner
Texas Parks and Wildlife Department
P.O. Box 688
Port O'Connor, Texas 77982

Staff

Larry B. Simpson
Executive Director

Richard L. Leard
Program Coordinator

J.Y. Christmas (Consultant)
132 Pine Drive
Ocean Springs, Mississippi 39564

Stephen Meyers
Program Coordinator (5/88-11/89)

Cynthia B. Dickens
Staff Assistant

David J. Etzold (Consultant)
7435 Magnolia Drive
Pass Christian, Mississippi 39571

ACKNOWLEDGEMENTS

The Gulf States Marine Fisheries Commission would like to thank the Blue Crab Technical Task Force and the Fisheries Management Committee for their many hours of work and dedication in developing the blue crab fisheries management plan (FMP). Grateful acknowledgement goes to the many people of the National Marine Fisheries Service who provided data necessary to complete the FMP. Thanks also go to Frances Lilly, Richard Condrey, Sharon Wilson, Kathleen Muzzy, Christine Trigg and the many people who reviewed the FMP. Finally, a very special thanks go to Cindy Dickens and Lucia Hourihan, whose dedication insured the development and production of a quality document, and to J.Y. Christmas and David Etzold, who helped implement the Interjurisdictional Fisheries Management Program.

PREFACE

The Gulf States Marine Fisheries Commission (GSMFC) was established by the Gulf States Marine Fisheries Compact under Public Law 81-66 approved May 19, 1949. Its charge was to promote the better management and utilization of marine resources in the Gulf of Mexico.

The commission is composed of three members from each of the five Gulf States. The head of the marine resource agency of each state is an ex officio member. The second is a member of the legislature. The third is a citizen with knowledge of and interest in marine fisheries, and he/she is appointed by the governor. The offices of the chairman and vice chairman are rotated annually from state to state.

The commission is empowered to recommend to the governor and legislature of the respective states action on programs helpful to the management of the fishery. However, the states do not relinquish any of their rights or responsibilities in regulating their own fisheries by being members of the commission.

One of the most important functions of the GSMFC is to serve as a forum for the discussion of various problems and needs of marine management authorities, the commercial and recreational industries, researchers and others. The GSMFC also plays a key role in the implementation of the Interjurisdictional Fisheries (IJF) Act.

The Interjurisdictional Fisheries Act of 1986 (Title III, Public Law 99-659) was established by Congress to: (1) promote and encourage state activities in support of the management of interjurisdictional fishery resources and (2) promote and encourage management of interjurisdictional fishery resources throughout their range. Congress also authorized federal funding to support state research and management projects which were consistent with these purposes. Additional funds were authorized to support the development of interstate fishery management plans (FMPs) by the GSMFC and the other marine fishery commissions.

After passage of the act, the GSMFC initiated the development of an FMP planning and approval process. The commission decided to pattern its plans after those of the Gulf of Mexico Fishery Management Council under the Magnuson Fisheries Conservation and Management Act of 1976. This decision ensured compatibility in format and approach to management among states, federal agencies and the council.

The commission also established the requirement that each plan be developed by a technical task force (TTF) of experts from each state and appointed by the respective states' commission representative of the regulatory agency. Also, it provided for a member of the TTF from each of the standing committees of the GSMFC (Industry Advisory, Law Enforcement and Recreational Fisheries) to be appointed by the respective committee.

Once developed, the commission established a review and approval process as follows:

TTF → TCC → FMC → GS-FFMB → FMC → GSMFC
↕
Outside Review
(standing committees,
trade associations,
general public)

TTF = Technical Task Force
TCC = Technical Coordinating Committee
FMC = Fisheries Management Committee
GS-FFMB = Gulf State-Federal Fisheries Management Board
GSMFC = Gulf States Marine Fisheries Commission

Once approved by the GSMFC, plans are recommended to the individual states for consideration of adoption and implementation.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

3.0 SUMMARY

The blue crab, Callinectes sapidus, supports one of the largest commercial and recreational fisheries in the U.S. Gulf of Mexico. Annual commercial landings exceeded 78 million pounds in 1987 with an ex-vessel value of approximately $29.7 million which was 38.9% of U.S. production. The recreational fishery is thought to contribute significantly to total fishing pressure. In addition to the commercial and recreational fisheries for hard crabs, there is an expanding fishery for soft-shell crabs. Variations in the abundance of crabs due to environmental factors and disease, use of more efficient gear, increased fishing effort from directed and non-directed fisheries and the economic condition of the market are reflected in historical blue crab catches. Blue crab landings were first recorded in the gulf in 1880 when 324,000 pounds with an ex-vessel value of $8,000 were landed from Texas and Louisiana.

The fisheries in Alabama and Mississippi have remained relatively stable over the past several decades with each state reporting 1 to 3 million pounds annually. Louisiana continues to be the largest producer in the gulf with 1987 landings exceeding 52 million pounds. Florida west coast landings were 10.3 million pounds in 1987 while landings in Texas exceeded 11 million pounds. Estimated landings for soft-shell crabs in the Gulf of Mexico during 1984 were 1,045,920 pounds valued at $7,213,600 (Virginia Sea Grant College Program 1985).

Reported landings for hard and soft-shell crabs are poor estimates of actual catch. Crabs are often shipped to out-of-state buyers with little or no accountability. Those sold on the "basket market," to the general public and to restaurant or retail outlets also go unreported. Even if landings data were accurate, their use as an index of adult stock abundance can be misleading. Moss (1981) noted that blue crab landings do not necessarily reflect populations but may merely reflect economic fluctuations. Lyles (1976) and Meeter et al. (1979) also suggested that socio-economic variables may influence blue crab landings.

The blue crab ranges from Nova Scotia to northern Argentina and is the principal species caught in the Gulf of Mexico. Gulf blue crabs support a significant, renewable fishery occurring almost exclusively in state waters. This species occupies a variety of habitats in fresh, brackish and shallow oceanic waters. Extensive alongshore migration northward by Gulf of Mexico blue crabs has been documented along the Florida west coast (Oesterling 1976, Steele 1987a,b). The existence of more than one stock of gulf blue crabs has not been demonstrated.

In general blue crab life history is typical of other estuarine-dependent species in the gulf. Mating may take place year round in brackish areas of the estuary while spawning occurs in high salinity waters nearshore. Larval forms are principally oceanic until metamorphosis into the megalopal stage when they are transported back into the estuary. Little is known concerning mechanisms of larval transport and dispersal of blue crab zoeae in the gulf. Juvenile crabs are widely distributed in estuaries. Adults show a differential distribution by sex and salinity with females commonly found in high salinity waters and males in waters of low salinity.

The major processed product from the blue crab fishery is meat picked from the cooked crab. Some meat is pasteurized although most is sold as a fresh, ice-pack product. Total U.S. production of canned crab meat accounted for approximately 1 million pounds of product in 1984 compared with a fresh, ice-pack total of 25 million pounds. Firms that produce meat may also process other specialty products including claws, deviled crab, crab cakes, crab patties, stuffed crab and soft-shell crab.

Numerous Federal laws, policies and regulations including the Magnuson Fishery Conservation and Management Act (MFCMA); Marine Protection, Research and Sanctuaries Act (MPRSA); Clean Water Act (CWA); and Coastal Zone Management Act (CZMA) directly affect or indirectly influence the management of blue crabs (Section 7.3). Various state laws, regulations and policies are also applicable for the management of the Gulf of Mexico blue crab fishery (Section 7.4). Legislative authority for enactment and enforcement of such laws in the gulf usually resides with the individual state's conservation and/or fisheries management agency or commission. These include the Florida Marine Fisheries Commission, Alabama Department of Conservation and Natural Resources, Mississippi Commission on Wildlife, Fisheries and Parks, Louisiana Wildlife and Fisheries Commission and Texas Parks and Wildlife Commission.

The Gulf State-Federal Fisheries Management Board (GS-FFMB) is charged with responsibility for developing regional management plans for fisheries resources that move between or are broadly distributed among the territorial waters and areas seaward thereof and for recommending suitable policies and strategies to each member state (Section 18.1).

Responsible management of the gulf blue crab fishery will require long-term continuation of on-going research programs as well as the implementation of other needed special projects of long and short duration. Biological, environmental, technological, economic and sociological research programs needed to support the gulf blue crab program are identified in Section 15.

The blue crab fishery management plan (FMP) is intended to provide fair and equitable management measures that allow for maintenance of the stock(s) and provide for optimum yield as defined in Section 12.4.2. The Crab Subcommittee should review the status of the fishery as necessary with a report to be submitted to the Technical Coordinating Committee and the Fisheries Management Committee of the Gulf States Marine Fisheries Commission.

4.0 INTRODUCTION

A program to promote and encourage state activities in interjurisdictional fisheries resources and to promote management of these resources throughout their range was created by Title III of P.L. 99-659 on November 14, 1986. This program addresses the national objective of regionally managing priority interjurisdictional resources not already addressed by the Magnuson Fishery Conservation and Management Act (MFCMA) plans. This program allows the states to utilize an existing mechanism, the Gulf States Marine Fisheries Commission (GSMFC), without creating a new entity to develop fishery management plans (FMPs). The GSMFC has initiated a program to address development of several interjurisdictional FMPs for selected species in the U.S. Gulf of Mexico.

4.1 Management Objectives

The generally acknowledged purpose of a FMP and the subsequent regulations promulgated to implement the plan are to provide effective and responsive action in a manner consistent with the best interests of the nation. These actions must consider several factors: conservation of the resource and the fishery, economics, social interactions, the habitat and others. Some factors may be contradictory and conflicting in some instances; however, in the plan development process they will all be considered and weighed in order to achieve management objectives.

4.2 Contractual Requirements

A contract was issued by the Southeast Regional Office of the National Marine Fisheries Service (NMFS) to the GSMFC January 1, 1988, to develop, prepare, publish and distribute interjurisdictional FMPs for the Gulf of Mexico. This planning effort involves accumulation of data on the biology, harvest, sociology and economic status of the blue crab fishery and the application of this data to the development of management and conservation measures for the fishery throughout its range in the the U.S. Gulf of Mexico. The contractor (GSMFC) is responsible for coordinating the efforts of the Gulf States, blue crab industry, NMFS and appropriate agencies in developing, producing, printing and distributing the FMP to the states, NMFS Southeast Fisheries Center, NMFS Southeast Regional Office and Gulf of Mexico Fishery Management Council. The FMP will serve as a data base for use in conservation and management activities. The GSMFC will provide a program coordinator and/or fishery consultants to assist with plan development and operating procedures. Specifically the GSMFC shall:

1. Organize a task force composed of at least one representative of the marine fisheries conservation agency of each Gulf State to guide and assist in acquiring and analyzing data for the blue crab FMP. This task force will be the existing GSMFC Crab Subcommittee members and experts in other disciplines as required for the development of the FMP.
2. Utilize consultants with expertise in areas of planning, statistical analysis, sociology, economics and/or other specialties.
3. Accumulate data from states, universities, Federal agencies and others as appropriate for the blue crab fishery including life history studies, ecology, socio-economics, characteristics of the fishery and fishery statistics.
4. Accumulate and summarize current fishery resource regulations and fishery management practices for the blue crab in the Gulf of Mexico.
5. Accumulate and analyze current and historical information on fishing activities, methods, areas and the economic impact of fishing and other socio-economic factors pertaining to the blue crab.

6. Identify problems in the blue crab fishery by type (i.e., administrative, legal, institutional, legislative, biological, technical, economic, sociological, environmental) by degree and area. Problems will then be evaluated and management measures developed. An action program will be developed to delineate and establish priorities necessary to develop management measures for the gulf blue crab FMP.

7. Be guided by the national standards of Title III of P.L. 94-265 (the Magnuson Fishery Conservation and Management Act) for interjurisdictional fishery management plans.

4.3 Task Force Members

J.Y. Christmas	Gulf States Marine Fisheries Commission (Consultant)
David J. Etzold	Gulf States Marine Fisheries Commission (Consultant)
Vince Guillory	Louisiana Department of Wildlife and Fisheries
Stevens Heath	Alabama Department of Conservation and Natural Resources
Walter R. Keithly	Louisiana State University
Charles Moss	Texas Agricultural Extension Service
Harriet M. Perry	Gulf Coast Research Laboratory
Philip Steele	Florida Department of Natural Resources
J. Stephen Thomas	University of South Alabama
Tom Wagner	Texas Parks and Wildlife Department

Credit for writing this plan has not been assigned to individuals. All members of the task force contributed in their area of expertise and in discussions that resulted in changes of draft material. Any assignment of authorship must include all members of the task force and the planning staff. The GSMFC made all necessary arrangements for task force workshops and under contract with NMFS funded travel for state agency representatives.

5.0 DESCRIPTION OF STOCK(S) COMPRISING THE MANAGEMENT UNIT

5.1 Biological/Environmental Description and Geographic Distribution

5.1.1 Data Bank

Considerable information is available on the biology of the blue crab. The earliest bibliography on the genus was published by Cronin et al. in 1957. Tagatz and Hall (1971) provided an annotated bibliography on the fishing industry and biology of the blue crab, Callinectes sapidus. Synopses of biological and fishery data on the blue crab were published by Millikin and Williams (1984) and Perry et al. (1984). Computerized blue crab bibliographies are available from various state and Federal agencies.

Life history and fishery information have been described for Delaware (Hall 1976), Chesapeake Bay (Hay 1905; Churchill 1921; Pearson 1948; Van Engel 1958, 1982, 1987; Cronin 1987), South Carolina (Eldridge and Waltz 1977), Georgia (Palmer 1974), Florida (Tagatz 1968a,b; Oesterling 1976; Oesterling and Evink 1977; Oesterling and Adams 1982; Steele 1982, 1987a,b), Alabama (Tatum 1980, 1982), Mississippi (Perry 1975; Perry and Stuck 1982; Stuck and Perry 1981; Stuck, Wang and Perry 1981), Louisiana (Darnell 1959; Adkins 1972a, 1982; Jaworski 1972; Roberts and Thompson 1982), Texas (More 1969; King 1971; Hammerschmidt 1982), Atlantic States (Sholar 1982, Harris 1982) and the Gulf of Mexico (Moss 1982; Perry, Moss and Malone 1985; Perry et al. 1984; Perry and McIlwain 1986).

Symposia on the soft-shell blue crab fishery reflect recent interest in soft crab fishery development. Published proceedings (Perry and Malone 1985) include information on molting physiology, disease, post-molt calcification, system design and management, economics, management and nutrition. Additional information on water quality and system design may be found in Haefner and Garten (1974), Ogle et al. (1982), Perry et al. (1982), Perry (1983), Manthe et al. (1983), Oesterling (1984), Manthe et al. (1984), Perry and Wallace (1985), Gates et al. (1985), Manthe and Malone (1987) and Malone and Burden (1987, 1988). Studies on molting endocrinology, hormonal induction of molting and post-molt calcification include Smith (1973), Vigh and Dendinger (1982), Dendinger and Alterman (1983), Price-Sheets and Dendinger (1983), Soumoff and Skinner (1983), Cameron and Wood (1985), Freeman et al. (1986), Freeman and Perry (1986) and Freeman et al. (1987a,b). Otwell et al. (1980) provided an overview of the fishery in Florida, and Otwell and Cato (1982) reviewed the United States fishery for soft-shell crabs. Jaworski (1971, 1982) provided a history and status of the fishery in Louisiana.

5.1.2 Taxonomy/Morphological Description

Phylum Arthropoda
  Class Crustacea
    Subclass Malacostraca
      Order Decapoda
        Infraorder Brachyura
          Family Portunidae
            Subfamily Portuninae

Williams (1974) and Millikin and Williams (1984) contain detailed morphological descriptions of C. sapidus. The frontal margin of the carapace has four inner orbital teeth. The antero-lateral margin of the carapace has nine spines or teeth with the posterior-most strongly developed. The carapace is about 2.5 times as wide as long, is moderately convex and nearly smooth. There are granulations on the inner branchial and cardiac regions of the carapace.

The abdomen and telson of the male reach about midlength of thoracic sternite IV. The telson is lanceolate and much longer than broad. The first gonopods are long, reaching beyond the suture between thoracic sternites IV and V but not exceeding the telson. The mature female abdomen and telson reach about midlength of thoracic sternite IV. The mature abdomen is broad and rounded. The abdomen in immature females is triangular in shape.

Color is variable with shades of grayish, bluish or brownish green occurring. The propodi of chelae of males are blue on the inner and outer surfaces and tipped with red. The fingers of chelae of mature females are orange tipped with purple.

According to Williams (1974), "there are morphological variations in (the) species having far greater systematic interest than size and color." Chace and Hobbs (1969) noted that extreme variants "are so different from each other that they could easily be interpreted as distinct species"; however, there is "no point of demarcation" either morphological, geographic or bathymetric between the usual blunt-spined individuals ('typical' form) found along the east coast and the acute spined individuals ('acutidens' form) found from Florida southward. Williams (1984) noted that even "though 'acutidens' individuals are uncommon outside of the tropics, intermediates occur everywhere to some degree and some 'typical' individuals occur in the tropics." He now considers the "whole C. sapidus complex to be a single species which has diverged into ill-defined populations in certain parts of its range--Callinectes sapidus is the member of the genus which has most successfully invaded the Temperate Zone, and in this respect it may be that speciation into forms associated with temperature regimes is progressing, but the process is not yet complete enough that morphological separation is distinct."

5.1.3 Distribution of the Genus in the Gulf of Mexico

The genus Callinectes belongs to the family Portunidae which contains approximately 300 extant species. It is a warm water genus whose poleward distribution appears to be limited by summer temperatures. According to Norse (1977), no species occur regularly in waters where peak temperatures fail to approach 20°C. There are currently 15 species recognized in the genus, three in the Pacific and 12 in the Atlantic and adjacent seas.

According to Williams (1974) eight species are found in the Gulf of Mexico; C. bocourti A. Milne Edwards, C. danae Smith, C. ornatus Ordway, C. exasperatus (Gerstaecker), C. marginatus (A. Milne Edwards), C. sapidus Rathbun, C. similis Williams and C. rathbunae Contreras.

Callinectes marginatus, C. exasperatus and C. danae are known from the southernmost portion of the gulf bordering the Caribbean. Callinectes ornatus occurs off central Florida through the southern gulf to Yucatan. Extraterritorial occurrences include C. bocourti recorded from Biloxi Bay, Mississippi (Perry 1973) and C. marginatus from Louisiana waters (Rathbun 1930). The blue crab C. sapidus and lesser blue crab C. similis show gulfwide distribution.

Callinectes sapidus is distributed throughout the Gulf of Mexico. The type locality is the eastern coast of the United States. Williams (1974) defined the range as: occasionally Nova Scotia, Maine and northern Massachusetts to northern Argentina, including Bermuda and the Antilles; Oresund, Denmark; the Netherlands and adjacent North Sea; northwest and southwest France; Golfo di Genova; northern Adriatic; Aegean, western Black and eastern Mediterranean seas; Lake Hamana-ko, central Japan.

In the Gulf of Mexico, C. sapidus occurs on a variety of bottom types in fresh, estuarine and shallow oceanic waters. Blue crabs have been reported as commonly occurring in the Atchafalaya River 160 miles upstream from the Gulf of Mexico (Gunter 1938) and to a depth of 90 meters offshore (Franks et al. 1972). They are most common in tidal marsh estuaries characterized by soft mud substrata and waters of moderate salinity. Greatest reported commercial landings of blue crabs generally occur north of 28°N latitude.

5.1.4 Spawning

Spawning of blue crabs in northern gulf waters is protracted with egg-bearing females occurring in coastal gulf and estuarine waters in the spring, summer and fall (Gunter 1950, Daugherty 1952, More 1969, Adkins 1972a, Perry 1975). Additionally, Adkins (1972a) found evidence of winter spawning in offshore Louisiana waters based on commercial catches of "berried" females in December, January and February. Daugherty (1952) noted that crabs in southern Texas may spawn year-round in mild winters.

For most estuarine animals mating and spawning are synonymous; however, in the case of the blue crab the two events occur at different times. Prior to her pubertal molt (in the female blue crab the cycle of growth and molting usually terminates with a final anecdysis), the female travels to brackish waters of the upper estuary to mate. The female mates in the soft shell state following her pubertal molt. After insemination, the male continues to carry the female until her shell has hardened. Spawning usually occurs within two months of mating in the spring and summer. Females that mate in the fall usually delay spawning until the following spring. Sperm transferred to the female remain viable for a year or more and are used for repeated spawnings.

The fertilized eggs are extruded and attached to fine setae on the endopodites of the pleopods forming an egg mass known as a "sponge," "berry," or "pom-pom." As many as two million eggs may be present in a single sponge. The sponge is initially bright orange becoming progressively darker as the larvae develop and absorb the yolk. Prior to hatching, the sponge is black. The eggs hatch in about two weeks.

There has been some discussion in the literature concerning the existence of a prezoeal stage in C. sapidus. Robertson (1938), Churchill (1942), Truitt (1942) and Davis (1965) reported prezoeae emerging from the eggs. Time estimates for length of stay in the prezoeal stage ranged from one to three minutes (Davis 1965) to several hours (Robertson 1938). Sandoz and Hopkins (1944) and Sandoz and Rogers (1944) noted that larvae emerged as prezoeae only in response to adverse biological or environmental conditions. Costlow and Bookhout (1959) made specific reference to the lack of the prezoeal stage for C. sapidus noting that the larvae emerged as zoeae. Additionally, Bookhout and Costlow (1974, 1977) do not mention a prezoeal stage for Portunus spinicarpus or C. similis.

Costlow and Bookhout (1959) reported seven zoeal stages and one megalopal stage for the blue crab. An eighth zoeal stage was sometimes observed though survival to the megalopal stage was rare. Development through the seven zoeal stages required from 31 to 49 days with the megalopal stage persisting from 6 to 20 days. In salinities below 20.1 ppt the larvae rarely survived the first molt.

5.1.5 Distribution and Abundance of Larvae and Juveniles

5.1.5.1 Zoeae and Megalopae

The larval life history of Callinectes sapidus in the Gulf of Mexico is poorly understood. Although Daugherty (1952), Menzel (1964) and Adkins (1972a) specifically discussed the distribution of blue crab larvae, the possibility of occurrence of the larvae of C. similis must be considered. The temporal and spatial overlap in spawning habits of the two species (Perry 1975), coupled with the difficulty in using the early morphological descriptions of C. sapidus from Atlantic specimens (Costlow and Bookhout 1959) to reliably identify gulf blue crab larvae, suggest that published accounts of the seasonality of C. sapidus larvae are questionable. Recognizing the difficulty in separating the two species, King (1971), Perry (1975) and Andryszak (1979) did not differentiate between the larvae of C. sapidus and C. similis.

Perry and Stuck (1982) noted that early stage Callinectes zoeae (I and II) were present in Mississippi coastal waters in the spring, summer and fall. Adkins (1972a) reported C. sapidus larvae present year-round in Louisiana but did not separate the zoeal and megalopal stages. The sampling programs of Menzel (1964) and Andryszak (1979) were of limited duration with no seasonal distribution data available. Both Perry and Stuck (1982) and Andyrszak (1979) found only the early stage zoeae abundant nearshore.

Callinectes megalopae have been reported to occur throughout the year. Perry (1975) found megalopae in Mississippi Sound in all months with peak abundance in the late summer-early fall and in February. In Texas coastal waters, Callinectes megalopae have been found in all seasons (Daugherty 1952, More 1969, King 1971). King (1971) noted three waves of megalopae in Cedar Bayou, the first from January through March, the second in May and June and the third in October.

Attempts to separate the larvae of C. sapidus from C. similis using the characters developed by Bookhout and Costlow (1977) have been largely unsuccessful due to apparent morphological differences in larvae from the gulf and Atlantic. Stuck, Wang and Perry (1981) provided characters useful in distinguishing the megalopae and early crab stages of the two species. Subsequent analysis of archived plankton samples from Mississippi and Louisiana coastal waters has furnished information on the seasonality of C. sapidus and C. similis megalopae in the northern gulf (Stuck and Perry 1981). These authors found C. similis megalopae present in offshore waters adjacent Mississippi Sound throughout the year peaking in abundance in February and March. Callinectes sapidus megalopae were rarely found in samples before May. Large numbers of C. similis megalopae were identified in February and March samples from Whiskey Pass, Louisiana. Based on the identification of first crabs reared from megalopae, Perry (1975) reported a February occurrence of C. sapidus. Reexamination of these specimens found them to be C. similis. These data suggest that the reported winter peaks of Callinectes larvae in the northern gulf are in all probability referable to C. similis.

Reports on the vertical distribution of Callinectes megalopae appear conflicting. Williams (1971), King (1971), Perry (1975) and Smyth (1980) reported Callinectes megalopae to be in greatest abundance in surface waters. In contrast, 96% of the Callinectes megalopae collected by Tagatz (1968a) and all of the megalopae collected by Sandifer (1973) were from bottom waters. Stuck and Perry (1981) found that portunid megalopae (C. sapidus, C. similis and Portunus spp.) showed no affinity for surface or bottom waters. They noted that the majority of large catches of C. sapidus megalopae were taken on rising or peak tides whereas the megalopae of C. similis and Portunus spp. were commonly collected on both rising and falling tides.

5.1.5.2 Juveniles

Recruitment of blue crabs to gulf estuaries occurs during the megalopal stage (More 1969, King 1971, Perry 1975, Perry and Stuck 1982). The relationship between numbers of megalopae recruited and subsequent abundance of young crabs is not well defined. Perry and Stuck (1982) noted that large catches of C. sapidus megalopae in August and September were usually followed by an increased catch of small crabs (10.0 to 19.9 mm) in October or November in Mississippi estuaries; however, inconsistencies between recruitment of megalopae and subsequent occurrence and abundance of juveniles were noted in the spring and summer in their samples. King (1971) found comparable population densities of juveniles between two years though recruitment was markedly different. Interpretation of his data is somewhat complicated by the taxonomic problems associated with the separation of C. sapidus and C. similis megalopae.

Young blue crabs show wide seasonal and areal distribution in gulf estuaries. Livingston et al. (1976) found maximum numbers of blue crabs in Apalachicola Bay in the winter and summer noting that an almost "continuous succession" of young crabs entered the sampling area during the year. Perry (1975) and Perry and Stuck (1982) found first crab stages in all seasons indicating continual recruitment to the juvenile population in Mississippi. In Lake Pontchartrain, Louisiana, Darnell (1959) noted recruitment of young crabs was highest in the late spring-early summer and in the fall.

Although juvenile crabs occur over a broad range of salinity, they are most abundant in low to intermediate salinities characteristic of middle and upper estuarine waters. Daud (1979) concluded that shallow brackish/saline waters are the major habitat for the early crab stages (5-10 mm). As they grow to a larger size, these blue crabs move into the freshwater areas. Swingle (1971), Perret et al. (1971), Christmas and Langley (1973) and Perry and Stuck (1982) determined the distribution of blue crabs (primarily juveniles) by temperature and salinity using temperature-salinity matrices. Both Perret et al. (1971) and Swingle (1971) found maximum abundance in salinities below 5.0 ppt (Table 5.1). In contrast, Christmas and Langley (1973) and Perry and Stuck (1982) found highest average catches associated with salinities above 14.9 ppt in Mississippi (Table 5.1). Based on one year of bag seine data, Hammerschmidt (1982) found no direct relationship between catches of juvenile crabs and salinity in Texas. Walter (1989) examined the relationship between recruitment of juvenile blue crabs (as measured by catch per unit of effort in 16 foot trawl samples) in Barataria Bay and salinity. He found a significant negative relationship between February-May blue crab catch per unit effort and salinity for the same time period (R^2=0.80). Although salinity influences distribution, factors such as bottom type and food availability also play a role in determining distributional patterns of juvenile blue crabs.

The importance of bottom type in the distribution of juvenile blue crabs is well established. More (1969), Holland et al. (1971), Adkins (1972a), Perry (1975), Livingston et al. (1976) and Perry and Stuck (1982) all noted the association of juvenile blue crabs with soft mud sediments. Evink (1976) collected the greatest number of individuals and biomass from mud bottoms and noted that blue crab biomass appeared to follow faunal food availability.

Table 5.1. Distribution of C. sapidus by salinity intervals showing number of samples (above) and catch per sample (below).

	Salinity (ppt)							
Modified from:	0.0-4.9	5.0-9.9	10.0-14.9	15.0-19.9	20.0-24.9	25.0-29.9	30+	Total
Swingle (1971)	41 6.0	15 4.7	14 2.6	19 2.3	33 3.1	18 3.3	18 4.4	179 3.9
Perret et al. (1971)	197 12.0	185 6.0	263 6.0	278 6.0	182 6.0	82 5.0	12 5.0	1,199 7.0
Christmas and Langley (1973)	134 1.2	87 2.7	110 3.8	99 3.2	145 4.1	169 2.2	74 0.9	818 2.6
Perry and Stuck (1982)	561 7.6	423 7.8	482 7.1	520 8.3	517 5.9	489 3.0	257 2.7	3,249 6.3

5.1.6 Growth

Growth in blue crabs occurs during ecdysis (molting). Newcombe et al. (1949) estimated the postlarval instars for male and female blue crabs to be 20 and 18, respectively. Assuming that the number of molts is fixed in blue crabs (Newcombe et al. 1949, Van Engel 1958), the variability in the average size of maturity in the female coupled with the observations that unusually large blue crabs are found in low salinities suggests that environmental conditions influence the percentage increase in size per molt. Blue crabs in Chincoteague, Chesapeake and Delaware bays show an increase in size with decreasing environmental salinity (Porter 1955, Cargo 1958). The data of Newcombe (1945), Van Engel (1958) and Tagatz (1965, 1968a) also suggest a possible correlation of size with the salinity of the water in which growth occurs. Van Engel (1958) believed that the osmoregulatory mechanism was involved; differences in the levels of salt concentration between the crabs and their environment affected the uptake of water resulting in increased growth per molt. In a study of growth increments occurring during the terminal molt of the female blue crab under different salinity regimes, Haefner and Shuster (1964) concluded that "within the parameters of the experiment, the salinity variation of the environment is not related to percentage increase in length at the terminal molt." Tagatz (1968b) also found that a decrease in salinity did not produce an increase in size and suggested that some factor other than salinity appeared to account for larger crabs in certain waters.

Growth of blue crabs is strongly affected by temperature. One of the more obvious effects of temperature on growth rate is the length of time required for crabs to reach maturity. Up to 18 months is necessary for maturation in Chesapeake Bay (Van Engel 1958) while blue crabs in the Gulf of Mexico may reach maturity within a year (Perry 1975, Tatum 1980).

In the laboratory, Leffler (1972) demonstrated that the molting rate (molts per unit of time) increased rapidly with increasing temperature from 13° to 27°C. This increase continued at a slower rate between 27° and 34°C, and growth virtually ceased at temperatures below 13°C. The growth per molt was significantly reduced above 20°C. Thus while the molting rate increased with temperature, the number of molts necessary to attain a certain size also increased. If the maximum size a blue crab attains is assumed to reflect the growth per molt rather than the number of molts, environmental temperatures may, in part, be responsible for the variation in size at maturity.

Perry (1975) estimated seasonal (July through January) growth by tracing modal progressions in monthly width-frequency distributions for crabs in Mississippi Sound. The estimated growth rate of 24 to 25 mm/month is somewhat higher than rates found in other gulf estuaries. Adkins (1972a) found growth in Louisiana waters to be approximately 14 mm/month for young crabs with slightly higher rates (15 to 20 mm/month) as crabs exceeded 85 mm in carapace width. Darnell's (1959) growth estimate of 16.7 mm/month for crabs in Lake Pontchartrain falls within the average reported by Adkins. More (1969) noted a growth rate of 15.3 to 18.5 mm/month in Texas. Plotting the progression of modal groups from February through August, Hammerschmidt (1982) reported higher growth rates for crabs in Texas (21.4 and 25.2 mm/month for seine and trawl samples, respectively) and attributed these rates to the use of seasonal rather than yearly data. Tatum (1980) found seasonal changes in the rate of growth of young blue crabs in Mobile Bay, Alabama. He observed monthly rates of 19, 10 and 5 mm for crabs recruited in April, August and December, respectively.

5.1.7 Factors Affecting Survival

Variations in salinity, temperature, pollutants, predation, disease, habitat loss and food availability all affect blue crab survival. The diversity of these parameters and their possible synergistic effects make precise identification of the influence of specific variables difficult. Additionally, the effect of variables such as salinity may be intrinsic (physiological) and/or extrinsic (affecting the composition of the biotic environment). Van Engel (1982) suggested that temperature, salinity and substratum are primary factors affecting growth, survival and distribution of blue crabs in Chesapeake Bay. Daud (1979) stated that the principal factors which control the abundance of blue crabs are food, salinity, water temperature, water circulation and tides. In contrast, Livingston et al. (1976) noted that temperature and salinity may not be as critical in the determination of estuarine population levels as are biological parameters related to trophic levels. The availability of an adequate food supply is a primary factor attracting the blue crab to a particular environment (Gallaway and Strawn 1975).

5.1.7.1 Mortality

5.1.7.1.1 Larvae

Availability of appropriate size zooplankton as prey may be important for larval blue crab survival. Phytoplankton is consumed by larvae (Costlow and Sastry 1966), but plant material alone is believed to be deficient in protein content. Survival rates of larvae fed various phytoplankton species or unicellular algae were depressed when compared to larvae fed zooplankton (Costlow and Bookhout 1959). Blue crab larvae fed rotifers show higher survival and molting rates (Sulkin and Epifanio 1975, Sulkin 1978) than do those fed Artemia (Costlow and Bookhout 1959).

In laboratory studies, successful hatching never occurred at 15 ppt (Costlow and Bookhout 1959) although Davis (1965) hatched larvae at 18 ppt. Sandoz and Rogers (1944) determined that optimum salinities for hatching lay between 23 and 30 ppt. Optimum temperatures for hatching of eggs were reported to be 19° to 29°C (Sandoz and Rogers 1944) and 20° to 35°C (Costlow 1967).

Early stage crab zoeae are good osmoregulators but lose this ability as they progress through later zoeal stages (Kalber 1970). Megalopae become good osmoregulators by the fifth day (Kalber 1970). Kalber (1970) suggested that osmoregulatory adaptations are apparently related to the sequence of salinity stress normally experienced during development. Costlow (1967) concluded that the survival and duration of the megalopal stage are directly associated with the time of hatching, the time at which the megalopal stage is reached in relation to seasonal changes in water temperature, and the salinity of the water when the final molt occurs.

Optimum salinities for metamorphosis during the first three zoeal stages ranged from 21 to 28 ppt (Sandoz and Rogers 1944). Costlow (1967) emphasized that survival and rate of larval development are extremely variable under different conditions of temperature and salinity. Greatest survival occurred between 16 and 43 ppt at temperatures between 21.5° and 34.5°C. Mortalities of 100% occurred at 15°C in salinities less than 8 ppt and at 11°C in salinities of 30 ppt. Megalopal development was most rapid (5 to 6 days) at 30°C in salinities from 10 to 35 ppt.

The dissolved phases of cadmium and mercury, methoxychlor, malathion, mirex, kepone, juvenile hormone mimic (MONO-585) and insect growth regulator (Dimilin) have been found to be toxic to blue crab larvae. Millikin and Williams (1984) provided a review of these studies.

5.1.7.1.2 Juveniles and Adults

Natural mortality rates for blue crabs are hard to quantify. Mortalities associated with chemical and biological pollutants, sediment, temperature, salinity and dissolved oxygen were discussed by Van Engel (1982). Millikin and Williams (1984) provided a review of chemical toxicity of organic compounds and inorganic contaminants on life history stages of the blue crab.

One of the most serious instances of chemical pollution affecting the blue crab fishery occurred in Virginia and was associated with the release of the chlorinated hydrocarbon kepone into the James River from the 1950s to late 1975. The annual mortality of young and adult blue crabs due to exposure to kepone remains unknown; however, both commercial landings and juvenile crab abundance have been lower in the James River than in the York or Rappahannock rivers for the past 15 years (Van Engel 1982). Lowe et al. (1971) reported mirex, a compound closely related to kepone, to be toxic to blue crabs either as a contact or stomach poison. Mirex accumulation in blue crabs and their sensitivity to this compound have been documented (Williams and Duke 1979). In a cooperative study among the states of North Carolina, South Carolina, Georgia and Florida, Mahood et al. (1970) found that 35% of the crabs collected contained detectable levels of mirex.

McHugh (1966) speculated that the ban on use of DDT and other chlorinated hydrocarbons resulted in the recovery of the blue crab resource in New York in the late 1970s. High mortality rates of blue crabs near Alligator Harbor, Florida, in November and December of 1973 were attributed to reduced temperatures (below 18°C) and high body burdens of DDT (Koenig et al. 1976).

Jaworski (1972) noted a decline in blue crab landings during the 1960s from the upper Barataria Bay basin, Louisiana and suggested that this decline may be associated with pollution and drainage alteration. Adkins (1972a) concluded that domestic, agricultural and industrial pollution as well as dredge and fill operations have adversely affected blue crab populations in Louisiana.

Levels of dissolved oxygen not only cause mortality of crabs but also impede migration. Trap death due to anoxia is a serious problem in many areas. Tatum (1982) reported that oxygen deficient bottom waters covered as much as 44% of Mobile Bay, Alabama, in the summer of 1971 and that some fishermen observed as much as 75% mortality in their catch. In this area 81,000 kg of blue crabs died along Great Point Clear during a two day period (May 1973). Low levels of dissolved oxygen in the deeper waters of Chesapeake Bay and associated tributaries during the summer months have also been implicated in trap death (Carpenter and Cargo 1957). Price et al. (1985) noted that blue crab fishermen in Chesapeake Bay have had to set their traps progressively closer to shore because of hypoxic conditions in deeper water. Periodic "kills" of blue crabs following excessive freshwater runoff and subsequent depletion of oxygen due to rapid decomposition of organic matter were reported by Van Engel (1982).

Juvenile and adult blue crabs are more tolerant of temperature and salinity variations than are zoeae and megalopae although mortalities do occur because of these factors. Above 30°C the survival rate of juvenile blue crabs decreases rapidly with only 20% survival at 35°C after 45 days (Holland et al. 1971). Heavy mortalities were also noted at 15°C. Tagatz (1969) suggested that blue crabs were less tolerant to temperature extremes at lower salinities, and the upper and lower tolerance limits increased as the acclimation temperatures increased from low (6 ppt) to high (43 ppt) salinities. Tolerance limits for adults and juveniles were similar. Holland et al. (1971) also reported that low salinities (1 ppt) were apparently lethal to small blue crabs at optimum growth temperatures (29° to 30°C).

Temperature/salinity tolerance limits of blue crabs have been reported by Waterman (1960), King (1961), Rees (1966), Tan and Van Engel (1966) and Mahood et al. (1970). These data indicate that an important physiological-ecological relationship exists among tolerance limits at various combinations of temperature and salinity. In general, blue crabs are less tolerant of low salinities at high temperatures and high salinities at low temperatures. A temperature-salinity tolerance zone was constructed by Mahood et al. (1970) for adult blue crabs using 96-hour TLm values. Crabs were acclimated to 20°C. At 0°C there was no survival at any salinity. At 8.6 ppt the tolerance zone extended from 3.2° to 22°C, and at 36 ppt it extended from 18.5° to 35.2°C. The greatest tolerance zone extended over 27°C at a salinity of 24.2 ppt. Tagatz (1969) evaluated maximum and minimum median thermal tolerance limits of juvenile and adult blue crabs acclimated at 7 or 35 ppt in temperatures of 6°, 14°, 22°, or 30°C. At both low and high salinities, the upper and lower thermal tolerance limits increased as acclimation temperature increased. Adult blue crabs from South Carolina were found to have an upper thermal tolerance limit of 35.2°C in 36 ppt and a lower thermal tolerance limit of 3.2°C in 8.6 ppt over 96 hours (McKenzie 1970). The crabs were less tolerant of low salinities at high temperatures and high salinities at low temperatures.

Blue crab mortalities in nature have been related to extreme cold or to sudden drops in temperature (Gunter and Hildebrand 1951; Van Engel 1978, 1982; Couch and Martin 1982) and to red tides (Wardle et al. 1975, Gunter and Lyles 1979). Adkins (1972a) and Perry (1975) reported large numbers of dead crabs periodically littered the beaches of Louisiana and Mississippi, respectively, observing that the vast majority of these crabs were spent females.

5.1.7.2 Morbidity

Couch and Martin (1982) provided a synopsis of the protozoan symbionts and related diseases of blue crabs. Of the protozoans that utilize the blue crab as host, the amoeba *Paramoeba perniciosa* and the dinoflagellate *Hematodinium* were identified as lethal pathogens. The history of the incidence of *P. perniciosa* along the eastern coast of the United States was reviewed by Couch and Martin (1982). This highly pathogenic amoeba is responsible for outbreaks of gray crab disease. Mass mortalities of blue crabs occurred in South Carolina, North Carolina and Georgia in June 1966 and in South Carolina and Georgia in June 1967. While the pathogenic amoeba (*P. perniciosa*) was alluded to as a possible cause of the mortalities, there was some implication that pesticides may have been involved. According to Newman and Ward (1973), blue crab mortalities of greater and lesser magnitude have occurred during May and June with *Paramoeba* involved in the majority of the kills that were investigated. Couch and Martin (1982) described *P. perniciosa* as an opportunistic parasite/pathogen of blue crabs and other Crustacea. To date, this organism has not been isolated from blue crabs in the Gulf of Mexico.

Hematodinium sp., a dinoflagellate found predominantly in the hemolymph, has been identified from *Callinectes sapidus* from the northern Gulf of Mexico (Couch and Martin 1982). The disease exhibits no external signs although infected crabs are weak and lethargic. In heavily infected crabs, the dinoflagellates may be found in the musculature, gonads and hepatopancreas.

Other protozoans infecting the blue crab are the haplosporidan parasite *Urosporidium crescens* and the microsporidan pathogen *Ameson michaelis*. *Urosporidium crescens* is a parasite of trematode metacercariae. Metacercariae of the microphallid trematode *Microphallus basodactylophallus* (as *Carneophallus basodactylophallus* [Perry 1975, Overstreet 1978]) are commonly infected by this hyperparasite in gulf waters. The metacercariae are found in the hepatopancreas and musculature of blue crabs. With the maturation of the spores of *U. crescens*, the metacercariae become black. Metacercariae containing such spores cause the condition known as "buckshot" by crab fishermen. Crabs thus affected are also known as "pepper" crabs. According to Perkins (1971), rupture of the metacercariae is necessary for the release of the spores of *U. crescens*, and this occurs after the death of the crab. He found no evidence that the trematode infection caused mortalities in crabs. Blue crabs infected with *U. crescens* pose problems to processors who must either pick around the cysts or discard the crab. According to Adkins (1972a), buckshot crabs are fairly common in Louisiana. More (1969) and Perry (1975) found infected metacercariae in crabs from Texas and Mississippi, respectively.

While *Ameson michaelis* is the more widely known microsporidan parasite of the blue crab, Couch and Martin (1982) reported that *A. sapidi* and *Pleistophora cargoi* have also been identified from muscle tissues of *C. sapidus*. *Ameson michaelis*, commonly found in blue crabs from gulf and Atlantic waters (Sprague 1977), infects the musculature and is thought to cause lysis of the muscle tissue. Overstreet (1978) noted the occurrence of this species in crabs from lakes Pontchartrain and Borgne, Louisiana and Mississippi Sound and diagrammed the life cycle. Heavily infected crabs can be distinguished from healthy individuals by the chalky opaque appearance of the muscle tissue.

Heavy infestations of ectocommensal ciliate protozoans have been implicated in mortalities of blue crabs held in confinement. Couch (1966) identified peritrichous ciliates of the genera Lagenophrys and Epistylis from gill lamellae of blue crabs from Chincoteague and Chesapeake bays. He suggested that severe infestations of these epibionts may interfere with respiration and contribute to mortality of crabs in holding or shedding tanks. Couch and Martin (1982) reported that the prevalence and intensity of infestation of Lagenophrys callinectes in natural populations of C. sapidus in Chincoteague Bay increased through the spring and summer, peaking in August. They noted that this ciliate may be a seasonal factor affecting the survival of blue crabs, particularly at times when oxygen tension in the water is borderline.

A variety of cirripede symbionts are either ecto-commensal or parasitic on blue crabs. Fouling species include the barnacles Balanus venustus niveus and Chelonibia patula (Overstreet 1978). Barnacle fouling of mature female blue crabs is common (Adkins 1972a, Perry 1975). Perry (1975) noted that large numbers of spent female crabs occasionally litter barrier island beaches in the northern gulf, and these crabs are heavily fouled and parasitized. The pedunculate barnacle Octolasmis muelleri (as O. lowei [Perry 1975]) is found on the gills and in the gill chamber of C. sapidus. Infestations have been observed on male and female crabs from waters of high salinity (More 1969, Perry 1975). Overstreet (1978) noted that heavy infestations may interfere with respiration by decreasing the amount of available gill surface.

The barnacle Loxothylacus texanus is a true parasite of blue crabs in the Gulf of Mexico. The cypris larvae infect immature crabs during the molting process. Following a period of internal development, an externa or sac protrudes from beneath the abdomen of the crab. The externa contains the male and female gonads and serves as a brood pouch for the developing larvae. Rhizocephalan infection alters the secondary sex characteristics of the crab causing the abdomen to appear as that of a mature female. There is some controversy in the literature as to the effect that rhizocephalan infection has on molting and growth. Reinhard (1956) reported that in infected crabs gonadal development is suppressed and that once the externa emerges, molting and growth cease. Overstreet (1978) observed that crabs with externae can molt but questioned whether this process was typical. The influence of rhizocephalan infection on blue crab stocks is of particular concern in Louisiana. Harris and Ragan (1970) reported that 43% of the blue crabs collected in May and June from two estuarine areas in Louisiana were infected with L. texanus. Adkins (1972b) found a direct correlation between temperature and percentage of infected crabs with peak occurrence of the barnacle from July through September. In September 1971, 17.1% of the crabs taken in his samples were infected. More (1969), Adkins (1972b) and Ragan and Matherne (1974) found peak occurrence of the barnacle in higher salinities. According to Ragan and Matherne (1974) adult rhizocephalans cannot tolerate low salinity; maturing externae do not protrude and ones already protruding take on water and rupture. Blue crabs infected with L. texanus are becoming more prevalent in Mississippi coastal waters. Christmas (1969) noted that the rate of infection in the sound was negligible in 1966. Perry (1975) reported that the barnacle was found on less that 1.0% of the crabs collected in 1971 and 1972, and Perry and Herring (1976) noted that 0.1% of the crabs taken in samples from October 1973 through September 1976 carried an externa or had a modified abdomen. Since these data were collected, the incidence of parasitism has risen to over 4.0% (Perry and Stuck 1982). Additionally, parasitized crabs now show wider areal distribution in Mississippi Sound. From 1971 through 1976 catches of parasitized crabs were highest in the western portion of Mississippi Sound. Subsequently, infected crabs have been collected throughout local waters. Overstreet (1978) noted that over half of the crabs taken aboard a shrimp trawler in Mississippi Sound in July 1977 exhibited infections. Overstreet (1978) suggested that the "dwarf" or "button" crabs that appear seasonally in the commercial catch in Mississippi may be a result of sacculinid infection. Gunter (1950) observed that only 1.5% of the crabs collected in Aransas and Copano bays, Texas, were parasitized. Daugherty (1952), however, noted that 25.8% of the crabs collected near the southwestern end of Mud Island in Aransas Bay from 1947-1950 were infected. More (1969) found 8.0% and 5.8% infection rates in crabs examined from the lower Laguna Madre and upper Laguna Madre, respectively, with the incidence of infection never exceeding 1.0% in other Texas bays. Steele and Hochberg (1987) reported a 4% incidence rate of L. texanus infection of blue crabs in Tampa Bay, Florida, during 1981-1983.

Carcinonemertes carcinophila, a parasitic nemertean, is common on the gills and egg masses of mature female crabs (More 1969, Perry 1975). Hopkins (1947) discussed the use of this worm as an indicator of the spawning history of Callinectes sapidus. Overstreet (1978) noted that while the blue crab is the usual host, it has been found on other portunids.

Digenetic trematodes of the family Microphallidae often use a crustacean as a second intermediate host. In those species infecting the blue crab, a snail usually serves as the first intermediate host with a fish, bird or mammal serving as the final host. The cercariae (shed from the snail) enter the branchial chamber of the crab, attach to the gill lamellae and penetrate into the gill lumen. The circulatory fluid of the crab carries the cercariae to various parts of the body where they encyst (usually in the hepatopancreas and/or musculature). The encysted or metacercarial stage may or may not be visible depending upon the species. The metacercariae of Levinseniella capitanea are very large and easily seen; whereas the metacercariae of Microphallus basodactylophallus are not visible unless they are hyperparasitized by U. crescens.

Because the types of habitats in which these trematodes complete their life cycle are often quite specific, they have potential use as "biological tags" (Heard, Gulf Coast Research Laboratory, personal communication). In the northern Gulf of Mexico, the life cycle of L. capitanea is completed in the high salinity marshes and baylets of the offshore barrier islands; thus the presence of the metacercariae of this species is an indication that the crab has spent time in the marsh habitats of these islands. Another example is Megalophallus diodontis, the metacercariae of which are found only in the gills of crabs that have spent all or part of their juvenile and/or adult life in high salinity turtle grass beds where the life cycle of this digenean is completed.

Perry (1975) and Overstreet (1978) found the metacercariae of M. basodactylophallus (as Carneophallus basodactylophallus) in blue crabs from the northern Gulf of Mexico. More (1969) and Adkins (1972a) reported a metacercaria similar to Spelotrema nicolli in blue crabs from Texas and Louisiana, respectively. Heard (1976) noted that the metacercariae observed by More (1969) and Adkins (1972a) were in all probability M. basodactylophallus because S. nicolli is known only from New England (Cable and Hunninen 1940). The taxonomic status of several species of microphallids is in question (Heard, Gulf Coast Research Laboratory, personal communication). Deblock (1971) placed Spleotrema and Carneophallus in synonymy with Microphallus. Heard and Overstreet (in preparation) are currently reviewing the taxonomic status of those species from the southeastern United States which have been previously assigned to the genus Carneophallus.

Levinseniella capitanea was described from blue crabs from lower Lake Borgne and western Mississippi Sound by Overstreet and Perry (1972). The large metacercariae of this species appear as opaque, white cysts in the hepatopancreas, gonads or musculature. There are no published data on the prevalence of this species; Overstreet (Gulf Coast Research Laboratory, personal communication) reports it to occur with more frequency in crabs from Alabama and northwestern Florida.

Leeches (Myzobdella lugubris) are common on crabs from low salinity waters. Although Perry (1975) and Overstreet (1978) found no evidence to suggest a harmful relationship, Hutton and Songandares-Bernal (1959) noted that M. lugubris may have been responsible for mortalities of blue crabs in Bulow Creek, Florida. A branchiobdellid annelid, Cambarincola vitreus, also infests blue crabs from low salinity and freshwater habitats. These small worms (2 to 3 mm long) are found in the gill chambers and on the external shell surface and apparently cause no harm to the crab (Overstreet 1978).

Microbial infections of blue crabs include the nonfatal bacteria responsible for "shell disease" and pathogenic species of Vibrio. In their study of the chitinoclastic bacteria associated with blue crabs and penaeid shrimp, Cook and Lofton (1973) isolated one strain, Beneckea type I, from all necrotic lesions but noted in all cases there was no penetration of the epicuticle by the bacteria.

Several species of Vibrio have been identified from blue crabs. Davis and Sizemore (1982) isolated bacteria taxonomically identical to V. cholerae, V. vulnificus and V. parahaemolyticus from blue crabs collected in Galveston Bay, Texas. Species of Vibrio were the predominant bacterial types in the hemolymph occurring in 50% of the crabs sampled in the summer. Vibrio cholerae and V. vulnificus were isolated from 3.5% and 9.0% of the crabs, respectively, with V. parahaemolyticus occurring in 30% of the study organisms. Vibrio parahaemolyticus and V. vulnificus were commonly isolated from the same crab; however, V. parahaemolyticus and V. cholerae were never found together. Vibrio parahaemolyticus has caused mortalities in blue crabs and food poisoning symptoms in humans eating contaminated crabs (Overstreet 1978). Keel and Cook (1975) found V. parahaemolyticus in Mississippi coastal waters and related its prevalence to temperature and distance from land. In 1978 gulf coast blue crabs were linked to an outbreak of human cholera in Louisiana. Evidence indicated that the outbreak was due to poor sanitary practices in home-prepared crabs with no implication of commercially processed crab meat. Moody (1982) discussed zoonotic diseases associated with blue crabs and reviewed the history of the 1978 Louisiana cholera outbreak.

5.1.8 Migration and Recruitment

5.1.8.1 Migration

Tagging studies in the gulf include those of More (1969), Perry (1975), Oesterling and Evink (1977) and Steele (1987). Migrational patterns observed by More (1969) and Perry (1975) were typical of the onshore/offshore movements as characterized in previous studies (Fiedler 1930, Van Engel 1958, Fischler and Walburg 1962, Tagatz 1968a, Judy and Dudley 1970, Benefield and Linton 1990). Oesterling and Evink (1977) and Steele (1987) provided evidence of an alongshore movement of females in Florida coastal waters. Migratory patterns observed in their studies demonstrated movement of females to sites north of their mating estuary. Oesterling and Evink (1977) reported that the Apalachicola Bay region appeared to be a primary spawning ground for crabs along the Florida peninsula gulf coast. A hypothesis for redistribution of larvae to southwestern Florida involved transport of zoeae in surface currents associated with Apalachicola River flow and Gulf of Mexico Loop Current. Steele (1987) reported spawning all along the west coast of Florida. Some females tagged in Tampa Bay traveled 750 km in 99 days.

5.1.8.2 Larval Recruitment

In addition to the direct and indirect influences of physico-chemical parameters on larval and juvenile blue crabs, larval transport mechanisms may be an important factor influencing year class strength. The vulnerability of blue crabs to changing environmental conditions is perhaps greatest during these stages. While most crab studies have emphasized the role of the nursery area as a limiting factor in determining the strength of a year-class or modal group, conditions that affect the initial movement of larvae and postlarvae toward the nursery area must also be considered. Sulkin and Epifanio (1986) suggest that physical factors regulating larval dispersal are paramount in determining year-class strength.

Little is known concerning mechanisms of larval transport and dispersal of blue crab zoeae in the northern gulf. Based on the data of Menzel (1964), Andryszak (1979) and Perry and Stuck (1982), it appears that development through the late zoeal stages (III through VII) takes place in offshore waters. At this time the larvae are subject to currents and may be transported considerable distances. This differential distribution of early- and late-stage zoeae, though it helps assure wide dissemination of the species, subjects recruitment to the vagaries of offshore transport. Recruitment to gulf estuaries occurs in the megalopal stage (Tagatz 1968a, More 1969, King 1971, Perry 1975).

Oesterling and Evink (1977) proposed a mechanism for larval dispersal in northeastern gulf waters in which blue crab larvae were transported distances of 300 km or more. If such transport mechanisms do exist in the gulf, larvae produced by spawning females in one state may, in fact, be responsible for recruitment in adjoining states.

Laboratory studies on Callinectes larvae indicate that there is a behavioral basis for the vertical distribution of blue crab zoeae. According to Sulkin (1981), "experiments indicate that during the course of blue crab zoeal development changes occur in critical behavioral responses which, through ontogeny, produce a characteristic pattern of differential vertical distribution." From these observations he developed a dispersal-based recruitment model for the Middle Atlantic Bight which included mechanisms for both the estuarine retention of larvae and the recruitment of larvae from offshore. He noted that significant retention of larvae was most likely to occur in stratified estuaries which are wide with respect to depth near the mouth. In such an estuary, larvae released at depth below the pycnocline would be retained. A revision of the concept of estuarine retention was published by Sulkin and Van Heukelem (1982) and Sulkin and Epifanio (1986). New data on larval behavioral traits coupled with field evidence suggest that offshore recruitment of larvae is the dominant recruitment mechanism in C. sapidus; blue crab larvae migrate to surface waters early in larval development and are not retained in estuaries. Early stage zoeae possess behavioral adaptations that promote export from the estuary. Additionally, Provenzano et al. (1983) and Epifanio et al. (1984) suggested that hatching in C. sapidus occurs synchronously at night on high slack tides. In both studies peak abundance of Stage 1 zoeae was noted on ebbing tides at night thus promoting seaward transport of larvae. Offshore, late stage zoeae and megalopae are also found more abundantly in surface waters (Smyth 1980, Johnson 1983). Sulkin and Epifanio (1986) suggest that surface presence of megalopae reflects distribution of late zoeal stages, and as megalopae develop and approach metamorphosis, they systematically move to deeper waters. They propose a conservative onshore transport mechanism of entrainment in shoreward moving deep water currents. Johnson (1983) proposed that shoreward movement of megalopae was dependent upon wind driven onshore flow of surface water, thus leaving recruitment subject to fortuitous, episodic climatic events. Understanding the biotic and abiotic factors affecting larval survival and recruitment are aspects of the life history of the blue crab that have received little attention in the Gulf of Mexico.

5.1.9 Predator-Prey Relationships

Blue crabs perform a variety of ecosystem functions and play a major role in energy transfer within estuaries (Van Den Avyle and Fowler 1984). Laughlin (1982) concluded that the blue crab is an omnivore, detritivore, cannibal and a scavenger, and shows a high degree of variability in food habits with respect to season, locality and ontogenetic stage.

While studying the food habits of fishes and invertebrates of Lake Pontchartrain, Louisiana, Darnell (1958) found blue crabs, mud crabs (Rhithropanopeus harrisii), unidentified crustacean pieces, molluscs, fish remains and detritus among the diet of C. sapidus. He noted that food differences between adults and young were not pronounced; however, as crabs exceeded 124.0 cm carapace width, molluscs became the dominant food item. The importance of molluscs in the diet has also been documented by Menzel and Hopkins (1956), Tagatz (1968a), Tarver (1970) and Jaworski (1972). In Apalachicola Bay, Florida, Laughlin (1982) divided blue crabs into three trophic groups based upon their stomach contents. Juveniles under 31 mm carapace width fed mainly on bivalves, plant material, detritus and ostrocods. Crabs 31 to 60 mm carapace width consumed fish, gastropods and xanthid crabs. Animals over 60 mm carapace width fed on fish, bivalves, xanthid crabs and other blue crabs. In an attempt to distinguish and clarify the fundamental nutritional relationship that he observed in the Lake Pontchartrain estuary, Darnell (1961) reevaluated the data presented in his 1958 paper in the context of the total estuarine community. He found that most consumer species, the blue crab among them, did not conform to specific trophic levels and utilized alternate food sources from time to time depending upon availability. Successful species were opportunists whose food habits were governed by availability thus characterizing blue crabs as opportunistic benthic omnivores. Data from O'Neil (1949), Suttkus et al. (1953) and Tagatz and Frymire (1963) support this characterization. Heard (1982) described blue crabs as voracious feeders with a variable diet. He noted that in tidal marshes, fiddler crabs (Uca spp.) and marsh periwinkles (Littorina irrorata) were important components of the diet of blue crabs. Hamilton (1976) suggested that movement of periwinkles up marsh grass stalks with a rising tide may, in part, be an "escape" reaction to avoid predation.

The generalized nature of blue crab feeding habits, coupled with size-related variability, led Laughlin (1982) to conclude that trophic stages rather than the species as a whole be considered for food web models.

The high density of blue crabs in estuaries and their feeding adaptiveness make them key predators of estuarine benthos. The influence of blue crab predation on the abundance of other commercially important species has been documented. Marshall (1954) studied the effects of predation on oysters in Florida and found survival of oysters was only 9% in a natural area as opposed to 85%-86% in areas where oysters were protected from predators. Carriker (1967) said that blue crabs pose an additional threat as estuarine oyster predators, because unlike starfish and oyster drills, they can move into low salinity waters. Lunz (1946) found blue crabs to be the most serious predator of young oysters (5 to 30 mm). In laboratory studies, juvenile blue crabs from 65 to 85 mm carapace width consumed cultchless oysters up to 25 mm shell length while blue crabs 100 to 150 mm carapace width consumed oysters up to 40 mm shell length (Krantz and Chamberlin 1978). Blue crabs also prey on the clams, Mercenaria americana (Van Engel 1958) and Mya arenaria (Hines et al. 1987).

Blue crabs are important prey species for a variety of organisms. Larval stages are eaten by other plankters, fish, jellyfish and comb jellies (Van Engel 1958). Juvenile and adult blue crabs are eaten by sport and commercial fishes such as spotted seatrout (Cynoscion nebulosus), red drum (Sciaenops ocellatus), sheepshead (Archosargus probatocephalus), black drum (Pogonias cromis) and southern flounder (Paralichthys lethostigma). At least 26 fish species have been identified as blue crab predators (Table 5.2).

Blue crabs form an important link in the basic food chain of mammals and birds. The primary mammalian predator is the raccoon (Procyon lotor). Avian predators include the clapper rail (Rallus longirostris), great blue heron (Ardea herodias), American merganser (Mergus merganser americanus) and hooded merganser (Lophodytes cucullatus).

Table 5.2. Fish predators of the blue crab.

Species	Gunter (1945)	Darnell (1958)	Fontenot and Rogillio (1970)	Overstreet and Heard (1978a)	Overstreet and Heard (1978b)	Overstreet (Unpub. data, GCRL)	Heard (Unpub. data, GCRL)
Aplodinotus grunniens		X					
Archosargus probatocephalus	X	X	X			X	
Arius felis	X	X					
Bagre marinus	X						
Bairdiella chrysoura		X					
Caranx hippos						X	
Carcharhinus leucas							X
Cynoscion arenarius						X	

Table 5.2. Continued.

Species	Gunter (1945)	Darnell (1958)	Fontenot and Rogillio (1970)	Overstreet and Heard (1978a)	Overstreet and Heard (1978b)	Overstreet (Unpub. data, GCRL)	Heard (Unpub. data, GCRL)
Cynoscion nebulosus	X		X			X	
Dasyatis americanus							X
Dasyatis sabina							X
Dasyatis sayi							X
Ictalurus furcatus		X					
Lagodon rhomboides		X					
Lepisosteus oculatus		X					
Lepisosteus spatula		X					
Lobotes surinamensis	X						
Micropogonias undulatus		X	X	X			
Micropterus salmoides		X					
Morone interrupta		X					
Opsanus beta							X
Paralichthys lethostigma		X				X	
Pogonias cromis	X		X			X	
Rachycentrum canadum						X	
Sciaenops ocellatus	X	X	X		X		
Sphyrna tiburo	X						

6.0 DESCRIPTION OF THE HABITAT OF THE STOCK(S) COMPRISING THE MANAGEMENT UNIT

6.1 Gulf of Mexico

Galstoff summarized the geology, marine meteorology, oceanography and biotic community structure of the Gulf of Mexico in 1954. Later summaries include those of Jones et al. (1973), Becker and Brashier (1981) and Holt et al. (1982).

6.1.1 Offshore Sediments

The continental shelf in the northern gulf ranges from 8 to 117 miles in width. The most abundant type of surface sediment exposed is sand which covers more than 62% of the shelf. Over 82% of this sand is over the eastern shelf. Three general offshore bottom types have been described. Bottom types off northwest Florida, Alabama and eastern Mississippi are quartz sand with shell or coral deposits. In some areas the quartz sands are mixed with alluvium from coastal rivers. The second bottom type extends from a point even with Pascagoula, Mississippi, to the Texas-Louisiana border. It is a complex of fine grained, muddy sediments with occasional surface deposits of sand and/or shell. Mississippi River deposition is the principal source of sediment. The third bottom type offshore from Texas is characterized by sand and finer grain sediments.

6.1.2 Circulation Patterns

Hydrographic studies depicting general circulation patterns of the Gulf of Mexico include those of Parr (1935), Dietrich (1939), Drummond and Austin (1958), Ichiye (1962), Nowlin (1971) and Jones et al. (1973).

Circulation patterns in the gulf are dominated by the influence of the upper-layer transport system of the western North Atlantic. Driven by the northeast trade winds, the Caribbean Current flows westward from the junction of the Equatorial and Guiana current, crosses the Caribbean Sea and continues into the gulf through the Yucatan Channel eventually becoming the eastern Gulf Loop Current. Upon entering the gulf through the Yucatan Channel, the Loop Current transports 25-30 million cubic feet of water per second (Cochrane 1965).

Moving clockwise, the Loop Current dominates surface circulation in the eastern gulf and generates permanent eddies over the western gulf. During late summer and fall the progressive expansion and intrusion of the loop reaches as far north as the continental shelf off the Mississippi River Delta. Nearshore currents are driven by the impingement of regional gulf currents across the shelf, passage of tides and local and regional wind systems. The orientation of the shoreline and bottom topography may also place constraints on speed and direction of shelf currents.

6.1.3 Salinity, Temperature and Tides

Gulf salinities beyond the continental shelf average between 36.0 and 36.5 ppt. However, salinity values in shelf regions may vary widely from the above values due to the opposing effects of river input and enhanced evaporation. Annual salinity variations may span 20 ppt. In general, lowest salinities occur in the spring, and highest salinities occur in the summer and fall. Temperature data are taken from Holt et al. 1982. In the eastern gulf, maximum surface temperatures range from 27°C in late winter to 30°C in the summer. A range of 22° to 29°C occurs in the western gulf. Values may drop as low as 10°C in the northern gulf due to the influence of the Mississippi River.

Gulf tides are small and noticeably less developed than along the Atlantic or Pacific coasts. The normal tidal range at most places is not more than 1-2 feet. Despite the small tidal range, tidal current velocities are occasionally high especially near the constricted outlets that characterize many of the bays and lagoons. Tide type varies widely throughout the gulf. Tides are diurnal (one high tide and one low tide each lunar day of 24.8 hours) from approximately St. Andrew's Bay, Florida, to western Louisiana. The tide is semi-diurnal in the Apalachicola Bay area of Florida and mixed in west Louisiana and Texas.

6.2 Estuaries

Vegetative, sedimentary and physical descriptors for major gulf estuarine systems are presented in Tables 6.1 through 6.5. The percent contribution to individual state commercial landings by estuarine system is also shown. Major estuarine systems for each state are shown in Figures 6.1 through 6.5.

6.2.1 Eastern Gulf

The eastern Gulf of Mexico extends from Florida Bay northward to Perdido Bay on the Florida/Alabama boundary. Considerable changes occur in type and acreage of submergent and emergent vegetation from south to north. Mangrove tidal flats are found from the Florida Keys to Naples. Sandy beaches and barrier islands occur from Naples to Cedar Key and from Apalachicola Bay to Perdido Bay; tidal marshes are common between Cedar Key and Apalachicola. The coast from Apalachee Bay to the Alabama border is characterized by wide sand beaches situated either on barrier islands or on the mainland itself. Tidal marshes are found from Escambia Bay to Florida Bay with greatest acreage in Suwanee Sound and Waccasassa Bay. Beds of mixed sea grasses and/or algae occur throughout the eastern gulf. Largest areas of submerged vegetation are found from Apalachee Bay south.

Coastal waters in the eastern gulf may be generally characterized as clear, nutrient-poor and highly saline. Rivers which empty into the eastern gulf carry little sediment load. Primary production is generally low except in the immediate vicinity of estuaries or on the outer shelf when the nutrient-rich Loop Current penetrates into the area.

6.2.2 North Central Gulf

The north central gulf includes Alabama, Mississippi and Louisiana. The Alabama and Mississippi coasts are bounded offshore by a series of barrier islands which are characterized by high energy sand beaches grading to saltmarsh in the interior. The mainland shoreline is made up of saltmarsh, beach, seawall and brackish-freshwater marsh in the coastal rivers. The eastern and central Louisiana coasts are dominated by sand barrier islands and associated bays and marshes. The most extensive marshes in the United States are associated with the Mississippi-Atchafalaya River deltas. The shoreline of the western one-third of Louisiana is made up of sand beaches with extensive inland marshes. A complex geography of sounds and bays protected by barrier islands and tidal marshes acts to delay mixing resulting in extensive areas of brackish conditions.

In general, estuaries and nearshore gulf waters of Louisiana and eastern Mississippi are low saline, nutrient-rich and turbid. These characteristics are due primarily to the high rainfall and high discharges of the Mississippi, Atchafalaya and other coastal rivers. The Mississippi River deposits 684 million metric tons of sediment annually near its mouth (Holt et al. 1982). Average (1980-1988) discharge for the Mississippi and Atchafalaya rivers are 500,000 ft^3/sec and 215,000 ft^3/sec, respectively. As a probable consequence of the large fluvial nutrient input, the Louisiana nearshore shelf is considered one of the most productive areas in the Gulf of Mexico.

Table 6.1. Vegetative, physical and sedimentary characteristics of Florida estuarine systems and percent contribution to reported commercial landings.

Hydrologic Unit	Tidal Marsh/ Mangrove Swamp[1] (hectares)	Submerged Vegetation[1] (hectares)	Sediment Type[1]	Surface Area[1] (hectares)	Drainage Area[1] (km^2)	River Discharge[1] (ℓ/sec)	Percent Contribution[2,3] to West Coast Landings
Escambia Bay	3,510	769	Sand, Sand/shell	51,005	14,315	268,402	1.7
Choctawhatchee Bay	1,139	1,251	Sand, Sand/shell, Mud	34,924	11,525	204,810	0.3
St. Andrew Bay	4,476	2,684	Sand, Silt, Clay	27,972	NA*	NA	5.2
St. Joseph Bay	345	2,560		17,755			0.1
Apalachicola Bay	8,621	3,795	Sand covered with silt and clay	68,788	47,818	768,123	5.7
Apalachee Bay	22,529	9,518	Sand	24,817	7,552	90,822	17.7
Suwanee Sound and Waccasassa Bay	25,560/354	13,030	Sand	35,618	26,304	322,760	37.9
Tampa Bay	699/7,088	8,450	Sand, Sand/clay, Clay/silt	110,338	3,398	43,530	3.6
Sarasota Bay	95/1,463	3,079	Sand, Sand/shell	14,061	160	2,285	0.3
Charlotte Harbor	3,678/9,500	9,463	Sand/shell, Mud/shell	49,290	5,174	55,739	6.9
Caloosahatchee River	687/1,203	293	Sand/shell	15,180	699	29,934	19.5
Florida Bay	4,916/14,932	103,849	Coral, Sand/shell, Sand/mud	225,631	NA	NA	1.2

*Data not available = NA.

[1] Source: McNulty, J. K., W. N. Lindall, Jr. and J. E. Sykes. 1972. *Cooperative Gulf of Mexico Estuarine Inventory and Study, Florida: Phase 1, Area Description.* NOAA Tech. Rept. NMFS Circ. 368:1–126.

[2] Florida Marine Fisheries Information System 1988

[3] Dixie-Taylor Counties-- 23.7%, Pasco-Citrus Counties -- 11.5%.

Table 6.2. Vegetative, physical and sedimentary characteristics of Alabama estuarine systems and percent contribution to reported commercial landings.

Hydrologic Unit	Tidal Marsh (hectares)	Submerged Vegetation (hectares)	Sediment Type[3]	Surface Area[3] (hectares)	Drainage Area[3] (km^2)	River Discharge[3] (ℓ/sec)	Percent Contribution[4] to State Landings
Mobile Bay	1,333[1]	2,024[3]	Sand, Clay, Mud	107,030	113,995	1,947,329	20.0
Mississippi Sound	5,369[2]	NA*	Sand, Clay, Mud	37,516	259	NA	57.0
Perdido Bay	434[3]	NA	Sand, Clay, Mud	6,989	2,637	26,539	0.2

*Data not available = NA.

[1] Source: Stout, J. P. 1979. Marshes of the Mobile Bay estuary: Status and evaluation, pp. 113–121. *In:* H. Loyacano and J. Smith (eds.), *Symposium on the Natural Resources of the Mobile Estuary, Alabama.* MASGP–80–022.

[2] Source: Stout, J. P. & A. A. de la Cruz. 1981. Marshes of Mississippi Sound: State of Knowledge, pp. 8–20. *In:* J. K. Kelly (ed.), *Symposium on Mississippi Sound.* MASGP–81–007.

[3] Source: Crance, J. H. 1971. Description of Alabama estuarine areas–Cooperative Gulf of Mexico Estuarine Inventory. *Alabama Mar. Res. Bull.* 6:1–85.

[4] Source: Swingle, W. E. 1976. Analysis of commercial fisheries catch data for Alabama. *Alabama Mar. Res. Bull.* 11:26–50.

Table 6.3. Vegetative, physical and sedimentary characteristics of Mississippi estuarine systems and percent contribution to reported commercial landings.

Hydrologic Unit	Tidal Marsh[1] (hectares)	Submerged Vegetation[2] (hectares)	Sediment Type[3]	Surface Area[4] (hectares)	Drainage Area[4] (km^2)	River Discharge[4] (ℓ/sec)	Percent Contribution[5] to State Landings
Pascagoula River	11,281		Sandy and Muddy Sandy Deposits	53,110	24,346	430,464	NA*
Biloxi Bay	4,683		Sandy and Muddy Sandy Deposits	60,896	1,735	38,232	NA
St. Louis Bay			Sandy and Muddy Sandy Deposits	66,568	291	41,347	NA
	9,927						
Pearl River			Sandy and Muddy Sandy Deposits	22,335	3,521	365,328	NA
Mississippi Sound South of Intracoastal Waterway	860 Barrier Islands	1,970	Sand Mud				NA

* Data Not Available = NA

[1]Source: Eleuterius, L. N. 1973. The marshes of Mississippi. *In: Cooperative Gulf of Mexico Estuarine Inventory and Study, Mississippi.* Gulf Coast Research Laboratory, Ocean Springs, Mississippi, pp. 147–190.

[2]Source: Eleuterius, L. N. and G. J. Miller. 1976. Observations on seagrasses and seaweeds in Mississippi Sound since Hurricane Camille. *J. Miss. Acad. Sci.* 21:58–63.

[3]Source: Otvos, E. G. 1973. Sedimentology. *In: Cooperative Gulf of Mexico Estuarine Inventory and Study, Mississippi.* Gulf Coast Research Laboratory, Ocean Springs, Mississippi, pp. 123–137.

[4]Source: Christmas, J. Y., Jr. 1973. Area description. *In: Cooperative Gulf of Mexico Estuarine Inventory and Study, Mississippi.* Gulf Coast Research Laboratory, Ocean Springs, Mississippi, pp. 1–71.

[5]Source: Majority of catch taken from Mississippi Sound (personal communication, Hermes Hague, NMFS).

Table 6.4. Vegetative, physical and sedimentary characteristics of Louisiana estuarine systems and percent contribution to reported commercial landings. (The size and complexity of Louisiana estuaries did not permit the use of a single classification scheme). This table uses the best scientific information available. Due to subsidence of estuaries, estimates may not be exact.

Hydrologic Unit	Tidal Marsh[1] (hectares)	Hydrologic Unit	Submerged Vegetation[2] (hectares)	Sediment Type[3]
Lakes Maurepas, Pontchartrain and Borgne; Chandeleur and Breton Sounds	189,804	Lakes Maurepas and Pontchartrain	8,094 (north shore of Lake Pontchartrain only)	Clayey Silt Silty Clay Sand
Active Mississippi River Delta	27,115	Lake Borgne, Brenton Sound	NA*	Silty Clay Clayey Silt
Barataria Basin	164,308	Barataria Bay	NA	Clayey Silt Sand
Timbalier-Terrebonne Bays, Caillou Bay	219,347	Timbalier-Terrebonne Bays	NA	Sandy Silt Clayey Silt Sand
Atchafalaya Bay	23,877	Lake Mechant, Caillou Lake	NA	Clayey Silt Sand, Clay
Cote Blanche-Vermilion Bays	100,770	Vermilion-Atchafalaya Bays	NA	Clayey Silt Silty Clay
Mermentau River,[2] White and Grand Lakes	121,410[2]	Calcasieu, White and Sabine Lakes	NA	Clayey Silt Silty Clay
Calcasieu and Sabine Lakes[2]	106,436[2]			

Hydrologic Unit	Surface Area[2] (hectares)
Lake Maurepas	23,549
Lake Pontchartrain	159,503
Lake Borgne	69,357
Chandeleur Sound	233,918
Breton Sound	79,050
Mississippi River and Active Delta	46,268
Barataria and Caminada Bays, Little Lake	28,571
Lakes Barre, Raccourci, Timbalier-Terrebonne Bays	69,052
Caillou Bay and Lake, Four League Bay, Lakes Mechant and Pelto	35,722
Atchafalaya Bay	54,505
Cote Blanche-Vermilion Bays	118,909
White and Grand Lakes	33,745
Calcasieu Lake	17,318
Sabine Lake	22,606

Hydrologic Unit	Drainage Area[4] (km^2)
Pearl River	22,454
Lakes Maurepas, Pontchartrain and Borgne; Chandeleur and Breton Sounds	14,394
Mississippi River	336,492
West Mississippi River Delta, including drainage into Barataria Bay, Timbalier-Terrebonne Bays, Caillou Bay, Atchafalaya Bay, Cote Blanche-Vermilion Bays	248,417
Mermentau River	9,896
Calcasieu River	9,780
Sabine River	54,244

Hydrologic Unit	Percent Contribution[5] to State Landings Hard/Soft
Lakes Maurepas and Pontchartrain	14.0/46.0
Lake Borgne, Chandeleur and Breton Sounds	10.0/00.0
Barataria Bay	22.0/53.0
Timbalier-Terrebonne Bays	8.0/00.0
Lake Mechant, Caillou Lake	14.0/00.0
Vermilion-Atchafalaya Bays	14.0/00.0
Calcasieu, White and Sabine Lakes	14.0/00.0

*Data not available = NA.

[1] Source: Wicker, K. M. 1980. Mississippi deltaic plain region ecological characterization: a habitat mapping study. A user's guide to the habitat maps. *U.S. Fish Wildl. Serv.*, Office of Biol. Ser. FWS/OBS-79/07.

[2] Source: Perret, W. S., et al. 1971. *Cooperative Gulf of Mexico estuarine inventory and study, Louisiana, Phase I, Area description:* pp. 1–38. Louisiana Wildlife and Fisheries Commission, New Orleans, Louisiana.

[3] Source: Barrett, B. B., et al. 1971. *Cooperative Gulf of Mexico estuarine inventory and study, Louisiana, Phase III, sedimentology*, pp. 131–191. Louisiana Wildlife and Fisheries Commission, New Orleans, Louisiana.

[4] Source: Sloss, R. 1971. Drainage area of Louisiana streams. U.S. Dept. Interior Geological Survey, Water Resources Division, Basic Records Report 6.

[5] Based on NMFS data for 1980.

Table 6.5. Vegetative, physical and sedimentary characteristics of Texas estuarine systems and percent contribution to reported commercial landings.

Hydrologic Unit	Tidal Marsh (hectares)	Submerged Vegetation (hectares)	Sediment Type	Surface Area (hectares)	Drainage Area (km^2)	River Discharge (ℓ/sec)	Percent Contribution[23, 24] to State Landings
Sabine Lake	NA*	NA	Mud, Silt, Shell[2]	22,605[2]	53,421[14]	434,424[1]	4.9
Galveston Bay	93,624[1]	7,323[1]	Mud, Shell, Clay[3], Sand	143,170[7]	51,958[15]	317,098[20]	22.1
East Matagorda Bay	NA	NA	Mud, Sand[1]	15,300[1]	NA	NA	2.9
West Matagorda Bay	48,552[1]	2,848[1]	Mud, Shell, Clay,[1] Sand	98,920[1]	10,713[16]	85,616[1]	8.0
San Antonio Bay	10,115[1]	6,615[1]	Silty Clay, Mud,[4] Sand, Shell	47,800[8]	26,563[17]	53,907[21]	30.1
Aransas Bay	18,207[1]	1,669[1]	Mud, Sand[1]	55,652[1,9]	6,800[18]	3,022[1]	24.2
Corpus Christi Bay	NA	NA	Mud, Sand[1]	50,505[8,10,11]	44,963[18]	25,368[11]	2.0
Upper Laguna Madre	NA	NA	Sand, Silt, Shell[5]	41,014[1,12]	7,752[19]	NA	0.8
Lower Laguna Madre	NA	NA	Sand, Silt, Clay[6]	73,983[13]	3,193[19]	3,100[22]	4.7

* Data Not Available = NA.

[1] Source: Diener, R. A. 1975. *Cooperative Gulf of Mexico estuary inventory and study-Texas: area description.* NOAA Tech. Rept., Nat. Mar. Fish. Serv., Circ. 393. 129 pp.

[2] Source: Wiersema, J. M., and R. P. Mitchell. 1973. Sabine power station ecological program. Vol. 2. TRACOR, 6500 TRACOR Lane, Austin, Texas. 54 pp.

[3] Source: Benefield, R. L. and R. E. Hofstetter. 1976. Mapping of productive oyster reefs–Galveston Bay, Texas. Texas Parks and Wildlife Dept., Austin. (unpublished manuscript)

[4] Source: Texas Parks and Wildlife Department. 1975. Fishery resources of the San Antonio Bay system and factors relating to their viability–preliminary draft. Texas Parks and Wildlife Dept., *Coastal Fish.* 116 pp.

[5] Source: Simmons, E. G. 1957. Ecological study of the Upper Laguna Madre of Texas. *Publ. Inst. Mar. Sci., Univ. Tex.* 4(2):156–200.

[6] Source: Shepard, P., and A. Rusnak. 1957. Texas bay sediments. *Publ. Inst. Mar. Sci. Univ. Tex.* 4(2):5–13.

[7] Source: Fisher, W. L., H. H. McGowen, L. F. Brown, Jr. and C. G. Croat. 1972. Environmental geologic atlas of the Texas coastal zone–Galveston-Houston area. Bureau of Economic Geology. Univ. Tex., Austin, Tex. 91 pp.

[8] Source: Collier, A., and J. W. Hedgpeth. 1950. An introduction to the hydrography of tidal waters of Texas. *Publ. Inst. Mar. Sci. Univ. Tex.* 1(2):120–194.

[9] Source: Heffernan, T. L. 1972a. An ecological evaluation of some tributaries of the Aransas Bay area. Texas Parks and Wildlife Dept., *Coastal Fish. Proj.* No. CE-1–1. 104 pp.

[10] Source: Hood, Donald W. 1953. A hydrographic and chemical survey of Corpus Christi bay and connecting water bodies. Texas A&M Research Foundation Project No. 40, Annual Report, Dept. of Ocean, Texas A&M University.

[11] Source: Stevens, H. R., Jr. 1959. A survey of hydrographic and climatological data of Corpus Christi Bay. *Tex. Game and Fish. Comm. Proj. Repts.* 1958–1959 (mimeo).

[12] Source: Breuer, J. P. 1957. An ecological survey of Baffin and Alazan Bays, Texas. *Publ. Inst. Mar. Sci., Univ. Tex.* 4(2):134–155.

[13] Source: Stokes, Gary 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 Wildlife Dept., Tech. Ser.* No. 15. 32 pp.

[14] Source: Texas Department of Water Resources. 1981. Sabine-Neches estuary: a study of the influence of freshwater inflows. Texas Dept. Water Res. LP-116. 321 pp.

[15] Source: Texas Department of Water Resources. 1981. Trinity-San Jacinto estuary: a study of the influence of freshwater inflows. Texas Dept. Water Res. LP-113. 411 pp.

[16] Source: Texas Department of Water Resources. 1980. Lavaca-TresPalacios estuary: a study of the influence of freshwater inflows. Texas Dept. Water Res. LP-106. 325 pp.

[17] Source: Texas Department of Water Resources. 1980. Guadalupe estuary: a study of the influence of freshwater inflows. Texas Dept. Water Res. LP-107. 344 pp.

[18] Source: Texas Department of Water Resources. 1981. Nueces and Mission-Aransas estuaries: a study of the influence of freshwater inflows. Texas Dept. Water Res. LP-108. 381 pp.

[19] Source: Texas Department of Water Resources. In Print. Laguna Madre estuary: a study of the influence of freshwater inflows. Texas Dept. Water Res. Draft Report.

[20] Source: Environmental Protection Agency. 1971. Pollution affecting shellfish harvesting in Galveston Bay, Texas. Div. Invest., EPA, Water Quality Office, Denver, Colorado. 98 pp.

[21] Source: Childress, R. E. Bradley, E. Hegen, and S. Williamson. 1975. The effects of freshwater inflows on hydrological and biological parameters in the San Antonio Bay system, Texas. Texas Parks and Wildlife Department, Coastal Fisheries Branch. 190 pp.

[22] Source: Bryan, C. E. 1971. An ecological survey of the Arroyo Colorado, Texas 1966–1969. *Texas Parks and Wildlife Dept., Tech. Ser.* No. 10, 28 pp.

[23] Average % of contribution for the period 1977-1988.

[24] Gulf of Mexico 0.3%

Figure 6.1. Major estuarine systems in Florida.

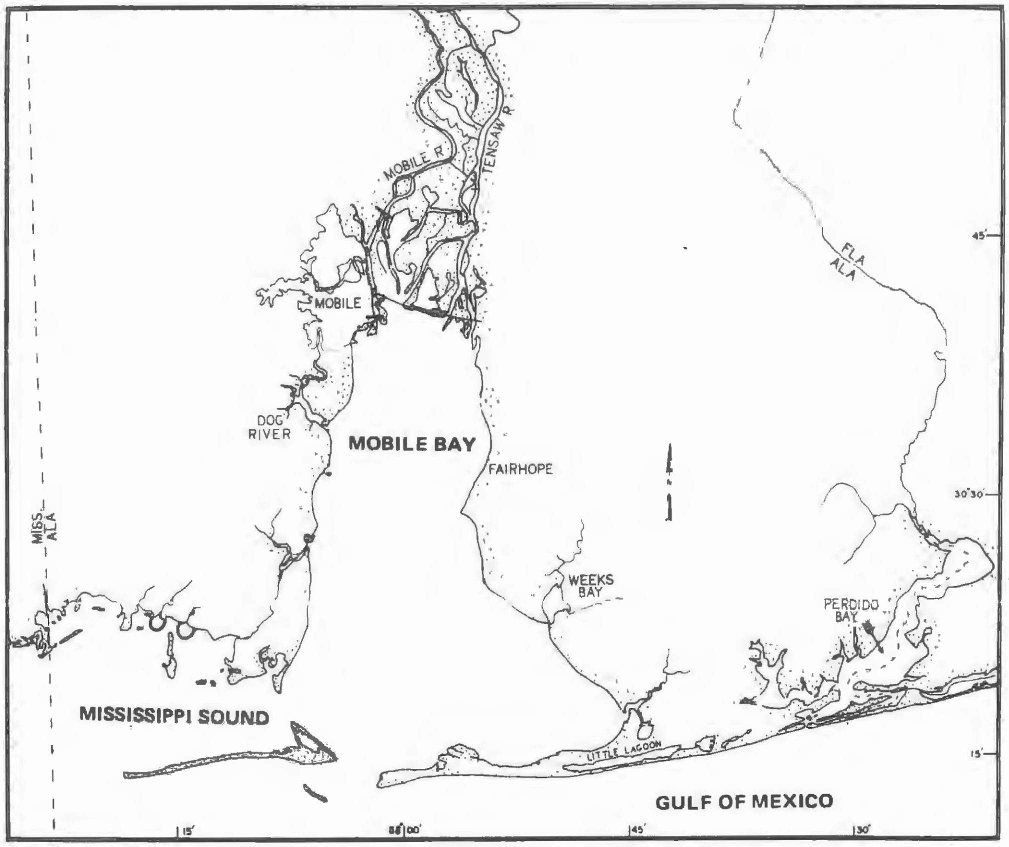


Figure 6.2. Major estuarine systems in Alabama.

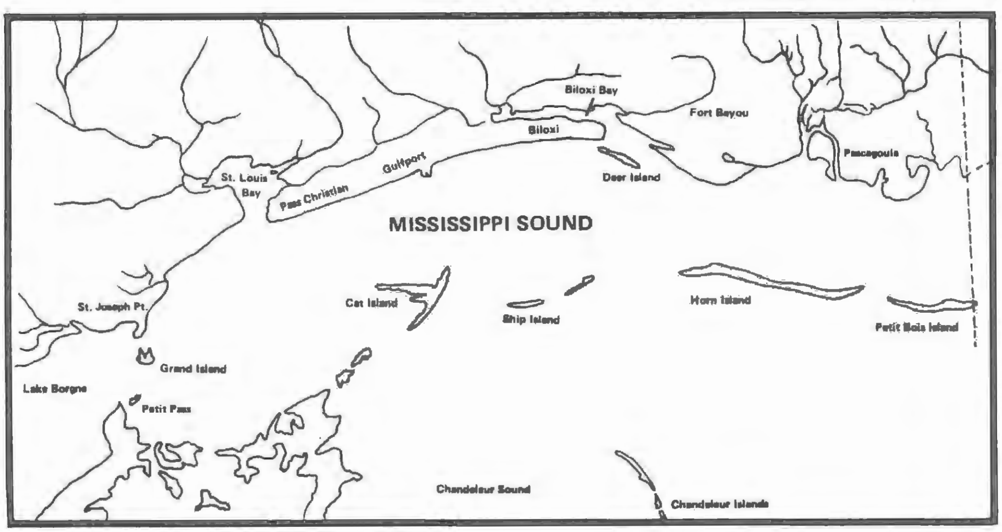


Figure 6.3. Major estuarine systems in Mississippi.

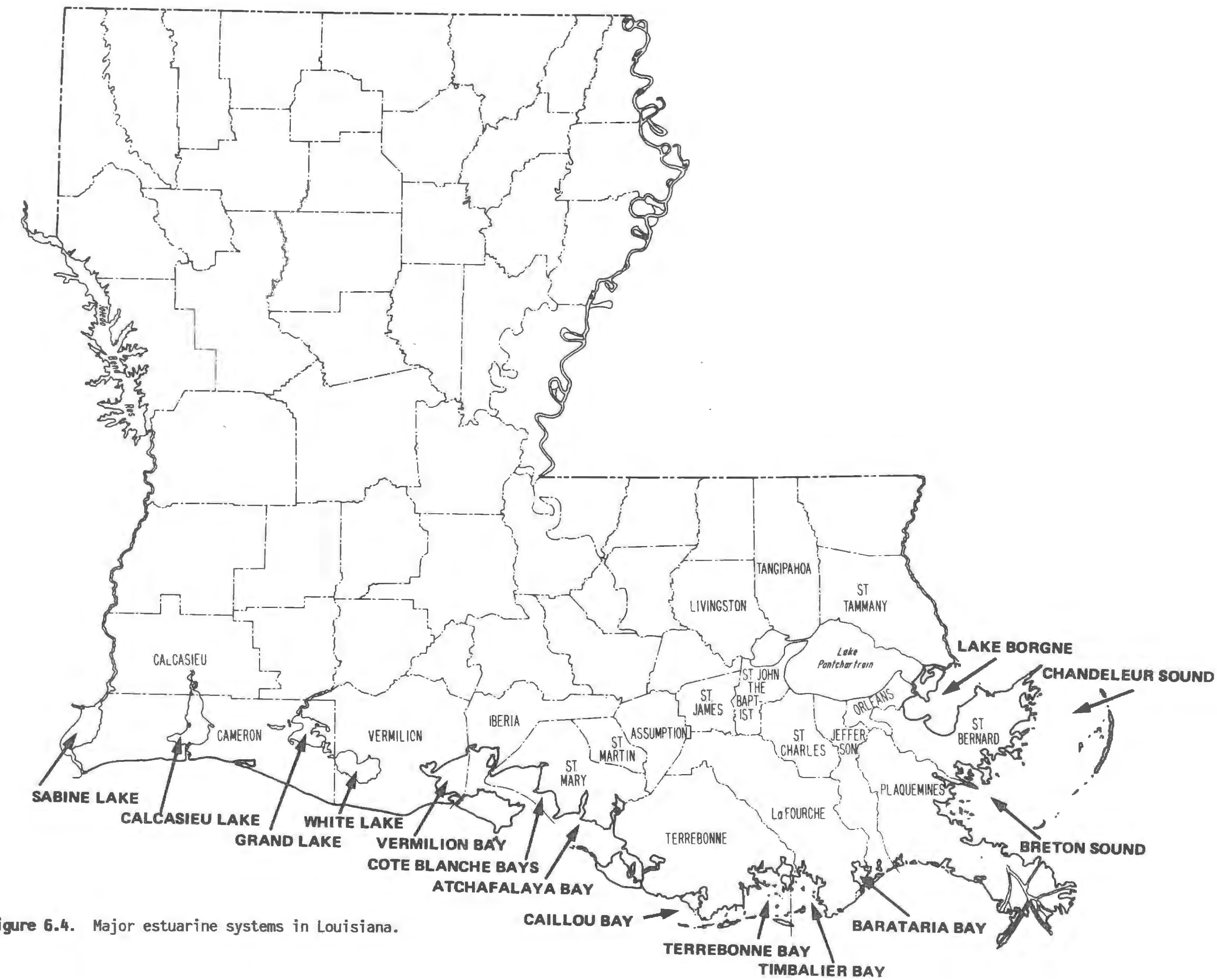


Figure 6.4. Major estuarine systems in Louisiana.

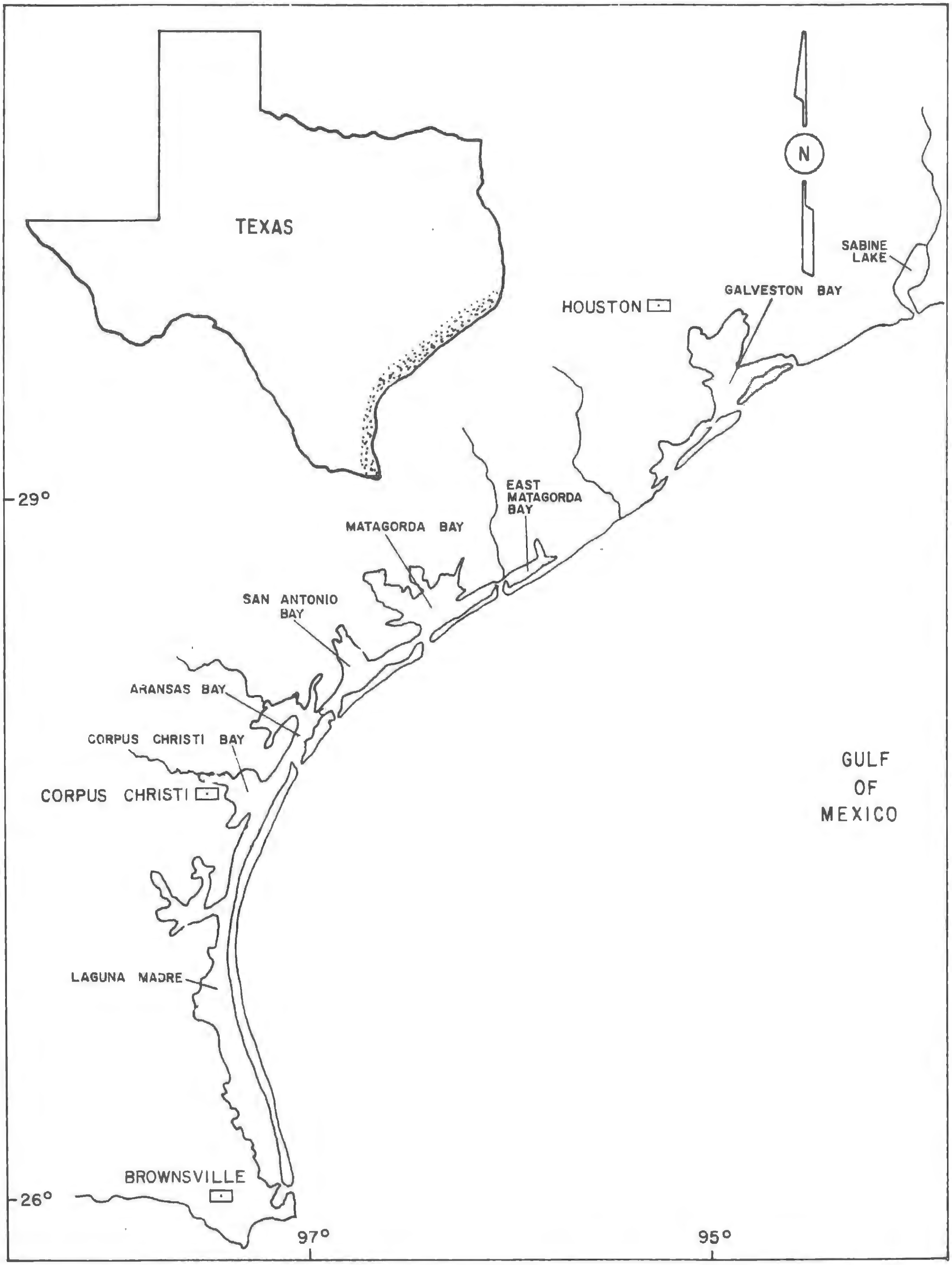


Figure 6.5. Major estuarine systems in Texas.

6.2.3 Western Gulf

The shoreline of the western gulf consists of salt marshes and barrier islands. The estuaries are characterized by low but extremely variable salinities and reduced tidal action. Riverine influence is highest in Sabine Lake and Galveston Bay.

6.3 Condition of the Habitat

A quantitative relationship between gulf blue crab production and habitat has not been determined. Turner and Boesch (1987) examined the relationship between wetland area and fisheries yields and noted evidence of a decrease in fishery production following wetland losses and stock gains following wetland gains. These data suggest loss of habitat may be a significant factor in determining blue crab production.

The wetland loss is of grave concern and is approaching crisis proportions in Louisiana where the rate of loss is approximately 35 square miles per year (May and Britsch 1987). Loss of habitat is occurring in all five Gulf States.

6.3.1 Sources of Environmental Degradation

According to Lindall et al. (1979), the major man-induced activities that affect the estuarine environment are:

1. construction and maintenance of navigation channels;
2. discharges from wastewater plants and industries;
3. dredge and fill for land use development;
4. agricultural runoff;
5. ditching, draining, or impounding wetlands;
6. oil spills;
7. thermal discharges;
8. mining, particularly for phosphate and petroleum;
9. entrainment and impingement from electrical power plants;
10. dams;
11. marinas;
12. alteration of freshwater inflows to estuaries;
13. saltwater intrusion; and
14. non-point-source discharges of contaminants.

In addition to man-induced changes, sea level rise, subsidence and erosion are natural processes responsible for loss of critical habitat. All gulf estuaries have been altered to some degree by one or more of the above activities and/or processes.

6.3.1.1 Reduction of Freshwater Inflow

Changes in the amount and timing of freshwater inflow may have a major effect on that segment of the blue crab life cycle taking place in the estuary. Wetlands are maintained by rivers that transport sediment and nutrients. Reduction in freshwater inflow denies the nutrients to wetlands that are necessary for healthy growth. Activities affecting freshwater inflow include leveeing of rivers (eliminates overflow into surrounding marshes), damming of rivers, channelization and pumping water for redistribution.

The feasibility of introducing freshwater from the Mississippi River into wetland areas experiencing saltwater intrusion has been under study since the 1950s. Various agencies have been working with the U.S. Army Corps of Engineers (COE) and Congress to design, build and operate freshwater diversions in Louisiana (Etzold 1980). Three diversion sites have been selected: (1) the Caernarvon site into Breton Sound; (2) the Bonnet Carre' site into Lake Pontchartrain; and (3) the Davis Pond site into upper Barataria Bay. The ultimate purpose of these three diversions is to reduce marsh loss and enhance wildlife and fishery production in the Mississippi Delta.

6.3.1.2 Impoundment

Impoundment of marsh areas may reduce habitat or restrict access to critical habitat for blue crabs. It is estimated that over 250,000 acres of Louisiana's coastal marshes are affected by impoundment (weirs) and that another 230,000 acres will be influenced by them in the future (Herke 1985). Weirs may hinder both immigration and emigration of estuarine dependent species and may impact stock levels. Reasons for impoundment of wetlands include spoil and waste containment, roadways and causeways, marsh management, aquaculture and mosquito control.

6.3.1.3 Pollution

Although the exact mechanisms through which environmental pollutants affect blue crab production are poorly understood, evidence suggests that chemical pollution may be responsible for blue crab mortality. Toxic compounds known to be lethal to larval blue crabs include heavy metals (cadmium and mercury) and chlorinated hydrocarbons (Millikin and Williams 1984).

Thermal effluent from steam and nuclear generating facilities using "once-through" cooling may also contribute to mortality by raising the temperature of estuarine waters to lethal levels or by entrainment and impingement.

6.3.1.4 Saltwater Intrusion

Saltwater intrusion, a result of altered freshwater inflow to natural waterways and construction of canals through coastal wetlands, has drastically altered the structure of estuarine ecosystems. Destruction of upper estuarine marsh areas through saltwater intrusion has decreased valuable nursery habitat for blue crabs.

6.3.1.5 Dredge and Fill Activities

The amount and rate of man-induced wetland losses have not been quantified. Mager and Thayer (1986) summarized five years of data on the COE's management of programs that regulate physical wetland alteration (Tables 6.6 and 6.7). For the Gulf States, almost 174,000 acres of wetland losses were proposed in more than 4,000 projects. Mager and Keppner (1987) showed that 6,354 permit applications involving almost 278,000 acres of wetlands took place in the Southeast. This provides an indication of the significance of the COE's program and the potential cumulative nature of wetland losses.

Dredge and fill activities have been identified as a major cause of wetland losses in Louisiana. Dredging of access and navigation canals to facilitate petroleum-drilling operations in coastal marshes has accounted for almost 90% of the present land loss (Louisiana State University Sea Grant, Aquanotes 1984).

6.4 Habitat Protection Program

6.4.1 Programs to Protect or Restore Habitat

6.4.1.1 Federal

Federal environmental agencies such as the NMFS, the FWS and the EPA evaluate projects proposing wetland alterations for potential impacts on resources under their purview. Recommendations resulting from these analyses are submitted to the COE where they are included in a public interest review that determines whether or not a permit will be issued for a proposed alteration. NMFS data reveal that implementation of its recommendations on more than 4,000 projects in the Gulf States would have resulted in the conservation of about 128,000 acres and the restoration and generation of more than 109,000 acres of wetlands (Mager and Thayer 1986). Most of these wetlands would provide suitable blue crab habitat.

The conservation of blue crab habitat relies largely on whether the recommendations of agencies such as the NMFS, FWS, EPA and the various state fish and wildlife agencies are incorporated into permitting decisions. Although granted input under Section 404 statutes, the NMFS, FWS and state regulatory and management agencies are not granted veto power in the permitting process. These agencies are, however, granted commenting authority on applications for Federal agency permits pursuant to the Federal Fish and Wildlife Coordination Act.

Other agencies are also involved in habitat matters that may affect blue crabs. The Soil Conservation Service assists owners of coastal wetlands in developing management plans to stabilize and/or freshen coastal marshes. NOAA's Office of Ocean and Coastal Resource Management may aid in establishing standards for approval to designate estuarine sanctuaries. The National Park Service also may establish coastal nearshore national parks and monuments such as Everglades National Park. The EPA has authority to regulate the discharge of spoil and disposal materials in wetlands covered under their programs. Construction in offshore areas is regulated primarily by Minerals Management Service and discharges are regulated by EPA. The COE can also regulate construction but does not accept comments relative to fish and wildlife resources. Recommendations pertaining to navigation and national defense issues are accepted.

Table 6.6. Number of proposed projects and acres of habitat by state proposed for dredging, filling, draining and impounding based on NMFS habitat conservation efforts from 1981 through 1985.*

State	Number of Permit Applications	Acreage Proposed by Applicants	Acreage NMFS Did Not Object To	Acreage Potentially Conserved	Mitigation Recommended by NMFS
Louisiana	1,229	149,875	38,932	110,943	103,386
Texas	684	16,644	3,694	12,950	4,462
Mississippi	94	578	307	211	44
Alabama	206	960	280	680	47
Florida	1,806	5,879	2,846	3,033	1,241
Georgia	194	1,106	204	902	247
South Carolina	576	5,610	450	5,160	109
North Carolina	547	3,119	1,673	1,446	576
Puerto Rico	42	347	33	314	159
Virgin Islands	7	129	81	48	134
Total	5,385	184,247	48,500	135,687	110,405

*Modified by Mager and Thayer (1986).

6.4.1.2 State

Each gulf state has a habitat protection program in conjunction with appropriate Federal agencies.

6.4.1.2.1 Florida

Florida has a number of statutes that have bearing upon habitat protection.

Land Conservation Act of 1972. The Florida legislature passed the act, and Florida voters subsequently approved a bond issue of $240 million to purchase "those areas of ecological significance the development of which by private or public works would cause the deterioration of submerged lands, inland or coastal water, marshes, or wilderness areas essential to the environmental integrity of adjacent areas." Currently, $220 million have been spent with about 80% of the money spent on lands within the coastal area.

State Parks and Preserves. Section 258.37, Florida Statutes, allows for establishment of aquatic preserves, defined as "an exceptional area of submerged lands and its associated waters set aside for being maintained essentially in its natural or existing condition." Aquatic preserves are protected against destruction of bottom or shoreline, except under certain specified conditions which are set forth in Section 258.42. There are 37 aquatic preserves throughout Florida's estuarine and continental shelf area. Maintenance of aquatic preserves and attendant rules and regulations are addressed in Sections 258.42 and 258.43.

Table 6.7. Acres of habitat by habitat type involved in NMFS habitat conservation efforts from 1981 through 1985.*

	Proposed	Allowed	Conserved	Mitigated
Black mangrove	324	93	231	155
White mangrove	348	132	216	128
Red mangrove	662	16	646	562
Saltgrass	1,781	105	1,676	2,315
Freshwater marsh	10,357	7,119	3,238	32,796
Freshwater unvegetated	237	238	-1	31
Freshwater submerged unvegetated	473	132	341	612
Hardwood swamp	3,507	1,234	2,273	2,641
Black needlerush	1,627	68	1,559	141
Other marsh	7,480	1,141	6,339	4,584
Smooth cordgrass	5,027	446	4,581	6,227
Saltmeadow cordgrass	14,538	1,211	13,327	37,904
Shoalgrass	192	13	179	80
Halophila	2	2	0	0
Widgeongrass	366	111	255	1,564
Manateegrass	20	4	16	2
Turtlegrass	85	20	65	111
Eelgrass	2	1	1	2
Algae	1,123	28	1,095	10
Clay	63	55	8	0
Mud	106,868	30,161	76,707	19,795
Miscellaneous	19,973	329	19,644	40
Oyster beds	56	31	25	10
Rock	377	12	365	64
Sand	7,301	4,520	2,781	629
Shell	101	7	94	2
Silt	1,297	1,271	26	0
Total	184,187	48,500	135,687	110,405

*Modified from Mager and Thayer (1986).

Florida Coastal Zone Management Act of 1978. This act is incorporated as Section 23.018(6) through 23.018 (10), Florida Statutes. The Florida Coastal Zone Management Act of 1978 represents no new protective legislation for coastal areas of Florida. The act authorized the Florida Department of Environmental Regulation to form a program based entirely on existing statutes and rules for submittal to the Office of Coastal Zone Management as the basis for receiving Federal funds. New protective regulations recommended by the State Coastal Zone Management Bureau were rejected, and both the funding level and staff of the bureau were reduced by the act.

Land Acquisition Trust Fund. Section 253.12 of this chapter deals with ownership of submerged land and with all dredge and fill activities.

National Estuarine Sanctuaries. Section 315 of the Coastal Zone Management Act Amendments of 1976 (P.L. 94-370) provided for acquisition, development or operation of estuarine sanctuaries to serve as natural field laboratories in which to study and gather data on the natural and human processes occurring within the estuaries. Florida has established national estuarine sanctuaries in Rookery, Florida, and Apalachicola bays. Florida has also established a marine sanctuary in Looe Key, Florida.

6.4.1.2.2 Alabama

Habitat protection programs in the Alabama estuarine area are provided by local, state and Federal agencies. Federal protective programs are pursuant to Section 10 of the River and Harbor Act of 1899 (33 U.S.C. 403), the Federal Water Pollution Control Act (amended P.L. 89-234 and P.L. 89-753) and the Fish and Wildlife Coordination Act. Each of these acts provides protection to the estuarine area by consideration of fish and wildlife interest for any construction, dredge and fill, channelization and waste discharge into the environment. Input is requested by the lead agency, usually the COE, by circulating the permit request along with detailed description of requested work among various government agencies (local, state and Federal), as well as private clubs and individuals. The Alabama Marine Resources Division investigates and provides critical review of all COE permits in the estuarine area.

State pollution control standards were revised in 1965 (Acts of Alabama, 1965, Regular Session, Act Number 574) strengthening requirements for effluent treatment of industrial and municipal wastes. Standards adopted categorized the Alabama estuarine area with the exception of a few isolated areas as "fish and wildlife" best use classification or better. The Alabama Gas and Oil Board has statutory authority over control and disposal of wastes from oil and gas wells in Alabama and the board cooperates with the Alabama Department of Environmental Management in controlling related wastes. The adoption of the Water Pollution Control Act with subsequent enactment of water quality standards has reversed water degradation trends of the 1950s and early 1960s.

Additional protection to the Alabama estuarine area was provided in 1976 with the enactment of the Coastal Area Board Act (Act Number 534) by the state legislature. This act was created to promote, improve and safeguard the lands and waters located in the coastal area of Alabama through a comprehensive and cooperative program designed to preserve, enhance and develop such valuable resources for the present and future well-being and general welfare of the citizens of Alabama. The director of the Alabama Marine Resources Division was one of nine permanent board members of the Alabama Coastal Area Board.

In 1982, commissions and boards involved with protection of air, land and water were combined by law in the creation of the Alabama Department of Environmental Management (Acts of Alabama, 1982 Regular Session Act Number 82-612). This increased the efficiency of habitat protection for Alabama by incorporating all existing regulations and standardizing the philosophy of environmental protection.

The Marine Resources Division of the Department of Conservation and Natural Resources is responsible for inspecting and commenting on any projects within the coastal zone which are being considered for permit to determine what effect those projects would have on the habitat and the marine resources.

Local protection to the estuarine area is provided by county health departments through the frugal issuance of septic tank permits. The primary intent of county health department regulations is public health oriented; however, a secondary benefit is realized by preventing over-enrichment of certain estuarine habitats. Local zoning ordinances have the potential of protecting estuarine areas by either eliminating activities which degrade, or minimizing degradation by localizing harmful activities.

6.4.1.2.3 Mississippi

Section 3 of the Mississippi Coastal Program (1980) includes three separate objectives for habitat protection. These are (1) habitat degradation which determines safe concentrations of toxicants and regulation of discharge at allowable levels, (2) habitat destruction which includes regulation of ditching and draining, dredging and filling, dam construction, alteration of barrier islands, etc. and (3) habitat creation which provides for marsh creation from dredged spoils, artificial reef construction and creation of seagrass beds.

The Mississippi Department of Environmental Quality is the regulatory agency for the state for all purposes of Federal air and water pollution legislation and programs and is also empowered to promulgate standards of water and air quality consistent with existing Federal regulations.

Management of the state's marine resources is carried out by the Mississippi Department of Wildlife, Fisheries and Parks, Bureau of Marine Resources (BMR). The BMR has the authority to manage, control, supervise and direct any matters pertaining to all saltwater aquatic life not otherwise delegated to another agency. The BMR has jurisdiction and control over all marine aquatic life, all public and natural oyster reefs and oyster bottoms of the state of Mississippi. Additionally, the BMR administers the state CZM program, the Mississippi Wetlands Protection Law of 1973, and regulations pertaining to Marine Litter Ordinance Number 10.001.

6.4.1.2.4 Louisiana

The state and local Coastal Resources Management Act was passed in 1979 by the Louisiana Legislature. The Department of Natural Resources (DNR) is charged with coastal zone management and overseeing permit activities. In addition, several coastal parishes have developed their own coastal zone management programs. In 1981, Act 41 of the 1981 Extraordinary Session of the Louisiana Legislature created a Coastal Environmental Protection Trust Fund and appointed the Governor's Task Force on Coastal Erosion. Act 5 of the 1988 First Extraordinary Session in effect abolished the Trust Fund. In the 1989 Second Extraordinary Session, Senate Bill Number 26 was important for coastal zone management. This bill created an office of Coastal Restoration and Management in DNR, a Wetlands Conservation and Restoration Authority in the Governor's Office and a Wetlands Conservation and Restoration Fund.

The Louisiana Department of Environmental Quality has the responsibility of setting and monitoring pollution standards for all waters of the state, including the Gulf of Mexico. The state of Louisiana is also pursuing protection of its estuarine habitats through the acquisition of land for the establishment of over 1,800,000 acres of wildlife management areas and refuges.

6.4.1.2.5 Texas

Nine Texas agencies (the Texas Parks and Wildlife Department, Texas Water Commission, Texas Water Development Board, Texas General Land Office, Texas Department of Agriculture, Texas Forest Service, Texas Railroad Commission, Texas State Department of Highways and Public Transportation and Texas Air Control Board) have separate responsibilities for managing the state's natural resources and regulating activities affecting them. Of this group, only the Air Control Board is unlikely to be involved in wetlands issues.

The Resource Protection Division of the Texas Parks and Wildlife Department, working with other branches and agencies, assesses the impact of construction and development on the estuarine environment and fish and wildlife resources. This division also investigates fish kills and pollution complaints, and issues various permits including those for removal of sand, shell and gravel from state-owned water bottoms. The Coastal Fisheries Branch, Fisheries Division, monitors fish and shellfish populations as well as hydrological parameters that might affect their abundance. In Texas, hundreds of local agencies are involved in activities potentially affecting wetlands. Flood control districts, water control and improvement districts, municipal utility districts, underground water districts, levee improvement districts, navigation districts and river authorities have been created by the state over several decades.

6.5 Coastal Zone Management Programs

Louisiana, Mississippi, Alabama and Florida have Federally approved coastal zone management programs. Texas has completed a revised program but has not submitted it for Federal approval. These programs allow for state input and/or regulation of activities within its boundaries, although this process is quite variable among states. Recently, the Louisiana Coastal Protection Task Force recommended that seven million dollars from the Coastal Environment Protection Trust Fund be approved to combat coastal erosion in six particular areas along the Louisiana coast (Rives 1982). The Louisiana Wetlands Conservation and Restoration Fund established in 1989 will provide additional funds for coastal zone management programs.

7.0 FISHERY MANAGEMENT JURISDICTION, LAWS AND POLICIES AFFECTING THE STOCK(S) THROUGHOUT THEIR RANGE OR FISHING FOR SUCH STOCK(S)

7.1 Management Institutions

Blue crabs are an estuarine dependent species occupying a variety of habitats depending upon the physiological requirements of each particular life history stage. The blue crab fishery is conducted predominantly within the territorial sea and internal waters of the Gulf States. Management is by individual state regulations. The following regulations are presented as an overview and are current at the date of FMP publication. State agencies should be consulted for subsequent changes in state laws.

In 1976 Congress passed the Magnuson Fisheries Conservation and Management Act (MFCMA) which claimed exclusive jurisdiction for 200 miles offshore but did not diminish (except under preemption provisions) jurisdictions of the states.

7.1.1 Federal Management Institutions

7.1.1.1 Regional Fishery Management Councils

With the passage of the MFCMA, the Federal government assumed responsibility for fishery management within the EEZ, a zone contiguous to the territorial sea and whose inner boundary is the outer boundary of each coastal state. The outer boundary of the EEZ is a line 200 miles from the (inner) baseline of the territorial sea. Management of the EEZ is to be based on plans developed by fishery management councils. Each council prepares plans with respect to each fishery requiring management within its geographical area of authority and amends such plans as may be implemented as Federal regulation.

Among the guidelines under which the councils must operate are standards which state that to the extent practicable, an individual stock of fish shall be managed as a unit through its range and that management shall, where practicable, promote efficiency and shall minimize costs and avoid unnecessary duplication (MFCMA Section 301a).

A fishery management plan should protect the stock from overfishing while achieving on a continuing basis the optimum yield from the fishery.

7.1.1.2 National Marine Fisheries Service (NMFS), National Oceanic and Atmospheric Administration (NOAA)

The Secretary of Commerce, acting through NMFS, has the ultimate authority to approve or disapprove all fishery management plans prepared by regional fishery management councils. Where a council fails to develop a plan, or to correct an unacceptable plan, the Secretary may do so. The NMFS also collects data and statistics on fisheries and fishermen to aid fishery management and conducts management authorized by international treaties. The NMFS has the authority to enforce the MFCMA and Lacey Act and is the Federal trustee for living and non-living natural resources in coastal and marine areas under United States jurisdiction pursuant to Section 107(f) of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA or "Superfund"), Section 311(f)(5) of the Clean Water Act (CWA), Executive Order 12580 of January 23, 1987, and Subpart G of the National Oil and Hazardous Substances Pollution Contingency Plan.

7.1.1.3 Office of Ocean and Coastal Resource Management (OCRM, NOAA)

The OCRM asserts authority through the National Marine Sanctuaries pursuant to Title III of the Marine Protection, Research and Sanctuaries Act (MPRSA). The OCRM Estuarine Sanctuary Program has designated Looe Key in Monroe County, Rookery Bay in Collier County, the Apalachicola River and Bay in Franklin County, Florida, and Weeks Bay in Baldwin County, Alabama, as estuarine sanctuaries. Lastly, by setting standards for approving and funding state coastal zone management programs, OCRM may further influence fishery management.

7.1.1.4 National Park Service (NPS), Department of the Interior (DOI)

The NPS retains the authority to manage shellfish primarily through the establishment of coastal and nearshore national parks and national monuments. Everglades National Park is an example of an area managed by the NPS. National Park Service under the DOI may regulate fishing activities within park boundaries. Padre Island National Seashore and Gulf Islands National Seashore have no special fishing regulations. State regulations apply within the boundaries.

7.1.1.5 Fish and Wildlife Service (FWS), DOI

The ability of the FWS to affect the management of shellfish is based primarily on the Endangered Species Act and the Fish and Wildlife Coordination Act. Under the Fish and Wildlife Coordination Act, the FWS reviews and comments on proposals for work and activities in or affecting navigable waters that are sanctioned, permitted, assisted or conducted by Federal agencies. The review focuses mainly on potential damage to fish and wildlife and their habitat.

7.1.1.6 Environmental Protection Agency (EPA)

The EPA may provide protection to shellfish communities through the granting of National Pollutant Discharge Elimination System (NPDES) permits for the discharge of pollutants into ocean waters and the conditioning of those permits to protect valuable resources.

7.1.1.7 Corps of Engineers (COE), Department of the Army

The COE jurisdiction over the disposal of dredged material, pursuant to both the Clean Water Act and the MPRSA, could be exercised in a manner protective of fishery resources. Proposals to dispose of materials during the construction of artificial reefs, for example, are assessed to assure that the disposed materials do not pollute or physically alter the environment.

7.1.2 State Management Institutions

Table 7.1 summarizes the basic characteristics of the state institutions involved in fishery management. Brief narrative descriptions are presented below for each state. Of primary importance is the identification of authority for establishing management regulations in the various states. While all states bordering on the Gulf of Mexico authorize some degree of authority to administrative bodies, Alabama, Mississippi, Florida and to a certain degree, Texas, utilize administrative authorities for establishing substantive management regulations. In Louisiana, statutes contain the specific regulatory measures used to manage fishery resources. However, Act 830 of the 1989 legislative session authorizes the Louisiana Department of Wildlife and Fisheries to manage wildlife species based on biological data and to establish seasons, size restrictions, quotas and other measures subject to the Administrative Procedures Act and legislative oversight.

Table 7.1. State management institutions - Gulf of Mexico.

	Administrative body and its responsibilities	Administrative policy-making body and decision rule	Legislative involvement in management regulations
FLORIDA	DEPARTMENT OF NATURAL RESOURCES • administers management programs • enforcement • conducts research • makes recommendations to legislature and Marine Fisheries Commission	FLORIDA MARINE FISHERIES COMMISSION • creates rules which must be approved by the governor and cabinet • seven member commission	• can override any rule of the commission • responsible for licensing, management of fishing in man-made canals and limited entry
ALABAMA	DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES • administers management programs • enforcement • conducts research	• Commissioner of department has authority to establish management regulation • Conservation Advisory Board is a thirteen member board and advises the commissioner • has authority to amend and promulgate regulations	• authority for detailed management regulations delegated to commissioner • statutes concerned primarily with licensing
MISSISSIPPI	DEPARTMENT OF WILDLIFE, FISHERIES AND PARKS • administers management programs • enforcement • conducts research	COMMISSION ON WILDLIFE, FISHERIES AND PARKS • five-member board • establishes ordinances on recommendation of deputy director (BMR)	• authority for detailed management regulations delegated to commission • statutes concern licenses and taxes with some specific restrictions on oysters
LOUISIANA	DEPARTMENT OF WILDLIFE AND FISHERIES • administers management programs • enforcement • conducts research • makes recommendations to legislature	WILDLIFE AND FISHERIES COMMISSION • seven-member board establishes policies and regulations based on majority vote of a quorum (four members constitute a quorum) consistent with statutes	• detailed regulations contained in statutes; • authority for detailed management regulations delegated to commission
TEXAS	PARKS AND WILDLIFE DEPARTMENT • administers management programs • enforcement • conducts research • makes recommendation to TPWD	PARKS AND WILDLIFE COMMISSION • nine-member body establishes regulations based on majority vote of quorum (five members constitute a quorum)	• licensing requirements are set by legislation

7.1.2.1 Florida Marine Fisheries Commission (FMFC), 2540 Executive Center Circle West, Suite 106, Tallahassee, Florida 32301

The Florida Marine Fisheries Commission, a seven-member board appointed by the governor and confirmed by the senate, was created by the Florida legislature in 1983. This commission was delegated rulemaking authority over marine life in the following areas of concern:

a. gear specification
b. prohibited gear
c. bag limits
d. size limits
e. species that may not be sold
f. protected species
g. closed areas
h. quality control codes
i. seasons
j. special considerations relating to egg bearing females and oyster and clam relaying

All rules passed by the commission require approval by the governor and cabinet. The commission does not have authority over endangered species, license fees, penalty provisions or over regulation of fishing gear in residential saltwater canals.

The agency charged with the administration, supervision, development and conservation of natural resources is the Florida Department of Natural Resources (FDNR) headed by the governor and cabinet. The governor and cabinet serve as the seven member board which approves or disapproves all rules and regulations promulgated by the FDNR. The administrative head of the FDNR is the executive director. Within the FDNR the Division of Marine Resources, through Section 370.02(2), Florida Statutes, is empowered to conduct research directed toward management of marine and anadromous fisheries in the interest of all people of Florida. The Division of Law Enforcement is responsible for enforcement of all marine resource related laws and all rules and regulations of the department.

7.1.2.2 Alabama Department of Conservation and Natural Resources (ADCNR), Marine Resources Division (AMRD), P.O. Box 189, Dauphin Island, Alabama 36528

Management authority of fishery resources in Alabama is held by the Commissioner of the Department of Conservation and Natural Resources. The commissioner may promulgate rules or regulations designed for the protection, propagation and conservation of all seafoods. He may prescribe manner of taking, times when fishing may occur and designate areas where fish may or may not be caught. However, all regulations are to be directed in the best interest of the seafood industry. Most go through the Administrative Procedures Act enacted by the Alabama Legislature in 1983; however, bag limits and seasons are not subject to that Act. The Administrative Procedures Act outlines a series of events which must precede the enaction of any regulations other than those of an emergency nature. Among this series of events is (a) the advertisement of the intent of the regulation, (b) a public hearing for the regulation, (c) a 35-day waiting period following the public hearing to address comments from the hearing and (d) a final review of the regulation by a joint house and senate review committee.

The AMRD has responsibility for enforcing state laws and regulations for conducting marine biological research and for serving as the administrative arm of the commissioner with respect to marine resources. The division recommends regulations to the commissioner.

7.1.2.3 Mississippi Department of Wildlife, Fisheries and Parks (MDWFP), Bureau of Marine Resources (BMR), 2620 Beach Boulevard, Biloxi, Mississippi 39531

The administrative organization of the state of Mississippi with respect to coastal fisheries is the MDWFP through the BMR. Power and duties related to marine resources are vested in the Mississippi Commission on Wildlife, Fisheries and Parks, the controlling body of the MDWFP. The commission consists of five members appointed by the governor. The commission has full power to "manage, control, supervise and direct any matters pertaining to all saltwater aquatic life not otherwise delegated to another agency" (Mississippi Code Annotated 49-15-11) and "said power shall be exercised through the Bureau of Marine Resources of the Mississippi Department of Wildlife Conservation..." (predecessors of the MDWFP).

7.1.2.4 Louisiana Department of Wildlife and Fisheries (LDWF), P.O. Box 98000, Baton Rouge, Louisiana 70898-9000

The LDWF is one of the 21 major administrative units of the Louisiana government. A seven-member board, the Louisiana Wildlife and Fisheries Commission, is appointed by the governor. Six of the members serve overlapping terms of six years, and one member serves a term concurrent with the governor. The commission is a policy-making and budgetary control board with no administrative functions. The commission has sole authority to establish management programs and policies. The Secretary of the Department of Wildlife and Fisheries is "the executive head and chief administrative officer of the department" and is responsible for the administration, control and operation of the functions, programs, and affairs of the department. The secretary is appointed by the governor with consent of the senate.

Within the administrative system an assistant secretary is in charge of the office of fisheries. In this office the marine fish division, headed by the division chief, performs "the functions of the state relating to the administration and operation of programs, including research relating to oysters, waterbottoms and seafoods including, but not limited to, the regulation of oyster, shrimp, and marine fishing industries." The enforcement division, in the office of the secretary, is responsible for enforcing all marine fishery statutes and regulations.

7.1.2.5 Texas Parks and Wildlife Department (TPWD), 4200 Smith School Road, Austin, Texas 78744

The Texas Parks and Wildlife Commission is the administrative unit of the state charged with management of the coastal fishery resources and enforcement of legislative and regulatory procedures. The nine members of the commission are appointed by the governor for a six-year term. The commission selects an executive director who serves as the chief administrative officer of the TPWD. A director of the fisheries division is named by the executive director. The coastal fisheries branch, headed by a branch chief, is under the supervision of the director of fisheries.

7.1.3 Other Management Institutions

7.1.3.1 Gulf State-Federal Fisheries Management Board (GS-FFMB)

The GS-FFMB is charged with responsibility for developing regional management plans for the fisheries that move between or are broadly distributed among the territorial waters and areas seaward thereof and for recommending suitable policies and strategies to each member state (see Section 18).

7.2 Treaties and Other International Agreements

There are no treaties or other international agreements that affect the harvesting of blue crabs. No foreign fishing permits to harvest blue crabs have been submitted to the United States Government at this time.

7.3 Federal Laws, Regulations and Policies

The following Federal laws, regulations and policies may directly or indirectly influence the management of blue crab.

7.3.1 Magnuson Fishery Conservation and Management Act of 1976 (MFCMA):16 U.S.C. Sections 1801-1882

The MFCMA mandates the preparation of fishery management plans for important resources within the EEZ which extends from the outer boundary of state jurisdiction to 200 miles. Each plan aims to establish and maintain the optimum yield for the subject fishery.

7.3.2 Marine Protection, Research and Sanctuaries Act of 1972 (MPRSA), Title I:33 U.S.C. Sections 1401-1444 and Title III:16 U.S.C. Sections 1431-1434

The MPRSA requires a permit for transportation of materials for the purpose of ocean dumping. The EPA issues all permits with the exception of those for transportation of dredged materials issued by the COE. Criteria for issuing such permits include consideration of effects of dumping on the marine environment, ecological systems and fisheries resources. The MPRSA also provides protection of fish habitat through the establishment of marine sanctuaries.

7.3.3 Clean Water Act (CWA):33 U.S.C. Section 1251 et seq.

The CWA requires that a National Pollutant Discharge Elimination System (NPDES) permit be obtained before any pollutant is discharged from a point source into waters of the United States including waters of the contiguous zone and the adjoining ocean. The disposal of drilling effluents and other wastes from drilling platforms is among the activities for which a NPDES permit from EPA is required. Issuance of such a permit is based primarily on the effluent guidelines found in 40 C.F.R. Section 435. However, additional conditions can be imposed on permit issuance on a case-by-case basis in order to protect valuable resources in the discharge area. The NMFS is the Federal trustee for living and non-living natural resources in coastal and marine areas under United States jurisdiction pursuant to Section 311(f)(5) of the CWA.

7.3.4 Oil Pollution Act of 1961, as amended:33 U.S.C. Sections 1001-1016

The Oil Pollution Act regulates intentional discharge of oil or oily mixtures from ships registered in the United States and thus provides some degree of protection to fishery resources. Tankers cannot discharge oil within 50 nm (92 km) of the nearest land. Ships other than tankers must discharge as far as practicable from land. The quantity of oil which can be discharged is also regulated.

7.3.5 Coastal Zone Management Act of 1972 (CZMA), as amended:16 U.S.C. Sections 1451-1464

Under the CZMA, states are encouraged with Federal funding grants to develop coastal zone management programs which establish unified policies, criteria and standards for dealing with land and water use issues in their coastal zone, an area which includes the state's territorial sea. Approved coastal programs are thus capable of directing activities away from areas possessing particularly sensitive resources. Authority for the establishment of estuarine sanctuaries is provided in 16 U.S.C. Section 1461. Guidelines for these areas were published in 15 C.F.R. 921 on June 4, 1974.

7.3.6 Endangered Species Act of 1973, as amended:16 U.S.C. Sections 1531-1543

The Endangered Species Act provides for the listing of plant and animal species as threatened or endangered. Once listed as a threatened or endangered species taking (including harassment) is prohibited, and a process is established which seeks to insure that projects authorized, funded or carried out by Federal agencies do not jeopardize the existence of these species or result in destruction or modification of habitat determined by the Secretary to be critical.

7.3.7 National Environmental Policy Act (NEPA):42 U.S.C. Sections 4321-4361

NEPA requires that all Federal agencies recognize and give appropriate consideration to environmental amenities and values in the course of their decision-making. In an effort to create and maintain conditions under which man and nature can exist in productive harmony, NEPA requires that Federal agencies prepare an environmental impact statement (EIS) prior to undertaking major actions which might significantly affect the quality of the human environment. Within these statements, alternatives to the proposed action which may better safeguard environmental values are to be carefully assessed.

7.3.8 Fish and Wildlife Coordination Act:U.S.C. Section 661-661c

Under the Fish and Wildlife Coordination Act, the FWS and NMFS review and comment on fish and wildlife aspects of proposals for work and activities sanctioned, permitted, assisted or conducted by Federal agencies which take place in or affect navigable waters. The review focuses on potential damage to fish and wildlife and their habitat and may therefore serve to provide some protection to fishery resources from Federal activities, particularly in nearshore waters, since Federal agencies must give due consideration to recommendations of the two agencies.

7.3.9 Fish Restoration and Management Projects Act:16 U.S.C. Section 777-777k

Under this act, the DOI is authorized to apportion funds to state fish and game agencies for fish restoration and management projects. Funds for protection of threatened fish communities located within state waters including marine areas could be made available under the act.

7.3.10 Lacey Act Amendment of 1981 (Public Law 97-79)

This amendment strengthens and improves enforcement of Federal fish and wildlife laws and provides Federal assistance in enforcement of state laws. The act prohibits import, export and interstate transport of illegally taken fish and wildlife.

7.3.11 Comprehensive Environmental Response, Compensation and Liability Act (CERCLA or "Superfund"): Section 311(f)(5)

This act names the NMFS as the Federal trustee for living and non-living natural resources in coastal and marine areas under United States jurisdiction.

7.3.12 United States Marine Plastic Research and Control Act of 1987 (MPRCA) and MARPOL Annex V

MARPOL V is Annex V of the International Maritime Organization's (IMO) Convention for the Prevention of Pollution from Ships. These regulations prohibit ocean discharge of plastics from ships, restrict discharge of other types of ship's garbage for up to 25 miles from any land and require ports and terminals to provide garbage reception facilities. The MPRCA of 1987 implements MARPOL V in the United States.

7.4 State Laws, Regulations and Policies

A summary of present state blue crab regulations is presented in Table 7.2. A more comprehensive review by state follows.

7.4.1 Florida

7.4.1.1 Administrative Organization

Florida Department of Natural Resources (FDNR)
Division of Marine Resources
3900 Commonwealth Boulevard
Tallahassee, Florida 32303
Telephone: (904) 488-6058

Florida Marine Fisheries Commission (FMFC)
2540 Executive Center Circle, West
Suite 106
Tallahassee, Florida 32301
Telephone: (904) 487-0554

The FDNR is the agency responsible for marine research and enforcement of marine fisheries resource regulations. The FMFC is the agency responsible for promulgation of rules managing marine fisheries resources. The governor and six cabinet members have final approval on regulations promulgated by the FMFC.

7.4.1.2 Legislative Authorization

Chapter 370 of the Florida Statutes Annotated contains law regulating the coastal fisheries. The legislature passes statutes for the management of fisheries resources as well as specific laws which are applicable within individual counties.

7.4.1.3 Reciprocal Agreement and Limited Entry Provisions

7.4.1.3.1 Reciprocal Agreement Provisions

7.4.1.3.1.1 Licenses

Florida statutory authority provides for reciprocal agreements related to fishery access and licenses.

Table 7.2. Summary of present state blue crab regulations.

	FLORIDA	ALABAMA	MISSISSIPPI	LOUISIANA	TEXAS
ADMINISTRATIVE ORGANIZATION	Department of Natural Resources, Division of Marine Resources	Department of Conservation and Natural Resources, Marine Resources Division	Department of Wildlife, Fisheries and Parks, Bureau of Marine Resources	Department of Wildlife and Fisheries	Parks and Wildlife Department, Coastal Fisheries Branch
LICENSES	Commercial fishing: $50 Wholesale dealer county resident: $300 non-resident: $500 alien: $1000 Retail dealer resident: $25 non-resident: $200 alien: $250 Recreational non-resident, annual: $30 non-resident, 7 day: $15 resident, annual: $12 resident, 7 day: $10	Commercial crab-catcher: $50 Seafood dealer: $125	Commercial crab boat: $75 Interstate commerce: $20 Seafood dealer: $100 Seafood processor: $200	Recreational crab pot resident: $10 non-resident: $20 Commercial fishermen resident: $55 non-resident: $105 Vessel license resident: $15 non-resident: $60 Crab trap license and miscellaneous gear license resident: $25 non-resident: $100	Sport license: $8 Saltwater sport stamp: $5 Commercial fishermen: $15 Commercial fishing boat: $10.50 Wholesale dealer business: $400 truck: $250
MINIMUM SIZE	5 inches, except for bait or shedding, 10% tolerance for undersize crabs	4 inches, except for bait, shedding and personal use	5 inches, peeler and soft-shell crab exempt	Hard crabs 5 inches; 5% tolerance of undersize crabs; peeler crabs exempt; soft crabs 4 1/2 inches	5 inches, 5% tolerance of undersize crabs
PROTECTION OF FEMALE CRABS	Illegal to sell sponge crabs	None	Seasonal and area closures	Illegal to sell or possess sponge crabs	Illegal to sell sponge crabs
GEAR RESTRICTIONS	None	(see text)	None	Trawls can be used only during open shrimp season and with legal mesh	Maximum 300 traps
TIME RESTRICTIONS	Daylight only working traps	Daylight only	None	Daylight only	None
AREA RESTRICTIONS	Traps illegal in navigable channels	Traps prohibited within 100 yards of marked navigational channels	Traps illegal in navigable waters and north of Interstate 10	Metal traps illegal north of Intercoastal Waterway, in the Calcasieu River estuary and off Cypremont Point in Vermilion Bay, in navigable channels and stream entrances	Traps illegal in navigable channels

7.4.1.3.1.2 Management

Florida has no statutory authority to enter into reciprocal management agreements.

7.4.1.3.2 Limited Entry

Florida has no statutory provisions for limited entry.

7.4.1.4 Commercial Landings Data Reporting Requirements

Processors are required to report monthly on volume of saltwater products with related effort (trips) information. Data are collected and published by the NMFS and FDNR.

7.4.1.5 Penalties for Violations

It is a felony of the third degree, punishable as provided in Sections 775.082, 775.083 or 775.084, for any person willfully to molest any traps, lines or buoys, as defined herein, belonging to another without permission of the license-holder.

Upon the arrest and conviction for violation of any of the blue crab regulations or laws, the license holder shall show just cause why his saltwater products license should not be suspended or revoked.

7.4.1.6 License Fees

Resident wholesale seafood dealer - county (state)	$ 300.00	(450.00)
Nonresident wholesale seafood dealer - county (state)	500.00	(1000.00)
Alien wholesale seafood dealer - county (state)	1000.00	(1500.00)
Resident retail seafood dealer	25.00	
Nonresident retail seafood dealer	200.00	
Alien retail seafood dealer	250.00	
Alien and nonresident commercial fishing license	200.00	
Recreational resident, annual	12.00	
Recreational resident, seven day	10.00	
Recreational nonresident, annual	30.00	
Recreational nonresident, seven day	15.00	

7.4.1.7 Laws and Regulations

7.4.1.7.1 Minimum Size

Except when authorized by a special activity license issued by the department pursuant to Section 370.06 for the soft-shelled crab or bait trade, it is unlawful for any person to possess for sale blue crabs measuring less than 5 inches from point to point across the carapace in an amount greater than 10 percent of the total number of blue crabs in that person's possession.

7.4.1.7.2 Protection of Female Crabs

It is unlawful for any person to sell or offer for sale any eggbearing blue crabs.

7.4.1.7.3 Fishing Methods and Gear Restrictions

No person, firm or corporation shall transport on the water, fish with, or cause to be fished with, set or place any trap designed for taking blue crabs, unless said person, firm or corporation is the holder of a valid saltwater products license issued pursuant to Section 370.06, and the trap has a current state number permanently attached to the buoy. The trap number shall be affixed in legible figures at least one inch high on each buoy used. The saltwater products license must be onboard the boat, and both the license and the crabs shall be subject to inspection at all times. Only one trap number may be issued for each boat by the department upon receipt of an application on forms prescribed by it. This subsection shall not apply to an individual fishing with no more than five traps.

A buoy or a time release buoy shall be attached to each trap or at each end of a weighted trot line and shall be of sufficient strength and buoyancy to float and of such color, hue and brilliancy to be easily distinguished, seen and located. Such color and trap number shall also be permanently and conspicuously displayed on the boat used for setting and collecting said traps and buoys in the manner prescribed by the Division of Law Enforcement so as to be readily identifiable from the air and water. This subsection shall not apply to an individual fishing with no more than five traps.

It is unlawful for any person willfully to molest any traps, lines or buoys belonging to another without permission of the license holder.

Traps may be worked during daylight hours only, and the pulling of traps from one hour after official sunset until one hour before official sunrise is prohibited.

7.4.1.7.4 Florida Recreational Saltwater Fishing License of 1989

The bill provides that no person may take, attempt to take, or possess any marine fish for noncommercial purposes nor may any person who is the owner, operator, or custodian of a fee-charging vessel operate such vessel or structure for such purpose, unless he has paid the fee for, and possesses, a license issued by the FDNR. The following are exempt from licensing requirements:

a. any person under 16 years of age,
b. any Florida resident fishing in salt water from land or a structure fixed to the land,
c. any person fishing from a vessel the operator of which is licensed pursuant to this bill,
d. any person who holds a valid saltwater products license issued in the name of an individual,
e. any person 65 years of age or older,
f. any resident who is a member of the Armed Forces of the United States, who is not stationed in this state, when fishing while home on leave for 30 days or less, upon submission of orders,
g. any person who has been accepted by the Department of Health and Rehabilitative Services for developmental services.

7.4.2 Alabama

7.4.2.1 Administrative Organization

Alabama Department of Conservation and Natural Resources (ADCNR)
Marine Resources Division
P.O. Box 189
Dauphin Island, Alabama 36528
Telephone: (205) 861-2882

The Alabama Conservation Advisory Board is endowed with the responsibility to advise on policies of the ADCNR. The board consists of the governor, the ADCNR Commission and ten regular board members. The marine resources division manages the marine fisheries with regulatory authority vested in the commissioner.

7.4.2.2 Legislative Authorization

Chapters 2 and 12 of Title 9, Code of Alabama, contain statutes that concern marine fisheries.

7.4.2.3 Reciprocal Agreement and Limited Entry Provisions

7.4.2.3.1 Reciprocal Agreement Provisions

7.4.2.3.1.1 Licenses

Statutory authority provides an arrangement that may permit nonresidents to fish in the coastal waters of Alabama on a reciprocal basis. The reciprocal arrangements are extended to include crabbing activities.

7.4.2.3.1.2 Management

Alabama has no statutory authority to enter into reciprocal management agreements.

7.4.2.3.2 Limited Entry

Alabama has no statutory provisions for limited entry.

7.4.2.4 Commercial Landings Data Reporting Requirements

While Alabama law requires that wholesale seafood dealers file monthly reports at quarterly intervals, these records were collected on a voluntary basis by NMFS prior to 1982. They have been collected through a cooperative NMFS/ADCNR agreement since 1982.

7.4.2.5 Penalties for Violations

Violations of provisions of any statute or regulation is considered a Class C misdemeanor and punishable by fines of $25 to $500.

7.4.2.6 License Fees

Crab catcher's license	$ 50.00
Seafood dealer's license	125.00

Any person taking crabs for commercial purposes or using more that five crab traps for personal, noncommercial purposes must first obtain and have in possession a "crab catcher's" license. The fee for said license shall be fifty dollars ($50.00) and shall be paid to the ADCNR.

7.4.2.7 Laws and Regulations

7.4.2.7.1 Minimum Size

It is unlawful to possess only crabs less than four inches carapace width except for bait, shedding or personal use.

7.4.2.7.2 Protection of Female Crabs

None

7.4.2.7.3 Fishing Methods and Gear Restrictions

Individuals can use up to but not more than five crab traps for taking crabs for personal, noncommercial purposes without said license.

All crab traps and commercial crab boats must display identifying markings to be developed by regulations of the ADCNR, and it shall be unlawful to take crabs from traps belonging to another person without written authorization. Traps are prohibited within 100 yards of marked navigational channels. Traps cannot be run between sunset and one half hour before sunrise. Traps must be marked with at least one buoy no smaller than six inches in diameter, one half of which must be white.

7.4.3 Mississippi

7.4.3.1 Administrative Organization

Mississippi Department of Wildlife, Fisheries and Parks (MDWFP)
Bureau of Marine Resources (BMR)
2620 Beach Boulevard
Biloxi, Mississippi 39531
Telephone: (601) 385-5860

The five-member Mississippi Commission on Wildlife, Fisheries and Parks (MCWFP) has the responsibility to manage, control, supervise and direct any matters pertaining to marine resources not otherwise delegated to another agency. The Bureau of Marine Resources manages the marine fisheries.

7.4.3.2 Legislative Authorization

Chapter 49-15 of the Mississippi Code of 1972 (Annotated) contains provisions for the management of marine fisheries resources.

7.4.3.3 Reciprocal Agreement and Limited Entry Provisions

7.4.3.3.1 Reciprocal Agreement Provisions

7.4.3.3.1.1 Licenses

Mississippi statutory authority allows reciprocal license agreements with other states.

7.4.3.3.1.2 Management

The MCWFP may enter into advantageous interstate and intrastate agreements with proper officials, which agreements directly or indirectly result in the protection, propagation and conservation of the seafood of the state of Mississippi, or continue any such agreements now in existence [49-15-15(3)(j)]. The commission may promulgate rules and regulations for nonresident permits in order to promote reciprocal agreements with other states (49-15-30).

7.4.3.3.2 Limited Entry

Mississippi has no statutory provisions for limited entry.

7.4.3.4 Commercial Landings Data Reporting Requirements

The quantity landed by each crabber is obtained from each firm weekly. Statistical agents may copy firm records and interview crabbers for areas in which traps are set and the number of traps set. The quantity of crabs caught incidentally by any other means and sold will also be reported by each landing or processing firm. Daily records on sales of bait (crabs) are kept and reported on forms furnished by the BMR. All data collected are considered confidential information.

7.4.3.5 Penalties for Violations

Any person, firm or corporation violating any of the provisions of Chapter 49-15 or any ordinance duly adopted by the commission shall on conviction be fined not less than $100 nor more than $500 for the first offense and not less that $500 nor more than $1,000 for the second offense when such offense is committed within a period of three years from the first offense; and not less than $2,000 nor more than $4,000, or imprisonment in the county jail for a period not exceeding thirty days for any third or subsequent offense when such offense is committed within a period of three years from the first offense and upon conviction of such third or subsequent offense. It shall be the duty of the court to revoke the license of the convicted party and of the boat or vessel used in such offense, and no further license shall be issued to such person or for said boat to engage in catching or taking of any seafoods from the waters of the state of Mississippi for a period of one year following such conviction. Further, upon conviction of such third or subsequent offense committed within a period of three years from the first offense, it shall be the duty of the court to order the forfeiture of any equipment or nets used in such offense. Provided, however, that equipment shall not mean boats or vessels. Any person convicted and sentenced under this section shall not be considered for suspension or other reduction of sentence. Except as provided under subsection (5) of Section 49-15-45, any fines collected under this section shall be paid into the seafood fund.

7.4.3.6 License Fees

	Resident	Nonresident
Commercial crab boat	$ 75.00	$200.00
Interstate commerce	20.00	20.00
Seafood dealer	100.00	100.00
Seafood processor	200.00	200.00

A nonresident will be charged the same fee for a license as is required of a Mississippi resident as a nonresident in that state. This is applicable only if the fee charged exceeds the non-resident fees herein listed.

7.4.3.7 Laws and Regulations

7.4.3.7.1 Minimum Size

It is unlawful for any person to catch, destroy, confine, hold or have in his possession, whether for individual use or for market, any blue crab or allied species, of a smaller size than five inches measured from the tip of one lateral spine across the back of the shell to the tip of the opposite lateral spine; provided that peeler crabs and soft-shell crabs are exempt from these limitations. Conservation officers may inspect any catch for violations of any of these provisions.

7.4.3.7.2 Protection of Female Crabs

It is unlawful to catch and hold in possession egg-bearing females from March 1 through June 30 of each year.

It is unlawful for any person, firm or corporation to hold in possession, sell or offer for sale any sponge crabs (egg bearing females) taken from an area described as follows:

"South of the Intracoastal Waterway, commencing at the Alabama-Mississippi boundary, and running west to the Gulfport Ship Island Channel." Any person taking sponge crabs by net, trap or any other means in said sanctuary shall immediately return same to the water.

It shall be unlawful for any person, firm or corporation to harvest or attempt to harvest or possess any crabs between January 1 and March 31 of each year, while trawling between the area bounded by the following line: beginning at a point on the Louisiana-Mississippi border due south of the "Intracoastal Waterway Grand Island Channel Light 1," thence running due north to said "Light 1," thence running northeasterly along the "Intracoastal Waterway Marianne Channel" through "Buoy 22," "Light 18," "Buoy 12," to "Light 8," thence running northeasterly along the most direct line to "Lighted Buoy 7," thence running northeasterly along the most direct line to "Lighted Buoy 4," thence running southeasterly along the most direct line to "Cat Island West End Channel Light," thence running southwesterly along the most direct line to "Cat Island Channel Buoy E," thence running due south to a point on the Louisiana-Mississippi border; thence running westerly along the Louisiana-Mississippi border to the point due south of the "Intracoastal Waterway Grand Island Channel Light 1."

7.4.3.7.3 Fishing Methods, Area and Gear Restrictions

It is unlawful for any person, firm or corporation in command of or control of any boat with a commercial shrimping license, fish net license or oyster license to fail to immediately return to the water any crabs caught in trawls regardless of the location unless the boat operating the trawl net or dredge has a valid commercial crab license.

It is unlawful for any person, firm or corporation, fishing for crabs to be offered for sale by means of crab traps or crab pots to fail to mark each said trap or pot with the corresponding commercial crab license number set out on the pot or trap in such a manner to be clearly visible to an inspecting officer.

In lieu of marking said crab traps or pots with corresponding license numbers, any licensed commercial crab fishermen may obtain a registered color code design from the Chief Inspector of the Bureau of Marine Resources' Enforcement Division or his designee. Once obtained, this color code must be placed on each buoy or float and painted or affixed to each side of the vessel used to harvest crabs from said traps or pots.

It is unlawful for any person fishing for crabs for personal use or consumption by means of crab traps or crab pots to use in excess of six such traps or pots; and each said trap or pot shall be marked with the owner's name in such a manner to be clearly visible to an inspecting officer.

It is unlawful for any person, firm, or corporation to place or cause to be placed any crab traps or pots north of the Interstate 10 (I-10) in the three coastal counties.

It is unlawful for any person, firm or corporation to place or cause to be placed any crab trap or pot in any marked channel or fairway.

It is unlawful for any person, firm or corporation to attach any buoy or float to any crab trap with materials other than lines of nylon, hemp, cotton or woven synthetic materials which can easily be cut with a standard steel knife.

It is unlawful for any person, firm or corporation to place or cause to be placed any crab trap or pot in any navigable waterway in such a manner that the trap line or float will interfere with normal boat traffic in said waterway and as such creating a hazard or nuisance to navigation.

It is unlawful for any person, firm or corporation to remove crabs from crab traps or pots that are not specifically licensed or permitted to said person, firm or corporation.

The MCWFP may establish a maximum number of crab pots allowable per license.

7.4.4 Louisiana

7.4.4.1 Administrative Organization

Louisiana Department of Wildlife and Fisheries (LDWF)
P.O. Box 98000
Baton Rouge, Louisiana 70898
Telephone: (504) 925-3617

The Secretary of the LDWF is the chief administrative officer of the department and is responsible for the administration, control and operation of the functions, programs and affairs of the department. The secretary is appointed by the governor with Senate consent and serves at the governor's pleasure.

The seven-member Louisiana Wildlife and Fisheries Commission, a policy making board, has sole authority to establish management programs and policies.

7.4.4.2 Legislative Authorization

Article VI, Section I (1921) of the Louisiana Constitution contains the statutes which govern marine fisheries in the state. Specific statutes for crabs are included in subparts 311, 326, 332 and 337.

7.4.4.3 Reciprocal Agreement and Limited Entry Provisions

7.4.4.3.1 Reciprocal Agreement Provisions

7.4.4.3.1.1 Licenses

The commission is authorized to enter into reciprocal fishing license agreements with the proper authorities of any other state.

7.4.4.3.1.2 Management

The commission is authorized to enter into reciprocal management agreements with the states of Arkansas, Mississippi and Texas on matters pertaining to aquatic life in bodies of water which form a common boundary.

7.4.4.3.2 Limited Entry

Interpretation of Louisiana laws that provide for limited entry as a management procedure is vague.

7.4.4.4 Commercial Landings Data Reporting Requirements

Any wholesale or retail dealer or commercial fisherman must report sales and other information on forms provided by LDWF.

7.4.4.5 Penalties for Violations

Crab violations vary from Class 1 to Class 4. Penalties depend upon the class of violation and previous offenses and may range from a $25-$100 fine to a fine of $1,000-$5,000, imprisonment of 180 days to two years and forfeiture of anything seized in connection with the violation.

7.4.4.6 License Fees

7.4.4.6.1 Recreational

Recreational crab pot (up to 10)--$10 for resident, $20 for nonresident. If attached to a trotline, $1 per trap for each trap up to 10.

Other recreational crab fishermen must have a basic saltwater sport fishing license ($5.50); recreational licenses run from July 1-June 30.

7.4.4.6.2 Commercial

	Resident	Nonresident
Commercial fishermen license	$ 55	$200
Vessel license	15	60
Crab trap license	25	100
Wholesale/retail dealer	105	405
Transport license	30	n/a
Trotline (miscellaneous gear license)	25	100

All crab fishermen need a commercial fishermen license, vessel license and either a trap or miscellaneous gear license.

All commercial licenses are good from January 1-December 31 and may be purchased at any time.

7.4.4.7 Laws and Regulations

7.4.4.7.1 Minimum Size

No more than five percent of the commercial catch by number may be less than five inches carapace width. Other undersized crabs must be returned immediately to the water from which they were taken without avoidable injury. To determine whether the total number of hard crabs are in violation, a random sample of 50 crabs will be taken from each crate or group of crabs equivalent to one crate; no more than 10% can be below the minimum size.

Softshell crabs less than four and one-half inches carapace width are illegal for commercial fishermen.

Crabs less than five inches carapace width may be retained by commercial fishermen, if used to produce softshell crabs or sold to a processor for shedding.

7.4.4.7.2 Protection of Female Crabs

It is illegal for any person to keep or sell adult female crabs with sponge, and such crabs must be returned immediately to the water.

7.4.4.7.3 Fishing Methods and Gear Restrictions

Crabs of legal size may be taken in any manner not detrimental to the resource; however, the taking of crabs with trawls is permitted only during the open shrimp season and only with legal trawls.

A recreational crab fisherman may use up to ten traps providing that he first obtains a recreational gear license at a cost of $10.

Each trap shall be attached to a visible float of at least six inches minimum diameter or one-half gallon volume size. Floats shall be attached to the traps by nonfloating line. A mandatory marking system sufficient to clearly identify all traps is required.

Crab traps which are no longer serviceable or in use shall be removed from the water by the owner. No person shall intentionally damage or destroy crab traps or the floats or lines attached thereto, or remove the contents thereof, other than the licensee or his agent.

No crab traps shall be set in navigable channels or entrances to streams.

It is illegal to bait, tend, check, or remove crab traps or their contents, lines, buoys or markers at night. Each crab trap on a trotline shall be registered with the LDWF and shall have attached thereto a tag bearing the fisherman's license number.

In lakes Des Allemands, Boeuf, Verret and in that portion of Belle River within Assumption Parish, traps may be attached to a trotline (nonfloating) to which at least one end is attached to a float.

All crabs sold shall be identified with the name and license number of the commercial fisherman. Any commercial fisherman identified as having sold undersized crabs shall be subject to the penalties.

No metal crab traps are allowed in public waters north of the Intracoastal Canal in the Calcasieu River system or in waters of Vermilion Bay from Cypremont Point one mile offshore to Blue Point.

7.4.5 Texas

7.4.5.1 Administrative Organization

Texas Parks and Wildlife Department (TPWD)
Coastal Fisheries Branch
4200 Smith School Road
Austin, Texas 78744
Telephone: (512) 389-4857

The nine-member Texas Parks and Wildlife Commission, each of whom is appointed by the governor for terms up to six years, is responsible for the management of coastal fisheries resources.

7.4.5.2 Legislative Authorization

Chapter 61, Texas Parks and Wildlife Code (Uniform Wildlife Regulatory Act) provides the Texas Parks and Wildlife Commission with responsibility of saltwater resources management. All eighteen coastal counties are under the Commission's regulatory authority.

7.4.5.3 Reciprocal Agreement and Limited Entry Provisions

7.4.5.3.1 Reciprocal Agreement Provisions

7.4.5.3.1.1 Licenses

Texas statutory authority allows reciprocal license agreements such as the one which provided that recreational fishing (for crabs) from either state are accepted on waters which are a common boundary between Texas and Louisiana.

7.4.5.3.1.2 Management

Texas has no statutory authority to enter into reciprocal management agreements.

7.4.5.3.2 Limited Entry

Texas has no statutory provisions for limited entry.

7.4.5.4 Commercial Landings Data Reporting Requirements

All seafood dealers who purchase directly from fishermen are required to file a monthly marine products report with the department. The reports must include species, poundage, price, gear utilized and location of fishing activity.

7.4.5.5 Penalties for Violations

A violation of any regulation of the commission is a misdemeanor and punishable by a fine of not less than $25 nor more than $200, and each individual fish (crab) constitutes a separate offense. Penalties vary with violations of sections of the Texas Parks and Wildlife Code.

7.4.5.6 License Fees

Resident sport license	$ 8.00
Saltwater sportfishing stamp	5.00
General commercial fisherman's license	15.00
Commercial fishing boat license	10.50
Wholesale dealer (business) license	400.00
Wholesale dealer (truck) license	250.00

7.4.5.7 Laws and Regulations

7.4.5.7.1 Minimum Size

No hard-shell blue crab less than five inches in carapace width, measured from tip of spine to tip of spine, may be possessed, except for bait or shedding purposes. Crabs shall be separated by the catcher at the time taken, and all crabs less than the minimum size shall be returned to the waters from which taken or placed in a separate container for possession as bait or for shedding purposes only. A tolerance of not more than five percent by number of undersized crabs may be possessed for purposes other than bait or for shedding.

7.4.5.7.2 Protection of Female Crabs

It is unlawful to possess egg-bearing female crabs (sponge crabs). No person may buy or sell a female crab that has its abdominal apron detached and was taken from coastal waters.

7.4.5.7.3 Fishing Methods and Gear Restrictions

Crabs may be taken in any number and at any time by dip net, set line, hand line, gig, trotline, crab trap and 20-foot seine. Crabs taken during legal shrimping operations may be retained. No more than 300 crab traps may be used by any person. Crab trap buoys must be marked with a gear tag. Crab traps must be marked with an orange floating, visible buoy not less than six inches in diameter or width, and such buoys must be six inches above the waterline or with orange plastic bottles of not less than one-gallon size. Crab traps may not exceed 18 cubic feet.

In Aransas County, it is unlawful to place a crab trap within 200 feet of a marked navigable channel, or to place a crab trap in Little Bay and the water area of Aransas Bay within one-half mile of a line from Hail Point on the Lamar Peninsula, then direct to the eastern end of Goose Island, then along the southern shore of Goose Island, then along the causeway between Lamar Peninsula and Live Oak Peninsula, then along the eastern shoreline of the Live Oak Peninsula past the town of Fulton, past Nine-mile Point, past the town of Rockport to a point at the east end of Talley Island including that part of Copano Bay within 1,000 feet of the causeway between Lamar Peninsula and Live Oak Peninsula.

In Harris County waters north and west of State Highway 146 where it crosses the Houston Ship Channel, crabs may be taken by crab lines, hook and line, trotline and with no more than three crab traps.

8.0 DESCRIPTION OF THE FISHERY

Blue crabs are abundant, environmentally tolerant estuarine organisms with year-round accessibility to the fishery. They produce a large number of young, exhibit large interannual production fluctuations, grow rapidly, mature early, have high mortality and a short life span (Van Engel 1987). The fishery has three basic components: commercial, recreational and incidental. The commercial hard crab fishery is comprised of licensed fishermen associated with a "first handler," the immediate commercial buyer. The catch is generally sold for processing or is sold to the live crab market. Sales information is the primary source of data for statistical reporting systems. The commercial soft crab fishery is primarily dependent upon the incidental catch of pre-molt crabs (peelers) by hard crab fishermen, although directed commercial fisheries for pre-molt crabs exist in some states. Individual fishermen may shed their own crabs or provide pre-molt crabs to shedding facilities. The final product is usually marketed through non-traditional (unreported) channels.

The recreational fishery does not require expensive equipment. All states except Alabama and Mississippi require a recreational license to take crabs from public waters. The impact of this component is partially monitored, but the weight of crabs taken is unknown. The important statistic is the number of fishermen participating. The sociological implications pertaining to management, as well as the impact of this harvesting sector on stock abundance, necessitate serious consideration be given to identifying and quantifying this sector. Many crabs are also taken as incidental catch in other fishing operations. Crabs caught in shrimp trawls and wingnets are often eaten, traded or sold locally and thus are not reported.

Accurate assessment of stock status is hindered by the lack of comprehensive data bases that report harvest from all components of the fishery from all states. Additionally, the lack of these data impedes a realistic assessment of the economic impact of all segments of the fishery. The soft crab fishery, in particular, has not been amenable to statistical reporting. Reported landings of hard and soft crabs are poor estimates of the annual catch. Many of the crabs sold out of state, to the general public and to the restaurant or retail trade are unreported. Roberts and Thompson (1982) observed that 60% of the hard crab landings from lakes Pontchartrain and Borgne, Louisiana, moved through market channels not covered by government statistical surveys. Keithly et al. (1988) also documented large unreported landings in Louisiana.

8.1 Commercial Hard Crab Fishery

8.1.1 Historical Catch Statistics

A historical description of the fishery is found in Section 18.2. Commercial blue crab landings from the Gulf of Mexico have been reported since 1880 (Table 8.1), although prior to 1948 the data were not continuous. Total reported landings gradually increased from less than 1 million pounds in the late 1800s to over 18 million pounds prior to World War II. In some years, Louisiana contributed as much as 91% of the total gulf landings during this period. Reported landings rose significantly in 1945 and may be attributable to curtailment of gasoline and commodity rationing and World War II veterans re-entering the fishery. Increased availability of raw product due to the introduction of the wire crab trap stimulated processing capacity and market development. Landings increased gradually from the 1960s through the early 1980s. Louisiana has accounted for more than one third of the total gulf poundage since the early 1970s and more than 50% since 1983.

Landings have increased greatly since 1984. This increased harvest is thought to reflect economic difficulties in oil producing states, economic overfishing in interdependent fisheries, movement of Indochinese into the fishery and stock reduction in oyster resources. With the exception of Mississippi, highest recorded landings in all Gulf States occurred during this time period. Record landings in Louisiana pushed 1987 gulf production to 78.3 million pounds.

Table 8.1. Historical hard-shell blue crab landing statistics, 1880-1987 (thousands of pounds; thousands of dollars).

Year	Florida West Coast Quantity	Florida West Coast Value	Alabama Quantity	Alabama Value	Mississippi Quantity	Mississippi Value	Louisiana Quantity	Louisiana Value	Texas Quantity	Texas Value	Total Quantity	Total Value
1880	--	--	--	--	--	--	288	7	36	1	324	8
1887	(2)	(2)	(2)	(2)	38	1	837	13	111	4	(2)	(2)
1888	3	(1)	96	6	16	(1)	851	13	115	4	1,081	23
1889	--	--	--	--	48	1	842	14	189	5	1,079	20
1890	--	--	--	--	33	1	851	13	191	5	1,075	19
1891	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1892	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1895	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1897	6	(1)	24	1	132	3	1,459	13	138	4	1,759	21
1898	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1899	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1901	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1902	1	(1)	75	2	235	5	312	16	43	2	666	25
1904	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1905	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1908	2	(1)	246	6	380	10	244	8	199	5	1,071	29
1915	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1918	--	--	96	3	216	6	282	10	193	11	787	30
1919	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1920	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1921	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1922	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1923	--	--	84	3	435	11	312	8	109	9	940	31
1924	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1925	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1926	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1927	12	1	32	1	2,426	62	1,091	51	121	9	3,682	124
1928	7	1	102	4	1,518	40	2,320	78	300	12	4,247	135
1929	2	(1)	103	3	1,247	33	2,675	78	163	11	4,190	125
1930	4	(1)	80	1	673	11	4,186	63	29	1	4,972	76
1931	4	(1)	78	1	454	7	4,985	53	49	1	5,570	62
1932	4	(1)	70	1	320	5	5,878	57	45	1	6,317	64
1933	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1934	49	1	257	4	603	7	11,676	164	258	13	12,843	189
1935	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1936	821	12	997	14	2,011	30	12,576	168	320	8	16,725	232
1937	775	12	756	11	1,435	25	14,717	195	922	24	18,605	267
1938	1,104	16	511	8	1,016	17	10,533	106	971	24	14,135	171
1939	722	11	558	8	1,469	25	11,228	129	406	8	14,383	181
1940	1,170	16	1,381	28	1,488	26	14,062	172	252	6	18,353	248
1941	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1942	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1943	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1944	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)

Table 8.1. Continued.

Year	Florida West Coast Quantity	Florida West Coast Value	Alabama Quantity	Alabama Value	Mississippi Quantity	Mississippi Value	Louisiana Quantity	Louisiana Value	Texas Quantity	Texas Value	Total Quantity	Total Value
1945	1,092	54	2,207	110	5,639	282	31,280	1,418	339	39	40,557	1,903
1946	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1947	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1948	(2)	(2)	2,373	119	5,503	275	21,110	608	526	34	(2)	(2)
1949	2,056	91	2,128	106	4,163	208	17,874	555	374	22	26,595	982
1950	684	27	599	26	4,040	202	13,106	599	387	30	18,816	884
1951	2,076	83	1,109	46	1,623	82	8,710	461	280	24	13,798	696
1952	1,984	89	655	39	1,726	86	7,334	314	338	24	12,037	552
1953	3,153	126	1,087	54	1,412	71	8,131	333	432	39	14,215	623
1954	2,903	145	972	49	1,256	68	7,085	294	379	26	12,595	582
1955	4,954	248	1,613	81	1,763	88	10,811	449	356	29	19,497	895
1956	3,728	180	725	36	1,979	99	9,402	433	195	20	16,029	768
1957	5,302	318	1,462	73	2,400	144	8,559	419	201	11	17,924	965
1958	8,693	461	1,182	56	2,124	123	9,336	402	570	51	21,905	1,093
1959	13,895	681	1,093	57	3,003	165	9,570	461	1,192	75	28,753	1,439
1960	18,648	895	499	26	2,812	169	10,050	497	2,867	177	34,876	1,764
1961	17,130	736	838	46	2,505	143	11,910	514	2,875	178	35,258	1,617
1962	10,356	487	634	35	907	55	9,523	463	4,473	289	25,893	1,329
1963	13,148	644	1,297	75	1,112	64	7,982	447	2,980	199	26,519	1,429
1964	14,068	843	1,762	110	1,286	82	5,692	379	2,484	175	25,292	1,589
1965	20,598	1,185	1,812	153	1,692	131	9,284	635	3,622	286	37,008	2,390
1966	16,547	912	2,183	182	1,457	105	7,986	537	2,778	228	30,951	1,964
1967	13,976	817	2,353	188	1,015	79	7,559	520	2,625	222	27,528	1,826
1968	9,008	674	1,980	159	1,136	108	9,551	807	4,084	329	25,759	2,077
1969	11,584	1,074	1,920	223	1,740	177	11,602	1,072	6,343	599	33,189	3,145
1970	14,786	1,073	1,407	144	2,027	193	10,254	928	5,525	509	33,999	2,847
1971	12,279	952	1,997	212	1,259	126	12,186	1,256	5,810	567	33,531	3,113
1972	10,673	959	1,612	195	1,362	169	15,083	1,777	6,464	653	35,194	3,753
1973	9,599	1,147	2,098	294	1,814	231	23,080	2,811	6,881	830	43,472	5,313
1974	10,134	1,280	1,826	284	1,667	227	20,639	2,701	6,088	832	40,354	5,324
1975	12,807	1,585	1,639	283	1,137	177	17,144	2,510	5,992	948	38,719	5,503
1976	12,049	1,966	1,299	281	1,334	268	15,211	3,061	6,668	1,179	36,561	6,755
1977	15,832	3,119	2,174	548	1,919	473	16,154	3,765	8,249	1,947	44,328	9,852
1978	11,679	2,256	2,009	458	1,940	422	15,074	3,189	7,470	2,004	38,172	8,331
1979	11,198	2,235	1,341	400	1,313	316	21,334	4,776	8,312	2,146	43,498	9,873
1980	11,276	2,387	1,557	465	2,760	693	18,183	4,327	8,953	2,456	42,729	10,328
1981	14,788	3,327	2,462	850	1,867	519	16,237	4,469	6,952	1,928	42,306	11,093
1982	8,871	2,209	1,266	479	1,297	348	17,284	4,843	8,010	2,375	36,728	10,254
1983	9,337	2,524	1,412	514	1,140	332	19,616	6,366	8,829	3,250	40,334	12,986
1984	12,912	3,197	4,216	1,374	2,250	640	29,617	8,192	7,229	2,252	56,224	15,655
1985	12,273	3,113	2,261	830	1,649	538	29,848	8,387	9,722	3,309	55,753	16,177
1986	7,644	2,981	2,886	950	1,303	470	31,611	9,295	9,482	3,170	52,926	16,866
1987	10,413	3,332	2,496	1,005	1,374	480	52,345	20,134	11,688	4,763	78,316	29,714

(1) Less tnan 500 pounds or $500
(2) Data not available
*Partial surveys were done prior to 1912 and in 1934, 1936 through 1940, 1945, 1948 and 1949 and 1951.

8.1.2 Trends in Landings by Gear

Dominant commercial gear types used in the gulf to harvest blue crabs are crab traps, trawls and trotlines. The fishery has gradually evolved from a trotline based fishery to one dominated by crab trap usage. Annual reported blue crab landings by gear and state are shown in Table 8.2.

Reported landings of blue crabs caught on trotlines declined sharply from 1948 to 1952, leveled off from 1952 to 1961 and steadily declined to less than 1% of the total 1976 gulf wide landings. The trotline was the primary method of harvesting crabs in Louisiana in the early years of the fishery. In lakes Pontchartrain and Maurepas, hoop nets were also used to harvest crabs. These nets were baited and often connected together with a longline. Benedict (1940) also made reference to thick wire (single loop) shallow drop nets used by Lake Pontchartrain crab fishermen.

The invention of the crab trap was a technological innovation that had a profound effect on the fishery. The Lewis crab trap, patented in 1938, enabled fishermen to use untended traps that both attracted crabs to bait and hindered their efforts to escape. The NMFS statistics record crab traps in use in Louisiana and Texas as early as 1948 with wide acceptance beginning in Florida in the middle 1950s (Table 8.2). The earliest date that the crab trap was used in Louisiana is not certain; however, the use of traps originated in Barataria Bay. Gowanloch (1952) described the crab trap and encouraged Louisiana crab fishermen to adopt this gear because it was efficient and economical. Trap-caught crabs began to influence total state landings in Florida by 1954 and in Texas as early as 1952. By 1960, every state except Alabama and Louisiana reported more crabs caught in crab traps than any other gear.

Reported landings of blue crabs taken in trawls have fluctuated widely. Although directed trawl fisheries for blue crabs exist, much of the fishing is seasonal and related to economic conditions in other fisheries. Record trawl landings in 1965 amounted to only 6% of the total reported gulf landings for that year. Drop nets were used only in Louisiana. Landings for this gear are reported in Table 8.3.

8.1.2.1 Gear Improvements

In 1927 B.F. Lewis of Harryhogan, Virginia, began experiments in Chesapeake Bay to design a crab pot. The first crab pot he used was constructed of poultry wire, 36x30x12 inches in size and was patented in 1928 (Wharton 1956). Lewis' early model pot was not widely used because it allowed too many crabs to escape (Van Engel 1962); this trap did not contain a wire partition to divide the trap into upper and lower chambers. Isaacson (1962) later showed that the wire partition in a crab pot was an effective means of crab retention.

B.F. Lewis later modified his early pot design to incorporate a partition (i.e., baffle or apron) across the trap. This gear was introduced in 1936 and patented in 1938 (Wharton 1956). These early traps were cubical in shape, two feet on each side, and made of 18-gauge galvanized poultry wire with 1 to 1 1/2 inch hexagonal mesh. Bait cups were made of 1 inch mesh wire or double thickness of 1 1/2 inch wire.

Only minor improvements to the basic Lewis crab pot design were implemented during the 1940s and 1950s (Van Engel 1962). Andrews (1947) noted that frames of iron rods were incorporated into the pot to increase rigidity, and that this design was abandoned because a heavier gauge wire was adopted. Isaacson (1962) evaluated the effect of the wire partition, funnel placement and one-way gates on crab catches and retention. Traps with funnels placed in the lowest row of meshes yielded the highest catches. The one-way gates (or escape triggers) were found to be as effective as the wire partition in retaining crabs and less costly in labor and materials.

Table 8.2. Blue crab catch (thousands of pounds) by gear by state, 1948-1986.

Year	Florida West Coast				Alabama				Mississippi			Louisiana				Texas		
	Trawls[3]	Traps	Trot-lines	Misc. Gears	Trawls[3]	Traps	Trot-lines	Misc. Gears	Trawls[3]	Traps	Trot-lines	Trawls[3]	Traps	Trot-lines	Misc. Gears	Trawls[3]	Traps	Trot-lines
1948	NS[2]	NS	NS		--	--	2,373		--	--	5,503	32	110	20,545		20	341	165
1949	--	89	1,964		--	--	2,128		--	--	4,163	37	85	17,274		8	228	138
1950	--	4	680		32	31	535		--	94	3,946	26	60	12,739		40	195	152
1951	(1)	(1)	2,071		61	22	1,027		--	307	1,316	1	706	7,654		10	185	85
1952	2	135	1,844		42	190	423		--	751	975	37	550	6,402		12	249	77
1953	3	9	3,141		47	394	647		--	674	738	34	517	7,243		22	284	126
1954	3	1,045	1,853		--	120	852		--	233	1,023	120	--	6,387		20	335	19
1955	1	2,735	2,218		--	420	1,193		--	456	1,307	55	--	9,827		21	335	--
1956	2	2,490	1,237		--	386	339		--	812	1,167	41	--	7,331		(1)	195	--
1957	2	4,861	431		--	360	1,102		--	1,018	1,382	73	17	6,795		35	142	25
1958	6	7,799	889		--	255	927		--	1,279	844	98	13	7,390		114	387	69
1959	11	12,844	1,041		--	241	852		--	2,797	206	137	19	7,414		256	928	8
1960	17	17,343	1,289		--	140	359		--	2,607	204	140	38	7,557		82	2,784	--
1961	64	16,065	1,001		--	420	418		--	2,335	170	904	38	8,613		131	2,744	--
1962	33	10,073	251		1	631	2		--	841	67	709	57	6,812		328	4,138	7
1963	81	12,828	240		(1)	1,293	4		--	1,029	83	568	82	5,902		180	2,801	--
1964	98	13,626	345		118	1,585	59		--	1,108	178	649	297	3,368		174	2,228	--
1965	118	20,021	457		36	1,760	16		5	1,634	54	1,953	1,119	4,640		245	2,944	--
1966	87	16,311	148		9	2,165	8		--	1,295	163	669	3,126	3,476		238	2,455	--
1967	164	13,688	120		10	2,343	--		--	996	19	464	4,279	2,263		54	2,571	--
1968	138	8,865	--		46	1,933	--		--	1,116	20	449	5,414	2,869		232	3,852	--
1969	243	11,331	--		103	1,817	--		--	1,713	27	945	6,686	3,199		172	6,171	--
1970	101	14,670	--		2	1,405	--		8	2,006	14	1,181	5,728	2,568		267	5,200	59
1971	78	12,201	--		441	1,556	--		--	1,259	--	1,065	9,386	1,734		295	5,496	18
1972	127	10,454	--		87	1,525	--		8	1,355	--	692	11,307	2,916		219	6,246	--
1973	246	9,439	--		120	1,979	--		20	1,795	--	1,301	19,157	2,622		308	6,573	--
1974	69	10,065	--		93	1,732	--		76	1,591	--	206	19,601	833		497	5,591	--
1975	118	12,688	--		49	1,591	--		16	1,121	--	266	17,788	1,089		305	5,687	--
1976	120	11,928	--		18	1,260	--	21[4]	199	1,135	--	354	14,713	130		125	6,543	--
1977	66	15,766	--		23	2,151	--	(1)[4]	4	1,914	--	153	15,794	202	6[6]	286	7,963	--
1978	77	11,602	--		1	2,008	--		--	1,940	--	212	14,824	38	--	105	7,365	--
1979	46	11,110	--	42[5]	146	1,195	--		56	1,257	--	148	21,186	--	--	--	8,312	--
1980	43	11,231	2		138	1,419	--		541	2,219	--	474	17,709	--	--	--	8,953	--
1981	89	14,688	10		122	2,341	--		8	1,859	--	203	16,033	--	--	--	6,952	--
1982	63	8,805	3		29	1,237	--	(1)[4]	--	1,297	--	160	17,125	--	--	--	8,010	--
1983	34	9,297	6		76	1,336	--		37	1,103	--	130	19,486	--	--	--	8,829	--
1984	46	12,864	--	2[4]	488	3,729	--	(1)[4]	188	2,062	--	145	29,458	14	--	--	7,229	--
1985	94	12,176	--	3[4]	81	2,180	--	(1)[4]	114	1,535	--	23	29,825	--	--	--	9,722	--
1986	142	7,486	--	3[4]	16	2,870	--		15	1,288	--	37	31,574	--	--	--	9,482	--

(1) Less than 500 pounds
[2] No survey taken
[3] Trawls-miscellaneous types
[4] Gill, trammel nets, other
[5] Dredges
[6] Butterfly nets

Table 8.3. Catch from drop nets and number of fishermen in Louisiana by year, 1948-1972.

Year	Catch (1,000 pounds)	Number of Regular Fishermen	Number of Casual Fishermen
1948	415	54	48
1949	466	90	32
1950	282	40	43
1951	330	39	55
1952	345	50	96
1953	338	74	152
1954	578	102	118
1955	930	58	76
1956	2,031	109	69
1957	1,675	119	65
1958	1,835	141	58
1959	2,000	143	60
1960	2,315	143	61
1961	2,354	230	51
1962	1,946	300	44
1963	1,431	285	59
1964	1,378	388	32
1965	1,573	357	46
1966	716	106	21
1967	553	94	34
1968	819	94	38
1969	772	78	55
1970	778	58	84
1971	2	30	50
1972	167	14	27

Van Engel (1962) noted that since all pots were handmade, their construction was varied to suit local conditions, individual preference and budget. Most crab fishermen added weight to their traps by using 1/2 to 3/4 inch iron rods tied to the base or galvanized pipe, bricks or cement inserted in the bottom corners.

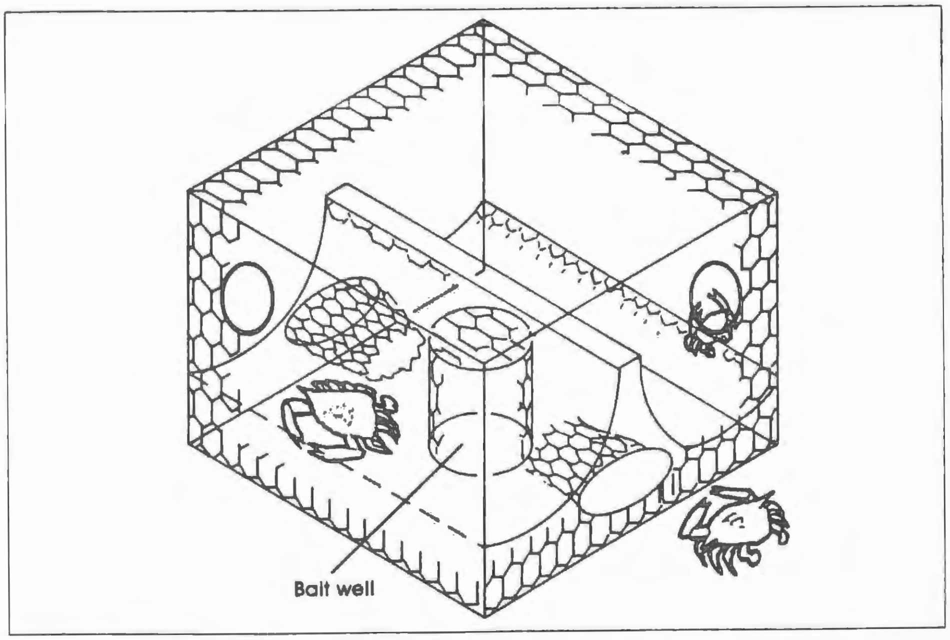
In the Gulf of Mexico, the term "trap" has been adopted as opposed to the term "pot" which is used on the East Coast although each term identifies the same device. The distinction between a crab pot/trap and other kinds of animal traps is that the crab is not ensnared and can exit on its own initiative.

Traps used in Louisiana up to the early 1970s were basically similar to the early Chesapeake Bay design (Adkins 1972a). Traps of vinyl coated wire were present but were undesirable to fishermen because of high initial cost and normal loss due to currents, storms, sinking of floats and theft. However, by the mid-1970s traps of vinyl coated wire were widely adopted by commercial fishermen because of their resistance to corrosion.

A wide variety of trap sizes and designs are presently used. The number of entrance funnels may range from two to four, dimensions may vary from less than 24 inches to over 36 inches in length and width, and the inner (bait) chamber may occupy the entire floor of the trap, half of the floor or even be absent in some traps.

The concept of self-culling blue crab traps originated in the Atlantic coast fishery. Large mesh panels (Cronin 1950), entire traps made of larger mesh (Van Engel 1962) and, more recently, escape rings (Eldridge et al. 1979) were evaluated. These self-culling traps were designed because of the large number of sublegal crabs in some areas. The problem of sublegal crab retention in traps has been recognized since the introduction of the gear (Green 1952).

Escape rings in blue crab traps (as illustrated below) were assessed by Guillory and Merrell (1988) in Louisiana. Ring size, number and location of rings were tested. Three 6.03 cm (2.38") diameter rings located flush with the floor or apron with at least two located in the outer chamber were recommended. Sublegal catch in traps with 6.03 cm diameter rings was reduced 78.8% from control traps while legal catch increased 9.7%. Rings with a diameter of 6.35 cm (2.5") performed satisfactorily with regard to loss of sublegal crabs; however, legal catch was reduced during certain times of the year. The 6.35 cm and 6.03 cm diameter rings were made by thin sectioning 6.35 cm diameter polyvinyl chloride (PVC) pipe and couplings for 5.08 cm diameter PVC pipe, respectively. Escape rings were attached to the trap with "hog rings."



Guillory (1989a) later compared square (5.08 cm side) and circular (6.03 cm diameter) escape vents. Sublegal catch in both experimental traps decreased 80% from control traps, and a slight but statistically insignificant decrease in legal catch in experimental traps was found. Both square and circular escape vents performed adequately and equally well; however, the square vents were more economical and easier to construct and apply than circular PVC vents. The square vents were made from 5.08 cm 14-gauge vinyl coated wire.

Catch rates of premolt blue crabs in traps with and without escape vents were compared by Guillory (1989b). Total peeler catches in traps with escape vents were reduced about 55%-60% from control traps, and rank peeler (imminent molting) catches were reduced about 70%. Since most premolt crabs in Louisiana come from hard crab trap fishermen, mandatory use of escape vents could adversely impact the soft shell crab industry by reducing the supply of premolt crabs.

Future improvements in gear technology may be associated with the development of biodegradable escape panels or hinged doors with a time release mechanism. Guillory (1989c) evaluated the impact of ghost fishing in blue crab traps and concluded that a substantial number (25 per trap year) of crabs will die in each trap, that unbaited traps will continue to attract crabs (35 per trap year) and that large numbers of traps are lost annually by commercial crab fishermen. Blott (1978) evaluated several "time release mechanisms" in lobster traps to reduce ghost fishing mortality. Blott concluded that a hinged door with a biodegradable attachment would be superior to natural twine panels or corrosion of pot-line hooks. Scarsbrook et al. (1988) recommended square or triangular escape panels and cotton butcher's twine as a binding material for use in sablefish traps.

8.1.3 Catch by Water Body

Steele (1982) reported that over 50% of the blue crabs landed from Florida's West Coast were from Apalachicola Bay south to Waccasassa Bay. In Alabama, the bulk of production comes from Mississippi Sound (57%) with 20% of the landings taken from Mobile Bay (Swingle 1976). No information on catch by estuarine system is available for Mississippi, although the majority of the catch probably comes from Mississippi Sound proper (Perry et al. 1984). NMFS data from 1980 show that Louisiana commercial hard crab landings are spread fairly evenly with Barataria Bay producing slightly more than other areas. Soft crab production was reported almost exclusively from Lakes Maurepas and Pontchartrain and Barataria Bay; however, with the adoption of closed, recirculating systems, the soft-shell crab fishery has expanded westward along the coast. From 1977 to 1988, 77% of Texas commercial hard crab landings came from Galveston Bay, San Antonio Bay and Aransas Bay systems (Quast et al. 1989). Catch by water body is listed in Tables 6.1 to 6.5.

8.1.4 Seasonal Landings by State

Seasonal fluctuations in reported commercial landings are similar among Gulf States (Figure 8.1). Commercial crab fishing generally begins in March or April as water temperatures rise above 15°C. Greatest commercial catches usually occur from May through August with June or July as peak months. Reported landings then begin to decline with water temperature. These general trends may shift slightly from month to month depending upon prevailing environmental and/or market conditions.

8.1.5 Percent Contributions - States to Gulf Landings and Gulf to United States Landings

The percent contribution of each individual gulf state to total gulf landings is shown in Table 8.4. In the 1960s, Florida dominated landings with Louisiana ranking second in production (Figure 8.2a). Through the 1970s into 1980, Louisiana has led the Gulf States in reported landings (Figure 8.2b), and in 1987 produced 66.8% of the total gulf catch (Figure 8.2c). Production in Mississippi and Alabama remained fairly stable with each state generally contributing between 3% and 5% of the total catch through the early 1980s; however, landings in Mississippi relative to Alabama have decreased steadily from 1984. The percent contribution of Texas to gulf landings increased through the early 1980s, dropped to 12.9% from 21.9% in 1984 with a slight rise to 14.9% in 1987. Florida's contribution to total gulf landings decreased from 35.0% in 1981 to 13.3% in 1987.

The percent contribution of gulf production to total United States landings for the years 1960 through 1987 is shown in Table 8.5. From 1962 through 1967, the Gulf States generally contributed less than 20% of the total U.S. landings. Gulf contribution increased gradually to 34.5% in 1977 and then declined to 18.8% in 1982. With the increase in Louisiana landings in the middle 1980s, gulf production has increased to 38.9% of total U.S. landings in 1987 (Figure 8.3).

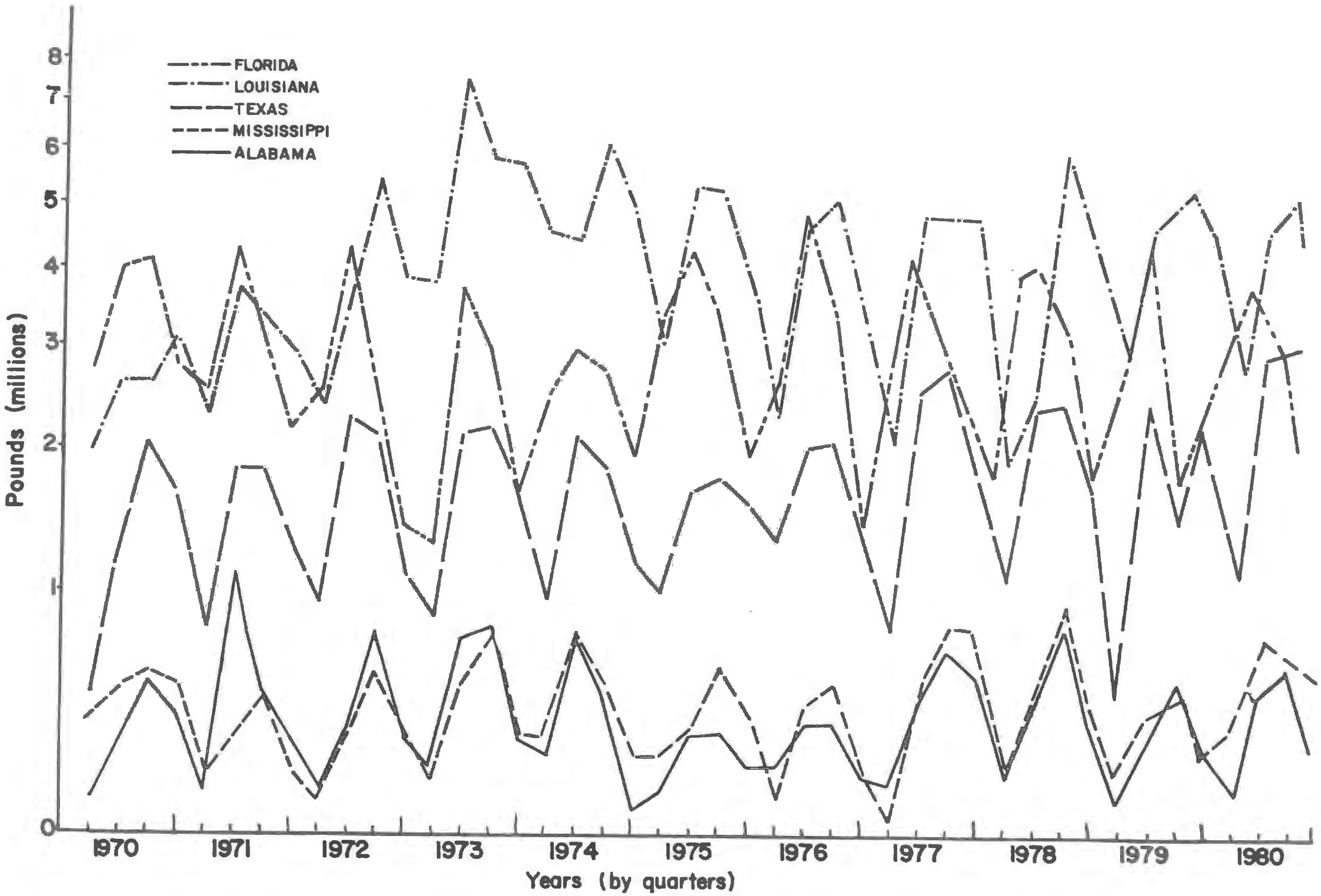


Figure 8.1. Seasonal blue crab landings by state, 1970-1980.

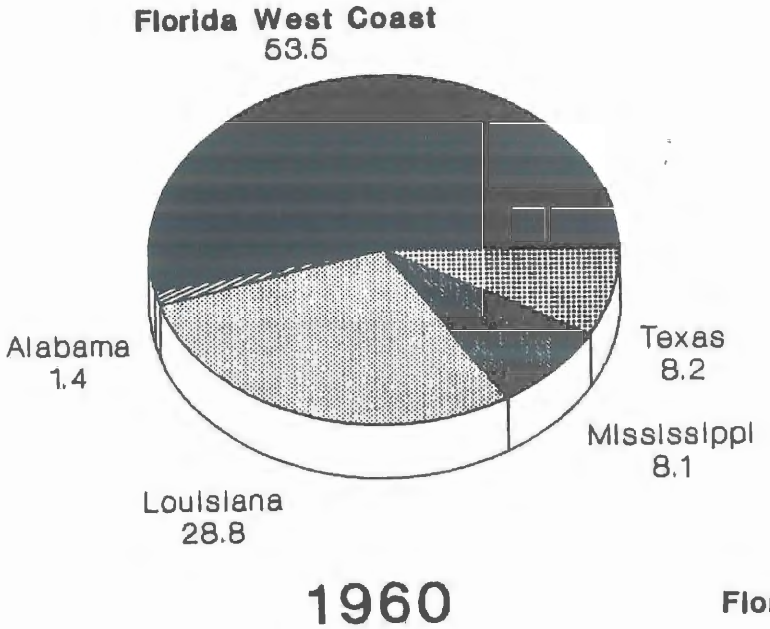


Figure 8.2a

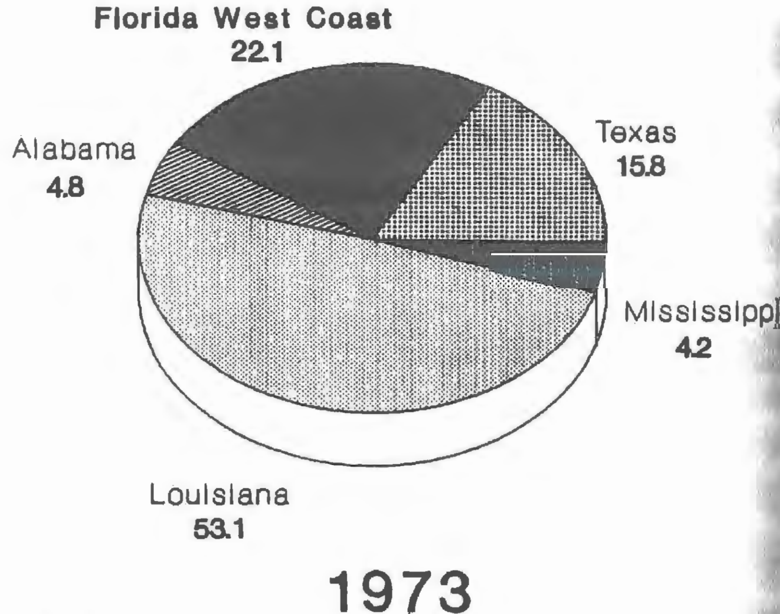


Figure 8.2b

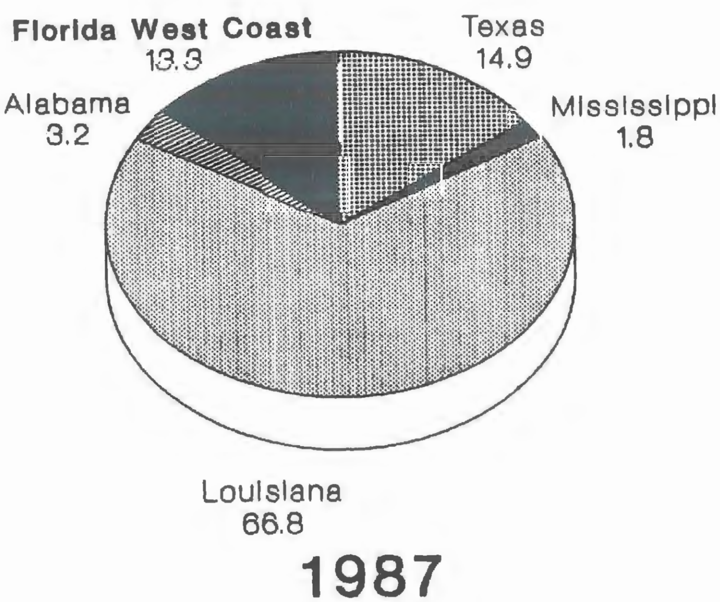


Figure 8.2c

Figures 8.2a, 8.2b, 8.2c. Total gulf blue crab landings percent contribution by state.

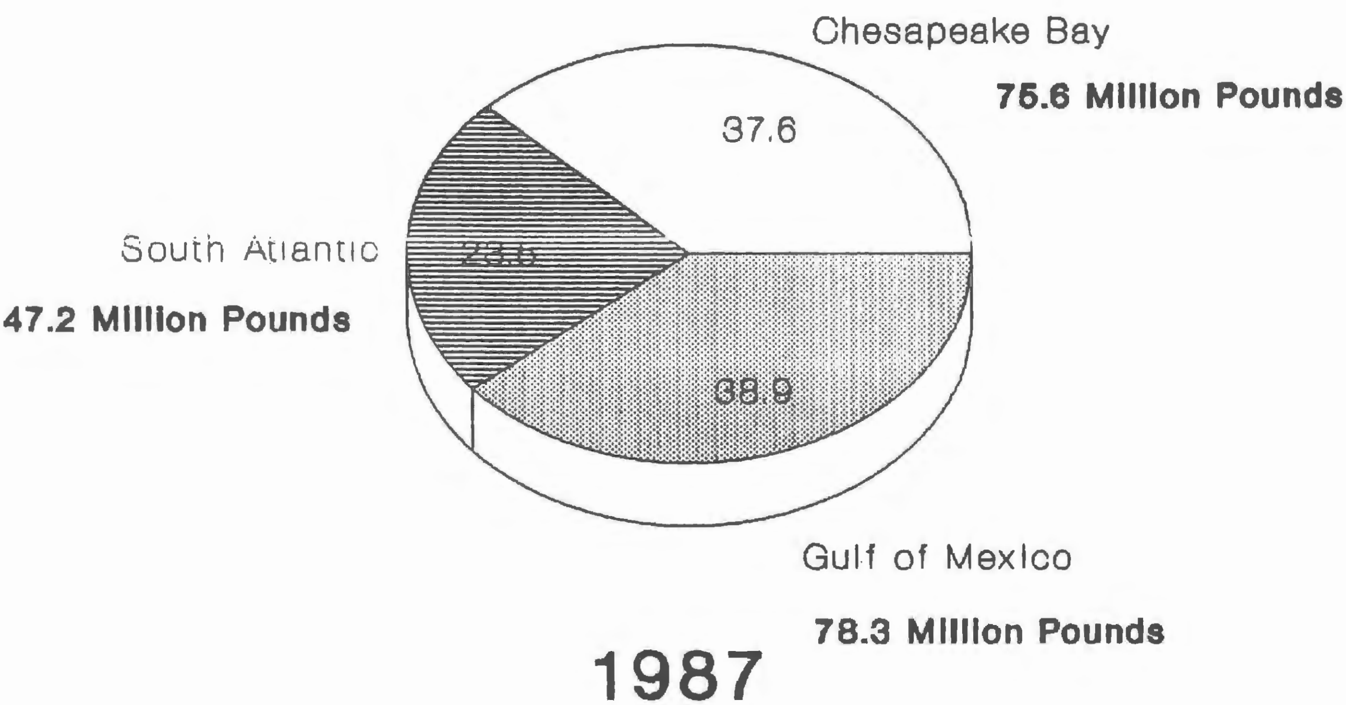


Figure 8.3. 1987 blue crab landings by region.

8.1.6 Factors Affecting Commercial Landings

Blue crab fisheries are characterized by seasonal, annual and geographic fluctuations in harvest. According to Van Engel (1982), fluctuations in Chesapeake Bay landings result primarily from variations in year-class strength and distribution of the stock, both of which he considered largely influenced by density independent environmental variables. More (1969) listed changes in recruitment to the fished population and migration to and from fishing grounds as factors influencing landings in Galveston Bay, Texas. In Florida, Tagatz (1965) reported that market conditions as well as crab migration and year-class strength were influential in determining the level of commercial catch.

The relationship between commercial fisheries landings (blue crabs, oysters, penaeid shrimp) and long-term environmental factors was investigated by Meeter et al. (1979) for the Apalachicola Bay estuarine system in Florida. Although there were indications that flow from the Apalachicola River influenced annual commercial landings of blue crabs from Franklin County, little of the long-term variation in blue crab harvest could be correlated with river flow. The authors suggested that unidentified socio-economic variables and individual species strategies relative to short- and long-term climatic changes may in part be responsible. According to Lyles (1976) fluctuations in the commercial catch of blue crabs appear to be governed more by economic conditions than by a scarcity of crabs. Moss (1981) noted that landings do not necessarily reflect population levels but may only reflect economic fluctuations.

Table 8.4. Percent contribution by state to total gulf landings of hard crabs, 1960-1987.

Year	Florida West Coast	Alabama	Mississippi	Louisiana	Texas
1960	53.5	1.4	8.1	28.8	8.2
1961	48.6	2.4	7.1	33.8	8.2
1962	40.0	2.4	3.5	36.8	17.3
1963	49.6	4.9	4.2	30.1	11.2
1964	55.6	7.0	5.1	22.5	9.8
1965	55.7	4.9	4.6	25.1	9.8
1966	53.5	7.1	4.7	25.8	9.0
1967	50.8	8.5	3.7	27.5	9.5
1968	35.0	7.7	4.4	37.1	15.9
1969	34.9	5.8	5.2	35.0	19.1
1970	43.5	4.1	6.0	30.2	16.3
1971	36.6	6.0	3.8	36.3	17.3
1972	30.3	4.6	3.9	42.9	18.4
1973	22.1	4.8	4.2	53.1	15.8
1974	25.1	4.5	4.1	51.1	15.1
1975	33.1	4.2	2.9	44.3	15.5
1976	33.0	3.6	3.6	41.6	18.2
1977	35.7	4.9	4.3	36.4	18.6
1978	30.6	5.3	5.1	39.5	19.6
1979	25.7	3.1	3.0	49.0	19.1
1980	26.4	3.6	6.5	42.6	21.0
1981	35.0	5.8	4.4	38.4	16.4
1982	24.2	3.4	3.5	47.1	21.8
1983	23.1	3.5	2.8	48.6	21.9
1984	23.0	7.5	4.0	52.7	12.9
1985	22.0	4.1	3.0	53.5	17.4
1986	14.4	5.5	2.5	59.7	17.9
1987	13.3	3.2	1.8	66.8	14.9

8.2 Commercial Soft Crab Fishery

8.2.1 Historical Catch Statistics

The first record of soft crab production in the gulf dates to 1887 when 133,000 pounds valued at $7,000 were harvested in Louisiana, and 15,000 pounds worth $1,000 were recorded from Mississippi. Recorded production in Texas, Florida and Alabama began much later with landings rarely exceeding 10,000 pounds. The catch and value of the soft crab fishery by state and total gulf production are shown in Table 8.6.

Louisiana remains the largest supplier of soft crabs to the southern states although landings in the state have fluctuated widely. Jaworski (1982) noted that the substantial increase in landings beginning in 1934 was the result of development of the bush line fishery. Growth of the industry has occurred with the adoption of closed, recirculating seawater systems to hold and shed peelers.

Table 8.5. Percent contribution of gulf landings to total United States landings of hard crabs, 1960-1987.

Year	Percent
1960	23.3
1961	23.9
1962	17.3
1963	18.7
1964	16.6
1965	22.2
1966	18.6
1967	19.0
1968	22.7
1969	25.1
1970	23.4
1971	22.5
1972	23.9
1973	31.8
1974	27.1
1975	28.7
1976	31.7
1977	34.5
1978	27.6
1979	28.5
1980	26.2
1981	21.7
1982	18.8
1983	21.0
1984	27.9
1985	29.3
1986	31.0
1987	38.9

8.2.2 Trends in Landings by Gear

In all states a variety of gear types have been and continue to be employed, although the catch of peelers is in most instances an incidental catch. Landings and value and number of fishermen (full time and part time) by gear type are given in Tables 8.7 through 8.9. Another unique method used in the past to harvest peeler crabs was the "tapaderos" or seine stretched loosely across the mouth of a bayou (Benedict 1940). Crabs following the tide would cling to the webbing.

8.3 Recreational Fishery

Data on the recreational catch of crabs in the gulf are lacking. The sport fishery is thought to contribute significantly to total fishing pressure, though estimates of the impact of recreational fishing on the resource vary widely. Gear in the recreational fishery is varied, including dip nets, "strings with baits," drop nets, fold up traps and the standard hard crab trap. Louisiana, Texas and Florida recreational fishermen are required to purchase a license; however, Alabama and Mississippi recreational fishermen are not required to purchase a license.

Table 8.6. Historical soft-shell blue crab landing statistics, 1880-1986 (thousands of pounds; thousands of dollars).

Year	Florida West Coast		Alabama		Mississippi		Louisiana		Texas		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1880	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1887	(2)	(2)	(2)	(2)	15	1	133	7	--	--	(2)	(2)
1888	--	--	--	--	40	1	143	7	--	--	183	8
1889	--	--	--	--	19	1	147	8	--	--	166	9
1890	--	--	--	--	15	1	130	7	--	--	145	8
1891	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1892	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1895	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1897	--	--	--	--	21	2	--	--	--	--	21	2
1898	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1899	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1901	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1902	(1)	(1)	--	--	30	3	--	--	--	--	30	3
1904	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1905	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1908	--	--	--	--	47	6	78	21	1	(1)	126	27
1915	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1918	--	--	--	--	9	2	--	--	1	(1)	10	2
1919	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1920	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1921	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1922	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1923	--	--	--	--	9	2	3	1	--	--	12	3
1924	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1925	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1926	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1927	--	--	--	--	8	2	137	48	--	--	145	50
1928	--	--	3	1	67	12	183	52	--	--	253	65
1929	--	--	4	1	12	4	81	25	--	--	97	30
1930	--	--	1	(1)	6	2	146	58	--	--	153	60
1931	--	--	1	(1)	5	1	121	45	--	--	127	46
1932	--	--	1	(1)	4	1	99	25	--	--	104	26
1933	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1934	--	--	2	(1)	4	1	651	86	--	--	657	87
1935	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1936	--	--	1	(1)	3	1	365	53	--	--	369	54
1937	2	(1)	--	--	2	(1)	329	51	--	--	333	51
1938	--	--	--	--	--	--	248	37	--	--	248	37
1939	--	--	--	--	--	--	215	33	--	--	215	33
1940	--	--	--	--	(1)	(1)	252	40	--	--	252	40
1941	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1942	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1943	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1944	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)

Table 8.6. Continued

Year	Florida West Coast Quantity	Florida West Coast Value	Alabama Quantity	Alabama Value	Mississippi Quantity	Mississippi Value	Louisiana Quantity	Louisiana Value	Texas Quantity	Texas Value	Total Quantity	Total Value
1945	--	--	--	--	--	--	2,370	1,706	--	--	2,370	1,706
1946	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1947	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1948	(2)	(2)	--	--	--	--	881	440	--	--	(2)	(2)
1949	--	--	--	--	--	--	455	192	--	--	455	192
1950	(1)	(1)	(1)	(1)	--	--	364	165	--	--	364	165
1951	4	1	(1)	(1)	6	2	350	188	--	--	360	191
1952	15	2	--	--	15	4	448	215	--	--	478	221
1953	3	(1)	--	--	(1)	(1)	488	203	--	--	491	203
1954	(1)	(1)	--	--	--	--	455	215	--	--	455	215
1955	1	(1)	--	--	7	3	581	290	--	--	589	293
1956	1	1	--	--	6	1	600	250	--	--	607	252
1957	10	5	--	--	17	3	551	192	--	--	578	200
1958	1	(1)	--	--	20	2	577	298	--	--	598	300
1959	3	2	--	--	11	1	605	302	--	--	619	305
1960	4	2	--	--	5	1	514	256	2	(1)	525	259
1961	5	3	--	--	7	1	620	310	2	1	634	315
1962	(1)	(1)	--	--	2	(1)	344	172	6	1	352	173
1963	4	2	--	--	3	1	329	164	2	(1)	338	167
1964	13	7	--	--	2	(1)	200	127	(1)	(1)	215	134
1965	12	9	--	--	1	(1)	204	141	--	--	217	150
1966	1	(1)	--	--	1	(1)	128	85	--	--	130	85
1967	7	4	--	--	1	(1)	146	121	--	--	154	125
1968	--	--	--	--	1	(1)	284	207	--	--	285	207
1969	(1)	(1)	--	--	(1)	(1)	197	161	--	--	197	161
1970	(1)	(1)	--	--	--	--	90	79	--	--	90	79
1971	--	--	--	--	--	--	127	126	--	--	127	126
1972	(1)	(1)	--	--	--	--	102	109	--	--	102	109
1973	--	--	--	--	--	--	119	132	--	--	119	132
1974	(1)	(1)	--	--	--	--	96	127	--	--	96	127
1975	2	1	--	--	--	--	111	155	--	--	112	156
1976	--	--	--	--	(1)	(1)	88	145	--	--	88	145
1977	--	--	--	--	--	--	225	570	--	--	225	570
1978	22	27	--	--	2	1	133	276	--	--	157	304
1979	9	5	--	--	--	--	147	338	--	--	156	343
1980	17	12	--	--	--	--	118	273	--	--	135	285
1981	23	15	--	--	--	--	100	238	--	--	123	253
1982	53	52	(1)	(1)	--	--	164	432	--	--	217	484
1983	36	80	(1)	(1)	--	--	101	290	--	--	137	370
1984	28	79	(1)	(1)	(1)	(1)	75	203	--	--	103	282
1985	17	47	3	4	--	--	82	200	--	--	102	251
1986	9	(3)	(1)	(1)	--	--	79	181	--	--	88	181

(1) Less than 500 pounds or $500
(2) Data not available
(3) No value available

Table 8.7. Number of regular and casual fishermen, operating units, catch, and value by gear type for the Florida soft and peeler crab fishery, 1950-1986.

Year	Dip Nets: Fishermen Regular	Dip Nets: Fishermen Casual	Dip Nets: Gear Units	Dip Nets: Catch*	Dip Nets: Value*	Trotlines with Baits: Fishermen Regular	Trotlines with Baits: Fishermen Casual	Trotlines with Baits: Gear Units	Trotlines with Baits: Catch*	Trotlines with Baits: Value*	Traps: Fishermen Regular	Traps: Fishermen Casual	Traps: Gear Units	Traps: Catch*	Traps: Value*	Otter Trawls: Fishermen Regular	Otter Trawls: Fishermen Casual	Otter Trawls: Gear Units	Otter Trawls: Catch*	Otter Trawls: Value*
1950	15	1	16	(1)	(1)															
1951	5	10	15	2	(1)	86		86	1	(1)										
1952	7	5	12	(1)	(1)	99		114	14	2										
1953						107		105	3	(1)	69		10,575	(1)	(1)					
1954											134	15	16,665	(1)	(1)					
1955											128	21	16,000	1	(1)	120	1	933	(1)	(1)
1956											152	20	17,875	1	1					
1957											227	23	27,265	10	5					
1958											188	20	25,516	1	(1)					
1959		10	100	(1)	(1)						305	15	39,720	3	2					
1960											266	16	34,300	4	2					
1960											221	12	30,358	5	3					
1961											228	15	32,059	(1)	(1)					
1962		Pound Nets									194	24	31,530	4	2					
1964	2		40	11	6						287	19	48,885	2	1					
1965	2		40	4	3						316	43	59,020	8	6					
1966											294	56	52,670	1	(1)					
1967	334	5	105	4	3											110	35	1,787	3	2
1968																85	30	1,850	(1)	(1)
1969											196	48	28,921	(1)	(1)					
1970											215	55	30,940	(1)	(1)					
1971																				
1972											153	37	28,405	(1)	(1)					
1973																				
1974											169	24	27,745	(1)	(1)					
1975											168	24	34,290	2	1					
1976																				
1977																				
1978				2	2									21	25					
1979				8	5									1	(1)					
1980				2	1									15	11					
1981				4	3									18	12					
1982				6	7									46	42					
1983				6	15									28	62					
1984				4	13									23	65					
1985				3	8									14	39					
1986				(2)	(2)									9	(2)					

(1) Less than 500 pounds or $500
*Thousands of pounds and thousands of dollars

Table 8.8. Number of regular and casual fishermen, operating units, catch and value by gear type for the Mississippi, Alabama and Texas ...
1950-1986.

Table 8.8. *Number of regular and casual fishermen, operating units, catch and value by gear type for the Mississippi, Alabama and Texas soft and peeler crab fishery, 1950-1986.*

Year	Mississippi										Alabama					Texas				
	Trotlines with Baits					Traps					Dip Nets (Drop)					Traps				
	Fishermen		Gear			Fishermen		Gear			Fishermen		Gear			Fishermen		Gear		
	Regular	Casual	Units	Catch*	Value*	Regular	Casual	Units	Catch*	Value*	Regular	Casual	Units	Catch*	Value*	Regular	Casual	Units	Catch*	Value*
1950													5	(1)	(1)					
1951	197	32	229	(1)	(1)	21		1,220	6	2	2	3		(1)	(1)					
1952	191	36	227	3	1	27		2,000	13	4										
1953	53	18	71	(1)	(1)															
1954																				
1955	40	4	44	2	1	22		2,660	4	2										
1956	37	4	41	1	(1)	21		2,510	5	1										
1957	34	4	38	7	1	23	3	2,520	10	2										
1958	27	4	31	9	1	23	8	2,820	12	1										
1959	15	4	20	1	(1)	49	16	4,535	10	1										
1960	11	4	15	2	(1)	57	11	5,150	3	(1)						71		7,099	2	(1)
1961	13	2	15	2	(1)	55	4	6,460	5	1						76		7,200	2	1
1962	11	2	13	(1)	(1)	46	3	5,065	2	(1)						84	3	9,220	6	1
1963						19	3	1,870	3	(1)						80	2	9,668	2	(1)
1964	8	3	11	1	(1)	26	3	2,930	1	(1)						72	4	8,680	(1)	(1)
1965	13	2	15	(1)	(1)	27	7	3,000	1	(1)										
1966						28	6	3,100	1	(1)										
1967						29	5	3,400	1	(1)										
1968						33	8	3,870	1	(1)										
1969						35	36	4,250	(1)	(1)										
1970																				
1971																				
1972																				
1973																				
1974																				
1975																				
1976						20	23	2,950	(1)	(1)										
1977																				
1978									2	1										
1979																				
1980																				
1981																				
1982																				
1983																				
1984																				
1985																				
1986																				

(1) Less than 500 pounds or $500
(2) Data not available
*Thousands of pounds and thousands of dollars

Table 8.9. Number of regular and casual fishermen, operating units, catch and value by gear type for the Louisiana soft and peeler crab fishery, 1946-1986.

	Traps					Trotlines with Baits					Otter Trawls				
	Fishermen					Fishermen					Fishermen				
	Regular	Casual	Gear Units	Catch*	Value*	Regular	Casual	Gear Units	Catch*	Value*	Regular	Casual	Gear Units	Catch*	Value*
1946	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
1947	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
1948															
1949															
1950															
1951	50	20	3,500	44	26										
1952	49	28	4,070	75	36										
1953	40	25	3,575	108	43										
1954						506	89	631	138	57					
1955						495	108	603	180	90					
1956						429	109	538	93	37					
1957						409	98	507	67	24					
1958						451	93	544	59	30					
1959	3	8	275			443	87	528							
1960						492	95	598	59	29					
1961						498	132	634	68	34					
1962						496	147	643	46	23					
1963						587	122	743	64	32					
1964	25	9	3,250	23	14	590	104	750	49	26					
1965	101	21	11,465	14	10	578	122	786	35	24					
1966	321	76	40,240	20	13	524	125	649	33	22					
1967	470	89	58,785	53	44	388	120	569	20	16					
1968	474	103	65,550	88	71	416	146	562	39	32					
1969	489	105	67,920	61	50	412	159	471	19	16					
1970	490	67	75,760	35	32	308	34	1,197	5	4	2,914	1,305	6,122	(1)	(1)
1971	530	136	84,070	30	32	292	49	629	(1)	(1)	2,791	1,260	6,233	(1)	(1)
1972	571	123	87,632	21	23	289	44	724	(1)	(1)	2,808	1,448	6,291	3	2
1973	609	148	93,595	50	59	151	50	415	8	9	3,188	1,599	7,756	9	4
1974	630	179	108,100	31	43						3,152	1,611	7,052	2	1
1975	687	212	122,840	28	40						3,130	1,595	6,201	2	1
1976	789	226	144,014	25	42						3,168	1,578	7,307		
1977				68	177										
1978				5	11									3	3
1979				68	162									1	(1)
1980				55	130									(1)	(1)
1981				52	125									1	1
1982				61	163									(1)	(1)
1983				45	139									1	1
1984				21	57									2	2
1985				21	60									6	8
1986				29	61									6	11

Table 8.9. Continued.

Table 8.9. Continued.

	Brush Traps					Haul Seines					Dip Nets (Drop)				
	Fishermen					Fishermen					Fishermen				
	Regular	Casual	Gear Units	Catch*	Value*	Regular	Casual	Gear Units	Catch*	Value*	Regular	Casual	Gear Units	Catch*	Value*
1945	526		143,220	877	632	189	6	64	460	331	39	20	2,410	1,033	744
1946	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
1947	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
1948	130		93,500	295	148	129	3	41	184	92	54	48	4,060	402	201
1949	125		88,500	213	90	108	7	44	82	35	90	32	6,800	160	67
1950	129		88,950	188	86	93	11	44	74	32	40	43	5,110	102	46
1951	130		96,500	243	124	99	3	36	22	13	39	55	4,945	41	25
1952	130		96,500	299	143	85	3	33	23	11	50	96	6,880	51	24
1953	133		101,600	296	123	76	2	29	31	12	74	152	8,270	52	25
1954	100		12,500	247	124	59		24	32	16	102	118	8,235	39	19
1955	152	37	26,825	327	164						58	76	6,990	73	36
1956	131	37	26,400	343	139						109	69	12,175	164	73
1957	105	30	21,000	317	111						119	65	13,750	167	57
1958	88	24	16,800	338	169						141	58	14,575	180	99
1959	88	20	16,200	340	170						143	60	14,750	209	105
1960	85	18	18,200	200	100						143	61	15,114	255	126
1961	141	18	52,300	274	137						230	51	20,559	278	139
1962	74	8	39,950	107	53						300	44	23,436	192	96
1963	88	16	43,160	52	26						285	59	22,792	213	107
1964	65		28,275	24	16						388	32	29,032	112	71
1965	48		17,000	40	27						357	46	28,957	115	80
1966	45		16,500	37	25						106	21	11,067	37	25
1967	48		16,600	52	43						94	34	9,952	553	38
1968	88		35,200	106	63						94	38	10,532	51	41
1969	86		38,300	78	64			Dip Nets (Common)			78	55	8,840	38	31
1970	117	35	41,730	37	33	6	9	15	5	5	58	84	10,520	6	6
1971	110	38	43,150	57	61	6	2	8	32	27	30	50	6,816	2	3
1972	105	28	42,750	44	47	6	6	12	17	18	14	27	3,222	16	18
1973	79	8	41,700	37	44	6	2	8	15	16					
1974	83	10	42,740	57	76	6	2	8	6	8					
1975	81	10	42,680	77	111	6	2	8	3	4					
1976	75	10	42,500	57	93	6	2	8	6	10					
1977				152	383				3	10					
1978				125	262										
1979				76	168				3	7					
1980				62	141				1	3					
1981				37	88				10	24					
1982				97	252				6	17					
1983				50	133				6	17					
1984				52	144										
1985				55	132										
1986				45	109										

(1) Less than 500 pounds or $500
(2) Data not available
NS-No survey taken
*Thousands of pounds and thousands of dollars

8.3.1 Hard Crabs

Based on interviews with 810 sports fishermen in the Mississippi Coastal Zone, Herring and Christmas (1974) reported a recreational catch of 50,000 pounds of hard crabs in 1971. Compared to commercial landings of 1,259,230 pounds for that year, the sports catch represented less than 4% of the total. Tatum (1982) conservatively estimated that the recreational catch in Alabama equalled approximately 20% of the annual commercial catch. Benefield (1968) estimated the recreational catch of blue crabs from Galveston Bay to be 33,125 pounds or 5.9% of the commercial harvest from that area.

Titre et al. (1988) surveyed outdoor recreational activities in Louisiana's Deltaic Plain parishes of St. Mary, Terrebonne, Lafourche, St. Charles, Jefferson, Plaquemines and St. Bernard. Saltwater fishing was the most preferred outdoor activity among 42% of the respondents. Less than 1% considered recreational crabbing as their most preferred activity, and slightly over 5% considered it their second most preferred outdoor activity. Less than one-third of the respondents indicated having made a recreational crabbing trip during the 12 month survey period compared to 85.4% of those interviewed who took a saltwater fishing trip. Respondents travelled a mean distance of 17.6 miles to crab compared to 70 miles to participate in saltwater fishing activities. Direct costs among those respondents who crabbed during the survey period were $6.24 per trip compared to $17.18 per recreational shrimping trip and $42.06 per saltwater fishing trip. Titre et al. (1988) found that though individuals do not generally have to pay for the right to fish or crab, other than an annual fishing license fee, they do value these activities and would be willing to pay for the right to participate in them. The amount individuals are willing to pay over and above current expenditures is an important economic concept which can be used in several issues currently facing managers of many of the nation's fisheries.

8.3.2 Soft Crabs

There are no data on the recreational catch of soft crabs.

8.4 Incidental Catch

In addition to the commercial and recreational hard and soft crab fisheries, large numbers of crabs are harvested as "by-catch" in other fisheries. Adkins (1972a) noted that commercial shrimp fishermen in Louisiana, "eat, give away, swap for supplies, or sell many of the crabs they catch while trawling for shrimp." Adkins (1972a) also reported that during the late fall and winter crabs are frequently taken in shrimp trawls following strong cold fronts, and one shrimper trawling in the mouth of a deep bayou caught 8,000 to 9,000 pounds of crabs in a single day. Commercial butterfly or wing net (paupier) fishermen also harvest large numbers of crabs that are eaten, given away or sold. Adkins (1972a) summarized the results of field interviews of sport trawlers and commercial trawlers showing bushels, pounds and percent of blue crabs utilized but not reported as landings as:

	Sport	Commercial
Number of interviews	26	40
Time interviewed	Daily	Weekly
Number bushels (pounds)* caught	42 (1,890)	5,538 (249,210)
Number bushels (pounds) not reported	42 (1,890)	203 (9,135)
Percent not reported	100	3.7
Total number bushels (pounds) yearly not reported	2,100 (94,500)	4,060 (182,700)

*1 bushel=45 pounds

Data on incidental catch from other Gulf States are lacking.

8.5 Condition of the Fishery

Data collected by the NMFS are the only comprehensive catch and effort survey information available for the Gulf of Mexico blue crab fishery. Some states maintain records of sales of crab licenses, but the percentage of part time to full time fishermen is unknown, and there is no corresponding catch information. Only Florida has catch and trip data obtained by the reporting requirements of the state's seafood products license; however, the data base extends only from 1986 to present. Complete and finalized NMFS data for all Gulf States are available through 1986, and these data were used to assess the condition of the fishery. Landings data were available for 1987 and are included in Figures 8.4, 8.9, 8.14, 8.19, 8.24 and 8.29. Though the data base does not contain complete information describing harvest and fishing effort, it is assumed to be representative of trends in the commercial trap fishery. Additional data from the Louisiana Department of Wildlife and Fisheries (LDWF) were used to contrast NMFS data for that state. The NMFS data used to define fishery parameters are summarized in Table 8.10.

8.5.1 Florida West Coast

8.5.1.1 Pounds Landed (Figure 8.4)

Considerable fluctuations in annual landings have occurred since 1969 with peaks in 1970, 1977, 1981 and 1984. Landings in 1986 (7.4 million pounds) were the lowest since 1969; however, landings increased to 10.4 million pounds in 1987.

8.5.1.2 Harvesting Sector (Figures 8.5-8.8, Table 8.10)

The number of commercial crab fishermen increased from 244 in 1969 to 486 in 1986. Number of traps used in the fishery increased from 28,621 in 1969 to 54,300 in 1986. Greatest increase in the number of fishermen and traps occurred from 1981 through 1986. Catch per fishermen decreased from 46,439 pounds in 1969 to 15,403 in 1986. Catch per trap also decreased from 396 pounds in 1969 to 138 in 1986.

8.5.1.3 Fishery Status

Landings in the Florida fishery have fluctuated with four to seven year cycles evident since 1969. Transport of crabs from the west coast to the east coast for processing may account for some of the observed decrease in annual landings during the 1980s (Florida Marine Fisheries Information Service). There has been an increase in effort with a corresponding decrease in catch per fisherman and catch per trap.

8.5.2 Alabama

8.5.2.1 Pounds Landed (Figure 8.9)

The fishery in Alabama remained relatively stable through the 1970s. Record landings occurred in 1984 with 3.7 million pounds reported.

8.5.2.2 Harvesting Sector (Figures 8.10-8.13, Table 8.10)

The number of commercial crab fishermen increased from 85 in 1969 to 137 in 1986. Number of traps used in the fishery increased from 13,490 to 40,500 for the same time period. Greatest increase in the numbers of fishermen and traps occurred during the 1980s. Catch per fisherman decreased from 21,376 pounds in 1969 to 20,949 pounds in 1986. Catch per trap decreased from 135 pounds in 1969 to 71 pounds in 1986.

Table 8.10. Annual blue crab catch in traps and related information.

Year	Florida West Coast						Alabama					
	Total trap harvest (1,000 lbs)	Number of crab trap fishermen (units)	Number of traps (units)	Traps per fisherman (units)	Catch per fisherman (pounds)	Catch per trap (pounds)	Total trap harvest (1,000 lbs)	Number of crab trap fishermen (units)	Number of traps (units)	Traps per fisherman (units)	Catch per fisherman (pounds)	Catch per trap (pounds)
1969	11,331	244	28,621	117	46,439	396	1,817	85	13,490	159	21,376	135
1970	14,670	272	30,940	114	53,934	474	1,405	94	14,100	150	14,947	100
1971	12,201	267	30,995	116	45,697	394	1,556	88	14,425	164	17,682	108
1972	10,454	190	28,405	150	55,021	368	1,525	106	16,240	153	14,387	94
1973	9,439	204	29,160	143	46,270	324	1,979	95	13,935	147	20,832	142
1974	10,065	193	27,745	144	52,150	363	1,732	85	13,400	158	20,376	129
1975	12,688	192	34,290	179	66,083	370	1,591	75	13,000	173	21,213	122
1971-1975 average	10,969	209	30,119	144	52,435	364	1,677	90	14,200	158	18,670	118
1976	11,928	198	38,930	197	60,242	306	1,260	65	10,650	164	19,385	118
1977	15,766	222	42,770	193	71,018	369	2,151	78	12,600	162	27,577	171
1978	11,602	--	--	--	--	--	2,008	108	14,200	131	18,593	141
1979	11,110	308	34,300	111	36,071	324	1,195	98	12,300	126	12,194	97
1980	11,231	319	39,200	123	35,207	287	1,419	135	22,350	166	10,511	63
1976-1980 average	12,327	262	38,800	148	58,870	397	1,607	97	14,420	149	16,597	111
1981	14,688	328	40,181	123	44,780	366	2,341	127	32,660	257	18,433	72
1982	8,805	392	41,900	107	22,462	210	1,237	93	31,500	339	13,301	39
1983	9,297	452	53,600	119	20,569	173	1,336	107	24,000	224	12,486	56
1984	12,864	488	53,300	109	26,361	241	3,729	133	41,700	314	28,038	89
1985	12,176	491	61,400	125	24,798	198	2,180	131	39,800	304	16,641	55
1981-1985 average	11,566	430	50,076	116	26,885	231	2,165	118	33,932	287	18,313	64
1986	7,486	486	54,300	112	15,403	138	2,870	137	40,500	296	20,949	71

Table 8.10. Continued

	Mississippi						Louisiana					
Year	Total trap harvest (1,000 lbs)	Number of crab trap fishermen (units)	Number of traps (units)	Traps per fisherman (units)	Catch per fisherman (pounds)	Catch per trap (pounds)	Total trap harvest (1,000 lbs)	Number of crab trap fishermen (units)	Number of traps (units)	Traps per fisherman (units)	Catch per fisherman (pounds)	Catch per trap (pounds)
1969	1,713	71	4,250	60	24,127	403	6,686	594	67,452	114	11,256	99
1970	2,006	71	4,600	65	28,254	436	5,728	557	75,760	136	10,284	76
1971	1,259	65	4,050	62	19,369	311	9,386	666	84,070	126	14,093	112
1972	1,355	62	4,720	76	21,855	287	11,307	694	87,632	126	16,293	129
1973	1,795	68	5,290	78	26,397	339	19,157	757	93,595	124	25,306	205
1974	1,591	61	4,150	68	26,082	383	19,601	809	108,100	134	24,229	181
1975	1,121	63	4,300	68	17,794	261	17,788	899	122,840	137	19,786	145
1971-1975 average	1,424	64	4,502	70	22,323	316	15,448	765	99,247	130	20,193	156
1976	1,135	43	2,950	69	26,395	385	14,713	1,015	144,014	142	14,496	102
1977	1,914	66	4,580	69	29,000	418	15,794	961	134,125	140	16,435	118
1978	1,940	65	4,875	75	29,846	398	14,824	1,067	151,847	142	18,893	98
1979	1,257	65	4,875	75	19,338	258	21,186	1,085	160,466	148	19,521	132
1980	2,219	63	4,580	73	35,222	485	17,709	885	154,673	175	20,010	114
1976-1980 average	1,693	60	4,372	72	28,030	387	16,845	1,003	149,025	149	16,801	113
1981	1,859	61	4,570	75	30,475	407	16,033	891	147,532	166	17,994	109
1982	1,297	56	4,370	78	23,161	297	17,125	975	152,334	156	17,564	112
1983	1,103	55	4,300	78	20,055	257	19,486	952	145,000	152	20,468	134
1984	2,062	42	4,600	110	49,095	448	29,458	1,010	170,300	169	29,166	173
1985	1,535	64	4,900	77	23,984	313	29,825	1,030	190,200	185	28,956	157
1981-1985 average	1,571	56	4,548	82	28,259	345	22,385	972	161,073	166	23,040	139
1986	1,288	68	5,100	75	18,941	253	31,574	1,046	198,100	189	30,185	159

Table 8.10. Continued

Year	Texas: Total trap harvest (1,000 lbs)	Texas: Number of crab trap fishermen (units)	Texas: Number of traps (units)	Texas: Traps per fisherman (units)	Texas: Catch per fisherman (pounds)	Texas: Catch per trap (pounds)	Gulf: Total trap harvest (1,000 lbs)	Gulf: Number of crab trap fishermen (units)	Gulf: Number of traps (units)	Gulf: Traps per fisherman (units)	Gulf: Catch per fisherman (pounds)	Gulf: Catch per trap (pounds)
1969	6,171	95	14,440	152	64,958	427	27,718	1,089	128,253	118	25,453	216
1970	5,200	100	14,300	143	52,000	364	29,009	1,094	139,700	128	26,516	208
1971	5,496	88	12,700	144	62,455	433	29,898	1,174	146,240	125	25,467	204
1972	6,246	95	14,225	150	65,747	439	30,887	1,149	151,222	132	26,882	204
1973	6,573	126	16,500	131	52,167	398	38,943	1,250	158,480	127	31,154	246
1974	5,591	120	16,950	141	46,592	330	38,580	1,268	170,345	134	30,426	226
1975	5,687	152	19,900	131	37,414	286	38,875	1,381	194,330	141	28,150	200
1971-1975 average	5,919	116	16,055	138	50,935	369	35,437	1,244	164,123	132	28,477	216
1976	6,543	179	23,375	131	36,553	280	35,579	1,500	219,919	147	23,719	162
1977	7,963	167	21,500	129	47,683	370	43,588	1,494	215,575	144	29,175	202
1978	7,365	146	16,425	113	50,445	448	37,739	--	--	--	--	--
1979	8,312	97	11,060	114	85,691	752	43,000	1,653	223,001	135	26,050	193
1980	8,953	111	12,890	116	80,658	695	41,531	1,513	233,693	154	27,449	178
1976-1980 average	7,827	140	17,050	122	55,909	459	40,287	1,540	223,047	145	32,701	226
1981	6,952	112	13,095	117	62,071	531	41,873	1,519	238,038	157	27,566	176
1982	8,010	141	20,400	145	56,809	393	36,474	1,657	250,504	151	22,012	146
1983	8,829	131	17,700	135	67,397	499	40,051	1,697	244,600	144	23,601	164
1984	7,229	219	29,400	134	33,009	246	55,342	1,892	299,300	158	29,251	185
1985	9,722	205	25,200	123	47,424	386	55,438	1,921	321,500	167	28,857	172
1981-1985 average	8,148	162	21,159	131	50,423	385	45,836	1,737	270,788	156	26,385	169
1986	9,482	209	28,300	135	45,368	335	52,700	1,946	326,300	168	27,081	162

Sources: Compiled from Fishery Statistics of the United States and unpublished data provided by the National Marine Fisheries Service.

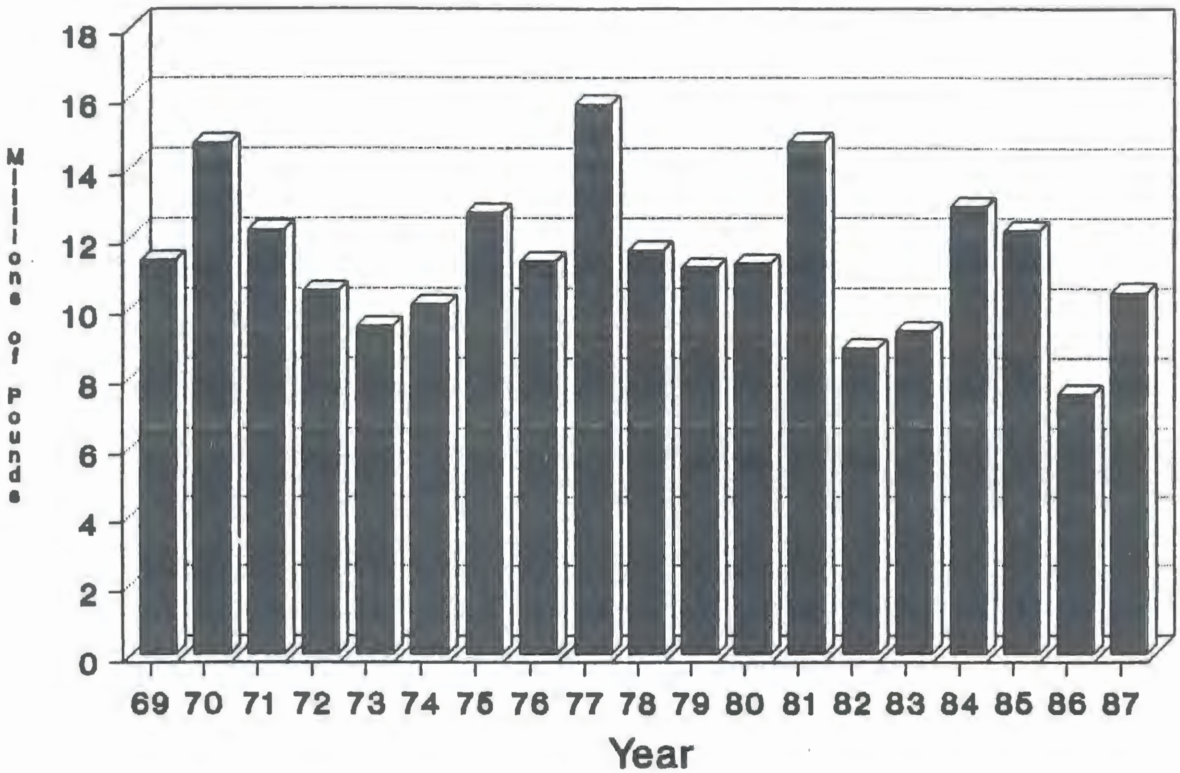


Figure 8.4. Florida West Coast landings, 1969-1987.

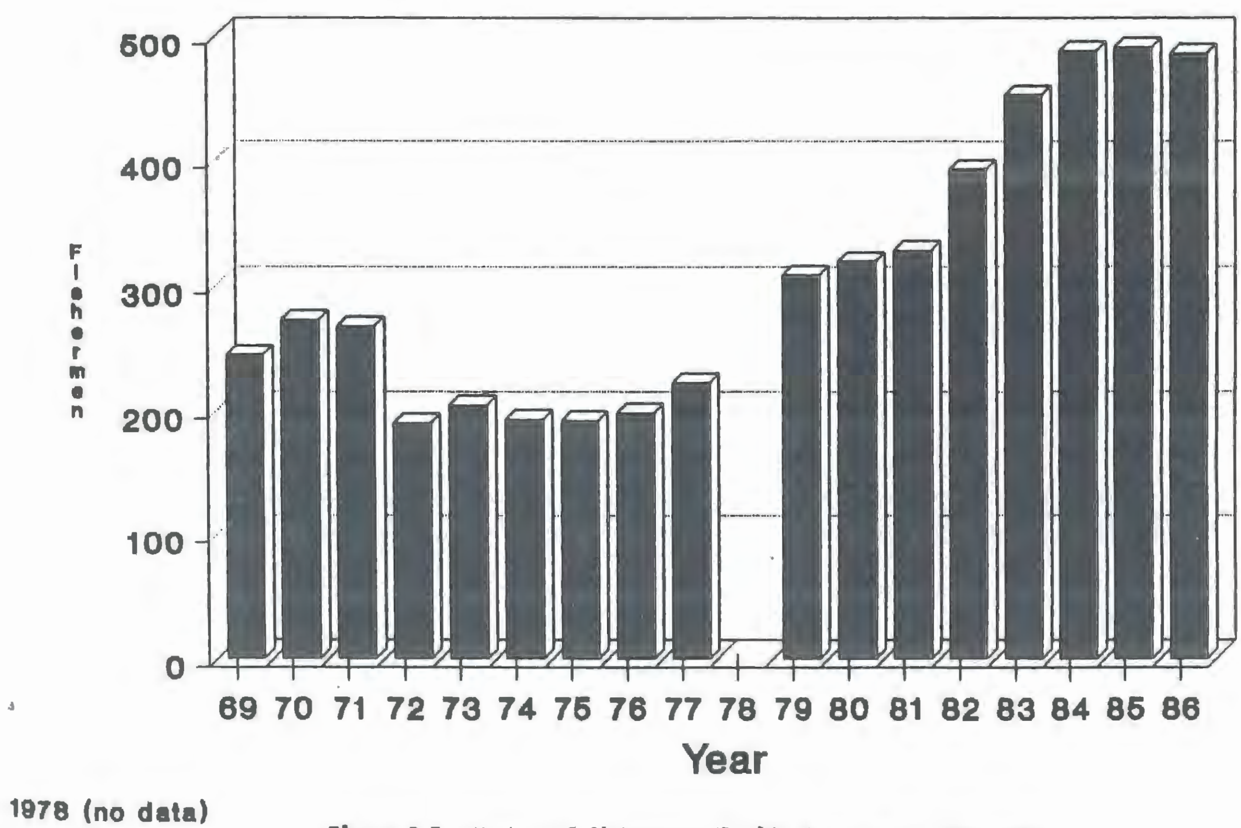
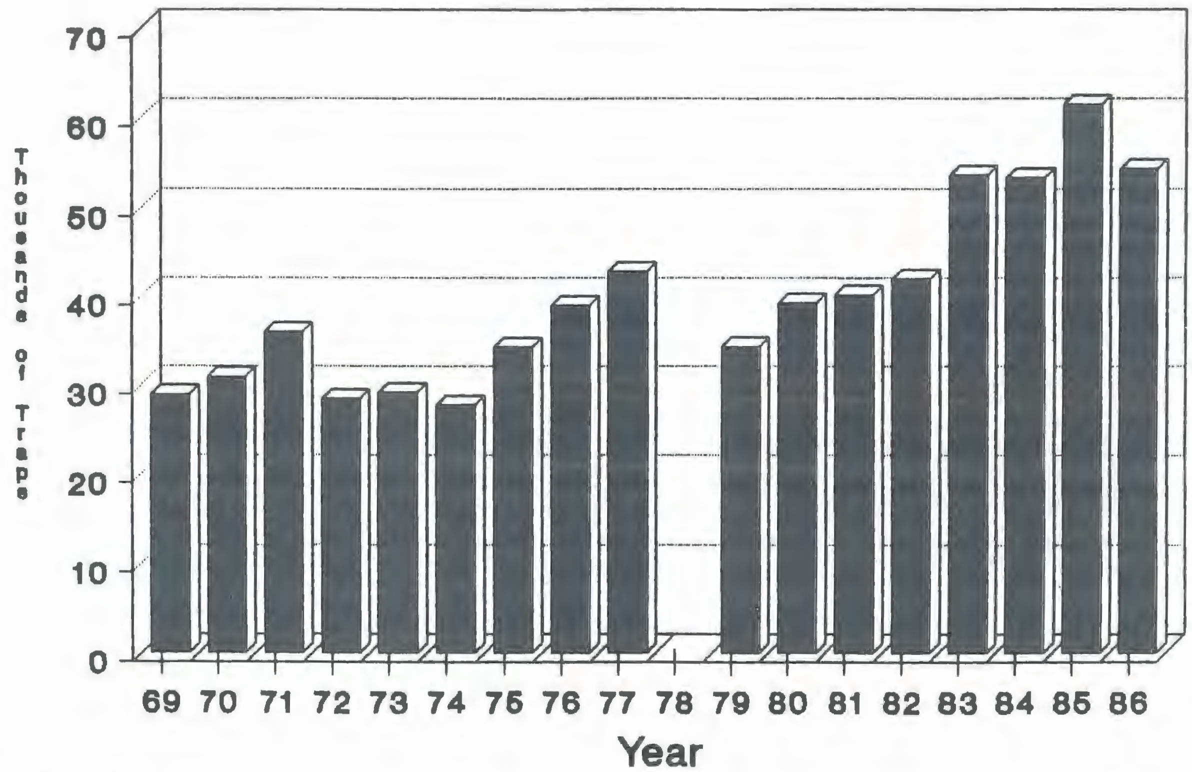
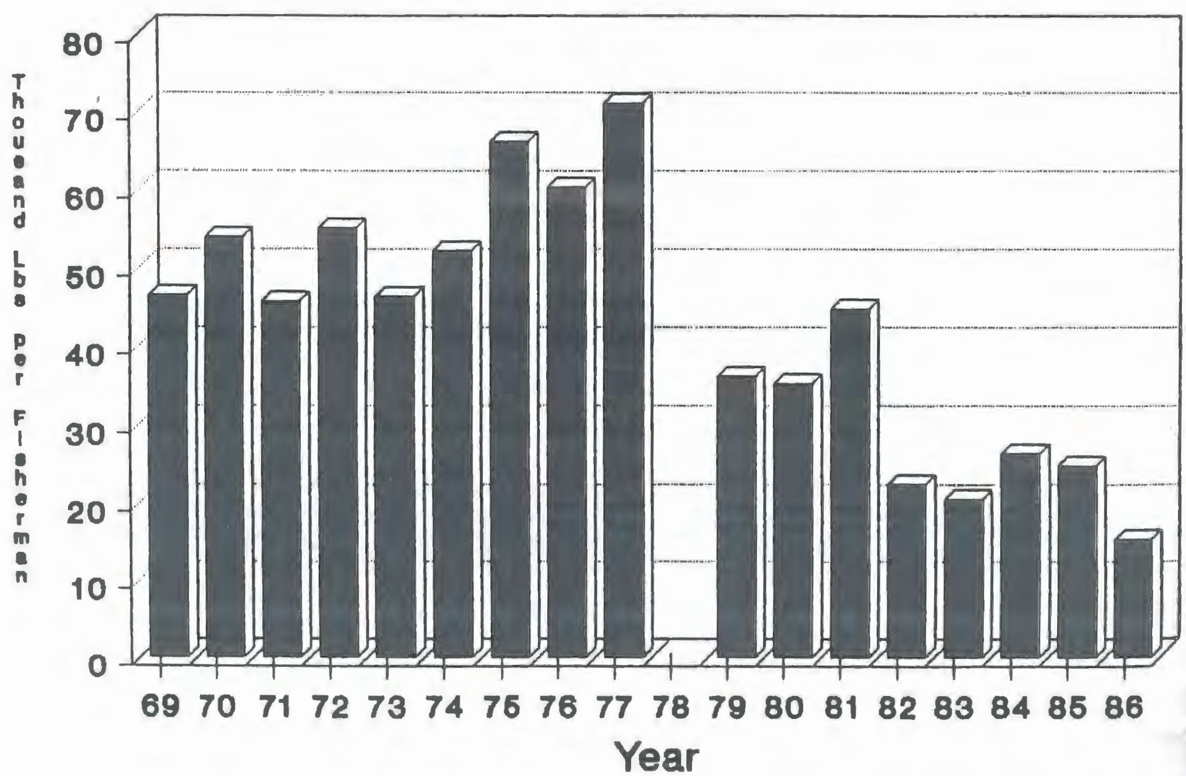


Figure 8.5. Number of fishermen, Florida West Coast, 1969-1986.



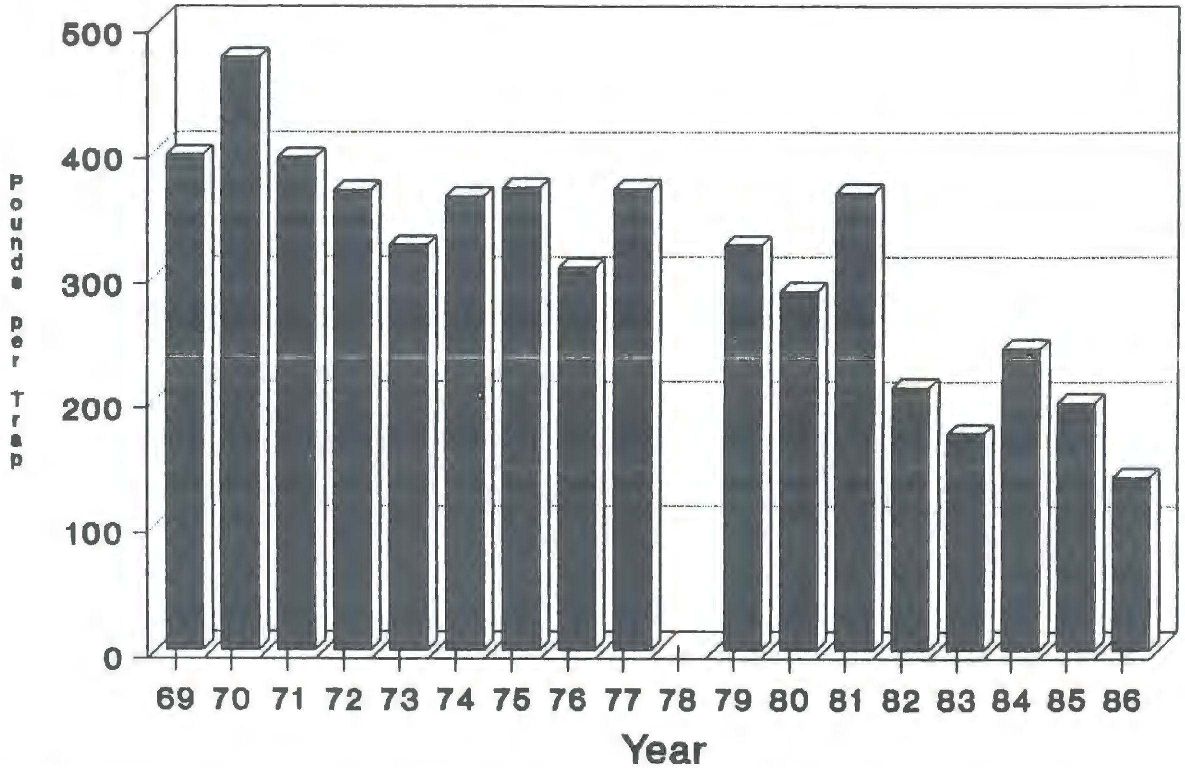
1978 (no data)

Figure 8.6. Number of traps, Florida West Coast, 1969-1986.



1978 (no data)

Figure 8.7. Pounds per fisherman, Florida West Coast, 1969-1986.



1978 (no data)

Figure 8.8. Pounds per trap, Florida West Coast, 1969-1986.

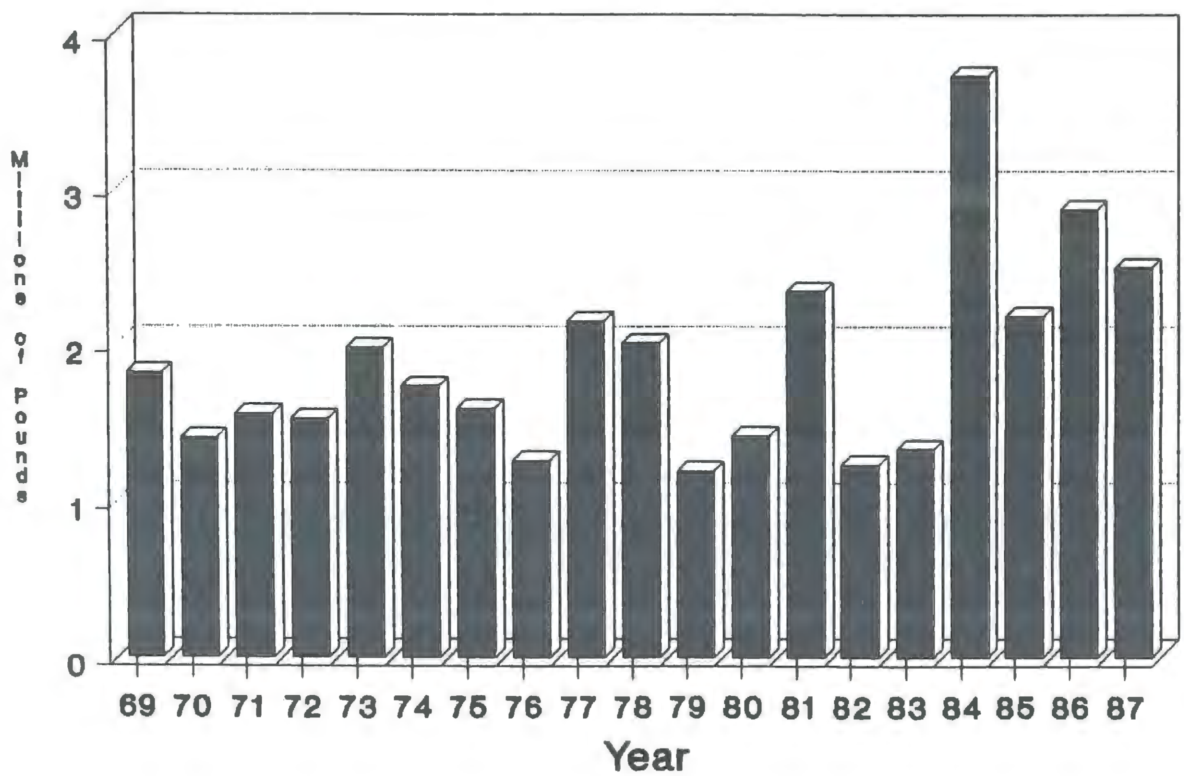


Figure 8.9. Alabama landings, 1969-1987.

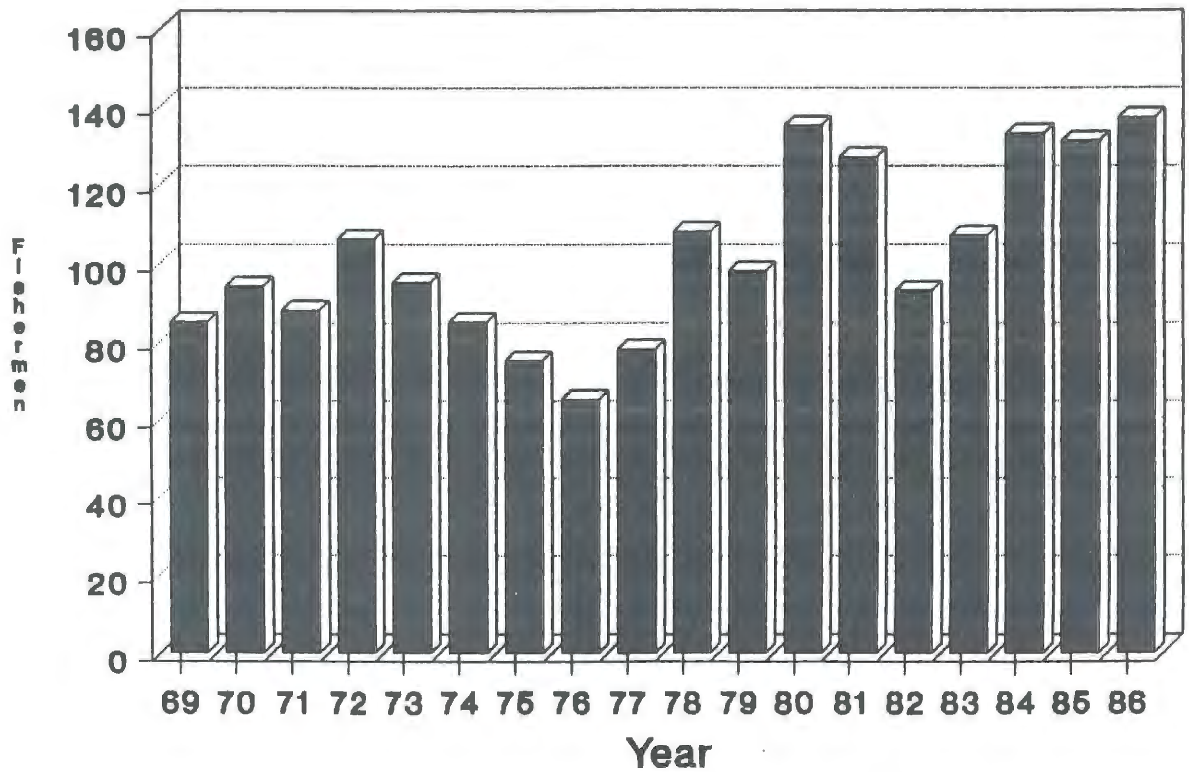


Figure 8.10. Number of fishermen, Alabama, 1969-1986.

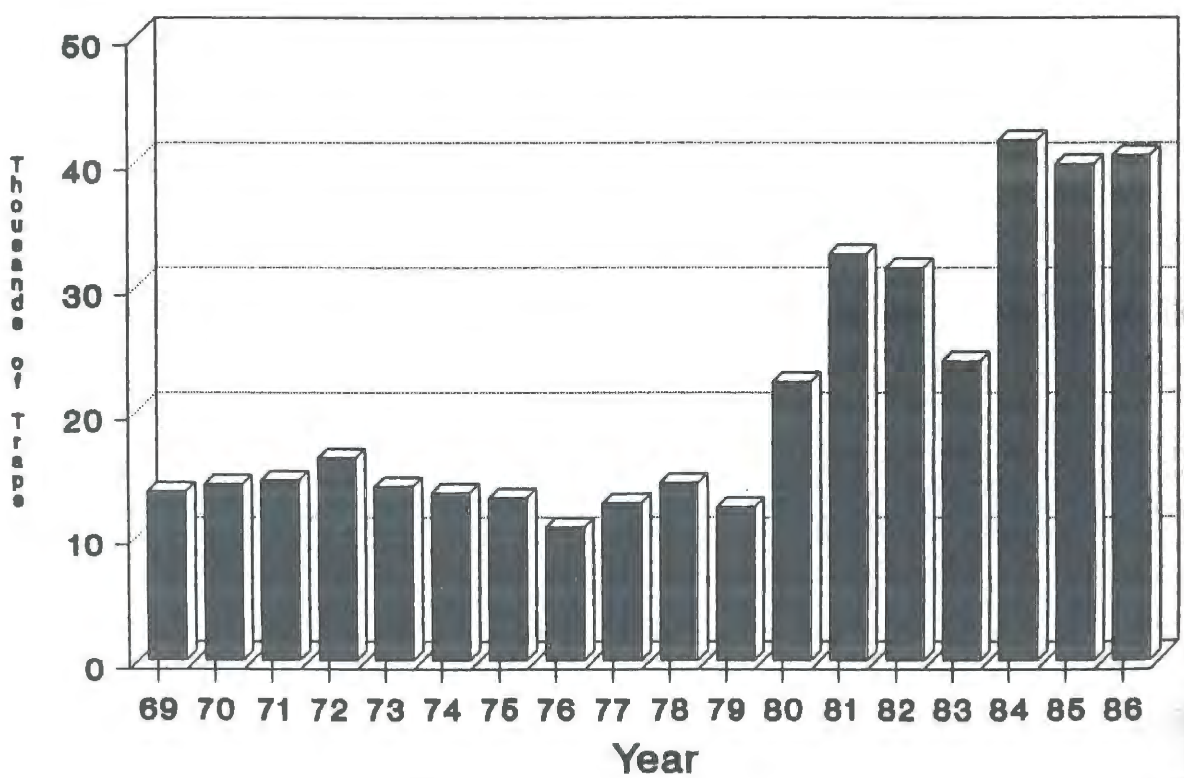


Figure 8.11. Number of traps, Alabama, 1969-1986.

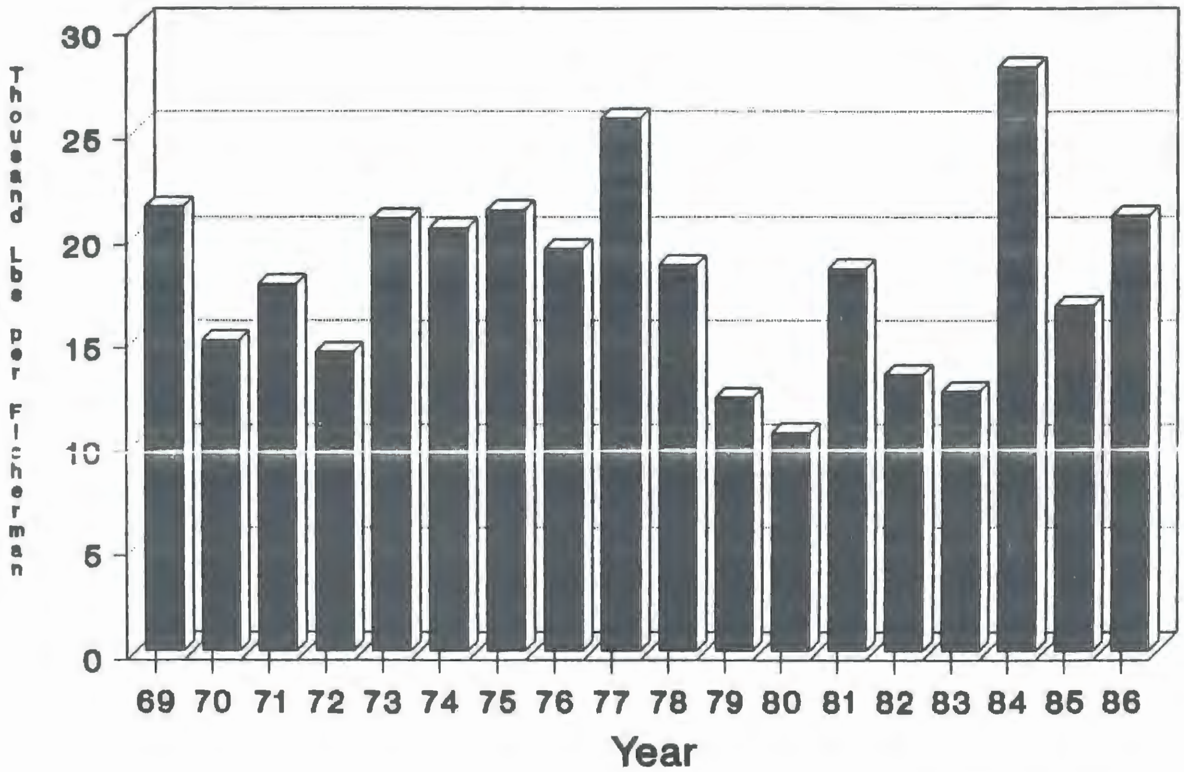


Figure 8.12. Pounds per fisherman, Alabama, 1969-1986.

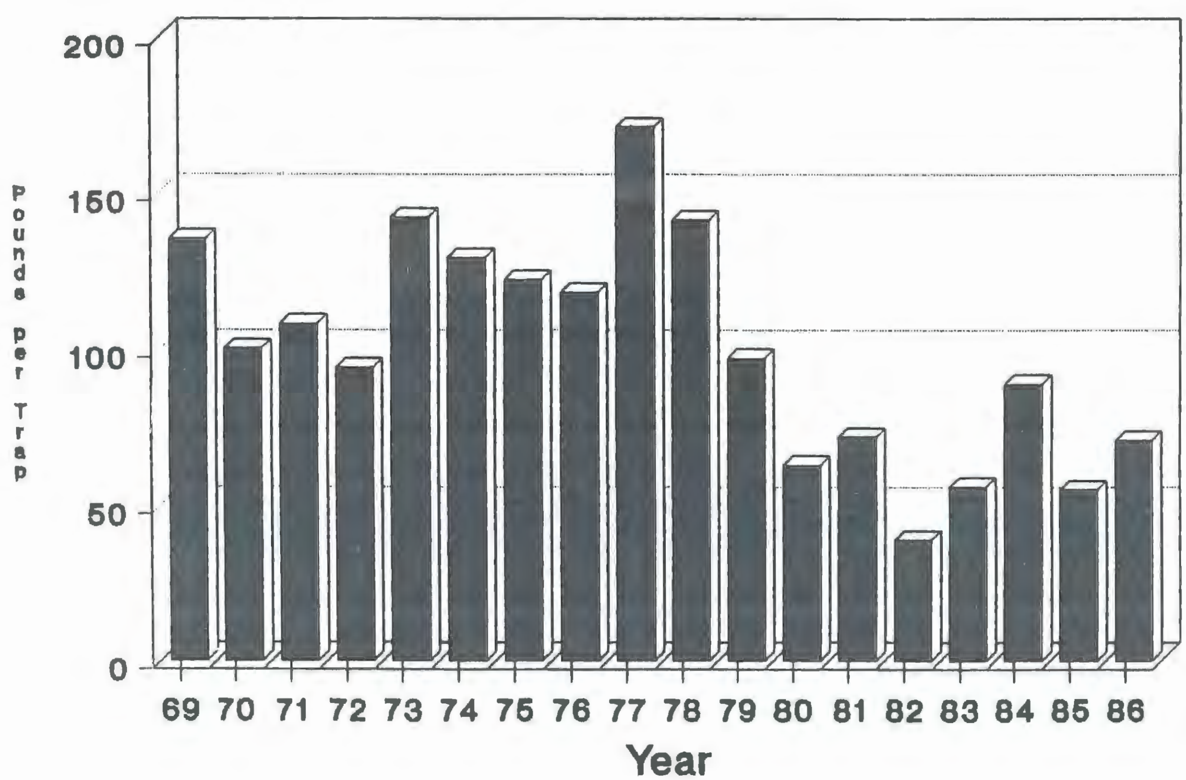


Figure 8.13. Pounds per trap, Alabama, 1969-1986.

8.5.2.3 Fishery Status

Annual landings remained steady through the 1970s averaging approximately 1.6 million pounds per year. From 1981 through 1985 average annual landings increased to 2.1 million pounds. The increase in fishing effort has resulted in a decrease in catch per trap. However, there was only a slight decrease in catch per fisherman indicating that the fishery has remained fairly stable.

8.5.3 Mississippi

8.5.3.1 Pounds Landed (Figure 8.14)

Fluctuations have occurred in annual landings since 1969 with 3 year cycles evident. Landings averaged 1.4 million pounds through the early 1970s and 1.5 million pounds through the late 1970s and early 1980s.

8.5.3.2 Harvesting Sector (Figures 8.15-8.18, Table 8.10)

The number of commercial crab fishermen has remained relatively stable, decreasing from an average of 64 fishermen in the early 1970s to 56 fishermen from 1981 to 1985. The number of traps used in the fishery has also remained stable averaging 4,500 traps during the period 1969 to 1986. Average catch per fisherman has increased due to increased trap usage per fisherman; however, average catch per trap has decreased slightly. Three to four year cycles are evident in both catch per fisherman and catch per trap.

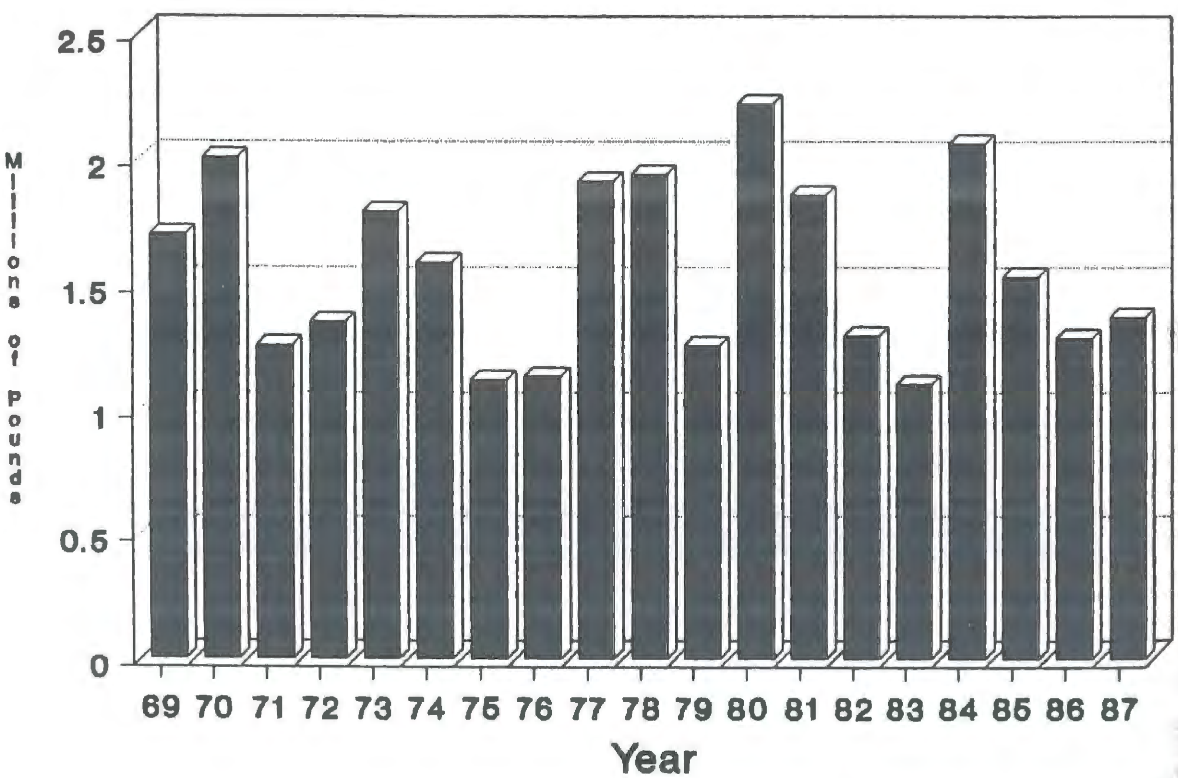


Figure 8.14. Mississippi landings, 1969-1987.

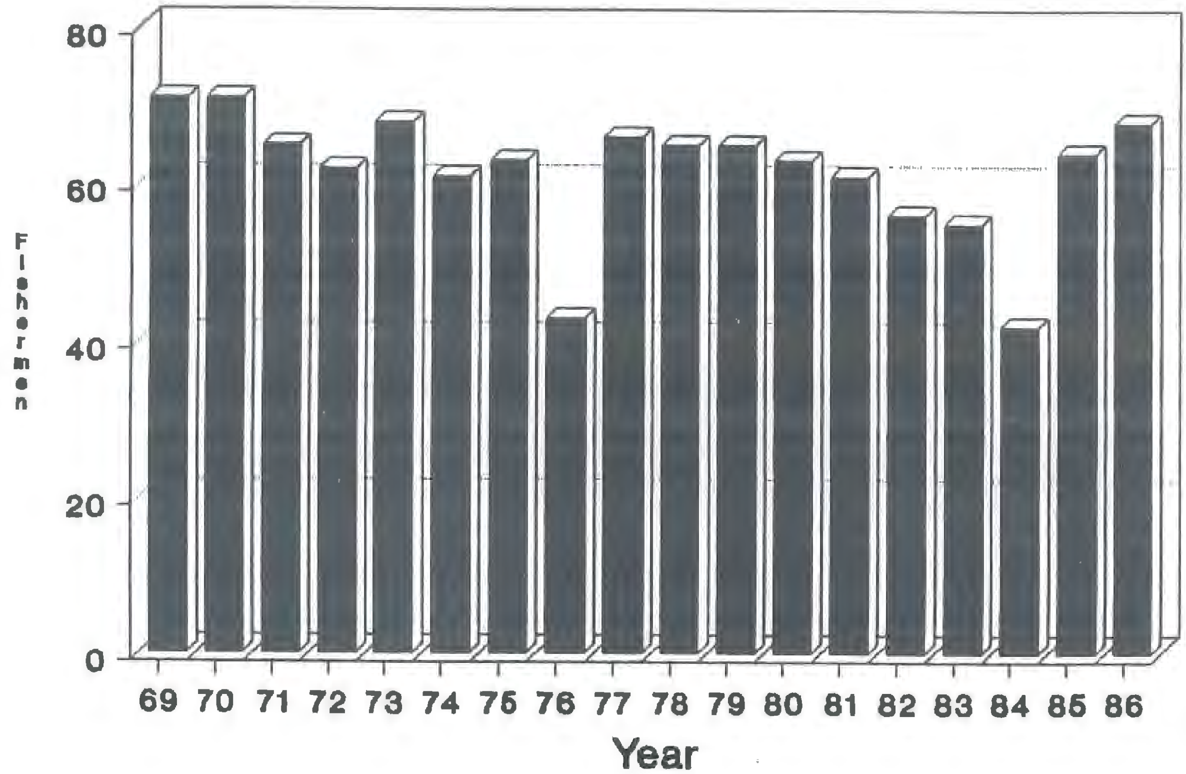


Figure 8.15. Number of fishermen, Mississippi, 1969-1986.

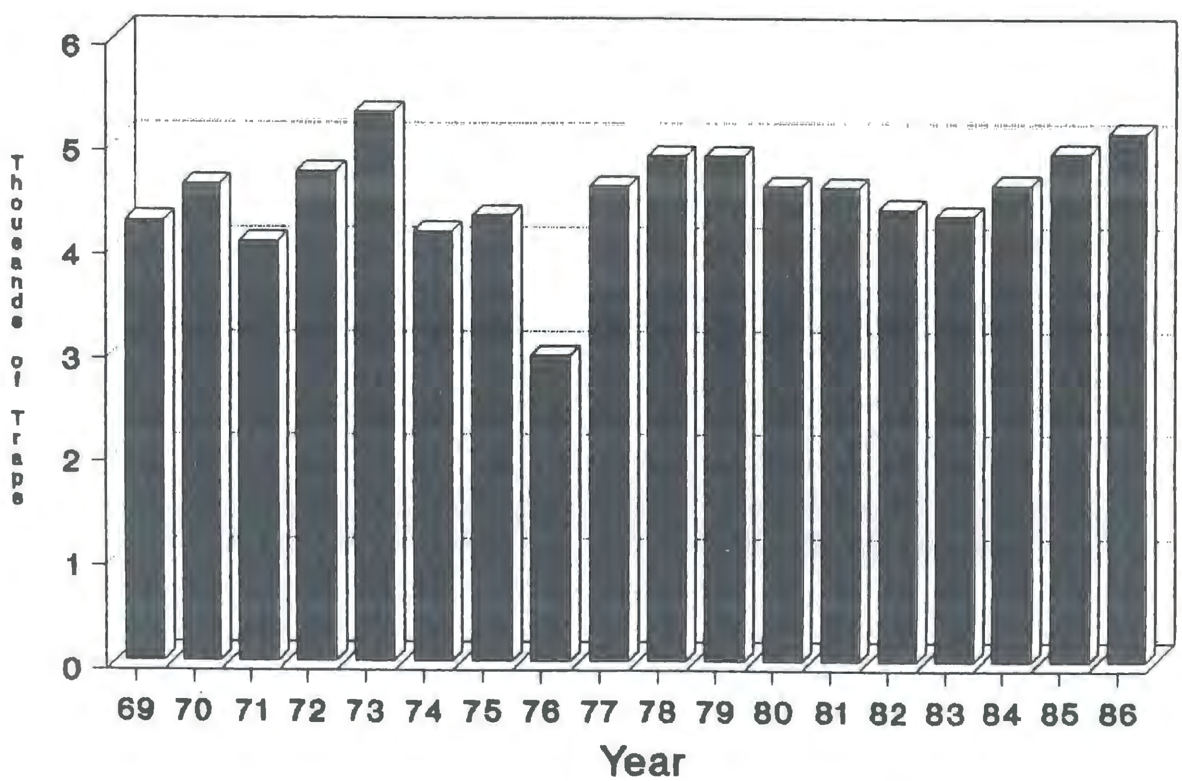


Figure 8.16. Number of traps, Mississippi, 1969-1986.

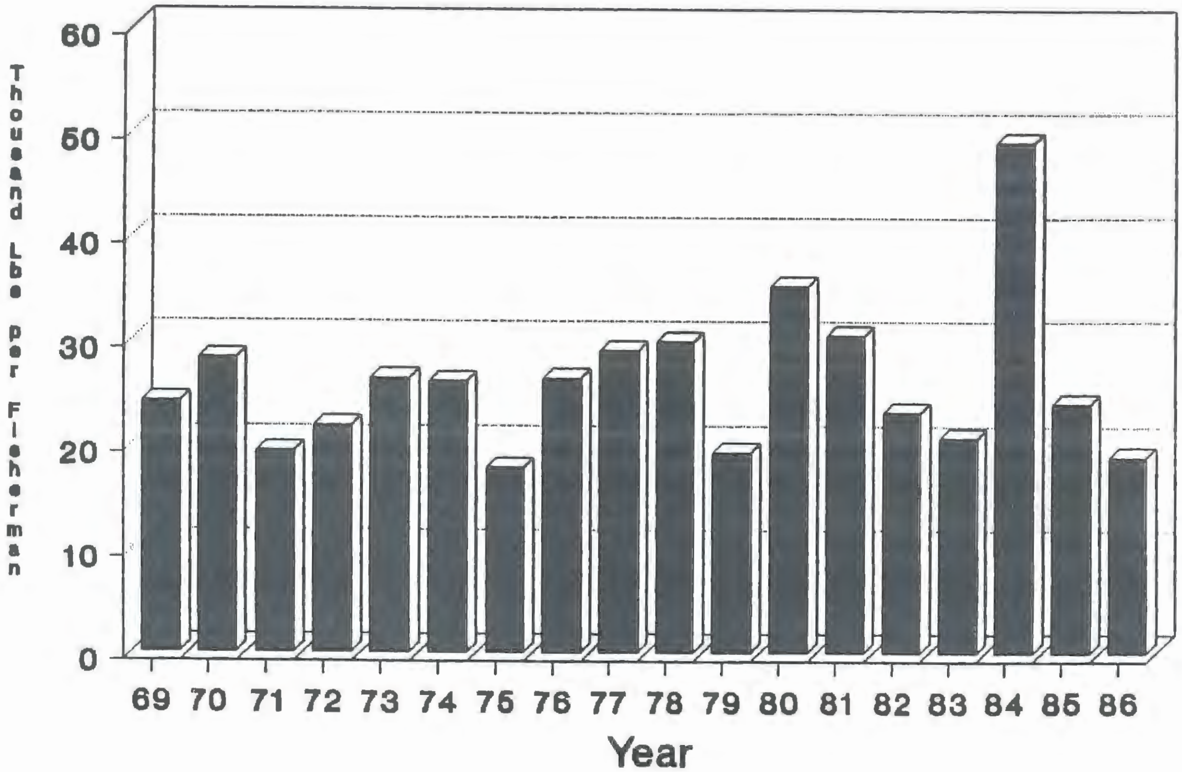


Figure 8.17. Pounds per fisherman, Mississippi, 1969-1986.

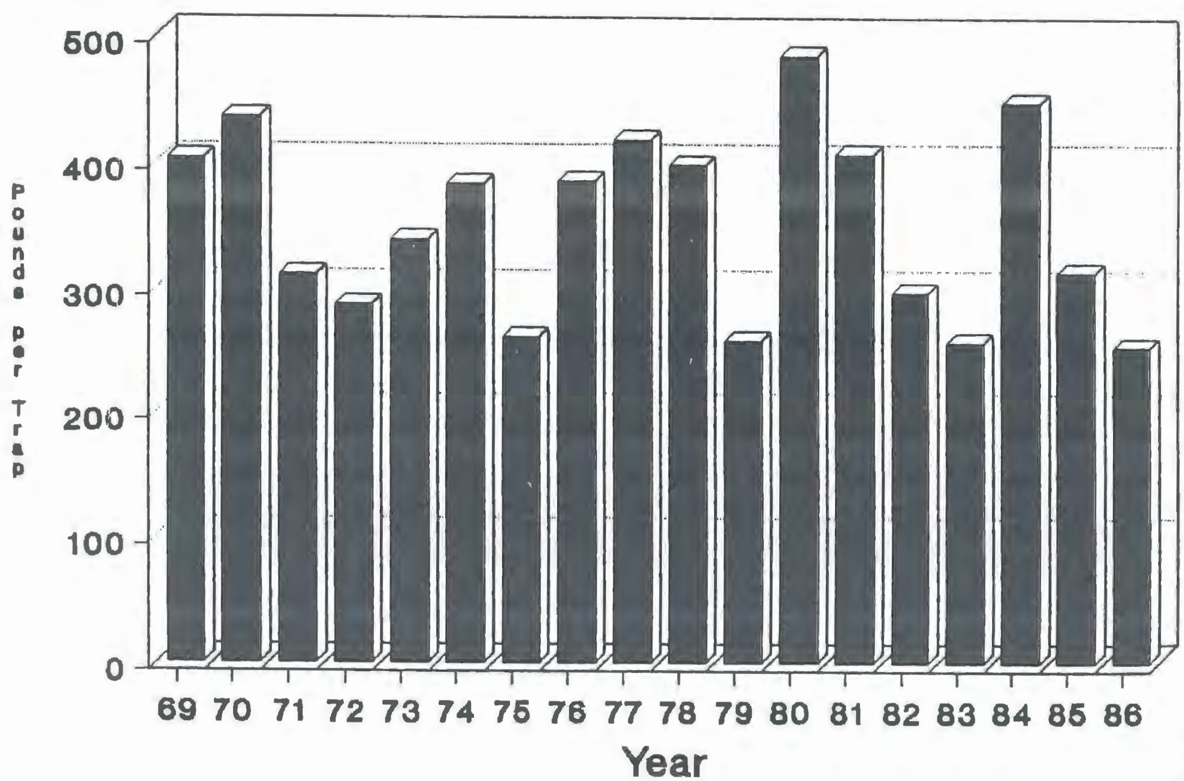


Figure 8.18. Pounds per trap, Mississippi, 1969-1986.

8.5.3.3 Fishery Status

Landings in Mississippi were below the ten year average (1978-1987) of 1.7 million pounds in 1986 and 1987. Fluctuations in landings are in some measure tied to socio-economic variables that operate in the state (economic interdependency with the shrimp and oyster fisheries, transport of crabs to neighboring states for processing), the migratory nature of the resource (highest catch periods are associated with the movement of crabs into local waters from neighboring states) and frequently changing management measures that affect harvest. Variable supply of raw product has hampered industrial development (Perkins 1979). Processing activity has decreased dramatically (Section 10) with the result that an increasing proportion of the catch from local waters is landed in neighboring states.

8.5.4 Louisiana

8.5.4.1 Pounds Landed (Figure 8.19)

Considerable fluctuations in annual landings have occurred since 1969 with peaks in 1974, 1979 and 1986. Landings in 1987 (52.3 million pounds) were the highest on record for Louisiana or any other gulf state and accounted for 66.8% of the total gulf production of blue crabs.

8.5.4.2 Harvesting Sector (Figures 8.20-8.23, Table 8.10)

The number of commercial crab fishermen increased from 594 in 1969 to 1,046 in 1986 according to NMFS estimates. According to LDWF license sales, the number of trap fishermen ranged from 751 in 1979 to 1,985 in 1986. Number of traps used in the fishery increased from 67,452 in 1969 to 198,000 in

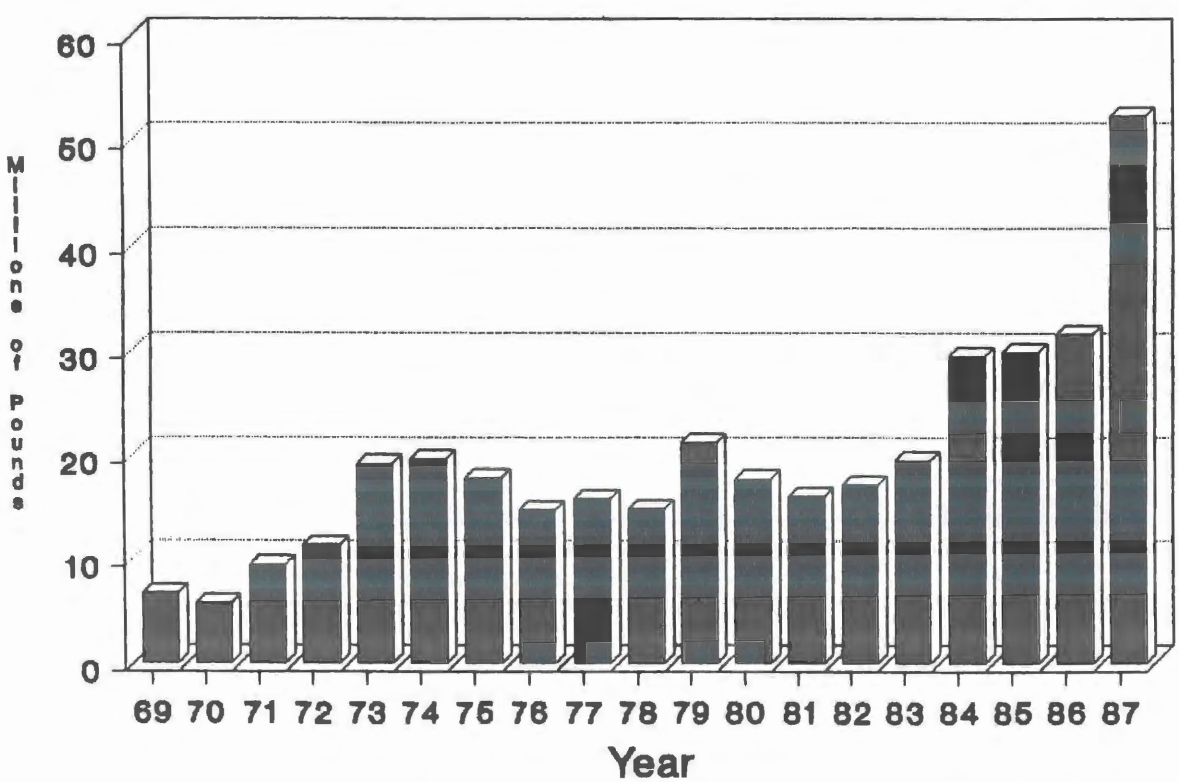


Figure 8.19. Louisiana landings, 1969-1987.

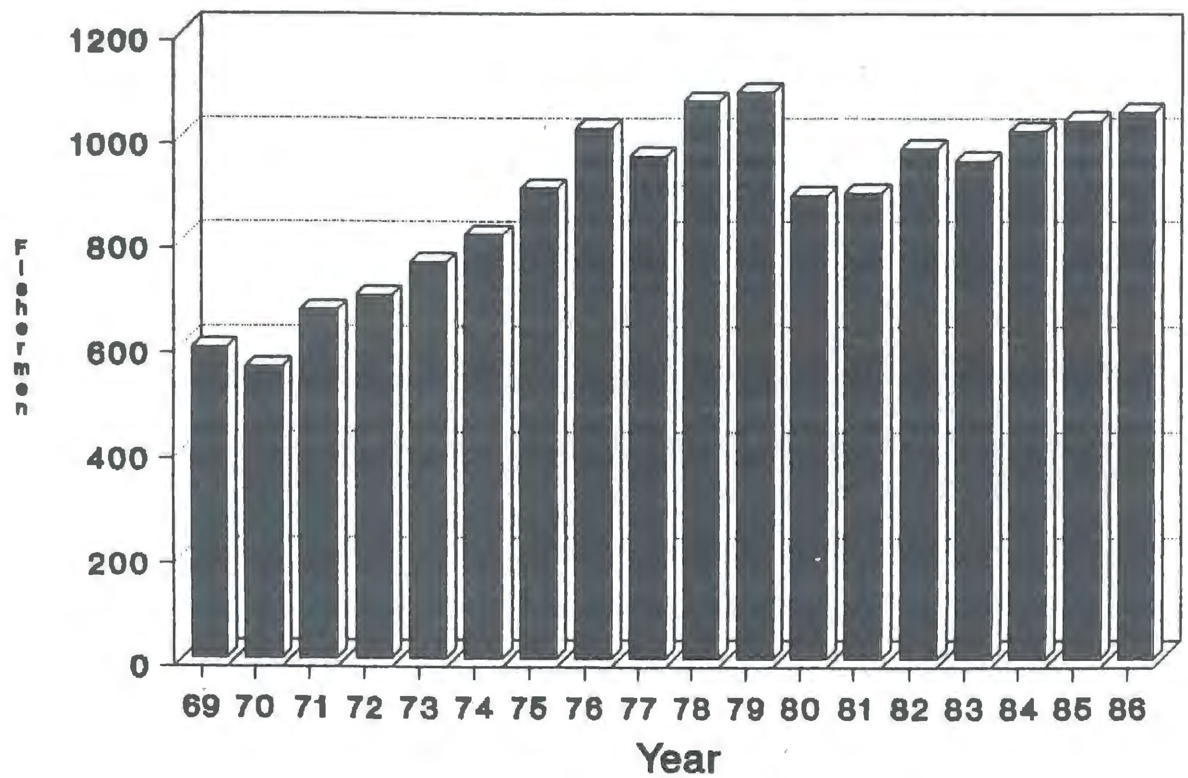


Figure 8.20. Number of fishermen, Louisiana, 1969-1986.

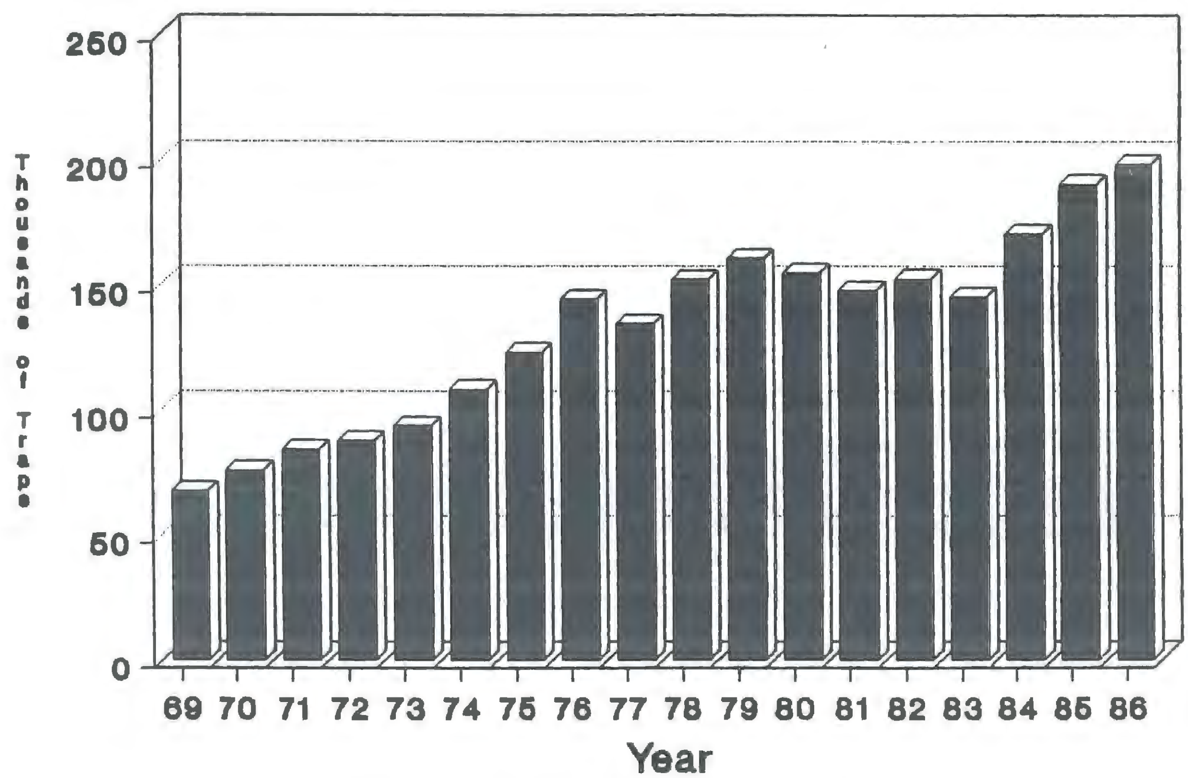


Figure 8.21. Number of traps, Louisiana, 1969-1986.

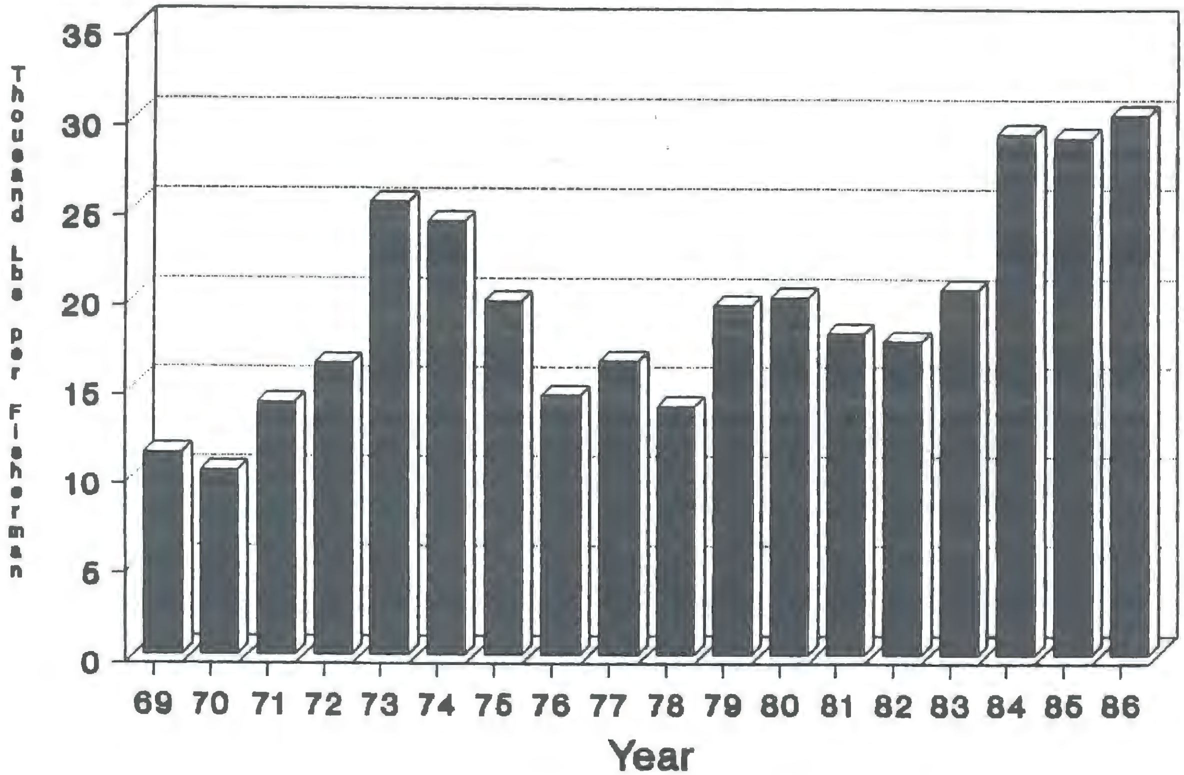


Figure 8.22. Pounds per fisherman, Louisiana, 1969-1986.

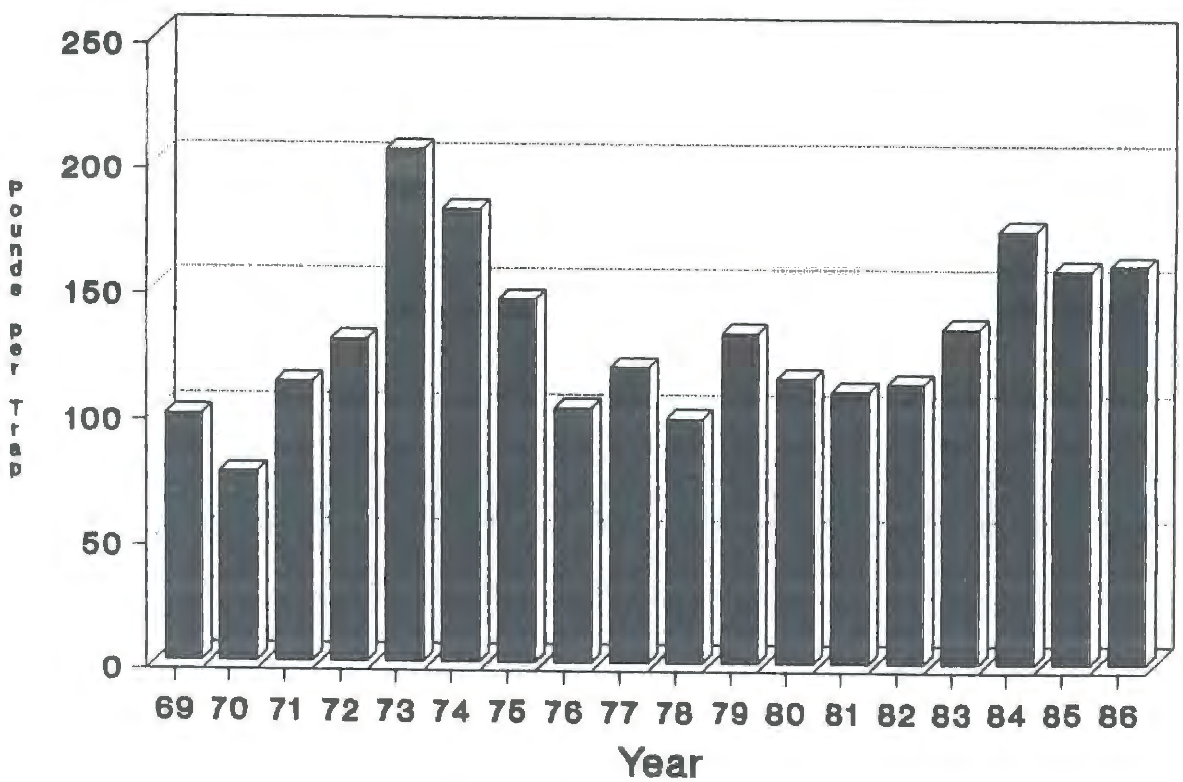


Figure 8.23. Pounds per trap, Louisiana, 1969-1986.

1986 (NMFS). Catch per fisherman increased from 11,256 pounds per year in 1969 to 30,185 pounds per year in 1986 (NMFS). However, using LDWF licenses as an index of fishing effort, catch per fisherman did not show an increase from 1978-1986; catch per fisherman averaged 21,200 pounds from 1978-1982 and 17,900 from 1983-1986. Corresponding values using NMFS data yielded 18,800 pounds and 27,200 pounds for the same time periods. Catch per trap increased from 99 pounds in 1969 to 159 pounds in 1986 (NMFS). There was no corresponding LDWF data for catch per trap.

8.5.4.3 Fishery Status

Annual landings continued to increase during the period 1969-1987. Landings in 1987 were 52.3 million pounds, an increase of 21 million pounds over 1986. Preliminary landings for 1988 indicate a harvest in excess of 50 million pounds. Fishing effort, pounds per fisherman and pounds per trap increased from 1969 to 1986 (NMFS estimates), indicating that the crab fishery in Louisiana is expanding.

Using LDWF license records of crab trap fishermen to measure effort produced a downward trend in catch per fisherman. The downward trend in catch per fisherman is especially relevant in light of the increase in number of traps per fisherman. Caution, however, should be used in interpreting this data since the NMFS and LDWF data sets apply to different groups of fishermen.

8.5.5 Texas

8.5.5.1 Pounds Landed (Figure 8.24)

Annual landings have increased from 6.1 million pounds in 1969 to a record 11.7 million pounds in 1987.

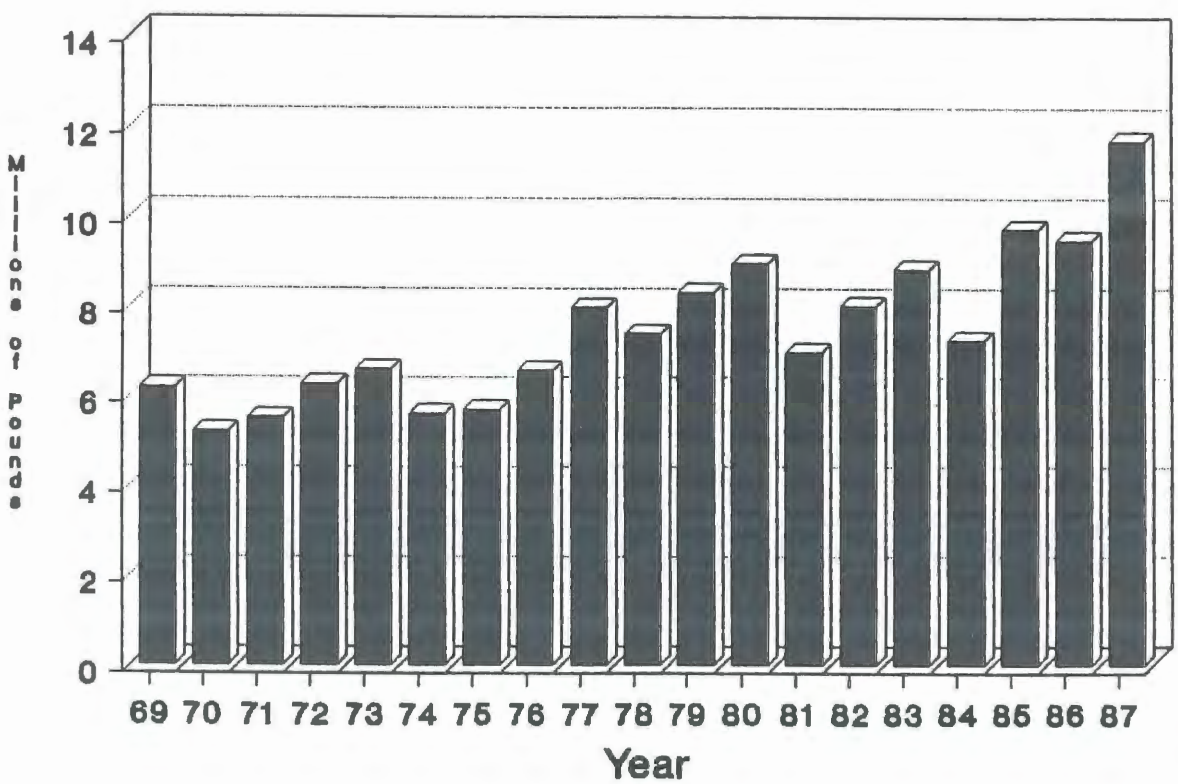


Figure 8.24. Texas landings, 1969-1987.

8.5.5.2 Harvesting Sector (Figures 8.25-8.28, Table 8.10)

The number of commercial crab fishermen has increased from 95 in 1969 to 209 in 1986. Number of traps used in the fishery increased from 14,440 in 1969 to 28,300 in 1986. Greatest increase in fishermen and traps occurred from 1981 through 1986. Catch per fisherman decreased from 64,958 pounds in 1969 to 45,368 pounds in 1986. Catch per trap also decreased from 427 pounds in 1969 to 335 pounds in 1986.

8.5.5.3 Fishery Status

Landings in the Texas fishery have increased since 1969 with peak cycles evident every three to four years. The fishery has experienced increased effort coupled with a decline in pounds per fisherman and traps.

8.5.6 Gulf of Mexico

8.5.6.1 Pounds Landed (Figure 8.29)

Although considerable fluctuations in landings have occurred in the gulf blue crab fishery, the overall trend has been one of increasing catch. Landings have increased from 27.7 million pounds in 1969 to a record 78.3 million pounds in 1987. Landings for 1987 accounted for 38.9% of total U.S. landings, an amount exceeding that produced by the Chesapeake Bay fishery.

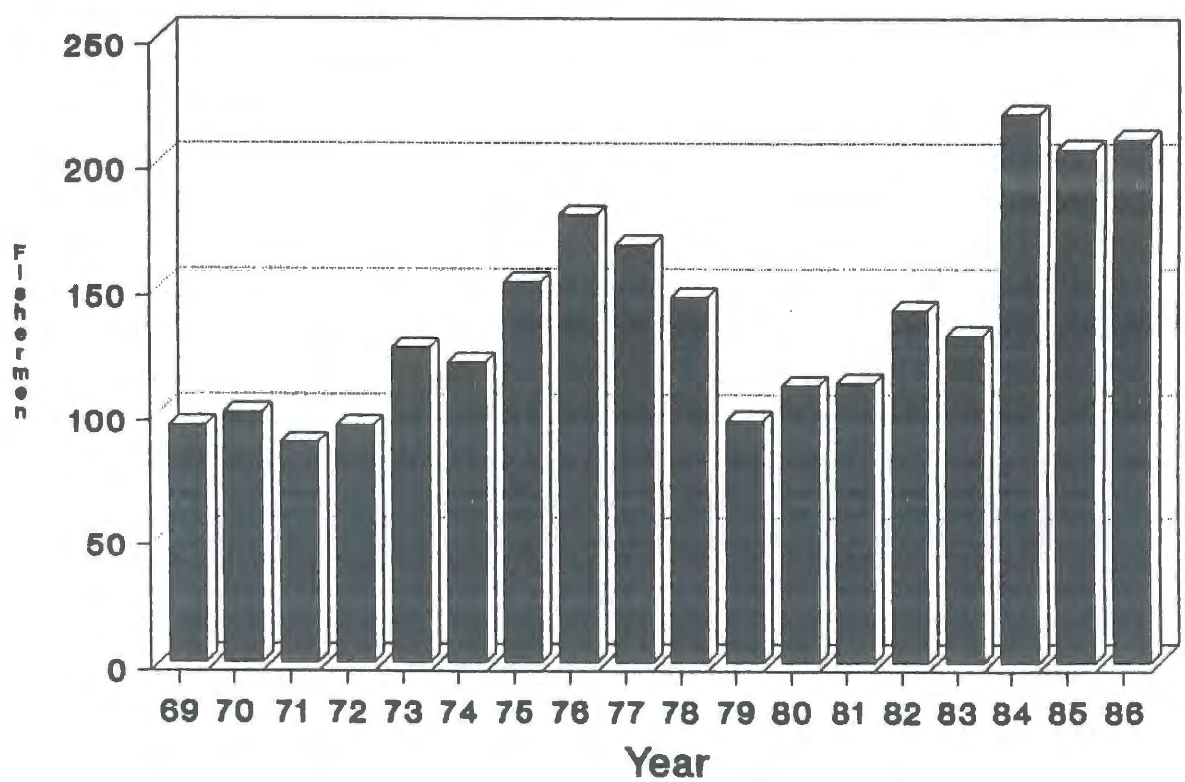


Figure 8.25. Number of fishermen, Texas, 1969-1986.

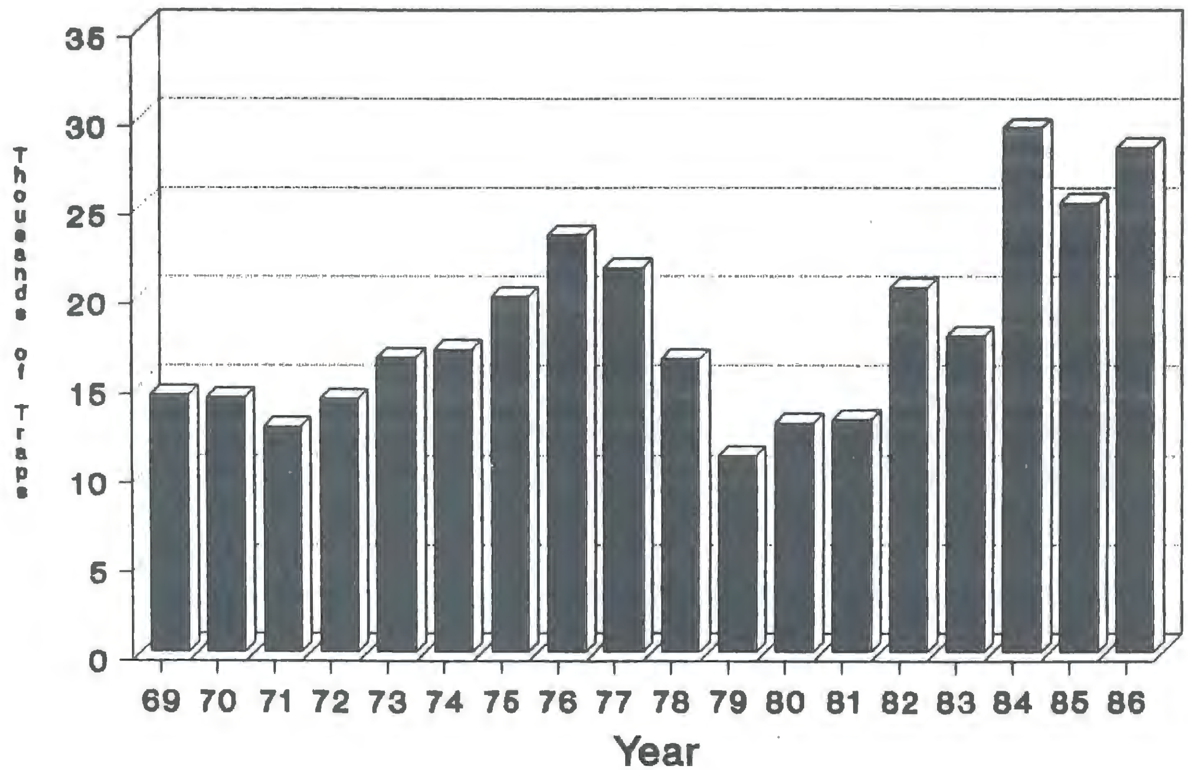


Figure 8.26. Number of traps, Texas, 1969-1986.

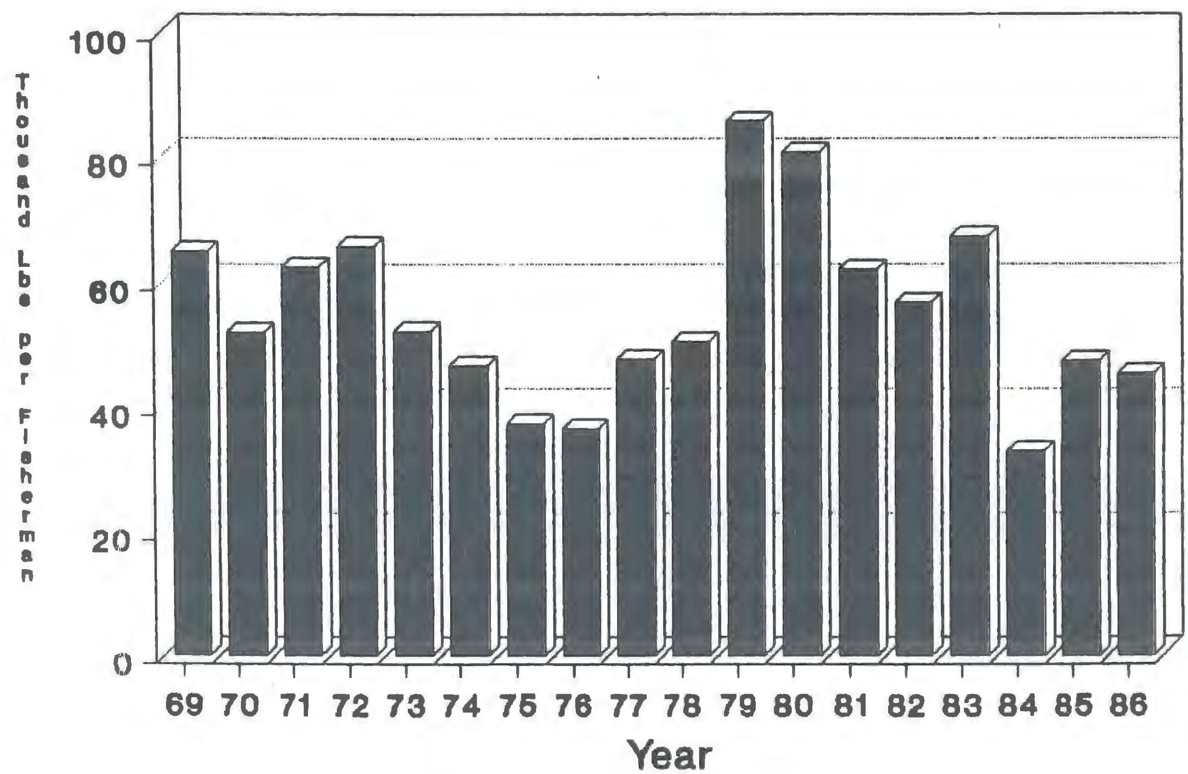


Figure 8.27. Pounds per fisherman, Texas, 1969-1986.

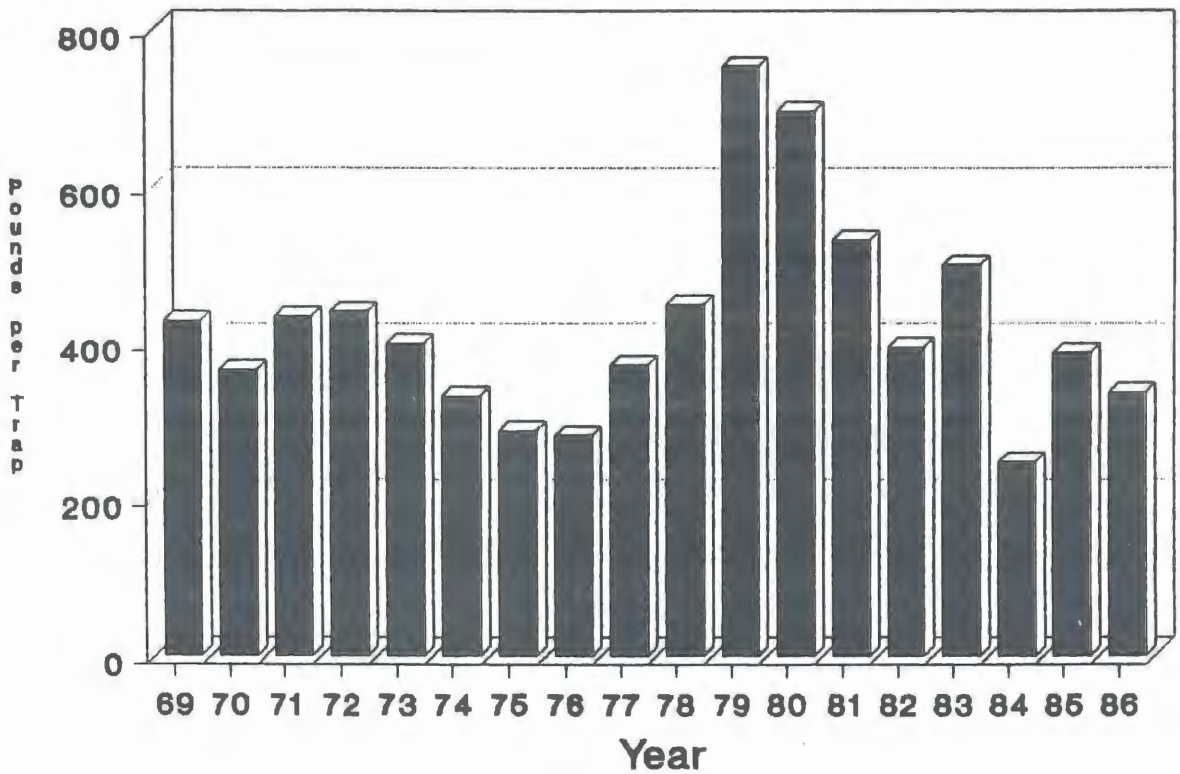


Figure 8.28. Pounds per trap, Texas, 1969-1986.

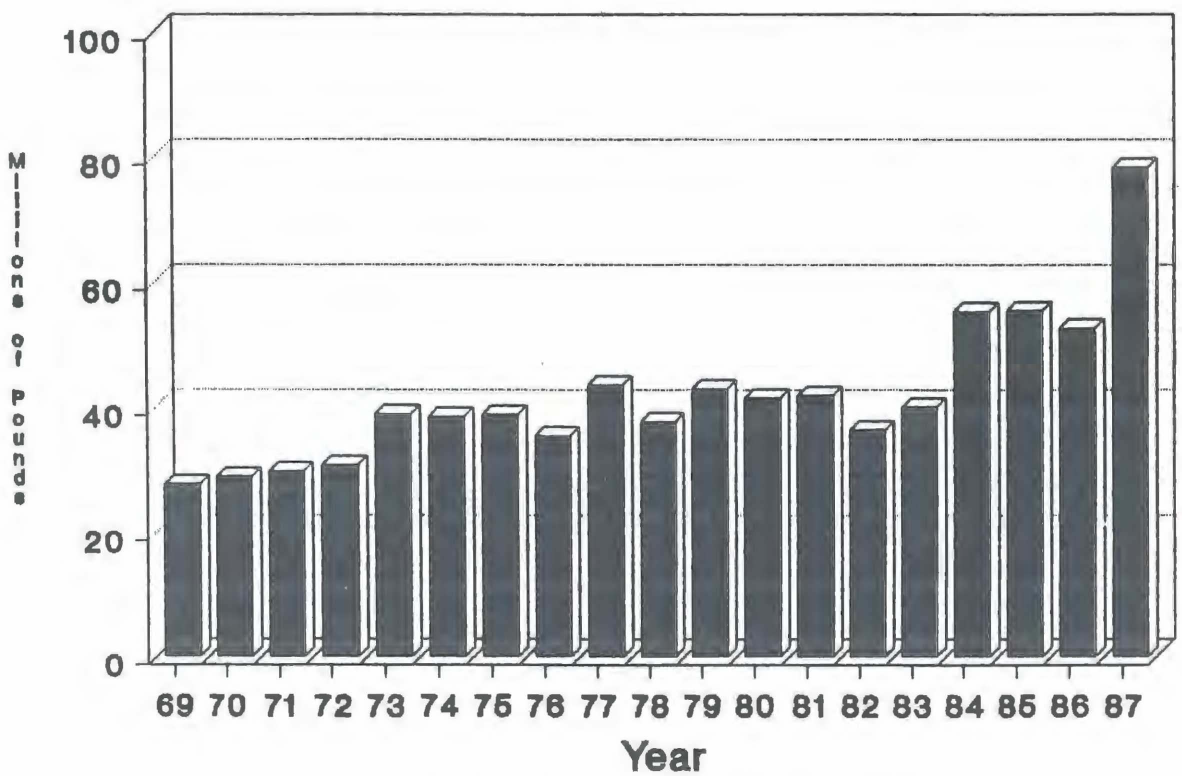


Figure 8.29. Gulf of Mexico landings, 1969-1987.

8.5.6.2 Harvesting Sector (Figures 8.30-8.33, Table 8.10)

The number of crab trap fishermen and traps fished gradually increased during the 1970s and 1980s. Averaging 1,244 fishermen annually during the 1971-1975 period, the number of trap fishermen increased about 40% to an annual average of 1,737 from 1981-1985. The 1,946 crab fishermen operating in the gulf in 1986 represent more than a 50% increase over the 1971-1975 average. With the concurrent increase in the number of traps pulled per fisherman, the total number of crab traps used in the fishery increased more than 60% from an annual average of 164,123 during 1971-1975 to 270,788 during 1981-1985. A two-fold increase in the number of traps used gulf-wide occurred in 1986 (326,300). The total pounds landed per fisherman gulf-wide has shown a slight decline. Average catch per fisherman from 1981-1985 was 26,385 pounds, a 7.4% decrease from the annual catch of 28,477 pounds for the period 1971-1975. The reason for the small decline in total catch per fisherman can be attributed to increased effort. While total catch per fisherman appears to have remained relatively constant, the average catch per trap has declined from 216 pounds during 1971-1975 to 169 pounds during 1981-1985, a decline of 22%.

8.5.6.3 Fishery Status

The fishery in the Gulf of Mexico is characterized by yearly and geographic differences in the population dynamics of blue crabs. Variations in measured fishery parameters (Table 8.10) occur both within and between states. Effort has increased in terms of the number of fishermen, the number of traps in the fishery and the number of traps per fisherman. A stable or declining gross income per fisherman in relation to an expected increase in operating costs suggests that profitability in the fishery may be declining.

Recruitment overfishing is not suggested by the data. Reduction of sources of juvenile mortality (natural and fishing) may increase available stocks.

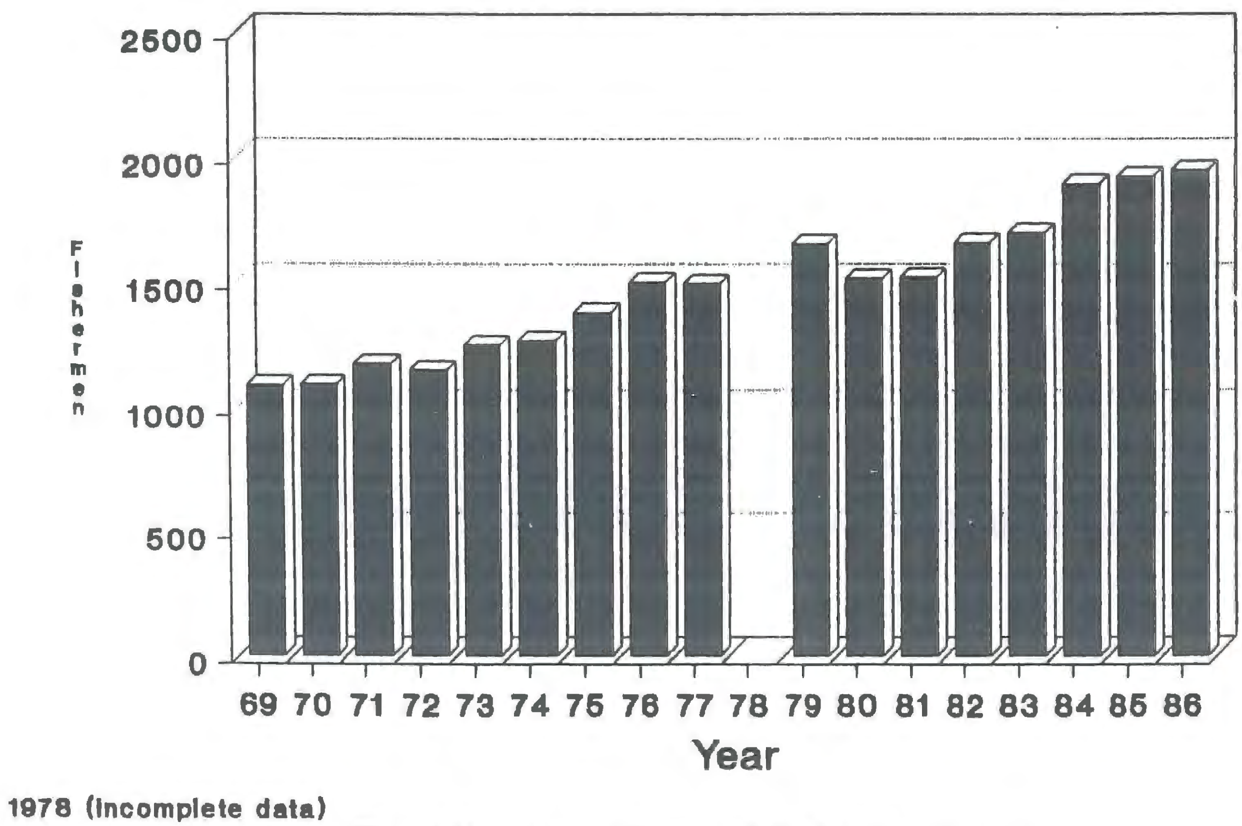


Figure 8.30. Number of fishermen, Gulf of Mexico, 1969-1986.

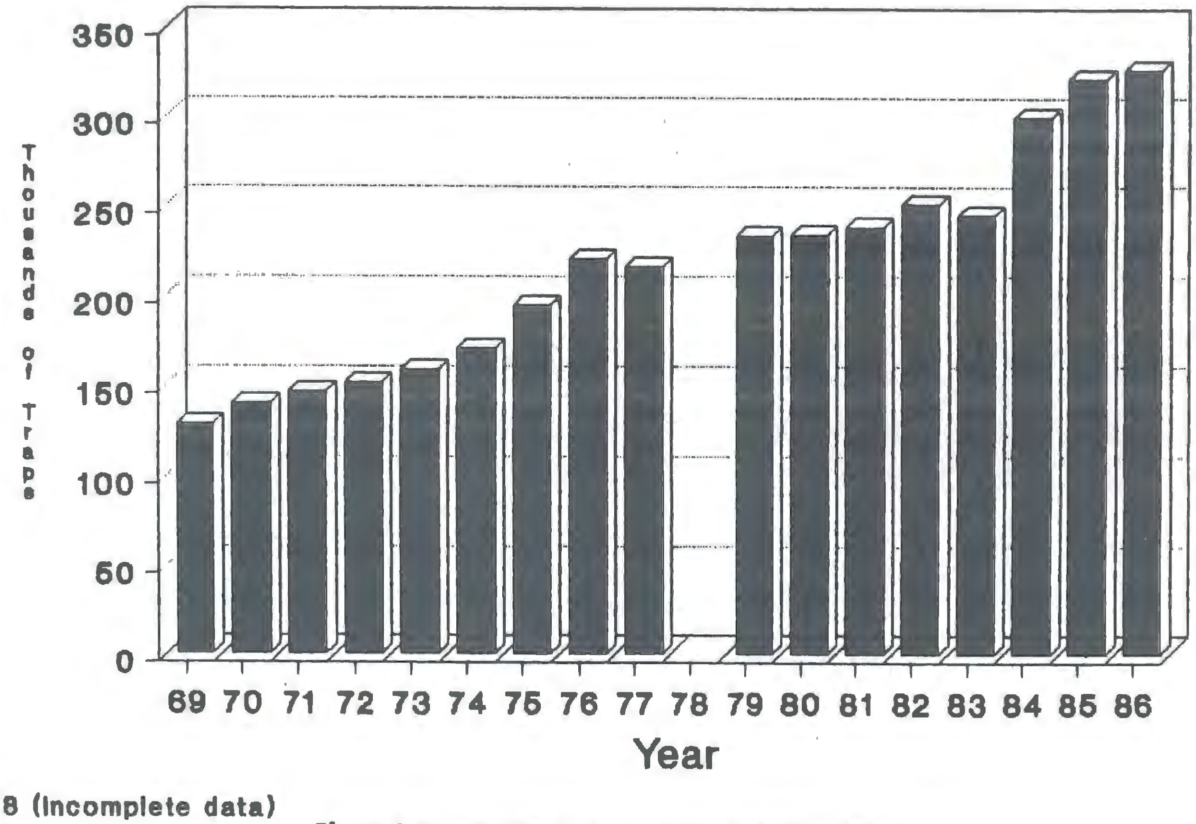


Figure 8.31. Number of traps, Gulf of Mexico, 1969-1986.

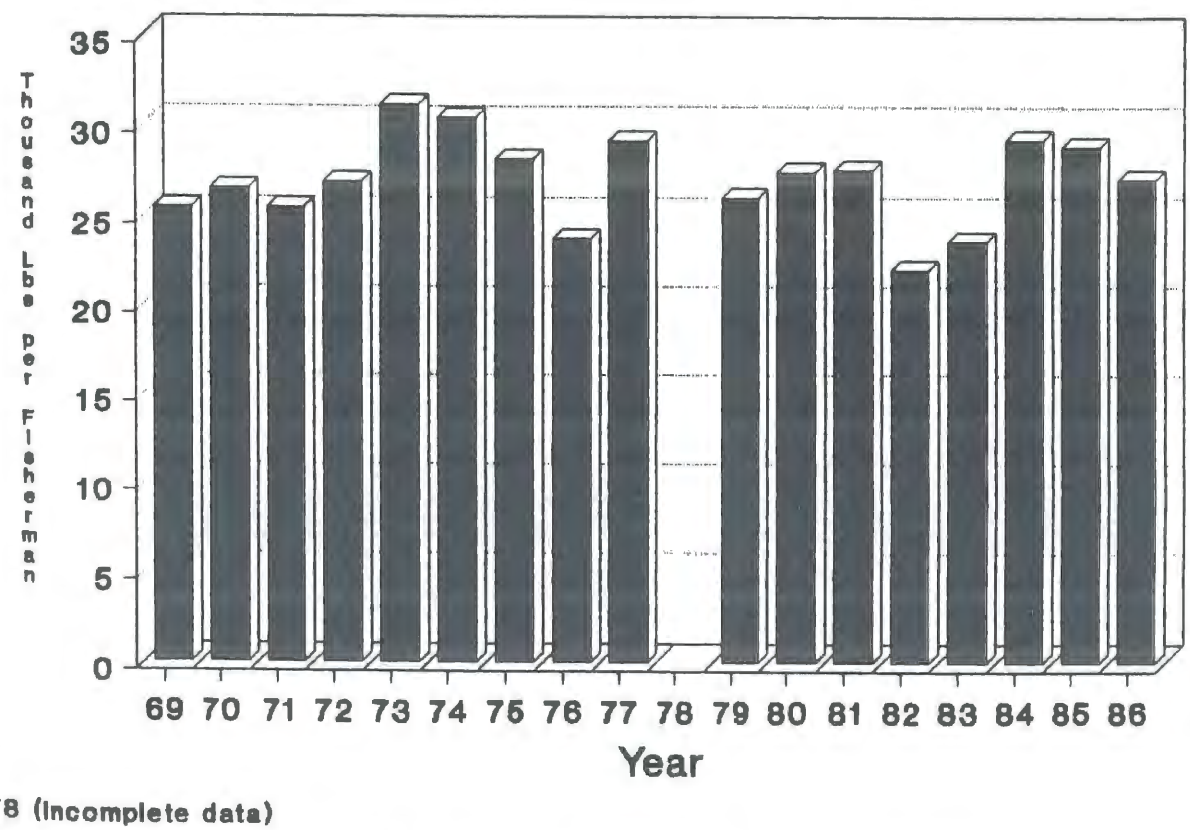


Figure 8.32. Pounds per fisherman, Gulf of Mexico, 1969-1986.

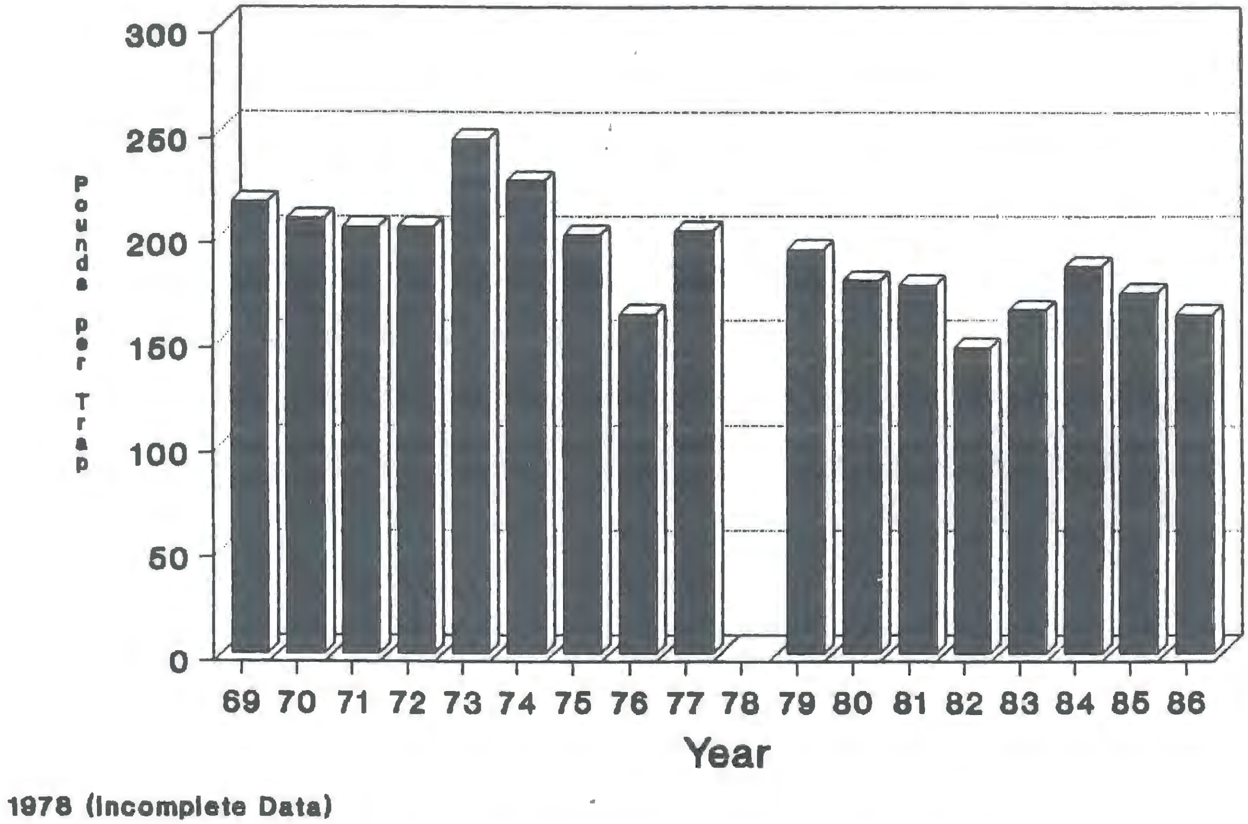


Figure 8.33. Pounds per trap, Gulf of Mexico, 1969-1986.

9.0 DESCRIPTION OF BLUE CRAB PROCESSING

9.1 Processing Sector

Methods of cooking and packing crab meat and the history of the development of mechanical processing were reviewed by Moody et al. (1982). A typical processing scheme for blue crabs is illustrated in Figure 9.1. Blue crab meat production is still predominantly a manual operation in the Gulf States. The physical structure of the internal crab body with its segments and partitions has impeded the development of mechanical means of picking the meat while still retaining some of the cohesiveness of the muscle fibers. Because of increasing costs associated with picking blue crabs, considerable effort has been expended toward mechanization of the industry. Research has been directed toward mechanical debacking and picking, reformation of machine-picked meat into "lump-like" pieces using an alginate binder and development of consumer-acceptable crab products using machine-picked meat. Miller et al. (1982) investigated techniques for recovering meat particles left in the core after hand and machine picking. Using a meat/bone separator, they were able to recover an additional 30 pounds of product from 100 pounds of crab cores. Included in their study was a review of the sanitation, production and marketing problems associated with mechanically separated meat.

9.2 Methods of Cooking

Unrefrigerated live crabs are normally delivered to the processor by boat or vehicle shortly after being harvested. The interstate trucking of live crabs over long distances has necessitated development of procedures to minimize mortality. A university study of the survival rate of crabs shipped from North Carolina to Baltimore, Maryland, showed that adequate ventilation, a moist cool environment and an upright position (dorsal side up) in the shipping container were three factors necessary to ensure the highest number of live crabs reaching their final destination. Once in the plant, those crabs not immediately cooked are stored in a refrigerated area.

Each state that produces crab meat has its own regulations governing the methods of cooking live crabs. A list of the five Gulf States' processing regulatory agencies is found in Section 18.3. In some states only pressure cooking or open steam is allowed. Traditionally, the Gulf States have cooked crabs by boiling. After the water is brought to a boil, the crabs are placed in the vat and cooked for 15 minutes after the water has started to boil again. They are hoisted or dipped from the vat and spread on the tables to air cool. The steam cooking of crabs involves placing them in a metal basket or expanded metal car, enclosing it in a retort and introducing steam at 15 pounds per square inch (psi) (250°F) for approximately 10 minutes after reaching pressure and temperature. Vertical and horizontal retorts are illustrated in Figures 9.2 and 9.3, respectively.

A boiling operation has a cheaper initial equipment cost; all that is needed is an open vat with gas or steam jets to heat the water. A steaming operation, however, requires a boiler to generate steam and a cooking retort. Both items are expensive. Some advantages and disadvantages of each cooking method are summarized below:

Steam Under Pressure

- Slightly lower meat yield
- Less water to get on pickers' hands and arms
- Cooking time begins shortly after packing retort with crabs; no need to preheat water
- Initial equipment cost high
- Better bacteriological kill

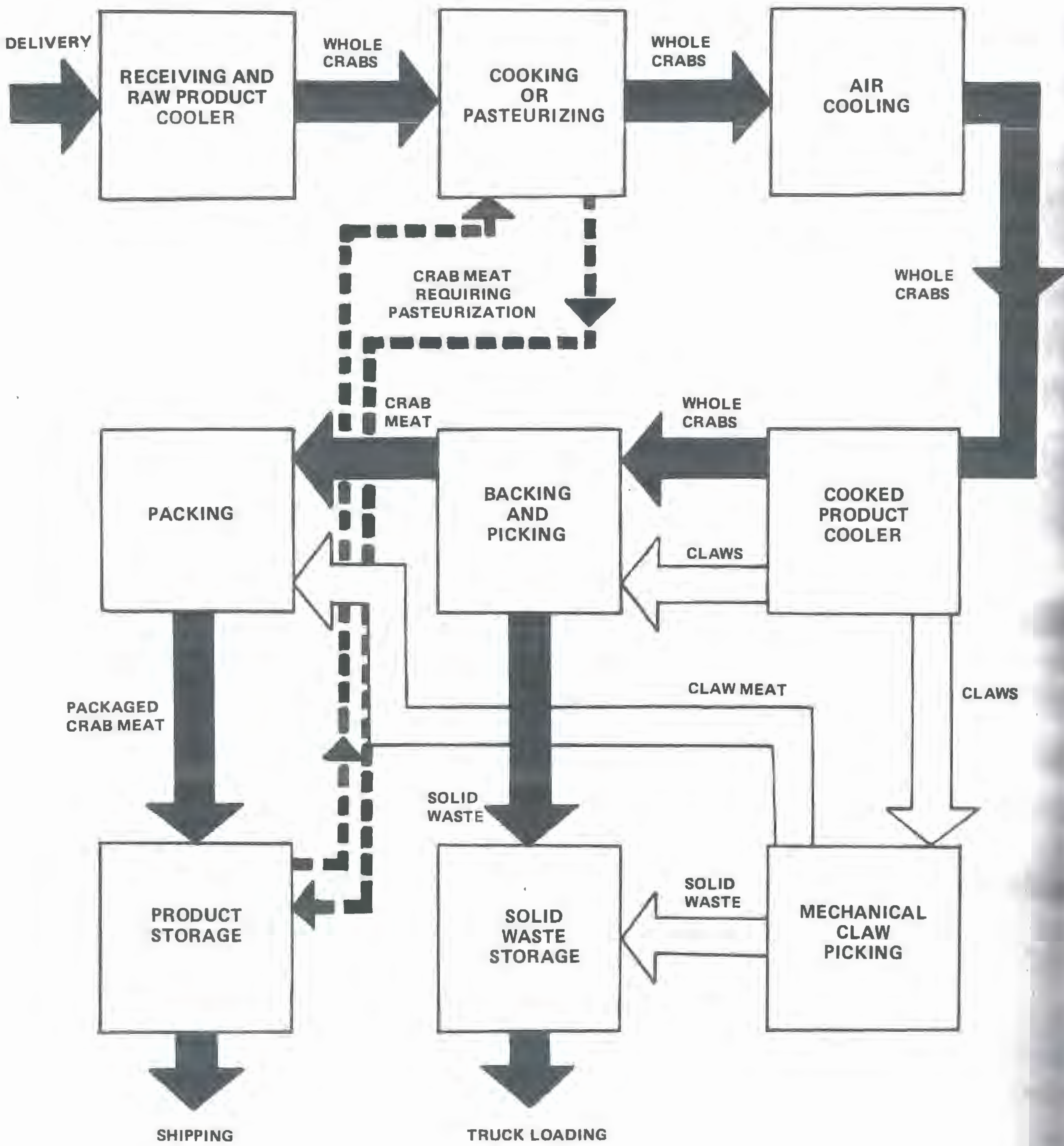
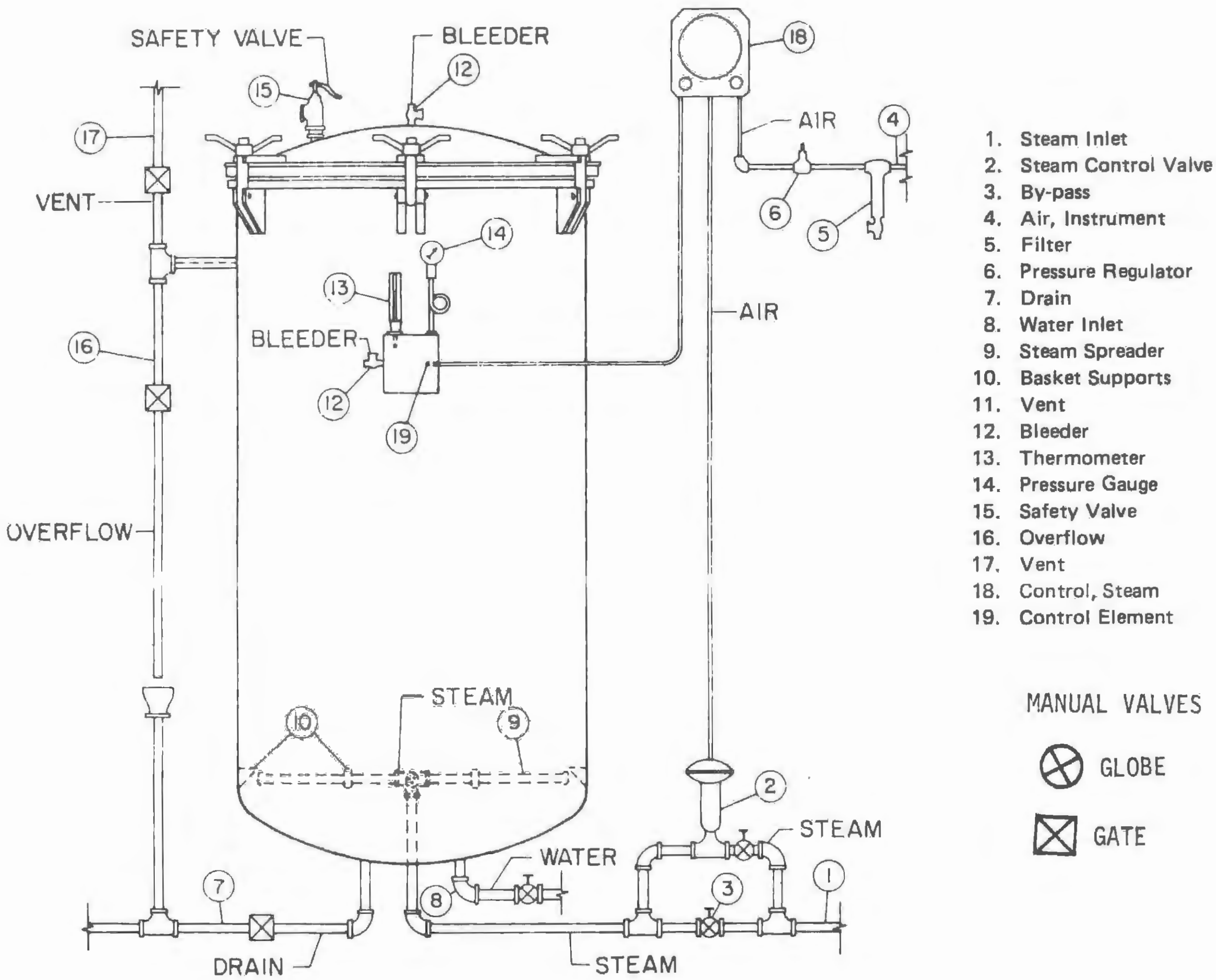
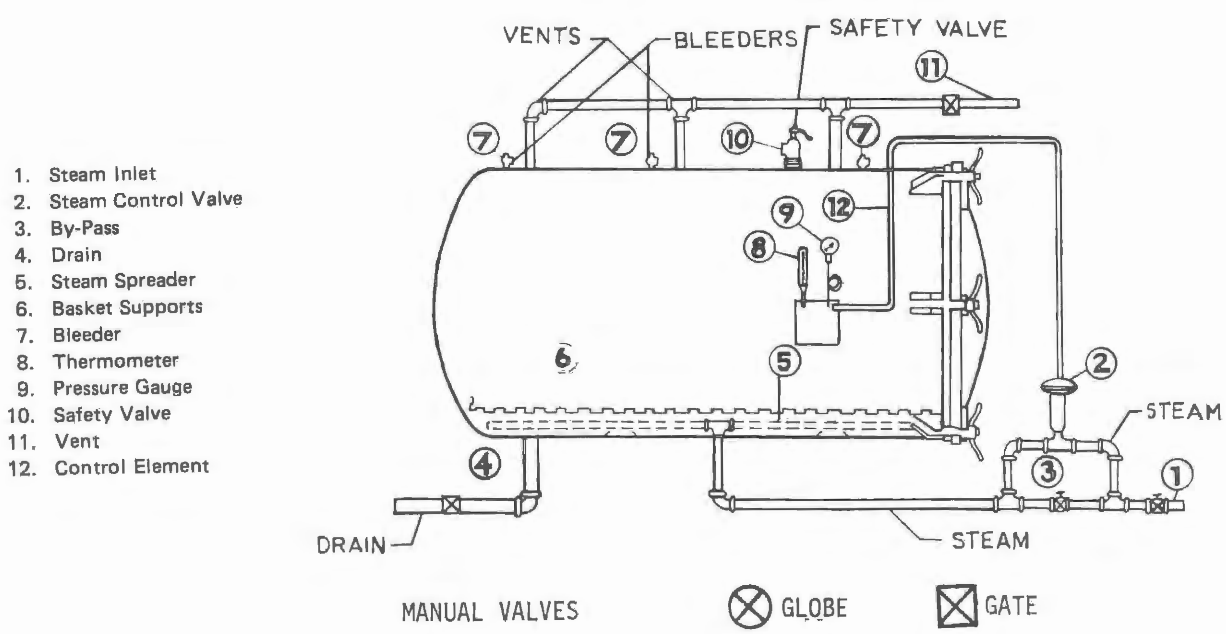


Figure 9.1. Processing scheme (from Miller et al. 1974).





Figures 9.2 (upper left) and **9.3** (lower right). Vertical and horizontal retorts, respectively (from Flick et al. 1976).

Boiling

- Slightly higher meat yield
- Crabs more difficult to pick
- Water must be brought to boiling before adding crabs; after adding crabs it needs to be brought to a boil again before cooking time begins
- Comparatively low initial equipment cost

Processing yield not only varies with the method of cooking but also with the sex and size of the crab, season and skill of the picker. The average yield is approximately 14% but can range from 8% to 22% depending upon the variables (Perry et al. 1984).

9.3 Methods of Preservation

Most blue crab meat is presently marketed in the Gulf States as a fresh, refrigerated product with a shelf life of one week. Several techniques for preserving blue crab meat have been developed to extend the shelf life. Heating and freezing are in use today by the industry with varying degrees of success.

9.3.1 Pasteurization

Pasteurization is the process of heating picked crab meat in a hermetically sealed can in a water bath until an internal temperature at 185°F is reached. The meat is held at that temperature for one minute. Heat penetration capabilities for each retort may vary and must be determined for each water bath. After reaching and holding the crab meat at the proper temperature and time, the crab meat should be cooled to 100°F within 50 minutes in an ice and water bath following removal from the hot water bath. Pasteurized crab meat has an extended shelf life but must be kept under refrigeration at temperatures between 32° and 36°F. A pasteurization tank hook-up is illustrated in Figure 9.4.

Dressel and Whitaker (1982) reviewed the advantages and costs of pasteurization. The extended shelf life of pasteurized crab meat was found to improve the economics of production by increasing the geographic distribution of sales, increasing the length of the processing season and allowing marketing of the product when demand and price are high. They noted that although difficult to quantify, the economic gains realized from lower production costs during times of "glut" and higher product prices during times of "famine" are significant. They estimated the 1981 costs for adding pasteurizing capabilities to an existing plant were:

Heating and cooling tanks	$1,000
Regulator with recording thermometers	3,000
Electric beam and hoist	1,000
Air compressor	400
Plumbing	400
Miscellaneous	1,700
Total	$7,500

Not included in the above estimates were the cost of the cans (approximately $0.30 to $0.50 each) or the rental of the can sealing machine. Additionally, the cost of trained personnel required to operate the machines and maintain quality control must be considered. The decision as to whether or not to pasteurize ultimately depends upon the product volume of the individual plant or the potential cost savings and marketing advantages.

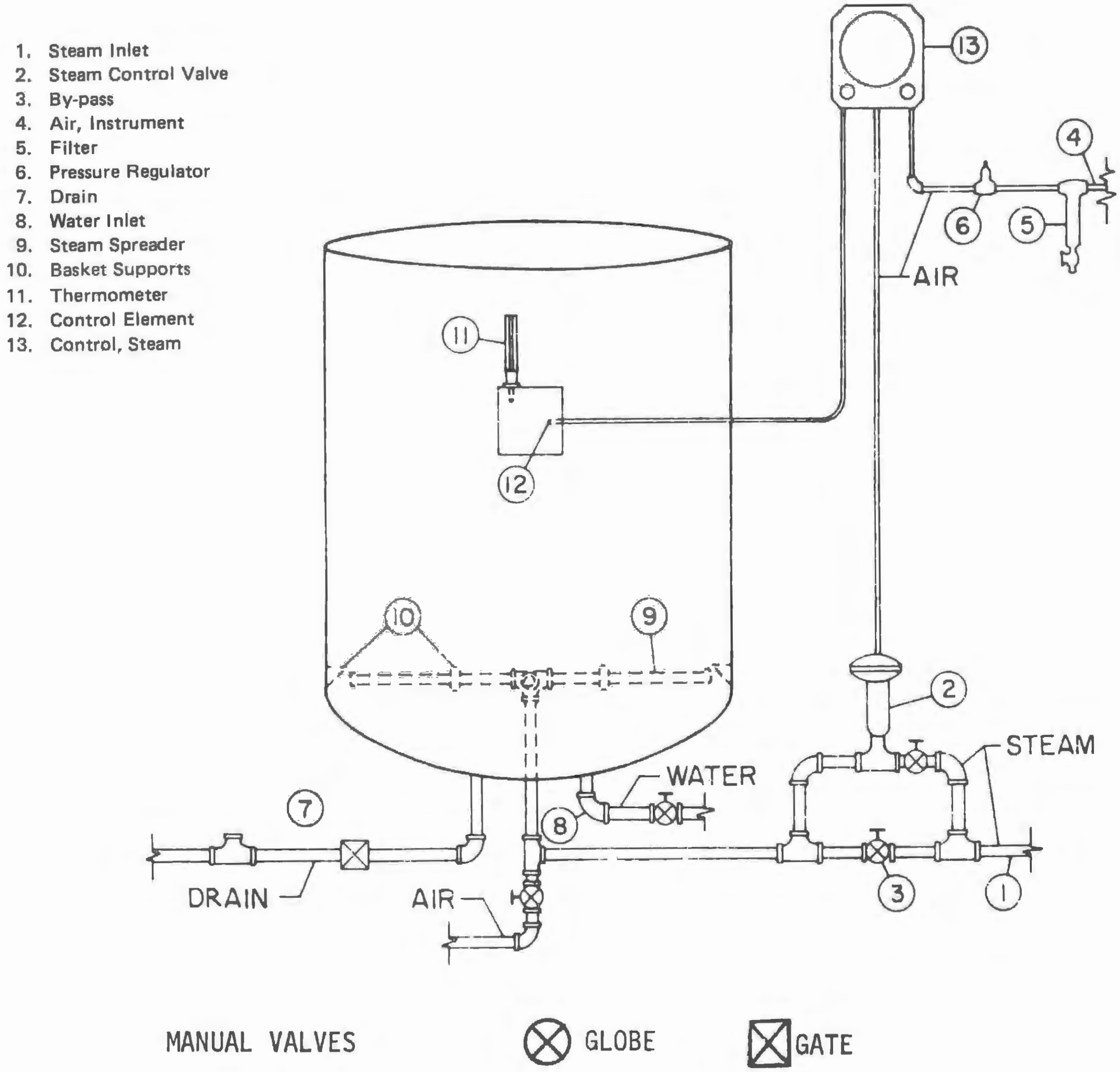


Figure 9.4. Pasteurization tank hook-up (from Flick et al. 1976).

9.3.2 Sterilization

Production of heat-sterilized crab meat is limited. The sterilization procedure involves cooking the crab meat in a hermetically sealed can in a retort until commercial sterility is reached. Problems arising from sterilization include heat-induced coloration changes in the meat, textural changes and an "off flavor."

9.3.3 Freezing-Picked Meat/Raw Cleaned Cores

Changes in the texture of the meat and a loss of flavor are characteristic of blue crab meat held at 0°F. Strasser et al. (1971) found that rapid freezing using Freon 12 (dichlorodifluoromethane) or low temperature nitrogen, storage below 0°F and vacuum packaging extended the shelf life of blue crab meat and provided a product that was highly acceptable when compared with fresh, refrigerated meat. They also noted that the quality of frozen-stored meat was directly related to the rapidity at which it was frozen.

Processors have attempted to freeze whole crabs for the purpose of controlling the supply cycle during the year. In most cases meat from these frozen crabs was of poor quality. The freezing of cleaned crab cores produces a more acceptable product. A series of experiments was designed to determine the best procedure for freezing raw crab or to quick freeze crabs in Freon (Tinker and Learson 1970). The cores were placed in plastic bags and stored at 0°F for two months. The results of these experiments were as follows:

1. The quality is best retained in the meats picked from crab cores that were given a lesser cook and quick frozen in Freon;
2. Meats picked from cores which had been given the maximum cook showed quality slightly lower than the cores given the lesser cook; and
3. Meats picked from quick frozen cores were always superior to the shelf frozen cores in all the quality attributes (appearance, odor, flavor and texture).

All results obtained in studies of the cooking of crabs have shown that meats from crabs given a lesser cook were better in quality after freezing, pasteurizing and sterilizing than were commercially picked meats. The minimal cooking process caused less damage to the meats and, therefore, they could be frozen, pasteurized and/or sterilized without further reduction in quality. The shorter cook and accelerated freezing caused less damage to protein. Also, by leaving the meat intact in the cores there was less physical damage to the meat than would occur during the normal picking operation. The quick freezing of crab cores from crabs exposed to a shortened or minimum cook could provide the industry with a ready source of crabs during the periods of low supply.

9.4 Disposal of Shell Waste

The blue crab fishery produces the second highest weight volume of solid waste in the seafood industry, surpassed only by the bivalve molluscan fisheries. According to Brown (1982), of the 50 million pound annual crab catch from the Chesapeake Bay, 10% is deducted for "cook loss," approximately 12% for picked meat with the remaining 78% designated as "crab scrap" or waste. Crab scrap has been landfilled, dumped into nearby bodies of water and used as fertilizer. Also, it has been processed into shrimp and fish feed, used as a nematocide, and converted into crab meal. The use of crab scrap as landfill, however, has come under stricter environmental control and has been disallowed in some areas. In certain areas swine farmers have used crab waste as a feed supplement. Husby et al. (1981) found that king or tanner crab meal could replace 50% of the soybean meal in a corn-soybean diet for swine with no reduction in weight gain. Additional studies with lactating dairy cows indicated that there was no significant difference in milk production or weight gain between prepared soybean rations and king crab rations. Beef cattle fed crab meal were found to maintain their body weight equal to control animals after a six-week period for adjustment to the rumen microbial populations.

Blue crab scrap has value as fertilizer although no work has been conducted with the waste to establish equivalent application rates with commercial prepared fertilizers. The use of dungeness crab scrap as fertilizer was evaluated by Costa (1978). Various application methods were incorporated with oven-dried, broken shell and tested with two types of pasture crops. No significant difference was found in nitrogen and phosphorous uptake by the plants fed either crab waste or inorganic fertilizers when applied at equivalent rates. The use of crab scrap to produce chitin/chitosan is still under study. Brown (1982) stated that the industrial production of chitin/chitosan is entirely feasible and economically viable; however, potential commercial users have not afforded it much attention.

The economic uncertainties associated with crab meal production was discussed by Brown (1982). Existing plants have had to meet increasingly strict and costly air pollution control regulations. Additional problems include an inconsistent supply of raw product, an anticipated decline in the protein content of crab scrap associated with increased use of mechanization and fluctuations in the commodities grain market which determines the price of meal. The feasibility of entering into crab meal production was evaluated by Murray (1981), Murray and DuPaul (1981) and Grulich and DuPaul (1989).

10.0 DESCRIPTION OF ECONOMIC CHARACTERISTICS

10.1 Domestic Harvesting Sector

10.1.1 Landings and Value

Ex-vessel values of blue crabs are listed for the U.S. gulf and individual states in Table 10.1. The dockside value of the gulf blue crab harvest has been increasing faster than harvest poundage. Averaging $4.6 million annually during 1971-1975, the dockside value increased approximately 200% to $13.2 million for the period 1981-1985. The 1987 value of $29.7 million is more than twice the five year average in the early 1980s.

Louisiana has accounted for more than one-half of the total gulf dockside blue crab value since 1983. Texas and Florida account for most of the remaining value with Mississippi and Alabama together representing 5%-10% of the total.

Price per pound to the fisherman has increased (Table 10.2). Averaging $0.120 per pound during 1971-1975, dockside price increased to an average of $0.286 per pound for the period 1981-1985. The 1987 price of $0.379 represents more than a 30% increase over the average 1981-1985 price and more than a 200% increase over the 1971-1975 reported price.

Dockside price in Alabama usually exceeds prices found in other Gulf States and may be a response to the larger processing activities in Alabama especially in relation to that state's landings. In general, ex-vessel value in the gulf approximates dockside prices for the United States, with deviations of more than $.02 per pound uncommon.

Much of the increase in the ex-vessel value is the result of inflation. Removing the effect of inflation by dividing the current blue crab dockside price by 1967 Consumer Price Index (1967=100) gives an estimate of price in deflated or constant dollars and is determined by dividing the current price by the consumer price index. Expressed in constant dollars (1967=100) the dockside value has increased only marginally during the 27 year period ending in 1987. The average 1981-1985 deflated price ($0.096) was only about 11% greater than the 1971-1975 deflated price of $0.086. With the exception of 1987, the highest reported deflated price for gulf blue crabs occurred during the 1976-1978 period, which was one of abnormally low United States harvest (Table 8.1). Rather than in response to a low harvest, the relatively high 1987 deflated gulf blue crab price may indicate a growing demand for gulf crabs to meet the region's expanding processing sector. Expressed in constant dollars (1967=100), the value of the gulf blue crab harvest in 1987, $8.729 million, was more than double the 1981-1985 average deflated value of $4.065 million and about 160% greater than the 1971-1975 average deflated value of $3.314 million. While this increase is substantial, it is significantly less than the increase which is observed before deflating.

10.1.2 Blue Crab Price Analysis

Statistical analyses of blue crab dockside prices suggest that they are relatively unresponsive to changes in landings. Prochaska et al. (1982) found that a 10% increase (or decrease) in Florida landings will lead to a less than 2% decrease (or increase) in the Florida blue crab dockside price. Analysis by Rhodes (1982) concluded that a 10% increase (or decrease) of gulf-wide blue crab landings will result in roughly a 4% decrease (or increase) in the gulf dockside price. Rhodes also concluded that changes in Chesapeake blue crab landings, traditionally the largest producer of blue crabs, did not significantly affect the gulf blue crab price. These authors suggest that consumer's disposable income rather than landings is the largest determinant of dockside blue crab price, and that the relatively large recent increases in dockside blue crab prices are directly related to large growth disposable income during the 1980s.

Table 10.1. Historical commercial value of blue crab landings by state, the Gulf of Mexico, and the United States, 1971-1987.

Year	West Coast Florida		Alabama		Mississippi		Louisiana		Texas		Gulf of Mexico		United States	
	Current	Deflated*	Current	Deflated	Current	Deflated	Current	Deflated	Current	Deflated	Current	Deflated	Current	Deflated
	Thousands of Dollars													
1971	952	785	212	175	126	104	1,256	1,035	567	467	3,113	2,566	12,921	10,652
1972	959	765	195	156	169	135	1,777	1,418	653	521	3,753	2,995	14,671	11,709
1973	1,147	862	294	221	231	174	2,811	2,112	830	624	5,313	3,992	17,661	13,269
1974	1,280	867	284	192	227	154	2,701	1,829	832	563	5,324	3,605	19,259	13,039
1975	1,585	983	283	176	177	110	2,510	1,557	948	588	5,503	3,414	20,310	12,599
1971-75 avg.	1,185	852	254	184	186	135	2,211	1,590	766	553	4,601	3,314	16,964	12,254
1976	1,966	1,153	281	165	268	157	3,061	1,795	1,179	691	6,755	3,962	23,563	13,820
1977	3,119	1,718	548	302	473	261	3,765	2,074	1,947	1,073	9,852	5,428	28,060	15,460
1978	2,256	1,144	458	235	422	217	3,189	1,633	2,004	1,026	8,329	4,200	28,180	14,429
1979	2,235	1,028	400	176	316	145	4,776	2,197	2,146	987	9,873	3,983	31,420	14,249
1980	2,387	969	465	188	693	280	4,327	1,753	2,456	995	10,328	4,068	35,167	14,249
1976-80 avg.	2,393	1,202	430	213	434	212	3,824	1,890	1,946	954	9,027	4,328	29,278	14,441
1981	3,327	1,221	850	312	519	191	4,469	1,640	1,928	708	11,093	3,539	46,441	17,049
1982	2,209	764	479	166	348	120	4,843	1,675	2,375	822	10,254	3,577	49,407	17,090
1983	2,524	846	514	172	332	111	6,366	2,133	3,250	1,089	12,986	3,890	55,131	18,663
1984	3,197	1,028	1,374	442	640	206	8,192	2,633	2,252	724	15,655	4,823	55,973	17,992
1985	3,113	977	830	261	538	169	8,387	2,633	3,309	1,039	16,177	4,495	53,603	16,830
1981-85 avg.	2,874	967	809	271	475	159	6,451	2,143	2,623	876	13,233	4,065	52,111	17,525
1986	2,981	735	950	289	470	143	9,295	2,835	3,170	965	16,866	5,086	58,005	17,663
1987	3,332	979	1,005	295	480	141	20,134	5,915	4,763	1,399	29,714	8,729	68,540	20,119

Sources: Compiled from Fisheries Statistics of the United States (various issues), and unpublished National Marine Fisheries Service data.
*Deflated values (1967=100)

Table 10.2. Historical commercial prices of blue crab landings by state, the Gulf of Mexico, and the United States, 1971-1987.

Year	West Coast Florida		Alabama		Mississippi		Louisiana		Texas		Gulf of Mexico		United States	
	Current	Deflated*	Current	Deflated	Current	Deflated	Current	Deflated	Current	Deflated	Current	Deflated	Current	Deflated
	---Dollars per Pound---													
1971	.078	.064	.106	.087	.100	.080	.103	.085	.098	.081	.093	.077	.087	.072
1972	.090	.072	.121	.097	.124	.099	.118	.094	.101	.081	.109	.085	.099	.079
1973	.119	.089	.140	.105	.127	.095	.122	.092	.121	.091	.122	.092	.129	.097
1974	.126	.085	.156	.106	.136	.092	.131	.089	.158	.093	.132	.089	.129	.087
1975	.124	.077	.173	.107	.156	.097	.146	.091	.158	.098	.142	.088	.151	.094
1971-75 avg.	.107	.077	.139	.100	.129	.093	.124	.090	.127	.089	.120	.086	.119	0.86
1976	.163	.096	.216	.127	.201	.118	.201	.118	.177	.104	.185	.109	.204	.119
1977	.197	.109	.252	.139	.246	.136	.233	.118	.236	.130	.199	.110	.213	.117
1978	.191	.098	.228	.117	.218	.112	.212	.103	.268	.137	.218	.112	.204	.104
1979	.200	.092	.291	.134	.241	.111	.224	.103	.258	.119	.228	.105	.206	.087
1980	.212	.086	.298	.121	.251	.102	.238	.096	.274	.111	.242	.098	.215	.087
1976-80 avg.	.193	.096	.257	.128	.231	.116	.222	.108	.243	.120	.214	.107	.208	.103
1981	.225	.083	.340	.125	.278	.102	.275	.101	.277	.100	.262	.096	.238	.087
1982	.249	.086	.368	.127	.268	.093	.280	.097	.289	.103	.279	.097	.253	.088
1983	.270	.090	.367	.123	.291	.098	.325	.109	.368	.123	.321	.108	.288	.097
1984	.248	.080	.327	.105	.284	.091	.277	.089	.311	.100	.278	.089	.277	.089
1985	.250	.078	.361	.113	.326	.102	.281	.088	.340	.107	.290	.091	.281	.088
1981-85 avg.	.248	.083	.353	.119	.289	.097	.288	.097	.317	.107	.286	.096	.267	.090
1986	.320	.096	.328	.100	.361	.110	.289	.088	.334	.102	.301	.092	.314	.096
1987	.320	.094	.402	.118	.349	.103	.381	.112	.408	.120	.379	.111	.358	.105

Sources: Compiled from data contained in Tables 8.1 and 10.1.
*Deflated values (1967=100)

10.1.3 Fishing Income

Apparent gross income per crab fisherman from trap fishing activities in the Gulf of Mexico has increased steadily during the 1971-1986 period (Table 10.3). For example, the 1986 gross income per fisherman of $8,151 exceeds the 1981-1985 average ($7,551) by about 8% and is 135% greater than the $3,458 derived annually during the 1971-1975 period. When examined in constant dollars (1967=100), however, income from crab fishing in the gulf has remained relatively stable averaging $2,246 per fisherman in 1986 compared to a high of $2,790 during the 1976-1980 period. Because of the increasing number of traps per fisherman, the gross income derived per trap has not kept pace with the increase in undeflated crab sales per fisherman. For example, the $48.60 derived per trap in 1986 is virtually the same as the 1981-1985 average of $48.40 but 85% greater than the $26.05 derived per trap annually during 1971-1975. In constant terms, however, gross revenues per crab trap in the gulf have been falling since the 1976-1980 period with the 1986 average of $14.86 per trap being almost 25% less than the 1976-1980 high of $19.39 per trap.

Gross income per fisherman and trap as indicated in Table 10.3 varies substantially among states in the gulf. Texas has historically experienced the highest gross income per fisherman and trap among states in the gulf with crab sales per fisherman and trap in that state averaging about twice that of the gulf. By comparison, Alabama generally shows the lowest crab sales per fisherman and trap among the Gulf States.

While the deflated gross income per fisherman has remained relatively constant in the gulf during 1971-1986, there has been significant variation among certain states in the gulf. The deflated gross income per fisherman in Florida, for instance, has fallen sharply since the 1976-1980 period. By comparison, deflated gross income per fisherman in Louisiana has been increasing with the 1986 average of $2,656 per fisherman exceeding the 1971-1975 average ($1,829) by almost 50%.

Current cost and return profiles for the gulf fishery are not available. However, increasing trap usage per crab fisherman suggests that the costs associated with the fishery expressed in either current or constant dollars have been increasing. Gross income (revenues), however, appears to be relatively constant when evaluated on a deflated basis, and this coupled with increasing costs suggests that profitability within the industry may be declining.

Fishing effort for gulf blue crabs is thought to be higher than that reported by National Marine Fisheries Service (NMFS). The Louisiana Department of Wildlife and Fisheries issued almost 2,000 commercial crab licenses in 1986 or about twice the number of commercial crab fishermen reported by the fisheries statistics division of NMFS. Some of the differences between licenses issued by the state and crab fishermen reported by NMFS may be due to some individuals purchasing licenses and then not using them. Another portion of the difference may reflect those fishermen marketing their catch directly to restaurants and retail outlets. Neither these fishermen nor their catches will be reported by NMFS. If, however, the effort (fishermen and traps) related to catch entering wholesale and processing establishments is accurate, then the catch per unit effort should be reflective of that portion of annual harvest entering wholesaling and processing establishments.

10.2 Domestic Processing Sector

10.2.1 Processing Capacity

Estimates of blue crab processing activities in individual Gulf States, the total gulf and for the United States are given in Table 10.4. These activities are measured only in terms of value and not poundage.

Table 10.3. Estimated gross blue crab income per fisherman and trap by state and total for selected periods.

	Catch per Fisherman		Catch per Trap	
	Current	Deflated*	Current	Deflated*
	--------$--------		--------$--------	
Florida West Coast				
1971-1975 average	5,605	4,025	38.89	27.93
1976-1980 average	9,060	4,571	61.18	30.87
1981-1985 average	6,624	2,229	56.88	19.14
1986	4,929	1,479	44.12	13.23
Alabama				
1971-1975 average	2,604	1,878	16.51	11.90
1976-1980 average	4,212	2,115	28.33	14.23
1981-1985 average	6,352	2,122	22.09	7.38
1986	6,871	2,095	23.24	7.08
Mississippi				
1971-1975 average	2,854	2,064	40.57	29.34
1976-1980 average	6,606	3,258	90.66	44.71
1981-1985 average	8,112	2,723	99.88	33.53
1986	6,837	2,084	91.17	27.78
Louisiana				
1971-1975 average	2,567	1,829	19.78	14.10
1976-1980 average	3,737	1,796	25.15	12.09
1981-1985 average	6,600	2,191	39.83	13.22
1986	8,724	2,656	46.06	14.03
Texas				
1971-1975 average	6,460	4,529	46.67	32.72
1976-1980 average	13,727	6,725	112.71	55.22
1981-1985 average	16,103	5,394	123.74	41.30
1986	15,153	4,628	111.91	34.18
Gulf of Mexico				
1971-1975 average	3,458	2,465	26.05	18.57
1976-1980 average	5,628	2,790	39.11	19.39
1981-1985 average	7,551	2,521	48.40	16.16
1986	8,151	2,246	48.60	14.86

Sources: Compiled from data contained in Tables 8.2, 8.10 and 10.2.
*Deflated values (1967=100)

Table 10.4. Number of establishments and value of processed blue crab products by state, the Gulf of Mexico, and the United States, 1971-1987.

	Florida West Coast			Alabama			Mississippi		
Year	Number of Establishments	Current Value	Deflated Value[a]	Number of Establishments	Current Value	Deflated Value	Number of Establishments	Current Value	Deflated Value
		-------$1,000-------			-------$1,000-------			-------$1,000-------	
1971	16	3,307	2,726	9	1,827	1,506	11	1,237	1,020
1972	19	2,819	2,250	12	2,033	1,623	11	1,305	1,042
1973	23	4,667	3,506	13	4,201	3,156	12	1,990	1,495
1974	24	4,882	3,305	13	3,989	2,701	13	2,664	1,804
1975	23	4,813	2,986	14	5,218	3,237	12	2,359	1,463
1971-75 avg.	21	4,098	2,955	12.2	3,454	2,445	11.8	1,911	1,365
1976	27	7,074	4,149	13	6,529	3,829	11	1,338	785
1977	24	5,601	3,086	16	8,795	4,846	9	1,335	736
1978	24	4,929	2,524	15	9,197	4,709	9	1,293	662
1979	22	5,257	2,418	17	11,944	5,494	7	1,150	530
1980	22	5,991	2,427	20	12,738	5,161	6	1,381	560
1976-80 avg.	23.8	5,770	2,921	16.2	9,841	4,808	8.4	1,299	655
1981	27	8,087	2,969	19	9,455	3,471	6	1,394	512
1982	24	8,503	2,941	24	10,654	3,685	6	1,076	372
1983	30	10,996	3,685	27	16,326	5,471	5	1,043	350
1984	32	10,833	3,482	28	28,336	9,108	5	1,699	546
1985	28	10,386	3,261	28	23,206	7,286	6	1,536	482
1981-85 avg.	28.2	9,761	3,268	25.2	17,595	5,804	5.6	1,350	452
1986	28	10,134	3,086	26	23,683	7,212	6	2,506	763
1987	24	13,871	4,075	25	18,812	5,526	6	1,846	542

--continued--

Table 10.4. continued.

Year	Louisiana			Texas			Gulf of Mexico		
	Number of Establishments	Current Value	Deflated Value[a]	Number of Establishments	Current Value	Deflated Value	Number of Establishments	Current Value	Deflated Value
		-------$1,000-------			-------$1,000-------			-------$1,000-------	
1971	22	1,220	1,006	6	835	688	64	8,426	6,946
1972	26	1,873	1,495	7	2,280	1,820	75	10,310	8,230
1973	30	3,580	2,690	7	2,453	1,843	85	16,891	12,690
1974	28	3,406	2,306	8	2,680	1,815	86	17,621	11,931
1975	25	3,917	2,430	8	1,926	1,195	82	18,233	11,311
1971-75 avg.	26.2	2,799	1,985	7.2	2,035	1,472	78.4	14,297	10,222
1976	29	5,350	3,138	11	2,647	1,552	91	22,938	13,453
1977	27	6,505	3,584	9	2,736	1,507	85	24,972	13,759
1978	29	5,461	2,796	7	3,109	1,592	84	23,989	12,283
1979	23	3,378	1,554	6	2,977	1,369	75	24,706	11,365
1980	23	5,245	2,125	6	3,259	1,321	77	28,614	11,594
1976-80 avg.	26.2	5,188	2,639	7.8	2,946	1,468	82.4	25,044	12,491
1981	22	6,673	2,450	7	3,511	1,289	81	29,120	10,691
1982	26	6,307	2,182	8	4,645	1,607	88	31,185	10,787
1983	27	8,882	2,977	9	4,140	1,387	98	41,387	13,870
1984	20	10,697	3,438	12	3,731	1,199	97	55,296	17,773
1985	22	11,759	3,692	10	4,092	1,285	94	50,979	16,006
1981-85 avg.	23.4	8,864	2,948	9.2	4,024	1,353	91.6	41,593	13,825
1986	28	21,313	6,490	8	2,889	880	96	60,525	18,431
1987	35	21,252	6,243	6	1,889	555	96	57,670	16,941

--continued--

Table 10.4. continued.

Year	United States	
	Current Value	Deflated Value[a]
	---------------$1,000---------------	
1971	39,661	32,697
1972	45,431	36,258
1973	56,755	42,641
1974	59,654	40,389
1975	58,231	36,123
1971-75 avg.	51,946	37,622
1976	66,398	38,943
1977	68,576	37,783
1978	72,970	37,363
1979	84,667	38,945
1980	87,424	35,423
1976-80 avg.	76,007	37,691
1981	101,562	37,284
1982	103,618	35,842
1983	146,812	49,200
1984	161,138	51,796
1985	162,374	50,981
1981-85 avg.	135,101	45,021
1986	160,762	48,593
1987	--	--

Sources:

The gulf and individual state figures were compiled from unpublished data provided by National Marine Fisheries Service. These figures will tend to be slightly larger than published data because the unpublished data include some unclassified products, and there have been corrections in the data used to compile published statistics.

The United States figures were compiled from unpublished data provided by National Marine Fisheries Service and Processed Fishery Products, Annual Summary (various issues).

[a]The deflated values of processed blue crab products were derived by dividing the current processed blue crab values by the Consumer Price Index (1967=100).

The number of establishments processing blue crab has increased overall from an average of 78 from 1971-1975 to 92 during 1981-1985. The associated processed value increased from an annual average of $14.3 million to $41.6 million or about 190% after adjusting for inflation (1967=100).

When compared to the United States, the gulf represented about 27% of the total value of processed blue crabs during 1971-1975. From 1981-1985, the gulf's share of the total United States processed blue crab value averaged about 30%.

Over 50% of the gulf harvest (Table 8.4) is from Louisiana; however, processing activity in the state typically represents less than a quarter of that for the gulf. The quantity of processed crab in Louisiana has increased in recent years. Keithly (1988) noted that there was an increase in the number of firms and amount of processed crab meat from 1985 to 1986. Alabama's blue crab harvest during 1981-1985 represented less than 6% of the gulf's total, but its share of gulf processing activities averaged 42%.

Greatest growth in blue crab processing capacity has taken place in Alabama. Averaging about 12 blue crab processors during 1971-1975, the number of processors in Alabama more than doubled during 1981-1985. The number of Florida blue crab processors increased almost 35% between 1971-1975 and 1981-1985, while the number of processors in Texas increased slightly. The number of processors in Mississippi, averaging about twelve during 1971-1975, decreased to less than six during 1981-1985.

Annual estimates of processed blue crab product sales per establishment in each of the Gulf States and in total are given in Table 10.5. These estimates are derived from the information contained in Table 10.4. Sales of processed blue crab products per establishment in the gulf have gradually increased. Average annual sales per establishment of $421.6 thousand during 1981-1985 represents an approximate 110% increase over 1971-1975 average annual sales of $202.4 thousand. When examined on a deflated basis, however, sales per establishment have decreased more than 3%, averaging $141.1 thousand during 1981-1985 compared to $146.1 thousand during 1971-1975. No growth in processed blue crab sales per establishment in the gulf is observed when comparing the 1976-1980 deflated sales per establishment ($159.1 thousand) to the 1981-1985 deflated sales per establishment ($141.0 thousand), suggesting that the recent increase observed in the deflated value of processed blue crab products in the gulf is in response to an increase in the number of establishments rather than growth among existing establishments.

To examine this in more detail, consider processed blue crab sales among Alabama establishments. Though the total deflated value of these sales increased from about $4.8 million annually during 1976-1980 to $5.8 million annually during 1981-1985 (Table 10.4), or about 20% per establishment, deflated processed sales fell from about $299 thousand to $225 thousand (Table 10.5), a decline of about 25%. The number of establishments processing crab in Alabama during this period increased, however, from an average of 16.2 during 1976-1980 to 25.2 during 1981-1985 (Table 10.4). This explains the overall increase in deflated value, while the deflated processed value per establishment declined.

The information in Table 10.5 suggests that processed blue crab sales per establishment are generally highest among Alabama establishments and, in recent years, lowest among Mississippi establishments. The greatest increase in sales per establishment is associated with Louisiana. This may be related to an increase in the number of establishments gulf-wide, all competing for the same source of raw product.

There is considerable movement within the gulf blue crab processing sector (Table 10.6). This movement is the result of entry and exit as gulf processing establishments add and delete blue crabs from processing lines, or in the extreme, begin or cease all processing activities. This movement is

Table 10.5. Average current and deflated value per establishment of processed blue crab products among Gulf States and the Gulf of Mexico, 1971-1987.

	Florida	Alabama	Mississippi	Louisiana	Texas	Gulf of Mexico
	---Thousand Dollars---					
1971	206.7	203.0	112.5	55.5	139.2	143.4
	(170.4)*	(167.3)	(92.7)	(45.7)	(114.7)	(118.2)
1972	148.4	169.4	118.6	72.0	325.7	166.8
	(118.4)	(135.3)	(94.7)	(57.5)	(260.0)	(133.2)
1973	202.9	323.2	165.8	119.3	350.4	232.3
	(152.4)	(242.8)	(124.6)	(89.7)	(263.3)	(174.6)
1974	203.4	306.8	204.9	121.6	335.0	234.3
	(137.7)	(207.8)	(138.8)	(82.4)	(226.9)	(158.7)
1975	209.3	372.7	196.6	156.7	240.8	235.2
	(129.8)	(231.2)	(121.9)	(97.2)	(149.4)	(145.9)
1971-75 avg.	194.1	275.0	159.7	105.0	278.2	202.4
	(141.7)	(196.9)	(114.5)	(74.5)	(202.9)	(146.1)
1976	262.0	502.2	121.6	184.5	240.6	262.2
	(153.7)	(294.5)	(71.4)	(108.2)	(141.1)	(153.8)
1977	233.4	549.7	148.3	240.9	304.0	295.3
	(128.6)	(302.9)	(81.8)	(132.7)	(167.4)	(162.7)
1978	205.4	613.1	143.7	188.3	444.1	318.9
	(105.2)	(313.9)	(73.6)	(96.4)	(227.4)	(163.3)
1979	238.9	702.6	164.3	146.9	496.2	349.8
	(109.9)	(323.2)	(75.7)	(67.6)	(228.2)	(160.9)
1980	272.3	636.9	230.0	228.0	543.2	382.1
	(110.3)	(258.1)	(93.3)	(92.4)	(220.2)	(154.9)
1976-80 avg.	242.4	600.9	161.6	198.0	405.6	321.7
	(121.5)	(298.5)	(79.2)	(99.5)	(196.9)	(159.1)
1981	299.5	497.6	232.3	303.3	501.6	366.9
	(110.0)	(182.7)	(85.3)	(111.4)	(184.1)	(134.7)
1982	354.3	443.9	179.3	242.6	580.6	360.1
	(122.5)	(153.5)	(62.0)	(83.9)	(200.9)	(124.6)
1983	366.5	604.7	208.6	328.9	460.0	393.7
	(122.8)	(202.6)	(70.0)	(110.3)	(154.1)	(132.0)
1984	338.5	1,012.0	339.8	534.9	310.9	507.2
	(108.8)	(325.3)	(109.2)	(171.9)	(99.9)	(163.0)
1985	370.9	828.8	256.0	534.5	409.2	479.9
	(116.5)	(260.2)	(80.3)	(167.8)	(128.5)	(150.7)
1981-85 avg.	345.9	677.4	243.2	388.8	452.5	421.6
	(116.1)	(224.9)	(81.4)	(129.1)	(153.5)	(141.0)
1986	361.9	910.9	417.7	761.2	361.1	562.6
	(110.2)	(277.4)	(127.2)	(231.8)	(110.0)	(171.3)
1987	578.0	752.5	307.7	607.2	314.8	512.0
	(169.8)	(221.0)	(90.3)	(178.4)	(92.5)	(150.4)

Source: Compiled from information contained in Table 10.3.
*The deflated value of processed blue crab products was derived by dividing the current processed blue crab values by the Consumer Price Index (1967=100). Numbers in parenthesis are the deflated value.

Table 10.6. Total number and entry and exit patterns among Gulf of Mexico blue crab processing establishments,[1,2] 1970-1985.

	GULF		
	Total	Entry	Exit
		Number of Establishments	
1970	56		
1971-1975		59	33
1975	82		
1976-1980		60	65
1980	77		
1981-1985		78	61
1985	94		
TOTAL		197	159
Average[3]	77	65.7	53
Rate of Change[4] (%)		85.1	68.7

Source: Keithly et al. (1988)

[1] An establishment, or plant according to National Marine Fisheries Service terminology, is a single processing entity. It is possible that two or more establishments may be under sole ownership of a company. To be considered a processing establishment, as opposed to a wholesaling establishment, some physical change of the product must be made. This can range from the picking and cooking of crab meat to breading, stuffing and the cleaning and polishing of shells.

[2] Establishments that exited and subsequently reentered are included as an exit and an entrance in the analysis.

[3] The average is based on a five-year period.

[4] The rate of change is calculated by dividing average entry or exit by the average total number of establishments and represents that occurring over a five-year period.

considerably more than what would be anticipated when observing only the 1970-1985 change in number of blue crab processing establishments (Table 10.4). The five year rate of entrance among blue crab processing establishments (85.1%) has greatly exceeded the rate of exits (68.7%) explaining the large increase in number of establishments processing blue crabs. As shown by Keithly et al. (1988) entering blue crab processing establishments tend to operate on a smaller scale than established crab processors though their sales do exceed processors who are leaving the industry. Altogether, of the 94 establishments processing blue crabs in 1985, only 19 of these same establishments were processing blue crabs in 1970 (Keithly et al. 1988).

Among the 94 gulf blue crab processors in 1985, the largest five establishments accounted for about 42% of processed blue crab sales while the largest 10 establishments accounted for about 58% of total processed blue crab sales (Table 10.7). Slightly more than half (50) of the establishments accounted for more than 90% of reported processed blue crab sales. By comparison, of the 56 gulf

Table 10.7. Concentration in the Gulf of Mexico blue crab processing sector, 1970 and 1985.

Largest n processing establishment[1]	Percent of Processed Value	
	1970	1985
n = 5	48.4	42.4
n = 10	65.9	57.6
n = 20	86.2	73.6
n = 50	99.8	93.3
Number of Establishments	56	94

Source = Keithly et al. (1988)
[1] Establishments are ranked from the largest to the smallest on the basis of value of sales.

establishments processing blue crabs in 1970, the largest 5 accounted for just under 50% of processed blue crab sales while the largest 10 represented about 66% of total sales. While generalizations are difficult to make, it appears that the increase in number of establishments processing blue crabs during 1970-1985 has lessened concentration thereby increasing competition in that sector.

10.2.2 Production Costs

A product cost profile (Table 10.8) based on data from Maryland blue crab processors indicated that raw product and labor comprise the largest cost components (Dressel and Whitaker 1982). Similar data were obtained from a profile prepared for Texas plants with raw product and labor accounting for over half of the production costs; however, raw product costs were higher and labor costs lower in the Texas study (Table 10.9). Variations in yield will alter raw material cost by as much as $1.18 per pound (Table 10.10).

The continued viability of seafood processing plants was projected by Dressel and Whitaker (1982) by examining trends in production cost increases in relation to changes in prices received as indicated by the average free on board (FOB) prices. The average percent increase in production costs for picked crab meat from 1975 to 1980 are shown in Table 10.11. The total cost of producing one pound of crab meat rose 35% or approximately 7% per year. Increases in product costs were offset by plant price increases of 33% (Table 10.12). Thus processors have been able to pass on price increases to consumers, indicating strong consumer demand.

10.3 Market Margins within the Fishery

Perry et al. (1984) reported that the consumer dollar was distributed among several entities from harvest to the table. The processor received the greatest portion (48%) and the wholesaler the least (5%). The fishermen and retail store received 28% and 19%, respectively.

Table 10.8. Percentage share of cost components of picked blue crab meat, 1980 (from Dressel and Whitaker 1982).

Cost Item*	Percent
Operating Costs	
Live crabs	34.4
Labor	28.6
Containers	7.1
Overhead	14.0
Fixed Costs	
Depreciation	1.9
Interest	0.2
Other	13.8
Total	100.0

*Cost profile based on estimated average yields from hand-picked crabs and an average weighted sales price based on variations in amounts and prices for each grade of crab meat. Distribution costs may be significantly different in highly mechanized plants.

Table 10.9. Costs per pound of processed crab meat in Texas (Texas A&M University, unpublished data).

Crab costs ($0.26 x 8 pounds at 12.5% yield)		$2.08
Processing Costs		
Direct:		
Cooking, backing, cleaning	$0.50	
Picking	0.90	
Container	0.15	
Total Direct	$1.55	
Indirect:		
Overhead	$0.80	
Taxes	0.20	
Transportation	0.20	
Processing Margin	0.67	
Total Indirect	$1.87	
Total Processing Costs		3.42
Total Production Costs		5.50
Wholesale Margin (7% on cost)		0.38
Retail Markup (24% on cost)		1.42
Price to Consumer		$12.80

Table 10.10. Raw materials costs* based on different yields (from Dressel and Whitaker 1982).

Yield	Dollars per Pound
8%	2.75
10%	2.20
12%	1.67
14%	1.57

*Based on 1980 U.S. average price of $0.22 paid to blue crab fishermen.

Table 10.11. Average percent increase in production costs for picked blue crab meat, 1975-1980 (from Dressel and Whitaker 1982).

Cost Item	Percent
Live Crab	23
Labor	21
Containers	65
Overhead	86
Depreciation	200
Interest	--
Total Costs	35
Wholesale Price Increase[1]	33
Retail Price Increase[2]	57

[1] At New York
[2] At Baltimore

Table 10.12. Increases in production costs and price increases, 1975-1980 (from Dressel and Whitaker 1982).

Production Costs	+35%	7.0% annual
Overall Inflation	+53%	10.6% annual
FOB Prices	+33%	6.6% annual
Retail Prices	+57%	11.4% annual

10.4 Economic Interdependencies

The interdependencies of the blue crab fishery with other fisheries have been established in a number of studies (Strand and Matteucci 1977, Meeter et al. 1979, Dressel and Whitaker 1982, Roberts and Thompson 1982). Strand and Matteucci (1977) provided empirical evidence for the existence of short-term economic interrelationships between the Virginia crab and oyster fisheries and suggested that the economic impact of this interdependency may argue for joint management considerations. While interrelationships between the crab fishery and the oyster fishery (Meeter et al. 1979) and the crab fishery and shrimp fishery (Roberts and Thompson 1982) have been identified in the gulf, the year-round availability of blue crabs in the gulf should serve to lower participation by crab fishermen in joint fisheries. Data indicate that the percent participation in more than one fishery varies from state to state. A 1982 survey of crab fishermen in Texas revealed that 73% derived their total income from crab harvesting (Texas A&M University, unpublished data). In a later survey, approximately 61% of the crab fishermen interviewed in Texas said they did not participate in any other fishery (Miller and Nichols 1986). The majority of the fishermen said they would exit the fishing industry if they could not make a living in the crab fishery. The percent of household fishing income derived from fisheries other than crabbing was less than 10% in nearly all cases. In contrast, Roberts and Thompson (1982) noted that 61% of the crab fishermen in Lakes Pontchartrain and Borgne, Louisiana, fished other species in 1980. In addition to full-time fishermen who engage in multi-species harvesting, part-time crab fishermen who derive a portion of their income from non-fishing activities move in and out of the fishery. Part-time crab fishermen, whether full-time fishermen or not, are becoming an increasingly important part of the blue crab fishery. According to Dressel and Whitaker (1982), there has been a six-fold increase in the number of part-time harvesters in the United States blue crab fishery since 1960. Data from the gulf tend to substantiate this trend. Landrum and Prochaska (1980) reported an increase in the number of part-time to full-time (more than 50% of income derived from fishing) fishermen in the Florida west coast fishery and suggested that it may reflect an increase in the actual number of part-time fishermen entering the fishery or that fishermen once classified as full-time have been reclassified as part-time because they receive the larger portion of their income from non-fishing activities.

The movement of part-time fishermen in and out of the fishery may be the result of economic factors external to the fishing industry or may reflect a seasonal "switch" to a more profitable fishery. During recession years, many individuals are inclined to supplement their income by crab fishing.

10.5 Marketing

10.5.1 Domestic/Live Product

Live crabs are marketed through sales to processing houses or first level crab buyers and through direct sales to the general public, restaurants or retail outlets. Although the vast majority of crabs are sold for processing, an undetermined percentage of crabs are marketed live locally or shipped to the east coast through the "basket trade." Dressel and Whitaker (1982) estimated that 30% of the total United States landings were marketed live in the basket trade. Among the Gulf States, Louisiana, Florida and Texas report significant activity in the basket trade with as much as 20% of the Texas landings sold as live product in eastern markets.

Roberts and Thompson (1982) found that the marketing channels for live crabs varied with geographic proximity to major population centers. They noted that isolation from consumers enhanced the role of the crab buyer, whereas in heavily populated areas the fishermen may market their products directly to the retailer, restaurant or the general public. The participation of part-time crab fishermen in the fishery was also found to affect distribution of live product; their relatively small volume allows them to market their catch through channels other than a first level buyer.

The variety of live markets and the large percentage of part-time fishermen in the fishery led to under-reporting of landings and thus economic impact. In their survey, Roberts and Thompson (1982) found that 70% of the crab fishermen used unsurveyed market channels in 1980 accounting for 60% of the total harvest from the lakes. This marketing pattern, if indicative of other areas, indicated that both catch and economic impacts from commercial crab fishing are grossly underestimated.

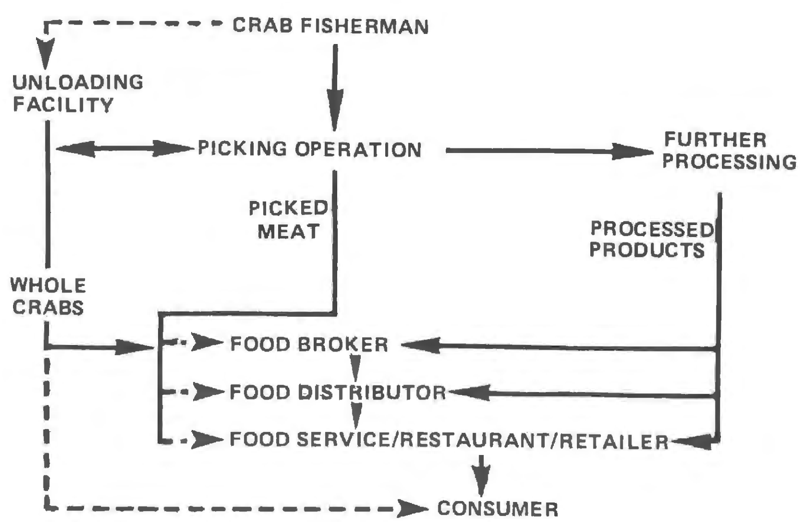
10.5.2 Domestic/Processed Product

Approximately 75% of hard crabs are sold as processed product. Product forms included fresh picked and pasteurized meat, breaded specialties and sterilized canned meat which accounted for 64.6%, 26.6% and 8.8% of the 1980 processed crab in the United States, respectively (Dressel and Whitaker 1982).

Although varying with the individual processors, general grades of fresh picked and pasteurized crab meat are as follows:

1. Lump or backfin - large muscles associated with the fifth pereopod. There are varying grades of lump including jumbo lump (largest pieces), lump or backfin (smaller pieces) and deluxe (a mixture of lump and flake).
2. Flake or special - muscles associated with pereopods two through four.
3. Cocktail claw or crab finger - muscle of the propodite of the cheliped with dactyl attached.
4. Brown claw or claw meat - muscle of the meropodite.
5. Machine processed - small pieces of meat used in institutional pack.

The following depicts the processing and marketing channel for blue crabs (unpublished data from the Texas A&M Sea Grant Program):



10.6 International Trade

Trade statistics do not reflect blue crab imports or exports. This is because the United States Customs Service aggregates blue crab trade data with other crab data. It is known, however, that processed blue crab products are being imported to the United States from Central and South American countries.

The Tariff Schedules of the United States (Schedule 1, Part 3) indicate that the rate of duty on fresh, chilled, or frozen crab meat under column 1 (imports from western countries) equals 7.5% ad valorem while crab meat in airtight containers is taxed at 11% ad valorem.

10.7 Market Competition

The following discussion was taken from a paper by John Vondruska prepared for and presented to the National Blue Crab Industry Association Annual Meeting, 1986:

> The U.S. market for crab products has undergone radical changes in the past few years. Blue crab landings have risen while landings of king, snow and dungeness crabs have decreased. Additionally, surimi-based imitation crab meat has increased the size of the total (natural and imitation) crab market to twice what it would be with natural crab products alone.
>
> The United States, Japan and other markets now include significant amounts of imitation crab. U.S. production of surimi-based seafoods was estimated at 10 million pounds in 1985 (NMFS, 1985). Twelve existing or planned plants in the United States in 1986 had an estimated total potential output of roughly 30 million pounds of surimi-based seafoods (NMFS, 1986). Imitation crab meat is the leading surimi-based food in the United States. Sales of imitation crab have grown rapidly, exceeding sales of all natural crab on a meat weight basis in 1985. The product has found market niches that natural crab cannot fill at current price levels.

11.0 SOCIAL AND CULTURAL FRAMEWORK OF DOMESTIC FISHERMEN AND THEIR COMMUNITIES

Understanding people's beliefs and expectations about natural resources is important in fisheries management, as fisheries administrators largely manage fish populations by regulating the actions of the people who catch the fish (Voiland and Duttweiler, 1984). Effective and successful fisheries management is thus dependent not only upon biological variables but also social, economic and political issues.

The social framework of the blue crab fishery is integrally linked to the activities of people involved both in the blue crab fishery and in other fisheries and industries. Aspects of this framework, such as traditional family employment patterns, conflicts within the fishery, changes in employment opportunities in fisheries and in other industries, have effects that may not be readily apparent. Other considerations, such as the general state of the economy and amount of disposable income, consumer preference for different seafoods and legislative processes (local, state and Federal) also affect the fishery.

To date only a few studies have examined the sociology of the blue crab fishery of the Gulf of Mexico. In a survey of the coastal fishermen in Louisiana, Pesson (1974) provided data on their attitudes, characteristics, practices and responsiveness to change. Paredes et al. (1977) conducted a study of a small fishing community in northwest Florida and presented a detailed description of the community structure and conflicts. A 1988 study of the blue crab industry in Alabama was conducted by Forbus et al. (1989).

11.1 Ethnic Characteristics, Family Structure and Community Organization

The ethnic character of the gulf coast's seafood industry has changed dramatically since the influx of Indochinese refugees beginning in the late 1970s (Thomas 1986). Prior to this time the crab fishery was comprised of a few well established families of mixed American descent. These families lived in the same communities for several generations and exerted virtual monopoly over the industry (Paredes et al. 1977). Community organization was around "native" and "outsider" groups, which did not mingle socially. In some cases even extended families kept to separate spheres of activity.

Before the arrival of the Indochinese, a large crab shop generally employed 30 to 35 pickers, with the majority being women. It is estimated that 60% to 65% of these women were white, and the remaining 35% to 40% were black. Workers were paid by the amount of meat picked.

The gradually increasing labor force at crab processing plants coincided with increases in demand for crabs, in the number of blue crab fishermen and in traps fished per fisherman. The oil glut beginning in the early 1980s resulted in massive lay-offs of oil industry workers, especially in Louisiana. Many of these workers were from families who traditionally had been fishermen before the development of the oil industry, and they provided a ready harvesting sector for the expanding blue crab fishery. Start-up costs for crab fishermen were minimal; many coastal residents already owned a boat and could begin fishing 150 traps (which cost about $2,000).

Thomas (personal communication) reported that the first Indochinese to work in the blue crab industry in Bayou La Batre, Alabama, began with a single processing firm. Once the work ethic of the Indochinese was realized, other shops were quick to employ this group. Recently the Indochinese have opened their own processing firms to take advantage of labor and business opportunities and have also become a major group fishing for blue crabs.

The Indochinese population is composed of three distinct ethnic groups: Vietnamese, Cambodians and Laotians. They have been described by some processors as somewhat clannish and inward looking. Often different ethnic groups working in processing shops will refuse to work adjacent to another ethnic group and must be assigned to different areas of the picking room. Some processors prefer to hire only Cambodians or only Vietnamese to avoid conflicts. As one processor noted, this strategy can also create problems since large clans are commonly controlled by an elder member. If that individual becomes dissatisfied, the entire work force may walk off the job leaving the processor in a potentially devastating situation. The best strategy is for processors to diversify their labor force.

The impact of this new and willing labor force to the processing sector was immediately felt. One processor stated, "Before the Asians moved in we were picking about 2,000 pounds of crab per day. Now we pick over 10,000 pounds." The Indochinese did not displace resident pickers; they filled a labor niche that had been occupied by an aging white female labor force that was not replacing itself.

A central aspect of crab processing in south Alabama is the kinship ties which exist between processing shops. Three families in south Alabama have direct ties with approximately half of the processors currently in operation. Family ties among shops are important as there is competition in purchasing crab, hiring employees and in the market place. For those shops linked with another through kinship, a reciprocal relationship exists and helps to reduce business risks. Several related shops may purchase large amounts of crabs and then divide the crabs between them to reduce costs. Another common practice is to shift pickers between allied shops when a shop is overloaded with crabs and needs additional pickers.

11.2 Relationships Between Blue Crab Fishermen and Other Fishing Groups

Interactions between crab fishermen and other commercial fishermen vary. The crab and oyster fisheries are complimentary in nature with little or no conflict. Both fisheries are at their peak during different times of the year with some crab fishermen fishing for oysters during winter months. In addition, gear conflicts generally do not occur between crab and oyster fishermen.

The situation is quite different, however, between crab and shrimp fishermen, and intense feelings of contempt often exist between the two groups. Both work in the same waters during a large portion of the year, and the traps are sometimes unavoidably caught in trawls. Shrimp fishermen lose time untangling traps which can foul and damage trawls. Crab fishermen often lose their traps as they are dragged from their position and sometimes destroyed by angry shrimp fishermen.

Some crab fishermen have moved their traps closer to the shore to reduce conflict. Some degree of conflict exists between crab and recreational fishermen. Some recreational fishermen object to crab traps and claim that they are navigational hazards. They consider that there are too many traps in some estuaries.

Theft is considered to be a major problem in the fishery. Crab traps are easily looted as they are marked by floats and are not tended 24 hours a day. Much of the poaching is thought to occur at night, and some states have enacted rules to prevent any harvesting of traps at night to prevent theft.

11.3 Age and Education Profiles of the Fishery

Pesson (1974) indicated that Louisiana coastal fishermen tended to be middle aged and poorly educated. Age characteristics showed 52% were 40 to 59 years old with 35% under age 40. Alabama crab processors average 41.9 years old (Thomas, personal communication). In 1970, Paredes et al. (1977)

stated the mean education levels for the Florida county in the study area were 8.8 years for men and 9.8 for women. These were below the state mean (12.1 years for both male and female). Schooling was not considered important to the fishermen and completion of the fifth or sixth grade was adequate. However, all fishermen were found to be good at "figuring," making fast and accurate computations of price per pound and amount caught. Average number of years of education for Alabama crab processors is 11.3 (Thomas, personal communication). Crab fishermen do, however, have intimate knowledge of the migratory patterns of crabs and optimum fishing areas.

11.4 <u>Employment Opportunities and Social Structures</u>

Paredes et al. (1977) found the fishing industry to be kinship-based in the community studied. Employment opportunities were dependent upon family connections. This probably remains true, though the influx of Indochinese may have increased the number of competing families in many areas. Thomas (personal communication) noted that except for one processor in his study, the proprietor lived next to the crab plant. All plants employed one or more immediate relatives. The nature of this industry seems to promote family solidarity and interdependence which may actually be an underlying success factor.

Paredes (1977) noted that the unemployment rate was higher in Florida communities more dependent upon the fishing industry. While the county in which the study took place experienced an unemployment rate of 5.1% in 1975 compared to 10.7% statewide in the same year, the county just to the west which was more fishery dependent had an unemployment rate of 11.5%. In some regions unemployment rates may have increased with the Indochinese immigration and the displacement of "native" fishermen. However, the number of individuals employed by the industry fluctuates annually with the natural cycle of catches. Crab processors and crab fishermen feel that the Indochinese saved the crabbing industry in Alabama. At present 60% of the work force in Alabama crab processing is Indochinese with the remaining 40% divided equally between blacks and whites.

Processors in Bayou La Batre are protective toward their fishermen. Crab fishermen have long-term relationships with a particular processor who may be related or a close friend so that there is a bond of trust and dependability. Some processors help fishermen with start-up costs. Shop owners who take care of their fishermen create feelings of indebtedness. These feelings create long standing social and economic relationships.

Paredes et al. (1977) reported that crab house relations could be divided into four general groups: (1) owner-crabber, where the crab house owner was directly involved with harvesting crabs; (2) house crabber, who worked on salary for a crab house regardless of the catch; (3) percentage crabber, who either gave the crab house a percentage of his catch to repay a specific amount of money or gave the house a percentage of his catch in return for a portion of his operating expenses and equipment; and (4) the independent crabber, who bears all the expenses for his operation and is paid by the pound for his catch. The latter group is the hardest hit by price fluctuations and is most likely to leave the fishery when crab catch declines.

12.0 MANAGEMENT CONSIDERATIONS

Fisheries management philosophy has evolved from the concept of inexhaustible ocean resources requiring minimal management to the concept of maximum sustainable yield from the resource. In recent years management strategies have changed from the use of MSY to the use of OY (MSY modified by relevant social, economic and ecological factors). Though the concept of MSY is attractive theoretically, uncertainty about stock recruitment relationships and the common property nature of the resource has compromised its use (Healy 1984). Extensive development of models to define population characteristics has created a perception of precision beyond that warranted by the data. "Since models by definition are simplification of a complex reality, the exact behavior of the system being studied is unpredictable to a significant degree" (Jamieson 1986).

12.1 Stock and Recruitment Relationships

The relationship between spawning stock and the subsequent number of progeny entering a fishery is not easily determined in the marine environment, and the difficulty in correlating size of spawning stock and subsequent recruitment has been well documented in fishery biology (Parrish 1973, Nelson et al. 1977, Shepherd and Cushing 1980, Smith and Walters 1981, Shepherd 1982, Garcia 1983). In a series of seminars sponsored by Woods Hole Oceanographic Institution and the Northeast Fisheries Center (NOAA, NMFS), fisheries biologists addressed recruitment variability in fish populations (summarized by Grice et al. 1984). The lack of correlation between spawning stock size and subsequent recruitment was noted, as was the inadequacy of stock recruitment models in explaining this relationship.

Early attempts to define stock recruitment relationships (SRR) were typically two-parameter models that utilized spawning stock size and number of recruits or pre-recruits (Ricker 1954, Beverton and Holt 1957). Regardless of the model used, the establishment of an SRR was based on the assumption that recruitment was a density-dependent compensatory function of the spawning stock. Density-dependent factors such as food availability and competition-predation between and within species were assumed to be the limiting factors determining abundance. Traditional fisheries theory considered recruitment variability as "density-independent random deviations (noise) about the true underlying density-dependent relationship" (Grice et al. 1984). The inability of these models to account for density-independent variables (environmental, physical, socio-economic) that may be the driving mechanisms underlying SRR's limits their practical application; however, multiple parameter SRR models have been developed. Tang (1985), using a modified Ricker SRR model, proposed that fluctuations in blue crab recruitment in Chesapeake Bay were dependent both on spawning stock size and on environmental conditions (salinity, temperature, solar heating/cooling days). Sulkin and Epifanio (1986), however, suggested that physical factors regulating larval transport were paramount in establishing year-class strength in Chesapeake Bay. They acknowledged that although the level of larval production was a function of spawning stock size, the presence or absence of favorable hydrographic conditions over the continental shelf were more likely to affect recruitment; "namely, flow reversal in the summer and onshore surface flow in the fall timed to enhance conservative mechanisms governing megalopal recruitment." Recruitment variability as a function of spawning stock size was deemed to be "more subtle due to the tremendous fecundity of the blue crab." Van Engel (1987) stated, "an examination of the life history pattern of the Chesapeake Bay blue crab and its population parameters suggests that a spawner-recruit model would not be useful in setting management policy, as it is not density-dependent."

Recruitment for most species is now considered to be the result of a synergistic combination of biological and physical factors that occur through the first year of life, with density-independent factors of primary importance during the larval stage and density dependent factors more important for juvenile survivorship.

According to Walters (1981) harvest policy can be used as an aid to determine mechanisms involved in recruitment. Populations driven by density-independent variables will react differently to harvest policy than those in which density-dependent factors act to determine stock size. The protection of egg-bearing females assumes a density-dependent relationship between spawning stock and level of recruitment that would be expected to produce a more stable (non-cyclic) population. Although egg-bearing females have been protected in all but one of the Gulf States, the fishery exhibits wide annual fluctuations in harvest suggesting that density-independent factors operate to control recruitment of blue crabs in the gulf.

12.2 Recruitment Variability/Stock Abundance

Year-class strength is determined by larval recruitment and estuarine survivorship of juveniles. A variety of biological and physical processes interact to influence survivorship of prerecruitment stages (larvae and juveniles). Density-independent factors appear to dominate larval mortality. However, adequate larval recruitment does not necessarily ensure a strong year-class. Estuarine carrying capacity and survival of juveniles may ultimately determine stock abundance. Current research suggests that density-dependent mortality may be more important in juvenile success. Knowledge of causes of recruitment variability is critical for stock assessment and prediction.

12.2.1 Larvae

A complex set of biotic and abiotic factors act to influence larval recruitment in the Gulf of Mexico. Environmentally transgressive species (those animals previously classified as "estuarine dependent") in the gulf utilize both the continental shelf and estuarine environments. Features of the gulf affecting recruitment are in many instances unique. Although seasonal cycles may have profound influence on recruitment in higher latitudes, small-scale episodic events are thought to be important in the tropical-subtropical ecosystems of the gulf (Boesch and Dagg 1986). Low tidal amplitude in conjunction with a broad shallow continental shelf allows for meteorological "forcing" of coastal processes. Of particular importance in the northern gulf is the presence of a well-developed, broad coastal boundary layer (CBL) and the occurrence of eddies or rings formed at the shelf/slope interface. Salinity gradients between the CBL and the waters immediately offshore may be extreme. It is not known if blue crab larvae remain in the CBL or pass through the frontal boundary seaward. However, longshore movement of waters within the CBL would tend to enhance the possibility that larvae will contact an estuary. Thus entrainment in the CBL would enhance recruitment. Entrainment of fish larvae in the eddies formed over the shelf and movement of the eddies into estuarine systems have been known to occur (M. Dagg, personal communication). The cyclic occurrence of the Loop Current in the eastern gulf may affect recruitment along the Florida coast. Because there are no data on the areal distribution of late-stage larvae in gulf waters, the influence of the CBL and Loop Current on recruitment is not known. The Gulf of Mexico receives runoff from approximately two-thirds of the contiguous United States due to the drainage of the Mississippi River. As a result, the shelf and slope waters off Louisiana are highly productive. Recent studies suggest that coastal fronts may be important in larval survival of fish and that the timing, position and characteristics of shelf fronts can exert a major influence on recruitment success. Extremely high concentrations of phytoplankton and microzooplankton have been documented in frontal regions near the Mississippi outflow, and the number of larval fish in the vicinity of these fronts is usually much higher than for adjacent shelf waters. Processes relating to the aggregation of plankton (upwelling, entrainment in the CBL, shelf eddies, riverine plumes) and the extent to which they influence survival and dispersion of larvae are not well defined. The physical and behavioral mechanisms that allow for seaward and subsequent shoreward transport of blue crab larvae in the gulf are unknown.

The fact that short-term, small-scale, episodic events are thought to govern recruitment processes in a large portion of the gulf, coupled with the protracted spawning season (9 to 12 months), of blue crabs complicate interpretation of the effect of abiotic variables in recruitment success. Although the loss of a wave or a modal group may be possible, loss of a year-class would be unlikely.

12.2.2 Juveniles

Once in the estuary, carrying capacity and survival of recruits through the juvenile stage become the driving forces of year-class strength. The identification of distinct year-classes in the gulf is virtually impossible. Studies in all Gulf States have demonstrated that there is a constant succession of early crab stages in the estuary, with continual recruitment to the juvenile population (Section 5). The effect of specific environmental variables known to affect juvenile blue crab abundance have not been quantified. The inability to relate juvenile abundance to changes in physical parameters suggests that these environmental variables may function extrinsically. Research to date points to biotic variables relative to trophic phenomena as being instrumental in juvenile survivorship (Livingston et al. 1976).

Louisiana is the major producer of blue crabs in the gulf. Degredation and loss of critical habitat through erosion, subsidence and saltwater intrusion may have a profound influence on carrying capacity in that state and could affect stock abundance both locally and in neighboring states. The augmentation of catch in other Gulf States resulting from crabs moving from Louisiana may be significant. The winter crab fishery in western Mississippi Sound is dependent upon the migration of crabs from lakes Pontchartrain and Borgne (Perry 1975). In addition to biotic and abiotic environmental parameters, fishing practices destructive to survivorship of juveniles may affect stock abundance (i.e., use of saltboxes to cull bay shrimp catch).

12.3 Blue Crab Life History Characteristics Relevant to Management

Van Engel (1987) summarized blue crab life history characteristics relevant to management of the fishery in Chesapeake Bay as follows:

> "The blue crab is characterized by the annual production of a large number of young, interannual fluctuations in production, rapid growth, early attainment of maturity, high mortality, and a short life span. These are the characteristics of a density-independent species, exposed to a variable environment in which the population's resources are spent mostly on reproductive (r) functions. In short, the blue crab appears to be an "r" selected strategist. Because of these characteristics, the blue crab can be fished at high levels of fishing effort, and, because of the short life span and rapid succession of year classes, would have a quick recovery if overfishing occurred."

These basic concepts also apply to the gulf fishery. Differences in life history parameters for Chesapeake Bay and the Gulf of Mexico are a function of latitude (climate). In the gulf, crabs may reach maturity within 12 months as opposed to 18 months in Chesapeake Bay. Additionally, females spawn over a protracted period of time and may have multiple broods within a year.

12.4 The Blue Crab Fishery and the Relevance of Maximum Sustainable Yield (MSY)

Population models were initially developed for vertebrate fisheries with multiple year-classes, and their use to describe population characteristics of invertebrates has often not taken into consideration the difficulty of age determination, discontinuous growth, intensive seasonal fishing effort, seasonal variation in catchability, annual nature of the fishery, and difficulty in effort standardization. The use of traditional fishery models is hampered by the lack of quantitative and qualitative data on population dynamics of crustacean fisheries and the environmental forces affecting recruitment.

Tang (1983) used surplus production models to estimate blue crab populations in Chesapeake Bay. He concluded that regardless of the specific surplus production model used, estimates of MSY did not vary greatly. He further stated that based on available catch and effort statistics, blue crabs were being overfished in Chesapeake Bay. Van Engel (1987), however, noted that life history characteristics of blue crabs hindered the use of population models as many of the biological characteristics of blue crab stocks are undefined. He also noted that blue crab life history parameters were characteristic of a density-independent species, and thus precluded the use of MSY. He further stated "it is axiomatic that for populations fluctuating widely as a response to environmental variation that the maximum sustained yield cannot be realistically estimated."

Assumptions associated with the use of surplus production models further negate its usefulness in formulating management strategies for the blue crab fishery. Major assumptions associated with production models which do not apply are:

1) The fishery is in equilibrium, i.e., adjusted to and stabilized at the current level of fishing effort.
2) Environmental factors are constant.
3) The fishery is operating on a "unit stock," i.e., a stock capable of independent exploitation or management and containing as much of an inbreeding unit or as few reproductively isolated units as possible (Royce 1972).
4) The number of recruits and the natural mortality rates are constant regardless of stock size.
5) One unit of fishing effort produces the same relative effect on the stock, that is, it catches the same percentage of the stock, regardless of the time or place it is applied or regardless of the size of the stock.
6) The rate of natural increase of the stock responds immediately to changes in population density, i.e., the time lag between spawning and recruitment of progeny to the catchable stock is ignored.
7) The rate of natural increase at a given weight of population is independent of the age composition of the population.

In addition to these assumptions, the catch/effort data available for input into the model has serious limitations. There is a lack of comprehensive data on catch and catch per unit of effort in the commercial fisheries to derive MSY from surplus production models. Accurate catch and effort data is needed. NMFS data on number of fishermen refers to fishermen selling through licensed wholesale dealers; whereas state license sales refer to the number of fishermen buying licenses. The extent to which these differences in numbers of fishermen and thus number of traps fished would affect reported commercial landings is unknown. Processing capacity may also limit catch and effort, and marketing conditions may dictate processing volume. Further, the data do not address other blue crab fisheries; recreational, trawl by-catch and soft crab. The recreational fishery is thought to contribute significantly to total fishing pressure, and the soft crab fishery continues to expand with the advent of closed system shedding technology.

The determination of MSY is also hampered by gaps in life history data - recruitment of larvae in determining estuarine population levels of juveniles, influence of environmental variables on growth, distribution and survival, and migration patterns. Identification of discrete year-classes is complicated by a protracted spawning period and a continuous succession of early crab stages to estuarine nursery grounds.

12.4.1 <u>Specification of MSY</u>

Because of the conceptual problems in application of MSY to the blue crab fishery and the acknowledged inadequacies of the data base, a numerical estimate of MSY is not given.

12.4.2 <u>Optimum Yield (OY)</u>

Under National Standard Guidelines for Fishery Management Plans, the determination of OY requires a specification of MSY. However, even where sufficient scientific data as to the biological characteristics of the stock do not exist, or the period of exploitation or investigation has not been long enough for adequate understanding of stock dynamics, or where frequent large scale fluctuations in stock size make this concept of limited value, the OY should be based on the best scientific data available." Given the lack of data necessary to formulate a numerical value for MSY, OY is defined as:

> All the blue crabs that can be harvested while allowing for replenishment of the stock(s) and providing maximum benefits to the region in light of relevant social, economic and ecological considerations.

13.0 MANAGEMENT MEASURES - GENERAL REQUIREMENTS

13.1 General

The generally acknowledged purpose for a fishery management plan (FMP) and the subsequent regulations promulgated to implement the plan are to provide effective and responsive action in a manner consistent with the best interests of the nation. These actions must consider several factors including: conservation of the resource, economic stability of the fishery, economics, social interactions, habitat and others. These factors are contradictory and conflicting in many instances; however, in the FMP development process they all must be considered and weighed if sound integration of those concepts are to be achieved.

13.2 National Standards

In the FMP development process and the resulting document, the Blue Crab Technical Task Force was guided by the national standards set forth in Title III of P.L. 94-265 (the Magnuson Fishery Conservation and Management Act). This group was highly qualified to handle the technical aspects encountered developing the crab management plan. The national standards as referenced are:

1. Conservation and management measures shall prevent overfishing while achieving on a continuing basis the optimum yield from each fishery.

2. Conservation and management measures shall be based upon the best scientific information available.

3. To the extent practicable, an individual stock of fish shall be managed as a unit throughout its range, and interrelated stocks of fish shall be managed as a unit or in close coordination.

4. Conservation and management measures shall not discriminate between residents of different states. If it becomes necessary to allocate or assign fishing privileges among various United States fishermen, such allocation shall be: (a) fair and equitable to all such fishermen; (b) reasonably calculated to promote conservation; and (c) carried out in such manner that no particular individual, corporation, or other entity acquires an excessive share of such privileges.

5. Conservation and management measures shall, where practicable, promote efficiency in the utilization of fishery resources except that no such measure shall have economic allocation as its sole purpose.

6. Conservation and management measures shall take into account and allow for variations among, and contingencies in, fisheries, fishery resources and catches.

7. Conservation and management measures shall, where practicable, minimize costs and avoid unnecessary duplication.

14.0 SPECIFIC MEASURES TO ATTAIN MANAGEMENT OBJECTIVES

14.1 Definition of the Fishery

The fishery includes one species of crab in the United States Gulf of Mexico.

Common Name	Scientific Name
Blue Crab	*Callinectes sapidus* Rathbun

14.1.1 Management Unit

The management unit is the population of blue crab, *Callinectes sapidus*, occurring in the Gulf of Mexico, United States waters.

14.1.2 Goal

The goal of this plan is to provide a fair and equitable management strategy that allows for maintenance of the stocks and provides for optimum yield as defined in Section 12.4.2.

14.1.3 Management Rationale

Using Jamieson's (1986) definitions of management strategies, the proposed management plan for blue crab fisheries in the gulf is categorized as preventative in that it seeks to obtain optimum resource utilization over the long term. Such measures used in the gulf include protection of spawning stock, area closures, gear restrictions and protection of nursery grounds.

Although the intention of these current measures is to conserve the stock, their effectiveness is difficult to measure. Past management of the fishery in the gulf has emphasized the protection of egg-bearing females. While spawning stock must be sufficient to ensure recruitment, blanket protection of egg-bearing females in and of itself will not guarantee increased harvest. Identification and protection of critical habitat and a reduction in fishing mortality from non-directed, inshore fishing activities must be an integral part of the management plan if stocks are to be enhanced. This plan identifies those data necessary for development and implementation of a rational management strategy.

14.1.4 Objectives

1. To implement and complete a research and data collection program that will provide basic information necessary for the proper management of blue crabs in the Gulf of Mexico.

2. To encourage the adoption of a gulf-wide management strategy as specified in this plan. Such strategy should provide a stable management system enabling changes to be addressed and enacted on efficiently and effectively.

3. To provide for a program of plan evaluation in which the biological, social and economic impact of existing and proposed fisheries management regulations are assessed as necessary.

4. To minimize conflicts between user groups and develop management measures to reduce these conflicts.

5. To identify and encourage opportunities for conservation, restoration and enhancement of blue crab habitats.

6. To identify and promote use of more efficient gear and fishing techniques which enhance conservation measures (e.g., escape vents, alternative baits, optimal trap soak-time, onboard handling).

7. To minimize the waste of potential recruits to the fishery.

14.2 Specific Management Recommendations

14.2.1 Permits and Fees

Commercial and/or recreational licenses, in some form, are required in all Gulf States for harvesting hard crabs (Section 7.4). Florida requires a commercial license for harvesting peeler crabs for soft-shell crab shedding operations. Fees are established by statute.

14.2.1.1 Recommendation

Each gulf state should be able to identify commercial and recreational fishing effort for the harvesting of blue crabs and for directed harvesting and shedding of peeler crabs (premolt crabs used to produce soft-shell blue crabs).

14.2.1.2 Rationale

Separate identification should provide user-group information within the harvesting sectors (commercial and recreational). Such information should include data delineating seasonality and areal distribution of the resource as well as fishing effort. It could provide a user impact fee that would generate potential revenue for priority research programs including stock assessment, fisheries-independent/dependent monitoring, life history studies, recreational and industrial surveys, law enforcement activities and licensing administration.

14.2.2 Time and Area Restrictions

14.2.2.1 Time Restriction

Time restrictions are categorized as (1) open/closed fishing seasons, (2) hours traps may be tended and (3) trap soak-time. There are no time restrictions (fishing seasons) for the blue crab fishery in any gulf state. Florida, Alabama and Louisiana statutes require crab traps to be tended during daylight hours only (Section 7.4). Some local ordinances in Florida mandate a maximum 72 hour trap soak-time.

14.2.2.1.1 Recommendation

Each gulf state should consider that

1) crab traps are to be tended during daylight hours only, and
2) crab traps are to be removed from the water when not actively fished.

14.2.2.1.2 Rationale

Requirements for daylight tending only of traps and their removal from the water when not in use would help to reduce two of the more serious problems in the blue crab fishery, trap theft and ghost fishing.

14.2.2.2 Area Restriction

Texas, Louisiana and Mississippi have imposed local restrictions on blue crab fishing in specified areas (Section 7.4). No recommendations for area restrictions are made at this time. However, such recommendations on state or regional levels may become necessary when the population dynamics of the fishery are fully understood (e.g., location of nursery grounds) or when gear (shrimp trawls versus crab traps) or user group (commercial shrimp fishermen, recreational boaters/fishermen versus crab traps) conflicts arise.

14.2.3 Catch Limitations

14.2.3.1 Size

All Gulf States mandate minimum size limits for commercial harvesting of hard blue crabs and crabs used as bait or in soft-shell shedding operations (Section 7.4).

14.2.3.1.1 Recommendation

Each gulf state should consider regulations requiring a minimum five inch carapace width (cw) for hard blue crabs. Adult female blue crabs and those taken for soft-shell crab shedding or bait are exempted from this recommendation. Minimum size regulations may also be reevaluated in consideration of biological, social and economic factors. Regulations may be modified, if necessary, to allow attainment of OY as defined in Section 12.4.2.

14.2.3.1.2 Rationale

Justification for a five inch minimum size in the gulf and in the Atlantic states has generally been recognized as a standard established by the processing sector. The principal reasons are difficulty in processing small animals and minimal meat yield.

Unpublished data from Florida indicates that the five inch carapace width closely corresponds to sexual maturity for most female crabs (Phil Steele, personal communication). Adult females smaller than five inches may make up a substantial portion of the catch at certain times of the year and thus would be lost to the fishery if included in this recommendation as they cease to molt. With regard to soft-shell and bait industries, the majority of hard crabs taken in these fisheries are juvenile and smaller than five inches. The application of this recommendation would eliminate these fisheries.

14.2.3.2 Sex

With the exception of Alabama, all Gulf States provide various levels of protection for egg-bearing females (Section 7.4).

14.2.3.2.1 Recommendation

Regulations prohibiting possession or sale of egg-bearing females should be reevaluated taking into consideration biological, sociological and economic factors. Regulations should be modified, if necessary, to allow the attainment of OY as defined in Section 12.4.2.

14.2.3.2.2 Rationale

Annual fluctuations in blue crab stocks are common in the gulf even though egg-bearing females have been protected for many years. Estuarine recruitment of postlarvae (megalopae) is determined in large part by density-independent variables, and a large spawning stock does not ensure increased adult abundance. Fluctuations in catch occur even in those crab fisheries where all females have been protected from harvest (Methot 1986). Some portion of the spawning stock must be maintained to provide for adequate recruitment; however, total protection of egg-bearing females is not biologically justified (Section 12.1) and may prevent attainment of OY in some states. Management strategies that are concerned solely with protection of spawning stocks are flawed in that they do not address sources of juvenile mortality (both natural and fishing).

14.2.4 Gear Restrictions

Mississippi, Louisiana and Texas limit the use of or prohibit specific types of gear in the blue crab fishery (Section 7.4).

14.2.4.1 Recommendations

1. Establish a trap identification system.
2. Utilize biodegradable escape panels.
3. Discourage the use of destructive species-specific culling practices in the bay shrimp fishery.
4. Encourage use of escape vents on crab traps not used to capture peelers.

14.2.4.2 Rationale

Establishment of a trap identification system will ensure trap accountability thus reducing trap theft and ghost fishing while facilitating law enforcement. The use of biodegradable escape panels will reduce ghost fishing by abandoned or lost traps. Discouragement of the use of species-specific culling devices (salt boxes) in the bay shrimp fishery will aid in reducing juvenile and adult mortality. The use of escape vents on traps not used for capture of peeler crabs will (1) reduce sub-legal catch, (2) increase or maintain legal catch, (3) reduce culling time and (4) reduce ghost fishing.

14.2.5 State, Local and Other Laws and Policies

A legal matrix incorporating all state laws pertaining to the Gulf of Mexico blue crab fishery is presented in Section 7.4. The section includes information on licensing, size and gear limitations, areas and penalties for violations.

14.2.6 Limited Entry

Attainment of OY may mandate that some form of limited entry may be necessary to allow the attainment of OY as defined in Section 12.4.2 in order to achieve maximum economic benefits to the fishery.

14.2.7 Habitat Conservation, Protection and Restoration

Habitat conservation, protection and restoration are essential to accomplishment of the goal and objectives of this plan. Each state has statutes, regulations and ongoing programs directed toward environmental enhancement favorable to blue crab habitat.

14.2.8 Total Allowable Level of Foreign Fishing

Since the United States' fishery is capable of fully utilizing the resource, there is no surplus available for foreign allocation.

15.0 REGIONAL RESEARCH PRIORITIES AND DATA REQUIREMENTS

The Interjurisdictional Fisheries Act established a program to promote and encourage regional management of those fisheries resources that cross administrative and geographic boundaries. Blue crab life history parameters necessitate a regional approach to both management and research. Tagging programs in Florida and Mississippi have documented the movement of crabs between states. Additionally, larval transport mechanisms may distribute zoeae and megalopae away from their home estuaries; spawning stock in one state may be responsible for recruitment in adjoining states. The harvesting sector is also characterized by high mobility. In the gulf, movement of fishermen between states is common, and trucking of crabs from one state to another to maintain supply of raw product to processing plants is routine. It is a fishery in which both stocks and harvesters are highly mobile. Attainment of the goals and objectives as defined in this plan will require long-range planning, coordination and funding for interstate research programs. Tagging, larval recruitment, monitoring and assessment of juveniles and stock identification programs require a multi-state approach. Standardized, gulf-wide data gathering systems that address all segments of the harvesting sector must be developed. Sources of juvenile mortality should be identified and quantified. Industrial surveys that provide data on catch per unit of effort, seasonal and areal distribution of catch, and size and sex composition of the commercial catch are long overdue. Reported landings in the U.S. Gulf of Mexico totalled 78.3 million pounds in 1988 with a dockside value of 29.7 million dollars. The fishery ranks fourth in the gulf after shrimp, menhaden and oysters in both pounds landed and value (NMFS Statistical Digest 1989). Lack of comprehensive harvest and industrial data has led to an underestimation of the economic importance of the blue crab fishery and has contributed to a perception of the fishery as one of "low-priority" in terms of funded research.

15.1 Research and Data Base Development (not prioritized)

15.1.1 Biological

1) distribution of _Callinectes sapidus_ zoeae and megalopae in offshore waters;
2) mechanisms of larval transport;
3) role of offshore recruitment of larvae in determining estuarine populations of juveniles;
4) influence of environmental variables on growth, distribution and survival;
5) abundance, distribution and habitat utilization of juvenile blue crabs;
6) migration patterns;
7) influence of parasites on subsequent levels of harvestable adults;
8) distribution and abundance of premolt crabs (peelers);
9) predator/prey relationships;
10) stock identification-genetic variation in blue crab stock(s).

15.1.2 Environmental

1) identification of sources of environmental degradation and the impact of habitat alteration on all phases of blue crab life history;
2) impact of salinity intrusion and freshwater inflow on blue crab nursery grounds;
3) impact of marsh and wetland loss on blue crab stocks.

15.1.3 Industrial

1) integrated data on the effects of different processing techniques on relative yield, quality and bacterial counts of picked crab meat;
2) economic impact of existing and proposed management regulations (e.g., size limits, protection of egg bearing females) on the processing sector;
3) industrial survey of catch per unit of effort, size, sex and weight of processed hard and soft-shell crabs.

15.1.4 Technological

1) development of an artificial crab bait;
2) utilization of crab waste.

15.1.5 Fisheries

1) effects of biodegradable escape panels, rings and vents on catch;
2) impacts of onboard culling practices in the crab fishery;
3) impact of ghost fishing on crab stocks;
4) impact of shrimping activities (by-catch, use of salt boxes for culling);
5) survey of incidental crab catch in other fisheries;
6) development of alternative trap designs, marking and retrieval systems;
7) development of alternative methods for harvesting peeler crabs for the soft shell fishery;
8) development of yield-per-recruit models.

15.1.6 Economic

1) data from harvesting, processing and marketing sectors for accurate assessment of economic impact of the hard and soft shell fishery;
2) data on the economic impact of existing and proposed management regulations on all sectors of the fishery;
3) data on the economic interdependency of the crab fishery with other fisheries;
4) data on the economic interdependencies of interregional landings and prices;
5) data on the economic impact of the recreational fishery.

15.1.7 Sociological

1) data on sociological and cultural impacts of ethnic diversity on all sectors of the fishery.

16.0 REVIEW AND MONITORING OF THE PLAN

The blue crab fishery management plan (FMP) is intended to provide fair and equitable management measures that allow for maintenance of the stocks and provide for optimum yield as defined in Section 12.4.2. The recommended strategy is to operate through the Crab Subcommittee of the Technical Coordinating Committee, Gulf States Marine Fisheries Commission. The subcommittee should review the status of the fishery as necessary with a report to be submitted to the Technical Coordinating Committee and the Fisheries Management Committee of the Gulf States Marine Fisheries Commission.

17.0 REFERENCES

Adkins, G. 1972a. Study of the blue crab fishery in Louisiana. Louisiana Wildlife and Fisheries Commission, Technical Bulletin 3, Baton Rouge, Louisiana, USA.

Adkins, G. 1972b. Notes on the occurrence and distribution of rhizocephalan parasite (Loxothylacus texanus Boschma) of blue crabs (Callinectes sapidus Rathbun) in Louisiana estuaries. Louisiana Wildlife and Fisheries Commission, Technical Bulletin 2, Baton Rouge, Louisiana, USA.

Adkins, G. 1982. The blue crab fishery of Louisiana. Pages 15-16 in H.M. Perry and W.A. Van Engel (editors), Proceedings Blue Crab Colloquium, Publication 7, Gulf States Marine Fisheries Commission, Ocean Springs, Mississippi, USA.

Andrews, E. 1947. Crab pot construction (Chesapeake Bay type). U.S. Fish and Wildlife Service, Fishery Leaflet Number 262, 4 pp.

Andryszak, B.L. 1979. Abundance, distribution and partial descriptions of reptant decapod crustacean larvae collected from neritic Louisiana waters in June, 1976. Master of Science Thesis, Louisiana State University, Baton Rouge, Louisiana, USA.

Benedict, 1940. Soft crabs-and hard. Louisiana Conservation Review, 48:11-48.

Benefield, R.L. 1968. Survey of the blue crab (Callinectes sapidus Rathbun) sport fishery of the Galveston Bay system 1968. Texas Parks and Wildlife, Coastal Fisheries Project Report 1968, Austin, Texas, USA.

Benefield, R.L. and T. Linton. 1990. Movement study of blue crabs in Trinity Bay. Texas Parks and Wildlife Department, Fisheries Division, Coastal Fisheries Branch, Management Data Series Number 16, Austin, Texas.

Beckert, H. and J. Brashier. 1981. Final environmental impact statement, proposed OCS oil and gas sales 67 and 69. Department of the Interior, Bureau of Land Management, New Orleans, Louisiana, USA.

Beverton, R.J.H. and S.J. Holt. 1957. On the dynamics of exploited fish populations. Fish. Invest. London, Ser. II, 19:1-533.

Blott, A.J. 1978. A preliminary study of timed release mechanisms for lobster traps. Marine Fisheries Review 40(5-6):44-49.

Boesch, D.F. and M.J. Dagg. 1986. Recruitment processes: scientific issues and approaches. Gulf of Mexico Workshop. Mimeo. 27 pp.

Bookhout, C.G. and J.D. Costlow, Jr. 1974. Larval development of Portunus spinicarpus reared in the laboratory. Bulletin of Marine Science 24:20-51.

Bookhout, C.G. and J.D. Costlow, Jr. 1977. Larval development of Callinectes similis reared in the laboratory. Bulletin of Marine Science 27:704-728.

Brown, K.F. 1982. Crab scrap - conventional and prospective utilization. Pages 227-228 in H.M. Perry and W.A. Van Engel, editors. Proceedings Blue Crab Colloquium, Publication 7, Gulf States Marine Fisheries Commission, Ocean Springs, Mississippi, USA.

Cable, R.M. and A.V. Hunninen. 1940. Studies on the life history of Spelotrema nicolli (Trematoda: Microphallidae) with the description of a new microphallid cercaria. Biological Bulletin 78(1):136-157.

Cameron, J.N. and C.M. Wood. 1985. Apparent H+ excretion and CO_2 dynamics accompany carapace mineralization in the blue crab (Callinectes sapidus) following moulting. Journal of Experimental Biology 114:181-196.

Cargo, D.G. 1958. Sizes of crabs compared. Maryland Tidewater News 13(3):1-4.

Carpenter, J.H. and D.G. Cargo. 1957. Oxygen requirements and mortality of the blue crab in the Chesapeake Bay. Johns Hopkins University Chesapeake Bay Institute, Technical Report 13.

Carriker, M.R. 1967. Ecology of estuarine benthic invertebrates: a perspective. Pages 442-487 in G.H. Lauff (editor), Estuaries, AAAS Publication 1983.

Chace, F.A., Jr. and H.H. Hobbs, Jr. 1969. The freshwater and terrestrial decapod crustaceans of the West Indies with special reference to Dominica. U.S. National Museum Bulletin 292, 258 p.

Christmas, J.Y., Jr. 1969. Parasitic barnacles in Mississippi estuaries with special reference to Loxothylacus texanus Boschma in the blue crab (Callinectes sapidus). Proceedings Annual Conference Southeast Association Game Fish Commissions 22:272-275.

Christmas, J.Y., Jr. and W. Langley. 1973. Estuarine invertebrates, Mississippi. Pages 255-317 in J.Y. Christmas, Jr. (editor), Gulf of Mexico Estuarine Inventory and Study, Mississippi. Gulf Coast Research Laboratory, Ocean Springs, Mississippi.

Churchill, E.P., Jr. 1921. Life history of the blue crab. Bulletin U.S. Bureau of Fisheries 36:95-128.

Churchill, E.P., Jr. 1942. The zoeal stages of the blue crab, Callinectes sapidus Rathbun. Publication of the Chesapeake Biological Laboratory 49:1-26.

Cochrane, J.E. 1965. The Yucatan Current, in Annual Report, Project 286, Texas A&M University, Ref. 65-17T College Station, 20-27.

Cook, D.W. and S.R. Lofton. 1973. Chitinoclastic bacteria associated with shell disease in Penaeus shrimp and the blue crab (Callinectes sapidus). Journal of Wildlife Diseases 9:154-159.

Costa, R.E., Jr. 1978. The fertilizer value of shrimp and crab processing wastes. Master of Science Thesis, Oregon State University, Corvallis, Oregon, USA.

Costlow, J.D., Jr. and C.G. Bookhout. 1959. The larval development of Callinectes sapidus Rathbun reared in the laboratory. Biological Bulletin 116(3):373-396.

Costlow, J.D., Jr. and A.N. Sastry. 1966. Free amino acids in developing stages of two crabs, Callinectes sapidus Rathbun and Rnithropanopeus harrisii Gould. Acta Embryologiae Morphologiae Experimentalis 9:44-55.

Costlow, J.D., Jr. 1967. The effect of salinity and temperatures on survival and metamorphosis of megalops of the blue crab, Callinectes sapidus Rathbun. Helgolaender Wissenschafliche Meeresuntersuchungen 15:84-97.

Couch, J.A. 1966. Two peritrichous ciliates from the gills of the blue crab. Chesapeake Science 7(3):171-173.

Couch, J.A. and S. Martin. 1982. Protozoan symbionts and related diseases of the blue crab, Callinectes sapidus Rathbun from the Atlantic and gulf coasts of the United States. Pages 71-80 in H.M. Perry and W.A. Van Engel (editors), Proceedings Blue Crab Colloquium, Publication 7, Gulf States Marine Fisheries Commission, Ocean Springs, Mississippi, USA.

Cronin, L.E. 1950. The Maryland crab industry, 1949. Chesapeake Biological Laboratory, Solomons, Maryland, Publication Number 84, 41 p.

Cronin, L.E., W.A. Van Engel, D.G. Cargo, and F.J. Wojcik. 1957. A partial bibliography of the genus Callinectes. Virginia Fisheries Laboratory, Special Scientific Report 8; and Maryland Department of Resource Education, Ref. 57-26, 21 p.

Cronin, L. Eugene (editor). 1987. Report of the Chesapeake Bay blue crab management workshop. The Chesapeake Commission.

Dagg, M. Personal communication. Louisiana University Marine Consortium, Chauvin, Louisiana, USA.

Darnell, R.M. 1958. Food habits of fishes and larger invertebrates of Lake Pontchartrain, Louisiana, an estuarine community. Publication of the Institute of Marine Science, University of Texas 5:353-416.

Darnell, R.M. 1959. Studies of the life history of the blue crab Callinectes sapidus Rathbun in Louisiana waters. Transactions of the American Fisheries Society 88(4):294-304.

Darnell, R.M. 1961. Trophic spectrum of an estuarine community, based on studies of Lake Pontchartrain, Louisiana. Ecology 42(3):553-568.

Daud, N.M.B. 1979. Distribution and recruitment of juvenile blue crabs, Callinectes sapidus, in a Louisiana estuarine system. Master of Science Thesis, Louisiana State University, Baton Rouge, Louisiana, USA.

Daugherty, F.M., Jr. 1952. The blue crab investigation, 1949-50. Texas Journal of Science 4(1):77-84.

Davis, C.C. 1965. A study of the hatching process in aquatic invertebrates. XX. The blue crab, Callinectes sapidus Rathbun. XXI. The nemertean Carcinonemertes carcinophila (Kolliker). Chesapeake Science 6(4):201-208.

Davis, J.W. and R.K. Sizemore. 1982. Incidence of Vibrio species associated with blue crabs (Callinectes sapidus) collected from Galveston Bay, Texas. Applied and Environmental Microbiology 43(5):1092-1097.

Deblock, S. 1971. Contribution a l'etude des Microphallidae Travassos, 1920 XXIV. Tentative de phylogenie et de taxonomie. Bulletin du Museum National d'Histoire Naturelle Zoologie 7:353-468.

Dendinger, J.E. and A. Alterman. 1983. Mechanical properties in relation to chemical constituents of postmolt cuticle of the blue crab, Callinectes sapidus. Comparative Biochemical Physiology 75A:421-424.

Dietrich, Gunter. 1939. Das Amerikanische Mittelmeer. Gesellsch. f. Erdkunde zu Berlin, Zeitschr., pp. 108-130.

Dressel, D.M. and D.R. Whitaker. 1982. An economic profile of the blue crab industry (preliminary draft). Regulations Coordination Branch, Fisheries Development Division, National Marine Fisheries Service, Washington, DC, USA (mimeo).

Drummond, K.H. and G.B. Austin, Jr. 1958. Some aspects of the physical oceanography of the Gulf of Mexico, in U.S. Fish and Wildlife Service, Gulf of Mexico physical and chemical data from Alaska cruises: U.S. Fish and Wildlife Service Special Scientific Report-Fisheries 249:5-13.

Eldridge, P.J. and W. Waltz. 1977. Observations on the commercial fishery for blue crabs, Callinectes sapidus, in estuaries in the southern half of South Caroline. South Carolina Marine Resources Center, Technical Report 21, 35 p.

Eldrige, P.J., V.G. Burrell, Jr., and G. Steele. 1979. Development of a self-culling blue crab pot. Marine Fisheries Review 41(11-12):21-27.

Epifanio, C.E., C.C. Valenti, and A.E. Pembroke. 1984. Dispersal and recruitment of blue crab larvae in Delaware Bay, U.S.A. Estuarine Coastal Shelf Science 18:1-12.

Etzold, D.J. 1980. Management, planning and organization in initiating, supporting and coordinating an ongoing freshwater diversion project. Readings on the Environment: Economic and Management implications.

Evink, G.L. 1976. Some aspects of the biology of the blue crab, Callinectes sapidus Rathbun, on Florida's gulf coast. Master of Science Thesis, University of Florida, Gainesville, Florida, USA.

Fiedler, R.H. 1930. Solving the question of crab migrations. Fishing Gazette 47(6):18-21.

Fischler, K.J. and C.H. Walburg. 1962. Blue crab movement in coastal South Carolina, 1958-59. Transactions of the American Fisheries Society 91(3):275-278.

Flick, G.J., C.F. Shoemaker, D.R. Ward, C.B. Wood, C.L. Rudolph, M. Moody, J. Janssen, and E. Nelson. 1976. Maintenance and test procedures. Section 11. Thermal Processing: Pasteurization Manual for the Blue Crab Industry. Sea Grant, Extension Division, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, USA.

Floyd, H.M. 1968. A trotline for blue crabs. U.S. Fish and Wildlife Service, Fishery Leaflet 616, Washington, DC, USA.

Fontenot, B.J. and H.E. Rogillio. 1970. A study of estuarine sportfishes in the Biloxi marsh complex. Louisiana Wildlife and Fisheries Commission, Completion Report F-8, Dingell-Johnson Project, Baton Rouge, Louisiana, USA.

Forbus, P.R., J.S. Thomas, W. Hosking, R.K. Wallace, J. Maes and S. Chang. 1989. The commercial seafood industry in Alabama, Center for Business and Economic Research Research Report 20, Coastal Research and Development Institute, University of South Alabama.

Franks, J.S., J.Y. Christmas, W.L. Siler, R. Combs, R. Waller and C. Burns. 1972. A study of nektonic and benthic faunas of the shallow Gulf of Mexico off the state of Mississippi as related to some physical, chemical and geological factors. Gulf Research Reports 4:1-148.

Freeman, J.A. and H. Perry. 1986. The crustacean molt cycle and hormonal regulation: its importance in soft shell blue crab production. Pages 23-30 in H.M. Perry and R.F. Malone (editors), Proceedings National Symposium on the Soft-Shelled Blue Crab Fishery. MASGP-86-017.

Freeman, J.A., D. Laurendeau, G. Kilgus, and H. Perry. 1986. Delayed hardening in blue crabs. Northeast Gulf Science 8(2):177-179.

Freeman, J.A., D. Laurendeau, G. Kilgus, and H.M. Perry. 1987. Postmolt and intermolt molt cycle stages of Callinectes sapidus. Aquaculture 61(1987):201-209.
Freeman, J.A., D. Laurendeau, H. Perry, and C. Trigg. 1987. Low calcium recirculating seawater/20-hydroxyecdysone: potential benefits to the soft shell crab fishery. Proceedings of the Second National Soft-Shelled Symposium, Virginia Institute of Marine Science, Gloucester Point, Virginia (in press).
Gallaway, B.J. and K. Strawn. 1975. Seasonal abundance and distribution of the blue crab, Callinectes sapidus Rathbun, in the discharge area of the P.H. Robinson Generating Station, Galveston Bay, Texas. Journal of Science 26:185-201.
Galstoff, P. (editor). 1954. Gulf of Mexico, its origin, waters, and marine life. Fisheries Bulletin 55(89):1-604.
Garcia, S. 1983. The stock-recruitment relationship in shrimps: reality or artifacts and misinterpretations? Oceanogr. Trop. 18:25-48.
Gates, K.W., J.G. Eudaly, A.H. Parker, and L.A. Pitman. 1985. Water quality of two closed recirculating soft shell crab shedding facilities. Technical Report 85-6. Marine Extension Service, University of Georgia.
Gowanloch, James Nelson. 1952. The Louisiana crab fishery. Louisiana Conservationist 4(9-10):6-9.
Green, J.C. 1952. Effectiveness of crab traps in South Carolina. Contributions from Bars Bluff Laboratories, Number 14, 12 pp.
Grice, G.D., M.D. Grosslein, P.H. Wiebe, S. Murawski, and C.S. Davis. 1984. Woods Hole Oceanographic Institution, Northeast Fisheries Center Fisheries Ecology Seminar Series. Mimeo. 23 pp.
Grulich, P.R. and W.D. DuPaul. 1989. Feasibility of crab meal processing in the Chesapeake Bay Region; II. An integrated economic analysis for Hampton-Newport News, Virginia. Special Report in Applied Marine Science and Ocean Engineering. Virginia Institute of Marine Science 273:1-41.
Guillory, V. and J. Merrell. 1988. An evaluation of escape rings in blue crab traps. Unpublished manuscript. Louisiana Department of Wildlife and Fisheries, Baton Rouge, Louisiana, USA.
Guillory, V. 1989a. Effects of escape vents on catch rates of premolt blue crabs. Unpublished manuscript. Louisiana Department of Wildlife and Fisheries, Baton Rouge, Louisiana, USA.
Guillory, V. 1989b. An evaluation of different escape vents in blue crab traps. Unpublished manuscript. Louisiana Department of Wildlife and Fisheries, Baton Rouge, Louisiana, USA.
Guillory, V. 1989c. Ghost fishing in blue crab traps. Louisiana Department of Wildlife and Fisheries. Unpublished report, 36 pp.
Gunter, G. 1938. The common blue crab in fresh waters. Science 87(2248):87-88.
Gunter, G. 1945. Studies on marine fishes of Texas. Publication of the Institute of Marine Science, University of Texas 1(1):1-190.
Gunter, G. 1950. Seasonal population changes and distributions, as related to salinity of certain invertebrates of the Texas coast, including the commercial shrimp. Publications of The Institute of Marine Science, University of Texas 1(2):7-51.
Gunter, G. and H.H. Hildebrand. 1951. Destruction of fishes and other organisms on the south Texas coast by the cold wave of January 23-February 3, 1951. Ecology 32:731-736.
Gunter, G. and C.H. Lyles. 1979. Localized plankton blooms and jubilees on the gulf coast. Gulf Research Reports 6(3):297-299.
Haefner, P.A., Jr. and C.N. Shuster, Jr. 1964. Length increments during terminal molt of the female blue crab, Callinectes sapidus, in different salinity environments. Chesapeake Science 5(3):114-118.
Haefner, P.A., Jr. and D. Garten. 1974. Methods of handling and shedding blue crab, Callinectes sapidus. Virginia Institute of Marine Sciences Marine Resources Advisory 8, and Special Report Applied Marine Sciences 5:114-118.
Hall, W.R., Jr. 1976. Delaware's blue crab. University of Delaware Sea Grant Program, Delaware Marine Advisory Services Publication 11.
Hamilton, P.V. 1976. Predation on Littorina irrorata (Mollusca: Gastropoda) by Callinectes sapidus (Crustacea: Portunidae). Bulletin of Marine Science 26(3):403-409.
Hammerschmidt, P.C. 1982. Population trends and commercial harvest of the blue crab Callinectes sapidus Rathbun, in Texas bays September 1978-August 1979. Texas Parks and Wildlife, Coastal Fisheries Branch, Management Data Series 38, Austin, Texas, USA.
Harris, A.H. and J.C. Ragan. 1970. Observations on the ecology and incidence of Loxothylacus texanus (Boschma), parasite in the blue crab (Callinetes sapidus Rathbun) in south Louisiana. Proceedings Southwest Association of Parasitology, Abstract.
Harris, R.E., Jr. 1982. Life history, ecology, and stock assessment of the blue crab Callinectes sapidus of the United States Atlantic coast - a review. Pages 59-63 in H.M. Perry and W.A. Van Engle (editors), Proceedings of the Blue Crab Colloquium, Publication 7, Gulf States Marine Fisheries Commission, Ocean Springs, Mississippi, USA.
Hay, W.P. 1905. The life history of the blue crab (Callinectes sapidus). Report U.S. Bureau of Fisheries, 1904, p. 395-413.
Healy, M.C. 1984. Multiattribute analysis and the concept of optimum yield. Can. Jour. Fish. Aquat. Sci. 41:1393-1406.
Heard, R.W., Jr. 1976. Microphallid trematode metacercariae in fiddler crabs of the genus Uca Leach, 1814 from the northern Gulf of Mexico. Doctoral dissertation. University of Southern Mississippi, Hattiesburg, Mississippi. 179 pp.
Heard, R.W., Jr. 1982. Guide to common tidal marsh invertebrates of the northeastern Gulf of Mexico. Mississippi-Alabama Sea Grant Consortium, MASGP-79-004.
Heard, R.W., Jr. Personal communication. Gulf Coast Research Laboratory, P.O. Box 7000, Ocean Springs, Mississippi, USA.
Herke, W. 1985. Weirs: pros and cons. Aquanotes 14(3).
Herring, R. and J.Y. Christmas, Jr. 1974. Blue crabs for fun... and food. Mississippi Game and Fish 1974:12-14.

Hines, A.H., T.G. Wolcott, and A.M. Haddon. 1987. Predator-prey interactions of blue crabs in a sub-estuary of central Chesapeake Bay. Smithsonian Environmental Research Center, Portunid Ecology Workshop, Abstract, Edgewater, Maryland, USA.

Holland, J.S., D.V. Aldrich, and K. Strawn. 1971. Effects of temperature and salinity on growth, food conversion, survival and temperature resistance of juvenile blue crab, Callinectes sapidus Rathbun. Texas A&M University, Sea Grant Collection TAMU-SG-71-222:166 pp.

Holt, J., M. Bartz, and J. Lehman. 1982. Regional environmental impact statement, Gulf of Mexico. Department of the Interior, Minerals Management Service. 735 pp.

Hopkins, S.H. 1947. The nemertean Carcinomertes as an indicator of the spawning history of the host, Callinectes sapidus. Journal of Parasitology 33(2):146-150.

Husby, F.M., A.L. Brundage, and R.L. White. 1981. Utilization of shellfish meals in domestic feeds. Pages 230-260 in W.S. Otwell (editor), Seafood Waste Management in the 1980's: Conference. Proceedings Florida Sea Grant College, Report 40.

Hutton, R.F. and F. Songandares-Bernal. 1959. Notes on the distribution of the leech, Myzobdella lugubris Leidy, and its association with mortality of the blue crab, Callinectes sapidus Rathbun. Journal of Parasitology 45(4):384,404,430.

Ichiye, T. 1962. Circulation and water mass distribution in the Gulf of Mexico. Geofisica Internac. 2:47-76.

Isaacson, P.A. 1962. Modification of the Chesapeake Bay commercial crab pot. Master of Science Thesis, Virginia Institute of Marine Science, Gloucester Point, Virginia, U.S.A.

Jamieson, G.S. 1986. A perspective on invertebrate fisheries management - the British Columbia experience. In G.S. Jamieson and N. Bourne (editors), North Pacific Workshop on Stock Assessment and Management of Invertebrates. Can. Spec. Publ. Fish. Aquat. Sci. 92:57-74.

Jaworski, E. 1971. Decline of the soft-shell blue crab fishery in Louisiana. Texas A&M University, Environmental Quality Note 4, College Station, Texas, USA.

Jaworski, E. 1972. The blue crab fishery, Barataria estuary. Center for Wetland Resources, Louisiana State University, LSU-SG-72-01, Baton Rouge, Louisiana, USA.

Jaworksi, E. 1982. History and status of Louisiana's soft-shell blue crab fishery. Pages 153-157 in H.M. Perry and W.A. Van Engel (editors), Proceedings Blue Crab Colloquium, Publication 7, Gulf States Marine Fisheries Commission, Ocean Springs, Mississippi, USA.

Johnson, D.F. 1983. A comparison of recruitment strategies among brachyuran crustacean megalopae of the York River, lower Chesapeake Bay, and adjacent shelf waters. Doctoral Dissertation, Old Dominion University, Norfolk, Virginia, USA.

Jones, James I., Ronald E. Ring, Murice O. Rinkel, and Robert E. Smith (editors). 1973. A summary of knowledge of the eastern Gulf of Mexico, State University System of Florida Institute of Oceanography, St. Petersburg, Florida.

Judy, M.H. and D.L. Dudley. 1970. Movements of tagged blue crabs in North Carolina waters. Commercial Fisheries Review 32(11):29-35.

Kalber, F.A. 1970. Osmoregulation in decapod larvae as a consideration in culture techniques. Helgolaender Wissenschafliche Meeresunters 20:697-706.

Keel, J.A. and D.W. Cook. 1975. Isolation of Vibrio parahaemolyticus from the Mississippi Sound. Journal of the Mississippi Academy of Science 20:30-34.

Keithly, W.R., K. Roberts, and C. Adams. 1988. Economic analysis of Gulf of Mexico shell fish processing industry. Proceedings of the 13th Annual Tropical and Subtropical Conference of the Americas. Florida Sea Grant Report SGR/92.

King, B.D., III. 1971. Study of migratory patterns of fish and shellfish through a natural pass. Texas Parks and Wildlife Department, Technical Series 9, Austin, Texas, USA.

Koenig, C.C., R.J. Livingston, and C.R. Cripe. 1976. Blue crab mortality: interaction of temperature and DDT residues. Archives of Environmental Contamination and Toxicology 4:119-128.

Krantz, G.E. and J. Chamberlin. 1978. Blue crab predation on cultchless oyster spat. Proceedings National Shellfisheries Association, 68:38-41.

Landrum, P.D. and F.J. Prochaska. 1980. The Florida commercial blue crab industry: landings, prices and resource productivity. Florida Sea Grant College, Report 34, Gainesville, Florida, USA.

Laughlin, R.A. 1982. Feeding habits of the blue crab, Callinectes sapidus Rathbun, in the Apalachicola estuary, Florida. Bulletin of Marine Science 32:807-822.

Leffler, C.W. 1972. Some effects of temperature on the growth and metabolic rate of juvenile blue crabs, Callinectes sapidus, in the laboratory. Marine Biology 14:104-110.

Lindall, W.N., Jr., A. Mager, Jr., G.W. Thayer, and D.R. Ekberg. 1979. Estuarine habitat mitigation planning in the southeast. Pages 129-135 in G.A. Swanson (Technical Coordinator), The Mitigation Symposium: A National Workshop on Mitigating Losses of Fish and Wildlife Habitats. U.S. Forest Service, Rocky Mountain Forest Range Experimental Station. General Technical Report RM-65.

Livingston, R.J., G.J. Kobylinski, F.G. Lewis, III, and P.F. Sheridan. 1976. Long-term fluctuations of epibenthic fish and invertebrate populations in Apalachicola Bay, Florida. Fisheries Bulletin 74(2):311-321.

Lowe, J.I., P.R. Parrish, A.J. Wilson, Jr., P.D. Wilson, and T.W. Duke. 1971. Effects of mirex on selected estuarine organisms. Transactions of the North American Wildlife and Natural Resources Conference 36:171-186.

Lunz, G.R., Jr. 1946. Callinectes versus Ostrea. Journal of the Elisha Mitchell Scientific Society 62:81.

Lyles, C.H. 1976. A management plan for Mississippi's marine fisheries. Mississippi Marine Conservation Commission, Biloxi, Mississippi, USA.

Mager, A., Jr. and G.W. Thayer. 1986. Quantification of National Marine Fisheries Service habitat conservation efforts in the southeast region of the United States from 1981 through 1985. Marine Fisheries Review 43(3):1-8.

Mager, A., Jr. and E.J. Keppner. 1987. National Marine Fisheries Service habitat conservation efforts in the coastal southeastern United States for 1986. Pages 49-70 in N.V. Brodtman, Jr. (editor), Fourth Water Quality and Wetlands Management Conference Proceedings. New Orleans, Louisiana, USA.

Malone, R.F. and D.G. Burden. 1987. High rate nitrification in recirculating blue crab shedding systems in Michael Oesterling and Christine Plummer (editors), Proceedings of the Second National Symposium on the Soft-Shell Blue Crab Fishery, Virginia Institute of Marine Science (in press).

Malone, Ronald F. and Daniel G. Burden. 1988. Design of recirculating blue crab shedding systems. Louisiana Sea Grant Program. Center for Wetland Resources. Louisiana State University.

Mahood, R., M. McKenzie, D. Middaugh, S. Bollar, J. Davis, and D. Spitsbergen. 1970. A report on the cooperative blue crab study - south Atlantic states. Georgia Game and Fish Commission, Coastal Fisheries Contribution Series Number 19, Brunswick, Georgia, USA.

Manthe, D.P., R.F. Malone, and S. Kumar. 1984. Limiting factors associated with nitrification in closed blue crab shedding systems. Journal of Aquacultural Engineering, Volume 3:119-140.

Manthe, D.P., R.F. Malone, and H. Perry. 1983. Water quality fluctuations in response to variable loading in a commercial closed blue crab shedding system. Journal of Shellfish Research, Volume 3(2):175-182.

Manthe, D.P. and R.F. Malone. 1987. Chemical addition for accelerated biological filter acclimation in closed blue crab shedding systems. Journal of Aquacultural Engineering, Volume 21(4):385-394.

Marshall, N. 1954. Factors controlling the distribution of oysters in a natural estuary. Ecology 35:322-327.

May, E.B. 1973. Extensive oxygen depletion in Mobile Bay, Alabama. Limnology and Oceanography 18:353-366.

May, J.R. and L.D. Britsch. 1987. Geological investigations of the Mississippi River deltaic plain: land loss and accretion. U.S. Army Corps of Engineers, Waterways Experiment Station, Technical Report G11-87-13.

McHugh, J.L. 1966. Management of estuarine fisheries. Pages 133-154 in R.F. Smith, A.H. Swartz, and W.H. Massman (editors), A Symposium on Estuarine Fisheries, American Fisheries Society Special Publication Number 3. Washington, DC, USA.

McKenzie, M.D. 1970. Fluctuations in abundance of the blue crab and factors affecting mortalities. South Carolina Wildlife Resources Department, Technical Report Number 1, Charleston, South Carolina, USA.

Meeter, D.A., R.J. Livingston, and G.C. Woodsum. 1979. Long term climatological cycles and population changes in a river-dominated estuarine system. Ecological Processes in Coastal and Marine Systems. Marine Science 10:315-338.

Methot, R.D., Jr. 1986. Management of dungeness crab fisheries. In G.S. Jamieson and N. Bourne (editors), North Pacific Workshop on Stock Assessment and Management of Invertebrates. Can. Spec. Publ. Fish. Aquat. Sci. 92:326-334.

Menzel, R.W. 1964. Report on preliminary studies on the blue crab in Alligator Harbor and adjacent Gulf of Mexico with some observations on stone crab larvae. Oceanographic Institute, Florida State University, Tallahassee, Florida, USA.

Menzel, R.W. and S.H. Hopkins. 1956. Crabs as predators of oysters in Louisiana. Proceedings of the National Shellfish Association (1955) 46:177-184.

Miller, T.M., N.B. Angel, and T.L. Miller. 1982. Conversion of blue crab raw materials into some new and/or improved marketable products. Report to the Mid-Atlantic Fisheries Development Foundation, Inc., Project Number 12-01-24000. 92 pp.

Miller, Charlotte L. and John P. Nichols. 1986. Economics of harvesting and market potential for the Texas blue crab industry. Texas A&M University Sea Grant Report 86-201, College Station, Texas, USA.

Miller, T.M., N.B. Webb, and F.B. Thomas. 1974. Technical operations manual for the blue crab industry. University of North Carolina Sea Grant Publication UNC-SC-74-12, Special Scientific Report Number 28, Chapel Hill, North Carolina, USA.

Milliken, M.R. and A.B. Williams. 1984. Synopsis of biological data on the blue crab, Callinectes sapidus Rathbun. U.S. Department of Commerce, NOAA Technical Report NMFS 1, Washington, DC, USA.

Moody, M.W. 1982. Zoonotic diseases. Pages 65-69 in H.M. Perry and W.A. Van Engel (editors), Proceedings Blue Crab Colloquium, Publication 7, Gulf States Marine Fisheries Commission, Ocean Springs, Mississippi, USA.

Moody, M., G. Flick, and B. Tinker. 1982. Processing: methods of cooking and packing crab meat, mechanization. Pages 205-214 in H.M. Perry and W.A. Van Engle (editors), Proceedings Blue Crab Colloquium, Publication 7, Gulf States Marine Fisheries Commission, Ocean Springs, Mississippi, USA.

More, W.R. 1969. A contribution to the biology of the blue crab (Callinectes sapidus Rathbun) in Texas, with a description of the fishery. Texas Parks and Wildlife Department, Technical Series 1, Austin, Texas, USA.

Moss, C.G. 1981. National blue crab industry association, report from the gulf states (mimeo).

Moss, C.G. 1982. The blue crab fishery of the Gulf of Mexico. Pages 93-104 in H.M. Perry and W.A. Van Engel (editors), Proceedings Blue Crab Colloquium, Publication 7, Gulf States Marine Fisheries Commission, Ocean Springs, Mississippi, USA.

Murray, T.J. 1981. Seafood waste management in Virginia. In W.S. Otwell (editor), Seafood Waste Management in the 1980's: Conference Proceedings Florida Sea Grant College, Report 40, Gainesville, Florida, USA.

Murray, T.J. and W.D. DuPaul. 1981. Feasibility of crab meal processing in the Chesapeake Bay region. Virginia Institute of Marine Science, Applied Marine Science and Ocean Engineering, Special Report 248, Gloucester Point, Virginia, USA.

Nelson, W.R., M.C. Ingham, and W.E. Schaef. 1977. Larval transport and year-class strength of Atlantic menhaden, Brevoortia tyrannus. Fisheries Bulletin 75:23-41.

Newcombe, C.L. 1945. The biology and conservation of the blue crab, Callinectes sapidus Rathbun. Virginia Fisheries Laboratory, Educational Series 4:1-39.

Newcombe, C.L., M.D. Sandoz, and R. Rogers-Talbert. 1949. Differential growth and moulting characteristics of the blue crab, Callinectes sapidus Rathbun. Journal of Experimental Zoology 110(1):113-152.

Newman, M. and C.W. Ward, Jr. 1973. An epizootic of blue crabs, Callinectes sapidus, caused by Paramoeba perniciosa. Journal of Invertebrate Pathology 22:329-334.

Norse, E.A. 1977. Aspects of the zoogeographic distribution of Callinectes (Brachyura: Portunidae). Bulletin of Marine Science 27(3):440-447.

Nowlin, W.D. 1971. Water masses and general circulation of the Gulf of Mexico. Oceanographic International 6(2):28-33.

Oesterling, M.J. 1976. Reproduction, growth, and migration of blue crabs along Florida's gulf coast. University of Florida, Florida Sea Grant Publication SUSF-SG-76-003, 19 p.

Oesterling, M.J. and G.L. Evink. 1977. Relationship between Florida's blue crab population and Apalachicola Bay. Pages 101-121 in R.J. Linvingston and E.A. Joyce (editors), Proceedings Conference on the Apalachicola Drainage System, Gainesville, Florida. Florida Marine Research Publication 26. St. Petersburg, Florida, USA.

Oesterling, M.J. and C.A. Adams. 1982. Migration of blue crabs along Florida's gulf coast. Pages 37-57 in H.M. Perry and W.A. Van Engle (editors), Proceedings Blue Crab Colloquium, Publication 7, Gulf States Marine Fisheries Commission, Ocean Springs, Mississippi, USA.

Oesterling, M.J. 1984. Manual for handling and shedding blue crabs (Callinectes sapidus), Special Report in Applied Marine Science and Ocean Engineering Number 271, Virginia Institute of Marine Sciences, College of William and Mary, Gloucester Point, Virginia 23062.

Ogle, J.T., H.M. Perry, and L. Nicholson. 1982. Closed recirculating seawater systems for holding intermolt blue crabs: literature review, design and construction. Gulf Coast Research Laboratory, Technical Report Series 3:1-11.

O'Neil, T. 1949. The muskrat in the Louisiana coastal marshes. Louisiana Wildlife and Fish Commission, Fish and Game Division, Federal Aid Section, Baton Rouge, Louisiana, USA.

Otwell, Steve. 1980. Harvest and identification of peeler crabs. Florida Sea Grant Publication, MAFS-26.

Otwell, W.S. and J.C. Cato. 1982. Review of the soft-shell crab fishery in the United States. Pages 129-136 in H.M. Perry and W.A. Van Engel (editors), Proceedings Blue Crab Colloquium, Gulf States Marine Fisheries Commission, Ocean Springs, Mississippi, USA.

Overstreet, R.M. and H.M. Perry. 1972. A new microphallid trematode from the blue crab in the northern Gulf of Mexico. Transactions of the American Microscopical Society 91(3):436-440.

Overstreet, R.M. 1978. Marine maladies? Worms, germs, and other symbionts from the northern Gulf of Mexico. Mississippi-Alabama Sea Grant Consortium, MASGP-78-021.

Overstreet, R.M. and R.W. Heard, Jr. 1978a. Food of the red drum, Sciaenops ocellata, from Mississippi Sound and the Gulf of Mexico. Gulf Research Reports 6(2):145-152.

Overstreet, R.M. and R.W. Heard, Jr. 1978b. Food of the Atlantic croaker, Micropogonias undulatus, from the Mississippi Sound and the Gulf of Mexico. Gulf Research Reports 6(2):145-152.

Overstreet, R.M. Personal communication. Gulf Coast Research Laboratory, P.O. Box 7000, Ocean Springs, Mississippi, USA.

Palmer, R.A. 1974. Studies on the blue crab (Callinectes sapidus) in Georgia. Georgia Department of Natural Resources, Contribution Series 29, 59 p.

Parr, Albert Eide. 1935. Report on hydrographic observations in the Gulf of Mexico and the adjacent straits made during the Yale Oceanographic Expedition on the MABEL TAYLOR in 1932. Bulletin of the Bingham Oceanographic Collections 5(1):1-93.

Parrish, B.B. (editor). 1973. Fish stocks and recruitment. Proc. Symp., Aarhus, July 7-10, 1970, Rapp. P.-V. Reun., Cons. Inst. Explor. Mer, Vol. 164, 372 pp.

Pearson, J.C. 1948. Fluctuations in the abundance of the blue crab in Chesapeake Bay. U.S. Fish and Wildlife Service, Research Report Res 14. Washington, DC, USA.

Paredes, J.A., J.C. Sabella, and M.J. Hepburn. 1977. Human factors in the economic development of a northwest Florida gulf coast fishing community. Sea Grant Program of the State University System of Florida. Final Report, Project Number R/AS-1. Tallahassee, Florida, USA.

Perkins, F.O. 1971. Sporulation in the trematode hyperparasite Urosporidium crescens DeTurk, 1940 (Haplosporida: Haplosporidiidae) - an electron microscope study. Journal of Parasitology 57(1):9-23.

Perkins, G.B. 1979. Economic value of the seafood processing industry in Mississippi, 1978. Food and Fiber Center, Mississippi Cooperative Extension Service, Mississippi State University, 29 pp.

Perret, W.S., W.R. Latapie, J.F. Pollard, W.R. Mock, G.B. Adkins, W.J. Gaidry, and J.C. White. 1971. Fishes and invertebrates collected in trawl and seine samples in Louisiana estuaries. Section I. Pages 39-105 in Cooperative Gulf of Mexico Estuarine Inventory and Study. Phase IV. Biology. Louisiana Wildlife and Fisheries Commission, Baton Rouge, Louisiana, USA.

Perry, H.M. 1973. The occurrence of Callinectes bocourti (A. Milne Edwards, 1879) (Decapoda: Portunidae) in Biloxi Bay, Mississippi, USA. Crustaceana 25:110.

Perry, H.M. 1975. The blue crab fishery in Mississippi. Gulf Research Reports 5(1):39-57.

Perry, H.M. 1983. Blue crab shedding system: determining water volume and preparing artificial seawater. MASGC-83-007.

Perry, H.M. and J.R. Herring. 1976. Fisheries assessment and monitoring, Mississippi. Completion Report (P.L. 88-309, Project 2-215-R), Gulf Coast Research Laboratory, Ocean Springs, Mississippi, USA.

Perry, H.M., J. Ogle, and L. Nicholson. 1982. The fishery for soft crabs with emphasis on the development of a closed recirculating seawater system for holding shedding crabs. Pages 137-152 in H.M. Perry and W.A. Van Engel (editors), Proceedings Blue Crab Colloquium, Publication 7, Gulf States Marine Fisheries Commission, Ocean Springs, Mississippi, USA.

Perry, H.M. and K.C. Stuck. 1982. The life history of the blue crab in Mississippi with notes on larval distribution. Pages 17-22 in H.M. Perry and W.A. Van Engel (editors), Proceedings Blue Crab Colloquium, Publication 7, Gulf States Marine Fisheries Commission, Ocean Springs, Mississippi, USA.

Perry, H.M., G. Adkins, R. Condrey, P.C. Hammerschmidt, S. Heath, J.R. Herring, C. Moss, G. Perkins, and P. Steele. 1984. A profile of the blue crab fishery of the Gulf of Mexico. Publication Number 9, Gulf States Marine Fisheries Commission, Ocean Springs, Mississippi, USA.

Perry, H.M. and R.F. Malone (editors). 1985. Proceedings of the national symposium on the soft-shelled blue crab fishery. Mississippi-Alabama Sea Grant Consortium MASGP-86-017, 128 pp.

Perry, H.M., C. Moss and R. Malone. 1985. Status of the blue and stone crab (western gulf form) fisheries of the Gulf of Mexico. Annual meeting National Shellfisheries Association, June 17-20, 1985, Norfolk, Virginia (abstract only).

Perry, H.M. and Richard Wallace. 1985. Blue crab shedding systems: water quality concerns. MASGP-85-001.

Perry, H.M. and T.D. McIlwain. 1986. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Gulf of Mexico)--blue crab. U.S. Fish and Wildlife Service Biological Report 82(11.55). U.S. Army Corps of Engineers. TR EL-82-4. 21 pp.

Pesson, L.L. 1974. The coastal fisherman of Louisiana: their characteristics, attitudes, practices and responsiveness to change. Cooperative Extension Service, Center for Agricultural Sciences and Rural Development, Louisiana State University, Baton Rouge, Louisiana, USA.

Porter, H.J. 1955. Variation in morphometry of the adult female blue crab, Callinectes sapidus Rathbun. Master of Science Thesis, University of Delaware, Newark, Delaware, USA.

Price, K.S., D.A. Flemer, J.L. Taft, G.B. Mackiernan, W. Nehlsen, R.B. Briggs, N.H. Burger, and D.A. Blaylock. 1985. Nutrient enrichment of Chesapeake Bay and its implications on the habitat of striped bass: a speculative hypothesis. Transactions of the American Fisheries Society 114:97-106.

Price-Sheets, W.C. and J.E. Dendinger. 1983. Calcium deposition into the cuticle of the blue crab Callinectes sapidus, related to external salinity. Comparative Biochemical Physiology 74A:903-907.

Prochaska, F.J., J.C. Cato, and W. Keithly. 1982. An analysis of dockside prices in the Florida blue crab industry. Pages 195-199 in H.M. Perry and W.A. Van Engel (editors), Proceedings Blue Crab Colloquium, Publication 7, Gulf Sates Marine Fisheries Commission, Ocean Springs, Mississippi, USA.

Provenzano, A.J., J.R. McConaugha, K.B. Phillips, D.F. Johnson, and J. Clark. 1983. Vertical distribution of first stage larvae of the blue crab, Callinectes sapidus, at the mouth of the Chesapeake Bay. Journal of Estuarine, Coastal and Shelf Science, 16:489-499.

Quast, W.D., B.G. Dansby, and M. Henderson. 1989. Trends in Texas commercial fishery landings, 1977-1988. Texas Parks and Wildlife Department, Fisheries Division, Coastal Fisheries Branch. Management Data Series Number 7, Austin, Texas.

Ragan, J.G. and B.A. Matherne. 1974. Studies on Loxothylacus texanus. Pages 185-203 in R.L. Ampborski, M.A. Hood and R.R. Miller (editors), Proceedings Gulf Coast Regional Symposium on Diseased Aquatic Animals, Louisiana State University Sea Grant, LSU-SG-74-05, Baton Rouge, Louisiana, USA.

Rathbun, M.J. 1930. The cancroid crabs of America of the families Euryalidae, Portunidae, Atelecyclidae, Cancridae and Xanthidae. U.S. Natural Museum Bulletin 152:1-609.

Rees, G.H. 1966. Informal progress report for July-December. U.S. Bureau of Commercial Fisheries Biological Laboratory, Beaufort, North Carolina: 1-3.

Reinhard, E.G. 1956. Parasitic castration of Crustacea. Parasitology 5(1):79-107.

Rhodes, R.J. 1982. Ex-vessel price trends in the blue crab fishery of the United States. Pages 167-172 in H.M. Perry and W.A. Van Engel (editors), Proceedings Blue Crab Colloquium, Publication 7, Gulf States Marine Fisheries Commission, Ocean Springs, Mississippi, USA.

Ricker, W.E. 1954. Stock and recruitment. Journal Fisheries Resources Board Canada 11:559-623.

Rives, J. (editor). 1982. Coastal protection task force makes recommendations. Cote de la Louisiana 7(2):1.

Roberts, K.J. and M.E. Thompson. 1982. Economic elements of commercial crabbing in Lake Pontchartrain and Lake Borgne. Louisiana Sea Grant Publication LSU-TL-82-001, Baton Rouge, Louisiana, USA.

Robertson, R.L. 1938. Observations on the growth stages in the common blue crab, Callinectes sapidus Rathbun, with special reference to post-larval development. Master of Science Thesis, University of Maryland, College Park, Maryland, USA.

Royce, W.F. 1972. Introduction to the fishery sciences. Academic Press, New York, 351 p.

Roedel, P.M. 1975. A summary and critique of the symposium on optimum sustainable yield. American Fisheries Society Special Publication 9:79-89.

Sandifer, P.A. 1973. Distribution and abundance of decapod crustacean larvae in the York River estuary and adjacent lower Chesapeake Bay, Virginia, 1968-1969. Chesapeake Science 14(4):235-257.

Sandoz, M. and S.H. Hopkins. 1944. Zoeal larvae of the blue crab Callinectes sapidus Rathbun. Journal of the Washington Academy of Science 34(4):132-133.

Sandoz, M. and R. Rogers. 1944. The effect of environmental factors on hatching, moulting, and survival of zoea larvae of the blue crab Callinectes sapidus Rathbun. Ecology 25(2):216-228.

Scarsbrook, J.R., G.A. McFarlane, and W. Shaw. 1988. Effectiveness of experimental escape mechanisms in sablefish traps. North American Journal of Fisheries Management 8:158-161.

Shepherd, J.G. 1982. A versatile new stock-recruitment relationship for fisheries, and the construction of sustainable yield curves. J. Const. Int. Explor. Mer. 40:67-75.

Shepherd, J.G. and D.H. Cushing. 1980. A mechanism for density-dependent survival of larval fish as the basis of a stock-recruitment relationship. J. Cons. Int. Explor. Mer, 39:160-167.

Sholar, T.M. 1982. Blue crab fisheries of the Atlantic coast. Pages 111-127 in H.M. Perry and W.A. Van Engel (editors), Proceedings of the Blue Crab Colloquium, Publication 7, Gulf States Marine Fisheries Commission, Ocean Springs, Mississippi, USA.

Smith, A.D.M. and C.J. Walters. 1981. Adaptive management of stock-recruitment systems. Can. J. Fish. Aquat. Sci., 38:690-703.

Smith, D.W. 1973. Effects of ecdysterone and inokosterone on ecdysis of the juvenile blue crab, Callinectes sapidus. Hattiesburg, Mississippi: University of Southern Mississippi. 33 p. Thesis.

Smyth, P.O. 1980. Callinectes (Decapoda: Portunidae) larvae in the Middle Atlantic Bight, 1975-77. Fisheries Bulletin 78(2):216-265.

Sprague, V. 1977. Classification and phylogeny of the Microsporidia in L.A. Bulla and T.C. Cheng (editors), Comparative Pathology: Treatises Volume 2, Systematics of the Microsporidia. Plenum Press, New York, New York, USA.

Soumoff, C. and D.M. Skinner. 1983. Ecdysteroid titers during the molt cycle of the blue crab resemble those of other Crustacea. Biological Bulletin (Woods Hole) 165:321-329.

Steele, P. 1982. Synopsis of the biology of the blue crab Callinectes sapidus Rathbun, in Florida. Pages 29-35 in H.M. Perry and W.A. Van Engel (editors), Proceedings Blue Crab Colloquium, Publication 7, Gulf States Marine Fisheries Commission, Ocean Springs, Mississippi, USA.

Steele, P. and R.J. Hochberg. 1987. Population dynamics of the blue crab, Callinectes sapidus Rathbun, in Tampa Bay, Florida. Smithsonian Environmental Research Center, Portunid Ecology Workshop, Abstract, Edgewater, Maryland, USA.

Steele, P. 1987a. Seasonal abundance and migration of the blue crab Callinectes sapidus Rathbun, along the Florida west coast. Smithsonian Environmental Research Center, Portunid Ecology Workshop, Abstract, Edgewater, Maryland, USA.

Steele, P. 1987b. Population dynamics and migration of the blue crab Callinectes sapidus Rathbun, in the eastern Gulf of Mexico. Proceedings Gulf and Caribbean Fisheries Institute, 40th Annual Meeting, November 9-13, Curacao, NA.

Steele, P. Personal communication. Florida Marine Research Institute, 100 8th Avenue, St. Petersburg, Florida, USA.

Strand, I. and A. Matteucci. 1977. Economic interdependencies in fisheries: empirical evidence and management implications. Paper presented at the American Agricultural Economic Association Meeting, San Diego, California. August 1, 1977.

Strasser, J.H., J.S. Lennon, and F.J. King. 1971. Blue crab meat. I. Preservation by freezing. II. Effect of chemical treatments on acceptability. U.S. Fish and Wildlife Service, Scientific Report Fisheries 630:1-26.

Stuck, K.C. and H.M. Perry. 1981. A preliminary study of the indentification of megalopae and early crab stages of Callinectes sapidus and C. similis from Mississippi coastal waters. Journal of Mississippi Academy of Sciences 26:121.

Stuck, K.C., S.Y. Wang, and H.M. Perry. 1981. A preliminary study of the identification of megalopae and early crab stages of Callinectes sapidus and C. similis from Mississippi coastal waters. Journal Mississippi Academy of Sciences 26:121.

Sulkin, S.D. 1978. Nutritional requirements during larval development of the portunid crab, Callinectes sapidus Rathbun. Journal of Experimental Marine Biology and Ecology, 34:29-41.

Sulkin, S.D. 1981. The behavioral basis for blue crab recruitment in mid-Atlantic estuaries. University of Maryland Sea Grant Publication UM-SG-TS-81-07, College Park, Maryland, USA.

Sulkin, S.D. and C.E. Epifanio. 1975. Comparison of rotifers and other diets for rearing early larva of the blue crab, Callinectes sapidus Rathbun. Estuarine and Coastal Marine Science 3:109-113.

Sulkin, S.D. and W. Van Heukelem. 1982. Larval recruitment in the crab Callinectes sapidus Rathbun: an amendment to the concept of larval retention in estuaries. Pages 459-475 in V. Kennedy (editor), Estuarine Comparisons, Academic Press, New York, New York, USA.

Sulkin, S.D. and C.E. Epifanio. 1986. A conceptual model for recruitment of the blue crab, Callinectes sapidus Rathbun, to estuaries of the Middle Atlantic Bight. Pages 117-123 in G.S. Jamieson and N. Bourne (editors), North Pacific Workshop on Stock Assessment and Management of Invertebrates. Canadian Special Publication of Fisheries and Aquatic Sciences, Ottawa, Canada.

Suttkus, R.D., J.H. Darnell, and R.M. Darnell. 1953. Biological study of Lake Pontchartrain. Bimonthly Progress Report to Louisiana Wildlife and Fisheries Commission (August 1, 1953 - September 30, 1953).

Swingle, H.A. 1971. Biology of Alabama estuarine areas - cooperative Gulf of Mexico estuarine inventory. Alabama Marine Research Bulletin 5:1-123.

Swingle, W.E. 1976. Analysis of commercial fisheries catch data for Alabama. Alabama Marine Research Bulletin 11:26-50.

Tagatz, M.E. 1965. The fishery for blue crabs in the St. John's River, Florida, with special reference to fluctuation in yield between 1961 and 1962. U.S. Fish and Wildlife Service, Special Scientific Report Fisheries 501:1-11.

Tagatz, M.E. 1968a. Biology of the blue crab, Callinectes sapidus Rathbun, in the St. John's River, Florida. U.S. Fish and Wildlife Service, Fisheries Bulletin 67(1):17-33.

Tagatz, M.E. 1968b. Growth of juvenile blue crabs, Callinectes sapidus Rathbun, in the St. John's River, Florida. U.S. Fish and Wildlife Service, Fisheries Bulletin 67(2):281-288.

Tagatz, M.E. 1969. Some relations of temperature acclimation and salinity to thermal tolerance of the blue crab, Callinectes sapidus. Transactions of the American Fisheries Society 98:713-716.

Tagatz, M.E. and G.P. Frymire. 1963. Florida studies, St. John's River. Report of the Bureau of Commercial Fisheries Laboratory, Beaufort, North Carolina, for the fiscal year ending June 30, 1963. Circular 198:7.

Tagatz, M.E. and A.B. Hall. 1971. Annotated bibliography on the fishing industry and biology of the blue crab, Callinectes sapidus. U.S. Department Commerce, NOAA Technical Report NMFS SSRF-640, 94 p.

Tan, E.C. and W.A. Van Engel. 1966. Osmoregulation in the adult blue crab, Callinectes sapidus Rathbun. Chesapeake Science 7:30-35.

Tang, Q. 1983. Assessment of the blue crab commercial fishery in Chesapeake Bay. In P. Jones, D. Heimbuch, and C. Stagg (editors), Report of the Workshop on Blue Crab Stock Dynamics in Chesapeake Bay. Chesapeake Biology Laboratory, Center for Environmental and Estuarine Studies, University of Maryland.

Tang, Q. 1985. Modification of the Ricker stock recruitment model to account for environmentally induced variation in recruitment with particular reference to the blue crab fishery in Chesapeake Bay. Fish. Res. 3:13-21.

Tarver, J.W. 1970. The clam story. The Louisiana Conservationist, May-June, 1970.

Tatum, W.M. 1980. The blue crab fishery of Alabama. Pages 211-220 in H.A. Loyacano and J. Smith (editors), Symposium on the Natural Resources of the Mobile Estuary, Alabama. MASGP-80-022.

Tatum, W.M. 1982. The blue crab fishery in Alabama. Pages 23-28 in H.M. Perry and W.A. Van Engel (editors), Proceedings Blue Crab Colloquium, Publication 7, Gulf States Marine Fisheries Commission, Ocean Springs, Mississippi, USA.

Thomas, Stephen J. Personal communication. University of South Alabama, Department of Sociology and Anthropology, BMSB 8, Mobile, Alabama, USA.

Thomas, Stephen J. 1986. The Indochinese in Bayou La Batre, Alabama: a preliminary assessment of social impacts. Alabama Sea Grant Extension Bulletin, The Alabama Cooperative Extension Service and Sea Grant Advisory Services Publication #MASGP-86-008. Auburn University.

Tinker, B. and R. Learson. 1970. Report to the National Blue Crab Industry Association. NOAA, NMFS, Fishery Products Technology Laboratory, Gloucester, Massachusetts, USA.

Titre, J., Jr., J.E. Henderson, J.R. Stoll, J.C. Bergstrom, and V.L. Wright. 1988. Valuing wetland recreational activities on the Louisiana coast. U.S. Army Corps of Engineers Final Report, 152 pp.

Turner, R.E. and D.F. Boesch. 1987. Aquatic animal production and wetland relationships: insights gleaned following wetland loss or gain. Chapter 3, pages 25-39 in D.D. Hook et al. (editors), The Ecology and Management of Wetlands, Volume 1: Ecology of Wetlands. Timber Press, Portland, Oregon, USA.

Truitt, R.V. 1942. Annual Report. Publication of the Chesapeake Biological Laboratory 47:1-35.

Van Den Avyle, M.J. and D.L. Fowler. 1984. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (South Atlantic). Blue Crab. U.S. Fish and Wildlife Service, Publication FWS/OBS-82/11.19, Washington, DC, USA.

Van Engel, W.A. 1954. Prepared crab products growing in popularity. Frosted Food Field 18(4):19-20.

Van Engel, W.A. 1958. The blue crab and its fishery in Chesapeake Bay. Part I. Reproduction, early development, growth and migration. Commercial Fisheries Review 20(6):6-17.

Van Engel, W.A. 1962. The blue crab and its fishery in Chesapeake Bay. Part 2. Types of gear for hard crab fishing. Commercial Fisheries Review 24(9):1-10.

Van Engel, W.A. 1978. Climatological effects on distribution, catch and abundance of the blue crab. Paper presented at the National Shellfisheries Association Meeting, New Orleans, Louisiana, USA.

Van Engel, W.A. 1982. Blue crab mortalities associated with pesticides, herbicides, temperature, salinity, and dissolved oxygen. Pages 89-92 in H.M. Perry and W.A. Van Engel (editors), Proceedings Blue Crab Colloquium, Publication 7, Gulf States Marine Fisheries Commission, Ocean Springs, Mississippi, USA.

Van Engel, W.A. 1987. Factors affecting the distribution and abundance of the blue crab in Chesapeake Bay. In S.K. Majumdar, L.W. Hall, Jr., and H.M. Austin (editors), Contaminant and Management of Living Chesapeake Bay Resources, The Pennsylvania Academy of Sciences.

Vigh, D.A. and J.E. Dendinger. 1982. Temporal relationships of postmolt deposition of calcium, magnesium, chitin and protein in the cuticle of the Atlantic blue crab, Callinectes sapidus Rathbun. Comparative Biochemical Physiology 72A:365-369.

Voiland, M.P. and M.W. Duttweiler. 1984. A look at what we're reading and writing. Fisheries Volume 9, Number 4.

Vondruska, J. 1986. Blue crab markets and analog products. Paper presented, National Blue Crab Industry Association Meeting, New Orleans, Louisiana, February 26-28, 1986.

Walter, D. 1989. The influence of salinities in lower Barataria Bay upon year class strength of the blue crab, Callinectes sapidus. Louisiana Department of Wildlife and Fisheries, Unpublished Report, 25 pp.

Walters, C.J. 1981. Optimum escapements in the face of alternative recruitment hypotheses. Can. Jour. Fish. Aquat. Sci. 38:678-689.

Wardle, W.J., S.M. Ray, and A.S. Aldrich. 1975. Mortality of marine organisms associated with offshore summer blooms of the toxic dinoflagellate Gonyaulax monilata Howell at Galveston, Texas. Pages 257-263 in Proceedings First International Conference on Toxic Dinoflagellate Blooms. Massachusetts Science and Technology Foundation, Wakefield, Massachusetts, USA.

Waterman, T.H. 1960. The physiology of Crustacea. Volume 1 - Metabolism and Growth. Academic Press, New York and London. 639 pp.

Wharton, J. 1956. The pot at the end of the rainbow. Baltimore Sunday Sun, June 3, Baltimore, Maryland.

Williams, A.B. 1971. A ten-year study of meroplankton in North Carolina estuaries: annual occurrence of some brachyuran development stages. Chesapeake Science 12:53-61.

Williams, A.B. 1974. The swimming crabs of the genus Callinectes (Decapoda: Portunidae). Fisheries Bulletin 72(3):3685-798.

Williams, A.B. and T.W. Duke. 1979. Crabs (Arthropoda: Crustacea: Decapoda: Brachyura). Pages 1711-233 in C.W. Hurt and S. Fuller (editors), Pollution ecology of estuarine invertebrates. Academic Press, New York, New York, USA.

Williams, Austin B. 1984. Shrimp, lobsters, and crabs of the Atlantic coast of the Eastern United States, Maine to Florida. Smithsonian Institution Press, Washington, DC.

18.0 APPENDIX

18.1 Gulf State-Federal Fisheries Management Board Charter

18.1.1 Establishment

The states of Florida, Alabama, Mississippi, Louisiana and Texas through their respective agencies for marine fisheries conservation, management and development and upon the legal authorities contained in their respective constitutions or otherwise, do hereby agree to the formation of a regional fisheries management body to be known as the Gulf State-Federal Fisheries Management Board (hereinafter referred to as the Board) based on the general approval of Congress contained in the Gulf States Marine Fisheries Compact Act of May 19, 1949 (P.L. 81-66).

18.1.2 Purpose

1. Recognizing that certain fisheries and fisheries resources upon which those fisheries are based, move between, or are broadly distributed among, the territorial waters of two or more states, or the territorial waters and areas seaward thereof;

2. And recognizing the need for the development of uniform or coordinated management systems;

3. And, recognizing the need to optimize economic and social returns and to take appropriate actions to develop and implement certain management plans for the conservation and management of certain identified fisheries resources of the Gulf States;

4. The Board, therefore, agrees to take the necessary steps to accomplish the objectives and purpose of this charter:

(a) Identify management plan priorities for fisheries and fisheries resources of common or interstate interest; and

(b) Identify and promote institutional arrangements which will foster integration of efforts among the states; and

(c) Encourage meaningful participation by user groups and the general public, in the development of management plans; and

(d) Develop and recommend suitable policies and strategies to each member state and encourage the implementation to the extent possible, of programs, laws and regulations for the effective management of fisheries to accomplish the objectives and purposes set out in this section.

18.1.3 Composition

1. The states of Florida, Alabama, Mississippi, Louisiana and Texas shall be represented on the Board by the Administrative Commissioner and one other member of that state appointed to the Gulf States Marine Fisheries Commission, or their proxies by that state.

2. The Federal Government shall be invited to participate through the Southeast Regional Director of the National Marine Fisheries Service or his proxy from that region and Region IV Director of the U.S. Fish and Wildlife Service or his proxy from that region.

3. The Executive Director of the Gulf States Marine Fisheries Commission shall be a non-voting member of the board.

18.1.4 Administrative Provisions

1. Each member state shall be entitled to one vote on all matters properly before said board.

2. Each designated Federal official shall be entitled to one vote on all matters properly before said Board.

3. A chairman shall be elected by majority vote to preside over all board business and activities.

4. The board shall meet:

   (a) at the call of the chairman, or

   (b) at the request of any three or more states acting jointly.

5. The place of each meeting shall be determined by the chairman.

6. All regular business of the board shall be conducted by a quorum of not less than fifty percent of the voting members/or their proxies.

7. Regular minutes showing questions offered, votes taken and a summary record of discussions shall be maintained by a person designated by the chairman and shall become the official record of the board upon approval by consensus of the board at the next succeeding meeting.

8. An annual report shall be prepared for the benefit of the member states by April 15 of each year summarizing the previous year's activities and accomplishments.

9. The board may consider any issue properly before it except that if Federal funds are accepted to defray the costs of Board meeting and operating expenses, it may not vote upon, record, or otherwise collectively express any official position concerning any measure, proposal or bill before the Congress of the United States in contravention of the "Lobbying with Appropriated Money Act," 18 U.S.C. 1913.

18.1.5 Operating Procedures

1. The board may establish one or more subsidiary committees known as sub-board, management plan committees, advisory committees and management committees. The board may invite scientific and technical personnel from the state and Federal governments, as well as user groups, persons interested in the conservation of fisheries resources and the general public, to serve on these committees, as appropriate.

2. The board will establish its own rules and procedures for conduct of business.

3. Amendments, deletions or additions to this charter may be made at any meeting of the board by a majority of the voting members providing that a ten (10) day notice of proposed change was given to all members.

4. This board may be dissolved by majority consent of the undersigned.

It shall be the responsibility of the board to oversee the work of such sub-boards and committees and insure that suitable participation by user groups and appropriate advice has been obtained. The board shall transmit upon adoption those findings to the Gulf States Marine Fisheries Commission and member states authorities for consideration, including recommending the adoption and implementation of rules, regulations, laws or other management measures as may be deemed necessary for effective fisheries management.

18.2 Historical Description of the Fishery

18.2.1 History of Exploitation/Hard Crab

Information in this section was obtained from interviews with crab fishermen and processors.

The states bordering the Gulf of Mexico were more similar than disparate in the development of the blue crab fishery. The search for the earliest activity in each state has, thus far, ended at least one generation away from inception. Names, places and dates are often vaguely recalled by early fishermen, and thus this information is subject to the limitations of retrospect.

The gaps in information and "foggy" dating in these early histories suggest that a more concerted effort be made to authenticate this fishery. As time passes the facts get more vague, dates fade, and names are lost. The obvious inadequacies in the following sections reinforce the need to learn and record what may soon be lost. The blue crab fishery is characterized by the uniqueness of the product which, in itself, prevented fishery development until the advent of railroads. The importance of the coming of the railroads cannot be overemphasized in the development of markets for perishable items such as crab meat. Prior to rail travel, the fastest mode of transportation was by sailing schooner with the trip from Biloxi, Mississippi, to New Orleans, Louisiana, requiring a full day. The onset of picking operations in the late 1920s heralded a new era of expansion for the fishery.

The earliest recorded blue crab landings in the Gulf of Mexico were in 1880, when 288,000 pounds in Louisiana and 36,000 pounds in Texas were documented.

18.2.1.1 Florida

In the 1880s, William H. Boyington and his son, Jesse, fished trotlines in Doyle and Whiskey George creeks trading their crabs for farm products and staples in West Point (now Apalachicola). Prior to 1930, the Florida blue crab fishery supplied a local, barter-type market where all the crabmeat and crabmeat products were consumed locally. "Seeb" Russell changed all that when he returned to Florida from Biloxi and reported that crabmeat was being picked and shipped in large-scale operations. Arthur Tucker, from the Apalachicola-East Point area, investigated the report and began his own full-scale picking operation in Florida by spring of 1930. He packed crab meat in pint jars and shipped it to New York. This is the earliest report of crabmeat produced for interstate shipment from Florida. The Tucker family operates their seafood business to this date.

Florida crab fishermen fishing trotlines could harvest as many as 2,500 pounds per day on good days. The fishermen were paid five cents per dozen, translating to about $10.00 per day. Expenditures for the Florida crab fisherman, as well as those for other Gulf States, were mainly for bait with two trotlines requiring about 100 pounds of bait. Florida's blue crab fishery began to expand significantly after World War II due to the development of large-scale processing plants. Charles Barwick, Sr. started a picking plant in Panacea in 1949, and Herman Metcalf opened another around 1953 or 1954. During this post-war period, Ralph Newton added crab processing to his importing and seafood business. From 1963 to 1971 Newton was processing more than 2,000 pounds of product per day requiring about 30,000 pounds of live crabs. Top production in Barwick's operation was 2,269 pounds per day requiring 111 crabmeat pickers.

18.2.1.2 Alabama

In Baldwin County, crab fishermen have been fishing since at least 1900 and selling the live crabs in Mobile. The first crab shop in Baldwin County opened in 1947; the meat was canned and trucked to Bayou La Batre for sale. Bayou La Batre developed into a distribution center which now competes with Mobile. The first crab shop in Mobile County was opened in the early 1920s at Alabama Port. Crabs were brought in and boiled on the beach in 55-gallon drums which were cut lengthwise and set on four pipes in the ground. The cooked crab was taken into the plant, backed, washed at a hand pump and picked. The meat was packed fresh for shipment. Southern Fish Company, owned by Jess Jemison, was the first company in Mobile to distribute crabmeat for intra- and interstate shipment.

18.2.1.3 Mississippi

Luke Dubaz, born in 1897 and of Yugoslavian descent, sailed with his parents and brothers from Pensacola, Florida, to Biloxi, Mississippi, in 1902. There he eventually entered the oyster fishery and crabbed and fished as a sideline. By the early 1920s there were three fish houses picking crabmeat for stuffed crab products. These were owned by Bill Cruso, Steve Papich and a man known only as Valpino. The Dubaz family bought Valpino's operation during the 1920s. A live market in Mobile, Alabama, bought 150 to 200-dozen live crabs per week from the Biloxi picking houses and from Lewis Johnson, who only shipped live crabs. The crabs were packed in moss, 8-dozen to an orange crate and shipped twice a week. The shippers received 20 cents per dozen. Markets quickly opened in Montgomery, Alabama; Washington, DC; and Baltimore, Maryland.

Crab fishermen supplying the Biloxi crab houses fished trotlines, baited every few feet with beef lips and tripe at a cost of three to eight cents per pound. Each fisherman ran two or more lines at night from a rowed skiff. They reportedly harvested 1,200 to 1,500 pounds per night and were paid ten cents per dozen. Pickers received four cents per pound of picked meat. Some of the pickers hand-dipped crabs in the shallows the night before with a good catch being about 200 pounds per person.

18.2.1.4 Louisiana

Any early history of the Louisiana fishery presents a formidable challenge for the researcher. The type of information gathered from other Gulf States is available for Louisiana but is scattered throughout a maze of wetlands, bays and estuaries. New Orleans grew into a major market for seafood products linking Houston, Texas; Mobile, Alabama; and Biloxi, Mississippi; with inland centers. One of the first crab fisheries in the gulf developed near New Orleans to supply the French Market and local restaurants. The first crabmeat plant was constructed in 1924 in Morgan City, and by 1931, there were seven more plants in the Morgan City/Berwick area. This time frame roughly corresponds with the onset of picking operations in most other Gulf States. Louisiana now supplies live blue crabs to Baltimore, Maryland, and surrounding eastern cities. These crabs are shipped by air freight, a practice which began in Louisiana. Verlon Davis, former manager of Bo Brooks of Texas, has stated that Charles Turan of Turan Seafood in Metairie, Louisiana, was the first to ship live crabs by air.

Louisiana's vast fertile wetlands have provided a surplus of blue crabs over local demand. Since 1968, Louisiana has produced one third to one half of the total gulf harvest. This surplus has historically been exported to other states. Mississippi and Alabama have consistently relied upon Louisiana crabs to keep their plants operating during years of low supply. Star Crab Company in Palacios, Texas, trucked crabs regularly from Hackberry, Louisiana, in the 1960s.

18.2.1.5 Texas

In the early 1900s, Homer Clark fished Galveston Bay, Texas, and shipped live crabs by the barrel to Houston via High Island and Bolivar Peninsula. Although there must have been other crab harvesting operations supplying Houston restaurants and markets with Texas blue crabs, this was the earliest documented Texas crab fishery. Owen Raby fished and crabbed around Port Arthur, Texas, in 1914. He used trotlines with stagings every three to six feet baited with fresh fish. He sold his crabs to a man who shipped the crabs live to Houston by train. Where this marketing chain ended is unknown. Raby's family currently harvests and processes crabs in Port O'Connor, Texas.

The earliest documented crab-picking plant in Texas was built in 1958 in Palacios by a Mr. Willis. However, there are reports of a plant of earlier construction built in Flour Bluff. The owner was said to be a man from Mississippi whose name and history remain as vague memories.

Mr. Joseph [Preston?] Lowe (originally of Crisfield, Maryland, and later of Pascagoula, Mississippi) purchased the Palacios plant from Mr. Willis sometime after 1958. The plant was called Star Crab Company, and Mr. Lowe bought crabs from Flour Bluff, Texas, to Hackberry, Louisiana. Joseph Lowe's death terminated an amazing career that began in Crisfield, Maryland, and profoundly affected the gulf coast fishery. His wife, Ruby, continued to operate Star Crab Company which was eventually absorbed by Ed Collins Seafood.

Edmond Collins operated a shrimp cannery in Palacios in 1960. In 1966, he sold out and opened a seafood business which became Ed Collins Seafood in 1967. By 1970, he had built a hard crab processing plant capable of handling 25,000 pounds of crabs per day, adopting the first steam cooking and first pasteurizing process in Texas. He also led in the development and promotion of legislation for regulations and inspection standards of Texas crab-processing plants.

Prior to the mid-1970s, blue crab production in Texas was severely limited due to the parochial marketing channels and small, local demand for crabmeat. Bill Marsh of Marsh Seafood in Anahuac, Texas, reported a man named Glen Pearson began shipping crabs from Texas in the early 1970s. As air freighting became popular and east coast markets developed, Texas began to fully exploit its blue crab resources.

East coast "crab barons" soon took interest in Texas' productivity and invested in or bought out Texas processors. Verlon Davis, a Louisiana crab buyer, shipped live crabs to Baltimore, Maryland. He sold his interest to Bo Brooks of Baltimore, who constructed a picking plant in Seadrift, Texas, in 1976. Mike and Susan Dietz now manage this plant. Ralph Newton of Florida took over South Bay Seafood in Aransas Pass, Texas, and renamed it Blue Sea. Ed Collins Seafood was purchased by a group of east coast crab buyers.

18.2.2 Gear Evolution

18.2.2.1 Hard Crabs

Early fishery techniques included dip nets, drop nets and trotlines. Dip nets were used in shallow waters with crab fishermen (both men and women) scooping up crabs and dropping them into towed skiffs, tubs, half-barrels or burlap sacks. The dip nets were long-handled with little webbing to facilitate removing the crab with a quick shake. When crabbing was good it was possible to dip 200 pounds a night. The hard crabs were kept for barter or for picked meat, and the peeler crabs kept until they shed.

Crab fishermen used drop nets in deeper water that could not be waded. These were net-covered iron bar frames 18 inches square with a bait fastened to the middle of the webbing. Lines, attached to the frame, led to a float. Periodically, the drop net was raised and the crabs were placed in the skiff, probably in a moss- or brush-lined barrel. The trotline was found to be more effective in catching crabs and quickly replaced the drop net.

Trotlines were of two basic types. The earliest type consisted of a length of rope (mainline) to which were attached short (10-inch) lines at approximately 2-foot intervals. Bait was attached to the ends of these shortlines (called snoods, drops, staglings or gangions) (Figure 18.1). When rollers or spools came into use with the advent of motor boats, the snoods were often abandoned as they easily became tangled in the roller; bait was then secured either in a slip knot in the mainline or tucked between the strands. A trotline with baits attached to the mainline is shown in Figure 18.2.

The bait varied, but beef lips and tripe were the most common. They were tough and durable. Chunks of salted eels were favored by some crabbers and were reported to be particularly effective for catching male crabs. Bait was constantly a problem; the lines had to be rebaited as needed after each use and then stored in a brine barrel in the bow of the skiff to preserve the cotton twine. As the bait became rank, the brine barrel began to develop a unique aroma. Sometimes the beef lips had to be boiled to remove them from the line. The whole gear was placed in a vat and boiled until the bait loosened up. If the bait was secured to the mainline with a slip knot, the line was strung around a tree and pulled in a sawing motion until the bait came loose or the slip knot gave way.

Most crab fishermen ran at least two lines with some of the lines longer than a mile. The lines were run from a skiff which had been rowed to the crabbing grounds. Small outboard motors were not used in the gulf until the 1950s. After the first line was set, the second was put out and the first run. If crabs were plentiful in a particular area, lines would be run until the supply was exhausted. The fishermen would then move the lines to more productive grounds.

To harvest the crabs, the crab fisherman pulled his skiff along the set line, reaching out and dipping the crabs which were feeding on the bait into the boat. The dip net was long enough to reach over the side of the skiff and into the water and was made of shallow webbing of chicken wire. Some nets were little more than tennis rackets used to bat the crabs off the bait and into the skiff. Most of the trotline fishing was done at night by lantern or in the early morning because the shadow of the skiff in clear water would "spook" the crabs, and they would release the bait. The orientation of trotlines in an estuary was dependent upon tide (Van Engel 1962), season and geographic location (Jaworski 1972).

The arrival of the crab pot moved the blue crab fishery from a kitchen operation to the large-scale processing plant. The most vivid change took place in Florida after 1950. According to Bill Marsh, the crab pot was introduced in Panacea, Florida, by his cousin Rose Bradshaw and her husband, Leroy. The reported landings and number of gear units (Table 8.2) for the 1950s and 1960s documents the impact of the crab pot in the Gulf of Mexico. The large picking plants expanded and the supply of hard crabs was increased beyond the capacity of local markets. Soon the industry was forced to seek new marketing channels.

Joseph Lowe brought the Chesapeake pots to Pascagoula. These pots were placed in the water near Gautier. Emile DeSilva, of the Mississippi Marine Conservation Commission, picked up 200 of the pots, confiscating them as outlaw devices. A justice of the peace tried the case and instructed the commission to return the pots to the water. Legality of the pot was based on the conclusion that the animal was not trapped but merely enticed by the bait and could leave as it entered. The term "pot" was coined to escape the connotation of trapping. Further details of this landmark case are reportedly a matter of public record and hopefully will be published.

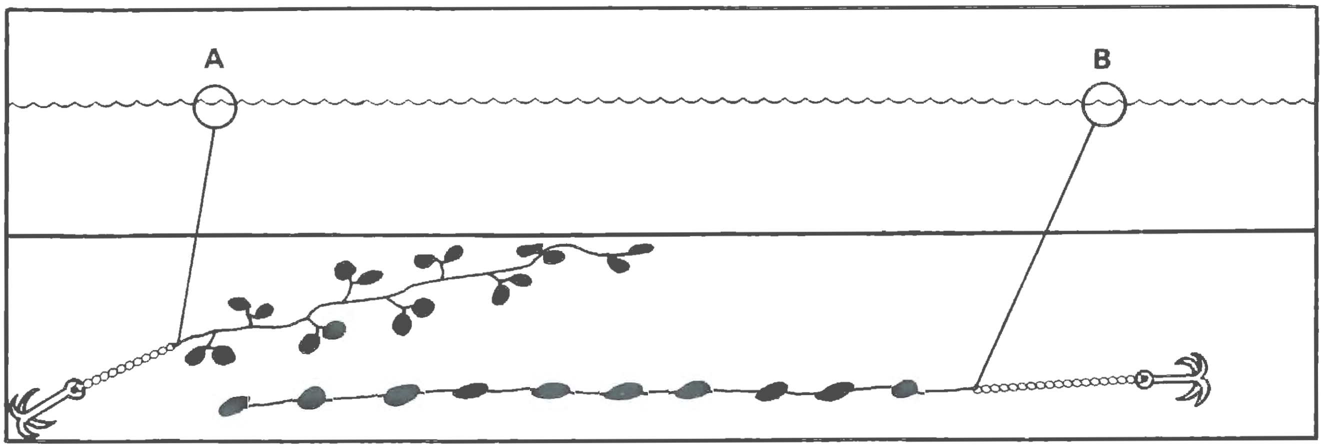


Figure 18.1. (A) Trotline with snoods. (B) Trotline with bait attached to mainline.

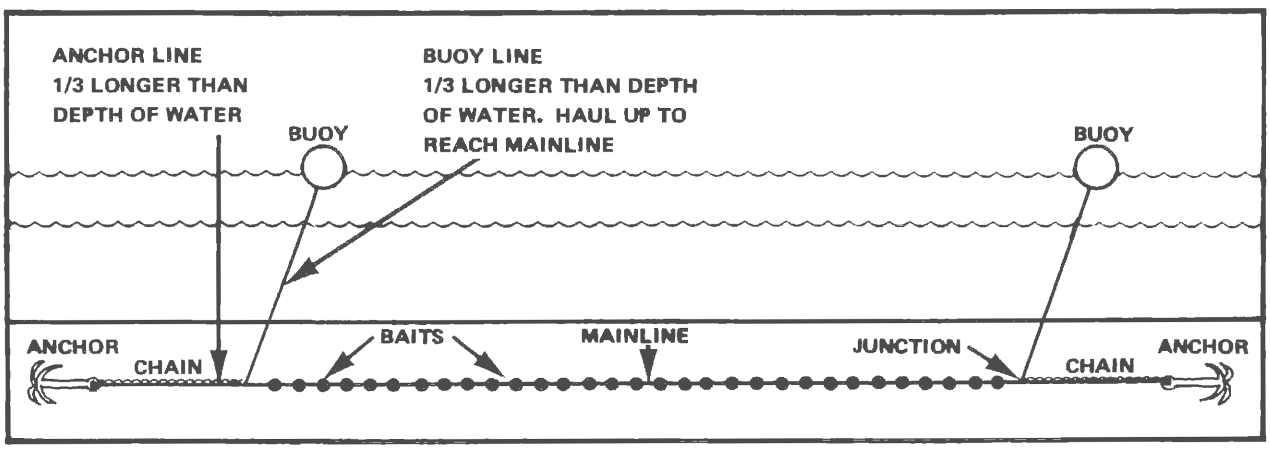


Figure 18.2. A trotline with baits attached to the mainline (from Floyd 1968).

It is not clear when the technology moved to Louisiana; however, both Alabama and Louisiana experienced difficulty in establishing pot fishing. Trotline fishermen felt that the more efficient pot was depleting the resource because their catch was decreasing. Another barrier to accepting the new technology was the capital investment required to purchase wire, floats, tools and other necessary materials.

With legal precedence established in Mississippi, small skirmishes occurred between pot and trotline fishermen. Pots were stomped flat and floatlines cut. Efficiency, however, won over tradition, and Louisiana crab fishermen finally adopted the pot throughout the fishery by the 1960s.

Modifications to the Lewis trap include changes in funnel placement and number of funnels and the structure and placement of the separating partition. In the late 1970s, Eldridge et al. (1979) developed a self culling trap that substantially reduced (82%) the catch of sublegal crabs.

18.2.2.2 Soft Crab

Louisiana has been the center for soft crab production in the Gulf of Mexico. According to Jaworski (1982) the soft and peeler crab fishery in the Gulf States developed along the northern shore of Lake Pontchartrain and in the area of Rigolets, borrowing from both terminology and shedding techniques of the Chesapeake Bay fishery. The fishery in the Barataria estuarine system, however, evolved quite differently. The discovery that peeler crabs could be harvested using the fresh willow branches (*Salix nigra*) designed to catch river shrimp and eels led to the development of folk-oriented fishing techniques [bush trotlines made of wax myrtle, (*Myrica cerifera*)] still in use today (Figures 18.3-18.6).

18.3 Processing Regulatory Agencies

The following lists the five Gulf States' processing regulatory agencies and a contact person:

Doug Morris, Environmental Administrator
Bureau of Marine Resources Regulation and Development
3900 Commonwealth Boulevard
Tallahassee, FL 32303

William Knight
Bureau of Inspection
Alabama Department of Public Health
State Office Building
Montgomery, AL 36130

John Cirino
Shellfish Specialist
Mississippi Department of Wildlife, Fisheries and Parks
Bureau of Marine Resources
2620 Beach Boulevard
Biloxi, MS 39531

Charles C. Conrad, Administrator
Seafood Sanitation Unit
Department of Health and Human Resources
Office of Preventive and Public Health Services
P.O. Box 60630
New Orleans, LA 70160

Richard Thompson
Division of Shellfish Sanitation Control
Texas Department of Health
1100 West 49th Street
Austin, TX 78756

Figure 18.3. Wax myrtle, Myrica cerifera (courtesy Lionel Eleuterius).

Figure 18.4. Bush trotline.

Figure 18.5. Running bushline.

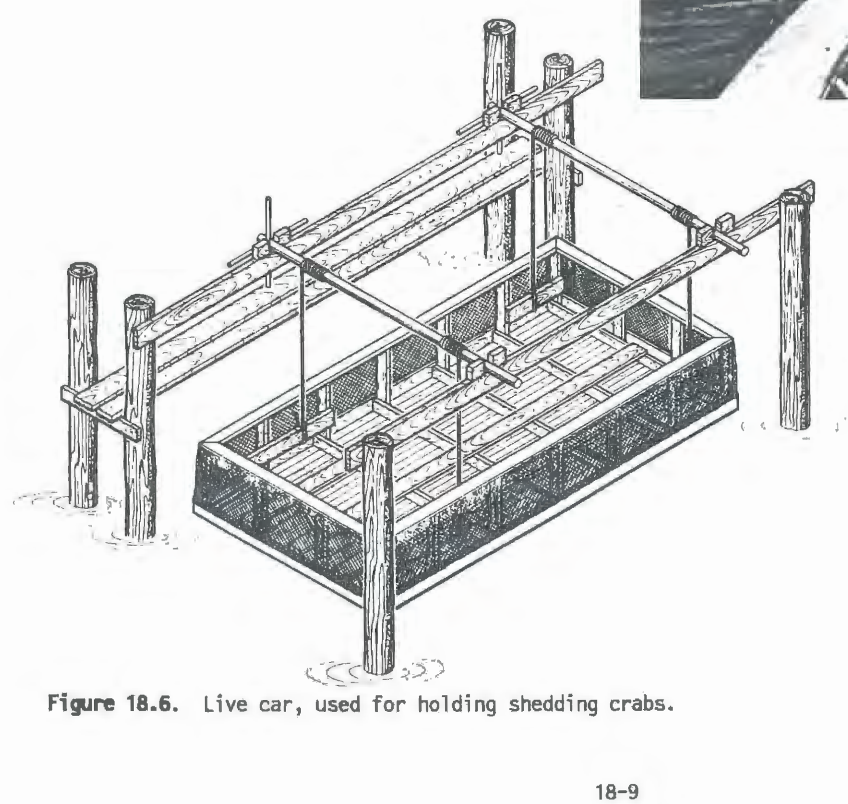


Figure 18.6. Live car, used for holding shedding crabs.