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Wildlife & Marine
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October 31, 1979

Dr. Wayne Beam
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Dear Wayne:

Attached is the final report for contract number 04-8-M01-365, entitled "Development of Management Planning Profiles for Major Coastal Fisheries of South Carolina".

Please advise as to whether this meets the requirements of the contract. If you need additional copies, let me know.

Sincerely,

CHARLES M. BEARDEN
Director, Office of Conservation
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CMB/mhj
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DEVELOPMENT OF MANAGEMENT PLANNING PROFILES FOR MAJOR COASTAL FISHERIES OF SOUTH CAROLINA

South Carolina Wildlife and Marine Resources Department
Marine Resources Division

Submitted to: S. C. Coastal Council.
Grant-in-Aid Award
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SECTION I

PROJECT SUMMARY AND OVERVIEW

PROJECT SUMMARY AND OVERVIEW

1. Introduction

This document has been prepared under contract with the South Carolina Coastal Council and represents the first stage of South Carolina's participation in the Office of Coastal Zone Management's Coastal Fisheries Assistance Program (CFAP). The stated purpose of the CFAP is to provide the states with financial and technical assistance to develop the information required for more effective management of fisheries within the territorial seas. This program is aimed at providing for adequate consideration of fisheries in the coastal zone management process.

Increasing demands and fishing pressure by commercial and recreational interests have accentuated the need for sound management of coastal fishery resources in South Carolina. In addition, alteration of the marine-estuarine habitat upon which coastal fisheries are dependent has increased considerably in recent years, further emphasizing the need for effective management and conservation of living marine resources. As the population of the coastal zone of South Carolina continues to grow and expand, the problems associated with the utilization of fishery resources will intensify and become increasingly complex. It is therefore essential that the State develop comprehensive management plans for important coastal fishery resources.

Basically, the CFAP is viewed as a three phased program to (1) develop management planning profiles characterizing the State's fisheries, (2) conduct research and data collection required for fisheries planning or management and (3) develop specific fisheries management plans or implement changes to existing plans.

It was therefore determined that the development of management planning profiles for important coastal fisheries was appropriate for the initial stage of South Carolina's participation in the CFAP. Based upon the current status of the various coastal fisheries, commercial and recreational significance, and other criteria, three management units - blue crab, molluscan shellfish (hard clam and eastern oyster), and coastal finfish were determined to have highest priority. These three units, along with the Penaeid shrimp and anadromous fishes (shad, herring and sturgeons) are presently the major coastal fisheries of the State in terms of economic and recreational importance. (Management plans have already been developed for Penaeid shrimp and anadromous fishes).

The following sections of this overview present pertinent background information on the State's coastal fisheries habitat and its present status, a general description of coastal fisheries, the current fisheries management program and a brief summary of project objectives and justifications.

2 The Coastal Habitat and Living Marine Resources of S. C.

The coastal zone of South Carolina as defined under the Coastal Management Act of 1977 consists of all coastal waters and submerged lands seaward to the State's jurisdictional limits and all lands and waters in the counties of the State which contain one or more of the critical areas (coastal waters, tidelands, beaches and primary ocean front sand dunes). These counties are Beaufort, Berkeley, Charleston, Colleton, Dorchester, Horry, Jasper and Georgetown.

In general, the coastal zone of the State extends from the three mile territorial limit in the Atlantic Ocean inland to the transition zones of coastal estuarine systems from predominately brackish to predominately fresh waters, and in a coast wise direction from the North Carolina border at Little River southward to the Georgia border on the Savannah River. The coastal zone's major environmental features are: salt, brackish and tidal fresh water marshes; estuarine and marine waters; subtidal bottoms; intertidal mud and sandflats; coastal impoundments; oyster reefs; barrier islands and beaches, swamp, bottomlands, savannahs and wooded uplands. The coastal zone contains approximately 1.2 million acres of marine and estuarine habitat, including wetlands, open waters and bottoms; 190 miles of Atlantic Ocean coastline, and almost 3,000 miles of tidal shoreline.

From the North Carolina line to Winyah Bay the coast forms a gentle crescent, called an arcuate strand. The coastal zone in this section is characterized by broad sandy beaches and few tidal inlets leading to small high salinity estuaries.

From Winyah Bay South to the Georgia border, the coast is fronted by a series of barrier islands separated from the mainland by vast expanses of marshlands intersected by networks of tidal streams. Numerous rivers traverse the coastal zone in the latter section, some of which rise in the coastal plain itself (minor rivers). The coastal plain rivers include the Black, Waccamaw, Wando, Cooper, Ashley, Ashepoo, and Combahee-Salkehatchie. These rivers in general have small drainage basins and are strongly-influenced by tidal fluctations. The other rivers, having origins outside of the coastal plain, are the Pee Dee, Santee, Savannah, and Edisto, with the Edisto having the smallest drainage basin and the Santee the largest. River discharge, after periods of heavy rain, is occasionally sufficient to create low salinity (10 o/oo) conditions in the vicinity of the mouths of these river and beyond. The major river valleys are generally characterized by broad flood plains with ox-bow lakes, natural levees, and sand dunes. Meanders are common and, as a result, steep banks and bluffs are frequently cut into the Tertiary bedrock.

The Pee Dee, Santee and Savannah Rivers do not have extensive deltas projecting onto the near-shore shelf, despite significant sediment loads and relatively low wave energy near the river mouths. At their mouths coastal marshes of Holocene age have buried river flood plains and Pleistocene sand dunes and terraces of the mainland. The deltas of the Santee and Savannah Rivers, as a result of marsh and sand deposits, appear to be sediment-filled, drowned valleys, rather than classic river deltas.

Besides the above examples, the coastline of South Carolina has other types of estuaries, among which are drowned river valleys, barbuilt estuaries, or a combination of the two. Charleston Harbor and Port Royal Sound are classic examples of drowned river valleys, while Murrells Inlet, Bulls Bay and Calibogue Sound are barbuilt estuaries. Since estuaries characteristically are sediment traps, a wide variety of deposits can be found in South Carolina's estuaries, ranging from tidal flats and marshes to inlet-associated deltas. Many marsh-covered plains, typical of South Carolina sea islands, are actually sediment-filled Pleistocene estuaries covered with a Holocene marsh veneer.

The sea islands region of South Carolina is characterized by low-lying, sandy islands covered with maritime forest and separated by vast expanses of saltmarsh intersected by networks of tidal creeks. In particular, barrier islands are composed of closely-spaced beach/dune ridges with sandy beaches fronting on the Atlantic Ocean. Marsh islands consist of isolated or widely-spaced sand ridges surrounded by salt marsh facing the Atlantic.

The marine, maritime and estuarine ecosystems of the South Carolina coastal zone are extremely significant in terms of biological, economic and social values, especially those associated with living marine resources. The wetlands and subtidal areas of these ecosystems cover approximately 1,200,000 acres of the coastal zone, extending from Little River southward to the Savannah River and from the upper limits of saltwater penetration in coastal rivers seaward to the three mile territorial limit in the Atlantic Ocean. Major habitats included within these ecosystems are: open ocean waters and bottoms (500,000 acres); beaches (10,700 acres); coastal marshes (430,000 acres), coastal impoundments (70,000 acres) and open estuarine waters and bottoms (242,000 acres).

The coastal waters and bottoms previously described provide habitat for many important species of fishes, invertebrates and other living marine resources. These living resources support valuable commercial and recreational fisheries and are important to nature enthusiasts and other interests. In addition to these values, living marsh and dune vegetation have considerable significance not only as productive habitat for fish and wildlife, but also in the protection of coastal lands from erosion and storm damage, for aesthetic reasons, and in the case of the former, in the assimilation of wastes from human activities.

Biologically, the coastal marine-estuarine system is among the most productive areas known to man, both in terms of species diversity and biomass. This unique environment supports complex assemblages of a wide variety of plant and animal life, including both resident and migratory forms. The biological richness of coastal marine-estuarine ecosystems is due in a large part to the concentrations of nutrients from upland sources, and the production of organic detritus from marsh plant decomposition.

Primary productivity by marsh plants, algae and phytoplankton as a result of the photosynthetic interaction between light energy and nutrients, as well as detrital production resulting from decomposition by bacteria and fungi, is extremely high, supporting a large and diverse fauna, including fishes, invertebrates, mammals, shorebirds, sea turtles, and other marine-estuarine species and groups. Much of the organic material and nutrients from the near shore environment is exported by currents to oceanic waters, and many species of fish and invertebrates nurtured in estuarine areas migrate long distances, thereby increasing the biological productivity of areas outside of the coastal marine-estuarine system.

Coastal marshes, dominated by vast expanses of saltmarsh cordgrass in South Carolina, play an important role themselves in providing habitat and cover for many estuarine fishes and invertebrates, such as shrimp, blue crab and many finfish species. In addition, coastal marshes are a significant habitat type for numerous species of birds and mammals, including clapper rail, wading birds, raccoons, mink and otters. Diked marshlands, many of which are vegetated by brackish water plant species, provide some of the most important habitat for waterfowl in the United States and are important for other species of birds, mammals, reptiles and amphibians as well. These impoundments also serve as habitat for estuarine fishes and invertebrates and are in some cases significant in the production and export of organic plant material and nutrients into the adjacent estuarine ecosystems.

The major values of the living marine resources of the coastal zone in human terms are expressed with respect to their utilization and economic significance. These values are primarily related to commercial and recreational fishing and the physical significance (erosion control, life support, waste assimilation), of tidal wetland vegetation. Although commercial and recreational fisheries are quantifiable in terms of utilization and economics, the values referred to wetlands vegetation are much more difficult to assess.

There are other real values of the living marine resources of the marsh-estuarine system for which there is no generally accepted economic equivalent. These include values related to the protection of coastal dunes and uplands from erosion and storm damage by emergent wetlands vegetation and waste assimilation by saltmarsh plants. Values assigned by various studies along the

Atlantic and Gulf coasts to these properties have varied widely, and therefore no attempt is made herein to estimate their economic benefits.

Social and aesthetic values associated with the living resources of the coastal marine-estuarine area are likewise often difficult or impossible to quantify. Such values include those related to natural beauty and a clean and healthy environment.

In summary, the living marine resources of the coastal zone of South Carolina are extensive and extremely important in terms of biological, economic, recreational and social values. Although some of these attributes may be evaluated in terms of dollar value or utilization, many cannot, and figures currently available with respect to economic impact and numbers of people benefiting from these resources must be considered grossly inadequate to express their total worth. At present, the great majority of the State's living marine resources have not been over-exploited or depleted, although public utilization and demand is increasing rapidly. The future of these resources will depend to a large extent on effective fisheries and wildlife management programs as well as adequate consideration of these resources and their habitat during all stages of the State's comprehensive coastal zone planning and management process.

3. Condition of Coastal Fisheries Habitat

Man-induced environmental alterations in the South Carolina coastal zone have increased significantly in recent years along with rapid population growth and expansion. Activities related to water transportation, industrial and residential development, agricuture (and silviculture), recreation and tourism have been the primary sources of man's perturbations upon the coastal zone and its living marine resources.

Dredge and fill operations, for the purpose of creating and/or improving navigation channels, recreational access and development opportunities have resulted in significant alteration of South Carolina's coastal wetlands area. The construction and continuing maintenance of the Atlantic Intracoastal Waterway and coastal shipping channels in major harbors (Charleston, Georgetown, and Beaufort) have had the most significant environmental impact, resulting in the loss of thousands of acres of wetlands, disruption of bottoms, and current patterns and contamination of estuarine waters in some areas.

Water pollution from industrial and domestic discharges has created serious problems in urbanized areas along the coast, including Murrells Inlet, Georgetown, Charleston and Beaufort. Industrial pollution has been severe enough to cause fish kills in the past in specific coastal areas near Georgetown and Charleston. Due to water quality problems resulting primarily from domestic sewage discharges, approximately 76,000 acres of the total of 240,000 acres of estuarine waters in the State are currently closed to shellfishing.

Agricultural and silvicultural practices have had significant environmental impact along the coast, also. Numerous fish kills have resulted from pesticide run-off or lack of adequate precaution during aerial application of pesticides near coastal wetlands. Altered drainage has resulted in excessive run-off and siltation in some coastal estuarine areas as a result of agricultural and silvicultural operations.

Although currently there are few extractive industries operating in coastal South Carolina, the mining of coquina near Little River and past phosphate mining operations in the Beaufort and Charleston county areas have had adverse impacts upon coastal wetlands.

Other activities having actual or potential adverse effects upon fisheries resources include impoundment of wetlands, recreational and commercial fishing operations, marine construction, and recreational boating.

Man's activities have severely modified fisheries habitat along the South Carolina coast, particularly in the Murrells Inlet-Little River, Georgetown, and Charleston Harbor areas. The proposed Santee-Cooper rediversion, which will result in greatly increased freshwater inflow into the Santee Estuary and reduced freshwater flow into the Cooper River, is expected to have considerable impact upon coastal fishery resources.

In spite of the above discussed alterations, the overall status of fisheries habitat in the coastal zone of South Carolina is considered to be relatively healthy. Some efforts have been made to bring about improved water quality in coastal waters, with Charleston Harbor being a notable example, and the current trend to discourage the use of additional wetlands for the disposal of dredge materials is encouraging. Many problem areas still exist however, and the continuing growth of population and concomitant development will require a concerted effort by all agencies and individuals involved in coastal zone management in order to prevent significant future degradation of estuarine fisheries habitat.

4. Overview of the Coastal Fisheries of S. C.

The coastal marine and estuarine fishery resources of South Carolina are extremely valuable to the people of the State both in economic and recreational terms.

The total economic impact of commercial and recreational fisheries in the coastal zone of South Carolina is conservatively estimated to be $130,000,000 annually. This includes values for commercial seafood landings and processed products, and conservative estimates of expenditures by recreational fishermen. Many indirect economic benefits of the State's commercial and recreational fisheries are not known with certainty, since no comprehensive survey of the overall economic impact of these fisheries has been conducted.

4.1. Recreational Fisheries

The major recreational fisheries of coastal South Carolina are saltwater angling, shellfishing, shrimping and crabbing. The most significant recreational fishery at present is for coastal finfish species, including sea trout, red drum, flounder and spot taken by hook and line from small boats, piers and the shore by marine anglers. Recreational shellfishing for oysters and clams, as well as recreational shrimping and crabbing using drop nets, seines, handlines and cast nets, are, however, becoming increasingly popular along the coast.

While current and complete information is not available on the participation rates and economic significance of all segments of the marine recreational finfish fishery, some earlier data is available which provides an insight into the magnitude of saltwater sport fishing in South Carolina's coastal zone.

During 1968, there was an estimated 174,000 South Carolina residents who participated regularly in saltwater fishing. Of this number, 41,600 residents participated in the surf and bank fishery and 121,000 participated in the small boat fishery. If children under the age of 12 and occasional fishermen had been included in this 1968 survey, the estimated number of total participants would have approached 250,000. A recent study conducted by the South Carolina Wildlife and Marine Resources Department of South Carolina's fishing piers estimated that a total of 25,000 residents fished a total of 228,000 days from 13 piers and harvested 210,000 pounds of fish during 1974.

These estimates only take into consideration South Carolina residents. If one were to also count the number of non-residents who participated in these fisheries, these figures would increase significantly. For example, a 1968 North Carolina survey indicated that 36,000 North Carolina residents fished in the marine and estuarine waters of South Carolina during that year. A survey conducted by the National Marine Fisheries Service estimated that 184,000 residents from the northeastern United States participated in the marine recreational fishery in South Carolina during 1973-74. These figures indicate that the number of non-residents participating in the finfish segment of South Carolina's marine recreational fishery is significant. The latest available (1975) published information on annual expenditures by saltwater anglers gives a figure of $210 per angler. As previously mentioned, a survey conducted during 1968 indicated there were an estimated 174,000 resident anglers who fished regularly in saltwater in South Carolina. Published information for the South Atlantic region indicates an annual growth rate of four percent in the number of marine recreational anglers. Based on these data, the current estimated number of resident anglers who fish in saltwater regularly would be 248,000. If this figure is applied to the 1975 average annual expenditure per angler, an estimated impact of $52 million is generated. This figure does not take into account non-resident anglers (whose numbers from all indications at least equal that of resident anglers), other segments of the recreational fishery (shrimping, crabbing and shellfishing), or indirect benefits related to retail sales and tourism. Conservatively, it is estimated that the total economic impact of coastal recreational fishing in the State is over $100,000,000 annually.

4.2. Commercial Fisheries

Historically, the most significant commercial fisheries of South Carolina have been based on estuarine dependent resources, principally Penaeid shrimp, blue crab, molluscan shellfish (eastern oyster and hard clam) and coastal finfish (including sciaenids, mullet and anadromous species).

During the latter part of the nineteenth and early part of the twentieth centuries, the major commercial fisheries in the state were for oysters and finfish (especially shad and sturgeon). For a variety of reasons, including man-induced environmental perturbations, overfishing, and economic factors, these fisheries had declined significantly by 1920. With the development of otter trawling, Penaeid shrimp became the most important commercial fishery resource in terms of landings during the 1920's and this is still the case at present. Between 1951 and 1957 Atlantic menhaden were a significant component of commercial fisheries landings. During the 1950's a significant fishery for blue crabs, which has continued up to the present time, was developed in South Carolina.

In recent years (1970-78) South Carolina commercial fishery landings have averaged about 20 million pounds valued at over 10 million dollars annually. Penaeid shrimp (chiefly shite shrimp, _Penaeus setiferus_), and brown shrimp (_P. aztecus_), and blue crab (_Callinectes sapidus_) have remained the predominant coastal fisheries in terms of both total landings and value. In the case of the shrimp and blue crab fisheries, rising demand and value continues to attract new investment and fishing effort in spite of the fact that these resources are apparently being exploited at or near their levels of maximum yield.

Molluscan shellfish, predominantly oysters and hard clams, continue to support significant commercial fisheries in South Carolina. Following the decline in landings mentioned previously, oyster production in South Carolina increased some what in the 1950's and 1960's, declined significantly in 1968 and has remained stable since then. Commercial landings of hard clams, a previously underutilized resource, have increased significantly in recent years, chiefly due to increasing demand and higher ex-vessel prices, as well as the development of a significant escalator fishery in the Santee Estuary.

In the case of coastal finfish, landings of the predominant species such as spot, mullet and herring have fluctuated considerably over the past twenty years, primarily due to the influence of natural environmental factors, variations in amount of fishing effort, and economic conditions. Landings of heavily exploited anadromous species such as shad and sturgeon have remained at fairly stable levels since the significant declines reported at the turn of the century.

Currently, major commercial fisheries in South Carolina's coastal area are centered around Penaeid shrimp, molluscan shellfish (hard clam, eastern oyster), blue crab and finfish (shad, spot, mullet, flounder, and others). In recent years the annual landings of seafood in South Carolina have averaged about twenty million pounds, having a dockside value of between $10,000,000 and $16,000,000. During 1978, total seafood landed at S. C. ports was valued at $16,091,422. Of this, the value of landings from State waters, (as opposed to landings from offshore beyond the territorial sea) was $13,603, 842, or 84.5% of the total). The total economic impact of commercial fishing in South Carolina is estimated to be several times that figure, taking into consideration the wholesale and retail trade, seafood processing and other factors.

5. Current Management System for Coastal Fisheries

The Division of Marine Resources of the S. C. Wildlife and Marine Resources Department is the State organizational unit having primary responsibility for the management and conservation of the living resources of the coastal zone, especially marine and estuarine fishery resources. These responsibilities are specified under

State legislation (Title 50, S. C. Code of Laws) which provides that the Division has jurisdiction over all fish, fishing and fisheries in the saltwaters of South Carolina, including shellfish, crustacean, finfish, sea turtles and marine mammals. Other legislation provides for the management and regulation of coastal and anadromous fisheries, including control of fishing seasons, areas and equipment; issuance of leases of state bottoms for shellfish culture and mariculture; management of public shellfish grounds; and the issuance of licenses and permits for fishing activities.

In addition, to its statutory and regulatory responsibilities the Division is active in environmental matters within the coastal zone, including the investigation of fish kills, environmental research and monitoring, wetlands inventory, and the review and evaluation of environmental impact statements and State and Federal permit applications for coastal alterations. A major goal of the Division is to manage and develop coastal fishery resources, emphasizing maximum protection of the marine-estuarine environment, in such a manner as to provide for optimum sustained benefits to the people of the State. Specific management objectives include the following:

(1) To sustain currently exploited fishery resources at their present levels.

(2) To provide, where possible, for the expansion and development of coastal fisheries through improved utilization of currently exploited species and unused or underutilized species.

(3) To design and implement State management plans and assist in the development and implementation of regional management plans for important coastal fishery resources.

(4) To provide for maximum protection of coastal fisheries habitat within the limits of regulatory authority and through imput into coastal zone management and permitting processes.

The Division of Marine Resources has made significant accomplishments in the area of fishery research, management and development since it was created under Departmental reorganization in 1969. Some major accomplishments include: the development of a long range management program for the Santee Estuary hard clam fishery; significant expansion and improvement of recreational shellfish grounds in the coastal zone; the establishment of a coastwide artificial fishing reef construction program, presently consisting of ten such reefs (a recent survey has indicated that the direct economic impact of these reefs on coastal communities in 1977 was approximately $5,000,000); the development of a calico scallop fishery off S. C.; a comprehensive inventory of the State's coastal wetlands; and the development of a large scale mariculture program in S. C. The Division was instrumental in the preparation of a regional South Atlantic shrimp management plan, completed in 1975. This plan has been published and is being implemented by the four South Atlantic States (N.C., S. C., Ga., and Fla.). A cooperative State-Federal fisheries statistics program, involving the comprehensive collection of shrimp catch and effort data essential for management is well underway as a result of this planning effort. Also in the area of management planning, the Division has recently completed a management plan for anadromous fishes (shad, striped bass, river herring) in cooperation with the State of Georgia under a PL 89-304 funded project.

Within the Wildlife and Marine Resources Department, the Division has a close working relationship with the Division of Law Enforcement and Boating, Coastal Law Enforcement District. The CLED is responsible for the enforcement of the coastal fisheries laws and regulations of the Marine Resources Division. Close cooperation is also maintained with the Department's Wildlife and Freshwater Fisheries Division with respect to the management of anadromous and catadromous species which range into both fresh and salt water.

The Division also works closely with other State agencies including the S. C. Department of Health and Environmental Control in matters related to shellfish sanitation and water quality standards, and with the S. C. Coastal Council in its coastal zone management programs. At the local level, the Division has a good working relationship with county agencies (PRT, County Public Works, etc.) involved in marine related activities.

On an interstate basis, the Division has been quite active in the State/Federal fisheries management program in cooperation with N. C., Ga. and Florida. Cooperative management programs have been developed on an interstate basis for Penaeid shrimp and anadromous fishes, including American shad. The Division Director is a member of the executive committee of the Atlantic States Marine Fisheries Commission and staff members serve on various other committess of the Commission.

At the Federal level, the Director of the Marine Resources Division is a permanent member of the South Atlantic Regional Fisheries Management Council and staff members serve on the Scientific and Statistical Committee and various management planning committees of the Council. Currently, the activities of the Council have little effect upon the management of South Carolina's coastal fisheries. A management plan for king and Spanish mackerel is currently under consideration, which would have some effect upon territorial waters, but most of the Council's management activities presently deal with species occurring almost entirely within the Fisheries Conservation Zone.

Also at the Federal level, the Division cooperates with the National Marine Fisheries Service and the Fish and Wildlife Service of the U. S. Department of Interior in various research and management programs related to environmental and fisheries matters.

6. Project Objectives and Justification

The three fisheries management units selected for this project are not only significant in an economic and/or recreational sense, but are also those (in addition to Penaeid shrimp and anadromous fishes) having highest priority in terms of long range management needs. All three are estuarine dependent, moderately to heavily exploited fisheries experiencing problems related to allocation among recreational and commercial interests. Available information pertinent to management of the three units varies, but significant gaps exist for each in terms of biological, economic and social aspects. All three, and especially molluscan shellfish, are susceptible to environmental alterations within the coastal zone.

Coastal finfish resources, primarily consisting of spotted sea trout (Cynoscion nebulosus), red drum (Sciaenops ocellata), and flounder (Paralichthys species) form the basis for an expanding inshore recreational fishery in South Carolina. These species are already apparently exploited to a high degree in some coastal areas of the State. In recent years, growing controversy has arisen concerning the use of gill nets for taking these species, particularly from inside waters. Information on the life histories, population dynamics, catch/effort and other aspects of these fisheries essential to proper management is very limited.

The blue crab (Callinectes sapidus) fishery is the second most important commercial fishery in coastal South Carolina. Recreational fishing for blue crabs is increasing, and conflicts related to user allocation are growing. Currently, blue crabs are felt to be heavily exploited in South Carolina by commercial interests. Biological information related to management is fairly good, but important information gaps still exist.

The coastal fishery for molluscan shellfish-hard clams (Mercenaria mercenaria), and eastern oysters (Crassostrea virginica) is also beset with numerous problems related to commercial vs. recreational allocation, inadequate and ineffective cultivation practices, environmental perturbations, and insufficient funding for management. The commercial fishery is faced with numerous problems associated with economics and labor supply and the public demand for increased recreational shellfishing opportunities is growing rapidly. The resource base itself has declined due to man-induced alterations of the coastal zone, including water pollution. Management has been complicated by the above mentioned conditions and by various other problems related to information gaps, enforcement and legislation.

The need for comprehensive management planning with respect to the aforementioned fisheries is imperative to their future well being and effective utilization. Although the Division has ongoing projects related to the management of each of these fisheries, no long range management planning effort has yet been attempted for them. The development of such plans, and their subsequent implementation, is felt to be critical within the near future.

Under this CFAP project, management planning profiles, including characterization and identification of information needs, have been developed for the three coastal fisheries under consideration. These profiles will assist the State in developing options and generally in achieving more effective management of coastal fisheries in the future.

SECTION II

COASTAL FINFISH

Coastal Finfish

Management Planning Profile

Joseph W. Smith

and

Charles J. Moore

South Carolina Wildlife and Marine Resources Department
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1 Introduction

This segment of the Coastal Fisheries Management Planning Profiles deals with coastal finfish and their fisheries. The three species groups selected for inclusion are the spotted seatrout, *Cynoscion nebulosus*, the red drum, *Sciaenops ocellata*, and two species of paralichthid flounders, the summer flounder, *Paralichthys dentatus*, and the southern flounder, *P. lethostigma*. All are estuarine-dependent during most or portions of their life history and are moderately to heavily exploited by coastal and recreational commercial fishermen in South Carolina.

The initial section of this profile addresses a description of the resource. A pervading theme throughout this section is the dearth of biological and ecological information available on the coastal finfish of South Carolina. Basic biological questions, essential for proper management decisions, remain unanswered for all but a few finfish species found in coastal South Carolina waters. Most life history information incorporated into this profile has been gleaned from investigations conducted elsewhere along the Atlantic and Gulf coast of the United States.

A comprehensive survey of South Carolina's marine recreational fisheries is lacking. However, numerous isolated and regional surveys have been reviewed. These studies give some indication as to catch composition, participation levels and related economic factors for various segments of the state's saltwater recreational fisheries. Additionally, postal card questionnaires were mailed to all persons holding South Carolina gig, gill net and swimfish licenses during 1978-1979. Survey responses helped fill numerous information gaps related to gig and gill net fisheries and the sale of saltwater finfish within the state. A small-scale survey of retail and wholesale seafood dealers was also conducted in order to obtain information on the flow of finfish through the state's seafood markets.

Subsequent sections of this profile list current monitoring programs for marine finfish in South Carolina and enumerate problem areas associated with the coastal finfish resources, their fisheries and management.

The profile presents a summary of information on spotted seatrout, red drum and the paralichthid flounders and their fisheries in South Carolina. Future needs and recommendations related to research, development and management of these resources are included. Hopefully, this report will aid in the implementation of long-range management planning efforts for the coastal finfish resources of South Carolina.

2 Description of the Resource

2.1 Spotted Seatrout

The spotted seatrout, Cynoscion nebulosus, is a member of the family Sciaenidae (drum and croakers) and is highly prized as a food and game fish. It's range is almost continuous from Delaware Bay on the Atlantic coast to northern Mexico along the Gulf coast. The species is euryhaline and prefers estuaries and brackish bays and lagoons. It is a year round resident of inside waters in the southern part of its range, showing little tendency to migrate from its natal area. Populations in North Carolina and further north tend to leave the estuaries with the onset of winter and return the following spring.

The spotted seatrout is a schooling species, although the largest members of a population may be somewhat solitary. Growth rates vary among different populations due to various biotic and abiotic factors. Generally, both sexes mature between ages 1 to 3 when approximately 200-300 mm long. Fecundity increases with size. Age classes 2 through 4 comprise most of the spawning stock. The relative abundance of older fish in the population decreases rapidly after age 5. Females are slightly larger and tend to outlive the males.

Along the Gulf and southeastern states spawning extends from April through October, being limited to spring and summer in the mid-Atlantic region. Spawning occurs at night in deep waters adjacent to shoal areas. The young inhabit grass beds and shell rubble during the early stages of growth.

The spotted seatrout is a voracious predator, feeding primarily on crustaceans and fish. Penaeid and caridean shrimps form an important portion of their diet.

Recreational catches of spotted seatrout in many areas rival commercial harvests. Commercial harvests are concentrated in western Florida, Louisiana and Texas. Atlantic coast commercial landings are minor in comparison.

Detailed studies of the biology and ecology of the spotted seatrout have been conducted in Texas (Pearson 1929; Miles 1950), Florida (Moody 1950; Klima and Tabb 1959; Moffett 1961; Stewart 1961; Tabb 1961 and 1966), and Georgia (Mahood 1974). A summary of biological and ecological information on the species has been produced by Lorio and Perret (1978).

2.1.1 Spawning

Tabb (1966) reported that spotted seatrout spawn at night. Spawning schools exhibit a milling motion; individuals within the school display side-to-side body contact.

2.1.2 Spawning Season

Spotted seatrout along the Gulf coast have a protracted spawning season, lasting from February through October (Lorio and Perret 1978). In Texas waters spawning extends from March to October, reaching its peak in April and May (Pearson 1929). Gunter (1945) suggested the possibility of twin spawning peaks in the spring and fall respectively.

Ripe or mature spotted seatrout have been collected in Louisiana from February to October (Fontenot and Rogillio 1970). Sundararaj and Suttkus (1962) reported one spawning peak in July and August in Louisiana waters.

Along Florida's northwest coast spawning occurs April through October with most activity in late May and early June (Moody 1950; Klima and Tabb 1959). The season is of similar duration along the west coast of Florida, but peaks during the summer months (Moffett 1961). Larval spotted seatrout (Jannke 1971) and ripe females (Stewart 1961) have been collected in Florida's

Everglades year round although peak spawning occurs April to June (Jannke 1971). Tabb (1961) reported mid-April to late July as the spawning season along the east coast of Florida.

In Georgia waters spotted seatrout spawn from April to August with a peak in May (Mahood 1974; Mahood et al. 1974). The spawning season in South Carolina is reported similar to that in Georgia (Powles and Stender 1978). In North Carolina and Chesapeake Bay spawning is believed to occur April through August (Hildebrand and Cable 1934; Lippson and Moran 1974).

Peak spawning activity, as noted by Tabb (1958 and 1966) in Florida waters, occurs where salinities range from 30-35°/oo and temperatures average 26°C. Most spawning is believed to cease once water temperatures have reached 28°C (Tabb 1958) or where salinities are greater than 45°/oo (Gunter 1945).

2.1.3 Spawning Area

In Texas spotted seatrout are believed to spawn largely within the deeper areas of the bays and lagoons (Pearson 1929). Sabins (1973) indicated spawning activity in Louisiana waters occurred near or in coastal passes.

In Florida waters Tabb (1961) claimed spawning occurs in deeper channels and holes adjacent to shallow, grassy areas, however, significant spawning activity may occur outside or in the tidal portions of estuaries (Tabb and Manning 1961; Jannke 1971).

Mahood (1974) cited tidal creeks, rivers, sounds and beaches near inlets as spawning areas in Georgia. The lower portions of estuaries and inlets are possible sites in South Carolina (Powles and Stender 1978). Both inside and outside areas have been suggested as possible spawning areas in

North Carolina and Virginia (Welsh and Breder 1923; Hildebrand and Cable 1934; Lippson and Moran 1974). Spawning activity north of Delaware Bay is negligible (Pearson 1929; Welsh and Breder 1923).

2.1.4 Fecundity

Egg production in spotted seatrout increases with the size of the female. In Texas Pearson (1929) recorded that a 480 mm long female produced about 430,000 eggs, while a 620 mm long specimen produced 1,118,000 eggs. Miles (1951) estimates of fecundity for spotted seatrout from Texas ranged from 100,000 eggs produced by a female 245 mm in length to 600,000 - 1,000,000 eggs for 5-8 year old females. Average production per female was thought to be 500,000 to 600,000 eggs.

Mean number of eggs produced by female C. nebulosus in Louisiana was calculated as approximately 140, 354, 661, and 1,144 thousands of eggs for age classes 1 through 4, inclusive (Sundararaj and Suttkus 1962). Age group 3 (mean size 450 mm long) contributed a majority (40.6%) of the eggs supplied to the spawn. Tabb's (1961) estimates for egg production by the Indian River (Florida) population of spotted seatrout ranged from 15,000 to 1,100,000 eggs (mean number per female) for females 325 to 625 mm in standard length.

2.1.5 Maturity

Size and age at maturity may vary between estuaries, however, spotted seatrout generally reach maturity at ages 1 to 3. Males mature earlier than females; the latter reach a greater maximum size (Pearson 1929). In Texas Pearson (1929) cited spotted seatrout mature for the first time at the end of their second year of life. In the same waters, Miles (1950) reported 10% of the population matures at the end of their first year (160 mm long) and 50% attains maturity by the end of their second year (250 mm long).

At Cedar Key, Florida females reached maturity at 210 to 250 mm in length while males matured at 200 to 240 mm in length (Moody 1950). Along Florida's northwest coast the smallest ripe male and female collected by Klima and Tabb (1959) measured 180 mm and 210 in standard length respectively. Some males attained maturity at the end of their first year, females by the end of their second year; all specimens had spawned at least once by the end of their third year (Klima and Tabb 1959). In the Florida Everglades maturity is reached between a length of 180-300 mm (Stewart 1961). Along the east coast of Florida Tabb (1961) found most males matured during the second and third years of life while most females matured in their third and fourth years; all fish greater than 380 mm in standard length were mature.

Ages 2 through 4 appear to be the largest classes of spawners (Guest and Gunter 1958).

2.1.6 Eggs and Larvae

Recently Fable et al. (1978) succeeded in rearing spotted seatrout eggs and larvae under laboratory conditions. They reported that the eggs are buoyant and spherical with one oil globule, occasionally two or three. Hatching occurred 16-20 hours after fertilization at 20°C. Newly hatched larvae average 1.46 mm long. Smith (1907) noted that spotted seatrout eggs collected near Beaufort, North Carolina hatched in 40 hours at 25°C. Metamorphosis is complete approximately 12 days after hatching (Taniguchi 1978).

2.1.7 Growth of the Larvae

Fable et al. (1978) indicated laboratory reared spotted seatrout larvae grew from 1.5 mm at hatching to 4.5 mm in 15 days. The yolk sac was almost completely absorbed in 40 hour old larvae.

Taniguchi (1978) found 28°C and 28.1 ‰ optimal conditions for larval C. nebulosus growth. Larval growth rates increased significantly as prey concentrations increased.

2.1.8 Food and Feeding Habits

The spotted seatrout is a carnivorous species exhibiting a preference for active near-bottom and mid-water prey. Fishes most often encountered in the diet include mullet, menhaden, croaker, spot, pinfish, silver perch, minnows, anchovies and silversides, while penaeid shrimps constitute the bulk of the crustaceans eaten by the larger spotted seatrout (Pearson 1929; Moody 1950; Darnell 1958; Tabb 1961; Mahood 1974). Some degree of cannibalism has been noted in larval (Fable et al. 1978) and adult spotted seatrout (Moody 1950; Tabb 1961).

The diet of C. nebulosus changes with growth. Moody (1950) examined the feeding habits of over 900 specimens from Cedar Key, Florida. Copepods and other planktonic crustaceans were consumed by fish under 50 mm in length. The 50-150 mm size class fed primarily on caridean shrimps. Penaeid shrimps were the major food item of seatrout between 150-300 mm long, whereas fish predominated in the diet of specimens greater than 300 mm long. Feeding studies conducted by Springer and Woodburn (1960) and Odum and Heald (1972) on young spotted seatrout in other areas in Florida are in agreement with Moody's findings.

The feeding habits of spotted seatrout reflect relative abundances of prey items. Penaeid shrimps usually predominate in the diet of the larger fish during the spring and summer and are replaced by fish in the fall and winter (Gunter 1945; Moody 1950). Due to the relative scarcity of penaeid and caridean shrimps in Lake Ponchartrain, Louisiana, young trout in this area feed mostly on mysids, benthic amphipods and larval anchovies (Darnell 1958).

Feeding is probably initiated by visual stimuli (Tabb 1961). Prey items are captured by a rapid darting motion (Tabb 1966). Locally, schools are thought to be constantly on the move in search of prey (Lorio and Perret 1978), however Darnell (1958) reported that in Louisiana waters most feeding occurs during early to mid-morning hours with little feeding during the afternoon. Feeding schools may invade very shallow areas along edges of a marsh with the incoming tide (Pearson 1929; Moody 1950). The spotted seatrout's preference for shallow grass beds is probably a reflection of the abundance of prey items in these areas (Pearson 1929; Moody 1950).

2.1.9 Migration of the Larvae

After being spawned in the deeper areas of the bays and lagoons, the eggs drift onto shoal areas and hatch in the bottom vegetation and debris (Pearson 1929; Tabb 1961 and 1966). Newly hatched young scatter about the grass beds and shell rubble (Tabb 1966).

In South Carolina postlarval and juvenile _C. nebulosus_ have been collected in small tidal marsh creeks (Turner and Johnson 1974; C. Bearden, personal communications).

2.1.10 Role of the Estuaries

The importance of the estuaries to the life cycle of the spotted seatrout has been stated most succinctly by Tabb (1966):

> "The spotted seatrout is essentially a non-migratory species. Its entire life history is spent in the estuarine habitat... Wide tolerance to change in the estuarine habitat has permitted the species to occupy a niche that is not used by other seatrout and is intolerable to most marine predators and competitors that thrive just outside the inlets. Destruction of the estuarine

habitat will have an immediate and direct effect on the abundance of the spotted seatrout and reversal of such effects will be slow."

2.1.11 Factors Affecting Survival

Tabb (1958) found that the optimum temperature range of the spotted seatrout in Florida was 15-27°C. The fish adjust to temperature extremes by moving from shoal areas to deeper channels, holes or offshore. Spotted seatrout may not recover if exposed to 7.2°C water temperature for 12 hours (Tabb 1958). Numerous accounts of mass mortalities of spotted seatrout due to severe cold waves have been recorded (Storey and Gudger 1936; Gunter 1941; Gunter and Hildebrand 1951; Tabb 1958). Once a cold spell effects movement to deeper waters, the fish are reluctant to return to shoal areas until spring; thus, there is usually only one cold kill per winter (Tabb 1958).

In Georgia estuaries Mahood (1974) found that as winter water temperatures fell, spotted seatrout apparently moved to deeper estuarine waters. The fish returned to shallower creeks, rivers and sounds as water temperatures warmed through the spring, but apparently retreated to cooler, deeper waters during the summer months of June, July and August. He concluded that when water temperatures fall below 16°C or above 25°C most spotted seatrout leave the shallow waters for deeper, cooler channels. A similar pattern of movement probably exists in South Carolina waters.

Spotted seatrout have been collected in nearly fresh water, 0.5 °/oo (Dahlberg 1972) to hypersaline conditions of up to 75°/oo (Simmons 1957), although most abundant where salinities range between 15-35 °/oo (Tabb 1966). Tabb (1966) reported that a sudden change in the salinity regime of an estuary, such as that which occurs from tropical storm runoff, may cause mass migration to more salinity stable areas. Despite the absence of reports of freshetinduced mortalities, he speculated that larvae and juvenile stage may be severely affected.

Lorio and Perret (1978) pointed out the paucity of data relating C. nebulosus abundance and distribution to factors such as dissolved oxygen concentrations, light intensity, and system productivity. They cited Vetter's (1979) work on oxygen requirements of spotted seatrout and suggested less stress would be encountered by the fish at an optimum salinity of 20 $^{o}/oo$.

Tabb and Manning (1961) have reported the only turbidity-induced deaths of spotted seatrout. The gill chambers of these fish were packed with sand displaced from the bottom by hurricane-force winds.

Lorio and Perret (1978) summarized existing information on parasites of spotted seatrout, but failed to cite any mortalities due to infestation.

2.1.12 Migrations

Tabb (1966) described the spotted seatrout as essentially a non-migratory species. He acknowledged movements to the channels, inlets and ocean to escape winter weather or freshets, but did not consider these true migrations. Tagging studies in Florida (Moffett 1961; Iverson and Tabb 1962) demonstrated that spotted seatrout rarely stray more than 30 miles from their release site and few leave their natal estuary. Tabb (1966) suggested that long stretches of beach between estuary act as barriers to exchanges between populations.

Studies by Weinstein and Yerger (1976) support these hypotheses. Using electrophoretic analysis of spotted seatrout blood serum, they successfully differentiated subpopulations of C. nebulosus in the Gulf of Mexico and on the Atlantic coast of Florida. The distinct subpopulation hypothesis for spotted seatrout along the East Coast of the U. S. (north of Florida) has yet to be tested.

2.1.13 Distribution of Adults

Along the southeastern and Gulf coasts spotted seatrout tend to remain year round residents of estuaries and brackish bays and lagoons (Tabb 1966). Tabb (1966) noted that both young and adults appear to have similar tolerances of various environmental parameters. He did not recognize any spatial partitioning of the estuary by size of the fish.

Spotted seatrout are most abundant in water one to several meters deep (Moody 1950). Adults form small schools and move onto shoal areas with the incoming tide to feed (Pearson 1929; Moody 1950). During low tide they tend to congregate in the deeper portions of the channels (Moody 1950). Spotted seatrout exhibit schooling behavior until about age 5-6 (Tabb 1966). By this time most males have died and the larger females adopt a semi-solitary lifestyle.

In order to escape low water temperatures during the winter, spotted seatrout move to deep channels, inlets or marine waters (Pearson 1929; Moody 1950; Tabb 1966). In the northern part of their range, spotted seatrout leave the estuaries when the water temperature falls below 10°C, and return in the spring when temperatures rise to 10-12°C (Tabb 1966).

2.1.14 Distribution of Juveniles

Young spotted seatrout less than 20 mm long have been observed in moderately deep water (less than 3 m) over algal or muddy sand bottoms (Tabb 1961). With growth the juveniles disperse onto shallow flats and show a marked preference for grassy areas (Pearson 1929; Moody 1950; Tabb 1961). Schooling behavior begins when the young are about 50 mm long (Tabb 1961). With the advent of winter weather, the juveniles appear to move to deeper portions of the estuaries as do the adults (Moody 1950; Mahood 1974). Trawl catches also indicate this is true in South Carolina (C. Bearden, personal communication).

Although Tabb (1966) failed to recognize differences in salinity or temperature tolerances between adults and juveniles, Dahlberg (1972) noted the occurrence of juveniles in the upper reaches of Georgia estuaries to 0.5 $^{o}/oo$.

2.1.15 Age and Growth

Tabb (1966) considered each estuarine population of spotted seatrout a separate entity, receiving little recruitment or immigration from adjacent populations. As such, each population is exposed to different sets of biotic and abiotic conditions. Predictably, the growth characteristics of each population are different (Iverson and Tabb 1962). Growth rates of five populations of spotted seatrout along the Gulf coast are presented in Table 1 (from Johnson 1978). Salient features of each population are that females grow faster, mature later, and outlive the males (Johnson 1978). Lorio and Perret (1978) pointed out that spotted seatrout are moderately long lived (up to 10 years of age, Tabb 1961), but the percentage of the oldest age classes is insignificant when compared to the remainder of the population. From the results of recreational fishing tournaments (1973-1976), Tatum (1978) reported that ages 2+ and 3+ were the most exploited age classes in the sport fishery in Alabama waters.

Length (L)-weight (W) regression equations for spotted trout populations have been summarized by Lorio and Perret (1978):

$\log W = 5.333 + 3.1131 (\log L)$ (N=307; Moffett 1961)

$\log W = 4.39 + 2.7995 (\log L)$ (N=49; Vetter 1977)

$\log W = 5.192 + 3.062 (\log SL)$ (N=9498; Harrington et al. in press).

2.1.16 Habitat Preference

Tabb's habitat characterization for spotted seatrout populations on the east coast of Florida consisted of large areas of shallow, quiet, brackish water with abundant submerged aquatic vegetation and fairly deep channels

Table 1. Mean calculated lengths in millimeters (SL) of *Cynoscion nebulosus* from different areas, based on scale analyses (From: Johnson 1978).

Year	Northwest Florida [a]	Everglades Florida [b]	Cocoa Florida [c]	Punta Gorda Florida [d]	Corpus Christi Texas [e]
1	116	133	165	120	147
2	190	224	248	230	239
3	255	275	317	310	304
4	312	339	384	360	352
5	369	397	457	400	397
6	422	434	533	430	440
7	437	451	561	–	487
8	–	–	616	550	518

a = Klima and Tabb 1959
b = Stewart 1961
c = Tabb 1958
d = Welsh and Breder 1923
e = Pearson 1929

(3.1-6.1 m) adjacent the flats to be used for retreat from winter cold. Similar spotted seatrout habitats exist along Florida's Gulf coast (Moody 1950), the Texas coast (Pearson 1929), Alabama and Mississippi (Lorio and Perret 1978). Submerged grass beds are not prerequisites for viable spotted seatrout populations however, since preferred habitats in Louisiana include sandy bottoms, near submerged or emergent islands, shell reefs and areas where structures such as oil platforms are present (Lorio and Perret 1978).

In Georgia waters, spotted seatrout occur throughout the estuaries from upper tidal marshes to the beaches (Mahood 1974). Shallow waters along the banks of tidal creeks, rivers and sounds near oyster beds and along inlet beaches are preferred habitats (Mahood 1974). In South Carolina spotted seat-trout are usually found around shell banks in the creeks, rivers and sounds (Bearden 1961). In light of the absence of marine grassbeds in South Carolina waters, nearshore oyster banks may serve as analogues to the Gulf coast's aquatic vegetation.

Optimum spotted seatrout temperatures in Florida are reported as 15-27^{o}C (Tabb 1958). In Georgia waters Mahood (1974) found that spotted seatrout left shallow, nearshore environment for the deeper waters of the estuaries when temperatures dropped below 16 ^{o}C or rose above 25^{o}C. Similar phenomena probably exist in South Carolina waters.

Optimum salinity ranges for spotted seatrout have been reported as 5-20 $^{o}/oo$ in Texas (Guest and Gunter 1958) and 15-35 $^{o}/oo$ in Florida (Tabb 1966).

2.2 Red Drum

The red drum, Sciaenops ocellata, a member of the family Sciaenidae (drums and croakers), is a euryhaline and eurythermal schooling species. Red drum commonly range from Maryland and Virginia to Key West, Florida on the Atlantic coast and southwestern Florida to northern Mexico along the Gulf coast. It is a fast grower, reaching about 330 mm in length and 1 kg after the first year's growth. Sexual maturity is attained at about 4 years of age and a length of about 700 mm. The juveniles (generally specimens less than 4.5 kg {10 lbs.}) often called "school bass", usually frequent inshore bays and estuaries. Larger juveniles and adults are more common in deeper waters and along oceanic beaches. The current hook and line world record red drum weighed 40.8 kg (90 lbs.) and was taken in North Carolina.

Spawning occurs during the fall and winter in marine waters near the mouths of inlets or passes. The young are transported into the estuaries by tidal action or subsurface density currents. Young Sciaenops disperse onto shallow mud or grass flats and move further up the estuary with growth. Cold winter weather signals a movement of the young to deeper channels or marine waters.

The diet of the red drum consists primarily of penaeid shrimps, portunid and xanthid crabs, and fish. Schools of red drum are often seen ascending tidal flats with the incoming tide.

The red drum is of prime commercial importance in the Gulf while being most significant to recreational interests along the South Carolina, North Carolina and Virginia coasts.

Comprehensive studies on the biology of the red drum have been conducted in Texas by Pearson (1929), Miles (1950) and Simmons and Breuer (1962).

Yokel (1966) examined the life histories of both the Atlantic and Gulf coast populations of red drum.

2.2.1 Spawning

Spawning of the red drum has not been observed. Pearson (1929) recounts personal observations and fishermens' reports of adult red drum congregating or milling near beaches and passes in the Gulf of Mexico September through November. Subsequent gonadal observations and larval collections suggested these were indeed spawning aggregations (Pearson 1929).

2.2.2 Spawning Season

Red drum spawn as early as July and continue through late December or January, with peak activity in September and October. Present evidence suggests spawning along the Atlantic coast may begin sooner than in the Gulf.

From extensive gonadal observations and collections of larval and juvenile red drum, Pearson (1929) concluded that peak spawning in Texas waters occurs during October with most activity ending by mid-November. Gunter (1945) resampled several of Pearson's seine stations and similarly reported spawning extends from late September through the first half of September. On the basis of a January collection of a few ripe fish and the presence of small red drum (50-125 mm long) in April, Simmons and Breuer (1962) suggested the Texas spawning season extends into December and January.

Bass and Avault (1975) reported most red drum spawning activity near Caminada Pass, Louisiana occurred in late September and October, as evidenced by a peak immigration of larval _S. ocellata_ (6-7 mm long) through the pass during this period.

Yokel (1966) indicated the red drum spawning season in Florida is similar to that in Texas, that is, reaching a peak in October.

Welsh and Breder (1923) recorded several young-of-the-year red drum from Chesapeake Bay and one specimen from Florida (no collection dates given). They suggested spawning occurs primarily in late fall or early winter, possibly as early as September in Florida. Hildebrand and Schroeder (1928) took 118 young-of-the-year (20-90 mm long) in Chesapeake Bay from mid-September to late November and recognized Welsh and Breder's account of the red drum's spawning season. Mansueti (1960) collected small young-of-the-year (ca.25 mm long) in upper Chesapeake Bay in mid-September. He reasoned that the time required to attain this size would be about one month. Thus, spawning in the mid-Atlantic region probably begins in mid-August with most larval production occurring in late September and October. Tagatz and Dudley (1961) collect 171 young-of-the-year red drum (10-85 mm long) in the Neuse River, North Carolina between August and December. The presence of 5 specimens 80-85 mm long in August strengthens Mansueti's argument and suggests spawning in North Carolina waters may begin as early as July (Yokel 1966). In South Carolina juvenile red drum (37-100 mm) have been collected during October and November (C. Bearden, personal communication).

Cessation of red drum spawning along the Atlantic coast is more difficult to assess. Yokel (1966) presented data suggesting possible late winter or early spring spawning along the east coast of Florida. Additionally, he cites 4 specimens (47-76 mm long) taken by Tagatz and Dudley (1961) in North Carolina during March and April which are evidence for possible December spawning in this area.

2.2.3 Spawning Area

Red drum spawn close to oceanic beaches near the mouths of passes and inlets. Pearson (1929) noted the absence of red drum with developing gonads from these areas in Texas waters during April to September. Similarly, Gunter (1945) cited red drum with developed gonads are rare in Texas bays, while Yokel (1966) and Mansueti (1960) noted the paucity of ripe fish from Florida estuaries and Chesapeake Bay, respectively.

Pearson (1929) observed that in mid-September large schools of adult Sciaenops, the females with well-developed ovaries, congregated near the mouths of passes. Seine collections in shoal areas of the bays during October indicated that the greatest number and smallest young-of-the-year red drum were located nearest to the passes. In late October and November, adult drum taken near the passes appeared emaciated and the females were spent. Pearson concluded there was little doubt the larvae were spawned outside the passes in the Gulf and were swept into the bays by flooding tidal currents.

Yokel (1966) synthesized existing data on spawning in red drum and suggested the spawning pattern noted by Pearson exists throughout the Gulf coast. Despite implications that spawning may occur in Chesapeake Bay (Hildebrand and Schroeder 1928; Pearson 1929), spawning along the mid- and south Atlantic coasts probably occurs in marine waters (Mansueti 1960; Yokel 1966).

2.2.4 Fecundity

The roe of a 90 cm long female red drum contained approximately 3.5 million eggs and weighed 13 ounces (0.37 kg) (Pearson 1929). Females measuring 750-825 mm long had about 2.5 million eggs (Miles 1951).

2.2.5 Maturity

Red drum are generally believed to mature at three to five years. In Texas Pearson (1929) noted the absence of mature specimens under 750 mm in length. He claimed ripe fish were unknown to commercial fishermen, who by law were to release red drum greater than 81 cm long. His data indicate a weight of 10 pounds (4.5 kg) is reached before first spawning. Additional collections in Texas produced ripe individuals between 500-625 mm long (Miles 1951).

Gunter (1950) recorded three females with roe from southern Texas waters measuring 406-432 mm long and also reported an average minimum length of 381 mm for ripe females from southwestern Florida. He hypothesized that in the southern extent of their range in the Gulf, S. ocellata mature at a smaller size. Yokel (1966) questioned this statement since the smallest mature red drum he encountered in southern Florida measured 630 mm long.

Estimates of size at maturity of red drum along the Atlantic coast are lacking. In an artificial spawning experiment conducted in South Carolina (Theiling 1974) the smallest mature red drum utilized measured 650 mm long, while a fish 550 mm in length was considered immature.

2.2.6 Eggs and Larvae

Descriptions of red drum eggs and yolk-sac larvae are unavailable. Theiling's (1974) attempts to induce spawning in red drum were unsuccessful. Recently, Heffernan and Kemp (1978) reported that red drum have been successfully spawned under laboratory conditions in Texas, however, egg and larval descriptions are as yet unavailable.

According to Pearson (1929), the dorsal and ventral finfolds of 4-5 mm long red drum larvae are continuous with the well-developed caudal fin. The presence of dorsal chromatophores at this stage aid in distinguishing red drum from other sciaenid larvae. At a length of 7 mm the yolk sac has disappeared and the chromatophores become more pronounced.

2.2.7 Growth of the Larvae

At Cedar Key, Florida, young-of-the-year red drum spawned in early fall were about 46 mm long by late November and slightly greater than 100 mm the following March (Kilby 1955). In Chesapeake Bay Mansueti (1960) presented indirect evidence that larvae grow to a length of 25 mm during their first month. Small red drum collected in Louisiana reached a mean length of 145 mm after the first 7.5 months of growth (Bass and Avault 1975). Average growth rate between October and February was 13.8 mm per month and between late February and May was 25.6 mm per month. Greater vernal growth rate was probably due to a higher spring metabolic rate (Bass and Avault 1975).

2.2.8 Food and Feeding Habits

Red drum feed primarily on fish and crustaceans. The proportions of each ingested appears related to size of the drum and local abundance of prey. Shrimp and crabs constitute a majority of crustaceans eaten. Fish most often consumed include mullet, menhaden, croaker, spot and minnows.

Pearson (1929) found red drum from the Gulf of Mexico consumed primarily commercial penaeids, whereas Gunter (1945) and Darnell (1958) noted a transition towards increased consumption of crabs in inside waters along the Gulf coast. Knapp (1950) found that red drum from various Texas waters preyed on shrimp, crabs and fish in order of importance, but failed to present his results by habitat. Red drum from a Louisiana coastal marsh consumed primarily fish during the winter and spring, while crustaceans (shrimp and crabs combined) were the most important prey items during the summer and fall (Boothby and Avault 1971). Yokel (1966) examined the food habits of red drum in southern Florida. Penaeid shrimps predominated in the diet during the summer, while crabs were more important during the remainder of the year. As red drum grew, the importance of fish in the diet decreased and that of xanthid crabs increased. Overstreet and Heard (1978) found blue crabs, penaeids, and fish important in the diet of red drum from the Mississippi Sound area. Polychaetes also contributed to a significant portion of the diet of small drum. Several large specimens taken from a high energy beach in Georgia consumed sand dollars and sea cucumbers.

Bass and Avault's (1975) extensive survey of the food habits of juvenile red drum collected behind a barrier island in Louisiana was based on over 500 specimens. Copepods were most important in the diet of larval red drum less than 10 mm long. Mysids were most important to the 10-49 mm group, while grass shrimp were heavily preyed upon by the 60-99 mm class. Penaeids, blue crabs and polychaetes entered into the diet at about 60-70 mm in length. Fishes were important prey items to red drum greater than 20 mm long. Previous studies (Hildebrand and Schroeder 1928; Odum and Heald 1972) which examined the prey of fewer small red drum are in agreement with Bass and Avault's work.

Pearson (1929) described red drum feeding habits as intermediate to those of black drum and the spotted seatrout, that is, a benthic feeder with the ability to pursue mid-water prey. Most feeding occurs in shallow to moderately deep waters over sand to mud bottoms; grassbeds are important feeding habitats, especially for the young (Overstreet and Heard 1978). Feeding schools may move onto shallow mud or grass flats with the rising tide (Ried 1955; Darnell 1958). Simmons and Breuer (1962) cited most feeding activity occurs in early morning and late evening. Yokel (1966) classified the red drum as primarily a superficial bottom feeder and secondarily a mid-water to surface feeder, capable of visual or tactile feeding. They are often observed "tailing" in shallow water, that is rooting through the substrate with the head down, body oblique to the bottom and tail exposed on the surface. Along the high energy beaches of the Atlantic coast, red drum often congregate behind sand bars in sloughs or run-off points where they feed on prey displaced by the currents (Yokel 1966). Overstreet and Heard (1978) hypothesized that red drum migratory patterns may be keyed to optimal abundance of specific prey items.

2.2.9 Migration of the Larvae

Along the Gulf coast the young, apparently spawned in the Gulf of Mexico (Pearson 1929; Yokel 1966), are swept into the estuaries of flooding tidal currents (Pearson 1929; Miles 1950). Inside the young seek shoal areas with mud or grass bottoms (Miles 1950; Simmons and Breuer 1962). Vegetative cover may serve to retain the young in the estuaries by protecting them from ebbing tidal currents (Miles 1950).

In the mid-Atlantic area Mansueti (1960) proposed that the young are carried from the Atlantic Ocean into Chesapeake Bay by the net up-stream movement of subsurface high density currents. Once in the estuary the small red drum move onto shoal areas.

Yokel (1966) suggested that in southern Florida small red drum are transported after dark into estuarine areas on the surface layers of flooding tidal currents.

2.2.10 Role of the Estuaries

Although spawning sites may be in marine waters, the young of red drum are apparently estuarine dependent (Pearson 1929; Miles 1950). The estuaries serve as nursery grounds and red drum spend up to the first few years in these areas. The productive estuarine systems harbor an abundant supply of small invertebrates, the primary food items of young red drum (Bass and Avault 1975). Submerged vegetation of the inside waters is thought to protect young red drum from predators (Miles 1950).

Yokel (1966) speculated that the abundance of red drum within its range along both coasts is controlled by the amount of estuarine environment available to the species. He showed that states with relatively high landings of _S. ocellata_ have large estuaries, while states with relatively small landings of red drum have relatively small estuarine areas.

2.2.11 Factors Affecting Survival

Red drum are euryhaline and eurythermal, although existing evidence suggests tolerances of both factors may change with growth.

Sciaenops have been taken in waters ranging from 2-33°C, and there appears to be a general movement to deeper waters with the advent of cold weather (Simmons and Breuer 1962). Sudden changes in temperature may cause mass mortalities (Gunter 1941; Gunter and Hildebrand 1951) of which the larger juveniles and adults appear more susceptible than the young (Gunter 1941 and 1947).

In Texas waters red drum have been reported from fresh water to salinities of 50 ‰ although most abundant at 30-45 ‰ (Simmons and Breuer 1962). Simmons (1957) reported that 5-9 inch (127-229 mm) specimens were absent in salinities greater than 45 ‰ while all members of the population were limited by salinities of 50 ‰ or more. Possibly adults are more tolerant of higher salinities (Yokel 1966).

2.2.12 Migrations

During the fall months along the Gulf coast a general migration of red drum from the bays to the Gulf is apparent, followed by a relatively rapid return to the bays in the spring (Pearson 1929; Gunter 1945; Miles 1950). Simmons and Breuer (1962) recognized these movements but suggested they are much less pronounced and of shorter duration than previously reported. Tagging studies in Texas bays (Simmons and Breuer 1962) demonstrated movement within bays is random and between bays migrations are minimal. Most red drum tagged in the Gulf failed to enter the bays. Small red drum and a small portion of the spawning stock utilize the bays, however there is a tendency to remain in the Gulf once maturity is attained (Simmons and Hoese 1959).

Along the Atlantic coast there is an apparent spring migration north along the North Carolina and Virginia coastline and a corresponding fall migration south (Yokel 1966). Summering grounds for these fish appear to be the ocean beaches along Virginia's Eastern Shore (Richards and Castagna 1970). Their overwintering site may lie slightly south of Cape Hatteras (Yokel 1966). Bearden (1961) noted the tendency of red drum in South Carolina to move offshore during the winter months.

2.2.13 Distribution of Adults

Adult red drum generally inhabit less accessible, marine waters, thus little is known of the habits of these larger fish (Yokel 1966). Following maturation, red drum along the Gulf coast show little tendency to return to estuarine waters (Pearson 1929; Simmons and Hoese 1959). Pearson (1929) stated that when a length of about 70 cm is attained, red drum tend to form schools and travel along the beaches of the Gulf of Mexico. Occasionally, large schools have been sighted in the Gulf up to 12 miles (19 km) offshore.

The seasonal movements of large juveniles and adult red drum along the Virginia and North Carolina coastlines is more pronounced (Yokel 1966). Yokel (1966) provided evidence indicating migration of these larger individuals north along the mid-Atlantic coastline in the spring and a corresponding southward movement in the fall. Adult schools apparently spend the summer along the ocean beaches of the barrier islands of Eastern Shore, Virginia (Richards and Castagna 1970). Large adults are recorded as rare to occasional summer time visitors in Chesapeake Bay (Hildebrand and Schroeder 1928; Musick 1972). Overwintering areas may be located slightly south of Cape Hatteras (Yokel 1966).

Red drum are reported as common in South Carolina coastal waters throughout the year, being most abundant in the fall; there appears some tendency to move offshore during the winter (Bearden 1961).

2.2.14 Distribution of Juveniles

Along the Gulf coast, tidal currents appear responsible for carrying larval red drum from marine spawning grounds, through passes and inlets and into shallow inside waters (Pearson 1929; Yokel 1966). The young-of-the-year distribute themselves over shallow areas with mud or grass bottoms (Pearson 1929; Miles 1950; Simmons and Breuer 1962). With growth the young move up the estuary (Pearson 1929; Miles 1950). With the advent of cold weather the juveniles in Texas bays move into deeper waters (Miles 1950). Some juveniles, however, may move into the Gulf and return to the bays in the spring (Simmons and Breuer 1962). There appears little intra-bay movement by the young during their residence in these areas (Simmons and Breuer 1962).

Yokel (1966) reported that young red drum in southern Florida estuaries move to deeper holes during cold weather. These fish again disperse to shallower waters in spring.

In Chesapeake Bay larval red drum are transported upstream by the net flow of subsurface density currents and distribute themselves over shallow estuarine areas during the fall (Manseuti 1960). Tagatz and Dudley (1961) collected young-of-the-year red drum in the Neuse River, North Carolina and identified this area as a nursery ground for red drum. Rapid descent to marine waters (Mansueti 1960) or movement to deep channels have been postulated as possible responses of young red drum to winter weather along the Atlantic coast.

Little is known of the movements of young red drum in South Carolina waters. Young-of-the-year red drum are found in shallow waters of marsh-tidal creeks nursery areas during September through November; they have also been collected in tidal impoundments during this time (C. Bearden, personal communication).

2.2.15 Age and Growth

Growth rates of red drum are known largely from Gulf coast studies. It seems generally agreed that red drum are rapid growers, reaching about 300-360 mm in length by the end of their first year (Pearson 1929;Miles 1950;

Simmons and Breuer 1962; Yokel 1966; Theiling and Loyacano 1976). Reliable estimates of size at age greater than 3 or 4 years are wanting.

From length frequency distributions, Pearson (1929) demonstrated that modal lengths of 340, 540, and 640 mm were attained after the first three years of growth in Texas waters. Smaller modes at 750 and 840 mm were thought to be 4 and 5 year old fish. Also from the Texas coast, Gunter (1945) reported lengths of 400 and 600 mm for ages 1 and 2 while Miles (1950) found modal lengths of 320 and 510 mm for these respective age classes. Miles also examined a limited number of otoliths from adult red drum and suggested lengths of 875 and 925 mm for ages 6 and 7. Simmons and Breuer (1962) recovered tagged red drum in Texas and reported mean lengths of 325 mm at age 1, 540 mm at age 2, and 730 mm at age 3.

Yokel (1966) indicated that by the end of their first year red drum in southern Florida waters are 300 mm long and are fully recruited into the sportfishery.

Theiling and Loyacano (1976) examined otoliths of red drum from a South Carolina saltwater marsh impoundment and found the first winter's annulus absent. Large specimens of their first age class (0-1 yrs.) attained a mean standard length of 365 mm and a mean weight of 0.95 kg, age 1+ was 486 mm and 2.1 kg, and age 2+ was 610 mm and 3.7 kg. Red drum isolated in 1968 reached a 9.5 kg in less than 6 years.

Boothby and Avault (1971) reported the length (L)-weight (W) relationship for large red drum (>24 cm) from a Louisiana coastal marsh as:

$$\log W = 4.4216 + (2.83234)(\log L).$$

The formula for juvenile red drum from the same area (Bass and Avault 1975) was:

$$\log W = 7.2052 + (4.1913)(\log L).$$

Condition factors which indicate the general "well-being" of a fish were calculated for red drum in each of the above studies. The authors noted that although data were not available for other areas, Louisiana specimens appeared to be in "good condition". A slight increase in the adult condition factor was noted from winter to fall.

Theiling and Loyacano (1976) recorded the length-weight relationship for red drum from a South Carolina saltwater impoundment as:

$$\log W = 1.29596 + (2.74031)(\log L).$$

They found no significant difference in the regression coefficient between sexes.

2.3 Paralichthid Flounders

Flounders of the genus Paralichthys belong to the family Bothidae, or the left-eyed flounders. Bothids are laterally compressed with both eyes on the pigmented left side of the body. Shortly after hatching, they begin their demersal lifestyle, lying on the bottom and feeding on small invertebrates and fishes.

2.3.1 Species Composition

Three species of paralichthid flounders occur in the coastal waters of the South Atlantic Bight (Ginsburg 1952). They are morphologically so similar that early investigators (Hildebrand and Cable 1930) were unable to recognize more than two groups within the genus. Ginsburg (1952) on the basis of morphological characters, successfully separated the complex into three valid species: *Paralichthys dentatus*, the summer flounder; *Paralichthys lethostigma*, the southern flounder; and *Paralichthys albigutta*, the gulf flounder. Subsequent workers (Deubler 1958; Woolcott et al. 1968) distinguished post-larval and juvenile specimens based on pigmentary, osteological, and meristic characters. The eggs and larvae of *P. dentatus* were also described from artificially fertilized specimens and collections made at sea (Smith and Fahay 1970).

The summer flounder occurs from Maine to Florida although most common from Cape Cod to North Carolina where it is of major commercial and recreational importance (Lux et al. 1966). Average specimens weigh between 2-5 pounds (0.9-2.3 kg) and measure 17-23 inches (43-58 cm) long, although summer flounder as large as 30 pounds (13.6 kg) have been recorded (Bigelow and Schroeder 1953).

The southern flounder is found along the South Atlantic and Gulf coasts of the United States from Albemarle Sound, North Carolina to Texas (Ginsburg 1952). On the average, southern flounder range between 12-20 inches long, while 30 inches in length is the maximum reported size (Ginsburg 1952).

South of Cape Hatteras where the ranges of the two species overlap, the southern flounder is generally believed to replace the summer flounder in importance to recreational and commercial fisheries. In South Carolina information on the relative abundance and distribution of both species however, is limited. Commercial landing statistics compiled by the National Marine Fisheries Service are of little value, since they fail to discriminate between species of flounder. In North Carolina, offshore winter trawl landings are almost exclusively _P. dentatus_, whereas _P. lethostigma_ dominates inshore pound net catches, as well as those made by inshore spear or gig fishermen (Warlen 1975; Wolff 1978). A similar distribution pattern may exist in South Carolina waters. Inshore recreational flounder catches are thought to be predominately _P. lethostigma_, while _P. dentatus_ are believed to be most abundant from the inlet entrances seaward (D. Hammond, SCWMRD, personal communication). Bearden (1960) also noted that the southern flounder appears more abundant in the coastal rivers of South Carolina, whereas the summer flounder is more plentiful in the sounds.

Although its range is similar to that of the southern flounder, _P. albigutta_ is primarily an offshore species, rarely moving inshore (Dahlberg 1972 and 1975). It is a relatively small flounder, the average specimen being under 10 inches (25 cm) (Ginsburg 1952). Extensive estuarine survey efforts failed to record the gulf flounder from inshore South Carolina waters (Shealy et al. 1974). Wolff (1978) listed it as a rare component of North Carolina inshore and offshore landings. No doubt the gulf flounder is of only minor economic importance to sport and commercial fishermen in the South Atlantic Bight.

Questions concerning relative abundance and/or spatial distribution of summer and southern flounders in South Carolina waters are not clearly resolved by the existing data base. On the other hand, *P. albigutta* is obviously of little value to both harvesting sectors in South Carolina. For the above reasons this section of the management profile will discuss *P. dentatus* and *P. lethostigma*, while excluding *P. albigutta*.

Considerable biological information exists for *P. dentatus* in the northern half of its range. Life history studies have been conducted in Delaware Bay (Smith and Daiber 1977), New York (Poole 1961, 1962, and 1964) and North Carolina waters (Powell 1974; Powell and Schwartz 1977). Little is known of its biology or ecology south of Cape Lookout, North Carolina.

Powell (1974) and Powell and Schwartz (1977) studied the spatial distribution of paralichthid flounders in North Carolina estuaries and produced the most comprehensive study of *P. lethostigma* to date. Only fragmentary biological information is available throughout the remainder of its range.

Generally, both the summer and southern flounder are believed to exhibit an inshore-offshore migration pattern, this being most pronounced and well-documented in the former. Spawning occurs offshore during the fall or winter. The larvae move inshore and utilize the estuaries as nursery areas. Adults return to inshore waters in the spring.

2.3.2 Spawning Seasons and Areas

Actual spawning of *P. dentatus* or *P. lethostigma* has not been witnessed. On the basis of gonadal observations and plankton collections most investigators agree that spawning in both species occurs in fall or winter during or at the terminus of their offshore migration.

Hildebrand and Schroeder (1928) observed that P. dentatus in Chesapeake Bay had relatively large gonads during the fall while spring-caught specimens appeared spent. Young-of-the-year were collected in May and June. These authors suggested winter offshore spawning for P. dentatus. Eldridge (1962) examined summer flounder gonads during the winter from offshore waters of Virginia and cited most spawning occurred in November. Murawski and Festa (1976) noted an increase in the maturation state of P. dentatus taken off New Jersey in the fall. Similarly, Smith and Daiber (1977) reported that mature summer flounder ripen as they leave Delaware Bay in the fall. Powell (1974) collected oceanic specimens off North Carolina in December and January with maturing and ripe ovaries.

Smith (1973) conducted an extensive survey of the distribution of summer flounder eggs and larvae on the continental shelf from Cape Cod to Cape Lookout, North Carolina. He concluded that spawning begins in September in the northern part of the Mid-Atlantic Bight, progresses southward with the season and ends in February off Cape Lookout. North of Chesapeake Bay peak spawning activity occurred in October, 22-61 km offshore of New Jersey and Delaware over depths of 20-48 m. In November eggs were concentrated 65 km east of Assateague Island, Maryland and 9-19 km off the North Carolina Outer Banks. Most specimens were collected over areas where bottom temperatures ranged from 12°-19° C.

Comprehensive gonadal observations of both species in the South Atlantic Bight are either lacking or inconclusive. Nevertheless, fall or winter spawning in offshore waters can be inferred from several ichthyoplankton surveys. As previously noted, Hildebrand and Cable (1930), working at Beaufort, North Carolina, were unable to separate the three species of paralichthids. However, from extensive larval collections and infrequent observations of ripening females, they concluded that Paralichthys spawn from September to May with peak activity in November and December. The smallest larvae were most abundant seaward of Beaufort Inlet, N. C.; hence, their conclusion that spawning occurs offshore. Williams and Deubler (1968) sampled macroplankton bi-weekly for ten years (1957-1966) in North Carolina estuaries. Summer and southern flounders were most abundant when water temperatures ranged from 8^{o}-16^{o}C, reflecting recruitment during the colder months of the year. Paralichthys larvae were the most abundant of seven bothid genera collected during the winter (13 February-23 March) MARMAP ichthyoplankton survey in the South Atlantic Bight in 1973 (Powles and Stender 1976). Although a majority of bothids were identified to genera only, several P. dentatus and P. lethostigma were recorded.

Additional observations from the Gulf of Mexico indicate a fall or winter spawning season for P. lethostigma in this area. Ginsburg (1952) cites young-of-the-year collected along the Texas coast (by J. C. Pearson, unpublished data) January through March.

It is of interest to note that despite an extensive year round faunal survey of Georgia's estuarine and inshore ocean waters (Mahood et al. 1974), P. lethostigma with advance gonad states were never observed.

2.3.3 Fecundity

Powell (1974) found that the ovaries of P. dentatus 682 mm (total length) yielded 1.7 million eggs; 582 mm (TL) 0.9 million eggs; and 506 mm (TL) 1.6 million eggs.

2.3.4 Maturity

Murawski (1963 and 1964) reported 370 mm to be the minimum length at which female summer flounder spawn. The smallest female summer flounder with ripening ovaries examined by Smith and Daiber (1977) from Delaware Bay was 36 cm long, while the smallest male P. dentatus with ripening testes was 30.5 cm long. The latter authors concurred with Eldridge (1962) that summer flounder become sexually mature at age 3. Powell (1974) reported the minimum size and age at maturity for P. dentatus from North Carolina waters was ca. 350 mm (TL) and age 3 respectively.

No estimates of size at maturity are available for P. lethostigma.

2.3.5 Eggs, Larvae and Larval Growth

Smith and Fahay (1970) described artificially fertilized summer flounder eggs and larvae hatched under laboratory conditons or collected at sea. The eggs are spherical with a mean diameter of 1.02 mm. They have one oil globule, are buoyant and drift at or near the surface. Eggs reared at about 17.5° C hatched 72 to 75 hours after fertilization. The right eye migrates to the left side of the body when the larvae is about 9.5 mm SL. Metamorphosis is complete by about 12-13 mm SL.

Summer flounder eggs and larvae are apparently more temperature tolerant than their spawning parents having been collected in water temperatures of 2°-22.9°C and 0°-23.1°C, respectively (Williams and Deubler 1968; Smith 1973).

Eggs and early larval stages of P. lethostigma have not been adequately described. Deubler (1958) distinguished postlarval P. dentatus from P. lethostigma on the basis of pigmentary characters. Woolcott et al. (1968) found osteological characters (gill raker, vertebral, and anal and dorsal fin ray counts) valuable for separating the same.

Under laboratory conditions where cool temperatures (ca. 15°C), light and food rations were controlled, Deubler (1960) demonstrated that postlarval southern flounder reared in more saline conditions (range = 0-30°/oo) tended to gain more weight. Under similar conditions, Deubler and White (1962) showed that postlarval summer flounder increased in weight with increasing salinities (range = 10-30°/oo. However, a marked reduction in weight was noted at 40°/oo.

2.3.6 Migration of the Larvae

Postlarval *Paralichthys* enter the estuaries during the winter months after hatching offshore (Hildebrand and Cable 1930; Williams and Deubler 1968). Early larval stages drift passively with the prevailing surface currents, however, an active shoreward migration probably begins following metamorphosis (ca. 12-13 mm SL) as the young become capable swimmers (Smith 1973). Since a majority of Smith's (1973) specimens were collected at night, he speculated that most postlarval movement may occur in the dark.

2.3.7 Food and Feeding Habits

Paralichthid flounders are highly predaceous, feeding largely on smaller fishes and invertebrates found in their habitat (Ginsburg 1952; Darnell 1958). Their predatory habits begin early in life, Deubler (1960) having noted the voracity with which *P. lethostigma* larvae consume *Artemia* nauphlii under laboratory conditions. The diet of the large individuals reflect local abundances of prey items (Darnell 1958; Smith and Daiber 1977). Bigelow and Schroeder (1953) found summer flounder fed largely on small fishes, squids and crustaceans, often chasing baitfish up to the surface. Poole (1964) examined over 1,300 *P. dentatus* stomachs from Long Island waters and found sand shrimp (*Crangon septemspinosa*) and winter flounder (*Pseudopleuronectes americanus*) the most important food items. De Sylva et al. (1962) reported that the food of summer flounder in Delaware Bay consisted primarily of mysids, while Smith and Daiber (1977) noted weakfish (Cynoscion regalis), sand shrimp and mysids in order of decreasing importance in the diet of P. dentatus from the same area. The latter authors reported that small flounder (<45 cm long) ate primarily invertebrates while those larger consumed fish. Darnell (1958) drew similar conclusions concerning the feeding habits of the southern flounder in Lake Pontchartrain, Louisiana.

Powell (1974) studied the feeding habits of P. dentatus and P. lethostigma in North Carolina sounds. He found that small southern flounder (<101 mm TL) were mysid feeders. With growth there was a transition to mysid-fish feeding (the 101-200 mm TL size group) followed by fish feeding in larger individuals. As with southern flounder, summer flounder showed the transition from mysid to mysid-fish feeding with growth. However, summer flounder ranging between 201-400 mm TL were classified as shrimp-fish feeders, while only the largest specimens (>400 mm TL) were strictly fish eaters.

Contrary to the popular belief that flounders lie-in-wait on the bottom to ambush their prey, Olla et al. (1972) observed that under laboratory conditions feeding in summer flounder was always preceded by an active search along the substrate. They reported that vision is the primary sense used during daytime feeding.

2.3.8 Role of the Estuaries

Estuaries serve as nursery grounds for summer and southern flounder for up to their first 18-20 months of life (Poole 1966; Powell and Schwartz 1977). In the northern half of their range, P. dentatus young-of-the-year move offshore during the winter months (Poole 1966), however, Smith and Daiber (1977) found a few overwintering young in Delaware Bay. In North Carolina, the young of both species reside in the estuaries until their second summer, when they are thought to move offshore (Powell and Schwartz 1977). It is suspected that a similar phenomenon occurs in Georgia estuaries, since Mahood et al. (1974) found both species present in the estuaries year round but did not provide frequency distributions by month. Presumably, the estuaries of South Carolina also harbor overwintering young-of-the-year of both species.

2.3.9 Factors Affecting Survival

A fair amount of information is available concerning the physical factors affecting the well-being of paralichthid flounders, however the effects of various chemical and biological factors on survival are less well-known. Williams and Deubler (1968) collected postlarval P. dentatus and P. lethostigma at salinities ranging from 0.02 to 35.0^{o}/oo. Smith (1973) took larval P. dentatus over a temperature range of 0 to 23.1^{o}C. P. dentatus have been collected along the Atlantic coast at temperatures ranging from 1.6 to 26.8^{o} C and is salinities as low as 3 to 5^{o}/oo (Smith and Daiber 1977; Powell and Schwartz 1977). P. lethostigma have been taken in nearly fresh-water and at temperatures ranging from 9.4 to 30.1^{o}C (Dahlberg 1972; Shealy et al. 1974; Powell and Schwartz 1977).

Deubler and White (1962) have shown that post-larval summer flounder exhibit an increase in weight with increasing salinities in 10-30^{o}/oo range, but show a marked reduction in weight in 40^{o}/oo. They concluded growth is optimum at salinities commonly found in the lower reaches of estuaries. Deubler (1960) found that postlarval southern flounder reared under more saline conditions (range = 0-30^{o}/oo) tended to gain more weight during a fixed period.

Oxygen depleted waters below the thermocline in the Mid-Atlantic Bight during the summer of 1976 was thought to modify the movements and habits of numerous finfish species. Freeman and Turner (1977) found that summer flounder became crowded within a narrow coastal zone or within estuaries, where they were readily available to fishermen.

2.3.10 Adult Migrations

Tagging studies (Poole 1962; Murawski 1970) and trends in sport (Poole 1961) and commercial landings (Bigelow and Schroeder 1953; Eldridge 1962) indicate a general inshore-offshore movement for summer flounder north of Cape Hatteras, North Carolina. During the warmer months of the year P. dentatus are found in estuaries and along open stretches of coast (Bigelow and Schroeder 1953). Poole (1961) collected most of his specimens in Great South Bay, Long Island between May and September. Smith and Daiber (1977) caught 95% of their study material during the same months in Delaware Bay. P. dentatus occurs in Chesapeake Bay March through November (Hildebrand and Schroeder 1928). With the advent of winter weather, there is a general offshore movement to deeper water. Adults overwinter on the outer continental shelf from Cape Cod to North Carolina at depths of 20-100 fathoms (37-183 m) (Bigelow and Schroeder 1953; Poole 1966; Gutherz 1967). Tagged adults tend to return to their inshore release points the following summer, while moving north and east in subsequent years (Poole 1966). Those that migrated to the northern half of the Mid-Atlantic Bight showed little tendency to return to more southernly waters (Lux et al. 1966).

The extent of paralichthid seasonal migrations in the South Atlantic Bight is uncertain. Offshore winter trawl catches in North Carolina are reported to be almost exclusively P. dentatus, while inshore pound net catches, September through November, are predominantly adult-sized P. lethostigma (22.5-70.5 mm TL) (Wolff 1978). Bearden (1961) cites that southern and summer flounders inhabit South Carolina's coastal waters during the warmer months, while moving to deeper waters during the winter. A faunal survey by Burch (South Carolina Wildlife and Marine Resources Department, unpublished MS) in the lower North Edisto River, South Carolina corroborates this observation for *P. dentatus*. A total of 104 summer flounder were collected between March 26 to October 30, 2976 and 1977, while only one specimen was taken for the period November 24, 1976 through March 19, 1977 (six sampling dates). Both *P. dentatus* and *P. lethostigma* are reported as present in Georgia waters throughout the year (Dahlberg 1972 and 1975; Mahood et al. 1974).

2.3.11 Age and Growth

Growth estimates for summer flounder are available primarily from the northern half of its range. North of Cape Hatteras, maximum size attained is about 15 pounds (6.8 kg) and 3 feet long (91 cm), although specimens as large as 30 pounds (13.6 kg) have been recorded (Bigelow and Schroeder 1953). At 15 inches (38 cm) *P. dentatus* are about 1 pound (0.5 kg), at 20 inches (51 cm) about 3 pounds (1.4 kg), and at 30 inches (76 cm) about 12 pounds (5.4 kg)(Lux et al. 1966).

Poole (1961) and Eldridge (1962) used otoliths as aging tools for summer flounder from New York and offshore Virginia waters, respectively, but disagree on their interpretations of the annular rings. Poole (1961) considered the first well-defined annulus formed at age 1 while Eldridge (1962) assumed it deposited at first spawning or age 3. Richards (1970) reinspected Poole's data using analog computer simulation and found a better fit to the growth curves when Poole's data were advanced to succeeding age classes. Smith and Daiber (1977) examined *P. dentatus* otoliths from Delaware Bay. They presented arguments supportive of first well-defined annulus formation at age 2. Thus

Poole's age 1 = Smith and Daiber's age 2 = Eldredge's age 3.

Powell (1974) examined P. dentatus otoliths from North Carolina and considered the first otolith ring a valid annulus for yearling summer flounder. North Carolina specimens measured about 170-180 mm (TL) by the end of their first year. Powell (1974) considered age determinations for older summer flounders using otoliths highly suspect. A comparison of mean back-calculated total lengths at age for P. dentatus as determined by several investigators is shown in Table 2.

Poole (1961) and Eldridge (1962) reported significant differences in the growth rates between sexes. Smith and Daiber (1977) suggested that this difference was masked in their study due to small sample sizes of the youngest and oldest age classes. Back-calculated lengths for yearling P. dentatus from North Carolina revealed that females grew larger than males (Powell 1974). Von Bertalanffy growth equations for each sex were developed by Richards (1970) from Poole's (1961) adjusted data. The equations describing theoretical growth of P. dentatus are:

$$L_t = 607 \{1-e^{-0.24(t+0.11)}\} \text{ for males, and}$$

$$L_t = 943 \{1-e^{-0.164(t+0.1)}\} \text{ for females.}$$

These suggest males grow faster, but females attain a greater maximum size.

Smith and Daiber (1977) found no significant difference in the length-weight relationships between sexes of summer flounder from Delaware Bay (Table 3). Lux and Porter (1966) suggested that males were slightly heavier than females of equal length. Powell (1974) pooled sexes for his length-weight relationship equation for P. dentatus (Table 3), since many of his fish were immature.

Table 2. Published mean lengths (TL;mm) at age for male and female summer flounder.

Author	Age 1		Age 2		Age 3		Age 4		Age 5		Age 6		Age 7	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Poole (1961)	251	271	326	377	387	465	–	–	–	–	–	–	–	–
Eldridge (1962)	170	170	240	240	319	377	357	424	381	471	399	518	414	566
Smith & Daiber (1977)	–	–	260	280	345	380	397	453	448	511	493	565	517	618
Powell (1974)	171 to	180a	–	–	–	–	–	–	–	–	–	–	–	–

a = sexes combined

Table 3. Total lèngth (TL, mm) - weight (W,g) relationships for summer flounder from Delaware Bay (Smith and Daiber 1977), the Virginia winter trawl fishery (Eldridge 1962) and North Carolina (Powell 1974).

Number of Fish	Sex	a	b	Correlation Coefficient	Locale
		W aL ^{b}			
333	Both	0.404×10^{-5}	3.151	0.995	Del.
102	Male	0.102×10^{-4}	2.994	0.953	Del.
167	Female	0.227×10^{-5}	3.246	0.987	Del.
-	Male	0.303×10^{-4}	2.81601	0.979	Va.
-	Female	0.28×10^{-5}	3.20947	0.972	Va.
1029	Both	0.5577×10^{-5}	3.0989	0.995	N.C.

Chang and Pacheco (1976) reported that in recent years (1967-1974) the available population of summer flounder in the Mid-Atlantic Bight consisted of at least 10 age-groups, 80-90% being age groups 1-3. Summer flounder were fully recruited at age 2 for the period 1973-1974. Due to the paucity of males age 5 or older, they concluded that "male summer flounder grow faster and die out at a younger age than females."

Little is known of the growth rates of adult summer and southern flounder in the South Atlantic Bight. Presumably, _P. dentatus_ does not attain as large a maximum size in this region as it does in the northern half of its range. The southern flounder is reported to reach a maximum length of 30 inches (76 cm), although marketable individuals usually range between 12-20 inches (30-51 cm) (Ginsburg 1952). Wolff (1978) sampled inshore North Carolina pound net catches of _P. lethostigma_ and reported a size range of 22.5-70 cm TL ($\bar{x} \approx 38$ cm, N = 760).

Powell and Schwartz (1977) reported rapid growth for the young-of-the-year of both paralichthids in North Carolina sounds. After entry into the estuaries during the winter as postlarvae (ca. 8-16 mm long), the young were about 90-100 mm in length by the spring. Summer flounder were about 170 mm long after the first year's growth while southern flounder were somewhat smaller at about 130 mm long. Growth of the yearlings resumed the following spring, and by mid-summer yearlings of both species disappeared from the estuaries. Citing laboratory experiments which showed the young of both species grew faster at combinations of high salinities and low water temperatures (Deubler 1960; Deubler and White 1962; Peters and Kjelson 1975), Powell and Schwartz (1977) speculated that yearling summer and southern flounders migrate to oceanic waters for the winter to increase growth efficiency.

2.3.12 Habitat Preferences

The summer flounder is euryhaline and tolerates a wide range of temperatures. During the summer in the northern half of its range, P. dentatus moves inshore to inhabit shallow bays, sounds and coastal areas to depths of 15 fathoms (27.4 m) (Ginsburg 1952). North of Cape Hatteras, larger individuals tend to remain offshore during the summer in 8-10 fathoms (14.6-18 m) of water (Bigelow and Schroeder 1953). Although specimens are occasionally taken in low salinity waters (de Sylva et al. 1962; Shealy et al. 1974; Powell and Schwartz 1977; Wolff 1978), numerous investigators have noted its preference for intermediate to high salinity estuarine waters (de Sylva et al. 1962; Tagatz and Dudley 1961; Dahlberg 1972 and 1975; Smith and Daiber 1977) and hard sand or shell bottoms (Ginsburg 1952; Bigelow and Schroeder 1953; Bearden 1961). P. dentatus have been collected in inshore waters as low as 1.6°C (Smith and Daiber 1977) and as high as 30.6°C (Shealey et al. 1974).

The southern flounder is more tolerant of low salinities occasionally being taken in fresh or nearly freshwater (Ginsburg 1952; Gutherz 1967; Dahlberg 1972 and 1975; Shealy et al. 1974). Ginsburg (1952) noted its preference for muddy substrates, hence the common name of "mud flounder" often ascribed to it along the Gulf coast.

Powell (1974) and Powell and Schwartz (1977) confirmed the observations of many previous authors. They found that salinity and substrate composition were the two primary factors influencing paralichthid distributions in North Carolina estuaries. "Southern flounder were most abundant at low saline stations....where clayey silt or organic-rich muddy sand predominated. Summer flounder were most abundant at stations of intermediate and high salinities, close to inlets where clean quartz sand or coarse sand and shell predominated" (Powell and Schwartz 1977). They speculated that the observed distribution in relation to salinity may optimize growth, since under laboratory conditions at warm temperatures summer flounder grew faster at intermediate to high salinities while southern flounder grew faster at low salinities (Peters and Angelovic 1971; Peter and Kjelson 1975). It is assumed that similar distribution patterns with regard to salinities and substrates prevail in South Carolina estuarine waters.

2.3.13 Races

Smith (1973) suggested the existence of three separate spawning populations of *P. dentatus*, the first located principally north of Delaware Bay, the second from Virginia to Cape Hatteras, and the third south of Cape Hatteras. His speculation was based on: 1) major distributions of eggs and larvae, 2) tagging studies which showed little tendency to stray from release points, 3) meristic differences between summer flounder from Chesapeake Bay and Beaufort, North Carolina (Ginsburg 1952), and 4) unlikely trends in commercial landings if a single population were being fished. Smith and Daiber (1977) reported a significant difference in the anal fin and gill raker counts of summer flounder from North Carolina and those from Chesapeake and Delaware Bays, thus supporting Smith's hypothesis of multiple populations. No meristic work has been conducted on *P. dentatus* south of Cape Lookout, North Carolina.

Ginsburg (1952) indicated that the gill raker count in *P. lethostigma* from the Atlantic coast averages somewhat higher than that of Gulf coast specimens.

3 Description of the Present Fishery for Coastal Finfish

3.1 Participation User Groups

The commercial fishery for coastal finfish in South Carolina is primarily a part-time activity with few, if any, full-time employees. Commercial harvesting gears include gill nets, stop nets and haul seines. Moreover, a majority of South Carolina's commercially-caught flounders are taken as a by-catch in the shrimp trawl fishery. Most spotted seatrout, red drum and flounders are sold to local seafood markets or restaurants.

The coastal recreational fishery for spotted seatrout, red drum and flounders consists primarily of hook and line anglers who fish from shore-based locations or small boats. Additionally, the inshore gill net and gig fisheries are apparently of a recreational nature, that is, catches are used primarily for home consumption. A small, but notable, percentage of persons employed in the above recreational harvesting activities sell portions of their catch to local seafood markets or restaurants.

3.2 Magnitude of Commercial Versus Recreational Harvest of Coastal Finfish

Formulation of a responsive management planning profile requires reasonably accurate knowledge of the total harvest of the species addressed (Eldridge et al. 1974). Comprehensive data on the total commercial and recreational harvests of spotted seatrout, red drum and flounders in South Carolina are unavailable. Nevertheless, it is generally believed that the recreational catch exceeds the commercial catch (Bearden 1969; Cupka 1977). This is due in part to the traditional orientation of South Carolina commercial fishermen towards shrimp, crab and oyster fisheries. For example, during the period 1970-1976 total South Carolina commercial fisheries landings averaged 20.5 million pounds valued at $9.4 million; finfish landings (5 of the 12 major species groups were estuarine or coastal marine fish) comprised only 20.2% of the total catch by weight (4.1 million pounds) and only 6.8% of the total value (ca. $640,000) (Ulrich, in preparation). Commercial harvest of coastal finfish in South Carolina is primarily a part-time occupation (G. Ulrich, SCWMRD, personal communication).

During 1968 Bearden (1969) reported that spotted seatrout, red drum and flounders ranked first, second and fourth, respectively, as the species most often caught by the state's marine anglers. Although total recreational harvest data for South Carolina are unavailable, the relative importance of the recreational fisheries for the three species groups addressed herein in the South Atlantic region (Cape Hatteras to southern Florida) is evidenced by a comparision of 1970 sport and commercial landings for the area (Table 4). The total estimated recreational harvest of spotted seatrout, red drum and flounders exceeded commercial landings for these species by a factor of ten. However, a word of caution in making this comparison - survey methodologies of the National Saltwater Angling Surveys are subject to numerous sampling errors (see Deuel 1973 and Ridgely and Deuel 1975). Likewise, commercial finfish landings are most probably underestimates of the actual commercial catch since (1) fishermen are not required by law to report finfish landings and effort data and (2) unknown quantities of finfish are sold outside normal marketing channels. Hopefully though, a trend is apparent and indicative of the relative importance of the recreational fishery for coastal finfish in the South Atlantic region.

Additional difficulties arise when attempting to characterize several of South Carolina's marine fishing activities as commercial or recreational, specifically, the gill net and gig fisheries. Broadly defined, marine recreational fishing is "fishing for pleasure, amusement, relaxation or home consumption. If part or all the catch is sold, the monetary returns constitute an insignificant part of the person's income" (Fisheries of the United States, 1978). During

Table 4. Estimated total recreational harvest of spotted seatrout, red drum and flounders by anglers in the South Atlantic region (Cape Hatteras to southern Florida) during 1970 and total reported commercial catch of these species for the same area in 1970.

Species	Estimated Recreational Catch (1000's of lbs.)	Total Commercial Catch For S. Atlantic Region (1000's of lbs.)	Reported Commercial Landings By States (1000's lbs.) N.C.	S.C.	Ga.	FLA. (E. Coast)
Spotted Seatrout	25,040	1,135	405	9	10	711
Red Drum	13,358	158	8	1	2	147
Flounders	8,938	3,397	3,163	16	37	181
	47,336	4,690	3,576	26	49	1,039

Sources: NMFS 1970 Salt-water Angling Survey (Deuel 1973).

NMFS Fishery Statistics of the U.S., 1970 (1973).

this project a survey of licensed gill net and gig fishermen in South Carolina was conducted via postal card questionnaire. Response (summarized below) indicated that both the gill net and gig fisheries are primarily of a recreational nature (according to the definition above) and are treated as such herein.

3.3 Commercial Fishery for Coastal Finfish

With the exception of the incidental flounder catch by the shrimp trawl fishery (Keiser 1976), the commercial harvesting sector for coastal finfish (excluding shad and sturgeon) in South Carolina is virtually undescribed. Present commercial finfishing activities are thought to be limited, part-time fisheries, primarily due to major commercial interest in the shrimp, blue crab and oyster fisheries (see preceeding section). Ulrich (in preparation and personal communication) cites that spotted seatrout, red drum and flounders are taken by gill nets, stop nets and haul seines in South Carolina, but reliable quantitative catch data are unavailable. Existing information on the stop net, haul seine and shrimp by-catch fisheries in South Carolina is summarized below. The state's gill net and gig fisheries are considered primarily of a recreational nature and are discussed in the succeeding recreational fishery section.

3.3.1 Harvesting Sector: Gears, Methods, Seasons, Areas and Catch Composition.

3.3.1.1 Stop Net Fishery

The following description of stop net gears and techniques is derived from Siebenaler (1955). Stop nets are defined as any nets used to cut off the mouth of a bay, arc of beach or other body of water during a falling tide in an effort to strand or gill trapped fish. In South Carolina it is illegal to set a net more than half-way across a waterway (S.C. Code of Mar. Fish. Laws 50-17-1030), thus legal stop sets in the state are primarily made along the arc of a shoreline. The net may consist of gill, trammel or seine netting (>2½ inch stretch mesh, Code of South Carolina Marine Fisheries Laws, 50-17-1020). The top line is buoyed by floats, while the bottom line is weighted with leads. Sections of net several hundred yards long are joined together to form a net of variable length. South Carolina has no restrictions on maximum net length; nets of up to one mile in length have been reported in the state (R. Low, SCWMRD, personal communication).

The "dry-stop", which is most effective during periods of very low, spring tides, is probably the most frequent type of set employed. The specific technique varies with the fisherman and area fished. Generally, at high slack water one end of the net is staked to the shoreline. The initial section of the set runs slightly perpendicular, then parallel, to the shoreline. The trailing end of the net is eventually secured to the shoreline. Alternately, in a small embayment or indentation in the shoreline the net is set in a large arc from bank to bank. Once set, the net is allowed to stand until the tide ebbs completely and the bottom is exposed. The catch is either gilled or concentrated in the center of the net and in shallow pools. The fish are transferred to a catch boat by hand, dip net or small seine.

Under present South Carolina statute, stop nets are licensed as "gill nets", hence accurate information on the number of stop net gears within the state are unavailable. Potentially, any gill net, or series of gill nets joined together, can be fished as a stop net. It is estimated that not more than 12 standard stop net seines operated in South Carolina coastal waters during 1978-79 (G. Ulrich, SCWMRD, personal communication). Although size and catch composition of this fishery is undescribed, presumably spotted seatrout, red drum and flounders are among the most sought-after species.

3.3.1.2 Haul Seine Fishery

The South Carolina haul seine fishery is concentrated along the beaches of Horry County in the northern section of the state; the fishery is directed towards the harvest of spot (Leiostomus xanthurus) and mullet (Mugil cephalus) and operates September through November (Ulrich, in preparation). Gear consists of a wall of seine netting, generally 1500-2000 yeds. (1.4 - 1.8 km) floated by a cork line and weighted with a lead line. Minimum mesh size is 2 inch stretch mesh. The net is stowed in a trailered boat which is launched into the surf. Generally a horseshoe shaped set is made around a school of fish. If it is known that a school is travelling in one direction, the net may be set in a large arc and the school allowed to swim into the net. A long hauling line is then used to pull the far end of the net to shore. The trailing end of the net is secured to a four-wheel drive vehicle which is used to haul the net onto the beach. The catch is eventually concentrated at one end of the net, the bunt, and hand-picked or dip netted into boxes.

During 1978 there were approximately six haul seine rigs operational in Horry County, S. C. (R. Beatty, personal communications). The haul seine by-catch remains undefined, however interviews with haul seine fishermen during this study suggest the incidental catch of spotted seatrout and flounders is small, red drum being relatively rare. The former two species are generally sold to retail markets. NMFS landing statistics (Table 27) suggest considerable numbers of spotted seatrout were harvested by the haul seine fishery during the late 1960's and early 1970's. No spotted seatrout landings have been recorded for this fishery 1973-1975.

3.3.1.3 Finfish By-Catch of the Shrimp Trawl Fishery

The incidental finfish catch by the South Carolina shrimp trawl fishery is often considerable, although a majority of the catch is discarded at sea (Keiser 1976). Traditionally, the state's shrimp season extends from May through December. Areas fished are from the coastline seaward to about 3 miles (4.8 km) offshore in 3-10 m of water. Several sounds and bays are usually opened to shrimping during the late summer and early fall. Otter trawls of various sizes (up to 120 ft., 37m) are the principal gears employed in the fishery; average mesh size ranges from 1.5-2 inches (4-5 cm) (McKenzie 1974).

Shrimp trawlers account for a majority of the flounder landings in South Carolina (Ulrich, in preparation). Keiser (1976) subsampled nearly 400 commercial and research vessel shrimp trawl catches and identified 14 saltwater gamefish in these samples. A total of 483 "commercial flounders" (79 P. lethostigma, 359 P. dentatus) were caught, representing 0.37% by number and 1.17% by weight of the total samples. All shrimpers sampled during the study saved and marketed large flounders, this primarily due to the ease with which they are culled from the catch and their relatively high market value. Keiser concluded that shrimpers "generally catch only a few flounder but those caught are usually of edible size".

Bearden (1969) pointed out that commercial shrimp trawling efforts have little effect on spotted seatrout and red drum populations in South Carolina, because (1) juveniles of these species are generally found in the more inshore, estuarine areas (off limits to shrimp trawling) and (2) adults of the species have the mobility to evade trawl gear.

Scant spotted seatrout records and the total absence of red drum in both Keiser's samples and an extensive estuarine trawl survey (Shealy et al. 1974) corroborate this observation. On the contrary, NMFS landings statistics (Tables 27 and 28) indicated sizable quantities of spotted seatrout were harvested by shrimpers during the mid-1960's and early 1970's, while minor quantities of red drum were also recorded during these years.

3.3.2 Processing and Marketing Sector

Little information is available concerning the market structure for inshore finfishes in South Carolina. During this project an attempt was made to trace spotted seatrout, red drum and flounders through the state's marketing channels via personal interviews with commercial fishermen (3), seafood retailers (14) and wholesalers (4). The task proved difficult primarily due to the perfunctory manner in which landings records are kept. Nevertheless, valuable insights were gained concerning the flow (or lack thereof) of these fishes through South Carolina markets.

Of the three groups of fishes dealt with herein, only flounders enter into South Carolina markets in appreciable quantities. A majority of these are harvested as a by-catch of the shrimp trawl fishery (see Keiser 1976), while small numbers are sold by hook and line and gill net fishermen. During the shrimp season (usually May through December) coastal retail markets with shrimp trawler connections receive 80-100% of their flounder for retail sale from shrimpers. Flounders sold across retail counters throughout the remainder of the year are shipped into the state from Alabama, Florida, North Carolina, Virginia and New York. Retailers without trawler contacts purchase flounders from the above states and New Jersey which contributes a significant portion of the supply to local markets during the summer months.

Several seafood dealers estimated flounder sales at two to three hundred pounds (ca. 90-136 kg) per week. This level of demand was reported as relatively constant throughout the year, however, local supplies fluctuate seasonally. Retail sales in the Myrtle Beach area peak with the summer tourist trade, while some outlets in the area close during the off-season. Some flounder are frozen for resale at a later date. Interviewees did not ship flounder harvested in South Carolina waters out of state, nor were they familiar with any South Carolina seafood dealers that engaged in this practice. Fishermen and seafood dealers in the Edisto area claim that all flounders caught in this region are retailed and consumed locally. Excluding transactions between shrimp trawlers and retail outlets, wholesale movements of flounders within the state are primarily limited to sales to local restaurants and those between retailers. The four major seafood wholesalers in South Carolina reportedly do not deal with locally caught flounders, rather they purchase their flatfishes from the aforementioned states.

Directed commercial fisheries for spotted seatrout and red drum in South Carolina are essentially non-existent; neither species is taken in significant numbers as a by-catch of other fisheries. According to a majority of seafood dealers interviewed, the marketing potential for both species in the state is promising, but supply is sporadic, if not altogether absent. Hook and line and gill net fishermen are the primary source of supply. Most retailers reported selling only about 25 pounds (11 kg) or less of each species per year. Occasionally, small quantities are sold to local restaurants.

Four retail outlets however, reported handling significant quantities of both species. The first of these dealers is located on a major access road to a popular fishing area and has sold as much as 1,500 pounds (680 kg) of both species combined per year. Hook and line anglers are this dealer's major source of supply. The second seafood dealer regularly buys small quantities of spotted seatrout and red drum from gill netters and hook and line fishermen. This firm claimed combined sales of both species in the past two years (1977 and 1978) of 4,000 and 2,000 pounds (ca. 1800 and 900 kg), respectively. Larger quantities reportedly could be sold, if reliable and constant sources of supply were available. A third retailer cited sales of 2,000 to 4,000 pounds (ca. 1360-1800 kg) of each species per year in the last few years. This dealer's major source of supply is the sportfishing effort of his own employees. The fourth firm which dealt with significant amounts of spotted seatrout and red drum reported selling about 500 pounds (225 kg) of each species per year. This retailer reportedly has a waiting list of persons to call as supplies of both species become available.

In a further effort to obtain information on the sources and movements of coastal finfish sold in South Carolina markets, a postal card questionnaire (Appendix Figure 1) was mailed to all persons who held South Carolina swimfish licenses during 1978. A swimfish license is required by law (Code of S.C. Marine Fisheries Laws, 50-17-330) of all persons engaged in the selling of saltwater finfish for market. A total of 671 swimfish questionnaires were mailed and preliminary results indicated a fair response rate of 14.8% (N=99) (Table 5). Only 27.3% (N=27) of the respondents claimed to have sold finfish during 1978 (Table 5). Only 2 (2%) of the respondents reported to have bought finfish for

Table 5. Swimfish questionnaire results: Number of respondents who sold and did not sell fish in 1978, and who plan to buy a swimfish license next year.

County	Number of Respondents	Number Who Sold Fish	Number Who Did Not Sell Fish	Number Who Plan To Buy License Next Year	
				Yes	No
Charleston	30	10	20	27	3
Beaufort	14	4	10	12	1
Georgetown	15	5	10	11	2
Horry	9	1	8	7	1
Berkeley	5	2	3	4	0
Hampton	4	0	4	2	1
Darlington	4	2	2	3	1
Dorchester	3	2	1	3	0
Orangeburg	2	0	2	1	1
Colleton	3	1	2	3	0
Jasper	2	0	2	1	1
Barnwell	2	0	2	2	0
Williamsburg	1	0	1	1	0
Lexington	1	0	1	0	1
Lee	1	0	1	1	0
Marlboro	1	0	1	0	1
Allendale	1	0	1	1	0
Florence	1	0	1	1	0
Totals	99	27(27.3%)	72(72.7%)	80(86%)	13(14%)

resale. Combined sales of spotted seatrout, red drum and flounders comprised a meager 7.2% of the total reported weight of finfish sold; flounder lead all listed species groups with total reported sales of 2,345 pounds (Table 6). Conspicuous is the "other" catagory (80.8% of total reported sales) which was primarily composed of shad and groupers. Clearly, the relative minor importance of coastal finfish in the overall commercial finfish harvest in South Carolina is further evidenced by these questionnaire results.

As was previously determined via interviews with seafood market personnel, questionnaire survey results indicate gill nets and hook and line were the principal gears used to take coastal finfish for market (Table 7). Questionnaire respondents seemed equally divided concerning the sale of their catches to either local wholesale or local retail markets, while local individuals received a slightly greater portion of the reported sales than these two former groups (Table 8).

3.4 Recreational Fishery for Coastal Finfish

3.4.1 Harvesting Sector: Gears, Methods, Seasons, Areas and Catch Composition

3.4.1.1 Hook and Line Fishery

Bearden (1969) described the major types of marine recreational angling activities in South Carolina as: surf and bank fishing, pier and bridge fishing, general inshore small boat fishing (inlets, sounds, beaches, bays and coastal rivers and creeks), offshore trolling and offshore bottom fishing. Spotted seatrout, red drum and paralichthid flounders generally exhibit near-to inshore distribution patterns, thus appreciable quantities of these fishes are only taken in the first three of the above fishing modes. Red drum and flounders are occasionally taken by offshore bottom fishermen, but these quantities are thought to be insignificant as compared to the inshore catch (C. Bearden, personal communication).

Table 6. Swimfish questionnaire results: Reported total weights of finfish sold in 1978 by species and by county.

County	Number of Respondents Who Sold Fish	Total Weight of Fish Sold	Total Weight Sold By Species						
			Spotted Seatrout	Red Drum	Flounder	Bluefish	Spot	Mullet	Other
Charleston	10	28,640	90	140	360	100	410	210	27,330
Beaufort	4	2,550	50	450	385	–	10	125	1,530
Georgetown	5	3,315	20	10	1,600	10	1,150[a]	350[a]	175
Horry	1	4,000	–	–	–	–	–	–	4,000
Berkeley	2	900	–	–	–	200	650	–	50
Darlington	2	2,000	–	–	–	–	–	–	–
Dorchester	2	2,250	–	–	–	–	–	–	2,250
Colleton	1	100	–	–	–	–	–	–	–
Totals	27	43,755	160	600	2,345	310	2,220	685	35,335
% of Total Reported Sales			0.4	1.4	5.4	0.7	5.1	1.6	80.8

[a] = One respondent noted a combined catch of 300 lb. of spot and mullet. For present purposes it is assumed equal amounts (150 lb.) of each species were present.

"Other" refers to primarily shad and groupers.

Table 7. Swimfish questionnaire results: Percent of catch sold by respondents by gear and by county.

	% Of Catch By Gear					
County	Gill Net	Seine	Fish Trap	Gig	Hook & Line	Other
Charleston	100%(7) 80%(1) 70%(1)	20%(1)	70%(1) 50%(1)	70%(1)	100%(2) 50%(1) 20%(1) 10%(2)	20%(1)
Beaufort	100%(2)	-	-	100%(2)	100%(2)	-
Georgetown	100%(9)	-	-		70%(1)	-
Horry	100%(3) 50%(1)	-	-	-	50%(1)	-
Berkeley	100%(3)	-	-	-	-	-
Hampton	100%(1)	-	-	-	-	-
Darlington	100%(1) 60%(1)	-	-	10%(1)	30%(1)	-
Dorchester	-	-	100%(1)	-	100%(1)	-
Colleton	100%(1)	-	-	-	-	-
Williamsburg	100%(1)	-	-	-	-	-
Allendale	100%(1)	-	-	-	-	-

Number within ( ) indicates the number of respondents that reported selling the given percentage of their catch.

Table 8. Swimfish questionnaire results: Percentage of the catch sold by respondents to local markets, wholesale markets and local individuals.

		% Finfish Sold To:		
County	Number of Respondents Who Sold Fish	Local Wholesale Fish Markets	Local Retail Fish Markets	Local Individuals
Charleston	10	100%(2) 90%(1)	70%(1) 10%(1)	100%(3) 30%(1) 20%(1)
Beaufort	4	80%(1)	100%(1)	100%(2)
Georgetown	5		100%(2)	100%(1) 90%(1)
Horry	1	-	100%(1)	-
Berkeley	2	-	100%(1)	-
Darlington	2	30%(1)	-	100%(1) 70%(1)
Dorchester	2	100%(1)	-	100%(1)
Colleton	1	-	-	100%(1)

Number within ( ) indicates the number of respondents that sold the given percentage of their catch.

3.4.1.1.1 Surf and Bank Fishing

South Carolina has approximately 190 miles of coastline, much of which is available for surf fishing (Bearden 1969). The readily accessible northern section of the coastline, the Grand Strand area, consists of expansive stretches of virtually uninterrupted beaches. Between Georgetown and the Charleston area the isolated barrier island beaches of Bull, Capers, Dewees and Morris Islands are accessible only by boat. South of Charleston, Kiawah, Edisto, Hunting and Hilton Head Islands offer convenient highway access.

Surf fishing catches reportedly peak in the fall, September through November (Bearden 1969). Catches along the gently sloping beaches of the Grand Strand area consist primarily of smaller sciaenid species such as whitings (Menticirrhus spp.) and spot (Leiostomus xanthurus). The irregular coastline south of the Georgetown area offers a more conducive habitat for the highly sought-after red drum. Best surf catches of Sciaenops are taken during the spring and fall "runs" of adult fish. Large red drum tend to congregate just beyond the breakers in the first slough between the beach face and an offshore bar with frequent cuts through to the ocean. The points of barrier islands near the mouths of ocean inlets are also popular fishing sites. Adult red drum tend to feed heaviest in these areas when the tide is running strong. Barrier island surf fishing also produces good catches of flounders and seatrouts (Cupka 1977). Peak catches of spotted seatrout from the surf reportedly occur during the fall when a portion of the population is thought to move out of the more inshore, estuarine areas (Cupka 1972).

Regulation surf casting tackle (conventional and spinning) is the most commonly used gear. Preferred baits include cut mullet, squid, shrimp and bloodworms.

Bank or shore fishing in South Carolina is a limited activity, this primarily due to a lack of access. A large tidal range and the characteristic steep, muddy banks of the state's tidal creeks and small rivers make for rather unattractive fishing sites. Most bank fishing occurs near the mouths of inlets on areas of hard, packed sand; it is a popular activity near resort areas (Bearden 1969). Bank fishing around the rocks of breakwaters reportedly produces good catches of flounder (Dennis 1973).

3.4.1.1.2 Pier and Bridge Fishing

Hammond and Cupka (1977) conducted an extensive survey of the South Carolina pier fishery during 1974. They concluded that pier fishing activity contributes significantly to the total marine recreational catch in South Carolina. The following description of this fishery is based on their findings.

The South Carolina pier fishery is primarily concentrated along the Grand Strand area from the North Carolina border south to Murrells Inlet. Additional coastal piers are located on the Isle of Palms and Edisto Beach. During 1978, a total of 12 piers were in operation (D. Hammond, personal communication). The pier fishing season generally extends from April to November with peak angling effort (angler hours) in October. Bottom fishing with natural baits is the predominant technique used. A wide variety of light to heavy saltwater tackle is employed in the fishery. Preferred baits include shrimp, cut mullet, bloodworms and earthworms.

From observed fish landings on four piers surveyed, Hammond and Cupka (1977) found that six species groups, spot, croaker (*Micropogonias undulatus*), whitings, pompano (*Trachinotus carolinus*), silver perch (*Bairdiella chrysura*) and bluefish (*Pomatomus saltatrix*) (in order of decreasing importance), comprised 91% of all fish harvested. Combined observed harvest of spotted seatrout (77), red drum (5) and paralichthid flounders (30) during the survey period amounted to less than 1.5% of the total observed harvest (N=8108 fish). Over 70% of the anglers interviewed were not in pursuit of a particular species. Few specifically sought spotted seatrout, red drum or flounders. Clearly, these three species groups are relatively unimportant components of South Carolina's pier fishery.

Bridge fishing over tidal waters is a popular activity in South Carolina, especially in the southern coastal region near Beaufort (Bearden 1969). Techniques and tackle used are similar to those of the pier fishery. Catch composition of the bridge fishery is virtually undefined, although Bearden (1969) reported that sheepshead, cobia, seatrout, drums and other sciaenids are the most sought after species.

Reported locations where bridge fishing for marine species occurs in South Carolina are listed in Table 9. Like the bank fishery, ~~the state's~~ bridge fishery suffers ~~from a~~ lack access. The South Carolina Highway Department prohibits fishing from many of the state's highway bridge due to the high

Table 9. Reported locations by county in South Carolina where recreational fishing occurs from bridges for marine species.

South Carolina

Georgetown County

Highway 46 at Pawleys Island Creek
Old Highway 17 at Pee Dee River
Highway 17 at South Santee River

Charleston County

Highway 703 at Breach Inlet
Highway 1028 at James Island Creek
Highway 171 at James Island Creek
Highway 700 at Bohicket Creek
Highway 17 at Rantowles Creek
Highway 174 at Russell Creek

Colleton County

Highway 26 at Ashepoo River

Beaufort County

Highway 17 at Combahee River
Highway 802 at Lucy Point Creek
Highway 21 at Beaufort River
Highway 21 at Harbor River
Highway 406 at Johnson Creek
Highway 170 at Broad River
Highway 170 at Chechessee River
Highway 278 at Mackays Creek
Highway 406 at Fripp Inlet

Source : Cupka (unpublished data).

risk of injury to anglers from passing motorists. Presently, there are only about six catwalks (or similar devices) statewide adjoining South Carolina highway bridges. Construction of additional bridge catwalks has been cited as a major need of the state's recreational fisheries since 1969 (Bearden 1969).

3.4.1.1.3 Inshore Small Boat Fishing

In terms of participants, inshore small boat fishing is South Carolina's most popular type of marine angling activity and constitutes the largest segment of the state's marine recreational fishery (Bearden 1969; Cupka, in preparation). Generally, small boats and skiffs equipped with outboard engines which can maneuver in shallow nearshore waters are employed in the fishery. South Carolina's coastal region with its vast networks of tidal rivers and creeks, sounds, bays and inlets harbors innumerable, productive fishing sites. Coastal aerial surveys conducted during 1973 (Cupka, unpublished data) give some indication of the distribution of small boat activity in South Carolina inshore coastal waters for the period (Table 10).

Spotted seatrout, red drum and flounders are among the most sought after and commonly taken species in the small boat fishery (Bearden 1969; Cupka 1977). Unfortunately, accurate estimates of size and species composition and overall harvest for this important fishery are unavailable. Moore (in preparation) conducted a summer survey of the Murrells Inlet sportfishery during 1978. Small boat anglers accounted for 88.5% of the fishing effort in this area. An estimated 19,507 fish were harvested during the study period, 85% being taken by boat anglers.

Table 10. Small boat activity in the coastal waters of South Carolina (April through November, 1973) by per cent of total boats observed and by area. Data were obtained through regular coastal flyovers.

Area	Per Cent of Total Boats Observed
Murrell's Inlet	23.6
Wando River	7.9
Little River	6.8
Sullivans Island	5.3
Myrtle Beach	4.7
Dewees and Capers Island	4.6
Winyah Bay	4.6
Broad River	3.5
Charleston Harbor	3.0
Isle of Palms	3.0
Cape Romain Area	2.9
Cooper River	2.9
North Inlet	2.9
St. Helena Sound	2.7
Hilton Head Island and Calibogue Sound	2.6
Stono River	2.6
Edisto Area	2.5
Port Royal Sound	2.5
Bull Point	2.2
Pawley's Island	2.1
Chechessee River	1.8
Kiawah Island	1.3
North and South Santee Rivers	1.2
Hunting Island	1.1
Folly River	0.7
Fripp Island	0.5
Morris Island	0.5

Source: Cupka (unpublished data).

Boat fishermen caught 97.2% of all flounder, 80% of all bluefish, 97% of all red drum and 100% of all spotted seatrout. A somewhat low overall catch rate of 0.31 fish/hr of effort was recorded. Preliminary results of a small - scale pilot study presently in progress indicate an equally low CPUE for the inshore small boat fishery in the Charleston Harbor area (R. Low, SCWMRD, personal communication).

Among other factors, small boat fishing methodologies vary with the particular fishing site, tidal stage, season and species sought. Nevertheless, some generalities can be made concerning techniques used to take spotted seatrout, red drum and flounders. South Carolina small boat anglers take spotted seatrout on both light to intermediate conventional and spinning tackle. Ultra-light spinning tackle is considered by some to offer the most sport. Popular natural baits include live and dead shrimp and live mud minnows (*Fundulus* spp.); bucktails and plastic grubs are preferred artificials. Since spotted seatrout feed throughout the water column, both bottom and float rigs are effective terminal tackle. Small boat anglers take spotted seatrout by anchoring, drifting or slow trolling near shell banks, pilings and deep holes close to shore. Schools also tend to congregate near mouths of small feeder creeks during ebb tide to feed on washed out baitfish (Cupka 1972). Peak catches are made during fall and winter (Bearden 1960), although May and June also produce good harvests.

Red drum are present in coastal South Carolina waters year round (Bearden 1960), although commonly taken by inshore, small boat anglers March through November (Bearden 1969).

Small red drum (up to 10-12 pounds (4.5-5.4 kg)) are generally taken in the inside or estuarine waters and are locally referred to as "spottails" or "school bass". The larger individuals of the population are generally caught in and near the inlets and along the ocean beaches of the barrier islands. A wide range of light to intermediate tackle is employed dependent on the area fished. Preferred natural baits include live or dead shrimp, mud minnows, whole "finger" mullet, cut mullet, clams or crabs which are fished on the bottom or suspended from float rigs. A wide assortment of underwater plugs, spoons, bucktails, and grubs are effective artificial baits. Schools of small red drum often ascend intertidal or shallow subtidal flats with the rising tide. Small boat anglers take them along the fringes of marshes, in tidal creeks and near shell banks and pilings.

Although flounder are present along the length of the South Carolina coast, sport fishing for flatfishes is most intensive in the northern part of the state, particularly in the Murrells Inlet area (Bearden 1969). Inshore small boat anglers take flounder spring through fall in coastal rivers, tidal creeks, sounds, bays and inlets. Flounder appear least abundant in winter when they are thought to move offshore (Bearden 1961). In inshore waters flounders tend to prefer sand, rather than muddy bottoms, and often congregate around rock areas, piers, bridge pilings and shell banks. Areas where moderate to strong tidal currents displace baitfish and food items are often the most productive flounder fishing sites. Several ardent flounder fishermen interviewed during this project indicated that the largest specimens are often caught near the mouths of inlets in more oceanic waters.

Various light to intermediate saltwater tackle are used to take flounder. Since flatfish feed on or near the substrate, bottom fishing with natural baits is one of the most popular methods for taking flounders. Live mud minnows, small sciaenids, "finger" mullet, and live or dead shrimp are preferred natural baits. Numerous underwater artificial lures are also effective.

3.4.1.2 Gig Fishery

Floyd (1966) addressed the gig fishery along the Gulf Coast states as primarily a commercial enterprise, while gigging in North Carolina waters has been described as a fall, recreational activity (Warlen 1975; Wolff 1978). To date little information has been recorded concerning the gig fishery in South Carolina coastal waters. During this project a postal card questionnaire (Appendix Figure 2) was mailed to all persons who purchased a gig license to fish in Colleton, Beaufort and Jasper Counties, South Carolina (the only S. C. counties in which gig license are required by law). Survey results indicate that the gig fishery in South Carolina is primarily of a recreational nature. Preliminary questionnaire responses concerning seasonality, areas fished and catch composition of the fishery are summarized below. Gear and technique descriptions are taken from reviews of the subject by Floyd (1966) and Warlen (1975).

The gig fishery is primarily directed towards the bottom-dwelling flounders, although during the colder months of the year spotted seatrout and red drum are taken (Bearden 1969; Cupka 1972). Gigging is done at night as the fisherman wades in shallow to waist-deep water or poles a shallow draft boat along the shoreline. Essential gear consists of a metal gig or spear and an artificial light. Flatfish are located on the bottom with the light which is thought to have a mesmerizing or blinding effect on the fish. Once spotted, the gig is thrust into the fish; the impaled fish is then carefully lifted from the bottom.

A simple gig consist of a metal rod, 4-5 ft. (1.2-1.5 m) long, sharpened at the tip which may be barbed or barbless. A stringer may be fastened to the opposite end of the gig and the fish threaded onto it as they are caught. A multi-pronged tip fastened to a wooden shaft can also be used, but may unnecessarily damage the prey's flesh. Wood fires, oil lights and gasoline lanterns have been used as illumination sources, but presently an electric light powered by a conventional storage battery is probably the most effecient lighting device. A typical light source is a waterproof, underwater light attached to one end of a wooden shaft or plastic pipe, 4-5 feet (1.2-1.5 m) long. The wiring is led up the pipe or shaft and clipped to the power source. The battery may be carried by the fisherman in a backpack or trailed behind in a skiff.

Clear, calm, moonless nights are ideal conditions for gigging. Windblown wave action tends to reduce visibility through the water, while flounders tend to be more wary of predators during moonlit nights. Gigging in the surf zone is reportedly most successful approximately 1.5 hours before and after low tide. The outer slope of the first offshore bar tends to be the most productive area in the surf. In the inlets and tidal rivers and creeks gigging seems most productive in the shallow water along the shoreline. Flounder tend to ascend and decend intertidal flats with rising and falling tide respectively. Areas with sand bottoms and shell banks or shell piles are reportedly most productive (Dennis 1973).

Of the 2570 gig questionnaires mailed, a moderate response rate of 25.4% (N=654) was received (Table 11). A total of 68.3% of the respondents reportedly went gigging in 1978. Gig licenses are only required in Colleton, Beaufort and Jasper Counties, thus survey results are primarily indicative of gigging efforts in the southern coastal portion of South Carolina. This is evidenced by the fact that 92.3% of the reported gigging effort occurred in Colleton, Beaufort and Jasper Counties (Table 12). Inshore areas, that is harbors, bays, sounds, rivers and creeks, as opposed to ocean and inlet areas, received a majority of the reported gigging effort (Table 13). That reported gigging activity was most intense in Beaufort County (1900 gigging days, 81.1% of total reported effort) is not surprising since it harbors a vast network of inshore waterways. Reported gig activity was greatest May through October with the peak months being July and August (Figure 1). Respondents averaged 5.2 gigging days during 1978 (Table 12). Flounder were the principal species group harvested and accounted for 66.3% (14,225 pounds, 6452 kg) of the total reported harvest (Table 14). Red drum and spotted seatrout were reportedly taken in lesser quantities, 13.8% and 4.3% of the total reported catch, respectively. As noted at the outset of this section, the gig fishery in South Carolina is primarily a recreational activity, only 7 (1.1%) of the respondents reported selling portions of their catch. Small quantities of spotted seatrout, red drum and flounders taken by gigs (= spears) are sporadically recorded in the state's commercial landings statistics (Tables 27, 28, and 29).

3.4.1.3 Gill Net Fishery

In the absence of information on South Carolina's gill net fishery (excluding the shad and sturgeon fisheries) a postal card

Table 11. Gigging questionnaire results: Number of questionnaires mailed, number of respondents and number of respondents that did and did not gig in 1978.

		RESPONSES		
County	Number Of Questonnaires Mailed	Number That Went Gigging In 1978	Number That Did Not Gig In 1978	Total Number Of Responses
Abbeville	2	1	0	1
Aiken	148	30	12	42
Allendale	140	25	12	37
Anderson	1	1	1	2
Bamberg	82	10	4	14
Barnwell	86	13	6	19
Beaufort	1,163	176	65	241
Calhoun	6	5	1	6
Charleston	40	7	5	12
Clarendon	2			
Colleton	82	21	7	28
Darlington	4	0	1	1
Dorchester	16	2	1	3
Florence	6	1	0	1
Georgetown	5			
Greenville	5	4	2	6
Greenwood	4	1	0	1
Hampton	261	40	34	74
Horry	12	6	2	8
Jasper	272	47	27	74
Kershaw	8	2	0	2
Laurens	4	1	0	1
Lexington	95	25	7	32
Marion	2			
Newberry	2			
Oconee	2			
Orangeburg	60	5	12	17
Richland	1			
Spartanburg	1	2	0	2
Sumter	3	2	1	3
Williamsburg	8	1	0	1
Misc. Locales	16	10	6	16
Out-Of-State	33	9	1	10
Totals	2,572	447	207	
Total Response				654(25.4%)

Table 12. Gigging questionnaire results: Total number of times respondents reported to have gone gigging in 1978 in S. C. coastal counties.

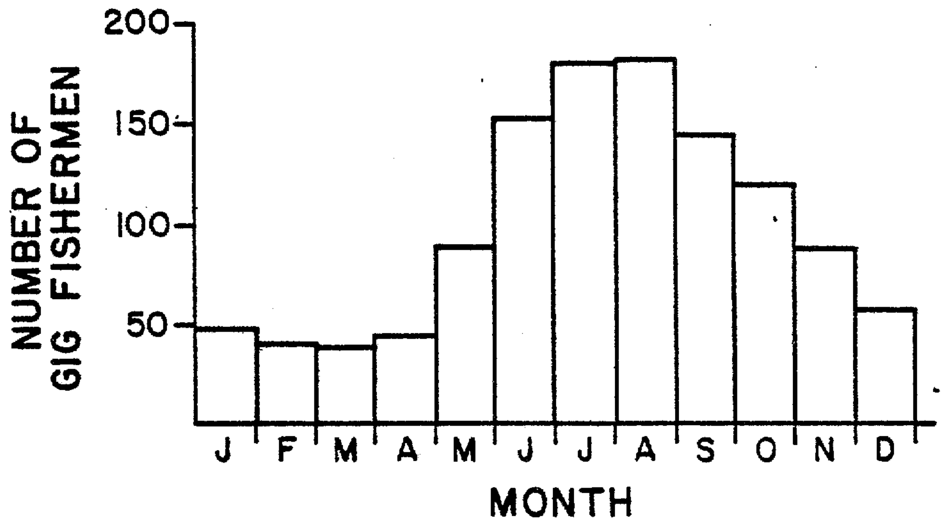
County			
Horry	8	0.3	
Georgetown	29	1.2	
Charleston	143	6.1	
Colleton	85	3.6	
Beaufort	1900	81.1	92.3%
Jasper	177	7.6	
Total number of reported gigging days	2342	99.9	
Total number of respondants that went gigging	447		
Average number of gigging trips per respondant	5.2		

Table 13. Gigging questionnaire results: Areas by counties where respondents did most of their gigging in 1978.

County	Ocean	Inlet	Harbor, Bay or Sound	River	Creek	Totals
Horry	2	3	0	1	0	6
Georgetown	0	5	0	0	0	5
Charleston	0	1	3	4	2	10
Colleton	3	1	3	1	3	11
Beaufort	11	10	65	160	163	409
Jasper	0	0	0	12	3	15
Totals	16	20	71	178	171	456

Figure 1. Gig questionnaire results: Number of gig fishermen who gigged during each month of 1978.

Figure 2. Gill net questionnaire results: Number of gill net fishermen who fished their nets during each month of 1978.


200
150
100
50
NUMBER OF
GIG FISHERMEN
J F M A M J J A S O N D
MONTH

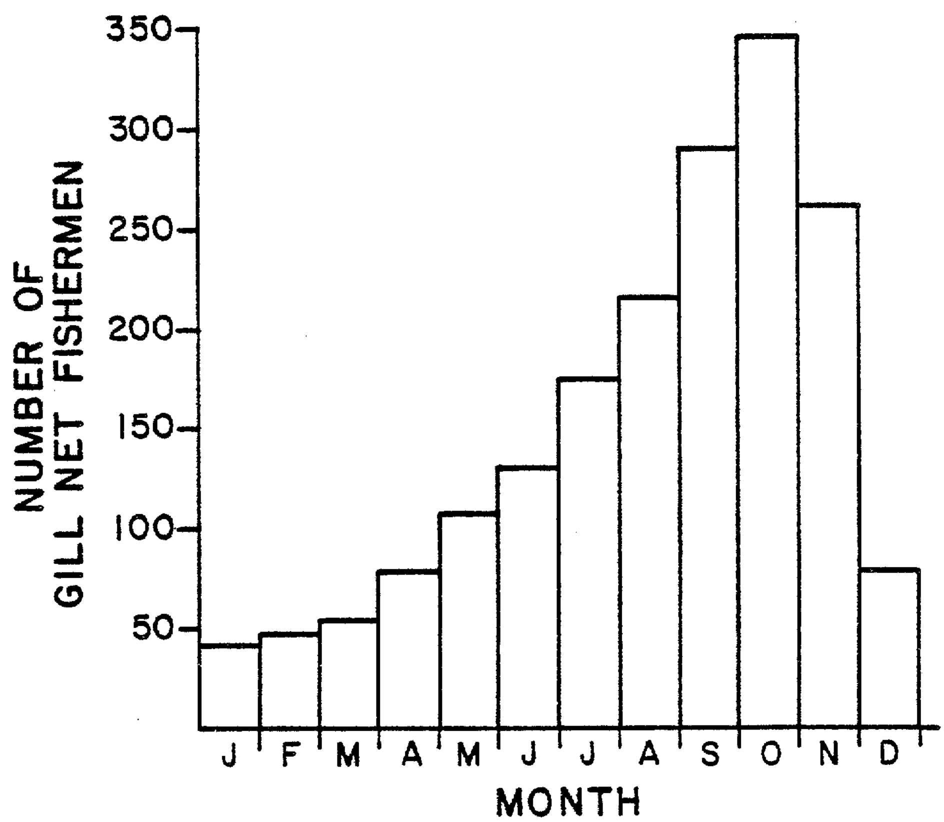

350
300
250
200
150
100
50
NUMBER OF
GILL NET FISHERMEN
J F M A M J J A S O N D
MONTH

Table 14. Gigging questionnaire results: Total reported gig harvest in 1978 by species.

Species	Total Reported Harvest (lbs.)	Percent Of Total Reported Harvest
Flounder	14,225	66.3
Red Drum	2,960	13.8
Spotted Seatrout	930	4.3
Mullet	517	2.4
Other Species	2,836	13.2
Total Harvest	21,468	100.0

questionnaire (Appendix Figure 3) was mailed to all 1978 South Carolina gill net licenses in order to obtain data on catch and effort, dimensions of nets fished, seasons and areas most often fished, and disposition of catch for this fishery. Preliminary results indicate that out of a total of 2,577 questionnaires mailed, a remarkable response rate of 34.1% (N=845) was received (Table 15). Only 4.8% (N=49) of the respondents indicated that they had sold portions of their catch. Based on this information, the coastal gill net fishery of South Carolina is considered to be primarily of a recreational nature and will be addressed as such in this profile.

The following discussion of gill net gears and methods is derived primarily from Siebenaler (1955) and Everhart et al. (1975). Gill nets are designed to entangle fishes attempting to swim through the meshes of the net. Ideally the fish's head may pass through the net but the gill covers become caught in the mesh. Fish may also be captured around the middle of the body, the teeth or the maxillary bone of the jaw.

Excluding shad and sturgeon nets, gill nets are generally constructed of a single wall of nylon monofilament webbing. A float or cork line along the top of the net and a leaded line along the bottom keep the net vertical in the water column. Nets are usually hung "full" (50% more net than the length of the float and lead lines), rather than taut, to increase fish entaglement . Nets are constructed in sections or panels one hundred to several hundreds yards long; these can be joined together to form a net of variable length. Gill net survey results indicate that 87.5% (N=674) of the respondents employed gill nets 100 yards or less in total length (Table 16). A 3 inch stretch mesh was the most

Table 15. Gill net questionnaire results: Number, effort and harvest information concerning a 1978 survey of South Carolina gill net fishermen.

	Did Not Fish Nets	Fished Net Did Not Sell Catch	Fished Net Sold Portions of Catch	Total
Number of Gill Net Fishermen				
Number of fishermen with 1978 gill net license				2577
Number of gill net fishermen returning cards	190(7.3%)	606(23.5%)	49(1.9%)	845(34.1%)
Percent of cards returned by disposition of catch	22.5%	71.1%	5.8%	100%
Number of gill net fishermen who plan to buy 1979 license	133(70%)	567(94%)	49(100%)	749(89%)
Estimated total number of 1978 gill net fishermen	584	1,848	150	2577
Effort				
Number of days fished by responding fill net fishermen		5,038	1,396	6,434
Estimated days fished by 1978 gill net fishermen		15,360	4,256	19,616
Average number of days fished by gill net fishermen		8.3	28.5	9.8*
Harvest				
Pounds harvested by reporting gill net fishermen		104,722	123,165	227,887
Estimated total harvest by 1978 gill net fishermen		319,279	375,504	694,793
Average number of pounds harvested per day		20.8	88.2	35.4*
Total 1978 harvest per gill net fishermen		173	2,514	348*

* Does not include those gill net fishermen who did not fish during 1978.

Table 16. Gill net questionnaire results: Nubmer of gill net fishermen reporting using gill nets of various lengths in 1978.

Length (Yards)	Frequency Of Gill Net Fishermen Who Used Nets Of Various Lengths
10	3
20	44
30	170
40	30
50	120
60	18
70	22
80	23
90	2
100	242
120	6
140	4
160	20
180	1
200	29
300	26
400	5
500	2
600	1
700	1
800	1
900	1
Total	771

frequently used mesh size by respondents with a majority of those polled using mesh sizes less than 4 inches (Table 17).

Gill nets may be fished using the runaround, drift or stake net methods. In a runaround set (sometimes referred to as a strike) the net is set in a large arc along the shoreline, similar to a stop net set. Various loud noises, such as slapping the surface of the water with an oar, are made within the arc of the net to frighten fish into the webbing. The net is picked up shortly thereafter. Mullet and mackerel fishermen may completely encircle a school of fish using this method. A drift gill net set is accomplished by attaching buoys or boats to the ends of the net and allowing it to drift with the current. The net is set perpendicular to the current flow. Stake gill net sets are stationary, each end being fastened to a fixed stake or anchor. Occasionally, one end of the net is secured to shore and the set made perpendicular or oblique to the shoreline. In either instance the net is set perpendicular to the prevailing current.

Most gill netting activity in South Carolina as reported by questionnaire respondents occurs June through November, with peak activity in October (Figure 2). Information concerning areas fished by survey respondents is summarized in Table 18. Overall, the ocean was the most frequently fished body of water (57.5%, N=364). Rivers (14.1%), inlets (12.2%), harbors, bays and sounds (10.0%), and creeks (6.3%) were fished less frequently by the respondents in order of decreasing importance (Table 18). Summarized catch and effort data as per response to these respective questions on the postal card questionnaire are presented in Table 19. Spot was by far the most important fish harvested and accounted for 54.7% (124,729 pounds, 56,576 kg) of the total reported harvest.

Table 17. Gill net questionnaire results: Frequency of gill net fishermen who reported using various size stretch mesh nets in 1978.

Stretch Mesh (In.)	Frequency Of Gill Net Fishermen Who Used Various Mesh Sizes
2	66
2½	129
3	375
3½	123
4	39
4½	12
5	6
5½	19
6	3
6½	-
7	1
Totals	773

Table 18. Gill net questionnaire results: Number of gill net fishermen who fished in the ocean, inlets, harbors, bays and sounds, rivers and creeks in the coastal counties of South Carolina in 1978.

Areas Fished	Total
All Coastal Counties	
Ocean	364(57.5%)
Inlets	77(12.2%)
Harbors, Bays, Sounds	63(10.0%)
Rivers	89(14.1%)
Creeks	40(6.3%)
Total	633(100.1%)

Table 19. Gill net questionnaire results: Total number of gill net fishermen who responded, those that fished and did not sell their catch and those who fished and sold at least a portion of their catch, the number of days fished and their total harvest by species.

	Did Not Sell Catch	Sold Part of Catch	Total
Number of Gill Net Fishermen	606	49	655
Number of days fished	5,038	1,396	6,434
Harvest (pounds)			
Spot	39,850	84,879	124,729
Mullet	24,892	17,300	42,192
Bluefish	10,572	5,313	15,885
Spotted Seatrout	6,570	5,711	12,281
Red Drum	6,101	3,667	9,768
Flounder	4,273	4,035	8,308
Shark	1,325	100	1,425
Shad	1,245	135	1,380
Gar	892	300	1,192
Herring	1,000	100	1,100
Gizzard Shad	466		466
Whiting	265	200	465
Menhaden	80	200	280
Spanish Mackerel	80	130	210
Croaker	205		205
Summer Trout (Gray Seatrout)	200		200
Catfish	85		85
Sheepshead	15		15
Drum	12		12
Pinfish	11		11
Other	6,583	1,095	7,678
TOTAL	104,722	123,165	227,887

Combined, reported harvests of spotted seatrout, red drum and flounders accounted for only 13.3% (30,357 pounds, 13,770 kg) of the total reported gill net harvest (Table 20). Estimated total gill net harvest by species for 1978 is shown in Table 21.

Admittedly, postal card questionnaires are subject to numerous sampling errors. Fishermen's recall of catch/effort data, as opposed to on site catch inspection, is often one of the more suspect bits of information. Nevertheless, the noteworthy response rate to the gill net questionnaire (34.1%) suggests some valid generalizations concerning South Carolina's gill net fishery can be made.

The gill net fishery in South Carolina (excluding the shad and sturgeon fishery) is primarily a recreational fishery with a majority of participants fishing nets of 100 yards or less. Responses indicate peak gill netting activity occurs in the fall and a majority of effort is directed towards ocean areas. This coupled with the fact that spot comprised an overwhelming majority of the total catch (54.7%) suggests that a majority of the gill netting effort in the state is directed towards the fall run of spot along the ocean beaches. Spotted seatrout, red drum and flounders comprised a relatively small portion of the total reported catch (as compared to total reported catches of spot and mullet). Survey results suggest these species groups are of relatively minor importance in the overall harvest of finfish in South Carolina's gill net fishery.

3.4.2 Participation in the Recreational Fishery for Coastal Finfish

Since 1968 numerous state and national surveys have addressed various segments of South Carolina's marine recreational fisheries. These data

Table 20. Gill net questionnaire results: Percent composition of 1978 gill net harvest by species as reported by questionnaire respondents.

Speices	Total Percent of Harvest	
Spot	54.7	
Mullet	18.5	
Bluefish	7.0	
Spotted Seatrout	5.4	
Red Drum	4.3	13.3%
Flounder	3.6	
All Others	6.5	

Table 21. Gill net questionnaire results: Estimated number of South Carolina gill net fishermen who did not fish their nets, who fished their nets and sold a portion of their catch, who fished their nets and did not sell any portion of their catch, and their total harvest by species during 1978.

	Did Not Fish Nets	Fished Nets and Did Not Sell Part of Catch	Fished Nets and Sold Part of Catch	Total
Estimated Number of Gill Net Fishermen	580	1,848	150	2,577
Estimated Days Fished		15,360	4,256	19,616
Estimated Harvest				
Spot		121,494	258,777	380,271
Mullet		75,890	52,744	128,634
Bluefish		32,232	16,198	48,430
Spotted Seatrout		20,030	17,412	37,442
Red Drum		18,601	11,180	29,791
Flounder		13,027	12,302	25,329
Shark		4,040	305	4,345
Shad		3,796	412	4,208
Gar		2,720	915	3,635
Herring		3,049	305	3,354
Gizzard Shad		1,421		1,421
Whiting		808	610	1,418
Menhaden		244	610	854
Spanish Mackerel		244	396	640
Croaker		625		625
Summer Trout (Gray Seatrout)		610		610
Catfish		259		259
Sheepshead		46		46
Drum		37		37
Pinfish		36		36
Other		20,070	3,338	23,408
Total		319,279	375,504	694,793

are summarized in Table 22. However, a comprehensive survey of all segments of the state's marine sport fisheries is unavailable. A review of past surveys gives some insight into participation levels in various coastal finfishing activities.

Although National Saltwater Angling Survey data (1960, 1965 and 1970) are summarized by biogeographical region rather than by state, significant growth of marine sport fisheries in the South Atlantic region (Cape Hatteras to southern Florida) is indicated. During 1960 an estimated 1,024,000 persons participated in saltwater angling in the South Atlantic region (Clark 1962). By 1965 this estimate had escalated to 1,720,000 anglers (Deuel and Clark 1968) and in 1970 had risen to 1,808,000 anglers (Deuel 1973). Results of the 1975 national survey are as yet unpublished, but Merriner (1978) cites (via personal communications with D. Deuel) that these data indicate the numbers of sport-fishermen continue to increase. Merriner (1976) also reported that recreational fisheries along the Atlantic and Gulf coasts have grown at about 4.7% per year since 1960.

Bearden (1969) estimated that in 1968 there were 240,500 resident saltwater anglers (age 12 and over) in South Carolina. An estimated 50.1% (ca. 121,000) of these anglers participated in the small boat fishery, 17.1% (ca. 41,100) in the surf fishery and 13.0% (ca. 31,100) in the pier fishery. Resident anglers spent an average of 9.1 days fishing in saltwater during 1968, while the state's coastal boat owners polled spent 30.7 days fishing in saltwater. A regional survey of the southeastern United States conducted by the National Marine Fisheries Service (NMFS) (Mabrey et al. 1977) estimated that 396,000 South Carolina residents (= 185,000 households) participated in marine recreational finfishing during 1974. This represents a 65% increase in number of marine anglers over Bearden's survey conducted 6 years earlier.

Table 22. Resident participation in various segments of South Carolina's marine recreational fisheries.

Activity	Number of Resident Participants	Number of Fishing Days	Survey Year	Source of Data
Total Finfishing	240,500		1968	Bearden (1969)
	396,000		1974	Mabrey et al. (1977)
Inshore Small Boat Fishing	121,000		1968	Bearden (1969)
Total Inshore Private Boat Fishing	19,507[1]	339,885[2]	1973	Bromberg (1973)
Pier Fishing	31,100		1968	Bearden (1969)
	25,000[3]	228,000	1974	Hammond and Cupka (1977)
Surf and Bank Fishing	41,100		1968	Bearden (1969)

1 = In terms of number of boats

2 = In terms of boat days

3 = Includes residents and non residents

Moore (in preparation) recently completed a survey of the summer saltwater sport fishery in Murrells Inlet, S.C. and found participation levels quite significant. An estimated 15,561 anglers made an average of 169 fishing trips per day to this inlet between 15 May and 15 August 1978. Over 80% of the trips were made by small boat with the average trip lasting 5.0 hours. Bank/pier fishing trips comprised less than 20% of the total trips and averaged 3.8 hours in duration. Hammond and Cupka (1977) estimated that 24,000 anglers utilized the state's 12 commercial ocean fishing piers between April and November 1974. Pier anglers expended an estimated 227,911 days of effort during the study period. Comparable participation data are unavailable for the remainder of the South Carolina coast.

Out-of-state participation appears to be an important segment of South Carolina's marine sport fisheries. The 1973-1974 NMFS regional surveys (Ridgely and Deuel 1975; Mabrey et al. 1977) estimated that a total of 658,000 non-residents participated in marine recreational fishing in South Carolina waters during the study years (Table 23). A majority of these out-of-state fishermen were from North Carolina. Out-of-state anglers, primarily from states north and northwest of South Carolina, accounted for 57% of the projected attendance in South Carolina's coastal pier fishery during 1974 (Hammond and Cupka 1977). Moore's study (in preparation) of Murrells Inlet, S.C. anglers indicated 30% of the interviewees were non-residents, 25% of these being from North Carolina. That North Carolina is a major contributor to non-resident segment of South Carolina's marine sportfisheries is substantiated by Hayne (1968). He reported that an estimated 19.5% (ca. 36,000) of North Carolina's resident saltwater anglers fished most often in South Carolina waters.

Participation in South Carolina's gig and gill net fisheries, as indicated by the number of licenses issued, has increased dramatically in the

Table 23. Estimated number of non-residents participating in marine recreational fishing (finfishing and shellfishing) in South Carolina in 1973 - 1974.

State of Residence	Number of Participants (1000's)
Connecticut	2
Delaware	3
Maryland	13
Massachusetts	6
New Jersey	8
New York	27
Pennsylvania	19
Vermont	1
Virginia	84
West Virginia	22
Alabama	2
Florida	8
Georgia	105
Mississippi	3
North Carolina	350
Texas	5
Total	658

Sources: NMFS, Participation in Marine Recreational Fishing, Northeastern United States, 1973 - 1974 (Ridgely and Deuel 1975).
NMFS, Participation in Marine Recreational Fishing, Southeastern United States, 1974, (Mabrey et al. 1977).

past decade. Gig licenses are only required in South Carolina's three southern coastal counties, presumably though, growth of the fishery in these areas is also indicative of increased participation in the central and northern coastal regions of the state. Gig license sales during the 1977-78 fiscal year showed an increase of almost 225% over the number of licenses sold during 1971-72 (Table 24). Sales increased an average of 23% per year during the same period (Table 24). Additional auguments for increased participation in the gig fishery are derived from the gigging survey questionnaire. A total of 27% (N=159) of the respondents claimed they had not purchased a gig license in previous years, while 86% (N=528) reported they intend to buy a gig license next year. Out-of-state participation in the southern coastal gig fishery is minimal (Table 24), probably due to the relatively expensive cost of a non-resident gig license ($25.25).

Participation levels in the gill net fishery have paralleled those of the gig fishery. Gill net license sales during the fiscal year 1977-78 showed an increase of 306% over the number of licenses sold during 1971-72 (Table 24). License sales increased an average of 27% per year during this period (Table 24). A total of 18% (N=146) of the gill net questionnaire respondents reported they had not purchased gill net licenses in previous years and 89% (N=749) claimed they plan to buy a license during the following year.

3.5 Current Economic Trends in the Fisheries

3.5.1 The Commercial Fishery

As cited previously, finfish landings presently comprise only a small portion of South Carolina's total seafood production. During the period 1970-1976 the state's total commercial fisheries landings averaged 20.5 million pounds valued at $9.4 million, of which finfish (anadromous, coastal and off-

Table 24. Number of gill net and gig licenses sold annually between 1971 - 1972 and 1978 - 1979 and the percent increase over 1971 - 1972 sales.

Fiscal Year (July through June)	Number of Gill Net Licenses Sold	Percent Increase in Gill Net Licenses Sold over 1971-72	Number of Gig Licenses Sold	Percent Increase in Gig Licenses Sold Over 1971-72
1971-72	705		590(2)	
1972-73	830	18%	746(2)	26%
1973-74	1,267	80%	912(6)	55%
1974-75	1,617	129%	925(5)	57%
1975-76	2,080	195%	1170(8)	98%
1976-77	2,434	245%	1167(11)	98%
1977-78	2,861	306%	1910(9)	224%
1978-79 (July-Feb)	2,999	325%	1774(9)	201%

Number within ( ) indicates number of non-resident gig licenses sold.

shore species combined) comprised only 20.2% (4.1 million pounds) of the weight and 6.8% ($640,000) of the value (Ulrich, in preparation). In recent years, 1975-78, reported commercial landings of spotted seatrout and red drum have shown precipitous declines, (Table 25 and Figures 3 and 4) the former species being most dramatic. Total value of the spotted seatrout catch during this period averaged about $2,500, while those of red drum averaged approximately $1,600. Flounder is by far the most commercially important fish of the three species groups addressed herein. Flounder landings during 1975-78 averaged 52,000 pounds per year having an average value of $17,000. Flounder is currently in tenth place among major finfish species by pounds landed (Ulrich, in preparation). Several seafood market personnel interviewed during this project claimed that despite the limited supply problems, the present marketing potential for spotted seatrout, red drum and flounder in South Carolina is encouraging.

3.5.2 The Recreational Fishery

Data on the socio-economic aspects of South Carolina's recreational fishery for coastal finfish is extremely limited. Existing information is either regional in scope or has addressed isolated segments of the state's saltwater fisheries. Cupka (in preparation) has summarized available data concerning the economic importance of the state's marine sportfisheries. Much of the following is gleaned from his report.

Although economic data on individual segments of the state's marine recreational fisheries is lacking, the overall economic importance of this activity is considerable. Angler expenditures for tackle, bait, food, lodging, vessels and vessel equipment form an important part of the state's economy and are paramount to the economies of many coastal communities. The estimated economic

Table 25. Reported commercial landings of spotted seatrout, red drum and flounders in South Carolina, 1950 - 1978.

	SPOTTED SEATROUT		RED DRUM		FLOUNDER	
	Total Weight(lbs.)	Total Value($)	Total Weight(lbs.)	Total Value($)	Total Weight(lbs.)	Total Value($)
1978*	119	48	4325	1391	57863	23164
77	523	230	779	261	16409	6586
76	5798	2740	2557	870	73276	21631
75	16971	7152	12371	3692	60395	17270
74	8865	3057	2169	686	45614	11091
73	5783	2046	620	155	74406	16636
72	12572	3935	1148	322	61974	12353
71	24161	6175	1250	235	50579	8983
1970	9073	2159	400	68	16111	2583
69	8345	2579	720	110	8577	1069
68	11949	3190	—	—	16647	3328
67	2000	1000	1000	1000	34000	8000
66	25000	7000	1000	1000	40000	10000
65	35000	10000	—	—	91000	23000
64	60000	20000	12000	2000	46000	12000
63	48000	11000	—	—	125000	30000
62	27000	6000	—	—	133000	27000
61	56000	13000	1000	1000	95000	20000
1960	53000	13000	4000	1000	54000	11000
59	37000	8000	—	—	30000	6000
58	21000	5000	1000	1000	33000	7000
57	56000	17000	1000	1000	62000	11000
56	223000	67000	57000	11000	86000	14000
55	139000	35000	67000	10000	121000	41000
54	—	—	17000	2000	97000	17000
53	50000	13000	55000	10000	84000	17000
52	86200	23100	73000	14000	83000	17300
51	119000	37050	120000	32000	95700	22495
1950	25500	6400	33500	5360	214300	23995

Sources: Fishery Statistics of the United States, 1950 - 1967.
1968 - 1978 statistics from R. Rhodes, SCWMRD.

* = Preliminary figures

Figure 3. South Carolina spotted seatrout landings, 1950-1978 (Source: Fisheries Statistics of the U. S.).

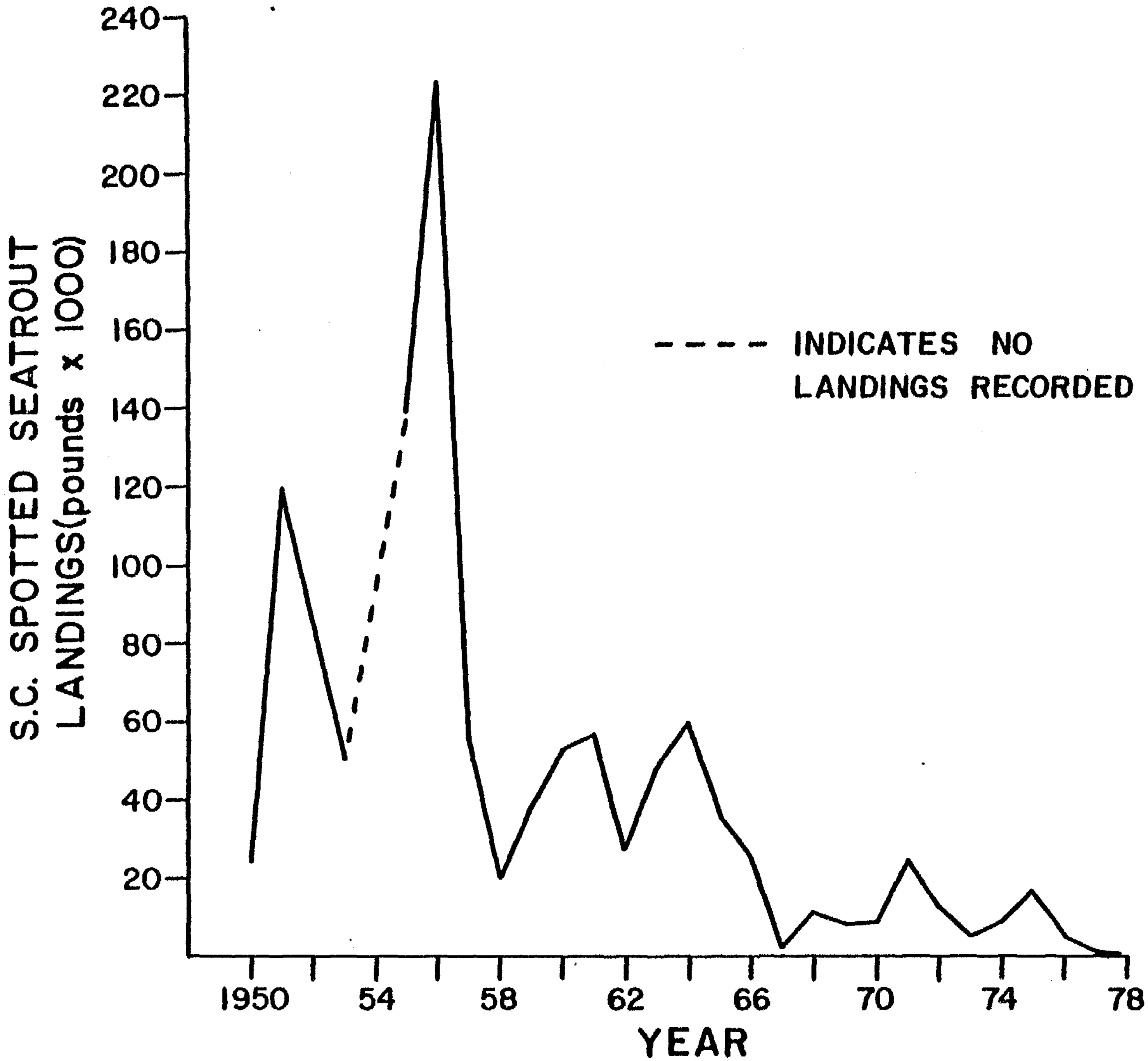
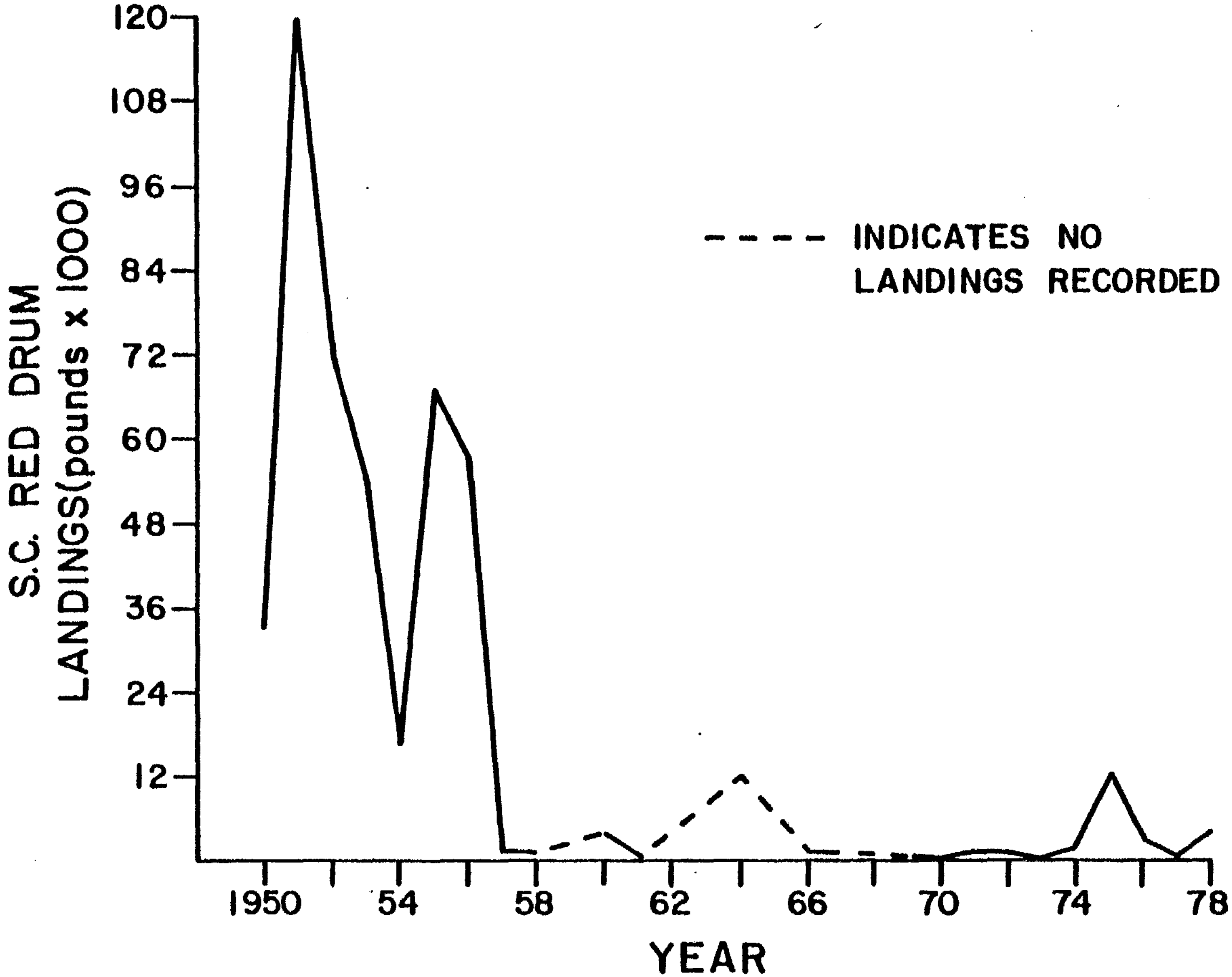

S.C. SPOTTED SEATROUT LANDINGS(pounds x 1000)
240
220
200
180
160
140
120
100
80
60
40
20
1950
54
58
62
66
70
74
78
YEAR
INDICATES NO LANDINGS RECORDED

Figure 4. South Carolina red drum landings, 1950-1978 (Source: Fisheries Statistics of the U. S.).


S.C. RED DRUM
LANDINGS(pounds x 1000)
120
108
96
84
72
60
48
36
24
12
1950
54
58
62
66
70
74
78
YEAR
INDICATES NO LANDINGS RECORDED

impact of marine recreational fishing to the South Atlantic region (Cape Hatteras to southern Florida) for 1975 was $457 million (Centaur Management Consultants 1977; Table 26). Hammond and Cupka (1977) reported that the South Carolina pier fishery injected $2.4 million in 1974 directly into local business economies. A total of $1.3 million was directly attributed to the presence of the pier fishing industry. Using the most recent estimates for participation levels in the state's marine sportfisheries and an average annual expenditure figure for saltwater anglers, Cupka (in preparation) estimated an overall economic impact of $117 million is generated by South Carolina's marine anglers. This does not include out-of-state participation. The trend towards increase participation in marine sportfisheries has no doubt increased this figure considerably in recent years.

3.6 Historical Trends in the Fisheries

3.6.1 The Commercial Fishery

Data presented in this section are derived from: (1) NMFS Fisheries Statistics of the U. S. Annual summaries, (2) South Carolina commercial fisheries landings as compiled by the Commerical Fisheries Section of the SCWMRD (R. Rhodes) and (3) Ulrich's (in preparation) characterization of South Carolina's commercial finfish fisheries. Commercial landings statistics are no doubt underestimates of the actual production since finfish are often sold outside normal market channels. An obvious need for the future is a more accurate system of accounting for coastal finfish landings.

3.6.1.1 Spotted Seatrout

Peak production of spotted seatrout occurred during the 1950's; landings declined during the 1960's, recovered slightly in the 1970's and have declined to the present (Table 27 and Figure 3). Average

Table 26. Economic impacts of marine recreational fishing in the South Atlantic region (Cape Hatteras to south Florida) during 1975.

	Sales (thousands of dollars)	Value-Added (thousands of dollars)	Wages & Salaries (thousands of dollars)	Employment (person-years)	Annual Capital Expenditures (thousands of dollars)
shing Tackle					
anufacturing	9,890	6,260	2,720	430	430
holesale Trade	11,100	1,040	820	90	70
etail Trade	23,600	9,020	2,740	400	680
ats					
anufacturing	14,150	6,210	3,000	420	170
etail Trade	21,170	3,360	1,590	210	120
tors					
anufacturing	5,060	2,300	860	60	150
etail Trade	6,890	1,070	520	70	50
ailers					
anufacturing	1,530	710	260	30	50
ail Trade	1,830	310	140	20	10
rinas	24,430	9,770	6,600	660	490
mercial Sport-ishing vessels	22,260	13,320	6,460	890	1,550
at Fuel					
anufacturing	4,990	810	90	10	220
olesale Trade	7,430	710	150	20	110
etail Trade	8,750	1,430	500	110	70
od	46,780	16,860	10,760	2,270	1,270
iging	10,950	5,740	2,900	600	300
avel					
anufacturing	24,800	4,290	580	40	1,100
olesale Trade	36,930	3,540	900	90	560
etail Trade	43,450	5,040	3,170	560	350
at Insurance	5,700	1,320	500	40	—
it	42,770	8,510	3,500	530	260
ner	30,330	6,070	3,640	540	610
	288,910	107,690	52,400	8,090	8,820

urce: Centaur Management Consultants (1977) via Cupka (in preparation).

Table 27. Reported commercial landings of spotted seatrout by gear in South Carolina, 1965 - 1975.

	Haul Seine	Shrimp Otter Trawl	Gill Nets	Spears (Gigs)	Hand Lines	Stop Net
1975		8300	5000	200	1600	2000
74		800	3500		4600	
73		4700	1000		100	
72	1000	10400	6300		400	
71	17300	6800	100			
1970	4700	4400				
69	7900	400				
68	11800				100	
67		1300	300			
66	23400	1100				
65	31900	3100				

Source: Fishery Statistics of the U.S., 1965 - 1975.

landings during 1960-1976 were 23,000 pounds and were ranked last among major finfish species. The average value of the landings during the same period was $6,400, which ranked twelfth in value for major finfish species. The depressed landings in 1977 and 1978 are thought to reflect the deleterious effects of the severe winters of 1976 and 1977 on the spotted seatrout populations.

During the period 1965-1971 haul seines accounted for a majority of the spotted seatrout landings (Table 27). Since then, haul seine catches of spotted seatrout have gone unrecorded and may reflect the recent decline in participation in this fishery. Shrimp otter trawl landings of spotted seatrout show an increasing trend through the early 1970's (Table 27). Likewise, beginning in 1970 gill net and hand line (hook and line) production of spotted seatrout have tended to increase (Table 27) and may reflect increased participation levels in these fisheries.

3.6.1.2 Red Drum

Reported red drum landings in South Carolina peaked during the early 1960's and subsequently declined to the present (Table 28 and Figure 4). Minor production peaks were recorded in 1964 and 1975. Landings averaged 3,000 pounds per year for the period 1960-1978, $900 being the average value of the catch. Shrimp otter trawls accounted for a majority of the red drum landings from 1966-1973 (Table 28). As with the spotted seatrout landings, red drum landings by gill net and hand lines increased significantly during 1974 and 1975 (Table 28).

3.6.1.3 Flounder

South Carolina flounder landings averaged 50,000 pounds for the period 1960-1978. Landings show a general decreasing trend from an

Table 28. Reported commercial landings of red drum by gear in South Carolina, 1965 - 1975.

	Haul Seine	Shrimp Otter Trawl	Gill Nets	Spears (Gigs)	Hand Lines	Stop Net
1975		1600	8000	200	2300	300
74			900		1400	
73		600				
72		1200				
71	500	700			100	
1970		400				
69		200			100	
68						
67			900			
66		200				
65						

Source: Fishery Statistics of the U.S., 1965 - 1975.

average high of 91,000 pounds during 1960-1964 to an average of 52,000 pounds in 1975-1978. (Table 29 and Figure 5). During the latter period the average value of the catch was $17,000. Shrimp by-catch landings account for most of the South Carolina flounder landings (Table 29). Sporadic gig and hook and line catches of flounder also appear in the landings record (Table 29).

3.6.2 The Recreational Fishery

Participation levels in South Carolina's marine recreatonal fin-fisheries have been discussed in a previous section of this profile, but will be reiterated for present purposes. The overall magnitude of the marine recreational fishery in South Carolina remains imprecisely defined, however the limited survey data available suggest participation in this activity has increased significantly since the late 1960's. Bearden (1969) estimated there were 240,500 saltwater anglers in South Carolina during 1968. A NMFS regional survey (Mabrey et al. 1977) estimated 396,000 South Carolinians participated in saltwater angling during 1974, a 65% increase over a six year span. Estimates of current participation levels are unavailable, however Merriner (1976) suggested recreational fisheries along the Atlantic and Gulf coasts have been growing at about 4.7% per year since 1960. Applying this rate to the 1974 NMFS study, it is estimated that nearly 470,000 persons participated in marine sportfish in South Carolina during 1978.

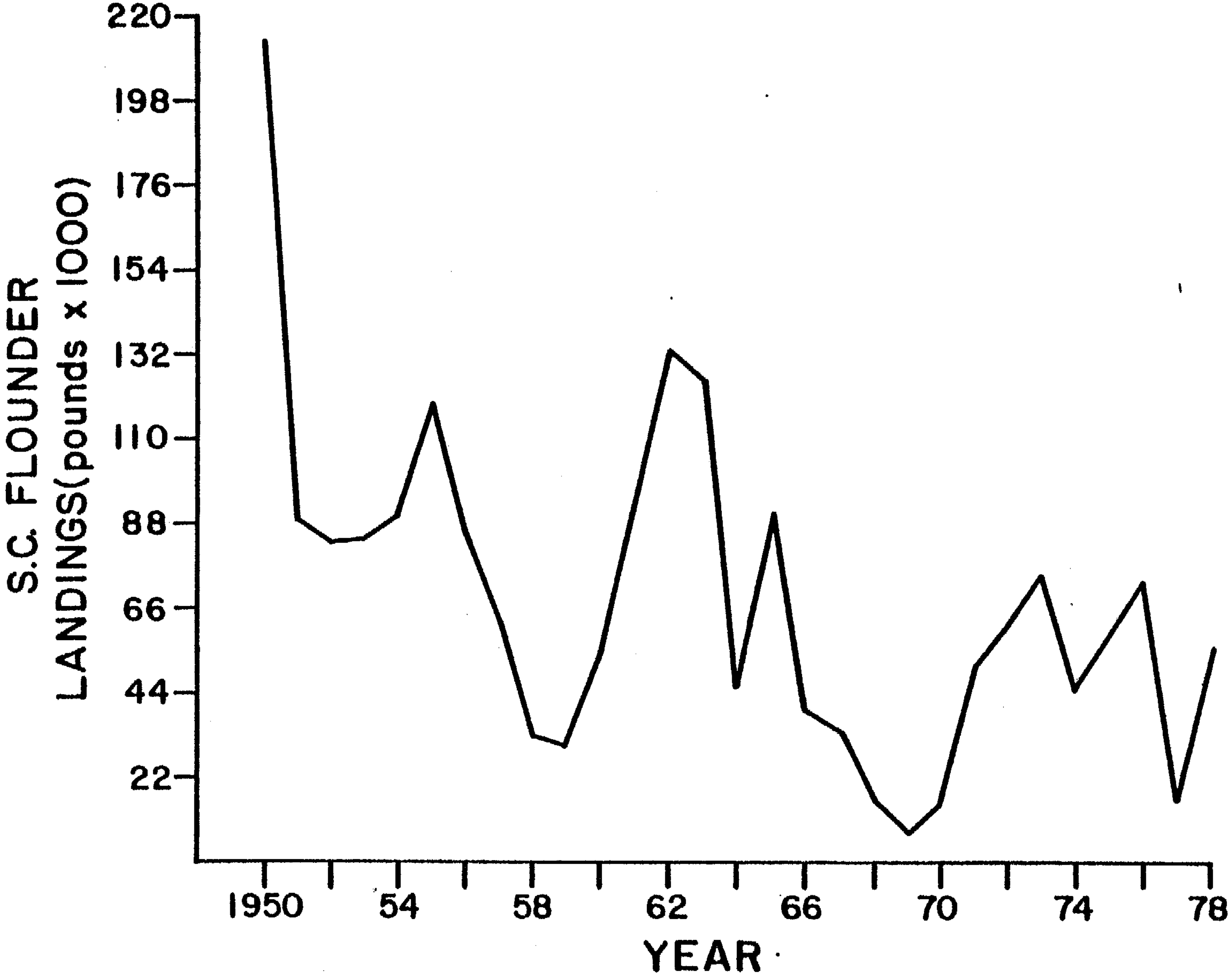
Sales of gill net and gig licenses indicate participation levels in these fisheries has increased dramatically since the early 1970's.

Table 29. Reported commercial landings of flounder by gear in South Carolina, 1965 - 1975.

	Haul Seine	Shrimp Otter Trawl	Gill Net	Spears (Gigs)	Hand Lines
1975	100	58500			1100
74		45100			600
73		74400			
72		62000		100	
71		48200		1600	400
1970	1000	15100			
69		8600			
68	100	17200			
67		33000			
66		40200			
65		89400		1200	31300

Source: Fishery Statistics of the U.S., 1965 - 1975.

Figure 5. South Carolina flounder landings, 1950-1978 (Source: Fisheries Statistics of the U. S.).


S.C. FLOUNDER
LANDINGS(pounds x 1000)
220
198
176
154
132
110
88
66
44
22
1950
54
58
62
66
70
74
78
YEAR

4 Present Management System

4.1 Legislative Authorization

Coastal fisheries regulations in South Carolina are enacted by legislative action. Statutory laws regarding coastal fisheries encompass licenses and taxes, gear restrictions, areas, seasons and sanitation regulations. These are set forth in Title 50, Volume 17, Code of Laws of South Carolina, Chapter 17 (1976, as amended). Exclusive of its control over the shrimping season and areas, the Division of Marine Resources possesses only a limited amount of legislative authorization over the management of finfishes and their fisheries.

Most violations against state statutes and regulations regarding finfish are gill net or channel net infractions where gears block more than one-half of a waterway or are left unattended or unmarked. Violations in the northern part of the state are primarily attributed to shad and sturgeon nets, whereas, from Georgetown County south to the Georgia border most infringements involve channel and gill nets.

4.2 Management Policies

The Division's policies regarding finfish management include a general commitment to the protection of estuarine nursery grounds. All coastal areas, other than offshore waters and six sounds and bays, are considered nursery areas and are closed to shrimp trawling. Where recent conflicts between sport- and net fishermen have developed in isolated geographical areas, the Legislature has enacted local regulations which serve to reduce contact between both groups (See Murrell's Inlet regulations below). In recent years the Division's Recreational Fisheries Section has sought to develop and cultivate the state's recreational fisheries via public relations work and encouraging media coverage of statewide sportfishing tournaments.

4.3 Laws and Regulations

South Carolina statutes and regulations pertaining to coastal finfish and fisheries (excluding shad and sturgeon regulations) are summarized below. Code sections of the South Carolina Marine Fisheries Laws are provided in parentheses. With the exception of a license required for persons taking swimming finfish from saltwater for market, coastal finfisheries laws make little distinction between commercial and recreational interests.

4.3.1 Licenses (Article 3) (annual fees)

Hook and Line	None
Anchor, staked, or drift gill nets, for each 100 yards or fraction thereof (50-17-360)	$ 5.00
Channel net (50-17-360)	5.00
Set net (50-17-360)	5.00
Floating trap net (50-17-360)	1.50
Submerged trap net (50-17-360)	3.00
Purse seine (50-17-360)	5.00
Gigging license (required only in Beaufort, Jasper and Colleton Counties)	
Residents (50-19-2820)	1.10
Non-residents (50-19-2810)	25.25
A power boat license must be purchased and displayed if net is transported to or from fishing site by power boat (50-17-500)	
Vessels up to and including 18 feet long	3.00
Vessels over 18 feet long	10.50
An annual license for the year beginning July first is required of each person engaged in taking swimming finfish from salt-water for market (50-17-330)	2.50
Fish dealers and processors engaged in buying, selling, shipping, canning, shucking or processing salt-water fish (50-17-450)	20.00-100.00

4.3.2 Regulations (Statutes)

4.3.2.1 Restrictions on Gear and Fishing Methods

Seines and gill nets - Minimum mesh size is 2½ inches, (except Game Zone 7, 2 inches for haul seines) however, there are no restrictions on maximum length of the net (50-17-1020).

It is unlawful to place or set any net, seine or similar device more than half-way across any creek, stream, channel, slough or other waterway at any tide stage (50-17-1030).

It is unlawful to set a net within 200 feet of another net or device previously set (50-17-1050).

Nets set and left unattended must be marked with the address of owner and license number (50-17-1050).

4.3.2.2 Seasons and Areas

Regulations regarding shrimp trawling seasons and areas indirectly affect coastal and estuarine finfish which are taken as a by-catch. All coastal areas, other than offshore waters and six sounds and bays, are considered nursery areas and are off-limits to shrimp trawling.

No channel or set net shall be used at anytime except during those periods open for shrimp trawling (50-17-1020).

It is unlawful to fish from a boat within 150 feet of commercial fishing piers extending into the Atlantic Ocean (50-17-120).

It is unlawful to fish from South Carolina highway bridges except where so posted (S. C. Highway Department).

It is unlawful to catch food fish with a purse seine in any of the state's waters except in the ocean 300 yards or more from the beach (50-17-1010).

It is unlawful to catch fish in the Combahee River from U. S. Highway No. 17 seaward using traps, trotlines or nets (50-13-770).

It is unlawful for a person to fish with anchor nets or seines in the waters of Midway Inlet between Pawley's Island and Litchfield (Magnolia) Beach south to the north causeway bridge to Pawleys Island in Georgetown County between September first and December thirty-first of each year (50-17-1040).

It is unlawful to use a gill net in either branch of the Cooper River or its estuaries from the upper "Ts" (50-13-760).

Except between the hours of six o'clock P.M. and six o'clock A.M. with one, one-hundred yard net with channel set or with one-hundred yard net with shore set it is unlawful to fish with a gill net in all waters and creeks of Murrells Inlet from the inlet buoy north of the State Secondary Highway No. 51 bridge between September first and December thirty-first of each year.

It is unlawful to use light, torch or gig for catching or killing fish in the waters of Horry and Georgetown Counties (50-13-950).

It is unlawful in Georgetown County for any person to gig for fish in saltwaters from the northern tip of North Island to the northern tip of Magnolia Beach during the daylight hours (50-19-330).

4.3.3. Scientific Collecting Permits

Special permits may be issued to recognized scientists and students actually engaged in the study of the inhabitants of the coastal waters of the state (50-17-70).

4.3.4 Penalties for Violations

General penalties for the violations of the Coastal Fisheries Laws in South Carolina, unless otherwise provided, include fines of $25-$100.00 or imprisonment for 10-30 days for the first offense. Subsequent offenses are punishable by fines of $50.00-$500.00 and imprisonment for 20 days to 6 months (50-17-130). Additionally, any nets or fishing devices used in violation of Article 7 (Use of nets, seines and like deviced) of the Coastal Fisheries Laws are subject to confiscations (50-17-1070).

5 Current Research and Monitoring Programs

South Carolina has no ongoing research directly concerned with the life history, ecology or the effects of environmental perturbations on populations of spotted seatrout, red drum or paralichthid flounders. Relevant research in South Carolina and bordering coastal states which may possibly yield biological or ecological information on these species are listed below.

5.1 South Carolina

S. C. Wildlife and Marine Resources Department, Division of Marine Resources

"An Environmental Baseline Study of South Carolina Estuaries". Project objectives include determinations of basic biological, chemical and physical characteristics of major estuaries in South Carolina. Field work for this statewide survey has terminated. Data on estuarine and marine fishes collected by bottom and mid-water trawl include species numbers, relative abundance, length frequencies, and related hydrographic conditions. Results of efforts for the period February 1973 through January 1974 have been published (Shealy et al. 1974). Subsequent data (1974-1978) have been placed on computer tapes.

Recently (October 1979), the Marine Resources Research Institute (M. Shealy, principal investigator) has initiated an investigation into several aspects of the life history of the spotted seatrout. Study objectives include defining the seasonality, relative abundance, and age composition of the recreational catch of spotted seatrout in South Carolina waters. Study specimens are being acquired primarily from gill net sets and statewide sportfishing tournaments.

"Ecological Characterization of the Sea Islands and Coastal

Plains of South Carolina and Georgia". Project goals are to develop an ecological characterization of the coastal region of both states and to synthesize and diseminate this information. Project objectives include a synthesis of available environmental data describing important resources, ecological processes and their interrelationships within the study area and to recommend future studies to fill present data gaps. The final report for this project is near completion. Funding level for this 2 year study has been approximately $500,000.

The Division's Office of Conservation, Management and Marketing, Recreational Fisheries Section conducts a small-scale estuarine and marine gamefish tagging program. The Section also monitors the state's saltwater sportfishing tournaments for catch/effort statistics.

University of South Carolina, Belle Baruch Institute.

"Material Fluxes Through a Tidal Salt Marsh Estuary: An Ecosystem Study in Outwelling". This National Science Foundation funded study is in its third and final year and is headed by Dr. F. John Vernberg. The overall objective of this multi-faceted study is to examine the movement of biotic and abiotic components through a saltwater marsh. Dr. Richard Moore (Carolina Coastal College) is studying the transport of larval fishes through the system. Proposed work in 1979 includes sampling adult fishes within the marsh using gill nets and trawls. Funding level for the three year study is approximately $800,000.

"Fish Production in the Creeks of the Santee Delta". This two year study has focused on the occurrence and abundance of fishes in the intertidal zone of old rice field creeks. Low salinities prevail in the study area. Predominant species sampled include anchovies, spot, croaker, and pinfish; small red drum are occasionally collected. Dr. John M. Dean is principle investigator.

College of Charleston

A biological study of the North Edisto River funded by the Environmental Protection Agency is presently in its third and final year. Information concerning feeding habits and trophic relationships of large pelagic and demersal fish has been compiled.

5.2 North Carolina

The North Carolina Division of Marine Fisheries has no ongoing research directed specifically at spotted seatrout, red drum or paralichthid flounders. The agency presently monitors the sciaenid stocks taken by the long haul fishery in the sounds, but has placed major emphasis on assessing croaker, spot, grey seatrout and whiting stocks.

5.3 Georgia

The Georgia Department of Natural Resources is presently conducting an extensive tagging program directed towards major inshore saltwater fishes. Target species include red drum, seatrout, black drum, flounder, croaker, spot, whiting and sheepshead. Expected research products include information on migratory routes, growth rates, seasonal abundance, and life history aspects of these species. The 4 year project is funded by the Federal Dingell/Johnson Sportfish Restoration Act and is being directed by Mr. Jim Music.

6 Identification of Problems

6.1 Resource Related Problems

6.1.1 Controllable Variables

6.1.1.1 Habitat Alteration and Loss

Juvenile spotted seatrout, red drum and paralichthid flounders utilize estuarine areas as nursery grounds. Adults of these species ultimately depend on the productivity of the estuaries for their forage fishes and crustaceans. An extreme example of this estuarine dependency is the case of the spotted seatrout, which may spend its entire life cycle within the estuary. Man-induced alterations of the estuarine habitat may have significant effects on the productivity of the inside waters which may eventually affect the abundance of coastal finfish stocks.

Prudent supervision of the coastal zone is required so that the adverse effects of man-induced environmental changes, such as dredging operations and point and non-point sources of pollutants, are minimized. More effective enforcement of existing state and federal regulations concerning the coastal zone is also needed.

6.1.1.2 Protection of the Spawning Stock

The spawning sites of spotted seatrout and red drum in South Carolina waters are not well-defined, although existing information suggests _C.nebulosus_ spawns in inside or nearshore coastal waters and _S. ocellata_ spawn near the mouths of inlets or nearshore marine waters. These spawning areas are within the state management agency's jurisdiction should protection of the spawning stocks be necessary.

Although the exact spawning locations of the summer and southern flounder have not been identified, both species apparently spawn offshore during the winter, probably beyond the state's 3-mile limit. Should these spawning areas be located and on offshore trawl fishery develop (as is the case in the Mid-Atlantic Bight), the state would be unable to regulate the fishery. These stocks could be protected via the South Atlantic Fishery Management Council.

6.1.1.3 Protection of Juvenile Fishes

South Carolina Wildlife and Marine Resources Department is committed to the protection of estuarine nursery grounds. All coastal areas, other than offshore waters and six sounds and bays, are considered nursery areas and are closed to shrimp trawling. Spotted seatrout, red drum and the paralichthid flounders utilize the estuaries as nursery grounds, and thus are indirectly protected from the adverse effects of extensive trawling efforts.

Juvenile stages of all three species groups are no doubt harvested by the state's inshore recreational fishermen. Should minimum size limits be deemed necessary, there is presently insufficient biological information on the species to make prudent management decisions.

Juvenile nursery areas can be protected from the degradative effects of dredge and fill operations and toxic chemical, thermal and sewage discharges through proper management of South Carolina's coastal zone.

6.1.2 Non-Controllable Variables

6.1.2.1 Mass Mortalities

Man has little ability to control mass finfish mortalities due to non-human induced environmental changes (cold kills, freshets or low summertime dissolved oxygen concentrations), diseases or parasite infestations. Such occurrences affect stock abundance, hence production of the fisheries.

Little information is available on the tolerance levels of coastal finfish to environmental variables and future "in vitro" investigations should focus on these areas. Armed with this information, managers will be better able to predict the impact of these variables and future stock abundance.

6.1.3 Biological Information Gaps

6.1.3.1 Identification of Stocks

One of the most fundamental problems faced by fisheries managers is identification of the exploited stock. Different stocks may exhibit heterogeneous growth parameters which may require separate management strategies. On the species level, the question of the relative abundance of *P. dentatus* versus *P. lethostigma* in the South Carolina recreational harvest requires resolution. It has been suggested that a distinct population of *P. dentatus* exists south of Cape Hatteras. Meristic and/or tagging studies would aid in defining this population.

Research along the Gulf and east Florida coasts indicates little inter-estuary movement among spotted seatrout populations, each population being essentially a separate management unit. Tagging and/or electrophoretic studies would help to identify estuary specific populations of spotted seatrout along the South Carolina coast.

6.1.3.2 Migrations

Specific overwintering sites of spotted seatrout, red drum and paralichthid flounders along the South Carolina coast are unknown. Tagging studies on all three species groups would aid in delineating these areas, as well as movements to and fro. Pending laboratory studies of tolerances to enviromental variables, managers might be better able to predict spring abundances of the species if environmental conditions in the overwintering habitats were known.

6.1.3.3 Age and Growth Determinations

Scant information is available on the age and growth of spotted seatrout, red drum and paralichthid flounders in South Carolina waters. Age at size data enables managers to provide information on stock composition, age at maturity, longevity, mortality, growth and yield estimates.

6.1.3.4 Maturity and Fecundity Determinations

Observations on the size at sexual maturity and fecundity are needed for all species groups addressed herein. This information is vital for determining (1) the percentage of immature fish taken by the fisheries and (2) the contribution of the various age groups to the spawning stock. Acquisition of these data would also aid in the definition of spawning sites and seasons.

6.2 User Related Problems

6.2.1 Comprehensive Survey of South Carolina's Marine Recreational Fisheries

Regional and isolated surveys have addressed various segments of South Carolina's marine fisheries in the past, however an overall, comprehensive survey of the state's saltwater anglers is wanting. Without accurate information on species and size composition of the harvest, catch and effort, and participation levels in the various segments of the recreational fishery, meaningful management decisions cannot be made.

6.2.2 More Accurate Commercial Catch Statistics

At present South Carolina commercial fishermen are not required by law to record their landings of coastal finfish. Additionally, many landings are often sold outside of normal marketing channels. The present method of recording commercial landings of coastal finfish can lead to spurious inferences about the magnitude of the commercial fishery. An obvious need is an improved system of accounting for commercial landings of coastal finfish.

6.2.3 Commercial Versus Recreational Gear Competition

The annual commercial finfish harvest in South Carolina constitutes a relatively small portion of the state's total seafood production, this is believed to result from traditional orientation of the state's commercial fishermen towards the shrimp, crab and oyster fisheries. Thus, South Carolina has been spared some of the more vehement confrontations between recreational and commercial fishermen witnessed in other coastal states. Where disputes have evolved, the state's management agency has elected to separate each faction on a temporal basis (see Murrells Inlet weekend gill netting restrictions, under Present Management System). Future disputes should be dealt with on a case-by-case basis. Management policies might be effected on a small geographical area basis.

6.2.4 Recreational Versus Recreational Gear Competition

Present evidence indicates South Carolina's gig and gill net fisheries are primarily of a recreational nature. License sales for both gears during the 1970's indicate participation in these fisheries is growing rapidly. Gear and space competition with recreational hook and line fishermen may become a major problem area in the near future.

6.2.5 Recreational Access

There are approximately 100 boat launching ramps in coastal South Carolina, many of which are in need of repairs ranging from ramp resurfacing to expanded parking area. The need for floating docks adjacent to ramps located on congested waterways is a common complaint of recreational fishermen. New ramp construction is also needed in some areas of the state, however land acquisition is often a difficult and expensive process.

Many of the state's coastal highway bridges span waterways which offer excellent saltwater fishing, but the fishermen's safety is often compromised due to vehicular traffic. The state Highway Department has therefore closed a majority of these bridges to fishing. Construction of additional catwalks is considered to be a major need for the state's coastal fisheries. Legal "red tape" and lack of sufficient funds are very real obstacles to this goal.

6.3 Economic Problems

6.3.1 Due to the limited nature of South Carolina's commercial fishery for coastal finfish, at present there does not appear to be any significant economic problems associated with this fishery. Interviews with local seafood market personnel suggest a majority of the coastal finfish sold at retail and wholesale levels are imported from other states. Stimulating in-state production of coastal finfish is a marketing problem which should be pursued.

6.3.2 The Recreational Fishery

Knowledge of the economic aspects of the state's recreational fisheries is essential in order to make optimum yield determinations. To date, economic information concerning the state's sportfisheries has only been available on a regional basis. Future state recreational surveys should seek to elicit cost information from respondents.

6.4 Management Regulatory and Administrative Problems

In the absence of well-defined policies directed toward coastal finfish (excluding anadromous species) the South Carolina Wildlife and Marine Resources Department has been faced with few real administrative problems related to coastal fishes and their fisheries. As the inshore gig, gill net and hook and line fisheries continue to grow, several potential problems may arise in the near future.

6.4.1. Licensing

The coastal gill net fishery of South Carolina appears to be primarily of a recreational nature, and although gill nets are presently licensed under a single all-inclusive gill net catagory, there is no distinction made between recreational versus commercial usage of this gear. Separate licensing of gill nets according to their major type of usage would greatly aid future management decisions.

Regulation stop nets are currently licensed as "gill nets" thus the number of rigs operating in this fishery is presently unknown. Separate licensing of these gears would enable managers to better define the commercial fishery for coastal finfish. Similarly, haul seines are licensed under the general term of "seines" and should be licensed separately.

At present gig licenses are only required in the southern coastal counties of Colleton, Beaufort and Jasper Counties. A more uniform, statewide licensing regulation levied at the present nominal fee ($1.10) would supply managers with more comprehensive information on the magnitude of this fishery. Much negative feedback has been received from the public concerning a statewide, recreational marine anglers' license. The benefits from such a license, namely improved marine sport fisheries programs, should be continually stressed via the various news media in order to help overcome this negative public attitude.

Computerization of present and historical license sales would aid managers in interpreting participation trends in various coastal fisheries.

6.4.2 Enforcement

Should the state's fisheries managers decide on size and/or catch limits for coastal finfish, there is some question as to whether the present number of coastal wildlife officers could effectively enforce these regulations. A greater number of enforcement officers may be required.

6.4.3 Jurisdictional Problems

Although generally nearshore coastal fishes, flounder and red drum also occur outside the state's 3-mile limit. If size and/or catch limits were imposed on these species, enforcement of these regulations outside the state's jurisdiction, specifically on or near artificial reefs, would present problems. Perhaps these might be solved via a state-federal management program.

6.4.4 Education

Public information and education are important segments of a recreational fisheries program. Through proper programs, the public can be informed of the need for prudent conservation and coastal zone management policies. It is through these channels also, that the public might be educated concerning the need and benefits of a marine recreational fisheries license.

7 Summary and Recommendations

7.1 Summary of Preceding Sections

Spotted seatrout, red drum and the paralichthid flounders form the nucleus of South Carolina's coastal finfisheries. The goal of this segment has been to furnish a management planning profile for these fish and their fisheries which will ultimately aid in providing for more effective management of the state's coastal zone resources. Existing information on the past and present status of the stocks and their fisheries in South Carolina waters has been summarized. Hopefully, this profile will aid the state in establishing future goals and objectives, identifying information gaps and developing management options for its inshore finfisheries.

The first section of this segment summarizes existing biological and ecological data on the spotted seatrout, red drum and paralichthid flounders. Abundant information is available from other areas along the East and Southeast coasts of the United States. However, basic biological questions concerning these species groups remain unanswered in South Carolina waters. Informational needs vital for the proper management of all three species groups include data on age and growth, population structure, reproductive biology, migratory routes, delineation of exploited stocks and tolerances to man-made and environmental perturbations.

The second section of this segment provides a description of the present fisheries for coastal finfish. Although comprehensive harvest data are unavailable it is generally believed that the recreational harvest of coastal finfish in South Carolina exceeds commercial catch. A comparison of total South Carolina commercial finfish landings versus the state's total seafood production during the first half of this decade indicates finfish harvests are relatively minor as compared to the fisheries for crustaceans and shellfish. Present commercial finfishing activities for coastal finfish are apparently limited, part-time fisheries. Gears, methods, seasons and areas of the commercial harvesting sector are reviewed. Future management decisions will require a more accurate system of collecting catch/effort information from coastal commercial finfishermen.

Only flounders enter into South Carolina commercial markets in appreciable numbers and a majority of these are harvested by the shrimp trawl fishery. Smaller amounts of spotted seatrout and red drum are taken by hook and line and gill net fishermen and sold to local retail markets or restaurants. Interviews with retail and wholesale seafood dealers suggest that significant portions of coastal finfish species are imported from other states for sale in South Carolina.

Spotted seatrout, red drum and paralichithid flounders are harvested primarily by South Carolina marine anglers participating in the surf and bank, pier and bridge and inshore small boat fisheries. In terms of participation, existing data suggests the inshore small boat fishery is the state's most popular marine angling activity. Gears, methods, seasons and areas of the above activities are reviewed. Questionnaire surveys conducted during this study indicate that the coastal gig and gill net (excluding shad and sturgeon) fisheries in South Carolina are primarily of a recreational nature.

Although a comprehensive survey of all segments of the state's marine recreational anglers is unavailable, numerous regional and/or localized surveys conducted since the late 1960's indicate the state's marine sport fisheries are growing at a significant rate. Out-of-state participation is apparently an important aspect of this growth. As indicated by the number of licenses recently issued, South Carolina's gig and gill net fisheries are also growing at a remarkable rate. Socio-economic data concerning South Carolina's recreational fisheries for coastal finfish is extremely limited.

Current laws, regulations and management policies pertaining to South Carolina's coastal finfisheries are addressed in the third section of this segment. The South Carolina Wildlife and Marine Resources Department has a commitment towards the protection of estuarine nursery grounds. However, further policies dealing with finfish management are not well-defined. Coastal finfisheries laws make little distinction between commercial and recreational interests.

The fourth section of this segment reviews current research and monitoring programs for coastal finfish in South Carolina. Readily apparent is the lack of ongoing research directly concerned with spotted seatrout, red drum and paralichthid flounders.

The final section presents a list of actual and potential problems relevant to coastal finfish resources and their fisheries. An awareness of these problems is essential to the development of fishery management plans.

7.2 Recommendations in Order of Priority

7.2.1 High Priority

7.2.1.1 That a state-wide survey of all South Carolina marine sportfishing activities be conducted.

7.2.1.2 That general life history, population dynamics, tagging, seasonality and availability studies for spotted seatrout, red drum and paralichthid flounders be initiated.

7.2.1.3 That a continuing catch/effort statistics program for coastal marine recreational finfishes be initiated.

7.2.2 <u>Medium Priority</u>

7.2.2.1 That licensing policies for gill nets, haul seines, stop nets and gigs be reviewed and reorganized to allow managers to better assess participation levels in these recreational and commercial activities.

7.2.2.2 That investigations be initiated concerning the effects of natural and man-made perturbations on juvenile and adult specimens of spotted seatrout, red drum and paralichthid flounders.

7.2.2.3 That access to South Carolina's coastal waterways be improved. Current needs include improvement of boat-launching ramp facilities, additional catwalks adjoining state highway bridges and improved access to break-waters, jetties and beach areas.

7.2.2.4 That assessment investigations be initiated concerning species catch and size composition in the various coastal commercial harvesting activities.

7.2.2.5 That a more accurate system be evolved for reporting commercial landings of coastal finfish in South Carolina.

7.2.3 Low Priority

7.2.3.1 That the market structure for coastal finfish in South Carolina and the potential for expansion of local coastal finfish production be investigated.

7.2.3.2 That licensing statistics be computerized for easy access.

7.2.3.3 That objective articles in the news media be encouraged concerning the pros and cons of a state-wide saltwater fishing license.

7.2.3.4 That pilot mariculture studies for red drum be conducted by the Marine Resources Research Institute.

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Appendix Figure. 1. Swimfish license postal card questionnaire.

Bulk Rate
U.S. Postage
PAID
Charleston, S.C.
29412
Permit No. 142

South Carolina Wildlife and
Marine Resources Department
P. O. Box 12559
Charleston, South Carolina 29412

SOUTH CAROLINA SWIMFISH LICENSE SURVEY

1. What is your residence? ____________________ County__________State.
2. Did you sell finfish during 1978? ________Yes ________No.
   a. Estimate the total pounds of finfish you SOLD during 1978, ________lbs. and the pounds of spottail bass______; winter trout______; flounder______; bluefish______; spot______; mullet______; other________.
   b. Give percentage of total pounds of finfish SOLD during 1978 to (1) local wholesale fish markets________ (2) local retail fish markets ________ (3) local restaurants________ (4) local individuals________ (5) you shipped out-of-state________.
   c. What percentage of the total pounds of fish SOLD by you were caught by you or your employees________%.
   d. What percentage of the fish caught by you were taken by (1) gill netting______ (2) seining______ (3) fish traps______ (4) gigging______ (5) hook & line______ (7) other______.
3. Did you BUY finfish caught in South Carolina during 1978 for resale? ______Yes ______No.
   a. Estimate the total pounds of finfish which you BOUGHT during 1978 for RESALE ______ lbs. and the pounds of spottail bass______; winter trout______; flounder______; bluefish ______; spot______; mullet______; other______.
   b. Of the total pounds of fish you bought for resale during 1978 estimate the percentage caught by (1) gill netting______ (2) seining______ (3) fish traps______ (4) gigging______ (5) hook & line______ (6) other______.
4. How many previous years have you purchased a S. C. swimfish license? ______years.
5. Did you or do you plan to purchase a swimfish license next year? Yes______ No______.

Appendix Figure 2. Gig license postal card questionnaire.

Bulk Rate
U.S. Postage
P A I D
Charleston, S.C.
29412
Permit No. 142

South Carolina Wildlife and
Marine Resources Department
P. O. Box 12559
Charleston, South Carolina 29412

SOUTH CAROLINA FINFISH GIGGING (GRAINING) SURVEY

1. Did you go gigging (graining) for finfish during 1978? Yes_____ No_____
2. What is your residence__________________County_______State
3. What is the approximate number of times you went gigging during 1978 in Horry______ Groegetown______ Charleston______ Colleton______ Beaufort______ Jasper______ counties.
4. In what water body (creek, river, bay or ocean) did most of your gigging occur? ______________ located in __________________(county).
5. Estimate the total pounds of fish gigged during 1978, _______ lbs. and the pounds of spottail bass_____; winter trout_____; flounder_____; mullet_____; other_____.
6. Check months that you went gigging: (J) (F) (M) (A) (M) (J) (J) (A) (S) (O) (N) (D) in 1978.
7. Did you sell any portion of your catch? Give percentage sold______%.
8. How many previous years have you purchased a gigging license? ______years.
9. Did you or do you plan to purchase a gigging license next year? Yes_____ No_____.

Appendix Figure 3. Gill net license postal card questionnaire.

Bulk Rate U.S. Postage PAID Charleston, S.C. 29412 Permit No. 142

South Carolina Wildlife and
Marine Resources Department
P. O. Box 12559
Charleston, South Carolina 29412

SOUTH CAROLINA GILL NET SURVEY

1. Did you set your gill net during 1978? Yes________ No________
2. What is your residence ________________County ______________State
3. What is the total length ________ yds. and stretch mesh ________ inches, of gill net fished during 1978.
4. What is the approximate number of days you set your gill net during 1978? ______________days.
5. In what water body (creek, river or bay) did most of your fishing occur? ________________________ located in ________________________ (county).
6. Estimate the total pounds of fish caught during 1978, ______ lbs. and the pounds of spottail bass ______; winter trout ______; flounder ______; spot ______; mullet ______; blue fish ______; other ______.
7. Check months that you fished your net(s): (J) (F) (M) (A) (M) (J) (J) (A) (S) (O) (N) (D).
8. Did you sell any portion of your catch? Give percentage sold ________%.
9. How many previous years have you purchased a gill net license? ______ years.
10. Did you or do you plan to purchase a gill net license next year? Yes________ No________.

SECTION III

BLUE CRAB

MANAGEMENT PLANNING PROFILE

FOR THE

SOUTH CAROLINA BLUE CRAB FISHERY

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and

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Division of Marine Resources
South Carolina Wildlife and Marine Resources Department
Charleston, South Carolina
October, 1979

I. INTRODUCTION

South Carolina's commercial fisheries have undergone major changes in the past 50 years with shrimp trawling replacing oyster harvesting as the major fishery. In addition, the fishery for blue crab has become second only to shrimp in terms of total dollar value. This comparison is deceiving because many of the crabs landed are processed in South Carolina for various markets throughout the United States; consequently, the harvesting sector supports an economically important processing sector. In comparison, only a small percent of the shrimp landed in South Carolina are processed. In addition, recent interest in soft shell crabs may expand into another fishery of commercial significance in South Carolina.

Although the economic impact of recreational crab harvesting is unknown, it is a very popular pastime in coastal South Carolina, as evidenced by the numbers of people who engage in this activity during the summer months. The popularity of recreational crabbing results from its simplicity, in that it involves little skill, inexpensive equipment and cooperative quarry. In addition, crabs are excellent table fare. Their capture is exciting to young and old, and crabbing is a sport which has been and will be enjoyed by the entire family.

This profile presents a synopsis of existing information on the biology of the blue crab and its fishery in South Carolina. Recommendations related to future needs for blue crab resources and management are included.

2. DESCRIPTION OF THE BLUE CRAB RESOURCE

2.1. Life History

The life history of the blue crab involves a relatively complex cycle of planktonic, nektonic and benthic stages which occur throughout the estuarine-nearshore marine environments. Female crabs mate only once, just after their terminal molt while their exoskeleton is soft, and fertilization usually occurs in low or moderate salinities (Van Engel 1958; William 1965). The spawning season may span eight months, from March to October, with peaks in March-April and July-August (Adkins 1972, More 1969, Palmer 1974, Van Engel 1958). Crabs which mated the previous fall and migrated to the ocean in spring to spawn probably account for the initial run of gravid females. Spent females re-enter the estuary and develop a second egg mass which hatches in summer. The second peak of sponge crabs may be reinforced by females which mated that spring and migrated to the lower estuary during the summer (Rees 1963). A third group of sponge crabs reported from the St. Johns River, Florida, probably mated during the summer and spawned the following fall (Rees 1963). Although a third spawning peak has not been reported for South Carolina, it may occur. One sponge crab was captured in the North Edisto River in October 1974, and sampling outside waters during the fall may reveal the presence of a third, but reduced, spawning peak. September catches of sponge crabs accounted for nearly 4% of the total catch in a three year study in Georgia (Palmer 1974).

As many as two million eggs may be excluded during a single spawn. Eggs maintained in 26-29°C hatch into zoeal larvae in approximately two weeks (Churchill 1921). Typically, there are seven zoeal larval stages with the last molting into a megalops (Costlow et al., 1959). Laboratory experiments show that, depending on salinity and temperature, these larval stages require four to seven weeks for development to megalops stage. Salinities <20.1 or >30.1 ‰ hindered development, and temperatures <20° or >30°C resulted in death to various larval stages (Costlow and Brookhout 1959). The megalops stage molts into the first crab stage, which resembles the adult in appearance. The first crab stage continues to grow and requires an estimated 18-20 molts to reach maturity (Van Engel 1958).

2.2. Food Habits

Although blue crabs frequently are considered to be scavengers, they typically consume a variety of foods. Commonly ingested items range from detritus to live plants and animals. That crabs are attracted to and consume dead flesh is substantiated by the success of the crab pot used in the commercial fishery; however, they prefer fresh flesh to putrid (Truitt 1939). The predatory nature of crabs in their natural habitat has become more widely recognized with studies of their feeding behavior and food consumption. In Lake Pontchartrain, Louisiana, juvenile crabs consumed roughly equal percentages, approximately 30%, of crustaceans (including blue crabs and barnacles) and mollusks, whereas adult crabs consumed two to six times more mollusks than crustaceans (Darnell 1958). Most frequently identified food items of crab from the St. Johns River, Florida, in descending order of abundance, were mollusks crustacean organic debris, and fish (Tagatz 1968). Herrnkind (1968) reported _C. sapidus_ leaving the water to prey on fiddler crabs, and Hamilton (1976) found that juvenile crabs commonly fed on the marsh periwinkle (_Littorina irrorata_) in the _Spartina_ marsh at high tide. Other items reported from crab stomachs include vegetation (Zostera, Ruppia, Ulva, and Spartina), bryonzoans, insects, annelids, and sand (Darnell 1958; Tagatz, 1968; Truitt 1939). Darnell (1958) concluded that the blue crab was a detritivore, bottom predator, and general scavenger and that "any less complete designation would seem inadequate."

2.3. Age and Growth Characteristics

Growth is rapid, and crabs may reach maturity in 1-1.5 years depending on time of year hatched. Crabs hatched in early spring may be 60 mm (2.5 inches) by late fall and reach legal size (5 inches) by August the following year. Crabs hatched in late summer or fall, however, may not reach maturity until their second spring. Upon reaching maturity, crabs may live at least one more year with maximum age estimated at 3.5 years (Van Engel 1958).

Crabs increase in size by periodically shedding their rigid exoskeleton, a process known as molting or ecdysis. Prior to each molt, a new pliable exoskeleton is formed beneath the old, and mineral salts from the hard shell are resorbed into the blood to be deposited on the new exoskeleton. After each molt the new shell expands to 25-35% greater than the previous width. Expansion is believed to be accomplished by hydrostatic pressure, and increased osmotic differences between internal and external media are throught to result in larger increases at each molt (Van Engel 1958).

During the growing season, molt frequency is associated with size. Crabs approximately 5 mm (0.2 inches) wide molt every 3-5 days, while those 10-25 mm (0.4-1 inch) molt every 10-15 days. For crabs > 100 mm (4 inches), 20-50 days may elapse between consecutive molts (Churchill 1921, Van Engel 1958). Growth is associated with the warmer seasons and

and is usually confined to the months March through October in South Carolina. Female crabs do not molt after reaching maturity.

Growth rates specifically for South Carolina are wanting, but Bishop, et.al., (1979), estimated from width-frequency distributions that crabs $<$ 80 mm total width may grow 14-25 mm per month depending on initial size and water temperatures. Estimating growth rates from monthly width-frequency distributions is not accurate because prolonged recruitment, mixed year classes, habitat preferences for particular size crabs, and crab movements in estuaries complicate repetitive sampling of the same population, i.e., crabs of uniform age. Field studies of crabs in other states encountered similar difficulties in obtaining growth rates. In Texas, More (1969) estimated that growth ranged from 14-16 mm per month for five to eight months depending on time of year. Tagatz (1968) stated that first-crab stage crabs (2-3 mm wide) require about one year to grow to "full size" in the St. Johns River, Florida. If full size represents commercial size ($\geq$ 120mm), then a minimum mean monthly increase of 10 mm is obtained. This rate does not take into account months of reduced water temperature and; consequently, months in which little or no growth occurred. Darnell (1959) and Adkins (1972) estimated that crabs in southeast Louisiana grew 14-20 mm per month, but just east of the Louisiana coast in Mississippi Sound, Perry (1975) reported growth rates of 24-25 mm per month.

2.4. Adult Size and Distribution

Adult crabs in low salinity waters are reported to be larger than those taken from more oceanic salinities (More 1969; Van Engel 1958; Williams 1965). This size-salinity relationship is thought to result from greater osmotic uptake of water after molting, but several studies have not shown that molting in reduced salinity results in greater expansion (Haefner 1963; Haefner and Shuster, 1964; Tagatz 1969). In fact, Tagatz (1969) found increases in size after ecdysis to be greater for crabs maintained in 6.9-25.8 o/oo S compared to crabs maintained in 1 o/oo S. Darnell (1959) failed to observe this salinity-size relationship in Lake Pontchartrain, Louisiana, but the fact remains that adult crabs taken from low salinity waters are frequently the larger in a particular estuarine system.

Reasons for the size differential between low and high salinities have not been shown to be related to any one variable, but osmoregulation is thought to be important. That is, crabs which exuviate in low salinities take up more water at the time of ecdysis and; consequently, their size increase is greater than that of crabs which exuviate in high salinities (Van Engel 1958; Williams 1965). Circumstantial evidence for this is provided by Fischler (1959), who reported 52.3-55.0 mm width ovigerous females from high salinities in North Carolina. Williams (1965) suggested that this exceptionally small size may result from a life in high salinities.

Ability to osmoregulate had been found to differ between sexes in laboratory experiments. Tan and Van Engel (1966) and Ballad and Abbott (1969) found that adult males could osmoregulate better than females in reduced salinities, but Ballad and Abbott (1969) suggested that distribution of sexes in relation to salinity may be behavioral rather than physiological.

Although osmotic differences between external and internal media may be partly responsible, other biological aspects are probably important. Male crabs do not have a terminal molt stage upon reaching maturity as do females, and one molt may result in a 25-33% width increase (Churchill 1921; Gray and Newcombe 1939; Van Engel 1958). This, coupled with the fact that adult male crabs generally remain in low salinity waters may tend to increase the size of crabs if osmotic pressure differences can influence shell expansion after ecdysis. Large male crabs may be able to more successfully compete for pre-terminal molt females, resulting in displacement of smaller mature males to areas where competition is reduced, i.e., more saline waters. Aggressive behavior and competition may be the reason that Tagatz (1968) found no mating male crab $<$120 mm wide in the St. Johns River, Florida. Size of adult males and competitive dominance for pre-terminal molt females has not been investigated.

Bishop et al. (1979) did not obtain conclusive evidence of salinity effects on sex or size of adult crabs with a two-year trawl study in South Carolina estuaries. They found crabs to be larger in estuaries with substantial freshwater input, but that within these estuaries, size of crabs captured in low and high salinities did not differ. Also, they reported that adult female crabs did comprise the majority in high salinities, but did not observe a predominance of adult males in low salinities (Bishop et al. 1979).

2.5. Population Dynamics

Very little if known about blue crab population dynamics. Fischler (1965) reported that in 1958, 80% of the 2.1 million pounds of commercially available crabs in Neuse River, North Carolina, were harvested. Van Engel (1978) believes that annual fluctuations in blue crab abundance are associated with climatic factors which influence distribution, larval and juvenile growth and general survival. Recent interpretations by Rhodes et al. (1977) and Robert Mahood (pers. comm.) suggest there may be cyclic changes in annual blue crab abundance.

It is generally assumed the annual abundance of blue crabs available to present harvesting technology is independent of the previous year's level of fishing effort, and there is no clearly defined relationship between the abundance of parents and progeny. Consequently, parabolic logistic models (e.g. Schaefer 1954) which emphasize maximum sustainable yield (MSY) based soley upon instantaneous recruitment and a relatively constant level of recruitment for a given parental stock size have not seemed applicable to blue crab fishery management models. Although blue crab stocks may not fit these simple fisheries models, the lag effects of fishing effort on future recruitment and the associated dynamic equilibrium are not known. Environmental factors, especially climatic conditions, may not be the only major force affecting harvestable yield. At present, no research has clarified the impact of fishing effort on blue crab sustainable harvest yield.

2.6. Mass Mortalities

Crab populations occasionally experience mass mortalities. The most recent of note extended from North Carolina to Georgia in June 1966 and from South Carolina to Georgia in June 1967. Landings in June of both years were substantially less than those of the two previous years (Lunz 1967, 1968). A cooperative effort to determine whether disease, parasites, hydrology, or pesticides was responsible was undertaken by the affected states and Florida. Results of their investigations were inconclusive (see Section 2.5), but a pathogenic amoeba (Paramoeba pernicosa) may have been responsible (Mahood et al. 1970, Sprague and Beckett 1966). Other mortalities of crabs have been noted during extremely cold winters or sudden drops in temperature (Gunter and Hildebrand 1951, Van Engel, 1978), red tide outbreaks (Gunter 1942), freshets (Breuer 1962), oxygen depletion

(May 1973), and from apparent "old age" (Overstreet 1978).

2.7. Effects of Environmental Alterations

A number of studies have been performed which show that man-induced alterations are detrimental to crabs as well as other estuarine fauna. Activities related to water transportation, agriculture, silviculture, extractive industries, water utilization and discharge, urbanization, and recreation may act singly or in combination to degrade the estuarine environment. Reduced water flow into estuaries by stream diversion, dam construction, or agricultural withdrawal results in reduced productivity (Copeland 1966, Thompson 1957). Numbers of macroinvertebrates are low in dredged areas (Lindall et al. 1973, Lindall 1975, Mock 1967), and spoil areas resulting from dredging activities physically remove the disposal site from production. Dredged spoil from harbors or near industrial complexes may contain a variety of heavy metals or toxic organics, and exposing them to leaching processes results in the contamination of contiguous waters.

Agricultural practices can significantly decrease water quality in coastal areas and cause drastic adverse reactions. Land runoff from tilled areas carries fertilizers (nitrates and phosphates), herbicides, pesticides, and silt. Nitrates and phosphates may not be toxic directly, but high concentrations encourage algal blooms which lead to eutrophication and possibly oxygen depletion. DDT applied at concentrations of 0.8 lb/acre resulted in high mortalities of crabs, and deaths continued for about two weeks after application (Springer and Webster 1951). This was in spite of semi-diurnal tidal flushing. Other studies have shown DDT, Toxaphene, and Mirex in concentrations of parts per million (ppm) to be more toxic at reduced salinities and temperature extremes (Bridges et al. 1963, Mahood et al. 1970, and

McKenzie 1970). Mirex at concentrations of 36 ppm was found to be 100% lethal to juvenile crabs after 192 hr exposure at 20°C and 22 o/oo S (Mahood et al. 1970).

Since 1972, mortalities of crabs, other invertebrates and fishes have resulted from the careless and accidental aerial application of pesticides (methyl parathion, toxaphene, endosulfan) on crop fields adjacent to coastal marshes in S.C. The pesticides are either sprayed directly on marsh lands or enter from land drainage following heavy rains.

Water utilization and discharge practices result in heterogeneous patches of chemicals, eutrophication, oxygen depletion, turbidity, and other conditions pernicious to crab life. Increasing levels of water pollution in estuarine waters not only degrade the suitability of the habitat and kill marine life directly, but also produce abnormalities. Such abnormalities include reduction in weight, external lesions, behavioral changes, morphological peculiarities, and reduced fecundity (Sinderman 1970). Therefore, regardless of the success of crab spawning and larval immigration to estuarine waters, estuaries with acceptable water quality are important for continued production of desirable blue crab stocks for recreational and commercial fishermen alike.

2.8. Crab Diseases and Parasites

Crabs are subject to attack by a number of diseases and parasites. Eggs of blue crabs may be attacked by the fungus <u>Lagenidium callinectes</u> (Couch 1942 , Newcombe and Rodgers 1947, Rogers-Talbert 1948, Sandoz et al. 1944, Sandoz and Rodgers 1944). Studies in Chesapeake Bay revealed that as many as 90% of the ovigerous female crabs may be infected and 25% of their eggs diseased. A nemertean parasite (Carcinore mertescarcinophila) also attacks crab eggs. This ribbonworm usually lives near the crab's gill lamellae but inhabits the crab sponge during a development period. Presence of yellow colored worms is indicative of the host spawning at least once(Humes 1942, Hopkins 1947).

Microsporidian protozoan infestation is a common debilitating disease of crabs, and those heavily infected are easily recognized by abnormal behavior and opaque colored muscle tissue (Overstreet 1978).

One of the more commonly encountered crab parasites is the digenean fluke Microphallus basodactylophallus. Blue crabs are an intermediate host for their larvae, which encyst in the musculature. For all practical purposes, this parasite is too small to be noticed, but may itself serve as a host for a dark colored urosporidan protozoan, in which case it becomes relatively visible to the discerning consumer (Overstreet 1978). Vernacular terminology for such crabs include pepper or buckshot crabs and is descriptive of the blackish spheres located within cooked crabmeat.

Common symbionts or antibionts include a number of barnacles and the leech Myzobdella lugubris which lays its eggs on the crab carapace. Overstreet (1978) and Sinderman (1970) summarized and reviewed the literature relevant to crab disease and parasites.

2.9. Zoonotic Diseases

The bacterium Vibrio parahaemolyticus readily kills crabs and is associated with intestinal disorders of humans, presumably from eating improperly handled seafood. Another bacterium which recently focused attention on zoonosis via crabs is Vibrio cholerae. This bacterium causes cholera in humans, but normal preparation renders carrier crabs safe for consumption. If cooked crabs are returned to the container in which they were transported alive, however, then "properly" prepared crabs may be responsible for transmitting the disease. This is apparently what happened in Louisiana in 1978, when several persons who had consumed home-cooked crabs were diagnosed as choleraic. Although severe cholera may cause death in as short a period as a few days, it can also be so mild that medical attention is unwarranted. The stigma associated with cholera as being a serious disease, however, is widespread, and its outbreak can result in the immediate collapse of the crabbing industry. Fortunately, the industry in Louisiana suffered only temporarily because of cooperation among industry, state, and federal authorities and the media (Greer 1979).

2.10. Current Stock Status

No widespread blue crab mass mortalities have been reported in South Carolina since 1967. Unlike the white shrimp (Penaeus setiferus), blue crab stocks have apparently not been severely affected by the relatively low winter temperatures in South Carolina. The 1977 and 1978 blue crab landings (in pounds) were 7% and 37% respectively higher than the previous 10-year average (1968-77), despite the low water temperatures during the 1976-77 and 1977-78 winters.

3. DESCRIPTION OF THE BLUE CRAB FISHERY - RECREATIONAL AND COMMERCIAL

3.1. Commercial Harvesting

3.1.1. Present Commercial Gear and Techniques

Probably more methods have been developed to harvest crabs than and other single marine species (Wharton 1949). Currently, only two two major methods are employed by the commercial fishermen to harvest crabs in South Carolina. These include the crab pot, patented by Lewis in 1937, and the otter trawl. Both techniques are selective for a particular segment of the crab population and, to a large extent, employed during different seasons.

Pots constructed in South Carolina are made of heavy galvanized or plastic coated wire "net" (similar to chicken wire) and are the basic design of Lewis' patented trap, but several inches shorter in height (Rhodes 1974). The reduced height is an adaptation to higher current velocities and tidal ranges in South Carolina compared to those in Chesapeake Bay where the pot was originally designed.

Fishing techniques are similar to those described by Van Engel (1962). Pots are generally set in a continuous line parallel to shore in subtidal waters usually no more than 25 feet deep. Distances between pots may vary 30-60 yards depending upon location and operator. South Carolina crabbers may fish as many as 120 pots, but 50-75 are more common. Non-resident crabbers (usually from Virginia) fish as many as 200 or more (M. M. Morris, pers. comm.). Pots are baited and checked daily, usually in the morning. When crab catches are good, lines may be run twice daily (Rhodes 1974). Bait usually consists of frozen whole menhaden or herring. The number of pots and months spent fishing for crabs, and boat characteristics have been described for South Carolina (Rhodes 1974) (Table 1). The quantity of pots used by individual crab fishermen may have increased in recent years due to relative high prices received for male crabs.

Catches of legal crabs per pot may range from three to seven pounds daily from February through September (Rhodes 1974), with the larger catches occurring in May - October. Legal crabs in South Carolina are all those five inches or larger (total width of the carapace) and in the case of females, non-ovigerous (Bearden 1978). Culling ovigerous female crabs from the catch requires considerable time at certain seasons and may be of no consequence to future generations of crabs;that is,no relationship has been established between the number of spawners and abundance of the next generation of harvestable crabs (see Section 2.5).

When catches are good, experienced fishermen sort their legal catch according to size, sex, and condition. These criteria are based on meat yield with male crabs weighing more and consequently yielding more meat than females of equal width (Newcombe et al 1949, Pullen and Trent 1970, Tagatz 1965). Also, newly molted crabs are "empty" and easily recognized by the clean white appearance of their ventral surface; they are vernacularly referred to as "white bellies" and are periodically captured in large quantities (pers. comm. with crabber). Prime crabs (No. 1's) i.e., those commanding top prices in South Carolina consist of males $\geq 5\frac{1}{2}$" total width which are not white bellies. Seconds (No. 2's) consist of all legal females, all white bellies, and legal males $<5\frac{1}{2}$" total width (M.M. Morris, pers. comm.). When catches are low, ungraded legal crabs may be sold at intermediate prices. A basket of No. 1's may bring twice as much to the crabber as No. 2's (M.M. Morris, pers. comm.).

Commercial harvesting of blue crabs is primarily confined to creeks, rivers, bays and sounds and may extend inland for distances greater than 10 miles depending on the estuarine system. Certain areas or rivers within the state are closed to crab pots (Bearden 1978). In South Carolina, the major tendency is to fish pots in rivers, creeks, and small bays generally away from major concentrations of mature female crabs. Consequently, Eldridge and Waltz (1977) observed that pot landings averaged about 72% male and 24% mature female crabs.

Table 1. The mean ($\overline{X}$), mode, and range for modified Lewis, blue crab traps (pots), months spent fishing per year, boat horsepower, and boat length for South Carolina commercial crab fishermen replying to a post card survey during the fall of 1973 (Rhodes, 1974).

	National Marine Fisheries Service Districts		
Variables	Central	Southern	Both
Number of Traps	(11)[a]	(10)	(21)
$\overline{X}$	59	59	59
Mode	21-40	61-80	61-80
Range	30-100	12-100	12-100
Months Fished	(11)	(10)	(21)
$\overline{X}$	8	9	9
Mode	5-8	5-8	5-8
Range	5-12	6-12	5-12
Horsepower	(10)	(10)	(20)
$\overline{X}$	38	47	43
Mode	1-50	1-50	1-50
Range	18-140[b]	20-125	18-140
Boat Length, ft.	(10)	(10)	(21)
$\overline{X}$	18	17	18
Mode	16-19	16-19	16-19
Range	14-23	15-21	14-23

a Number of observations

b This was a diesel powered fishing craft.

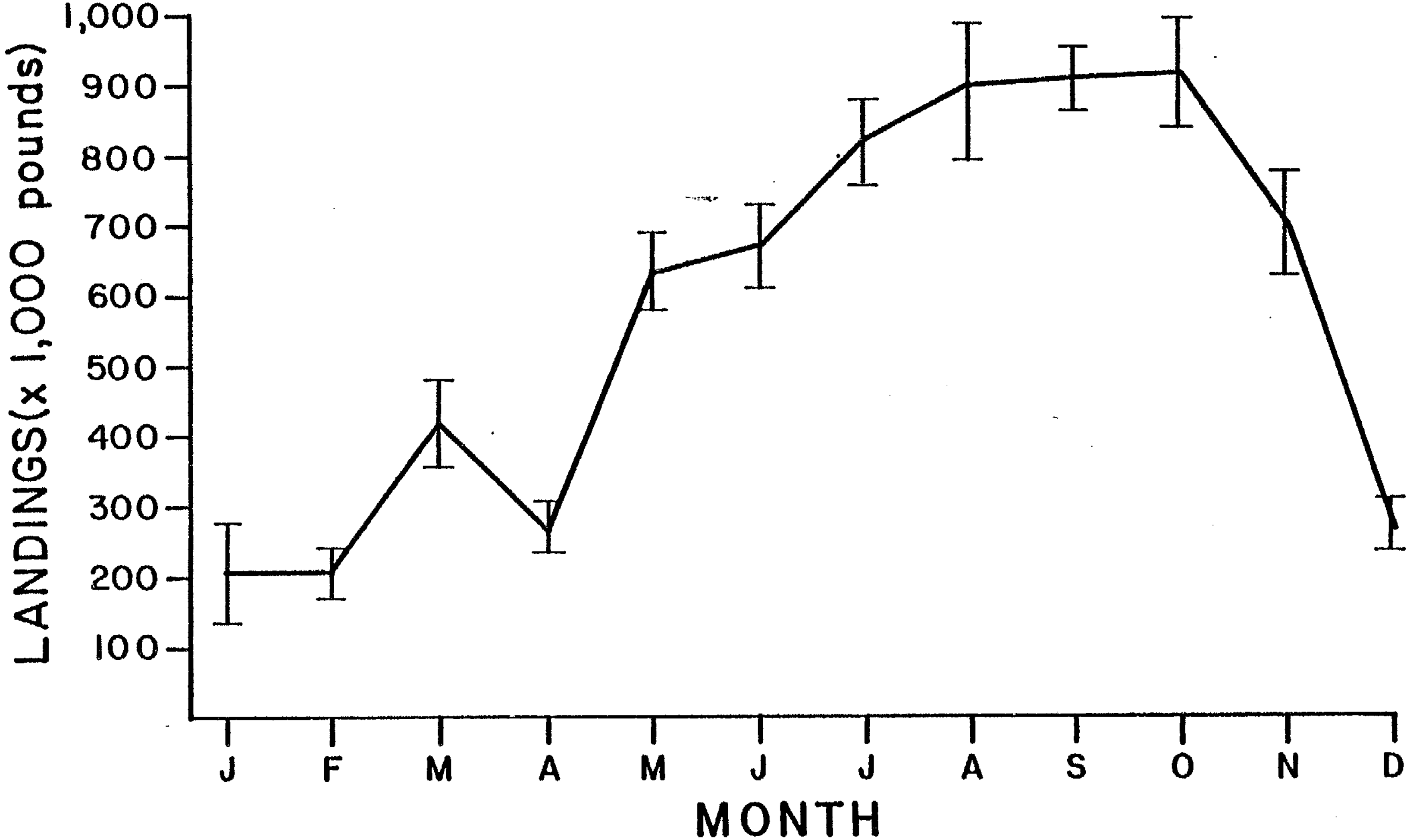

Fig. 1. Average monthly crab landings ($\pm$ 1 standard error) in South Carolina from 1968 through 1978.

3.1.2. Seasonal Trends

Landings by pot are reduced from December through February (Eldridge and Waltz 1977) because cold water temperatures reduce crab activity and food intake (Fig. 1). Landings generally increase in March through October when water temperatures are conducive to feeding and growth (Fig. 1).

Mature female crabs move to deeper, more saline waters in the fall and overwinter (Van Engel 1958). In South Carolina, a winter trawl fishery has developed to harvest these crabs, and catches are about 84% female. The gear and techniques for crab trawling have been described by Cummins and Rivers (1962). The greatest trawl activity is located in the sounds of Port Royal and St. Helena in the southern part of the state, and the typical gear is a 50' two seam otter trawl with 4" mesh (L. Porcher and S.R. Hopkins, pers. comm.). Trawling activity is primarily restricted (see Bearden 1978) from December through March and accounts for an estimated 12% of the annual landings (Eldridge and Waltz 1977). When water temperatures begin to rise and crab pot catches increase, picking houses will refuse to purchase trawled crabs because of high sand content and relatively lower yields of female crabs.

During the last 10 years (1968-77), blue crabs prices have usually attained their highest levels during the spring months (Table 2). This seasonal pattern seems to be associated with the decline in processor inventories, the low catches in the Middle Atlantic states, and South Carolina regulations. South Carolina's blue crab catches begin to increase as the water warms in March and April. The market demand for crabs becomes seasonally high due to reduced live crab supplies in Middle Atlantic states for retail outlets and the desire by South Carolina processors to increase their inventories. Consequently, this market interaction of processors

Table 2. Summary of monthly ex-vessel price and total value trends, for blue crabs in South Carolina, 1968-77, as reported by the N.M.F.S., U.S. Department of Commerce.

MONTH		MEAN	MAXIMUM	MINIMUM
Jan.	Price*	$.122	$.212	$.052
	Value**	(27)	(91)	(3)
Feb.	Price	.121	.200	.060
	Value	(27)	(69)	(1)
March	Price	.139	.286	.066
	Value	(47)	(90)	(11)
April	Price	.145	.308	.070
	Value	(41)	(85)	(13)
May	Price	.141	.320	.077
	Value	(94)	(251)	(28)
June	Price	.128	.241	.070
	Value	(87)	(165)	(13)
July	Price	.112	.197	.060
	Value	(89)	(166)	(20)
August	Price	.108	.182	.061
	Value	(93)	(202)	(3)
Sept.	Price	.112	.186	.062
	Value	(99)	(174)	(47)
Oct.	Price	.113	.183	.061
	Value	(111)	(218)	(53)
Nov.	Price	.120	.199	.070
	Value	(80)	(191)	(33)
Dec.	Price	.129	.205	.070
	Value	(34)	(60)	(9)

*Prices expressed in current dollars.

** Total or aggregate ex-vessel value in thousands of current dollars.

and basket crab buyers results in a seasonal "bidding-up" of ex-vessel prices.

Historically, this competition was partially intensified by state restrictions on the possession of sponge crabs, which constrained crab supplies for processors. In 1973, this problem was reduced by allowing the purchase of sponge crabs caught in other states (C.M. Bearden, pers. comm.).

The price usually begins to decline in June as South Carolina as Middle Atlantic crab catches increase. Usually by July, "basket" market prices (Table 3) have dropped, reflecting the increased supplies in Virginia and Maryland. By August, the lowest prices are recorded and processors may place limits on purchase and/or new accounts as their facilities reach capacity. Also, high shipping mortalities of blue crabs tend to depress basket market prices in the summer months.

With the decline in Virginia and Maryland landings, South Carolina catches then once again become a source for the "basket" markets. Consequently, ex-vessel prices begin to increase in November as competition between buyers intensifies,reaching a seasonal peak in the following spring months.

Seasonal trends in blue crab prices usually do not interact in a manner resulting in the highest catches occurring with maximum seasonal prices. As previously discussed, the peak of ex-vessel prices usually occurs before peak blue crab landings in the summer months or early fall. Apparently, the seasonal increase of blue crab supplies within the state and in other major producing states (i.e. Virginia and Maryland) tend to shift supplies toward lower prices. In essence, the net effect between seasonal catches and ex-vessel prices has been maximum aggregate ex-vessel values in the summer or early fall (Table 2). The minimum of aggregate

Table 3. Ex-vessel modal prices for #1 ("Jimmies"), #2, #3, and average monthly price for South Carolina commercial blue crab fishery during 1976-1978 (see text for grade description).

	YEAR											
	1976				1977				1978			
MONTH	#1	#2	#3	A*	#1	#2	#3	A	#1	#2	#3	A
May	$.43	.20	.20	.18	**	---	---	.32	---	---	---	.17
June	.42	.19	.19	.17	.38	.22	.19	.24	---	---	---	.21
July	.40	.18	.18	.16	---	---	---	.20	.45	.25	.17	.17
August	.30	.15	.13	.16	---	---	---	.18	.30	.20	---	.18
September	.32	.15	.13	.16	---	---	---	.19	.30	.20	.20	.18
October	---	---	---	.17	---	---	---	.18	.20	---	---	.21
November	.40	.18	.18	.20	.30	.20	.15	.19	.40	.20	---	.19
December	.55	.20	.20	.20	.33	.20	.15	.21	.40	---	---	.32

* Average monthly blue crab price computed from National Marine Fisheries Services South Carolina Landings, Annual Summary series.

**Data not available

ex-vessel value occurs during the winter months and seems to be caused by the seasonal decline in blue crab market demand and the low catches during the cold weather.

3.1.3. Harvesting Costs

The cost of harvesting blue crabs has risen steadily in recent years, with fuel costs constituting the most current increase. Gasoline as a percentage of total cost almost doubled between 1972(Rhodes 1974) and 1976 (Folsum 1976). In addition to fuel, the price and cost of storing bait has also increased, as well as that of boats and outboard motors.

In the last 12 years, wholesale cost of a roll of pot wire has risen from $12 to $30 and is steadily increasing. During this same period, cost of prefabricated "irons" which are attached to the bottom of the pot for anchorage has risen from $0.75 to $2.50 (J. W. Meek, pers. comm.). Ten pots can be constructed from a 150 ft. roll of wire, so wholesale cost of materials alone is approximately $6.00 for one pot. Labor for pot construction has basically remained the same for the last 10 years, and wholesale prices for pots range from $6.80 to about $12.00 depending on quality of construction and the individual maker.

Pot losses occur from storms, extreme high tides, theft, vandalism, and entanglement by other boats and can represent a considerable investment loss. Lost pots, commonly referred to as "ghost" pots, may also cost other crabbers because the pots cannot be recovered and continue to capture and kill crabs in the area (Whitaker and Farmer 1979).

3.2. Recreational Harvesting

The magnitude of crabs captured by recreational fishermen is unknown. No creel surveys of the recreational harvest have been attempted. Based upon purchases of crab pots for recreational use and other information, it is assumed that the magnitude of the recreational harvest would be no more than 2% of the average annual reported commercial catch (6.9 million pounds, 1968-77).

3.2.1. Harvesting Methods and Other Observations

Most recreational crabbing occurs from May through August, and the most productive periods are before and just after low tide. Usual equipment from shore, low bridges, or boats includes a long-handle dip net, one or more 12-25' strings to which a piece of weighted meat is tied for bait, and a container for holdling captured crabs The bait is fished on the bottom and checked periodically, the frequency contingent on the amount of crab activity and crabber patience. Crabs are generally adamant in their will to hold onto the bait and can be netted when the bait is carefully retrieved into dipping range. Chicken necks are among the most popular bait fished in this manner; consequently, a regional sobriquet for the weekend recreational crabber is "chicken necker".

Recreational fishing also includes fishing with standard commercial crab pots, various types of drop nets, and patented traps of metal of rigid plastic construction which open flat when fished on the bottom and enclose the catch when lifted. The latter are available in square and pyramid shapes. These methods of taking crabs are generally employed from bridges, piers and docks where the distance between the water surface and fisherman is greater than the handle length of a dip net. Legally, two commercial type crab traps are allowed per person without a crab license. This law is particularly attractive to those living on or near the water since checking the pots daily requires little effort.

Crabbing from bridges may interfere with traffic flow. Few bridges in the coastal area were constructed with the recreational fisherman in mind, and people frequently disobey no fishing signs posted at such bridges. Fortunately, some fishing catwalks have been added onto existing bridges near population centers, and this trend seems to be continuing in other areas.

Besides chicken necks, bait may include smoked herring, raw fish, or various scraps of meat. A common misconception among recreational crabbers is that crabs are entirely scavengers and relish putrid flesh. Crabs, in fact, are active predators (see Section 2.2) and fresh meat is preferred. Experienced commercial crabbers know that it is necessary to change bait daily to ensure good catches.

3.3. Historical Harvesting Trends

The gathering and reporting of landing data in the past was not conducted with the accuracy that it has since 1971 (D.L. Theiling, pers. comm.). Thus, data prior to 1971 are considered to be relatively rough estimates of the actual landings, but trends of recorded landings, employment, and gear used are believed to be indicative of gross changes in the State's commercial blue crab fishery.

3.3.1. Gear and Employment

Commercial capture of crabs in South Carolina has involved three primary methods (Fig. 2). Prior to 1950, baited trotlines were used almost exclusively. In 1939, a few crabs were caught by otter trawl (Fishery Statistics of the U.S., 1939), and in the early 1950's, crab pots were introduced from Chesapeake Bay (Green 1952). Until the early 1960's, however, the large majority of the landings was taken by trotline. Today, virtually the entire commercial catch is landed by pot except for a minor trawl fishery

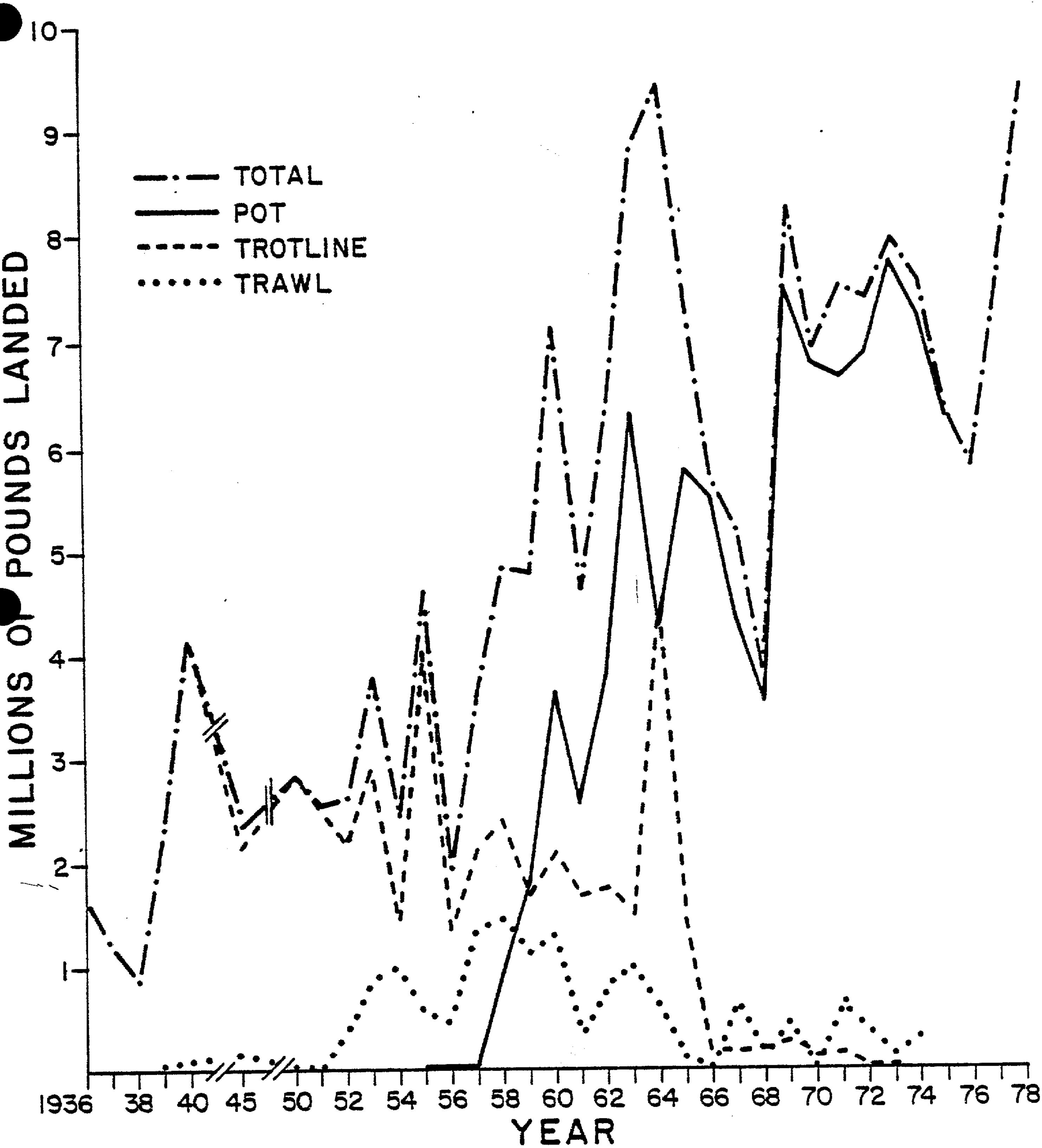

Fig. 2. South Carolina blue crab landings by gear. Data from Fishing Statistics of the U. S., NMFS, and Office of Conservation and Management, S. C. Wildlife and Marine Resources Department.

which operates during winter months. During 1970's, escalating use of crab pots has continued. From July 1978 through June 1979, 504 licenses were issued to crabbers, an increase of 240 in just four years (K.H.Howell, pers.comm.). Although this represents a 91% increase since 1974, comparative landings increased only 25% (about 2 million pounds).

The initial report of fishermen using pots commercially occurred in 1957. The numbers of fishermen using pots increased annually to 231 in 1965. From 1965 through 1968, numbers of pot fishermen decreased to 124; this decrease followed closely the decline in commercial landings and observed blue crab dieoffs (see Section 2.6). So successful was the gear that virtually all landings in South Carolina have been captured by pots since 1966 (Fig. 2).

Fishermen involved in crabbing have fluctuated in number and gear used has varied over the years (Fig. 3). An all time high of 532 fishermen were employed in commercial crabbing in 1945. Reasons for this high involvement are unknown, but because of World War II, gasoline was rationed and possibly many of those unable to take part in the war effort found crabbing an attractive method of employment. Following the war years, fishermen used trotlines extensively from 1956 to 1962; since 1966, however, trotline crabbers have not numbered more than eight during any single year.

Popularity of trawling for crabs peaked in 1953 and has decline since. In the winter of 1978-1979, as few as four trawlers were actively landing crabs (D.L. Theiling, pers. comm.). There is a tendency, however, for more tralwers to enter the winter fishery after poor shrimp years (S.R.Hopkins, pers. comm.).

3.3.2. Hard Crab Catch Trends

Crab landings fluctuate widely from year to year (Fig.2) and are generally regarded as representing blue crab abundance. Abundance

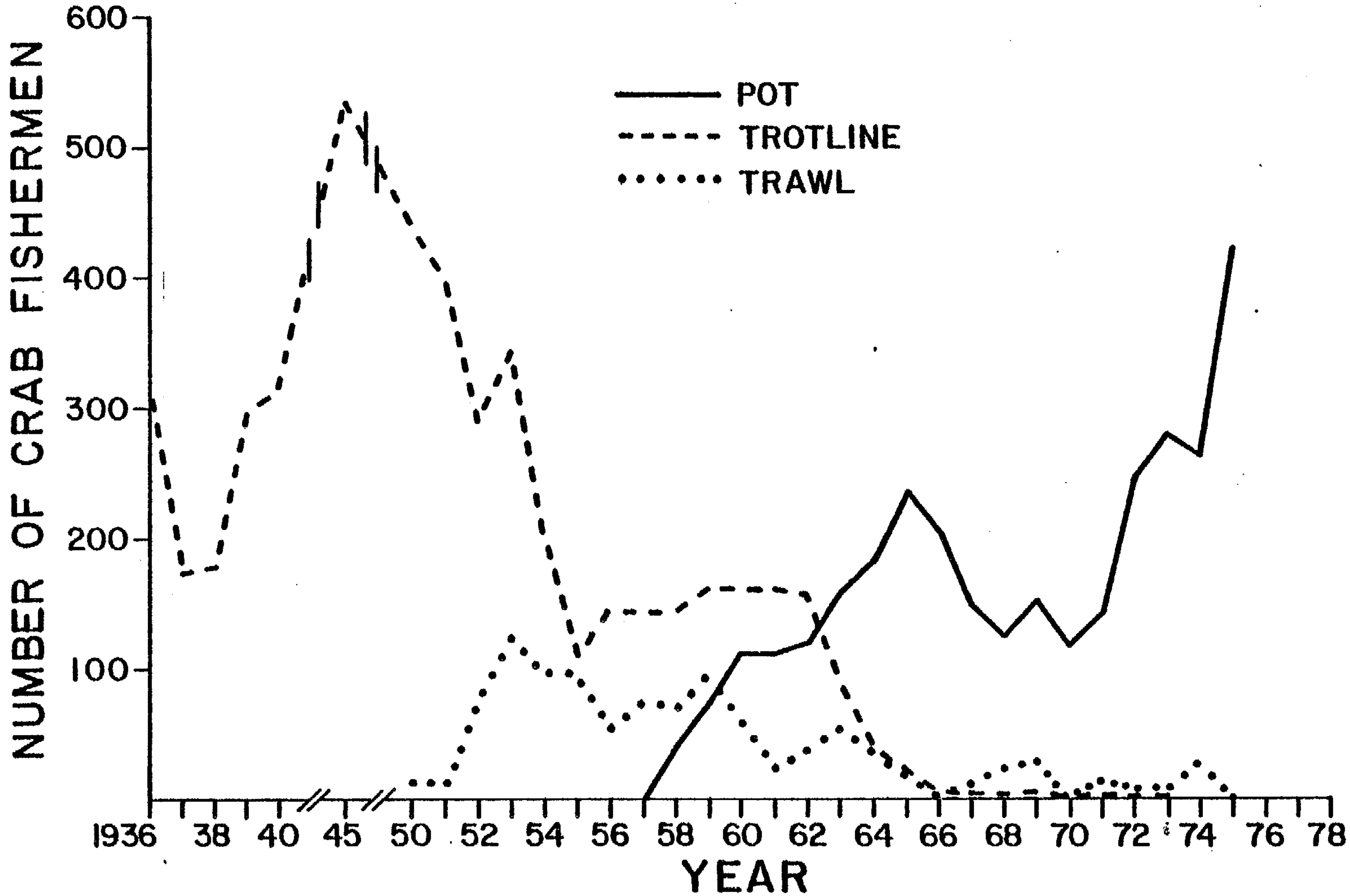

Fig. 3. Annual number of blue crab fishermen in South Carolina. Data from Fishing Statistics of the U. S., NMFS, and Office of Conservation and Management, S. C. Wildlife and Marine Resources Department.

of crabs, however, may not fluctuate as widely as landings indicate because of the nature of the fishery and the methods employed in gathering reported statistics. In years of high crab supplies in the Middle Atlantic states and other regions, the price of crabs may decrease so that aggregate fishery effort is reduced and the total S.C. catch may not be indicative of actual crab population size. On the other hand, in years of relatively low crab supplies, the market demand may increase such that aggregate fishery effort is high and comparatively more crabs are landed in South Carolina.

Prior to 1960, annual crab landings did not exceed five million pounds. Since 1960, however, annual landings have not been less than five million pounds except in 1961 and 1968 (Fig. 2). The relative high landings reported in 1960 were attributed to strong crab prices by Chesapeake Bay wholesalers, which resulted in the closing of a processing plant in South Carolina (Low 1960). Apparently, the establishment of a higher minimum wage in September, 1961, also reduced processing capabilities (Power 1963). The poor white shrimp season in 1963 and 1964 stimulated trawling effort for crabs, and many trawl crabs were shipped to Georgia (Low 1963 and 1964). In 1963, crabs were shipped to the Chesapeake Bay area due to a decline in landings in that area (Lyles 1965). After 1965, there was a general return to shrimping and a poor crab meat yield for South Carolina crabs (Lyles 1967).

In 1966, there were record Chesapeake Bay landings, and this apparently depressed the prices in South Carolina. Due to the concern for the lower percentage of males in crab catches and the associated poor meat yields, there was also a prohibition on crab trawling in South Carolina during the 1966 spring (Low 1966). The poor 1968 catch was considered a result of unexplained blue crab dieoffs (Lunz 1967; Mahood et al. 1970) and was experienced in neighboring states. Plants began to reduce processing efforts, and in 1968, two plants closed in South Carolina (Low 1968).

With the decline in crab landings, ex-vessel prices (Table 4) began to reflect the increased demand by state processors. The landings began to increase in 1969 and 1970, reaching normal levels during the early 1970's. South Carolina crab landings again declined in 1975 and 1976, supporting a cyclic fluctuation hypothesis (Rhodes et al. 1977). Apparently, landings returned to an upswing period in 1977 and 1978 with over nine million pounds of blue crab being reported in 1978 (Table 4).

3.3.3. Catch and Effort Indices

Aggregate catch data for a given year were divided by various annual operating unit data to obtain crude indices of annual catch-effort trends (Fig. 4). The trotline catch data for 1964 and 1965 are so inconsistent with those reported for other years that their accuracy is suspect. Recorded pounds of crabs landed in 1964 via trotline and the number of trotline fishermen were 4.4 million and 40, respectively; thus each fisherman's catch-effort index averaged over 110,000 pounds. This and the following year's average trotline fisherman's index of ca. 70,000 pounds are substantially higher than other averages and probably result from incorrect reporting. This conclusion is supported by the general decrease in trotline fishermen prior to and after 1964 (Fig.2), i.e., if trotlines were so productive, the number of fishermen would have probably increased. Also, Lunz et al. (1944) reported that trotline crabbers could average 200 pounds of crab daily. Such a rate of capture every day of the year would account for only 73,000 pounds of crabs. Maximum annual catch-effort indices per crabber in South Carolina probably range from 25,000-50,000 pounds (see indices by pot fishermen from 1964-1971 of Fig.4).

Table 4. Annual hard blue crab pounds landed, ex-vessel value and prices as reported in South Carolina Landings, N.M.F.S., U. S. Dept. of Commerce with dollars deflated using the Consumer Price Index (base year = 1967) Bureau of Labor Statistics, U.S. Dept. of Labor.

Year	Pounds*Landed	Current Dollars Value*	Current Dollars Price**	Deflated Dollars Value*	Deflated Dollars Price
1960	7,121	534	$.075	602	$.085
1961	4,672	186	.040	207	.045
1962	6,337	293	.046	323	.051
1963	8,839	423	.048	461	.052
1964	9,436	376	.040	404	.043
1965	7,419	369	.050	391	.053
1966	5,724	284	.050	292	.051
1967	5,247	290	.055	290	.055
1968	3,862	295	.076	283	.073
1969	8,250	675	.082	614	.074
1970	6,950	455	.065	391	.056
1971	7,508	616	.082	508	.068
1972	7,422	778	.105	620	.084
1973	7,952	1,114	.144	855	.107
1974	7,548	984	.130	670	.089
1975	6,380	843	.132	525	.082
1976	5,740	976	.170	574	.100
1977	7,336	1,576	.214	863	.118
1978	9,397	1,840	.196	942	.100

*In Thousands
**Predicted current ex-vessel price = .01444 x "Year" + .12712 r^2 = .851
In this simple linear regression from 1968-77, "year" is 1973 = 0
1972 = -1 etc.

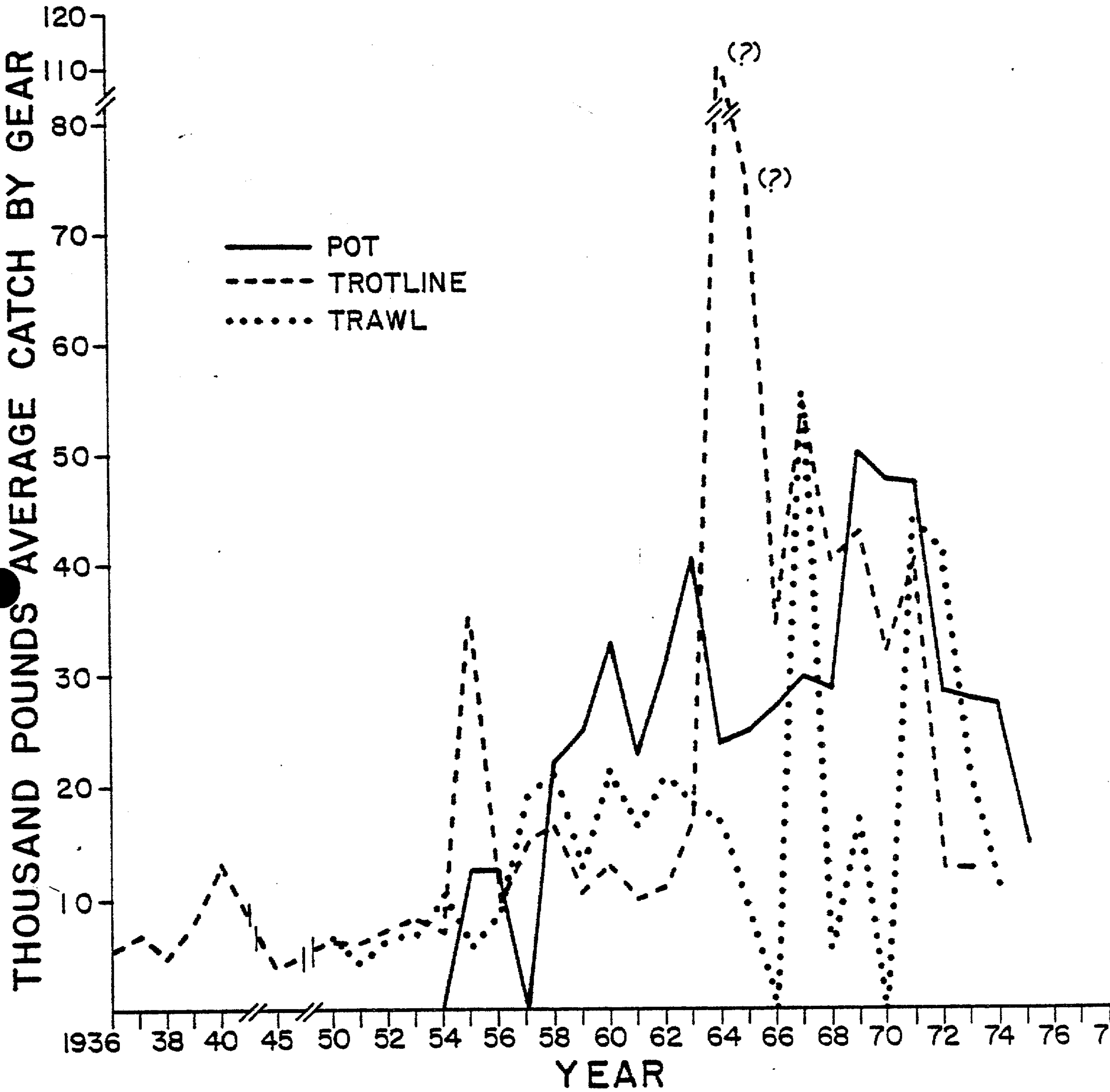

Fig. 4. Average South Carolina blue crab landings by gear. Data from Fig. 2 and 3.

Annual indices per crabber have varied from 5,000 to a calculated 110,000 pounds depending on gear and year. The 110,000 pound figure is considered unrealistic as discussed previously. Prior to 1944, there was considerable area for expansion of the crab industry. The coastal area from the North Edisto River to the North Carolina state line received little fishing pressure (Lunz et al. 1944). Today crabbers number more than at any time during recorded statistics except during World War II, and competition for space has resulted in conflicts not only among crabbers but also sport and commercial boat traffic. From 1969 through 1974 crab landings were about seven million pounds or greater, but the crude catch-effort indices for crab-pot fishermen decreased from an average of 50,000 to 27,000 pounds (Fig. 2 and 4). This decrease was accompanied by a 76% increase in crab fisherman numbers.

3.3.4 Annual Ex-vessel Value Trends

The annual ex-vessel value of blue crabs in South Carolina between 1968 and 1978 has generally increased through time due to the increase in ex-vessel prices (current dollars)(Table 4). For example, in the 1968-77 period ex-vessel price increases displayed a linear trend with an increase of $.014 (Table 4) per year. By 1978, the blue crab ex-vessel price was over 2.5 times the 1968 price. If this trend continues, annual ex-vessel prices could average over $.27 per pound in 1983.

The causative factors for rising blue crab prices are probably associated with the following: (1) inflationary trends within the U.S. economy, especially in the 1970's; (2) a general increase in crab product demand, and (3) localized changes in marketing practices for the seasonal Virginia and Maryland "basket" markets.

The general price level in the United States soared 169% between 1947 and 1976, although in past years the sharpest inflation rates in U.S. history occurred in peacetime—33.7 percent from 1973 to 1976 (Peterson 1978).

Reese (1977) has found that current inflation has lasted longer than any previous inflationary trends.

When current ex-vessel prices are deflated (Table 4), there is still a general upward trend in crab prices. A preliminary interpretation would suggest that the aggregate domestic demand for blue crabs has generally shifted upward. The causality of this shift may be associated with increases in income levels, changes in buyer preferences due to seafood promotion, rising population levels, etc.

In recent years, more non-processing buyers have entered the live crab market in South Carolina. Their presence has obviously been motivated by the market demand for live crabs in the Middle Atlantic states. Improvements in transportation logistics and the entry of fishermen less oriented to processor buyers has probably contributed to this situation. Their presence has apparently stimulated at least some seasonal shifts in market demand within South Carolina (see Section 3.1.2).

In general, blue crab ex-vessel prices have been increasing in South Carolina; whether this trend will continue in the future is not known. There have been no studies of factors effecting blue crab price trends in the United States, let alone South Carolina.

3.3.5 Soft-Shell Crab Harvesting Trends

One of the potential areas of the crab industry that has not been exploited in recent years is the production of soft-shell crabs. In 1936, over 9,000 pounds of soft crabs were produced, but by 1957, production had dropped to 500 pounds. Between 1957 and 1978, no soft shell crab were commercially produced in the state. The industry apparently used dip nets as the principal gear to capture soft-shell crabs and ceased to exist when crab pots became the accepted piece of gear. Whether the introduction of the pot directly caused the death of the industry is unclear, since essentially noting has been published on soft crab production in South Carolina.

3.3.6. Future Harvesting Trends

The total harvest of blue crab might be increased with additional crab trapping effort (McKenzie et al. 1976) assuming blue crab price level continues to rise. The possibility of a large increase in fishing effort does not seem likely, considering commercial crabber conflicts with recreational users and waterfront land owners, who have sought support for legislation (McCollough 1978) to further restrict crab trapping activities in creeks and rivers. In South Carolina, these pressures are expected to increase in the future (C.M. Bearden, pers. comm.).

In 1979, there was renewed interest in revitalizing soft shell crab production, and at least 8-10 operators set up pilot programs. Initial success was encouraging, and shedding operators have received as much as $25.00 per dozen softshells by selling direct to restaurants. The availability of a constant supply of peelers plagued all the operations, however, and most ceased operating after the spring run. It is believed that shedding operations will increase in number and production with increased awareness of additional profits and the education of crabbers to recognize pre-molt crab signs.

4. COMMERCIAL PROCESSING AND MARKETING SECTOR

4.1 Processing Sector

There are three blue crab processing plants in South Carolina: Blue Channel Corporation, Port Royal; Coastal Seafood, Inc., Frogmore; and S.C. Crab Co., McClellanville. Blue Channel is the largest blue crab canning operation in the U.S. and utilizes a major portion of the South Carolina landings. These processors will purchase blue crabs caught in other states (e.g., Georgia) or meat picked by other processors (e.g., Virginia) as sources of crab meat.

The processing technology has not changed significantly during the last 80 years (Harrison 1978) for the small processors. Crabs are loaded into retort baskets and batch-cooked for about 12 minutes at 250°F. After cooking, the hot crabs are cooled and dumped into a cart before moving into the picking room. After the cooled crabs have been debacked and cleaned, the body meat, the lump meat and the claw meat are picked out separately into cans or pans. Some crab meat is fresh packed with a friction lid, while others meat may be sealed in cans for pasteurizing. Mechanization with the Harris machine, which utilizes the principle of separating meat by flotation, was developed in the 1960's by a South Carolina processor (Lee et.al., 1963). In recent years, attempts have been made to develop a machine for a product comparable to hand-picked meat but with less shell fragments (Ringel 1978).

The yield of picked meat varies considerably, but the average yield is approximately 15%. Consequently, about 85% of the weight of the live crab become waste. In South Carolina, the largest plant has a scrap dryer to convert this crab scrap into meal containing 30-35% crude protein (Lee and Sanford, 1964). The other crab processors have DHEC permits for dumping their crab waste in designated adjacent waters.

4.2 Marketing Sector

Most of the crabs harvested in S.C. are purchased for processing or shipping directly to mid-Atlantic states. Processors purchase the bulk of crabs landed in the State. In the spring and early summer, however, crabbers are often able to sell the larger crabs from their catch to "shippers" rather than processors (see Section 3.1.2.). The extent to which these sales occur is largely determined by the price spread between the local processor and the shippers (Rhodes 1974). Most of the "shippers" (assemblers, wholesalers) purchase and take possession of the crabs directly from the fishermen. They are usually resident seafood firms involved in the wholesaling of other seafood (e.g. oysters) during the year. In recent years, major markets for live "basket" crabs have included Baltimore and Washington, D.C. The crabs are sold to restaurants which specialize in crab dishes or to retail seafood stores. A very small percentage of the state's catch is sold to retail stores directly by the crabbers or indirectly by dealers.

The crab meat canned in South Carolina moves into national distribution channels under a brand name and is commonly found in supermarkets and gourmet shops throughout the country. Crab meat processed by smaller plants move largely to northern markets or regional institutional channels (e.g., supermarkets). An institutional dealer supplying deviled crabs to South Carolina retail and restaurant outlets uses some quantities of South Carolina crab, although machine-picked crab from Virginia constitutes the bulk of their supply since they report the price of the Virginia crab is cheaper and the supply more reliable than higher quality South Carolina handpicked product (Laurent et al. 1975).

The present crab marketing system in South Carolina allows crabbers more flexibility than shrimpers to sell to alternative buyers when prices are favorable for doing so (see Section 3.1.2.). This flexibility results from the fact that crabs sold fresh require few facilities--only an assembly point.

4.3 Historical Trends - The decline or fluctuation in Chesapeake Bay blue crab stocks and rising demand for crab meat stimulated the development of blue crab processing in South Carolina (Lunz et al. 1944). The first modern blue crab processing operation was established by Sterling Harris on Ladies Island across from Beaufort in 1937 (Adams 1950). By 1960, there were five processing plants in South Carolina (Lunz 1960).

Blue crab processing costs increased significantly in 1961 due to the revision of the Fair Labor Standards Act which included blue crab plant employees (Lee et.al. 1964). Prior to 1961, crab pickers were paid on a piece-work basis, and only the faster pickers were able to earn a dollar or more per hour. Many of the pickers could not work fast enough to earn this minimum wage required by the Act. Investigations (Lee et.al., 1964) of the industry at that time indicated that economic productivity was also declining due to marketing problems and the lack of mechanization regardless of the Act.

During the 1960's three blue crab plants were closed in South Carolina. Bumper crops in the Chesapeake Bay area (Low 1960), low meat yields (Low, 1966) and poor catches (see Section 2.6) contributed to the closure of plants during the 1960's.

There are no published data on the price of processed products for South Carolina plants. Assuming the processing price in South Carolina has followed the trend in the Chesapeake Bay area, the price of processing blue crab meat tripled (Strand 1977) between 1967 ($1.27 per pound) and 1976 ($3.82). Since 1970, the processor increased the price of a pound of crab meat by about 64%, compared to 58% during the 1959-69 period. This increased markup maybe indicative of both rising processing costs and consumer demand.

5. BIOECONOMIC CONSIDERATIONS

Blue crab fishery management generally focuses on problems such as the desirable rate of exploitation, policies toward various kind of habitat alteration, and conflicts between user groups. Economic costs and benefits probably represent the most practical measure for evaluating various management alternatives. One of the real issues to confront analysis is the relative amounts of money that could be linked with each benefit and cost and the method of aggregation of these amounts so that the fishery manager(s) can evaluate the most beneficial course for the affected groups. This does not imply that quantifiable economic data should receive the most "weight" in analyzing various management alternatives. In addition, the use of economic information as a crude surrogate for measuring social welfare doesn't necessarily simplify policy analysis.

Based upon the above assumptions and associated disclaimers, the modeling of the blue crab exploited stock dynamics with the market system would seem important. The bioeconomic dynamics of South Carolina's blue crab fishery have shown sensitivity to changes induced by new technology, shift in market demand, entries from other fisheries, and other changes. When evaluating regional and national crab supplies, bioeconomic dynamics of the U.S. blue crab fishery may be subject to more than one local aggregate profit maximization point (Anderson 1973) due to variable ex-vessel prices associated with harvested supplies. When considering the small contribution of South Carolina to the regional and national blue crab supplies and South Carolina's apparent environmental isolation from factors affecting blue crab stocks in the major producing states (i.e. Maryland and Virginia), the bioeconomic dynamics as described by Anderson (1973) and others (e.g. Gates 1974) may not be applicable to the modeling of South Carolina's blue crab fishery. Consequently, the modeling of blue crab population dynamics could be the most critical component in developing a bioeconomic model for management. Unfortunately, there is a paucity of information for developing a harvestable-yield model.

6. CURRENT MANAGEMENT SYSTEM

6.1 Management Policies - South Carolina's blue crab management policies have been strongly influenced by the concern with exploitation due to an expansion of the industry in the Middle Atlantic states. The State Board of Fisheries articulated this concern in their 35th Annual Report (1941): "The blue crab is declining in abundance as a result of overfishing in...the Middle Atlantic States. At the present time, the supply of crabs has not been endangered in our State, but the establishment of canneries will, in the course of time, deplete the supply unless some conservation measures are adopted..."

It was generally believed that blue crab catches had declined in other states due to the lack of laws protecting egg bearing ("sponge") crabs (Lunz 1944 and Adams 1950). Lunz (1944) justified the prohibition on the taking of sponge crabs because it "...undoubtedly provides for many times the catch." Current consensus among blue crab biologists supports the importance of environmental factors and deemphasizes the effects of fishing effort on future harvest (Rhodes 1978).

Current management policies in South Carolina are oriented to sustaining future blue crab harvest, protecting other desirable species (e.g. shrimp) from crab gear, providing property protection for the harvesting sector while fishing, and preventing conflicts between crabbers and other coastal user groups (e.g. shrimpers). Management strategies have included protecting spawning females and small crabs; controlling fishing effort through restrictions on fishing areas,

and season; and requiring identification for gear and fishermen. In some cases, creeks and portions of rivers have been closed to commercial crab trapping solely due to conflicts with other user groups. It is questionable whether the regulations protecting egg bearing females crabs or juvenile crabs are really necessary for future sustainability of the resource. The value of such regulations may rest in their ability to improve crab yield per recruit, or in the case of mesh size restrictions on crab trawls, regulations may facilitate the escape of valuable juvenile species (Bearden 1978).

6.2. Statutes and Regulations

Statutes and regulations administered by the S.C. Wildlife and Marine Resources Department were summarized by Bearden (1978):

Protection of female crabs - unlawful to catch, hold or possess any female crabs bearing visible eggs or any female crab from which the egg pouch has been removed. Does not apply to importing sponge crabs from other States under permit.

Minimum size of blue crabs - unlawful to catch, destroy, hold or possess any blue crab of a smaller size than five inches across the shell from tip to tip. Does not apply to peeler crabs.

Restrictions on fishing methods and gear - (a) crab trawls - unlawful to have on-board any boat trawling for crabs, a net having a mesh size of less than four inches (stretch mesh).

Lawful to trawl for crabs in legal offshore areas and sounds, bays during December, January, February and March. (Commission many regulate seasons and areas for crab trawling as it sees fit, however).

Trawling for crabs prohibited near shoreline of Horry County and off ocean beaches of Hilton Head in Hunting Islands during May 15-September 30.

Shrimp trawlers may retain and market crabs taken incidentally during June 1 - November 30. (b) Crab pots - unlawful in Chechessee Creek, except for personal use, May 1 - October 1.

Unlawful in Pawleys Island and Midway Creeks, Georgetown County except for personal use.

Identification cards required of crab pot helpers or assistants.

Crabbing for personal use - no license required for crabbing for personal use with handlines, dip nets, drop nets or two crab pots per person.

(c) Commercial fishermen who are residents of a state prohibiting commercial crabbing by non-resident commercial crabbers are themselves prohibited from the commercial harvesting of crabs in South Carolina waters.

Departmental Regulations or Rules

Operation of Crab Pots

(a) Every crab pot, float or buoy shall be marked with number issued by Division

(b) No crab traps may be placed within 100 yards of a public boat ramp.

(c) No crab pots may be set so as to be left dry at low water.

(d) No glass bottles, jugs or metal cans may be used as floats or crab pots.

(e) No crab pots shall be abandoned or left unattended for more than five days.

Licenses and Taxes

1. Commercial fishermen - $5.00 (vessel captain)

2. Crab pots - Resident $10.00/100; Non-resident $50.00/100

3. Crab trawl vessel - Resident - $75.00/Non-resident $200.00

4. Crab boat (other than trawl) - 18 ft. and under - $2.50. Over 18 ft.-$10.00

5. Crab canning - $100.00;crab processor - $25.00;crab buyer/shipper $20.00

6. Soft-shell crab operator - $75.00

7. Crab trap net (pound, etc.) - $3.00 each

8. Taxes on crabs - $.10/100 lbs. (hard or soft)

9. License registration number must be displayed on crab trawlers in two in. x 18 in. numerals.

Recent (1979) Statutes and Regulations Concerning Peeler and Soft-Shell Crabs

(a) "Peeler crab" is defined as a blue crab (Callinectes sapidus) having a new soft shell fully developed under the hard shell and having a definite white, pink or red line or rim on the outer edge of the back fin or flipper.

(b) "Soft-shell crab" is defined as a peeler crab which has recently shed its hard shell.

(c) Any person engaged in catching, taking or transporting of peeler crabs or in the shedding peeler crabs for the purpose of producing soft-shell crabs is required to have a valid permit or identification cards issued by the Division of Marine Resources.

Permits under this section shall be issued only to bona fide dealers engaged in shedding peeler crabs and in possession of a valid crab dealer license. Identification cards may be issued to a permit holder under this section to be used by persons employed by him to catch and transport peeler crabs to his shedding operation.

(d) The Marine Resources Division and Department law enforcement officers have authority to inspect the business premises of any person engaged in shedding peeler crabs.

(e) On each permit issued under this section the Division shall have the authority to specify:

(1) The area from which peeler crabs may be caught or taken by gear other than crab pots.

(2) The types of gear or fishing equipment which may be used to take peeler crabs;

(3) Catch reporting requirements;

(4) Boat identification requirements;

(5) Any other provisions the Division deems necessary.

(f) Scrapes, dredges, peeler pounds lawful under special permit from Division of Marine Resources.

6.3. Law Enforcement Considerations

The enforcement costs of South Carolina statutes and regulations have generally increased with the increase in the number of crab fishermen and potential for conflicts with other user groups in the coastal area. Crab pot theft has placed emphasis on the identification of pots. Various methods for the legal identification of crab pots have been proposed by both the industry and the Department. In addition to the identification of the pot itself, law enforcement must also be able to identify traps according to their floats when keeping surveillance on an area for potential theft.

The cheeking of crab catches for "sponge" females or undersize crabs is usually performed at the boat landings or at the point of purchase. Illegal size crabs may consitute about 10% of South Carolina crab pot catch,and 85% of the immature females are taken below the minimum legal size (Eldridge & Waltz 1977).

7. CURRENT RESEARCH AND MONITORING PROGRAMS

7..1 Division of Marine Resources

7.1.1 Office of Conservation, Management and Marketing

.1.1.1 Juvenile Blue Crab Project - A new program designed to locate and estimate relative abundance of juvenile blue crabs and shrimp was initiated in March 1978 and continued through November 1978. Sampling was resumed again in April 1978 and was usually restricted to sites in the Charleston-Edisto area with three sampling trips per week. Juvenile trawling was conducted with a small mesh net towed from an outboard boat for 5 to 10 minutes.

7.1.1.2 Blue Crab Monitoring Program - In March 1979, a blue crab monitoring program was incorporated in the Commercial Crustacean Management Section's existing shrimp survey. During months of state-wide cruises, blue crab catches in all major sounds and bays were quantified, measured (width), sexed and examined for premolt signs. The programs major objective is to develop a data base for the reliable prediction of blue crab abundance.

7.1.1.3 Escape Ring Project - In June 1979, Section personnel began preparation for a large scale project to test the effectiveness of a passive blue crab sorting device in the form of escape ports in commercial crab pots. Previous work by the Crustacean Management Section and the Marine Resources Research Institute has determined a circular 2½ in. escape port /allows the greatest number of sublegal blue crab to escape. Results were promising, and currently (summer 1979) pots with escape rings are being tested by commercial crabbers in the Cooper and Folly Rivers.

7.1.1.4 Crab Float Project- In an effort to reduce the number of crab pots lost in South Carolina's coastal waters, a study of various types of crab floats was initiated. This work included examination of various floats and field tests which are continuing into August 1979. Many crabbers presently use inexpensive plastic jugs. These jugs are very susceptible to damage from weather, boat propellers and friction wear from the crab pot line.

7.1.2. Marine Resources Research Institute

7.1.2.1. Estuarine Survey Program - A six-year survey of the state's estuarine area was completed in December 1978. This survey was divided into an extensive and intensive phase. The extensive phase sampled 15-18 stations located throughout the state's coastal zone each quarter. The intensive phase concentrated on monthly sampling at four to nine stations within a particular estuary for a two-year period and investigated the following estuaries: North and South Santee Rivers, and Winyah Bay and source rivers. Sampling consisted of towing a 20 ft. otter trawl, one inch stretch mesh, for 20 minutes. Sex, maturity, various abnormalities, and total width of nearly every crab captured during this study was recorded and entered on a computer.

7.1.2.2. Sea Grant Crab Pot Project - In 1978, a study to determine the feasibility of using escape rings in commercial crab pots to reduce the catch of sublegal blue crabs was completed (see Section 7.1.1.3.).

7.1.2.3. Soft-Shell Crab Project - Presently, South Carolina does not have a viable soft-shell crab industry. To help stimulate the establishment of this facet of the crab industry, a cooperative study involving the Marine Resources Research Institute and the Office of Conservation, Management and Marketing was funded by the Coastal Plains Regional Commission this year (1979) to determine the most successful methods, seasons, and areas for capture of peeler crabs. In conjunction with this field program, a shedding facility has been established to determine methods of reducing peeler crab mortality in shedding tanks. In the Chesapeake Bay area, mortality of peeler crabs in shedding tanks may approach 60%.

7.2 National Marine Fisheries Service

The Charleston Laboratory of the National Marine Fisheries Service's Southeast Fisheries Center will be initiating a program to survey microbiological contaminants (coliform, Vibrio parahaemolyticus) and concentration of trace metals (arsenic, cadmium, copper, lead, mercury, zinc) and polychlorinated biphenyls in crabs. Differences will be correlated with salinity, temperature, sediment, and pH. Samples will be taken from selected stations along the South Carolina and Georgia coast each qaarter for 18 months, and results will be assessed for future programs.

8. IDENTIFICATION OF PROBLEMS AND OPPORTUNITIES

8.1 Resource Related Problems

8.1.1 Habitat - Alteration of the estuarine habitat has been considerable in the past 30 years (see Section 2.7) and is likely to continue. Dredging, pesticides, silting, eutrophication, silviculture practices, waste disposal and other man-induced perturbations may singly and/or synergistically reduce blue crab populations in a given area. In addition, these alterations may reduce fecundity, larval survival, and growth rates dramatically without immediate effects on the adult population.

The filling of a small wetland area may not itself cause a significant decrease in the abundance of blue crabs and other species. However, as more and more areas are filled, the aggregate impact can lead to long-term deleterious effects on estuarine species. Unfortunately, the costs (i.e. negative externaltities) arising from the reduced blue crab harvest are borne by fishermen, the fishing industry and associated tourism. The protection of the blue crab's habitat (and other fisheries resources) should be given adequate consideration during all stages of the Coastal Zone Management Program.

8.1.2.1 . Bioeconomic Information Gaps - A primary mission of the Division of Marine Resources is to develop the optimal economic benefits from South Carolina's fishery resources. At present, major information gaps exists concerning the bioeconomic dynamics of the blue crab resource which are essential to the long-term wise use of this resource. Although problems do exist in the integration of fishery population dynamic concepts and economic concepts, bioeconomic models have been identified as critically needed management tools for similar crustacean fisheries (e.g. Grant and Griffin 1979) in the southeast.

8.1.2.2. Stocks Dynamics - A knowledge of natural and fishing mortality is needed to assist decision makers in evaluating the effects of harvesting size and/or time on biological yield. Regulations concerning size have generally been continued due to past legal precedent and the lack of information concerning natural or fishing mortality rates for blue crabs. Insufficient information concerning age and growth is also a definite problem in yield-per-recruit analysis. In addition, the lack of knowledge concerning survival rates makes it difficult for management to predict supply, thus increasing the risk for industry.

The development of a population model for blue crabs should include the effects of critical natural parameters affecting crab abundance. Crab landings have fluctuated from year to year and an ability to forecast such fluctuations would greatly aid the entire industry (Rhodes and Van Engel 1978). Processing plants could plan accordingly and coordinate with adjacent crab producing areas on supplies.

8.1.2.3. Economic Data - The integration of economic concepts into biological models of fish populations must be carefully considered. For example, measures of fishing effort applicable to biological models may not be an adequate proxy for fishing costs (Carlson 1975). Besides the information gaps identified for developing a population model, additional information would include price trends and harvesting costs. Harvesting costs information should include trends in variable costs like bait and gasoline consumption. Accurate price information on crabs sold for the basket market is also lacking.

The benefits of developing a bioeconomic model include the stimulation of variations in biological and economic parameters in order to explore sensitivity of results to regulatory changes or trends such as changes in regional crab landings. In essence, a practical mathematical model and the associated data base is lacking for South Carolina's blue crab fishery. Consequently functions describing the effects of harvest pressure on blue crab stocks,as modifie by environmental and economic factors, aee not available for evaluating alternative resource allocation schemes. In addition, the lack of a readily identifiable bioeconomic model hinders the evaluation and possible improvement of current catch and effort reporting methods.

8.1.3 Special Resource Problems

8.1.3.1 Blue Crab Diseases and Dieoffs- Unlike Penaeid shrimp dieoffs associated with severe winters, mass mortalities of blue crabs have generally been observed during the summer months. Management agencies can do little other than to identify possible causes and predict the impact of such mortalities on crab supplies.

Blue crab diseases (see Section 2.6) have been directly implicated with blue crab dieoffs. Although these blue crab diseases do not significantly affect the market acceptability of blue crabs, little is known of the possible inpact of disease on blue crab populations and harvestable-yield. In contrast, the prevention of chemical contaminations like the perturbation of Virginia's James River by Kepone can constitute a dual impact by both reducing crab abundance (Schimmel et al. 1979) and threatening the health of consumers eating contaminated crabs.

8.1.3.2 Zoonotic Diseases and Chemical Contaminants - Probably one of the most critical environmental issues facing the future utilization of blue crab is the short-term and long-term effects of contaminants and zoonotic diseases. The recent occurrence of cholera in Louisiana (see Section 2.9) emphasizes both the world-wide concern for diseases like cholera and the immediate economic impact of contaminants on blue crab demand. The long-term effects of heavy metal contaminants and the associated regulatory impact must not be under-estimated.

The future harvest of blue crabs can be significantly affected by research results on potential contaminants. Research oriented toward the detection and evaluation of chemical and microbiological contaminants in the blue crab must be equally sensitive to consumer safety and the potential economic impact of contaminant research on the blue crab industry.

8.2 User Conflict Problems

8.2.1 Space and Gear Conflicts - There has been some controversy between crab trap fishermen and shrimp trawler operators. Friction has also arisen among commercial crabbers over commercial trap theft and fishing grounds (Section 2.1.3). It is assumed that these problems will increase in the future.

Some commercial fishermen view recreational activities as detrimental to their livelihood. This viewpoint has been intensified in recent years due to increased recreational activities. The theft of crabs from commercial traps by the recreationalists has especially accelerated concern over the effect of escalating recreational use. The commercial crabber's views have been partially supported by the passage of legislation eliminating commercial crabbing in certain creeks due to recreational use conflicts with commercial trapping activities (see Section 6.1).

8.2.2 Non-resident Fishermen - The presence of non-resident commercial fishermen in South Carolina has always created controversy regardless of the fishery. Some of the problems perceived by the resident crabbers concerning non-resident fishermen include reduction of crab catch, especially during seasonally low catch periods (November to March), increased trap theft, reduction of fishing grounds, and general lack of familiarity with state regulations.

8.3 Industry Problems and Opportunities

8.3.1 Lack of Diversification - The short-term economic productivity of individual firms can usually be improved by reducing costs or increasing the price received for these various products (e.g. crabs). In the case of the crab fishermen this might include the diversification into other small-scale fisheries (e.g. eels), although South Carolina's freshwater fishery regulations generally hinder commercial fish trapping (Ulrich 1976).

8.3.2 Harvesting and Processing Technology - Regardless of regulatory hinderances to diversification by commercial crabbers, there are needs to improve the existing harvesting technology. The research in self-culling crab pots, and the capture of peeler crabs are examples of cost effective methods for improving existing technology.

Other problems include the high mortality of crabs during shipment, the rising cost of fuel, bait and other materials, the short life span of existing traps and the need for a peeler crab market.

Technology needs for the processing sector were outlined at the National Blue Crab Workshop in Charleston (see Rhodes and Van Engel 1978). The Processing Technology Committee report emphasized technology transfer from other food industries and continued government support for advisory and extension programs. Sepcifically, they recommended that the use of retortable pouches, sealed traps and plastic containers for fresh pasteurized and frozen sterilized meat should be considered by crab processors. It is also expected that energy costs will be especially severe for the crab processor.

8.3.3 Marketing - The existing marketing logistics for the commercial crabber could probably be improved. Marketing channels are generally inconsistent for live crab shipments both in terms of selling arrangements and buyers. As previously discussed, the entire problem is complicated by the high mortality of crabs when shipping during the warmer months.

8.4 Administrative and Management

8.4.1 Law Enforcement - As previously discussed, the enforcement of existing regulations often involves crab trap theft. The methods for improving enforcement logistics, namely the identification of crab traps, needs additional research. Since South Carolina processors often purchase crabs from other states, differences in legal requirements related to size limits and the possession of "sponge" crabs also create enforcement problems. The controversy over the cost and utility of protecting "sponge" crabs and size limits has hindered approaches to standardize regulations.

8.4.2 Selection of Management Strategies - Due to diverse views of the blue crab, specific management objectives have generally been lacking. Unless there are commitments to specific objectives to improve and maintain the existing fishery, harvesting needs will continue to yield to other local coastal interests which conflict with recreational and commercial crab harvesting. This does not imply an active development of the blue crab fishery without regard to other management priorities. It is also assumed that bioeconomic information as previously discussed would be essential to the selection and monitoring of management objectives.

8.4.3 Public Involvement - Considering the conflicts between various user groups, there appears to be a need for the formal input of these groups. Problems seem to arise due to inequalities within the present processes for resolving conflicts between various user groups.

8.4.4 Extension and Education Activities - Concomitant with any research to improve industry technology or inform recreational fishermen are extension and education programs. Cooperation and coordination between the Sea Grant Marine Advisory Program and the S.C. Marine Resources Center will be important to such activities by both agencies.

9. RECOMMENDATIONS

9.1 Resource Related

9.1.1 Habitat Alterations - Probably one of the most important functions of the Department is identifying potential negative environmental impacts and external fishery diseconomics of various man-induced perturbations in the coastal environment. This commitment should continue and be supported by the blue crab industry, because regardless of fishery management policies for various consumptive users, these policies become inconsequential if blue crab stocks are undesirably diminished by gradual habitat degradation.

9.1.2 Bioeconomic Information Gaps- As identified and discussed previously (Section 7.1.2 and 4), there is a need for development of a simple bioeconomic model of South Carolina's blue crab stocks. The first priority should be given to a simple population model (e.g., Gulland 1969) which includes the effects of critical environmental parameters (e.g., salinity). The methodology could include estimations of mortality rates and growth rates using mark-recapture techniques. The experimental design should also incorporate the evaluation of the existing blue crab catch-effort system (see Rhodes 1973).

As previously discussed (Section 5), economic data should be simply integrated into the population model without a major concern for variable prices due to state landing trends. Ex-vessel price trends should be investigated in order to predict price patterns for various crab population yields. Cross sectional production data on crab harvesting should also be investigated in order to quantify cost relationship and correlate measurements of relative fishing power with economic data (see Carlson 1975)

9.1.3 Blue Crab Contaminants and Zoonoses - Considering the special impact of chemical and microbiological contaminants on the blue crab industry and recreational interests, research like that performed by the National Marine Fisheries Service should be continued and actively supported by the public sector and industry. The safety of the consumer and the associated market quality of blue crab products will in the long run depend upon the rational and objective evaluation of possible health hazards. Such research represents a safeguard for both the consumer and industry against irrational regulations which may result in costs that far exceed the social benefits.

9.2 User Conflict Problems

Within South Carolina,the potential for major conflicts between commercial crab fishermen and other groups seems to increase each year. Present methods for resolving these conflicts seem to lack a mechanism for identifying the motives of the various parties,especially when closing an area to commercial crabbing activities. Perhaps in the case of closures a formal hearing of all parties to be affected could be held based upon a petition signed by those requesting the closure. This approach would identify those affected and may facilitate the resolution of problems between individual parties before a ruling is made or legislation passed.

9.3 Industry Problems and Opportunities

The present effort to develop a soft-shell crab industry in South Carolina should continue including coordination with the South Carolina Sea Grant Marine Advisory Program in transferring technology developed at the Division. The development of other small-scale commercial fishing activities which are compatible with equipment used by commercial crabbers should be investigated For example, an eel fishery similar to the North Carolina's fishery could be a potential target.

Additional technology on improving survival rates for shipping blue crabs to both processors and other markets is needed. Such technology would improve marketing logistics and complement marketing promotion for South Carolina crabs.

There is also a need to improve the existing harvesting technology for hard crabs. For example, artificial baits which do not depend upon refrigeration and can be used several times might decrease costs. A flotation system which doesn't depend upon surface floats might decrease trap loss due to entanglement and theft.

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SECTION IV

EASTERN OYSTER

MANAGEMENT PLANNING PROFILE

FOR THE

SOUTH CAROLINA OYSTER FISHERY

W. J. Keith

MANAGEMENT PLANNING PROFILE FOR THE SOUTH CAROLINA OYSTER FISHERY

I. Introduction

The oyster fishery of South Carolina is the third most valuable fishery in the State. It is exceeded in annual ex-vessel value by only shrimp and crabs. Oyster production peaked in 1908 with an excess of seven million pounds of meat reported. While production has fluctuated since 1908, it has exhibited a downward trend. Although current production is higher now than at any time since the mid-1960's, this decline has generally continued. The resource itself has declined due to man-induced alterations of the coastal zone, including water pollution.

Harvesting intertidal oysters is currently the dominant practice within the industry. Subtidal growing areas are more limited than intertidal areas and yield only a small portion of the State's total production. The industry is totally dependent on hand labor for intertidal harvesting operations. Changing socio-economic conditions have tended to reduce the necessary supply of hand labor. Few persons enter the industry. The average participant's age is above 30 years. Markets are limited to canned, shucked and shellstock oysters. Much of the demand is seasonal. Increasing coastal populations, requiring recreational shellfish harvesting opportunities, place additional burdens on both industry and management.

Examination of current statutes, regulations and management practices reveal that some changes should be beneficial. Management has been complicated by various other problems related to information gaps, enforcement and funding. If future demands are to be met, additional personnel should be assigned on a permanent basis to both commercial and recreational oyster management activities. Research, extension and monitoring programs should be upgraded to meet expanded demands.

The need for comprehensive management planning for South Carolina fisheries has long been recognized as necessary for the well being and effective utilization of these resources. The development of this profile and its subsequent implementation as a part of a comprehensive plan is considered necessary to secure the future of the oyster fishery.

2. Description of Resource

2.1. Species - Three species of oysters are commercially cultivated in the United States. The Olympia oyster (*Ostrea lurida*) and the larger Pacific (Japanese) oyster (*Crassostrea gigas*) are grown on the West Coast. The Eastern oyster (*Crassostrea virginica*) is most abundant. It is found in the estuarine waters along the Atlantic and Gulf coasts (Wallace and Lunz, 1968). The South Carolina oyster fishery is based entirely on the Eastern oyster (Gracy and Keith, 1972).

2.2. Life History and Ecology-The oyster is a suspension feeder. An adductor muscle attached to each shell controls opening and closing of the shells. Particulate matter suspended in the water is drawn into the shell and upon the gills by motion of small cilia. The quantity of water pumped by large oysters may approach four gallons per hour. Matter retained by the gills is conducted by ciliary action to the mouth and then to the stomach. Waste products are expelled as feces. Other matter brought into the shell, but not passed through the mouth, are agglomerated by mucous on the gills and discharged as pseudofeces. Large amounts of silt are rejected in this manner. This latter function apparently allows survival in many estuarine waters of high turbidity (Haven, et.al., 1978).

Spawning begins in the spring when the water temperature exceeds about 70^{o}F (Wallace and Lunz, 1968). Individual oysters are capable of alternating sex, although the sexes are, at any given time, separate (Haven, et.al., 1978). Spawning may occur in South Carolina from April to October. During 1950, a set occurred every month of the year (Lunz, 1950). Setting is extensive,and during the Summer months intensive. Both sperm and eggs are released directly into the water column, Fertilization and the early stages of development occur in nearby waters (Haven, et.al., 1978).

In approximately 24 hours, free swimming larvae develop. Locomotion is produced by controlled movements of the cilia. Free movement occurs for a duration of about one to three weeks (Haven, et.al., 1978). After this time lapse, the free swimming larvae sink to the bottom. They must locate a hard, clean surface for permanent attachment (Wallace and Lunz, 1968).

Embryonic shells develop before attachment. If a place for attachment can not be found, the larvae sink to the bottom and die. If a suitable surface for attachment is found, the larvae secretes a fluid that cements the left shell permanently to the object. When this attachment has been accomplished, a "set" is said to have occurred. Unless removed by some external force, the oyster will not again move (Galstoff, 1964). Almost any hard clean surface is acceptable for attachment, however, oyster shell appears to be the most favored object. When oyster shell is purposely placed or "planted" to induce a set it is known as "cultch" (Wallace and Lunz, 1968).

2.3. Habitat - After attachment occurs the small oysters are called spat. In southern waters, there is nearly a continuous setting of spat. This generally produces overcrowding and results in thin, elongated oysters. Most oysters found along the East Coast, north Cape Fear, North Carolina are subtidal, growing on bottoms that are covered with water throughout the tidal cycle (Lunz, 1952). In the region south of Cape Fear to northeastern Florida, the majority of oysters grow intertidally, that is, between the tides. Tidal range in South Carolina is from approximately four feet at Little River to about seven feet near Beaufort. Twice every 24 hours, these intertidal oysters are exposed by the tides. Rapid temperature changes, especially during the winter, are common. Exposed oysters are frequently subjected to freezing air temperature. Rarely are they killed by either low or high temperatures.

Oyster predators appear to suffer much more from exposure to the atmosphere than do the oysters. South Carolina's intertidal oysters are subjected to less predation than are oysters growing subtidally. Intertidal oysters are almost entirely free of boring sponge (Cliona sp.) which, as a subtidal inhabitant, is probably the most detrimental oyster pest in the State. Starfish (Asterias forbesi) are seldom found on intertidal beds. Oyster drills (Urosalpinx cinerea) are numerous, but their presence has never been considered a threat. Blue crabs (Callinectes sapidus) as well as some other species of crabs, are serious predators often causing high mortalities among small oysters (Wallace and Lunz, 1968).

South Carolina intertidal oysters are found in all estuarine areas. The State contains a number of sounds, bays and river mouths. These are connected by an intricate system of creeks and rivers separating extensive marsh (primarily Spartina alterniflora) islands and mainland. Oysters occur along most of the creeks and river banks and on exposed mud flats. They occur both isolated from, and in immediate proximity to, the marsh. The reason for this predominantely intertidal distribution has never been positively determined. However, as early as 1890, it was suspected that high salinity, heavy sediment and the soft character of much of the bottom influenced a heavy intertidal set (Battle, 1890).

Intertidal oysters have a wide diversity of configuration. Apparently, ultimate morphology is dependent upon conditions prevailing in locations where the set occurs. The most common type of growth is that which produces oyster clusters. These are formed by successive annual sets one upon another. Each living oyster in a cluster owes his place to succeeding generations. The cluster continues to grow as new sets occur. Sometimes individual clusters reach a foot or more in thickness (Keith and Gracy, 1972). The added weight tends to push the lower-most oysters into mud where they eventually suffocate. Only the outer and top-most will remain alive.

Intertidal oysters are also found in groups sometimes known as "oyster rocks". These oysters grow on a firm foundation and probably initially started out as a dense collection of cluster oysters. Successive annual sets occur and eventually the clusters join together to form a continuous group. Through a period of many years, tiers of oyster are laid one upon another. The lower-most oysters die of suffocation or starvation before they ever reach a harvestable size. Oyster rocks can grow to be several feet thick. Only the uppermost oysters remain alive and, due to their prolonged exposures to the elements, they remain of an unharvestable size. Their only use is to be broken up into seed and distributed to better growing areas.

Eventually, if this process is unaltered, the elevation will increase to a point where marsh (Spartina alterniflora) will begin to grow in the mud trapped among the oysters. This results in the ultimate destruction of the oyster bed. A marsh island, with the dead oysters as a substrate, develops (Maggioni, 1978).

While about 1,500 acres of oysters do exist in natural subtidal beds in the State (Table 1), the majority of these are suitable only for seed (Gracy, et.al., 1978).

Table 1. Natural Subtidal Oyster Bed Locations

Name	Locations	Acres (1975 survey)	Use
Ashepoo River	Near AIWW	10 (or less)	Seed
Santee Estuary	Below AIWW	904	Shellstock & Seed
Wando River & tributaries	Beresford Creek to Paradise Island	584	Seed
Alligator Creek	Below AIWW	5 (or less)	Shellstock
Maximum Total Acreage		1,503	

Although this comprises about 10 to 20 percent of the States total oyster acreage, these bottoms furnish much less than five percent of total oyster production. This chief use for subtidal oysters, when utilized at all, has been as seed.

2.3.1. Effects of Environmental Alteration - Although no comprehensive studies, with the possible exception of local water quality, have been conducted of the effects of environmental alteration on oyster habitat it has been recognized by both management and industry that the results of many coastal changes have been detrimental to oyster propagation and utilization.

Most of the environmental changes which have affected oyster production have been man-induced. Destruction of bottoms through dredging, filling, channelization and alteration of drainage, which has affected current and salinity patterns, have produced the most pronounced effects (Bearden, 1977). Several coastal alterations are thought to have had a considerable effect on the productivity of oyster bottoms:

a) The navigational improvements accomplished in the Atlantic Intracoastal Waterway (AIWW) from about 1935 thru 1941 have resulted in a lasting influence. In addition, to localized damage to oysters as a result of dredging and spoil deposit, the most harmful effects have been the interruption of normal tidal flow and the confusion of salinity gradients in streams joined by artificial dredge cuts. One of the most damaging results was the destruction of subtidal oyster beds in such waters as the Ashepoo and Edisto Rivers and Rock and Saint Pierre Creeks. The alteration of natural tidal flow, attributed to AIWW improvements, has resulted in the silting of "cut-off" streams and adjacent areas. Dawhoo River and Church Creek are examples of this silting (Maggioni, 1976).

b) The diversion of the Santee River into Cooper River in 1942 is the suspected cause of much silting in Charleston Harbor. The requirement for channel maintenance has created a need for extensive spoil areas that has resulted in destruction of marsh and oyster bottoms. A concomitant effect has been noted in the Santee estuary which, after the early 1940's, has been compatible with shellfish production. The currently proposed rediversion will undoubtedly destroy the majority of the shellfish in the Santee estuary.

c) The entire AIWW, as well as approach channels to major docking facilities, can no longer be considered as oyster producing areas primarily because of the scouring effects of vessel wakes on the shore (Maggioni, 1976).

d) Rapid draining of modern coastal forests is believed to have a direct affect on oyster production. Coincident with the 1929 Depression, and the abandonment of subsistance agriculture, the "Kraft Process" for the reduction of yellow pine to pulp was perfected. Vast acreages in the Southeast began to be utilized for rapidly growing pine trees. A brief overview indicates, aside from urban areas, approximately half of South Carolina's coastal counties are devoted to "pulp-pine" forests. This forest is of necessity, well drained resulting in surges of freshwater being released into the estuaries after each rainfall. Oyster growth in the upper portions of some estuaries has been much reduced. It is reflected in the bleaching of the shell and stunted growth normally associated with high incidences of freshwater (Maggioni, 1976). The Upper Broad River and Whale Branch are examples of this condition.

e) The lowered water table of today may also be associated with the southern pulp industry. From about 1935 to about 1950, almost all of the flowing wells in the estuary areas stopped (Maggioni, 1976). In many estuaries and tidal streams the existence of flowing wells tended to maintain even salinities, less than seawater strength, thereby enhanced growing conditions especially for subtidal and low bank intertidal oysters (Maggioni, 1976).

f) Coastal resort, industrial and residental developments have not been compatible with oystler production. Industrial and domestic waste discharge never improves adjacent oyster bottoms. Along with dredging and wake action, the proliferation of pleasure boats has affected oysters. Construction of numerous private wharves, in areas of oyster leases, may not conflict with leasing arrangements,but serves to inhibit both planting and harvesting from the area (Maggioni, 1976).

g) Pollution, with regard to oysters, is normally considered to be indicated by an elevated coliform count. Large areas have been closed because of this pollution. Charleston Harbor once produced a large volume of oysters for human consumption. The Ashley and Cooper Rivers were closed to oyster harvesting prior to World War II. The Wando River and Clark's Sound have been closed since the 1950's. The Beaufort River and some if its tributaries are closed. The area of pollution from the Savannah River northward now approaches the northern end of Daufauskie Island (Maggioni, 1976). Major problems exist at Little River and Murrells Inlet. Buffer zones are required around sewage outfalls and processing facilities. Presently, about one-third of the estuarine waters in South Carolina are classified by the Department of Health and Environmental Control (DHEC) as closed to shellfish harvesting, due specifically to contamination by fecal coliform bacteria (Bearden, 1977). Low-level industrial pollution is not generally monitored or measured. Its effects are not readily observed, but such pollution may be detrimental to oyster quality and perhaps growth.

h) Beach erosion has removed some areas from oyster production. Examples are apparent even to the casual observer. Bull Point (Beaufort County) is eroding so rapidly that marsh and mud outcroppings are visible on the front beach. Morris Island at Charleston exhibits the same condition. The upper branches of Block Island Creek, near Morris Island, no longer exists, having been filled with beach sand. Sand transported from the eroded ocean front of Botany Bay Island has obliterated the lower reaches of Townsend Creek.

The most pragmatic approach concerning the loss of oyster bottoms through environmental alteration, with the exception of pollution, would probably not be an attempt to reclaim vast acreages, but rather to arrest proposed future destructive changes.

2.3.2. Effects of Utilization and Harvesting - The effects of over-harvesting have not caused a coast-wide lack of oysters in South Carolina. Some specific areas, generally very accessible ones, have a shortage of oysters. However, current observations in all the major estuarine areas of the State indicate that it is not a general lack of oysters that has lowered production in recent years. Lowered production must be attributed to other factors such as the non-availability of labor (Gracy and Keith, 1972).

In past years, steam canneries may have temporally depleted certain areas. It has been implied that lack of proper cultivation may have been responsible for the gradual decline in landings since 1900 (Lunz, 1950 & 1967). The decline in oyster meat yield per bushel, after 1939, was thought to have been caused through over harvesting by the canneries (Lunz, 1950). However, other factors, such as those attributed to environmental degradation, are probably more important (Gracy et al., 1978). Proper shell and/or seed planting will do much to insure continued production from any naturally productive beds.

No mechanical harvesting device is currently used in South Carolina to gather intertidal oysters. All harvesting is done by hand, or hand grabs, with the oyster fishermen physically present on the exposed oyster bank.

Always labor intensive, the South Carolina oyster industry has prospered inversely with general local businesses, usually realizing its highest production when other employment was not readily available. The industry's employment probably peaked about 1930 with about 10 steam canneries in operation and about twice that number of raw-shucking houses in production. The numbers employed during this period must have approached 3,000 persons (Maggioni, 1976).

Oystermen explain the increase in production up to 1933 by recognizing that this was a period of economic depression in South Carolina at which time oysters were in demand and labor, necessary for all phases of the industry's harvesting, shucking and canning, was abundant (Lunz, 1952). The decline in production from 1939 through 1945 is viewed as the result of increasing opportunities and the removal of men from the industry by military service requirements. Also equipment, especially floating equipment, was extremely hard to maintain because of the war (Lunz, 1952). The same situation apparently had occurred during World War I as well as again during the Korean War. It therefore appears that oyster production in South Carolina is a great deal more dependent upon economic conditions than on over harvesting or biological conditions (Lunz, 1952).

3. Description of the Fishery - Recreational and Commercial

3.1. Methods - In South Carolina the oyster industry developed as sea-island cotton and tide-water rice cultivation declined in importance. It began about the same period as phosphate mining although it has outlasted it. The oyster industry also developed concurrently with sea-island truck farming with which it was compatible since it offered alternate winter employment for hand labor. The oyster industry has always been labor intensive, with hand labor still required in both harvesting and shucking operations.

3.2. Gear - The weakest point of the industry is its total dependence on hand harvesting oysters. Harvesting techniques have changed little since the 19th century. Oyster harvesters still use flat bottom boats 16 to 25 feet long, known locally as bateaux, to gather and transport oysters. They are either towed by a larger vessel or propelled with outboard motors to the harvesting area. Upon arrival at the oyster grounds, the pickers spread out over the beds, picking by gloved hand or with short (2-2½ feet) steel grabs. Harvesting continues from ebb tide, through low tide, or until flood tide becomes too high for gathering. Oysters are loaded, generally unculled, into the bateaux for unloading at the processors docks (Lunz, 1944). While several attempts have been made, and at least one is currently in progress, to develop a successful intertidal oyster harvester, none has been adopted for South Carolina commercial application. Until such a harvesting device is developed, the industry will, of necessity, remain dependent on hand harvesting. Unless there are unforeseen socio-economic developments, labor available to the industry will remain limited and commercial oyster production will probably not be able to expand or even reverse its downward trend (Gracy and Keith, 1972 and Gracy , et.al., 1978).

3.3. Seasons - Harvesting and planting seasons are regulated by the South Carolina Code of Laws of 1976 as amended. Oyster harvesting is prohibited between May 1 and September 15 annually (Section 50-17-1240). The Wildlife and Marine Resources Commission can shorten or extend this season by a period of only 15 days. Seed planting can be accomplished during any month by Division permit. "Green shell" can be planted at any time provided such shell is planted within three days of shucking (Section 50-17-800). Shell planting is covered by the same statute and is rigidily fixed between May 15 and August 15, which appears to be the period of most concentrated spat fall.

While a closed harvesting season and limited shell planting requirements are perhaps theoretically desirable, a more useful management approach would be to amend the current law whereby the Division or Commission would acquire the authority to open and close seasons basing such action on current conditions. This would provide the flexibility necessary to adjust to local requirements; thus, allowing more realistic management. Some other states currently provide these management options (Bearden, 1977).

3.4. Harvesting Areas - The majority of South Carolina's oyster production is obtained from intertidal oyster bottoms which are under lease to the producer. Provision for granting exclusive control of oyster growing bottoms are provided for by Section 50-17-710. There are presently 62 leases in the State all of which are intertidal. Of these, 44 are considered to be commercial leases; the remainder, which do not exceed two acres each, are recreational (Sea Island Study, 1979). Public Recreational Oyster Grounds are also provided for the use of State citizens. These are limited to 50 acres per county. Harvesting limits are also imposed on persons using the grounds. Seasonal requirements are the same as for commercial harvesting.

While intertidal oysters can be found in almost every estuarine area of the State, only a small portion of oysters in these regions grow isolated below the low tide mark (Keith and Cochran, 1968). In South Carolina, approximately 1,500 acres of subtidal oyster bottoms are known to exist (Gracy, et.al., 1978). These are mostly small and are, on a limited scale, utilized as a seed source by commercial leaseholders. There is presently little direct marketing of subtidal oysters although some small scale hand tonging is undertaken in Alligator Creek, usually during the winter holidays. Production from this stream in 1978-1979 was only 842 S.C. bushels of oysters. The greatest direct marketing of subtidal oysters has been from limited harvesting in the Santee estuary as ancillary production to hard clam harvesting by hydraulic escalator clam dredges (Sea Island Study, 1979). This oyster production for 1979 was 1,719 S.C. bushels. It has never exceeded this amount since escalator harvesters were first permitted in the Santees during the 1973-1974 season (Leasing and Licensing, 1979).

3.5. Landings - Available records indicate that from about 1888 to 1908, South Carolina oyster landings increased from less than one million pounds to over seven million pounds of meat annually. Afterward production declined rapdily until about 1918-1919 when an upward trend was begun. The 1908 production has never again been equalled. Although almost four million pounds of meat were reported harvested in the late 1920's and again in the mid-1960's, production has generally declined since 1908 (Figure 1), (Gracy, et.al., 1978).

Historically, cannery production has accounted for the majority of the oyster landings in the State. Canning processes are able to utilize the intertidal oyster despite its clustering tendencies, irregular shell morphology and low meat yield. Reportedly, 16 steam canneries operated between 1890 and 1905 (Keith and Gracy, 1972). In 1919, there were five operational canneries in and around Charleston and six near Beaufort (Churchill, 1920).

Despite the adoption of mechanized shucking and meat floating methods during the mid-1950's (Lunz, 1960), harvesting problems have reduced oyster processing in South Carolina to one cannery; the Ocean, Lake and River Fish Company's steam cannery; located on Lady's Island (Beaufort). Concurrent with the cannery reduction, there has been a corresponding decline in oyster landings. In excess of 50% (179,070 S.C. bushels) of the 1977-1978 reported oyster production of 291,336 S.C. bushels is accounted for by the cannery.

In spite of the decline in production, the overall oyster situation in South Carolina is not as bleak as might be surmised. South Carolina is still the major oyster producing state in the Southeastern Atlantic Region. In 1976, it produced over 50% of the total recorded oyster harvest for the regions four states of North Carolina, South Carolina, Georgia and

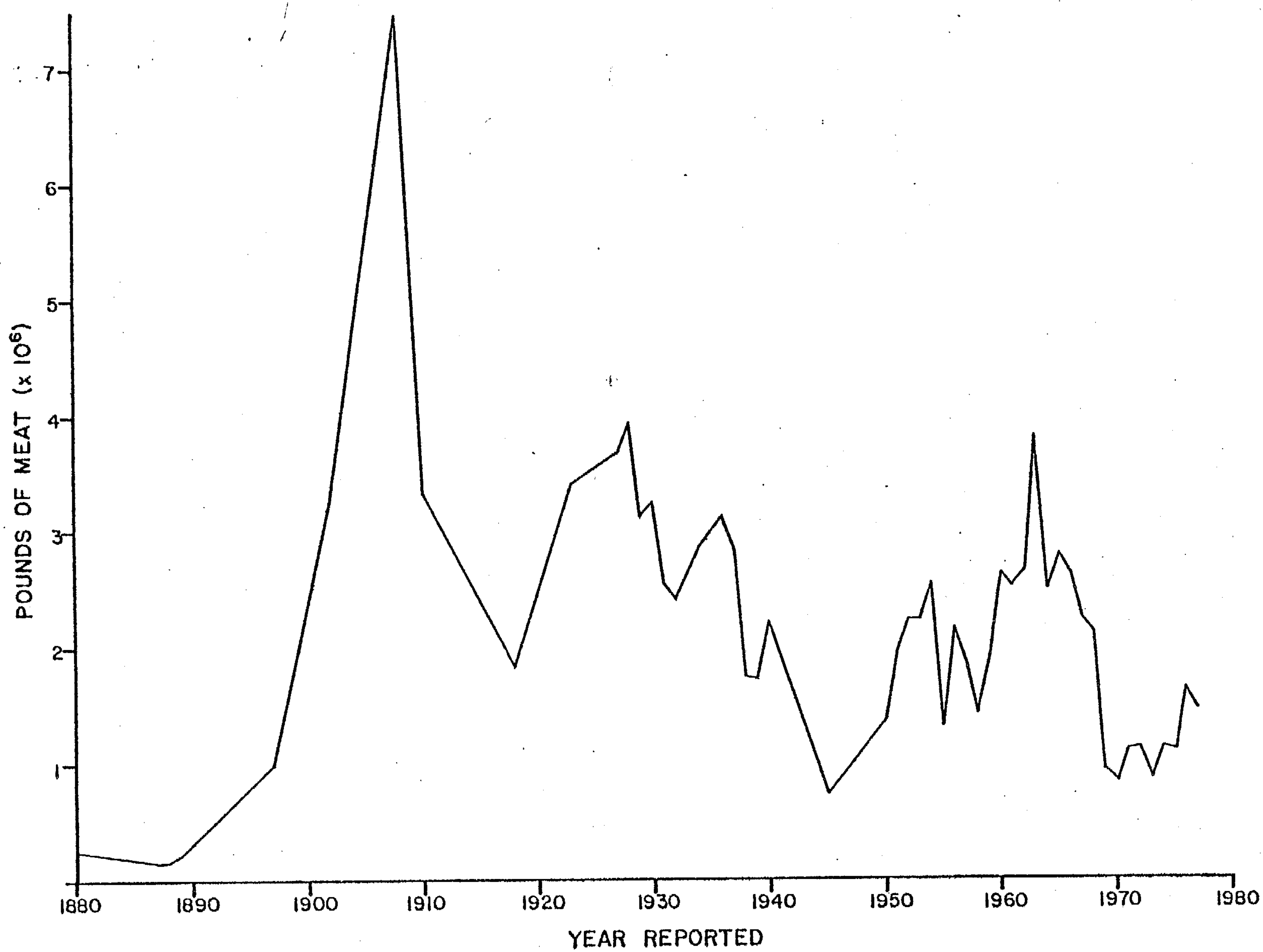

Figure I. South Carolina Oyster Production (pounds of meat) 1880 to 1978.

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Florida (east coast) (Table 2). Currently, production is about as high as it has been during the past decade.

The demand for South Carolina oysters continues to be strong with the price of canned oysters restrained by the presence of Korean imports in the retail market. The demand for shell stock, and to some extent raw shucked oysters, is seasonal. The demand becomes strong about Thanksgiving, peaks around Christmas and New Years then falls rapidly with the advent of warm weather (Maggioni, 1976). Canned oysters appear to enjoy a year around market.

3.6. Structure - South Carolina oyster production is presently categorized into three major marketing segments:

1. Canned - Steam canned oysters
2. Raw shucked - Opened raw or "shock assisted" by the "thermal-dip" method. Packaged in containers which have to be refrigerated.
3. Shell stock - Priced according to shell quality. Utilized almost entirely for private oyster roasts.

The Lady's Island oyster cannery accounts annually for 100% of the canned oysters produced in the State and for about 50% of the commercially harvested oysters. This operation is characterized by a high degree of vertical integration from harvesting to wholesale inventory control. Shell obtained from canning operations is returned to the oyster bottoms via barges and tow boats utilizing high pressure water hoses to wash the shell overboard. Intertidal oysters, generally of the cluster variety, are bought from fishermen working on the company's leases or from other leases through agreement. Price is based on the S.C. bushel as the standard unit of measure. Payment is made upon delivery to the company's dock.

The second category is raw shucked oysters. Shucking is accomplished by hand, either with a completely fresh oyster such as practiced by the Bluffton Oyster Cooperative, or with an oyster which has been shocked into

Table 2. Pounds of meat and ex-vessel value (dollars) of oysters harvested four South Atlantic States from 1973-1977.[a]

	1973		1974		1975		1976		1977	
STATES	POUNDS	DOLLARS	POUNDS	DOLLARS	POUNDS	DOLLARS	POUNDS	DOLLARS	POUNDS	DOLLARS
North Carolina	548,431	$ 446,485	558,821	$ 435,804	424,831	$ 329,794	333,315	$ 292,058	365,714	$353,581
South Carolina	878,014	505,362	1,119,021	657,308	1,036,401	616,549	1,187,077	759,063	1,280,962	866,725
Georgia	105,998	65,122	64,664	36,040	44,062	25,613	71,839	49,240	87,221	75,009
Florida-East Coast	122,389	98,505	97,724	85,523	79,417	76,891	111,781	114,267	Not Available	Not Availabl
TOTALS	1,654,832	$1,115,474	1,840,230	$1,214,675	1,584,711	$1,084,847	1,704,012	$1,214,628	Not Available	Not Availabl

[a] Data from National Marine Fisheries Service, NOAA, Dept. of Commerce.

a partially opened state by the "thermal dip" method as used by the Carolina Seafood Company. Regardless of the method, meats are removed by hand from the shell and packaged in one-half pint, one-pint or gallon containers for sale to retain outlets or directly to the consumer (Rhodes, 1974). From 1972-1977, raw-shucked oyster meat production ranged from a recent low of 21,460 in 1977-1978 to a high of 34,181 gallons in 1972-1973 (Table 3) (Leasing and Licensing 1979).

Table 3. S.C. Raw-Shucked Oyster Production 1971-1978

Year	S.C. Bushels Shucked	Gallons Produced
1971-1972	56,553	28,276
1972-1973	68,362	34,181
1973-1974	55,850	27,925
1974-1975	61,680	30,840
1975-1976	53,050	26,525
1976-1977	44,617	22,308
1977-1978	42,920	21,460

Seafood firms dealing in raw shucked oysters are characterized by horizontal integration; especially the wholesaling of shrimp. Personnel used in raw shucking operations are also often utilized in shrimp packing activities. (Gracy, et.al., 1978).

The third category is that of shell stock sales. Most of these sales are probably to individuals for use at private oyster roasts. While small quantities in this category may come from State Grounds such as Alligator Creek, most producers are leaseholders. Shellstock businesses are often family owned and many may be involved in other types of commercial fisheries.

In most cases, the fisherman who actually harvests the oysters does not control any leases, but will periodically work for different leaseholders. These independent harvesters will occasionally take personal orders from private parties, which in some cases may promote illegal harvesting and raw shucking activities.

A special category of operations has developed mostly around the Murrells Inlet area. Oysters harvested from leases within Murrells Inlet are frequently sold as a prepared food product, i.e. steamed or half-shell, in the leaseholders restaurant. This, of course provides a higher margin of profit than the average leaseholder can realize.

3.7. Economic Aspects - As previously stated, employment dropped sharply during World War II, recovered to some extent afterward and dropped again about the time of the Korean War. Since that time, it has not approached former levels. The advent of minimum wage laws, and to some extent application of mechanical shucking methods in the 1950's, reduced cannery employment. Through the 1950's, only three canneries remained in production. About the end of the decade of the 1950's, alternate coastal employment, such as in construction, began to become available. In the 1960's, expanded welfare programs resulted in further attrition of the labor supply (Bearden, 1977).

3.7.1. Number of Fishermen - In 1975, there were 384 persons engaged in the industry. A survey conducted during that year, the last year for which figures are available, categorizes this number into 13 boat operators, 173 pickers, 129 shuckers and 69 miscellaneous personnel (Gracy, et.al., 1978). Current employment is probably about 350 persons; however, exact numbers are not known. The lack of labor recruitment into the industry is reflected in the average ages of those currently employed. Less than one percent of those engaged in the South Carolina oyster industry in 1975 were less than 30 years of age (Gracy, et.al., 1978).

3.7.2. Number of Vessels - The number of vessels and floating equipment is consistent with the general lack of harvesting personnel. In 1975, there were 195 vessels in service. These ranged from 16 foot gathering boats to vessels capable of carrying in excess of 1,000 South Carolina bushels of oysters. Categories were; 184 gathering or transport vessels, nine tow boats, two mechanical harvesters and 126 outboard motors, mostly for use by the gathering boats (Gracy, et.al., 1978). The two experimental mechanical harvesters failed after tests and are no longer in service. Tow boats and gathering vessels should not have decreased appreciably except for a few of the smaller gathering vessels.

3.7.3. Market Channels - South Carolina canned oysters no longer appear in local retail outlets. A large portion of the cannery production is shipped into the Atlanta area. Foreign imports, especially those from Korea, tend to restrain the price of locally canned oysters (Maggioni, 1976 and 1978). However, the demand for South Carolina oysters continues to be strong.

Raw shucked oysters are marketed largely within the State although some production is introduced into interstate commerce. The demand for raw shucked oysters is largely seasonal, peaking during the Fall and Winter holiday seasons and falling rapidly with the advent of warm weather. Sales are usually directly from the producer or from the producer to local retail groceries. Retail establishments generally stock containers of half-pint and pint sizes. The producer frequently sells in gallon cans.

Shell stock is sold mostly within the State. Of the 63,346 South Carolina bushels of shell stock sold in 1977-1978 season, only 10,063 bushels left the State. The demand for shell stock closely parallels that for raw-shucked oysters. Two grades, select and cluster, are generally offered. A sale price of often twice as much for select shell stock is not uncommon. Few retail outlets handle shell stock. Most is either retailed or wholesaled directly from the producers establishment.

No other marketing categories presently exist in South Carolina. Consideration should be given to marketing alternatives. Additional categories, such as frozen breaded oysters, might be developed. Frozen oyster products facilitate handling, increase shelflife and are amenable to diversification in packaging, display, arrangement and advertising all of which appeal to large retailers (Gracy, et.al., 1978). If production could be increased, institutional buyers would provide a potentially large outlet for frozen oyster products (Sea Island Study, 1979).

4. Present Management System

4.1. Management Policies - The present shellfish management system in South Carolina has evolved over the past half-century. It is based upon extensive experience and biological knowledge gained during that time. The primary objectives of this system have been to maximize shellfish production and to protect the resource from environmental damage. Through legislation and regulations, the Marine Resources Division administers the State oyster bottom leasing system, controls seasons, harvesting areas and types of gear used. The Division is responsible for overseeing the management of commercial shellfish grounds, including the monitoring of shell and seed planted by lessees, and the maintenance of public recreational shellfish areas.

The Office of Conservation, Management and Marketing (OCMM) is assigned the responsibility by the Division for the management and regulation of coastal fisheries resources, including shellfish. Routine functions of the OCMM, related to oyster resources, include the administration of the shellfish leasing system, the issuance of licenses and permits, collection of license and tax revenue, the regulation and control of shellfish areas, seasons and harvesting methods. Other activities include resource surveys, legislative recommendations and the implementation of management programs aimed at the conservation and development of the State's shellfish resources. Management activities are implemented through OCMM sections.

The Shellfish Management Section (SMS) of the OCMM has the primary responsibility for collecting information and making recommendations relevant to the management of the commercial oyster fishery. The SMS has routine duties including the monitoring of shell and seed planting on oyster leases, surveys of intertidal oyster leases and conducting special shellfish surveys as needed. This Section is also responsible for management, survey and development of other commercial shellfish, both estuarine and marine in habitat.

The Recreational Fisheries Section (RFS) of the OCMM is assigned the responsibility for recreational shellfish management. No specific State funds are appropriated for this purpose. Prior to the 1975-76 fiscal year, planting of shell and seed oysters on public grounds has usually been limited to the required 5% of the quota of raw shuck houses and canneries located within 20 miles of these grounds, (Section 50-17-790), plus whatever funds the Division was able to provide from its other appropriations. Since 1975, infrequent grants have been awarded to the Division for development and maintenance of Public Oyster Grounds.

Currently, there are only two full-time permanent personnel assigned to the Shellfish Management Section. It is usually necessary to rely on temporary employees for contractual projects and part-time summer aides to monitor shell and seed planting. The current annual budget of this Section is approximately $70,000; however, this total currently reflects salaries for four persons, two of which work exclusively offshore.

The Recreational Fisheries Section has provisions for more permanent personnel, but is severely restricted in public shellfish management because of a lack of both annual funding and an assigned shellfish biologist.

4.2. Laws and Regulations - A variety of statutes govern shellfish bottoms, ownership, harvesting methods, seasons and other special requirements of the oyster fishery. These laws are periodically amended and published in the South Carolina Code of Laws. In the Code of Laws, they are not abridged. The following is an abridged summary of laws pertaining to shellfish. The full text is available in the current (1976) statutes (S.C. Code of Laws for 1976).

SUMMARY OF SHELLFISH LAWS AND REGULATIONS

S.C. MARINE RESOURCES DIVISION

ARTICLE I

(Definitions)

SECTION

50-17-20 (1) "Fish" includes finfish, shellfish, crustaceans, turtles and terrapin;

(2) "Shellfish" includes oysters, clams, mussels, scallops and all immobile fish having shells;

(3) "Crustacean" includes crabs, shrimp, crayfish, stone crabs and any other mobile fish having a shell;

(4) "Bottoms" includes all of the tidelands of the State covered by water at mean high water; and

(5) "Fishing and Fisheries" includes all operations involved in taking or catching fish and preparation and transporting them to market.

ARTICLE 3

Licenses and Taxes

SECTION

50-17-310 Provides for a tax of one and one-half cents per bushel on oysters harvested for market in S.C. and additional ten cents per bushels on oysters harvested in S.C. and exported out of State. Also provides for a tax of five cents per hundred pounds on clams.

SECTION

50-17-320 Requires a tax of two cents per bushel on seed oyster exported from S.C.

SECTION

50-17-350 Licenses required on floating equipment for taking shellfish for markets.

(1) On each barge or lighter not self-propelled of five tons or over, $15.00, or less than five tons, $5.00.

(2) On any self-propelled boat, barge or lighter less than customhouse tonnage, $3.00, and on any boat registered in U.S. Customhouse $1.50 per gross ton.

SECTION

50-17-450 Dealer and Processor Licenses

(1) Shellfish canner - $100.00

(2) Shellfish shucker - $25.00

(3) Shellstock buyer and shipper - $20.00

ARTICLE 5

(Shellfish Leases)

SECTION

50-17-710 Lease Authorization

Provides that S.C. Wildlife and Marine Resources Commission may lease State bottoms to S.C. residents for Shellfish culture, not to exceed 1,000 acres per person for commercial purposes, or two acres for other purposes. Also provides that leases not exceed a term of five years, but shall be renewed for an additional five years at the option of the lessee.

SECTION

50-17-720 Lease Preference to Owners of Adjacent Highlands

Provides that any person owning highlands abutting tidewaters may lease up two (2) acres of bottoms adjacent to said highlands for oyster culture.

SECTION

50-17-730 <u>Application for Lease</u>

Provides procedures for applying to Marine Resources Division for the leasing of State shellfish bottoms. Includes application forms, fees, description of area, survey requirements, etc. Also provides for perimeter boundaries and specify that no other lease shall be granted within said boundaries during the term of said lease. Lessee shall have first opportunity to lease any additional areas suitable for shellfish culture within perimeter boundaries of lease upon the renewal of the lease.

SECTION

50-17-740 <u>Notice of Application</u>

Provides that approved leases be advertised in a newspaper, notifying the public of the applicant's intent to lease a described area.

SECTION

50-17-750 <u>Hearing or Objections; appeal</u>

Provides for Commission hearings in the event of objections to the leasing of bottoms applied for, based upon lawful or sufficient ground. Preference to leasing bottoms shall be given to applicants holding the lease on such bottoms for the term immediately preceding the term for which application is made.

SECTION

50-17-760 <u>Annual Rental for Shellfish Bottoms</u>

Provides an annual lease rental of $1.50/acre.

SECTION

50-17-770 <u>Payment of rental - forfeiture for non-payment</u>

Provides annual payment schedule for lease rental and for lease forfeiture for non-compliance.

SECTION

50-17-780 <u>Recordation of Leases; cancellation</u>

Provides that all oyster leases must be recorded within thirty days in the Office of Clerk of Court or mesne conveyances of the county where such leased bottoms are located. Also, requires that lease expirations or cancellations be likewise recorded.

SEDTION

50-17-790 <u>Planting of Shell or Seed Oysters by Lessees</u>

Provides that each lessee shall plant 65 bushels of shell or seed oysters per leased acre per year. All shell (except green shell) shall be planted between May 15 and August 15. Also requires that shell planting be under supervision of the Marine Resources Division, which may require 5% of total quota of shells from canneries or shucking houses to be planted on State bottoms. Leases or portions of leases from which oysters are harvested may be set aside for growth and propogation for a period of two years without replanting, but the total quota of shell or seed to be planted by lessee during any year shall not be diminished.

SECTION

50-17-800 Gathering Seed Oysters for Planting for Lessees

Provides for gathering of seed oysters by lessees from public beds for replanting on leased grounds, as permitted by the Division.

SECTION

50-18-810 Revocation of Leases for Non-Cultivation

Provides that leases may be cancelled after a period of one year, if not effectively cutlivated or harvested.

SECTION

50-17-820 Transfer of Leases

No leases shall be transferred from one person to another without Commission endorsement.

ARTICLE 9

(Shellfish Generally)

SECTION

50-17-1210 Gathering of Shellfish

Requires that permission must be obtained for gathering shellfish on State-owned and leased bottoms. Also, provides that the head of any household may, in person, or by employee, gather for private use not more than two bushels of oysters and/or one-half bushel of clams for not more than two days in any week from any unleased State bottoms.

SECTION

50-17-1220 Workers employed to handle shellfish must have an annual permit issued by the S.C. Department of Health and Environmental Control.

SECTION
50-17-1230 Minimum Depth for Dredges, etc.

Unlawful to use dredges, scoopers, scrapes for taking shellfish in waters less than 12 feet deep on low tide without a permit from the Department.

SECTION
50-17-1240 Closed Seasons for Shellfish

(1) Oysters - May 1 - Sept. 15; (2) Clams - June 1 - Sept. 1. Season may be opened early and/or extended by 15 days. Does not apply to permitted replanting operations. Possession of clams or oysters during closed season is prima facie evidence of violation.

SECTION
50-17-1250 Ownership of Oyster Beds

S.C. Wildlife and Marine Resources Department may lease any bottoms owned by the State for shellfish cultivation, mariculture, or as is it may determine.

SECTION
50-17-1260 Public Oyster Grounds

Provides that areas not exceed fifty (50) acres per coastal county; shall be maintained (and marked by signs) for gathering shellfish for personal use by State residents. Provisions of 50-17-1260 not applicable to areas for Cherry Grove Beach in Horry County.

SECTION

50-17-1280 Cultivation of Seed Oysters for Market

Provides that the Division of Marine Resources shall require licenses for cultivating seed oysters; that no seed oysters shall be produced on unpolluted lands leased for marketable oyster culture; that seed oysters shall not exceed 1½ inches in length; provides that the volume of seed oysters shall be measured by S.C. bushels; that no shell planted for the culture of market oysters be used for seed oyster culture.

SECTION

50-17-1290 Standard Measures

Provides that standard S.C. bushel measurements be used for taxes or license purposes.

SECTION

50-17-1300 Purchase of Shucked Oysters

Provides that persons shucking raw oysters who purchase previously shucked oysters show such purchases separately on their records and monthly reports. No shuckers shall purchase shucked raw oysters from other than approved shellfish dealers.

SECTION

50-17-1310 Records and Reports

Requires that all persons licensed to deal in shellfish shall keep records as required by the Division and shall furnish such records to the Division at such time it may prescribe.

SECTION

50-17-1320 Provides penalties as specified in Section 50-17-130 and any violations of Article 5.

SECTION

50-17-1330 Unlawful to harvest shellfish commercially between Pawleys Inlet and Midway Inlet in Georgetown County.

RULES AND REGULATIONS

No.

123-25 Provides that each vessel harvesting shellfish for market shall display an identification number issued by the Marine Resources Division. The number shall be issued to all commercial operators holding shellfish leases and permits for harvesting shellfish. The number shall be valid only for harvesting shellfish on the lease or area for which it is issued.

NOTE: In addition to the above laws and regulations of the Marine Resources Division (MRD), the S.C. Department of Health and Environmental Control (DHEC) also has a number of regulations pertaining to the sanitary quality of shellfish, promulgated under Section 61-47 of the S.C. Code of Laws for 1976, as amended. Under these regulations, permits are required by any person selling or possessing (other than for personal consumption) shellfish. All shell stock (shellfish in the shell) offered for sale must be identified by a DHEC tag attached to the shipping container bearing the name, address, and certificate number of the shipper as well as the kind and quantity of shell stock in the container.

Regulations also require that any person operating a shucking, packing, repacking or shell stock plant must have a certificant from DHEC.

Other regulations require permits from DHEC for harvesting and relaying (transplanting) shellfish from polluted waters, and various specifications, etc. related to shucking, processing and handling of shellfish. (The above summary of laws and regulations of the Marine Resources Division and DHEC are subject to change and are presented for reference only).

A draft copy of a bill, proposed to be submitted to the South Carolina legislature for the purpose of updating and clarifying shellfish laws, will be found in Appendix I of this Profile.

5. Current Research and Monitoring Programs

5.1. Objectives - The objective of all oyster research programs sponsored by the Marine Resources Division has been to provide for optimum sustained yield of the resource consistent with accepted management practices. Research and management programs are directed at improving both the quality and quantity of the resource.

Presently, the Shellfish Management Section is conducting two formal survey programs for offshore shellfish; whelks and calico scallops. It is not currently engaged in any oyster programs other than routine management activities such as monitoring lease shell and seed planting and general supervision of private oyster gathering. However, recently two proposals have been drafted; one to attempt to acquire funding for a comprehensive intertidal oyster survey and another to assist in the development of a practical intertidal oyster harvester.

Although no formal oyster research programs are currently being carried out by OCMM, some significant accomplishments of the Shellfish Management

Section during the past few years include:

(a) Block Leasing - The completion of a revised "block leasing" system for all oyster leases in the coastal area. This system provides, under current laws, the basis for improved management and control of leased areas.

(b) Subtidal Survey - A survey of the subtidal oyster and clam resources on unleased subtidal bottoms of the State has been completed.

(c) Area Surveys - Comprehensive surveys of intertidal oysters (and subtidal clams) in the Little River and Murrells Inlet areas, under contract with the U.S. Army Corps of Engineers, have been accomplished. Information gained during the surveys was used in preparing environmental impact studies concerning proposed jetty construction in those areas.

(d) Shell Planting - Development of an improved system, within personnel limitations, for the monitoring of shell and seed planting by oyster bottom leaseholders.

(e) Lease Surveys - Surveys, including the preparation of plats, of numerous oyster leases at no cost to the lessees.

Also, the Marine Resources Research Institute (MRRI) has been engaged in a variety of oyster studies since 1972. Some if its more significant oyster programs have been;

(a) Tray Culture of Subtidal Oysters - Since 1972, experiments on the growth and survival of subtidal seed oysters in plastic trays have been conducted in various areas of the State's coastal zone. This study was completed in May 1976.

(b) Off-bottom (String) Culture of Subtidal Oysters - Studies investigating the feasibility of off-bottom oyster culture were initiated in the summer of 1976. Rigid structures were constructed at seven locations to support string culture of subtidal oysters. This study, which incorporated several ancillary objectives continued through the spring of 1978.

(c) Mechanical Harvesting - In attempts to revitalize the intertidal oyster industry of South Carolina, personnel at MRRI in cooperation with engineers from Clemson University have worked on increasing the efficiency of intertidal oyster operations by attempting to introduce harvesting mechanization. A prototype mechanical harvester was developed and field tested in 1975-76. Modifications suggested through the field tests are presently being incorporated in the design and a new prototype harvester should be available for testing sometime during 1979.

(d) Oyster Recruitment Monitoring Program - In order to provide the industry with information on the time and intensity of oyster population recruitment, MRRI instituted monitoring stations on the Wando and North Edisto Rivers in May 1972. This survey was expanded to include a total of 13 stations covering the State from Murrells Inlet to Beaufort. Stations were sampled every 10 days to determine the time and intensity of oyster strikes. Shell bags are used seasonally to estimate survival and growth of each year's recruits.

(e) *Labyrinthomyxa marina* Monitoring Program - South Carolina oyster populations occasionally suffer from endemic infestiations of a fungal disease caused by *Labyrinthomyxa marina*. Monitoring oyster populations on a regular basis was begun in September 1972. Monthly samples from the Wando River were analyzed for presence and intensity of fungal infections. In addition to these samples, oyster populations throughout the State were sampled on an intermittent basis as circumstances and time permitted.

(f) Hydrography - Aside from the hydrographic data generated through the experimental aspects of the oyster program, routine hydrographic studies are performed in the Wando River. These studies, instituted in May 1972, provide monthly biological, chemical and physical data which will be used to characterize intertidal and subtidal oyster grounds. In February 1976, monthly hydrographic sampling was reduced to quarterly sampling to allow more staff time in oyster culture studies.

(g) Cultch Planting Program - In order to formulate a cultch planting program to maintain and enhance subtidal seed beds, several shell plantings and transplantings have been performed. Principal plantings occurred in July 1973 and August 1975. On both occasions 3,000 bushels of shells were broadcast over subtidal oyster beds in the Wando River. These plantings were designed to assure continuous supplies of subtidal seed oysters for various projects performed through the MRRI Oyster Project in concert with the South Carolina oyster industry.

(h) Condition Index - In order to determine the condition of oyster meats at various times of the year, a condition index project was undertaken in May 1973. This monitoring program provides information on oyster meat yields throughout the year and could eventually be used as a predictive tool in establishment of harvesting schedules for the oyster industry. Since 1974, monitoring meat yields have been performed on oysters provided through the oyster industry.

(i) Artificial Cultch Investigation - A cooperative study with the Ceramic Engineering Group at Clemson University investigated the efficiency of using reconstituted dredge spoil as a substitute for oyster shell for cultch was completed in 1973. A concurrent study, with the help of Westvaco showed that paper box trimmings dipped in concrete were as efficient as natural shell as attachment surfaces for young oysters.

(j) Trace Metals,Determinations in Oysters - Concentrations of selected trace metals (mercury, lead, iron, copper and others) have been determined in South Carolina oysters since 1973. Oysters containing high levels of copper were moved from a polluted estuary to unpolluted waters in order to determine how much time is required for their copper content to reach levels similar to oysters native to the clean area. Preliminary results indicate that this takes about nine months. This work is continuing with other metals.

5.2. Problems and 5.3 Funding Levels

The majority of the monies received for both research and management have been through grants or matching funds. Operations, especially annual management activities involving both commercial and recreational shellfish grounds are difficult under this funding system. Currently, only two shellfish biologists are permanently assigned to the Shellfish Management Section and none to the Recreational Fisheries Section. Additional personnel should be funded if an adequate management effort is to be continued especially since many of the Shellfish Management Section functions are required by law.

6. Identification of Problems

6.1. Biological

6.1.1. Environmental - The present shellfish management system, in spite of past accomplishments, is not adequate and is currently operating under a number of constraints which limits its effectiveness. Some major constraints include biological information gaps on effects of environmental degradation, habitat alteration, growth determinants, natural factors affecting set, survival, growth, meat quality and shell configuration. Also, there is insufficient data as to the effects of environmental conditions, as sedimentation and salinity on shellfish growing areas, inadequate information on substitute cultch materials, limited knowledge of shellfish diseases and predators and insufficient information concerning optimum methods, areas and times of year for planting seed and shell.

The general lack of commercially harvestable subtidal oysters has been recognized by authorities since at least the late 19th century (Battle, 1890). Although several theories concerning a lack of spat set have been promulgated; such as high salinity, soft bottom, etc., no conclusive proofs have, to date, been found. Perhaps, the discovery of the natural inhibitor of subtidal oyster survival would allow expansion of currently very limited subtidal oyster production.

6.1.2. Information Gaps - A major constraint to the management of shellfish resources is the lack of comprehensive survey information on the location, acreages and qualitative aspects of existing and potential intertidal oyster bottoms. Although recent coast-wide surveys of subtidal oyster and clam growing areas have been carried out, no detailed survey of leased and unleased intertidal oyster bottoms has been conducted. A project proposal for an intertidal oyster survey was drafted and recently submitted for funding considerations. Other information gaps include; inadequate statistics on the commercial and recreational oyster harvest, incomplete information concerning the acreage and potential of intertidal oyster growing areas, insufficient social and economic data related to the fishery, institutional problems and inadequate management personnel and funding.

6.2. User Related

6.2.1. Space Competition - Currently, there appears to be no pronounced competition for shellfish bottoms among various segments of the shellfish industry. Hard clams and oysters are found on bottoms having similar conditions; however, their harvesting has not yet produced insurmountable conflicts wihtin the industry. The annually increasing value of clams will undoubtedly promote intensified harvesting and will probably encourage clam mariculture operations. If existing oysters beds, or bottoms reasonably capable of supporting oysters, are distributed or are otherwise denied to oyster production then bottom utilization conflicts will certainly result.

6.2.2. Commercial versus Recreational - With the growing number of permanent coastal residents, coupled with the pronounced mobility of the general public, both on land and water, there has been ever increasing competition between commercial and recreational fishermen for South Carolina oyster resources.

The bottoms allotted to recreational grounds were either donated by leaseholders or were unleased bottoms already under State control. By law, (Section 50-17-1260), acreage is limited to a maximum of 50 acres per county. Some recreational areas such as the Pinckney Island, Murrells Inlet and Folly Island areas are seasonally depleted of oysters. Other locations such as Toogoodoo Creek and Otter Island are lightly utilized. When the designated public areas no longer contain harvestable oysters, some recreational fishermen harvest from adjacent leases. Often this unauthorized harvesting is quite pronounced.

Presently, there are no annual State sppropriations for maintenance of existing Recreational Oyster Grounds. Funds are sometimes acquired from Federal grants and are applied to seeding and marking the perimeter of the grounds. However, these funding sources are not adequate and are not available with any degree of certainty. No effective management practices can be accomplished under these conditions.

Annual State appropriations, sufficient to properly cultivate existing Public Recreational Oyster Grounds, and the retention of a full time shellfish biologist to manage these grounds, are necessary if the State is to fulfill its current commitment of maintaining shellfish bottoms for recreational use.

6.2.3. Impact of Non-Resident Entry - State law (Section 50-17-710), prohibits the issuance of leases to non-residents; likewise, only residents can gather shellfish from State bottoms and Recreational Oyster Grounds (Sections 50-17-1210 & 50-17-1260). In the past, businesses from out-of-state have incorporated under the laws of South Carolina and have been allowed to lease shellfish bottoms. Currently, this procedure would probably also apply if the prospective lessees could meet the established leasing guidelines (Appendix II) and there was unleased acreage available for leasing.

6.2.4. Pollution Control - Raw shucking activities produces relatively low levels of processing waste. Waste which does occur can be handled with minimum facilities which should be within the financial capabilities of the shucking establishment. The oyster shell is, from a standpoint of bulk, the major by-product of shucking operations. Shell however, is easily stored without deterioration and is ultimately utilized in required planting activities during the Summer months.

Steam canning of oysters produces a larger quantity of waste. The one operational cannery handles many times more oysters than the largest raw shucking producers thus multiplying any waste disposal problems. Water, carrying both liquid and solid waste, must be disposed of satisfactorily. Quantities of shell are accumulated, and while they are disposed of during seasonal planting activities, their bulk requires a suitable storage area. Increasingly stringent State and Federal health standards will ultimately cause additional expenses to be incurred by producers. These may be prohibitive to continued production. A possible solution would be relocation of canning operations to the proposed Seafood Industrial Park near Beaufort. Here centralized waste disposal facilities for both processors and vessels would meet all State and Federal requirements (McKenzie, et.al., 1976).

Shell stock handling and sales produce no waste products other than mud washed from the shells. There is no processing and shell is not usually returned to the producer since there is no legal requirement to do so.

6.2.5. Industry Organization - The lack of an effective shellfish industry organization makes it difficult for management to adequately determine the desires and needs of the industry and weakens the influence of the industry in matters of importance (Bearden, 1977).

Within the State, there is no trade association, formal or informal, to present the views of the industry. Approaches from the industry and resource user groups to management and others in authority have been piecemeal. Legislative proposals have in the past often been fragmentary. Legislation has generally been introduced at the request of individuals who may not have considered the total ramifications of their proposals.

An association of oyster, or shellfish producers, organized as a professional trade group, would provide a means to the industry of expressing its needs and influencing management activities.

6.2.6. Delineation of User Groups - Resource user groups can conveniently be divided into the broad segments of commercial and recreational utilization. Industry's interests can further divided into the marketing categories of; shell stock, raw shucked and canned products. Industry is concerned with exploiting the oyster resource in a manner best suited to producing maximum sustained yields. Also, it is interested in retaining, or re-enforcing, private property rights to segments of the resource through a leasing system. This security is necessary to encourage investment, proper management practices and to avoid depletion of the resource.

Recreational users can be sub-divided into those who harvest from State controlled bottoms and those who have acquired recreational leases, of two acres or less, due to rights acquired through riparian (high-land) ownership. Presently, there are approximately 100 acres of oyster bottoms identified for recreational harvesting. Some have recently been planted with seed and some have not. Consequently, some grounds are in good condition and some are not. The lack of annual funding for cultivation promotes the practice of highly selective planting.

Users of State controlled bottoms are governed only by seasons and weekly limits on shellfish harvested for personal use. They incur no license or permit fees and are not required to return shell to the beds. Obviously, they have very limited responsibilities toward resource management. Recreational lessees also have to abide by seasonal restrictions, but may harvest in any amount from personal recreational leases. They are also required to plant the same quota per acre, 65 S.C. bushels of seed and/or shell, as commercial leases.

6.3. Economic

6.3.1. Marketing - Only a small portion of any seafood resource harvested from South Carolina waters is processed and sold within the State. Local processing facilities are few in number. Currently, there is only a very limited promotional program directed toward local consumption although this situation should gradually improve.

The completion of the proposed South Carolina Seafood Industrial Park near Beaufort would, if properly utilized by the industry, do much to alleviate the current lack of long term product handing and processing facilities (McKenzie, et.al., 1976). Diversified processing and packaging might expand demand for local shellfish products and, in conjunction with an advertising program, provide an increased monetary return to the producer.

6.3.2. Labor Supply - The most serious and immediate problem confronting the oyster industry is the inadequate supply of labor needed to harvest intertidal oysters (Stein, 1979). Continued use of labor-intensive technology, especially in harvesting, hampers attempts to increase or even sustain production. This technology is; however, used from necessity. To date, no practical mechanical intertidal oyster harvester has been introduced into the State although recent research could possibly perfect such a device. Considering current socio-economic conditions, large numbers of hand laborers will probably never again become available to the industry. The most certain method of overcoming the non-availability of harvesting labor is to encourage the perfection of a harvesting device which can be easily operated with a minimum number of permanent personnel.

6.3.3. Recreational Economic Aspects - There is no specific information concerning the use of Public Oyster Grounds. This deficiency should be overcome as quickly as possible since such information is essential in planning for future recreational management needs.

An immediate approach would be to conduct a mail survey of a sampling of registered South Carolina boat owners. Such a survey would provide estimates as to magnitude of use. A long term action would be to provide for a license or permit requirement, if the State legislature decided to do so, for harvesting from Public Recreational Oyster Grounds. This requirement would provide the basis for a more comprehensive user survey. Also, it would provide annual funds for cultivation of public grounds which are presently lacking.

6.3.4. Costs versus Earnings - There are no known studies dealing with the local oyster industries operational and production costs. Individual leaseholders, shell stock dealers, shucking house operators and the cannery manager are undoubtedly aware, in varifying degrees of detail, of their expenses and profits. A detailed economic study should be implemented to provide data not now available for knowledgeable coast-wide management decisions.

6.4. Management, Regulatory and Administrative

6.4.1. Legislative and Regulations - Some of the statutes controlling oysters are archaic, inadequate or unusually restrictive. Improvement is needed in laws affecting such areas as lease rights, cultivation, harvesting and the overall management system. Suggestions for the amendment, deletion or implementation of new laws are found in Part VI.

6.4.2. Enforcement - Coastal fisheries law enforcement is not controlled by the Marine Resources Division as it once was by its predecessor, the Division of Commercial Fisheries. The previous system of enforcement placed Commissioned Fisheries Inspectors on shell planting vessels and allowed for monitoring of a high percentage of individual cultivation management activities.

It is the stated policy of the Law Enforcement Division to assist OCMM in such areas as the control of out-of-season harvesting, exceeding harvesting limits on State bottoms and removal of shellfish from polluted waters. However, implementation of viable policies regarding prosecution of poaching (trespass) on leased bottoms and requiring monitoring of legally required planting of leased shellfish bottoms would do much to improve oyster mangement.

The diversified activities of the current Division of Law Enforcement, personnel limitations and its operational structure allows only a minimal effort to be directed toward oyster management activities. Direction at the Departmental level may be the most feasible method of generating additional effort toward monitoring harvesting and cultivation requirements.

6.4.3. Common Property Rights - In South Carolina the State, with few exc tions, controls tidal bottoms from the mean high water (MHW) mark to three miles offshore. There are only three known means by which tidal bottoms have been conveyed to private citizens; a Proprietary land grant, a Crown land grant, both requiring unbroken chain of title to be currently valid, and a State legislative grant. Although no survey has ever been conducted, oyster beds controlled through grants probably amount to substantially less than 500 acres. This is less than 5% of the total oyster bottom acreage in the State.

No subtidal oyster beds have ever been leased by the State. Preference has been to retain these beds for common use under acceptable controls. Some intertidal bottoms are not leased for the specific purpose of providing non-leased commercial and recreational harvesting areas. Actual utilization by the industry appears small. These areas, when used at all commercially, provide mostly seed oysters for relaying.

6.4.4. Assessment of Management Policies - Available funding has not allowed adequate means to address, to the required degree, all areas of oyster management. Numerous biological and socio-economic informaton gaps exist. Monitoring of, and assistance in, cultivation and harvesting practices will require additional funding if current efforts are to be expanded or, with rising costs, even maintained. Not withstanding the complexity of the problems related to oyster resource management in South Carolina, the Marine Resources Division has, through the Office of Conservation, Management and Marketing, provided assistance to the industry and community in such areas as leasing surveys, monitoring planting requirements, surveying subtidal oyster bottoms, issuance and control of harvesting permits, transplanting experiments, etc. Limitations imposed by current funding levels will not allow for an appreciable expansion of services. The acquisition of additional full-time Shellfish Management Section personnel should be given high priority.

6.4.5. Limited Entry - There is no direct statutory authority to restrict the number of persons engaged in the oyster fishery. However, there is a degree of control due to legal provisions that allow only State residents, or organizations incorporated under South Carolina laws, to lease oyster grounds.

The most productive oyster grounds in the State are already under lease and from a practical standpoint, are seldom available to other parties unless non-compliance with planting and/or rental requirements has forced cancellation by the Division. Some State controlled shellfish bottoms are available for independent commercial harvesting; however, sales must be made through a licensed dealer who is also generally a leaseholder.

6.4.6. Jurisdictional Limitations - The State has pre-empted control of all harvesting, cultivation, dealing, shipping and seasonal activities. With the possible exception of retail sale licensing requirements, there is no local, municipal or county control of either the oyster industry or resource. This allows a non-fragmatized approach to management and enforcement of regulations. Oyster bottoms controlled by land grants are not subject to planting or rent requirements, but owners must abide by seasonal requirements and other regulations.

6.4.7. Optimum Yield Determination - In South Carolina, no determination of the optimum sustained yield from an intertidal bottom has yet been attempted. An immediate approach to rectify this condition would be to conduct a pilot demonstration project in a selected intertidal area to determine the most acceptable methods of attaining maximum production. Such a study would be useful in determining conditions and methods for the cultivation of quality oysters, especially those to be utilized as shell stock.

6.4.8. Extension and Information Needs - Marine extension agents are available through Clemson University. Assistance is available to the commercial fishing community, although it is thought the majority of the extension efforts have been directed at shrimping and finfishing, and not oystering. There is a demonstrative need for programs which will directly assist the oyster industry with pragmatic instruction and suggestions.

Information gaps exist in numerous biological and socio-economic aspects of the oyster industry. User information on the recreational use of State Shellfish Bottoms and Recreational Oyster Grounds is lacking. While adequate survey information exists for the States limited subtidal oyster bottoms, there is not a similar resource inventory available for intertidal oyster bottoms. The accomplishment of such an inventory survey, with ancillary data on bottom types, sediment, potential growing areas, etc. should be given priority.

7. Summary and Recommendations

The previous sections of this report have presented an overview of the current oyster situation in South Carolina including the status of the resource, the commercial and recreational fishey, and the recent research and management programs of the Marine Resources Division. It is apparent that the problems related to oyster management are very complex, involving biological, economic and social aspects, which will require much time and effort to solve.

The major and most immediate concern with respect to shellfish management in South Carolina is the intertidal oyster resource. In the recent past, the issue has been raised as to whether existing intertidal oyster resources are capable of supporting a viable commercial fishery along with unrestricted public harvesting for private use. Considering the decline in commercial oyster production, as a result of environmental and economic conditions and the uncertain status of the industry, along with the increasing public demand, this seems very doubtful.

It is recognized that most of the productive intertial oyster growing areas in South Carolina are, and have been in some cases for many years, under lease to commercial interests. Although some progress has been made in recent years in increasing and upgrading Public Recreational Oyster Grounds, these areas do not seem adequate to meet the growing demand. It seems obvious that simply opening up all oyster bottoms, including leased areas, to public harvesting is not the solution to this complex problem. This approach would discourage future investments in shellfish management and cultivation by the industry, encourage poaching on leases and result in the depletion of many oyster growing areas thru overharvesting.

In reviewing the programs of other states, it is apparent that oyster management concepts and practices vary considerably. Some feel that a fishery based upon a strong private lease system is much more efficient and economically feasible than a State managed public fishery. Although some states, such as Florida, North Carolina and Louisiana have large scale public oyster management programs, there are still mixed opinions as to the benefits and effectiveness of such programs as compared to the private lease system. In these states, public grounds are open to commercial as well as recreational harvesting. In view of the uncertainties concerning the effectiveness of state managed public commercial oyster programs, it might be more practical at this time for South Carolina to consider placing emphasis on improving the management of oyster areas for public recreational use, and at the same time, initiating additional research and management efforts, along with needed legislative changes aimed at enhancing and upgrading the commercial fishery within the present leasing system.

It must be recognized that the problems related to the management of all estuarine shellfish resources in South Carolina are extremely complex. Numerous biological and socio-economic information gaps exist to some degree in every fishery. Consideration must be given to all difficulties which confront the oyster fishery. While no problems can be totally ignored, priorities of action should be assigned. The recommendations which follow are an attempt to address those problem areas felt to be of most critical concern to both commercial and recreational shellfish interests and to the management of the resources. It is hoped that they will assist in the solution of some of the more immediate problems and provide the basis for continued future development of the resource. These recommendations include provisions for research, management and needed legislation. In view of potential limitations with respect to funding, several alternative approaches related to shellfish research and management are possible.

The following is a list of recommendations which are felt to address some of the more immediate oyster management needs and are aimed at upgrading the industry as well as improving recreational harvesting opportunities. Brief justifications, action approaches and funding estimates for each of these recommendations are suggested. Summaries of recommended management action, alternate approaches and priorities are appended (Appendix III and IV).

RECOMMENDATIONS

<u>Recommendation 1</u>. Conduct a comprehensive survey, to be periodically updated, of intertidal oyster growing areas in South Carolina.

<u>Recommendation 2</u>. Conduct a demonstration project on intensive management of intertidal oyster bottoms.

<u>Recommendation 3</u>. Conduct a mail interview survey of the public shellfish harvesting sector.

<u>Recommendation 4</u>. Initiate applied research and related assessment of (a) "washed shell" use as spat collectors and (b) the effects of environmental parameters upon shellfish growing areas.

<u>Recommendation 5</u>. Conduct a pilot project to investigate the feasibility of the development of a managed program for mechanical

harvesting and relaying of intertidal oysters from polluted and overcrowded areas in order to improve public shellfish grounds and revitalize the State's oyster industry.

Recommendation 6. Identify additional funding sources and develop a funding system for expanded shellfish management and research programs.

Recommendation 7. Place in operation, a long range, comprehensive shellfish management plan, based on this planning profile, for South Carolina.

Recommendation 8. Expand and improve public recreational harvesting areas in the State's coastal zone.

Recommendation 9. Upgrade and expand the existing shellfish management programs with respect to the monitoring of lease cultivation practices and in assisting the industry with such practices.

Recommendation 10. Revise existing State legislation and enact new statutes designed to improve the shellfish management program, facilitate the growth and development of the shellfish industry and upgrade public shellfish harvesting opportunities

Justification, Suggested Approaches and Funding Levels

Recommendation 1. Conduct a comprehensive survey, to be periodically updated, of intertidal oyster growing areas in South Carolina.

Justification: In order to effectively manage the resource, it is essential that the intertidal oyster growing areas of the State be accurately charted and classified. Due to insufficient funding and the part lack of cost-effective intertidal oyster survey techniques, such a survey has never been conducted on a coast-wide basis.

Such a survey is essential for the evaluation of oyster cultivation practices on leased grounds, evaluating the effectiveness of the State shellfish management programs, determining suitable areas which may be acquired for additional public harvesting grounds and providing baseline information needed for the implementation of a comprehensive management plan. Information from this survey could also be of use to other governmental agencies involved in shellfish activities, such as the South Carolina Department of Health and Environmental Control and those involved in coastal zone management activities. This information is much needed in the evaluation of coastal developments which have potential adverse effects on water quality.

Approach: To obtain maximum effectiveness, a survey of intertidal oyster growing areas would have to be conducted from aircraft in conjunction with ground truth inspections and survey from small boats. Intertidal oyster beds would be located on existing aerial photographs from low altitudes during periods of low tide. Coast-wide mapping would be accomplished on especially prepared large scale maps. Assessment of bottom types, qualitative aspects of shellfish beds, and standing crop estimates would be accomplished by ground level inspection from boats. The initial survey of intertidal oyster bottoms would require an estimated two years of field work. Periodic updating of a less detailed nature, would be required at two to three year interval

Funding: Initial two year survey - -$100,000. Periodic resurveys - $20,000/year. Source of funds not identified.

Recommendation 2. Conduct a demonstration project on intensive management of intertidal oyster bottoms.

Justification: A small scale pilot or demonstration project conducted by the Division on a selected area of intertidal bottom would be of significant value in determining optimum methods for intensive management and maximum production for such areas. Such a project could be useful in assisting the industry in determining the optimum conditions and methods for the culture and production of quality oysters for shell stock and shucking purposes. It would provide much needed experience and baseline information to the Division for future management of Public Recreational Oyster Grounds on a larger scale than currently practiced.

Approach: An area of oyster grounds, of not more than 10 acres, would be selected for intensive management by the Division. This area would be managed using a combination of techniques, such as planting washed shell, steamed shell and other cultch materials as well as seed oysters. Monitoring of spat set, growth rates, and environmental parameters would be conducted. Specific details of the project would be submitted in the form of a written proposal at a latter date. Project duration would be three years.

Funding Estimates: $25,000 per year for the three year period. Source of funds not yet identified.

Recommendation 3. Conduct a mail survey of the public oyster harvesting sector.

Justification: No specific information concerning the nature or magnitude of public oystering for private use is currently available. Such information is essential to plan for future needs related to the management of publicly utilized oyster grounds.

Approach: A mail survey of a selected sampling of private boat owners in South Carolina could be conducted to obtain estimates of the number of individuals engaged in shellfish harvesting for private use, their annual catch, days harvested, areas utilized, etc. If an individual license or permit requirement should be put into effect through legislative action, a more comprehensive and meaningful survey of this type could be accomplished.

Funding: Estimated at $10,000 for one year period. Source of funds not yet identified.

Recommendation 4. Initiate applied research and related assessment of (a) value of washed shell resources, as an oyster management material and (b) the effects of environmental parameters on shellfish growing areas.

Justification (a): Large deposits of accumulated washed shell occur in extensive banks along the shore of many tidal waterways in South Carolina. This material has significant potential as a source of cultch, or matrix material, for planting and revitalizing intertidal oyster grounds. A recent study has been made of the locations and quantities of this material; however, little research has been done to determine its suitability for oyster cultivation purposes.

Approach: Conduct research aimed at determining the value of washed shell as cultch material and for revitalizing intertidal oyster grounds. This would be done through experimental large scale plantings of washed shell and steamed shell in adjacent intertidal areas. In addition, shell bags containing washed shell would be placed at several locations throughout the coastal zone and monitored during summer months to determine spat accumulation and growth.

Funding: Estimated at $25,000 for two years. Funding not yet identified.

Justification (b): While a brief study was initiated in 1977, more information is required concerning environmental effects. Adequate information on the effects of environmental conditions such as salinity, sedimentation, dissolved nutrients, etc. on intertidal shellfish growing areas is lacking.

Such information could be of significance in evaluating the productivity of growing areas, in determining optimum locations for future oyster culture operations and in documenting the effects of environmental factors upon intertidal shellfish areas.

Approach: A preliminary environmental monitoring investigation should be made. Sampling stations would be established at several coastal locations and monitored on a long term basis. Salinity, temperature, nutrients and sedimentation are parameters that should be monitored on a regular basis.

Funding: Estimated at $25,000 for two years. Source of funds not yet identified.

Recommendation 5. Conduct a pilot project to investigate the feasibility of the development of a management program for mechanical harvesting and relaying of intertidal oysters from polluted or overcrowded areas in order to improve public shellfish grounds and revitalize the State's oyster industry.

Justification: In recent years, the commercial fishery for oysters in South Carolina has declined due to a combination of biological,economic and sociological factors. An increase in coastal population has occurred during the same period as the oyster fishery has declined. This has resulted in additional demands for improved recreational shellfish harvesting opportunities.

The intertidal oyster industry has always depended on hand labor, especially in harvesting and seed planting operations. The labor supply is no longer adequate; hence, production has declined. Inroduction of a successful mechanical intertidal oyster harvester would do much to alleviate the industries dependency on hand harvesting and should encourage an increase in production.

Currently, due to low water quality, over 30% of South Carolina's intertidal oyster growing areas are closed to harvesting. These polluted areas contain significant intertidal oyster resources which could be utilized for both recreational and commercial purposes by relaying to unpolluted areas where depuration would occur.

Approach: Either independently or as a cooperative effort with a commercial oyster firm, the Division should develop a pilot project to operate a proven mechanical intertidal oyster harvester, such as the one now in use by the North Carolina Division of Marine Fisheries.

This project would be directed at evaluating:

(1) The feasibility of a mechanized harvesting and transplanting programs for rehabilitiating public oyster grounds.

(2) The applicability and economic feasibility of a mechanical harvesting system to South Carolina commercial oystering activities.

(3) The environmental effects of mechanical harvesting on intertidal oyster beds.

If successful, recommendations would then be made concerning a long-range program, conducted by the State, for the management and improvement of oyster growing areas. This program would utilize a mechanized system of direct harvesting as well as relaying both unpolluted and polluted seed to superior growing bottoms.

Funding: Estimated at $150,000 for two (2)years. Source of funds not yet identified.

Recommendation 6. Identify additional funding sources and development of a funding system for expanded shellfish mangement related research programs.

Justification: The current funding level for shellfish management and research programs is inadequate. In order to properly manage and regulate the fishery, revitalize the resource, aid in the development of the industry and provide for recreational shellfish harvesting needs, additional funding and personnel are essential. Current funding from State appropriations, revenues and Federal sources is not sufficient for a comprehensive shellfish program.

Approach: Possible sources of additional funding for shellfish management and research should be identified and investigated. Currently, funding is limited to State appropriated Division monies, PL 88-309 funds from the National Marine Fisheries Service, Sea Grant, Coastal Plains Regional Commission and Coastal Zone Office contracts. Currently, total annual funding for shellfish management and research is only about $120,000. Division funds are the only ones consistently available and are limited for the magnitude of work required.

Increased State appropriated funds,on a continuing basis,are felt to be essential to the shellfish program, and should be strongly considered. In addition, the possiblity of revenues generated by new legislation, such as those which might be provided from individual harvest permits, should be considered as another source of revenue. Known potential source of funding are: State appropriations and revenues from fisheries licenses and taxes, Sea Grant, National Marine Fisheries Service, Environmental Protection Agency, Coastal Plains Regional Commission and Office of Coastal Zone Management. These and other sources of funding should be investigated. As indicated previously, however, the most promising source of continuing funds to provide the basis for a long range shellfish management program would appear to be from State appropriations or revenues. It is recommended that the Office of Coastal Zone Management be considered as a potential source of funding for the recommended comprehensive intertidal oyster survey. As mentioned previously, information from such a survey would not only be essential to shellfish management, but would also be of significant value to other agencies involved in water quality programs and coastal zone management activities. Qualitative and quantitative information on the oyster resource is much needed in evaluating the potential effects of coastal developments such as marinas, industrial and residental developments,etc., and for environmental planning.

Recommendation 7. Implement a comprehensive shellfish management program for South Carolina.

Justification: In order to provide for a responsive and effective shellfish management system, a definitive comprehensive shellfish management plan needs to be implemented. At present, major information gaps concerning the resource, the recreational fishery and local shellfish cultivation techniques are such that it would be difficult, or impossible, to place in operation a comprehensive intertidal management plan without additional research and the development of additional information.

Approach: A comprehensive shellfish management plan should be developed by the Marine Resources Division following as soon as possible after the completion of this management profile. However, it must be emphasized that a baseline survey of the intertidal oyster resource is required before the resource can be properly managed. The operation of this plan should utilize the technical expertise of the Division in the fields of management, research and economics. The approach could be similar to that used for the South Atlantic Regional Shrimp Management Plan completed in 1975, except that it would be restricted to the State level. Such a plan should provide for the future management of all South Carolina shellfish resources in the best interests of both the recreational and commercial sectors. It should be aimed at identifying social and economic problems as well as solving biological ones.

Recommendation 8. Expand and improve public recreational oyster harvesting areas.

Justification: Existing public recreational harvesting areas are inadequate from the standpoint of quality, quantity and spatial distribution in the coastal area. Increased efforts and funding should be directed at maintaining and upgrading existing recreational oyster grounds. Also, additional recreational areas should be established. This is viewed as an interim program to provide for current recreational demands until a more comprehensive long range plan for public shellfish harvesting can be developed. A long range program for public harvesting should not be attempted until detailed information from the intertidal oyster survey under Recommendation 1 is available, and a management demonstration project, as suggested under Recommendation 2, has been completed.

Approach: 1. Existing intertidal oyster growing areas presently designated for public use would be more intensively managed through shell and seed planting, possibly through contractual arrangements with commercial oyster operators. Eventually, it would be desirable for the Division to acquire the necessary vessels, equipment and personnel to conduct large scale planting of public oyster areas on its own. Division personnel would be responsible for selecting and marking specific grounds within public areas to be planted.

2. Additional sites for the location of potential recreational oyster areas would be selected in various areas along the coast. These potential recreational areas would be of limited acreage and would be selected from

both leased and unleased intertidal shellfish bottoms. Although several fairly sizeable areas having potential suitability for public recreational shellfishing have been acquired from cancelled leases (Toogoodoo Creek, McCalley Creek, Edding Creek),other locations within existing oyster leases may possibly be identified which can be acquired from lessees. Selection of additional public recreational areas would be based upon the experience of Division personnel followed by field inspections. General coastal areas known to have significant recreational shellfishing demands, such as the Port Royal-Hilton Head, Fripp-Hunting Islands, Edisto Beach, Kiawah-Folly Island, Isle of Palms-Capers Island and Murrells Inlet areas would receive primary emphasis. Once potential sites have been selected, acquisition negotiations would have to be conducted.

Funding Estimates: In order to maintain and manage existing public recreational oyster grounds, a minimum funding level of $30-50,000 would be needed. If new public areas are established, additional funding will become necessary. Source of funding not identified.

Recommendation 9 . Upgrade and expanded the existing shellfish management program of the Marine Resources Division with respect to the monitoring of lease cultivation practices and assisting the industry in lease cultivation.

Justification: Currently, sufficient trained personnel are not available to adequately monitor private management practices, including shell and seed planting on leased grounds, or to properly assist the industry in these aspects. Consequently, accurate assessments of the performance of individual leaseholders is often not possible. This has probably resulted in some lessees retaining more oyster bottoms than they can properly manage. Also, there is a definite need to assist the industry in lease management such as advice on areas which should be planted, planting methods, etc.

Approach: A minimum of two additional personnel, to be assigned to the Shellfish Management Section, would be initially required to work with commercial leaseholders in monitoring shell and seed planting activities, and assessing lease management performance. In addition, assistance could be given to the management of State controlled public areas.

Recommendation 10. Revise existing State legislation and enact new statutes designed to improve the shellfish management programs, facilitate the future development of the oyster industry and upgrade public harvesting opportunities.

Justification: Many current statutes concerning oysters are archaic, inadequate or overly restrictive. Changes are needed to provide for improved protection of private lease rights, allow more flexibility for improved conservation and cultivation practices on leased grounds, provide for regulation of individual oyster harvesting, and, in general, to upgrade the entire shellfish management system.

Approach: (1) Amend Section 50-17-1210, South Carolina Code of Laws, relating to the limits of shellfish which may be harvested for personal use. These laws could be amended to limit any person to one bushel of oysters and one-half bushel of clams per day. The present wording of the law, whereby the "head of any household", by servant or employee may gather two bushels of oysters and/or one-half bushel of clams is not enforceable and encourages illegal and excessive public harvesting. (2) Amend Section 50-17-1240, South Carolina Code of Laws, pertaining to shellfish seasons. Under existing laws, the closed season for clams is between June 1 and September 1 and for oysters between May 1 and September 15. The Commission can shorten or extend the season by only 15 days. Consideration should be given to amend this law whereby the Division (or Commission) could open or close the shellfish season in any given area at any time. Provision for more flexibility could allow public harvesting of clams, for example, in designated areas even during the summer months, as is the case in most other states along the coast. (3) Enact legislation to strengthen lease protection and property rights of lessees, and to provide for better conservation and management of leased grounds. (4) Amend Section 50-17-790 of the South Carolina Code of Laws to provide that the Marine Resources Division may require any leaseholder (rather than only canneries and raw shuck houses as the law now reads) to plant a portion of his shell or seed quota on public grounds. Double credit towards the lessee's planting quota could be given for each bushel planted on public grounds. This would aid in the public grounds management program by supplementing State planting on such areas. (5) Enact new legislation providing for individual licenses or permits for all persons gathering shellfish on State bottoms not under lease, as well as on leased bottoms.

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9. Appendices

APPENDIX I

Recommended legislative amendments pertaining to all shellfish laws in South Carolina.

A BILL

TO AMEND SECTIONS 50-17-20, 50-17-1210, 50-17-1240, 50-17-710, 50-17-730, 50-17-790 and 50-17-810, SOUTH CAROLINA CODE OF LAWS FOR 1976 AS AMENDED, RELATING TO SHELLFISH HARVESTING, SEASONS AND LEASES, AND TO PROVIDE NEW CODE SECTIONS RELATED TO THE OWNERSHIP OF SHELLFISH ON LEASED AREAS: LEASING OF BOTTOMS FOR THE PURPOSE OF HARVESTING AND CULTURING CLAMS: INDIVIDUAL SHELLFISH PERMITS: AND THE REGULATION AND CONTROL OF NATURAL SHELL DEPOSITS.

Be it enacted by the General Assembly of the State of South Carolina:

SECTION 1. Section 50-17-20 (4), South Carolina Code of Laws as Amended, is further amended to read as follows: "Section 50-17-20."

(4) "Bottoms" includes all of the tidelands and submerged lands of the State covered by water when at the stage of ordinary high tide; and,"

SECTION 2. Section 50-17-1210, South Carolina Code of Laws as Amended, is further amended to read: "Section 50-17-1210." It shall be unlawful for any person to enter upon any lands owned by another or by the State for gathering of shellfish for market without the written permission of the owner or lessee. Any South Carolina resident may gather for private use not more than one bushel of oysters or one-half of one bushel of clams, or both, in any one day from any lands owned by the State; provided, that in the

Stein, Robert J. 1979. "Proposal for the Revitalization of South Carolina's Recreational and Commercial Oyster Resources." Report submitted to the S.C. Wildlife and Marine Resources Department; 26 February 1979. (Unpublished).

Wallace, E.M. and G. R. Lunz. 1968. "The Oyster a Shellfish Delicacy." Marine Resources of the Atlantic Coast, Leaflet Number 11, October 1968, Atlantic State Marine Fisheries Commission, Washington, D.C.

9. Appendices

APPENDIX I

Recommended legislative amendments pertaining to all shellfish laws in South Carolina.

A BILL

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Any person violating the provisions of this Section shall, upon conviction, be punished as provided in Section 50-17-1320.

SECTION 3. Section 50-17-1240 of the Code of Laws of South Carolina, 1976 as Amended, is further amended by striking it out and inserting in lieu thereof the following: "Section 50-17-1240." It shall be unlawful for any person to remove, take or harvest any shellfish as defined in Section 50-17-20 from the coastal waters and bottoms of the State between May fifteenth and September fifteenth, inclusive. Provided; however, the South Carolina Wildlife and Marine Resources Division, shall have the authority to open or close any area or areas of State waters or bottoms for the removal, taking or harvesting of shellfish for specified periods at any time during the year when biological and other conditions warrant such action. Nothing in this Section shall prevent the removal of shellfish for the purpose of replanting under permits granted by the Marine Resources Division. Possession of live oysters or clams during the closed seasons shall constitute a prima facie violation of the provisions of this Section. Provided; however, that clams and oysters may be imported during the closed season in South Carolina from other States where the taking and possession of such shellfish is lawful. Each shipment or load of such imported shellfish must be properly marked and identified to verify that it was legally taken from another State.

Any person violating the provisions of this Section shall, upon conviction, be punished as provided in Section 50-17-1320."

SECTION 5. Section 50-17-710 of the South Carolina Code of Laws is further amended to read as follows: "Section 50-17-710." The South Carolina Wildlife and Marine Resources Commission, through the Division of Marine Resources, may lease to any State resident portions of the bottoms owned or controlled by the State, for the purpose of shellfish culture for commercial purposes, not exceeding an aggregate of one thousand acres to any person, firm or corporation, for a term not to exceed five years. The words "shellfish culture for commercial purposes" shall mean the harvesting and cultivation of shellfish by any State resident licensed to do business in this State and who makes his livelihood or substantial portion of his livelihood from the commercial fisheries industries. To all other State residents who lease lands for any other shellfish culture purposes than for commercial use, the Commission may lease as many as two acres, but no more, at the yearly rental provided in Section 50-17-760 Provided, that no lessee shall sublease without the written permission of the Marine Resources Division. Any such lease shall be renewed at the option of the lessee for an additional term of five years at the yearly rental specified in Section 50-17-760 provided the lessee has satisfactorily met the planting and cultivation requirements of the Division.

SECTION 6. Section 50-17-730, South Carolina Code of Laws as Amended is further amended to read as follows: "Section 50-17-730." Any person desiring to lease any bottom, as provided in Sections 50-17-710 and 50-17-720, shall apply to the Division of Marine Resources upon such forms as may be prescribed by the Commission. The sum of ten dollars shall accompany each application and shall be retained by the Division. Such application shall include the location and boundaries of the area desired to be leased. If the area is subject to lease, the Division shall determine the acreage capable of producing shellfish. The applicant then shall have the area surveyed and a plat thereof made showing the acreage capable of producing shellfish and filed in triplicate with the Division. No other lease for gathering of shellfish within the perimeter boundaries of such area leased shall be made during the terms of such lease. If any additional area suitable for the cultivation of shellfish shall be found within the perimeter boundaries of the area leased, then upon the renewal of such lease or at the time of application for a new lease, the original lessee shall have first opportunity to lease such area capable of producing shellfish. The plat may be based on a survey or may be based on an aerial photographic compilation or comilation from maps, plats or charts of the United States

Army Engineers or United States Geological Survey. The rental shall be based upon an agreed number of acres capable of producing shellfish within the boundaries of the entire lease area.

SECTION 7. Section 50-17-790,South Carolina Code of Laws as Amended, is further amended to read as follows: "Section 50-17-790." The Division shall establish each year an annual quota of shell, cultch or seed oysters to be planted on each lease issued under Section 50-17-710, based upon the quantity of oysters harvested from the lease, and other considerations related to sound management practices. The annual quota for each lease shall in no case be less than 50 bushels for each acre under lease. All shell shall be planted between May first through August thirty-first, except that raw shuck houses may replant green shell from current operations if such shell is replanted within three days after gathering. All shell and seed planting may be under supervision of the Division of Marine Resources, which may require up to five percent of the total quota of shell or seed oysters of any lessee to be planted on State shellfish bottoms not under lease but within a twenty-mile radius of the lessee's place of business. Shell or seed oysters planted by a lessee on such bottoms shall be credited to said lessee's annual quota in an amount equal to two times that of the number of bushels actually planted. If a lessee does not plant the required quota of shell or seed oysters on his lease(s), the entire lease(s) or portions thereof, based upon the percentage of the of the quota planted shall be cancelled by the Commission. Provided; however, that in the event that lessee believes that a lease or portion thereof does not require planting during a given year for reasons of sound management, he may apply in writing to the Division for a variance in his annual quota. The Division may then conduct an inspection of the lease or portion thereof to determine whether that requested variance shall be granted, and notify the lessee of its decision. The decision of the Division in such matters shall be legally binding. For the purpose of shell planting, a South Carolina oyster bushel shall be the same as defined in Section 50-17-1290. One cubic yeard of shell for planting shall be considered as eleven and one-half bushels. Any person violating any provisions of this Section shall, upon conviction, be punished as provided in Section 50-17-1320.

SECTION 8. Section 50-17-810, South Carolina Code of Laws for 1970 as Amended, is further amended by striking it out.

SECTION 9. All clams and oysters found upon or in the bottoms lying within the perimeter boundaries of lease shall be considered the property of the lessee and any person who shall remove, take or harvest any clams or oysters from a lease without permission of the lessee shall be guilty of larceny and punished accordingly.

SECTION 10. All provisions of Title 50, South Carolina Code of Laws as Amended, referring or relating to the leasing oyster bottoms shall also include the right of the South Carolina Wildlife and Marine Resources Commission to lease bottoms for the purpose of harvesting and culturing clams.

The Commission may use the same application and lease forms and procedures for the purpose of clam culture as provided for the leasing of bottoms for oyster culture. The Marine Resources Division, by rule and regulation, establish annual planting quotas of seed clams and other requirements for the cultivation and management of areas under lease for the harvesting and culturing of clams.

SECTION 11. Any person engaged in harvesting shellfish for market from State owned bottoms, including bottoms under lease by the State, shall be required to obtain an annual permit from the Division of Marine Resources for the year beginning July first. Any person harvesting shellfish from leased bottoms must furnish to the Division written authorization to gather shellfish from the lessee(s) of said bottoms prior to the issuance of said permit. Individual permits for harvesting shellfish on unleased State bottoms will be issued only to persons who are employed by or who sell their shellfish directly to a licensed shellfish dealer. The permit issued shall specify the lease number(s) or area(s) from which the permit holder is authorized to harvest shellfish, and must be in possession of the permit holder at all times while harvesting shellfish. The permit shall be valid for harvesting shellfish only on the lease(s) or area(s) for which it is issued. Said permit shall be in addition to any other permit requirements of the Division concerning the areas from which shellfish may be harvested. The annual fee for such permit shall be ten (10) dollars. Any person violating the provisions of this Section shall upon conviction for a first offense be punished as provided in Section 50-17-1320, and, in addition, any shellfish harvesting permits issued to him shall be suspended for thirty days from the date of conviction. Any shellfish harvesting permits issued to a person convicted for a first offense under this Section within thirty days after the date of conviction shall be invalid. Any person convicted for a first offense under this Section who is found harvesting shellfish within thirty days after the date of conviction shall be deemed guilty of a misdeameanor and upon conviction shall be fined 250 dollars or imprisoned for thirty days.

SECTION 12. The Division of Marine Resources of the South Carolina Wildlife and Marine Resources Department shall have jurisdiction over all natural shell deposits, including those of oysters, clams and other molluscs occurring upon or within State owned bottoms. In addition, the Division shall have jurisdiction over all such shell deposits lying above the mean high water mark, provided such deposits have been created by processes of natural accretion upon State owned lands or bottoms.

The Division of Marine Resources may grant permission to any person, firm or corporation to remove shell from natural deposits for use in shellfish cultivation, mariculture or for other purposes. Such permits shall be issued for a term not to exceed five years, and shall specify such conditions as the Division may require, including areas from which shell may be harvested, dates and schedules of harvesting, type(s) of equipment which may be used, and reporting requirements.

The Division shall specify a fixed price for each unit of shell removed, not to exceed one dollar per cubic yard, Payments for shell removed shall be made by the permit holder on or before the 10th day of each month for the preceding month.

All monies derived from the sale of shell under this act shall be deposited in a special fund,to be used for the management and improvement of State owned shellfish bottoms.

The Division shall promulgate such rules and regulations as it may determine are necessary to carry out the provisions of this Act. Any person violating the provisions of this Act shall be deemed guilty of a misdeameanor and, upon conviction, punished as provided in Secton 50-17-1320. In addition, any permits issued for the removal of shell shall be revoked by the Division.

SECTION 13. This Act shall take effect upon approval by the Governor.

Guidelines for the Leasing of State Oyster Bottoms by the S. C. Wildlife and Marine Resources Commission

The following is a summarization of current legislative authority and guidelines pertaining to the leasing of state oyster grounds by the S. C. Wildlife and Marine Resources Commission. These guidelines were approved by the Marine Advisory Committee to the Commission on May 8, 1974.

I. Statutory Authorization

Provisions related to the leasing of State owned bottoms are included in Articles 4 and 5, S. C. Code of Laws as Amended. Section 50-17-1250 provides general leasing authorization, specifying that the S. C. Wildlife and Marine Resources Commission may lease all or part of State bottoms below the high watermark for shellfish culture, mariculture, or as it may determine. Section 50-17-710 provides specific authorization for shellfish leases and includes the basic requirements for lessees. Under this section, the Commission, through the Marine Resources Division may lease no more than one thousand acres of State bottoms to any resident for shellfish culture for "commercial purposes". Conditions pertaining to lessees under this section are specifically as follows:

(1) Lessee must be a State resident.

(2) Lessee must be licensed to do business in South Carolina.

(3) Lessee must make his livelihood or a "substantial portion" of his livelihood from the "commercial fisheries industries".

(4) State residents who lease lands for shellfish culture for other than commercial use may lease no more than two acres of bottoms.

Sections 50-17-730 through 50-17-820 deal with application procedures, hearings on objections; lease rental fees; cancellation provisions, transfer of leases, and shell or seed planting requirements. Specific provisions related to leasing policy in these sections are that no other lease for the gathering of oysters shall be made within the perimeter boundaries of an existing lease. Also, no leases may be subleased or transferred without the approval of the Commission.

II. Administrative Guidelines

Existing statutes in the South Carolina Code of Laws do not include specific provisions for leasing policies as related to the experience, capitalization or other capabilities of the individual applicant. Nor are any specific statutory provisions made that leases shall be granted on a first come, first serve basis. In making decisions concerning the granting of a lease for an area which several legally qualified individuals have applied, the Commission and Marine Resources Division must exercise a considerable amount of administrative discretion. It has been the practice in the past in such cases to grant the lease in question to the individual or corporation which has, according to available information, the best capabilities for properly managing the lease. There have been, however, no specific guidelines or criteria to be followed by the Division in evaluating lease applications.

Of major concern to the Division is that a public resource such as State oyster bottoms be properly utilized and not allowed to sit idle or be depleted through improper management practices. To insure that leases are acquired by qualified individuals who will abide by the conservation and management requirements of the Division, it is felt that a definitive, yet flexible set of leasing policy criteria are necessary. The following guidelines concerning the leasing of State oyster grounds are therefore proposed to achieve this purpose.

(1) The lease applicant must have an approved (certified by DHEC) shellfish house or processing facility or be able to satisfy the Division that all shellfish harvested for sale will be handled through a bona fide shellfish dealer having an approved facility.

(2) The lease applicant must be able to meet all requirements and regulations of the S. C. Department of Health and Environmental Control which pertain to his operations or place of business.

(3) The applicant must satisfy the Division that he has sufficient shellfish industry experience and will directly manage and supervise the cultivation of the lease(s) applied for himself, or will employ a qualified individual as lease manager within three months following the date that the lease becomes effective.

(4) The applicant must own and employ or show proof that he is capable of acquiring the necessary equipment and personnel to effectively harvest and manage the area(s) in question. Minimum requirements pertinent to labor, boats, barges and other facilities needed to effectively harvest and meet shell or seed planting quotas for the area(s) applied for will be established by the Division.

(5) The applicant must possess all shellfish licenses and permits required by the Division and any other State or Federal Agency, or be qualified to obtain same following the granting of the lease(s), and prior to working the lease.

(6) If an applicant has existing shellfish lease(s) or has formerly held any lease(s), his past performance record in managing said lease(s) (shell planting, production, etc.) will be evaluated and given due consideration in determining whether he shall be granted additional leases. In the event that an individual who is not fully utilizing his existing leased grounds has applied for an available lease and another individual has applied for the same area who has no lease but meets all the necessary requirements, the lease will be granted to the latter applicant.

(7) In cases where two or more individuals apply for a lease who are in the opinion of the Division equally qualified, the granting of the lease may be determined by lottery.

(8) The order in which applications are received will have no bearing on the granting of a lease as long as said applications are filed in a timely manner.

S. C. Wildlife and Marine Resources Department
Marine Resources Division

SUMMARY OF RECOMMENDED MANAGEMENT ACTIONS

RECOMMENDATION	1st Year	2nd Year	3rd Year	4th Year	REMARKS
	TIME FRAME AND ADDITIONAL FUNDING REQUIRED				
I. Action for long-term Development & Upgrading of the Oyster Fishery					
a) Comprehensive Intertidal Survey	50K	50K			Update periodically
b) Mgt. Demonstration Project	25K	25K			
c) Mail Survey(Recreational Harvesting)	---	10K			Update periodically
d) Applied Research, etc.					
(1) Washed Shell Research	13K	12K			
(2) Environmental Studies	+	(May be expanded,w. add. funding)			
e) Mechanical Harvesting Project	75K	75K (May be expanded, w. add. funding)			
f) Develop Funding System	+	+	+	+	
g) Develop Mgt. Plan	+		+	+	
II. Interim Measures for improving the Shellfish Fishery					
a) Upgrade Public Grounds	30K/50K	(Continue, w. possible increase)			
b) Upgrade Mgt. Program	25K	(Continuing, with increased funding)			
c) Legislative Action	+	(Future revisions as required)			

Estimated Additional Funding Required	$218,000	$172,000	$105,000		

Annual sequence in which activity would be undertaken

APPENDIX III

APPENDIX IV

Alternative Approaches Based
Upon Priorities and Funding Levels

RECOMMENDATION	ALTERNATIVE AND PRIORITY HIGH	MEDIUM	LOW
Comprehensive Oyster Survey	X	-	-
Survey of Public Harvesting	X	-	-
Mgt. Demonstration Project	X	-	-
Applied Research Project	X	X	X
(1) Washed Shell Research	X	X	X
(2) Environmental Monitoring	X	X	X
Identify Funding Sources	X	-	-
Mechanical Harvesting Project	-	X	-
Implement Shellfish Management Plan	X	-	-
Expand Recreational Grounds	X	X	-
Upgrade Shellfish Program	X	X	-
Enact Legislation	X	X	X
Est. five year funding required	$480,000	$470,000	$100,000

SECTION V

HARD CLAM

MANAGEMENT PLANNING PROFILE

FOR THE

SOUTH CAROLINA HARD CLAM FISHERY

by

William D. Anderson

MANAGEMENT PLANNING PROFILE FOR THE
SOUTH CAROLINA HARD CLAM FISHERY

1. Introduction

The hard clam fishery is one of the largest clam industries in the United State with current dockside landings in excess of 20 million dollars. Hard clams are harvested commercially in 18 clam-producing states and are generally found in protected and relatively shallow estuaries (Ritchie, 1976). Regulation of the industry has been imposed by state or local governments, usually in response to institutional conflicts and localized overfishing of the resource.

South Carolina possesses a small,though rapidly developing commercial hard clam fishery with exceptional potential. Dockside landings in 1978 totaled 205,000 pounds of meat valued at over $370,000 dollars.

Growth of the coastal population, particularly in areas of seaside developments has resulted in an increasing demand by the public for recreational harvesting privileges. The resource is further affected by man-induced alterations in the coastal zone as well as ever increasing pollution problems.

Before any resource can be properly managed, the following questions must be answered in regard to the population: (1) How large is the resource? (2) How many animals are added each year by spawning and growth? (3) How many die from natural causes? (4) How many are harvested? and (5) How do the quantities vary from year to year? (McHugh, 1975). Some progress has been made in regard to questions (1) and (4), but further research, management, resource assessments, and legislative action must be accomplished to enhance management capability. Furthermore, hard clam mariculture in our coastal waters has exceptional potential for future development of the commercial industry. Existing statutes that pertain to shellfish culture apply entirely to oysters with no provisions for leasing bottoms for clam culture.

In order to maintain reasonable management of South Carolina's hard clam resource, the following management profile is presented as a framework to initiate measures for solving some of the most urgent problems concerning the State's viable hard clam resource.

2. Description of the Resource

2.1. Species Composition - Mercenaria mercenaria is by far the most prolific of the hard clams found in South Carolina. However, the southern clam Mercenaria campechiensis is sympatrically distributed in considerably smaller numbers in the State's estuaries and in higher salinity waters offshore. Eldridge, et al., (1976a)estimated relative abundance of Mercenaria mercenaria notata from 11 South Carolina locations to be 1.23% of the population sampled. The reciprocal hybrids of M. mercenaria and M. campechiensis are also found in smaller numbers throughout South Carolina's coastal waters (Anderson,et al.1978)

2.2. Biology - Hard clams are bivalves with their shells attached by two adductor muscles and have a muscular burrowing foot. This bivalve proliferates in suitable environmental conditions from Florida to the Gulf of St. Lawrence and is also found along the Gulf of Mexico to the Yucatan Peninsula. Growth occurs throughout the year in South Carolina and spawning begins in the spring and continues through mid-summer. During the spawning season, the ovaries and testes enlarge and eggs and spermatozoa are discharged into the water where fertilization occurs. The amount of spawn extruded at a specific time is variable.

Clams normally spawn when approximately two years old at an average size of 32 to 38 mm. The fertilized egg develops and in approximately 36 hours after fertilization the early veliger stage is formed with a transparent shell. At this time the animal is slightly larger than the trochosphere larvae (12-14 hours) and possesses a cilitated velium and both adductor muscles. The velium gradually disappears with the development of the foot during the final part of the veliger stage. Duration of the veliger period is subject to water temperature and usually lasts from 6 to 12 days. The veliger swims, floats and, less frequently, settles to the bottom. The stage is terminated as the animal increases in size, loses the swimming function of its foot and becomes capable of attachment and crawling. The clam then develops a byssal gland in the foot, which secrets a fine, tough thread that attaches the animal to a suitable substrate.

Once attached, new shell growth is easily differientiated from the embryonic shell by color, morphology and lines of growth. As the animal attaches it possesses all of the organs characteristic of the adult. However, the visceral mass and sexual organs are inconspicious and the foot is more mobile.

Mantle edges at the posterior end of the young clam are modified when the animal attaches to form the excurrent and incurrent siphons, which are contained in the "neck". The siphon serves three purposes: breathing, obtaining food, and eliminating waste products. Inflowing water is pumped through the siphon, passed over the gills and strained to remove food particles. After receiving carbon dioxide from the gills and other waste products from the digestive tract, the water is expelled through the outgoing siphon. Constant water circulation is maintained by the beating of a multitude of microscopic hairs (called cilia) located inside the tube and gill chamber.

The early shell stages in the hard clam are characterized by smooth valves, but after the clam becomes buried, shell ridges appear, and the byssal gland becomes non-functional. The shell ridges then take over the function of holding the young clam in the sediment. Depending upon the temperature of the water, it can take from two to four weeks from spawning until the juvenile clam is buried in the substrate. Sexual maturity is reached in two to four years, depending upon the water temperature and other environmental parameters (Carriker, 1961; Belding, 1912).

2.3. Habitat Description - In South Carolina, the highest densities of clams are found coincident with a mixture of shell and sand. In a recent resource survey (Anderson, et al. 1978), 68% of the total number of clams sampled were found in shell and sand substrates. The trend was reiterated by the percent incidence of occurrence in a bottom type (Figure 1). Lowest clam densities per area sampled were found in mud. South Carolina's survey results (Figure 2) are basically in agreement with Wells (1957) who observed a coincidence of higher densities with certain bottoms types in the Chicoteague Bay, Maryland area. Shell containing bottoms were found to contain the highest average population level. A growth and mortality study in South Carolina of hatchery seed clams (Eldridge, et al., 1976b) indicated that survival was highest in the particulars and substrate that had the greatest fraction of shell.

Mercenaria mercenaria were found in contagious distributions, which simply indicates that the presence of one clam in a unit sample increases the chance that one or more clams may be present in the same sample. A high positive value of "d" (532.07) (Elliott, 1971) for South Carolina's distribution data is further substantiation that hard clams are found throughout the State in a contagion that approximates a negative binomial distribution.

Hard clams in South Carolina are usually found in small feeder creeks and protected areas not exposed to wave actions or strong currents. With the exception of the Santee River Estuary, commercial quantities of clams are scarce in open estuarine areas. Furthermore, Mercenaria mercenaria in South Carolina is often found in conjunction with oyster populations and in environmentally favorable areas that are protected by overlying shell substrate. (Anderson, et al. 1978). With the distinct exception of the Santee Delta area, hard clams are normally found in estuarine areas of higher salinities

($>$18 o/oo). Favorable conditions for clam growth and survival are considered to be above 12.5 o/oo (Castagna and Chanley, 1973).

2.4. Effect of Environmental Alterations - The majority of man-induced environmental changes directly affecting shellfish in South Carolina have occurred since the 1930's. Although some alterations have perhaps been beneficial, most are considered detrimental to propagation and survival of the resource and were initiated with little consideration for local shellfish standing crops. Six environmental perturbations are summarized (Maggioni, 1976) to indicate effects of estuarine alterations on the habitat of both *C. virginica* and *M. mercenaria.*

(1) Pulpwood production - The Kraft process of reducing yellow pine to pulp originated during the depression and resulted in abandonment of numerous small farmsteads in the southeast. Vast acreage was drained and transformed into pine tree production, causing extensive freshwater inundation of the estuaries following each rainfall. Drastically lowered salinities in the upper estuaries inhibited oyster growth and decimated viable hard clam populations.

(2) Intracoastal Waterway Improvements - Dredged cuts have been completed between natural rivers to shorten the Intracoastal Waterway. Most of these improvements were accomplished from 1935-1941 and intended to maintain a controlling depth of seven feet. The most detrimental effect of the cut has been the interruption of tidal flow and normal salinity gradients within the joined rivers. Extensive destruction of sub-tidal oyster growth has occurred in the Ashepoo, Rock Creek, and Edisto Rivers. Furthermore, interruption of tidal flow due to waterway improvement has resulted in extensive silting and permanent blocking-off of streams.

(3) Erosion - Many areas of hard clam habitat in the State have been removed from production due to erosion. Current examples of deterioration may

be observed at Bull Point (Capers Island in Beaufort County). Also, Botany Bay Island erosion has obliterated the lower reaches of Townsend Creek and the eastern branch of Block Island creek behind Morris Island no longer exists.

(4) Pollution - The entire Beaufort River and several tributaries are currently closed to shellfish harvesting due to fecal coliform pollution. As mentioned elsewhere (user related problems) approximately 20% of the State's hard clam bottoms are currently contaminated by sewage disposal. Perhaps one of the more alarming aspects of latent contamination is low-level industrial pollution which is rarely monitored throughout the State.

(5) Santee-Cooper Rediversion - The initial diversion in 1942 has resulted in increased deposits of silt in Charleston Harbor and has created a need for extensive spoil areas and subsequent marsh destruction. The Santee Delta, however, is the most productive hard clam production area in the State. Rediversion is expected to decimate the population in the early 1980's.

(6) Residental, Resort & Industrial Development - Use of the estuaries by diverse groups is usually not compatible with shellfish production. Proliferation of private wharves, although not in direct conflict with hard clam habitats, serves to inhibit cultivation and harvesting from the immediate area.

3. Description of the Fishery - Recreational and Commercial

3.1. Fishing Methods - Prior to 1974, hard clams in South Carolina have been harvested by a variety of hand gathering techniques. Equipment such as oyster tongs, clam rakes and "bull" rakes have been utilized for successful commercial harvesting.

Based on sampling results from a comprehensive survey of South Carolina's hard clam resource (Anderson, et al., 1978) and the interest of clam fishermen, hydraulic escalators were introduced into the Santee Estuary in 1974 (Gracy, et al., 1978). The harvester (described by Manning, 1957; MacPhail, 1961;

Mathieson and De Rocher, 1974) (Figure 3) consists of several water jets that loosen the substrate in front of a scoop (escalator head). Hard clams and substrate are flushed onto a conveyor belt and carried to the surface for hand sorting (Rhodes, et al., 1977). Currently, seven permits are issued annually and harvesting is managed by the Division of Marine Resources. Harvesting is restricted to two days per week and the hydraulic escalator fishery normally operates from January to April, depending largely on ex-vessel clam prices. Escalator harvesting accounted for approximately 75% of the State's total clam harvest during the 1974-75 season (Table 1). Since the 1974-75 clam season, South Carolina's hard clam ex-vessel revenue has exceeded the pre-survey annual overall production level by six times (Anderson, et al., 1978). It is felt that a continuing fishery can be maintained in the Santee Estuary by limiting fishing effort and rotating harvest areas to allow for natural recruitment. However, it is anticipated that the proposed rediversion of freshwater discharge from the Cooper River into the Santee River by the U.S. Army Corps of Engineers will have a detrimental impact upon the currently viable industry (U.S. Army Corps of Engineers, 1975).

Nevertheless, hand tonging in subtidal areas and raking in intertidal areas continue to be the most common fishing methods, and these techniques account for a large amount of production (Table 1).

Raking clams in the State's intertidal areas is the most popular method of recreational clam harvesting. Although there is a paucity of data regarding the extent of recreational demand, recreational clammers may dig clams from 22 public oyster and State shellfish grounds along the South Carolina coast. Public grounds in such areas as Parris Island, Folly River and Sewee Bay are chronically popular with local recreational clam diggers and the catch is usually consumed steamed, raw and, most popularly, in home made chowders.

Table 1. South Carolina hard clam landings in bags (250 ungraded clams per bag) from the 1971-72 clam season thru 1976-77. (In South Carolina the clam season is from September 1 until May 31 of the following year).

CLAM SEASON	HARVEST METHOD: Non-mechanical QUANTITY	Non-mechanical PERCENT[a]	Hydraulic Escalator QUANTITY	Hydraulic Escalator PERCENT[a]	TOTAL	Ex-vessel Value
1971-72	5,296	100%	0	0%	5,296	$ 17,350
1972-73	11,292	100%	0	0%	11,292	44,273
1973-74	4,594	64%	2,852	36%	7,176	45,339
1974-75	11,302	27%	30,917	73%	42,220	213,382
1975-76	2,480	9%	25,805	91%	28,288	353,600
1976-77	7,767	39%	12,104	61%	19,877	248,462

[a]Percent of total clam harvest for the clam season.

3.2. Seasons and Geographic Locations of the Fishery - The clam season in South Carolina normally opens on September 1 and continues until May 31 of the following year. The Division of Marine Resources may extend the season 15 days by opening early, delaying closing, or both. Possession of clams during the closed season is prima facie evidence of violation.

At least 2,756 ha (6,809 acres) or approximately one percent of South Carolina's marsh-estuarine area of 302,086 ha (746,445 acres) contain clams in various densities (Table 2).

The commercial fishery is located near areas of highest clam densities. Figure 2 illustrates 7.5 minute^2 quadrangle areas of arbitrary density categories compiled from the 1973-1977 hard clam resource survey. The Santee River Estuary, with the largest commercial concentration of clams, supports the greatest industry production.

3.3. Background of the Hard Clam Fishery - The clam fishery in South Carolina has always been limited compared to that of the middle Atlantic and Chesapeake Bay states. The earliest record of significant clam production in South Carolina was in 1900 when 1,120 bags of clams were shipped by steamer from Charleston to New York. State fisheries statistics for the period of 1924-1947 indicate that the State's hard clam production did not exceed 5,000 bushels each year.

Prior to 1940, the majority of clams harvested each year in South Carolina were consumed locally (Lunz, 1944), and the existing clam industry was located in Georgetown County. Reasons for low clam harvests were the lack of demand and small profit for shellfishermen at current market prices. In 1940, clams were sold for slightly less than 30 cents per bushel (Bearden et al., 1976).

Since 1960, hard clam production in South Carolina has fluctuated considerably, ranging from a low of 1,162 bushels in 1968 to a high of 23,429

Table 2. Locations (north to south) of hydraulic patent tong clam sampling areas and estimated acreage of clam bottoms in South Carolina.

LOCATION	SAMPLES	SAMPLES CONTAINING 1 or MORE CLAMS	PERCENT CONTAINING CLAMS	ESTIMATED ACRES OF CLAM BOTTOMS*
Little River	969	153	15.8	50
Winyah Bay	1,629	9	0.6	18
North Island	810	52	6.4	854
North Santee	3,293	1,137	34.2	349
South Santee	2,957	1,058	35.8	361
Cape Island	4,536	195	4.3	755
Cape Romain Harbor	1,271	0	0.0	0
Muddy Bay	1,244	35	2.8	490
Raccoon Key	1,192	38	3.2	158
Bull Bay	3,637	368	10.1	88
Awendaw Creek	96	19	19.8	20
Bull Island	631	36	5.7	980
Capers Island	63	16	25.4	35
Dewee's Inlet	450	1	0.2	185
Isle of Palms	759	22	2.9	318
Kiawah Island	1,236	31	2.5	905
North Edisto	272	2	0.7	4
South Edisto	394	0	0.0	0
Stono River	119	0	0.0	0
St. Helena Sound	2,626	112	4.3	70
Port Royal Sound	2,993	52	1.7	104
Parris Island	2,378	226	9.5	540
Broad Creek	821	8	1.0	525
Mackay Creek	600	0	0.0	0
May River	302	0	0.0	0
Calibogue Sound	644	0	0.0	0
TOTALS	35,922	3,570		6,809

*Acreage was determined by planimetry of areas where clams were found. Clam densities, however, vary from extremely high (North Santee) to very low (Dewee's Inlet).

bushels in 1978. The clam fishery in South Carolina has been recently stimulated by three factors: (1) a comprehensive state-wide resource survey resulting in the discovery of commercial density subtidal beds in the Santee River Estuary, (2) mechanization of harvesting methods, and (3) increases in hard clam prices.

3.4. Interaction of the Hard Clam Fishery - Commercial clam production is frequently associated with harvesting the American oyster, Crassostrea virginica (Gmelin) in both subtidal and intertidal areas. Escalator harvesters operating on leased bottoms and during the Santee River Estuary fishery often cull subtidal oysters from the conveyor belt for market. Hand tongers likewise will keep higher quality oysters in conjunction with the clam catch. However, clam fishermen using hand rakes in the intertidal zone rarely harvest the lower quality intertidal oysters.

3.5. Processing - Practically all clams harvested in South Carolina are shipped to out-of-state markets. Clams are either stored dry or refrigerated for short periods prior to shipment.

3.6. Economics - The escalator harvester fishery currently consists of seven vessels, a decrease from nine during the 1974-75 fishery. Estimates of vessel costs range from $8,000 to $16,000. Daily operational costs, including fuel and equipment depreciation is approximately $170 (1974 dollars) (Rhodes, 1979 pers. comm.). The owners usually contract labor for a percentage of the ex-vessel production. In three cases, the current owners operate their own escalator harvesters. The Division of Marine Resources has restricted the fishery fleet size at the current seven vessel level. Permits are issued annually and harvest operations are subject to Department regulations. Although vessels have been sold on several occasions, they were purchased by South Carolina residents. The clam escalator harvesters are specialized vessels used only for gathering clams and oysters in environmentally suitable areas. Future uses may include utilizing the harvesters for transplanting clams to leased areas for holding and grow-out purposes. Profits are based entirely on the ex-vessel revenue received per bag of clams (250 ungraded clams per bag). Capital costs necessary for fishery entry are moderate. Limited entry (restricted to seven vessels) is based on estimates of maximum sustainable production from previous years' harvests.

Vessel productivity is largely due to the knowledge and efficiency of the captain and crew, and to some degree the fishing attitude of the escalator head. High current velocities caused by the release of freshwater from the Santee-Cooper flood gates also affect the efficiency and production of escalator harvesters.

Hand gathering and tonging clams is also regulated by ex-vessel clam prices. Small outboard powered wide beam boats with one or two people aboard usually constitutes the tonging and raking operation. Although the season is longer (September 1 thru May 31), the marketing prospects are similar to the escalator harvester fishery. Clams are harvested in smaller volumes throughout the clam season, but production usually increases with rising prices. More clam fishermen are inclined to enter the fishery at this time, which results in greater production.

4. Present Management System - The present hard clam fishery experiences problems related to commercial vs. recreational allocation; practically non-existent cultivation practices; environmental perturbations; and insufficient funding for management. The resource has been adversely affected by man-induced alterations to the coastal zone and contamination by fecal coliform pollution. Management has been complicated by the previously mentioned conditions and other problems of insufficient information, law enforcement and legislation.

4.1. Management Policies - Current shellfish management policies in South Carolina have evolved over a 50 year period and are the result of experience and biological knowledge gained during that time. The primary objectives of the current management policies have been to maximize shellfish production and to protect the resource from over exploitation. The Marine Resources Division, through laws and regulations, controls seasons, harvesting areas, and types of gear permitted. The Division is also responsible for the maintenance of public recreational shellfish areas. Furthermore,the Division conducts resource surveys and applied research on hard clams aimed at protection, revitalization and development of the commercial fishery.

Prior to the opening of the hydraulic escalator clam fishery, Marine Resources Division personnel survey the harvest areas to estimate the standing crop and recruitment into the fishery. Based on these results and through comparisons with previous surveys, a decision is made to open certain harvest areas to not more than seven vessels for a specified time period. During fishery operations, total catch and effort are reported on each fishing day. Shellfish Management Section personnel monitor the fishery at least once weekly and board vessels during harvesting. Samples are collected from two production areas and measured. Furthermore,weekly production is assessed in relation to an estimated standing crop. The Marine Resources Division may terminate the fishery at any time if it appears necessary.

Hand tonging and raking operations are managed in areas of high production such as Battery Creek, Parris Island, South Carolina. Utilizing resource survey data, a standing crop is estimated and fishing effort is restricted to the maximum sustainable yield.

4.2. Current Laws and Regulations - South Carolina Marine Fisheries Laws pertaining to shellfish were written primarily for oysters. Hard clam mariculture and commercial cultivation of clams on leased bottoms was not a consideration at the time of legislative action.

Current laws and regulations applicable to hard clams are summarized as follows from South Carolina Marine Fisheries Laws (1976):

Section	Article 1
50-17-20	Definitions used in Article 1. (2) "Shellfish" includes oysters, clams, mussels, scallops and all immobile fish having shells;
	Article 5
50-17-710	Lease Authorization - Provides that S.C. Wildlife and Marine Resources Commission may lease State bottoms to S.C. residents for shellfish culture, not to exceed 1,000 acres per person for commercial purposes, or two acres for other purposes (usually recreational). Also, provides that leases not exceed a term of five years, but shall be renewed for an additional five years at the option of the lessee.
50-17-720	Lease Preference to Owners of Adjacent Highlands - Provides that any person owning highlands abutting tidewaters may lease up to two (2) acres of bottoms adjacent to said highlands for oyster culture.
50-17-730	Application for Leases - Provides procedures for applying to Marine Resources Division for the leasing of State shellfish bottoms. Includes application forms, fees, description of area, survey requirement, etc. Also provides for perimeter boundaries and stipulates that no other lease shall be granted within same during the term of said lease. Lessee shall have first opportunity to lease any additional areas suitable for shellfish

culture within perimeter boundaries of lease upon the renewal of the lease.

50-17-740 Notice of Application - Provides that approved leases be advertised in a newspaper, notifying the public of the applicant's intent to lease a described area.

50-17-750 Hearing or Objections; Appeal - Provides for Commission hearings in the event of objections to the leasing of bottoms applied for based upon lawful or sufficient ground. Preference to leasing bottoms shall be given to applicants holding the lease on such bottoms for the term immediately preceding the term for which application is made.

50-17-760 Annual Rental for Shellfish Leases - Provides an annual lease rental of $1.50/acre.

50-17-770 Payment of Rental - Forfeiture for Non-Payment - Provides annual payment schedule for lease rental and for lease forfeiture for non-compliance.

50-17-810 Revocation of Leases for Non-Cultivation - Provides that leases may be cancelled after a period of one year if not effectively cultivated or harvested.

50-17-820 Transfer of Leases - No leases shall be transferred from one person to another without Commission endorsement.

50-17-1310 Records and Reports - Requires that all persons licensed to deal in shellfish shall keep records as required by the Division and shall furnish such records to the Division at such times it may prescribe.

50-17-1320 Provides penalties as specified in Section 50-17-130 for any violations of Article 5.

Article 9

50-17-1210 Gathering of Shellfish - Requires that permission must be obtained for gathering shellfish on State-owned and leased bottoms. Further provides that the head of any household may, in person, or by employee, gather for private use not more than two bushels of oysters and/or one-half bushel of clams for not more than two days in any week from any unleased State bottoms.

50-17-1220 Workers Health Certificate - Shellfish employees must have health certificates from the Department of Health and Environmental Control stating that the individual is free of typhoid bacilli.

50-17-1230 Minimum Depth for Dredges, etc. - Unlawful to use dredges, scoops, scrapes for taking shellfish in waters less than 12 feet deep on low tide without a permit from the Department of Marine Resources.

50-17-1240 Closed Seasons for Shellfish - Clams - June 1 - September 1. Season may be opened early and/or extended by 15 days. Does not apply to permitted replanting operations. Possession of clams or oysters during closed season is prima facie evidence of violation.

RULES AND REGULATIONS

No.

123-25 Provides that each vessel harvesting shellfish for market shall display an identification number issued by the Marine Resources Division. The number shall be issued to all commercial operators holding shellfish leases or permits for harvesting shellfish. The number shall be valid only for harvesting shellfish on the lease or area for which it is issued.

5. Current Research and Monitoring Programs

There is a paucity of data on the hard clam, *Mercenaria mercenaria* in the waters of South Carolina. This is due primarily to the low priority this commercially important species has traditionally held in comparison to the larger, more economically rewarding shrimp and oyster harvests. Recently however, relatively large clam beds have been discovered by the Marine Resources Division and placed into production. This, coupled with the advent of escalator harvesting and the increased value of hard clams have resulted in the hard clam fishery becoming an increasingly important component of South Carolina's commercial fisheries. It is thus now appropriate to merge existing data with proposed research to obtain needed information in order to formulate and implement meaningful management criteria for this blossoming commercial fishery. Only in this way can the State realize the full hard clam fishery potential without fear of jeopardizing the parental stocks by overfishing and poor management policies.

5.1. Description of Research and Monitoring Programs- Although the State has supported some hard clam research, sufficient data do not exist to formulate reasonably valid management policies. Existing research and data include (1) a preliminary study on hard clam recruitment performed during the spring and summer of 1975 (Eldridge, unpublished), (2) gametogenesis in the hard clam, presently being investigated by Manzi et al. (in progress), (3) a resource survey of the State's hard clam resource and (4) culture of hard clams in rafts and trays presently being investigated (Eldridge et al. 1976, 1979; Manzi et al., in progress). In addition, the State has monitored harvesting operations in the Santee Estuary.

These studies, with the possible exceptions of the raft and tray mariculture investigations have been preliminary in nature, yielding only enough information to indicate that extensive work must be performed to establish the recruitment potential of hard clam populations in South Carolina.

5.2. Research Objectives - The rapid growth of the South Carolina hard clam fishery has stimulated a great deal of interest for both the general public and the professional fisherman. This interest is enhanced by several recent developments, i.e.,

(1) It is expected that the planned rediversion of the Santee River by the U.S. Army Corps of Engineers will severely impact upon the major commercial clam grounds in South Carolina.

(2) Clam fisheries in the northern states are presently experiencing a drastic decrease in production. This is especially true for Great South Bay, N.Y., and the Chesapeake Bay, the two largest clam production areas in the eastern U.S.,

(3) The price of clams has significantly increased over the last five years. The increase has been rather dramatic over the past twelve months as the price of little necks has exceeded 150% of the price one year ago,

(4) No additional marketing is necessary for increased production from South Carolina. The tremendous latent market for clams and the general decrease in natural production in northern states has created a situation favorable to increased production from South Carolina.

The high degree of interest resulting from these developments make certain research objectives immediately requisit to the formulation of a hard clam fishery management program in South Carolina. In general, the three major goals sought by states in the management of their fishery resources are:

(1) the optimization of biological yields

(2) the optimization of economic and social benefits

(3) the reduction of management costs

The first of these goals relates to the resource itself, the second relates to resource use and the third to the organization governing the resource and users. The optimization of the biological yield of any fishery rests with a valid assessment of the resource, a determination of its reproductive potential, general information on the biology of the resource (environmental parameter limitations, growth rates, predator and disease problems, etc.) and evaluations of gear and harvesting protocols (including resource management activities, mariculture potential, etc.). The attached outline (Appendix I) lists the research activities associated with fishery resource management. Although all of these listed areas of research are desirable, the list can be abbreviated to three principal research objectives;

(1) Resource Assessment - The location and assessment of standing stocks and the location and the classification of bottom types have been partially performed. A principal priority should be a survey of the resource and bottom types in the coastal waters of South Carolina.

(2) Basic Biological Studies - Several aspects of hard clam growth and survival in South Carolina waters need to be investigated. These include studies on:

(a) gametogenesis and the factors controlling reproductive cycles,

(b) larval migrations and juvenile recruitment,

(c) in situ growth and mortality assessments including information on sybionts, predators and disease.

(d) mariculture potential, including ray and raft culture, hatchery development and genetic manipulation of wildstock populations;

(3) Fishery Methodology - Harvest limitations (size of organisms, times of harvesting and harvest intensity), gear efficiency and environmental impact, product handling and fishing mortality.

5.3. Proposed Research and Funding Levels Required (1979 dollars) - The research proposed in preceding sections and in the Appendix could conceivably cost more than the present net worth of the hard clam fishery. While this research effort is certainly desirable it could be trimmed to an absolute minimum based on priorities necessary for appropriate resource management. The following is a rough estimate of funds necessary to carry out this minimum program.

Resource Assessment	Basic Biological Studies	Fishery Methodology
$95,000 over two years	$186,000 over three years	$195,000 over three years

6. Identification of Problems

6.1. Biological or Resource Related - Biological information gaps related to shellfish management include: (1) insufficient data concerning reproduction and recruitment in South Carolina estuaries; (2) paucity of information on growth rates, predators, susceptibility to predation, and optimum growth densities; (3) inadequate information pertaining to overlying protective substrate and optimum planting periods for various size categories of seed; (4) inadequate information as to whether *Mercenaria campechiensis* or the reciprocal hybrids with *M. mercenaria* are more conducive to mariculture.

6.1.1. Habitat alteration - (1) information regarding depuration times when hard clams of varying contamination levels are transplanted to areas of specific salinities; (2) effects of siltation caused by freshwater runoff and dredge spoil; (3) effects of excavations, drainage and alterations of the marshland on viable habitats of *Mercenaria*.

6.1.2. Information gaps relevant to management - (1) Recruitment of juveniles into the standing crop in relation to the maximum sustainable yield, (2) insufficient information pertaining to a wide range of harvesting effects.

6.2. User Related

6.2.1. Commercial vs. recreational - Lack of demand in the local market area for hard clams has prevented conflicts between recreational and commercial interests in the State. However, increased recreational fishing pressure upon the State's oyster gathering areas is an indication of future needs. Large numbers of New England residents retiring in South Carolina are expected to increase local demand, particularly in such areas as Hilton Head.

6.2.2. Space Competition - Currently, space competition presents no problem. However, as technological advances in clam mariculture become more common, space competition with oyster standing crops will certainly become a reality.

6.2.3. Impact of non-resident entry into fishery - As described earlier, the hard clam escalator harvester fishery is currently restricted to seven local vessels operating within the constraints of the permits issued annually. Non-resident commercial entry is currently discouraged by the OCMM due to the limited standing crop capacity of the fishery.

Hand gathering and raking operations would be less affected by small numbers of non-resident fishermen, with exceptions such as overfishing in certain limited habitats. However, organized fishing operations such as migrant labor could create severe over-harvest problems and result in exclusion of the indigenous labor force.

6.2.4. Pollution control and waste disposal - Bacteriological contamination of waters in shellfish growing areas has presented the largest pollution control problem to the hard clam industry. Furthermore, fecal coliforms persist in subcontamination levels in most commercial clam areas.

Industrial pollution is only occasionally monitored, and is currently not identified as a contamination problem. High levels of copper have been found in low density hard clam populations in an area polluted by fecal coliforms.

The careless use of pesticides in South Carolina coastal areas, associated with freshwater runoff, is a growing problem - particularly the aerial application of parathian and toxaphene for crop pest control. Improper use has resulted in temporary closure of certain local areas to shell fishing and poses potential health hazards.

Overboard discharge of sewage from pleasure boats contributes to contamination and closure of shellfish growing areas. The problem is aggravated in populous areas, marinas and heavily trafficked estuaries.

6.2.5. Industry organization - The lack of an effective shellfish industry organization makes it difficult for management to adequately determine the desires and needs of the industry and weakens the influence of the industry in matters of importance.

6.2.6. Problem areas related to management and regulation - The current shellfish management system, in spite of past accomplishments, is inadequate and is currently operating under a number of constraints that limit its effectiveness. Some major constraints are as follows:

(1) Biological information gaps

(2) Inadequate landing data for commercial and recreational harvests

(3) No capability to assess recruitment of juvenile seed clams into harvested populations.

(4) Inadequate information concerning the potential of clam grow-out areas.

(5) Legislation necessary to provide for hard clam mariculture.

(6) Outdated legislation regarding opening and closure of hard clam seasons.

A further constraint pertains to insufficient funding and personnel allocated for shellfish management, research and extension activities. This imposes serious handicaps with respect to: (1) monitoring and assisting commercial clam mariculturists with seed planting and harvest operations, (2) maintenance and upgrading of public hard clam areas; (3) applied research programs; (4) acquiring information pertaining to harvesting, economic and marketing aspects of the fishery. Furthermore, current efforts in the areas of extension and advisory services are inadequate to assist the industry with product quality improvements, developing new technology, and coping with various water quality and waste disposal programs.

6.3. Economic

6.3.1. Marketing - Currently, almost all hard clams commercially harvested in South Carolina are shipped out of state in the shell. Inconsistent production volume of hard clams shipped out of state has inhibited strong market development. Furthermore, hard clams in South Carolina are ungraded and shipped to areas of less favorable market potential, such as New York City. Although the New York area consumes large quantities of hard clams, it also produces extremely large harvests. More favorable pricing arrangements may be established in areas such as Pennsylvania, the mid-west and southwest. Limited quantities of South Carolina hard clams are sold in seafood specialty stores and restaurants, however, the in-state demand for shell stock remains low. The limited production of clams and the seasonal nature of the fishery in South Carolina has impeded development of a major in-state processing facility.

6.3.2. Labor supply - Escalator harvester vessel labor is currently seasonal and the captain and crew's compensation depends on each days' catch. Several escalator harvester clam fishermen enter the shrimp and oyster fisheries during the off-season. High clam prices have resulted in drawing labor from other industries such as building construction into hand raking for clams.

Due to the small size of the commercial fishery, however, labor supply is not a significant problem at this time.

6.4. Management,Regulatory and Administrative Problems

6.4.1. Legislation and regulations - Existing statutes that pertain to the leasing of State bottoms for shellfish culture apply entirely to oysters, with no provisions for leasing bottoms for clam culture. State law also provides for a closed season for harvesting clams between June 1 and September 1 of each year. Some shellfish industry members feel that this restriction prevents them from establishing year round markets. Revision of existing shellfish laws and regulations should be drafted with provisions included for a year round clam season. Provisions for clam lease rights similar to those currently in effect for oysters and legal size limits should be established.

6.4.2. Enforcement - It is the stated policy of the Law Enforcement Division to assist the Office of Conservation, Management and Marketing (OCMM) in such areas as the control of out of season harvesting, exceeding harvesting limits, and the removal of hard clams from polluted waters. However, implementation of a workable program regarding prosecution for poaching clams on leased bottoms and enforcement of boundaries during the hydraulic escalator fishery must be coordinated within the Department to improve hard clam management and provide protection for the resource.

6.4.3. Common property rights - An increasing administrative problem concerns the issuance of permits to clam fishermen on public grounds. The OCMM has no authority to deny permits to perspective hand gathering fishermen on these State controlled areas. Increasing numbers of fishermen entering the fishery each year pose serious problems regarding the protection of the resource.

6.4.4. Limited entry - The legality concerning restriction of the number of hydraulic escalator harvester vessels in the Santee Delta fishery is a moot question. However, an increase in the number of harvesting vessels or fishin days would certainly overfish and subsequently damage the resource. No legal criteria has been established to determine access or denial into the fishery. Furthermore, no legislative guidelines have been established to restrict the number of participants on clam bottoms that are opened to hand raking and tonging. Highly favorable market conditions during a period of depressed building construction may endanger areas of established standing crops.

6.4.5. Optimum yield determinations - Knowledge regarding the maximum sustainable yield (MSY) remains a critical management problem throughout the State. Lack of technically feasible methods to assess seed and juvenile recruitment in clam beds heavily protected by overlying shell substrates are fundamental obstacles to determining the optimum yield and allowable production.

6.4.6. Extension and information needs - Expertise in clam mariculture will certainly become a necessary requirement for extension agents as well as the capability to measure standing stock, gauge predator problems and disseminate cultivation information. Further information needs concern the education of recreational clam fishermen in regard to harvesting and habitat.

7. SUMMARY AND RECOMMENDATIONS

In order to properly manage South Carolina's hard clam resource, a consolidation of biological, economic and social information is necessary to provide a framework for sound management decisions. Furthermore, the legal authority to take action based on these management decisions is necessary to the implementation of any functional management program. With adequate legal authority and a viable enforcement program, the Shellfish Management Section can effectively manage the State's hard clam resource for both recreational and commercial utilization.

As evidenced in the preceding sections, information is wholly inadequate in many areas of importance bearing directly on impending management problems. In particular, information concerning the hard clam recreational fishery is almost non-existent. Also, it is difficult to estimate the effects of management actions on commercial and recreational fishermen, dealers, processors, and their employees. Therefore, the following recommendations are made to address the current problem areas felt to be of most critical concern to commercial and recreational shellfish interests in South Carolina.

(1) Legislation must be proposed to provide for hard clam mariculture in South Carolina. Existing statutes are inadequate and the current lease regulations were written specifically for oyster culture with no provisions for leasing bottoms for clam culture.

(2) Establish a year round clam season in the State for leased acreage and public grounds. Areas such as the Santee Delta and Parris Island could be opened and closed at Departmental discretion.

(3) Establish a legal minimum harvest size for hard clams and a system of harvest accountability in order to statistically record the number of clams harvested from specific areas.

(4) Implement research objectives in order of critical biological information priorities. The ability to determine the number of juveniles recruited into a natural population each year is a necessary management tool that is currently lacking.

(5) Establish tasking criteria for Law Enforcement that is compatible with management needs to coordinate shellfish laws with biological and economic needs.

(6) Establish a program of educating recreational clam fishermen through existing Division extension capabilities. This program would also assist in the determination of recreational demand and harvesting pressures.

(7) Conduct a demonstration commercial scale seed planting operation with the cooperation of commercial shellfishermen. This project should be completed in the immediate future to illustrate the mariculture potential of hard clams prior to the Santee-Cooper rediversion.

(8) Extension activities should also be devoted to the formation of an effective shellfish industry organization. The current lack of industry organization makes it difficult for management to determine industry needs and weakens its influence.

(9) Identify funding sources and develop a funding program for expanded shellfish management and research programs.

Figure 1. Bottom types and clam densities. Percent incidence of clam occurrence and total clams are compared to their respective substrates.

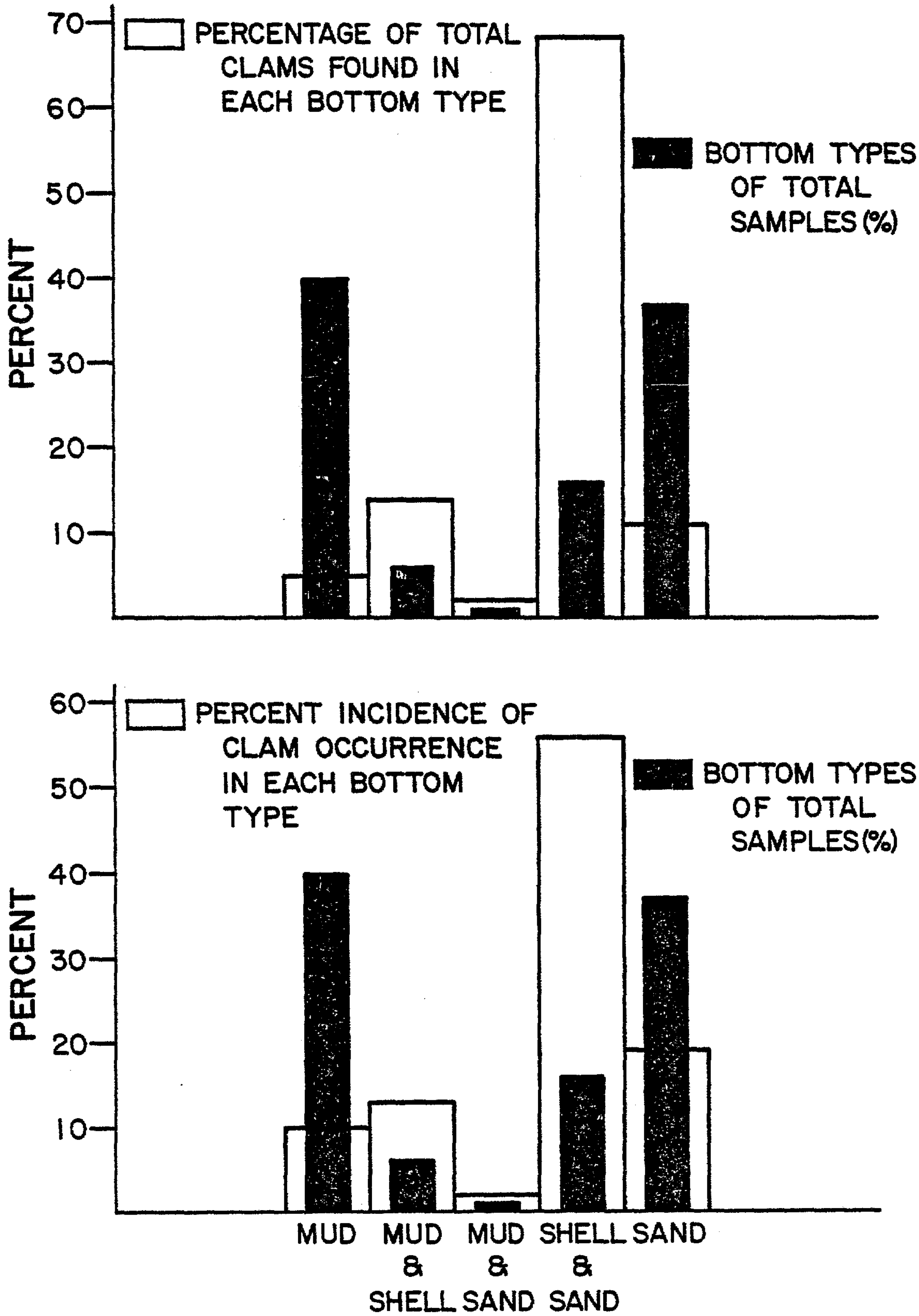
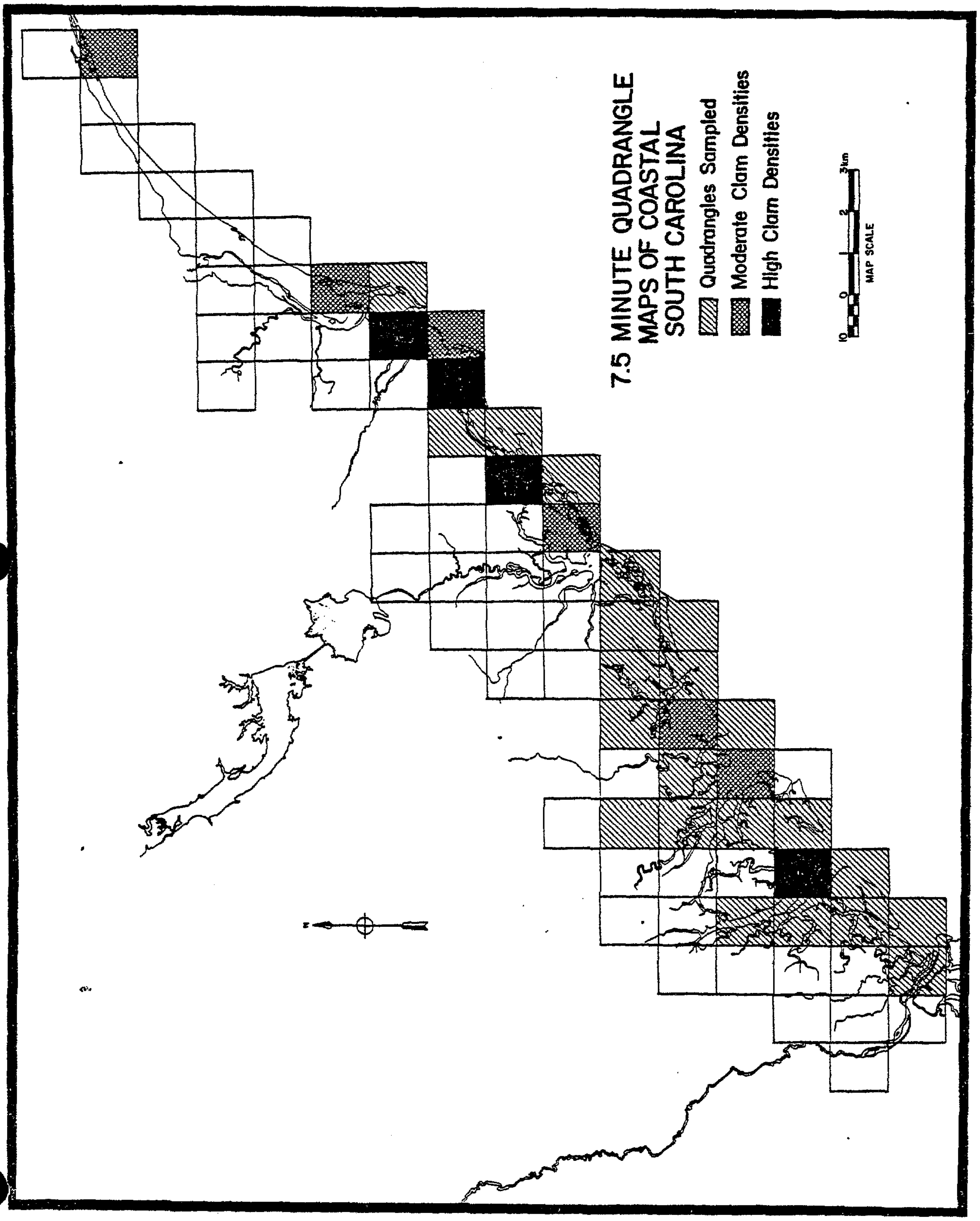


Figure 2. Quadrangles sampled within coastal South Carolina's seventy-seven 7.5 minute[2] (1:24,000) quadrangle maps. Moderate and high density clam areas are depicted.



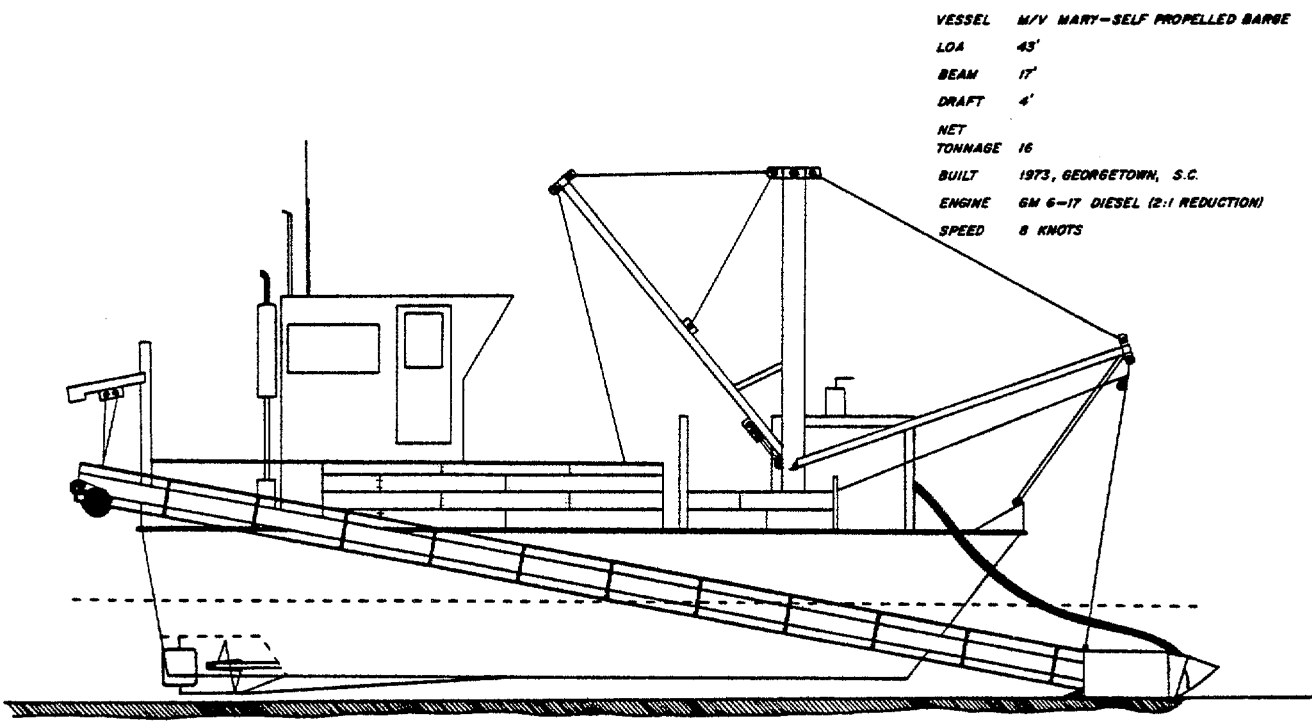
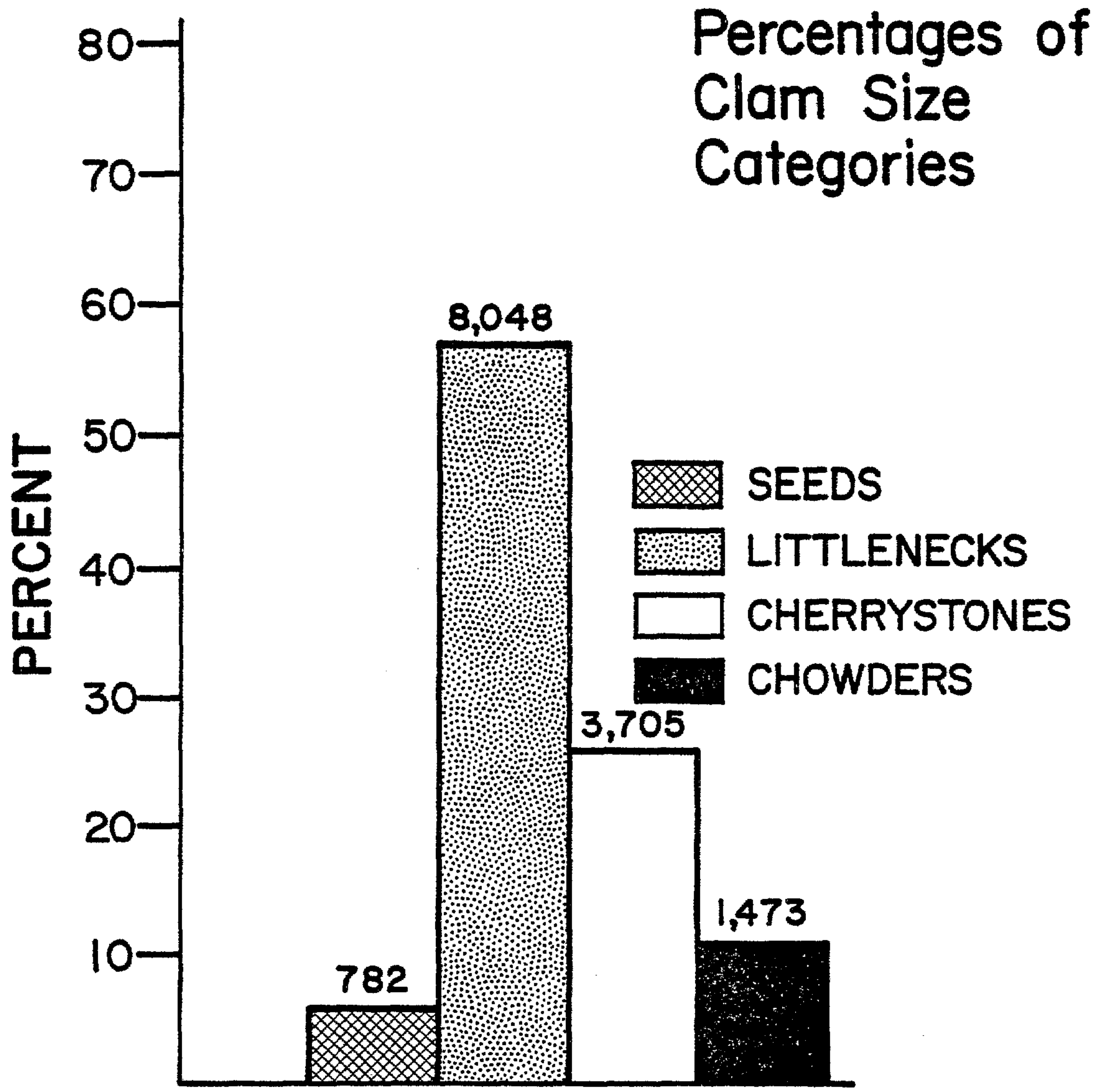


FIGURE 3. *A diagram of a hydraulic escalator shellfish harvester employed in the Santee River from 1974 to* present.

Figure 4. Commercial size category percentages of hard clams sampled.



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9. Appendix I

MOLLUSCAN FISHERY MANAGEMENT

In the preparation of a planning document for the utilization of any fishery resource the priorities of proper management must be organized into a rational, effective approach for fisheries development. In order to implement reasonable management policies certain information is necessary. In this regard, the following outline briefly summarizes those research efforts needed to provide the information which should be considered in any attempt to develop major molluscan fisheries in South Carolina.

I. Resource Assessment - A carefully planned, systematic program of resource assessment is a primary consideration and should include:

A. Location and assessment of standing stocks

B. Surveys of available literature and landing statistics

C. Investigations of standing stock habitats to determine "preferred"

1. Hydrographic conditions (temp., sal., etc.)
2. Bottom conditions and substrate relationships
3. Planktonic components
4. Benthic components

D. Location and classification of bottom types based on productivity

E. Pollution studies to determine:

1. Types and sources to common pollutants
2. Quantitative and qualitative effects upon the marine resource
3. Effects of dredge and fill operations

II. Recruitment Assessment - In order to plan the efficient recreational and commercial utilization of molluscan marine resources reliable data on the renewability of the resources must be available. This data should include information on:

A. Life cycles

B. Nursery areas

C. Gametogenesis

D. Spawning time

E. Spawning areas

F. Spawning success

plankton surveys

set traps (shell bags, strings, etc.)

abundance of year class

G. Larval migrations

III. Growth Studies - In addition to recruitment assessment,natural growth in the various areas of appreciable standing stocks must be determined.

A. In situ growth and mortality determinations

B. Supplementary laboratory analysis on growth and factors influencing growth and survival.

IV. Symbionts,Predators & Disease - Studies should be initiated to determine primary symbiotic relationships,predator identification, density and effectiveness, and the penetrance, expressivity and causation of disease. These studies should be followed up with:

A. Continuous monitoring of standing stocks for disease

B. Continuous monitoring for predators

C. Predator control studies

V. Gear Evaluation - Harvesting operations must be evaluated to provide information on catch and effort. Included in this area should be studies on:

A. New gear design

B. Existing gear effectiveness

C. Product handling and fishing mortality

D. Gear caused environmental damage

E. Cost analysis

VI. Mariculture - Development of intensive culture of commercially valuable species is now a reasonable alternative to the management of natural stocks. Several areas of investigation immediately warrant consideration.

A. Pond culture

B. Raft culture

C. Hatchery development

1. To augment natural resource

2. To supply seed stocks

3. Selective breeding

4. Initiate polyculture

5. Provide organisms (larvae and juveniles) for various laboratory and field experients

Other areas which may be considered in a molluscan fishery management planning document include:

VII Economics
VIII Education
IX Advisory Services
X Analysis of existing laws & regulations
XI Establishment of permanent monitoring programs
XII Marketing research