South Carolina Wildlife and Marine Resources Department

The Shrimp Fishery of the Southeastern United States:

A Management Planning Profile

A Co-operative State - Federal Study

Edited by: D. R. Calder P. J. Eldridge E. B. Joseph

South Carolina Marine Resources Center
Technical Report Number 5
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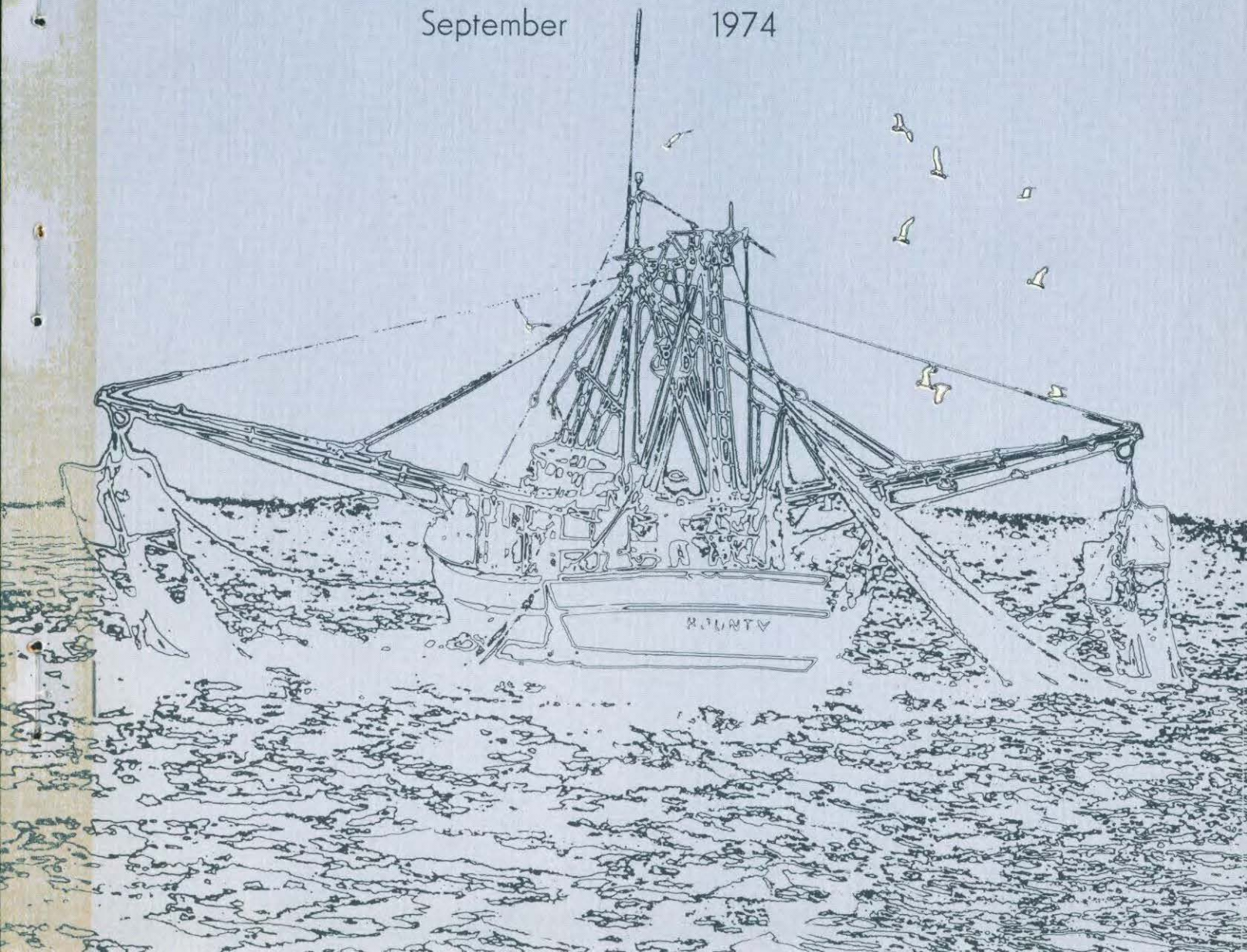

THE SHRIMP FISHERY OF THE SOUTHEASTERN UNITED STATES:

A MANAGEMENT PLANNING PROFILE

Edited by

Dale R. Calder
Peter J. Eldridge
Edwin B. Joseph

TECHNICAL REPORT NO. 5

SOUTH CAROLINA MARINE RESOURCES CENTER

SOUTH CAROLINA WILDLIFE AND MARINE RESOURCES DEPARTMENT

CHARLESTON, SOUTH CAROLINA 29412

SEPTEMBER 1974

PREFACE

The South Atlantic Technical Committee for Shrimp Management was established in 1973 to examine the feasibility and desirability of managing the shrimp fishery of the states of North Carolina, South Carolina, Georgia, and the Atlantic coast of Florida on a regional basis, and within the concept of a state-federal partnership. The committee is comprised of two representatives from each of the four states: Thomas L. Linton and Edward G. McCoy of the North Carolina Department of Natural and Economic Resources; Edwin B. Joseph and Charles M. Bearden of the South Carolina Wildlife and Marine Resources Department; William W. Anderson and David H. Gould of the Georgia Department of Natural Resources; and Harmon W. Shields and Edwin A. Joyce, Jr., of the State of Florida Department of Natural Resources. Irwin M. Alperin, executive director of the Atlantic States Marine Fisheries Commission, is an ex officio member of the committee.

Among the items discussed at an early committee meeting was the need for a management planning profile for the shrimp fishery of the South Atlantic region. The staff of the Marine Resources Center of the South Carolina Wildlife and Marine Resources Department agreed to prepare the profile with the assistance of committee members and personnel from the respective state management agencies. The committee met four times at various locations within the region during preparation of the profile to specifically review progress and discuss content of the study. This document represents the completed profile.

We are indebted to Irwin M. Alperin, William W. Anderson, I. B. Byrd, Johnie H. Crance, Paul J. Hooker, David H. Gould, Edwin A. Joyce, Jr., Thomas L. Linton, Edward G. McCoy, Richard Schaefer, Harmon W. Shields, William H.

Stephenson, and James A. Timmerman for their participation in the formulation and development of this study. Particular thanks are due to Johnie H. Crance, Walter F. Godwin, David H. Gould, Edwin A. Joyce, Jr., and Kenneth Roberts for critically reviewing sections of this report and adding significantly to its content. We especially acknowledge the assistance and effort of William W. Anderson, whose knowledge of shrimp and the shrimp fishery of this coast is unequalled. Mrs. Lourene Rigsbee prepared many of the tables and typed most of the final manuscript. This study was supported by Contract No. 03-3-042-29 from the U. S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. Funds for travel were made available from the Atlantic States Marine Fisheries Commission through a grant from the National Marine Fisheries Service.

Edwin B. Joseph, Chairman

South Atlantic Technical Committee for Shrimp Management

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SECTION 1

INTRODUCTION

by

Edwin B. Joseph
Director, Division of Marine Resources

Fishery scientists and managers readily conceded several decades ago that their efforts to successfully manage fishery stocks were far from adequate. With this concession was the widely held belief that inadequacies in fishery management were due almost solely to a lack of information on the biology of the species or stock in question. Accordingly, the principal emphasis over the last 25 years has been directed toward increasing the state of such knowledge. Although many significant information gaps still exist, considerable progress has been made in fisheries biology. Yet, our ability to manage marine and estuarine fisheries has improved but little.

Slowly but surely we face an increasing awareness that social, economic, and particularly institutional arrangements may be more serious as deterrents to successful management than our still imperfect state of biological knowledge. Federal fishery scientists, while not bound by narrow geographic confines, have virtually no management authority. State fishery managers, who do have the constitutional authority for fisheries management, are frequently hampered by a lack of adequate technical support. They must also deal within jurisdictional limits seldom coinciding with the geographic limits of a given species or stock.

Continually expanding demand for fishery products, coupled with the greatly increased efficiency of the harvesting sectors of many fisheries,

raises the possibility or even probability that many fishery stocks will ultimately be overexploited and damaged. The fate of haddock, yellow tail flounder, halibut, Atlantic menhaden, king crab, and the river herrings, among others, bear out this point.

These conditions, plus the increasing pressures of foreign fleets on U. S. coastal fishery stocks, have forced state and federal fishery scientists and managers to seek new management alternatives to the traditional institutional arrangements under which they have operated, rather unsuccessfully. One obvious alternative is to combine federal technical capability and authority of the contiguous zone with the technical capabilities and separate management responsibilities of the contiguous states of a particular region into a state-federal partnership.

In November 1972, representatives of the federal government met in Miami, Florida, with representatives of four southeastern states (North Carolina, South Carolina, Georgia, and Florida) to informally discuss the concept of a state-federal partnership for regional management. Initially, there was less than uniform agreement that such an arrangement was feasible, necessary, or even desirable. Since most participants were dissatisfied with existing efforts, however, it was agreed that such an alternative deserved careful study and should be considered with regard to the most important fishery of the region, namely that for penaeid shrimp.

At a meeting during January 1973 in Charleston, South Carolina, the South Atlantic Technical Committee for Shrimp Management was formally established. A need to compile a management planning profile of the shrimp fishery was identified at this meeting, and a decision was made to seek federal support for such a study. It was agreed that the staff of the

Marine Resources Division of the South Carolina Wildlife and Marine Resources Department would serve as prime contractor but that the study would be on behalf of, and would involve participation by all four member states.

This report constitutes the initial output of the study. Objectives of the investigation were to summarize the state of knowledge concerning southeastern penaeid stocks; to provide a baseline picture of the present state of the fishery; to review the historical trends that brought the fishery to its present state; to summarize the current laws and regulations pertaining to the shrimp fishery in each of the four states; to identify problems and management needs of the fishery; and to provide an outline of ongoing and projected research and monitoring relevant to penaeid shrimp stocks. It was not within the scope of this project to undertake original research; neither was it considered necessary to repeat in detail any information already available from reviews such as those published in the FAO Fisheries Reports on shrimp and shrimp fisheries. However, efforts were made to include relevant literature published subsequent to these reports. Potential problems within the fishery, as well as potential management solutions to those problems, will be the subject of a future report.

SECTION 2

DESCRIPTION OF RESOURCE

by

Dale R. Calder, Peter J. Eldridge, and Malcolm H. Shealy, Jr.
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2.1 Species Composition

Shrimp represent the principal fishery resource of the southeastern states of North Carolina, South Carolina, Georgia, and Florida. The shrimp industry of these states is based almost entirely on three shallow-water species of the family Penaeidae, the white shrimp (Penaeus setiferus), the brown shrimp (P. aztecus aztecus), and the pink shrimp (P. duorarum duorarum). Of minor importance to the shrimp fishery at present are rock shrimp (Sicyonia brevirostris) and royal red shrimp (Hymenopenaeus robustus); further information on these species is given in Sections 3.6 and 5.

Relative proportions of the three predominant species in catches from 1967-1971 are shown in Fig. 2.1. P. setiferus accounts for the bulk of the landings in Georgia and the Atlantic coast of Florida, with maximum catches in late summer, autumn, and early winter. In South Carolina, small landings of white shrimp in spring are augmented by a much larger catch in autumn. The spring white shrimp fishery in that state is based on adults which have overwintered, while the autumn catch is based almost entirely on young-of-the-year. White shrimp are caught in North Carolina principally during autumn, but of the three species taken in the state, P. setiferus accounts for the smallest proportion of the catch.

P. a. aztecus predominates in the North Carolina fishery. During some years, catches of brown shrimp may exceed those of white shrimp in South Carolina as

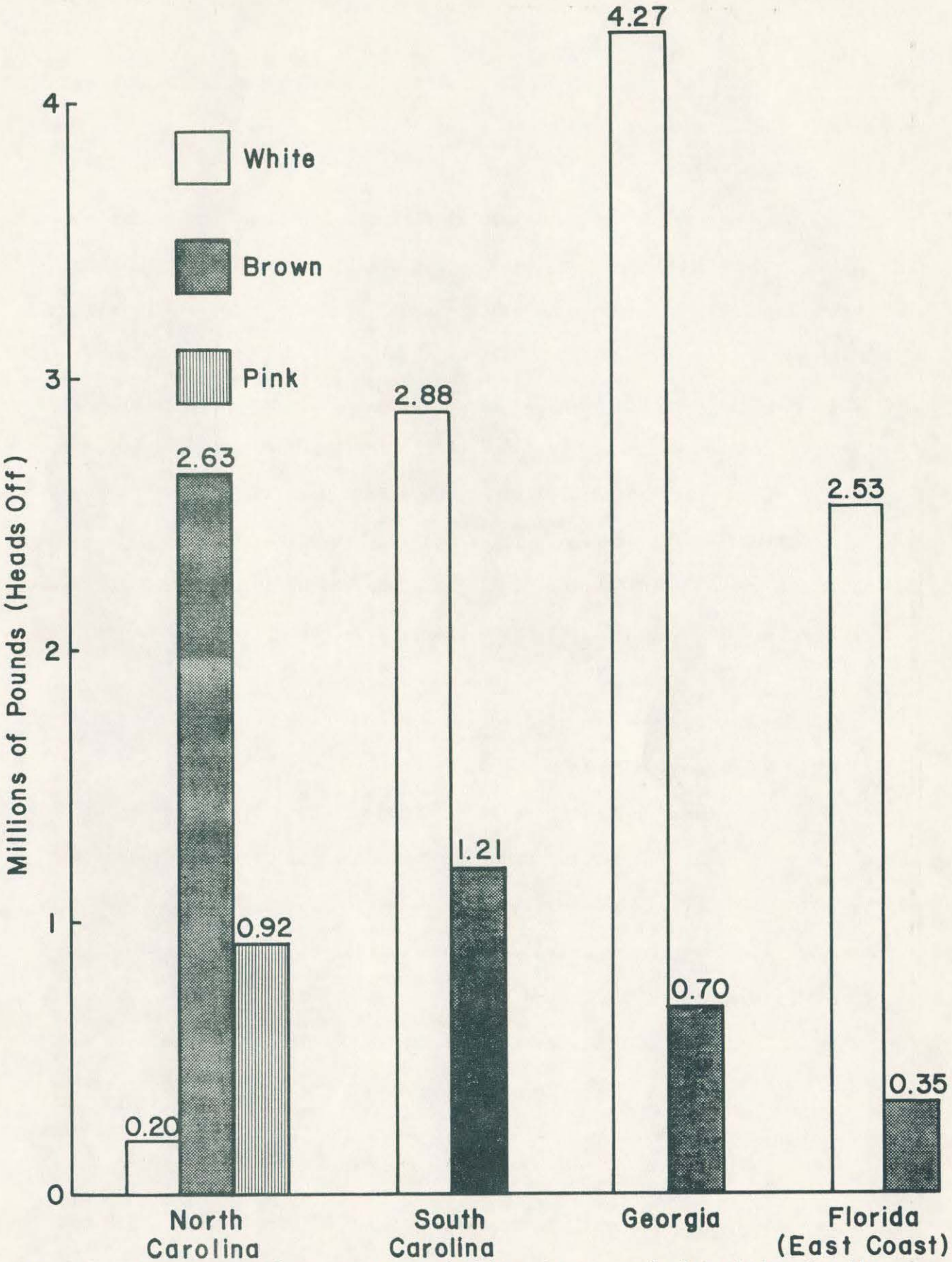

Fig. 2.1 Average landings per year of white, brown, and pink shrimp for the years 1967-1971 (data from Fishery Statistics of the United States, Statistical Digests No. 61-64).

well. The peak of the brown shrimp harvest occurs during summer in all four states. This species enters and leaves the Florida east coast fishery earlier than in the other three states.

P. d. duorarum is of major commercial significance along the Atlantic coast only in North Carolina, where it accounts for about one quarter of the total shrimp landings. Fishing for pink shrimp usually begins in the spring and ends by mid-summer.

The various shrimp species undergo considerable fluctuations in abundance from year to year as reflected by catch statistics (see Section 5). However, landings of white shrimp normally exceed those for brown shrimp when data are pooled for the four-state region. Together, these two species typically account for about 95% of the total shrimp landings in the southeastern United States.

Seasons and geographic location of the shrimp fishery in the four-state region are discussed in greater detail under Section 3.3.

2.2. Life History of Predominant Species

2.2.1 Reproduction Cycle

The commercially important penaeids of the southeastern United States are dioecious and sexually dimorphic (Lindner and Cook, 1970; Cook and Lindner, 1970; Costello and Allen, 1970). While the ratio of sexes appears to be about 1:1 for the three species, some segregation by sex may occasionally be observed (Weymouth, Lindner, and Anderson, 1933; Pérez Farfante, 1969). Beyond a total length of 100 mm, females are larger than males of the same age (Williams, 1955). Broad (1965) reported that sexual maturity in P. setiferus is attained at a total length of 140 mm, while Burkenroad (1934) indicated that females of this species reached maturity at about 165 mm and males at about 119 mm. In P. a. aztecus, maturity is reached at about 140 mm (Cook and Lindner, 1970). In P. d. duorarum, females become mature at lengths of 85 mm and males

at 74 mm (Eldred, et al., 1961). No observations on mating in white, brown, and pink shrimp have evidently been published, although the three species are believed to be promiscuous. Spermatophores are transferred to the female before spawning (King, 1948), and the eggs are presumably fertilized externally during the spawning process. Estimates place the number of eggs spawned by an individual white shrimp at 500,000 - 1,000,000 (Anderson, Lindner and King, 1949; Anderson, 1966). Eggs of the three species are demersal, measuring 0.28 mm, 0.26 mm, and 0.31 - 0.33 mm in diameter for P. setiferus, P. a. aztecus, and P. d. duorarum, respectively (Pearson, 1939; Dobkin, 1961; Cook and Lindner, 1970; Lindner and Cook, 1970).

In Georgia and northern Florida, some spawning by P. setiferus may occur inshore, although most spawning occurs more than 1.9 km (1.2 miles) from the coastline (Lindner and Anderson, 1956). Joyce and Eldred (1966) also noted that spawning in white shrimp may occasionally take place inshore at or near inlets, but that most occurs offshore at depths from 20-80'. Pink and brown shrimp spawn offshore in deeper water than white shrimp (Joyce and Eldred, 1966).

Spawning is correlated with bottom water temperatures (Lindner and Anderson, 1956; Cummings, 1961; Barrett and Gillespie, 1973). Rapid temperature changes, rather than the attainment of a particular optimum temperature, apparently act as the stimulus for spawning, at least for white shrimp (Pérez Farfante, 1969). According to Lindner and Anderson (1956), spawning in P. setiferus commences during April (Florida and Georgia) or May (South Carolina), and continues into September (South Carolina, Georgia, and northern Florida) or October (central Florida). It is uncertain whether individual shrimp spawn once or several times per year, although repeated spawning is probable (Pérez Farfante, 1969). Lindner and Anderson (1956) believed that a given shrimp may spawn up to four times a season, and that some females may survive to spawn a second season.

Observations on populations of P. a. aztecus from the Gulf of Mexico indicate that duration of spawning period and time of spawning peaks are dependent upon water depth (Cook and Lindner, 1970). Studies in the southeastern states indicate that maximum recruitment of brown shrimp postlarvae to estuaries occurs during February or March (Williams, 1959; Bearden, 1961; Joyce, 1965). A smaller peak in autumn has also been reported in this species (Williams, 1959; Joyce, 1965; Hoese, 1973). Hoese noted that the small wave of young brown shrimp from autumn spawning was obscured by the abundance of white shrimp. The appearance of postlarvae in nursery grounds may not be a reliable indicator of actual spawning periods. Research conducted in the northwestern Gulf of Mexico suggests that larvae, postlarvae, or both may overwinter in offshore waters and migrate into estuaries the following spring (Temple and Fischer, 1967; Cook and Lindner, 1970). Some evidence exists for autumn spawning of brown shrimp in the south Atlantic states. Frisbie (1967) found a few maturing, mature, and spent females in Georgia about one mile off Sapelo Sound during October of 1966. In South Carolina, Charles Bearden (personal communication) found mature females and males three to four miles off Stono Inlet during October and November of 1965 and 1966.

There are indications that as pink shrimp mature, they migrate beyond the coastal fishing areas into deeper water (Anderson, 1970). Off northeastern Florida, spawning in this species may begin as early as May, and is believed to reach a peak during June and July (Joyce, 1965). Where the North Carolina populations of P. d. duorarum spawn has yet to be determined, although there is some evidence that concentrations of pink shrimp occur in coral beds off the coast, and that these areas may serve as spawning grounds (Connell Purvis, personal communication). Recruitment of pink shrimp postlarvae in North Carolina waters extends from May to November (Williams, 1965).

2.2.2 Age and Growth Characteristics

After hatching from the egg, white, brown, and pink shrimp larvae pass through five naupliar, three protozoeal, and three mysis stages (Pearson, 1939; Anderson, Lindner, and King, 1949; Pérez Farfante, 1969). Duration of larval life is dependent upon temperature, food, and habitat. Records suggest 10 - 12 days for P. setiferus (Johnson and Fielding, 1956), 11 - 17 days for P. a. aztecus (Cook and Murphy, 1969), and 15 - 25 days for P. d. duorarum (Ewald, 1965). These developmental rates were determined from laboratory studies under a variety of temperature conditions. Water temperature in the weeks following spawning is critical to the survival of larval and postlarval penaeids. Barrett and Gillespie (1973) in Louisiana noted an inverse correlation between May production of brown shrimp and the number of hours that temperatures were below 20 C after the first week of April.

Rates of growth in shrimp are highly variable, and depend upon such factors as season, water temperature, and size and sex of the organisms (Pérez Farfante, 1969; Costello and Allen, 1970). Adolescent shrimp grow rapidly, with estimates ranging from 1.0 - 2.3 mm per day in P. setiferus, 1.0 - 2.5 mm per day in P. a. aztecus, and 0.25 - 1.7 mm per day in P. d. duorarum (Lindner and Cook, 1970; Cook and Lindner, 1970; Costello and Allen, 1970).

Most estimates place growth of maturing and adult P. setiferus at about 20 - 40 mm per month during summer, while growth in winter is generally considered to be negligible (Pérez Farfante, 1969). Lindner and Anderson (1956) developed Walford growth lines from successive 10-day intervals during periods of rapid growth in white shrimp. These data, when converted to 30-day lines, were as follows:

Males	$Y = 45.8 + 0.7427X$	$L_\infty = 178.0$ mm
Females	$Y = 56.4 + 0.7225X$	$L_\infty = 203.0$ mm
Combined	$Y = 51.0 + 0.7322X$	$L_\infty = 190.5$ mm

Data on growth in offshore populations of P. a. aztecus were given by Chavez (1973). Results for the population as a whole were:

L_∞ = 207 mm $\qquad$ W_∞ = 70 g

k = 0.1904 $\qquad$ t_o = -0.872

St. Amant, Broom, and Ford (1966) observed that growth in brown shrimp was generally negligible below 16 C, less than 1 mm per day below 20 C and less than 1.5 mm per day below 25 C.

Growth for adult and subadult P. d. duorarum ranged from 0 - 22 mm total length per month in references cited by Costello and Allen (1970).

Fontaine and Neal (1971), accounting for sex and seasonal differences, provided information on length-weight relations in the three species (Table 2.1).

No valid method is available for age determination of individual P. setiferus and P. a. aztecus (Lindner and Cook, 1970; Cook and Lindner, 1970). A size-age conversion developed by Kutkuhn (1966) has been used to estimate age in P. d. duorarum. Estimates of longevity indicate that white shrimp may live at least 16 months, although the percentage living two years or more is small because of high mortality rates (Lindner and Anderson, 1956). Average maximum age in pink shrimp was estimated by Kutkuhn (1966) to be 83 weeks; Eldred, et al. (1961) believed some specimens may live for two years or more. Cook and Lindner (1970) suggested that some female brown shrimp may exceed 18 months in age.

Knowledge of mortality rates is important in maximizing yield from the fishery. A high estimate of weekly instantaneous mortality (Z = 1.51) led Kutkuhn (1966) to recommend harvesting as soon as shrimp reached acceptable market size, while Lindner (1966) and Berry (1967), calculating lower mortality rates (Z = 0.22 - 0.27), recommended that fishing be postponed until shrimp were considerably larger. Other estimates of mortality in shrimp are given in

Table 2.1 Equations describing length-weight relations for P. setiferus, P. a. aztecus, and P. d. duorarum (from Fontaine and Neal, 1971).

Species and Sex		Equation
White		
	Male	Log W = -5.694 + 3.261 Log L
	Female	Log W = -5.635 + 3.234 Log L
	Combined	Log W = -5.665 + 3.247 Log L
Brown		
	Male	Log W = -4.935 + 2.911 Log L
	Female	Log W = -5.021 + 2.966 Log L
	Combined	Log W = -4.978 + 2.938 Log L
Pink		
	Male	Log W = -4.999 + 2.967 Log L
	Female	Log W = -5.227 + 3.092 Log L
	Combined	Log W = -5.113 + 3.029 Log L

Table 2.2. These estimates, based on the von Bertalanffy equation, assume a constant mortality rate over a range of sizes. Since the mortality rate of shrimp may decrease with increasing size, it is important in establishing proper yield strategies that mortality rates for all relevant sizes be determined.

P. setiferus is generally considered as the least hardy of the three species (de Sylva, 1954; Butler, 1962; Lindner and Cook, 1970). P. d. duorarum is apparently the hardiest (Lindner and Cook, 1970). Costello and Allen (1970) noted that pink shrimp withstand rough handling without excessive mortality, although they are the least tolerant of the three species to low salinity (Joyce and Eldred, 1966). Shrimp are extremely vulnerable to pesticides, particularly the younger stages, while juvenile and preadult P. setiferus are apparently more cold-tolerant than adults (Lindner and Cook, 1970).

2.2.3 Population Dynamics

2.2.3.1 Introduction

The discipline of population dynamics is still in a formative stage within the field of fisheries. While many sophisticated models have been developed, few appear to adequately describe many commonly observed changes in commercially-exploited species. This is true in particular for commercially-exploited crustaceans, in part because: (1) crustaceans are extremely difficult to age; (2) adequate catch and effort data are lacking for many crustacean fisheries; (3) crustaceans are apparently vulnerable to a variety of exogenous factors, including droughts, pesticides, and sudden climatic changes; (4) most crustaceans not only have several life stages, but also molt more or less continuously throughout life, thereby being regularly exposed to greater physiological stresses and higher rates of predation than other organisms such as fishes; (5) clearly-defined relationships between parents and progeny are often apparently lacking.

Table 2.2 Estimates of weekly instantaneous mortality rates for Penaeus. F indicates fishing mortality; M indicates natural mortality; Z denotes total mortality.

Species	F	M	Z	Source
P. setiferus	-	-	0.46	Klima (1964)
	0.06-0.19	0.08	0.14-0.27	Klima & Benigno (1965)
P. a. aztecus	0.06	0.21	0.27	Klima (1964)
	-	-	0.99, 1.24	McCoy (1968)
P. d. duorarum	0.96	0.55	0.76, 1.51	Kutkuhn (1966)
	0.16-0.23	0.02-0.06	0.22-0.27	Berry (1967)
	0.03, 0.07	0.08, 0.11	0.11, 0.18	Costello & Allen (1968)
♀	0.02-0.16	-	0.07-0.12	Berry (1970)
♂	0.02-0.16	-	0.10-0.16	Berry (1970)
	-	-	0.32-0.35	Purvis & McCoy (1972)

A literature survey of the relationship between stock and recruitment in exploited invertebrates by Hancock (1973) revealed virtually nothing pertaining to crustaceans. Lindner and Cook (1970), Cook and Lindner (1970) and Costello and Allen (1970) also found little published information concerning dynamics of white, brown, and pink shrimp (Table 2.3).

Effort data are not available for the penaeid fishery of the southeastern Atlantic states, further complicating an understanding of shrimp dynamics. Thus, it is extremely difficult to monitor trends in abundance. Whether fishing has any effect on the stability of the resource will also be difficult to determine until adequate catch and effort statistics are available.

2.2.3.2 Factors which may be affecting the dynamics of shrimp on the southeastern Atlantic coast

A critical knowledge gap exists regarding the impact on shrimp of man-made changes in estuarine habitats. Estuaries are being subjected to an ever-increasing array of stresses, ranging from increased levels of human and industrial pollution to outright loss of marsh areas due to channelization projects. Chapman (1968) observed that 200,000 acres of shallow coastal bays had been dredged and filled in the southeast and Gulf states during the previous 20 years. Trent, Pullen, and Moore (1972) noted that demand for waterfront housing, which frequently involves dredging, filling, and bulkheading, is apt to increase. While it is difficult to assess the total effect that alterations of coastal areas have on the stability of shrimp resources, a study by Mock (1967) suggests that such activity may be significant in decreasing production. In comparing a natural area with one altered by bulkheading, Mock found 2.5 times more brown shrimp and 14 times more white shrimp in the natural area. Estuarine nursery grounds are vital to postlarval and juvenile penaeids, and extensive alterations of these habitats may key a decline in this valuable

Table 2.3 Summary of knowledge concerning populations of white, brown, and pink shrimp (Lindner and Cook, 1970; Cook and Lindner, 1970; Costello and Allen, 1970). Asterisks indicate no data were available.

Population	*P. setiferus*	*P. a. aztecus*	*P. d. duorarum*
1. Structure			
1.1 Sex ratio			
1.2 Age composition			
1.3 Size composition			
2. Abundance and density of population			
2.1 Average abundance	*	*	*
2.2 Changes in abundance			
2.3 Average density			*
2.4 Changes in density			
3. Natality and recruitment			
3.1 Reproduction rates	*	*	
3.2 Factors affecting reproduction	*	*	
3.3 Recruitment			

Table 2.3 (continued)

Population	*P. setiferus*	*P. a. aztecus*	*P. d. duorarum*
4. Mortality and morbidity			
4.1 Mortality rates			
4.2 Factors causing or affecting mortality			
4.3 Factors affecting morbidity		*	
4.4 Relation of morbidity to mortality rates	*	*	*
5. Dynamics of population (as a whole)	*		*

resource.

Another cause for concern is the use of pesticides, some of which may cause significant mortalities of crustaceans, including penaeid shrimp. For example, Conte and Parker (1971) observed mortalities of 14 - 80% of juvenile brown and white shrimp exposed to malathion. Studies are needed on the effects of other pesticides, including DDT and mirex, on penaeids.

A considerable literature exists concerning the effect of physical parameters on the survival of postlarval and juvenile shrimp. These effects appear to adequately account for much of the observed variation in annual catches (Berry, 1966; Gunter and Edwards, 1969; Ford and St. Amant, 1971). However, it is not known how intermediate trends in climatological factors may affect the abundance of shrimp.

A number of other factors influencing the dynamics of shrimp, including diseases and parasites, and the interactions between penaeids and other marine organisms such as fishes, birds, and other decapod crustaceans, are beyond the scope of this report.

The final topic, comprising the remainder of this section of the report, discusses the effect or lack of effect of fishing upon the dynamics of penaeid populations.

2.2.3.3 Stock Definition

The fishery for pink shrimp on this coast is confined almost entirely to North Carolina, where it appears to be endemic (see Section 2.2.5.3). Thus, pink shrimp can be treated as one stock, at least for present management strategies.

Little is known about either the migration of brown shrimp once they leave coastal waters (see Section 2.2.5.3), or the location of their spawning grounds (see Section 2.2.1); thus, it is uncertain whether

there is one or several stocks along this coast. The degree of similarity between landings of brown shrimp in the respective states, especially in 1961, suggests that there may be but one basic stock in this area. It is probably sufficient to treat brown shrimp as one stock until the number is definitely established.

White shrimp are known to migrate extensively along the southeastern Atlantic coast (see Section 2.2.5.3). This suggests, albeit inconclusively, that there may be one stock in this region. Yet the difference in variability of annual landings in the respective states indicates that there may be several stocklets of white shrimp along the coast. If this is true, considerable mixing undoubtedly occurs between stocklets. It is probably sufficient, at least temporarily, to treat white shrimp as belonging to one general stock for management purposes.

2.2.3.4 Conduct of the Fishery

The availability of shrimp to the fishery varies greatly from year to year, not only because of environmental conditions, but because shrimp fishing on the southeast Atlantic coast is restricted to bays, sounds, and a narrow strip along the coast. Brown and pink shrimp, in particular, move into offshore waters where they are lost to the fishery. White shrimp migrate in a southerly direction during autumn, rendering them unavailable to fishermen who restrict their activities to one state.

2.2.3.5 Parent-Progeny Relationships

Penaeid shrimp along the American Atlantic are generally regarded as an annual crop, i.e., one year class produces the next with little or no help from any previous year classes.

No existing model adequately describes the relationship between parents and progeny for penaeid shrimp, although it is generally believed

that a very low level of spawners will result in lower than average production. Griffin, et al. (1973) used two economic models to estimate maximum sustainable yields for shrimp in the Gulf of Mexico. However, neither model seems appropriate as a vehicle for improved understanding of penaeid dynamics because the basic assumptions for each appear invalid for penaeid shrimp. Relative to the first model, it has not been demonstrated that fishing has had any appreciable effect upon penaeid shrimp populations. In the case of the second it is known that the abundance of penaeid shrimp varies annually and, at least in the case of white shrimp, has varied significantly during the development of the fishery.

Lindner and Anderson (1956) described the effect of a severe winter during 1939 - 1940 on white shrimp production. They revealed that: (1) very little spawning stock was left north of central Georgia in the spring of 1940; (2) catches in Georgia and Florida in 1940 were about 90% of the previous two-year average; (3) catches in South Carolina were about 50% of the average for the preceding two years; (4) catches during 1941 were normal along the entire coast. From these observations, Lindner and Anderson concluded that a normal crop may be produced by relatively few spawners. They also concluded that it is doubtful fishing could reduce shrimp populations to a level where there was a direct relation between the number of spawners and the resulting crop. These conclusions are supported by catch statistics for the southeast, as well as for the Gulf of Mexico. For instance, while catches of shrimp in South Carolina during 1963 and 1964 were the poorest since 1937, the catch in 1965 was excellent.

There is little evident relationship between abundances of shrimp from year to year; the abundance of shrimp for any given year is apparently dependent primarily upon environmental factors influencing the survival of post-larval and juvenile shrimp. Obviously, there must be some threshold level of spawners to produce progeny, but it appears that present fishing activities do

not reduce the stocks to such a level. However, fishing might have a significant effect upon the parent-progeny relationship if uncontrolled development should destroy a significant portion of the nursery grounds.

2.2.3.6 Variability of Annual Landings

Annual landings of shrimp vary considerably; Table 2.4 shows the variability of catches by state and species. Although the range illustrates variability of catches, the ratio of the standard deviation to the mean annual landing is a better index of variability because it uses all available data. This ratio,which increases as the variability increases, will be referred to as the stability ratio.

Several trends are apparent from Table 2.4. First, the stability ratio for white shrimp decreases markedly from North Carolina to Florida. Second, the stability ratio of brown shrimp remains rather constant between North Carolina and Florida. Third, the stability ratio of the combined catch of white, brown, and pink shrimp for each state is lower than that of the individual species within each state, with the exception of brown shrimp in South Carolina. The stability ratio for brown shrimp is only slightly lower than that of the combined catch.

Assuming that the exploitation rate of shrimp has remained reasonably constant from 1957 to the present, one can conclude that annual landings of shrimp truly reflect actual levels of abundance. This conclusion appears at least somewhat valid because the number of operating units has remained rather constant (see Table 5.5) and the nominal indices of catch-per-unit-effort have also remained rather constant (see Table 5.6).

If annual landings truly reflect the relative abundance of shrimp, data in Table 2.4 infer that: (1) several stocklets of white shrimp exist in the southeastern Atlantic, and that those found in Georgia and the east

Table 2.4 Variability of annual commercial landings of shrimp by species and by state for 1957 - 1972 (landings in thousands of pounds, heads off).

State	White	Brown	Pink	Total
North Carolina				
Max catch	1,020	3,657	1,403	7,933
Min catch	0	601	331	2,519
Range	99.6*	6.1	4.2	3.1
Mean catch	252.2	2,171.5	901.5	5,354.7
S.D / Ratio X	1.05	0.37	0.40	0.31
South Carolina				
Max catch	5,194	2,244		10,753
Min catch	184	527		2,201
Range	28.3	4.3		4.9
Mean catch	2,241.0	1,436.4		5,750.7
S.D / Ratio X	0.59	0.33		0.38
Georgia				
Max catch	5,069	2,111		10,403
Min catch	2,270	348		5,448
Range	2.2	6.1		1.9
Mean catch	3,735.8	1,071.3		7,727
S.D / Ratio X	0.24	0.44		0.18
East Coast Florida				
Max catch	3,699	901.7		6,793
Min catch	1,632	74		3,970
Range	2.3	12.2		1.7
Mean catch	2,598.4	485.3		5,074.9
S.D / Ratio X	0.19	0.43		0.14
Total Commercial Shrimp Landings for Southeast Atlantic Fishery				
Max catch	12,214.5	7,207.7		
Min catch	4,720.1	1,550.1		
Range	2.6	4.6		
Mean catch	8,688.6	5,162.6		
S.D / Ratio X	0.27	0.26		

* Calculated from second lowest annual landing.

coast of Florida are much more stable than those found in North and South Carolina; (2) the stability of brown shrimp appears to be similar for all states, suggesting that browns may belong to one stock; (3) the combined abundance of commercially-exploited penaeids within states is more stable than the abundance of individual species within states. This suggests that the exploited species may be interacting in complex ways, and that various environmental stresses may give one species a temporary advantage over its rival.

When the combined catch of brown shrimp in the southeastern Atlantic is compared, the combined stability ratio is lower than that found in the individual states, again suggesting that browns may belong to one stock. Conversely, the combined stability ratio for white shrimp was lower than that found in either North or South Carolina, and higher than that found in either Georgia or the east coast of Florida. The reason for this is unknown; it may indicate that white shrimp are found in several stocklets rather than in one stock along the southeastern Atlantic. If white shrimp belonged to a single stock, one would expect the variance of the combined landings to be less than those in the individual states; this was clearly not the case.

2.2.3.7 Immediate Needs for Population Dynamics Research

If managers wish to fully evaluate the effectiveness of their programs and understand the dynamics of penaeid populations, a comprehensive program of catch and effort statistics must be initiated. Such a system will allow scientists to: (1) monitor trends in the abundance of shrimp; (2) document the effect of various projects in the coastal region upon shrimp stocks; (3) define user groups and their impact upon the resource; (4) describe the economics of shrimp exploitation; (5) develop a data base to (a) evaluate present management strategies and (b) develop models to describe the shrimp fishery as a system, including biological, economic, legal, and sociological factors.

A second set of problems needing further research is the estimation of the "loss" rates, such as natural mortality. These rates can be determined by mark and recapture experiments if the experiments are devised carefully, provided there are adequate catch and effort data to interpret the results of the experiment.

A fundamental problem in understanding penaeid population dynamics is the lack of knowledge concerning: (1) mechanisms controlling the stability of the population; and (2) how the stress of exploitation affects those mechanisms. In particular, it would be interesting to know the level of fishing that would affect a parent-progeny relationship, should one exist; especially if a significant portion of the nursery grounds are altered or lost due to other coastal development projects.

Once an adequate system of catch and effort statistics is implemented and "loss" rates have been determined, simulation models can be developed to offer managers a wide array of management strategies. These models would employ standard techniques commonly used in operations research and fisheries population dynamics.

2.2.4 Food Requirements

Penaeid larvae subsist on yolk granules until the Protozoea I stage, when feeding commences (Lindner and Cook, 1970; Cook and Lindner, 1970; Costello and Allen, 1970). Availability of an abundance of food is important during the postlarval and juvenile stages, when rapid growth occurs (Williams, 1955).

Juvenile and adult penaeids are omnivorous bottom feeders. Ingestion of food occurs largely at night, although in turbid waters daytime feeding may occur (Eldred, et al., 1961; Costello and Allen, 1970). Lindner and Cook (1970) considered shrimp to be selective and particulate feeders. From observations on specimens held in aquaria, they noted that shrimp select food items after searching through the sand grains with their pereiopods. Polychaetes appeared to be

a preferred food item.

Williams (1955) found that stomachs of shrimp taken in estuaries of North Carolina were usually full in summer, full or half-full in autumn, and empty in winter. He suggested that any available organic material may be ingested. Specific food items utilized are often difficult to assess because stomach contents are finely triturated. Williams observed that material in the stomach of shrimp consisted primarily of unrecognizable debris believed to be semi-digested tissue and organic bottom deposit, fragments of chitin from crustaceans, setae, annelid jaws, plant fragments, and sand. Other items included foraminiferans, small gastropod and pelecypod shells, squid suckers, entire small fishes and fish scales, muscle fibers, ribs, eggs, and plant seed pods.

Stomach analyses on pink shrimp have revealed the presence of algae, fragments of higher plants, foraminiferans, hydroids, nematodes, mollusks, polychaetes, crustaceans, tunicates, and fish larvae, as well as sand, mud, and organic debris (Pérez Farfante, 1969). Eldred, et al. (1961) reported finding sand, debris, algae, diatoms, particles of seagrass, dinoflagellates, foraminiferans, nematodes, polychaetes, ostracods, copepods, mysids, isopods, amphipods, mollusks, fish scales, and caridean shrimps and their eggs.

While shrimp are able to ingest a wide variety of potential food items, much of the actual material digested is believed to consist of soft parts because large, hard fragments cannot be passed through the straining apparatus of the pyloric stomach (Williams, 1955). Williams was uncertain whether hard parts, which may accumulate in the stomach, were further broken down or regurgitated.

Condrey, Gosselink, and Bennett (1972) found that assimilation efficiency in juvenile white and brown shrimp was high (80-85%) for a variety of plant and animal material. Rates of food intake and assimilation were found to vary

Fig. 2.2 Geographic range of Penaeus setiferus, the white shrimp.

in relation to the length of time necessary for occurrence of trituration and filtering into the digestive gland. They also noted that lipases and proteinases were more active than carbohydrases.

Recent studies by S. P. Meyers suggest that postlarvae obtain their nutrients from yeasts and algae in Spartina detritus rather than from the decaying marsh grass itself (Anonymous, 1973).

Shrimp nutrition is currently receiving considerable attention because of interest in shrimp aquaculture. Significant advances can be expected in this field over the next few years.

2.2.5 Geographic Distribution Throughout Life Cycle

2.2.5.1 General and Bathymetric Range

Much of the information in this subsection is summarized from Pérez Farfante (1969), who reviewed in detail the geographic occurrence of white, brown, and pink shrimp. With the exception of P. d. duorarum, which is also found off Bermuda, the three species are restricted to the Atlantic coast of the United States and the Gulf of Mexico.

P. setiferus ranges from Fire Island, New York, to Saint Lucie Inlet on the Atlantic coast of Florida, and from the Ochlockonee River on the Gulf coast of Florida to Ciudad Campeche, Mexico (Fig. 2.2). Atlantic and Gulf populations have presumably been separated since the elevation of the Florida peninsula and closure of the Suwannee Straits at the end of the Pleistocene. In addition to its disjunct distribution around the Florida peninsula, other gaps occur in the range of the white shrimp within restricted areas. These interruptions have not been adequately explained, although salinity, temperature, substrate, food, and cover have been suggested as possible limiting factors.

Along the Atlantic coast of the United States, the white shrimp has centers of abundance in South Carolina, Georgia, and northeast Florida.

Fig. 2.3 Geographic range of Penaeus aztecus aztecus, the brown shrimp.

Anderson and Lunz (1965) and Lindner and Cook (1970) noted that it is most abundant in regions where extensive brackish marshes are in contact through passes to a shallow offshore area of relatively high salinity having a mud or clay substrate. White shrimp generally are concentrated in waters of 27 m (86') or less, although Lindner and Cook (1970) noted that specimens have been obtained from depths of 82 m (269').

P. a. aztecus is known from Martha's Vineyard, Massachusetts, to the Florida Keys and northward into the Gulf to the Sanibel grounds (Fig. 2.3). It reappears near Apalachicola Bay and occurs around the Gulf coast to northwestern Yucatan. While it may occur seasonally along the middle Atlantic states, breeding populations apparently do not range north of North Carolina.

While brown shrimp reach maximum abundance in the Gulf of Mexico, the species is moderately abundant along the Atlantic coast of the United States, particularly in North and South Carolina (Cook and Lindner, 1970). Although brown shrimp occur in commercially-exploitable quantities to 110 m (361'), the species is most abundant in waters of less than 55 m (180'). Specimens have been taken in depths to 165 m (541').

P. d. duorarum occurs from southern Chesapeake Bay to the Florida Keys, and around the coast of the Gulf of Mexico to Yucatan south of Cabo Catoche (Fig. 2.4). Maximum abundance is reached off southwestern Florida and the southeastern Golfo de Campeche. Along the Atlantic coast of the United States it occurs in sufficient abundance to be of major commercial significance only in North Carolina. Costello and Allen (1970) observed that largest numbers of pink shrimp occur in regions where shallow bays and estuaries of the coastline border on a broad and shallow shelf area. Pink shrimp are most abundant in waters of 11 - 37 m (36 - 121'), although in some areas they may be abundant as deep as 64 m (210'). Specimens have been recorded down to depths of 329 m (1079').

Fig. 2.4 Geographic range of Penaeus duorarum duorarum, the pink shrimp.

2.2.5.2 Distribution of the Developmental Stages

Larvae and early postlarvae of the three species are normally planktonic in offshore waters. Transport of these stages toward the coastline has been attributed to water currents (Pérez Farfante, 1969). Upon reaching 6 - 7 mm (P. setiferus), 8 - 14 mm (P. a. aztecus), and 8 mm (P. d. duorarum), they enter the estuarine nursery grounds (Weymouth, Lindner, and Anderson, 1933; Anderson, King, and Lindner, 1949; Lindner and Cook, 1970; Cook and Lindner, 1970; Costello and Allen, 1970). Tidal action is believed to be important in transporting postlarvae into these grounds (Pérez Farfante, 1969). In the nursery grounds they become benthic, congregating in waters generally less than 1 m (3.3') deep (Williams, 1955; Loesch, 1965; Cook and Lindner, 1970; Costello and Allen, 1970). Eventually the rapidly-growing juveniles migrate from the shallows into deeper waters of the estuary before returning to the sea. It has been reported (Pérez Farfante, 1969) that this migration is evidently influenced by the stage of gonad maturation, but other investigators (William Anderson, personal communication) doubt that gonads start developing before migration occurs. In North Carolina waters, some indication exists that this migration is at times influenced by heavy rainfall (Walter Godwin, personal communication). On reaching offshore waters, white, brown, and pink shrimp have total lengths of about 100 mm, 100 mm, and 87 - 155 mm, respectively (Lindner and Cook, 1970; Cook and Lindner, 1970; Costello and Allen, 1970).

While larvae are generally believed to move shoreward from the offshore spawning grounds, Sick (1970) presented evidence of a seaward transport of larvae off North Carolina. Rather than being lost from the population, he pointed to speculation by Temple and Fischer (1967) that postlarvae may overwinter in areas offshore before being carried inshore to the estuarine nursery grounds.

Vertical distribution of penaeid larvae and postlarvae has been studied by Subrahmanyam (1971) in Mississippi. Protozoea and mysis stages tended to congregate near the surface in winter and near the bottom in summer. Postlarvae were found to be randomly distributed in the water column.

2.2.5.3 Migrations

In addition to the inshore and offshore migrations by various developmental stages of the commercial penaeids, adult shrimp undergo migrations along the coast. Lindner and Anderson (1956) attributed these movements to changes in water temperature. They observed that white shrimp along the southeastern states moved southward in autumn and early winter, and northward during late winter and early spring. McCoy and Brown (1967) and Bearden and McKenzie (1972) also noted a southward migration of white shrimp late in the year from North Carolina and South Carolina, respectively.

While large, adult white shrimp leave South Carolina estuaries in late autumn, a population composed of juveniles and sub-adults having a total length generally less than 120 mm overwinters in the state (Charles Bearden, personal communication). Bearden observed that these shrimp undergo inshore-offshore migrations depending upon water temperatures.

Whereas the spawning stock of P. setiferus in Georgia is believed to have consisted in former years partly of larger, migratory shrimp, most spawning at present is attributed to non-migratory shrimp that overwinter as juveniles and mature in spring (William Anderson, personal communication). Similarly, the size of the spawning stock of white shrimp in South Carolina appears directly related to the size of the overwintering population (Charles Bearden, personal communication). Thus, a severe winter could have a greater impact on the population now than in the past, when the late fall stocks of large shrimp moved to the south off Florida and returned in late winter and early spring.

McCoy and Brown (1967) noted a southward movement of brown shrimp released near Beaufort Inlet, North Carolina, from June through October. Numbers of P. a. aztecus decline abruptly during autumn along the entire southeast (Anderson, 1970). Hoese (1973) observed in Georgia that brown shrimp move from just offshore in July to about six miles offshore in October, from which point they disappear completely. Joyce (1965) indicated that brown shrimp were rare off northeastern Florida during winter, and suggested that the species migrates or overwinters further south. Anderson (1970) reported finding large concentrations of very large P. a. aztecus during January of 1965 at 55 - 59 m (180-194') south of Cape Canaveral, and he believed that this population received recruits from the Carolinas and Georgia, as well as Florida. Further information is needed regarding the movements and location of brown shrimp during autumn and winter.

Little is known about the coastal migrations of P. d. duorarum (Pérez Farfante, 1969). The population of pink shrimp in North Carolina, supporting the most northerly commercial fishery for this species, is known to be endemic rather than a migratory population (Williams, 1955). From their marking study in North Carolina, McCoy and Brown (1967) found a small southward movement of pink shrimp within the state from May through August. Purvis and McCoy (1972) demonstrated that there is little migration of pink shrimp out of Core and Pamlico Sounds during autumn, and that the species overwinters there. With the return of spring, however, migration to offshore waters begins. Purvis and McCoy recommended that harvesting be initiated before or shortly after the shrimp reach the ocean so that they would not be lost to the fishery.

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SECTION 3

DESCRIPTION OF INDUSTRY: HARVESTING SECTOR

by

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3.1 Fishing Methods

Vessels, gear, and methods of operation in the shrimp industry have obviously changed over the years. Such change and innovation has taken place primarily due to an increase in availability of reliable power units, the necessity of fishing deeper and more distant shrimping grounds, and technological advances which have reduced fishing costs and increased production.

Application of the shrimp otter trawl between 1912-1915 at Beaufort, North Carolina (Johnson and Lindner, 1934) was pivotal in development of the southeastern shrimp fishery. Prior to that time, almost the entire catch of shrimp was taken by haul seines. Today, commercial shrimping in the South Atlantic region is primarily a trawling operation with different vessel-gear combinations and fishing practices in North Carolina, South Carolina, Georgia and Florida (east coast).

For a great many years, sailing vessels, row boats, and other small non-powered boats were used for shrimping operations. Most of the shrimping was in shallow water from 6 inches to 6 feet and many of the shrimpers operated without floating equipment. The original inshore and offshore

shrimp boats were developed from types already in use along the Florida and Gulf coasts. Their hull forms were developed by rule of thumb and fishing experience. The basic design was derived from the forms of Mediterranean work-boats and adapted to the conditions peculiar to the South Atlantic operation. A large percentage of vessels are still built with rather crude plans, without regard for engineering practices. Early shrimp trawlers were open skiffs 15 to 25' long and powered with gasoline engines. During the twenties, vessels were decked over, engines placed forward and a pilot house added; this design is standard today. In the thirties the diesel engine was introduced and, coinciding with the need for larger vessels to fish offshore grounds, horsepower increased. The contemporary shrimping fleet consists of trawlers which are quite mobile and distinctively designed relative to the various types of fishing. Offshore trawlers have recently undergone significant design changes making them larger and more versatile than ever before (Captiva, 1966). Most newer offshore vessels, the so-called Florida trawlers, are 75-80' or more in length and are double-rigged for towing two nets simultaneously. Double-rig fishing has been estimated to increase the catch by 15 to 30% as well as reducing fuel costs and repair and labor time (Klima and Ford, 1970).

Juhl (1961) demonstrated a fairly close relationship between the gross and net tonnages and the lengths of vessels in the shrimp fleet. Such correlation is probably due to the uniform hull design of the "Florida-type" vessels which have a round bottom, flared bow and a broad, square transom stern. The deckhouse is forward; the clear fishing decks aft. Double-rig nets are towed from booms. The engine room is below the deckhouse with the fishholds aft. Typically, the vessels are diesel

powered with pronounced variations between length and horsepower in single and double-rigged vessels. Generally, the vessels in the 50-70' class are powered by 100-200 h.p. diesels. Cable rigs with drum hoists are powered from the main engine. A large portion of the vessels are equipped with electronic navigational aids and have the capacity for wide-ranging fishing operations. Using the data collected by Juhl (1966) and the National Marine Fisheries Service (1972) showing certain vessel modal measurements and chatacteristics, a representative South Atlantic double-rig shrimp trawler may be described as follows:

Gross tonnage ------	42 - 45	Main engine --------	200 h.p.
Length ----------	55 - 60'	Trawl net size ----- (both nets)	90' (frontrope)

The double-rigged shrimp trawler has two outrigger booms mounted on the port and starboard sides of the mast some distance above the deck. The booms are stayed fore, aft, and vertically. The use of stabilizer planes suspended from the outriggers during moderate and rough seas when fishing and while at anchor to dampen the roll has become quite popular in recent years. Also, the use of tag lines on trawl doors has been a popular development. The tag line is permanently attached to the doors and facilitates easier handling of the doors when hauling aboard.

The vessels used in the inshore type of shrimping in the South Atlantic states generally do not exceed 30-45' in length. There are many smaller boats of 5 net tons or less, displaying quite a variety of designs and individual styles of construction. Many of the smaller boats are gasoline powered or distillate burning engines, although there is a growing trend toward diesel power. These boats are usually equipped with power winches and rope towlines, rigged for towing a single trawl

from the stern. The use of commercial skiff-type vessels operated by one man on the inshore grounds has become a major operation in certain local bays and sounds in North Carolina and South Carolina.

Without doubt, the expansion of the present day shrimp fishery is due to the acceptance and use of diesel motor power. All of the offshore vessels in the South Atlantic states are equipped with diesel power with reduction gears. The main engines are equipped with power take-offs to run the winch through a system of chains, shafts, and sprockets. Main engine installation for most of the vessels is convenient, with maintenance kept as simple as possible. Most experienced boat captains and crew members can make minor repairs at dockside.

Electronic instruments aboard shrimp trawlers serve both as navigational and as fishing aids. They guide the fisherman to and from the shrimping grounds and also provide information about the bottom that is fished. The principal items of equipment found on shrimp vessels are automatic pilots, depth recorders, radar, and radio telephones. All vessels have the compass for basic navigation and most of the newer crafts are equipped with LORAN.

Automatic pilots were introduced into the shrimp fleets to relieve the chores of steering, which on long runs presents a considerable fatigue problem. Since a course steered electronically is more accurate than one steered by hand, both running time and fuel consumption are reduced by the use of automatic pilots.

Depth recording equipment is used for navigation and fishing. When used for navigation, depth of water and bottom contours are determined

to obtain vessel position. When used for fishing, good bottom (smooth and muddy) is distinguished from bad bottom (rock or coral) by the appearance of the graph on recording paper. When properly used, depth recorders are probably the most important instruments on board. A depth sounder with a cathode ray tube, designed to function as a fish finder, is commonly found aboard the large vessels. Supersonic signals transmitted downward are reflected back from the bottom schools of fish and a clear visual indication is obtained on the cathode ray tube. The practical value of this type of sounder as applied to locating shrimp is questionable.

Radar equipment, quite common aboard large and intermediate vessels today, affords protection for the fishermen especially during fishing operations at night or in fog.

LORAN equipment has enabled fishermen to accurately fix their fishing locations and return to the same area repeatedly for successful catches. At present, however, LORAN is probably insignificant when dragging close to the beach.

3.1.1 Fishing Gear and Operation

3.1.1.1 Otter trawls

There are three basic trawl designs employed in the South Atlantic fishery; flat, semi-balloon, and balloon. Results of a survey conducted by Juhl (1961) indicated that there was no distinct preference found among operators of single-rigged vessels as a group, but flat trawls were preferred by operators of double-rigged vessels in the southeastern shrimp fishery (57% used flat, 36% used balloon, and 7% used semi-balloon). A more recent survey of double-rigged trawlers in South Carolina revealed that the balloon and semi-balloon nets are now generally preferred by vessel operators (Rhodes, 1973). These basic designs have been described by Bullis (1951), Fuss (1963), Marinovich and Whiteleather (1968), and Kristjonsson (1968).

The otter trawl consists of: (1) a cone-shaped bag in which the shrimp catch is gathered in the tail or cod end; (2) wings on each side of the bag for herding the shrimp into it; (3) trawl doors at the extreme end of each wing for holding the wings apart and holding the mouth of the net open; and (4) two lines attached to the trawl doors and fastened to the vessel. A lead or ground line extends from door to door on the bottom of the wings and mouth of the net while a float or cork line is similarly extended at the top of the wings and mouth of the net. The size of the net is measured by the width of the mouth. Floats of hollow plastic and hollow foam are employed; the number of floats used varies considerably. Generally, only about half as many floats are used on sandy bottoms as on muddy bottoms. Juhl (1961) reported the average number of floats for the three types of nets as follows: flat nets, 2.1; balloon nets, 4.1; and semi-balloon nets, 6.1. With flat nets, the mouths of shrimp trawls are rectangular, the lead or bottom line and float or cork line being more or less straight horizontally. However, with the balloon net, the float line forms a pronounced arc when the trawl is being towed. The type of net design used by shrimpers appears to vary with the species sought. Generally, it has been found that brown shrimp burrow into the bottom to escape the trawl and white shrimp try to escape by jumping off the bottom. Therefore, when fishing for brown shrimp, a flat net with two or three floats is often used since this design gives a wider horizontal spread than the other designs and supposedly facilitates the catching of burrowing shrimp. In contrast, four-seam, semi-balloon or two-seam balloon nets are usually employed when fishing for white shrimp since these nets have more vertical webbing than a flat net. Additional floats are used to increase the height of the trawl when needed.

Juhl (1961) reported that foot ropes differ only in the amount of weight attached to them. A 1/4 - 3/8" loop chain attached to the foot rope at about one foot intervals with a 14 - 16" drop is commonly used to add weight to the net. A chain may also be attached to the trawl doors, resulting in a "tickler" chain which tows ahead and separate from the net. The tickler chain is used to frighten shrimp off the bottom into the oncoming trawl. Another common foot rope arrangement is the attachment of the tickler chain to the foot rope chain (not looped) at about three feet intervals using short chain extensions; this arrangement is usually called a "Texas" chain or "Texas drop down." It is generally believed by commercial fishermen that the Texas chain lifts the foot rope further off the bottom, resulting in catches with less mud, debris, and undesirable organisms. The tickler/loop chain arrangement may not be effective in reducing "trash" caught by the net, but the effectiveness of the Texas chain can be reduced by a small change in its alignment.

Most of the larger nets are constructed of synthetic webbing including various synthetic blends, i.e., nylon, nycot, marlon, and nylon-rayon combination. The most common mesh size in the nets range from 1 1/2 to 2". For protection, the tail-bag is covered by a hula skirt or chafing gear of polyethylene strands tied into the bag or by a false bag of large mesh webbing.

The length of the dragging warp carried by shrimp vessels depends on the depth of water being fished; within the South Atlantic states this may vary from 75 to 750 fathoms. Single-rig vessels may carry from 75 - 200 fathoms of warp with an average of 133 fathoms

per drum. Double-rig vessels carry from 75 - 750 fathoms or an average of 145 fathoms of warp per drum. The cable used varies from 1/4 to 5/8" diameter in multiples of 1/16". The towlines are secured to the trawl doors using bridles (consisting of four chains) fastened to the doors. The chains fastened to the net end of the trawl door are larger than the front chains and the top chains are longer than the bottom chains. Thus, the doors have an outward, downward thrust while being towed. The shearing power necessary to offset the drag of the trawl and create the desired wing spread is directly related to the area of the doors and the speed of the vessel. Ideally, the door-net relationship should be such as to obtain the greatest possible wing spread without deforming the net opening or causing excessive drag. Trawl doors of 4 - 5' in length are used on trawl nets up to 50' in width, 6 - 8' doors on 80' nets and 9 - 14' doors on nets up to 120' wide. The doors are constructed so that the length is slightly more than twice as long as the height. There appears to be a lack if uniformity in the angle of trawl-door set but there is a tendency for setting lower chains from one to two links shorter than the upper chains. The dragging warp ratio commonly used for determining the required length of cable is five or six fathoms of line to each fathom of water. Occasionally, this ratio varies when fishing in deeper waters.

Recently, there have been scattered attempts to test the application of twin trawling techniques in the South Atlantic region. Some of these trials have been encouraging and a few shrimpers are using these techniques on an experimental basis. The principle of twin trawling involves towing two trawls on a single pair of doors or otter boards. Both trawls are joined together at the head rope and foot rope to a "neutral door" connected to a third bridle leg. Bullis and Floyd (1973)

gave an illustrated description of this rig. The reported advantages of this rig over the conventional double rig include: (1) the increase in fishing efficiency (25% increase in some cases); (2) the light weight and ease of handling two 35' trawls as opposed to a single 70' trawl; (3) the nets can be towed slower and the vessel can make sharper turns with fewer incidents of tangling.

In the South Atlantic region, almost all commercial shrimping is done within 6 miles of shore during the season. The vessels are stocked for trips of short duration, generally not exceeding 12 - 24 hours. They are fueled weekly with enough fuel for six or seven days operation. This is done at dock where the vessel is lying or at a nearby fuel dock.

Upon arrival at the fishing grounds, the net doors are swung out to hang from the outriggers by the towing cables and the nets lowered to the proper depth. The length of the drag varies with fishing conditions, most frequently ranging from one to over five hours. Usually, long hauls are made when shrimp are scarce and the possibilities of catching large quantities of trash fish are small. During night-time fishing operations, two or three drags are usually made by the larger vessels. Smaller boats fishing the inside grounds make much shorter drags. Those inshore shrimpers catching shrimp for live bait may haul in their nets as often as every five or ten minutes.

During the drag on larger vessels, frequent tries are made with the try-net, a miniature of the large otter trawl. Frequently, one or two try-net drags are made before the large nets are set to determine the bottom type and to estimate the abundance of shrimp

in a particular area. The 12 - 16' try-net is pulled in at frequent intervals; as soon as shrimp appear in sufficient abundance to indicate grounds worth exploiting, the large nets are put over. By consistently checking the try-net ahead of the big nets, fishermen can tell whether or not they are still trawling through the concentration. In cases where the shrimper passes the concentrations, he changes course and resumes trawling through the area where the try-net showed good signs.

When the captain thinks that the nets are ready for hauling, the speed of the vessel is decreased and the doors are cleared for hauling. The cables are brought in with the winch until the two doors are blocked at the outrigger. Once the doors are up, the lazy line, attached around the mouth of the bag, is led through the block of the running whip which is then hoisted to the boom's end. The lazy line is led to the winch and heaved in until the neck of the bag is above the bulwark rail. The block and fall at the end of the boom is secured around the neck of the bag with a sling. The bitter end of this tackle is led to the winch and the bag of the net is raised out of the water and brought aboard and held suspended over the deck for emptying. The catch is then culled and iced down.

Shrimp trawl gear is operated essentially the same by both offshore and inshore fleets. However, there are differences in methods of locating shrimp, and use of the try-net for such purposes is not as widespread among inshore vessels as among the offshore fleet.

3.1.1.2 Haul Seines

Haul seines were introduced in the late 1880's and became the most important gear in the commercial shrimping industry

prior to the otter trawl. Originally, the seines were made of 1/2" stretched mesh netting and were up to 120' long and 10' deep. The smaller seines could be handled by two men in a row boat. Gradually, the net mesh was made larger and the seines were increased in size, some of them reaching 1,800' in length with 14' depths at the center, graduated to about 7' at each end. With seines of this size, fewer boats were necessary and crews of up to 20 or more men were required to handle them. Basically, the haul seine today is rectangular in shape and constructed of nylon webbing, having a stretched mesh of 1/2 to 1 1/2". This net varies in length and depth, with a lead line running along the bottom and a cork or float line running along the top. Many of the seines have bags or pockets into which the shrimp are herded.

Most seining operations are carried out in shallow waters near the shoreline where the net can be hauled out and the catch culled. During the peak of commercial seining, nets were designed to fish waters as deep as 20' or more but at present they are rarely used in waters more than six feet deep. Most of the seining fishermen consist of bait shrimp dealers and sportsmen. The laws dealing with minimum mesh sizes and lengths for sizes vary among the South Atlantic states and are discussed in Section 7.

3.1.1.3 Cast Nets

These nets vary considerably in size, and their use is fairly widespread throughout the South Atlantic region, particularly in South Carolina, Georgia and Florida. Cast nets are circular, usually having a spread of 6 - 20', with a lead line running around the outside edge. A cord line extends through a ring or horn in the center of the

net, and from this end there radiates numerous smaller cords (tuck lines) fastened at regular intervals to the lead lines. Mesh sizes vary from 1/4" square mesh to 3/4" square mesh. Most modern cast nets are constructed of nylon webbing. The net is thrown or cast in such a manner that it falls flat on the water when fully open. After the weighted edges of the net have settled to the bottom the cord is drawn, pulling the tuck lines into the center forming a bag to hold the shrimp.

Cast nets are used primarily by sportsmen casting for bait shrimp and for home consumption purposes and by commercial men fishing for live bait shrimp. These nets are particularly effective in the tidal creeks on ebb tides where "creek shrimp" congregate at the mouths of small tributaries and sloughs and along the shoreline adjacent to the channel.

3.1.1.4 Channel Nets

Channel nets are essentially shrimp trawls anchored at the surface of the water. Instead of otter boards to hold the net open, poles are secured to the lead and cork lines to hold the nets open and extra floats are used to keep the net at the surface. One end of the net is usually attached to an anchored boat while the other end is held in position by a separate anchor. The net is fished by emptying the tail bag into the skiff. Channel nets are fished mostly in North Carolina and South Carolina in the bays and sounds on ebb tides at night. The mesh sizes and widths of channel nets vary in the different states.

The employment of channel nets in North Carolina is very productive for pink shrimp, which begin their seaward migration during the spring each year. A major portion of the commercial catch is accomplished through the use of this gear during the early spring

The channel net has also carried over into South Carolina recently and is effectively employed in harvesting white and brown shrimp. Most of the net sets are commercial operations and are located in the more productive bays, sounds, and rivers where migrating shrimp are passing.

3.1.1.5 Butterfly Nets

These nets are hung on rectangular pipe frames and attached to the sides of the boat. Similar to trawls, these nets vary considerably in size and are used only in areas where strong tidal currents exist. When in operation, the boat is anchored heading against the tidal flow and the nets lowered at right angles from the sides of the boat so that the current sweeps into the mouth of the net. The nets are lifted from the water, without removing the frame, through the use of a tail bag line which facilitates emptying the catch. The use of these nets is largely a commercial operation, although bait shrimpers and sportsmen do employ this type of gear infrequently in the bays and sounds.

3.1.1.6 Drop Nets

Drop nets consist of a large hoop up to 3 - 4' in diameter to which a cone-shaped net is attached. The hoop or frame is attached to main line by a bridle. The main line is tied to a bridge, boat, or pier while the net is dropped into the water. The nets are baited with smoked herring, cut fish, canned dog food or other local varieties of bait which attract shrimp. This method is strictly recreational, used for catching bait shrimp or shrimp for home consumption.

3.1.1.7 Push Nets

Push nets are usually rectangular frames varying from 3 to 10' in width and from 2 to 4' in height. A bag of small mesh (1/2") nylon webbing is hung to the frame. A handle, 6 to 8' long, is attached to the frame at the midpoint of the long side. A cross piece 6 to 10" in length is fastened perpendicular to the handle so that the fisherman can push against the handle with his chest.

This gear is operated mostly in Florida. Fishermen push the net in shallow water areas; the length of push time depends on the quantities of shrimp in the area. The catch is usually emptied into the bow of the skiff that the fisherman drags behind and is sorted by someone in the boat. This gear is most productive on grassy and muddy bottoms.

3.2 Sport Fishing For Shrimp

Most of the minor gears, such as seines, cast nets, drop nets, push nets, and dip nets are employed in the sport and recreational shrimp fishery. Recreational shrimping has become a popular pastime in the South Atlantic region. During the period from 1966 through August 1973, approximately 79 - 80% of all boats licensed for commercial fishing in North Carolina were believed to participate in sport shrimping (C. Purvis, personal communication). Generally, a 15 to 25' try-net with 3/4" bar mesh is used in the North Carolina sport fishery. However, hand seines have been very popular during peak migrations in near-shore waters.

South Carolina's sport shrimp fishery is primarily a cast net and seining operation. The tidal creeks and rivers are especially productive and accessible to sports fishermen. Georgia's sport fishery for

shrimp is primarily a trawl net operation with some casting and seining. In Florida, as in South Carolina, sport fishing for shrimp is primarily a cast netting and seining operation and is variable along the northeast coast as to methods of capture. In the St. John's River area, there is a significant amount of recreational shrimping. Various types of fish meal and dog food are used as bait in staked out areas which are lighted at night. In many areas, casting platforms are constructed along the shore in these staked areas. The catch is mostly composed of white shrimp taken at night. However, in other areas south of Daytona Beach, cast-netting is done in the channels during daylight hours. Further south along the Florida coast, brown and pink shrimp are caught in recreational shrimping through the use of dipnets and push nets. Push nets are used on the shallow grass flats in both day and night fishing operations, whereas the dipnets are used mostly at night on ebb tides to dip shrimp as they surface to the lights.

3.3 Seasons and Geographic Location of the Shrimping Industry

The shrimp fishery of the South Atlantic region has been shaped by geographical factors and in all likelihood these factors will play a vital role in the future development of the industry. The form and geologic structures of the eastern coastline have been the main determinants of ports. Distances from newly-discovered shrimp beds have influenced the location and, in many cases, the relocation of fishing activities. Weather conditions prevailing in specific areas of the coast have been responsible for the peculiar seasonal pattern of the fishery. Commercial, industrial, and to some extent agricultural conditions, too, have affected the growth and character of the fishing segment, its organization, and its labor force.

In general, the location of the shrimp industry is closely tied in with the geography of the fishing grounds. This is also true of the processing segment of the industry. The coastal waters of the South Atlantic states and the Gulf of Mexico are the major shrimp producers. Therefore, the shrimp industry is concentrated in the states bordering these waters. The South Atlantic region consists of North Carolina, South Carolina, Georgia and Florida (east coast).

The shrimp fishery along the South Atlantic coast is seasonal in character; availability of the species to the fishery is governed by the inherent life cycle of the shrimp and the influence of environmental factors on reproduction, growth and migration. Fishing effort is dependent on market conditions and economics, weather, and conservation laws. In conformity with biological patterns, the fishing seasons along the South Atlantic begin in spring and end in December as a general rule. May is usually the first month shrimp begin to appear offshore in commercial sizes, quantities, or both. The peak for shrimping occurs during the interval from July through October and drops off until the closure of the season. To protect the growing shrimp, the various states have enacted statutes establishing or authorizing regulations prohibiting or restricting activities seasonally (see Section 7). Fig. 3.1 illustrates the general shrimping grounds for the South Atlantic states.

3.3.1 North Carolina

Commercial quantities of shrimp appear in early spring when the overwintering populations (mostly Penaeus d. duorarum) begin a seaward migration. The overwintering pink shrimp populations constitute the first catches of the year and are usually available in late March or early April, although peak catches do not occur until mid-May. Opening

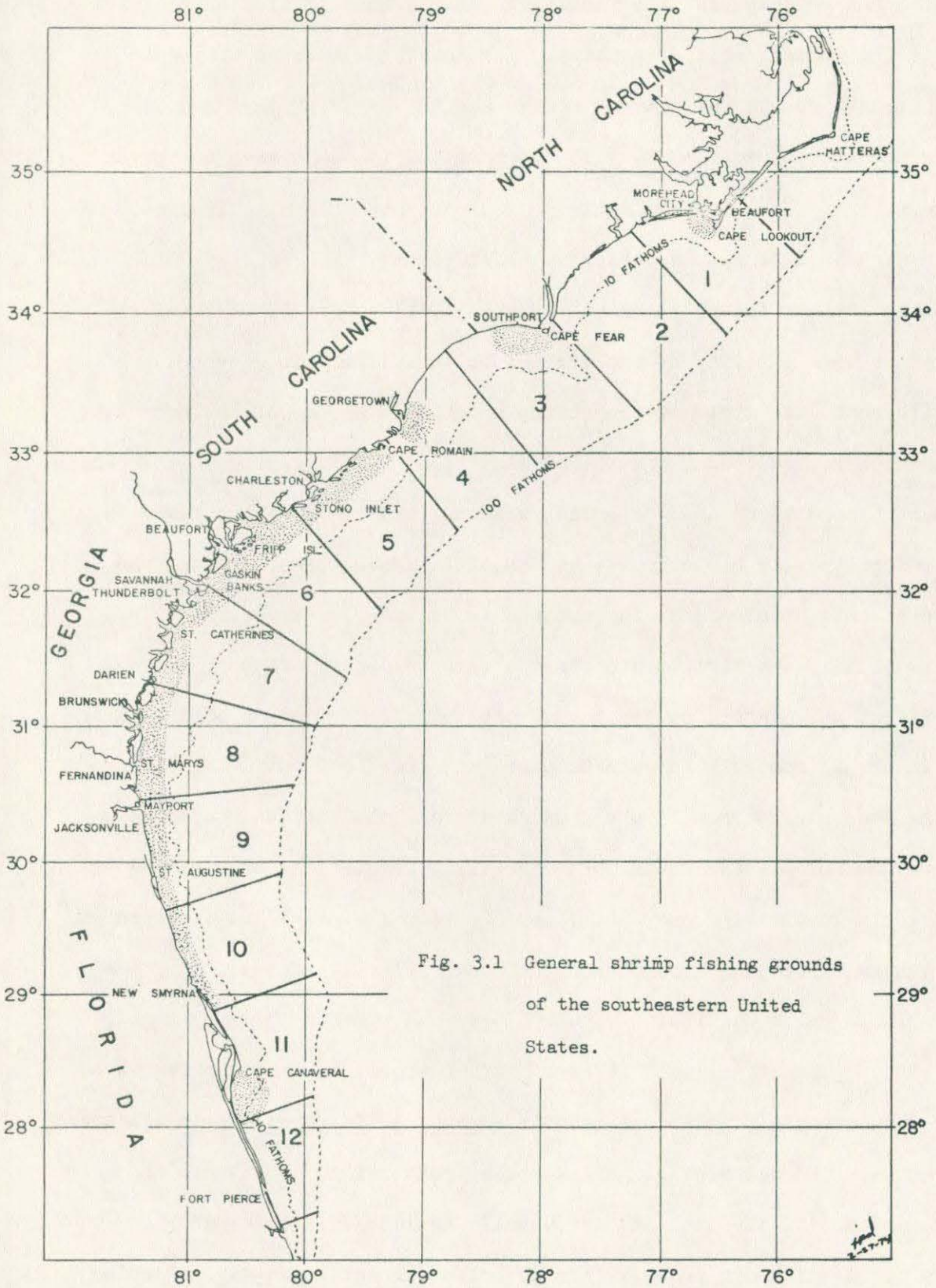

Fig. 3.1 General shrimp fishing grounds of the southeastern United States.

dates for the shrimp seasons in North Carolina have had a broad range. In January 1972 the season was opened to take advantage of the overwintering population of pink shrimp in Pamlico and Core Sounds. Purvis and McCoy (1972) indicated that late openings of the shrimping season restrict utilization of the overwintering pink shrimp populations. Migration of small shrimp occurs during the early spring when water temperatures exceed 13°C (55°F). If these shrimp are not harvested before reaching the ocean they possibly become unavailable to the fishery.

The intensity of the trawler activity during spring is largely dependent on the size of the population. By mid-July, the season for brown shrimp is at a peak and continues until late fall, when the shrimp disappear from coastal waters.

Brown shrimp (Penaeus a. aztecus) and pink shrimp (Penaeus d. duorarum) appear to be relatively more abundant in North Carolina as compared to other South Atlantic states. White shrimp (Penaeus setiferus), although occurring as far north as Cape Hatteras, are most abundant in the region of the Cape Fear estuary and furnish the bulk of the fall fishery outside in this area.

During spring and summer, brown and pink shrimp are caught mostly at night. White shrimp are captured during the daylight hours in autumn. Core Sound is an exception in that all three species are caught only at night. The principal fishing areas in North Carolina include the mouths of the Neuse and Newport Rivers and Core and Pamlico Sounds; Bogue Sound, White Oak River, New River, and Cape Fear River. The northern extreme for offshore fishery is Ocracoke Inlet, extending to the South Carolina line and usually within one to two miles of shore. Pamlico

Sound, the state's largest estuary, produces approximately 50% of the North Carolina shrimp landings. Brown shrimp in this area attain larger sizes than shrimp in any other estuarine area of the state.

3.3.2 South Carolina

Commercial size shrimp usually appear during April-May off the South Carolina coast. These are primarily white "roe" shrimp, congregating along the coast off the Charleston and Beaufort areas. The season usually opens in late spring on these "roe" shrimp, with the trawler fleet fishing on those populations through June - early July. During mid-June, brown shrimp begin to show up in offshore waters and this species supports the fishery into early autumn. Usually during the latter part of July or early August, the major sounds and bays are opened to shrimping, with large brown shrimp comprising most of the catch. The white shrimp population begins to appear in offshore waters during late-August and constitutes the bulk of the fishery through December, and overall is harvested to a greater extent than the browns. Pink shrimp occur in the catches but comprise a relatively insignificant part of the commercial catch.

The major offshore shrimping areas in South Carolina within six miles of shore include the area from Winyah Bay and Bulls Bay to Tybee Roads. The most productive inshore areas include waters of St. Helena, Port Royal, and Calibogue Sounds and Bulls Bay. For the most part, shrimping in South Carolina waters is a near-shore activity. The catch drops off as the trawlers get beyond three to four miles from shore.

3.3.3 Georgia

Like South Carolina, Georgia's shrimp fishery consists primarily of white shrimp, the season starting on the "roe" shrimp population during the spring, usually in June. A relatively small brown shrimp population appears in July and August for the trawlers to harvest when the sounds open from September - December. The fishery for shrimp is carried on throughout the entire extent of the inside and littoral offshore waters of Georgia from the Savannah River to St. Mary's River. Generally, the coast is uniform in its production of shrimp. The autumn season is the most productive, with the trawlers harvesting the annual crop of white shrimp . The major shrimping grounds in Georgia include Wassaw Sound, Ossabaw Sound, Sapelo Sound, St. Simons Sound, St Andrews Sound, Cumberland Sound, and the offshore waters five to seven miles out from the beach along most of the coast.

3.3.4 Florida

The east coast fishery of Florida differs somewhat from that of Georgia in that shrimp concentrations are more scattered and primarily centered around the mouths of various inlets of the central and northern coast. Almost the entire catch of shrimp on the east coast of Florida is from the Atlantic Ocean within 6 - 8 miles of shore in depths of 20 - 80'. The major Florida east coast shrimping grounds are in the areas of Fernandina, the mouth of the St. Johns River, St. Augustine, New Smyrna and Cape Canaveral. South of the Cape Canaveral grounds, which extend to Melbourne, the shrimp fishery is of lesser magnitude although shrimp are caught off Vero Beach and Fort Pierce. South of this point, coral bottoms prohibit extensive trawling operations.

Joyce (1965) and Joyce and Eldred (1966) presented a detailed discussion of the Florida shrimping industry and observed that all three commercial penaeid species are taken in east coast waters. However, pink shrimp landings are small due to their being lumped with brown shrimp landings and because night shrimping, during the period of greatest pink shrimp abundance, is illegal. In Florida, the "off" season extends from January through May; the brown shrimp season runs from June 1 through August 31, and the white shrimp season lasts from late August through December. In effect, the brown shrimp season begins with the opening of legal night fishing on June 1. However, the white shrimp season is the most important and represents the money crop just as in South Carolina and Georgia, with October, November and December bringing top dollar.

3.4 Bait Shrimp Harvesting

The live bait shrimp industry has become a profitable business with the increasing demand for live shrimp to catch speckled trout, spot-tail bass, flounders and other game-fish occurring in inshore waters. The live bait fishery along the South Atlantic is comprised of all three commercial penaeid species. The species that predominates varies according to the time of year and locality.

On the northern and central coast of North Carolina, the bait fishery depends primarily on pink and brown shrimp, while white shrimp are used in the southern area around Cape Fear. A permit, required by North Carolina to take live shrimp, entitles the premittee to shrimp with a 5/8" bar mesh net instead of the minimum standard 6/8" mesh. The sale

of permits in the past few years does not indicate an increase; however, field personnel generally agree that the live bait fishery is definitely increasing. The discrepancy is that many commercial shrimpers are harvesting live shrimp during routine shrimping operations with standard nets and selling to an authorized shrimp dealer. Thus, no accurate record is available on the number of live-bait fishermen or the number of live-bait dealers.

South Carolina's bait shrimp fishery consists mostly of white shrimp, although some small browns are used in the late spring and early summer fishing seasons. The peak season for live bait, however, occurs during the fall run of seatrout and school bass. Like South Carolina, Georgia's live bait fishery is comprised primarily of white shrimp with a coinciding peak in sports fishing. The bait fishery along the northeast coast of Florida consists of white shrimp north of New Smyrna, while that from New Smyrna south to Fort Pierce is dependent on brown and pink shrimp. Both live shrimp and dead packaged shrimp are produced in the Florida bait fishery. Pink and brown shrimp are more viable and constitute the bulk of the live-bait fishery. White shrimp, considered to be of poorer quality for live bait due to the larger size attained in the nursery grounds, make up the greatest portion of the dead bait. The majority of all bait shrimp in Florida is the pink shrimp, although in certain localized areas brown shrimp may predominate. Also, Penaeus brasiliensis, a close relative of P. d. duorarum and P. setiferus, enters the bait shrimp catches of Biscayne Bay in the summer and is considered to be of good quality. Most bait shrimping in Florida takes place at night since P. d. duorarum is primarily nocturnal (Joyce and Eldred, 1966).

Several types of gear are used by bait shrimp fishermen along the South Atlantic coast. The bulk of the catch is made by small trawl nets in North Carolina, Georgia and Florida while in South Carolina this gear is prohibited through closed inshore waters. Thus, the South Carolina commercial bait shrimp are caught primarily by cast nets and seines. In certain areas along the several states other types of gear are also employed in the fishery, including push nets, cast nets, channel or lift nets, and dip nets. In Georgia, any person can at any time use up to a 10' trawl net in any of the state's saltwaters to catch shrimp for live bait for personal use to a limit of 2 qt. per person or 4 qt. per boat daily. Commercial bait shrimping must be licensed, and nets up to 20' are allowed. The only other nets which can be used for catching shrimp in the inside waters are cast nets.

Bait shrimp fishermen use small and modified versions of standard otter trawls and in some areas beam trawls. The beam trawl, referred to as a roller frame trawl, consists of a rectangular pipe frame of varying widths and lengths to hold the net open. Also, various devices such as sled runners and roller rigs are attached to the lower part of the frame to prevent the rig from bogging in soft, muddy bottoms (Inglis and Chin, 1966). The trawls are usually towed by small outboards which vary considerably in length and power. Generally, tows are relatively short (10 - 20 minutes or less) to prevent high shrimp mortality. Trash fish, crabs, etc., are discarded and live shrimp are placed in holding tanks aboard the boat or into partially sunken skiffs or barges being pulled. The holding tanks are equipped with pumps for circulating fresh or aerated sea water to keep the shrimp alive. To minimize mortality

during the hotter months, tows are made during the early morning and late afternoon hours depending on the tidal stages.

In the use of trawl nets, size of mesh and width of nets varies among the several states (see Section 7). In South Carolina, cast nets and seines are used in the small creeks and tributaries to stock-pile the holding boxes. This method is most efficient during the low tidal stages and is carried out predominantly in the central and southern part of the state.

The northeast coast of Florida has bottom conditions requiring a variety of bait shrimping gear (Tabb and Kenny, 1969). In general, otter trawl nets and roller frame trawls account for the greatest percentage of the catch (Joyce and Eldred, 1966). In areas not satisfactory for trawling, fishermen use cast nets, dip nets, and push nets (Inglis and Chin, 1969).

Methods of holding live bait shrimp vary according to the magnitude of the business. Small dealer operations employ live boxes suspended in the water from a dock for holding live shrimp. Water exchange in the live boxes is by natural tidal currents and the boxes can usually be raised by winch from the dock.

Another type of holding pen is a water-tight tank set on the ground and made of concrete, fiberboard, plywood, or planks. Water from the nearby creeks and tidal waters is pumped into the tank continuously, with waste products and old water passing out through the overflow pipe. This arrangement requires shade both for cooling purposes and for preventing excessive plankton growth. Holding capacities vary with tank sizes. A wooden tank measuring 4 x 4 x 8' will usually accommodate

30 to 80 quarts of live bait shrimp. Concrete tanks 4 x 4 x 16' will hold approximately 75 to 150 quarts. Some bait shrimp dealers have up to six holding tanks.

Another method of holding involves the use of diked-off salt water ponds. In South Carolina, small 1/4 acre ponds with adequate tide-control structures are used in the southern part of the state. Maintaining high water quality within these ponds is a necessity for profitable survival of bait shrimp.

With the increasing demand for shrimp in recent years, friction of competition between bait shrimping and commercial fishing has presented some problems. Commercial shrimpers are generally against most shrimping activities involving large catches of small creek shrimp; their feelings are based on the proposition that such inside shrimping is deleterious to their welfare from the standpoint of economics and biology. For example, the number of dead shrimp comprising a pound of creek shrimp (i.e., 80 - 100 count) taken in July may be worth $0.75 to $1.00 per pound. This would equal 2 or 3 pounds worth $2.00 per pound to the commercial trawlers later on in September. Also, there are complaints against the destruction of small shrimp in the creeks and inshore waters. Godwin (1973) discussed the possibilities of shrimp trawl nets damaging young crops of shrimp in shallow estuarine areas; in his survey, Godwin mentioned that some nursery areas produced three different crops (three species) over a period of six to eight months out of the year. As soon as one crop matured and migrated out, another crop was recruited into the area. In contrast, some areas where shrimp trawl nets were dragged repeatedly along the bottom produced only one crop of shrimp. Preliminary research has indicated that small shrimp soon disappear in areas characterized by soft bottom types after heavy trawling. It has been suggested

that disappearance of small shrimp in heavily trawled areas is due to young shrimp being killed by suspended mud clogging their gills.

Another complaint, especially prevalent in Florida, is that inside trawling destroys nursery ground bottom habitat such as grass beds, thus affecting the available feeding and protection areas so vital to young shrimp and fish. Also, serious protests have been directed at the sale of dead bait shrimp to fish houses, restaurants, and to individuals for human consumption. This practice is criticized not only for the early harvesting of undersized shrimp but also for the undercutting effects on the market and prices to the commercialmen.

3.5 International Participation

The extent of international participation of vessels in the South Atlantic region is rather limited as compared to the Gulf. There is no foreign vessel traffic fishing the territorial shrimping waters of any of the South Atlantic states. There are, however, several vessels out of the South Atlantic region fishing the waters off Mexico in the Campeche Banks and Yucatan Straits areas.

3.6 Extent of Participation in Complementary or Supplemental Fisheries

Commercial shrimpers in the South Atlantic states have become quite diversified in their fishing activities during the "off season". Many of the vessels and fishermen participate in the black sea bass fishery in the Carolinas. Rivers (1966) described the sea bass fishery with emphasis on gear and techniques. This fishery has been particularly important to the smaller 35 - 50' class vessels which do not move southward to shrimp during winter. Also, many of the smaller trawlers are

employed in clamming, crabbing and oyster fisheries. Crab trawling in South Carolina and Georgia during December - April is also a common activity for trawlers in the sounds and bays.

The larger North Carolina shrimp vessels are converted for fish trawling off Cape Lookout and north to Oregon Inlet. The large vessels operating out of South Carolina, Georgia and Florida rig up for demersal fishing activities with snapper, grouper, porgy, grunts, sea bass and other bottom species comprising the bulk of the catches.

During the off-season, or in poor stretches of the regular shrimping season, South Carolina, Georgia and Florida vessels have fished the deeper continental shelf zone for royal red shrimp (Hymenopenaeus robustus). The commercial production of this species has been rather limited and does not constitute a significant off-season fishery as yet. However, there have been several offshore exploratory surveys conducted and potential does exist for expanded commercial harvesting of this species. Good catches of royal red shrimp have been made off Florida between Cape Canaveral and St. Augustine. Royal red depth distribution is seasonal; the shrimp move offshore to about 275 fathoms in summer and inshore to about 200 fathoms in winter. They are also restricted to soft bottoms and to water temperatures of 8 - 12°C; greatest concentrations have been found at 9° - 10°C (Klima and Ford, 1971).

Cummins and Rivers (1962) devised a method for vessels with small winch capacity to fish a single trawl in the 200 - 250 fathom depth range. This method employs the three-drum winch carried on most shrimp vessels.

Usually, the larger vessels fishing for royal red shrimp employ two nets, either a 55 - 75' flat net or 45 - 60' semi-balloon trawl. Mesh size of the body is two inches and ranges from 1 3/4 to 2" in the tailbag. Most fishermen use tickler chins.

The shrimp industry has been rather slow to fully utilize the royal red resource due to a number of factors, as pointed out by Klima and Ford (1971): (1) increased outfitting cost for deep-water trawling; (2) initial problems of fishing single and double-rigged trawls in deep water; (3) reduced yield from heads-off shrimp (55% yield) compared to 62% for penaeid shrimp (Klima, 1969); (4) no economic advantage in market price over penaeid shrimp prices; (5) lack of adequate market which could provide a price differential; (6) reluctance on the part of processors to handle products due to processing problems.

The rock shrimp (Sicyonia brevirostris) also appears to be a potential commercial species. Some of the more industrious South Atlantic shrimpers have landed significant quantities of rock shrimp in the past. Bullis and Rothjen (1959) reported catches at several locations between Cape Hatteras and Cape Canaveral during January through March in 70' of water at night.

As a supplement to the vessels, the catching and wholesaling of fresh finfish (and at certain times of the year, crabs) is practiced by fishermen. The most desirable species caught for the fresh fish market include flounder, whiting, sea trout, blue fish, spanish mackerel, croaker, and spot, among others.

Fishing in the more productive year-round fisheries of the Gulf of Campeche and off the Texas coast is quite profitable and complements

earnings of the larger South Atlantic boats. The average annual catch, average catch per day and average number of fishing days are greater in the Gulf than for vessels fishing just the Atlantic area. However, the majority of larger South Atlantic vessels do not participate in the Gulf fishing but rather remain at home ports during the off-season.

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SECTION 4

DESCRIPTION OF INDUSTRY: ECONOMICS

by

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4.1 Introduction

Although the shrimp fishery of the southeastern United States is structured rather simply, this structure becomes more complex when the various elements and relationships affecting its performance and economic viability are considered. The fishery has several separate and distinct parts, each of which is acted upon by a differing set of economic forces. It consists of a large number of producers or harvesters, a small number of well-established dockside dealer-wholesalers, a small number of processors, few effective middlemen (brokers, wholesale distributors, etc.), few major retail outlets drawing directly on the fishery, and a limited product storage capacity. It has a traditionally oriented market system that is motivated by and oriented toward relationships among individuals and reductions of uncertainty rather than a market that has been willing to expand and explore such advances as new marketing arrangements and new product forms. As a result, it is a market having a definite lack of supporting services and facilities and has, in essence, closed the door to many marketing channels.

Landings of shrimp in the South Atlantic region are influenced by factors affecting (1) biological abundance of commercial species, and (2) fishing effort. Total supply of shrimp for the U. S. market is dependent on the domestic catch and imports. Demand is dependent on such factors as retail price, consumer income, and the influence of other seafoods and meats. The price received by harvesters is related to the retail price minus the costs of selling shrimp

through the market system.

While this study is primarily concerned with the shrimp fishery of the southeast, adequate information on the nature of the national demand or how this demand manifests itself through the various levels of the fishery is not available. Although several studies have been undertaken, the results are not sufficiently definitive to allow one to account for national variables in a South Atlantic management program.

4.2 South Atlantic Market Levels

The various economic forces impinging on the South Atlantic shrimp fishery operate in a market structure which may be outlined as follows. Nearest the source is the demand of dockside dealer-wholesalers and processors for the dockside landings. At the next level is the demand on processors and dealers by secondary wholesalers. At this point demand broadens beyond the limits imposed by regional landings as secondary wholesalers and processors seek inputs over the available landings. This results in processors and secondary wholesalers importing shrimp from outside the region. Neither secondary wholesalers nor processors within the region have large storage capacities, resulting in a demand for cold storage holdings. At the next higher level is the demand of retailers on the processors and secondary wholesalers. Finally, there are the demands on the retailers by consumers.

Unfortunately, there is very little quantitative information on any market level above the harvester level for the four-state region covered in this report.

4.2.1 The Landings Market

Although fishermen or harvesters are usually not viewed as components of market distribution channels, they determine the product available to other distribution channels. As such, it is important to understand the

major forces influencing them and their general economic viability.

The typical fishing unit, with some exceptions, is the boat-unit with owner and crew sharing the proceeds and certain trip costs. In addition, there are multiple-boat-units, as well as multiple-boat-units owned by a few vertically integrated firms wherein various operations such as catch, processing, and merchandising are combined. It is generally agreed that multiple-boat-units make up a small percentage of the vessels in the separate fishery and that these have been declining over the past 10 years. Unfortunately, there is no readily available information to substantiate this concensus. However, it appears reasonable at present to accept the owner-operated boat unit as representative of the landing market.

Landings involve more than biological abundance, weather, and catch. Also important are ability of crew, owner-crew relationships and condition of the vessel. Landings appear to be related more closely to biological abundance and weather than to price (Batie, 1974). There is no evidence of any attempt by fishermen to influence prices by deliberate variation in quantities landed. In fact, some preliminary unpublished studies on breakeven prices indicated that some larger trawlers may shrimp regularly when it is not justified by price. The decision to shrimp or not to shrimp apparently revolves around the captain's expectations of poundage. If the captain feels that shrimp are relatively scarce, he may decide not to shrimp, or to fish for crabs or some other species instead.* As a result,

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*The decision to trawl for crabs or finfish appears to be determined almost solely by price, although no work has been done in the South Atlantic region on the attitudes and variables determining such decisions.

quantity landed may be viewed as largely independent of price variables within a given season.

Knowledge of the landings market, long run supply conditions, and the effect of alternative management policies on the fishery requires an understanding of the economic conditions of boat-units in the fishery and cognizance of any trends that appear to be developing. Unfortunately, data are not available to describe the current condition of the fishery in any definitive fashion, much less estimate trends.

Data on costs and returns were compiled from an unpublished 1970-71 South Carolina survey covering 23 vessels, and a 1965-66 survey of 50 Georgia vessels by Carley (1968). Although limited in terms of the regional fishery, these two surveys provide a useful starting point. Although no specific data were available for North Carolina and Florida East Coast trawlers, individuals familiar with the fishery generally have agreed that the costs and returns structure of these vessels would probably not differ substantially from the vessels surveyed. However, this conclusion needs verification.

Although the Georgia and South Carolina surveys were taken during different time periods, under very different price and cost conditions, and under somewhat different formats, the results were similar when costs items were compared as a percent of total costs. Combined results of the two studies are presented in Table 4.1.

Based on the South Carolina survey, efforts were made to show the costs and returns of some "better" trawlers in the fishery. In most fisheries, certain vessels generally maintain a top rank in landings and returns over time. Understanding the attributes of these vessels is important because they form the core of the fishery; such information would be useful in up-grading

Table 4.1 Average Costs and Returns for South Atlantic Shrimp Vessels. Data on Georgia Survey from Carley (1968).

Item	Georgia Survey (1965-66)	Georgia and South Carolina Surveys	South Carolina Survey (1970-71) of Vessels Greater than 55'
Vessels (no.)	50	73	14
Length (feet)	47.9	56.5	64
Investment ($)	-	45,797.00	61,004.00
Landings (lbs.)	30,160	54,564	75,384
Price (cents)	.667	.84	.95
GROSS RECEIPTS ($)	20,126.00	47,305.00	69,453.00
VARIABLE COSTS ($)			
Net Maintenance	622.00	873.00	1,512.00
Vessel Maintenance	2,683.00	1,789.00	4,166.00
Fuel and Lube	2,214.00	1,684.00	3,076.00
Ice	681.00	802.00	1,304.00
Groceries	1,200.00	456.00	748.00
License	-	104.00	140.00
Heading and Packing	1,534.00	4,214.00	7,998.00
Crew Share 1/	5,300.00	16,820.00	32,850.00
Other 2/	98.00	501.00	912.00
Subtotal	14,332.00	35,073.00	52,706.00
FIXED COSTS ($)			
Depreciation, taxes, insurance, interest 3/	2,038.00	5,499.00	7,052.00
TOTAL COSTS ($)	16,370.00	40,572.00	59,758.00
Net Return Before Taxes ($)	3,756.00	6,733.00	9,695.00
Return on Investment	-	.147	.158

1/ Includes an inputed return for the Captain's share.

2/ Includes miscellaneous items such as telephone, accounting and legal fees, office expenses, transportation, etc.

3/ To make depreciation comparable for all vessels, straight line depreciation over a ten year period was used.

the general economic condition of the fishery. In fact, future efforts directed toward developing economic information on the fisheries within each of the four states might well be initiated in this area.

As shown in Table 4.1, average landings were 30,160 pounds for Georgia vessels, 54,564 for all vessels, and 75,384 for the top vessels. Average incomes or return to the boat were $3,756, $6,733, and $9,695 respectively with returns on investment ranging from 15-16%. By adding the return to the captain and the boat, an owner-operator's income before taxes averaged $16,320 for all vessels and $28,420 for the better trawlers. The 1971 season was a good season both in terms of price and quantity landed.

Total costs averaged from $15,183 for Georgia vessels, $40,572 for the combined data, and $59,758 for the better trawlers. Major costs items in the combined and better trawler surveys in order of importance were crewshares, heading and packing, depreciation, net maintenance, and vessel maintenance. The Georgia survey differed substantially with crewshares, vessel maintenance, fuel and lubrication, ice and icing, and depreciation as major costs items.

South Carolina vessels on the average in 1971 fared considerably better than Georgia vessels in the 1965-66 period (Table 4.1). How much of this difference is due to different price-cost relationships, biological abundance, sampling technique or other factors is unknown. Unfortunately, the South Carolina survey did not cover a large enough number of vessels to provide detailed comparison of length categories. Some general statements regarding functional relationships affecting costs and returns can be made, however.

Fixed costs appear related to the size and age of the vessel, and

the quantity and types of gear. Fixed costs are greater in absolute terms for larger vessels, but when viewed as a percentage of total costs, they account for about the same relative share of total costs for all vessels.

Variable costs appear related to such components of effort as the size of the vessel, quantity of shrimp landed, and number of crew members.* Such costs account for about 87% of total costs and, in terms of cash outlays, are greater for larger vessels.

As illustrated in Table 4.1, the higher cost of operating larger vessels is justified by returns in a "good year". Whether this would hold true in "bad years" is unknown. This is particularly important because a definite trend in Georgia toward larger vessels in the 1960-1965 period was noted by Carley (1968). This trend appears to have continued to the present for the entire South Atlantic fishery, although not to the same extent as in the Gulf of Mexico. Also, detailed functional relationships cannot be specified due to lack of data on such variables as horsepower, and number of trips.

In summary, the landings market level of the South Atlantic shrimp fishery, as in many other primary industries, appears to be composed of large numbers of very small part-time units that fish intermittently, depending on expectations, time available, etc.; a number of marginal units who move in and out of the fishery depending on price and biological abundance in a particular season; and a group of generally successful units that form the core of the fishery. However, the variables and attributes distinguishing successful and marginal producers has yet to be defined. It also appears that vessel owners,

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*Carley (1968) did not find a significant relationship between variable costs and vessel size. However, this appears to be a function of his treating major repair costs as fixed costs.

financial institutions, and others are optimistic about the shrimp fishery and were willing to invest additional resources in the industry at the time of this study. More recent marketing and cost conditions may have altered this attitude.

4.2.2 Dockside Dealer-Wholesalers

The "dealer" is the primary wholesaler in the market system and is an important link in the chain of distribution channels. He is typically the first to receive shrimp from the harvester and, as such, determines the ex-vessel price. The dealer generally purchases shrimp for resale without further processing beyond sorting, grading, re-boxing, or re-icing. In some cases, the dealer owns a boat or financially supports one or more boats who bring the dealer their catch. The overall importance of dealers in this role is not known.

The dealer also sells services (e.g. heading and packing, diesel fuel, gas, ice, etc.) to the boat-unit. The dealer purchases shrimp and sometimes other species from the boat unit for sale to processors, secondary wholesalers, and other primary wholesalers. A few dealers by-pass the wholesaler and sell directly to the retail level or maintain retail outlets of their own. Dealers, however, sell primarily to secondary wholesalers or processors. For example, 82-86% of the South Carolina landings are sold directly to the Fulton Fish Market or to processors in Georgia and Florida. Data for Georgia were approximately the same in 1966 with 88% of shrimp handled by dealers being sold to processors and secondary wholesalers (Carley, 1968). Apparently a somewhat larger proportion of shrimp landings in North Carolina and Florida move directly to the retail level, but this cannot be substantiated.

Because they handle most of the shrimp landings, make decisions concerning sales to secondary wholesalers, other primary wholesalers, processors,

and retailers, and control the supply of essential services to boat-units, dockside dealer-wholesalers receive little competition for the purchase of shrimp from boat-units. Dealers form the initial assembly point for the product and determine the first step in the market channel into which South Atlantic shrimp move. The dockside dealer-wholesaler level determines the shrimp market's traditional character. When inland wholesalers attempt to buy local shrimp, but dockside dealer-wholesalers do not feel that it is worth the effort or risk, they are effectively blocked from accessing the local supply. Apparently, most dealers have done well in recent years and are unwilling to experiment with either new product forms or market channels. Another factor affecting this situation is the general lack of local freezer space. Although a recent unpublished South Carolina survey has indicated that "certainty of supply" is not as important in accessing higher market channels as once believed, capacity to store some minimum quantity of shrimp over time is required. The failure or inability of dealers to access higher market levels may severely limit ex-vessel price stabilization and increases.

4.2.3 Processor Level

Due to the paucity of data and the rapidity of innovation, it is difficult to make any detailed statements about the processor level.* As indicated earlier, processors are an important outlet for South Atlantic shrimp. Generally, they support the industry as the New York price begins to drop. Major processors are located in Georgia and Florida; several small processors are located throughout the South Atlantic region. Their primary

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*The first study of shrimp processors in the South Atlantic that the author is aware of has just been initiated by Dr. Fred Prochaska at the University of Florida.

processed products are frozen breaded and peeled-deveined shrimp.

Processors supply the demands of secondary wholesalers and distributors, large institutional buyers, and retailers. To meet this demand, processors draw on a combination of local shrimp, imports, and cold storage holdings. What the relationships among these sources of supply are, how this affects ex-vessel price, and what their supply preferences include are virtually unknown.

4.2.4 Secondary Wholesalers

Secondary wholesalers buy shrimp for resale, but unlike dealers they purchase from other wholesalers and processors. Indications are that secondary wholesalers move large volumes of shrimp in the South Atlantic region. However, such wholesalers deal primarily in processed products with the fresh, breaded, and frozen shrimp coming from large wholesale outlets. Secondary wholesalers sell primarily to large institutional markets including restaurants, supermarket chains, and the military.

There appears to be a lack of communication between secondary wholesalers and coastal dealers. In South Carolina, for example, few secondary wholesalers think kindly of the commercial fishing industry of that state; with the possible exception of Florida, this appears to be the case for the entire South Atlantic shrimp fishery. Yet, this market level is responsible for moving large volumes of breaded, peeled-deveined, and a surprising quantity of frozen green shrimp to restaurants, schools, hospitals, military bases, and in some cases, chain stores.

No attempt can be made at present to analyze this market level, since no data exist as to the number, distribution, or relative importance of the level's various components. This paucity of data becomes important because of the large volume of shrimp distributed by secondary wholesalers

in the South Atlantic region and the possibility of altering market channels to increase ex-vessel prices.

4.2.5 Retailers

The retail level is composed of specialty fish markets, supermarket chains, independent grocers and institutional outlets such as restaurants and schools. With the exception of specialty markets and some restaurants, this level deals in processed products and only provides storage and packaging services. Again, there is insufficient information available to adequately analyze this level.

4.2.6 Market Channels for Fresh Shrimp

The market channels or combinations of market levels involved in distributing shrimp and shrimp products to consumers are diverse. Fig. 4.1 outlines the major market channels for fresh shrimp in the South Atlantic (Carley, 1968).

Most shrimp landed in the South Atlantic region (approximately 90%) are sold to dockside dealer-wholesalers. They in turn sell heads-off shrimp to four types of buyers: processors, secondary wholesalers, brokers, and retail outlets. In the Georgia study, 55% of coastal dealer sales were to processors, 33% to secondary wholesalers, 9% to retail outlets, and 3% through brokers (Carley, 1968). The 1971 South Carolina survey indicated dealer sales as follows: 36% to secondary wholesalers, 56% to processors, 7% to retail outlets, and 1% to brokers. Results of the two surveys are obviously similar. It is noteworthy that in South Carolina 81% of sales to secondary wholesalers are outside of the South Atlantic region. In Georgia, an estimated 34% of sales to secondary wholesalers are outside of the region. Note that Fig. 4.1 illustrates the market channels for shrimp landed in the

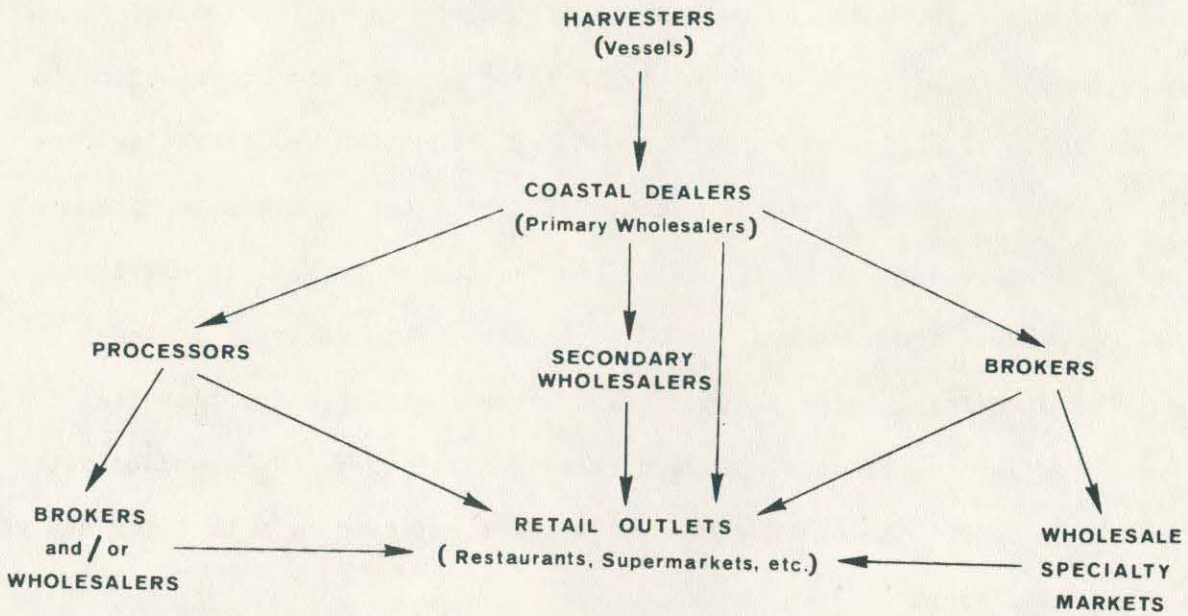

Fig. 4.1 Market channels for shrimp in the southeastern United States.

South Atlantic region, not for all shrimp marketed in the region. Large quantities of shrimp are imported into the region at the processor, wholesaler, and broker levels.

4.3 Value-Added Analysis

The standard criterion for measuring the size of the industry in the South Atlantic has been the value of the catch received by fishermen. A more complete determination of the size of the total industry in terms of dollars, however, is the value added at each stage of production and marketing.

The purpose of a value-added analysis is to measure the contribution to the final value of shrimp at each stage of the production and marketing process. The price of shrimp at the point of its sale to the ultimate consumer is the total value that is available to the various activities involved in moving the product from the boat to the consumer. This analysis includes payments to materials, labor, equipment and other costs, plus profits that accrue to the various production and marketing activities. Value-added data are useful in describing the market system and for providing a base for analysis of market efficiency.

Only crude estimates of value added are available for the South Atlantic. The 1965 Georgia study estimated that the value of shrimp to crew and vessel owners was $0.57 per pound and the estimated value of the shrimp at the wholesale level was $1.19 per pound, an increase of $0.62 in value accruing to the various functions involved in moving shrimp from the vessel to the wholesale level (Carley, 1968). Thus, fishermen received an estimated 48% of the wholesale value and the marketing functions received about 52% of the wholesale value. The 1971 South Carolina survey indicated that the wholesale share of value had increased to about 60%.

Table 4.2 provides estimates on a national basis for price spreads and mark-ups at the ex-vessel, wholesale, and retail levels for the years 1966-1971. These data indicate that the fisherman's share of the retail price of shrimp has varied widely since 1966. In general, however, the fisherman's share has dropped well below the 50% received in 1966. Conversely, there appears to be a definite upward trend in the mark-up at the wholesale level.

Although these figures are probably fair "ball-park" figures, they should be considered as rough estimates. None of the sources surveyed had complete information on the percentages of shrimp moving through each marketing channel. The difficulty of generating definitive estimates of value added is further complicated in that quantities and prices vary seasonally and annually. It is important, however, to begin to develop estimates of value-added, as this provides a basis for analyzing the marketing system and for estimating the contribution of the shrimp industry to the South Atlantic region.

Table 4.2 Fresh and frozen shrimp: Prices at three market levels, fisherman's share at retail level, and mark-ups at two market levels, 1966-1971.

Year	Prices			Fisherman's share of Retail Price	Mark-ups	
	Ex-vessel[1/]	Wholesale[2/] cents/lb.	Retail[3/]		Wholesale	Retail
					Percent	
1966	65.0	110	128	50	40	14
1967	54.5	107	136	40	49	21
1968	62.4	120	135	46	48	11
1969	63.8	131	153	41	51	43
1970	57.9	126	163	35	54	23
1971	70.5	151	167	42	53	10

1/ Heads-off weight basis of all shrimp loaded.

2/ Frozen brown shrimp at Chicago, 26-30 count, U. S. Department of Labor, Bureau of Labor Statistics.

3/ U. S. Department of Labor, Bureau of Labor Statistics, U. S. 41-city average, 10-ounce frozen raw headless.

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SECTION 5

THE SOUTHEAST SHRIMP FISHERY: HISTORICAL CATCH STATISTICS

by

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5.1 General Development of the Fishery

Johnson and Lindner (1934), Anderson, Lindner and King (1949), and Gunter and McGraw (1973) have described the development of the shrimp fishery, which has been prosecuted at least since 1817. Commercial catch statistics were apparently not collected and published for the fishery until 1880 (see Table 5.1), and then only sporadically until 1950. Moreover, landings were not identified to species until 1957. Initially, the fishery was prosecuted by dipnets, haul seines, and cast nets (Gunter and McGraw, 1973). During the early part of this century the Bureau of Fisheries at its station in Beaufort, North Carolina, had been collecting marine organisms with a small otter trawl. Fishermen, observing that shrimp were being captured by this gear, adopted the idea and built larger nets specifically for shrimp fishing (Anderson, Lindner, and King, 1949). Shrimp trawling apparently occurred first at Fernandina, Florida, and by 1917 the otter trawl had become the standard gear of the shrimp fishery (Anderson et al., 1949). Weymouth, Lindner and Anderson (1933) reported that by the 1930's, 90% of the commercial catch of shrimp was taken by

Table 5.1 Landings (round weight) of South Atlantic shrimp by states, 1880-1973.

	North Carolina		South Carolina		Georgia		Florida (East Coast)		Total	
	thousand pounds and thousand dollars									
year	quantity	value	quantity	value	quantity	value	quantity	value	quantity	value
1880	63	4	630	38	56	4	72	4	821	50
1887	120	5	338	18	185	6	(1)	(1)	(1)	(1)
1888	124	5	359	19	191	7	(2)	(2)	(1)	(1)
1889	135	5	380	19	150	6	78	3	743	33
1890	144	5	372	19	162	6	66	3	744	33
1897	146	6	374	18	68	3	39	1	627	28
1902	84	3	370	13	344	8	3,013	63	3,811	87
1908	371	9	452	19	528	19	4,346	91	5,697	138
1918	940	23	55	6	5,793	174	8,868	267	15,656	470
1923	1,658	51	355	13	10,668	373	11,024	385	23,705	822
1927	1,276	46	1,657	67	12,280	469	14,779	592	29,992	1,174
1928	845	30	431	18	9,526	545	22,507	865	33,309	1,458
1929	897	31	288	17	12,378	581	17,266	820	30,829	1,449
1930	1,299	41	793	32	8,853	335	15,260	571	26,205	979
1931	338	14	2,635	91	5,471	181	17,050	628	25,494	914
1932	292	9	1,501	33	3,602	90	17,068	504	22,463	636
1934	2,564	80	1,801	54	6,843	203	14,753	452	25,961	789
1936	3,815	120	1,101	37	9,715	291	18,936	574	33,567	1,022
1937	4,184	126	1,201	36	9,504	284	12,547	382	27,436	828
1938	4,569	137	3,723	112	10,426	302	8,847	270	27,565	821
1939	4,811	161	4,090	123	10,802	324	7,982	249	27,685	857
1940	4,156	125	1,784	55	9,336	281	7,426	293	22,702	754
1945	10,614	849	4,696	404	16,392	1,068	11,879	1,663	43,581	3,984
1950	8,311	1,999	7,746	2,169	11,157	3,177	9,267	2,687	36,481	10,032
1951	8,200	1,950	3,730	1,043	7,608	2,133	8,233	2,256	27,771	7,382

see notes at end of table

(continued on next page)

Table 5.1 (continued)

	North Carolina		South Carolina		Georgia		Florida (East Coast)		Total	
	thousand pounds and thousand dollars									
year	quantity	value	quantity	value	quantity	value	quantity	value	quantity	value
1952	8,713	1,905	4,072	940	5,991	1,677	6,895	2,063	25,671	6,585
1953	14,645	3,623	5,086	1,482	7,535	2,616	5,667	2,210	32,933	9,931
1954	9,182	1,836	6,644	1,661	7,742	2,013	5,078	1,373	28,646	6,883
1955	10,324	2,369	6,918	1,591	7,161	1,862	4,136	1,117	28,539	6,939
1956	6,243	1,594	5,589	1,393	7,991	2,662	5,695	2,157	25,518	7,806
1957	7,933	2,263	6,690	1,751	8,788	2,987	5,179	2,149	28,590	9,150
1958	2,519	719	5,815	2,091	8,746	2,939	5,504	2,209	22,584	7,958
1959	6,378	1,413	7,515	1,917	7,602	1,837	4,511	1,360	26,006	6,527
1960	5,988	1,607	8,030	2,167	10,403	2,575	6,793	2,163	31,214	8,512
1961	3,016	830	3,907	1,301	6,810	2,371	6,016	2,437	19,749	6,939
1962	5,805	2,239	6,474	2,613	8,610	3,880	5,189	2,543	26,078	11,275
1963	3,374	1,065	2,201	643	5,448	1,802	4,506	1,736	15,529	5,246
1964	4,279	1,503	2,632	861	5,939	2,298	4,491	1,971	17,341	6,633
1965	5,416	1,719	6,795	2,635	8,585	3,418	5,395	2,388	26,191	10,160
1966	5,697	2,566	4,263	2,181	6,476	3,341	5,039	2,726	21,475	10,814
1967	4,919	1,809	4,088	1,679	6,657	3,022	4,934	2,500	20,598	9,010
1968	4,612	2,357	6,330	3,684	8,536	4,929	4,800	3,024	24,278	13,994
1969	7,854	4,476	5,817	3,429	8,447	4,984	5,188	3,298	27,306	16,187
1970	4,918	2,421	4,951	2,879	5,996	3,371	4,609	2,645	20,474	11,316
1971	7,615	4,766	10,753	6,388	8,862	6,466	3,970 3/	3,300 3/	31,200 3/	20,920 3/
1972	5,563	3,549	8,085	5,547	7,258	5,611	4,341 4/	3,758 4/	25,247 4/	18,465 4/
1973	5,000	5/	8,256	5/	7,907	5/	2,632	5/	23,885	5/

1/ data not available
2/ data includes west coast of Florida
3/ includes 347,236 pounds of rock shrimp valued at $103,821
4/ includes 50,304 pounds of rock shrimp valued at $29,027
5/ data not available
Source: Fishery Statistics of the United States
Shrimp landings, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service

otter trawl, with only 10% being taken by cast nets and seines. Improved technology since the 1930's has increased the efficiency of the shrimp fishery fleet tremendously. Unfortunately, the lack of adequate catch and effort statistics has made it impossible to accurately document the effect of gear changes and vessel efficiency over the development of the fishery. However, the general development of the fishery has been described by Johnson and Lindner (1934), Anderson, et al. (1949), and Lindner and Anderson (1956).

Although shrimp must have been taken along the entire southeastern Atlantic coast, catch data indicate that the bulk of the commercial landings from 1880 to 1897 were taken in South Carolina and Georgia (see Table 5.1). The east coast of Florida produced most of the landings from 1902 to 1936. Since then, catches have declined drastically on the east coast of Florida, and the center of production has been in Georgia.

Major changes in location of landings (not necessarily the location of capture) over the period examined include the development of the pink and brown shrimp fisheries in North Carolina, and the change in distribution of landings of white shrimp among South Carolina, Georgia, and Florida. Changes in distribution were produced apparently by two factors: (1) the decline in abundance of white shrimp between the 1927-1940 and 1950-1972 periods, which may have occurred between 1945 and 1948 (Lindner and Cook, 1970), although the lack of catch statistics between 1941 and 1949 makes it impossible to determine when the decline actually occurred; (2) the increased level of fishing in the Carolinas and Georgia. The decline in white shrimp production appears to have been more severe in Florida than further north; white shrimp, which were formerly caught after migrating to

Florida, are now being caught before they migrate there (William Anderson, personal communication).

5.2 Evaluation of Historical Catch and Effort Data

Shrimp biologists have been concerned about inadequate catch and effort statistics in the southeastern Atlantic shrimp fishery for at least 40 years. In this section the major weaknesses of the statistical program will be discussed.

Perhaps the greatest weakness of the program is the virtual absence of any detailed effort data. Ideally, one should have a trip ticket for each landing which would give as a minimum: (1) landing site and/or dealer; (2) vessel name; (3) date; (4) fishing location(s); (5) time expended fishing; (6) catch by species and size category. Additional information, such as gear size and type as well as vessel characteristics, could be obtained from licensing information and "dockside" interviews. The present system provides only the entire monthly catch handled by a dealer by species and size; there is no estimate of the fishing effort expended to produce the catch. This deficiency makes it very difficult to either monitor trends in abundance of the shrimp resource or to estimate mortality rates. Moreover, the absence of effort data makes it difficult, if not impossible, to develop a realistic population dynamics model for penaeid shrimp (see Section 2.2.3).

Other problems associated with the lack of effort data are that it is extremely difficult to: (1) describe actual temporal and spatial distribution of catches on fishing grounds; (2) determine actual fishing

strategies of larger fishing vessels which fish in more than one state; (3) analyze costs and returns of fishing. In short, one must have good catch and effort data to document the prosecution of the fishery and to determine the effect of fishing upon the resource.

The effects of socio-economic factors upon shrimp landings, especially for the period prior to 1950, have not been documented. One must therefore be cautious when interpreting past catches because landings may not have reflected true abundance of shrimp. This is particularly true for brown and pink shrimp, which were not extensively exploited until the late 1940's or early 1950's.

Commercial catch statistics for the southeastern Atlantic fishery underestimate the true catch of shrimp because: (1) an unknown portion of the catch of larger vessels is apparently transferred to small retailers and restaurants without being reported; (2) people with small otter trawls catch an unknown quantity of shrimp to either sell or use for food; (3) large numbers of sportsmen with cast nets, dipnets, and beach seines obtain significant quantities of shrimp either for food or bait (see Section 5.9). Apparently 10 to 35% of the actual catch (our estimate based on conversations with state management officials in this region) may never be reported. Whether the ratio of reported to unreported catch has remained relatively constant or has changed over time during the development of the fishery is uncertain.

Finally, there are few statistics describing the sports catch of shrimp, and the only state collecting bait shrimp statistics in the south Atlantic region is Florida.

5.3 Species Composition of Catch

Weymouth, Lindner and Anderson (1933) reported that 95% of the

commercial catch in the southeastern Atlantic was comprised of the white shrimp, P. setiferus. This situation held until the late 1940's because brown and pink shrimp were not accepted by the market prior to 1946 (William Anderson, personal communication). The decline in abundance of white shrimp, which occurred between 1940 and 1950, provided industry with an incentive to develop a market for pinks and browns; this occurred around 1950.

At present, pink and brown shrimp comprise the bulk of the catch in North Carolina, whereas white and brown shrimp predominate in the fisheries of South Carolina, Georgia, and the east coast of Florida.

Table 5.2 and Appendix 5.1 show the species composition of the southeastern Atlantic catch for those years having data available. The data indicate that species composition has been relatively constant from year to year. However, catches of rock shrimp, Sicyonia brevirostris, are increasing in Florida and this species may soon be a major component of the catch (Edwin A. Joyce, Jr., personal communication).

5.4 Apparent Trends in Size Composition Data of Commercial Landings

Size composition data were examined to determine if there were any obvious differences in size distribution of catches either between states or between high and low annual catches within states. Only white and brown shrimp were used because they are the two dominant species.

5.4.1 White Shrimp

In general, the relative abundance of larger white shrimp increases progressively in the catch toward the south, particularly in Florida (Table 5.3, Appendix 5.2). Presumably this is due to larger shrimp migrating south into Georgia and Florida (Lindner and Anderson, 1956).

Table 5.2 Shrimp landings (heads off) by state and species, 1957-1973.

	North Carolina	South Carolina	Georgia	Florida (East Coast)
1957				
brown	2,976,628	1,443,133	912,094	717,936
pink	1,324,201	5,700	15,481	2,895
white	421,158	2,533,074	4,270,689	2,328,625
royal red	-	-	5,212	33,303
1958				
brown	941,859	2,000,466	2,110,880	654,623
pink	508,171	-	6,496	-
white	50,959	1,461,032	3,069,618	2,621,568
1959				
brown	2,435,350	1,813,631	1,133,204	477,947
pink	1,288,110	-	475	-
white	72,962	2,659,317	3,387,159	2,207,326
royal red	-	-	4,000	-
1960				
brown	2,564,394	1,430,690	1,274,330	344,397
pink	766,560	-	-	-
white	233,601	3,349,393	4,917,880	3,699,046
1961				
brown	601,419	526,869	347,816	73,967
pink	1,092,389	-	-	-
white	101,525	1,798,603	3,705,799	3,506,656
1962				
brown	2,180,044	2,243,892	1,837,501	901,727
pink	1,402,714	-	-	1,355
white	32,743	1,858,097	3,586,488	2,401,789
royal red	-	-	71,111	19,975
1963				
brown	1,751,336	1,191,204	1,175,602	631,107
pink	346,462	-	-	-
white	-	183,675	2,269,950	2,266,457
royal red	-	-	32,742	-

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Table 5.2 (continued)

	North Carolina	South Carolina	Georgia	Florida (East Coast)
1964				
brown	1,444,942	1,139,318	1,221,485	597,743
pink	1,210,430	-	7,100	-
white	10,248	516,011	2,541,272	2,204,688
royal red	-	-	25,444	73,709
1965				
brown	1,774,880	1,554,428	1,203,379	514,732
pink	1,054,523	-	-	-
white	565,844	2,787,023	4,315,722	2,918,427
royal red	-	-	664	39,822
1966				
brown	2,955,446	2,151,235	1,377,787	723,265
pink	330,870	-	1,149	-
white	265,997	519,423	2,763,460	2,400,217
royal red	-	-	-	99,211
1967				
brown	1,951,916	1,463,377	1,126,382	414,125
pink	986,974	-	-	525
white	127,977	1,124,753	3,132,982	2,693,576
royal red	-	-	10,444	66,806
1968				
brown	1,963,982	963,093	453,064	296,575
pink	827,905	3,800	-	4,501
white	83,809	3,102,002	5,068,825	2,749,187
royal red	-	-	-	45,483
1969				
brown	3,656,663	795,226	559,454	341,743
pink	1,060,627	-	-	636
white	175,316	2,977,273	4,900,279	2,930,734
royal red	-	-	-	55,528
1970				
brown	2,379,976	1,160,420	633,802	256,314
pink	534,235	-	775	2,855
white	238,844	2,001,730	3,230,167	2,640,380
royal red	-	-	-	68,323

(continued on next page)

Table 5.2 (continued)

	North Carolina	South Carolina	Georgia	Florida (East Coast)
1971				
brown	3,175,038	1,710,094	716,047	463,702
pink	1,196,660	-	-	-
white	381,994	5,194,397	5,006,227	1,631,865
royal red	-	-	-	87,285
1972				
brown	1,989,967	1,395,522	1,058,507	354,403
pink	492,673	-	-	-
white	1,020,220	3,790,630	3,606,302	2,373,359
royal red	-	-	-	15,408
1973				
brown	1,053,826	1,067,868	377,737	297,401
pink	947,410	-	-	4,423
white	1,166,497	4,244,717	4,960,773	1,473,138
royal red	-	-	-	5,906

Source: Fishery Statistics of the United States.
Shrimp Landings, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

There did not appear to be any clear trend between magnitude of annual catch and size distribution of catch.

The most common sizes of shrimp in the catch were 31-40 and 41-50 counts except in Florida, where the most common counts were 21-25 and 26-30.

5.4.2 Brown Shrimp

The size distribution of brown shrimp did not appear to vary as much between states as did white shrimp. Data in Table 5.3 suggest that slightly larger shrimp may be taken in North Carolina and Florida than in South Carolina and Georgia. However, this apparent difference may be artificial because the size distribution estimates may not be too accurate.

There did not appear to be any clear relationship between magnitude of annual catch and size distribution of catch.

The most common sizes of shrimp in the catch were 26-30 and 31-40 counts, and it appears that brown shrimp in the commercial catch are slightly larger than white shrimp.

5.5 Seasonal Distribution of Catch

Anderson et al. (1949) gave the percentage of shrimp catch by months. They reported that peak catches were obtained from August through November in North and South Carolina as well as Georgia. The period of greatest production in the north Florida area occurred from August to November; in central Florida, production was greatest from December to March with the peak occurring in January and February. Anderson (1970) confirmed these observations.

Since 1957, peak landings in North Carolina have occurred between June and October; in South Carolina and Georgia, catches have been greatest

Table 5.3 Annual catch (heads off) in millions of pounds and counts of two most numerous size groups in commercial shrimp catch by species and by states, 1957-1973.

brown shrimp

	North Carolina		South Carolina		Georgia		Florida (East Coast)	
year	count	catch	count	catch	count	catch	count	catch
1957	31-40 15-20	2.98	31-40 68- +	1.44	31-40 41-50	0.91	31-40 26-30	0.72
1958	41-50 51-67	0.94	31-40 41-50	2.00	31-40 41-50	2.11	31-40 26-30	0.65
1959	31-40 15-20	2.44	31-40 26-30	1.81	31-40 26-30	1.13	31-40 26-30	0.48
1960	31-40 41-50	2.56	26-30 41-50	1.43	31-40 26-30	1.27	31-40 26-30	0.34
1961	31-40 41-50	0.60	31-40 26-30	0.53	26-30 31-40	0.35	31-40 26-30	0.07
1962	21-25 26-30	2.18	31-40 41-50	2.24	31-40 41-50	1.84	31-40 26-30	0.90
1963	31-40 41-50	1.75	31-40 41-50	1.19	31-40 26-30	1.17	31-40 26-30	0.63

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Table 5.3 (continued)

brown shrimp

	North Carolina		South Carolina		Georgia		Florida (East Coast)	
year	count	catch	count	catch	count	catch	count	catch
1964	31-40 21-25	1.44	31-40 26-30	1.14	31-40 26-30	1.22	26-30 31-40	0.60
1965	31-40 41-50	1.77	31-40 41-50	1.55	31-40 41-50	1.20	31-40 26-30	0.51
1966	21-25 41-50	2.95	26-30 31-40	2.15	31-40 26-30	1.38	31-40 26-30	0.72
1967	41-50 31-40	1.95	31-40 26-30	1.46	31-40 26-30	1.13	31-40 41-50	0.42
1968	21-25 31-40	1.96	26-30 31-40	0.96	26-30 31-40	0.45	26-30 31-40	0.30
1969	31-40 21-25	3.66	31-40 41-50	0.76	31-40 26-30	0.56	31-40 51-67	0.34
1970	31-40 26-30	2.38	31-40 26-30	1.16	26-30 31-40	0.63	26-30 31-40	0.26

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Table 5.3 (continued)

brown shrimp

	North Carolina		South Carolina		Georgia		Florida (East Coast)	
year	count	catch	count	catch	count	catch	count	catch
1971	21-25		31-40		31-40		31-40	
	31-40	3.17	41-50	1.71	26-30	0.72	26-30	0.46
1972	21-25		31-40		31-40		31-40	
	41-50	1.99	41-50	1.40	26-30	1.06	26-30	0.35
1973	31-40		31-40		31-40		51-67	
	26-30	1.05	41-50	1.07	26-30	0.38	26-30	0.30

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Table 5.3 (continued)

white shrimp

	North Carolina		South Carolina		Georgia		Florida (East Coast)	
year	count	catch	count	catch	count	catch	count	catch
1957	31-40		41-50		31-40		21-25	
	21-25	0.42	31-40	2.53	41-50	4.27	26-30	2.33
1958	41-50		31-40		31-40		26-30	
	31-40	0.05	26-30	1.46	41-50	3.07	21-25	2.62
1959	31-40		31-40		31-40		21-25	
	41-50	0.07	26-30	2.66	26-30	3.39	26-30	2.21
1960	31-40		26-30		31-40		21-25	
	51-67	0.23	31-40	3.35	66-+	4.92	26-30	3.70
1961	31-40		31-40		31-40		21-25	
	41-50	0.10	26-30	1.80	26-30	3.71	26-30	3.51
1962	41-50		31-40		26-30		26-30	
	31-40	0.03	41-50	1.86	31-40	3.59	31-40	2.40
1963	-		31-40		31-40		21-25	
			26-30	0.18	41-50	2.27	26-30	2.27

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Table 5.3 (continued)

white shrimp

	North Carolina		South Carolina		Georgia		Florida (East Coast)	
year	count	catch	count	catch	count	catch	count	catch
1964	31-40 26-30	0.01	31-40 26-30	0.52	31-40 41-50	2.54	21-25 26-30	2.20
1965	31-40 41-50	0.56	31-40 41-50	2.79	31-40 41-50	4.31	21-25 26-30	2.92
1966	31-40 41-50	0.26	31-40 68-+	0.52	31-40 41-50	2.76	21-25 26-30	2.40
1967	41-50 31-40	0.13	26-30 41-50	1.13	31-40 26-30	3.13	21-25 26-30	2.70
1968	31-40 41-50	0.08	26-30 51-67	3.10	31-40 26-30	5.07	21-25 26-30	2.75
1969	31-40 41-50	0.18	31-40 26-30	2.98	31-40 41-50	4.90	31-40 26-30	2.93
1970	31-40 41-50	0.24	31-40 26-30	2.00	31-40 26-30	3.23	21-25 31-40	2.64

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Table 5.3 (continued)

white shrimp

	North Carolina		South Carolina		Georgia		Florida (East Coast)	
year	count	catch	count	catch	count	catch	count	catch
1971	41-50		51-67		31-40		21-25	
	31-40	0.38	31-40	5.19	26-30	5.01	26-30	1.63
1972	51-67		31-40		26-30		26-30	
	41-50	1.02	51-67	3.79	31-40	3.61	21-25	2.37
1973	51-67		51-67		31-40		21-25	
	41-50	1.17	31-40	4.24	26-30	4.96	26-30	1.47

Note: two highest count groups
small - large

Source: Fishery Statistics of the United States
Shrimp Landings, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

between July and November. Most of the production on the east coast of Florida has occurred between September and December (Table 5.4).

The change in seasonal distribution of catches in the Carolinas and Georgia appears to be due to increased exploitation of pink and brown shrimp.

5.6 History of Landings by State

5.6.1 North Carolina

North Carolina did not contribute greatly to the catch until 1934. Landings increased until 1940 and over 10 million pounds were taken in 1945. Unfortunately, the lack of catch data for the rest of the 1940's makes it impossible to document catch for that period. This is particularly unfortunate because the abundance of white shrimp in North Carolina prior to 1940 appears to have been much greater than that reported for the interval from 1957-1973, the only period in which landings have been identified by species.

The apparent change in abundance of white shrimp in North Carolina is interesting because it suggests that competition may exist between brown and white shrimp in this area (William Anderson, personal communication). Anderson's hypothesis is supported by the fact that a severe cold spell in the 1939-40 winter decimated the white shrimp in North Carolina. However, landings of shrimp in North Carolina during 1940 were almost normal but the catch consisted of "brownies" instead of white shrimp (Lindner and Anderson, 1956).

Shrimp catches peaked in North Carolina between 1950 and 1955. Apparently, the bulk of the landings during this period were brown and pink

Table 5.4 Percent of mean annual landings (heads off) by month by state, 1957-1973.

month	North Carolina	South Carolina	Georgia	Florida (East Coast)
January	0.01	0.20	1.51	7.63
February	-	-	0.32	2.08
March	-	0.03	0.40	1.33
April	0.03	0.05	0.51	0.83
May	3.30	1.14	1.73	1.61
June	10.03	7.05	5.84	4.16
July	25.73	19.38	11.92	7.77
August	26.97	16.37	12.01	7.80
September	16.60	18.91	22.11	11.31
October	11.46	19.60	19.36	15.27
November	5.35	11.99	14.11	22.12
December	0.47	5.21	10.11	18.02

Source: Fishery Statistics of the United States.

Shrimp Landings, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

shrimp, although this is not known with certainty. Since 1956, landings have stabilized at a slightly lower level, with brown and pink shrimp predominating. With the exception of the past two seasons, white shrimp have been particularly scarce. White shrimp presently appear to be increasing in abundance in the southern and central districts in North Carolina, although the level of abundance is still much lower than that prior to 1940 (Walter Godwin and Connell Purvis, personal communication).

Finally, annual landings of shrimp in North Carolina have varied significantly, especially whites. The heads-off catches for the 1957-1972 period range from 0-1,020,220 pounds, 601,419-3,656,663 pounds and 330,870-1,402,714 pounds for white, brown, and pink shrimp, respectively.

5.6.2 South Carolina

Data in Table 5.1 suggest that white shrimp were not exploited extensively in South Carolina until 1938. This is supported by Anderson, et al. (1949), who reported that the low price of shrimp during depression years provided little incentive for fishermen. Landings of shrimp prior to 1940 do not appear to represent true abundance during that period. The lack of catch statistics for most of the 1940's makes it impossible to document the abundance of shrimp for that period. Since 1957, shrimp landings have been identified by species and these data show that annual landings of heads-off white shrimp have varied from 183,675 pounds in 1963 to 5,194,397 pounds in 1971. Similarly, brown shrimp landings have varied from 526,869 pounds in 1961 to 2,243,892 pounds in 1962.

These data suggest: (1) whereas the abundance of white shrimp was relatively low between 1963 and 1966 (1965 excepted), their abundance

since 1968 has been quite high, especially since 1971; (2) while the bulk of brown shrimp landings occur in July and August, substantial landings of browns have occurred in September and October, particularly in those years when the abundance of white shrimp has been well below normal; (3) because of economic factors and inadequate catch statistics, it is not possible to determine if the abundance of white shrimp declined sometime between 1940-1957.

5.6.3 Georgia

Catches in Georgia increased rapidly after 1918 and remained quite high through 1930. Landings were depressed during the 1931 to 1934 period because dealers limited the amount of shrimp that a vessel could unload (William Anderson, personal communication). Landings were quite high from 1936-1940 and apparently a record catch was produced in 1945. Again, data are missing for most of the 1940's.

Since 1957, the catch of heads-off white shrimp has varied from 2,269,950 pounds in 1963 to 5,068,825 pounds in 1968. Similarly, landings of heads-off brown shrimp varied from 377,737 pounds in 1973 to 2,110,880 pounds in 1958.

These data suggest that: (1) like North Carolina, a significant decline in abundance of white shrimp occurred sometime between 1940 and 1957; (2) as with South Carolina, there has been an increase in abundance of white shrimp from the early 1960's to the present time; (3) although landings of brown shrimp have declined in both South Carolina and Georgia since 1967, the decline in Georgia may be more severe.

5.6.4 East Coast of Florida

The otter trawl fishery began here and the area produced a major share

Table 5.5 Operating unit data 1950-1971.

South Atlantic Region

otter trawls

year	total fishermen	vessels (1) + motor boats (2)	gross tonnage	yards at mouth
		(1) (2)		
1950	3,783	944 + 847 = 1,791	9,429 1/	36,302
1951	3,997	1,154 + 749 = 1,903	11,995 1/	39,388
1952	3,768	1,041 + 738 = 1,779	11,626 1/	35,416
1953	4,100	1,085 + 837 = 1,922	12,331 1/	38,230
1954	3,631	970 + 766 = 1,736	12,061 1/	34,437
1955	3,591	1,128 + 675 = 1,803	14,390 1/	35,976
1956	4,146	1,321 + 758 = 2,079	18,690 1/	41,244
1957	4,506	1,438 + 835 = 2,273	20,458 1/	44,723
1958	4,507	1,415 + 833 = 2,248	21,107 1/	45,114
1959	4,461	1,385 + 888 = 2,273	20,751 1/	46,537
1960	4,329	1,400 + 814 = 2,214	40,354	46,852
1961	4,201	1,394 + 747 = 2,141	40,308	45,361
1962	4,216	1,330 + 863 = 2,193	38,968	45,795
1963	3,983	1,317 + 736 = 2,053	38,277	45,937
1964	3,644	1,194 + 641 = 1,835	34,856	41,666
1965	3,559	1,191 + 691 = 1,882	35,864	43,451
1966	3,531	1,107 + 910 = 2,017	35,983	43,975
1967	3,426	1,144 + 755 = 1,899	38,180	43,368
1968	3,510	1,079 + 746 = 1,825	44,617	46,218
1969	5,993	1,151 + 747 = 1,898	49,564	47,751
1970	3,498	1,193 + 727 = 1,933	47,615	46,664
1971	4,210	1,446 + 825 = 2,271	61,334	56,804

(continued on next page)

Table 5.5 (continued)

North Carolina

otter trawls

year	total fishermen	vessels (1) + motor boats (2)			gross tonnage	yards at mouth
		(1)	(2)			
1950	2,201	402	+ 677	= 1,079	3,115 1/	21,611
1951	1,942	401	+ 544	= 945	3,285 1/	19,619
1952	1,938	383	+ 573	= 956	3,352 1/	18,159
1953	2,136	395	+ 666	= 1,061	3,655 1/	20,152
1954	1,963	397	+ 575	= 972	3,966 1/	18,551
1955	1,766	389	+ 521	= 910	4,241 1/	17,637
1956	1,824	389	+ 556	= 945	4,669 1/	17,355
1957	1,817	399	+ 561	= 960	4,948 1/	17,428
1958	1,380	325	+ 405	= 730	4,184 1/	13,286
1959	1,509	362	+ 426	= 788	4,898 1/	15,282
1960	1,575	389	+ 427	= 816	8,533	15,782
1961	1,407	407	+ 321	= 728	8,686	14,501
1962	1,410	371	+ 379	= 750	8,343	14,642
1963	1,349	383	+ 319	= 702	8,181	13,951
1964	1,361	371	+ 349	= 720	7,832	14,111
1965	1,314	370	+ 356	= 726	8,112	14,529
1966	1,313	301	+ 564	= 865	7,136	14,561
1967	1,241	305	+ 460	= 765	7,549	13,524
1968	1,126	277	+ 402	= 679	7,313	12,583
1969	1,171	266	+ 462	= 728	7,876	12,360
1970	1,326	360	+ 430	= 790	10,794	15,155
1971	1,500	407	+ 477	= 884	12,701	17,238
total	34,469	8,714	+ 10,423	= 19,137	143,369	352,017

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Table 5.5 (continued)

South Carolina

otter trawls

year	total fishermen	vessels (1) + motor boats (2)	gross tonnage	yards at mouth
		(1) (2)		
1950	453	164 + 61 = 225	1,690 1/	4,498
1951	977	364 + 117 = 481	3,937 1/	9,902
1952	694	251 + 94 = 345	2,525 1/	7,029
1953	718	253 + 104 = 357	2,695 1/	7,137
1954	575	148 + 139 = 287	1,489 1/	5,683
1955	730	295 + 68 = 363	3,648 1/	7,283
1956	826	310 + 90 = 400	4,159 1/	7,818
1957	989	380 + 97 = 477	5,445 1/	9,746
1958	951	316 + 149 = 465	4,406 1/	9,975
1959	812	264 + 167 = 431	3,433 1/	9,352
1960	819	273 + 167 = 440	7,368	9,941
1961	702	224 + 133 = 357	5,972	8,711
1962	740	242 + 141 = 383	6,229	9,708
1963	665	221 + 106 = 327	5,762	9,361
1964	503	183 + 63 = 246	4,677	7,319
1965	489	203 + 36 = 239	5,318	7,751
1966	442	187 + 29 = 216	5,018	7,770
1967	476	217 + 16 = 233	6,218	8,064
1968	633	280 + 23 = 303	8,514	10,297
1969	718	316 + 30 = 346	10,967	11,500
1970	642	288 + 26 = 314	10,697	10,657
1971	874	372 + 54 = 426	15,436	13,759
total	15,428	5,751 + 1,910 = 7,661	125,603	193,267

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Table 5.5 (continued)

Georgia

otter trawls

year	total fishermen	vessels (1) + motor boats (2)	gross tonnage	yards at mouth
		(1) (2)		
1950	613	220 + 84 = 304	2,392 1/	6,155
1951	660	268 + 55 = 323	3,151 1/	6,603
1952	563	229 + 48 = 277	2,797 1/	5,673
1953	502	204 + 45 = 249	2,469 1/	4,942
1954	506	204 + 49 = 253	3,006 1/	4,802
1955	587	216 + 70 = 286	2,748 1/	5,286
1956	713	290 + 77 = 367	4,129 1/	7,230
1957	793	284 + 143 = 427	3,596 1/	7,621
1958	1,096	346 + 234 = 580	4,575 1/	10,148
1959	1,106	328 + 266 = 594	4,618 1/	10,134
1960	953	307 + 195 = 502	8,433	8,969
1961	1,092	312 + 270 = 582	9,027	9,587
1962	1,177	324 + 308 = 632	9,421	10,045
1963	1,156	363 + 264 = 627	10,523	12,343
1964	1,104	333 + 213 = 546	10,343	11,048
1965	1,095	325 + 282 = 607	10,570	12,419
1966	1,079	314 + 296 = 610	10,430	12,346
1967	1,076	332 + 270 = 602	11,812	13,024
1968	1,139	347 + 303 = 650	14,286	14,567
1969	1,219	388 + 300 = 688	17,196	16,196
1970	1,003	307 + 267 = 574	12,744	13,154
1971	1,277	416 + 283 = 699	18,840	17,386
total	20,509	6,657 + 4,322 = 10,979	177,106	219,678

(continued on next page)

Table 5.5 (continued)

Florida (East Coast)

otter trawls

year	total fishermen	vessels (1) + motor boats (2)	gross tonnage	yards at mouth
		(1) (2)		
1950	516	158 + 25 = 183	2,232 1/	4,038
1951	418	121 + 33 = 154	1,622 1/	3,264
1952	573	178 + 23 = 201	2,952 1/	4,555
1953	744	233 + 22 = 255	3,512 1/	5,999
1954	587	221 + 3 = 224	3,600 1/	5,401
1955	508	228 + 16 = 244	3,753 1/	5,770
1956	783	332 + 35 = 367	5,733 1/	8,841
1957	907	375 + 34 = 409	6,469 1/	9,928
1958	1,080	428 + 45 = 473	7,942 1/	11,705
1959	1,034	431 + 29 = 460	7,802 1/	11,769
1960	982	431 + 25 = 456	16,020	12,160
1961	1,000	442 + 23 = 465	16,623	12,562
1962	889	393 + 35 = 328	14,975	11,400
1963	813	356 + 47 = 397	13,811	10,282
1964	676	307 + 16 = 323	12,004	9,188
1965	661	293 + 17 = 310	11,864	8,746
1966	697	305 + 21 = 326	13,399	9,298
1967	633	290 + 9 = 299	13,201	8,756
1968	612	275 + 18 = 293	14,504	8,771
1969	543	241 + 14 = 255	13,525	7,695
1970	527	238 + 4 = 242	13,380	7,698
1971	559	251 + 11 = 262	14,357	8,421
total	14,656	6,032 + 490 = 6,522	185,543	170,128

1/ net tonnage

Source: Fishery Statistics of the United States.

of the southeastern Atlantic shrimp landings from 1903 to 1937. However, landings declined steadily from 1936 to 1940 and again more gradually from 1950 to the present. Once again, there appears to have been a significant drop in landings of white shrimp between 1940-1957. Part of the decline in landings on the east coast of Florida must be attributed to the development of large fisheries for shrimp in Georgia and South Carolina. However, some of the decline must also be due to the general decline of white shrimp previously discussed.

Landings from this fishery at present appear to be relatively stable.

5.7 Operating Unit Data

Table 5.5 shows the number of fishermen, number of vessels and motor boats combined, gross tonnage of vessels, and quantity of otter trawl gear used in the southeastern Atlantic fishery since 1950. Data for earlier years are lacking. In general, the total number of fishermen and number of vessels and motor boats combined have remained about the same. However, the gross tonnage and yards of shrimp net have increased considerably over this period. This suggests that newer, more efficient vessels have replaced older, smaller vessels. This is supported by a report by Osterbind and Pantier (1965), which concluded that while the number of vessels increased by one-third from 1950 to 1959 in the entire shrimp fishery, the total tonnage capacity of the vessels in use more than doubled.

Table 5.6 shows three crude indices of mean annual catch per operating unit. These data clearly indicate that each index declined significantly between the 1927-1940 and 1950-1970 periods. Part of the decline appears to be a direct result of the change in abundance of white shrimp between

Table 5.6 Crude annual indices of catch per unit effort by state, 1927-1971.

North Carolina

year	catch per vessels and motor boats combined	catch per fishermen	catch per 100 yards otter trawl
1927	19,934	9,967	120,362
1928	20,127	9,606	118,231
1929	17,259	8,547	110,939
1930	24,973	12,486	143,019
1931	8,673	4,281	46,530
1932	5,727	2,808	29,007
1934	19,722	9,602	97,339
1936	17,045	7,615	94,353
1937	21,342	9,674	127,518
1938	26,947	12,111	156,930
1939	33,802	15,626	191,333
1940	19,683	9,208	121,938
1945	20,369	9,844	113,428
1950	7,315	3,586	36,525
1951	8,304	4,100	40,594
1952	8,812	4,347	46,396
1953	13,324	6,618	70,152
1954	9,054	4,483	47,444
1955	11,097	5,718	57,258
1956	6,527	3,381	35,541
1957	8,003	4,228	44,085
1958	3,038	1,607	16,695
1959	7,935	4,143	40,916
1960	7,216	3,738	37,310
1961	4,074	2,108	20,454
1962	7,639	4,063	39,132
1963	4,628	2,408	23,288
1964	5,651	2,989	28,836
1965	7,081	3,912	35,386
1966	5,856	3,858	34,793
1967	6,020	3,711	34,055
1968	6,310	3,805	34,050
1969	10,232	6,361	60,269
1970	6,225	3,708	32,451
1971	8,614	5,076	44,174

(continued on next page)

Table 5.6 (continued)

South Carolina

year	catch per vessels and motor boats combined	catch per fishermen	catch per 100 yards otter trawl
1927	59,183	29,591	309,165
1928	47,937	23,968	95,241
1929	11,987	4,426	59,691
1930	22,020	10,295	117,442
1931	43,922	21,082	209,154
1932	53,595 1/	25,435 1/	267,980 1/
1934	40,940	19,580	178,533
1936	36,242	15,856	170,268
1937	29,530	12,940	144,868
1938	91,297	38,040	448,636
1939	57,415	23,700	239,653
1940	32,814	12,391	146,567
1945	24,174	11,383	103,075
1950	34,428	17,100	172,219
1951	7,755	3,818	37,674
1952	11,803	5,867	57,936
1953	14,245	7,083	71,257
1954	23,149	11,554	116,907
1955	19,034	9,465	94,872
1956	13,831	6,697	70,766
1957	13,845	6,677	67,764
1958	12,355	6,041	57,596
1959	17,162	9,109	79,096
1960	17,967	9,652	79,525
1961	10,880	5,533	44,592
1962	16,804	8,697	66,297
1963	6,725	3,306	23,492
1964	10,556	5,162	35,482
1965	27,994	13,682	86,254
1966	19,406	9,483	53,949
1967	17,176	8,407	49,630
1968	20,622	9,871	60,683
1969	16,812	8,101	50,583
1970	15,767	7,711	46,457
1971	25,240	12,302	78,150

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Table 5.6 (continued)

Georgia

year	catch per vessels and motor boats combined	catch per fishermen	catch per 100 yards otter trawl
1927	65,318	32,659	326,595
1928	40,025	19,322	72,304
1929	74,117	35,877	349,059
1930	44,710	25,365	234,571
1931	34,194 1/	16,578 1/	165,790 1/
1932	28,812 1/	14,406 1/	143,489 1/
1934	45,925	22,885	210,680
1936	54,885	25,837	251,679
1937	38,791	18,819	202,815
1938	45,527	21,765	223,872
1939	50,712	23,229	212,760
1940	46,445	19,530	202,111
1945	60,265	27,830	237,567
1950	36,699	18,200	181,262
1951	23,554	11,527	115,220
1952	21,628	10,641	105,605
1953	30,261	15,010	152,473
1954	30,598	15,299	161,210
1955	25,038	12,199	135,469
1956	21,773	11,207	110,523
1957	20,580	11,081	115,313
1958	15,072	7,976	86,147
1959	12,790	6,869	74,970
1960	20,710	10,909	115,916
1961	11,695	6,233	70,998
1962	13,614	7,310	85,660
1963	8,681	4,708	44,099
1964	10,876	5,379	53,752
1965	14,143	7,840	69,130
1966	10,616	6,001	52,453
1967	11,058	6,186	51,115
1968	13,131	7,493	58,595
1969	12,277	6,929	52,155
1970	10,446	5,978	45,584
1971	12,678	6,940	50,974

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Table 5.6 (continued)

Florida (East Coast)

year	catch per vessels and motor boats combined	catch per fishermen	catch per 100 yards otter trawl
1927	37,817 2/	15,060 2/	182,279 2/
1928	53,441 2/	26,442 2/	315,412 2/
1929	48,235 2/	20,282 2/	249,545 2/
1930	51,525 2/	22,053 2/	296,161 2/
1931	49,224 2/	19,866 2/	264,750 2/
1932	48,235 2/	19,930 2/	254,188 2/
1934	61,713 2/	29,303 2/	306,014 2/
1936	63,491 2/	27,331 2/	313,121 2/
1937	43,267 2/	19,243 2/	223,250 2/
1938	31,161 2/	14,726 2/	162,317 2/
1939	38,032 2/	15,130 2/	192,160 2/
1940	36,510 2/	15,376 2/	206,059 2/
1945	(3)	(3)	(3)
1950	50,599	17,945	229,314
1951	51,824	19,093	244,516
1952	33,807	11,859	149,186
1953	22,225	7,617	94,474
1954	22,666	8,649	94,007
1955	16,942	8,137	71,646
1956	15,517	7,273	64,416
1957	12,662	5,729	52,166
1958	11,612	5,085	46,925
1959	9,790	4,355	38,268
1960	14,857	6,899	55,714
1961	12,918	6,007	47,820
1962	12,068	5,810	45,310
1963	11,305	5,520	43,651
1964	13,857	6,621	48,715
1965	17,402	8,161	61,683
1966	15,458	7,230	54,198
1967	16,502	7,794	56,352
1968	16,381	7,842	54,724
1969	20,345	9,554	67,421
1970	19,043	8,744	59,866
1971 4/	15,153	7,102	47,146

note: includes operating units for the inland lakes of Florida.

1/ finfish included.
2/ data for entire state of Florida.
3/ data not available.
4/ preliminary

Source: Fishery Statistics of the United States.

the two periods. The average catch per operating unit indices from 1955-1970 have remained rather stable, apparently fluctuating in response to variations in annual landings. In essence, these data suggest - as do the annual landings - that since 1955 the total abundance of shrimp has remained reasonably stable, although pronounced fluctuations do occur from year to year.

Unfortunately, the lack of effort data precludes a more detailed analysis of those changes that have occurred during the prosecution of the fishery.

5.8 Apparent Trends in Total Catch

Shrimp landings fluctuate markedly from year to year, and one must proceed with caution when attempting to describe trends in catches. Catches tend to vary in the same direction from state to state, suggesting that regional climatic conditions may have a profound effect upon the abundance of shrimp. In addition, catch statistics, particularly those prior to 1957, are only approximate. However, three trends appear to be real. They are: (1) the decline in white shrimp landings between the 1927-1940 and 1950-1972 periods; (2) the change in distribution of landings among states, particularly the shift in landings between Florida and the other states; (3) commercial landings have been relatively stable since 1955 in the southeastern Atlantic region.

The stability of the total landings of the southeastern Atlantic shrimp fishery since 1955 is reflected in Table 5.1. Landings during this period have averaged 24,329,000 pounds, having been less than 20 million pounds on only three occasions and more than 30 million pounds on two occasions. The major cause of the annual fluctuations appears to be changes in abundance of white shrimp (Anderson, 1970). As noted by Anderson, the

abundance of white shrimp appeared to decline in the early 1960's. However, landings of shrimp have increased in recent years, and it is possible that if the magnitude of the bait and recreational fisheries were known, the total catch of shrimp may be comparable to that experienced in the 1953-57 period.

5.9 Recreational Shrimping

Recreational shrimping is a popular activity along the coast of the southeastern United States. Shrimp caught in this fishery are used not only for personal consumption but also as bait for fin fish. The major types of gear employed include seines, cast nets, drop nets, trawls, push nets and dip nets (see Section 3.2).

In order to formulate a meaningful management profile, it is necessary to know the magnitude of the total harvest of a species. Unfortunately, no historical data are available on the recreational catch of shrimp for the south Atlantic region. However, recent studies have provided an estimate of the magnitude of this fishery for North Carolina, South Carolina and northeastern Florida (Nassau and Duval counties). A projected total of 233,906 angler days produced an estimated annual catch of 1,470,930 pounds of shrimp (heads-on) by recreational shrimpers in these three areas during 1973 (Table 5.7). The average catch per trip ranged from 4.56 pounds to 9.81 pounds ($\bar{x}$ = 6.29 pounds) and the percentage of the recreational catch from these areas as compared with their commercial landings ranged from six to ten percent.

An obvious need is a more comprehensive catch and effort sampling scheme for the southeastern states so that the recreational impact on the total shrimp fishery can be determined on an annual basis.

Table 5.7 Estimated number of angler days, landings and average catch per trip on an annual basis for the recreational shrimp fisheries of northeast Florida, South Carolina, and North Carolina.

	northeast Florida[1]	South Carolina	North Carolina	Total
Estimated annual angler days	24,672	155,597	53,637	233,906
Estimated annual total pounds	112,450	832,227	526,253	1,470,930
Average catch per trip	4.56	5.35	9.81	6.29
Percent of 1973 commercial catch for geographic region	6.0	10.1	10.5	9.7

[1] Nassau and Duval counties

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Appendix 5.1 Annual catch (heads off) by species and size for South Atlantic region, 1957-1973.

year 1957	brown	pink	white	royal red
15-20	497,716	1,158	179,910	2,600
21-25	186,943	2,838	1,076,148	11,188
26-30	723,182	5,898	1,813,043	6,668
31-40	2,025,545	264,227	3,150,882	4,207
41-50	1,015,088	409,769	1,897,617	9,705
51-67	893,305	478,233	1,032,794	4,147
68 & over	708,012	186,154	403,152	-

year 1958	brown	pink	white	royal red
15-20	20,985	7,318	94,324	-
21-25	305,676	22,404	958,349	-
26-30	887,900	25,567	1,502,895	-
31-40	2,125,987	34,789	2,436,598	-
41-50	1,289,657	150,558	1,082,375	-
51-67	795,919	153,171	637,704	-
68 & over	281,704	120,860	490,932	-

year 1959	brown	pink	white	royal red
15-20	441,921	16,342	224,558	2,000
21-25	504,775	50,470	1,836,939	-
26-30	992,324	111,532	1,707,979	-
31-40	2,295,950	346,642	2,053,764	1,600
41-50	1,012,547	209,634	1,003,881	-
51-67	470,143	303,492	813,305	400
68 & over	142,472	250,473	686,338	-

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Appendix 5.1 (continued)

year

1960	brown	pink	white	royal red
15-20	327,711	9,356	45,276	-
21-25	637,757	32,764	2,115,744	-
26-30	1,527,481	47,607	2,962,534	-
31-40	1,809,779	138,294	3,430,499	-
41-50	864,539	191,515	1,593,611	-
51-67	354,816	209,767	1,004,950	-
68 & over	91,728	137,257	1,047,306	-

year

1961	brown	pink	white	royal red
15-20	74,404	47,016	321,790	-
21-25	118,935	27,465	1,827,830	-
26-30	479,484	56,990	2,218,356	-
31-40	484,818	231,061	2,384,959	-
41-50	233,039	299,560	1,157,491	-
51-67	124,585	272,055	682,615	-
68 & over	34,806	158,242	519,542	-

year

1962	brown	pink	white	royal red
under 15			487	-
15-20	145,713	50,105	66,307	-
21-25	651,342	177,535	767,604	27,809
26-30	1,133,216	133,206	1,718,370	51,239
31-40	2,575,242	195,035	2,170,495	7,219
41-50	1,499,955	316,241	1,526,077	2,263
51-67	881,351	332,845	1,160,470	1,135
68 & over	276,345	199,102	469,307	1,421

(continued on next page)

Appendix 5.1 (continued)

year 1963	brown	pink	white	royal red
15-20	306,622	50,672	206,667	3,629
21-25	377,985	27,717	842,402	19,781
26-30	820,308	40,282	954,740	1,161
31-40	1,917,212	66,507	1,350,048	460
41-50	992,401	90,320	805,466	5,105
51-67	274,511	44,180	427,125	2,606
68 & over	60,210	26,784	133,634	-

year 1964	brown	pink	white	royal red
15-20	246,902	61,066	165,744	3,108
21-25	530,812	91,692	1,167,714	33,884
26-30	1,241,223	129,123	1,175,366	1,227
31-40	1,786,915	388,744	1,302,211	-
41-50	375,789	246,411	711,420	36,843
51-67	194,768	274,596	580,161	24,091
68 & Over	27,079	25,898	169,603	-

year 1965	brown	pink	white	royal red
under 15	11,521	-	-	-
15-20	30,252	-	277,900	-
21-25	328,565	-	1,606,409	7,066
26-30	908,628	-	1,913,896	8,450
31-40	1,881,333	69,168	3,217,013	19,880
41-50	1,318,900	862,310	2,213,564	2,766
51-67	535,756	119,130	1,176,264	2,324
68 & over	32,464	3,915	181,970	-

(continued on next page)

Appendix 5.1 (continued)

year 1966	brown	pink	white	royal red
15-20	3,878	-	72,247	-
21-25	1,163,849	215	1,248,378	30,821
26-30	1,642,546	754	1,005,264	6,891
31-40	2,337,934	1,349	1,729,921	22,669
41-50	1,245,753	175,280	920,354	30,566
51-67	744,315	153,937	615,048	8,264
68 & over	69,458	484	357,885	-

year 1967	brown	pink	white	royal red
15-20	296,021	31,335	121,844	-
21-25	353,748	-	1,250,907	24,334
26-30	673,120	-	2,240,277	5,467
31-40	2,123,356	317,044	2,049,710	11,517
41-50	1,188,527	634,920	1,028,100	16,803
51-67	320,489	4,200	354,219	19,129
68 & over	539	-	34,231	-

year 1968	brown	pink	white	royal red
under 15	538	-	-	-
15-20	198,030	15,145	140,895	-
21-25	722,076	69,385	1,660,028	17,011
26-30	1,130,602	14,457	3,246,682	1,460
31-40	1,112,285	171,288	2,976,984	8,427
41-50	305,912	359,564	1,787,007	18,585
51-67	184,818	206,367	1,118,692	-
68 & over	22,453	-	73,535	-

(continued on next page)

Appendix 5.1 (continued)

year 1969	brown	pink	white	royal red
under 15	-	-	38	-
15-20	252,217	13,946	18,149	-
21-25	904,805	48,668	988,358	25,731
26-30	880,535	46,078	2,193,340	1,544
31-40	2,149,721	220,199	3,620,761	7,059
41-50	730,122	442,516	2,133,389	17,209
51-67	373,814	289,856	1,656,858	3,985
68 & over	31,872	-	372,709	-

year 1970	brown	pink	white	royal red
15-20	236,363	1,567	79,314	-
21-25	666,313	6,781	1,885,859	32,044
26-30	1,246,645	62,096	1,867,021	100
31-40	1,515,354	155,575	2,389,544	5,205
41-50	495,604	249,356	1,133,882	29,021
51-67	222,869	62,490	590,182	1,953
68 & over	47,364	-	165,319	-

year 1971	brown	pink	white	royal red
15-20	145,634	-	168,456	3,737
21-25	1,081,833	-	1,910,951	32,665
26-30	843,425	31,837	2,004,238	-
31-40	1,997,194	190,323	3,175,224	12,664
41-50	1,218,920	324,433	2,333,347	36,796
51-67	643,512	516,064	2,107,840	1,423
68 & over	134,363	134,003	648,292	-

Appendix 5.1 (continued)

year 1972	brown	pink	white	royal red
15-20	33,218	-	86,756	-
21-25	573,860	-	814,500	6,754
26-30	804,949	3,989	2,137,568	-
31-40	1,668,898	112,135	3,037,918	4,043
41-50	966,187	192,137	1,844,488	4,611
51-67	635,669	130,842	2,161,902	-
68 & over	115,618	53,570	707,379	-

year 1973	brown	pink	white	royal red
15-20	18,938	2,942	124,126	-
21-25	226,819	2,286	1,001,546	2,900
26-30	416,562	33,655	2,369,827	-
31-40	1,073,890	153,096	2,752,830	-
41-50	506,166	365,051	2,391,491	3,006
51-67	487,939	277,328	2,464,390	-
68 & over	66,518	114,644	740,915	-

Source: Fishery Statistics of the United States.
Shrimp Landings, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

Appendix 5.2 Annual catch (heads off) by species, size, and state, 1957-1973.

year: 1957

species & size	North Carolina	South Carolina	Georgia	Florida (East Coast)
brown	quantity	quantity	quantity	quantity
15-20	497,716	-	-	-
21-25	167,269	-	-	19,674
26-30	381,277	75,550	36,300	230,055
31-40	846,603	461,774	433,130	284,038
41-50	400,342	222,603	323,534	68,609
51-67	396,438	306,112	119,130	71,625
68 & over	286,983	377,094	-	43,935
total	2,976,628	1,443,133	912,094	717,936
pink	quantity	quantity	quantity	quantity
15-20	962	-	-	196
21-25	2,838	-	-	-
26-30	5,898	-	-	-
31-40	256,927	5,700	-	1,600
41-50	400,641	-	8,150	978
51-67	470,781	-	7,331	121
68 & over	186,154	-	-	-
total	1,324,201	5,700	15,481	2,895

(continued on next page)

year: 1957

species & size	North Carolina	South Carolina	Georgia	Florida (East Coast)
white	quantity	quantity	quantity	quantity
15-20	29,844	-	17,282	132,784
21-25	78,335	5,500	95,101	897,212
26-30	17,683	216,108	723,716	855,536
31-40	178,959	861,342	1,877,176	233,405
41-50	45,687	889,739	819,373	142,818
51-67	40,061	278,773	673,404	40,556
68 & over	30,589	281,612	64,637	26,314
total	421,158	2,533,074	4,270,689	2,328,625
royal red	quantity	quantity	quantity	quantity
15-20	-	-	2,600	-
21-25	-	-	-	11,188
26-30	-	-	-	6,668
31-40	-	-	2,087	2,120
41-50	-	-	-	9,705
51-67	-	-	525	3,622
total	-	-	5,212	33,303

(continued on next page)

Appendix 5.2 (continued)

year: 1958

species & size	North Carolina	South Carolina	Georgia	Florida (East Coast)
brown	quantity	quantity	quantity	quantity
15-20	19,698	-	-	1,287
21-25	116,287	97,564	9,890	81,935
26-30	48,697	223,960	409,700	205,543
31-40	199,289	579,661	1,110,656	236,381
41-50	274,412	489,437	438,976	86,832
51-67	224,469	448,600	94,762	28,088
68 & over	59,007	161,244	46,896	14,557
total	941,859	2,000,466	2,110,880	654,623
pink	quantity	quantity	quantity	quantity
15-20	7,318	-	-	-
21-25	22,404	-	-	-
26-30	25,567	-	-	-
31-40	33,743	-	1,046	-
41-50	146,158	-	4,400	-
51-67	152,121	-	1,050	-
68 & over	120,860	-	-	-
total	508,171	-	6,496	-

(continued on next page)

Appendix 5.2 (continued)

year: 1958

species & size	North Carolina	South Carolina	Georgia	Florida (East Coast)
white	quantity	quantity	quantity	quantity
15-20	2,128	-	-	92,196
21-25	9,066	108,856	42,676	797,751
26-30	5,458	215,510	457,860	824,067
31-40	12,029	960,663	1,007,826	456,080
41-50	13,531	135,205	660,172	273,467
51-67	8,272	25,298	479,286	124,848
68 & over	475	15,500	421,798	53,159
total	50,959	1,461,032	3,069,618	2,621,568

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Appendix 5.2 (continued)

year: 1959

species & size	North Carolina	South Carolina	Georgia	Florida (East Coast)
brown	quantity	quantity	quantity	quantity
15-20	441,839	-	-	82
21-25	284,490	153,145	14,800	52,340
26-30	255,883	406,847	231,675	97,919
31-40	568,202	840,294	690,564	196,890
41-50	392,786	378,201	169,401	72,159
51-67	381,827	35,144	20,752	32,420
68 & over	110,323	-	6,012	26,137
total	2,435,350	1,813,631	1,133,204	477,947
pink	quantity	quantity	quantity	quantity
15-20	16,342	-	-	-
21-25	50,470	-	-	-
26-30	111,457	-	75	-
31-40	346,517	-	125	-
41-50	209,359	-	275	-
51-67	303,492	-	-	-
68 & over	250,473	-	-	-
total	1,288,110	-	475	-

(continued on next page)

Appendix 5.2 (continued)

year: 1959

species & size	North Carolina	South Carolina	Georgia	Florida (East Coast)
white	quantity	quantity	quantity	quantity
15-20	-	218,554	-	6,004
21-25	-	481,980	302,343	1,052,616
26-30	813	532,227	754,475	420,464
31-40	43,777	695,007	968,926	346,054
41-50	23,386	474,056	336,617	169,822
51-67	4,286	188,331	469,492	151,196
68 & over	700	69,162	555,306	61,170
total	72,962	2,659,317	3,387,159	2,207,326
royal red	quantity	quantity	quantity	quantity
15-20	-	-	2,000	-
31-40	-	-	1,600	-
51-67	-	-	400	-
total	-	-	4,000	-

(continued on next page)

Appendix 5.2 (continued)

year: 1960

species & size	North Carolina	South Carolina	Georgia	Florida (East Coast)
brown	quantity	quantity	quantity	quantity
15-20	322,539	-	4,750	422
21-25	275,854	277,515	45,275	39,113
26-30	302,512	672,563	458,000	94,406
31-40	842,557	167,200	670,250	129,772
41-50	448,011	291,400	85,705	39,423
51-67	296,066	19,012	10,350	29,388
68 & over	76,855	3,000	-	11,873
total	2,564,394	1,430,690	1,274,330	344,397
pink	quantity	quantity	quantity	quantity
15-20	9,356	-	-	-
21-25	32,764	-	-	-
26-30	47,607	-	-	-
31-40	138,294	-	-	-
41-50	191,515	-	-	-
51-67	209,767	-	-	-
68 & over	137,257	-	-	-
total	766,560	-	-	-

(continued on next page)

year: 1960

species & size	North Carolina	South Carolina	Georgia	Florida (East Coast)
white	quantity	quantity	quantity	quantity
15-20	-	-	5,300	39,976
21-25	-	293,619	321,208	1,500,917
26-30	44,255	1,132,198	919,975	866,106
31-40	99,934	1,111,780	1,577,233	641,552
41-50	43,846	647,100	581,528	321,137
51-67	45,566	147,200	538,828	273,356
68 & over	-	17,496	973,808	56,002
total	233,601	3,349,393	4,917,880	3,699,046

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Appendix 5.2 (continued)

year: 1961

species & size	North Carolina	South Carolina	Georgia	Florida (East Coast)
brown	quantity	quantity	quantity	quantity
15-20	74,404	-	-	-
21-25	46,678	19,251	44,850	8,156
26-30	77,694	155,147	222,219	24,424
31-40	184,086	193,817	79,975	26,940
41-50	117,677	107,654	772	6,936
51-67	66,355	51,000	-	7,230
68 & over	34,525	-	-	281
total	601,419	526,869	347,816	73,967
pink	quantity	quantity	quantity	quantity
15-20	47,016	-	-	-
21-25	27,465	-	-	-
26-30	56,990	-	-	-
31-40	231,061	-	-	-
41-50	299,560	-	-	-
51-67	272,055	-	-	-
68 & over	158,242	-	-	-
total	1,092,389	-	-	-

(continued on next page)

year: 1961

species & size	North Carolina	South Carolina	Georgia	Florida (East Coast)
white	quantity	quantity	quantity	quantity
15-20	-	-	1,500	320,290
21-25	-	209,357	468,549	1,149,924
26-30	6,471	571,719	857,828	782,338
31-40	72,752	684,715	871,124	756,368
41-50	20,583	263,752	590,016	283,140
51-67	1,719	69,060	433,054	178,782
68 & over	-	-	483,728	35,814
total	101,525	1,798,603	3,705,799	3,506,656

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Appendix 5.2 (continued)

year: 1962

species & size	North Carolina	South Carolina	Georgia	Florida (East Coast)
brown	quantity	quantity	quantity	quantity
15-20	145,551	-	-	162
21-25	501,131	83,483	40,542	26,186
26-30	394,282	321,233	246,098	171,603
31-40	373,318	1,029,031	761,660	411,233
41-50	283,772	589,145	478,836	148,202
51-67	371,413	163,000	227,349	119,589
68 & over	110,577	58,000	83,016	24,752
total	2,180,044	2,243,892	1,837,501	901,727
pink	quantity	quantity	quantity	quantity
15-20	50,105	-	-	-
21-25	177,535	-	-	-
26-30	133,206	-	-	-
31-40	195,035	-	-	-
41-50	316,241	-	-	-
51-67	332,845	-	-	-
68 & over	197,747	-	-	1,355
total	1,402,714	-	-	1,355

(continued on next page)

Appendix 5.2 (continued)

year: 1962

species & size	North Carolina	South Carolina	Georgia	Florida (East Coast)
white	quantity	quantity	quantity	quantity
under 15	-	-	-	487
15-20	-	-	-	66,307
21-25	2,427	31,439	401,187	332,551
26-30	1,165	229,283	785,128	702,794
31-40	6,438	796,091	757,722	610,244
41-50	20,720	546,000	580,121	379,236
51-67	1,648	234,284	636,650	287,888
68 & over	345	21,000	425,680	22,282
total	32,743	1,858,097	3,586,488	2,401,789
royal red	quantity	quantity	quantity	quantity
21-25	-	-	17,352	10,457
26-30	-	-	43,776	7,463
31-40	-	-	5,642	1,577
41-50	-	-	1,785	478
51-67	-	-	1,135	-
68 & over	-	-	1,421	-
total	-	-	71,111	19,975

(continued on next page)

Appendix 5.2 (continued)

year: 1963

species & size	North Carolina	South Carolina	Georgia	Florida (East Coast)
brown	quantity	quantity	quantity	quantity
15-20	306,355	-	-	267
21-25	213,448	32,023	60,902	71,612
26-30	226,321	169,989	253,103	170,895
31-40	513,721	577,373	609,834	216,284
41-50	383,259	300,819	216,349	91,974
51-67	89,420	101,500	34,160	49,431
68 & over	18,812	9,500	1,254	30,644
total	1.751.336	1,191,204	1,175,602	631,107
pink	quantity	quantity	quantity	quantity
15-20	50,672	-	-	-
21-25	27,717	-	-	-
26-30	40,282	-	-	-
31-40	66,507	-	-	-
41-50	90,320	-	-	-
51-67	44,180	-	-	-
68 & over	26,784	-	-	-
total	346,462	-	-	-

(continued on next page)

year: 1963

species & size	North Carolina	South Carolina	Georgia	Florida (East Coast)
white	quantity	quantity	quantity	quantity
15-20	-	-	700	205,967
21-25	-	-	73,900	768,502
26-30	-	50,236	292,529	611,975
31-40	-	100,939	855,589	393,520
41-50	-	32,500	612,182	160,784
51-67	-	-	335,788	91,337
68 & over	-	-	99,262	34,372
total	-	183,675	2,269,950	2,266,457
royal red	quantity	quantity	quantity	quantity
15-20	-	-	3,629	-
21-25	-	-	19,781	-
26-30	-	-	1,161	-
31-40	-	-	460	-
41-50	-	-	5,105	-
51-67	-	-	2,606	-
total	-	-	32,742	-

(continued on next page)

Appendix 5.2 (continued)

year: 1964

species & size	North Carolina	South Carolina	Georgia	Florida (East Coast)
brown	quantity	quantity	quantity	quantity
15-20	246,311	-	283	308
21-25	285,127	36,960	111,361	97,364
26-30	218,833	323,966	463,881	234,543
31-40	415,108	601,815	582,780	187,212
41-50	154,800	151,032	38,466	31,491
51-67	122,004	24,545	20,254	27,965
68 & over	2,759	1,000	4,460	18,860
total	1,444,942	1,139,318	1,221,485	597,743
pink	quantity	quantity	quantity	quantity
15-20	61,066	-	-	-
21-25	88,492	-	3,200	-
26-30	129,123	-	-	-
31-40	388,744	-	-	-
41-50	242,511	-	3,900	-
51-67	274,596	-	-	-
68 & over	25,898	-	-	-
total	1,210,430	-	7,100	-

(continued on next page)

Appendix 5.2 (continued)

year: 1964

species & size	North Carolina	South Carolina	Georgia	Florida (East Coast)
white	quantity	quantity	quantity	quantity
15-20	-	-	2,095	163,649
21-25	2,562	45,806	184,921	934,425
26-30	3,587	133,598	474,554	563,627
31-40	4,099	176,466	849,708	271,938
41-50	-	102,089	493,943	115,388
51-67	-	58,052	453,539	68,570
68 & over	-	-	82,512	87,091
total	10,248	516,011	2,541,272	2,204,688
royal red	quantity	quantity	quantity	quantity
15-20	-	-	-	3,108
21-25	-	-	12,594	21,290
26-30	-	-	-	1,227
41-50	-	-	574	36,269
51-67	-	-	12,276	11,815
total	-	-	25,444	73,709

(continued on next page)

Appendix 5.2 (continued)

year: 1965

species & size	North Carolina	South Carolina	Georgia	Florida (East Coast)
brown	quantity	quantity	quantity	quantity
under 15	-	-	10,020	1,501
15-20	-	-	10,737	19,515
21-25	5,976	198,006	38,099	86,484
26-30	263,838	349,263	175,714	119,813
31-40	731,083	402,761	586,188	161,301
41-50	636,531	367,759	244,898	69,712
51-67	137,452	236,639	114,806	46,859
68 & over	-	-	22,917	9,547
total	1,774,880	1,554,428	1,203,379	514,732
pink	quantity	quantity	quantity	quantity
31-40	69,168	-	-	-
41-50	862,310	-	-	-
51-67	119,130	-	-	-
68 & over	3,915	-	-	-
total	1,054,523	-	-	-

(continued on next page)

year: 1965

species & size	North Carolina	South Carolina	Georgia	Florida (East Coast)
white	quantity	quantity	quantity	quantity
15-20	-	-	12,386	265,514
21-25	-	125,328	296,331	1,184,750
26-30	44,273	473,429	818,072	578,122
31-40	282,923	1,109,243	1,396,370	428,477
41-50	186,660	874,355	972,032	180,517
51-67	51,988	204,668	674,660	244,948
68 & over	-	-	145,871	36,099
total	565,844	2,787,023	4,315,722	2,918,427
royal red	quantity	quantity	quantity	quantity
21-25	-	-	-	7,066
26-30	-	-	-	8,450
31-40	-	-	616	19,264
41-50	-	-	-	2,766
51-67	-	-	48	2,276
total	-	-	664	39,822

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Appendix 5.2 (continued)

year: 1966

species & size	North Carolina	South Carolina	Georgia	Florida (East Coast)
brown	quantity	quantity	quantity	quantity
15-20	338	-	3,414	126
21-25	874,947	190,967	55,204	42,731
26-30	393,533	835,202	301,387	112,424
31-40	289,646	829,091	856,935	362,262
41-50	785,260	244,575	117,350	98,568
51-67	605,423	51,400	30,706	56,786
68 & over	6,299	-	12,791	50,368
total	2,955,446	2,151,235	1,377,787	723,265
pink	quantity	quantity	quantity	quantity
21-25	-	-	215	-
26-30	549	-	205	-
31-40	1,249	-	100	-
41-50	174,859	-	421	-
51-67	153,729	-	208	-
68 & over	484	-	-	-
total	330,870	-	1,149	-

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Appendix 5.2 (continued)

year: 1966

species & size	North Carolina	South Carolina	Georgia	Florida (East Coast)
white	quantity	quantity	quantity	quantity
15-20	-	-	6,853	65,394
21-25	-	4,485	173,455	1,070,438
26-30	4,527	41,255	521,476	438,006
31-40	128,217	184,943	1,015,690	401,071
41-50	86,580	104,652	531,573	197,549
51-67	41,040	23,130	410,817	140,061
68 & over	5,633	160,958	103,596	87,698
total	265,997	519,423	2,763,460	2,400,217
royal red	quantity	quantity	quantity	quantity
21-25	-	-	-	30,821
26-30	-	-	-	6,891
31-40	-	-	-	22,669
41-50	-	-	-	30,566
51-67	-	-	-	8,264
total	-	-	-	99,211

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Appendix 5.2 (continued)

year: 1967

species & size	North Carolina	South Carolina	Georgia	Florida (East Coast)
brown	quantity	quantity	quantity	quantity
15-20	293,866	-	893	1,262
21-25	296,820	2,700	39,292	14,936
26-30	77,427	342,559	196,754	56,380
31-40	446,468	763,320	694,829	218,739
41-50	634,344	326,616	165,152	62,415
51-67	202,991	28,182	29,462	59,854
68 & over	-	-	-	539
total	1,951,916	1,463,377	1,126,382	414,125
pink	quantity	quantity	quantity	quantity
15-20	30,925	-	-	410
31-40	316,929	-	-	115
41-50	634,920	-	-	-
51-67	4,200	-	-	-
total	986,974	-	-	525

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Appendix 5.2 (continued)

year: 1967

species & size	North Carolina	South Carolina	Georgia	Florida (East Coast)
white	quantity	quantity	quantity	quantity
15-20	-	-	6,258	115,586
21-25	4,000	42,341	333,156	871,410
26-30	2,500	497,318	968,349	772,110
31-40	34,628	163,380	1,234,903	616,799
41-50	65,367	339,092	406,364	217,277
51-67	21,482	82,622	174,549	75,566
68 & over	-	-	9,403	24,828
total	127,977	1,124,753	3,132,982	2,693,576
royal red	quantity	quantity	quantity	quantity
21-25	-	-	800	23,534
26-30	-	-	3,837	1,630
31-40	-	-	1,891	9,626
41-50	-	-	639	16,164
51-67	-	-	3,277	15,852
total	-	-	10,444	66,806

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Appendix 5.2 (continued)

year: 1968

species & size	North Carolina	South Carolina	Georgia	Florida (East Coast)
brown	quantity	quantity	quantity	quantity
under 15	-	-	-	538
15-20	174,947	-	-	23,083
21-25	592,925	30,343	61,750	37,058
26-30	338,098	474,343	200,374	117,787
31-40	568,113	288,398	178,438	77,336
41-50	183,149	85,487	10,838	26,438
51-67	100,750	75,522	1,112	7,434
68 & over	6,000	9,000	552	6,901
total	1,963,982	963,093	453,064	296,575
pink	quantity	quantity	quantity	quantity
15-20	15,145	-	-	-
21-25	66,128	-	-	3,257
26-30	13,405	-	-	1,052
31-40	171,288	-	-	-
41-50	359,372	-	-	192
51-60	202,567	3,800	-	-
total	827,905	3,800	-	4,501

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Appendix 5.2 (continued)

year: 1968

species & size	North Carolina	South Carolina	Georgia	Florida (East Coast)
white	quantity	quantity	quantity	quantity
15-20	-	-	1,815	139,080
21-25	-	299,686	354,287	1,006,055
26-30	6,500	1,193,920	1,233,526	812,736
31-40	45,067	585,175	1,967,050	379,692
41-50	32,242	326,579	1,084,580	343,606
51-67	-	648,876	406,662	63,154
68 & over	-	47,766	20,905	4,864
total	83,809	3,102,002	5,068,825	2,749,187
royal red	quantity	quantity	quantity	quantity
21-25	-	-	-	17,011
26-30	-	-	-	1,460
31-40	-	-	-	8,427
41-50	-	-	-	18,585
total	-	-	-	45,483

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Appendix 5.2 (continued)

year: 1969

species & size	North Carolina	South Carolina	Georgia	Florida (East Coast)
brown	quantity	quantity	quantity	quantity
15-20	251,027	-	-	1,190
21-25	848,737	10,668	30,914	14,486
26-30	486,514	146,643	189,744	57,634
31-40	1,404,524	342,745	276,178	126,274
41-50	452,848	188,903	46,405	41,966
51-67	194,861	75,763	14,193	88,997
68 & over	18,152	504	2,020	11,196
total	3,656,663	765,226	559,454	341,743
pink	quantity	quantity	quantity	quantity
15-20	13,946	-	-	-
21-25	48,668	-	-	-
26-30	46,078	-	-	-
31-40	220,199	-	-	-
41-50	441,880	-	-	636
51-67	289,856	-	-	-
total	1,060,627	-	-	636

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year: 1969

species & size	North Carolina	South Carolina	Georgia	Florida (East Coast)
white	quantity	quantity	quantity	quantity
under 15	-	-	-	38
15-20	-	-	106	18,043
21-25	-	120,870	242,964	624,524
26-30	8,661	713,425	751,314	719,940
31-40	87,386	1,013,761	1,474,385	1,045,229
41-50	56,250	542,582	1,149,117	385,440
51-67	23,019	438,862	1,080,014	114,963
68 & over	-	147,773	202,379	22,557
total	175,316	2,977,273	4,900,279	2,930,734
royal red	quantity	quantity	quantity	quantity
21-25	-	-	-	25,731
26-30	-	-	-	1,544
31-40	-	-	-	7,059
41-50	-	-	-	17,209
51-67	-	-	-	3,985
total	-	-	-	55,528

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Appendix 5.2 (continued)

year: 1970

species & size	North Carolina	South Carolina	Georgia	Florida (East Coast)
brown	quantity	quantity	quantity	quantity
15-20	205,362	318	1,548	29,135
21-25	402,498	108,975	104,266	50,574
26-30	411,329	453,952	306,736	74,628
31-40	761,439	492,959	209,213	51,743
41-50	356,557	103,933	10,509	24,605
51-67	199,550	283	1,530	21,506
68 & over	43,241	-	-	4,123
total	2,379,976	1,160,420	633,802	256,314
pink	quantity	quantity	quantity	quantity
15-20	-	-	-	1,567
21-25	6,781	-	-	-
26-30	62,096	-	-	-
31-40	153,872	-	415	1,288
41-50	248,996	-	360	-
51-67	62,490	-	-	-
total	534,235	-	775	2,855

(continued on next page)

year: 1970

species & size	North Carolina	South Carolina	Georgia	Florida (East Coast)
white	quantity	quantity	quantity	quantity
15-20	-	288	9,180	69,846
21-25	-	419,116	541,802	924,941
26-30	29,356	604,426	717,666	515,573
31-40	97,566	668,819	1,073,601	549,558
41-50	71,214	239,264	515,328	308,076
51-67	40,708	62,120	316,922	170,432
68 & over	-	7,697	55,668	101,954
total	238,844	2,001,730	3,230,167	2,640,380
royal red	quantity	quantity	quantity	quantity
21-25	-	-	-	32,044
26-30	-	-	-	100
31-40	-	-	-	5,205
41-50	-	-	-	29,021
51-67	-	-	-	1,953
total	-	-	-	68,323

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Appendix 5.2 (continued)

year: 1971

species & size	North Carolina	South Carolina	Georgia	Florida (East Coast)
brown	quantity	quantity	quantity	quantity
15-20	82,511	56	-	63,067
21-25	947,753	14,110	24,254	95,716
26-30	524,111	95,673	126,808	96,833
31-40	761 478	678,403	432,698	124,615
41-50	579,414	499,652	103,477	36,377
51-67	229,128	363,365	20,551	30,468
68 & over	50,643	58,835	8,259	16,626
total	3,175,038	1,710,094	716,047	463,702
pink	quantity	quantity	quantity	quantity
26-30	31,837	-	-	-
31-40	190,323	-	-	-
41-50	324,433	-	-	-
51-67	516,064	-	-	-
68 & over	134,003	-	-	-
total	1,196,660			

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Appendix 5.2 (continued)

year: 1971

species & size	North Carolina	South Carolina	Georgia	Florida (East Coast)
white	quantity	quantity	quantity	quantity
15-20	-	52	17,462	124,907
21-25	-	263,119	844,227	738,845
26-30	12,430	545,472	1,074,334	360,328
31-40	126,815	1,299,034	1,485,986	249,869
41-50	194,350	1,202,033	847,633	79,830
51-67	40,673	1,464,939	560,804	35,239
68 & over	7,726	419,748	175,781	42,847
total	381,994	5,194,397	5,006,227	1,631,865
royal red	quantity	quantity	quantity	quantity
15-21	-	-	-	3,737
21-25	-	-	-	32,665
31-40	-	-	-	12,664
41-50	-	-	-	36,796
51-67	-	-	-	1,423
total	-	-	-	87,285

Appendix 5.2 (continued)

year: 1972

species & size	North Carolina	South Carolina	Georgia	Florida (East Coast)
brown	quantity	quantity	quantity	quantity
15-20	12,412	2,700	550	17,556
21-25	445,310	37,219	34,504	56,827
26-30	359,691	147,948	228,159	69,151
31-40	410,539	538,262	586,638	133,459
41-50	433,334	335,484	161,591	35,778
51-67	259,900	304,244	42,226	29,299
68 & over	68,781	29,665	4,839	12,333
total	1,989,967	1,395,522	1,058,507	354,403
pink	quantity	quantity	quantity	quantity
26-30	3,989	-	-	-
31-40	112,135	-	-	-
41-50	192,137	-	-	-
51-67	130,842	-	-	-
68 & over	53,570	-	-	-
total	492,673	-	-	-

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Appendix 5.2 (continued)

year: 1972

species & size	North Carolina	South Carolina	Georgia	Florida (East Coast)
white	quantity	quantity	quantity	quantity
15-20	-	-	764	85,992
21-25	21,239	13,499	182,614	597,148
26-30	122,447	221,808	1,117,623	675,690
31-40	142,673	1,531,521	845,808	517,916
41-50	246,723	788,777	622,778	186,210
51-67	345,945	940,235	630,375	245,347
68 & over	141,193	294,790	206,340	65,056
total	1,020,220	3,790,630	3,606,302	2,373,359
royal red	quantity	quantity	quantity	quantity
21-25	-	-	-	6,754
31-40	-	-	-	4,043
41-50	-	-	-	4,611
total	-	-	-	15,408

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Appendix 5.2 (continued)

year: 1973

species & size	North Carolina	South Carolina	Georgia	Florida (East Coast)
brown	quantity	quantity	quantity	quantity
15-20	2,973	1,171	234	14,560
21-25	139,513	14,408	20,400	52,498
26-30	218,618	65,714	62,289	69,941
31-40	380,333	448,501	188,282	56,774
41-50	163,909	259,167	56,985	26,105
51-67	138,420	225,259	48,317	75,943
68 & over	10,060	53,648	1,230	1,580
total	1,053,826	1,067,868	377,737	297,401
pink	quantity	quantity	quantity	quantity
15-20	-	-	-	2,942
21-25	2,286	-	-	-
26-30	33,655	-	-	-
31-40	153,096	-	-	-
41-50	363,893	-	-	1,158
51-67	281,839	-	-	323
68 & over	112,641	-	-	-
total	947,410	-	-	4,423

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Appendix 5.2 (continued)

year: 1973

species & size	North Carolina	South Carolina	Georgia	Florida (East Coast)
white	quantity	quantity	quantity	quantity
15-20	-	7,266	11,401	105,459
21-25	6,818	69,072	354,488	571,168
26-30	40,865	841,354	1,189,197	298,411
31-40	99,080	1,017,700	1,381,592	254,458
41-50	343,496	861,483	1,079,443	107,069
51-67	568,840	1,103,531	710,465	81,554
68 & over	107,398	344,311	234,187	55,019
total	1,166,497	4,244,717	4,960,773	1,473,138
royal red	quantity	quantity	quantity	quantity
21-25	-	-	-	2,900
26-30	-	-	-	-
31-40	-	-	-	-
41-50	-	-	-	3,006
total	-	-	-	5,906

Source: Fishery Statistics of the United States.
U.S. Department of Commerce, National Oceanic and Atmospheric Administration,
National Marine Fisheries Service.

SECTION 6

THE SOUTHEAST SHRIMP FISHERY: YIELD

by

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Gulland and Boerema (1973) have described a number of yield strategies for managers of commercially exploited species. This section relies heavily upon their ideas; readers are urged to review their article for additional details.

The concept of maximum sustainable yield (MSY) has gained wide recognition in the field of fisheries management, and an estimated MSY for penaeid shrimp in the Gulf of Mexico was recently put forth by Griffin, et al. (1973). Some comments are warranted relative to the properties and limitation of the MSY concept, and whether it is applicable to the southeastern Atlantic shrimp fishery.

The MSY concept treats the population as a single unit and ignores all disturbing influences on the population other than removals by man (Gulland and Boerema, 1973). The model also assumes that recruitment to the population will depend only upon the biomass of the population, with low recruitment resulting when the abundance of the population is either relatively high or low and a maximum recruitment resulting when the population is at an intermediate level of abundance, perhaps 1/3 to 2/3 of the virgin state. Silliman

(1971) discussed the advantages and limitations of "simple" fisheries models which have been used extensively to estimate maximum sustainable yields, namely the logistic described by Schaefer (1954, 1957), an adaptation of the Gompertz growth curve developed by Fox (1970), and a generalized model which includes the other two as special cases (Pella and Tomlinson, 1969). All of these models assume instantaneous recruitment (Silliman, 1971), and further assume that the exploited population will attain states of equilibrium permitting a rather constant level of recruitment for a given size of parental stock. Thus, the simple models do not have the capability of coping with significant lags in recruitment, pronounced changes in climatic conditions which may alter the basic growth curve of the population, or the situation in which the pattern of exploitation is such that the exploited component of the population never achieves a state of equilibrium. Moreover, these models are generally employed in fisheries where the catch has significant components of two or more year classes, and there is evidence that the level of exploitation on one year has an impact on the abundance of the stock in future years.

In addition to the biological problems associated with MSY, economists (Christy and Scott, 1965) have roundly criticized the concept because it does not consider economic objectives such as maximizing employment or potential economic rent which could be derived from an ocean resource. Further, the MSY concept does not adequately account for sociological and institutional constraints which often limit management alternatives, particularly when diverse user groups exploit a common resource.

Is the MSY concept relevant to the southeastern Atlantic shrimp fishery?

Firstly, it appears that the abundance of shrimp in this fishery changes annually, apparently independent of any prior level of fishing activity. Secondly, there is little evidence of a clearly defined relationship between parents and progeny, except that recruitment of a particular species, such as P. setiferus, can be severely affected temporarily by extreme environmental stresses such as the cold spell that occurred in the 1939-40 winter (Lindner and Anderson, 1956). However, landings in North Carolina were equivalent in magnitude to normal years, with the catch consisting almost entirely of brown shrimp. Hence, the commercial catch was relatively unaffected by the severe winter, even though the abundance of white shrimp was greatly reduced. This suggests that yield strategies should attempt to optimize the total yield in multispecies fisheries rather than maximize the yield of individual species. This particular point is discussed extensively by Dickie (1973), and should be considered when managing any multispecies fishery. Thirdly, the abundance of white shrimp has changed dramatically during the development of the fishery, apparently in complete independance of fishing activities. This sort of phenomenon could not be predicted by conventional models used to estimate MSY because these models lack the ability to cope with factors exogenous to fishing. Finally, Gulland and Boerema (1973) stated that when the abundance of recruits is independent of the abundance of the parent stock, as appears to be the case in this fishery, it is sufficient to maintain fishing at whatever level is considered the optimum position on the yield-per-recruit curve.

It is apparent for the southeastern Atlantic shrimp fishery that (1) there are significant problems associated with MSY; (2) this is a multispecies

fishery which may include direct competition between the component species (see Section 5); (3) penaeid shrimp do not appear to satisfy the basic assumptions necessary to estimate MSY, at least by the models discussed by Silliman (1971); and (4) effort data do not exist for this fishery. Thus, the MSY concept does not appear appropriate for the southeastern Atlantic shrimp fishery.

The shrimp fishery of the southeast is primarily conducted in estuaries, sounds, and within 10 miles of the shore (Anderson, 1948). There is no offshore fishery comparable to that practiced in the Gulf of Mexico; this fact influences present management strategies as will be described below.

Unfortunately, the natural mortality rate of the commercially exploited penaeid shrimp on the southeastern Atlantic is unknown. This has made it impossible to construct yield-per-recruit curves of sufficient precision for management decisions. Thus, managers have chosen to open seasons and areas of fishing based on the availability of 50 to 70 count shrimp (heads off). Quotas are not used and do not appear appropriate for this fishery at present because (1) there does not appear to be any clearly defined relationship between fishing and future levels of recruitment; (2) at least some shrimp escape by moving offshore, particularly browns and pinks; and (3) in South Carolina and by inference in other states small white shrimp during most years remain in waters deeper than 20' in sounds, bays and larger tributaries where they escape the fishery (Charles Bearden, personal communication). In essence, it appears that managers are employing a prudent yield strategy based on the information available at this time, at least as far as the biological yield is concerned. Once better estimates of

fishing and natural mortality rates are determined, it will be a relatively simple matter to "fine tune" this strategy because legal procedures for this type of activity are well established.

States are not presently utilizing economic concepts, such as net economic yield or marginal yield (Gulland, 1968), in their management strategies. Thus, the cost of fishing shrimp under the present system may be higher than it would be under a system which attempted to maximize net economic yields. However, the present system probably does tend to maximize employment, which has considerable merit. Moreover, the present system also allows people to choose a life style which may better fit their psychological needs, even though it may not provide them with the greatest net profit. In short, some people prefer shrimping to other forms of employment, and who is wise enough to deny them their choice.

What is the present yield of shrimp in the southeastern Atlantic fishery, and what of the future? Although annual landings of shrimp have varied considerably and short term trends in the abundance of white shrimp have appeared (Anderson, 1970), the level of landings for the combined catch of brown, pink and white shrimp appears to have stabilized at approximately 25 million pounds round weight. This level of landings should hold for the immediate future.

It does not appear that the level of landings of the presently exploited shrimp in the southeastern Atlantic will be increased dramatically by management policies. However, in North Carolina managers have instituted a policy of nursery ground protection in their southern district, and the production of shrimp has increased substantially (Walter Godwin, personal communication). This

suggests that the new policy is beneficial, although some or all of the increase may be due to favorable environmental conditions. It is simply too early to tell at this point.

Once the natural mortality rate is defined, managers may be able to increase biological yields perhaps in the order of 5-15%. Although it does not appear that managers will be able to significantly increase the biological yield of shrimp, it does appear that managers will be able to devise strategies that will increase the net economic yield substantially. Political and sociological attitudes will determine whether these strategies are ultimately accepted.

Three other factors that will affect future commercial landings of shrimp along this coast are (1) the recreational catch of shrimp; (2) the use of presently under-exploited species, such as rock shrimp, Sicyonia brevirostris; and most importantly (3) the degree of alteration of coastal environment in this area.

The recreational catch of shrimp may represent a substantial portion of the total catch. Thus, any increase in the recreational fishery may, but not necessarily, reduce the commercial catch. Growth and natural mortality rates, as well as the emigration rate of shrimp from the estuaries, will determine whether or not the recreational will affect the commercial catch.

Increased exploitation of rock shrimp and other underutilized species should increase commercial landings of shrimp, perhaps substantially.

As mentioned earlier, the alteration and/or destruction of the coastal estuaries will ultimately decide whether or not there will be a viable shrimp resource in the southeastern Atlantic. In essence, shrimp management programs can only succeed if adequate safeguards are taken by appropriate governmental

agencies to maintain suitable nursery grounds for this valuable resource.

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SECTION 7

THE SOUTHEAST SHRIMP FISHERY: CURRENT LAWS AND REGULATIONS

by

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Laws and regulations pertaining to the shrimp fishery in the four southeastern Atlantic states vary considerably, but from a management standpoint are generally designed to control seasons, fishing areas, and the size of shrimp that can be caught. The regulation of fishing areas is largely aimed at the protection of juvenile and young adult shrimp and inshore estuarine nursery areas. Seasons are controlled primarily to provide for maximum economic returns, although the protection of young shrimp (and spawners in some instances) is also considered. The size of shrimp that can be caught is controlled to a significant extent by restrictions on seasons and fishing areas, as well as by regulations on gear and methods. Specific regulations concerning seasons, areas, gear, methods, licenses and taxes, reciprocal agreements, etc., exhibit much variation from state to state, as do law enforcement systems and penalties for violations.

Administrators in the southeastern Atlantic states generally agree that there is a need for greater regulatory flexibility and responsiveness in the various shrimp management programs. Although all four states have provisions for the adoption of rules and regulations pertaining to the shrimp fishery, in many instances existing statutes or legislative and administrative procedures impede short term decision-making in critical situations. Of the four states included in this study, North Carolina presently has perhaps the most flexible administrative and regulatory system pertaining to shrimp manage-

ment. The states of South Carolina, Georgia, and Florida all have limited flexibility in various aspects of shrimp management due to existing state and local statutes.

Enforcement and monitoring programs related to shrimp regulations also differ significantly among the four states. In some cases, specific law enforcement units exist under the direct control of the coastal management unit or division, while in others law enforcement sections are responsible for enforcing game and freshwater fisheries as well as coastal fisheries laws. Manpower, equipment, and other coastal law enforcement capabilities and needs also vary widely among the four states.

The following portion of this study consists of a summarization of existing regulatory and enforcement systems in each state.

7.1 North Carolina

The organizational unit responsible for management and regulation of marine and estuarine resources in North Carolina is the Board of Conservation and Development. The Board's Division of Commercial and Sports Fisheries is the organizational unit charged with coastal fisheries management-enforcement functions. This Division is headed by the Commissioner of Commercial and Sports Fisheries.

Within the Board of Conservation and Development exists a Commercial and Sports Fisheries Advisory Committee, the staff of which consists of personnel from the Division, including the Commissioner. This staff prepares suggested regulations and submits them to the Committee which makes recommendations thereon to the full Board. The specific authority of the Board with respect to regulation of coastal fisheries is provided in North Carolina G. S. 113-181.

The North Carolina coastal shrimp management system is quite flexible,

with practically all regulatory authority being with either the Board, its Director, or the Commissioner. General statutes themselves deal primarily with licenses, taxes, record keeping, enforcement, and leasing procedures. All other matters, including opening or closure of seasons and areas to shrimping, gear and equipment restrictions, and other aspects of shrimp management are controlled through regulations promulgated by the Board. North Carolina G. S. 113-133 abolished local coastal fishing laws, although there are some regulations promulgated which deal with the restriction of shrimping in specific areas of coastal waters. The Director of the Board of Conservation and Development, acting upon the advice of the Commissioners, may temporarily suspend regulations without Board action, and is authorized to establish open and closing dates for seasons relating to shrimp, provided biological data so warrant.

The Law Enforcement Section of the North Carolina Division of Commercial and Sports Fisheries has approximately 42 fisheries inspectors in the coastal area who are primarily concerned with the enforcement of fisheries, dredge and fill, and state health laws. The Section has four large patrol boats (46 - 61'), three of which are equipped with radar; two patrol planes; and 26 outboard motor boats.

During the 1972-73 fiscal year, 466 arrests were made, 170 of which were for shrimping violations in closed areas. Fines totalled $2,090.00 and court costs were $6,341.00. About 90% of the fines administered in magistrates' courts amounted to less than $20.00, with court costs averaging $25.00-$50.00. There is some question as to the effectiveness of the license suspension law (G. S. 113-166); a boat found in violation may be transferred to another person, licensed in his name, and be back in operation on the same day.

A major concern in North Carolina is the large number of licensed shrimp boats under 18' in length. Over 10,000 such licenses are sold annually and approximately 80% of these are reportedly non-commercial fishermen.

The following is an outline of the management and regulatory system applicable to the shrimp fishery of North Carolina:

7.1.1 Administrative Organization

7.1.1.1 Management Unit - North Carolina Board of Conservation and Development, Division of Commercial and Sports Fisheries.

7.1.1.2 Enforcement Unit - Division of Commercial and Sports Fisheries, Coastal Law Enforcement Section.

7.1.2 Legislative Authorization

7.1.2.1 General Statutes - Chapter 113, Subchapter IV, General Statutes of North Carolina specifies the jurisdiction, duties, and powers of the department related to coastal fisheries management and conservation. General provisions for the regulation, licensing, and taxation of coastal fisheries are included.

7.1.2.2 Departmental Regulations - Subchapter IV of Chapter 113 authorizes the Board of Conservation and Development to promulgate specific regulations for the control of coastal fisheries. The board meets every three months to adopt new regulations or to amend or abolish existing regulations.

7.1.3 Licenses and Taxes (Article 14)

7.1.3.1 Commercial Fishing Vessels

Without motors - $1.00.

With motors, less than 18' length - $3.00.

With motors, 18-26' length - $0.50/ft.

With motors, over 26' length - $0.75/ft.

7.1.3.2 Shrimp Dealer and Individual Licenses - $10.00/year (also applies to bait dealers). Land and sell licenses are required for sale of all fish in lieu of other licenses if receipts are less than $200.00 for a 12 month period.

7.1.3.3 Taxes on Shrimp Caught - Green, heads off - $0.15/100 lbs., or $0.10/100 lbs., heads on.

7.1.3.4 Shrimp Gear Licenses - None.

7.1.3.5 Annual Licensing Period - January 1-December 31.

7.1.3.6 Record Keeping Requirements - G. S. 113-157(e).

7.1.4 Reciprocal Agreements

Sections 113-223 and 113-181 (N.C.G.S.) contain general provisions whereby the State of North Carolina may enter into reciprocal agreements concerning coastal fisheries matters. Under these statutes, the state has reciprocal agreement authority which would include practically any aspect of shrimp management in territorial waters. Section 113-161 also provides for reciprocity with other states in license privileges, provided that such states accord similar privileges to North Carolina license holders.

7.1.5 Regulations

7.1.5.1 Restrictions on Gear and Fishing Methods

7.1.5.1.1 Non-commercial shrimp gear is defined as seines less than 12' in length, and dip nets.

7.1.5.1.2 Channel or stationary nets may not be used in any location where they might constitute a hazard to navigation, and cannot block more than two-thirds of any natural or man-made waterway. Other restrictions on channel nets or fixed nets apply to specific areas and locations throughout coastal waters. Channel nets used in coastal fishing waters for taking shrimp may not exceed 40 yards in length and must be properly buoyed and marked.

7.1.5.1.3 Butterfly or Float Nets - May be used to take shrimp in areas designated by the Commissioner, under permit only.

7.1.5.1.4 Mesh Size of Shrimp Nets - Minimum mesh size for shrimp nets is 1 1/2", stretched mesh. A 1973 regulation provides that hand seines and channel nets may have a minimum mesh size of 1 1/4", stretched.

7.1.5.2 Seasons, Areas, Etc.

7.1.5.2.1 No shrimp may be taken, other than by a fixed or channel net, by any vessel:
Between the hours of 8:00 P.M. on any Saturday and 8:00 P.M. on the following Sunday.
Between January 1 and the date upon which the season shall be opened by the Director.

7.1.5.2.2 Opening and Closing Season - The Director, acting upon the advice of the Commissioner,

shall open the shrimp season in various waters by proclamation when the major portion of sample catches therein reach commercial size. Likewise, the season may be closed at any time for the protection of undersized shrimp (this regulation does not apply to channel or fixed nets).

7.1.5.2.3 Bait Shrimping - North Carolina has no specific regulations on bait shrimping.

7.1.5.2.4 Miscellaneous - Other general regulations apply to the restriction of nets and seasons in specific areas of North Carolina coastal waters.

7.1.6 Penalties for Violations

Section 113-135, N.C.G.S., provides general penalties for violations of fisheries laws and regulations. Unless a different level of punishment is elsewhere specified, anyone convicted of such a misdemeanor may be fined an amount not to exceed $50.00.

7.1.7 Scientific Permits - Section 113-261, N.C.G.S.

7.1.8 Limited Entry - No provisions for limited entry are contained in fisheries laws or regulations.

7.2 South Carolina

In South Carolina, the Wildlife and Marine Resources Department is the agency having coastal fisheries management responsibility. The Department is governed by a nine-man board, the South Carolina Wildlife and Marine Resources Commission. The Department's Division of Marine Resources has jurisdiction over all saltwater fish, fishing, and fisheries.

Coastal fisheries laws for South Carolina are contained in Chapter 7, Title 28, South Carolina Code of Laws, 1962 as amended. The Division is authorized to promulgate rules and regulations for the control of fisheries consistent with existing state policies and statutes.

Most of the regulatory authority of the Division is specified by statute, including provisions for seasons, areas, gear restrictions, licenses and taxes, etc. The Division does have considerable flexibility in shrimp management insofar as control of the season in coastal waters is concerned, and any area where legal trawling is permitted may be opened or closed at any time.

The law enforcement unit of the South Carolina Wildlife and Marine Resources Department is the Division of Law Enforcement and Boating. The duties of this Division include the enforcement of statutes and regulations relative to game and freshwater fisheries, boating, and marine resources. The Division has nine districts throughout the state with one, the Coastal Environmental Enforcement District, being primarily responsible for marine resources law enforcement. Approximately 20 conservation officers are directly involved in coastal law enforcement at present.

Currently, the Division of Law Enforcement and Boating has one large (32'), radar-equipped coastal patrol boat, used primarily for enforcement of shrimp trawling laws. Approximately 20 outboard motor boats are used by Conservation Officers in the coastal area. Two departmental planes are available for coastal patrols. Plans call for a second large patrol boat, and for a plane to be permanently based along the coast.

During the 1972-73 fiscal year, 50 arrests for shrimp trawling violations were made; 48 of these resulted in convictions. The majority of these cases were for trawling out of season or in restricted areas, and fines averaged

$100.00 per case. Fines totalled $5,600.00 for the year. Existing shrimp legislation was amended during 1973 to provide for increased penalties and clarification of former legislation. All shrimping violations, with the exception of those in Game Zone 7, are tried in magistrate's court. Relationships between local magistrates and conservation officers have been excellent and the percentage of convictions versus arrests has been high. Major needs with respect to the enforcement of shrimping legislations and regulations in South Carolina are related to manpower and equipment. This situation is improving steadily, however.

The following is a summarization of the management and regulatory system pertaining to the shrimp fishery of South Carolina:

7.2.1 Administrative Organization

7.2.1.1 Management Unit - Division of Marine Resources, South Carolina Wildlife and Marine Resources Department.

7.2.1.2 Enforcement Unit - Division of Law Enforcement and Boating, South Carolina Wildlife and Marine Resources Department.

7.2.2 Legislative Authorization

7.2.2.1 General Statutes - Chapter 7, Title 28, South Carolina Code of Laws, 1962 as amended, specifies the jurisdiction of the Division and general regulatory, licensing, taxes, and leasing provisions.

7.2.2.2 Departmental Regulations - Section 28-174 authorizes the Division to adopt and promulgate rules and regulations for the government of the force under its control, and the control of fisheries not contrary to or inconsistent with the laws and policy of the state. Section 28-757

specifies that the Commission may prescribe and require permits of all persons engaged in the taking of fish in the waters of the state, and also provides for the issuance of scientific permits.

7.2.3 Licenses and Taxes

7.2.3.1 Commercial Fishing Vessels

Resident shrimp trawler - $75.00.

Non-resident shrimp trawler - $200.00.

*Commercial vessels under 18' - $2.50.

*Commercial vessels in excess of 18' - $10.00.

7.2.3.2 Shrimp Dealers and Individual Licenses

Individual Commercial Shrimp License** - $5.00.

Shrimp Dealer's License - $20.00.

Shrimp Processor's License - $100.00.

Bait Dealer's License - $5.00.

7.2.3.3 Taxes on Shrimp caught in South Carolina - None.

7.2.3.4 Shrimp Gear Licenses

Channel net - $5.00.

7.2.3.5 Annual Licensing Period - July 1-June 30.

7.2.3.6 Record Keeping Requirements - Sections 28-962, 28-846, 28-891.

7.2.4 Reciprocal Agreements

There is presently no authorization in the South Carolina

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* Not required of shrimp trawlers.
** Captain's license.

Code of Laws for the Department or Division to enter into reciprocal agreements with other states pertaining to shrimp management or licensing.

7.2.5 Regulations (Statutes)

7.2.5.1 Restrictions on Gear and Fishing Methods

7.2.5.1.1 Section 28-922.1 - It is unlawful to place or set any net, seine, or other device to extend more than one-half the width of any tidal stream or waterway at any stage of the tide.

7.2.5.1.2 Shrimp Seines (Section 28-922) - Such seines may be used for commercial or personal use and cannot exceed 40' in length. A minimum mesh requirement of 1/2" (nylon) or 9/16" (cotton), square mesh, is provided. No restrictions exist on cast nets, drop nets, or dip nets for personal shrimping.

7.2.5.1.3 Channel Nets (Section 28-922) - Maximum mouth width allowable for channel nets is 80', and a mesh size no smaller than 3/4" square mesh, may be used.

7.2.5.2 Seasons, Areas, Etc.

7.2.5.2.1 Trawling Season and Areas *(Section 28-861, 28-861.1).

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* Section 28-861.5 provides that the Commission may open or close any of the listed areas at any time, if it believes such action should be taken in the best interests of the state.

Shoreline to three-mile limit - May 15-December 15 (June 1-December 15 in Game Zone 7).

Sounds and bays - August 15-December 15, except for Calibogue Sound (September 1-November 1).

Trawling is restricted within one-quarter or one-half mile of the shoreline along most inhabited beaches during May 15-September 15.

It is also unlawful to trawl within one-half mile of any fishing pier in Horry County.

All coastal areas, other than offshore waters and six sounds and bays, are considered nursery areas and are off-limits to shrimp trawling.

7.2.5.2.2 Trawling is unlawful from two hours after official sunset to two hours before official sunrise in any legal state waters from September 15-December 31.

7.2.5.2.3 Bait Shrimp Regulations - South Carolina has no provisions for bait shrimp operations, other than the requirements for bait dealers' licenses. Cast nets, seines, drop nets and dip nets may be used to take bait shrimp in tidal creeks, rivers, or streams.

7.2.5.2.4 Miscellaneous Provisions

Any vessel operating in areas where trawling is closed is required to have trawl nets on

board at all times. Legal trawling boundaries are specified in Article 7, South Carolina Code of Laws, 1962 as amended. Requirements for shrimp channel net permits are specified by rule and regulation. Persons using a channel or set net for shrimp in coastal waters must obtain a permit from the Division, which specifies the area(s) where said net may be used.

7.2.6 Penalties for Violations

7.2.6.1 Section 28-761 - This is a general penalty section providing fines and/or imprisonment for violations not dealt with in other code sections. Under 28-761, persons convicted for violations are punished by a fine of $25-$100 for first offense or by imprisonment of not less than 10 or more than 30 days. For subsequent offenses, fines range up to $500.00 or imprisonment up to 60 days.

7.2.6.2 Section 28-862 - Penalties are provided for shrimp trawling in restricted areas which are never opened to shrimping. First offense fines for conviction are $100.00 or thirty day imprisonment; suspension of Captain's license for one year; suspension of boat license for seven days; and confiscation of catch. Subsequent violations result in increased license suspension periods. Boat captains found operating during the license suspension period may be fined up to $1,000.00; boats used during the period

of license suspension may be confiscated, with rigging and equipment, and either redeemed for set value or sold by the Division.

7.2.6.3 Section 28-862.2 - This section applies to shrimp trawling during the closed season in sounds, bays, and from the shoreline to the three-mile limit. Fines and penalties are as specified in Section 28-862.

7.2.6.4 Section 28-944 - Penalties are provided for trawling without a license. Under this section, boats trawling in any state waters without being licensed shall be confiscated with rigging and equipment, and if not redeemed for value set by the Division, sold at public sale.

7.2.6.5 Miscellaneous Penalty Provisions

During 1973, legislation was enacted to require any commercial fishing vessel operating in state waters to heave to, allow boarding, and cooperate in every reasonable way with conservation officers of the Department. Penalty for violation of this law is a fine of $1,000.00 or imprisonment for one year.

Section 28-866.6 provides penalties for violations of shrimp trawling legislation in Georgetown and Horry counties. Violations are punishable by a fine not to exceed $1,000.00, or six months imprisonment, or both, in the discretion of the court.

7.2.7 Scientific Collection Permits - Section 28-757, South Carolina Code of Laws, as amended.

7.2.8 Limited Entry - No specific provisions for limited entry are contained in the South Carolina Code of Laws.

7.3 Georgia

The Division of Game and Fish of the Georgia Board of Natural Resources is the organizational unit primarily responsible for coastal fisheries management and enforcement. As in South Carolina, much of the regulatory authorization of the Division is specified by state legislation.

Georgia statutes pertaining to shrimp allow some flexibility in the opening and closing of seasons, based on count size. Other aspects relating to vessel licenses, gear restrictions, etc., are specified by statute. The Board has the authority to promulgate regulations pertaining to coastal fisheries not contrary to existing statutes.

The Law Enforcement Section of the Game and Fish Division has enforcement powers pertaining to all game, freshwater fishing, coastal fishing, dredge and fill, boating, and water quality laws in the state.

The Law Enforcement Section has approximately 15 officers involved in patrol activities within the coastal area. Coastal patrol vessels include 15 boats, ranging in length from 16' to 26'; two airplanes are available for surveillance work.

During 1972-73, approximately 67 arrests were made for shrimping violations resulting in 40 convictions. The most common type of violations were for shrimp trawling in closed waters, and trawling without a license. Fines amounted to about $3,100.00, and at least 13 vessels were confiscated in the above cases. Generally, law enforcement personnel in Georgia feel that there are no major problems related to obtaining convictions in cases involving shrimping violations. Current regulations related to commercial and sport bait shrimping, which is allowed in inside waters, are a major concern in

coastal law enforcement. In addition, it is felt that present personnel and equipment capabilities are insufficient to carry out an adequate surveillance program in the coastal estuarine area.

An outline of the management and regulatory system pertaining to the shrimp fishery of Georgia is as follows:

7.3.1 Administrative Organization

7.3.1.1 Management Unit - Georgia Board of Natural Resources, Division of Game and Fish.

7.3.1.2 Enforcement Unit - Division of Game and Fish (Law Enforcement Section).

7.3.2 Legislative Authorization

7.3.2.1 General Statutes - Title 45, Chapters 1-12, Game and Fish. Chapter 1 of Title 45 specifies the duties and powers of the Division of Game and Fish. General provisions for the regulation and control of commercial fisheries are included.

7.3.2.2 Regulations - Under Section 45-114, (2) and (3), the Board and the Commissioner can promulgate rules and regulations to control and regulate limits, seasons, methods of capture, devices, etc., for all wildlife in the state, except as otherwise provided by statutory law.

7.3.3 Licenses and Taxes (Chapter 45-2)

7.3.3.1 Commercial vessels* - Trawlers 18' and under - $25.00. Trawlers over 18' - $25.00 + $0.50 per each foot in excess

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* Legislation enacted in 1974 requires that a $5,000.00 bond be posted by the owner of the trawler prior to issuance of the license.

of 18'.

Boats other than trawlers under 18' - $5.00.

Boats other than trawlers over 18' - $5.00 + $0.50 per foot in excess of 18'.

Non-residents are charged an additional license fee of $25.00 per vessel, plus vessel's home state non-resident fee in excess of $25.00.

7.3.3.2 Individual and Dealer Licenses

Boat Operator (Resident) - $2.00.

Boat Operator (Non-resident) - $5.00.

Wholesale Fish Dealer - $50.00 (Dept. of Agriculture).

Personal License (other than boat operator) - Resident $2.00; non-resident $5.00.

7.3.3.3 Taxes on Shrimp Caught - None.

7.3.3.4 Annual Licensing Period - April 1-March 31.

7.3.3.5 Shrimp Gear Licenses - None.

7.3.3.6 Record Keeping Requirements - Sections 45-217; 45-218.1.

7.3.4 Reciprocal Agreements - Section 45-114(9) provides that the Board of Natural Resources may enter into cooperative agreements with educational institutions and federal, state, and other agencies to promote wildlife management and conservation. This section apparently provides broad authority to enter into reciprocal agreements.

7.3.5 Regulations (Statutes)

7.3.5.1 Restrictions on Gear and Fishing Methods

Only cast nets and bait shrimp trawls of less than 20' may be used for taking shrimp in tidal creeks, streams, and rivers.

7.3.5.2 Seasons, Areas, Etc.

7.3.5.2.1 Trawling Season (Section 45-905)

The shrimp trawling season in Georgia is closed from January 1-May 31; however, the Director may open any sound or seaward territorial waters during January and February when the shrimp count is below 50 per pound, heads on.

Sounds are open from September 1 through December 31, when the shrimp count is 45 or less per pound, heads on (applies only to Wassaw, Ossabaw, St. Simons, St. Andrews, and Cumberland Sounds).

Provision is also made that adequate sampling must be conducted to determine count sizes; notice must be posted at least 24 hours prior to closure of areas.

7.3.5.2.2 Bait Shrimp Regulations (Section 45-935, 45-935.1)

Any person may at any time and in any of the state's saltwaters use a power-drawn net not exceeding 10' across the mouth, for the purpose of taking shrimp to be used for live

bait for personal use. Catch is limited to two quarts of shrimp per person, or four quarts per boat.

Any person engaged in commercial bait shrimping must own or be employed by an established bait dealership in Georgia, and must post a $1,000.00 bond and obtain the necessary licenses required under Sections 45-212, 45-214, 45-219, and 45-220 (Boat and Fishermen's Licenses). Qualified persons so licensed may use trawl nets not larger than 20' across the mouth for taking live bait for sale in state waters. The only other nets which can be used in tidal creeks and rivers for taking shrimp are cast nets (Section 45-904(c)).

Section 45-935.1 specifies that the bait shrimping provisions of 45-935 are not applicable in the tidal rivers, streams, or creeks of any county having a population of more than 150,000. There is some question as to the constitutionality of this law, however (Legislative intent to repeal subsection (f), Georgia Laws 1968, p. 202-205).

7.3.5.2.3 Miscellaneous (45-905(e))

The Division of Game and Fish has the power to close any area in the tidal or salt-

water areas of the state to commercial shrimping in the event of disaster or emergency situations.

7.3.6 Penalties for Violations

7.3.6.1 Section 45-905(d). This section provides penalties for trawling violations, and specifies that any boat and its equipment used in violation of 45-905 or 45-935 shall be declared contraband and seized by peace officers. Following adequate notification and conviction, the boat and equipment may be sold by order of the courts (it must be shown, however, that the illegal use of the boat and equipment was with the express or implied consent of the owner).

7.3.6.2 Section 45-906. Persons violating any provision of license, boat tag, or trawling laws shall upon conviction be guilty of a misdemeanor and punished as provided by law. In addition, the court may suspend the license of the violator for two weeks upon conviction for a third offense.

7.3.6.3 Section 45-906.1. This section provides penalties for violation of statutes or regulations pertaining to licenses, tags for boats, shrimping with power drawn nets, etc. Under this section, violators are guilty of a misdemeanor punishable as provided by law. Upon conviction, license(s) shall be revoked, but can be reinstated if good cause is shown. The Division, independent of any criminal prosecution or conviction, may refuse to renew, suspend, or

revoke the license(s) of any person for the violations specified.

7.3.6.4 Under 1974 legislation, shrimp boat owners applying for a license must file with the Commissioner of Natural Resources a $5,000.00 forfeiture bond which shall be for one year, corresponding to the period of the shrimp license. When such a bond has been filed, the provision of subsection 45-905(d) shall not apply to the boat covered by the bond.

When a boat covered by the above bond is used in violation of trawling laws, either with or without the knowledge or consent of the owner, the Commissioner shall have the right to recover on the bond as follows:

First violation - $500.00.

Second violation within a two year period - $1,000.00.

Third violation within a two year period - $5,000.00.

If the total amount of the bond is forfeited, the boat license will be suspended until another bond is filed. In addition, the captain of a boat found in violation of the law is subject to the following penalties:

First offense - not less than $250.00 and suspension from any fishing activity for 30 fishing days.

Second offense - not less than $500.00 fine and suspension from fishing for 60 days.

Third offense - not less than $500.00 fine and suspension from any fishing for one year.

Any person violating the mandatory fishing suspension period is subject to imprisonment for up to 12 months.

7.3.7 Scientific Collection Permits - Georgia Statute 45.208.

7.3.8 Limited Entry - Sections 45-114(3) and 45-101.1, in the absence of any constitutional impediments, would apparently provide for the establishment of a system of limited entry.

7.4 Florida

In Florida, the Department of Natural Resources is charged with the administration, supervision, development, and conservation of all natural resources. The Marine Resources Division of the Department is specifically responsible for the management of coastal fisheries resources, including shrimp.

Legislation pertaining to the shrimp fishery is contained in Chapter 370 of the Florida Statutes Annotated, and in Chapter 16B of the Florida Administrative Code (Regulations). General statutes include provision for licenses and taxes, enforcement, general gear restrictions, and the regulation of fisheries for various species such as shrimp. Administrative regulations promulgated by the Director of the Department are approved by the Governor and Cabinet of the state and implement, interpret, or make specific the statutory requirements concerning various species.

Generally, the shrimp management system in Florida, as set forth in the

statutes, is relatively inflexible, and allows for limited regulatory authority through administrative discretion.

In 1973, the Florida Legislature passed a bill (73-208) providing for the repeal of all county ordinances regulating the taking or possession of saltwater fish. Whether this legislation effectively abolishes the numerous local laws pertaining to shrimp management in Florida has not yet been determined.

The Department's Bureau of Law Enforcement, Marine Patrol, is the organizational unit responsible for the enforcement of saltwater fisheries laws and regulations. The Marine Patrol is also responsible for the enforcement of boating, dredge and fill, water quality, and shellfish sanitation laws and regulations. Officers have powers of search without warrant of vessels, vehicles, or fish houses suspected of being involved in violations.

Florida has approximately 178 marine patrol officers at present. Two coastal patrol planes and 180 patrol boats, ranging from 15' outboards to 57' inboard vessels, are available for marine enforcement activities.

During 1972-73, 37 arrests were made for shrimping violations in Florida coastal waters, resulting in 14 convictions. Fines and court costs amounted to $862.00. Bonds in excess of $12,770.00 are pending on 15 arrests made within the Tortugas closed area. The most common types of violation reported involved shrimp size regulations and trawling in closed areas.

Of significant concern in Florida has been the strong influence of local politics on shrimp management laws and regulations. This has apparently hampered coastal law enforcement activities and resulted in difficulties in obtaining convictions for shrimping violations. Another problem area has been the high personnel and equipment requirements for sampling shrimp populations and conducting surveillance and enforcement activities in the

various open and closed shrimping areas along the coast of Florida.

The following is a summarization of the shrimp management and regulatory system in Florida:

7.4.1 Administrative Organization

7.4.1.1 Management Unit - Department of Natural Resources, Division of Marine Resources.

7.4.1.2 Enforcement Unit - Department of Natural Resources, Bureau of Law Enforcement, Marine Patrol.

7.4.2 Legislative Authorization

7.4.2.1 General Statutes

Chapter 370 of the Florida Statutes Annotated contains the legislation pertaining to saltwater fisheries. Section 370.02 specifies the jurisdiction of the Division of Marine Resources over marine and anadromous fishery resources. Other statutes provide for regulation of fisheries, licensing and taxation, record-keeping, and law enforcement.

7.4.2.2 Departmental Regulations

Rules and regulations concerning saltwater fisheries are contained in Chapter 16B of the Florida Administrative Code. Section 370.021 provides statutory authorization for the promulgation of rules and regulations by the Department of Natural Resources.

7.4.3 Licenses and Taxes

7.4.3.1 Motorboats*

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* An additional license fee of $50.00 per vessel is required of aliens or non-residents.

Class 1 - All boats less than 12' - $2.00.

Class 2 - 12' or more and less than 16' in length - $6.00.

Class 3 - 16' or more and less than 26' in length - $11.00.

Class 4 - 26' or more and less than 40' in length - $31.00.

Class 5 - 40' or more and less than 65' in length - $51.00 + $0.50.

Class 6 - 65' or more and less than 110' in length - $61.00 + $0.50.

Class 7 - 110' or more in length - $76.00 + $0.50.

Dealer Classification - $10.00 + $0.50.

7.4.3.2 Individual and Dealer Licenses

Resident Wholesale - $100.00.

Non-resident Wholesale - $150.00.

Alien Wholesale - $500.00.

Resident Retail - $10.00.

Non-resident Retail - $25.00.

Alien Retail - $50.00.

Alien and Non-resident Commercial Fisherman's License* - $25.00.

Shrimp fishery permits are required by the Director which specify the type of gear to be used in different sections of open areas.

7.4.3.3 Taxes on Shrimp Caught - None.

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* This applies to persons engaged in the taking and sale of fishery products, but does not apply to crew or employees not involved in the sale of catch.

7.4.3.4 Annual Licensing Period - July 1-June 30.

7.4.3.5 Shrimp Gear License - None.

7.4.3.6 Record Keeping Requirements - Section 370.061(5).

7.4.4 Reciprocal Agreements

Section 370.18 pertains to access to fishery resources, specifically shrimp and prawn. Provision is made whereby the citizens of Florida may be permitted to catch shrimp or prawn from the waters under the jurisdiction of other states upon similar agreements to allow non-residents to fish or catch seafood in Florida.

7.4.5 Regulations (Statutory)

7.4.5.1 Restrictions on Gear and Fishing Methods

It is unlawful to obstruct any tidal waterway with a seine, net, or other device except gill nets, to prevent the free passage of fish (370.08).

7.4.5.2 Seasons, Areas, Etc.

7.4.5.2.1 Trawling season and areas - Generally, the shrimping season is controlled by the Department under the provisions of Sections 370.15, 370.151, and 370.152. No specific dates are set for statewide seasons, with areas being opened or closed according to count size, as determined by sampling by the Marine Resources Division.

7.4.5.2.2 Night Shrimping - It is unlawful to catch or attempt to catch shrimp or prawn in any county

bordering on the Atlantic Ocean of Florida at night by trawling, except during the months of June, July and August.

7.4.5.2.3 Bait Shrimping - Live bait shrimping, including trawling, is legal in most of the territorial waters of Florida's east coast. Permits are required for bait shrimping from the Director of Conservation, who may specify the type of equipment necessary to catch and maintain shrimp alive after capture, as well as requirements for handling, transporting, and marketing (Section 370.152(5)). In some counties, a license fee is required and size of trawls, restricted areas, etc., are defined. Bait shrimp permits for pleasure fishermen are specified by regulation on a county basis.

Specific areas in coastal waters are designated as sanctuaries or nursery areas and are closed permanently to shrimp trawling. In most inland waters (tidal creeks, estuaries), only cast nets or bait shrimping is allowed. Section 370.152 provides that any waters contiguous to the St. Johns River, or along the coast of Georgia to and including Brevard County, may be closed following notification any time sampling indicates that the shrimp

in any particular area are undersized.

7.4.5.2.4 Shrimp Catch Regulations - It is illegal to have in possession on board any vessel or in any place of business small shrimp in excess of 5% of the total poundage. Small shrimp or prawn are defined as those requiring more than 47, heads on, or 70, heads off, to make one pound. Random sampling is done to determine the percentage of small shrimp in a catch (Section 370.15(2)).

7.4.5.2.5 Miscellaneous - Special provisions relating to the Tortugas shrimp beds are made in Section 370.151. Under this section, the Tortugas beds are defined. No shrimping except for live bait under permit, is allowed at any time in this area.

7.4.6 Penalties for Violations

7.4.6.1 General - Section 370-021(2) specifies general penalties for violations of the provisions of Chapter 370, unless otherwise provided. This section provides for a fine of not more than $500.00, or imprisonment for one year in the county jail, or both.

7.4.6.2 Section 370-061. This section provides that fishing gear, vessels, catch, and vehicles shall be seized upon arrest and conviction for illegal taking, sale, possession, etc., of saltwater fish or fishery products in Florida. The

person holding title to such property may reclaim same if it is proven he had no participation in, or knowledge of, the illegal act(s). If the owner is unknown or cannot be located, the equipment involved is forfeited to the Department for its use, sale, or disposal.

7.4.6.3 Section 370.15(2) and (5) provides a fine of $100-$500 for first offense violations of the 5% count law and shrimp permit requirements. Licenses may be suspended six months to one year on subsequent offenses.

7.4.6.4 Section 370-151(4) provides for confiscation of vessels and fines of up to $500.00 for illegal trawling or live bait shrimping of the Tortugas beds without a permit.

7.4.7 Scientific Collecting Permits - G. S. 370.10.

7.4.8 Limited Entry - No precedents for limited entry have been established, and there are no specific legislative provisions for same in Florida saltwater fisheries laws.

Table 7.1 Licenses, taxes, and fees relative to shrimping in the southeastern Atlantic states.

	NORTH CAROLINA	SOUTH CAROLINA	GEORGIA	FLORIDA
Licenses - Vessels, Motors	Less than 18' - $1.00 18 - 26' - $0.50/ft. Over 26' - $0.75/ft.	Resident Trawler - $75.00 Non-resident Trawler - $200.00 Vessels other than trawlers-$2.50-$10.00	Trawler - 18' and under- $25.00 + $0.50 for each foot over 18' Other-$5.00 + $0.50/ft. over 18'	8 classifications, based on vessel length Ranges from $2.00 for boats under 12' to $60.00 - $70.00 for larger shrimp trawlers
Dealer or Processor	$10.00/yr.	Dealer - $20.00 Processor - $100.00 Bait Dealer - $5.00	$50.00/yr. (Dept. of Agriculture)	Resident Wholesale - $100.00 Non-resident Wholesale - $150.00 Resident Retail - $10.00 Non-resident Retail - $25.00
Individual	Land & Sell - $2.00	Shrimp - $5.00	Boat Operating Resident - $2.00 Non-resident - $5.00 Personal - $2.00-$5.00	Non-resident fishermen - $25.00
Gear	None	Channel Net - $5.00	None	None
Taxes on Catch	$0.15/100 lbs., heads off $0.10/lb., heads on	None	None	None
License Period	January 1 - December 31	July 1 - June 30	April 1 - March 31	July 1 - June 30
Miscellaneous		Captain License (trawler) $5.00	Additional license fee for non-resident vessels $25.00 + home state non-resident fee in excess of $25.00	Additional license for non-resident vessels - $50.00

Table 7.2 Summary of shrimp management laws and regulations, southeastern Atlantic states.

LAWS OR REGULATORY MEASURES	NORTH CAROLINA	SOUTH CAROLINA	GEORGIA	FLORIDA
I. Restrictions on Gear or Method				
A. General	Stop Netting Illegal	Stop Netting Illegal	Stop Netting Illegal	Stop Netting Illegal
B. Mesh Size, Minimum	Shrimp nets - 1 1/2" stretched mesh. Channel nets and seines 1 1/4" stretched mesh	Seines - 1" stretched. Channel nets - 2" stretched	No provisions	No statewide provisions
C. Net Restrictions				
(1) Channel Nets	Legal, most areas (120' max. width)	Legal, by permit (80' max. width)	No provisions - illegal, inside waters	No provisions, illegal in most inside waters
(2) Seines	Legal, all waters (No max. size, commercial)	Legal, all waters year-round (40' max. length)	Illegal, inside waters; legal, public beaches	Legal only in certain areas with size restrictions
(3) Cast Nets	Legal, all waters	Legal, all waters year-round	Legal, all waters year-round	Legal in most inside waters; size restrictions in some areas
(4) Dip or Drop Nets	Legal, all waters	Legal all waters year-round	No provisions	Legal in most areas
(5) Butterfly, Float Nets	Permit required	No provisions	No provisions	No provisions
(6) Shrimp Trawls	Legal in open areas (no restrictions, except mesh size)	Legal in open areas (no size restrictions)	Legal in open areas (size limit on bait trawls)	Legal in open areas, (no size limits generally)

Table 7.2 (Continued)

LAWS OR REGULATORY MEASURES	NORTH CAROLINA	SOUTH CAROLINA	GEORGIA	FLORIDA
II. Trawling Season(s)	Set by Director and Commissioner, based on shrimp size	Offshore - May 15 - Dec. 31, Sounds - Aug. 15 - Dec. 15 (Commission may open or close any area by discretion)	Offshore - Jun. 1- Dec. 31, Sounds - Sept. 1 - Dec. 31 (Director may close any area based on shrimp count)	Set by Marine Resources Division based on shrimp count sampling
III. Trawling Areas, Legal	Specified by Regulation (legal in offshore waters, most inside waters)	Six major sounds and offshore waters only	Sounds and offshore waters only	Specific area designated as sanctuaries closed permanently to trawling
IV. Shrimp Count Law (Minimum)	No provisions	No provisions	45/lb. heads on	70/lb. heads off
V. Bait Shrimp Trawling	No specific provisions for bait shrimping	No specific provisions; illegal in restricted areas (nursery areas), with trawl	Legal in most waters. Recreational - 10' trawl max. Commercial- 20' trawl max. only by qualified dealers	Legal in most waters, under restrictions and permit requirements. Push nets legal in some areas.
VI. Other	Trawling prohibited 8 P.M. Saturday to 8 P.M. Sunday	Night trawling illegal, Sept. 15 - Dec. 31	Night trawling illegal; sounds closed 8 P.M. Saturday to 5 A.M. Monday	Night shrimping unlawful except during June - August

SECTION 8

THE SOUTHEAST SHRIMP FISHERY: ONGOING AND PROJECTED RESEARCH AND MONITORING

by

Peter J. Eldridge
Marine Resources Research Institute

A number of research projects concerning various aspects of the shrimp fishery of the southeastern United States are currently underway. This section lists some of the more relevant projects that have come to our attention. Further information on these projects can be obtained by contacting the principal investigators.

8.1 Sea Grant Program

8.1.1 North Carolina

8.1.1.1 The effects of construction and operation of a nuclear power plant on the ecology of the Cape Fear River estuary, Dutchman Creek estuary, Waldon Creek estuary, and the ocean off Oak Island, North Carolina. B. J. Copeland, North Carolina State University, Raleigh.

8.1.1.2 Nutrients and eutrophication in North Carolina estuaries. J. E. Hobbie and B. J. Copeland, North Carolina State University, Raleigh.

8.1.1.3 The effects of mosquito ditching on natural shrimp and crab populations in the marsh. Edward Kuenzler, University of North Carolina, Chapel Hill.

8.1.1.4 Effects of trawling on shrimp nursery grounds. Annette Pittman, University of North Carolina, Wilmington.

8.1.1.5 Anadromous fish and larger invertebrates in the lower

Cape Fear estuary. F. J. Schwartz, Institute of Marine Sciences, University of North Carolina, Morehead City.

8.1.2 South Carolina

8.1.2.1 A study of laws relating to the utilization of South Carolina's marine resources. J. E. Montgomery, University of South Carolina, Columbia.

8.1.2.2 Assessment of labor availability for fisheries industries in South Carolina coastal counties. Cliff Patrick, Clemson University, Clemson, and John McAlhany, The Citadel, Charleston.

8.1.2.3 Shrimp heads as a source of flavoring and chemotrophic components. L. W. Stillway, Medical University of South Carolina, Charleston.

8.1.2.4 Compatibility of industry-labor requirements and labor characteristics in two counties. C. G. Williams and J. M. Marr, University of South Carolina, Columbia.

8.1.3 Georgia

8.1.3.1 Recovery and utilization of by-products from shellfish processing wastes. W. A. Bough, University of Georgia, Athens.

8.1.3.2 An evaluation of shrimp by-product meal as an ingredient in poultry feeds. O. W. Charles, University of Georgia, Athens.

8.1.3.3 Economic and financial alternatives for handling shellfish processing wastes. R. M. North, University of Georgia, Athens.

8.1.3.4 Treatment of shellfish processing wastewaters. Frederick Pohland, Georgia Institute of Technology, Atlanta.

8.1.4 Florida

8.1.4.1 Storage qualities of rock shrimp. Jack Koburger, University of Florida, Gainesville.

8.1.4.2 The Florida shrimp processing industry: Economic structure and marketing channels. F. J. Prochaska, University of Florida, Gainesville.

8.1.4.3 Economics and management. Charles Rockwood, Florida State University, Tallahassee.

8.2 Coastal Plains Program

8.2.1 North Carolina

8.2.1.1 Direct technical assistance to commercial shrimp fishermen in the design, rigging, and gear handling techniques of the four-net (twin-trawl) shrimp trawling method. Staff, Marine Advisory Program, School of Engineering, North Carolina State University, New Bern.

8.2.1.2 Insulation of ice bunkers and fish holds of older fishing vessels. Staff, Marine Advisory Program, School of Engineering, North Carolina State University, New Bern.

8.2.1.3 Four-net (twin-trawl) shrimp trawling gear. Staff, Marine Advisory Program, School of Engineering, North Carolina State University, New Bern.

8.2.2 South Carolina

8.2.2.1 Economic analysis of the South Carolina seafood industry.

E. A. Laurent, South Carolina Wildlife and Marine Resources Department, Columbia.

8.2.2.2 Environmental base line study of South Carolina estuaries. M. H. Shealy, Jr., South Carolina Wildlife and Marine Resources Department, Charleston.

8.2.2.3 Description and ecology of decapod crustacean larvae of the shelf waters off North Carolina, South Carolina, Georgia, and northeast Florida. P. A. Sandifer, South Carolina Wildlife and Marine Resources Department, Charleston.

8.2.3 Georgia

8.2.3.1 Assessment of Georgia's shrimp and crab fishery resources. D. H. Gould, Georgia Department of Natural Resources, Brunswick.

8.2.3.2 Crewman training: (1) Shrimp fishing; (2) net repair; (3) fishing techniques. D. L. Harrington, James Higgins, Jack Rivers, and James Whitted, Marine Fisheries Extension Program, University of Georgia, Brunswick.

8.2.3.3 Exploratory fishing: (1) Shrimp; (2) fish. D. L. Harrington, James Higgins, Jack Rivers, and James Whitted, Marine Fisheries Extension Program, University of Georgia, Brunswick.

8.2.3.4 Processing and utilization of fisheries resources in Georgia. R. T. Toledo, University of Georgia, Athens.

8.3 MARMAP Program

8.3.1 Offshore bottom trawl survey of marine resources from Cape Fear,

North Carolina, to Cape Canaveral, Florida. Charles Barans, South Carolina Wildlife and Marine Resources Department, Charleston.

8.3.2 Survey of the incidental catch of shrimp trawlers in South Carolina. P. J. Eldridge, South Carolina Wildlife and Marine Resources Department, Charleston.

8.4 State-Federal Program, National Marine Fisheries Service

8.4.1 The shrimp fishery of the southeastern United States: A management planning profile. South Atlantic Technical Committee for Shrimp Management, E. B. Joseph, Chairman, South Carolina Wildlife and Marine Resources Department, Charleston.

8.4.2 Documentation and analysis of present data acquisition and management systems of the shrimp fishery of the South Atlantic states. South Atlantic Technical Committee for Shrimp Management, E. B. Joseph, Chairman, South Carolina Wildlife and Marine Resources Department, Charleston.

8.4.3 Design of a catch and effort statistics program for the shrimp fishery of the South Atlantic states. South Atlantic Technical Committee for Shrimp Management, E. B. Joseph, Chairman, South Carolina Wildlife and Marine Resources Department, Charleston.

8.4.4 Survey of larval Penaeus spp. along the southeastern United States: An attempt to identify spawning grounds of the brown shrimp, P. a. aztecus. South Atlantic Technical Committee for Shrimp Management, E. B. Joseph, Chairman, South Carolina Wildlife and Marine Resources Department, Charleston.

8.5 Other Programs

Fisheries management agencies in the four states, namely the North Carolina Department of Natural and Economic Resources, the South Carolina Wildlife and Marine Resources Department, the Georgia Department of Natural Resources, and the Florida Department of Natural Resources, continually monitor the commercial fishery for shrimp. Surveys are also conducted by these agencies to determine the abundance, size, and migration habits of commercial penaeids. In addition, the Florida Department of Natural Resources is conducting an extensive study of the rock shrimp, Sicyonia brevirostris, a species of increasing commercial significance.

In addition to efforts by state management agencies, students at colleges and universities in the region conduct thesis research concerning the shrimp resource from time to time. A recent example is the masters thesis of Jose Alvarez of the University of Florida entitled "The Florida shrimp processing industry: Economic structure and marketing channels".

SECTION 9

THE SOUTHEAST SHRIMP FISHERY: ANNOTATED LIST OF ACTUAL AND POTENTIAL PROBLEMS

by

Staff

Marine Resources Center

9.1 Resource-Related

9.1.1 Controllable variables

9.1.1.1 Habitat alteration and loss - Alteration and loss of habitat has been considerable in the past 25 years (see Section 2.2.3.2), and is likely to continue. Such activities may be significant in decreasing the production of shrimp. Environmental changes due to human activity, such as siltation from dredging and pesticide or heavy metal contamination, could be examined on a case-by-case basis to determine possible ways of eliminating or preventing the recurrence of a particular factor or factors.

Effective coastal zone management is needed so that the development of coastal areas can be supervised, thereby ensuring that adverse environmental effects are minimized. Further, effective enforcement of current state and federal regulations is needed.

9.1.1.2 Protection of juvenile stages - Protection of juveniles is partly a problem of proper coastal zone management (see Section 9.1.1.1). Juveniles are protected in the

bays and sounds by the opening and closing of seasons, and by prohibiting any fishing activities in certain areas known to be important nursery grounds. While attempts are made to protect juveniles in nursery grounds, the success of these efforts is uncertain largely because of insufficient information on growth and mortality rates. However, the industry generally supports such efforts as good conservation policy. Problems often arise when the fishery for one species adversely affects the juveniles of another (see Section 9.1.1.4). Injudicious use of pesticides and other chemicals could be a management problem, particularly when used directly in the coastal zone.

9.1.1.3 Protection of Spawning Stock - Pink and brown shrimp spawning stocks are unexploited; their spawning grounds are largely unknown. If such grounds are located offshore beyond the 3-mile limit, state management agencies at present would not have jurisdiction to protect the spawning stocks, should protection be necessary. Such stocks could be protected through an appropriate state-federal fisheries management program.

Spawning populations of white shrimp are currently exploited. The fishery on these stocks within the 3-mile limit is presently controlled by regulating the open season.

9.1.1.4 Exploitation of mixed penaeid populations - In some

areas, the fishery for one species has an adverse effect on juveniles of another. In North Carolina, management officials are faced with a problem of deciding when to prohibit fishing for pink shrimp to protect juvenile brown shrimp. Presently, seasons for pink shrimp are closed temporarily in the hope of increasing the economic yield of brown shrimp. However, it is difficult to document the benefits of such a policy. Similar problems occur in protecting brown shrimp juveniles during the fishery for white shrimp in South Carolina and Georgia.

Options available for coping with the exploitation of mixed penaeid populations include: (1) regulating the seasons of capture; (2) development of gear selective for one species, allowing escapement of others, (3) prohibiting any trawling in nursery grounds and other areas where excessive mortality of juveniles may occur.

9.1.2 Non-controllable variables

9.1.2.1 Mass mortalities - This problem directly affects biological supply and the economics of the industry. Management agencies can normally do little else than work with industry to seek possible causes and predict the impact of such mortalities on future production of shrimp.

9.1.2.2 Diseases - Diseases may either reduce the acceptability of shrimp or actually lower shrimp supplies through mortality. As with mass mortalities, little can normally be done by management agencies other than attempting to

determine the cause, incidence, and possible impact of the disease on shrimp populations.

9.1.2.3 Environmental factors - Such factors present problems over which management agencies have little control, unless they are man-induced. Rates of survival in nursery grounds are probably highly variable and depend to a large extent upon weather conditions. The impact of natural phenomena can be studied to determine the possible influences on shrimp. For example, a correlation has been noted in Florida between the incidence of red tide one year and abundances of shrimp and blue crabs the following year.

9.1.3 Information gaps

9.1.3.1 Definition of adequate parental stock size - Adequate parental stock size for brown and pink shrimp cannot be defined until the spawning grounds of these species are located. Since we do not know the parent-progeny relationship in white shrimp, the spawning stocks of which are exploited, problems exist in establishing when the season should be opened on roe shrimp, and documenting whether the autumn fishery is adversely affected by the spring roe shrimp fishery.

Good catch and effort statistics would be of considerable value in establishing adequate parental stock size.

9.1.3.2 Natural and fishing mortality rates of commercial shrimp -

A major problem for any fishery is determining the rate of fishing that will maximize yield. Because neither natural nor fishing mortality rates for shrimp on this coast are well established, managers must subjectively select those sizes of shrimp to be exploited.

An adequate catch and effort statistics program would facilitate determining natural and fishing mortality rates which would aid managers in determining better yield strategies.

9.1.3.3 Age and growth determinations - Methods of aging shrimp with any degree of precision are presently lacking, although a size-age conversion for pink shrimp has been developed (see Section 2.2.2). Until age can be more precisely determined, various estimates of growth remain approximations. Insufficient information concerning growth is a definite problem in yield-per-recruit analysis. The lack of knowledge concerning survival rates also makes it difficult for management to predict supply, thus increasing the risk for industry.

9.1.3.4 Characterization of overwintering patterns - Annual assessments of overwintering populations of white shrimp in South Carolina, Georgia, and Florida would facilitate predictions concerning the size of the spring fishery. Without such knowledge, it is difficult for managers to decide when the fishing season should be opened, and for industry to make wise investment decisions.

Overwintering patterns of pink shrimp in North Carolina are documented. Brown shrimp overwinter somewhere offshore and it would be both difficult and expensive to determine their overwintering patterns.

9.1.3.5 Spawning grounds of white, brown, and pink shrimp - Spawning grounds of brown and pink shrimp are not known, but both species probably spawn beyond the 3-mile limit. None of the states has jurisdiction to control fishing on such grounds, were they to be located.

White shrimp spawning grounds are at least generally known, and exploitation of spawners can be partially controlled within existing jurisdictional limits of each state.

9.1.3.6 Emigration - A knowledge of emigration rates is needed to facilitate estimates of both fishing and natural mortality rates. Problems arise in determining emigration of brown and pink shrimp in particular because these species move to non-fishing areas where recoveries are not made. While white shrimp migrate north and south, precise estimates of emigration are difficult without adequate catch and effort statistics.

Emigration of pre-adults into fishing areas, particularly in response to environmental factors such as heavy rains, may result in the harvesting of a majority of the population before the individuals reach optimal size. A possible solution to this problem would be to monitor

the relative abundance of pre-adults in both nursery and fishing grounds, and to regulate the fishery in accordance with optimum size.

9.1.3.7 Distribution and recruitment patterns of larvae and postlarvae - Although recruitment patterns of larvae and postlarvae might be inferred if current patterns were better known, it would be very difficult to locate where these stages originated because specimens from different areas cannot be discriminated. Clarification of this problem would require expensive ship time and should be assigned a relatively low priority level.

9.2 Industry-Related

9.2.1 Gear competition

9.2.1.1 Commercial vs. commercial - Such problems involve competition among shrimpers utilizing different harvesting techniques. For example, in South Carolina there is a controversy between users of fixed gear (channel or set nets) and moving gear (trawlers). Friction has also arisen between bait shrimp fishermen and commercial shrimpers (see Section 3.4). In addition to competition among shrimp fishermen, there may be competition between shrimpers and other types of fishermen such as crabbers.

Such competition may be reduced by establishment and enforcement of improved management policies.

9.2.1.2 Commercial vs. recreational - This is largely an allocation of resource problem; some commercial fishermen view the

recreational fishery as detrimental to their livelihood. With the possible exception of the St. Johns River, Florida, and the sounds of North Carolina, where large numbers of shrimp licenses are sold, actual gear and space competition between commercial and recreational shrimping does not appear to be a major problem at this time.

9.2.2 Space competition - Dredging operations, shipping, and artificial reefs may present space competition for shrimpers. The possible development of offshore oil rigs and deep water ports in offshore fishing grounds presents potential for space problems.

Captains of small shrimp boats, who traditionally fish the bays and sounds, may be irritated by the presence of large boats when the latter move in to fish in such grounds. Space competition occasionally arises between shrimpers and crab pot fishermen in the bays and sounds.

9.2.3 Out-of-state entry - Problems arising from out-of-state entry include (1) in-state resentment against out-of-state boats; (2) competition for fuel resources; (3) crowding of dock facilities, which tends to disrupt business activities and may cause problems in the public health sector by taxing local facilities for waste disposal; (4) potential law enforcement difficulties because of lack of familiarity with state laws; (5) complication of management activities, when agencies do not know the number of vessels to be concentrated in an area to be opened; (6) the introduction of a source of error in catch and effort statistics when shrimp are caught in one state and landed in another.

9.2.4 Foreign vessel entry and competition - This does not presently constitute a problem to the southeast shrimp fishery. With the exception of the developing fishery for rock shrimp, shrimping on this section of the coast is confined to near-shore waters, and under maritime law foreign vessels are prohibited from fishing within the 12-mile limit.

9.2.5 Bait shrimp fishery - Commercial fishermen in some areas oppose bait shrimp fishing because (1) they oppose the harvesting of large numbers of small shrimp for bait; (2) destruction of nursery ground habitat has been alleged in some cases; (3) bait shrimp are occasionally sold for human consumption (see Section 3.4). Despite these criticisms, bait shrimp are particularly valuable to recreational fishermen, and command a good price for bait dealers.

9.2.6 Fluctuations in supply - Fluctuations in the supply of shrimp occur both seasonally and from year to year. Immediate problems arise for the primary harvesters, the dock dealers, and others whose income depends upon a supply of shrimp when supplies fluctuate markedly. Fluctuation in biological production is largely an uncontrollable variable, although management agencies or extension personnel can advise the industry of predicted supply and its potential impact on prices. The price structure is also influenced by imports and exports of shrimp, which also vary. Distribution of dockside landings could be more evenly allocated throughout a calendar year to consumers if adequate cold storage facilities were developed by the industry.

9.2.7 Recreational fishery - Recreational shrimping will probably continue to increase in popularity and may or may not have an impact on commercial landings depending upon the natural mortality rates of shrimp. Recreational and commercial fishing for shrimp can apparently coexist, although management of the recreational fishery may be necessary in the future.

9.2.8 Availability of shore-side facilities - From an economic viewpoint it is essential to have adequate dock space and supply facilities in areas within reasonable distance of the fishing grounds. Dock and supply facilities, as well as storage space and adequacy of local processing all appear to be rather limited in most areas of the southeast.

A progressive step toward improvement of shore-side facilities was recently undertaken in North Carolina. Known as the Wanchese Harbor Project, a thoroughly outfitted major fishing port was constructed on state ports authority land, with facilities being leased on a long-term basis from the ports authority.

9.2.9 Utilization or elimination of incidental catch - The occurrence of species other than shrimp in the catch is generally regarded as a problem because of the time and effort necessary to pick out the shrimp. Disposal of dead fish, crabs, jellyfish, etc. may be a problem, particularly near beaches or in harbors. Theoretically, gear can be constructed to minimize incidental catch. For example, deflectors or slits in trawl nets may be significant in reducing the catch of "jellyballs" (Stomolophus meleagris). However, the incidental catch probably represents a missed opportunity as much as it does a problem. Fish, including large numbers

of sciaenids, are taken by the gear presently in use, and the Japanese are currently interested in exploring the possibility of using these fish for food.

A potential problem exists that the abundance of one or more finfish species of recreational or commercial value may be adversely affected. This could provoke a confrontation between shrimpers and other fishermen.

Management can reveal to the industry available information on stocks of potential importance and recommend how these might be utilized. Management might also work with state agencies or processors to initiate utilization of potentially valuable species.

9.2.10 Waste disposal - This is a problem for the vessels, and especially for the dockside dealers. Waste disposal regulations at present are largely in the form of guidelines. A number of agencies are currently establishing standards relating to waste disposal; industry will be required to comply with these. Management agencies should participate by seeking involvement in the setting of these regulations.

9.2.11 Product inspection - This is an industry problem; prices to the fishermen are not related to the price incentive system except at the extremes of good versus poor quality. A price incentive system could be recommended, but it would be the responsibility of industry to implement it.

9.2.12 Entry to and exit from industry - At present the productivity of each vessel is quite low due to the large number of units in the fishery, and only the high price of shrimp enables many vessels

to operate at a profit. It is easier to enter the shrimp industry than to leave it; capital once invested in the industry has low salvage value and as a result is fixed. With adequate catch and effort statistics, management agencies could advise individuals as to the potential of the industry. Such statistics would also be a major criterion for any limited entry policy, should such be necessary. Limited entry legislation appears to be a trend, and pressures may increase on management agencies of the southeast to recommend such legislation.

9.2.13 Effective law enforcement - Industry rightfully expects management agencies to effectively enforce laws regulating the fishery. Effective law enforcement is a problem because the various law enforcement agencies are understaffed and constrained by a lack of funds. Law enforcement personnel do the best possible job with the resources at their disposal, but additional personnel, equipment, and aircraft, would increase their effectiveness.

9.2.14 Inadequate navigational aids and underwater obstructions - These constitute definite hazards to personnel and property in some areas. The solution appears to be adequate budgeting for Coast Guard maintenance and surveillance.

9.2.15 Rate of return on investment - This is a problem closely tied to entry (see Section 9.2.12) and the economy. Theoretically, limited entry would be one way to improve or stabilize the rate of return on investment. Studies are needed to determine rig effectiveness and the most economical operating procedures.

9.2.16 Labor market - Low wages and seasonal employment result in a

shortage of labor, particularly of strikers. Frequent personnel changes also decrease operating efficiency of a crew.

9.2.17 Effective market utilization - There is a need, particularly in North and South Carolina, to identify and effectively utilize alternative markets, and to improve existing markets.

9.2.18 Cost and availability of insurance - The availability and cost of insurance is a definite problem to the shrimp fisherman. The major problem relating to hull insurance is obtaining coverage on a used boat at a reasonable premium, particularly for an older vessel. Property and indemnity insurance is so expensive that a large percentage of the owners cannot afford to carry it.

A potential solution would be a cooperative effort on the part of shrimpers to seek group policies at reduced rates.

9.2.19 Seasonal aspects of the fishery - This adversely affects (1) the rate of return on investment, since capital is tied up in idle equipment for a portion of the year; (2) marketing, particularly of the incidental catch; (3) labor, since help may be unemployed for part of the year.

Shrimpers can and do participate in other fisheries during the off-season (see Section 3.6). Management can work with the fishermen to recommend potential alternative fisheries.

9.2.20 Availability and cost of fuel - The cost of fuel has doubled over the past year and is now a major influence in the rate of return on investment; long-term availability of fuel represents a potential problem.

Fishermen might consider forming a fuel cooperative, and

make their needs known to appropriate agencies such as the Federal Energy Office and the National Marine Fisheries Service.

9.2.21 General lack of economic information - As noted in Section 4, there is a paucity of information and data on the economics of the southeastern shrimp fishery. Such information is particularly lacking for the market above the harvester level.

9.3 Institutional problems

9.3.1 Jurisdictional problems - While both federal and state agencies lack adequate management authority outside the 3-mile limit, this has little impact on the contemporary shrimp fishery of the southeast, which is conducted in near-shore waters. States have jurisdiction over the fishery within the 3-mile limit. However, problems frequently arise because each of the four states in the region has its own set of laws and regulations. In addition, a sizeable fishery for rock shrimp (Sicyonia brevirostris) has developed in Florida beyond the 3-mile limit.

9.3.2 Federal, state, and local regulations - Differing laws and regulations at three levels of government represent a problem for both industry and management. It adds to the administrative workload on industry and especially on the dealers, who sometimes must file reports to federal, state, and local agencies. Such problems tend to create poor rapport between industry and management.

Changes to improve the existing system could be proposed to the legislatures by management agencies. A State-Federal Shrimp Management Program would offer the potential for better management of the fishery from a regional approach.

9.3.3 Common property nature of resource - Fishermen have no ownership rights over the shrimp resource of the South Atlantic region and entry to the fishery is unlimited. Consequently, investment in vessels and equipment has now exceeded an optimal level. Increased operating costs and lower prices for shrimp during 1974 have caused severe economic stress on the harvesting sector of the industry over the entire region.

9.3.4 Effective industry organization - The lack of a cohesive organization weakens the influence of the shrimp industry in matters of importance to it. Without effective organization it is difficult for management to ascertain who speaks for the industry. Strong organization would enable industry to better recognize the causes of specific problems, and facilitate resolving these problems.

9.3.5 Federal unemployment taxes applied to fishermen - This is perceived as a problem by some vessel owners and shrimp dealers who must hire labor. The federal government has jurisdiction over this area, and industry must comply with existing regulations.

9.3.6 Improving catch and effort statistics - Adequate catch and effort statistics are needed to (1) monitor biological and economic trends in the fishery; (2) document changes in the efficiency of vessels and gear; (3) estimate fishing and natural mortality rates; (4) evaluate such management decisions as the opening of bays and sounds; (5) estimate the abundance of roe shrimp.

Improving catch and effort statistics is a high priority item

of the State-Federal Shrimp Management Program. Plans are being made to design, test, and eventually implement a regional catch and effort statistics program.

9.3.7 Imports of shrimp - Shrimp imports have primarily had a negative effect on the price structure of domestic shrimp, particularly within the past three to five years.

State agencies have no jurisdiction over international trade, but they could recommend to appropriate federal agencies that the quality of imports be equal to that of the domestic supply.

9.3.8 Extension, education, and training activities - American agriculture has progressed well with a strong background of extension activities leading it forward. A parallel effort is needed in the shrimp fishery of the southeastern United States to assist in marketing, improving product quality, developing technology, and encouraging offseason fisheries.

Some progress in these services has been made; improving them is a matter of improved budgeting.

SECTION 10

SUMMARY AND CONCLUSIONS

by

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This report embodies the first of a two-part study designed to provide a management planning profile of the shrimp industry of the southeastern United States, including a plan for improved management on a regional basis. The purpose of this phase of the study was to summarize the past and present state of both the resource and the fishery dependent upon that resource. This report seeks to identify the most important problems facing the resource and the fishery, and to differentiate between those which are at least potentially amenable to solution and those over which man has no control or those which are beyond the scope of regional management to solve. The second phase of the study, currently in progress, will establish a course of action leading to improved regional management. Publication of the second phase is projected for early 1975.

Section 2 of this report provides a brief summary of biological information on the three major species upon which the shrimp fishery of the region is based - the white shrimp (Penaeus setiferus), the brown shrimp (P. aztecus aztecus), and the pink shrimp (P. duorarum duorarum). Literature dealing with these three species is voluminous and it was not our intent to provide an exhaustive review. Instead, the relatively recent species synopses in FAO Fisheries Reports were used as a starting point; these summaries were updated with the more recent literature. Where several papers dealt with the same topic, only the more definitive, in our judgment, was included. The rapidly developing literature dealing with shrimp aquaculture contains much information that advances knowledge of the basic biology of these crustaceans. Nevertheless, such literature was deliberately excluded as being outside the scope of the

present study.

Much is still to be learned despite the magnitude of the available literature. Many knowledge gaps are noted, paragraph by paragraph, but some are sufficiently critical to the management process that they deserve mention here. Present lack of information concerning the population dynamics of all three species is of especial importance. This gap is expressed in such parameters as parent-progeny relationships, pre-recruit survival-mortality rates, and fishing and natural mortality rates of fishable stocks. In the area of general life history, a lack of information exists on definition of spawning stocks; even the spawning sites of brown and pink shrimp are virtually unknown.

The evolution of vessels and gear utilized in the harvesting sector is outlined in Section 3, along with a brief examination of the recreational and bait shrimp fisheries. This section provides insight into such current industry problems as the seasonal aspects of the fishery and gear competition.

An economic description of the industry is provided in Section 4; the paucity of information and lack of attention that this aspect of the fishery has received is emphasized. Fisheries economics is beginning to receive the attention it deserves, and if this profile were being developed just a few years in the future a much more thorough summary could undoubtedly be written.

Despite the limited attention that the economics of the shrimp industry has received, a number of problems surface that deserve future consideration. The extreme fragmentation existing in the harvesting sector and the awkward marketing channels that exist are readily evident. In addition, market conditions can change very rapidly. Recent years have seen an apparently insatiable market demand, accompanied by gradually increasing prices. Yet, while this section is being written, the industry is suddenly faced with a glutted

market and depressed prices at a time when operating costs have increased markedly. While this probably represents a very short-term problem caused by changes in international trade and currency shifts, the economic stress on the industry is serious and the problem must receive careful attention in the future.

The authors of Section 5 have provided a review of available catch records from 1880 to 1973. Data were analyzed for trends by species and total catch on an individual state and regional basis. A point of critical importance is the significant decline in white shrimp production that occurred sometime between 1940-1950. Evaluation of changes in the abundances of brown and pink shrimp over the same interval is complicated in that market acceptance for these species was not great before 1945, and landings prior to that time had little relationship to abundance. Changes in the distribution of landings among states, particularly between Florida and the other states, are apparent. Such changes are believed to reflect changes in seasons and patterns of fishing rather than large-scale environmental changes. The apparent stability of total landings for the region from 1955 to the present is considered particularly significant. Although catches by species have fluctuated rather dramatically, the combined catch of white, brown, and pink shrimp for the region has been remarkably consistent at about 25,000,000 pounds, round weight. This stability must be interpreted in light of constantly increasing demand, gradually increasing prices, and increasing modernization of the shrimp fleet throughout the period. While fishing effort has probably increased significantly during the years since 1955, effort data are so inadequate that it is impossible to document such changes. The continuing inadequacy of catch and effort data is a

recurrent theme throughout the entire profile.

From a discussion of yield strategies in Section 6 it appears that the fishery for penaeid shrimp in the South Atlantic region does not meet most of the criteria or assumptions generally considered essential for the application of a maximum sustainable yield (MSY) concept. Present management techniques are largely based upon a best yield-per-recruit strategy. Lack of knowledge concerning mortality rates currently precludes a refined application of this technique. Nevertheless, yield-per-recruit models probably hold the best hope for future management strategies. Economic yield strategies will probably be difficult to apply effectively on a single state or even a regional basis so long as world market and monetary conditions play as dramatic a role as they do at present.

Current laws and regulations pertaining to the shrimp fishery of the four states are summarized in Section 7. While existing regulations are far from identical among the four states, they are generally parallel in most aspects. However, several elements of existing law in one or more states would provide barriers to regional management without some change. For example, North Carolina and Georgia have provisions permitting reciprocal agreements with other states, yet this means relatively little when the intervening State of South Carolina does not. The only state in the South Atlantic region presently having legislation that would seem to permit adoption of limited entry in some form is Georgia. All four states are members of the Atlantic States Marine Fisheries Commission, but they have not all adopted amendment one to the compact that permits interstate agreement without specific congressional approval.

That many of the laws in the four states differ in detail is not considered

a major impediment to future regional management. Regional management does not imply or require uniform regulation over the entire region. This is especially true for a fishery that can perhaps best be managed on a yield-per-recruit basis, which by its very nature requires much adjustment to local conditions.

Section 8 briefly reviews ongoing research and monitoring pertinent to penaeid stocks and fisheries of the four-state region. Current research on shrimp is at a surprisingly low level both in state and federal agencies and in the universities. This was somewhat unexpected because shrimp represent the most important fishery resource of the southeastern Atlantic states. The low level of ongoing shrimp research is at least partly attributable to the number of individuals with expertise in shrimp biology currently engaged in crustacean aquaculture. More research on natural shrimp populations is probably underway on the Gulf Coast than on the Atlantic; such studies were largely excluded by the geographic scope of this study. Although some of the research being conducted on shrimp in the Gulf may be site-specific, much of it is still applicable to the South Atlantic region.

An annotated list of actual and potential problems is presented in Section 9. These problems were categorized as resource-related, industry-related, and institutional in nature. Because the section is already in summary form, no further condensation is provided here. Many of the problems deserving highest priority attention have already been discussed in other paragraphs of this summary.

This report is being used as background material for a planning effort now underway to organize and develop a systematic methodology for future activities of the South Atlantic Technical Committee for Shrimp Management.

In addition, a study is currently underway to document existing statistical systems in the southeastern shrimp fishery, which will provide background material for a future project to design a catch and effort statistics program for the region. If funds are available, a regional catch and effort statistics program could be implemented as an integral part of a regional management plan for the region should such a program be deemed feasible and desirable by the participating states.