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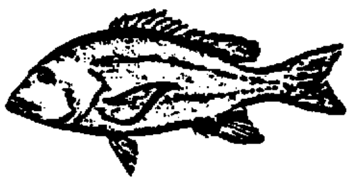
FOR THE
SNAPPER-GROUPER FISHERY
OF THE
SOUTH ATLANTIC REGION

FEBRUARY 1983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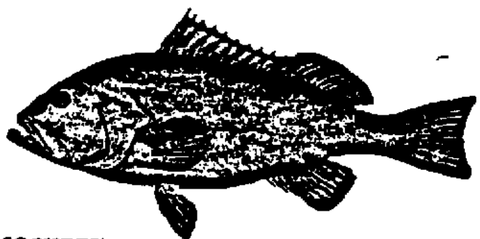
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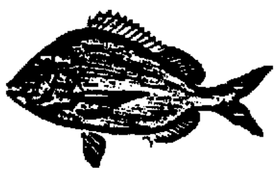
PORGY


BLACK SEA BASS


HOGFISH


GRUNT


TILEFISH

PREPARED BY THE
SOUTH ATLANTIC FISHERY MANAGEMENT COUNCIL
ONE SOUTHPARK CIRCLE, SUITE 306
CHARLESTON, SOUTH CAROLINA 29407

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The description of the fishery for the first version of the Source Document dated November 1981 was prepared by a Plan Development Team (PDT) consisting of the following individuals: Roger Anderson, Gulf and South Atlantic Fisheries Development Foundation, Inc., Tampa, Florida; William Anderson, St. Simons Island, Georgia; David Cupka, South Carolina Marine Resources Research Institute, Charleston, South Carolina; James Easley, P.O. Box 5576, Raleigh, North Carolina; Peter Eldridge, National Marine Fisheries Service, Southeast Fisheries Center, Charleston Laboratory, Charleston, South Carolina; Duane Harris, Georgia Department of Natural Resources, Brunswick, Georgia; Gene Huntsman, National Marine Fisheries Service, Southeast Fisheries Center, Beaufort Laboratory, Beaufort, North Carolina; Charles Manooch, III, National Marine Fisheries Service, Southeast Fisheries Center, Beaufort Laboratory, Beaufort, North Carolina; Martin Moe, Aqua-Life Research Corporation, Marathon Shores, Florida; and Maury Wolff, North Carolina Division of Marine Fisheries, Morehead City, North Carolina

Deborah A. Canavan (B.A., Technical writing) was responsible for coordinating the input from the PDT and had the principal writing responsibility. Jackson Davis (Ph.D., Fishery biology and management) was responsible for development of the first version of the source document.

The present source document was prepared by the South Atlantic Fishery Management Council staff:

Gregg T. Waugh, M.S. Applicable Experience:	 Fishery biology and management Coordinator
Scott Bannerot, M.S. Applicable Experience:	 Fishery biology; population dynamics Consultant
Barbara S. Anderson, B.S. Applicable Experience:	 Biology technician
C. Bruce Austin, Ph.D. Applicable Experience:	 Marine resource economics Plan Monitor
Loretta J. Glatfelter	Typist

In addition to the PDT and council staff, we have received extensive input from Robert Low (Ph.D., Fishery biology and population dynamics). Glenn Ulrich (M.S., Fishery biology, South Carolina Marine Resources Research Institute, Charleston, South Carolina) joined the PDT during 1981 and contributed extensively to the source document.

The FMP is based extensively on yield-per-recruit analyses which required many computer runs and a number of hours spent analyzing the results. We wish to thank Scott Bannerot (M.S., Fishery biology and population dynamics) whose timely employment with the South Atlantic Council allowed us to complete gathering information on the necessary population parameter estimates and complete the computer analyses. The entire computer analysis package (program as well as computer time and assistance) was kindly provided by the NMFS Beaufort Lab. We especially wish to acknowledge the yet unpublished transitional YPR model developed by Jim Waters (M.S., Economics), his extensive programming assistance and time spent performing computer analyses. In addition, Bill Schaaf (Ph.D., Biometrics), Gene Huntsman (Ph.D., Fishery biology, biometrics), and Charles Manooch, III (Ph.D., Fishery biology) provided a great deal of assistance.

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4.0 INTRODUCTION

The Magnuson Fishery Conservation and Management Act of 1976 (MFCMA) provides the U.S. with exclusive management authority over all fisheries except tunas within a fishery conservation zone (FCZ) which extends from the seaward boundary of the states' territorial seas to 200 nautical miles from the baseline from which the territorial sea is measured. The Act established eight Regional Fishery Management Councils and charged them with responsibility for preparing Fishery Management Plans (FMP's) for the fisheries within their geographic areas of jurisdiction. The South Atlantic Fishery Management Council, in accordance with the legislative mandate, is preparing a FMP for the snapper-grouper fishery.

This source document is the background material for the Snapper-Grouper Fishery Management Plan of the South Atlantic Region, containing detailed supportive documentation on which the management regime for the snapper-grouper fishery is based. It was prepared by the South Atlantic Fishery Management Council in compliance with the provisions of the MFCMA. The source document and the fishery management plan are available for review at the following locations:

South Atlantic Fishery Management Council
Southpark Building, Suite 306
1 Southpark Circle
Charleston, South Carolina 29407-4699

National Marine Fisheries Service
Southeast Regional Office
Duval Building, 9450 Koger Boulevard
St. Petersburg, Florida 33702

National Marine Fisheries Service
Southeast Fisheries Center
75 Virginia Beach Drive
Miami, Florida 33149

U.S. Department of Commerce, NOAA
National Marine Fisheries Service
3300 Whitehaven St., N.W.
Washington, D.C. 20235

Definitions of Terms Used

Age liable to capture: Age or size at which fish are first vulnerable to specific fishing gear.

Catch-per-Unit of Effort (CPUE): The total number or weight of fish harvested by a defined unit of fishing effort.

Domestic Annual Harvest (DAH): The amount of fish harvested annually by United States fishermen.

Draft Regulatory Impact Review (DRIR): An assessment of the impacts of proposed government regulations.

Environmental Impact Statement (EIS): Required by the National Environmental Policy Act of 1969 whenever major Federal actions may significantly affect the quality of the environment, including the human environment. A draft (DEIS) and a final (FEIS) environmental impact statement are prepared.

Executive Order 12291 (E.O.): Directs agencies to develop or revise informal rulemaking procedures to ensure that regulations are necessary, appropriate, and cost effective.

Fishery Conservation Zone (FCZ): The area in which the United States asserts exclusive fishery management authority, established and defined by the Magnuson Fishery Conservation and Management Act of 1976: "The inner boundary of the FCZ is a line coterminous with the seaward boundary of each of the coastal states, and the outer boundary of such zone is a line drawn in such a manner that each point on it is 200 nautical miles from the baseline from which the territorial sea is measured."

Fishing Effort: Also fishing pressure; the amount of fishing activity as measured by fishing mortality in yield-per-recruit analyses.

Fishing Mortality (F): Instantaneous rate of fishing mortality calculated in yield-per-recruit analysis is that portion of total mortality attributable to fishing. It is equal to total mortality (Z) minus natural mortality (M). F is the measure of "fishing pressure" for stock assessment and management considerations in the FMP.

Growth Overfishing: The harvesting of a fish stock to the point that the harvest is less than the maximum possible (by weight). Growth overfishing can be controlled by limiting fishing mortality on all size fish (e.g. quotas) and/or by reducing the range of sizes that are liable to capture (impose minimum size limits). Growth overfishing is defined in the FMP as an existing combination of fishing pressure (F) and age liable to capture such that an increase in age liable to capture (minimum size limit) or a decrease in fishing pressure will significantly increase YPR. Growth overfishing is an established scientific definition measured by YPR anlayses but is not considered to be overfishing in the context of National Standard One of MFCMA.

Incidental Catch: The catch of species other than the target species. Also called bycatch.

Internal rate of return (IRR): The discount rate (i) that produces a net present value of zero for a stream of values over a number of years.

Magnuson Fishery Conservation and Management Act (16 U.S.C. 1801 et seq.) (MFCMA): Established the FCZ and eight regional fishery management councils to prepare, monitor, and revise fishery management plans.

Marine Resources Monitoring Assessment and Prediction (MARMAP): A program, initiated by NMFS, that sponsors research on adult fish stocks and ichthyoplankton.

Maximum sustainable yield (MSY): The largest quantity (by weight) of fish that can be harvested annually from a resource without reducing its long-term productive potential.

Maximum Yield-Per-Recruit (YPR): Maximum YPR is equivalent to maximum yield (MY) for the purposes of management which is comparable to MSY if there is constant recruitment.

National Marine Fisheries Service (NMFS): A division of the National Oceanic and Atmospheric Administration, Department of Commerce, responsible for conservation and management of fisheries.

Natural Mortality (M): Instantaneous rate of natural mortality calculated in yield-per-recruit analysis is equal to total mortality (Z) minus fishing mortality (F) or that portion of total mortality attributable to all causes except fishing.

Net present value (NPV): The results of discounting a stream of numbers (v) for a specified number of years (n) by a specific discount rate (i):

$$NPV = \sum_{t=1}^{n} \frac{V_{(t)}}{(1+i)^{t}}$$

Optimum Yield (OY) (defined by MFCMA): "the amount of fish A) which will provide the greatest overall benefit to the Nation, with particular reference to food production and recreational opportunities; and B) which is prescribed as such on the basis of the maximum sustainable yield from such fishery as modified by any relevant economic, social, or ecological factors."

Plan Development Team (PDT): Consists of professionals chosen to gather data and submit recommendations to a Steering Committee for a particular fishery management plan.

Recruitment: Number of fish growing into the smallest harvestable size category each year.

Recruitment overfishing: The harvesting of a stock to the point that reproduction by the remaining brood stock is inadequate to produce as many fish as the habitat can support. Recruitment overfishing is an established scientific definition that is not measured by YPR analyses. Recruitment overfishing is considered to be overfishing in the context of National Standard One of MFCMA.

Regional Director (RD): Southeast Regional Director of the National Marine Fisheries Service.

Secretary: Secretary of Commerce.

Steering Committee: Committee of a regional fishery management council.

Stock: A group of fish manageable as a unit.

Total Allowable Level of Foreign Fishing (TALFF): OY minus DAH.

Total Length (TL): Measurement of a fish, from most anterior tip of the head to most posterior tip of tail which is the measurement length for the minimum size limits in the FMP (see diagram on next page).

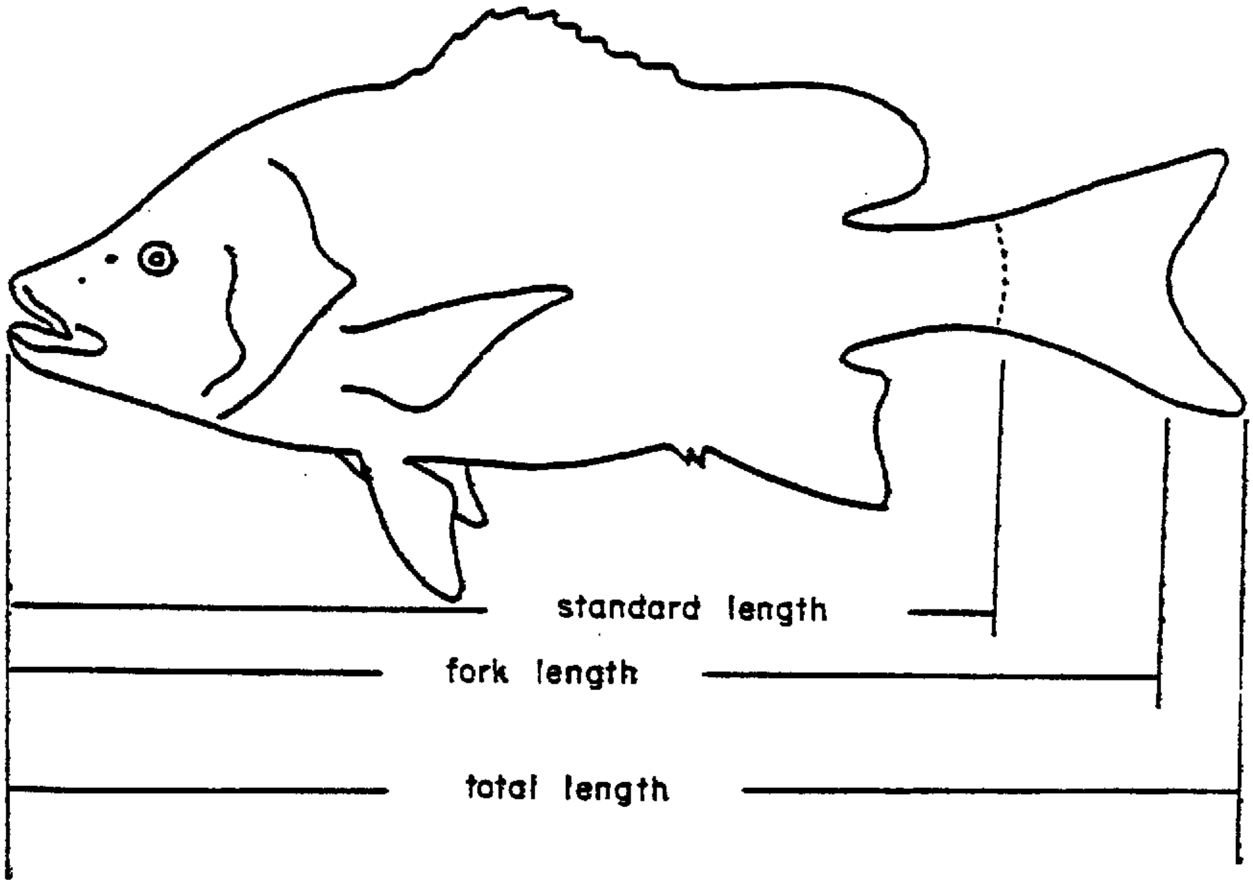

Figure 4-1. Length measurements. All minimum sizes specified in the FMP are measured as total length. (Source: Low and Ulrich, 1982).

Total Mortality (Z): Instantaneous rate of mortality calculated in yield-per-recruit analysis is equal to the sum of natural mortality (M) and fishing mortality (F). Z represents the total instantaneous mortality from both natural causes and fishing.

Yield-per-recruit (YPR): A theoretical calculation based on known growth and natural mortality rates that allows an estimate of relative yield from a fishery without knowing landings. It does not permit a calculation of total landings but it is possible to calculate the relative amount of fishing pressure and landings if recruitment is constant.

A Short Primer on YPR:

Two major approaches exist for the problem of determining yield from a fishery: (1) surplus production models and (2) yield-per-recruit analysis.

Surplus production models are descriptive. They are based on population growth curves that assume the rate of population growth is related to population size and that catch-per-unit effort (CPUE) is a valid index of population size. Catch and effort data are used to derive a yield curve from which maximum sustainable yield (MSY) can be calculated.

The major shortcoming of this approach for management is that only one datum point can be generated each year. Approximately 10 years of data are required which can result in a post-mortem of the fishery by the time enough knowledge exists to implement regulations. Even when historical catch records exist, they are often available for only a portion of the range and there are further problems with the accurate estimation of fishing effort, particularly for recreational fishing.

Yield-per-recruit analysis is based on an analytical rather than a descriptive model. This approach predicts yield according to the growth pattern of individual fish rather than the growth of the entire population. The only prerequisite information is ages of fish at different lengths and natural mortality. Yield is not calculated in terms of total weight per year from the fishery. Instead, an index of yield, rather than an absolute total weight is calculated. This index is called yield-per-recruit.

The advantage of YPR analysis is that it can be a more rapid method of assessment than surplus production modeling and does not require catch-per-unit effort data. It allows a quick assessment of the stock using basic biological information (see diagram on next page).

All mathematical abstractions designed to simulate natural phenomena are at the mercy of their imperfectly met assumptions, and neither of the two approaches is exempt from this imperfection. YPR analysis is not subject to some of the delays imposed by surplus production models but fulfills the basic management task of monitoring the stock and estimating the relative yield from a fishery with different regulations.

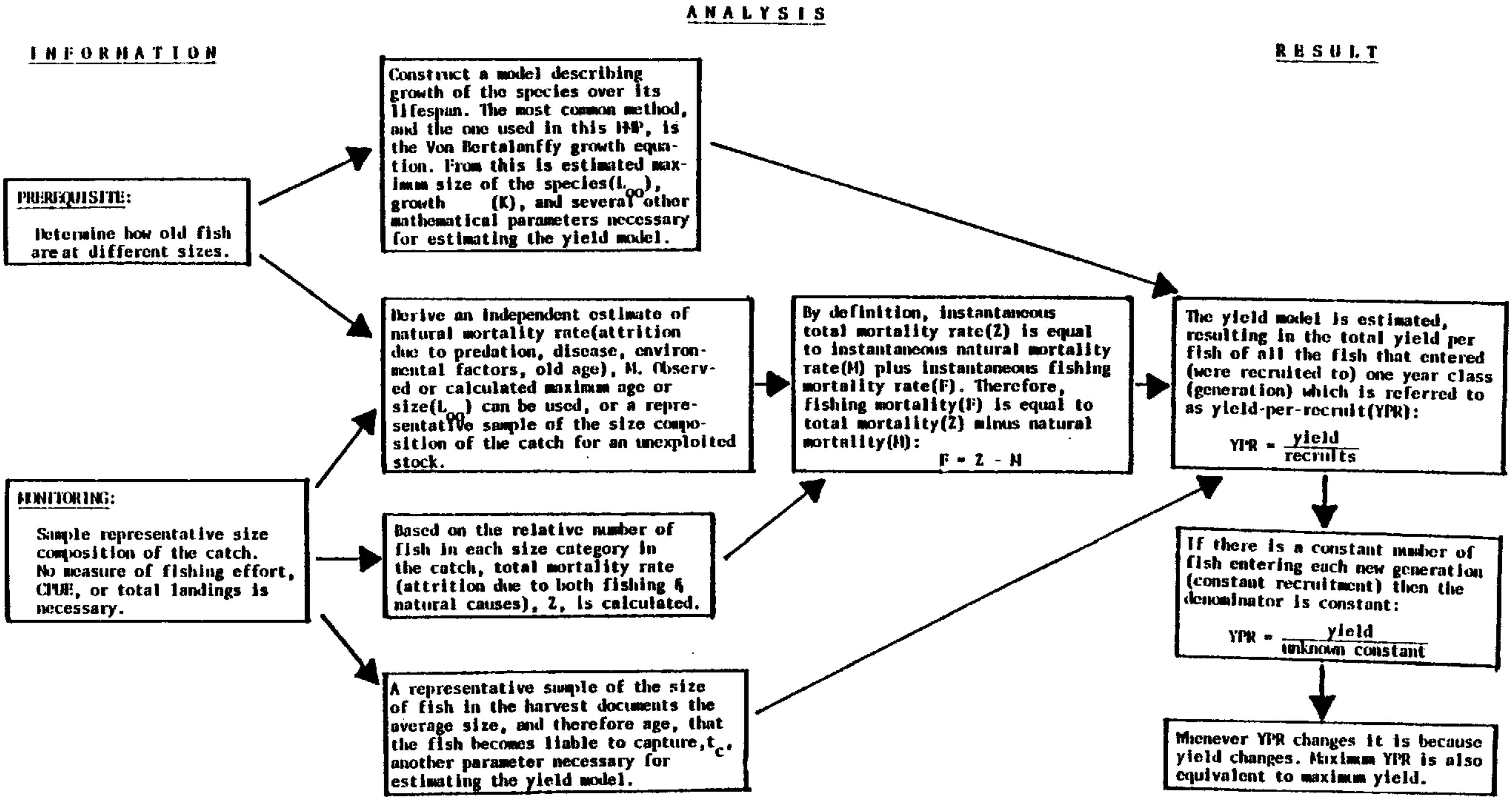

Figure 4-2. Flow chart describing yield-per-recruit analysis.

5.0 THE FISHERY MANAGEMENT UNIT

5.1 Description of the Species

The fish community referred to as the snapper-grouper complex consists of demersal tropical and subtropical species which occupy the same type of habitat and are caught simultaneously by common fishing methods on the continental shelf off the southeastern United States. This complex includes snappers (Lutjanidae), sea basses and groupers (Serranidae), porgies and scup (Sparidae), tilefishes (Malacanthidae), grunts (Pomadasyidae), triggerfishes (Balistidae), wrasses (Labridae), and jacks (Carangidae). A list of the species which comprise the fishery is provided in Table 5-1.

5.1.1 Snappers (Lutjanidae)

Snappers generally have a long triangular face with upper margin sloping more strongly than the lower; jaws are equal or the lower slightly projecting (Randall, 1968). Nearly all species have some enlarged canine teeth on the jaws (Böhlke and Chaplin, 1968). Coloration varies widely between species, but deeper water species tend to be more red (Randall, 1968).

Lutjanus griseus, L. analis, L. apodus, L. synagris, L. cyanopterus, L. mahogoni, and L. jocu are fairly heavily bodied benthic species with slightly notched tails and somewhat large, distinct scales. They inhabit inshore and/or reef areas. Ocyurus chrysurus occur in similar areas but live in midwater and have a yellow mid-lateral stripe ending in a deeply forked tail (Böhlke and Chaplin, 1968; Randall, 1968; Fischer, 1978). Rhomboplites aurorubens, like O. chrysurus, has a more streamlined body than the more benthic snappers; the tail is not as deeply forked as O. chrysurus, but more so than the preceding lutjanids. R. aurorubens generally inhabits deeper water than the others (Böhlke and Chaplin, 1968; Fischer, 1978).

L. buccanella, L. vivanus, and L. campechanus, like R. aurorubens, inhabit deeper offshore areas. They are benthic, morphologically similar to other Lutjanus species and predominately pink or reddish in color (Walls, 1975; Fischer, 1978).

Apsilus dentatus and Etelis oculatus are distinctive deepwater species. A. dentatus is a dusky black color with a violet tinge (Böhlke and Chaplin, 1968; Fischer, 1978). E. oculatus is a uniform reddish color with lighter belly, large red eyes, and a deeply forked tail (Fischer, 1978).

Table 5-1. Common and scientific names of species in the complex.

Common Name [1]	Scientific Name [1]	Additional Common Names in Current or Recent Use in the Region [2]
LUTJANIDAE - Snappers		
Black snapper	Apsilus dentatus	
Queen snapper	Etelis oculatus	
Mutton snapper	Lutjanus analis	Muttonfish, Pargo cebadal
Schoolmaster	Lutjanus apodus	School snapper, Pargo cotorro
Blackfin snapper	Lutjanus buccanella	Hambone snapper
Red snapper	Lutjanus campechanus	American red snapper, Pargo colorado
Cubera snapper	Lutjanus cyanopterus	Cuban snapper
Gray snapper	Lutjanus griseus	Mangrove snapper, Mango snapper Caballerote, Pargo prieto
Mahogany snapper	Lutjanus mahogoni	
Dog snapper	Lutjanus jocu	
Lane snapper	Lutjanus synagris	Spot snapper, Pargo guanapo
Silk snapper	Lutjanus vivanus	Yelloweye snapper, Goldeneye
Yellowtail snapper	Ocyurus chrysurus	Rabirrubia
Vermilion snapper	Rhomboplites aurorubens	Beeliner, B snapper, Mingo snapper
SERRANIDAE - Sea Basses, Groupers		
Bank sea bass	Centropristis ocyurus	Sea bass
Rock sea bass	Centropristis philadelphica	Rock bass
Black sea bass	Centropristis striata	Blackfish
Rock hind	Epinephelus adscensionis	Mero cabrilla
Graysby	Epinephelus cruentatus	
Speckled hind	Epinephelus drummondhayi	Kitty Mitchell, Strawberry grouper
Yellowedge grouper	Epinephelus flavolimbatus	
Coney	Epinephelus fulva	Corruncha
Red hind	Epinephelus guttatus	Strawberry grouper, Tofia
Jewfish	Epinephelus itajara	Giant sea bass, Junefish, Guasa
Red grouper	Epinephelus morio	Deer hamlet, Mero paracamo
Misty grouper	Epinephelus mystacinus	
Warsaw grouper	Epinephelus nigritus	Giant sea bass
Snowy grouper	Epinephelus niveatus	Cherna pintada

Table 5-1 (continued)

Common Name [1]	Scientific Name [1]	Additional Common Names in Current or Recent Use in the Region [2]
Nassau grouper	*Epinephelus striatus*	Nassau Rockfish, Hamlet, Mero Rockfish, Cuna quarei
Black grouper	*Mycteroperca bonaci*	
Yellowmouth grouper	*Mycteroperca interstitialis*	
Gag	*Mycteroperca microlepis*	Black grouper, Grey grouper Cuna garopa
Scamp	*Mycteroperca phenax*	
Tiger grouper	*Mycteroperca tigris*	
Yellowfin grouper	*Mycteroperca venenosa*	
SPARIDAE - Porgies		
Sheepshead	*Archosargus probatocephalus*	Convict fish
Grass porgy	*Calamus arctifrons*	
Jolthead porgy	*Calamus bajonado*	
Saucereye porgy	*Calamus calamus*	
Whitebone porgy	*Calamus leucosteus*	
Knobbed porgy	*Calamus nodosus*	Key West porgy
Red porgy	*Pagrus pagrus*	Silver snapper, Pink snapper, Guerito
Longspine porgy	*Stenotomus caprinus*	
Scup	*Stenotomus chrysops*	
POMADASYIDAE - Grunts		
Black margate	*Anisotremus surinamensis*	
Porkfish	*Anisotremus virginicus*	
Margate	*Haemulon album*	
Tomtate	*Haemulon aurolineatum*	Cuji
Smallmouth grunt	*Haemulon chrysargyreum*	
French grunt	*Haemulon flavolineatum*	
Spanish grunt	*Haemulon macrostomum*	
Cottonwick	*Haemulon melanurum*	
Sailors choice	*Haemulon parrai*	
White grunt	*Haemulon plumieri*	Key West snapper, Key West grunt Corocoro margariteno
Blue striped grunt	*Haemulon sciurus*	

Table 5-1 (continued)

Common Name [1]	Scientific Name [1]	Additional Common Names in Current or Recent Use in the Region [2]
MALACANTHIDAE - Tilefishes		
Blueline tilefish	*Caulolatilus microps*	Paleta, Gray tilefish
Tilefish	*Lopholatilus chamaeleonticeps*	Golden tilefish, Rainbow tilefish Golden snapper
Sand tilefish	*Malacanthus plumieri*	
BALISTIDAE - Triggerfishes		
Gray triggerfish	*Balistes capriscus*	Triggerfish, Leatherjacket, Cachua
Queen triggerfish	*Balistes vetula*	
Ocean triggerfish	*Canthidermis sufflamen*	
LABRIDAE - Wrasses		
Hogfish	*Lachnolaimus maximus*	Hog snapper, Pargo gallo
Puddingwife	*Halichoeres radiatus*	
CARANGIDAE - Jacks		
Yellow jack	*Caranx bartholomaei*	
Blue runner	*Caranx crysos*	
Crevalle jack	*Caranx hippos*	
Bar jack	*Caranx ruber*	
Greater amberjack	*Seriola dumerili*	
Almaco jack	*Seriola rivoliana*	

1/ Source: Robins et al. (1980)
2/ Source: Cervigon (1966)

5.1.2 Sea Basses and Groupers (Serranidae)

Serranids are characterized by a robust body, large mouth with lower jaw often projecting anterior to the upper jaw, bands of slender sharp depressible teeth in the jaws and usually a few stout fixed canines; body scales are small (Randall, 1968; Fischer, 1978). Some species are strikingly colored, others are drab, and many have considerable ability to alter the density of their color to match the bottom; deeper water species tend to have more red (Randall, 1968; Fischer, 1978).

Epinephelus morio and E. striatus have a rather sharply sloping upper head margin in profile. E. morio is one of the most changeable of fishes in color; most commonly it is a uniform dark reddish brown above and lighter below (Fischer, 1978). It may show a banded pattern similar to E. striatus but the latter can be distinguished by a dark dorsal saddle on the caudal peduncle.

E. fulva, E. guttatus, E. adscensionis, and E. cruentatus are small (usually less than 51 cm; 20 in) and covered with dots, which are blue on E. fulva and red on the others. Black dorsal blotches distinguish E. adscensionis from E. guttatus (Böhlke and Chaplin, 1968; Fischer, 1978).

E. cruentatus has a more rounded tail, smaller more closely spaced dots, and three small black on white dorsal spots. E. drummondhayi is another of the smaller speckled groupers. The spots are white on a dark background. E. niveatus is easily recognized by rows of distinct white spots in the juvenile stage; the spots fade in the adult phase, where body color tends to a more uniform golden hue. An enlarged posterior nostril separates E. niveatus from all but E. mystacinus, which displays a dull brownish body color crossed by darker bands (Böhlke and Chaplin, 1968; Fischer, 1978).

E. itajara and E. nigritus are very large (commonly over 90 kg; 200 lb), stout-bodied groupers. E. nigritus is a uniform dark color, occasionally with a few scattered white spots. E. itajara is variably colored, usually in black or brown. Adults are covered with numerous distinct black spots on head, body, and fins (Fischer, 1978). E. flavolimbatus, a deepwater grouper, has a distinct yellow margin on the dorsal fin which separates it from all other groupers (Fischer, 1978).

Mycteroperca phenax and M. interstitialis are small (usually less than 76 cm; 30 in) groupers with concave posterior caudal margins. M. phenax is light brown with small dark spots in round or elongate clusters. M.

interstitialis is a darker brown, often with light lines forming reticulations surrounding small dark spots, and yellow around the mouth (Fischer, 1978).

M. microlepis, M. bonaci, and M. venenosa are similar in size (often to 92 cm; 36 in) and general appearance. M. microlepis is uniform brown or gray with clustered darker vermiculations and a lunate caudal fin. M. bonaci has a more straight posterior caudal margin and rows of rectangular dark blotches. M. venenosa exhibits a similar pattern, distinguishable by a strong yellow margin over the outer third of the pectoral fin (Fischer, 1978).

M. tigris has a distinctive color pattern of strong dark bars on the body separated by narrow pale bands and notably large canine teeth (Randall, 1968; Fischer, 1978). It does not often exceed 76 cm (30 in) total length.

Centropristis ocyurus, C. philadelphica, and C. striata are sea basses, characterized by pectoral, pelvic, anal, and second dorsal fins being relatively larger in proportion to body size than in the groupers. These species are small, usually less than 35 cm (14 in). They are variably colored. C. striata ranges from dark gray to brownish to black, and may have a mottled or barred appearance. C. ocyurus and C. philadelphica are more slender-bodied than C. striata and have a strongly trilobed caudal fin (Walls, 1975; Hoese et al., 1977). C. ocyurus is brown with darker lateral bands. C. philadelphica is also brown, with vague darker bands and a black spot on the last two dorsal spines (Walls, 1975; Fischer, 1978).

5.1.3 Porgies (Sparidae)

Porgies are similar in size and general appearance to grunts (Pomadasyidae). They are deep bodied and compressed with a small horizontal mouth placed low on the head. The sides of the jaws are broad and blunt. Teeth are stout; low and molariform laterally, canines or incisors anteriorly (Böhlke and Chaplin, 1968; Randall, 1968; Walls 1975). Several species are barred or striped, but generally porgies have a bright silvery appearance. They have a single continuous dorsal fin.

Calamus bajonado, C. calamus, C. nodosus, and C. leucosteus are predominately silver and usually well under 76 cm (30 in). C. calamus has yellow on the nape and anterior region of the back (Randall, 1968). C. bajonado has brassy cheeks without blue markings and the snout of the adult is less steep than others in the genus Calamus. C. leucosteus may have splotches or crossbars of varying intensity on the sides. C. nodosus has a large knob above the posterior nostril (Hoese et al., 1977).

Pagrus pagrus and Archosargus probatocephalus are easily distinguished from the others. P. pagrus is reddish above and silver-white below. A. probatocephalus has strong, broad black bars on the entire body. P. pagrus may reach 76 cm (30 in) (Manooch and Hassler, 1978) and A. probatocephalus 91 cm (36 in).

Stenotomus chrysops and S. caprinus are distinguished from the other western Atlantic sparids by lanceolate incisor teeth. S. caprinus has greatly elongated third, fourth, and fifth dorsal spines (Walls, 1975; Hoese et al., 1977). S. chrysops lacks these. It has a silvery to brown body color with traces of darker vertical bars on the sides.

5.1.4 Grunts (Pomadasyidae)

Grunts are similar to snappers in general morphology. The mouth is the major difference; in grunts it is low on the head, the upper jaw projects slightly in front of the lower, and no prominent canine teeth are present (Randall, 1968). The tail is generally more deeply notched in grunts. Juveniles of most species are difficult to distinguish.

Haemulon aurolineatum and H. chrysargyreum have a more slender, elongate body form than other pomadasyids in the complex. H. chrysargyreum has strong yellow stripes, H. aurolineatum is silvery white with a yellow to brown midlateral stripe and a large dark spot at the base of the caudal fin.

Anisotremus virginicus and A. surinamensis are deep-bodied, similar to porgies. A. virginicus has two strong black bars on the head and yellow stripes on the body. A. surinamensis has a large black area on the sides and belly.

H. sciurus, H. melanurum, and H. flavolineatum are yellow striped. In H. sciurus the yellow stripes alternate with blue stripes. The yellow stripes in H. flavolineatum are diagonal midlaterally and horizontal elsewhere. H. plumieri, H. parrai, and H. album have silvery to dark gray or bronze backgrounds. H. plumieri has strong blue stripes on the head. H. parrai has dark fins and often dark spots forming indistinct stripes over the sides. H. album has no strong body markings and a higher back profile than H. parrai. Adults are usually much larger than adult H. parrai. H. macrostomum has strong black stripes, a yellow saddle at the base of the tail, and usually a yellow back. H. melanurum is black along the back and into the tail and usually has pale yellow stripes over a silver to grayish background on the sides.

5.1.5 Tilefishes (Malacanthidae)

Tilefishes are elongate, with long dorsal and anal fins. Malacanthus plumieri is slightly compressed, almost eel-like in appearance. Coloration is pale, with light blue lines near the eye and a dusky blotch on the caudal above mid-fin (Böhlke and Chaplin, 1968). The tail is lunate with upper and lower rays greatly elongated.

Lopholatilus chamaeleonticeps has a slightly lunate tail, bluish to olive-green color on back and upper sides, and irregular yellow spots on back and sides above the laterial line. The head is more blunt with greater distance between eye and mouth than in M. plumieri, and the body is considerably more compressed. A fleshy appendage protrudes from the nape before the dorsal fin (Hoese et al., 1977).

Caulolatilus microps has a truncate tail with extended uppermost and lowermost rays, rather small eyes, and lacks definite markings on the sides (Hoese et al., 1977).

5.1.6 Triggerfishes (Balistidae)

Triggerfishes are relatively deep-bodied and moderately compressed with a long, unattenuated snout, highly placed eye, and usually terminal mouth; jaws are short and strong and contain protruding incisiform teeth (Randall, 1968). A single spinous knob replaces the pelvic fins. The skin is tough and covered with modified plate-like scales. They have a stout first dorsal spine which can be locked in a vertical position.

Balistes capriscus and Canthidermus sufflamen are both predominately grayish or brown. B. capriscus may be somewhat mottled, with various pale blue, olive-green, and yellowish markings. C. sufflamen is uniformly colored with bases and axils of the pectoral fins dark.

B. vetula changes color considerably, but can always be identified by two bright blue sripes below the eye and exaggerated, elongate trailing upper and lower caudal tips (Böhlke and Chaplin, 1968).

5.1.7 Wrasses (Labridae)

Two very different wrass species occur in the complex. Lachnolaimus maximus is deep-bodied like a snapper. The first three dorsal spines are long and streamer-like, tail is lunate, and males have larger snouts and mouths (Randall, 1968). Color is highly variable but most often uniform or mottled gray to reddish brown, almost always with a black spot at rear base of dorsal fin (Böhlke and Chaplin, 1968; Randall, 1968). Halichoeres radiatus is much more slender-bodied and elongate, the body deepening somewhat with maturity. Coloration is bright; adults are primarily blue and green, young have a large black dorsal blotch at the middle of the dorsal fin and two orange or yellow stripes the length of the body (Böhlke and Chaplin, 1968; Randall, 1968). The tail is truncate, sometimes with corners slightly rounded (Randall, 1968).

5.1.8 Jacks (Carangidae)

Jacks are silvery fishes, darker dorsally, and typically have two detached spines in front of the anal fin (Böhlke and Chaplin, 1968). They are compact, strong-swimming, and Caranx and Seriola are moderately deep-bodied. Scales are small, caudal fin is deeply forked or lunate, teeth are small to moderate in size (Randall, 1968).

C. crysos and C. ruber are among the more slender jacks of the genus Caranx. They do not commonly exceed 51 cm (20 in). C. crysos is olive to bluish green above, silvery gray below, with black-tipped caudal fin and a black spot on the gill cover. C. ruber has a strong blue-bordered black stripe along the dorsal extending through the lower caudal lobe. C. bartholomaei is also a slender Caranx jack. It grows to about 102 cm (40 in). The body is pale greenish blue above, silvery below, with a yellowish cast, and the caudal fin is yellow.

C. hippos is deeper-bodied and has a more blunt forehead. A row of enlarged bony scales occur posteriorly along the lateral line. A prominent black spot is present on the gill cover at eye level.

Seriola dumerili and S. rivoliana are dark, usually brownish, above and lighter below. Both have a dark band from the snout through the eye to the nape. S. rivoliana is deeper-bodied than S. dumerili and does not grow as large. S. dumerili may exceed 152 cm (60 in), while S. rivoliana does not often exceed 91 cm (36 in).

In addition to the referenced scientific literature, a number of descriptive pictorial guides were used to prepare this section (McClane, 1974; Pfleuger and Smiley, 1974; Goodson, 1976; Stokes, 1980).

5.2 Range of the Fishery

The range of the snapper-grouper fishery extends from the North Carolina-Virginia border to the end of the Florida Keys in the Fishery Conservation Zone (FCZ) under jurisdiction of the South Atlantic Fishery

Management Council and in the territorial seas of the states. The range of Centropristis striata is from Cape Hatteras south to Cape Canaveral. Lutjanus campechanus, L. griseus, L. vivanus, L. buccanella, and Rhomboplites aurorubens may be found throughout the FCZ and territorial seas. L. analis, L. apodus, L. synagris, L. cyanopterus, L. mahogoni, L. jocu, Ocyurus chrysurus, Apsilus dentatus and Etelis oculatus are found primarily off Florida, as are Epinephelus morio, E striatus, E. guttatus, Mycteroperca venenosa, and M. bonaci.

5.2.1 Snappers (Lutjanidae)

Lutjanus campechanus, L. vivanus, L. buccanella, and Rhomboplites aurorubens are important components of the catch in the deeper shelf waters (20 m; 66 ft or more). L. campechanus is not common off southeastern Florida; below Cape Canaveral it is largely replaced by L. analis, a similar species.

Important shallow water (less than 20 m; 66 ft) snapper fisheries occur primarily in Florida and include many Ocyurus chrysurus, L. griseus, and L. analis. Aggregations of large (30-60 cm; 12-24 in) O. chrysurus are the basis for an important summertime fishery in southeastern Florida at 20-36 m (66-118 ft). L. analis is commonly caught in 20-61 m (66-200 ft). L. griseus is caught inshore with gill nets in the Florida Keys, mostly in the Gulf and Florida Bay areas.

L. cyanopterus, L. jocu, L. mahogoni, and L. synagris are not often caught by commercial or recreational fishermen. Apsilus dentatus and Etelis oculatus are deepwater species and are very rarely caught in the FCZ.

5.2.2 Sea Basses and Groupers (Serranidae)

Important recreational and commercial fisheries for sea basses exist inshore and offshore from Cape Hatteras to Cape Canaveral. Centropristis striata, C. ocyurus, and C. philadelphica occur in similar areas, but C. striata comprises by far the largest proportion of the commercial and recreational sea bass catch.

The groupers Epinephelus drummondhayi, E. flavolimbatus, E. mystacinus, E. nigritus, and E. niveatus occur throughout the FCZ. Commercial and recreational fishermen take these species almost exclusively in deep water, usually not less than 46 m (150 ft) and mostly much deeper.

E. morio and E. striatus are similar in size, growth, and general appearance. E. morio juveniles may be common inshore, but adults are caught mostly in relatively deep offshore waters (20-61 m; 66-200 ft). E. striatus usually frequents more shallow areas (31 m; 100 ft and less). E. itajara juveniles sometimes appear in inshore catches; large adults occur offshore on wrecks and reefs and are not often caught.

E. adscensionis, E. cruentatus, E. fulva, and E. guttatus are small, shallow water (5-31 m; 15-100 ft) groupers. They are common primarily south of Cape Canaveral and do not comprise an important component of commercial or recreational grouper catches.

Mycteroperca microlepis, M. bonaci, and M. venenosa are similar in size, appearance, growth, and depth range of capture (usually 6-46 m; 20-150 ft). M. microlepis is important from Cape Hatteras to Cape Canaveral, occasionally to Key West. M. bonaci and M. venenosa are more predominant below Cape Canaveral. M. bonaci is caught more frequently than M. venenosa. M. tigris occurs in tropical shallow waters (6-31 m; 20-100 ft) and is rarely caught in the FCZ.

M. phenax and M. interstitialis are smaller, very similar groupers most often caught in moderately deep water (18-46 m; 60-150 ft). M. phenax is more common from Cape Hatteras to Cape Canaveral. M. interstitialis is relatively common on deeper reefs south of Cape Canaveral but is seldom caught.

5.2.3 Porgies (Sparidae)

Pagrus pagrus is perhaps the most important porgy in recreational and commercial catches in the FCZ. It occurs on offshore shelf areas primarily from Cape Hatteras to Cape Canaveral. Stenotomus caprinus, S. chrysops, Calamus leucosteus, and C. nodosus are smaller, less important species also caught in this range.

C. bajonado and C. calamus occur south of Cape Canaveral. They often occur in commercial and recreational bottom fishing catches in this area but are seldom the subject of directed effort.

Archosargus probatocephalus occurs primarily in inshore waters of the FCZ from Cape Hatteras to Key West. It is the subject of considerable recreational hook and line effort.

5.2.4 Grunts (Pomadasyidae)

Grunts are ubiquitous in the FCZ from Cape Hatteras to Key West. Haemulon melanurum often inhabits deeper water as an adult. It is sometimes caught incidentally by snapper fishermen, particularly with Rhomboplites aurorubens. H. plumieri and H. aurolineatum are the major grunt species in catches north of Cape Canaveral. H. plumieri is usually most prevalent south of this point as well, but may be joined in the catch by a number of other species including H. album, H. flavolineatum, H. sciurus, H. chrysurus, H. parrai, H. macrosomum, Anisostremus virginicus, and A. surinamensis. These grunt species are most common from shore to approximately 37 m (120 ft).

5.2.5 Tilefishes (Malacanthidae)

Tilefishes are an important commercial and to a lesser extent recreational family caught mostly in deep water, not less than 61 m (200 ft) and usually over 91 m (300 ft). Most commercial effort is north of Cape Canaveral. Lopholatilus chamaeleonticeps accounts for the largest proportion of the catch, with Caulolatilus microps second. Malacanthus plumieri is caught incidentally by recreational fishermen south of Cape Canaveral in shallow water (6-46 m; 20-150 ft).

5.2.6 Triggerfishes (Balistidae)

Balistes capriscus occurs throughout the FCZ. It is amenable to a variety of fishing gears and may comprise a large proportion of commercial and recreational incidental catches. It occurs inshore and offshore. Canthidermis sufflamen is common from Florida south, primarily in outer reef and offshore areas. B. vetula occurs primarily in southern Florida and the Florida Keys and is not often caught.

5.2.7 Wrasses (Labridae)

Exploitable wrasses important to this region of the FCZ are limited to Florida waters. Halichoeres radiatus is an occasional component of the incidental catch of a number of different gears. Lachnolaimus maximus is highly sought after by spear fishermen in southern Florida and the Florida Keys. It is not frequently caught by other types of gear.

5.2.8 Jacks (Carangidae)

The jacks listed in this source document are not often subjected to directed effort, with the exception of Seriola dumerili. S. dumerili frequents offshore reefs and wrecks from Cape Hatteras to Key West. It is an important component of recreational and to a lesser extent commercial interest. Large S. rivoliana are sometimes caught with S. dumerili. Smaller S. rivoliana, Caranx crysos, and C. hippos are usually caught incidentally, although C. crysos is commonly sought for bait by recreational fishermen. C. ruber and C. bartholomaei more frequently occur south of Cape Canaveral and are also caught incidentally.

5.3 Management Unit

The fishery management plan for which this source document has been written concerns management of the snapper-grouper fishery in the waters of the Fishery Conservation Zone (FCZ) in the area of authority of the South Atlantic Fishery Management Council and the territorial seas of North and South Carolina, Georgia and the east coast of Florida. Regulations will apply to the South Atlantic FCZ which extends from the North Carolina/Virginia border through the Atlantic side of the Florida Keys to 83° West longitude. The inner boundary of the FCZ is a line coterminous with the seaward boundary of each of the coastal states and the outer boundary of such zone is a line drawn in such a manner that each point on it is 200 nautical miles from the baseline from which the territorial sea is measured. In the case of black sea bass, the management regime applies only south of Cape Hatteras, which is believed to be the boundary between two distinct stocks of sea bass (Mercer, 1978).

5.4 Rationale for Choosing This Unit

The snapper-grouper complex in the area of authority of the South Atlantic Fishery Management Council can be managed as a unit because the complex is considered to be subtropical/tropical in distribution and therefore limited to south of Cape Hatteras on the eastern coast of the U.S. Some of the species are different between the South Atlantic Fishery Management Council area and the Gulf and Middle Atlantic Bight and those that are similar are subjected to different fishing patterns. Socioeconomic characteristics of fishermen are fairly constant within this region, facilitating imposition of regulations and management solutions. The unit comprises the overlapping ranges of a large multi-species fishery. The cost of plan preparation is reduced through development of a single, comprehensive plan.

Cape Hatteras is the boundary between two distinct stocks of sea bass (Mercer, 1978). Mercer (1978) collected black sea bass monthly from north and south of Cape Hatteras, North Carolina and reported the following on stock structure:

> Gulland (1969) states that before population theory can be applied to a particular situation it is necessary to determine to what extent the fish population and the fishery based on it can be treated as a unit system. He defines a unit stock as one where happenings external to the stock, for example fishing in other areas, do not have a significant effect, and there are no subgroups within the unit stock with significantly different population characteristics. Distribution data, tagging studies, commercial catch statistics, and age and growth results indicate that there are two stocks of black sea bass: one north of Cape Hatteras, N.C.; and one to the south. The stock north of Cape Hatteras is migratory, wintering off Virginia and Currituck, N.C. in 30 to 50 fathoms, and moving inshore and northward along the coasts of the Middle Atlantic states as far north as southern New England in spring and summer (Musick and Mercer, 1977). The stock south of Cape Hatteras, N.C. is more stationary, concentrated on inshore "live-bottom" areas (Struhsaker, 1969). Tagging studies by Cupka et al. (1973) off South Carolina indicate that sea bass undertake no significant seasonal movements in that area. This agrees with tagging studies off the northeast coast of Florida (Topp, 1963; Beaumariage, 1964; Moe, 1966). This lack of seasonal movement is most likely the result of higher year-round water temperatures in the South Atlantic (Cupka et al., 1973).

Furthermore, black sea bass are commercially fished north of Cape Hatteras primarily by trawls and south of Cape Hatteras by traps, with some hook and line. The Mid-Atlantic Council is developing a plan for sea bass north of Cape Hatteras.

6.0 PROBLEMS IN THE FISHERY

See FMP document, Section 6.0.

7.0 MANAGEMENT OBJECTIVES

See FMP document, Section 7.0.

8.0 DESCRIPTION OF THE FISHERY

8.1 Description of the Stocks

8.1.1 Distribution

Lutjanids and serranids form a large and important element of tropical marine fish faunas around the world (Böhlke and Chaplin, 1968; Randall, 1968; Hoese et al., 1977; Fischer, 1978). The snapper-grouper complex is comprised primarily of species with a tropical or subtropical distribution. Several of the families are represented in temperate waters; however, few of the listed species are common north of Cape Hatteras.

8.1.1.1 Snappers (Lutjanidae)

Lutjanus analis, L. griseus, L. apodus, L. campechanus, and Ocyurus chrysurus have been recorded from New England to southeastern Brazil, including the Gulf of Mexico. L. campechanus occurs only as far south as Yucatan. All are rare north of Cape Hatteras.

L. synagris, L. mahogoni, L. vivanus, L. buccanella, and Rhomboplites aurorubens have been recorded from the Carolinas to at least the northern coast of South America. L. buccanella reportedly occurs only as far south as the Lesser Antilles.

L. cyanopterus has been recorded from South Florida to Brazil, including the Central American Coast. Apsilus dentatus has been reported from the Florida Keys, Cuba, and various West Indies Islands, and Etelis oculatus from deep tropical waters off southernmost Florida and the Bahama Banks.

8.1.1.2 Sea Basses and Groupers (Serranidae)

Centropristis striata is the most widely distributed of the listed sea basses, occurring from Maine to Florida and the eastern Gulf of Mexico. The distributions of C. philadelphica and C. ocyurus extend northward only to the Carolinas.

Epinephelus morio, E. adscensionis, E. niveatus, E. nigritus, Mycteroperca microplepis, and M. bonaci have been reported from New England to southeastern Brazil, including Bermuda and the Gulf of Mexico. M. microlepis reportedly does not occur in the West Indies. Individuals of these species are not common north of Cape Hatteras.

M. phenax has been recorded from Massachusetts to Yucatan. However, it may be easily confused with M. interstitialis which appears to be common in the southern part of this range through Central America. Hoese et al. (1977) state that these two may actually be a single species.

E. drummondhayi occurs from North Carolina through Florida. E. striatus and E. guttatus extend southward to Brazil. Other tropical groupers in the complex include E. itajara, E. mystacinus, E. fulvus, E. flavolimbatus, E. cruentatus, M. venenosa, and M. tigris, all of which have been reported from Bermuda and Florida to southeastern Brazil.

8.1.1.3 Porgies (Sparidae)

Porgies have more temperate species than the other families of the snapper-grouper complex. They are also well represented in the tropics. Pagrus pagrus has been reported from New York to Argentina, including the Gulf of Mexico. It is quite common in the South Atlantic Bight. Calamus leucosteus and Stenotomus caprinus have also been reported from this South Atlantic region. S. chrysops reportedly occurs from Nova Scotia to Florida. Archosargus probatocephalus is also limited to the mainland, occurring from New England to Brazil, including the Gulf of Mexico. C. bajonado occurs in this range and around Bermuda as well. C. calamus has a similar range except it occurs northward only to North Carolina. C. nodosus occurs from North Carolina to Yucatan.

8.1.1.4 Grunts (Pomadasyidae)

The majority of grunts listed in the complex are tropical species, ranging from southern Florida to Brazil, including Bermuda. These include Haemulon album, H. melanurum, H. macrostomum, and H. parrai. H. chrysargyreum, Anisostremus virginicus, and A. surinamensis are similarly distributed except they occur further north on the Florida coast. H. flavolineatum and H. sciurus occur as far north as South Carolina. H. plumieri and H. aurolineatum range northward to Virginia and New England respectively.

8.1.1.5 Tilefishes (Malacanthidae)

Lopholatilus chamaeleonticeps occurs from Nova Scotia to Key West and throughout the Gulf of Mexico. Caulolatilus microps, also a continental species, has been reported from Virginia to Florida and in the eastern Gulf of Mexico. Malacanthus plumieri is most abundant in subtropical and tropical waters, but ranges from Cape Lookout, North Carolina throughout the Caribbean and Gulf of Mexico.

8.1.1.6 Triggerfishes (Balistidae)

Balistes capriscus occurs from Nova Scotia to Argentina and the Gulf of Mexico. B. vetula has been recorded from New England to southeastern Brazil, including the Gulf of Mexico. These two species occur on both sides of the Atlantic. Canthidermis sufflamen is distributed from New England to the Lesser Antilles, and in Bermuda and the Gulf of Mexico.

8.1.1.7 Wrasses (Labridae)

Halichoeres radiatus ranges from North Carolina to Brazil, and also occurs in Bermuda. Lachnolaimus maximus is known from North Carolina to the northern coast of South America, including Bermuda, the Gulf of Mexico, and the coast of Central America.

8.1.1.8 Jacks (Carangidae)

Seriola dumerili is known from New England to Brazil, including the Gulf of Mexico. S. rivoliana is similarly distributed, ranging north to New Jersey and south to Buenos Aires, Argentina. These two species occur on both sides of the Atlantic.

Caranx crysos occurs from Nova Scotia to southeastern Brazil, C. ruber from New Jersey to the Lesser Antilles. C. hippos has been recorded from Nova Scotia to Uruguay, and C. bartholomaei from New England to Brazil. These four species also inhabit the Gulf of Mexico. C. hippos occurs throughout the warm waters of the world.

8.1.2 Reproduction

8.1.2.1 Snappers (Lutjanidae)

Detailed information is available on the reproductive biology of Rhomboplites aurorubens, Lutjanus campechanus, L. vivanus, L. analis, L. apodus, L. synagris, L. buccanella, Ocyurus chrysurus, and L. griseus. Little is known about reproduction of L. cyanopterus, L. jocu, L. mahogoni, Etelis oculatus, and Apsilus dentatus, all of which are either relatively or extremely rare in the catch within the management unit.

R. aurorubens is heterosexual. Females are more numerous than males (Grimes, 1976). In the fishery off North and South Carolina, Grimes (1976) found that there were no males older than eight years and almost all of the large fish were females. Grimes (1976) reported that most R. aurorubens matured around age four (350-400 mm TL; 14-16 in). South Carolina Marine Resources Research Institute personnel report that a substantial percentage mature at 203 mm (8 in) total length, which is approximately two years (Low and Ulrich, 1982). The number of eggs

(150,000-200,000) produced each season by these small females is much less than the number of eggs (1.5 million) produced by larger females (Grimes, 1976). Grimes (1976) evaluated three predictors of fecundity: length, weight, and age of fish. He found weight to be the best predictor: $F=e^{10.2183+.00195\ wt}$.

Walker (1950) and Munro et al. (1973) report spawning in cooler months in the West Indies. Laroche (1977) reported that larvae and juveniles were collected off Georgia in August 1973 in depths of 22 m (72 ft) and water temperatures of 27°C (81°F). Off the Carolinas, R. aurorubens spawn from late April or May to September at depths of 31-92 m (102-392 ft) and bottom temperatures of 21°C to 25°C (70-77°F). Ripe eggs (stage IV) were 0.46 to 0.71 mm (0.02 to 0.03 in) in diameter (Laroche 1977).

Lutjanus campechanus remain the same sex throughout their lifespan. Sexual maturity is probably reached after the second year. Camber (1955) concluded that maturity is attained at approximately 300-370 mm (12-15 in) fork length (FL). Moseley (1966) estimated that maturity is reached at 190-300 mm (7-12 in) standard length (SL).

Off the west coast of Florida, spawning occurs from July through October, with a peak in August and September. Camber (1955) reported that spawning on the Campeche Banks occurred from early July to mid-September, with the major activity occurring in July and August. Moseley (1966) reported that the spawning season off the Texas coast extended from June through mid-September, with the peak activity occurring in August. However, Bradley and Bryan (1973) believed that the presence of smaller snappers (34-70 mm; 1-3 in SL) off Texas in January, March, June through October, and December indicates a more protracted spawning season.

The spawning grounds of L. campechanus are not well known. Commercial fishermen along the Texas coast have reported catches of roe-bearing fish on level bottom at depths of 37 m (121 ft). Moe (1963) described two spawning areas south of Panama City, Florida, characterized by water depths of between 18-37 m (59-121 ft) over a firm sand bottom of gentle gradient and little relief. Fishermen have observed L. campechanus spawning off the northeast coast of Florida in 18-22 m (59-72 ft) over hard sand and shell bottoms with low rock relief. Spawning was reported in July and August (M. Moe, Aqua-Life Research Corp., Marathon Shores, Florida; pers. comm.).

No hermaphroditism has been documented for L. vivanus. A difference exists between the sexes in growth rate and sizes at maturity. Thompson and Munro (1974a) estimated that males attain sexual maturity at 550-600 mm (22-24 in) FL, and females at 500-550 mm (20-22 in) FL. Boardman and Weiler (1980) obtained similar results. There are no data on age at sexual maturity.

Ripe L. vivanus were collected off North Carolina in June, July and August, from 1972-1974 (Grimes et al., 1977). In the Caribbean, ripe fish were collected in March, April, May, August, September, and November. Spawning groups have been observed; prespawning groups were observed to "mill around." Year-round spawning was reported by Munro et al. (1973) in Jamaica and Boardman and Weiler (1980) in Puerto Rico.

L. analis reach sexual maturity at approximately 400 mm (16 in) FL (Druzhinin, 1970). Druzhinin (1970) reported that a single female specimen caught off the Cuban coast contained 1,366,000 eggs.

L. analis are reported to spawn during July and August (Jordan and Evermann, 1920), and apparently spawning occurs in groups (Thompson and Munro, 1974a). The eggs are non-adhesive and 0.8 to 0.9 mm (0.03-0.04 in) in diameter (Jordan and Evermann, 1920).

The estimated mean size at maturity for L. apodus in Caribbean waters is about 250 mm (10 in) FL for both sexes. Peak spawning occurs during the winter months in the Caribbean area (Munro et al., 1973). Thompson and Munro (1974a) also collected ripe or recently spent fish in February, June, August and November.

L. synagris females attain sexual maturity at 200 mm (8 in) TL and some males are sexually mature at 180 mm (7 in) TL and both at age I. Druzhinin (1970) reported that six females caught off the coast of Cuba contained from 347,000 to 995,000 eggs. Munro et al. (1973) observed ripe females in the Caribbean area during February and March. Ripe females have been found off Cuba from March through September with peak months during July and August, and ripe males from March through September with the majority of adults ripe from June through September (Rodriguez Pino, 1962).

L. buccanella has separate sexes (Thompson and Munro, 1974a). Estimated mean sizes at sexual maturity for fish in Caribbean waters are: males, 25 to 27 cm (10-11 in) FL; females, 23 to 25 cm (9-10 in) (Thompson and Munro, 1974a). Boardman and Weiler (1980) estimated 20 cm (8 in) and

38 cm (15 in) FL at sexual maturity for females and males. Munro et al. (1973) suggest that spawning occurs almost continuously on oceanic banks in the Caribbean area with a possible peak in April, September and October.

Ocyurus chrysurus reach sexual maturity at approximately 11 to 12 cm (4-5 in) TL (Druzhinin, 1970). The estimated mean sizes at sexual maturity for fishes in Caribbean waters are: males, about 26 cm (10 in) FL; females, 29 to 31 cm (11-12 in) FL (Thompson and Munro, 1974a). These results are similar to results recently obtained in Florida (Johnson, unpubl. ms.) Druzhinin (1970) reported that four female O. chrysurus caught off the Cuban coast contained from 100,000 to 1,473,000 eggs.

The spawning period in Cuban waters was reported as March through September, with a peak period during April and May (Druzhinin, 1970). However, Munro et al. (1973) suggested that year-round spawning occurs on oceanic banks in the Caribbean area, with possible maxima around February, and September or October.

L. griseus females examined by Starck and Schroeder (1971) in the Florida Keys matured as early as 195 mm (8 in) SL. The smallest ripe male examined was 185 mm (7 in) SL. A 315 mm (12 in) SL female was estimated to have about 500,000 eggs (Starck and Schroeder, 1971). Ripe females were common in July and August and spent females were common in early September (Starck and Schroeder, 1971). Spawning occurs more than once during the spawning season and the timing may be influenced by lunar phases.

8.1.2.2 Sea Basses and Groupers (Serranidae)

Detailed information on reproductive biology is available for representatives of each of the three listed genera of Serranidae. These representatives are Centropristis striata, Epinephelus morio, E. striatus, E. fulva, E. guttatus, E. cruentatus, and Mycteroperca microlepis. C. striata may provide a reasonable approximation of the reproductive biology of the genus Centropristis. Similarly, the smaller Epinephelus groupers are probably well represented, although the reproduction of larger members such as E. itajara and E. nigritus is not. Information on the reproductive biology of M. microlepis may approximate, with some exceptions (such as seasonality) that of two similar congenerics, M. bonaci and M. venenosa. Little is known about the reproductive biology of E. drummondhayi, E. flavolimbatus, E. mystacinus, E. niveatus, E. adscensionis, and M. phenax.

Most members of this family are protogynous hermaphrodites and sex cannot be accurately determined macroscopically unless the gonads are ripe.

Centropristis striata is a protogynous hermaphrodite, i.e., it functions first as a female and later as a male (Cupka et al., 1973). This sexual transition occurs in ages one through five before and after spawning in the South Atlantic (Mercer, 1978) (Table 8-1). Waltz et al. (1979) observed transitional individuals through age eight (Table 8-2). Fish over 25 cm (10 in) are predominantly males. Most females do not spawn until age two, but usually are mature by age three. Male C. striata mature at age one or more (Mercer, 1978). Fecundity estimates of fishes one to five years old ranged from 29,770 to 121,500 eggs (Cupka et al., 1973) for fish off South Carolina and up to 333,000 eggs for C. striata in the Middle Atlantic Bight.

Cupka et al. (1973) found peak spawning off South Carolina occurs offshore during March through June. Mercer (1978) reports that spawning occurs from February through May with peak activity in April and May, and a second period of spawning activity in November in the South Atlantic Bight. They are multiple spawners. Spawning occurs in ocean depths of 10-45 m (33-148 ft) during spring and summer (D. Harris, Ga. Dept. of Natural Resources, Coastal Resources Div., Brunswick, Ga; pers. comm.).

Eggs of black sea bass are buoyant in sea water, non-adhesive and range from 0.9-1.0 mm (0.04 in) in diameter. They are free-floating in nature during development. There is a single small oil globule in the yolk. Eggs are colorless when they are spawned (Kendall, 1977).

Epinephelus morio undergoes sexual transition (from female to male) at any length over approximately 275 mm (11 in) SL, but most often after 500 mm 20 in) SL. Percentage of males in the population does not exceed 10 percent until after age 9 (greater than 500 mm SL; 20 in) and the ratio of males to females is not equal until age 15 (greater than 675 mm SL; 27 in) (Moe, 1969) (Table 8-3).

For females, sexual maturity occurs between ages 4 and 6 and about 450 mm (18 in) SL. Greatest reproductive potential, in terms of fecundity, occurs between ages 8-12. Males are reproductively most important in the population after 10 years of age (Moe, 1969). No regression equations have been developed for E. morio, but for 14 females fecundity estimates average 1.5×10^6 eggs (range 3.1×10^5 to 5.7×10^6) per ovary (Moe, 1969).

Table 8-1. Frequency of sexual types in each 20 mm size interval for C. striata from the South Atlantic region (Source: Mercer, 1978).

Standard Length (mm)	Number of Fish	Immature	Female	Transitional	Male
20- 39	1	1	0	0	0
40- 59	3	2	1	0	0
60- 79	5	4	1	0	0
80- 99	7	4	3	0	0
100-119	14	0	11	0	3
120-139	85	0	60	6	19
140-159	148	0	116	2	30
160-179	179	0	157	6	16
180-199	124	0	99	4	21
200-219	102	0	61	8	33
220-239	88	0	46	5	37
240-259	55	0	19	3	33
260-279	13	0	5	0	8
280-299	3	0	0	1	2
300-319	4	0	0	0	4
320-339	3	0	0	0	3
Totals	834	11	579	35	209

Table 8-2. Total number male, female, transitional, and undifferentiated C. striata by age (Source: Waltz et al. 1979).

Age Group	Number of Fish	Undifferentiated	Male	Female	Transitional
0	2	2	0	0	0
1	92	1	5	84	2
2	272	0	56	181	35
3	448	0	110	215	123
4	284	0	114	119	51
5	268	0	158	51	59
6	133	0	93	25	15
7	53	0	38	11	4
8	40	0	31	6	3
9	3	0	3	0	0
10	3	0	2	1	0
Totals	1,598	3	610	693	292

Table 8-3. Distribution of female, male, and transitional E. morio by age group (Source: Moe, 1969).

Age Group	Grand Total	Females			Males			Transitionals		
		Number	Percent	Mean SL in mm	Number	Percent	Mean SL in mm	Number	Percent	Mean SL in mm
1	13	13	100	198	-	-	-	-	-	-
2	27	26	96	274	1	4	300	-	-	-
3	47	46	98	316	-	-	-	1	2	320
4	52	51*	98	370	1	2	328	-	-	-
5	44	40	91	407	1	2	475	3	7	400
6	42	39	93	438	1	2	329	2	5	438
7	62	57	92	491	4	6	452	1	2	554
8	80	73	91	504	7	9	528	-	-	-
9	88	77	88	541	10	11	588	1	1	547
10	91	75	82	560	15	16	576	1	1	514
11	31	25	81	584	6	19	585	-	-	-
12	29	22	76	588	6	21	640	1	3	545
13	36	21	58	626	14	39	626	1	3	686
14	45	35	78	614	10	22	628	-	-	-
15	23	12	52	628	11	48	616	-	-	-
16	23	15	65	618	8	35	641	-	-	-
17	10	5	50	624	5	50	558	-	-	-
18	8	1	12	665	7	88	613	-	-	-
19	3	1	33	565	2	67	666	-	-	-
20	5	1	20	655	4	80	726	-	-	-
21	2	1	50	684	1	50	510	-	-	-
22	-	-	-	-	-	-	-	-	-	-
23	1	1	100	691	-	-	-	-	-	-
24	1	1	100	663	-	-	-	-	-	-
25	2	-	-	-	2	100	635	-	-	-
26	-	-	-	-	-	-	-	-	-	-
27	-	-	-	-	-	-	-	-	-	-
28	-	-	-	-	-	-	-	-	-	-
29	-	-	-	-	-	-	-	-	-	-
30	1	-	-	-	1	100	592	-	-	-

*Excluding one specimen without a recorded SL. (Editor's Note: Apparently the specimen without a recorded SL was not counted in the grand total column either.)

Peak spawning off the west coast of Florida takes place in April and May in water depths between 20 and 91 m (80 and 300 ft) and water temperatures ranging from 19^{o} to $21^{o}C$ (66-70°F). Gonadal activity was observed in January and February and culminated in late spring spawning. Photoperiod was the only environmental factor correlated with gonadal development (Moe, 1969).

E. morio eggs contain an oil droplet, have no filaments, and are generally less than 1 mm (0.04 in) in size (Moe, 1969).

Sexual transformation from females to males in E. striatus occurs at 30-80 cm (12-31 in), presumably indicating that more than one spawning season may be passed as a functional female (Smith, 1971). According to Bardach and Menzel (1957) fish weighing 3 kg (7 lb) are just reaching sexual maturity. Thompson and Munro (1974b) found this species first matures sexually at or before about 48 cm (19 in) TL and 2 kg (4 lb).

Smith (1961) estimates the fecundity of this species as 785,100 eggs (in a female measuring 45 cm; 18 in SL).

In Bermuda, the spawning season lasts from early May to mid-August. Munro et al. (1973) reported ripe fish in the Caribbean area during February, April, and May; samples taken in July, October and November contained no sexually active fish. Manday and Fernandez (1966) reported that E. striatus spawns at night. According to Smith (1972), the species forms spawning aggregations which may last up to two weeks.

Thompson and Munro (1974b) report that E. fulva exhibits protogynous hermaphroditism. An example of synchronous hermaphroditism was found in 1971. Length frequency distribution of males and females shows that males are larger, although there is a broad overlap in the length distribution of the sexes. The percentage of males in the population increases steadily with increasing total length. Sex reversal occurs at or about 27 cm (11 in) TL.

E. fulva matures at or before 16 cm (6 in) TL (Thompson and Munro, 1974b). Estimates of fecundity ranged from 67,883 to 282,389 eggs for fish between 23 and 24 cm (9 in) TL. Gonadal structure was described by Smith (1965).

Erdman (1956) reported that the species spawns in December in Puerto Rican waters. Ripe fishes were found between November and July in the Caribbean, with peak spawning in January to March and a subsidiary peak in June and July.

Eggs ranged from 0.50 to 0.65 mm (0.02-0.03 in) in diameter.

E. guttatus are protogynous hermaphrodites, the females usually having more than one spawning season before becoming males (Smith, 1959). Burnett-Herkes (1975) gives detailed information on sex ratio, maturation sizes, fecundity, spawning seasons and areas, and eggs and larvae. Nagelkerken (1979) gives most of this information for E. cruentatus. Transformation from females to males in E. cruentatus occurs between 19.5 and 23.4 cm (7.7 and 9.2 in) in age groups 4 and 5. Mature females are found mainly between 16 and 25 cm (6.3 and 9.8 in) TL at age 4-5 years, mature males between 21.5 and 27.4 cm (8.5 and 10.8 in) TL in age groups 5-7.

Mycteroperca microlepis display the type of hermaphroditism where the entire gonad transforms from an ovary to a testis (McErlean and Smith, 1964). Gross examination of gonads could not be used to sex this species (McErlean, 1963). Sexual transition (female to male) occurs at approximately age 10-11.

McErlean and Smith (1964) found females to be mature at 5-6 years; they found two mature males at 13 years and 15 years. McErlean (1963) states that females do not mature until five years of age.

McErlean and Smith (1964) provide an illustration of a gonad cross-section (male, 860 mm; 34 in SL; age 13). McErlean (1963) presented fecundity estimates for three fish: 946 mm (37 in) TL (8+ years) = 6.5×10^5; 930 mm (36 in) TL (7 years) = 5.3×10^5; and 938 mm (37 in) TL (8 years) = 1.5×10^6 eggs.

Ripe females have been collected off the Carolinas in February (Manooch and Haimovici, 1978). McErlean (1963) states that spawning in the Gulf of Mexico probably occurs from January to March.

McErlean (1963) describes eggs as probably pelagic with no appendages or filamentous processes, with an oil droplet.

8.1.2.3 Porgies (Sparidae)

The reproductive biology of Pagrus pagrus, Archosargus probatocephalus, Stenotomus caprinus and S. chrysops has been studied in some detail. Reproduction in the genus Calamus is little known with the exception of C. leucosteus.

Pagrus pagrus collected from the west coast of Florida appear to display protogynous hermaphroditism, based on histological analysis of gonadal tissue. However, the data supporting this are insufficient for quantitative description. Manooch (1976) reported a predominance of females at smaller size intervals (less than 400 mm TL; 16 in) and a large proportion of males at larger size intervals (over 450 mm TL; 18 in). Discovery of individuals with both testicular and ovarian tissue supports the theory of protogyny. Hermaphroditic P. pagrus collected off the Carolinas ranged in size from 325 mm (13 in) to 424 mm (17 in) TL and Manooch (1976) has suggested that sexual transition may take place over this length range.

Manooch (1976) determined age at sexual maturity for female P. pagrus. The correlation of age with maturity suggests that none of the age I fish, 37 percent of the age II fish, 81 percent of age III, and 100 percent of age IV fish were mature. Approximately 50 percent of the females were mature at 304 mm (12 in) TL, and 75 percent were mature at 334 mm (13 in). All fish 364 mm (14 in) or more in length were sexually mature.

Manooch (1976) evaluated three predictors of fecundity: total length, weight, and age from 50 fish. All three variables could be used to predict fecundity, but weight of fish proved to be the best predictor. Predicted fecundity ranged from 48,660 eggs for fish 304 mm (12 in) TL and 390 g (14 oz) in weight to 488,600 ova for fish 515 mm (20 in) TL and 1,783 g (4 lb) in weight.

In their study of egg and larval development, Ciechomski and Weiss (1973) reported that P. pagrus spawn in the Argentine Sea from December through January when water temperatures were approximately 20° to $21^{\circ}C$ (68°-$70^{\circ}F$). Ranzi (1969) mentioned the period of sexual maturity of P. pagrus off Algiers as April to June. Manooch (1976) collected ripe females from Raleigh and Onslow Bays, North Carolina over irregular bottom from January through April in water depths from 21 to 100 m (69-328 ft) and water temperatures from 16° to $22^{\circ}C$ (61°-$72^{\circ}F$). Peak spawning appears to be correlated with increased photoperiod.

Ripe, unfertilized P. pagrus eggs were pelagic, spherical, without appendages, and measured 0.64 to 0.92 mm (0.03 to 0.04 in) in diameter. They contained a single oil droplet which averaged 0.25 mm (0.01 in) in diameter (Manooch, 1976). Ciechomski and Weiss (1973) described fertilized eggs measuring 0.81 to 0.88 mm (0.03 in) in diameter with an oil droplet which measured 0.18 to 0.21 mm (0.007 to 0.008 in) in diameter.

A description of embryonic development in the Argentine Sea is provided by Ciechomski and Weiss (1973). They described the larval phase of P. pagrus. Ranzi (1969) described larval and juvenile phases of P. pagrus from the Bay of Naples.

No evidence of hermaphroditism has been reported for A. probatocephalus. Older and larger fish, however, are typically female. Hildebrand and Cable (1938) reported that spawning occurs off North Carolina from April through June. In Florida waters, spawning may occur as early as March and along sandy shores (Rathbun, 1895).

Eggs have been described as transparent, buoyant, and approximately 0.8 mm (0.03 in) in diameter. They hatch in about 40 hours at temperatures of 24°-25°C (76°-77°F) (Rathbun, 1895). Drawings of larvae, post larvae, and early juveniles are provided by Hildebrand and Cable (1938).

S. caprinus is heterosexual and sufficiently dimorphic to distinguish sexes at a length of 9 cm (3.5 in) (Geoghegan, 1981). Maturation and spawning seasonality and areas are discussed by Geoghegan (1981). Information about maturation, sex ratio, and spawning in S. chrysops is variously available from Bigelow and Schroeder (1953), Smith and Norcross (1968), Finkelstein (1969a, b) and Morse (1978).

Waltz et al. (in press) have completed a detailed study including reproduction biology of C. leucosteus. The following information is from this study. C. leucosteus is a protogynous hermaphrodite; younger, smaller fish are predominantly females and older, large fish are mostly males. Sexual transition most commonly occurs between ages 2-4 and fork lengths of 18-25 cm (7-10 in). Peak spawning occurs in May with total fecundity ranging from 30,400 to 1,587,400 eggs.

8.1.2.4 Grunts (Pomadasyidae)

The reproductive biology of the two most exploited grunts in this fishery management unit, Haemulon plumieri and H. aurolineatum, has been fairly intensively studied. The reproduction of the Haemulon grunts, Anisostremus surinamensis, and A. virginicus has been little studied.

No evidence of hermaphroditism exists for H. plumieri. The species spawns once a year for a relatively short duration off the Carolinas (C. Manooch, III, NMFS, SEFC, Beaufort Laboratory, Beaufort, N.C.; pers. comm.). Manooch (pers. comm.) has estimated that most females are mature by age 4, although some mature at age 3.

Tentative analyses of gonadal indices point to spawning taking place from April - July and peaking in May and early June. Ripe fish have been collected over irregular bottom in water depths of 27 to 40 m (89-131 ft). Spawning in Puerto Rico occurred in March (Erdman, 1956). Munro et al. (1973) reported that the species spawns in March at Port Royal in the Caribbean. Sampling in February and April on Pedro Bank produced all ripe females; in November, 50 percent were ripe. Ripe females comprised 35 percent of the samples from Navidad Bank in September.

Saksena and Richards (1975) examined four eggs which were 0.90 to 0.97 mm (0.04 in) in diameter with an oil globule 0.22 to 0.24 mm (0.009 in) and with a narrow perivitilline space. Eggs were hatched after 20 hours at 24°C (75°F).

Saksena and Richards (1975) provide drawings and descriptions of larvae and juvenile H. plumieri.

No evidence of sexual dimorphism or hermaphroditism exists for H. aurolineatum. Munro (1974d) reported that the smallest mature male he found was 147 mm (6 in) FL and the smallest mature female was 130 mm (5 in) FL. Manooch and Barans (in press) estimate that maturity is attained at ages 1 and 2. Mean fecundity for 13 females was 30,000 ova. The highest number of eggs was 83,000.

In the Caribbean, most ripe fish were collected between January and June. Inactive fish were observed in September-December. Erdman (1956) found ripe fish in March, and Cervigon (1966) states that the species spawns throughout most of the year. Munro et al. (1973) reported that spawning started when temperature dropped to 28°C (82°F).

The diameter of ripe eggs was 0.5 mm (0.02 in). The mean ripe ovary weight or percentage of body weight was 4.07, higher than four other Haemulon species. Courtenay (1961) describes the larval phase.

8.1.2.5 Tilefishes (Malacanthidae)

The reproductive biology of Caulolatilus microps and Lopholatilus chamaeleonticeps is fairly well known. Almost nothing is known about this aspect of the life history of Malacanthus plumieri, although a detailed description of pre-juveniles is given by Dooley (1978).

Ross (1978) studied C. microps in detail and is the source of the following information unless otherwise cited. He found evidence of hermaphroditism. Females mature and spawn by the fourth or fifth year (400-500 mm; 16-20 in) and occasionally as early as the third year. Males show spermatogenic activity with production of some sperm by the fifth year (450-500 mm; 18-20 in), but probably don't spawn until the sixth year (500-550 mm; 18-22 in).

Gonads comprise 2.0-4.5 percent of body weight in developing, ripe females and 0.1 to 0.3 percent of body weight in mature males. Females developing ovaries contain several modes of ova in a continual developing process from March-April to October. Males show analagous testicular development with cysts in all stages of development in all the fish examined. Fecundity correlated well with total length ($F = e^{8.3804 + 0.00986TL}$) and weight ($F = 1.01656 \text{ weight}^{1.8324}$).

Off North Carolina, well developed females have been collected from late April and May through October. Spawning seems to be correlated with increased photoperiod. Based on modal frequency distribution of ova within ovaries, it has been estimated that individual fish are capable of spawning two to three times seasonally. The gonad index had two peaks: May-June and September. Dooley (1978) found ripe female C. microps in January and from May through September off the southeastern United States.

Ripe ova (0.78-0.91 mm; 0.03 to 0.04 in), classified stage V, were found in several very ripe, prespawning fish from May, June, July and September. A single oil globule is present, usually measuring 0.17-0.20 mm (0.007 to 0.008 in).

Freeman and Turner (1977) provided most of the information that follows on reproductive biology of L. chamaeleonticeps unless otherwise cited. This tilefish is hermaphroditic with evidence of sexual dimorphism (C. Grimes, Rutgers University, New Brunswick, New Jersey; pers. comm.). Dooley (1974) suggests protogynous sex reversal in tilefish based on his observance of a disproportionate ratio of females to males in smaller (less than 90 cm; 35 in) fish and a preponderance of males in larger size fish (over 90 cm).

Morse (unpubl. ms.) found that female tilefish mature at about 70 cm (28 in) and 4 kg (10 lb). The smallest mature female found by Freeman and Turner (1977) measured 57 cm (23 in) and weighed 3 kg (7 lb). However, they also observed immature females of 67 cm (27 in) and 5 kg (11 lb) and 71 cm (28 in) and 5 kg (11 lb).

Morse (unpubl. ms.) estimates that a female tilefish produces from about 2 million to 8 million eggs. He found that the number of eggs produced increased with the size of the fish and estimates that from a half million to one million eggs are produced per kilogram of body weight. Morse gave the relationship of gonad weight to body weight (x 100) of ripe females as ranging from about 1.2 to 5.5.

Freeman and Turner (1977) observed ripe females off New Jersey throughout a seven month period, extending from mid-March to mid-September. Starting in March, progressively more females became ripe and a peak was reached during late May and June. By late August and early September, very few females were found to be ripe. Morse (unpubl. ms.) reported ripe or running ripe females from March to August and suggested that females spawn more than once during the season and perhaps as many as three times. This is based on his observations of eggs of several size groups in ripe females.

Bigelow and Schroeder (1953) state that L. chamaeleonticeps appears to spawn in July and August. Dooley (1978) collected ripe females in February, March, June, and July.

Fahay (1971) collected ripe L. chamaeleonticeps in August off New Jersey and artificially fertilized some eggs. Fertilization was successful and hatching was first observed in 40 hours continuing through to 60 hours. The spherical eggs were 1.16 to 1.25 mm (0.05 in), usually with a single oil globule of from 0.18 to 0.20 mm (0.007 to 0.008 in). The eggs were non-adhesive and appeared to be buoyant and pelagic. Eigenmann (1902) also describes L. chamaeleonticeps eggs.

8.1.2.6 Triggerfishes (Balistidae)

Some aspects of the reproductive biology of Balistes capriscus are known. Relatively little is known about reproduction in B. vetula or Canthidermis sufflamen.

Sexual dimorphism is not apparent in B. capriscus. Some distinct pairing has been observed, usually offshore in shallow seas (Breder and Rosen, 1966). Ripe females have been observed offshore North Carolina in June, July, and September (C. Manooch, III, NMFS, SEFC, Beaufort Laboratory, Beaufort, N.C.; pers. comm.).

Balistid eggs may be pelagic and non-adhesive or demersal and adhesive. Some parental care may take place if the eggs are in fact demersal and adhesive (Breder and Rosen, 1966).

8.1.2.7 Wrasses (Labridae)

Some basic aspects of the reproduction biology of both Halichoeres radiatus and Lachnolaimus maximus are known. Halichoeres radiatus is probably sexually dichromatic (Warner and Robertson, 1978) and certainly hermaphroditic (Reinboth, 1975). The smallest mature female collected by Warner and Robertson (1978) was 160 mm (6.3 in).

Davis (1976) studied reproduction of L. maximus more closely. The following information is from his work. L. maximus is a dichromatic, protogynous hermaphrodite in which transformation of sex, color, and morphology coincide. All males are sex-reversed females. Sexual transformation may be regulated by a combination of size and possibly social control, particularly in small and medium size fish. All females eventually transform. Peak spawning occurred in February and March with some spawning occurring from September to April. Fecundity, ranging from 41,061 to 146,813 eggs in 12 females, increased approximately linearly with weight and exponentially with length. Mean relative fecundity was 158.3 ova per g and showed no relation to weight or length.

8.1.2.8 Jacks (Carangidae)

Various aspects of the reproduction of jacks listed for this management unit are known. Burch (1979) states that the occurrence of Seriola spp. larvae in the eastern Gulf of Mexico and Straits of Florida in all seasons shows that as a group they spawn year-round. During his study of S. dumerili, however, he found that this species spawns from March through June with peak activity in April and May off southern Florida. The smallest ripe male S. dumerili found by Thompson and Munro (1974c) was 93.0 cm (36.6 in) FL, the smallest ripe female 79.7 cm (31.4 in) FL. The smallest ripe male S. rivoliana they found was 53.0 cm (20.9 in) FL. They observed large female S. dumerili, Caranx bartholomaei, and C. hippos with over 1 million eggs and C. ruber with 131,917 to 230,690 eggs.

Thompson and Munro (1974c) provide size at sexual maturity, sex ratio, and spawning season information on each of the jack species in this fishery. Berry (1959) gives larval descriptions of each Caranx species. McKenney et al. (1958) describe early phases of C. crysos and state that it may spawn year-round with main activity between January and August.

8.1.3 Age, Growth, Mortality, and Other Parameters

Information about age, growth, and mortality for species of the snapper-grouper complex forms the basis for yield-per-recruit (YPR) models. These are used in the FMP to assess the stock of species in the snapper-grouper fishery to determine whether or not a species is in growth overfishing, and, if growth overfishing is occurring, what is the potential gain in yield from a minimum size. The parameters necessary for constructing a yield-per-recruit model are:

M	=	Instantaneous natural mortality
F	=	Instantaneous fishing mortality
t_r	=	Age at first recruitment to the fishing grounds*
t_c	=	Age first liable to capture*
t_λ	=	Maximum age
t_o	=	Theoretical age at length zero (no biological significance)
K	=	Brody growth coefficient
L_{oo}	=	Maximum length
W_{oo}	=	Maximum weight

Total instantaneous mortality, Z, is sometimes calculated in order to derive F or M. Gulland (1969) and Ricker (1975) give full explanations of yield-per-recruit (YPR) models and the parameters used to construct these models. Everhart and Youngs (1981) provide a more basic description of YPR analysis. Wise (1972) provides an applied example of this kind of analysis.

Age, growth, and mortality studies provide the necessary parameters for YPR models. They have been conducted for a number of species in the snapper-grouper fishery. These studies follow a very similar format. A representative sample of individual fish is collected. Hard parts, often otoliths or scales, are used to age each fish according to periodic calcified rings. Calculation of a theoretical growth curve mathematically describes the growth of natural populations of the fish. The von Bertalanffy growth curve is used in almost all cases (von Bertalanffy, 1938; Ricker, 1975; Everhart and Youngs, 1981). Usually, a Walford (1946) line is fitted to back-calculated size at age data to obtain parameters necessary for the von Bertalanffy equation. At this point the investigator has obtained the parameters K, t_o, and L_{oo} (t_c and t_r are directly observed, t_λ is calculated from L_{oo} using the von Bertalanffy equation).

Mortality estimates are frequently derived from catch curves, plots of age frequency observed in the catch on age. Various techniques exist for calculation of the mortality rates (Heinke, 1913; Jackson, 1939; Rounsefell and Everhart, 1953; Beverton and Holt, 1957; Robson and Chapman, 1961). If any two of Z, F, or M are known, the other is calculated according to the relationship Z = F + M (Everhart and Youngs, 1981).

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* t_c was developed as an aid to discussing the effect of minimum size regulations. For all calculations $t_c = t_r = t_p$, of Beverton and Holt (Ricker, 1975; 251).

Asymptotic or maximum weight (W_{∞}) is calculated using L_{∞} according to a standard length-weight relationship derived from the von Bertalanffy growth curve (Ricker, 1975; Everhart and Youngs, 1981).

All parameters necessary for YPR analysis are not available for every species in the snapper-grouper fishery. Species for which some or all of the parameters have been obtained are given in tables by family with representative parameters from recent studies in the following sections. The tables give source and geographic location of each study. Detailed information on aging techniques, age and size composition, and other topics may be found in the references given for each study. This information is not repeated here.

8.1.3.1 Snappers (Lutjanidae)

Necessary parameters for YPR analysis were available for *Lutjanus campechanus*, *L. griseus*, *Ocyurus chrysurus*, and *Rhomboplites aurorubens* (Table 8-4). Some parameters were obtained for *L. buccanella*, *L. vivanus*, and *L. analis* (Table 8-4).

8.1.3.2 Sea Basses and Groupers (Serranidae)

Necessary parameters for YPR analysis were available for *Centropristis striata*, *Epinephelus morio*, *E. drummondhayi*, *E. niveatus*, *E. guttatus*, *E. cruentatus*, *E. fulva*, *Mycteroperca microlepis*, and *M. phenax*; some parameters were obtained for *E. striatus* (Table 8-5). Similarities between species for which YPR analysis is possible and for those which it is not (due to lack of some parameters) is important for management. Lack of information which precludes direct YPR modeling does not preclude evaluation by analogy when there are strong reasons to believe that similar species (usually congenerics) exhibit similar biology and population dynamics.

8.1.3.3 Porgies (Sparidae)

YPR analysis was conducted only on *Pagrus pagrus*; some biological parameters are presented for *Calamus nodosus*, *C. leucosteus*, and *Stenotomus caprinus* (Table 8-6).

8.1.3.4 Grunts (Pomadasyidae)

YPR analysis was conducted on *Haemulon plumieri* and *H. aurolineatum*; some biological parameters are presented for *H. album* and *H. sciurus* (Table 8-7).

Table 8-4. Yield-per-recruit parameters for snappers (Lutjanidae).

SPECIES	t_c	t_r	t_o	t_λ	K	Z	M	F	L_∞ (mm)	LENGTH-WEIGHT RELATIONSHIP W =	GEOGRAPHIC AREA	SOURCE
L. camphechanus	2		0.10		0.175	0.80	0.30	0.50	950		Louisiana Florida Panhandle	Nelson and Manooch (1982)
			-0.10		0.170	0.43	0.30	0.13	941			
			-0.01		0.155	0.58	0.30	0.28	970	$1.36 \times 10^{-5} L^{3.017}$	Daytona, Florida	Nelson and Manooch (1982)
			-0.01		0.165	0.35	0.30	0.05	970	$3.15 \times 10^{-5} L^{2.887}$	North and South Carolina	Nelson and Manooch (1982)
	5			16	0.170				941		Gulf of Mexico	Nelson (1980)
			0	16	0.160				975			
L. griseus				18	0.101				890		Florida	Manooch and Matheson (unpubl.)
			-1.2745	21	0.0878				890	$2.4 \times 10^{-8} L^{2.9122}$	Northeast Florida, Gulf of Mexico	Manooch (1982)
O. chrysurus			-0.305	14	0.288				600.2	$6.13 \times 10^{-5} L^{2.76}$	Southern Florida, East and West Coasts of Florida	Johnson (unpubl. ms.)
					0.160		0.20		529	$7.327 \times 10^{-5} L^{2.73927}$	Cuba	Piedra (1965)
R. aurorubens			0.1277		0.198				626.5	$1.722 \times 10^{-5} TL^{2.9456}$	North and South Carolina	Grimes (1976)
L. buccanella									470	Log W = 3.05 Log $(FL)^{-4.86}$	Puerto Rico	Boardman and Weiler (1980)
L. vivanus	2								1170	Log W = 3.10 Log $(FL)^{-5.0}$	U. S. Virgin Islands	Boardman and Weiler (1980)
L. analis					0.120	0.87	0.20	0.67	807.5		Cuba	Baisre and Páez (undated)

Table 8-5 Yield-per-recruit parameters for sea basses and groupers (Serranidae).

SPECIES	t_c	t_r	t_o	t_λ	K	Z	M	F	L_∞ (mm)	LENGTH-WEIGHT RELATIONSHIP W =	GEOGRAPHIC AREA	SOURCE
C. striata			0.1855	10	0.222		0.27		350	$2.654 \times 10^{-5} L^{3.0237}$	North and South Carolina	Mercer (1978)
						0.60 - 0.83	0.30	0.30 - 0.53			South Carolina and Georgia	Low (1981)
				10	0.088				625		South Carolina	Cupka et al. (1973)
E. morio	1		-0.449		0.179	0.322			672	$4.3441 \times 10^{-5} L^{2.9287}$	Central West Florida	Moe (1969)
	3		0.090574	25	0.11269	0.48	0.20	0.28	928	$1.4791 \times 10^{-4} L^{2.5895}$	Mexico	Melo (undated)
					0.159	0.48	0.33	0.15	802		Mexico	Baisre and Paez (undated)
E. drummondhayi	3.3		-1.92	15	0.088		0.09-0.30	0.21 - 0.31	1105	$1.1 \times 10^{-8} L^{3.073}$	North and South Carolina	Matheson (1981)
E. niveatus	3.3		-2.32	17	0.063		0.06-0.30		1350	$7.0 \times 10^{-8} L^{2.755}$	North and South Carolina	Matheson (1981)
E. guttatus	3		-0.44	8	0.180		.20		420		Caribbean, Florida Keys, Bermuda	Burnett-Herkes (1975)
	2				0.240	0.68-0.90			520	$1.76 \times 10^{-5} L^{2.960}$	South Jamaica Shelf	Thompson and Munro (1974b)
E. cruentatus			-0.94	10	0.13		0.13		415	$0.0121 L^{3.0821}$	Curacao	Nagelkerken (1979)
E. fulva					0.63				340	$0.729 L^{2.574}$	Caribbean	Thompson and Monro (1974b)
M. microlepis			-1.127	>13	0.122		0.20		1290	$1.2x \times 10^{-8} L^{2.996}$	North and South Carolina, Georgia, Northern Florida	Manooch and Haimovici (1978)
M. phenax	1		-3.91	21	0.067				1090	$2.4 \times 10^{-8} FL^{2.910}$	North and South Carolina	Matheson (unpubl. data)
E. striatus	4		0.488		0.185				974	$0.1393 L^{3.112}$	St. Thomas, U. S. V. I.	Olsen and LaPlace (1978)
					0.09		0.17 - 0.30			$0.0107 L^{3.112}$	South Jamaica	Thompson and Munro (1974b)

Table 8-6. Yield-per-recruit parameters for porgies (Sparidae).

SPECIES	t_c	t_r	t_o	t_λ	K	Z	M	F	L_∞ (mm)	LENGTH-WEIGHT RELATIONSHIP W =	GEOGRAPHIC AREA	SOURCE
P. pagrus	5		-1.88		0.096		0.20		763		North and South Carolina	Manooch and Huntsman (1977)
C. nodosus			-1.746		0.212	0.52			469	$e^{-2.86 + .0073L}$	South Atlantic Bight	Horvath and Grimes (unpubl. data)
C. leucosteus			-2.639		0.1739					$4 \times 10^{-5} FL^{2.907}$	South Atlantic Bight	Waltz et al. (in press)
S. caprinus				2.5-3.0		1.77-4.61			256	Log W = -4.85 + 3.05 Log L	Gulf of Mexico	Geoghegan (1981)

Table 8-7. Yield-per-recruit parameters for grunts (Pomadasyidae).

SPECIES	t_c	t_r	t_o	t_λ	K	Z	M	F	L_∞ (mm)	LENGTH-WEIGHT RELATIONSHIP W =	GEOGRAPHIC AREA	SOURCE
H. plumieri			-1.007	13	0.1084	0.46 - 0.71	0.40 - 0.60		640	$1.426 \times 10^{-5} L^{3.0229}$	North and South Carolina	Manooch (1977a)
H. aurolineatum	4		1.28	9	0.22017	0.887			310	$0.86 \times 10^{-5} L^{3.0905}$	North and South Carolina, Georgia Florida to Cape Canaveral	Manooch and Barans (1982)
					0.235				295		Campeche Banks	Sokolova (1969)
H. album					0.196	1.0	0.33	0.67	621		Cuba	Baisre and Páez (undated)
H. sciurus					0.184	1.7	0.32	1.38	497		Cuba	Baisre and Páez (undated)

8.1.3.5 Tilefishes (Malacanthidae)

Insufficient data are available to perform YPR analyses on tilefishes. However, Ross (1978) provides detailed age and growth information on Caulolatilus microps off the Carolinas. He obtained L_{oo} = 813.5 mm, K=0.137, and t_o=1.03. He also obtained detailed information on age and size composition. The length-weight relationship is expressed by the equation: $W = 0.0000003973\ TL^{3.1407}$.

Age, growth, and mortality of Lopholatilus chamaeleonticeps are poorly known. Freeman and Turner (1977) procured preliminary observations on age composition and some data on size composition. Dooley (1978) has some evidence that they may live more than 20 years.

No age, growth, or mortality data are available on Malacanthus plumieri.

8.1.3.6 Triggerfishes (Balistidae)

Age, growth and mortality of triggerfishes have not been studied.

8.1.3.7 Wrasses (Labridae)

Age, growth, and mortality of Halichoeres radiatus have not been studied. Davis (1976) provides partial information for Lachnolaimus maximus. He fitted the von Bertalanffy growth model to back-calculated lengths at age for females (he was unable to age males), obtaining K = 0.1896, t_o = -2.33, and from a Walford plot, L_{oo} = 566 mm. He also presents survival rates for females. Length-weight relationships were $W = 2.55 \times 10^{-5} L^{2.97}$ for females and $W = 4.56 \times 10^{-5} L^{2.85}$ for males.

8.1.3.8 Jacks (Carangidae)

The most complete age and growth work available to date for Seriola dumerili is Burch (1979). He was able to age the dimorphic sexes using scales, assigning t_λ = 10 for females and t_λ = 8 for males. Von Bertalanffy parameters were L_{oo} = 146.3 cm, t_o = -0.798, and K=0.193 for males and L_{oo} = 159.7 cm, t_o = -0.490, and K = 0.194 for females. He also gives survival rates for both sexes.

Thompson and Munro (1974c) gave the following age, growth and mortality data for Caranx ruber: K = 0.24, M=1.3-1.5, and L_{oo} = 60 cm. They calculated total mortality at different study sites near Jamaica; the mean was 1.59. Length weight equations were listed for C. ruber, $W = 0.00834L^{3.191}$; C. bartholomaei, $W = 0.00632L^{3.368}$; and C. crysos, $W = 0.0065L^{3.302}$. Observed L_{oo} values were listed for six species of jacks.

8.1.4 Migration, Movement, and Differential Distribution

8.1.4.1 Snappers (Lutjanidae)

Migration, movement, and differential distribution on Lutjanus campechanus, L. griseus, L. vivanus, L. analis, L. apodus, L. synagris, L. buccanella, Ocyurus chrysurus, Rhomboplites aurorubens and to a lesser extent L. cyanopterus have been studied.

Camber (1955) and Moseley (1966) have suggested that as L. campechanus grow they move offshore to deeper waters. Bradley and Bryan (1975) supported this but suggested a movement of a portion of the adult reef population back into shallower water in the spring and summer months. Moseley (1966) has suggested that the offshore movement in colder months may be related to food availability. Moe (1963) stated that the offshore-inshore seasonal movement was accepted by fishermen in Florida as fact. Off North Carolina, Manooch (NMFS, Beaufort, N.C.; pers. observ.) has noticed increased catches of red snapper inshore (37-64 m; 121-210 ft) during spring (April and early May). It is not known whether or not this is a spawning related phenomenon.

No quantitative data are available on schooling by L. campechanus. Fishermen in South Carolina have reported schooling concentrations, i.e., catches of up to 200 snapper have been made without changing locations (G. Ulrich, S.C. Marine Resources Research Institute, Charleston, S.C.; pers. comm.).

Eggs and larvae are pelagic (Futch and Bruger, 1976). Juveniles are often found inshore of adult fish. Moseley (1966) reported that juveniles were collected in the northwestern Gulf of Mexico only in waters over sandy and muddy bottoms.

There are several theories on the distribution of larvae and juveniles off the Carolinas, because the number of juveniles appears low compared with the number of large fish caught. One theory states that larvae are spawned to the south and are carried by the Gulf Stream to the Carolinas. The other theory is that the local population reproduces itself.

L. griseus was studied in the Florida Keys by Starck and Schroeder (1971). Feeding movements occur at night over rather short distances. Large fish may range a mile or more at night from points of diurnal concentrations. Adults migrate to offshore reefs to spawn in summer. Tagged fish have moved as much as 75 km (40.5 nautical miles) in 7 days following the fall breakup of the summer schools.

Schooling behavior is strongest in adult fish and schooling coherence is greatest in areas of reduced cover. Schools of mixed species including L. griseus are common. For example, the sailors choice, Haemulon parrai, commonly mixes with L. griseus and sometimes in large numbers.

Eggs and larvae are pelagic; however, the planktonic life of the larvae is very short (Starck and Schroeder, 1971). Under artificial conditions, the duration of the larval stage was 25-30 days (M. Moe, Aqua-Life Research Corp., Marathon Shores, Fla.; pers. comm.). Juveniles have frequently been recorded from inshore areas. Grass beds form the most important inshore nursery grounds for L. griseus. Demersal fish measuring 10 mm (0.4 in) SL have been collected from these beds off the Florida Keys. Adults generally occur offshore of juveniles.

Thompson and Munro (1974a) provide information on L. vivanus from studies in the Caribbean. Eggs and larvae are believed to have a rather short pelagic stage. Juveniles have been taken in inshore waters as shallow as 30 m (98 ft) off Puerto Rico.

Adults usually occur in water depths of 151-243 m (495-797 ft) off the Bahamas, 128-156 m (420-512 ft) off Bermuda, and 75-100 m (246-328 ft) off the Carolinas. Best catches off Puerto Rico were in water depths of 101-250 m (331-820 ft); no fish were caught in depths less than 40 m (131 ft). Lists of associated species are provided by Thompson and Munro (1974a), Manooch (1975), and Huntsman (1976b).

Randall (1967) indicates that L. analis is more of a roving species than many other snappers of the genus Lutjanus.

Eggs and larvae of L. analis are pelagic (Roberts and Able, 1974). Juveniles occur inshore of adults in tidal creeks, bights surrounded by mangroves, and on grass beds (Roberts and Able, 1974).

Adults assume a benthic mode and generally occur in deeper water than juveniles. They are most abundant (70 percent occurrence) in water depths ranging from 40-59 m (131-194 ft) (Rivas, 1970). Starck and Schroeder (1971) report that adults are often observed in offshore grass areas over bottom with scattered growths of sponges and alcyonarian, around coral patches, and to the outer edges of deep reefs where they are common in depths of about 30 m (98 ft). Adults are sometimes taken along with L. campechanus in areas of deeper water (45 m; 148 ft) beyond the outer reefs (Starck and Courtenay, 1962).

Much of the information about L. apodus that follows is from Thompson and Munro (1974a) unless otherwise cited.

Randall (1962) reported a tagged specimen, free for 880 days, which was recaptured at the original release site. Tagging studies by Randall (1961) indicated little (one mile or less), if any, movement from the home reef.

L. apodus form schools (sometimes mixed with L. griseus) of several hundred to several thousand individuals over rocky bottom and on the reef-top (Starck and Davis, 1966). They found that daytime schools dispersed at sunset on Alligator Reef, Florida, and the species foraged individually at night.

Small L. apodus are frequently seen with L. griseus around mangrove roots and in turtle grass beds. They also occur around rocks and wreckage in channels, along rocky shores, on patch reefs, and on outer reefs (Starck and Schroeder, 1971). According to Randall (1967), L. apodus seems to be more confined to reefs than other species of snappers. The interaction of this species with other benthic carnivores has been described by Collette and Talbot (1972) and is the same as that discussed for L. synagris. On reefs studied in the Virgin Islands (Collette and Talbot, 1972), this species was usually seen singly or in pairs. It has been reported on algal flats in the middle of the night and early morning, but was also commonly seen on reefs in the pre-dawn and at dusk, suggesting it feeds nocturnally on the reefs as well (Collette and Talbot, 1972). Starck and Davis (1966) found that daytime schools dispersed at sunset on Alligator Reef, Florida, and that they foraged individually in reef-top rocky areas at night. According to Böhlke and Chaplin (1968), L. apodus and L. griseus occur together on the reefs during the day and then separate to feed at night when the two species proceed to different grounds appropriate to their feeding habits.

Eggs and larvae are pelagic (Rivas, 1970). Juveniles tend to occur in shallower water than adults (Rivas, 1970). This species is known to spend most of its juvenile life in shallow mangrove and grass flats areas and is not recruited to the reef habitat until a size of 127 to 203 mm (5-8 in) FL is reached. Adults are demersal and generally occupy deeper water than juveniles (Rivas, 1970).

L. synagris is reported to occur in a number of habitats, from coral reefs in clear waters to murky brackish water over a mud bottom (Randall, 1967). Juveniles are often found along with young L. griseus (Starck and

Schroeder, 1971). Collette and Talbot (1972) observed large schools of L. synagris, Haemulon sciurus, H. plumieri, small numbers of H. flavolineatum, L. apodus, and L. griseus moving slowly over reef areas during the day, often including in their schools several Mulloidichthys martinicus (yellow goatfish). The bulk of these schools moved off the reefs at dusk. With the exception of a few H. flavolineatum and L. apodus which were found on the reef at night, it is assumed that these fish hunt nocturnal invertebrates on the algal flats. Starck and Davis (1966) reported similar behavior at Alligator Reef, with small daytime schools in back-reef areas and nocturnal movement to grass patches and rubble areas. Smith et al. (1975) recorded the occurrence of this species on the Florida Middle Ground and provided information on associated species.

Eggs and larvae are pelagic. This species is known to spend most of its juvenile life in shallow mangrove and grass flats areas and is not recruited to the reef habitat until a size of 130 to 200 mm (5-8 in) FL (Thompson and Munro, 1974a). Rivas (1970) suggested that juveniles generally occur in waters shallower than 44 m (144 ft). Adults usually occur in deeper water than juveniles with 70 percent occurrence in the 29 to 59 m (95-194 ft) depth range. Adults occupy mud and sand bottoms in bays and channels, as well as sandy back reef areas (Starck and Schroeder, 1971).

Eggs and larvae of L. buccanella are pelagic (Starck and Davis, 1966). Young or juvenile fish occur in shallower water than adults (Starck and Davis, 1966). Rivas (1970) suggested that juveniles and young generally occur in waters less than 88 m (289 ft). Adults occupy a wide horizontal and vertical range and do not occur in water as shallow as juveniles. They are most abundant (70 percent occurrence) in the depth range of 49-126 m (161-413 ft.) (Rivas, 1970). They are often found in the same areas as L. vivanus and sometimes with Rhomboplites aurorubens.

Ocyurus chrysurus is a semi-pelagic wanderer over reef habitats (Moe, 1972). Randall (1961) reports that the species is more migratory than other species of snappers. They travel in large schools and this behavioral pattern is partly responsible for the success of the commercial fishery for this species off Florida and on the Bahama Banks (Moe, 1963).

Ocyurus chrysurus ranges throughout the reef habitat (Starck and Davis, 1966). The species is found on patch reefs to the outer edges of deep reefs and is apparently less closely associated with bottom types than other snappers, although O. chrysurus is most common over rough bottom of coral or rocks. Juveniles occur in grass beds, especially where finger coral is present (Randall, 1967; Starck and Schroeder, 1971). Both adults and young are active fish which usually swim well above the bottom (Randall, 1967). Collette and Talbot (1972) reported that this species schools with Scomberomorus regalis (cero mackerel), Caranx ruber, and L. synagris. They also observed O. chrysurus following goatfishes and feeding on the sand, presumably to obtain small food particles disturbed by the goatfishes. Smith et al. (1975) recorded the occurrence of this species on the Florida Middle Ground and provided information on associated species. The ecology of O. chrysurus has been discussed by Smith (1976).

Eggs and larvae are pelagic; juveniles commonly occur over shallow grass flats with larger juveniles inhabiting shallow reef areas (Thompson and Munro, 1974a). This species is known to spend most of its juvenile life in shallow mangrove and grass flats areas and is not recruited to the reef fisheries until a size of 12 to 20 cm (5-8 in) FL; adults are generally found on deeper reefs than juveniles (Thompson and Munro, 1974a).

Information concerning Rhomboplites aurorubens is from Grimes (1976) unless cited otherwise. No evidence of migrations exists for this species.

Schooling behavior was indicated during hook and line sampling. Fish were usually caught in sudden bursts of fishing activity. Experienced divers have observed vermilion snapper schools while diving on wrecks in 26 m (85 ft). Fish were in rather dense schools several feet above the wreck (S. Winner, headboat captain, Marathon, Florida; pers. comm.).

R. aurorubens is but one of many species of temperate, tropical, and subtropical species which occurs along the outer Continental Shelf of the South Atlantic Bight. Species lists have been provided by Manooch (1975), Grimes (1976), and Huntsman (1976a). Austin (unpubl. ms.) describes the habitat of associated species off Tampa, Florida. Kawaguchi (1974) lists R. aurorubens with other species caught in the Caribbean and adjacent waters. Best catches occurred with L. campechanus off the east coast of French Guiana. Also, see Springer and Woodburn (1960) for species lists for the west coast of Florida.

Eggs and larvae are pelagic (Grimes, 1976). Juveniles occur inshore of adults, but the inshore occurrence is probably short-lived. Adults occupy a wide horizontal and vertical range, preferring hard substrate, both low and high profiles, and do not display marked seasonal movements. Adults do not occur in water as shallow as larvae and juveniles.

L. cyanopterus occupies a wide range of habitats preferring deep channels, ledges, and coral patches (Starck and Schroeder, 1971). Associated fish species caught along with the four specimens taken off North Carolina are given by Schwartz (1972). Individuals occasionally associate with schools of L. griseus in channels and around patch reefs and offshore reefs in the Florida area. They are fairly common around Cuba in channels with grass bottoms in depths less than 8 m (26 ft) (Starck and Schroeder, 1971). Smith et al. (1975) recorded the occurrence of this species on the Florida Middle Ground and provided information on associated species. The ecology of L. cyanopterus has been discussed by Smith (1976).

Eggs and larvae are pelagic. Adults assume a demersal mode and appear to occupy a somewhat narrow vertical range.

8.1.4.2 Sea Basses and Groupers (Serranidae)

Information is available on Centropristis striata, Epinephelus morio, E. nigritus, E. striatus, Mycteroperca microlepis, M. phenax, and M. bonaci. Limited knowledge exists about E. adscensionis, E. itajara, E. mystacinus, and E. niveatus.

The extent of movement of C. striata is not well known. Tagging studies suggest limited movement. In returns from Florida, Beaumariage, (1969) reports that C. striata are non-migratory in the areas studied. Cupka et al. (1973) reported that fish tagged near buoys off Charleston, South Carolina, were caught year round at the release locations, indicating little seasonal movement. The longest distance traveled was 20.4 km (11 n mi). Parker et al. (1979) tagged individuals on artificial reefs off Murrells Inlet; tagged returns were all captured near the site of release. Harris (1977) reported that fewer than 0.3 percent of fish recaptured were caught at locations other than reefs where they were tagged. Younger, smaller fish (mostly females) are found in shallow inshore waters (less than 20 m; 66 ft). Older, larger fish are caught in deeper water (Cupka et al., 1973). C. striata immigrates to reefs searching for shelter (Myatt, 1978).

Eggs and larvae are pelagic; larvae have been collected from 4 to 82 km (2-51 mi) from shore in water depths between 15 and 51 m (49-167 ft) (Kendall, 1977).

Some larvae are transported inshore until they reach estuarine areas, in salinities above 30 ‰ and temperatures above 10°C (50°F). The juveniles leave when water temperature drops, usually in December.

Apparently C. striata hovers above bottoms individually or in loose aggregates (Kendall, 1977).

E. morio move offshore from shallower reef environments as sexual maturity is attained at about age 5 (40 cm; 16 in SL). Commercial fishermen report seasonal movement in deeper offshore (27-91 m; 89-299 ft) stocks of adult fishes. Tagging returns have verified extensive movement of adult E. morio, but patterns of migration, if any, are not known. Young do not move during their residence on nearshore reefs.

Group movement of tagged adults and the catches of many individuals at one place by commercial fishermen indicate some schooling or group movement among adults.

Lists of species associated with E. morio have been provided by Manooch (1975), Grimes (1976), and Huntsman (1976a) for North and South Carolina, Springer and Woodburn (1960) for Florida, and Kawaguchi (1974) for the West Indies. Moe (1969) has described the habitat of E. morio off Florida.

Eggs are pelagic (Moe, 1969). Duration of the pelagic larval stage is estimated at 30-40 days (Moe, 1969). E. morio leave the plankton to become benthic between 20-25 mm (1 in) SL (Moe, 1969). Juveniles are distributed in low densities over rocky bottom in depths of at least 37 m (121 ft) and are often taken inshore of adult populations (C. Manooch, III, NMFS, Beaufort Lab., Beaufort, N.C.; pers. observ. for N.C.). Juveniles are found in inshore grass beds along with M. microlepis and M. bonaci in North Carolina (M. Wolff, N.C. Division of Marine Fisheries, Morehead City, N.C.; pers. comm.) and E. striatus and M. bonaci in southern Florida (S. Bannerot, RSMAS, University of Miami, Fl.; pers. comm.).

Young E. morio leave the nearshore reef environment between 4 and 6 years of age and at about 450 mm (18 in) SL (corresponding with attainment of sexual maturity) and migrate to deep offshore waters (greater than 37 m; 121 ft). Huntsman (1976b) reported that E. nigritus taken by the Carolinas headboat fishery averaged 11 to 18 kg (23 to 40 lb). E. nigritus is the largest of the groupers taken by the South Carolina commercial fishery, with specimens exceeding 136 kg (300 lb) occasionally landed (Ulrich, unpubl. paper).

Smith et al. (1975) recorded the occurrence of this species on the Florida Middle Ground and provided information on associated species. The ecology of E. nigritus has been discussed by Smith (1976).

Eggs and larvae of E. nigritus are pelagic. Juveniles have been captured inshore by seining (Smith, 1971). Adults are demersal and occupy a wide horizontal and vertical range.

Beaumariage and Bulloch (1976) reported that when individual E. striatus were tagged and transported to other reefs in the vicinity, they returned to their original reef, displaying a strong home-reef specificity. Tagging studies by Springer and McErlean (1962a, b) indicated that there is a tendency for this species to stay in established areas. Randall (1962) reported that of five fish (23-25 cm; 9-10 in) tagged in the Virgin Islands and free for a period of 313 to 737 days, two were recaptured at the original release location and the others at a distance of from 91-823 m (100-900 yd) from the point of release. Smaller individuals are found in the shallow reef environment, while larger and older individuals move into deeper water (Bardach and Menzel, 1957). Collette and Talbot (1972) described the species as being diurnal or crepuscular in regards to their movements. E. striatus does not usually go far from cover (Starck and Davis, 1966). This species reportedly does not school (Brice, 1896).

East of the Gulf Stream, E. striatus is one of the most common species, but west of the Florida Straits it is outnumbered by E. morio. In Bermuda, it is exceeded in abundance among groupers only by E. guttatus, and possibly E. fulvus (Smith, 1971). Bardach (1959) presents information on other species associated with E. striatus on reef areas in Bermuda waters.

The eggs and larvae are pelagic; juveniles are common in seagrass beds (Randall, 1968). Adults are demersal and occupy a wide horizontal and vertical range.

Little is known of movement or migration of E. drummondhayi. Eggs and larvae are pelagic. Adults are demersal and occupy deep water. E. drummondhayi are usually caught at depths of 46 to 100 m (150-328 ft) (Huntsman, 1976a). Roe (1976) noted their occurrence in 165 m (540 ft) on the Campeche Bank.

Huntsman (1976a) and Bearden and McKenzie (1971) give lists of associated species. Smith et al. (1975) recorded the occurrence of this species on the Florida Middle Ground and provided information on associated species. The ecology of E. drummondhayi has been discussed by Smith (1976).

Some isolated facts are known about four additional Epinephelus species. E. adscensionis is one of the most common groupers on reefs in the Bahamas in shallow waters. Off southeastern United States, it is taken out to about 55 m (180 ft), but is not abundant in catches. Off the southeastern United States, E. itajara is most abundant along the coast of Florida. Apparently E. mystacinus is not abundant off the southeastern coast of the United States. It is a deepwater species and occurs to depths of 274 m (899 ft) or more and is most common at depths greater than 110 m (361 ft) (W. Anderson, St. Simons Island, Ga.; pers. comm.). Eggs and larvae of E. niveatus are known to be pelagic.

No long range, extensive movements have been documented for M. microlepis. Divers report some movement offshore of the Carolinas in winter when water temperature drops drastically (R. Parker and R. L. Dixon, NMFS, Southeast Fisheries Center, Beaufort Lab., Beaufort, N.C.; pers. comm.). Also, large M. microlepis show up in numbers off the Atlantic side of the Florida Keys in late winter and early spring but are relatively uncommon the rest of the year (S. Bannerot, RSMAS, University of Miami, Florida; pers. comm.).

M. microlepis is but one of many species of temperate, tropical and subtropical species which occur along the outer Continental Shelf of the South Atlantic Bight. Species lists are provided by Manooch (1975), Grimes (1976), and Huntsman (1976a). Also, see Springer and Woodburn (1960) for a species list for the west coast of Florida.

Eggs and larvae of M. microlepis are believed to be pelagic, although McErlean (1963) mentions that eggs and larvae are probably demersal and pelagic. Juveniles often occur inshore of larger fish, even extending up into estuaries (Manooch and Haimovici, 1978). Hoese et al. (1961), McErlean (1963), and Milstein and Thomas (1976) report young M. microlepis in coastal waters of Virginia, Florida (Gulf Coast) and New Jersey, respectively. Off the Carolinas, adults occur from 18 to 55 m (59-180 ft) (C. Manooch, NMFS, SEFC, Beaufort Laboratory, Beaufort, N.C.;

pers. comm.). Smith (1959) states that the species is taken from the Campeche Banks at 48-81 m (157-266 ft.). M. microlepis tend to concentrate just above irregular bottoms, particularly ledges.

There is some evidence that M. phenax may migrate to deeper water during the winter off the Carolinas (Ulrich, unpubl. ms.). This species does not usually go far from cover (Starck and Davis, 1966).

Huntsman (1976a) and Bearden and McKenzie (1971) give lists of species associated with M. phenax. Smith et al. (1975) recorded the occurrence of this species on the Florida Middle Ground and provided information on associated species. The ecology of M. phenax has been discussed by Smith (1976). Eggs and larvae are pelagic. Adults are demersal and occupy a fairly wide horizontal and vertical range.

M. bonaci is primarily a Caribbean species and is apparently not abundant off the southeastern coast of the U.S., except along the southern coast of Florida and on the Atlantic side of the Keys. Juvenile M. bonaci have been identified in a 3:106 ratio, M. bonaci vs. M. microlepis, in North Carolina estuaries (M. Wolff, N.C. Div. of Marine Fisheries, Morehead City, North Carolina; pers. comm.).

8.1.4.3 Porgies (Sparidae)

Knowledge of Pagrus pagrus is detailed. Some information is available on Archosargus probatocephalus, Calamus leucosteus, and Stenotomus caprinus.

Pagrus pagrus do not undergo long range migrations and local movements are not extensive. Tagging studies off the Carolinas (Manooch, 1975) revealed that P. pagrus did not move far from the original tagging site. The average distance moved over a two year period was 6 km (3.7 mi) and the farthest a tagged fish moved was 24 km (15 mi) after 47 days. Recaptures of P. pagrus tagged off the west coast of Florida indicate no movement (Beaumariage, 1969). P. pagrus does occur in schools (Manooch and Hassler, 1978).

Although the habitats are fairly similar off northwest Africa, South America, and southeastern U.S., with respect to depth, range, temperature, and substrate, species of fish associated with P. pagrus vary (Wozniak, 1967; Klimaj, 1970; Austin, unpubl. ms.; and Manooch, 1975).

Ranzi (1969) referred to vertical migration of larval and post-larval phases of Pagrus pagrus: "All of these stages (less than 10 mm; .4 in) can be fished in deep plankton, but at 10 mm Pagrus comes to the surface." Also, he noted a shift from planktonic to benthic existence at lengths above 20 mm (0.8 in). It is highly probable that young Pagrus are distributed inshore of adult populations, but the inshore occurrence of young is probably short-lived. Not only are eggs and larvae transported inshore by Ekman transport, but they are probably transported from relatively long distances. Adults occupy a wide horizontal and vertical range, preferring hard substrate, both low and high profiles, and do not display marked seasonal movements. Adults do not occur in waters as shallow as larvae and juveniles.

Some seasonal movements, which may be temperature related, have been observed in A. probatocephalus. Experienced divers in Morehead City, North Carolina, have seen schooling of large adults (up to 200 individuals) over artificial and natural reefs.

Eggs and larvae of A. probatocephalus are pelagic (Hildebrand and Cable, 1938). Larvae and juveniles are found in eelgrass beds in the summer. Adults occur around jetties, pilings, rocks, and wrecks, during the warm months north of Cape Hatteras and year round to the south. Adults do not occur in waters as shallow as juveniles.

Seasonal trawl data indicate that C. leucosteus moves into warmer offshore waters during winter months in the South Atlantic Bight (Waltz et al., in press). Adults are most abundant at depths from 10 to 100 m (33-325 ft) (Fischer, 1978; Powles and Barans, 1980).

S. caprinus eggs and larvae are transported inshore from offshore spawning areas (Geoghegan, 1981). Recruitment takes place in nursery areas less than 27 m (88 ft). Geoghegan (1981) states that young-of-the-year gradually disperse, as they mature, to waters 36 to 55 m deep (117 to 179 ft).

8.1.4.4 Grunts (Pomadasyidae)

Fairly complete information is available on Haemulon plumieri, H. flavolineatum, and H. aurolineatum. Partial information is available on some of the other species.

No evidence exists of extensive, large scale migration in H. plumieri or other pomadasyids.

There is some evidence of offshore movement by H. plumieri in the Carolinas during extremely cold weather (R. Parker, NMFS, SEFC, Beaufort Laboratory, Beaufort, N.C.; pers. comm.). Ogden and Ehrlich (1977) document large mixed resting schools of juvenile H. plumieri and H. flavolineatum on inshore patch reefs in the U.S. Virgin Islands. Movement to night-time feeding grounds on grass beds occurs each evening at the same light intensity levels (McFarland et al., 1979). Return migrations to the same patch reef occur at the same light levels as departure (McFarland, 1980).

Adult H. plumieri, H. flavolineatum, H. aurolineatum, H. chrysargyreum, H. parrai, H. sciurus, and H. melanurum have been observed on outer Florida reefs in resting schools. H. album is usually solitary or in small groups. Anisotremus surinamensis is usually solitary (S. Bannerot and J. A. Bohnsack, RSMAS, University of Miami, Florida; pers. comm.)

Eggs and larvae of H. plumieri and H. flavolineatum are pelagic (Courtenay, 1961). Courtenay (1961) states that young H. plumieri are especially abundant in Florida and Bahamian waters on grass beds at the edge of sand flats. Adults probably occur a little offshore of juveniles, particularly in late spring, summer and fall. Pelagic eggs and larvae are carried into waters largely uninhabited by adults (McFarland et al., 1979).

H. plumieri is associated with temperate, tropical and subtropical fishes throughout the range. Species lists off North and South Carolina are provided by Manooch (1975), Grimes (1976), and Huntsman (1976a). Springer and Woodburn (1960), and Austin (unpubl. ms.) include H. plumieri in their lists of fishes and ecological descriptions from Florida.

H. aurolineatum eggs and larvae are probably pelagic. Juveniles are often found inshore in grass beds (Billings and Munro, 1974). Juvenile and adults were not collected deeper than 9 m (30 ft) off Bermuda (Böhlke and Chaplin, 1968). On the Campeche Banks, most adults occur between 30-35 m (98-115 ft) (Sokolova, 1969).

8.1.4.5 Tilefishes (Malacanthidae)

Information is available on the three species listed for the management unit. Most of the following text on Caulolatilus microps is from Ross (1978) and on Lopholatilus chamaeleonticeps from Freeman and Turner (1977).

C. microps is possibly territorial: male dominance with size for reproductive females. The extent of migrations, if any, would be localized and upslope over the shelf edge for feeding purposes or seasonally to seek preferable temperature regimes. Schooling is unlikely.

C. microps is a member of a rather diverse community of tropical deep reef species with Caribbean-Gulf of Mexico affinities (Huntsman, 1976a). In the northern extents of its ranges off the Carolinas, C. microps occurs over the shelf break-upper slope regions due to the warming and moderating Florida current influence. Species lists are provided by Struhsaker (1969), Manooch (1975), Grimes (1976), and Huntsman (1976b).

Eggs and larvae of C. microps are pelagic. Catch records and food analysis indicate that adults are strict benthic browsers, showing close association with, and probably restricted to, the shelf break-upper slope zone off North Carolina and South Carolina. Fish concentrations are found over rugged, high relief areas, and sudden drop offs, but also on gently sloping bottoms.

It is very unlikely that L. chamaeleonticeps migrate extensively. However, the pattern of fishermen's catches and the retrieval of broken fishing hooks used in one area in another area several miles away, indicate that there is some local movement. This movement seems to be restricted to a rate of only a mile or two a day.

There is no evidence of schooling behavior, although the species does seem to occur in clusters, often with similar size fish occurring in close association. Divers have observed L. chamaeleonticeps clustered along the heads and sides of submarine canyons.

These fish occupy a narrow band of relatively warm water along the edge of the Continental Shelf. Within this band, the physical properties of the bottom water remain very stable allowing the existence of a warm-water community. Although tilefish is the top carnivore in the food web of this warm-water community, it depends mostly on species occurring only within the warm band for its food.

Adults usually occur in depths greater than 110 m (361 ft) and at a temperature of 13^{o}-15^{o}C (55^{o}-59^{o}F), along the east coast of the United States, and 247 m (810 ft) along the Gulf coast and off South America. As these fish become larger, they move to deeper depths. Along the east coast of the United States, large L. chamaeleonticeps seem to occur in fewer numbers beyond about 238 m (780 ft).

Prejuveniles of M. plumieri are pelagic. Adults are primarily shallow water benthic fish, found most abundantly between the depths of 10 and 50 m (33 ft and 163 ft) (Dooley, 1978).

8.1.4.6 Triggerfishes (Balistidae)

Documentation of movement or migration in balistids does not exist. Adults occur in a variety of habitats. Canthidermis sufflamen is an open water fish, while Balistes vetula is a near-shore reef dweller (Böhlke and Chaplin, 1968; Randall 1968). As an adult, B. capriscus is more common off the Carolinas, Georgia, and Northern Florida than it is in more tropical waters of the management unit. It is often caught on the same offshore ledge areas with Centropristis striata, Lutjanus campechanus, and Rhomboplites aurorubens.

8.1.4.7 Wrasses (Labridae)

No migration or movements have been documented for Halichoeres radiatus. Warner and Robertson (1978) found it to be largely restricted to areas of coral cover at depths of 3 to 18 m (10-59 ft). Juveniles may be found in greater abundance in more shallow, rocky areas in southeastern Florida while adults occur on offshore reefs (S. Bannerot, RSMAS, University of Miami, Florida; pers. comm.).

Juvenile Lachnolaimus maximus are found exclusively in inshore grass beds (Davis, 1976). They recruit to shallow patch reefs (less than 6 m; 20 ft) at 200 mm (8 in) and continue seaward as they grow larger (Davis, 1976). Adults are common from 8 m (25 ft) to 31 m (102 ft) and occur at least to a depth of 46 m (150 ft).

8.1.4.8 Jacks (Carangidae)

Migration and movement of only Seriola dumerili has been well documented by Burch (1979). Some information on differential distribution of Caranx species is available.

Tagging and recapture data for the years 1959-1977 supplied by the Cooperative Gamefish Tagging Program of NMFS/WHOI and analyzed by Burch (1979) indicate some seasonal migration of S. dumerili along the U.S. Atlantic coast, moving southward during December-May and northward during June-November. The range of this migration in at least some cases was nearly the length of the management unit. Adults are widely distributed, occurring from inshore inlets and over shallow reefs, down to depths exceeding 350 m (1,148 ft) (Böhlke and Chaplin, 1968).

Berry (1959) and Thompson and Munro (1974c) provide limited information on differential distribution of Caranx species and S. rivoliana. Adolescent C. bartholomaei, C. ruber, and C. crysos have been collected in abundance in shallow reef areas (0 - 15 m; 0-50 ft). Juvenile C. bartholomaei and C. hippos have been encountered in association with floating weeds and other objects in reef areas and in open water. Apparently the egg and larval stages are pelagic, pre-adults inhabit more shallow areas, and adult Caranx species generally occur around outer reef areas and in deeper channels and inlets when near shore.

8.1.5 Ecological Relationships

The snapper-grouper fishery consists mostly of carnivores and includes some omnivores. Trophic levels vary depending on family and species. Inter- and intra-family competition is in many cases intense. Trophic level, competition, predation, and feeding relationships are addressed for families of the snapper-grouper fishery in the following sections. Available references are given for species for which significant work has been done.

8.1.5.1 Snappers (Lutjanidae)

Lutjanids are usually primary, secondary, or tertiary carnivores. They feed opportunistically on fishes, crustaceans, and other invertebrates. Predators include almost any of the large carnivorous fishes in grass beds and other inshore areas where young lutjanids reside. Jacks, groupers, sharks, barracudas, and morays are examples (Thompson and Munro, 1974a). Large sea mammals and turtles are other potential predators. Adults of the larger species remain vulnerable to top level carnivores, for example, large sharks, groupers, and amberjacks. Lutjanids compete for food and space primarily with other fishes in the highly diverse, subtropical to tropical habitat that they normally occupy. Sparids, serranids, pomadasyids, and carangids comprise the major groups whose diet and/or habitat preference may at various times and localities result in competitive interaction with members of the family Lutjanidae. More specific work has been done on most of the Lutjanus species, Rhomboplites aurorubens, and Ocyurus chrysurus (Longley et al., 1925; Longley and Hildebrand, 1941; Rodriquez Pino, 1962; Piedra, 1965; Stark and Davis, 1966; Randall, 1967; Böhlke and Chaplin, 1968; Randall, 1968; Druzhinin, 1970; Starck and Schroeder, 1971; Collette and Talbot, 1972; Bradley and Bryan, 1973; Thompson and Munro, 1974a; Smith et al., 1975; Smith, 1976; Grimes, 1976; Futch and Bruger, 1976).

8.1.5.2 Sea Basses and Groupers (Serranidae)

Smaller serranids tend to be primary and secondary carnivores. Larger species are more often secondary, tertiary, or quaternary carnivores. All serranids are unspecialized and opportunistic. They generally engulf their prey whole by opening the mouth, dilating the gill covers, and rapidly drawing in a current of water, effectively inhaling the food item. Foods include fishes, crustaceans, cephalopods, and other invertebrates.

The smaller serranid species are subject to the same predators as lutjanids. The adults of larger species are subject only to large sharks and conceivably large carnivorous marine mammals.

Interspecific competition is probably more prevalent between serranids than lutjanids because of the high degree of similarity in food habits, habitat, distribution and size between family members. James Bohnsack (RSMAS, University of Miami, Miami, Florida; pers. comm.) has unpublished data showing a preponderance of small serranids in areas where larger species are removed by spearfishing. Various lutjanids, carangids, and to some extent sharks probably comprise the majority of other competitors with overlapping diet preferences.

Specific studies have been carried out on *Centropristis striata* (Kendall 1977) as well as *Epinephelus* and *Mycteroperca* species (Randall, 1965, 1967, 1968; Stark and Davis, 1966; Moe, 1969; Collette and Talbot, 1972; Thompson and Munro, 1974b; Burnett-Herkes, 1975; Smith, 1976; Nagelkerken, 1979).

8.1.5.3 Porgies (Sparidae)

Sparids are largely carnivores, although several species not listed in the management unit are omnivorous and eat more plant than animal material. The species in the management unit are almost always primary or secondary carnivores. They are extremely generalized and opportunistic, feeding on a wide variety of benthic invertebrates and some small fishes.

Sparids generally occupy a lower trophic level than many lutjanids and serranids. They have the same predators as listed for Lutjanidae, but in some cases may remain an important prey species rather than grow out of that phase as do larger lutjanid species.

Serranids, lutjanids, and pomadasyids are the major food competitors of the family sparidae. The diet of sparids in general probably overlaps more with Pomadasyidae than other families, particularly in the more southern area of the management unit. Sparids are primarily diurnal feeders while most pomadasyids feed actively at night.

Species specific studies include Hildebrand and Cable (1938), Manooch (1977b), Geoghegan (1981), and Waltz et al. (in press).

8.1.5.4 Grunts (Pomadasyidae)

Pomadasyids are carnivores. They feed primarily on benthic invertebrates, and most in turn serve as important prey items for a wide variety of predators throughout their lifespan. Serranids, carangids, and some lutjanids are prominent among these. Sharks and morays also eat pomadasyids.

Sparids, lutjanids, and smaller serranids compete with pomadasyids for food. Some additional competition for daytime resting space may occur between pomadasyids and some lutjanid species. Specific information for various pomadasyids may be found in Beebe and Tee-Van (1928), Longley and Hildebrand (1941), Reid (1954), Randall (1967, 1968), Carr and Adams (1973), Billings and Munro (1974), and Ogden and Ehrlich (1977).

8.1.5.5 Tilefishes (Malacanthidae)

Malacanthids are very generalized foragers. They feed on a large variety and size range of benthic organisms, mostly invertebrates but some epibenthic fishes, crabs, and shrimp. Conger eels, hakes, sea robins, goosefish, and various sharks, serranids, lutjanids and pomadasyids compete with malacanthids for one food item or another. At least some species are highly cannibalistic.

Shallow water species such as *Malacanthus plumieri* are vulnerable to most of the same predators as lutjanids, sparids, and smaller serranids. Deepwater species such as *Caulolatilus microps* and *Lopholatilus chamaeleonticeps* are preyed upon mainly by large, bottom-dwelling *Carcharhinus* sharks and large serranids. Juveniles are preyed upon by dogfish, conger eels, and adults of the same species. Specific studies on malacanthids listed for the management unit are Freeman and Turner (1977), Dooley (1978) and Ross (1978).

8.1.5.6 Triggerfishes (Balistidae)

Balistids are carnivores that rely on large teeth and powerful jaws to break apart and crush the relatively large, well-armored invertebrates upon which they feed (Randall, 1968). Foods include crabs, molluscs, echinoderms, and even coral.

Little information on specific competitors or predators is available. Some serranids, lutjanids, pomadasyids, sparids, and labrids occur in similar habitats and have overlapping diets. Certainly balistids are vulnerable to some of the larger predators of other snapper-grouper complex species. They may not be preferred, however, due to their tough, leathery skin and prominent, interlocking dorsal spines. Ecological studies of balistids are scarce, but some information appears in Berry and Vogele (1961), Moore (1967), Böhlke and Chaplin (1968), and Randall (1968).

8.1.5.7 Wrasses (Labridae)

Labrids are primary and secondary carnivores. They possess prominent canine teeth and well-developed pharyngeal teeth which they use to grasp and crush hard-shelled invertebrates. Their trophic level is comparable to sparids and pomadasyids. They are subject to most of the same predators as these two families. They compete for food with sparids, pomadasyids, lutjanids, and some serranids. More specific information is available in Böhlke and Chaplin (1968), Randall (1968), Glynn (1972), Davis and Birdsong (1973), and Davis (1976).

8.1.5.8 Jacks (Carangidae)

Carangids are carnivores, their trophic level varying depending on species. Extremes within the management unit are the largely planktivorous *C. ruber* and *S. dumerili*, a top level piscivore.

Predators and competitors vary accordingly. Carangids are exposed to predators not usually encountered by the more demersal families of the snapper-grouper complex. In addition to large serranids, morays, sharks, and sea mammals, carangids are consumed by various mackerels, billfishes, dolphin fish, and pelagic shark species. Competitors for food vary widely. Serranids, pomadasyids, lutjanids, morays, sharks, and mackerels all compete to some extent with carangids in this respect. Specific information is available from Randall (1967, 1968), Böhlke and Chaplin (1968), Thompson and Munro (1974c), and Burch (1979).

8.1.6 Abundance and Present Condition

Surplus production models have traditionally been used to assess the condition of exploited fish stocks in relation to maximum sustainable yield (MSY). Effort levels below that which produce MSY (E_u) theoretically produce an underexploited condition where potential for further yield exists (Figure 8-1a).

Effort levels above that which produce MSY theoretically produce an overexploited condition where effort (E_o) exceeds that level of effort which produces MSY (Figure 8-1b). This condition is called growth overfishing, and although it results in overcapitalization of the fishery it may be socially justified. A state of growth overfishing holds the productive capacity of the stock below the potential maximum level but does not generally risk stock collapse.

Surplus production models have not been used to assess present condition of species in the snapper-grouper fishery because accurate landings and effort data for the management unit do not exist. Theoretical maximum yield has instead been estimated with a yield-per-recruit (YPR) analysis, which is based on biological parameters of the species rather than landings data.

Assessment of the state of exploitation of the stock using YPR is analogous to surplus production analysis. Prevailing fishing mortality (F) and age liable to capture (t_c) in a fishery produce a level of yield that is equal to or below maximum yield. For a given species F is proportional to effort while t_c is inversely related to effort. Therefore, if the model indicates increased YPR in response to either an increase in t_c or a decrease in F the fishery is in a state of growth overfishing. Minimum size regulations effectively increase t_c and may therefore be used to mitigate growth overfishing and increase yield (Figure 8-1c).

If an increase in t_c from the existing t_c in the fishery causes an increase in YPR at a given F, then the existing t_c allows growth overfishing and is denoted t_{cgo} (Figure 8-1c). At any given F there exists a t_c that will maximize YPR, denoted t_{cmy} (Figure 8-1c). Usually t_{cmy} is above the range of t_c's dictated by socioeconomic factors of the fishery. However, growth overfishing can still be reduced to the optimum yield level by increasing t_c to a compromise level between t_{cgo} and t_{cmy} by using minimum sizes. Notice that the left hand portion of the curve in Figure 8-1c is analogous to the right hand portion of the curves in Figures

Figure a.

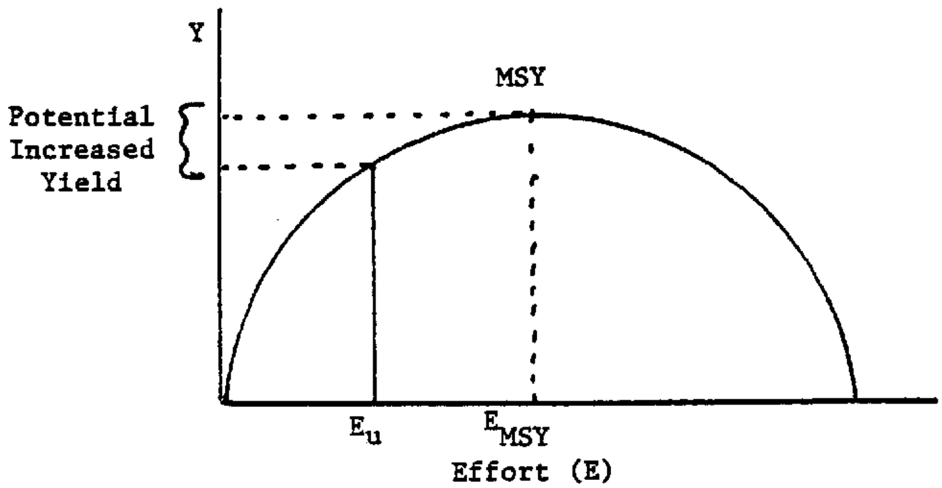

Figure b.

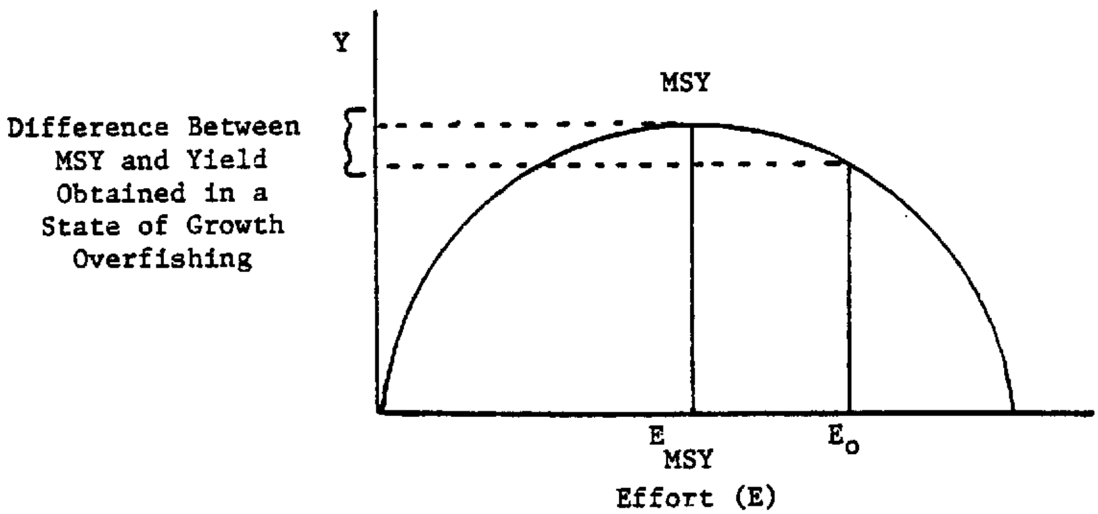

Figure c.

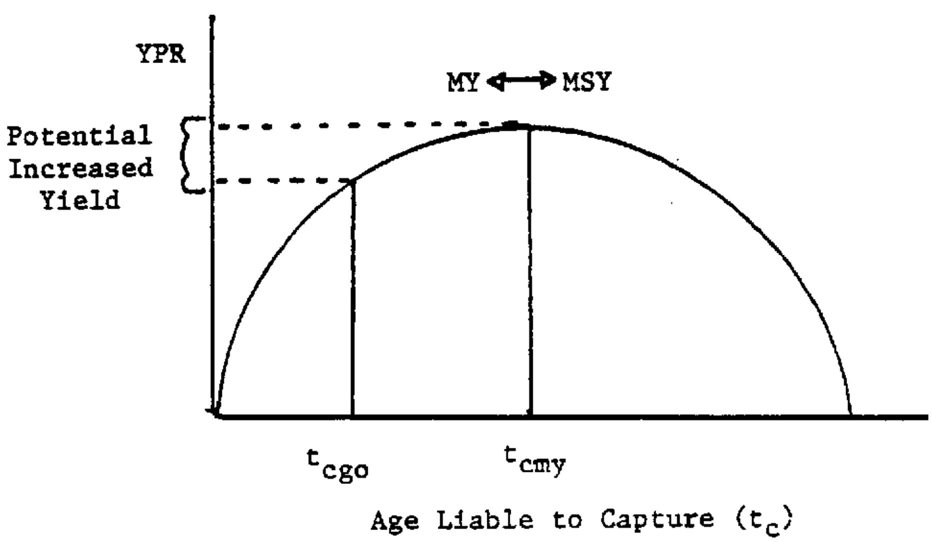

Figure 8-1. Theoretical yield curves.

8-1a and b. The right hand portion of the curve in Figure 8-1c corresponds to values of t_c that do not result in growth overfishing and is analogous to the left hand portion of the curves in Figures 8-1a and b.

The present state of 17 species in the snapper-grouper fishery was assessed by this method. Table 8-8 summarizes some of the results. Columns 5, 6 and 8 give existing YPR by weight, minimum sizes, and potential increased yield respectively for each species. Examination of Column 8 indicates that only Epinephelus guttatus, Haemulon plumieri, and H. aurolineatum are not in a state of growth overfishing. L. campechanus, E. drummondhayi, M. phenax, Pagrus pagrus, and E. cruentatus, appear to be in a state of borderline or mild growth overfishing. State of overfishing can be estimated based on assumed, undocumented F values. This approach was taken in the FMP. These values of F are given in Tables 8-8 and 8-9. All nine other species listed are in a state of growth overfishing, although regulation by minimum size is not always justified due to prohibitively low internal rates of return.

Minimum size limits for reef fishes based on yield-per-recruit models are discussed in Huntsman and Manooch (1976). Further discussion on the development of size limits is given in Appendix B. The dynamics of establishing minimum size limits is discussed by J. Waters in Appendix C.

8.1.7 Maximum Yield (MY) for Individual Species

The analogy between maximum yield calculated using YPR analysis and MSY from surplus production modeling is explained in Section 8.1.6. No surplus production models have been done to estimate maximum yield for individual species. Such models are unlikely in the near future because of the difficulties in obtaining accurate landings data, particularly from the recreational fisheries which are relatively large for a number of the species in this fishery.

Based on known age, growth, and natural mortality estimates, theoretical maximum yield has been estimated for 17 species (Table 8-9). These are the point estimates of the unique combination of fishing pressure (F) and age liable to capture that produces the theoretical maximum yield-per-recruit. This maximum yield would never likely occur because both fishing pressure and age liable to capture would have to be precisely regulated.

Table 8-8. Summary of the minimum size limit evaluations of all the species where YPR analysis is possible at this time.

SPECIES	EXISTING YPR: DOCUMENTED FISHING PRESSURE (F)	ASSUMED F FOR EVALUATION	PREVAILING AGE LIABLE TO CAPTURE	AVERAGE WEIGHT OF THE CATCH (GRAMS)	YPR (GRAMS)	YPR WITH MINIMUM SIZE LIMITS: PROPOSED MINIMUM SIZE/AGE	AVERAGE WEIGHT OF THE CATCH (GRAMS)	YPR WITH MINIMUM SIZE/% GAIN (GRAMS)	EVALUATION OF MINIMUM SIZE LIMITS: IRR WITH 100% SURVIVAL	SURVIVAL RATE THAT PRODUCES 3% IRR OR 60% SURVIVAL, WHICHEVER IS LESS
R. aurorubens	U*	.37	1.5	279.43	132.37	12"/3.5yr	688.11	177.19/ 34%	26.1%	80%=10.8% IRR
L. campechanus	.30	.30	2.0	1353.87	501.37	12"/3.0yr	2075.54	569.31/ 14%	42.6%	60%=6.1% IRR
L. griseus	U*	.39	1.0	246.08	140.62	8"/1.7yr	403.23	170.70/ 21%	43.1%	60%=6.1% IRR
O. chrysurus	U*	.50	1.0	489.47	335.87	12"/2.2yr	801.24	450.10/34%	50.0%	60%=14.1% IRR
C. striata (inshore)	.53	.53	1.0	82.42	52.60	8"/3.0yr	269.63	94.21/ 79%	32.4%	80%=13.9% IRR
C. striata (offshore)	.30	.30	1.0	116.93	61.04	8"/3.0yr	308.13	87.50/ 43%	17.3%	80%=3.1% IRR
E. drummondhayi	.42	.42	3.0	2184.22	983.43	18"/4.1yr	2906.04	1070.60/ 9%	8.0%	80%= 1% IRR
M. phenax	U*	.25	1.0	1010.06	498.54	14"/2.0yr	1317.10	532.94/ 7%	05.9%	80%= 1% IRR
E. morio	.35	.35	1.0	436.04	273.96	12"/4.0yr	1587.55	549.97/101%	50.0%	60%=23.2% IRR
E. striatus**	U*	.35	1.0	436.04	273.96	12"/4.0yr	1587.55	549.97/101%	50.0%	60%=23.2% IRR
M. microlepis	U*	.30	1.0	1511.53	650.00	18"/3.0yr	3352.20	789.77/ 22%	19.4%	80%= 6.8% IRR
M. venenosa**	U*	.30	1.0	1511.53	650.00	18"/3.0yr	3352.20	789.77/ 22%	19.4%	80%= 6.8% IRR
M. bonaci**	U*	.30	1.0	1511.53	650.00	18"/3.0yr	3352.20	789.77/ 22%	19.4%	80%= 6.8% IRR
E. guttatus	U*	.20	2.0	354.07	131.80	12"/4.5yr	657.29	122.95/ -7%	N/A	N/A
E. cruentatus	U*	.20	1.0	103.58	50.37	9"/5.0yr	289.95	57.82/ 15%		
P. pagrus	.40	.40	3.0	581.85	259.37	14"/3.5yr	672.18	270.89/ 4%	3.5%	90%= 1% IRR
H. plumieri	.40	.40	2.0	204.09	44.80	10"/3.0yr	330.23	39.78/-11%	N/A	N/A
H. aurolineatum	U*	.40	3.5	75.36	4.95	6"/4.0yr	75.36	4.95/ 0%	N/A	N/A

* Fishing pressure unknown.
** Evaluation by analogy.

Table 8-9. Existing YPR and theoretical maximum YPR.

SPECIES	EXISTING YPR VALUES				VALUES THAT MAXIMIZE YPR				PERCENT CHANGE FROM EXISTING TO MAXIMUM YPR
	Fishing Pressure (F)	Age Liable to Capture	Size Liable to Capture+ (in)	YPR	Fishing Pressure (F)	Age Liable to Capture	Size Liable to Capture (in)	YPR	%
R. aurorubens	.37*	1.5	5.9	132.37	.67	4.5	14.3	201.41	52
L. campechanus	.30	2.0	10.5	501.37	.60	4.5	19.7	667.98	33
L. griseus	.39*	1.0	6.3	140.62	.80	5.0	14.8	211.51	50
O. chrysurus	.50*	1.0	7.4	335.87	1.10	4.0	16.8	571.58	70
C. striata	.53	1.0	2.3	52.60	.63	4.0	7.9	103.02	95
E. drummondhayi	.42	3.0	15.3	983.43	.61	4.9	19.6	1,131.71	15
M. phenax	.25*	1.0	12.0	498.54	.80	5.0	19.3	619.66	24
E. morio	.35	1.0	3.6	273.96	.80	8.0	21.6	695.94	154
E. striatus	.35*	1.0	3.6	273.96	.80	8.0	21.6	695.94	154
M. microlepis	.30*	1.0	11.6	650.00	.60	4.0	23.6	894.01	52
M. venenosa	.30*	1.0	11.6	650.00	.60	4.0	23.6	894.01	52
M. bonaci	.30*	1.0	11.6	650.00	.60	4.0	23.6	894.01	52
E. guttatus	.20*	2.0	7.3	131.80	1.00	4.9	12.6	232.77	77
E. cruentatus	.20*	1.0	3.6	50.37	.80	4.9	8.7	87.10	73
P. pagrus	.40	3.0	11.2	259.37	.60	5.0	14.5	298.43	15
H. plumieri	.40	2.0	7.0	44.80	1.10	2.0	7.0	53.75	20
H. aurolineatum	.40*	3.5	4.7	4.95	1.10	4.0	5.5	6.47	31

*Age, growth, and natural mortality estimated, but fishing pressure (F) is not documented. F values are assumed for the purpose of making the comparison with maximum YPR.

+ Size was calculated using von Bertalanffy growth equation.

8.1.8 Maximum Sustainable Yield for the Fishery

It is not theoretically possible to estimate MSY for the fishery. Maximum yield for individual species where YPR data exist is presented in Table 8-9. It is expected that most of the species in the fishery were near MSY (with existing fishing methods) in 1979 except tilefish which were expected to be below MSY. For tilefish, 1981 landings are expected to be closer to MSY. Landings for 1979 (1981 for tilefish) are presented in Table 8-10 as an approximation of MSY for the fishery. (Confusion often exists between MSY, a term technically used in fishery science in connection with surplus production models that are estimated from actual catch and effort data, and yield-per-recruit which is estimated from natural growth and mortality estimates of fish independent of catch and effort statistics.)

8.1.9 Probable Future Conditions

Increasing fishing effort will result in most species in the fishery experiencing growth overfishing. Inshore locations will continue to be more intensively fished than offshore locations. For most species it is likely that more smaller fish are encountered inshore than offshore. Therefore, there will remain intense and growing fishing pressure on smaller fish. There will be particularly intense competition between user groups and fishing methods on the narrowing shelf south of Cape Canaveral which is close to growing population centers. Without regulations, growth overfishing will significantly reduce potential yield and recruitment failures could occur.

8.1.10 Marine Mammal/Endangered Species Interaction

The Endangered Species Act of 1973 (P.L. 93-205) is for the conservation of endangered and threatened species. The South Atlantic Fishery Management Council initiated the Section 7 procedure with the National Marine Fisheries Service and prepared a biological assessment on interactions of endangered and threatened species and the snapper-grouper complex. The National Marine Fisheries Service concurred with Council determination that endangered/threatened species under their purview would not be affected by the proposed management measures in the FMP.

The following species that occur in the South Atlantic are listed as endangered (E) or threatened (TL) (C. Oravetz, NMFS, Southeast Region, St. Petersburg, Florida; pers. comm.):

Table 8-10. Commercial and recreational landings of fishes in the snapper-grouper fishery in the south Atlantic FCZ in 1979 that are presumed to approximate MSY for the fishery.

	Commercial Landings (thousand lb)	% Total Commercial Landings	Recreational[a] Harvest (thousand lb)	% Total Recreational Harvest	Total Commercial & Recreational (thousand lb)	% Total	% Total Fishery Landings Minimum Size Limits Will Address
Snappers							
Red	425	5.2	1,010[k]	7.0	1,435	6.3	6.3[d]
Vermilion	373	4.5	19	0.1	392	1.7	1.6[e]
Gray	247	3.0	480	3.3	727	3.2	
Unclassified	944	11.5	2,357	16.4	3,301	14.6	2.2[f]
Total Snappers	1,989	24.2	3,866	26.8	5,855	25.8	
Black Sea Bass	954	11.6	1,854	12.9	2,808	12.4	12.4[g]
Groupers	2,551	31.0	2,187	15.2	4,738	20.9	3.1[h]
Porgies	1,076	13.1	413	2.9	1,489	6.6	
Sheepshead	230	2.8	2,014	14.0	2,244	9.9	
Grunts	129	1.6	1,568	10.9	1,697	7.5	
Tilefish	1,180[b]	14.4	-	-	1,180	5.2	
Triggerfish	46	0.6	304	2.1	350	1.5	
Hogfish	26	0.3	-	-	26	0.1	
Jacks	38	0.5	2,201	15.3	2,239	9.9	
Total	8,219	100.1	14,407	100.1	22,626[c]	99.8	25.6[j]

a. Recreational fish include those landed whole and those harvested but not brought ashore whole, used as bait, filleted, or discarded dead.
b. Tilefish are 1981 landings.
c. Presumed to approximate MSY for the fishery. Landings do not necessarily represent the MSY of individual species or species groups.
d. 12 inch minimum size for all commercial and recreational red snapper.
e. 12 inch minimum size for vermilion snapper through a 4 inch trawl mesh.
f. 12 inch minimum size for yellowtail snapper (2.2 percent of the total is approximately 15 percent of the unclassified group).
g. 8 inch minimum size for all commercial and recreational black sea bass.
h. 12 inch minimum size for red and Nassau grouper (3.1 percent of the total is approximately 15 percent of the unclassified groupers).
j. While minimum size limits at this time address only 8.7 percent of the species in the fishery by number (6 of 69 species), the size limits cover 25.6 percent of the fishery by weight.
k. Concern has been expressed that this figure over-estimates red snapper harvest because red porgies were included as red snappers in some states (B. Low, S.C. Wildlife and Marine Resources Dept., Charleston, S.C.; pers. comm.).

LISTED SPECIES	SCIENTIFIC NAME	STATUS	DATE LISTED
Finback Whale	Balaenoptera physalus	E	12/2/70
Humpback Whale	Megaptera novaeangliae	E	12/2/70
Right Whale	Eubalaena glacialis	E	12/2/70
Sei Whale	Balaenoptera borealis	E	12/2/70
Sperm Whale	Physeter catodon	E	12/2/70
Green Sea Turtle	Chelonia mydas	E	7/28/78
Hawksbill Sea Turtle	Eretmochelys imbricata	E	6/2/70
Kemp's (Atlantic) Ridley Sea Turtle	Lepidochelys kempi	E	12/2/70
Leatherback Sea Turtle	Dermochelys coriacea	E	6/2/70
Loggerhead Sea Turtle	Caretta caretta	Th	7/28/78

Sea turtles are found most often in relatively shallow waters (less than 60 m) and if found in deeper waters, they are usually in transit to and from feeding areas or overwintering near the shelf break. Fish traps for snappers and groupers formerly were set in these shallow waters, but there were no reports of turtles becoming entangled in trap lines or in traps. Florida has recently banned the use of fish traps in the state. There is no known effect on listed species by black sea bass traps used off the Carolinas in 20-35 m (10-17 fm) depths. Hook and line fishermen do not normally catch sea turtles, although they report seeing turtles around reef areas.

The trawl fishery for snapper-grouper consists of a small number of shrimp boats (about 25-30 in 1979) fishing during the off-season when shrimp are unavailable. The vessels are generally trawling during winter months, when turtles are dispersed on the Continental Shelf. During late winter the turtles appear to move to the shelf-break area (about 25-35 fathoms) before moving to inshore areas during spring. On the shelf-break area turtles tend to aggregate near structures of great relief and heavy concentrations of coral. The snapper-grouper trawlers tend to avoid areas of rock outcrops and broken relief because the nets are expensive (about $8,000-$9,000 in 1980) and snag on rough bottom, despite the large rollers designed to sweep the gear over uneven bottom. Thus, the chances of turtles encountering snapper-grouper trawlers are not great.

In summer, turtles generally are found in nearshore waters. Snapper-grouper trawlers do not fish during this season. According to Glenn Ulrich of the South Carolina Wildlife and Marine Resources Department, the possibility exists for turtles to be caught by snapper-grouper trawlers, but the number of captured turtles must be very small.

Mr. Ulrich stated that no turtles were caught during four trips (two days each) of exploratory trawling for snapper-grouper, nor has he heard of any turtles being caught by the commercial snapper-grouper trawlers in South Carolina.

The recent introduction of bottom longlines in the snapper-grouper fishery has brought changes in the fishery. However, because longline gear is relatively new for this fishery, no data have been collected on catches.

The whales listed are mostly surface or near-surface feeders and do not include bottom dwelling snappers and groupers in their diet. There are no known or suspected interactions between the fishery and these endangered whales.

8.2 Description of Habitat

8.2.1 Habitat Description

On the basis of bottom types and temperature, the Continental Shelf between Cape Hatteras and Cape Canaveral can be divided into five general habitats: coastal, open-shelf, live-bottom, shelf-edge, and lower-shelf (Figure 8-2), each harboring a distinct association of demersal fishes (Struhsaker, 1969*). The principal snapper-grouper fishing areas are located in the live-bottom and shelf-edge habitats and, to a lesser extent, the lower-shelf habitat.

The temperature regimes of the offshore shelf habitats mentioned above are strongly influenced by the Gulf Stream, which runs along the edge of the Continental Shelf north to Cape Hatteras where it swings northeasterly away from the shelf. This current maintains these habitats at a higher temperature than would normally be expected during the winter months at higher latitudes which partially explains the presence of tropical and semi-tropical snapper-grouper communities as far north as Cape Hatteras.

All of the snapper-grouper habitat areas mentioned above contain hard-bottomed areas which provide surfaces for the growth of invertebrate organisms and the development of an ecosystem capable of supporting members of the snapper-grouper fishery.

*This discussion is largely taken from Struhsaker (1969), unless otherwise noted.

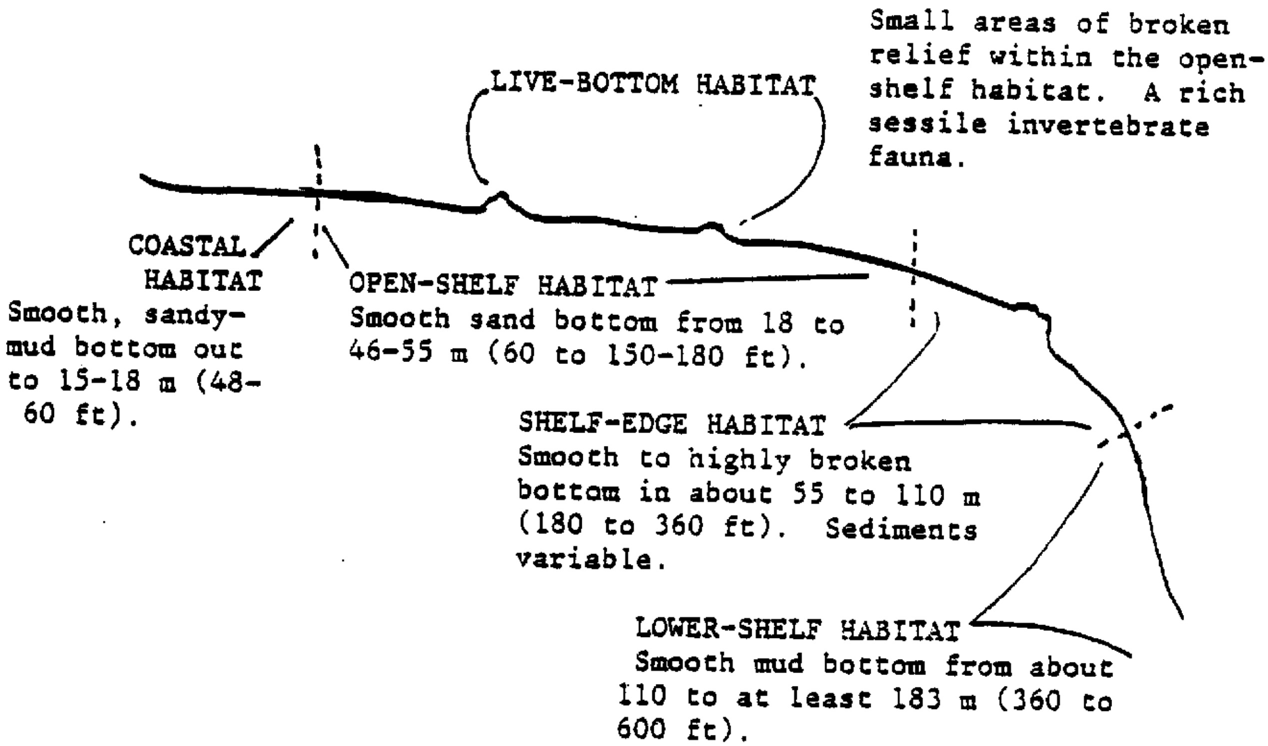

Figure 8-2. The five major types of habitat on the Continental Shelf off the Southeastern United States. (Source: Struhsaker, 1969)

The live-bottom habitats are small areas of broken relief consisting of outcrops of rock that are heavily encrusted with such sessile invertebrates as sponges and sea fans. These outcrops are scattered over most of the shelf north of Cape Canaveral but they are most numerous off northeastern Florida. Continental Shelf Associates (1979) studied two live bottom habitats off Georgia and South Carolina and found three types: 1) emergent hard bottom dominated by sponges and gorgonians; 2) sand bottom underlain by hard substrate dominated by anthozoans, sponges and polychaetes, with hydroids, bryozoans and ascidians frequently observed; and 3) soft bottoms not underlain with hard bottom. Temperatures range from 11^{o} to 27^{o} C (52^{o} to 80^{o} F). Most live-bottom areas are at depths greater than 27 m (90 ft), but many are at depths of from 16 to 27 m (54 to 84 ft), especially off the Carolinas.

Generally, snappers (Lutjanidae), groupers (Serranidae), and porgies (Sparidae) inhabit the live-bottom habitats off northeastern Florida and the offshore areas of Georgia and the Carolinas. The live-bottom areas inshore (at depths of about 18 m; 60 ft) have fewer invertebrates and are occupied largely by black sea bass.

The shelf-edge habitat runs more-or-less continuously along the edge of the Continental Shelf at depths of 55 to 110 m (180 to 360 ft). The bottom types in this zone vary from smooth mud to areas that are characterized by great relief and heavy encrustations of coral, sponge, and other predominantly tropical invertebrate animals. Some of these broken-bottom areas (at least those off Onslow Bay, North Carolina) may represent the remains of ancient reefs that existed when the sea level was lowered during the last glacial period.

Struhsaker (1969) reported that, as a result of the proximity of the Gulf Stream, average temperatures at the shelf-edge are higher than those further inshore and range, depending on the season and location, from about 12^{o} to 26^{o} C (55^{o} to 78^{o} F). However, Miller and Richards (1980) found that there is a stable area between 26 and 51 m (85-167 ft) where the temperature is not cooled below 15^{o} C (59^{o} F). Cold water intrusions may cause the outer shelf bottom temperatures to drop (Avent et al., 1977; Mathews and Pashuk, 1977; Leming, 1979).

Generally, fishes inhabiting this zone are tropical types, such as snappers, groupers, and porgies. The fishes are rather diffuse in this zone, but often they concentrate in aggregations over broken-bottom areas and form associations similar to those formed inshore on the live-bottom habitat.

The lower-shelf habitat occurs at depths of about 110 to at least 183 m (360 to 600 ft). Temperatures in this zone vary from about 11° to 14° C (51° to 57° F).

The lower-shelf area has a predominantly smooth mud bottom, but it is interspersed with rocky areas where deepwater groupers (*Epinephelus* sp.) and tilefishes are found. This habitat and its association of fishes roughly marks the transition between the fauna of the Continental Shelf and the fauna of the upper Continental Slope.

The exact extent and distribution of productive snapper-grouper habitat on the Continental Shelf north of Cape Canaveral is unknown, and estimations are difficult because of the discontinuous and patchy nature of live bottom. Numerous studies have attempted to assess the area involved.

Hazard surveys by the U.S. Geological Survey in connection with oil Lease Sale 43, and information derived from fishermen and researchers by the Bureau of Land Management (R. O. Parker, NMFS, Beaufort, N.C.; pers. comm.) suggest that hard-bottom areas occupy only about three percent of the shelf (2,719 km^2). Henry and Giles (1979) estimated about 4.3 percent of the Georgia Bight surveyed to be hard bottom, but this is considered an underestimate.

Miller and Richards (1980) report that live-bottom reef habitat comprises a large area of the South Atlantic Bight. The method used to determine areas of live bottom was to review station sheets from exploratory fishing cruises and locate stations where reef fishes were taken in the catch. "Parker et al. (in preparation) suggest that 'rock-coral-sponge' habitat accounts for nearly 30 percent of the substratum between the 27 m and 101 m isobaths from Cape Fear to Cape Canaveral" (S.C. Wildlife and Marine Resources and Georgia Department of Natural Resources, 1981).

The configuration, bottom composition and structure, and flora and fauna of the Continental Shelf from Cape Canaveral south to Key West and the Dry Tortugas is so different from the northern shelf areas that generalized descriptions cannot apply to both regions. The Continental Shelf narrows from 129 km (80 mi) or more off north Florida to 56 km (35 mi) off Cape Canaveral and further narrows to 16 km (10 mi) and less off the southeast coast of Florida and the Florida Keys. This lack of extensive shelf area, presence of extensive, rugged living and fossil coral rock reef formations, and dominance of a tropical Caribbean fauna are the distinctive characteristics. The Florida Current courses rapidly northwards just beyond and oftentimes over the shallow shelf.

Compared to the north Florida shelf, the southeast Florida shelf is rough and craggy due to a series of coral rock reefs that extend parallel to the shoreline. These rocky reef areas are interspersed with sandy, rubble, and grassy bottoms. Although much of this intermediate bottom is "live" in the sense that it harbors extensive small fish life, the high reef areas are the primary fishing grounds. The reef lines north of West Palm Beach are widely separated and erratic in form and occurrence. The shelf is narrowest between West Palm Beach and Miami and the reef lines are most sharply defined in this area. The shallowest reef line occurs in depths of 9 to 14 m (30 to 46 ft), is the weakest in definition and relief, and is often totally obscured. The third and deepest reef occurs at depths of 24 to 38 m (80 to 125 ft) and exhibits the most rugged relief and greatest continuity. The second or middle reef line is intermediate in form and depth. All three reef lines have areas of pronounced relief that are the most sought after fishing areas. The fossil coral rock that forms these reefs is the substrate for growths of sponge, hard and soft corals, and other invertebrates and algae that provide cover and forage.

The living coral reef of the Florida Keys is properly termed a bank reef and extends 96 km (60 mi) from just south of Miami to the Dry Tortugas bounding the Atlantic edge of the Florida Plateau (Marszalek et al., 1977). The basic configuration of parallel reef lines is still present, but obscured. Extensive patch reefs of living reef-building corals are present wherever underlying fossil Pleistocene reefs break above the bottom sediments. These patch reefs are occasionally quite extensive in area and the most rugged of these are the favored fishing areas.

An estimated 20 to 30 percent of the shelf area in this region is composed of rubble or reef bottom that is considered live bottom.

8.2.2 Habitat Areas of Particular Concern

In 1981, John Reed of Fort Pierce, Florida, nominated the shelf edge Oculina varicosa coral reefs off central eastern Florida as a Habitat Area of Particular Concern (HAPC). The banks consist of colonies growing up to 1.5 m (5 ft) high, several hundred meters long, and capping pinnacles up to 25 m (82 ft) in relief at depths of 70-100 m (230-328 ft) (Reed, 1980). Two options were presented. Option I includes all presently mapped Oculina banks, encompassing 390 nm^2. This is a unique region which could be damaged by trawls, traps, bottom longlines, anchors, dredges, and discharges. Snappers and groupers utilize shelf-edge reefs for feeding, breeding grounds, or migration pathways. Option II includes the area of greatest occurence of Oculina heads and four Oculina banks encompassing 92 nm^2. Option II has been incorporated in the Coral Fishery Management Plan for the South Atlantic and Gulf of Mexico Councils as an area to be protected.

In addition to natural hard-bottom and reef habitats, wrecks and man-made tire reefs also furnish suitable substrate for the growth of live-bottom. The species composition on artificial reefs is similar to that found on natural rough bottom habitat at the same depth and in the same areas (Parker et al., 1979; Stone et al., 1979). Some recent data indicate that these reefs do increase total biomass within a given area without detracting from biomass potential in other areas (Stone et al., 1979). These artificial structures, found adjacent to the four states within the management area, are used primarily by the recreational segment of the fishery.

Because many species of the complex spend most or all of their adult lives in close association with reefs and other types of hard-bottom areas, any activities which result in significant destruction or degradation of these areas would, to some extent, adversely affect the productivity of the snapper-grouper fishery.

Of potential concern are drilling activities which may occur off the Carolinas, Georgia, and northeast Florida. Increased sedimentation resulting from discharge of drilling muds and cuttings could bury hard bottom unless tidal currents dispersed the sediments (S.C. Wildlife & Marine Resources Department and Ga. Department of Natural Resources, 1981). The amount of snapper-grouper habitat contained within these lease tracts is unknown. However, it is likely that detrimental effects on reef fish habitat will be minimal in that the agency in charge of leasing tracts, The United States Department of Interior, Bureau of Land Management, requires that lease-holders use procedures and equipment which will minimize environmental damage (J. Rankin, U.S. Bureau of Land Management, New Orleans, La.; pers. comm.).

The habitat and environmental requirements of species in the snapper-grouper complex during their larval, post-larval and juvenile stages are not well known. However, some habitat areas of importance can tentatively be identified based on the limited data available (Courtenay, 1961; Randall, 1968; Starck and Schroeder, 1971; Billings and Munro, 1974; Roberts and Able, 1974; Thompson and Munro, 1974a; Manooch and Haimovici, 1978).

During certain times of the year large numbers of juvenile groupers and some snappers are found in grass and algal beds. It is likely that these beds serve as nursery areas. The areal extent and exact location of these areas are unknown. Estuarine areas contain young of some members of the snapper-grouper complex as do mangrove areas in southern Florida. Both these habitat areas would be protected, to some degree, by the state marine management and protection programs discussed in Section 8.3.4.

8.3 Fishery Management Jurisdiction, Laws, and Policies

8.3.1 Management Institutions

The species under consideration depend on natural and artificial reef and other hard-bottomed habitats during all or most of their adult lives. These habitats are found within both the U.S. Fishery Conservation Zone and the territorial waters of the states within the management area.

Adjacent to the states of North Carolina, South Carolina, and Georgia, all known, natural habitat for mature snappers and groupers is located within the FCZ. However, artificial reefs are found within the territorial waters of both North and South Carolina. Adjacent to the state of Florida, both natural and artificial reef areas occur in territorial waters, as well as in the FCZ.

Snappers and groupers within the FCZ will be managed by the U.S. Department of Commerce in accordance with the Fishery Management Plan developed by the South Atlantic Fishery Management Council pursuant to the Magnuson Act (P.L. 94-265). The states have management authority over snapper-grouper stocks which occur within their territorial seas. Basic characteristics of the state institutions involved in fishery management are summarized in Table 8-11. The characteristic of primary importance is the identification of authority for establishing management regulations in the various states. All states delegate some degree of authority to administrative bodies. North Carolina utilizes administrative authority for establishing substantive management regulations. In the other three states, the statutes contain the specific regulatory measures used to manage the fishery resources.

Table 8-11. State management institutions: South Atlantic Region.

	Administrative Body and its Responsibility	Administrative Policy-Making Body and Decision Rule	Legislative Involvement in Management Regulations
North Carolina	Department of Natural Resources and Community Development *administers management programs *makes recommendations to Commission *enforcement *conducts research	Marine Fisheries Commission *15-member board *establishes regulations based on a majority vote of the members consistent with statutes	Authority for detailed management regulations delegated to Commission *statutes concerned with licensing and enforcement
South Carolina	Department of Wildlife and Marine Resources *administers management programs *makes recommendations to Commission and Legislature *enforcement *conducts research	Wildlife and Marine Resources Commission *nine member board *establishes regulations based on majority vote of a quorum (five members constitute quorum)	Detailed regulations contained in the statutes; changes require legislative approval

-continued-

Table 8-11. (Continued)

	Administrative Body and its Responsibility	Administrative Policy-Making Body and Decision Rule	Legislative Involvement in Management Regulations
Georgia	Department of Natural Resources *administers management programs *conducts research *enforcement *makes recommendations to Board and Legislature	Board of Natural Resources *15-member board *establishes regulations based on a majority vote of quorum (8 members constitute a quorum)	All management regulations currently contained in statutes; changes require legislative approval
Florida	Department of Natural Resources *makes recommendations to Legislature *administers management programs *conducts research	Department of Natural Resources *may establish regulations consistent with statutes; require approval of Governor and Cabinet	Detailed regulations contained for individual counties, and entire state included in statutes; require legislative approval and limit regulatory authority of Department of Natural Resources

North Carolina

The agency responsible for the management of fishery resources in North Carolina is the Department of Natural Resources and Community Development. The Marine Fisheries Commission is a 15-member board appointed by the governor which serves as the policy-making body for marine fisheries. The Commission has the power to adopt rules and regulations consistent with statutes to properly manage the taking, processing and disposition of marine resources. Regulations are adopted by majority vote of the Commission. There also exists within the department a nine-member Commercial and Sports Fisheries Committee. It is composed of representatives of fishing interests and the scientific community. Its responsibilities are largely to advise and recommend actions to the Secretary of the Department.

North Carolina statutes deal with matters such as licenses and fees, enforcement, and leasing procedures for oysters and clams. Management authority such as size limits, seasons, or gear restrictions is left largely to the discretion of the Marine Fisheries Commission and Department of Natural Resources and Community Development, Division of Marine Resources.

South Carolina

The Wildlife and Marine Resources Department is responsible for marine fisheries resource management in South Carolina. A nine-member governing board, the Wildlife and Marine Resources Commission, establishes policy for the Department. Regulations of the Commission are adopted by majority vote of a quorum (five members required for a quorum). Within the Department is the Marine Resources Division. Its personnel serve as staff to the Commission. The Division has the authority to adopt and implement rules and regulations for the control of fisheries consistent with the laws and policies of the state. The Division has jurisdiction over:

> All salt water fish, fishing and fisheries, all fish, fishing and fisheries in all tidal waters of the state and all fish, fishing and fisheries in all waters of the state whereupon a tax or license is levied for use for commercial purposes (including) shellfish, crustaceans, diamond-back terrapin, sea turtles, porpoises, shad, sturgeon, herring and all other migratory fish except rock fish (striped bass). S.C. Code S28-159.

The Division of Law Enforcement and Boating is responsible for enforcement of the state's fisheries laws.

The legislature has passed rather detailed laws concerning the major species sought off South Carolina. Because all rules and regulations are currently contained in the statutes, changes in the management scheme require legislative action. Current statutes include provisions for allowable fishing methods and seasons for oyster, prawn, shrimp, crabs, clams, industrial fish, shad, sturgeon, terrapin and sea turtles.

<u>Georgia</u>

Fisheries management is the responsibility of the Department of Natural Resources in Georgia. The policies for the Department are established by the Board of Natural Resources, a 15-member commission. Regulations may be adopted by a majority vote of a quorum (eight members constitute a quorum). Marine fisheries resource management is administered by the Coastal Resources Program of the Division of Fish and Game. The Department and the Board have authority to fix creel limits and establish closed seasons for all wildlife on a statewide, regional, or local basis consistent with the state statutes. They may also regulate the method, manner and devices used for the taking of fish except where otherwise provided by law. Those resources for which relatively detailed statutes are in effect include oysters, shrimp, prawns, and crabs.

<u>Florida</u>

In Florida, the Division of Marine Resources in the Department of Natural Resources is responsible for the preservation, management and protection of marine fisheries. In addition, it is the duty of the Division to regulate operations of all fishermen and vessels engaged in taking state fishery resources both within and without the state. Any rules or regulations designed by the Division of Marine Resources and approved by the Director of the Department of Natural Resources must also be approved by the governor and his cabinet.

While rules and regulations may be established without legislative consent, any such rules must be consistent with the existing statutes. Currently the state statutes include extensive provisions for the management of shrimp, spiny lobster and oysters. Specific statutory provisions have also been enacted for stone crab, blue crab and shad.

In addition to laws passed by the legislature for statewide application, the legislature also passes special laws directed at local areas, usually counties, that regulate fishing practices in the designated areas.

8.3.2 Treaties and International Agreements

There are no treaties or international agreements which apply directly to the stocks under management consideration.

8.3.3 Federal Programs, Laws, and Policies

The only Federal law that directly relates to management of the snapper-grouper fishery is the Magnuson Fishery Conservation and Management Act of 1976 (P.L. 94-265). Other Federal laws relate indirectly to the fishery, as indicated by the following.

The Coastal Zone Management Act of 1972 (16 U.S.C. 1451) establishes a national policy and initiates a national program to encourage state planning for the management, beneficial use, protection and development of the Nation's coastal zones (generally, the submerged lands and waters of the territorial sea and the adjacent shorelands having a direct and significant impact on such waters). Three states within the management area, North Carolina, South Carolina, and Florida have coastal zone management programs which have been approved by the Secretary of Commerce. These programs for protection and enhancement of the marine environment within state waters should complement the management initiatives in the FMP.

The National Environmental Policy Act of 1969 (42 U.S.C. 4321-4347) requires detailed Environmental Impact Statements (EIS) on proposals for legislation and other major Federal actions which may significantly affect the quality of the human environment. Preparation of the EIS requires applicants to consider alternative approaches that eliminate or minimize adverse environmental impacts.

The National Ocean Pollution Research and Development and Monitoring Planning Act of 1978 (P.L. 95-273) designates NOAA as the lead agency in the development of a comprehensive 5-year plan for a Federal program relating to ocean pollution research, development, and monitoring. This plan is to provide for the coordination of existing Federal programs relating to the oceans and for the dissemination of information emerging from these programs to interested parties. In addition, the plan shall provide for the development of a base of information necessary to the utilization, development, and conservation of ocean and coastal resources in a rational, efficient, and equitable manner.

The Marine Protection, Research and Sanctuaries Act of 1972 (16 U.S.C. 1431-1434) authorizes the Secretary of Commerce to designate as marine sanctuaries those areas of ocean waters within United States jurisdiction which the Secretary determines to be necessary for the purpose of preserving or restoring their conservation, recreational, ecological, or aesthetic values. This designation is made with the agreement of the Governor of any affected state should such designation include waters lying within the territorial limits of the state. Four areas have been designated as marine sanctuaries in the South Atlantic FCZ. The Key Largo Coral Reef Marine Sanctuary encompasses a 100 nautical square mile area of the Florida Reef Tract. Gray's Reef National Marine Sanctuary lies approximately 18 nautical miles off Sapelo Island, Georgia and encompasses about 17 square nautical miles. Looe Key National Marine Sanctuary is located seven nautical miles southwest of Big Pine Key, Florida and consists of five square nautical miles of a submerged section of the Florida reef tract. The USS Monitor National Marine Sanctuary off North Carolina is designated on National Ocean Survey charts as a protected area. Fishing is prohibited in this area.

The National Park Service within the Department of Interior operates several marine areas in the South Atlantic region. Biscayne National Park is located north of Key Largo and includes state and Federal waters. Currently there are no special regulations for the Park. It is listed as a Habitat Area of Particular Concern in the Coral FMP and is administered by the National Park Service.

The Dry Tortugas-Fort Jefferson National Monument is located at the southwestern tip of the Florida reef tract and administered under National Park Service regulations. It contains approximately 26,166 ha (64,657 acres) of water area. Only recreational hook and line fishermen are allowed to harvest species in this fishery. All areas within the monument's administrative boundaries (except Garden Key) are classified as an outstanding natural area.

Marquesas Keys - Key West National Wildlife Refuge is a protected Federal area.

Reefs for Marine Life Conservation (16 U.S.C. 1220-1220C) provides for state acquisition of Liberty ships to sink for offshore artificial reefs.

The Endangered Species Act of 1973 (16 U.S.C. 1531 et seq.) names animals endangered or threatened throughout their range and makes it a crime to harm or kill them.

The Marine Mammal Protection Act of 1972 (16 U.S.C. 1361 et seq.) seeks to conserve and protect marine mammals. There are no records of marine mammals having been adversely affected by activities of the snapper-grouper fishery.

State Commercial Fisheries Research and Development Projects (16 U.S.C. 779-779f) provide for cooperation and funding by the Secretary of Commerce for research and development by states covering their commercial fisheries resources.

The Estuarine Areas Act (16 U.S.C. 1221-1226) supports coordination with states for the purpose of conservation, protection and restoration of resources of estuarine areas.

The Federal Water Pollution Control Act and Amendments of 1972 (33 U.S.C. 1251-1376) require that states and regions engage in land use planning to control the location of new sources of pollution and restrain the dredging and filling of wetlands or other waters without a permit from the Army Corps of Engineers. Discharge of effluents is regulated by the Environmental Protection Agency.

The Deepwater Port Act of 1974 (33 U.S.C. 1501-1524) establishes procedures for the location, construction, and operation of deepwater ports off the coasts of the U.S.

8.3.4 State Progams, Laws, and Policies

8.3.4.1 North Carolina

In addition to a federally approved Coastal Zone Management Program, the state of North Carolina has provisions for establishing research sanctuaries and protecting nursery areas for economically important seafood species (15 N.C. Admin. Code 38/.0111 and 313/.1401, respectively). Other laws having indirect impact on snapper-grouper habitats include the regulation of dredge and fill activities in estuarine areas (N.C. Gen. Stat. 113-229(e)(5)) and the regulation of discharges of oil and wastes into ocean waters (143-215.84 and 215.90). North Carolina General Statutes (113-262) also prohibit the use of poisons, drugs, explosives, or electricity for taking fish within state waters.

8.3.4.2 South Carolina

Under South Carolina's Coastal Zone Management Program, a permit or certification is required from the South Carolina Coastal Council for all dredge and fill activities. Regulations controlling the pollution of state territorial seas by oil, gas, or other wastes (S.C. Code 48-1-13(b)) and prohibiting the use of poison, electricity or explosives to take fish (S.C. Code 50-13-1420 and 1440) may also provide protection to snapper-grouper habitats.

8.3.4.3 Georgia

Georgia Code 43-120 requires that a permit be obtained before dredge and fill activities are conducted. Georgia Water Quality Criteria require that certain standards of water quality sufficient for the survival of fish and other aquatic life be met in specified areas. The use of firearms, electricity, explosives, or poisons for taking fish is prohibited (Ga. Code 45-711).

8.3.4.4 Florida

Florida is the only state within the management area which has laws that directly impact snapper-grouper stocks or fishing for these stocks.

Section 370.11 of the Florida Statutes prohibits the taking of certain groupers of length less than 12 inches (31 cm) from tip of nose to rear center edge tail (fork length). Species covered by this statute are red grouper (Epinephelus morio), Jewfish (E. itajara), Nassau grouper (E. striatus), black grouper (Mycteroperca bonaci), and gag (M. microlepis).

Section 370.172 of the Florida Statutes prohibits spearfishing in state territorial waters beginning at the county line between Dade-Monroe Counties and running south, including all the Keys down to and including Long Key.

Section 370.110 of the Florida Statutes prohibits the taking of certain species of corals, thus affording direct protection to coral reef habitats used by snapper-grouper species.

The Florida Legislature has passed a bill (Section 370.1105 of the Florida Statutes) prohibiting the use and possession of fish traps as a means for taking saltwater finfish, with the following exceptions: 1) crab, crawfish or shrimp traps permitted under Statutes 370.13, 370.135, 370.14 or 370.15; 2) pin fish traps of specified sizes; and 3) black sea bass traps, north of 27° N. lat., of specified sizes with biodegradable panels.

The Florida Legislature, in 1981, passed a bill stating that there would be a moratorium on roller net trawler fishing except for shrimp within state waters until the Department of Natural Resources had adequate data to determine the effect of such fishing.

The Florida Aquatic Preserves Act of 1975 (Fla. Stat. 258.35) authorizes the permanent preservation of submerged lands of exceptional biological, aesthetic, or scientific value. Three areas of the Florida Keys, which contain coral habitat, have been designated as Aquatic Preserves. In addition, Section 370.110 of the Florida Statutes prohibits the taking or selling of certain species of coral. Other statutes which may provide indirect protection to snapper-grouper habitat areas include ocean water contamination regulations (Section 370.09), regulation of dredge and fill activities (Section 370.03), and a prohibition on the use of explosives or firearms for the purpose of killing fish (Section 370.08).

Monroe County, Florida law (Chapter 29299, Special Acts 1953) states that each commercial fishing boat may have only one wire fish trap five feet long, two feet high and two feet wide and that such trap must be pulled each day, and not left overnight. This law has been superseded by Florida Statute Section 370.1105.

8.3.5 Fishery Management Plans

A. Coral and Coral Reef Resources Management Plan

Coral reefs provide shelter and habitat for fishes of the snapper-grouper complex. The Fishery Management Plan for Coral and Coral Reef Resources (April 1982) developed jointly by the Gulf of Mexico and South Atlantic Fishery Management Councils, includes measures designed to minimize, where appropriate, adverse human impacts on these resources.

B. Spiny Lobster Fishery Management Plan

A Fishery Management Plan for Spiny Lobster was jointly developed by the Gulf of Mexico and South Atlantic Fishery Management Councils. The snapper-grouper and spiny lobster fisheries in the south Florida and Florida Keys areas are interrelated, in that a small number of commercial fishermen participate in both. This may result in fishermen shifting their activities from one fishery to the other as changes are made in the regulation of a fishery.

C. Stone Crab Fishery Management Plan

Fishermen in the stone crab fishery in the south Florida and Florida Keys areas also participate in the snapper-grouper fishery. These same fishermen also participate in the spiny lobster fishery. A Fishery Management Plan for Stone Crab has been implemented in the area of jurisdiction of the Gulf of Mexico Fishery Management Council.

D. Reef Fish Resources Fishery Management Plan

The Gulf of Mexico Fishery Management Council has prepared a Fishery Management Plan for Reef Fish Resources of the Gulf of Mexico. The plan includes snappers, groupers, and sea basses in the management unit. Commercial fishermen may fish both areas, use similar markets and/or processors. The management measures proposed by the Gulf's FMP should complement those of the South Atlantic Council.

8.4 Description of Fishing Activities

8.4.1 History of Exploitation [1/]

8.4.1.1 Commercial

Commercial fishing for snappers and groupers in the South Atlantic has occurred since the late 19th century. Since the early years of the fishery, handlines, and more recently electric reels, have been the primary gear employed.

Many early handline vessels were of the New England dory schooner design and were equipped with live wells to keep the catch fresh. Catches landed in a state were generally taken in local offshore waters. After World War II, the commercial handline fleet became increasingly mobile, operating in deeper waters and farther from ports of departure, as a result of improvements in electronic navigation and depth recording equipment and the introduction of power reels.

Grouper and red snapper landings in North Carolina, South Carolina, and Georgia were first recorded in 1880. From 1908 to 1956, North Carolina annual landings rarely were more than a few thousand pounds. The first modern attempts at handline snapper fishing in North Carolina began in 1956 when 130,000 pounds of "red snapper" (mixed red, silk, and blackfin snappers) and 27,000 pounds of groupers were landed by a single vessel at Beaufort, North Carolina.

In 1957, 225,100 pounds of red snapper and 64,900 pounds of groupers were landed. In the winter of 1957-58, water temperatures in outer Onslow Bay were the lowest recorded from 1948 to 1967 (McLain et al., unpubl. ms.). Red snapper, the only species with high market value, suffered high mortality and the incipient commercial fishery ended. From 1958 to 1973, North Carolina landings were small compared to 1956-57 landings.

1/ Most of this discussion is from Huntsman (1976a).

South Carolina had moderate snapper and grouper landings from 1880 through 1908, but virtually no landings were recorded from 1908 until 1956. As in North Carolina, South Carolina local interest in offshore fishing revived in 1956. Annual snapper and grouper landings since have fluctuated considerably, but have trended upward.

Georgia landings have displayed historical patterns similar to those of the Carolinas; however, early landings were much larger and continued for a longer period. Georgia reported snapper and grouper landings annually from 1890 through 1930, with peak landings (snappers and groupers combined) of 1,040,000 pounds in 1908. From 1931 to 1967, Georgia landings were no more than 10,000 pounds in any year. Since then landings have been recorded annually.

The snapper-grouper fisheries off Florida began in the 1830's with the New England fishermen operating in Key West. By the 1850's the fishery had extended to northwest Florida, and by 1975, the fleet had over 300 vessels (Klima, 1976).

8.4.1.2 Recreational

The historical fishing effort by private recreational vessels and charter boat vessels throughout the region and head boat vessels in south Florida is not known. The following discussion describes the historical head boat fishery from Cape Hatteras to Cape Canaveral (Huntsman, 1976a).

The offshore head boat fishery began in the early 1900's and by the late 1920's and early 1930's head boats, as we now know them, had appeared along the South Atlantic coast. Those early operators sought black sea bass on nearshore reefs, fishing with handlines.

The end of World War II brought a supply of inexpensive and relatively high-powered boats and an overwhelming improvement in marine electronic technology. War surplus vessels equipped with depth recorders and loran were important in the fishery for over 15 years. Sea bass grounds farther offshore were exploited and some vessels occasionally made trips to the edge of the Continental Shelf to fish for snappers and groupers.

Head boat operations were sufficiently lucrative to stimulate construction of a third generation of vessels in the 1960's. These boats also were wooden-hulled, had V-12 or V-16 engines, and attained speeds of 18 - 21 knots. This allowed anglers to fish Gulf Stream waters and return in a single day. Most third generation vessels are still active in the offshore fishery.

8.4.2 Participating User Groups

8.4.2.1 Commercial

The commercial snapper-grouper fishery is composed of four main segments: 1) a hook and line fishery (including both part-time and full-time users), 2) a trap fishery (including both part-time and full-time users), 3) a seasonal trawl fishery (primarily part-time), and 4) a bottom longline fishery. Additional minor commercial activities include spearfishing by divers and a gill net (locally called "stab" net) fishery off the east coast of Florida.

Hook and line vessels engaged in the fishery on a full-time basis are highly mobile, fishing the entire region and landing their catch wherever it is most convenient and profitable. For the most part, the part-time handline fishery consists of shrimp trawlers converted to produce off-season income.

In 1979, 45 handline vessels landed catches of snapper and grouper in South Carolina. Of these, approximately 17 were based in South Carolina ports. Three were shrimp trawlers fishing on a part-time basis (S.C. Wildlife and Marine Resources Center, unpubl. data). An estimated 20 North Carolina vessels (M. Wolff, N.C. Department of Natural Resources & Community Development, Morehead City, N.C.; pers. comm.) and 2 Georgia vessels (D. Harris, Ga. Department of Natural Resources, Brunswick, Ga.; pers. comm.) are engaged in the hook and line fishery on at least a part-time basis.

The National Marine Fisheries Service has reported a total of 1,071 hook and line vessels and boats along the east coast of Florida, including Monroe County (J. E. Snell, NMFS, Southeast Fisheries Center, Miami Lab., Miami, Fla.; pers. comm.). However, hook and lines are also used in other fisheries and no distinction is made at the reporting level on the number of vessels involved in different fisheries. Consequently, of these, the number engaged in snapper-grouper fishing is unknown. In Florida, king mackerel hook and liners also fish for snapper and grouper on a part-time basis.

The trap fishery north of Cape Canaveral is directed primarily at black sea bass, although there is an incidental catch of other species. Many of the vessels which have operated in this fishery have been shrimp boats seeking alternative employment during the closed season for shrimp.

The number of vessels engaged in the sea bass trap fishery in 1978 was 68. In 1981, South Carolina had between 45 and 50 vessels fishing traps, an increase from the six reported in 1978. During the early 1970's, the fishery seemed to be developing into a year-round fishery, but in recent years most landings have been made during November-May. Many shrimp vessels which used to trap sea bass during the closed season for shrimp now conduct trawl or handline operations for those species of the complex which bring higher returns.

Wire fish traps have been used intermittently off the east coast of Florida and the Florida Keys since the 1920's. A marked increase in the number, productivity, and individual size of the traps employed in this area occurred in recent years, until the Florida legislature passed a bill prohibiting the use and possession of fish traps. Large groupers, particularly red and black groupers, were generally the target species, although significant catches of gray and mutton snappers and some yellowtail snappers had also been noted. An incidental catch of tropical ornamentals and small fish of target species also occurred.

There were approximately 108 vessels fishing about 4,025 traps in the Dade-Broward-Monroe County area from December 1979 until October 1, 1980, according to studies by Sutherland and Harper (in press) and Taylor and McMichael (in press). These figures represent the maximum number of vessels and traps during one quarter.

Most of the vessels operating in the snapper-grouper trawl fishery are shrimp boats seeking to supplement their income during the off-season. These vessels generally fish north of Cape Canaveral and number from 25 to 30 (PDT estimate).

The number of divers engaged in commercial spearfishing for deepwater species numbers about 50 in 1982 from North Carolina through the Florida Keys (Nelson Waite, Advisory Panel, Commercial Diver, West Palm Beach, Florida; pers. comm.). In addition, Duane Harris (Ga. Department of Natural Resources, Brunswick, Ga.; pers. comm.) reports that three vessels out of Mayport, Florida, have employed divers with spearguns to harvest snapper-grouper off Georgia.

8.4.2.2 Recreational

Three categories of vessels participate in the recreational fishery: 1) head boats, 2) charter boats, and 3) private boats. Additional recreational participants include divers, some of whom use spearguns to harvest snapper-grouper for personal consumption.

Head boats fish primarily for species in the snapper-grouper fishery. Approximately 46 head boats operate between Cape Hatteras and Cape Canaveral, Florida (G. Huntsman, NMFS, Southeast Fisheries Center, Beaufort Lab., Beaufort, N.C.; pers. comm.), and approximately 49 head boats operate between Cape Canaveral and Key West (L. Smith, Ga. Department of Natural Resources, Brunswick, Ga.; pers. comm.).

North of Florida, head boats fall into two major classes according to the habitat they fish: 1) inshore vessels, which fish the rocks and coral patches in shallow (less than 46 m; 150 ft) water, and 2) offshore vessels, which fish the shelf edge and lower shelf (46 - 146 m; 151-479 ft). South Carolina inshore boats could be subdivided further into those fishing almost entirely for black sea bass and those fishing for porgies and vermilion snapper, although this subdivision is not clear-cut (Huntsman, 1976a). In Florida, all head boats are of the inshore type.

An estimated 151,593 angler days of recreation were provided by the head boat fleet between Cape Hatteras and Cape Canaveral in 1978, and 105,886 days in 1979. An estimated 133,737 angler days of recreation were provided by the head boat fleet between Cape Canaveral and Key West in 1978 and 238,063 days in 1979 (G. Huntsman, NMFS, Southeast Fisheries Center, Beaufort Lab., Beaufort, N.C.; pers. comm.).

The activity of the charter boat fleet in the region consists primarily of trolling for pelagic species, although some boats fish for snapper-grouper as well. The amount of bottom fishing done by a charter boat is often dependent on the seasonal availability of pelagic species (Manooch and Laws, 1979). Bottom fishing accounted for 11 percent of the total effort (number of trips taken) of the North Carolina charter boat fleet in 1977 and 12 percent of the effort in 1978 (Manooch et al., 1981). The catch, consisting primarily of sea bass, porgies, snappers, and amberjacks in 1977, represented slightly less than 20 percent of the 1977 North Carolina head boat catch of demersal species. In 1978, black sea bass, red porgy, and white grunt were the major species caught bottom fishing offshore.

Gentle (1977) reported that 5 percent of the effort of the Dade County, Florida, charter boat fleet in 1976 consisted of still-fishing for tilefishes and deepwater groupers at 120-180 m (394 - 590 ft); 1.6 percent of the effort of the fleet consisted of trolling the reef for shallow-water groupers; and 1.4 percent of the effort of the fleet consisted of still-fishing for deepwater jacks at 60-100 m (197 - 328 ft). These species combined represented almost 20 percent of the total catch (in numbers of fish) of the fleet in 1977.

Browder et al. (1978) reported that seasonal effort for snapper-grouper by the Florida Keys offshore charter fleet in 1977 varied from a low of 6 percent in winter to a high of 16 percent in fall.

During 1979, there were 134 charter boats operating in North Carolina (C. Manooch, NMFS, Southeast Fisheries Center, Beaufort Lab., Beaufort, N.C.; pers. comm.), 49 in South Carolina (D. Cupka, S.C. Wildlife and Marine Resources Department, Charleston, S.C.; pers. comm.), 30 in Georgia (D. Harris, Ga. Department of Natural Resources, Brunswick, Ga.; pers. comm.), and approximately 428 along the east coast of Florida (M. Moe, Aqua-Life Research Corp., Marathon Shores, Fla.; pers. comm.).

Bromberg (1973) estimated a total of 191,225 private recreational boats fished in salt water in the South Atlantic Region in 1973; however, since he did not separate Florida east and west coast vessels, this estimate includes both coasts of Florida (Table 8-12). This estimate includes those boats which fished in salt water portions of rivers, sounds, and bays in addition to those fishing in open ocean waters. Bromberg (1973) estimated that 133,449 of these boats fished in the open ocean in 1973.

The total number of private boats in the region which utilize the snapper-grouper resource is unknown, but it is likely that this segment harvests a large share. Liao and Cupka (1979a) estimated that fishing over artificial reef areas alone accounted for 26 percent of the total South Carolina private boat effort (days of offshore fishing) in 1977. Species of the snapper-grouper fishery accounted for approximately 20 percent of the catch of the private boat anglers surveyed (Liao and Cupka, 1979b).

The NMFS Marine Recreational Fishery Statistical Survey (1980) estimated the number of private/rental fishing trips in the South Atlantic Region to be 5,966 during 1979 (Table 8-13). An indication of 1979 recreational effort (number of trips) by state is given in Table 8-14. Estimates were: (1) Florida - 8,756, (2) Georgia - 406, (3) North Carolina - 3,566 and (4) South Carolina - 1,044.

8.4.3 Description of Vessels and Gear Employed

8.4.3.1 Commercial

8.4.3.1.1 Vessels

Commercial vessels currently engaged in the snapper-grouper fishery range between 8 and 21 m (26-70 ft) in length, are of wood or fiberglass construction, and are mostly diesel powered. Some of the vessels engaged

Table 8-12. Estimated number of private recreational boats that fished in salt water in the South Atlantic Region in 1973, by state and size class. (Source: Bromberg, 1973.)

State	Number of private recreational vessels	Size Class		
		<16 ft	16-26 ft	>26 feet
North Carolina	28,763	11,916	12,738	4,109
South Carolina	27,311	11,314	12,095	3,902
Georgia	39,155	16,221	17,340	5,594
Florida	95,996	52,253	38,886	4,857
Total	191,225	91,704	81,059	18,462

Table 8-13. Estimated number of fishing trips in the South Atlantic by marine recreational fishermen by mode and subregion, January 1979 through December 1979. (Source: NMFS, 1980.)

Mode	Trips by Coastal Residents	Trips by Non-Coastal Residents	Trips by Out of State Residents	All Trips
	---------- thousands ----------			
Man-made	2,503	577	896	3,977
std err*	304	240	327	506
Beach/bank	1,219	802	1,140	3,161
std err	183	623	519	831
Party/Charter	329	21	319	668
std err	120	18	231	261
Private/Rental	4,726	515	725	5,966
std err	392	194	271	514
Totals	8,777	1,915	3,080	13,772
std err	542	695	709	1,131

*Standard Error

Table 8-14. Estimated number of fishing trips in the South Atlantic by marine recreational fishermen by state and subregion, January 1979 through December 1979. (Source: NMFS, 1980.)

State	Trips by Coastal Residents	Trips by Non-Coastal Residents	Trips by Out of State Residents	All Trips
	thousands			
Florida	6,835	42	1,879	8,756
std err*	505	67	492	708
Georgia	324	52	29	406
std err	83	46	38	102
North Carolina	1,082	1,694	790	3,566
std err	153	687	484	854
South Carolina	535	127	382	1,044
std err	91	69	158	195
Totals	8,777	1,915	3,080	13,772
std err	542	695	709	1,131

*Standard Error

in this fishery are of multi-purpose design to facilitate use in other fisheries. The purpose of such diversification is to operate profitably thoughout the year. For that reason, many of the snapper-grouper fishermen are part-time and are also active in other fisheries and/or occupations.

Most boats are equipped with loran, white-line fathometer (echo-sounder), and VHF and/or CB radio. In addition, a few boats have a scope scale expander (CRT) used in conjunction with the white-line fathometer.

8.4.3.1.2 Hook and Line and Bottom Longlines

Most snappers and groupers are caught using hook and line, although gear specifics vary with location fished and species and sizes of fish targeted (Allen and Tashiro, 1976). The catch is retrieved with handlines and hand-powered, electric, hydraulic, or pneumatic reels. All are classified as handlines by NMFS statistical agents. Most vessels fish four reels, with the largest having eight. On most vessels a fisherman works only one reel but on others, several reels may be fished by one person. Although up to 40 baited hooks may be used with each reel line, fishermen operating off the South Atlantic coast rarely employ more than five hooks per rig.

Bottom longlines were installed on some vessels starting in 1981. Longlines 2-8 km (1-5 miles) in length have short gangions 30 to 46 cm (12 to 18 in) long connected by longline clips. Tuna circle hooks are generally used.

8.4.3.1.3 Fish Traps

Social Aspects

Fish traps have been used sporadically in Florida from 1919 (Schroeder, 1924) until the recent prohibition by the State of Florida. The use of fish traps increased in the mid 1970's after the successful experimental work of Craig (1976) off Boca Raton, Florida in 1974-1975 and the closure of Bahamian waters to foreign fishermen on August 1, 1975.

Before describing the historical background concerning fish traps it is important to recognize that this gear has precipitated a large amount of social conflict. In an effort to document the social conflict two newspaper articles and a Sierra Club Newsletter are being included:

FISH TRAP BAN EYED IN STATE

Sarasota Journal

September 20, 1978

The 1979 Legislature will be asked to enact a law banning the use of large fish traps to catch fish for sale according to Harmon Shields, executive director of the State Department of Natural Resources (DNR).

Shields said the action is being taken on the basis of a unanimous recommendation from the Recreational Saltwater Fishing Advisory Council, named by the governor and cabinet last June to provide advice to the department.

The Council made the recommendation at its meeting recently in Miami Springs, where it was told that some of the traps being used to catch fish for sale are so large that "four men could not raise one trap off the bottom."

Shields said the greatest objection to uses of the large wire traps is that they are nonselective in types of fish caught.

According to the executive director, the council's recommendation excludes the uses of traps of two cubic feet or smaller used to catch bait fish such as pinfishes or those of the small size used by aquarium dealers to catch live tropical fish for sale.

The council received reports that large wire fish traps - some of them as large as 10 by 8 by 3 feet - are catching great number of fish for sale. The catch of the large numbers of reef fish is placing a strain on the resource in local area, said Shields.

The council's meeting was its second since being named this past June to provide in-depth advice and recommendations to the executive director on fisheries management. Shields serves as chairman of the council.

He said the council also was told the Gulf of Mexico Fishery Management Council and the South Atlantic Fishery Management Council are considering Florida's position on the use of large fish traps before they establish management proposals.

According to Shields, "The council's recommendations for a ban on the large traps will be Florida's position to both councils."

Ed Joyce, director of the Division of Marine Resources, and Dale Beaumariage, chief of DNR's Bureau of Marine Science and Technology, told the council the increasing use of traps could have serious availability.

Beaumariage also told the council that when traps are pulled by wench from between 60 and 80 feet of water, most fish die because of the rapid ascent. Included in these traps are dead undersize fish, angel fish and other non-food varieties.

Shields said DNR's technical staff reviewed the problem for several months before it was brought before the council for recommendation. The greater part of the uses of these traps is in southeast Florida, Shields said.

MARINE WILDERNESS SOCIETY SEEKS FISH TRAP RULES
KEYS KEYNOTER
MARATHON
SEPTEMBER 21, 1978
By Jerry Powell, Staff Writer

CORAL GABLES - A spokesman for the marine Wilderness Society, a fledgling environmentalist organization headquartered here, said the group will seek passage during the next session of the state Legislature, of a bill regulating the use of commercial fish traps.

Alexander Stone, public information officer for the society, says regulatory legislation is necessary before "the impact (of commercial trapping) gets out of hand.

"The number of fish traps in use," Mr. Stone says, "could mushroom from the present 10,000 to a possible 150,000 traps or more in the next five to 10 years."

Mr. Stone says he bases his estimate on traps presently in use on information gained during a commercial fish trap workshop held June 14 in Tavernier.

"At the workshop," Mr. Stone explains, "Maj. Ed Little (of the Florida Marine Patrol) estimated there were 8,000 fish traps in use in Monroe County alone. That figure was not disputed by anyone at the workshop. With further information from the West Palm area and spotty areas along the west coast, we arrived at the 10,000 figure."

He said the Marine Wilderness Society, less than a year old and with a membership of slightly under 200, is concerned about the effects of the commercial traps on the state's reef and on fish populations.

In Monroe County, it is illegal to use fish traps within the state's three-mile boundary, but the outer edges of the reef are beyond that jurisdictional unit.

Capt. Ralph Tingley, supervisor of the Florida Marine Patrol's Dist. Nine in the Florida Keys, says commercial trapping has grown considerably in the past five to eight months.

"It would be difficult for me to put an exact figure on the number of traps in use here," Capt. Tingley says, "because many of them are being used by Dade County fishermen working the Upper Keys and taking their catch back to Dade County."

The patrol supervisor did say that a recent survey of six Key West fish houses came up with a total of 34 boats fishing 550 traps during the closed crawfish season and 14 boats fishing 240 traps all year.

Capt. Tingley adds that while his partrolman was making the survey he observed one fisherman, who had been fishing only 10 traps for six days, return to the fish house with 7,000 pounds of grouper.

The traps, made of vinyl-covered wire of various gauges, are used to capture "bottom fish" that include groupers and different species of snappers.

"We hear reports," Capt. Tingley goes on, "that many of the crawfishermen are anticipating increasingly bad years in catching crawfish and are prepared to use more and more fish traps to make their living."

Mr. Stone says his society is receiving "more and more complaints about fish traps every week."

He said the society's planned legislation will include sections regulating wire mesh size to allow juvenile fish to escape the traps and requiring biodegradable trap door hinges that will prevent traps from becoming "permanent death cells."

The proposed legislation also will limit the size and number of traps a fisherman can use and delineate "off limit" areas to prevent destruction of coral formations.

Mr. Stone says his society has attempted to maintain a dialogue with the Organized Fishermen of Florida (OFF) through a member he met at the Tavernier workshop, but has not been successful.

Jerry Sansom, OFF executive director, says he was not aware of the society's efforts to work with his group.

"At this point," Mr. Sansom says, "our organization feels that completely unrestricted use of fish traps can be harmful. We are aware of the situation and are presently trying to determine ways to limit the use of traps to responsible fishermen."

Mr. Sansom says the issue will be one of the topics of discussion at an OFF directors meeting scheduled for Oct. 13-14 at the Indies Inn on Duck Key.

SIERRA CLUB NEWSLETTER
MIAMI GROUP P.O. BOX 011776 MIAMI 33101
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FISH TRAPS

The rapid increase in the use of fish traps in Florida calls for the development of regulatory guidelines now, before the impact of fish traps gets out of hand. The number of fish traps in use could mushroom from a present 10,000 to a possible 150,000 traps or more in the next five to ten years. And the effects on Florida's reefs and fish populations could be disastrous if the issue is not faced squarely now.

Fish traps are handmade from chicken wire of various gauges, measuring up to 8 feet by 4 feet by 2 feet. Bottom fish are lured into the trap's cone-shaped opening, but are unable to find their way back out. It is not necessary to bait the traps in order for them to work; various behavior patterns characteristic of many fish species compel them to enter the traps even when empty.

Prompted by sagging catches, more and more of Florida's commercial fishermen are turning to fish traps as the way to increase their fishing production. In particular, lobster and crab fishermen are starting to flock towards the use of fish traps during the closed seasons for spiny lobster and crab.

There are roughly 2500 commercial lobster fishing licenses issued by the State and current, at any given time. Fish trap advocates suggest that each fisherman can handle 50 to 60 traps and work them every four to five days. If just the lobster fishermen all adopted the fish trapping practice during the closed season for lobster, it would mean 150,000 traps in the water—just in South Florida. Since the average catch per trap is 25 pounds of fish every four days, this would potentially equal more than THREE AND A HALF MILLION POUNDS of fish removed from South Florida's bottom fishing grounds EVERY FOUR DAYS. If this projection became a reality, it would not take long before the sportfishermen and sportdivers were hardpressed to find any fish at all to enjoy.

Even if only a portion of the commercial fishing fleet adopted fish traps, the results — without regulations — would be alarming. For a standard of comparison, realize that the entire seasons' catch of Florida lobster is about seven million pounds. If only 20% of all lobster fishermen start using fish traps, they will haul in over FOUR MILLION pounds of fish in just one month.

There are several other things about fish traps that should be of great concern to all sportdivers and sportfishermen.

Traps do not discriminate about the types of fish they catch. Snappers and groupers go into the traps right along with tropical species such as damselfish, butterflyfish, and angelfish. These are not separated until the trap boats reach the dock, and all the fish are dead.

> With the wire gauge size used now, juvenile fish — the future of our fisheries — cannot escape the traps. This situation could lead definitely to diminishing stocks of our most basic bottom species in a very serious way.
>
> On an average, 20% of all fish traps are lost during the course of each season due to lost buoys and other factors. This means that each year we may have thousands of these traps left on the reefs, unattended and still trapping fish which will either batter themselves to death against the wire or starve to death inside these death cells.
>
> And the impact of traps on the reef itself is also a serious matter. Caught in the surge, a trap will batter the soft coral gorgonians, break off the branches of staghorn and other species of coral, tear up the sponges and other bottom-affixed species that populate and add beauty to our reefs.

In addition, the Gulf of Mexico Fishery Management Council held two series of public hearings on their Reef Fish FMP: 1) In May, 1979, 15 hearings were held with an attendance of 485 persons; and 2) during 1980, 11 hearings were held with an attendance of 205 persons. A large portion of the comments (GMFMC, 1981) concerned fish traps. Comments included a total ban on fish traps, prohibiting the use of fish traps during the spawning season, prohibit the setting of fish traps on coral reefs, place a moratorium on expansion of the trap fishery or provide for limited entry into the trap fishery, increase the minimum trap mesh size, limit the trap volume, limit the number of traps per vessel and prohibit the baiting of traps. The GMFMC Reef Fish FMP also includes letters commenting and/or offering recommendations concerning traps from the Marine Wilderness, Underwater Society of America, Islamorada Charter Boat Association and Florida League of Anglers, Inc.

The South Atlantic Fishery Management Council held two series of public hearings on the Snapper-Grouper FMP: 1) August/September, 1982, 10 hearings were held with an attendance of 213 persons; and 2) December, 1982, 3 hearings were held to present changes resulting from the comments received during the August/September hearings; attendance was 76 persons. A large portion of comments addressed the fish trap issue (see Snapper-Grouper FMP for letters received and public comments) and ranged from a total ban on fish traps to regulating mesh size and area/seasonal limits.

Background*

A diversity of portable fish traps are used throughout the world, but the fundamental concept is the same in most areas. Basically, fish enter these traps via one or several entrance funnels, the innermost end of which is directed downward or is constricted. The configuration of the trap varies but frequently may be rectangular, hexagonal, chevron-shaped, conical, semi-cylindrical, heart-shaped or circular.

Traps are the primary fishing gear used throughout most of the Caribbean, accounting for some 65 percent of the total neritic fish production (Munro, 1974b). In the Virgin Islands, more than 80 percent of the fishermen utilize only fish traps in their operations (Olsen et al., 1975). These traps, commonly known as Antillean traps, are fabricated of galvanized wire surrounding a mangrove pole frame (described by Munro et al., 1971). There is a certain amount of geographic variation in their construction, largely reflecting local availability of materials used and preferred trap design.

Puerto Rican and Virgin Island fishermen frequently use chevron or "arrowhead" traps with a single entrance funnel (Munro, 1974b) and these are remarkably similar to those used in Singapore (Burdon, 1954) and Madeira (Hornell, 1950). Jamaican fishermen typically use double chevron or Z-shaped traps with two entrances (Munro, 1974b). Various S-shaped traps, apparently originating in Haiti, are employed in Cuban and Jamaican fisheries (Buesa Mas, 1962). The University of the West Indies Laboratory has used some experimental metal-framed, stackable traps (Munro, 1973, 1974b). Plan configurations of these basic trap types are diagrammed in Munro (1974b). Recently, Craig (1976) reported good success at capturing snappers with traps slightly modified from Munro's (1973) design.

Munro (1974a) tested various trap types in Jamaica and concluded that the S-shaped traps yielded slightly higher catches than Z-shaped Jamaican traps of comparable size. Z-traps, in turn, collected more fishes than single-funnelled arrowhead (chevron) traps. S-traps also have the distinct advantage of relatively lower (by about 20 percent) construction costs. Moreover, they realize a longer working life due to increased structural rigidity imparted by the curved sides (Munro, 1974a).

*This is taken directly from the Fishery Management Plan for the Reef Fish Resources of the Gulf of Mexico prepared by the GMFMC (1981).

Fish traps are used in waters of less than 1.0 m (3.28 ft) to about 100 fathoms (183 m; 600 ft), although the normal fishing depth is between five and 45 m (16-148 ft) (Sylvester and Dammann, 1972; Munro, 1974a). Handling of gear is complicated at depths greater than 45 m and generally hook and lining replaces trapping as the usual mode of fishing deeper (i.e., 45-300 m; 148-984 ft) waters.

Trap location relative to bottom irregularities (e.g., ledges, coral heads, rock piles) may be critical; distances as little as five feet from reefal biotopes have shown surprising differences in catch rates of tropical, coral reef associated species (Sylvester and Dammann, 1972). However, some reports suggest that the relationship of trap location to catch composition may vary geographically, by species, and by depth (Boardman and Weiler, 1980). For example, Craig (1976) found the highest catch weights were obtained in traps set over open sandy bottoms, but High and Ellis (1973) reported the greatest catch rates when traps are positioned on sandy bottoms peripheral to reefs. Traps placed on the reef's surface caught fewer fish than those positioned alongside (High and Ellis, 1973). However, Craig's catch was predominantly snapper (70 percent) whereas High and Ellis reported on tropical reef fish catches. Off southeast Florida, traps positioned on high-relief (to 5 m; 16 ft) reefs produced many unwanted fishes, e.g., angelfishes, surgeonfishes, and parrotfishes (Craig, 1976). However, recent studies conducted in south Florida have shown that fish trap fishermen normally place their traps adjacent to the desirable relief areas rather than directly on them (Sutherland and Harper, in press; Taylor and McMichael, in press). Summarizing, it seems as though successful trapping techniques may vary widely for differing ichthyofaunas and for dissimilar environmental settings.

Fish traps may be baited or not (Sylvester and Dammann, 1972). High and Ellis (1973) suggested that there was little difference in catch rates between baited and unbaited traps. Conversely, black sea bass fishermen believe that bait is absolutely essential to successful fishing operations (Rivers, 1966).

Most traps in use in the Florida fishery are baited, except in Broward County (Sutherland and Harper, in press; Taylor and McMichael, in press), whereas most of the traps in the Caribbean fishery (Swingle et al., 1970) are apparently not baited and which is a practice recommended by some researchers (Munro et al., 1971). However, Wolf and Chislett (1974) found baited traps to be much more effective in taking snapper from deeper waters. Baited traps were more effective in catching fish than unbaited traps during short periods (<24 hours) in inshore habitat in the South Atlantic Bight (Powles and Barans, 1980). Craig (1976) reported an average catch per unbaited trap haul of 9.26 kg (20.4 lb) for trap sets of five days duration from South Florida. During a six-month period he harvested 9,188 pounds of snapper and approximately 3,000 pounds of other reef fish utilizing 20 traps. Wolf and Chislett (1974) reported catch rates of 40 pounds per baited trap haul in areas where the catch was predominantly snapper.

Swingle et al., (1970) reported on a fishing technique in use in the Virgin Islands which was locally called "fundering." This consisted of lowering a thoroughly baited fish trap (usually baited on the outside as well as the inside, to induce a feeding frenzy) to depths of 183 m (600 ft) or more. After a short interval the trap was hauled. Catches of up to 200 pounds per set were reported. This method was primarily used to harvest snapper (Swingle, Gulf Council, personal communication).

Biological personnel of the Alabama Department of Conservation and Natural Resources utilized this method to collect red snapper for tagging studies. Bill Wade (Department of Conservation and Natural Resources, personal communication) reported an average catch of approximately 100 red snapper averaging about 0.75 pounds for each 10 to 15 minute set on a relatively unfished reef in 12 m (35 ft) of water utilizing traps of 27 cubic feet in volume. He feels that the technique, if commonly used, could result in overfishing reefs substantially reducing hook and line fishing success.

Research conducted by the various scientists cited in this section suggests that traps set for several days duration are likely just as effective if unbaited. However, traps which are set in relatively unfished areas appear to be much more effective if baited, but must be pulled during the same day and usually within a few hours after setting. Discussions of fish escapement from traps, thigmotrophic associations and behavior which follow support this observation.

Baits, when used, range from materials of nonmarine origin (e.g., animal skins, fruits, cactuses, bread) to fish (commonly sprat, Harengula) and shellfish (e.g., conch). Sea bass fishermen may use punctured cans of cat food to lure fish into traps. Some West Indian fishermen feel that traps should be "preconditioned" or "aged" in the marine environment until algae foul the structure (Swingle et al., 1970). In Florida, however, Craig (1976) discovered that new (unfouled) traps caught more fish than older traps.

High and Beardsley (1970) contend that fish enter traps for reasons other than pursuit of bait. Random movements, use of traps as shelter, curiosity, intraspecific social behavior, thigmotrophic associations and predator escapement are probably all important factors contributing to the success of fish traps.

Certain fishes enter traps individually (e.g., groupers), others enter traps as groups (e.g., goatfishes and young jacks) or as pairs (butterfly fishes and angelfishes). Conspecific attraction in schooling species certainly plays an important role in trapping fishes. For example, when a few grunts are trapped within a cage, other grunts outside the enclosure try to join them. Catch composition within traps may actually change appreciably during the period of submergence. Frequently, traps will contain certain species almost to the exclusion of others resulting in considerable intertrap variation in composition (Craig, 1976).

Fish traps do not necessarily prevent escapement of fish from the trap although there is much interspecific variability in ability to escape. Many territorial reef fish have been observed to swim freely in and out of pots (Dammann et al., 1969). Munro (1974a, b) also reported high escapement rates, averaging almost 12 percent of the daily catch and suggested that the installation of nonreturn devices in funnels would markedly improve the catch. Craig (1976) also believed that fish, for the most part, are not actually trapped within the cages but utilize them for shelter and living quarters. This suggests that the fear that lost pots will operate as "death traps" or "ghost traps" (Hipkins, 1974) until their deterioration is not well grounded in fact. This is not to say, however, that certain fishes or groups of fishes do not die in traps. In fish trapping studies conducted by Billings and Munro (1974), four percent of the white grunts entering traps within a two-week interval had died. A recent study in south Florida (Sutherland and Harper, in press) revealed an overall, average mortality of 2.6 percent within fish traps. Moreover, certain grouper species may die from the "stress" associated with capture. Thompson and Munro (1974b) reported that only three of 32 red hind were alive when traps were hauled from 40 m (131 ft) depths after a three-day soak. Craig (1976) commented upon the possibility of installing highcorrosion rate panels in traps to eliminate any chance that fish would be wasted if traps should accidentally become lost in the environment.

Daytime catches in traps are generally greater than nighttime catches for the dominant species groups, i.e., the groupers, squirrelfishes and parrotfishes. In the Bahamas, where grunts dominate trap catches, nocturnal trapping is quite successful (Munro et al., 1971). Daytime catches may be higher for some species that utilize the traps as habitat and leave via the funnel to forage at night. Catch rates undoubtedly vary according to moon phase, corresponding to tidal pattern, and are generally greatest at the time of spring tides (Munro et al., 1971; Munro, 1974b). Off southeast Florida, Craig (1976) found that greatest catches were usually associated with rough sea conditions, turbid water and strong bottom currents.

Traps are fished (soaked) for varying periods depending upon the species sought, their abundance, and local fishing customs. Soak time is short, averaging 20-40 minutes per trap, for black sea bass. Sea bass are extremely gregarious and are rather quickly attracted to baited traps. Daily catches of 6,300 pounds per boat have been reported (Rivers, 1966). In the Caribbean, traps are usually soaked from one to several days. Munro (1974b) reported that cumulative catch in a trap reaches a maximum at seven to 10 days. After that, escapement equilibrates with ingress. Escapement reaches about 50 percent in about seven to ten days. Large numbers of fish within a trap may discourage others from entering, thereby further contributing to this 'saturation effect' (Sylvester and Dammann, 1972). Unlike the temperate sea bass fishery, Caribbean pots catch an average of less than 5.5 pounds per trap per three-day period (Olsen, 1978). At relatively unexploited oceanic banks, demersal fish production for traps is 10 to 12 times this figure (Juhl, 1969). Off southeast Florida, Craig (1976) reported an average catch of about 20.4 pounds (of which 15.8 pounds was snappers) in traps soaked for 108 hours. Sutherland and Harper (in press) found the average catch to be 8.6 pounds per trap haul for traps fished for seven days in Broward County, Florida. A similar study conducted in Monroe County, Florida revealed an overall average catch of 11.37 pounds per haul (Taylor and McMichael, in press). Boardman and Weiler (1980) reported an average catch rate of 9.0 pounds per trap lift of which 86 percent consisted of snapper by number off Puerto Rico. This catch rate was reduced over previous samples, possibly due to increased fishing pressure.

It is commonly believed that traps are highly nonselective and that many species of noncommercial interest are consequently wasted in this type of fishing. A review of the facts resulting from scientific studies and testimony presented at public hearings suggest that this may not be the case. Munro (1974b) reported that nine species of fish and spiny lobster made up about 50 percent (by weight) of the trap catch in the Port Royal area; the remaining catch was divided amongst another 100 species. Olsen et al. (1975) reported that of 1,559 individual fish caught in West Indian traps, lane snapper and vermilion snapper together with tomtate (a grunt), accounted for 90 percent by number. Munro (1974b) mentioned that white grunt is clearly the most abundant fish at Port Royal reefs, but only comprises eight percent of the total trap catch. All of this evidence suggests that traps are generally selective and can be set so they are highly selective (Craig, 1976; Boardman and Weiler, 1980). As shown in a series of reports by Thompson and Munro (1974a, c), length-frequency distributions for trap catches do not differ significantly from those for hook and line catches.

Unbaited traps or traps set (soaked) for several days duration are probably less efficient than hook and lines at high stock densities; however, baited traps pulled after soaks of short duration (before mass escapement) would be highly efficient. Munro (1974a) believed that deep trap fishing in the Caribbean might be an economically viable alternative to exploiting reef fishes in areas where hook and lining yielded unacceptable catch rates. Huntsman (1980) felt traps were especially appropriate to reef fisheries. In the Gulf of Mexico, most grouper and snapper are taken from relatively few reef complexes where they are concentrated enough to make hook and lining feasible. However, grouper (particularly the red grouper) and the red snapper are also widely distributed in low densities over vast expanses of flat, low relief rock and hard bottoms (Smith, 1976). Trap fishing might be successful in such areas (the Cubans extensively fished such habitats a few years ago with bottom longlines). Trap fishing would also seem well suited for use in highly exploited areas (e.g., Florida Keys) where population densities of groupers and snappers are comparatively low. In some trapping experiments off southeast Florida, Craig (1976) reported a drop in average trap catches from 9 kg per 108 hour soaks to about 7 kg for snappers at the end of only six months (620 trapping events, 101 trap months). However, this may have been related to seasonality.

Munro (1974b) found the dominant fishes in traps around Port Royal (Jamaica) to be white grunt, surgeonfishes, parrotfishes, red hind, gray angelfish, and bar jack. Other fishes commonly included in Caribbean trap catches include gray and queen triggerfishes, wrasses and boxfishes (Juhl, 1969).

In most Caribbean areas, trap catch rates for snappers are relatively low and generally represent an insignificant portion of the total catch (Munro et al., 1971). Three species (schoolmaster, lane snapper, and yellowtail snapper) largely dominate snapper catches. In contrast to Caribbean snapper catches Craig (1976) found snappers to be readily caught by traps off southeast Florida where they (almost wholly lane snapper) comprised about 70 percent by weight of the total catch. Snappers comprised only four percent of the catches by weight in the Jamaican study by Munro et al., (1971). However, Boardman and Weiler (1980) fished from 40 to 150 fathoms (73 to 274 m; 240 to 900 ft) off Puerto Rico and caught primarily blackfin and vermilion snapper between 41 and 60 fathoms (75 to 110 m; 246 to 360 ft) and primarily silk snapper from 61 to 90 fathoms (112 to 165 m; 366 to 540 ft).

Jacks enter traps, with the most important species being bar jack and yellow jack. Interestingly, these two species are never taken on baited lines (Thompson and Munro, 1974a). Horse-eye jack, on the other hand, is the most important species in the Caribbean hook and line fishery but rarely enter traps. Grunts are frequently taken in traps. Their schooling behavior is important; when a few individuals enter traps, conspecific attraction induces ingress of other individuals (Billings and Munro, 1974). Grunts comprised nearly 12 percent of Jamaican trap catches analyzed by Munro et al., (1971). Groupers are readily trapped; red hind and coney dominate West Indian catches (Thompson and Munro, 1974b). The grouper family made up about eight percent by weight of the Jamaican fish trap catch (Munro et al., 1971). Lyons (1965) reported the second most important species (by number) in lobster pots at Grand Cayman Island to be the Nassau grouper. Craig (1976) compared composition (by weight) of trap catches off southeast Florida with those of Munro et al. (1971) from Jamaica. The three most important families off southeast Florida were snappers (70 percent), jacks (12 percent) and grunts (10 percent). The most important groups in the Jamaican fishery were parrotfishes (16 percent), surgeonfishes (15 percent), grunts (12 percent), groupers (eight percent), snappers (four percent) and jacks (3.5 percent). In a recent study of the Monroe County, Florida trap fishery, Taylor and McMichael (in press) reported the following trap composition (by weight): grouper (57.32 percent), grunts (8.21 percent) and snapper (4.61 percent).

However, these data on catches must be viewed in relation to species composition of the areas fished. For example, during 1968 the Virgin Islands Ecological Research Station (Dammann et al., 1969) studied the fish population composition and density and the effects of trapping on a typical fringing coral reef. The reef was completely surrounded by a 1/4 inch mesh net to prevent fish from leaving or entering the reef complex. Standard Caribbean fish traps were used to harvest fish from inside the enclosure and eventually all the remaining fish were killed with emulsifiable rotenone and collected. During a 67-day period, three traps were pulled six times and removed 38 percent of the total poundage of reef fish from the reef. This catch was equivalent to 280 pounds of fish per acre of reef with a constant trap density of 30 traps per acre.

The percentage by weight of snapper and grouper taken by traps during this study was 9.62 percent of the total catch. The percentage of snapper and grouper in the reef population was 8.13 percent by weight as determined by collecting and weighing all fish from the reef. Therefore, in this study the catch of snapper and grouper species was in direct relation to their abundance in the reef population.

In general, the Caribbean studies on catch composition were conducted on the fringing reef areas of the shelf where the fish density was generally lower and where the ichthyofauna differs considerably from the Florida and Gulf waters. In general, grouper and particularly snapper make up a smaller percentage of the biomass in the Caribbean than the Gulf area; therefore, percentages of these species in the catches would be lower for the Caribbean.

Craig (1976) believed catch composition could be regulated somewhat by placing traps in different habitats. For example, setting traps on high-relief (to 5 m; 16 ft) rocky bottoms produced a preponderance of "unwanted" species such as surgeonfishes, parrotfishes, and angelfishes. However, when traps were positioned over open sandy bottoms, snappers largely dominated catches.

Recent studies conducted in south Florida by National Marine Fisheries Service and Florida Department of Natural Resources have resulted in the following estimates of fish trap effort. Dade County - 575 traps, 90 fishermen; Broward County - 665 traps, 18 fishermen; Monroe County - 998 traps, 43 fishermen; Collier County - 250 traps, 8 fishermen (Sutherland and Harper, in press; Taylor and McMichael, in press). This amounts to an estimated total of 2,488 traps being fished by 159 fishermen in south Florida.

Although trap sizes vary greatly in south Florida, the most common size is 2 x 3 x 4 feet. These traps are normally fished at depths ranging from 8-46 m (25 to 150 ft) (Taylor and McMichael, in press). The number of traps generally runs from 20 to 100 per fisherman.

Currently, the most common material used in fish trap construction in south Florida is vinyl-covered welded wire mesh usually of the size one by two inches or larger. This material is generally favored over the more traditional hexagonal poultry wire. For trap fisheries in the Caribbean, Stevenson (1978) recommended a minimum mesh size of 4.6 cm (1.8 in) for protection of the red hind stocks of Puerto Rico, and Wolf and Chislett (1974) suggested a two-inch mesh size for protection of silk snapper. Olsen et al. (1977) recommended a minimum size of 1.5 by 1.5 inches as near optimum ecologically and economically for the Virgin Islands since it releases small fish while larger mesh sizes would release marketable fish.

Many noncommercial fish taken incidental to trapping operations are killed by embolisms when traps are hauled surfaceward from deep waters. However, the same problem exists for fish that are taken by hook and line from deep reefs. One way to prevent high losses of incidentally taken fish (such as colorful tropical fishes utilized by the aquarium trade) would be to require a larger minimum mesh size. By utilizing the Beverton & Holt yield equation, Munro (1974a) predicted that increasing mesh size above 3.2 cm (1.25 in) would increase the total catch value. Because the minimum marketable size is larger in the U.S., it is likely that larger mesh size would be appropriate for the management area. Research should be conducted to determine minimum mesh size that is optimum for the Gulf (and South Atlantic) reef fish fishery and the effect of larger mesh sizes on the fishing effectiveness of the traps, i.e., smaller fish may serve as attractants for the larger fish.

If the use of fish traps becomes a significant fishing method for harvesting reef fish in the Gulf of Mexico (and the South Atlantic) there is a possibility of seriously overfishing the stocks of reef fish particularly in the nearshore waters unless effort by other gear is reduced. Further, the widespread use of this gear could seriously reduce the fishing success (CPUE) of recreational and commercial hook and line fishermen by reducing population abundance in the more accessible areas. Presently, the use of fish traps is largely confined to south Florida.

In the Caribbean where the great majority of all fish harvested are taken by traps, several scientists have expressed concern over overfishing of the resources.

Munro et al. (1971) report the following:

> "In Jamaica, where the intensity of fishing on the nearshore reefs appears to be higher than any other island in the Caribbean, the abundance of fishes on the reefs is remarkably low. We are working on the hypothesis that the low density of fishes is a direct consequence of exploitation with small mesh traps; that is, that the largest reef fishes and thus usually those which mature at a relatively larger size are subjected to severe biological overfishing, while the smaller reef fishes which mature before recruitment to the traps, are subject to intense exploitation with corresponding low stock density, but are not biologically overfished."

Reporting on another area where the predominant fishing gear used is fish traps, Olsen et al., (1975) make the following statement:

> "Our efforts are somewhat tempered by the evidence that the Puerto Rico-Virgin Islands shelf is overfished."

However, during 1979, Dammann (1980) reported as follows:

> "There was never any consideration of making traps illegal; only in making them responsive to the needs of the fish populations and people of the area."

Fish traps are an efficient (Huntsman, 1980), low cost fishing gear for reef fishes. The use of this gear in various localities should be clearly examined through research (Murray, 1980). Current research (largely conducted in other areas) indicates that traps are unlikely to biologically decimate the stocks. If excessive trap fishing is introduced to areas currently fished by hook and line, the CPUE of hook and line fishermen could be materially reduced. Because of the current status of the Gulf (and South Atlantic) reef fish stocks in the nearshore waters and the harvesting potential of traps, some restrictions should (probably) be placed on the use of traps in the Gulf (and South Atlantic) fishery.

These restrictions may include: imposing a reasonable limit on the number of traps per vessel, limiting the number of traps in a given area, prohibiting traps in certain "overfished" areas, regulating size of fishing power of the traps, regulating mesh sizes to allow escapement of juvenile fish, requiring degradable hinging devices, and requiring buoy identification by color and number. The number of traps in use in the Gulf (and South Atlantic) and their catch should be determined annually by a statistical system.

The sea bass trap fishery is described by Rivers (1966). The majority of vessels are small (11-15 m; 35-50 ft) shrimp trawlers operating during the closed shrimp season. All of these vessels are equipped with a standard trawling winch, which is used for hauling traps. The principal gear is the Chesapeake Bay crab trap, constructed of poultry-wire usually with 38 mm (1.5 in) hexagonal mesh, similar to that described by Isaacson (1963).

Data from South Carolina indicate that the standard, commercial, black sea bass trap measuring 1½ inch by 2 inch (uncoated, hex mesh) effects a minimum retention size of approximately 8 inches for black sea bass (Table 8-15 and Figure 8-3). Over three thousand black sea bass were collected during June 1982 on four reef sites in depths from 10 to 19 fathoms (19 to 35 m, 60 to 114 ft) with commercial type traps 24 inches wide by 24 inches long by 18 inches high. Black sea bass less than 8 inches total length accounted for approximately 5 percent (151 fish) of the 3,029 black sea bass caught. More than 90 percent of the South Carolina commercial catch of black sea bass during 1979-1981 was produced by the trap fishery.

A two-man vessel fishes an average of 15-20 traps a day. Larger vessels with five man crews can work as many as 40 traps daily, and then at night may move into deeper water along the edge of the Shelf to handline for red snapper and grouper.

Construction costs for an Antillean, Z, or rectangular trap are between \$75-\$80 and between \$45-\$50 for a modified Z trap (Sutherland and Harper, in press). Trap loss is estimated to be an average of 20 percent per year for Broward fishermen who attribute losses to strong currents, entanglement with other fishing gear or anchors, vandalism, and theft (Sutherland and Harper, in press).

The management problems associated with lost traps has been discussed. There is another potential management problem associated with mesh size. Mesh size for traps fished off Florida was usually 2.5 x 5.1 cm

Table 8-15. Total length frequency, percent and cumulative percent of 3,029 Centropristis striata (black sea bass) caught in commercial 1½ inch by 2 inch hex uncoated mesh. (Source: South Carolina Wildlife and Marine Resources Center, Charleston, S.C.).

Total Length (cm)	(in)	Frequency	Percent	Cumulative Percent
15	5.9	3	0.10	
16	6.3	3	0.10	0.20
17	6.7	14	0.46	0.66
18	7.1	45	1.49	2.15
19	7.5	99	3.27	5.42
20	7.9	200	6.60	12.02
21	8.3	284	9.38	21.40
22	8.7	311	10.27	31.67
23	9.1	339	11.19	42.86
24	9.3	283	9.34	52.20
25	9.8	260	8.58	60.78
26	10.2	211	6.97	67.75
27	10.6	170	5.61	73.36
28	11.0	162	5.35	78.71
29	11.4	123	4.06	82.77
30	11.8	114	3.76	86.53
31	12.2	108	3.57	90.10
32	12.6	86	2.84	92.94
33	13.0	57	1.88	94.82
34	13.4	43	1.42	96.24
35	13.8	35	1.16	97.40
36	14.2	26	0.86	98.26
37	14.6	21	0.69	98.95
38	15.0	11	0.36	99.31
39	15.4	10	0.33	99.64
40	15.7	5	0.17	99.81
41	16.1	1	0.03	99.84
42	16.5	2	0.07	99.91
43	16.9	-		
44	17.3	1	0.03	99.94
45	17.7	1	0.03	99.97
46	18.1	-		
47	18.5	1	0.03	100.00
TOTAL		3,029	100.00	

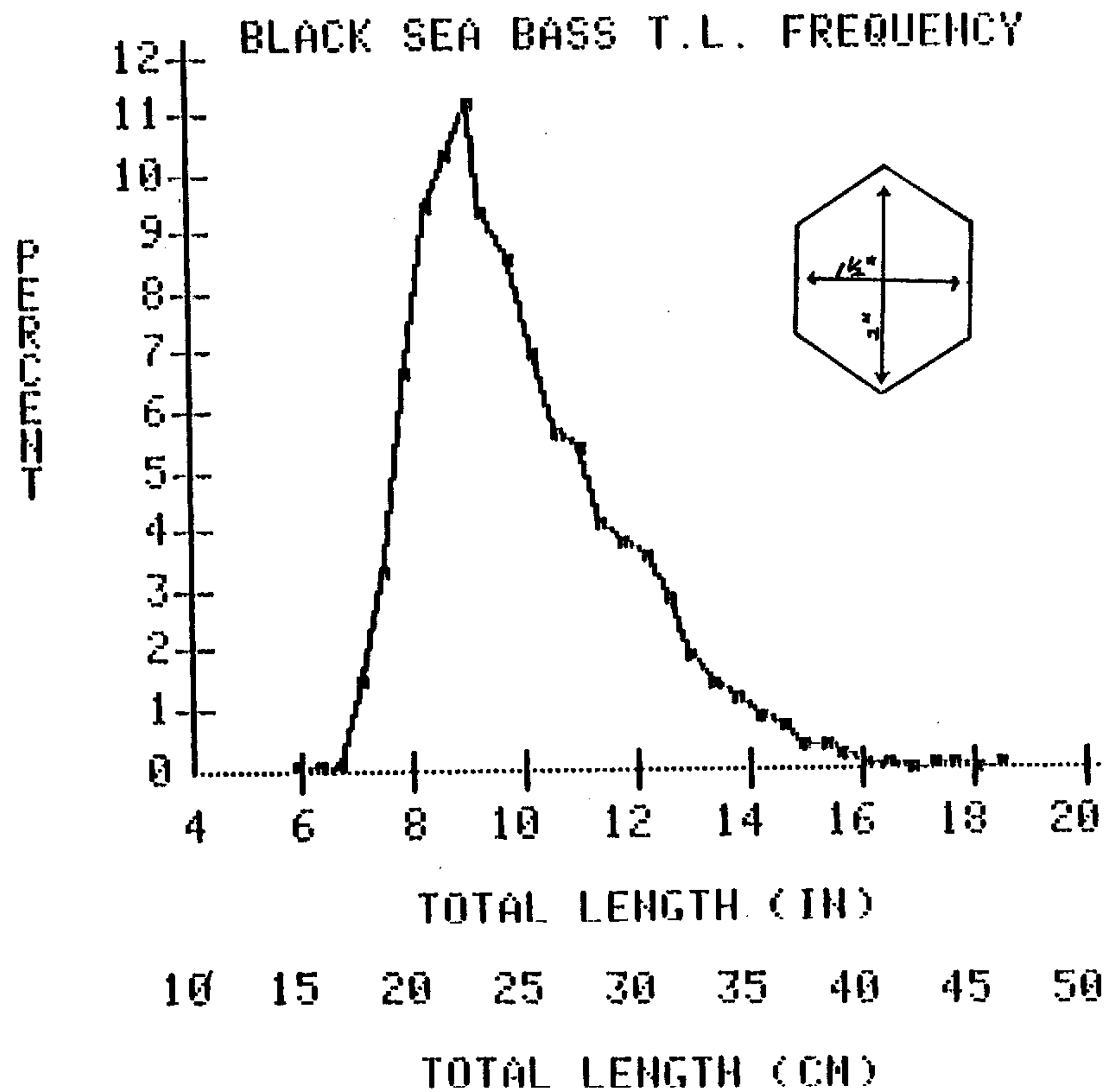

Figure 8-3. Total length frequency of 3,029 Centropristis striata (black sea bass) caught in commercial 1¼ inch by 2 inch hex uncoated mesh. (Source: South Carolina Wildlife and Marine Resources Center, Charleston, S.C.; unpubl. data.)

(1 in x 2 in) rectangular wire mesh. A study by Olsen et al. (1978) to gather information on mesh-related mortality reported that 1.0 in mesh traps killed 17.9 times more fish than 1.5 in hexagonal mesh traps. The 1 in x 2 in mesh traps killed 9.5 times more fish than the 1.5 in hexagonal mesh traps. The 1.5 in mesh size was species selective for the larger species, assuming equal ingress for all sizes (Olsen et al., 1978).

8.4.3.1.4 Trawls and Nets

High-rise bottom trawls outfitted with roller sweeps are also used to harvest species in the snapper-grouper complex (Figure 8-4). The majority of vessels engaged in this fishery are shrimp trawlers, which fish primarily during the closed shrimp season.

The weight and size of the gear employed limit its use to the larger class of shrimp trawlers. Certain modifications to the vessels are necessary for effective use of fish trawls. These modifications include the construction of gallows frames (removable) for supporting doors and towing blocks, notches in the stern for shooting and retrieving the net, and heavy duty winches with larger diameter cable than normally used for shrimp trawling.

Nets used in this fishery are high-rise trawls (large vertical opening) with heavy roller-rigged ground lines. Foot ropes on the nets range from 100 to 180 feet with head ropes ranging from 80 to 150 feet. Vertical openings on these nets are 20 to 30 feet. Long leg lines and numerous floats on the head rope are used to achieve these high openings. Steel vee-doors are used to spread the nets. Codend mesh size is usually 2 inch stretch measure.

Trawling is done over relatively flat areas of predominantly hard bottom, including sections considered live bottom. High-relief areas and slab rock bottoms are avoided because of problems of gear damage or loss.

The Georgia Marine Extension Service conducted bottom trawl cruises in 1981 and 1982 to evaluate the feasibility of commercial trawling on various offshore bottom areas on Georgia's continental shelf, study gear modifications of roller-rigged Yankee 36 trawl, and to collect biological and hydrographic information. A modified Yankee 36 roller-rigged fish trawl with a tongue, additional wings, and 3 ½ in bag was used during most operations.

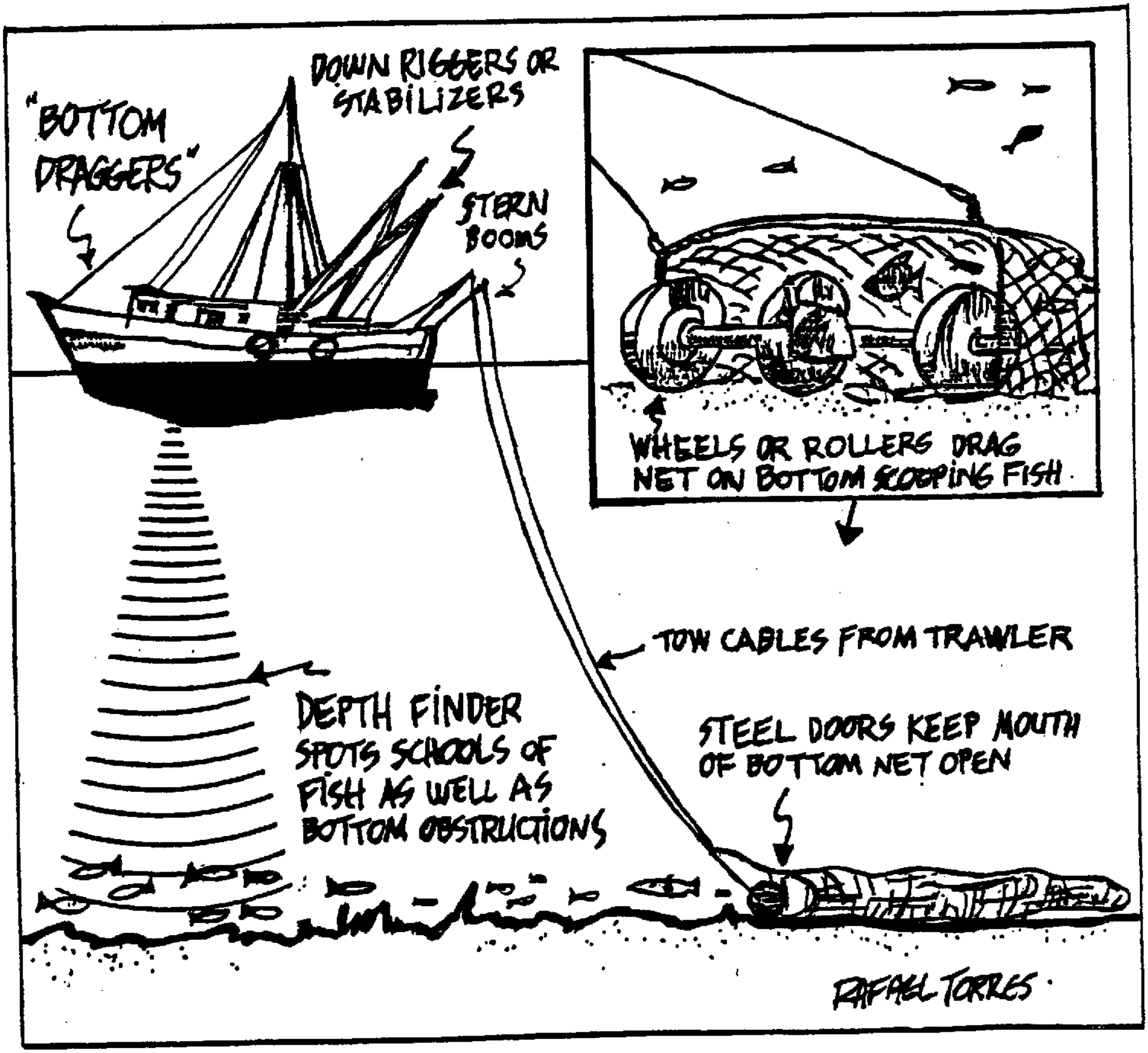

Figure 8-4. Diagram of a bottom roller trawl.

The following tables (Tables 8-16 to 8-21) show the total length frequency of the commercially important species caught during a September 1981 cruise using a 3 1/2 inch stretch mesh cod end. Catch frequencies for Epinephelus niveatus, Balistes capriscus, Haemulon plumieri, Calamus nodosus, Seriola dumerili, and Scomberomorus maculatus were low and are not shown in tabular form. Table 8-22 provides a summary of total number and weight caught, mean weight and length as well as the range of total length for the 13 species.

In December 1981, the Georgia Marine Extension Service used a four inch stretch mesh cod end on their trawl. Length frequencies of some of the commercially important species on this cruise are shown in Tables 8-23 to 8-27. A summary of the total number and weight caught is given in Table 8-28.

Other cruises conducted by the Georgia Marine Extension Service varied the cod end mesh size to determine the correlation between bag mesh size and catch. On R/V Georgia Bulldog cruises number 3 and 5, a 2 and 3/4 in stretched mesh bag liner was sewed inside the bag for the first four tows and first three tows, respectively. Some of the commercial species caught are found in Tables 8-29 and 8-30. On Cruise number 5, tows 1 and 2 did not yield commercial quantities of fish. However, on tow three, 790 pounds of small vermilion snapper were caught. After the liner was removed, the average catch of vermilions dropped to 62 pounds for each of the remaining 12 tows. Similar results were experienced during cruise number 3. The average catch of vermilions was reduced from 185 pounds per trawl to 13.4 pounds per trawl.

Stab nets are being used on reefs off the east coast of Florida, primarily during the snapper spawning season. These are heavily weighted monofilament gill nets about four to five feet high and 100 feet long. The cork line is light so that the heavy lead line sinks the net to the bottom. It is set around part or all of a patch reef and catches snapper, grouper, and other reef species as they move on and off the reef.

8.4.3.2 Recreational

The majority of the head boats in use in the South Atlantic region are wooden hulled and diesel powered. Some offshore vessels, constructed along the lines of the crew boats developed in the offshore oil industry, have aluminum or steel hulls, and are powered by two V-12 diesel engines. This type of vessel predominates in the offshore head boat fleet in South Carolina.

Table 8-16. Total length frequency of vermilion snapper (*Rhomboplites aurorubens*) caught on the *Georgia Bulldog* Cruise Number 9, September 8-15, 1981.

Total Length (cm)	Total Length (in)	Frequency	Relative Frequency
11	4.3	1	.001
12	4.7	6	.005
13	5.1	22	.017
14	5.5	66	.051
15	5.9	95	.073
16	6.3	114	.088
17	6.7	89	.069
18	7.1	109	.084
19	7.5	165	.127
20	7.9	206	.159
21	8.3	185	.143
22	8.7	112	.086
23	9.1	52	.040
24	9.5	24	.019
25	9.8	17	.013
26	10.2	5	.004
27	10.6	3	.002
28	11.0	3	.002
29	11.4	8	.006
30	11.8	4	.003
31	12.2	2	.002
32	12.6	5	.004
33	13.0	2	.002
34	13.4	1	.001
TOTAL		1,296	1.001

Table 8-17. Total length frequency of red snapper (*Lutjanus campechanus*) caught on the *Georgia Bulldog* Cruise Number 9, September 8-15, 1981.

Total Length (cm)	(in)	Frequency	Relative Frequency	Total Length (cm)	(in)	Frequency	Relative Frequency
22	8.7	3	.044	69	27.2	-	—
23	9.1	-	—	70	27.6	-	—
24	9.4	1	.015	71	28.0	-	—
25	9.8	4	.059	72	28.3	-	—
26	10.2	2	.029	73	28.7	-	—
27	10.6	4	.059	74	29.1	-	—
28	11.0	1	.015	75	29.5	-	—
29	11.4	3	.044	76	29.9	-	—
30	11.8	3	.044	77	30.3	-	—
31	12.2	-	—	78	30.7	1	.015
32	12.6	-	—	79	31.1	1	.015
33	13.0	-	—	80	31.5	3	.044
34	13.4	1	.015	81	31.9	2	.029
35	13.8	2	.029	82	32.3	-	—
36	14.1	1	.015	83	32.7	1	.015
37	14.6	-	—	84	33.1	-	—
38	15.0	-	—	85	33.5	2	.029
39	15.3	2	.029	86	33.9	1	.015
40	15.7	1	.015	87	34.3	1	.015
41	16.1	3	.044	88	34.6	1	.015
42	16.5	3	.044	89	35.0	-	—
43	16.9	2	.029	90	35.4	-	—
44	17.3	2	.029	91	35.8	-	—
45	17.7	2	.029	92	36.2	1	.015
46	18.1	2	.029				
47	18.5	1	.015	TOTAL		68	1.001
48	18.9	-	—				
49	19.3	1	.015				
50	19.7	1	.015				
51	20.1	-	—				
52	20.5	-	—				
53	20.9	-	—				
54	21.3	-	—				
55	21.7	1	.015				
56	22.0	-	—				
57	22.4	2	.029				
58	22.8	1	.015				
59	23.2	1	.015				
60	23.6	2	.029				
61	24.0	1	.015				
62	24.4	1	.015				
63	24.8	-	—				
64	25.2	-	—				
65	25.6	-	—				
66	26.0	-	—				
67	26.4	-	—				
68	26.8	-	—				

Table 8-18. Total length frequency of black sea bass (Centropristis striata) caught on the Georgia Bulldog Cruise Number 9, September 8-15, 1981.

Total Length (cm)	Total Length (in)	Frequency	Relative Frequency
19	7.5	1	.007
20	7.9	-	—
21	8.3	3	.020
22	8.7	6	.039
23	9.1	3	.020
24	9.5	6	.039
25	9.8	8	.052
26	10.2	8	.052
27	10.6	10	.065
28	11.0	15	.098
29	11.4	5	.033
30	11.8	11	.072
31	12.2	16	.105
32	12.6	8	.052
33	13.0	3	.020
34	13.4	11	.072
35	13.8	4	.026
36	14.1	7	.046
37	14.6	8	.052
38	15.0	2	.013
39	15.3	4	.026
40	15.7	3	.020
41	16.1	4	.026
42	16.5	2	.013
43	16.9	-	—
44	17.3	3	.020
45	17.7	1	.007
46	18.1	-	—
47	18.5	1	.007
TOTAL		153	1.002

Table 8-19. Total length frequency of gag grouper (*Mycteroperca microlepis*) caught on the *Georgia Bulldog* Cruise Number 9, September 8-15, 1981.

Total Length (cm)	(in)	Frequency	Relative Frequency
58	22.8	1	.023
59	23.2	-	—
60	23.6	1	.023
75	29.5	1	.023
76	29.9	1	.023
77	30.3	-	—
78	30.7	1	.023
79	31.1	2	.047
80	31.5	1	.023
81	31.9	-	—
82	32.3	2	.047
83	32.7	2	.047
84	33.1	3	.070
85	33.5	2	.047
86	33.9	2	.047
87	34.1	1	.023
88	34.6	-	—
89	35.0	3	.070
90	35.4	1	.023
91	35.8	1	.023
92	36.2	1	.023
93	36.6	1	.023
94	37.0	-	—
95	37.4	1	.023
96	37.8	1	.023
97	38.2	-	—
98	38.6	1	.023
99	39.0	-	—
100	39.4	-	—
101	39.8	2	.047
102	40.2	3	.070
103	40.6	-	—
104	40.9	-	—
105	41.3	1	.023
106	41.7	-	—
107	42.1	1	.023
108	42.5	1	.023
109	42.9	1	.023
110	43.3	1	.023
111	43.7	1	.023
112	44.1	1	.023
113	44.5	1	.023
TOTAL		43	.998

Table 8-20. Total length frequency of scamp grouper (*Mycteroperca phenax*) caught on the *Georgia Bulldog* Cruise Number 9, September 8-15, 1981.

Total Length (cm)	Total Length (in)	Frequency	Relative Frequency
48	18.9	1	.019
49	19.3	1	.019
50	19.7	1	.019
51	20.1	2	.038
52	20.5	1	.019
53	20.9	1	.019
54	21.3	2	.038
55	21.7	1	.019
56	22.0	-	—
57	22.4	3	.058
58	22.8	1	.019
59	23.2	2	.038
60	23.6	2	.038
61	24.0	2	.038
62	24.4	3	.058
63	24.8	1	.019
64	25.2	2	.038
65	25.6	2	.038
66	26.0	3	.058
67	26.4	2	.038
68	26.8	-	—
69	27.2	-	—
70	27.6	-	—
71	28.0	2	.038
72	28.3	2	.038
73	28.7	1	.019
74	29.1	1	.019
75	29.5	1	.019
76	29.9	-	—
77	30.3	1	.019
78	30.7	-	—
79	31.1	-	—
80	31.5	-	—
81	31.9	3	.058
82	32.3	2	.038
83	32.7	1	.019
84	33.1	1	.019
85	33.5	2	.038
86	33.9	-	—
87	34.3	-	—
88	34.6	2	.038
TOTAL		52	0.992

Table 8-21. Total length frequency of porgies caught on the Georgia Bulldog Cruise Number 9, September 8-15, 1981.

Red porgy (Pagrus pagrus)				Whitebone porgy (Calamus leucosteus)			
Total Length			Relative	Total Length			Relative
(cm)	(in)	Frequency	Frequency	(cm)	(in)	Frequency	Frequency
20	7.9	1	.002	20	7.9	3	.005
21	8.3	6	.013	21	8.3	2	.004
22	8.7	16	.034	22	8.7	8	.014
23	9.1	24	.052	23	9.1	10	.018
24	9.5	35	.075	24	9.5	16	.029
25	9.8	32	.069	25	9.8	22	.039
26	10.2	14	.030	26	10.2	35	.063
27	10.6	19	.041	27	10.6	34	.061
28	11.0	14	.030	28	11.0	42	.075
29	11.4	18	.039	29	11.4	38	.068
30	11.8	26	.056	30	11.8	34	.061
31	12.2	37	.080	31	12.2	47	.084
32	12.6	26	.056	32	12.6	56	.100
33	13.0	30	.065	33	13.0	49	.088
34	13.4	34	.073	34	13.4	43	.077
35	13.8	23	.050	35	13.8	43	.077
36	14.1	26	.056	36	14.1	21	.038
37	14.6	19	.041	37	14.6	18	.032
38	15.0	10	.022	38	15.0	16	.029
39	15.3	7	.015	39	15.3	8	.014
40	15.7	19	.041	40	15.7	4	.007
41	16.1	10	.022	41	16.1	2	.004
42	16.5	4	.009	42	16.5	3	.005
43	16.9	6	.013	43	16.9	2	.004
44	17.3	1	.002	44	17.3	1	.002
45	17.7	2	.004	45	17.7	-	—
46	18.1	1	.002	46	18.1	1	.002
47	18.5	2	.004	TOTAL		558	1.000
48	18.9	1	.002				
49	19.3	-	—				
50	19.7	1	.002				
TOTAL		464	1.000				

Table 8-22. Total number and weight caught, mean weight, mean total length and range of fish caught during *Georgia Bulldog* Cruise Number 9, September 8-15, 1981.

Species	Total Number[a]	Total Weight (lb)	Mean Weight (lb)	Mean Total Length (cm)	Total Length Range (cm)
Red snapper *Lutjanus campechanus*	68	425.5	6.3	37	22-92
Vermilion snapper *Rhomboplites aurorubens*	2,029	427.5	0.2	19	11-34
Gag grouper *Mycteroperca microlepis*	43	923.5	21.5	91	58-113
Scamp grouper *Mycteroperca phenax*	52	428.5	8.2	66	48-88
Black sea bass *Centropristis striata*	179	235.5	1.3	32	19-47
Red porgy *Pagrus pagrus*	1,123	1,657.5	1.5	31	20-50
Whitebone porgy *Calamus leucosteus*	1,833	2,778.0	1.5	31	20-46
Gray triggerfish *Balistes capriscus*	30	121.0	4.0	45	27-60
Snowy grouper *Epinephelus niveatus*	9	29.0	3.2	38	26-55
White grunt *Haemulon plumieri*	1	3.0	3.0	41	41
Knobbed porgy *Calamus nodosus*	3	8.0	2.7	41	35-47
Greater amberjack *Seriola dumerili*	14	189.0	13.5	76	57-98
Spanish mackerel *Scomberomorus maculatus*	2	3.0	1.5	49	48-50
TOTAL	5,386	7,229.0			

a. Total numbers may not agree with length frequency tables. All fish caught were weighed, but not all were measured.

Table 8-23. Total length frequency of vermilion snapper (Rhomboplites aurorubens) caught by the Georgia Bulldog on Cruise Number 13, December 11-16, 1981 using a four inch stretch mesh cod end.

Total Length (cm)	Total Length (in)	Frequency	Relative Frequency
10	3.9	-	-
11	4.3	-	-
12	4.72	2	.003
13	5.12	2	.003
14	5.51	4	.006
15	5.91	4	.006
16	6.30	12	.019
17	6.69	38	.060
18	7.09	69	.109
19	7.48	81	.128
20	7.87	100	.158
21	8.27	119	.188
22	8.66	75	.118
23	9.06	57	.090
24	9.45	37	.058
25	9.84	17	.027
26	10.24	3	.005
27	10.63	3	.005
28	11.02	4	.006
29	11.42	4	.006
30	11.81		
31	12.20	2	.003
TOTAL		633	1.000

Table 8-24. Total length frequency of red snapper (*Lutjanus campechanus*) caught by the *Georgia Bulldog* Cruise Number 13, December 11-16, 1981 using a four inch stretch mesh cod end.

Total Length (cm)	Total Length (in)	Frequency	Relative Frequency
25	9.8		
26	10.2		
27	10.6	3	.038
28	11.0	1	.013
29	11.4	8	.100
30	11.8	4	.050
31	12.2	7	.088
32	12.6	9	.113
33	13.0	4	.050
34	13.4	5	.063
35	13.8	1	.013
36	14.1	1	.013
37	14.6	2	.025
38	15.0		
39	15.3		
40	15.7	3	.038
41	16.1	1	.013
42	16.5	2	.025
43	16.9	3	.038
44	17.3	2	.025
45	17.7	3	.038
46	18.1	5	.063
47	18.5	2	.025
48	18.9	3	.038
49	19.3		
50	19.7		
51	20.1	2	.025
52	20.5	1	.013
53	20.9	2	.025
54	21.3		
55	21.7		
56	22.0		
57	22.4	1	.013
58	22.8		
59	23.2	1	.013
60	23.6		
61	24.0	1	.013
62	24.4	1	.013
75	29.5	1	.013
88	34.6	1	.013
TOTAL		80	1.010

Table 8-25. Total length frequency of black sea bass (Centropristis striata) caught by the Georgia Bulldog Cruise Number 13, December 11-16, 1981 using a four inch stretch mesh cod end.

Total Length (cm)	Total Length (in)	Frequency	Relative Frequency
23	9.1	1	.030
24	9.4		
25	9.8	1	.030
26	10.2	3	.091
27	10.6	3	.091
28	11.0		
29	11.4	3	.091
30	11.8	2	.061
31	12.2	1	.030
32	12.6	2	.061
33	13.0	4	.121
34	13.4	1	.030
35	13.8	4	.121
36	14.1		
37	14.6	2	.061
38	15.0		
39	15.3	1	.030
40	15.7	1	.030
41	16.1	2	.061
42	16.5	1	.030
43	16.9		
44	17.3		
45	17.7		
46	18.1	1	.030
TOTAL		33	0.999

Table 8-26. Total length frequency of red porgy (*Pagrus pagrus*) caught by the *Georgia Bulldog* Cruise Number 13, December 11-16, 1981 using a four inch stretch mesh cod end.

Total Length (cm)	Total Length (in)	Frequency	Relative Frequency
18	7.1	1	.015
19	7.5		
20	7.9		
21	8.3		
22	8.7	2	.029
23	9.1	3	.044
24	9.5	3	.044
25	9.8	1	.015
26	10.2	1	.015
27	10.6	2	.029
28	11.0	3	.044
29	11.4	1	.015
30	11.8	2	.029
31	12.2	3	.044
32	12.6	2	.029
33	13.0	3	.044
34	13.4	5	.074
35	13.8	3	.044
36	14.1	6	.088
37	14.6	6	.088
38	15.0	2	.029
39	15.3	7	.029
40	15.7	2	.029
41	16.1	4	.059
42	16.5	2	.029
43	16.9	3	.044
44	17.3	1	.015
45	17.7		
TOTAL		68	0.998

Table 8-27. Total length frequency of white porgy (Calamus leucosteus) caught by the Georgia Bulldog Cruise Number 13, December 11-16, 1981 using a four inch stretch mesh cod end.

Total Length (cm)	(in)	Frequency	Relative Frequency
19	7.5	2	.007
20	7.9	1	.004
21	8.3		
22	8.7	1	.004
23	9.1	3	.011
24	9.5	9	.033
25	9.8	10	.037
26	10.2	10	.037
27	10.6	15	.056
28	11.0	35	,130
29	11.4	28	.104
30	11.8	27	.100
31	12.2	29	.108
32	12.6	18	.067
33	13.0	18	.067
34	13.4	22	.082
35	13.8	15	.056
36	14.1	9	.033
37	14.6	6	.022
38	15.0	7	.026
39	15.3	1	.004
40	15.7	1	.004
41	16.1	1	.004
42	16.5		
43	16.9		
44	17.3	1	.004
TOTAL		269	1.000

Table 8-28. Total number and weight caught, mean weight, mean total length and range of fish caught during R/V *Georgia Bulldog* Cruise Number 13, December 12-14, 1982.

Species	Total Number[a]	Total Weight (lb)	Mean Weight (lb)	Mean Total Length (cm)	Total Length Range (cm)
Red snapper *Lutjanus campechanus*	100	228	2.3	36.5	27-88
Vermilion snapper *Rhomboplites aurorubens*	1,273	286	0.2	20.5	12-31
Gag grouper *Mycteroperca microlepis*	14	134	9.6	70.6	61-86
Scamp grouper *Mycteroperca phenax*	7	58	8.3	66.7	43-82
Black sea bass *Centropristis striata*	33	40	1.2	32.7	23-46
Red porgy *Pagrus pagrus*	68	90	1.3	33.8	18-44
Whitebone porgy *Calamus leucosteus*	293	317	1.1	30.5	19-44
Gray triggerfish *Balistes capriscus*	15	30	2.0	64.4	30-55
Jolthead porgy *Calamus bajanado*	1	1	1	34.0	34
Sheepshead porgy *Calamus penna*	5	2.5	0.5	27.8	24-31
White grunt *Haemulon plumieri*	2	5	2.5	42.5	41-44
Sheepshead *Archosargus probatocephalus*	6	33	5.5	51.0	46-61
Almaco jack *Seriola rivoliana*	-	500			
Cobia *Rachycentron canadum*	2	59	29.5	115.5	100-131
TOTAL	1,819	1,783.5			

a. Total numbers may not agree with length frequency tables. All fish caught were weighed but not all were measured.

Table 8-29. Numbers and weights of commercially valuable species caught on R/V Georgia Bulldog Cruise Number 3, May 13-15, 1981.

Tow Number	Lutjanus campechanus #	Lutjanus campechanus lb	Rhomboplites aurorubens #	Rhomboplites aurorubens lb	Mycteroperca microlepis #	Mycteroperca microlepis lb	Lutjanus griseus #	Lutjanus griseus lb	Calamus nodosus #	Calamus nodosus lb	Pagrus pagrus #	Pagrus pagrus lb	Calamus leucosteus #	Calamus leucosteus lb	Balistes capriscus #	Balistes capriscus lb
1			947*	225	1	20	1	11			53	73	24	19	16	80
2	1	5	883*	206	2	45	1	8	11	46	72	192	4	10	14	59
3			1046*	244	6	99	1	9	1	4	14	35	2	5	41	181
4	1	6	279*	65			3	34			43	71	6	18	22	78
5	5	18			1	23	6	32	9	40	16	42	8	18	20	123
6			23	16							15	29	37	86	3	6
7	4	20	84	27	4	142	2	11			27	50	54	97	8	18
8											1	2	1	3		
9	4	14	20	7	1	18	14	93			7	18	56	161	5	22
10			16	4	1	20	32	176			13	24	57	164	1	8
11	13	28											6	24		
12	8	17	113	40			18	93			27	32	50	95	1	2
13			38	16	2	70	10	54			5	8	37	93	4	13
14			124	50	2	93					21	28	33	93		
15	3	69			2	66	5	42			3	2	35	117		
16	2	51	2	1	5	165	8	44			11	23	60	150		
Totals	41	228	3375	901	27	761	101	607	21	90	328	629	470	1153	135	590
Av.Wt.(Lb)		5.6		.25		28.2		6.0		4.3		1.9		2.4		4.4

*Extrapolated from subsamples

Table 8-30. Numbers and weights of commercially valuable species caught on R/V Georgia Bulldog Cruise Number 5, June 9-12, 1981.

Tow Number	Lutjanus campechanus #	Lutjanus campechanus lb	Rhomboplites aurorubens #	Rhomboplites aurorubens lb	Mycteroperca microlepis #	Mycteroperca microlepis lb	Mycteroperca phenax #	Mycteroperca phenax lb	Centropristis striata #	Centropristis striata lb	Pagrus pagrus #	Pagrus pagrus lb	Calamus leucosteus #	Calamus leucosteus lb	Haemulon plumieri #	Haemulon plumieri lb
1																
2											4	3.0	6	8.0		
3	34	48.0	4920*	790.0	2	16.0			42	40.0	47	50.0	6	6.0	2	5.0
4	4	6.5	120	29.0					10	12.0	16	19.0	3	2.0		
5	28	38.0	485*	116.5	4	29.5	1	3.5	25	27.5	16	19.0	22	18.0	2	7.5
6	13	48.0	524*	131.0	4	29.0	2	8.0	22	22.5	28	29.0	9	11.5	3	9.5
7	3	28.5	76	18.5					8	12.0	6	7.5	7	6.0		
8	6	40.0	398*	83.0	7	54.0	1	5.0	7	7.5	29	35.0	9	29.5		
9	11	52.0	136	41.0					5	5.0	13	15.0	20	18.5		
10			41	11.5							6	8.0	8	8.0		
11	1	3.0	114	28.0					20	20.0	37	45.0	22	20.5		
12	24	63.0	531*	130.0			1	11.0	37	43.0	20	29.0	13	11.0		
13																
14	10	12.0	429*	106.5	5	30.0	4	25.0	38	50.0	57	68.0	15	15.0	3	10.0
15	19	35.0	202	50.0	7	71.0	1	5.5	35	40.0	91	110.0	20	33.0	4	12.0
Totals	153	374.0	7976	1535.0	29	229.5	10	58.0	249	279.5	370	437.5	160	187.0	14	44.0
Av.Wt.(Lb)		2.4		0.2		7.9		5.8		1.1		1.2		1.2		3.1

*Extrapolated from subsamples.

An aluminum hulled catamaran style head boat, that originated in Florida, is now appearing in the Carolinas. Catamarans, while providing more angling space than conventional head boats, are expensive and can be profitably operated only where there is a large volume of business.

Most of the head boats in the region are equipped with depth recorders to detect fish schools and loran to enable the relocation of productive areas. Vessels are usually crewed by a captain and two or three mates and capacity varies between 30 and 75 anglers.

Characteristics of south Florida headboats surveyed in 1980 and 1981 are shown in Table 8-31. The average age is close to 16 years and all have two diesel engines (Taylor et al., 1982).

In the Carolina-Georgia region a typical full-day trip lasts 10 to 14 hours, approximately 2 to 4 hours of which is spent traveling to and from the fishing area. In Florida, where the fishing grounds are closer to shore, half-day trips are common. Some head boats in this area make two trips per day, and night trips are also common.

A survey of 66 of the charter boats in the North Carolina fleet (Abbas, 1978) found that the majority had wooden hulls, although a few had fiberglass or combination wood-fiberglass hulls. Lengths ranged from 9 to 17 m (29 to 56 ft), with an average length of 13 m (42 ft). Newer vessels tended to be larger than the older ones. The average age of vessels surveyed was 16 years, with the oldest being 44 years. Sixty percent of the charter boats were powered by a single diesel engine, with roughly 25 percent powered by twin diesels. The remaining 15 percent had gasoline engines. The minimum equipment found on most of the boats included radios (CB and VHF) and fathometers. Slightly over half had loran. A few of the boats (approximately 2 percent of those surveyed) had radar.

Vessel characteristics of South Carolina charter boats are available from a 1976 survey of 26 of the boats in that state's fleet. The average length was 12 m (39 ft), and the average age was 7 years. Seventy-five percent had diesel engines. All of the vessels surveyed were equipped with UHF radios and fish finders, 80 percent had loran, and 25 percent had radar (Liao, unpubl. ms.).

Characteristics of charter boats from north and south Florida Atlantic Coast are shown in Table 8-32. The charter boats in south Florida depend upon tourists while those in the northern section of Florida, where there is less competition from company boats, depend upon repeat business

Table 8-31. Characteristics of the surveyed party boats from the south Florida Atlantic Coast during August 1980 to July 1981 (Source: Taylor et al., 1982.)

Item	Average[a]	Range Low	Range High
Hull:			
Length (feet)	62.0	53	65
Fabrication:			
Fiberglass (percent)	0.0		
Wood (percent)	100.0		
Age (years)	15.8	2	28
Engine:			
Horsepower	306.3	170	425
Number of engines	2.0	2	2
Fuel type:			
Diesel (percent)	100.00		
Gasoline (percent)	0.0		
Age (years)	15.8	2	28
Fishing Characteristics:			
Number of:[b]			
Half-day trips	32.0	0	96
Full-day trips	184.0	0	360
Night trips	198.0	120	312
Average hours per trip:			
Half-day trip	3.5	3	4
Full-day trip	6.7	5	9
Night trip	4.7	3	7
Number of passengers (year):			
Half-day trip	768.0	0	2,304
Full-day trip	4,842.0	768	9,813
Night trip	3,863.0	2,455	5,523
Average fare per passenger (dollars)			
Half-day trip	11.0	11	11
Full-day trip	18.0	16	22
Night trip	13.2	11	15

[a]Based on a sample of 4 boats.

[b]Per year, 1980-81.

Table 8-32. Characteristics of charter boats from the north and south Florida Atlantic Coast during August 1980 to July 1981 (Source: Taylor et al., 1982.)

Item	North Florida[a]			South Florida[b]		
		Range			Range	
	Average	Low	High	Average	Low	High
Hull:						
Length (feet)	32.0	30	35	44.8	35	53
Fabrication:						
Fiberglass (percent)	100.00			29.0		
Wood (percent)	0.0			71.0		
Age (years)	7.2	2	18	14.5	8	21
Engine:						
Horsepower	237.0	150	350	259.0	120	370
Number of engines	2.0			2.0		
Fuel type:						
Diesel (percent)	60.0			86.0		
Gasoline (percent)	40.0			14.0		
Age (years)	3.3	2	6	8.9	1	25
Fishing Activity:						
Number of:[c]						
Half-day trips	72.0	38	123	186.0	0	450
Full-day trips	62.0	14	126	44.0	0	195
Average hours per trip:						
Half-day trip	4.6	4	6	4.1	3	5
Full-day trip	9.5	7	12	8.1	7	9
Average fare per trip (dollars)						
Half-day trip	242.2	225	250	188.7	170	200
Full-day trip	365.3	325	425	371.0	300	400

a Based on a sample of five boats from Nassau and Duval counties.
b Based on a sample of 14 boats from Palm Beach, Broward, and Dade counties.
c Per year, 1980-81.

(Taylor et al., 1982). Distance from port to the fishing grounds is less in the southern portion of Florida, thereby influencing the type of boat and necessary equipment.

There is very little information available on the vessels and gear used by private boat anglers involved in the snapper-grouper fishery. Most are probably in the 5.5-8.5 m (18-28 ft) range, gas engine powered, and equipped with radios and depth finders (B. Low, S.C. Marine Resources Research Institute, Charleston, S.C.; pers. comm.).

The standard gear used in this fishery is a 4/0 to 6/0 rod and reel combination with a two or three hook bottom rig. A small number of anglers use electric reels.

8.4.4 Employment in Commercial and Recreational Sectors

The total amount of employment generated as a result of the snapper-grouper fishery cannot be estimated. The number of vessels operating in several segments of the fishery is unknown and many vessels, both commercial and for-hire recreational, only engage in snapper-grouper fishing on a seasonal basis when more highly desired species are not available. The extent to which employment on these part-time vessels is dependent on the snapper-grouper resource is unknown. In addition, employment is generated in support industries.

Consequently, the following estimates of 1979 employment, based on currently available data, should be considered tentative. (Also see Section 8.7.2.)

1. Hook and line vessels (Both part-time and full-time)- Based on an assumed average employment per vessel of 3 people.
   - North Carolina, South Carolina, Georgia: 39 vessels employ a total of 117.
   - Florida: 1,071 vessels employ a total of 3,213
2. Charter boats - Based on an assumed average employment per vessel of 2 people.
   - North Carolina through Florida: The total fleet is approximately 641 vessels of which only about 11 percent (71) direct their effort towards species of the snapper-grouper complex. These 71 vessels employ a total of 142.
3. Head boats - Based on an assumed average employment per vessel of 3 people.

- North Carolina, South Carolina, Georgia, Florida to Cape Canaveral: 46 boats employ a total of 138.
- Cape Canaveral to Key West, Florida: 49 boats employ a total of 147.

4. Trap Fishery
   - Sea bass trap vessels, 68, employ a total of 136 fishermen (NMFS, Fisheries Statistics Div., Beaufort, N.C.).
   - South of Cape Canaveral, in Dade, Broward, and Monroe Counties, 108 boats employed a total of 280 fishermen (Sutherland and Harper, in press; Taylor and McMichael, in press). These data are for 1979. The ban on fishing traps off Florida has reduced the number of vessels trapping in that area.
5. Private Recreational vessels.
   - An estimated 133,449 private vessels fished in the open ocean in 1973 (Bromberg, 1973). The number of persons utilizing these vessels is unknown.

Total: 3,893 jobs (excluding South Florida trappers and private recreational fishermen).

8.4.5 Fishing and Landing Areas

Snapper-grouper fishing activities are concentrated over those natural hard-bottomed and artificial reef habitats described in Section 8.2. The distribution of effort varies between the commercial and recreational fleet and is discussed below. It should be noted that the precise locations and actual areal extent of many of the natural habitat areas are unknown except to local fishermen who employ loran and fish finding equipment to locate and return to productive fishing grounds.

8.4.5.1 Commercial

Commercial fishermen are far more mobile than the recreational fisherman. Commercial vessels fish inshore waters out to the shelf-edge and beyond. The majority of effort expended by the commercial fleet north of Cape Canaveral has been on the live-bottom and shelf habitats, primarily in depths of 37-64 m (120 to 210 ft). As a result of its greater mobility, the commercial fishery utilizes the shelf-edge more extensively than does the recreational fishery.

Since 1976, an increasing amount of effort has been expended on the lower-shelf habitat. Currently, there are two different fisheries: 1) the inshore (37 to 73 m; 120 to 240 ft) fishery for shallow water species such as red and vermilion snappers, gag, scamp, porgies and grunts, and 2) the deepwater (91 to 219 m; 300 to 720 ft) fishery for snowy and yellowedge groupers and tilefish. An exception to the fishing patterns discussed above is the black sea bass trap fishery which occurs primarily in near offshore waters (12-30 m; 40 - 100 ft).

A limited amount of commercial trap and hook and line fishing occurs on artificial reefs.

Vessels fishing out of Florida ports south of Canaveral fish the reef areas described in Section 8.2.1, most of which occur in relatively shallow inshore waters. These vessels also fish reef areas outside the United States FCZ.

North of Florida, the major port of landing for snappers and groupers is Charleston, South Carolina. In general, snapper-grouper boats unloading in Charleston fish as far north as Cape Lookout, North Carolina, and south to offshore of Savannah, Georgia.

Significant landings of snappers and groupers also occur in Southport, North Carolina, and Morehead City, North Carolina. The only major port of landing for snapper and grouper between Cape Canaveral and Jacksonville, Florida, is Mayport.

Major ports of landing for snapper and grouper south of Cape Canaveral include Marathon and Key West and, to a lesser extent, Miami and Ft. Pierce, Florida.

8.4.5.2 Recreational

Between Cape Hatteras and Cape Canaveral, the majority of head boats and private boats fish the inshore live-bottom habitat areas and artificial reefs. Many of the latter are located within state territorial waters. A small number of head boats, charter boats, and larger private vessels fish the offshore live-bottom habitat areas and out to the shelf-edge.

South of Cape Canaveral, most natural and artificial reef areas are found inshore, and consequently most recreational vessels fish the same areas.

Snappers and groupers caught by the recreational fishery are landed at the point of departure. The major ports for offshore charter boat fishing in the Florida Keys are Islamorada, Marathon, and Key West. Inshore-offshore charter boats dock mainly in Key West, while head boats work out of Key Largo, Islamorada, Marathon, and Key West (Browder et al. 1981). Those ports where significant recreational activity occurs are listed in Section 8.7.2.

8.4.6 Conflicts Among Domestic Fishermen

The deployment of fish traps (south Florida) and trawls (north of Canaveral) in the snapper-grouper fishery has generated a great deal of controversy in recent years. The concerns that have been raised by some participants in the fishery about the use of these gears are discussed below.

Fish traps used in the south Florida snapper-grouper fishery were deployed, prior to enactment of Florida state law prohibiting their use, for the most part, in inshore waters (less than 46 m; 150 ft) adjacent to areas of known relief which were also intensively utilized by both recreational and commercial hook and line fishermen. These groups contend that unregulated use of traps will result in decimation of local snapper-grouper populations. In addition, they claim that the trap buoys interfere with navigation and their gear becomes entangled in traps and trap buoys.

The substantial increase in trawling off South Carolina, Georgia, and northeast Florida during 1979 and 1980 has also led to contention. Hook and line fishermen claim that trawlers, by taking large quantities of small fish, are reducing the amount of larger fish that will become available. They also maintain that trawling damages physical habitat by destroying invertebrate growth on live bottom and disrupts schooling activity so that fish do not return to areas that have been heavily trawled. Additional concern is expressed about the non-selectivity of trawls. Trawl fishermen are experimenting with gear which has less contact with the bottom and is more selective.

Relations between commercial hook and line, head boat, charter boat, and private boat fishermen are generally cordial. However, as a result of the habitat specific nature of snappers and groupers, competition for productive sites is sometimes intensive.

With increasing fuel costs, more and more recreational fishermen are selling their catch. Commercial fishermen allege that the participation of recreational fishermen in the commercial market depresses the market price and that these fish are generally of poorer quality than those supplied by the commercial sector.

8.4.7 Commercial Landings

Total commercial landings of species in the snapper-grouper fishery in the South Atlantic region (Appendix A, Table A-1) have fluctuated since 1967, remaining around 4 to 5 million pounds until 1978, when landings increased to 6.5 million pounds (Figure 8-5). Total landings were 9.9 million pounds in 1981. This amounts to an annual rate of incrase of 3.77 for the years 1967-1981.*

8.4.7.1 Snappers (Lutjanidae)

Total regional commercial landings for all snappers (Appendix A, Table A-1) have fluctuated since 1967, from a high of 2.5 million pounds in 1968 to a low of 1.9 million pounds in 1969, 1973 and 1976 (Figure 8-6). In 1979, snappers comprised 28 percent of the total regional reef fish catch; in 1981 they were 23 percent. Vermilion snapper landings in the Carolinas have been increasing rapidly from 1977 to 1980, when a high of 0.6 million pounds was docked (Figure 8-7). Preliminary 1981 landings were only 0.4 million pounds. Red snapper landings have decreased - the high of 1.1 million pounds in 1968 has gradually decreased to 0.3 million pounds in 1981 (Figure 8-8). The decrease is mainly attributable to Florida landings. Gray snapper landings, particularly south of Cape Canaveral where most are caught, have changed very little from 1967 to 1981. Yellowtail snapper, found in the Florida Keys, have decreased from a high of 0.9 million pounds in 1968 to 0.6 million pounds in 1981 (Figure 8-9).

8.4.7.2 Sea Basses and Groupers (Serranidae)

Commercial landings (primarily in the Carolinas) of black sea bass, south of Cape Hatteras, fluctuated irregularly from 1967 through 1974, averaging approximately 1.3 million pounds (Figure 8-10) (Appendix A, Table A-1). Peak landings of 1.6 million pounds occurred in 1970. Landings declined sharply after 1974, reaching a low of 274,000 pounds in 1978. Landings in North and South Carolina increased significantly in 1979 and increased further to 1.2 million pounds in 1981 (Appendix A, Tables A-3 and A-5).

Grouper landings, historically, have not been broken into species except in South Carolina. Beginning in 1977, South Carolina has recorded increases in gag landings, from 155,000 pounds in 1977 to 323,000 pounds in 1981 (Appendix A, Table A-5). Scamp landings have not changed greatly from 1977, and snowy grouper landings have fluctuated wildly, from 3,000

*$\ln(\text{landings}) = 8.3279 + 0.0377 \ln(\text{years})$; $R^2 = 0.5772$; $n = 15$

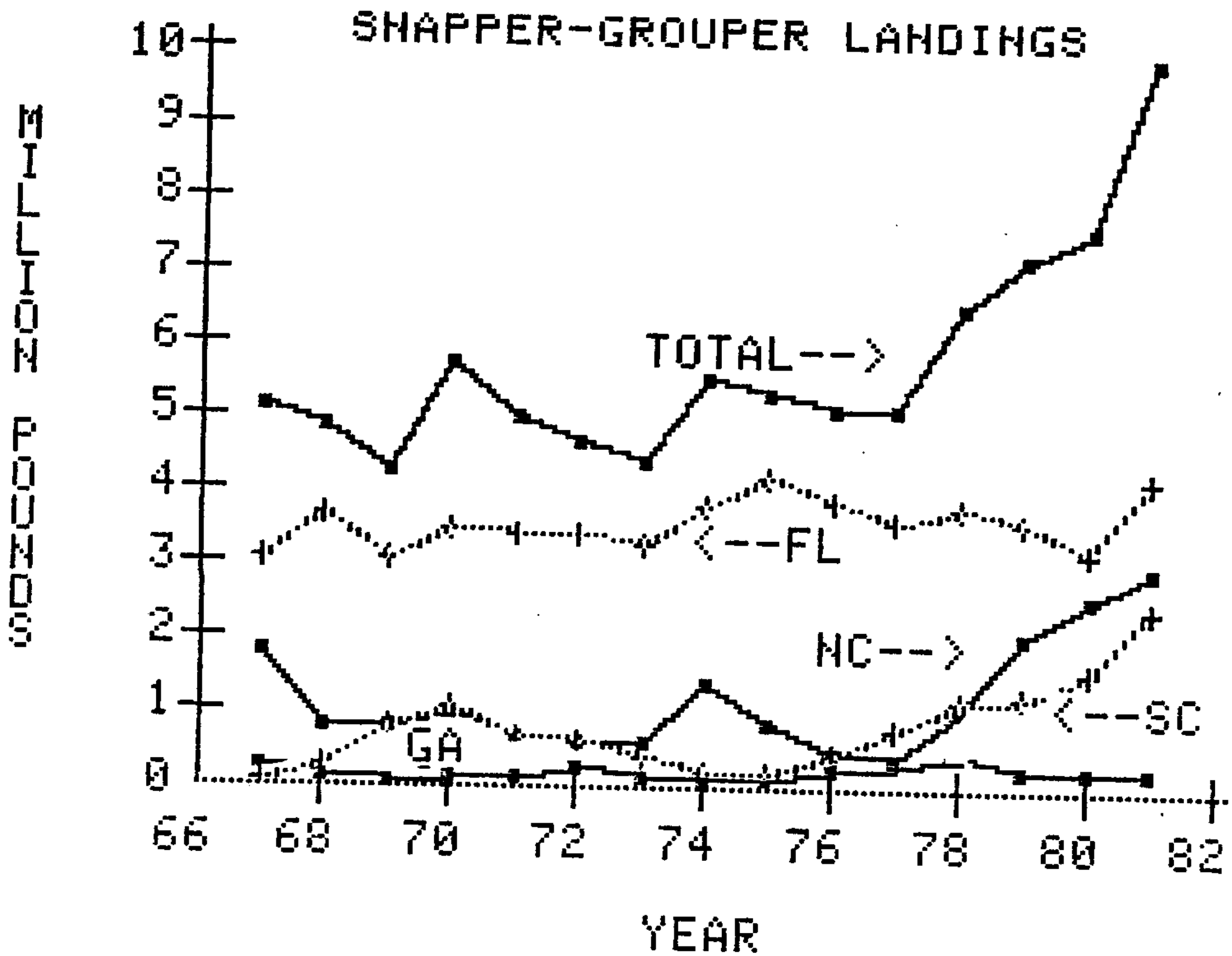

Figure 8-5. Total commercial landings in the South Atlantic region. (Source: NMFS,Fishery Statistics of the U.S. and Fisheries of the U.S.; various issues.)

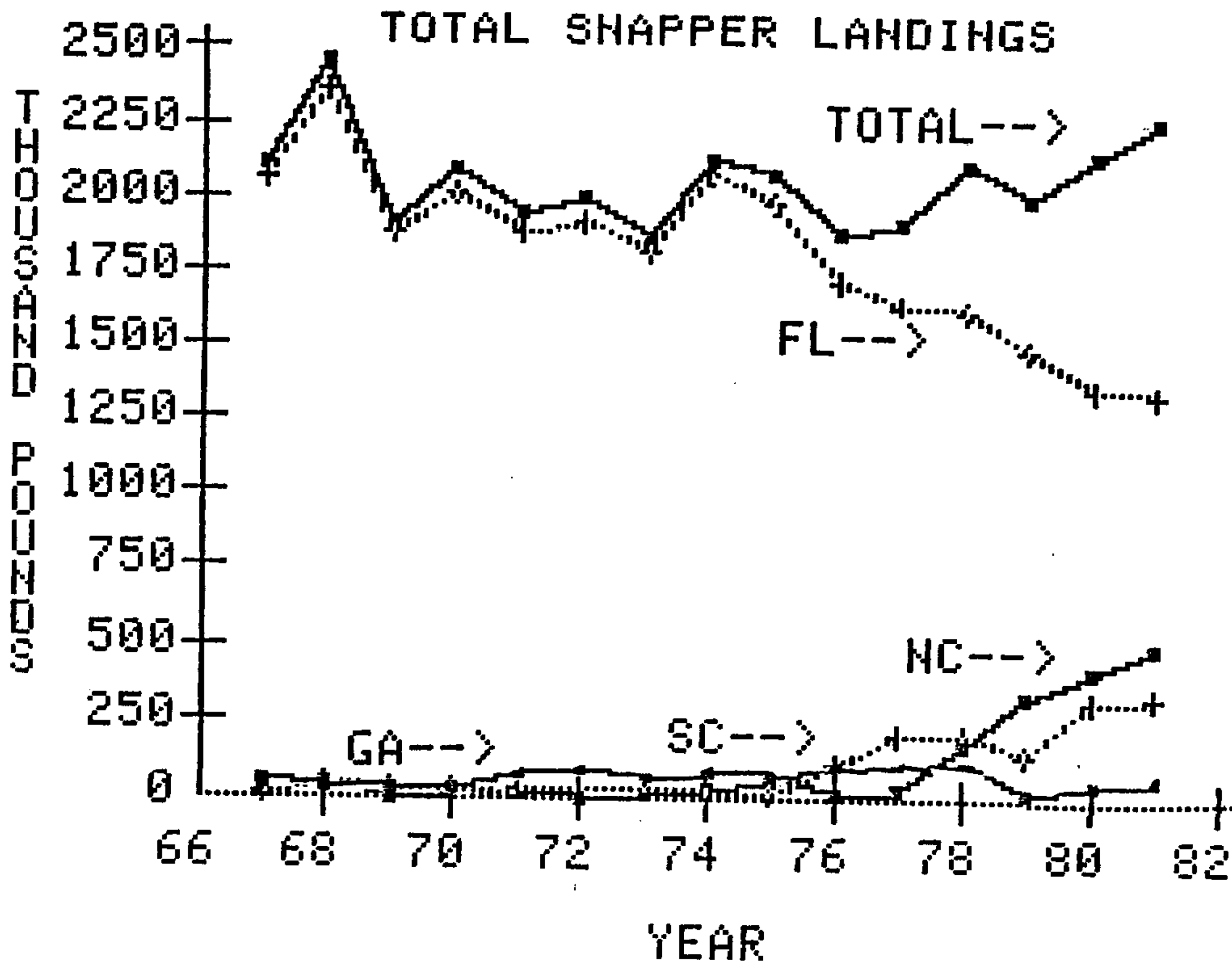

Figure 8-6. Total commercial landings for all snappers by state and region. (Source: NMFS, Fishery Statistics of the U.S. and Fisheries of the U.S.; various issues.)

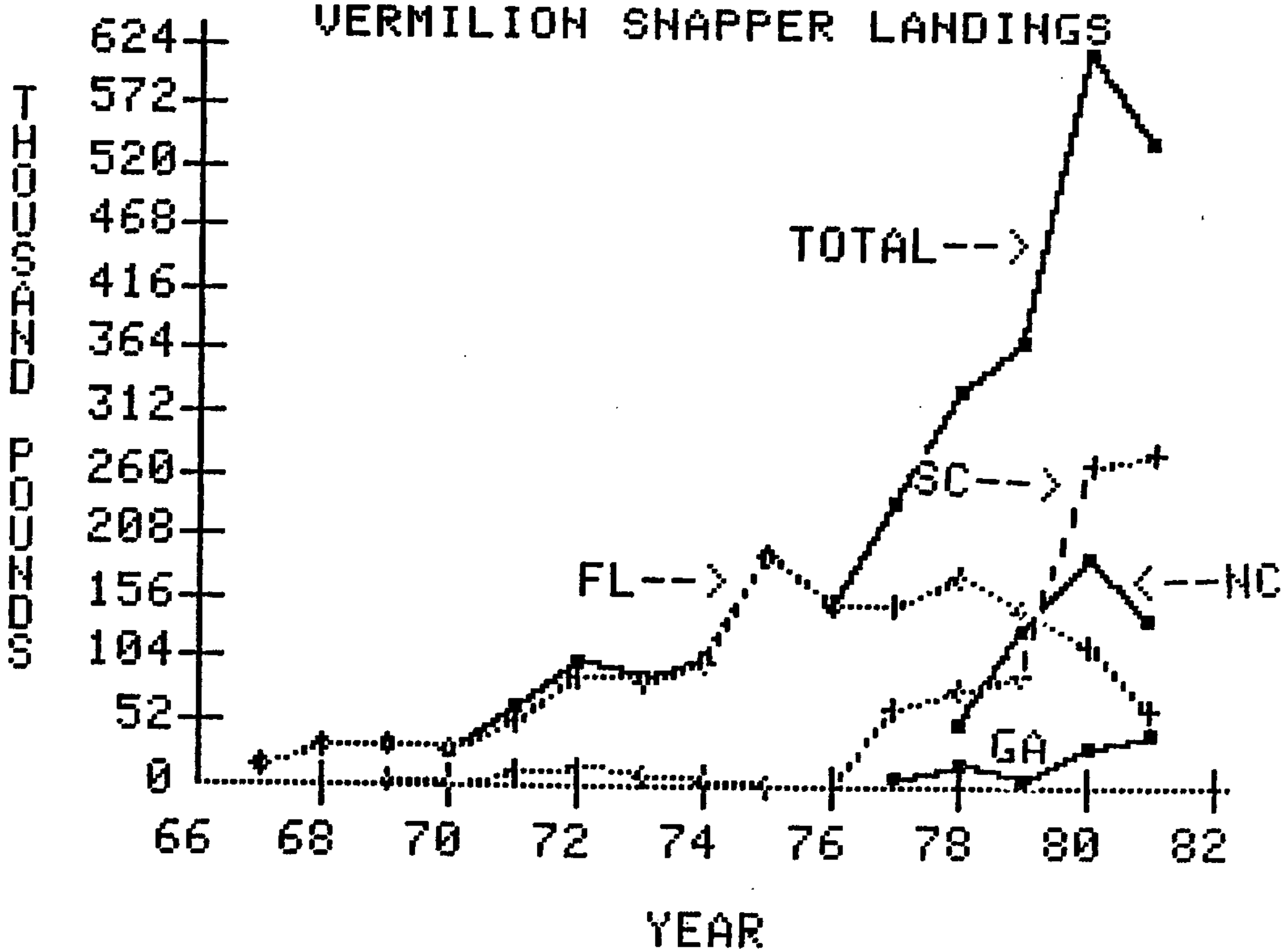

Figure 8-7. Total commercial landings for vermilion snappers by state and region. (Source: NMFS, Fishery Statistics of the U.S. and Fisheries of the U.S., various issues.)

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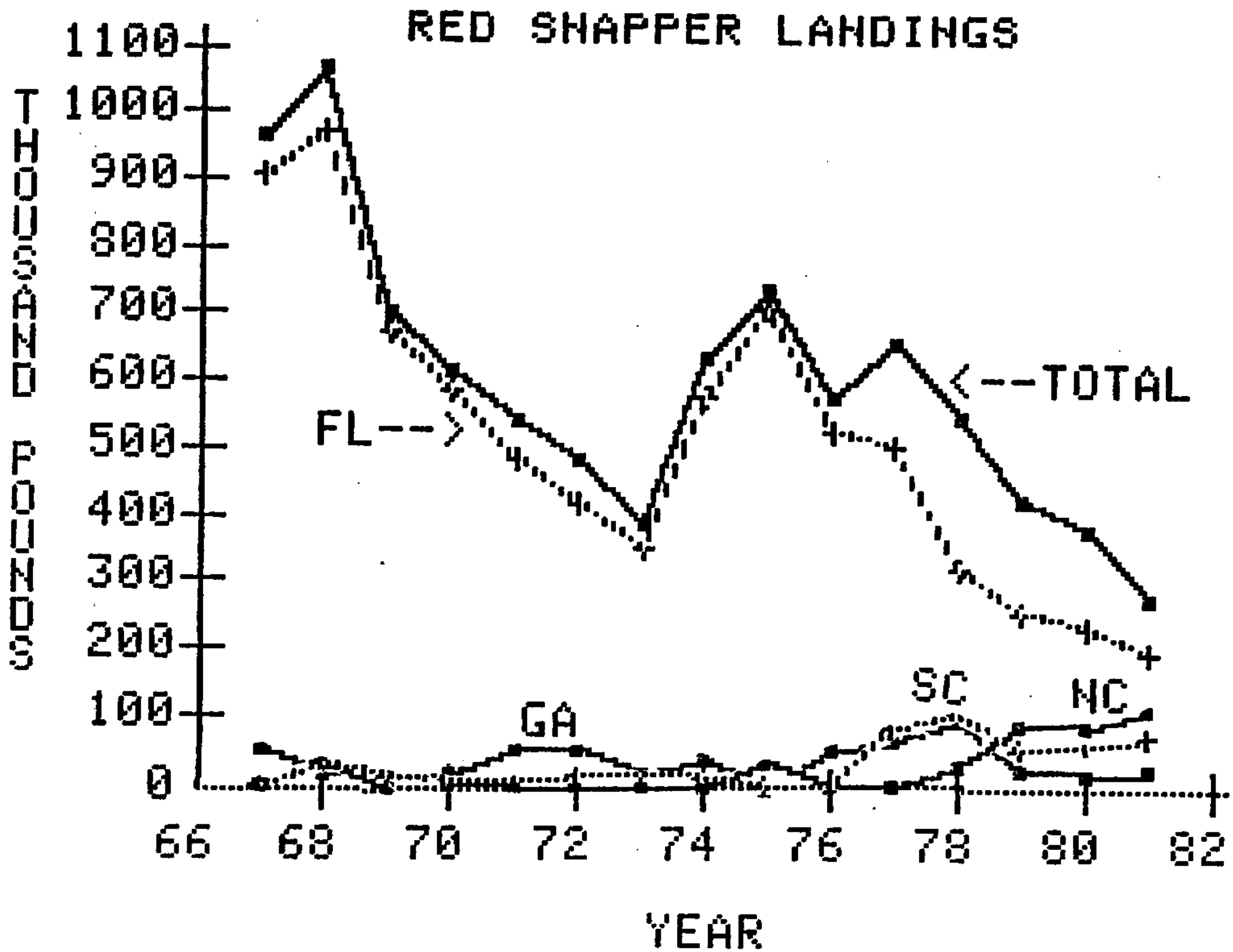

Figure 8-8. Total commercial landings of red snapper by state and region. (Source: NMFS, Fishery Statistics of the U.S. and Fisheries of the U.S., various issues.)

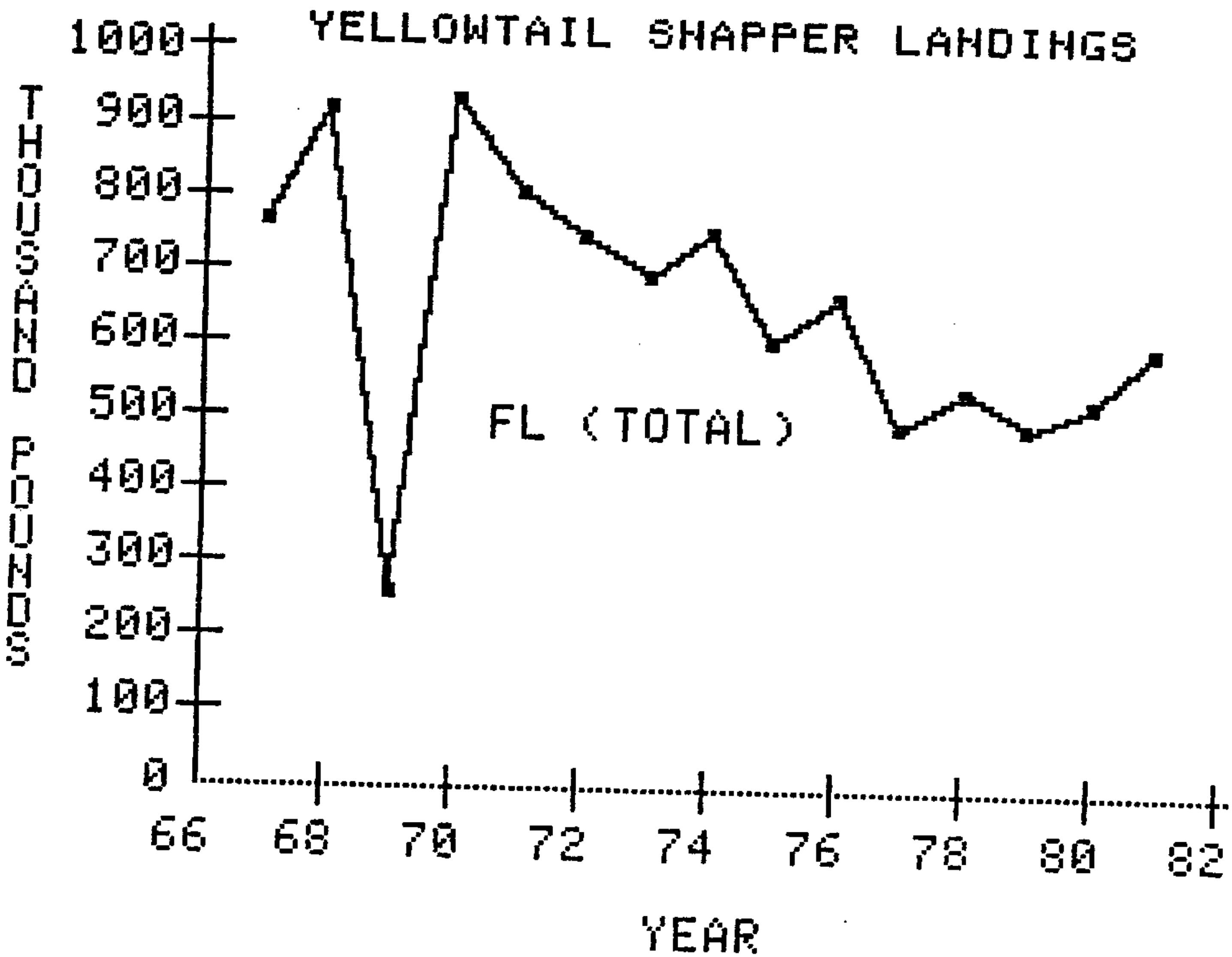

Figure 8-9. Total commercial landings of yellowtail snapper by state and region. (Source: NMFS, Fishery Statistics of the U.S. and Fisheries of the U.S., various issues.)

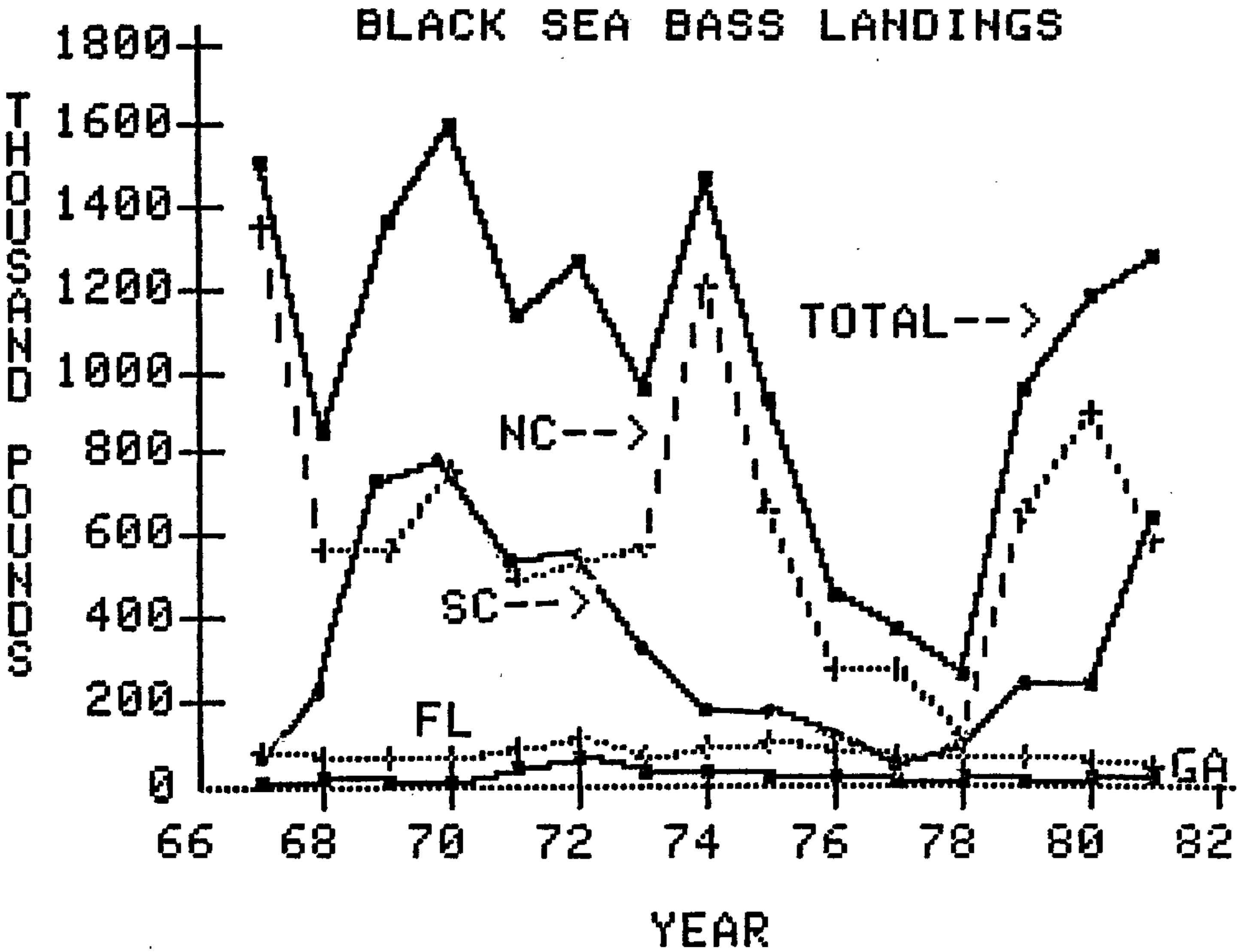

Figure 8-10. Commercial landings of black sea bass, by state and regional total, 1967 through 1981. (Source: NMFS, Fishery Statistics of the U.S. and Fisheries of the U.S., various issues.)

pounds in 1981 to 212,000 pounds in 1978, which indicates differing fishing pressure. Jewfish, caught mainly south of Cape Canaveral, have decreased in pounds landed from a high in 1977 of 72,000 pounds to 19,000 pounds in 1981. For the region, grouper landings have increased from the low of 750,000 pounds in 1967 to the high in 1978 of 2.8 million pounds (Figure 8-11) (Appendix A, Table A-1).

8.4.7.3 Porgies (Sparidae)

Porgy landings have fluctuated, but in 1979 began to increase (Figure 8-12) from 1.1 million pounds to 1.8 million pounds in 1981 (Appendix A, Table A-1). Sheepshead landings have averaged approximately 224,000 pounds from 1967 to the present (Appendix A, Table A-1).

8.4.7.4 Grunts (Pomadasyidae)

Landings of grunts have gradually increased over the years, from 66,000 pounds in 1967 to 149,000 pounds in 1981, but there were a few years in which the poundage dropped below 40,000 pounds (Appendix A, Table A-1).

8.4.7.5 Tilefishes (Malacanthidae)

Tilefish landings have shown a very large increase in a few years (Figure 8-12) (Appendix A, Table A-1). In 1969, landings were 6,000 pounds. By 1974, landings had increased to 102,000 pounds, and by 1981, landings were 1.2 million pounds.

8.4.7.6 Triggerfishes (Balistidae)

Triggerfish landings have shown an upward trend, and total landings in 1981 of 82,000 pounds was an increase over the 2,000 pounds reported for 1969 (Appendix A, Table A-1).

8.4.7.7 Wrasses (Labridae)

Hogfish landings fluctuated between 8,000 and 17,000 pounds from 1967 to 1976. Landings averaged 24,000 pounds from 1977 to 1979 (Appendix A, Table A-1).

8.4.7.8 Jacks (Carangidae)

Amberjack landings have increased some over the years. In 1968, 26,000 pounds were landed on the Florida east coast; in 1981 Florida landed 48,000 pounds (Appendix A, Table A-9), and total regional landings were 103,000 pounds (Appendix A, Table A-1).

8.4.8 Recreational Landings

Estimates of Carolina head boat landings are available since 1972 (Appendix A, Tables A-11, 12, 13). Total landings through 1978 have fluctuated irregularly. Effort (angler days) has been relatively stable,

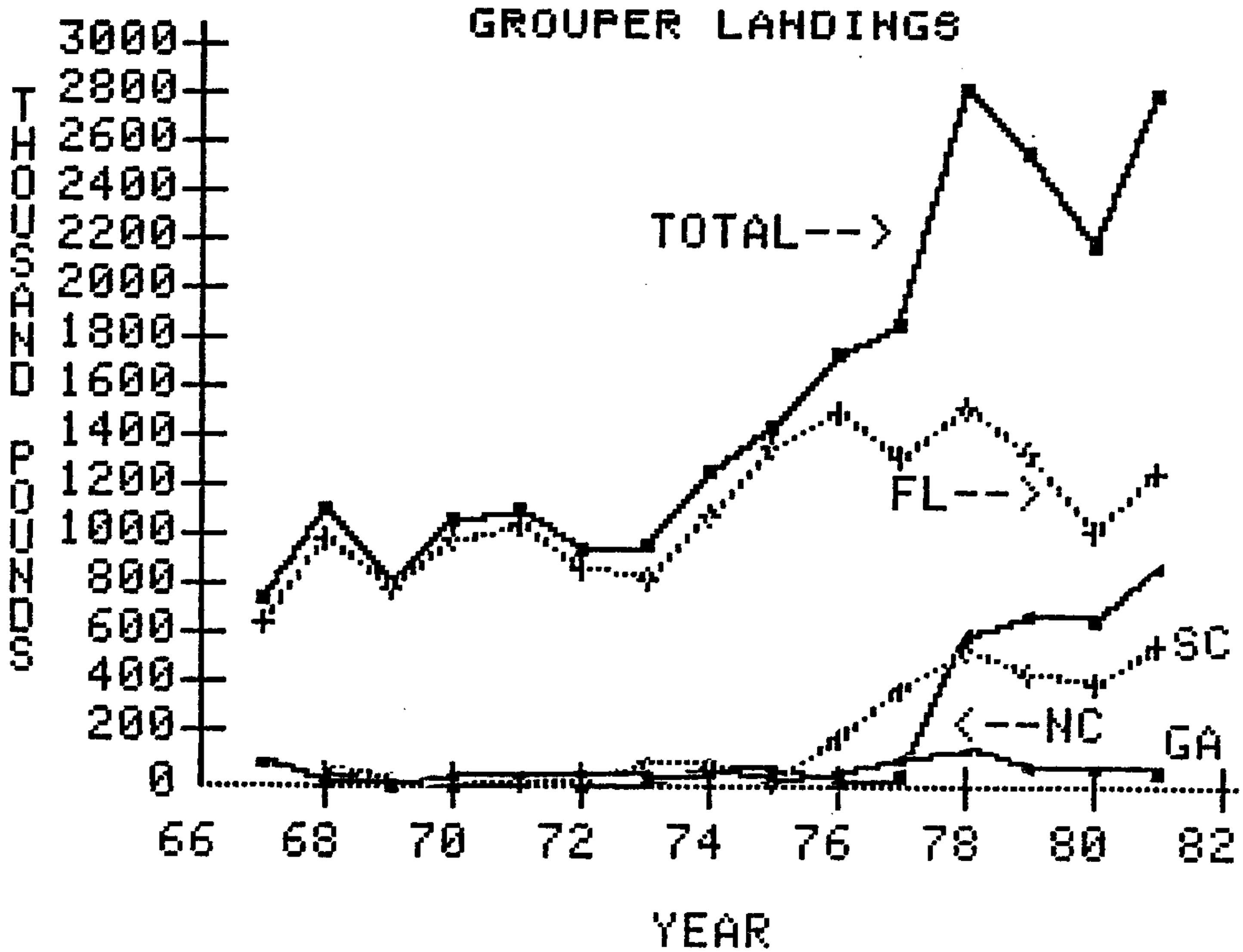

Figure 8-11. Total commercial landings of groupers by state and region. (Source: NMFS Fishery Statistics of the U.S. and Fisheries of the U.S., various issues.)

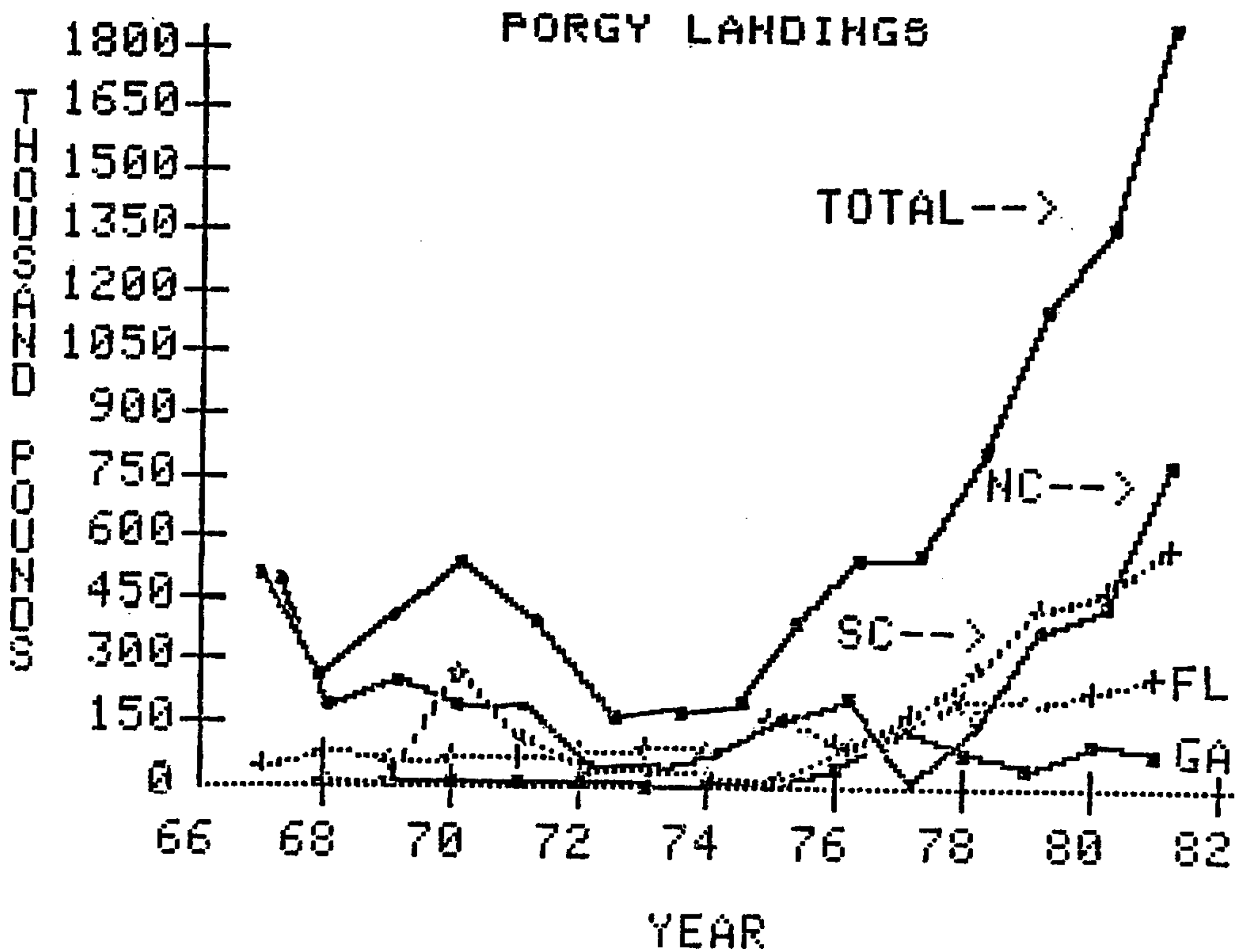

Figure 8-12. Total commercial landings of porgies by state and region. (Source: NMFS Fishery Statistics of the U.S. and Fisheries of the U.S., various issues.)

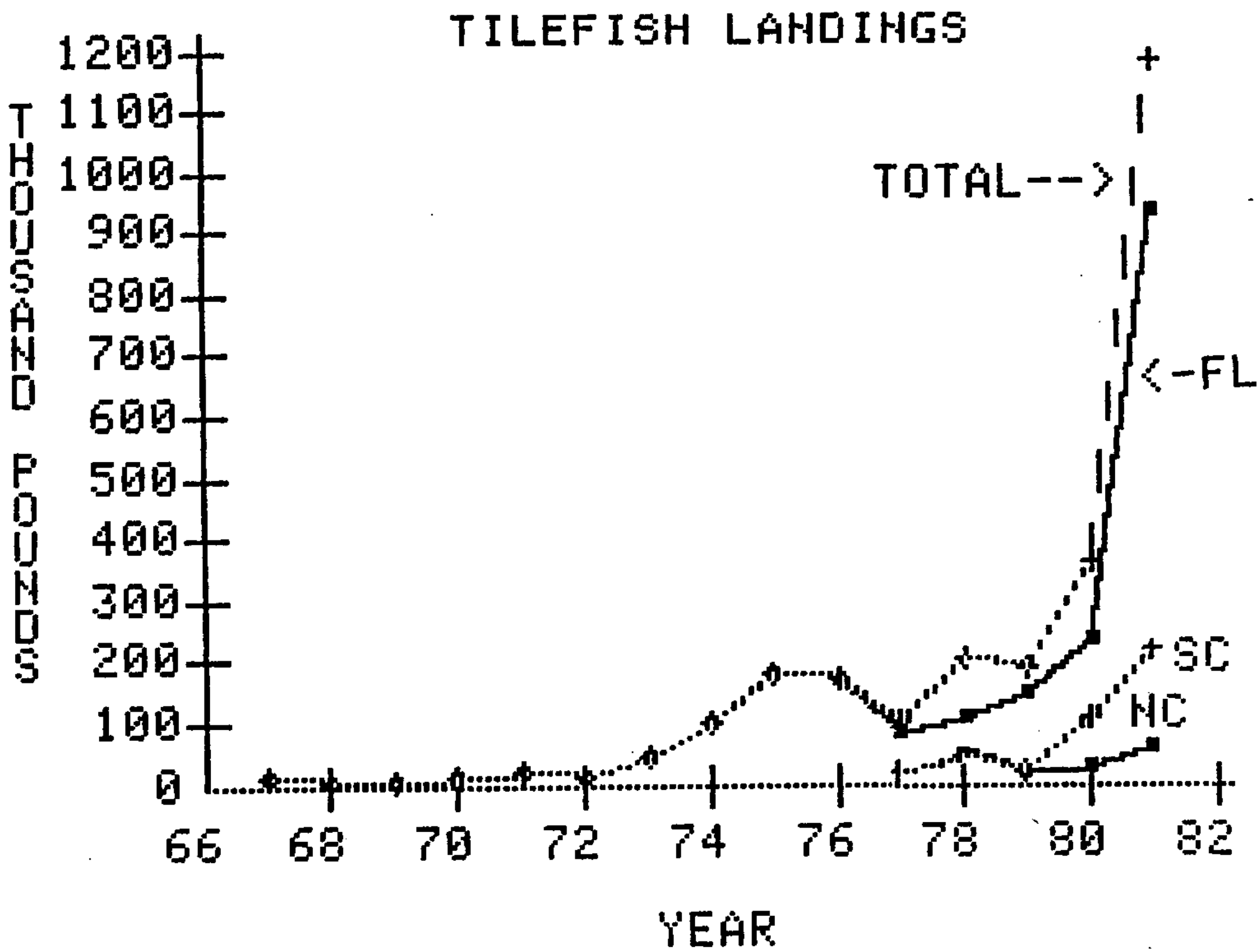

Figure 8-13. Total commercial landings of tilefish by state and region. (Source: NMFS Fishery Statistics of the U.S. and Fisheries of the U.S., various issues.)

increasing slightly inshore off Cape Lookout, N.C. and offshore Cape Fear, N.C. (Table 8-33). In other areas the catch by number of fish per angler day decreased or remained about the same for 1978 and 1979. The pounds of fish per angler day increased in South Carolina and off Daytona, Florida in 1979, mainly due to black sea bass inshore catches. The NMFS head boat survey was expanded to include the area from Savannah, Georgia, through Daytona, Florida, in 1976, and more recently (1978) to include south Florida (Ft. Lauderdale to Miami) and the Florida Keys. In 1978, head boat landings of reef fishes from North Carolina through Daytona, Florida, were estimated to be approximately 2 million pounds (Appendix A, Table A-12). Landings from Ft. Lauderdale through the Florida Keys were 913,000 pounds. Landings of reef fishes in 1979 from North Carolina through Daytona, Florida decreased slightly to 1.8 million pounds (Appendix A, Table A-13). The 1979 landings from Ft. Lauderdale through the Florida Keys and including Dry Tortugas were 1.3 million pounds. A breakdown of the percent of each species caught by region is shown in Table 8-34.

Head boat catches vary in the Carolinas according to whether inshore vessels fishing the rocks and coral patches in shallow (<46 m; 150 ft) water or offshore vessels fishing the shelf edge and lower shelf (from 46 to 146 m; 151 to 479 ft) are used. South Carolina inshore boats are subdivided further into those fishing for porgies and vermilion snapper and those fishing almost entirely for black sea bass. In Florida, all the head boats are of the inshore type. Table 8-35 gives the percent by weight of head boat landings in 1979 which were inshore and offshore of the Carolinas. Off South Carolina, 98 percent of the head boat landings of black sea bass were from inshore, while off Cape Lookout, North Carolina, 77 percent were from inshore waters.

Black sea bass comprised 29 percent by weight of the head boat catch from North Carolina through Daytona, Florida in 1979. Red porgy were the next most frequently caught species, 16 percent by weight for the same area. For the entire area, North Carolina through the Florida Keys, black sea bass had the largest total poundage estimated for 1979: 588,400 pounds. Fifty eight percent of the total weight of black sea bass was caught off South Carolina, 20 percent off the Daytona, Florida area, and 19 percent off North Carolina.

Table 8-33. Catch-per-unit of effort by head boat anglers, Cape Lookout, N.C. through the Florida Keys, 1978 and 1979. (Source: G. Huntsman and C. Manooch, NMFS, Beaufort, N.C.; pers. comm.))

Area	Number of fish per angler day (black sea bass excluded)		Pounds of fish per angler day (black sea bass excluded)		Pounds of fish per angler day (Including black sea bass)	
	1978	1979	1978	1979	1978	1979
Cape Lookout, N.C. (Inshore)	3.31	4.50	7.7	15.0	14.0	21.4
Cape Lookout, N.C. (Offshore)	8.44	5.44	33.9	20.5	35.3	21.6
Cape Fear, N.C. (Inshore)	7.66	6.09	21.6	15.9	29.7	22.3
Cape Fear, N.C. (Offshore)	4.09	6.55	13.4	19.5	14.3	23.3
South Carolina (Inshore)	1.50	1.36	2.4	2.4	7.1	10.5
South Carolina (Offshore)	7.95	3.60	23.6	11.5	24.1	12.0
Savannah, GA to Jacksonville, FL	5.32	4.46	6.2	6.3	8.1	9.9
Daytona, FL to Ft. Pierce, FL	7.06	7.45	8.0	11.0	10.4	13.0
Ft. Lauderdale, FL to Miami, FL	3.82	2.24	9.3	9.7	9.3	9.8
Florida Keys	5.79	3.50	7.1	6.5	7.1	6.5

Table 8-34. Annual percent by weight for each species caught by headboats in 1979 by area (Source: G. Huntsman, NMFS, Beaufort Lab., N.C.; pers. comm.)

SPECIES	North Carolina Inshore	North Carolina Offshore	South Carolina Inshore	South Carolina Offshore	Savannah	Jacksonville	Daytona	Miami	Florida Keys	Dry Tortugas	Regional Total
Snappers											
Gray	-	-	-	-	-	-	-	0.8	2.0	0.7	0.5
Lane	-	-	-	-	-	-	-	0.3	2.8	0.1	0.3
Mutton	-	-	-	-	-	-	-	4.6	19.7	27.8	7.1
Red	1.3	1.3	1.1	3.6	5.5	16.6	20.2	4.1	0.4	-	5.4
Silk	-	-	-	-	-	-	-	1.6	0.6	-	0.6
Vermilion	6.9	8.4	0.1	2.5	3.2	12.4	16.3	1.9	0.5	-	4.7
Yellowtail	-	-	-	-	-	-	-	3.5	22.6	31.2	7.5
Others	-	0.4	0	0.6	2.8	9.2	2.6	0.6	0.2	-	0.8
Total Snappers	8.2	10.1	1.2	6.7	11.5	38.2	39.1	17.4	48.8	59.8	26.9
Groupers											
Epinephelus	1.6	4.5	0.2	10.2	2.7	1.9	1.5	1.8	7.6	3.2	2.8
Mycteroperca	9.4	30.0	3.0	11.5	2.2	7.8	7.8	4.5	6.6	22.4	10.0
Total Groupers	11.0	34.5	3.2	21.7	4.9	9.7	9.3	6.3	14.2	25.6	12.8
Others											
Black sea bass	28.8	10.5	76.8	4.4	46.3	21.6	15.3	0.8	-	-	13.1
Grunts	11.8	11.5	3.0	6.3	1.9	20.7	3.2	1.4	13.6	2.4	4.8
Porgies	34.0	21.2	13.7	45.8	9.5	2.9	4.2	1.6	6.6	4.8	9.1
Triggerfish	6.1	9.2	2.0	9.6	12.7	1.0	3.9	0.8	2.4	0.2	2.8
Tilefish	-	0.3	0	1.1	-	-	-	-	-	-	0.1
Others	1.0	2.9	0.5	4.4	13.2	6.0	24.9	71.7	14.3	7.2	30.5
Total Others	81.7	55.6	96.0	71.6	83.6	52.2	51.5	76.3	36.9	14.6	60.4
TOTALS	100.9	100.2	100.4	100.0	100.0	100.1	99.9	100.0	99.9	100.0	100.1

Table 8-35. Percent of headboat landings of specific species inshore and offshore for North and South Carolina, 1979 (Source: G. Huntsman, NMFS, Beaufort, N.C.; pers. comm.)

	Cape Lookout		Cape Fear		Cape Romain	
	Inshore	Offshore	Inshore	Offshore	Inshore	Offshore
Red Porgy	48	52	68	32	41	59
Vermilion snapper	37	63	71	29	10	90
Epinephelus grouper	11	89	42	58	5	95
Mycteroperca grouper	6	94	28	72	34	66
Red snapper	7	93	75	25	41	59
Other snapper	4	96	0	0	0	100
Gray triggerfish	34	66	37	63	33	67
Tilefish	0	100	100	0	0	100
Black sea bass	77	23	64	36	98	2
White grunt	64	36	45	55	44	56

North Carolina charter boats landed 220,840 pounds of reef fishes in 1978 on 1,188 trips (Manooch et al., 1981). The bulk of the catch was black sea bass (75 percent by number; 64 percent by weight). Other species caught frequently were red porgy, white grunt, vermilion snapper, and groupers. A breakdown of the catch and effort by species is provided in Table 8-36.

Georgia recreational fishermen landed 28,652 pounds of reef fishes, as indicated by a 1977 creel survey; private boat anglers comprised 95 percent of the recreational fishermen sampled and their catch constitutes the majority of the estimated landings (D. Harris, Ga. Department of Natural Resources, Brunswick, Ga.; pers. comm.).

No estimates are available regarding private boat landings of reef fishes in the Carolinas. However, it is likely that these landings constitute a significantly smaller share of the total harvest than that of the head boat fishery which concentrates a large part of its effort on snappers and groupers. Off the east coast of Florida, however, the private boat fishery for these species is believed to be substantial.

Estimates of 1979 regional recreational catch of fishes of the snapper-grouper fishery are presented in Table 8-37. Note that the total is the sum of landed and harvested fish. The landed category is derived from the 1979 Marine Recreational Fishery Statistics Survey and includes fish brought ashore whole, and identified (as to species) by the port sampler, measured and weighed. Harvested fish include those that were brought ashore filleted, gutted, etc. Fish in the harvested category were identified, by species, whenever possible. However, in some cases species identification was based on interviews with fishermen. Some major species (e.g., red snapper) comprised a significantly higher proportion of the harvested catch (in numbers of fish) than of the landed catch. Estimates of the number of pounds of fish harvested are based on the average weight of fish in the landed category. Released fish include all fish released alive as estimated from interviews with fishermen.

8.4.8.1 Snappers (Lutjanidae)

Vermilion snappers have increased in head boat landings, but only slightly. Total landings in 1978 of vermilion were 288,600 pounds according to the NMFS head boat survey (Appendix A, Table A-12). The estimate of recreational catch of vermilion snapper by the Marine Recreational Fishery Statistics Survey for 1979, was 100,000 fish caught by party/charter boats

Table 8-36. Catch and effort data for 1,188 North Carolina offshore bottom fishing charter trips in 1978. (Source: Manooch et al., 1981.)

Species	Total Number	Total Weight (lb)	Number Per Trip	Weight Per Trip (lb)
Black sea bass	162,227	141,162	136.55	118.82
Red porgy	30,873	38,066	25.99	32.04
White grunt	14,299	16,606	12.04	13.98
Vermilion snapper	6,037	6,468	5.08	5.44
Red snapper	61	382	0.05	0.32
Grouper	1,292	15,632	1.09	13.16
Gray triggerfish	370	1,192	0.31	1.00
Amberjacks	20	388	0.02	0.33
Sharks	107	944	0.09	0.80
TOTAL	215,286	220,840	181.22	185.89

Table 8-37. Estimates of recreational catches of fishes of the snapper-grouper complex from North Carolina through Dade County, Florida. (All figures are in thousands.) (Source: NMFS, 1980.)

	Landed[a]		Harvested[b]		Total[c]		Released[d]		Total Catch	
Species	# fish	# lb	# fish	# lb[e]	# fish	# lb[e]	# fish	# lb[e]	# fish	# lb[e]
Groupers	214	1,104	210	1,083	424	2,187	113	583	537	2770
Grunts										
White	568	309	122	66	690	375	280	152	970	528
All Others	978	715	654	478	1,632	1,193	1,555	1,137	3,187	2,330
Total Grunts	1,546	1,024	776	544	2,322	1,568	1,835	1,289	4,157	2,858
Jacks	1,072	1,532	468	669	1,540	2,201	465	665	2,005	2,865
Porgies										
Sheepshead	835	1,737	133	277	968	2,014	138	287	1,106	2,301
All Others	283	375	29	38	658	413	35	476	347	460
Total Porgies	1,118	2,112	162	315	1,280	2,427	173	334	1,453	2,761
Sea Basses	622	598	1,306	1,256	1,928	1,854	1,413	1,358	3,341	3,212
Snappers										
Red	190	316	417	694	607	1,010	80	133	687	1,143
Gray	292	349	110	131	402	480	258	308	660	789
Vermilion	57	15	17	4	74	19	79	21	153	40
All Others	494	554	1,608	1,803	2,102	2,357	106	119	2,209	2,477
Total Snappers	1,033	1,234	2,152	2,632	3,185	3,866	523	581	3,709	4,449
Triggerfishes	79	161	70	143	149	304	215	438	364	742
TOTALS	5,684	7,765	5,144	6,642	10,828	14,407	4,737	5,248	15,566	19,657

a. Landed fish - whole fish counted, measured and verified by on-site samplers.
b. Estimate of total number of fish harvested (not brought ashore in whole form, used as bait, filleted, or discarded dead) is derived from the 1979 survey. Estimates by species and species groups are based on species composition, by number, of landed fish.
c. Total is the sum of landed and harvested fish.
d. Fish released alive - estimated from interviews with fishermen, as reported in the 1979 survey.
e. Based on the average weight of landed fish.

(NMFS, 1980). This would be about 26,300 pounds assuming average weight was 0.26 lb per fish. Total recreational catch was reported to be 40,000 pounds for 1979.

Red snapper landing statistics often include other species of snapper. Red snapper landed by recreational fishermen in 1979 was 1.0 million pounds (NMFS, 1980). The head boat landings reported in 1978 were 185,700 pounds and 245,400 pounds in 1979 (Appendix A, Tables A-12 and A-13). Gray snapper, found primarily south of Cape Canaveral, head boat landings were 86,500 pounds in 1978 and 24,700 pounds in 1979 (Appendix A, Tables A-12 and A-13). Yellowtail snapper headboat landings were 268,600 pounds in 1978 and 340,600 pounds in 1979 (Appendix A, Tables A-12 and A-13).

8.4.8.2 Sea Basses and Groupers (Serranidae)

Black sea bass are an important target species for recreational fishermen. The head boat survey reported 547,900 pounds landed in 1978 and 588,400 in 1979 (Appendix A, Tables A-12 and A-13). The Recreational Statistics Survey of 1979 reports a total catch of 3.2 million pounds, of which 1.4 million pounds were released.

Grouper landings in the head boat survey were 294,300 pounds in 1978 and 585,600 pounds in 1979 (Appendix A, Tables A-12 and A-13).

8.4.8.3 Porgies (Sparidae)

Porgy landings, including sheepshead, were 2.4 million pounds (NMFS, 1980). The head boat survey recorded 591,600 pounds landed in 1978 and 417,800 pounds in 1979 (Appendix A, Tables A-12 and A-13).

8.4.8.4 Grunts (Pomadasyidae)

Total grunt landings were 1.6 million pounds (NMFS, 1980). Landings from the head boat survey were 212,200 pounds in 1978 and 217,800 pounds in 1979 (Appendix A, Tables A-12 and A-13).

8.4.8.5 Tilefishes (Malacanthidae)

Tilefish recreational landings were not reported in the Recreational Fishery Statistics Survey. Head boat landings were 9,000 pounds in 1978 and 2,900 pounds in 1979 (Appendix A, Tables A-12 and A-13).

8.4.8.6 Triggerfishes (Balistidae)

NMFS reported 364,000 triggerfish as being caught by recreational fishermen in 1979. Head boat landings for the Carolinas, Georgia and Northern Florida were 101,300 pounds in 1976 and 100,000 pounds in 1977. The 1978 catch included the Florida Keys and the total catch was 110,500 pounds. In 1979 this increased to 126,100 pounds including the Tortugas area.

8.4.8.7 Wrasses (Labridae)

No hogfish were reported in the recreational catch although it is a popular species for spearfishermen in South Florida.

8.4.8.8 Jacks (Carangidae)

Total jack landings were 2.2 million pounds in 1979 (NMFS, 1980).

8.4.9 Foreign Fishing Activities

There is no record of any foreign exploitation of the snapper-grouper resource within the management area. While Cuban vessels have fished in the vicinity of the Florida Keys prior to implementation of MFCMA, their effort was not on the Atlantic side (Tashiro and Coleman, 1977).

8.4.10 Interactions Between Domestic and Foreign Participants in the Fishery

There is no record of any interaction between domestic and foreign participants in the fishery.

8.5 Description of the Economic Characteristics of the Fishery

8.5.1 Domestic Harvesting and Processing Sector

8.5.1.1 Commercial Sector

The ex-vessel value of commercial landings of snappers, groupers and associated species has generally increased since 1968, from $1.3 million to $9.6 million in 1981 (Table 8-38). The total regional economic impact of the commercial snapper-grouper fishery is estimated to have been approximately $28.5 million in 1981 using a multiplier of 2.96 derived from Rorholm et al. (1967).

Red and yellowtail snappers, black sea bass, and groupers (unclassified) have accounted for the major share of value over this period (Appendix A, Table A-2). Deflated values (based on 1967 dollars) shown in Figure 8-14 indicate what has happened to "real" values. Upward trends in values are less significant than current dollar measures, and fluctuations are more pronounced. These fluctuations reflect both quantity (and probably) price fluctuations from shifts in demand.

In the early 1970's, black sea bass was one of the most valuable (in terms of total revenue) of the snapper-grouper species landed in the region. Since 1975, the share of total value attributable to black sea bass has steadily declined from 20 percent in 1974 to 7 percent in

Table 8-38 Value in current dollars of snapper-grouper commercial landings by state and region, 1968-1981. (Source: NMFS, Fisheries of the U.S.; NMFS, Fishery Statistics of the U.S.)

Year	State				Region Total
	N.C.	S.C.	Ga.	Fla.	
1968	131,492	57,550	12,959	1,091,699	1,293,700
1969	141,937	184,754	14,615	1,114,309	1,455,615
1970	173,722	204,544	23,203	1,279,122	1,680,591
1971	149,821	154,532	65,022	1,394,800	1,764,175
1972	185,559	228,482	81,251	1,630,327	2,125,619
1973	205,622	141,595	40,431	1,733,805	2,121,453
1974	553,445	94,000	78,000	2,139,035	2,864,480
1975	390,141	66,185	41,363	2,094,519	2,592,208
1976	225,365	298,238	126,817	2,361,884	3,012,304
1977	219,402	544,108	288,744	2,890,446	3,942,700
1978	1,102,822	813,989	377,800	3,398,185	5,692,796
1979	2,032,579	974,576	163,816	2,263,087	5,434,058
1980	2,175,818	1,315,659	189,712	3,354,628	7,035,617
1981	2,770,659	2,129,213	210,768	4,516,128	9,626,768

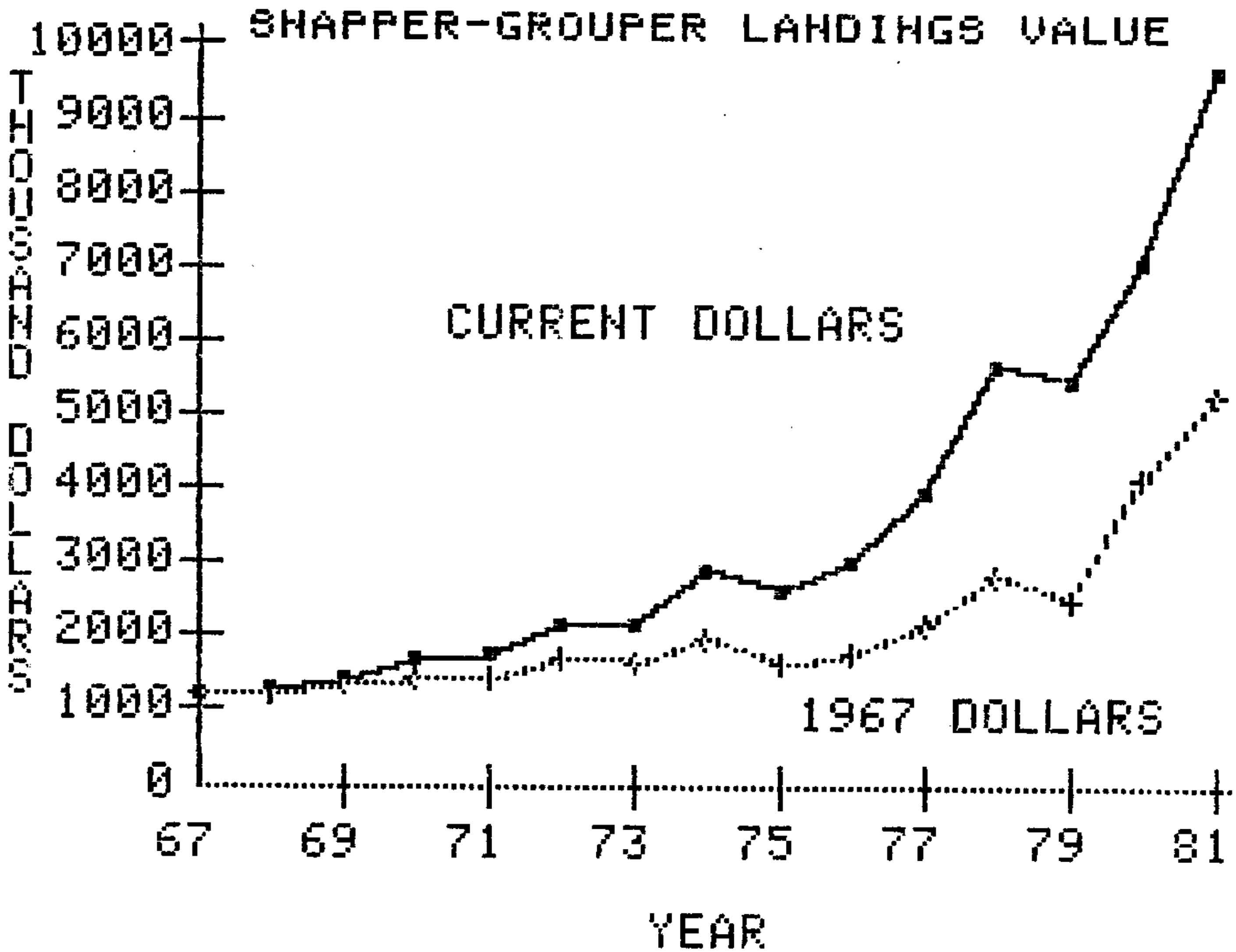

Figure 8-14. Deflated values (based on 1967 dollars) of commercial snapper-grouper landings in the South Atlantic Region, 1967-1981. (Source: NMFS, Fishery Statistics of the U.S., various years; U.S. Department of Commerce, consumer price index.)

1976, as a result of decreased landings. The share of total value was 9.5 percent in 1981. In contrast, the share of total value attributable to groupers has steadily increased from 13 percent in 1970 to 30 percent in 1979. The ex-vessel value of red snapper has increased since 1970; however, the share of total revenue attributable to this species has remained relatively stable through 1979.

Ex-vessel prices by state for selected species of the management unit for the years 1968-1981 are given in Table 8-39. These prices are derived from annual statistics of the National Marine Fisheries Service by dividing "value of landings" (dollars) by "quantity landed" (pounds). It should be noted that dockside prices actually paid to individual captains or boat owners may vary substantially from those derived from the annual statistics. The actual price paid depends on the type of agreement between captains or boat owners and buyers (fish house owners). For example, in Florida buyers frequently pay higher prices to independent boats than to company boats with the latter frequently reflecting "accounting prices" which result from internal record keeping procedures. The average prices reported here represent a weighted average of the two kinds of prices. Thus, the accuracy of the average prices computed from the annual statistics would depend, among other things, on the mix of independent and company owned boats.

Dockside prices for major species of the fishery landed in the South Atlantic Region are heavily influenced by landings of similar species from other areas, notably the Gulf of Mexico (groupers, red snappers) and the mid-Atlantic states (porgies, sea bass).

Cato and Prochaska (1976) demonstrated, using price response equations, that the quantity of red snapper landed in Florida was a significant factor influencing Florida prices. Similar equations for other Gulf states did not indicate a significant relationship between quantity landed and dockside prices. Rather, further analysis showed that prices paid for red snapper in Florida were a significant factor influencing prices in other Gulf states. Cato and Prochaska (1976) also reported that Florida dockside prices are much higher than dockside prices in other Gulf states.

U.S. commercial landings of red snapper in 1973 were about 9 million pounds, approximately 4 million pounds of which were landed in Florida (primarily on the west coast). The other Gulf states landed slightly over 3

Table 8-39. Average ex-vessel prices of selected species by state, 1968-1981.

Year	N.C.	S.C.	Ga.	Fla.
		Red Snapper		
1968	.37	.41	.41	.43
1969	a	.70	.66	.58
1970	.15	.70	.72	.67
1971	—	.71	.73	.70
1972	—	.82	.78	.83
1973	a	.99	.90	.93
1974	—	1.00	1.00	.89
1975	1.08	1.04	1.00	.98
1976	—	1.48	1.35	1.24
1977	—	1:77	1.75	1.65
1978	1.56	1.89	1.91	1.84
1979	1.84	2.13	2.11	2.00
1980	—	2.21	1.92	2.09
1981	—	2.32	2.21	2.20
		Vermilion Snapper		
1968	—	—	—	.39
1969	—	.45	—	.44
1970	—	—	—	.50
1971	—	.32	—	.38
1972	—	.44	—	.63
1973	—	.51	a	.81
1974	—	.33	—	.75
1975	—	.69	—	.62
1976	—	1.02	—	.91
1977	—	.93	1.18	1.09
1978	1.24	1.24	1.52	1.28
1979	1.46	1.45	1.26	1.35
1980	—	1.21	1.07	1.20
1981	—	1.17	1.17	-

Table 8-39. (continued)

Year	N.C.	S.C.	Ga.	Fla.
		Groupers, unclassified		
1968	.17	.16	.16	.18
1969	a	.22	.19	.21
1970	—	.11	.16	.21
1971	.18	.17	.18	.22
1972	—	.24	.20	.30
1973	.48	.35	.35	.35
1974	.40	.52	.41	.42
1975	.40	.57	.47	—
1976	.56	.52	.51	.51
1977	.54	.58	.58	.63
1978	.54	.65	.67	.78
1979	.68	.75	.86	.60
1980	.49	.83	.69	.95
1981	.93	1.04	1.02	1.13
		Grunts		
1968	.07	—	—	.08
1969	.10	.13	—	.09
1970	.09	.08	—	.10
1971	.06	.10	—	.11
1972	.08	.21	—	.11
1973	.14	.24	—	.22
1974	.50	—	—	.14
1975	.14	—	—	.14
1976	.13	.25	.24	.16
1977	.25	.30	—	.18
1978	.19	.12	.24	.13
1979	.18	.14	.20	.10
1980	.50	.27	a	.25
1981	.22	.30	.23	.31

Table 8-39. (continued)

Year	N.C.	S.C.	Ga.	Fla.
		Porgy		
1968	.10	.05	.19	.13
1969	.14	.10	.25	.16
1970	.13	.10	.19	.17
1971	.17	.10	.23	.20
1972	.24	.21	.27	.26
1973	.27	.22	—	.29
1974	.31	.20	.25	.29
1975	.31	.35	.38	.30
1976	.33	.45	.38	.38
1977	.36	.43	.55	.45
1978	.36	.52	.53	.46
1979	.40	.63	.64	.59
1980	.69	.60	.60	.71
1981	.67	.67	.51	.72
		Black Sea Bass		
1968	.17	.16	.19	.17
1969	.18	.23	.29	.21
1970	.19	.21	.23	.26
1971	.22	.26	.37	.29
1972	.32	.36	.46	.31
1973	.33	.30	.35	.38
1974	.40	.35	.49	.32
1975	.39	.31	.37	.31
1976	.51	.30	.42	.33
1977	.43	.34	.49	.38
1978	.61	.54	.58	.57
1979	.55	.49	.64	.63
1980	.60	.77	.54	.62
1981	.69	.74	.70	.67

[a]Less than 500 pounds
—No landings reported

million pounds. Cato and Prochaska (1976) concluded that because Florida lands a large portion of the total commercial catch and pays a higher price, the less dominant states in the industry (in terms of landings) may pay prices based on Florida prices.

The impact of Florida landings on prices within the management area has not been examined. However, given landings of red snapper in the entire South Atlantic region (including the east coast of Florida) of generally less than 1 million pounds, it is likely that the South Atlantic region may be close to the "small fishery" situation relative to the effect of landings on prices. Prices received in the South Atlantic area (given consumer demand) are likely to be heavily influenced by Florida west coast landings and dockside prices. It should be noted that this impact occurs only when Florida west coast and Gulf landings represent a major share of the total commercial catch of a species landed in both regions, which is not the case for all species in the management unit. The dockside prices received for these other species are affected by the quantities landed, the supply of other consumable fish and meat products, consumer desires, and income, etc. How these variables interact to determine prices in the region has not been examined.

Marketing margin is the difference between the price the producer receives (dockside ex-vessel price) and the price received at wholesale or retail market levels. Average margins occasionally are used to describe gross income contributions (with volumes) to an economy, or in some sense to act as a barometer of marketing performance. Beyond some descriptive data, they are of limited usefulness without considerable knowledge of the product and marketing input prices, etc. A preliminary analysis of gross margins for red snapper landed in Florida has been done by Cato and Prochaska (1976). While absolute numbers are somewhat dated now, it appeared from their data that local fish dealers and wholesalers (as opposed to fishermen) absorbed most of the price variation and associated risks and costs of unstable prices.

The weight and price breakdown of fish shipped to the Fulton Fish Market in Septemebr 1981 from a Georgia Marine Extension Service Research Cruise is shown in Table 8-40. The highest price per pound was $2.40 for red snapper and large black sea bass. Gag and scamp were second at $1.00 followed by a group (small vermilion snapper, red porgy, medium sea bass and whitebone porgy) at $0.45-$0.70 and gray triggerfish at $0.25.

Table 8-40. Weight and price breakdown of fish shipped to Fulton Fish Market from Georgia Bulldog Cruise No. 9, 8-15, September 1981.

Weight (lb)	Market Name	Species Name	Price Per Pound
739	Grouper	Gag grouper *Mycteroperca microlepis*	1.00
258	Scamp grouper	Scamp Grouper *Mycteroperca phenax*	1.00
327	Red snapper	Red snapper *Lutjanus campechanus*	2.40
332	Small B-liner	Vermilion snapper *Rhomboplites aurorubens*	.70
430	Large Pink snapper	Red porgy *Pagrus pagrus*	.50
760	Medium Pink snapper	Red porgy *Pagrus pagrus*	.50
100	Large C-Bass	Black Sea Bass *Centropristes striata*	2.40
95	Medium C-Bass	Black Sea Bass *Centropristes striata*	.75
2,000	Silver snapper	Whitebone porgy *Calamus leucosteus*	.45
100	Trigger	Gray Triggerfish *Balistes capriscus*	.25

Black sea bass exhibit a marked price differential by size (Table 8-41). The 1981 average ex-vessel price per pound in South Carolina was $1.31 for large, $0.65 for medium and $0.33 for small.

Vermilion snapper also differ in price by size category (Table 8-42). The ex-vessel price varied from $1.40 per pound for 3/4 - 1 pound fish to $1.80 per pound for 2 plus pounds.

Costs and returns of commercial snapper-grouper vessels operating in the South Atlantic area are, for the most part, unknown. Statistical and budgetary analyses of the costs and returns of commercial red snapper and grouper vessels operating in the Gulf of Mexico (Cato and Prochaska, 1977) indicate that vessel size and area fished (a proxy for measuring resource productivity) are important determinants of profitability. However, costs and returns of Gulf vessels are not directly applicable to South Atlantic vessels because of the probability that differences in areas fished and the species composition of the catch will yield considerably different cost and return data.

The only available data on the costs and returns of commercial fishing for snapper-grouper within the management area are from a 1976 experimental trawling program conducted by the South Carolina Marine Advisory Program (Table 8-43). The break-even price after paying all variable and fixed costs and a share for the captain was found to be $0.69 per pound. The net profit represented a 22 percent increase in profit earned by similar vessels fishing only for shrimp in 1975 (Ulrich et al., 1977). While the partial budget demonstrates some potential for successful trawling, caution is urged in interpreting the results as only one vessel was involved and the captain's trawling skills were considered far above average (Ulrich et al., 1977).

8.5.1.2 Recreational Sector

The direct economic impact in 1975 of recreational fishing for snappers, groupers, and other species in the management unit is estimated to have been $135 million, approximately 30 percent of the total economic impacts of $457.8 million estimated to be associated with marine recreational fishing in the South Atlantic Region. The estimate is derived from a report prepared for the National Marine Fisheries Service (Centaur Management Consultants, 1977). A portion of these regional impacts were allocated to the species in the management unit based on the number of fishermen who fished for species in the management unit as a percent of the numbers of fishermen who fished for all species in the

Table 8-41. Ex-vessel average prices in South Carolina and North Carolina for black sea bass by size. (Source: B. Low, S.C. Wildlife and Marine Resources Research Institute; pers. comm.; North Carolina Dept. Natural Resources & Community Development landings data.)

	South Carolina			North Carolina		
Grade*	1979	1980	1981	1979	1980	1981
Small	$0.24	$0.35	$0.33	$0.30	$0.49	$0.36
Medium	0.47	0.72	0.65	0.52	0.49	0.61
Large	0.72	1.18	1.31	0.83	0.57	1.07
Ungraded	0.47	0.70	0.49	0.62	0.63	0.76

*Grade:

	g	lb
Small	113-339	0.5 - 0.75
Medium	340-567	0.75 - 1.25
Large	567	1.25
Ungraded		

Table 8-42. Ex-vessel prices of vermilion snapper by size in South Carolina. (D. Theiling, S.C. Wildlife and Marine Resources Research Institute, Charleston, S.C.; pers. comm.)

MONTH	GEAR	POUNDS	SIZE	PRICE/LB
1981				
May	H/L	55	1-4	1.80
May	H/L	71	3/4-1	1.50
Jul	Trl	5	L	1.80
Jul	Trl	3	S	1.65
Jul	H/L	30	2-4	1.80
Jul	H/L	103	1-2	1.65
Jul	H/L	108	3/4-1	1.40
Jul	H/L	83	1-2	1.65
Jul	H/L	50	2-4	1.80
Jul	H/L	52	L	1.80
Jul	H/L	15	S	1.40
Jul	H/L	83	3/4	1.40
Jul	H/L	100	1-2	1.65
Jul	H/L	5	2-4	1.80
Jul	H/L	15	1-2	1.65
Jul	H/L	9	2-4	1.80
Jul	H/L	41	1-2	1.65
Jul	H/L	100	2+	1.80
Jul	H/L	185	1-2	1.65
Jul	H/L	73	3/4-1	1.45
Jul	H/L	68	2+	1.80
Jul	H/L	107	1-2	1.70
Jul	H/L	81	3/4-1	1.40
Jul	H/L	196	2+	1.80
Jul	H/L	364	1-2	1.65
Jul	H/L	258	3/4-1	1.40
Jul	H/L	32	2+	1.80
Jul	H/L	255	1-2	1.65
Jul	H/L	165	3/4-1	1.40
Jul	H/L	493	2+	1.80
Jul	H/L	160	1-2	1.65
Jul	H/L	120	3/4-1	1.40

Table 8-42. Continued

MONTH	GEAR	POUNDS	SIZE	PRICE/LB
May	H/L	39	2-4	1.80
May	H/L	42	1-2	1.80
June	Trl	20	L	1.80
June	Trl	81	S	1.75
June	H/L	29	L	1.80
June	H/L	53	S	1.65
Jul	H/L	83	2+	1.80
Jul	H/L	207	1-2	1.65
Jul	H/L	122	3/4-1	1.40
Jul	H/L	12	2+	1.80
Jul	H/L	18	1-2	1.65
Jul	H/L	48	2+	1.80
Jul	H/L	23	1-2	1.65
Jul	H/L	43	3/4-1	1.40
Jul	H/L	3	2+	1.80
Jul	H/L	13	3/4-1	1.40
Jul	H/L	703	2+	1.80
Jul	H/L	139	1-2	1.65
Jul	H/L	64	3/4-1	1.40
Mar	H/L	19	L	2.05
Mar	H/L	89	S	2.05
Mar	—	26	L	2.10
Mar	—	84	S	1.90
Mar	H/L	10	L	1.95
Mar	H/L	30	S	1.85
Mar	H/L	61	L	2.05
Mar	H/L	75	S	2.05
Mar	H/L	36	L	2.00
Mar	H/L	88	S	1.85
Mar	H/L	10	L	2.15
Mar	H/L	29	S	1.90
Apr	H/L	10	L	2.10
Apr	H/L	113	S	2.10
Apr	H/L	45	L	2.10
Apr	H/L	40	S	1.85

Table 8-43. Gross and net profit from a fish trawl demonstration conducted in South Carolina, 1976. (Source: Ulrich et al., 1977.)

Gross revenue from 30,711 lb	$26,986 [a]
Costs	
Variable costs	
Ice	$ 243
Vessel modification	310
Social Security tax	631
Maintenance and repairs	1,571
Fuel	1,788
Shares to crew	10,794
Total Variable Costs	$15,337
Fixed cost	
Net, doors, floats, sweep [b]	$ 3,890
Total Costs	$19,227
Net profit	$ 7,759

a Does not include pounds and revenues produced on all fishing trips.

b This represents the only fixed cost that would be different from current use of the vessel. The gear is "written off" in one year because of the high probability of the entire rig being lost.

region (method suggested by Centaur). Estimates of the number of anglers fishing in the region, by species caught, are derived from the 1970 Salt Water Angling Survey (Deuel, 1973).

The Salt Water Angling Survey estimated that of the 6.4 million anglers who fished for saltwater species along the South Atlantic coast (from Cape Hatteras through the Florida Keys) in 1970, 1.9 million were snapper-grouper fishermen. This estimate includes anglers who fished from privately owned vessels, as well as from charter boats and head boats. The ratio of snapper-grouper anglers to total anglers in the region in 1970 was 0.295. Consequently, of the direct economic impact of marine recreational fishing in the South Atlantic Region in 1975, 29.5 percent is estimated to have been attributable to the snapper-grouper fishery.

Definitions of the four economic variables used to estimate total economic impact follow:

Annual sales are the value of shipments (excluding excise taxes) for manufacturers, the value of purchases (including excise taxes) by retailers at the wholesale level, and consumer expenditure (including excise taxes) for goods and services at the retail (or business services) level.

Annual wages and salaries is an estimate of the personal income associated with annual employment and includes employee compensation prior to deductions for social security, withholding taxes, group insurance, union dues, and savings bonds.

Annual value added, for manufacturing, is the value of shipments (excluding excise taxes) in a particular year less the cost of materials, supplies, fuel, electric energy, cost of resales, and miscellaneous receipts. For wholesale and retail trade, value added is the gross margin (including excise taxes) less the cost of containers, fuel, electric energy, water purchased from other firms and the cost of contract work on materials of the wholesaler in a particular year. This provides a measure of income (i.e., wages, interest, rent, and profit) generated by an industry; that is, the returns to all factors of production (labor, capital, land).

Annual capital expenditures are an estimate of the purchases of plant and equipment chargeable to fixed asset accounts.

Estimates of the economic input of saltwater recreational fisheries in Florida for 1980-81 are given in Bell et al., (1982). They estimated that in one year, Florida resident saltwater recreational fishermen spent over $1.1

billion on variable expenditures, which amounted to $26.29 per angler day. The variable expenditures included boat fuel and oil, 27 percent; food and drink, 18 percent; automobile, 17.4 percent; and maintenance for boats and motors, 15 percent. The employment impact of the estimated sales, at the retail level, was 20,368 jobs directly attributable to Florida resident saltwater fishermen; these jobs generated approximately $173 million in wages. Bell et al., (1982) considered the estimates as approximations only, but the figures provide an idea of the economic importance of recreational fishermen. Almost 30 percent of anglers surveyed listed snapper as one of the top three species caught and about 24 percent listed grouper in the top three.

Florida saltwater fishing tourists spent over $763 million, which was $46.41 per day for variable expenditures (Bell et al., 1982). Food and drink amounted to 23 percent; lodging, 22 percent; charter and party boats, 14 percent; and boat fuel, 10 percent. At the retail level, 23,740 employees are supported by tourist variable expenditures on saltwater recreational fisheries in Florida. The total impact of saltwater fishing tourist expenditures on Florida, using a multiplier of 5.18, is $3.95 billion (Bell et al., 1982).

Estimates of the localized economic impact of expenditures incurred by fishermen who participate in the snapper-grouper fishery are available from a 1977 South Carolina survey (Liao and Cupka, 1979a). Based on estimates of 33,550 fishing days over artificial reefs by resident private boat anglers and $66.88 for average trip expenses per day, total trip expenditures for reef fishing are estimated at $2.24 million during 1977. Fuel and oil were the largest single expenses, accounting for approximately 26 percent of total trip expenses of reef users. Total expenditures by South Carolina private boat anglers for boats and fishing equipment related to reef fishing were $2.28 million. Thus, the total expenditures or direct economic impact of South Carolina resident private boat anglers for artificial reef fishing was $4.52 million in 1977. The total economic impact of South Carolina private boat fishermen, including the multiplier effects of expenditures, was estimated to be $9.09 million.

Average trip supply expenditures incurred by head boat anglers in South Carolina in 1977 was estimated at $33.70. The largest expenditure for head boat anglers surveyed was the fishing fee. The second and third largest items were lodging and food, respectively. Thus, the primary beneficiaries of head boat anglers' expenditures, aside from the head boat industry, were motels, restaurants, etc., in coastal communities.

The total direct economic impact on coastal communities of South Carolina head boat fishing in 1977 was $3.5 million, approximately 7 percent of which is attributable to artificial reef fishing. The total economic impact (including multiplier effects) on the economy of the State of South Carolina as a result of expenses incurred by head boat anglers was $8.2 million.

The average costs and returns of head boat fishing enterprises in South Carolina in 1976 are shown in Table 8-44 (Liao, unpubl. ms.). These data are based on a survey of 14 of the 16 head boat captains in the South Carolina fleet. Gross return represents only the amount received from the sale of fishing tickets during the year. Additional income results from the sale of fish from head boat operations and from vendor operations such as the sale of beverages on the boat. Variable costs or operating costs are those that vary with the actual amount of fishing effort. These costs constituted at least 60 percent of the total costs of the head boat captains surveyed. Fixed costs or overhead are not related to fishing effort and, in most cases, will be incurred whether the vessel fishes or not.

The average net return to South Carolina head boats in 1976 was approximately $41,500. It should be noted that the return to management and labor will be considerably less than net return which does not take into account taxes on income earned or the opportunity costs of investing in the operation. Opportunity costs are an estimate of the return that could have accrued to the owner had he invested his capital in an alternate use.

The average net return to south Florida head boats in 1981 was approximately $29,818 as shown in Table 8-45 (Taylor et al., 1982). They reported that the average fare per passenger for headboats surveyed in south Florida for a half-day trip was $11; for a full day trip, $18; and for a night trip, $13.20. Average number of passengers on half-day trips was 768 passengers, 4,842 on full-day trips, and 3,863 passengers on night trips. Fuel was the largest cost, averaging $23,690 annually. Twice each year the boats were hauled out, with an average annual cost of $6,166. A major repair cost was for engine repair, averaging $2,788. Total costs were $116,770 annually; gross revenues were $146,588.

Table 8-44. Costs and earnings for South Carolina head boats in 1976 (Source: Liao, unpubl. paper.)

Item	Average per head boat
Annual effort per vessel	143 trips
Gross returns	$98,828
Costs:	
Variable costs:	
Fuel	$ 9,775
Oil & grease	845
Ice	562
Hired labor costs	9,004
Bait	2,321
Tackle	1,888
Boat repairs & maintenance	11,192
Total of variable costs:	$35,587
Fixed costs:	
Depreciation	7,747
Boat insurance	4,779
Advertising	2,765
Dockage & launching fees	5,346
Others	1,112
Total of fixed costs	$21,749
Total costs:	$57,336
Net returns (before taxes, interest, & proprietor's wages)	$41,492

Table 8-45. Average annual costs and net returns for the surveyed party boats from the south Florida Atlantic Coast, 1980-81. (Source: Taylor et al., 1982.)

Item	Average	Range Low	Range High
	dollars		
REVENUE			
Half-day trips	$ 8,448	$ 0	$ 25,344
Full-day trips	87,152	13,824	176,640
Night trips	50,988	32,400	72,900
Total	$146,588		
COSTS:			
Variable costs:			
Haul-outs (2)	6,166	1,000	10,000
Fuel	23,690	4,518	39,192
Oil	1,427	484	3,115
Bait	10,215	3,602	21,770
Ice	3,208	0	8,520
Terminal tackle	3,196	1,742	4,649
Telephone	1,764	480	3,360
Referrals-Booking fees	13,500	0	27,000
Repairs:			
Hull	450	0	900
Engine	2,100	1,200	3,000
Electronics	100	0	200
Equipment	138	100	175
Captain salary	14,333	0	26,880
Crew salary	10,624	6,240	15,552
Total variable costs	$ 90,911		
Fixed Costs:			
Depreciation[a]			
Hull and engine	12,607		
Electronics	752		
Equipment	430		
Boat registration	52	52	52
Insurance	3,850	3,500	4,100
Advertising	5,000	0	12,200
Dockage fee	3,618	0	7,500
Total fixed costs	$ 25,859		
Total costs	$116,770		
Net returns before taxes	$ 29,818		

[a]Average hull purchase price (including engine) was $88,250. Average electronics purchase price was $3,760. Average equipment purchase price was $2,150.

As noted in Section 8.4.2.2, most of the effort of the charter fleet in the region is directed toward pelagic species. While charter fishing for snapper-grouper does occur, it is primarily a seasonal activity which depends on the availability and abundance of the more highly desirable pelagic species.

Estimated yearly costs and earnings for charter boat operations off four states within the management area are presented in Table 8-46. It should be noted that these budgets represent what is expected for the "average" vessel in the fleet. Considerable variation in costs and earnings occurs within charter fleets.

As indicated in Table 8-46, the profitability of charter operations within the management area varies considerably. Profitability is determined by a number of factors: the length of the fishing season, the seasonal availability of customers, the seasonal availability of fish, weather conditions, the revenue derived from sources other than charter fees (fish sales and mounting deposits), the number of trips taken each year and the distance from port to the fishing grounds.

8.5.2 International Trade

Published U.S. statistics do not record snapper and grouper as export items. Consequently, it is unlikely that there is a significant export market for snappers and groupers landed in the southeast region.

Imports of snappers and groupers through the southeast (including the Gulf of Mexico) ports are presented in Table 8-47. Miami is the major port of importation for processed snapper-grouper products within the management area. Other ports involved are Brownsville, Texas; Tampa, Florida; and Savannah, Georgia.

Snapper imports are recorded at customs offices as snapper, snapper fillets, red snapper, red snapper fillets, red snapper steaks, throats and flanks and dressed. Red snapper has been the most common form of import, with snapper fillets and red snapper fillets the next most common. In 1972, snapper imports were almost 2.0 million pounds. The amount increased until there were 3.9 million pounds imported in 1976 and 1978. Imports of red snappers have decreased since 1978, but remained at 3.4 million pounds in 1981.

Imports of groupers in 1972 were 3.1 million pounds. By 1976, 4.0 million pounds were recorded. Since then, imports of grouper have fallen, to reach a low in 1981 of 325,600 lb. Grouper fillets are the most common form of import, although diverse other products forms are also recorded.

Table 8-46. Estimated yearly costs and returns for representative charter vessels in the states within the management area (estimates adjusted to January 1979 dollar values for the first four columns).

	N.C.[a]	S.C.[b]	Ga.[c]	Fla.Keys[d]	North Fla.[e]	South Fla.[e]
Annual Effort per vessel	86 trips	73 trips	81 trips	158 trips	134 trips	230 trips
Gross Revenue	$20,453	$21,887	$31,258	$38,248	$40,090	$51,419
Costs:						
Variable						
Repair & Maintenance	$ 4,875	$ 3,876	$ 4,610	$ 5,154	$ 4,396	$ 6,224
Fuel & Oil	3,634	3,254	4,973	4,073	11,932	7,776
Wages to hired labor	3,129	2,910	2,385	4,482	7,628	7,582
Bait and tackle	1,137	789	878	2,464	2,625	3,803
Ice	276	117	349	197	752	347
Miscellaneous	73			1,191	2,050	1,850
Total Variable Costs	$ 13,124	$10,946	$13,195	$ 17,561	$29,383	$27,582
Fixed						
Depreciation	2,032	2,017	1,705	3,250	9,901[f]	9,459[f]
Insurance	516	1,081	976	1,076	1,290	1,696
Advertising	166	288	73	320	563	735
Dockage	565	727	998	2,209	2,024	4,003
Taxes			440			
Miscellaneous	104	171	598	644	117	0
Total Fixed Costs	$ 3,384	$ 4,284	$ 4,790	$ 7,499	$13,927	$15,942
TOTAL COSTS	$ 16,508	$15,230	$17,985	$ 25,060	$43,310	$43,524
Net Revenue per vessel (before income taxes, interest and proprietor's wages)	$ 3,945	$ 6,657	$13,273	$ 13,188	($ 3,220)	$ 7,895

a Data taken from Abbas (1978) for an average charter vessel in 1977.
b Data taken from Liao (unpubl.) for an average charter vessel in 1976.
c Data taken from Brown & Holemo (1975) for an average charter vessel in 1972.
d Data taken from Browder et al. (1978) for an average charter vessel in 1977.
e Data taken from Taylor et al. (1982) for an average charter vessel in 1980-81.
f Purchase prices used for depreciation purposes were: North, $64,380, (hull, 81%; electronics, 10%; equipment, 9%), South, $63,757, (hull, 90%; electronics, 2%; equipment, 8%).

Table 8-47. Imports of snappers and groupers, 1972-1981 (in thousands of pounds). (Source: E. J. Barry, NMFS, Market News, New Orleans, La.; pers. comm.)

Year	Grouper	Snapper	Total
1972	3,141.2	1,978.5	5,119.7
1973	2,626.8	2,793.1	5,419.9
1974	1,659.4	3,090.0	4,749.4
1975	2,369.4	3,877.3	6,246.7
1976	4,001.1	3,917.1	7,918.2
1977	3,430.8	3,721.5	7,152.3
1978	3,048.1	3,916.3	6,964.4
1979	1,768.2	2,618.3	4,386.5
1980*	517.5	1,853.9	2,371.4
1981	325.6	3,420.5	3,746.1

*No report received for periods: Week ending October 7, October 14, October 21, and October 28.

Cato and Prochaska (1976) reported that imports of snappers and groupers are important in determining United States ex-vessel price through their effect on the available market supply.

8.6 Description of the Businesses, Markets and Organizations Associated With the Fishery

8.6.1 Relationship Among Harvesting, Brokering, and Processing Sectors

Snappers, groupers, and other species of the complex enter commercial channels from both the recreational and commercial sectors of the fishery. The amount of the recreational catch entering commercial channels is unknown.

Fish caught by the commercial sector are generally eviscerated, washed and iced on board and sold to local fish houses at the port of landing. These primary wholesalers in turn sell to fresh fish markets, restaurants, freezer companies and secondary wholesalers. The products at the primary wholesale level are generally fresh whole gutted fish which are boxed packed in ice. Fish houses also sometimes head and fillet the larger fish for special customers and restaurants.

8.6.2 Fishery Cooperatives or Associations

Major associations involved in the snapper-grouper fishery and their constituencies are shown in Table 8-48. In addition to the associations listed, there are numerous local recreational fishing, diving, and boating clubs throughout the region which have members who utilize the snapper-grouper resource.

In 1981, there were 3 cooperatives with 122 members and 120 craft in Florida, 1 in Georgia with 22 members and 33 craft, and 2 in South Carolina with 41 members and 23 craft (NMFS, 1982). Major functions of the cooperatives included marketing and purchasing. These cooperatives meet at least one of the following two requirements: (1) each member of the Association has one vote irrespective of the amount of stock or membership capital he may own therein; or (2) the Association's dividends on stock or membership capital does not exceed 8 percent per year and the Association shall not deal in the products of non-members in an amount greater in value than is handled for members (NMFS, 1982).

The formation and operation of fishery cooperatives is discussed by Napoli (1973) in a report on the Workshop on Fishery Cooperatives held in Galilee, Rhode Island, in 1972. Cooperatives generally perform a number of functions for their members, including marketing, supply, production,

Table 8-48. Associations and cooperatives representing commercial and recreational fishermen in the region

Organization		Constituency
1.	North Carolina Fisheries Association, Inc.	Commercial
2.	South Carolina Shrimpers Association	Commercial
3.	Organized Fishermen of Florida	Commercial
4.	Southeastern Fisheries Association, Inc.	Commercial, Charter and Head Boat Operators
5.	Gulf and South Atlantic Fisheries Development Foundation, Inc.	Commercial
6.	Sport Fishing Institute	Recreational, Charter and Head Boat Operators
7.	North Carolina Saltwater Sport Fishing Association	Recreational, Charter and Head Boat Operators
8.	International Gamefish Association	Recreational, Charter and Head Boat Operators
9.	National Coalition for Marine Conservation	Recreational, Charter and Head Boat Operators
10.	Southern Offshore Fishing Association	Commercial
11.	Bryan County (Ga.) Fishermens Cooperative	Commercial
12.	McIntosh County (Ga.) Fishermens Cooperation	Commercial
13.	Hilton Head (S.C.) Fishermens Cooperative	Commercial
14.	Niceville, Florida Fishermen's Cooperative	Commercial
15.	Miami International Fisheries Cooperative Association	Commercial
16.	Lee County Fishermen's Cooperative	Commercial

and bargaining. Profits earned by the cooperatives are distributed to members on the basis of gross landings of each member in proportion to total landings (Napoli, 1973).

8.6.3 Labor Organizations

Most employees engaged in the commercial fishing industry are covered by the Fair Labor Standards Act, which provides for minimum wages and maximum hours (University of Mississippi Law Center, 1976). However, employees are exempt from these provisions when they are engaged in certain types of offshore fishing activies, namely, during the catching or taking of aquatic forms of animal life; in the first processing when done while at sea; and during the loading and unloading of the aquatic life so taken and processed. The exemption from the Act also applies to employees whose activities are essential to any of the aforementioned activities.

There are no labor organizations known to be involved in the harvesting or processing sectors of the fishery.

8.6.4 Foreign Investment

There is no known foreign investment in any aspect of the fishery.

8.7 Description of Social and Cultural Framework of Domestic Fishermen and Their Communities

8.7.1 Ethnic Character, Family Structure, Community Organization, Age and Education Profiles of Fishermen

It can be expected that ethnic character, family structure, community organization, age and education profiles of snapper-grouper fishermen will vary according to area and will reflect characteristics of the general fishery population in each particular area.

In the South Florida and Florida Keys area, significant numbers of fishermen of Cuban-American heritage participate in both the harvesting and processing sectors of the fishery.

8.7.1.1 Commercial Fishermen

The average age of commercial fishermen surveyed in Florida in 1974 was 48 years (Prochaska and Cato, 1977). The average Florida commercial fisherman has had approximately 17 years of fishing experience, 16 of which have been in Florida waters. The average level of education of these fishermen corresponds to slightly less than a high-school diploma (11.3 years).

The extent to which the characteristics of commercial snapper-grouper fishermen with home ports in Florida conforms to those of commercial Florida fishermen as a whole is unknown. No other information on the ages and education levels of commercial fishermen within the management area is known to exist. No data are available regarding employment opportunities or unemployment rates within the fishery.

8.7.1.2 Recreational Fishing

Information about socio-economic characteristics of the general marine recreational fishing population is available on a state-by-state basis from the 1975 U.S. Fish and Wildlife Survey (Table 8-49). Data on the socio-economic characteristics of South Carolina private boat anglers who utilize artificial fishing reefs are summarized as follows (Liao and Cupka, 1979b): Private boat anglers surveyed tended to have a high family income, averaging approximately $26,000 per year. The majority of these anglers were in their thirties or forties, were professional, managerial or self-employed people, and had been actively engaged in offshore fishing for over 10 years.

As part of a South Carolina artificial reef survey (Liao, unpubl. ms.), information on the socio-cultural characteristics of head boat operators in the South Carolina fleet was obtained. The average age of the captains surveyed (N = 14) in 1976 was 39 years. Approximately 71 percent of the captains owned their own boat, with an average length of time in the business of 13 years. Twenty-one percent of the captains indicated they had another occupation in addition to head boat fishing.

The average age of Florida Keys head boat captains surveyed (N = 6) in 1977 was 33 years (Browder et al., 1978). Approximately 33 percent of the head boats operating in this area are owner-operated. While these captains have lived an average of 6 years in the area of their home port, they have had an average of 10 years experience as head boat captains. One-third of the captains represent at least second generations in the fishing business. A small percentage of the captains (17 percent) have second jobs.

Charter boat captains (N = 66) interviewed in North Carolina in 1977 ranged in age from 21 to 77 (Abbas, 1978). Less than 5 percent of the captains were under 30 years of age which lends credence to the claim of the charter captains interviewed that it has become more difficult in recent years for young men to get started in the business due to the large capital investment required. Approximately 75 percent of the captains

Table 8-49. Socio-economic characteristics of saltwater recreational participants by state of residence, 1975. (Source: U.S. Department of the Interior, 1977.)

	FL	GA	NC	SC
Number of Participants (thousands)	1,740	471	865	311
	PERCENT			
Age				
9-17	18	32	15	15
18-24	11	18	12	23
25-34	28	13	30	30
35-44	13	11	14	14
45-54	8	16	20	12
55-64	13	9	5	4
65 or older	9	1	4	2
Sex				
Male	73	74	72	73
Female	27	26	28	27
Income				
Under $2,000	7	14	11	7
$ 2,000-$4,999	6	4	6	8
$ 5,000-$7,499	5	3	8	3
$ 7,500-$9,999	21	5	16	8
$10,000-$14,999	22	13	21	32
$15,000-$24,999	26	31	26	29
$25,000-$34,999	12	9	9	5
$35,000-$49,000	1	15	1	6
$50,000 or more	*	6	2	2

*Less than one percent.

surveyed owned their own boats, with an average length of time in business from their present ports of 17 years. Hence, mobility appears to be low in this group. Approximately 50 percent of the captains indicated that they held another job during 1977. Some hold full-time jobs and charter during vacations and weekends (several captains taught in public schools, for example). Most of the remaining captains supplemented their charter incomes during the winter months with income derived from other occupations which were compatible with chartering such as commercial fishing or building and repairing boats.

The average age of charter boat captains surveyed in South Carolina in 1976 (N = 20) was 42 years (Liao, unpubl. ms.). Approximately 80 percent of these captains owned their own boat, with an average length of time in the charter business of 10 years, considerably less than in North Carolina. As in North Carolina, a substantial percentage of South Carolina charter captains (45 percent) had another occupation in addition to chartering.

In 1972, Brown and Holemo (1975) conducted a study of the charter boat fleet in Georgia. The educational level of the 17 captains interviewed was high, with only one not having a college or high school diploma. Fifteen of the 17 operators had other means of support in addition to their charter income.

The average age of offshore charter boat captains based in the Florida Keys was 44 in 1977 (Browder et al., 1978). On the average, these captains have been in business for 14 years and, as in North and South Carolina, most of them (73 percent) owned their own boats. Only 13 percent of the captains interviewed had second jobs in addition to chartering, and 40 percent had retirement income. Forty-two percent of the currently operating offshore charter boat captains who reported are second-generation fishermen.

The estimated mean income of head boat anglers in South Carolina in 1976 was about $23,400 annually (Liao and Cupka, 1979b). Approximately 47 percent of the anglers surveyed were professional and blue collar workers. The majority of the head boat fishermen (67 percent) were from out-of-state and had an average of 8 years offshore fishing experience.

The average age of head boat anglers in the Florida Keys in 1977 was 40 years (Browder et al., 1978). Local (within 50 miles of home port) and in-state customers accounted for 60 percent of the head boat business.

Most of the head boat fishing parties are family groups (47 percent) and friends (28 percent). The head boat captains surveyed estimated that fishing is the major purpose of visits to the Florida Keys area for 52 percent of their customers and a large, though not the most important, reason for an additional 37 percent.

Charter boat anglers in South Carolina in 1976 had, on the average, family incomes considerably higher than the head boat and private boat anglers surveyed. About two-thirds of the charter anglers were professional and managerial level people and slightly over 50 percent were South Carolina residents. Almost all of the South Carolina charter fishermen had offshore fishing experience, with an average of 11 years of experience for this group as a whole.

The average age of charter boat customers in the Florida Keys was 43 years in 1977 (Browder et al., 1978). Local and in-state people together accounted for 32 percent of charter business in this area. Origin of the out-of-state customers was approximately evenly divided among the northeast (43 percent) and the northwest (41 percent), with most of the remaining customers (14 percent) coming from the mid-west.

In the opinion of the captains interviewed, fishing is the major purpose of visits to Florida for 67 percent of their customers and a large, though not the most important, reason for another 24 percent. Most of the fishing parties are comprised of families (42 percent), business groups or associates (23 percent), and friends (23 percent), while individuals that are grouped into parties accounted for only 9 percent of charter boat customers in 1977.

8.7.2 Economic Dependence on Commercial or Marine Recreational Fishing and Related Activities

Commercial and/or recreational fishing is conducted from a great many coastal communities in the South Atlantic Region; however, there are no data currently available concerning economic dependence on commercial or marine recreational fishing and related activities for the snapper-grouper fishery. Coastal communities in the management area where fishing activities associated with the snapper-grouper fishery are important to the local economy, as listed in Table 8-50.

The extent to which fishermen engaged in the snapper-grouper fishery are dependent on income derived from the fishery is unknown. Although fishing for snapper-grouper is a year-round commercial activity,

Table 8-50. Coastal communities in the management area where fishing is important to the local economy.

Locality	Activity of Economic Importance	
	Commercial	Recreational
North Carolina:		
Southport	X	X
Carolina Beach	X	X
Wrightsville Beach	X	X
Topsail Beach		X
Sneads Ferry	X	X
Swansboro	X	X
Morehead City	X	X
South Carolina:		
Charleston	X	X
Rockville	X	
McClellanville	X	
Murrell's Inlet		X
Little River		X
Georgetown	X	X
Beaufort	X	X
Hilton Head	X	X
Edisto Beach	X	X
Georgia:		
Savannah	X	X
Brunswick	X	X
Darien	X	X
St. Mary's	X	X
Shellman Bluff	X	X
Richmond Hill	X	X
Sunbury	X	X
Valona	X	X
Crescent	X	X
Woodbine	X	

Table 8-50. (continued)

Locality	Activity of Economic Importance	
	Commercial	Recreational
Florida		
Mayport	X	
Stuart		X
Riviera Beach		X
Hillsboro Inlet		X
Fort Lauderdale		X
Miami Beach		X
Miami	X	
Key Biscayne		X
Key Largo		X
Tavernier		X
Islamorada		X
Marathon	X	X
Key West	X	X
St. Augustine	X	
Fernandina Beach	X	
Port Canaveral Area	X	X
Sebastian	X	X
Ft. Pierce	X	X
Port Salerno	X	X
Jupiter	X	X
Big Pine Key	X	X

many of the participants are involved in the fishery on a part-time or seasonal basis as a means of supplementing income derived from other fisheries.

Prochaska and Cato (1977) estimate that 52 percent of Florida commercial fishermen derive part of their income from employment in occupations other than fishing. Thirty percent of these fishermen earned over half of their total income from non-fishing employment. Of these surveys, fishermen over 60 years of age earned the smallest proportion of their total income (21 percent) from employment outside of fishing, while fishermen in the 21 to 30 year old age group earned the greatest proportion (48 percent).

Twenty eight percent of the fishermen reporting non-fishing income were employed in the construction industry; 17 percent were employed in marine related activities, as tug boat captains, marine operators, and boat builders; and 10 percent were employed in agriculture. Other major categories of employment from which fishermen derived outside income included security and mechanics and repair. Only 21 percent of those surveyed said their non-fishing employment was seasonal.

It is estimated that there are 1,374 vessels fishing on species in the snapper-grouper complex (Table 8-51). Crew sizes are estimated to be 3 for hook and line, 4 for trawling, 2 for trap, 2 for charter, and 3 for headboat vessel types. Thus, it can be concluded that there are approximately 4,000 fishermen who derive at least half of their income from snapper-grouper fishing activities (Table 8-51).

Table 8-51. Estimate of the number of vessels and crew that derive a major portion of their income from species of the snapper-grouper complex.

Vessel Type	Number[a]	Crew[b]
Commercial		
Hook & Line	1,110	3,330
Trawl	30	120
Traps (excluding FL)	68	136[d]
Recreational		
Charter	71[c]	142
Head boat	95	285
Totals	1,374	4,013

a. Section 8.4.3.

b. Crew size is 3 for hook & line, 4 for trawling, 2 for traps, 2 for charter, and 3 for head boat vessels.

c. Only about 11 percent (71) of the charter boat fleet effort is directed toward species of the snapper-grouper complex. The total fleet is approximately 641 vessels.

d. Sutherland and Harper (in press) report that during 1979 108 boats employed a total of 280 in the trap fishery south of Cape Canaveral. Current Florida law prohibits the use of fish traps.

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APPENDIX A

COMMERCIAL LANDINGS AND VALUES AND HEAD BOAT LANDINGS

Sources of the commercial landings data were NMFS and the Departments of Natural Resources for North Carolina, South Carolina, Georgia and Florida. The Monroe County Atlantic landings were obtained from E. Snell, NMFS, Southeast Fisheries Center, Miami, Fla. The head boat data were furnished by G. Huntsman, NMFS, Beaufort Lab., Beaufort, N.C.

Table A-1. Commercial landings of species in the snapper-grouper complex in the South Atlantic Region, 1967-1981 (in thousands of pounds).

SPECIES	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Snappers															
Lane	2	13	12	13	13	11	19	17	20	23	30	34	56	20	34
Gray	240	261	271	241	243	370	293	308	215	155	209	208	247	232	231
Mutton	126	162	140	245	282	277	380	311	239	197	252	330	275	221	199
Red	967	1,070	701	643	546	487	388	634	741	582	660	551	425	381	372
Vermilion	15	33	33	20	62	103	89	106	194	152	223	331	373	616	543
Yellowtail	763	915	761	931	804	747	694	752	605	663	492	542	495	527	601
Unclassified	-	-	-	-	7	-	6	21	71	115	100	126	123	152	280
Total Snapper	2,113	2,454	1,918	2,093	1,957	1,995	1,869	2,149	2,085	1,887	1,966	2,122	1,994	2,149	2,260
Groupers															
Jewfish	71	68	54	31	17	23	35	66	56	59	72	39	29	23	19
Warsaw	25	69	37	44	92	47	66	66	44	32	40	25	25	9	20
Unclassified	654	960	719	979	995	866	858	1,120	1,335	1,644	1,737	2,756	2,497	2,145	2,711
Total Groupers	750	1,097	810	1,054	1,104	936	959	1,252	1,435	1,735	1,849	2,820	2,551	2,177	2,750
Others															
Amberjack	22	27	4	39	22	11	37	35	55	67	67	38	38	78	103
Grunts	66	67	68	75	78	74	96	49	36	30	49	59	129	101	149
Hogfish	8	16	10	17	14	15	12	11	14	9	23	24	26	35	37
Porgies[a]	503	264	322	577	407	149	135	150	328	467	479	731	1,076	1,284	1,761
Sea bass[a]	1,502	851	1,370	1,600	1,144	1,269	959	1,469	930	462	375	274	954	1,181	1,277
Sheepshead	157	117	207	219	218	272	295	302	235	247	260	182	230	180	274
Tilefish	11	7	6	11	17	11	46	102	176	169	101	203	190	363	1,180
Triggerfish	4	3	2	2	5	9	10	18	36	21	28	45	46	57	82
Total Others	2,273	1,352	1,989	2,540	1,905	1,810	1,590	2,136	1,810	1,472	1,382	1,556	2,689	3,279	4,863
Total Region	5,136	4,903	4,717	5,687	4,966	4,741	4,418	5,537	5,330	5,094	5,197	6,498	7,234	7,605	9,873

a. South of Cape Hatteras, N.C.

Table A-2. Value of Snapper-Grouper Commercial Landings by Species in the South Atlantic Region, 1968-1981 (in dollars).

SPECIES	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Snappers														
Lane	1,950	3,058	4,160	5,694	5,052	6,287	6,080	7,901	10,543	18,580	23,389	41,005	16,839	30,855
Gray	64,769	86,648	82,219	111,239	158,893	149,496	167,920	93,788	68,292	154,757	179,092	148,685	256,170	274,792
Mutton	58,208	71,184	124,217	176,699	191,026	295,215	236,600	145,191	154,127	259,160	440,022	174,378	306,235	285,202
Red	458,853	407,935	429,205	382,369	408,467	359,646	568,690	738,980	785,418	1,088,956	1,114,360	846,598	629,889	613,038
Vermilion	13,203	14,149	10,029	23,055	49,720	70,696	77,750	143,550	196,383	226,707	335,548	526,276	508,220	475,855
Yellowtail	319,103	335,347	376,288	434,492	510,091	472,279	549,310	264,166	547,315	456,850	549,454	61,573	721,200	879,100
Unclassified				3,591	36	3,043	17,000	57,073	23,888	113,834	164,931	188,956	730,001	948,410
Total Snappers	916,086	918,321	1,026,118	1,137,139	1,323,285	1,356,662	1,623,350	1,450,649	1,785,966	2,318,844	2,806,796	1,987,471	3,168,554	3,507,252
Groupers														
Jewfish	8,160	8,200	4,666	2,205	3,871	8,455	18,600	15,799	19,671	29,610	8,156	10,166	12,789	12,664
Warsaw	7,263	5,496	9,097	16,233	13,533	16,268	23,850	14,292	13,168	17,807	11,473	13,169	6,387	15,362
Unclassified	170,900	152,388	203,257	217,720	252,753	299,276	472,680	537,419	683,559	1,041,167	1,831,491	1,628,642	1,870,702	2,800,154
Total Groupers	186,323	166,084	217,020	236,158	270,157	323,999	515,130	567,510	716,398	1,088,584	1,851,120	1,651,977	1,889,878	2,828,180
Others														
Amberjack	1,615	1,192	2,825	2,088	1,431	3,784	5,482	8,436	7,794	7,911	4,381	6,293	16,569	24,710
Grunts	5,317	5,738	7,667	8,565	8,203	20,869	7,380	5,486	5,073	8,728	6,505	14,932	38,934	36,143
Hogfish	4,569	2,521	4,116	5,050	5,031	4,962	5,500	4,972	4,206	14,320	15,855	2,222	37,255	47,828
Porgy[a]	28,726	46,742	69,657	63,136	36,539	36,776	44,000	101,698	173,990	255,135	703,163	1,095,258	834,675	1,181,764
Sea Bass[a]	139,806	292,762	329,422	283,378	439,125	313,184	579,820	342,220	202,159	156,965	176,875	513,589	749,155	911,864
Sheepshead	10,265	21,218	22,084	26,226	39,223	43,319	44,625	35,538	37,323	44,025	33,904	50,847	40,008	73,321
Tilefish	743	787	1,417	1,999	1,293	16,708	36,040	69,896	74,886	42,563	84,511	98,127	244,713	990,826
Triggerfish	250	250	265	436	1,332	1,190	3,153	5,803	4,509	5,625	9,686	13,342	15,876	24,880
Total Others	191,291	371,210	437,453	390,878	532,177	440,792	726,000	574,049	509,940	535,272	1,034,880	1,794,610	1,977,185	3,291,336
Total Region	1,293,700	1,455,615	1,680,591	1,764,175	2,125,619	2,121,453	2,864,480	2,592,208	3,012,304	3,942,700	5,692,796	5,434,058	7,035,617	9,626,768

a. South of Cape Hatteras, N.C.

Table A-3. Commercial landings of species in the snapper-grouper complex in North Carolina, 1967-1981 (in thousands of pounds).

SPECIES	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Snappers															
Red	4	42		1					31			24	86	77	95
Vermilion												52	129	191	144
Unclassified					7		6	21	33	5	27	98	117	152	273
Total Snappers	4	42		1	7		6	21	54	5	27	174	332	420	512
Total Groupers															
Unclassified	9	25			14		16	70	45	12	29	597	676	664	883
Others															
Amberjack													4	7	15
Grunts	8	2	3	3	1	2	1	2	4	1	1	12	20	57	78
Porgies[a]	462	176	252	212	207	39	28	65	155	216	19	158	394	460	806
Sea bass[a]	1,356	566	569	754	494	546	574	1,205	667	279	280	123	665	900	593
Sheepshead										10	12	17	16	30	10
Tilefish												50	20	25	56
Triggerfish												3	9	30	41
Total Others	1,826	744	824	969	702	587	603	1,272	826	506	312	363	1,128	1,509	1,599
Total Reef Fish	1,839	811	824	970	723	587	625	1,363	925	523	368	1,134	2,136	2,593	2,994

a. South of Cape Hatteras, N.C.

Table A-4. Value of Snapper-Grouper Commercial Landings by Species in North Carolina, 1968-1981 (in dollars).

SPECIES	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Snappers														
Lane														
Gray														
Mutton														
Red	15,593	109	80			198		32,998			37,274	158,889		211,152
Vermilion											64,997	188,436		256,893
Yellowtail														
Unclassified				3,591	36	3,043	17,000	26,073	4,305	33,171	128,090	179,302	727,178	470,819
Total Snappers	15,593	109	80	3,591	36	3,241	17,000	59,071	4,305	33,171	230,361	526,627	727,178	938,864
Groupers														
Jewfish														
Warsaw														
Unclassified	4,267	63		2,520		3,950	28,000	21,842	6,575	15,753	323,223	456,953	537,458	824,392
Total Groupers	4,267	63		2,520		3,950	28,000	21,842	6,575	15,753	323,223	456,953	537,458	824,392
Others														
Amberjack												608	1,531	3,490
Grunts	120	274	292	72	124	110	1,000	608	71	212	2,216	3,694	28,478	16,802
Hogfish												76		
Porgy[a]	17,223	35,648	26,990	34,732	9,364	7,434	20,000	47,952	71,484	48,677	433,808	671,878	319,083	536,862
Sea Bass[a]	94,024	105,625	146,276	108,680	175,812	190,568	486,820	260,130	142,290	120,400	97,692	362,935	542,964	411,373
Sheepshead	265	218	84	226	223	319	625	538	640	1,189	1,642	1,949	3,389	1,386
Tilefish											13,236	5,180	8,907	26,391
Triggerfish											644	2,679	6,830	11,099
Total Others	111,632	141,765	173,642	143,710	185,523	198,431	508,445	309,228	214,485	170,478	549,238	1,048,999	911,182	1,007,403
Total State	131,492	141,937	173,722	149,821	185,559	205,622	553,445	390,141	225,365	219,402	1,102,822	2,032,579	2,175,818	2,770,659

a. South of Cape Hatteras, N.C.

Table A-5. Commercial landings of species in the snapper-grouper complex in South Carolina, 1967-1981 (in thousands of pounds).

SPECIES	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977[a]	1978[a]	1979	1980	1981
Snappers															
Blackfin											3	2	1		(1)[b]
Cubera											1			(1)	(1)
Gray											1	1	2	1	2
Red	3	37	16	12	8	15	17	13			84	105	49	46	54
Silk											60	17	5	(1)	3
Vermilion			1		10	15	6	3			65	82	92	272	285
Unclassified									7	109				(1)	3
Total Snappers	3	37	17	12	18	30	23	16	7	109	214	207	149	319	347
Groupers															
Gag											155	165	259	294	323
Rock Hind											1	1		(1)	(1)
Scamp											88	83	53	79	97
Snowy											69	212	78	29	3
Speckled Hind											37	31	22	7	
Warsaw											7	7	4	2	9
Yellowedge											21	44	16	6	(1)
Unclassified		63	10	14	10	17	83	62	17	181	18	12	18	(1)	137
Total Groupers		63	10	14	10	17	83	62	17	181	396	555	450	417	569
Others															
Amberjack									1	1			2	23	34
Grunts			4	3	1	1	5			1	1	3	5	8	32
Porgies		1	12	290	122	30	21	5	13	102	186	290	444	489	607
Sea bass	66	204	722	773	514	547	289	134	147	89	16	65	220	215	621
Tilefish											19	45	23	105	221
Triggerfish											7	14	11	10	31
Total Others	66	205	738	1,066	637	578	315	139	161	193	229	417	705	850	1,546
Total Reef Fish	69	305	765	1,092	665	625	421	217	185	483	839	1,179	1,304	1,586	2,462

a. Landings adjusted upward to round weights (D. Thieling, S.C. Wildlife and Marine Resources Department, Charleston, S.C.; pers. comm.).
b. Less than 1,000 pounds

Table A-6. Value of Snapper-Grouper Commercial Landings by Species in South Carolina, 1968-1981 (in dollars).

SPECIES	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Snappers														
Lane														
Gray										577	520	3,166		
Mutton														
Red	15,213	11,113	8,263	5,325	12,549	16,749	13,000	5,797	56,962	133,356	180,315	105,290	101,433	125,218
Vermilion		241		3,188	6,707	2,832	1,000	1,205	55,881	53,737	92,634	133,331	330,265	332,040
Yellowtail														
Unclassified									17,909	67,663	25,841	9,524	2,823	9,505
Total Snappers	15,213	11,354	8,263	8,513	19,256	19,581	14,000	7,002	130,752	255,333	299,310	251,311	434,521	466,763
Groupers														
Jewfish														
Warsaw										2,527	3,473	2,125	1,357	7,977
Unclassified	10,231	2,345	1,576	1,632	4,174	29,330	32,000	9,772	94,184	202,177	326,107	323,078	345,058	584,505
Total Groupers	10,321	2,345	1,576	1,632	4,174	29,330	32,000	9,772	94,184	204,704	329,580	325,203	346,415	592,482
Others														
Amberjack										24	13	543	4,177	10,795
Grunts		490	260	125	159	1,139		21	232	176	277	719	2,145	9,536
Hogfish											555	54	1,712	10,537
Porgy	29	1,235	30,072	12,300	6,268	4,655	1,000	4,634	45,947	72,658	137,687	280,175	292,753	416,212
Sea Bass	31,987	169,330	164,373	131,962	198,625	86,890	47,000	44,686	26,802	5,665	29,926	106,936	166,418	457,197
Sheepshead											256	317	169	3
Tilefish								70	321	4,923	13,441	6,552	64,205	156,015
Triggerfish										625	2,944	2,766	2,944	9,673
Total Others	32,016	171,055	194,705	144,387	205,052	92,684	48,000	49,411	73,302	84,071	185,099	398,062	534,523	1,069,968
Total State	57,550	184,754	204,544	154,532	228,482	141,595	94,000	66,185	298,238	544,108	813,989	974,576	1,315,459	2,129,213

Table A-7. Commercial landings of species in the snapper-grouper complex in Georgia, 1967-1981 (in thousands of pounds).

SPECIES	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Snappers															
Red	55	17	14	16	55	52	20	42		56	71	99	28	18	24
Vermilion											7	20	5	37	48
Unclassified									31	1	9	9			1
Total Snappers	55	17	14	16	55	52	20	42	31	57	87	128	33	55	73
Total Groupers															
Unclassified	92	17	12	49	43	58	37	44	6	45	110	140	77	64	42
Others															
Amberjack		1									3			2	6
Grunts										1		3	1	(1)[a]	2
Porgies		4	3	7	7	2		4	4	47	135	78	42	103	81
Sea Bass	3	12	9	11	43	61	27	35	16	19	8	21	8	13	17
Sheepshead										5				1	(1)
Tilefish														2	3
Total Others	3	17	12	18	50	63	27	39	20	72	146	102	51	121	109
Total Reef Fish	150	51	38	83	148	173	84	125	57	174	343	370	161	240	224

a. Less than 1,000 pounds.

Table A-8. Value of Snapper-Grouper Commercial Landings by Species in Georgia, 1968-1981 (in dollars).

SPECIES	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Snappers														
Lane														291
Gray													106	757
Mutton														21
Red	7,136	8,996	11,471	39,873	40,902	17,888	42,000		75,550	124,700	189,000	59,000	34,564	53,100
Vermilion						93				8,700	30,300	6,300	39,420	56,192
Yellowtail														
Unclassified								31,000	1,674	13,000	11,000	130		41
Total Snappers	7,136	8,996	11,471	39,873	40,902	17,981	42,000	31,000	77,224	146,400	230,300	65,430	74,090	110,402
Groupers														
Jewfish														695
Warsaw														191
Unclassified	2,698	2,345	7,863	7,619	11,372	13,052	18,000	2,930	23,052	64,087	93,700	66,000	44,246	41,919
Total Groupers	2,698	2,345	7,863	7,619	11,372	13,052	18,000	2,930	23,052	64,087	93,700	66,000	44,246	42,805
Others														
Amberjack										557			324	1,298
Grunts									262		600	200	185	454
Hogfish														
Porgy	819	766	1,384	1,543	490	67	1,000	1,437	17,793	73,800	41,000	27,000	61,883	41,318
Sea Bass	2,306	2,508	2,485	15,987	28,487	9,331	17,000	5,996	8,186	3,900	12,200	5,100	6,964	11,845
Sheepshead									300				492	95
Tilefish												25	883	1,564
Triggerfish												61	645	987
Total Others	3,125	3,274	3,869	17,530	28,977	9,398	18,000	7,433	26,541	78,257	53,800	32,386	71,376	57,561
Total State	12,959	14,615	23,203	65,022	81,251	40,431	78,000	41,363	126,817	288,744	377,800	163,816	189,712	210,768

Table A-9. Commercial landings of species in the snapper-grouper complex in Florida, 1967-1981 (in thousands of pounds).

SPECIES	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Snappers															
Lane	2	13	12	13	13	11	19	17	20	23	30	34	56	20	34
Gray	240	261	271	241	241	370	293	308	215	155	208	207	245	231	229
Mutton	126	162	140	245	282	277	380	311	239	197	252	330	275	221	199
Red	905	974	671	614	483	420	351	579	710	526	505	323	262	240	199
Vermilion	15	33	32	20	52	88	83	103	194	152	151	177	147	116	66
Yellowtail	763	915	761	931	804	747	694	752	605	663	492	542	495	527	601
Total Snapper	2,051	2,358	1,887	2,064	1,877	1,913	1,820	2,070	1,983	1,716	1,638	1,613	1,480	1,355	1,328
Groupers															
Jewfish	71	68	54	31	17	23	35	66	56	59	72	39	29	23	19
Warsaw	25	69	37	44	92	47	66	66	44	32	33	18	21	7	11
Unclassified	553	855	697	916	928	791	722	944	1,267	1,406	1,209	1,471	1,298	1,002	1,226
Total Groupers	649	992	788	991	1,037	861	823	1,076	1,367	1,497	1,314	1,528	1,348	1,032	1,256
Others															
Amberjack	22	26	4	39	22	11	37	35	54	66	64	38	32	46	48
Grunts	58	65	61	69	76	71	90	47	32	27	47	41	103	36	37
Hogfish	8	16	10	17	14	15	12	11	14	9	23	24	26	35	37
Porgies	41	83	55	68	71	78	86	76	156	102	139	205	196	232	267
Sea bass	77	69	70	62	93	115	69	95	100	75	71	65	61	53	46
Sheepshead	157	117	207	219	218	272	295	302	235	232	248	165	214	149	264
Tilefish	11	7	6	11	17	11	46	102	176	169	82	108	147	231	900
Triggerfish	4	3	2	2	5	9	10	18	36	21	21	28	26	17	10
Total Others	378	386	415	487	516	582	645	686	803	701	695	674	805	799	1,609
Total Reef Fish	3,078	3,736	3,090	3,542	3,430	3,356	3,288	3,832	4,153	3,914	3,647	3,815	3,633	3,186	4,193

Table A-10. Value of Snapper-Grouper Commercial Landings by Species in Florida, 1968-1981 (in dollars)

SPECIES	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Snappers														
Lane	1,950	3,058	4,160	5,694	5,052	6,287	6,080	7,901	10,543	18,580	23,389	41,005	16,839	30,564
Gray	64,769	86,648	82,219	111,239	158,893	149,496	167,920	93,788	68,292	154,180	178,572	145,519	256,064	274,035
Mutton	58,208	71,184	124,217	176,699	191,026	295,215	236,600	145,191	154,127	259,160	440,022	174,378	306,235	285,181
Red	420,911	387,717	409,391	337,171	355,016	324,811	513,690	700,185	652,906	830,900	707,771	523,419	493,892	434,720
Vermilion	13,203	13,908	10,029	19,867	43,013	67,771	76,750	142,345	140,502	164,270	147,617	198,209	138,535	87,623
Yellowtail	319,103	335,347	376,288	434,492	510,091	472,279	549,310	264,166	547,315	456,850	549,454	61,573	721,200	879,100
Unclassified														
Total Snappers	878,144	897,862	1,006,304	1,085,162	1,263,091	1,315,859	1,550,350	1,353,576	1,573,685	1,883,940	2,046,825	1,144,103	1,932,765	1,991,223
Groupers														
Jewfish	8,160	8,200	4,666	2,205	3,871	8,455	18,600	15,799	19,671	29,610	8,156	10,166	12,789	11,969
Warsaw	7,263	5,496	9,097	16,233	13,533	16,268	23,850	14,292	13,168	15,280	8,000	11,044	5,030	7,194
Unclassified	153,614	147,635	193,818	205,949	237,207	252,944	394,680	502,875	559,748	759,150	1,088,461	782,611	943,940	1,349,338
Total Groupers	169,037	161,331	207,581	224,387	254,611	277,667	437,130	532,966	592,587	804,040	1,104,617	803,821	961,759	1,368,501
Others														
Amberjack	1,615	1,192	2,825	2,088	1,431	3,784	5,482	8,436	7,794	7,330	4,368	5,142	10,537	9,127
Grunts	5,197	4,974	7,115	8,368	7,920	19,620	6,380	4,857	4,508	8,340	3,412	10,319	8,126	9,351
Hogfish	4,569	2,521	4,116	5,050	5,031	4,962	5,500	4,972	4,206	14,320	15,300	2,092	35,543	37,291
Porgy	10,655	9,093	11,211	14,561	20,417	24,620	22,000	47,675	38,766	60,000	90,668	116,205	160,956	187,372
Sea Bass	11,489	15,299	16,288	26,749	36,201	26,395	29,000	31,408	24,881	27,000	37,057	38,618	32,809	31,449
Sheepshead	10,000	21,000	22,000	26,000	39,000	43,000	44,000	35,000	36,383	42,836	32,006	48,581	35,958	71,837
Tilefish	743	787	1,417	1,999	1,293	16,708	36,040	69,826	74,565	37,640	57,834	86,370	170,718	806,856
Triggerfish	250	250	265	436	1,332	1,190	3,153	5,803	4,509	5,000	6,098	7,836	5,457	3,121
Total Others	44,518	55,116	65,237	85,251	112,625	140,279	151,555	207,977	195,612	202,466	246,744	315,163	460,104	1,156,404
Total State	1,091,699	1,114,309	1,279,122	1,394,800	1,630,327	1,733,805	2,139,035	2,094,519	2,361,884	2,890,446	3,398,186	2,263,087	3,354,628	4,516,128

Table A-11. Headboat landings (in thousands of pounds) in North and South Carolina, Georgia, and northeast Florida (east coast south to Daytona), 1972 through 1977.[a]

	1972 Carolina TOTAL	1973 Carolina TOTAL	1974 Carolina TOTAL	1975 Carolina TOTAL	1976 N.C.	1976 S.C.	1976 GA.	1976 FLA.	1976 TOTAL	1977 N.C.	1977 S.C.	1977 GA.	1977 FLA.	1977 TOTAL
Snappers														
Vermilion	107.1	156.8	119.3	181.7	45.4	53.4	49.0	106.0	253.8	33.3	26.9	11.4	81.3	152.9
Red[b]	40.9	60.2	36.8	34.5	15.0	39.9	17.5	154.1	226.5	7.2	10.9	17.1	154.0	189.2
Other														
								15.9	15.9				15.8	15.8
Total Snappers	148.0	217.0	156.1	216.2	60.4	93.3	66.5	276.0	496.2	40.5	37.8	28.5	251.1	357.9
Groupers														
Epinephelus	92.0	99.5	83.1	56.3	8.5	55.6	1.0	27.1	92.2	10.3	20.2	1.0	24.3	55.8
Mycteroperca	238.1	262.9	253.2	135.7	82.5	47.6	10.1	68.3	208.5	82.5	33.2	4.2	52.5	172.4
Total Groupers	330.1	362.4	336.3	192.0	91.0	103.2	11.1	95.4	300.7	92.8	53.4	5.2	76.8	228.2
Others														
Black sea bass			590.1	764.1	168.5	331.1	27.0	106.4	633.0	75.4	424.2	20.2	113.0	632.8
Grunts	228.2	142.9	170.4	162.0	71.0	71.7	14.4	11.5	168.6	97.4	36.0	8.2	15.5	157.1
Porgies	518.9	745.7	523.8	459.8	163.4	232.1	3.2	11.2	409.9	296.6	277.7	1.4	23.6	599.3
Triggerfish			132.0	107.4	41.8	36.5	3.3	19.4	101.0	29.5	46.5	1.0	23.1	100.1
Tilefish			15.0	9.5	5.1	12.8			17.9	4.5	2.1			6.6
Total Others	747.1	888.6	1431.3	1502.8	449.8	684.2	47.9	148.5	1330.4	503.4	786.5	30.8	175.2	1495.9
Total Reef Fish	1225.2	1468.0	1923.7	1911.0	601.2	880.7	125.5	519.9	2127.3	636.7	877.7	64.5	503.1	2082.0

a. Landings totals for the years 1972 through 1975 and 1976 and 1977 are not directly comparable as the headboat survey was expanded in 1976 to include ports in Georgia and northeast Florida.

b. Includes other species of snapper, as well as red snapper in North and South Carolina.

Table A-12. Head boat landings of snappers, groupers, and associated reef fishes, by area, 1978 (in thousands of pounds).

SPECIES	N.C.	S.C.	Savannah-Jacksonville	Daytona	Ft. Lauderdale-Miami	Florida Keys	Regional Total
SNAPPERS							
Gray					13.2	73.3	86.5
Lane					1.7	23.4	25.1
Mutton					116.5	9.8	126.3
Red	12.4	8.9	16.6	129.5	16.6	1.7	185.7
Silk					215.0	.3	215.3
Vermilion	44.2	37.4	10.8	151.9	44.3		288.6
Yellowtail					105.7	57.9	163.6
Others	.7	1.0	9.4	15.5		1.0	27.6
TOTAL SNAPPERS	57.3	47.3	36.8	296.9	513.0	167.4	1,118.7
GROUPERS							
Epinephelus	6.5	23.3	2.9	13.2	10.4	59.1	115.4
Mycteroperca	90.5	24.6	3.9	30.1	13.5	16.2	178.8
TOTAL GROUPERS	97.0	47.9	6.8	43.3	23.9	75.3	294.2
OTHERS							
Black sea bass	102.7	261.8	22.1	160.3	1.0		547.9
Grunts	72.9	18.9	8.7	22.1	4.7	84.9	212.2
Porgies	191.4	295.6	3.4	68.5	13.8	18.9	591.6
Triggerfish	40.4	24.5	3.0	32.8	6.8	3.0	110.5
Tilefish	1.2	7.5			.3		9.0
TOTAL OTHERS	408.6	608.3	37.2	283.7	26.6	106.8	1,471.2
TOTALS	562.9	703.5	80.8	623.9	563.5	349.5	2,884.1

Table A-13. Head boat landings of snappers, groupers, and associated reef fishes, by area, 1979 (in thousands of pounds).

SPECIES	N.C.	S.C.	Savannah-Jacksonville	Daytona	Miami	Florida Keys	Dry Tortugas	Regional Total
Snappers								
Gray					12.1	7.7	4.8	24.6
Lane					4.0	10.6	0.4	15.0
Mutton					68.8	76.1	179.2	324.1
Red	5.1	11.5	9.5	156.3	61.5	1.5		245.4
Silk					23.6	2.2		25.8
Vermilion	45.2	5.1	7.1	125.9	29.1	1.8		214.2
Yellowtail					52.5	87.5	200.6	340.6
Others	1.5	1.1	5.3	20.3	9.3	1.3	0.2	39.0
Total Snappers	51.8	17.7	21.9	302.5	260.9	188.7	385.2	1,228.7
Groupers								
Epinephelus	18.7	19.8	1.3	11.5	27.6	29.3	20.7	128.9
Mycteroperca	121.9	32.4	4.4	60.6	67.5	25.6	144.2	456.6
Total Groupers	140.6	52.2	5.7	72.1	95.1	54.9	164.9	585.5
Others								
Black sea bass	109.3	342.8	16.8	118.2	1.3			588.4
Grunts	68.1	24.9	11.2	25.1	20.3	52.7	15.4	217.7
Porgies	157.6	144.6	2.6	32.6	23.8	25.4	31.1	417.7
Triggerfish	46.1	26.7	2.0	30.0	11.2	9.0	1.1	126.1
Tilefish	0.9	2.0						2.9
Total Others	382.0	541.0	32.6	205.9	56.6	87.1	47.6	1,352.8
Totals	574.4	610.9	60.2	580.5	412.6	330.7	597.7	3,167.0

APPENDIX B

SIZE LIMIT DISCUSSION PAPER

Plan Development Team Meeting

July 30-31, 1981

TO: Plan Development Team

FROM: Huntsman and Manooch

SUBJECT: Further development and update of size limit discussion.

Jack Davis's request that we continue development of size limits has prompted effort by us in five areas. These are:

1) estimation of natural mortality rates,
2) development of yield/recruit models and size limits for species not previously covered,
3) discussion of the interaction of yield/recruit in weight, size limits, and expected mean size and number of individuals caught,
4) investigation of the interaction of protogyny - and yield/recruit-based management (size limits) in grouper, and
5) development of a model to predict the amount of time required for a size limit to affect yield.

Before proceeding to those discussions, we want to briefly review our rationale for setting size limits. The basis for the proposed size limits are yield/recruit models. Examination of any of the models we have constructed for reef fish (several are attached Figures 1, 2, 3, 4) will show that for all but very low fishing mortalities increasing recruitment age up to about the age of sexual maturity for any species results in great increases in yield. Further increase in recruitment age at first have no effect but eventually decease yield. Examining the yield surface with respect to fishing mortality shows that after very rapid increase in yield as F increases to about F=0.3 (usually) yield remains constant as long as recruitment age is held constant. Thus, regulating recruitment age by size limit has the very valuable advantage of allowing managers to maintain a constant (as long as reproduction holds up) yield without having to tinker with effort in any way. As an aside we should note that what does happen as F increases greatly is that catch per unit effort drops quickly even though total yield is constant. Thus fisherman satisfaction decreases, and there is ever increasing motivation to take smaller fish in an attempt to maintain the CPUE.

Our method for choosing proposed size limits was to choose the youngest age (= size) that would allow the fishery to operate on the yield plateau (see graphs) regardless of F. Naturally, the validity of the proposed size limits is a direct function of the validity of the Y/R model which in turn is a direct function of the validity of our estimates of the two principal parameters shaping the Y/R surface. These parameters are 1) von Bertalanffy growth equation and 2) natural mortality rate.

We believe we have good information on growth of species for which we have proposed size limits. Indeed we have not proposed limits for any species for which good growth data were unavailable. However, we have been challenged in our attempts to estimate natural mortality rates. Having no real data we have been forced, most of the time, to rely on very "fuzzy" estimations based on the ralationship of M (natural mortality rate) to the von Bertalanffy K propsed by Beverton and Holt in a 1959 paper. We need better estimates of M. The best would result from studies of age structure in unexploited populations. We know of neither any studies, nor of any unexploited populations. Recently, a paper has come to our attention that offers the possibilities of "defuzzing" our estimates. Thus we come to the first of our four discussions.

I. Pauly estimates of natural mortality.

A 1978 paper by Dan Pauly formerly of Institut für Meereskunde, West Germany, now at ICLARM in the Phillipines takes the suggestion of Beverton and Holt that M and K are related and modifies it by suggesting the M-K relationship interacts with temperature. Pauly obtained estimates of M and K and annual mean water temperature for 122 stocks of fish and developed multiple regressions for use in predicting M. These are

$$\log_{10} M = 0.1228 - 0.1912 \log L_\infty + 0.7485 \log K + 0.2391 \log T$$

and

$$\log_{10} M = -0.1091 - 0.101\ F \log W_\infty + 0.5912 \log K + 0.3598 \log T$$

where L_∞ is total length in cm and T is mean annual temperature in degrees C. With 118 degrees of freedom, the multiple correlation coefficients are 0.817 and 0.800 while 0.303 is significant at $\alpha = 0.01$.

The Pauly approach offers at least the illusion of being able to provide reasonably precise estimates of M. It is published, both as an ICES paper and later in hard literature (I've lost the citation); it is rigorous and allows probability statements to be made about M estimates. Consequently, we have used it to calculate M estimates for several species, and to generate new maximum yield size limits (presented later). We do feel that there may be difficulties remaining in the Pauly estimates. One reason for this is that the method is itself based on estimates of unknown quantity. Some, we're sure, are very good. But others may be awry. For instance many of his estimates of M for tropical animals came from Munro's Jamaican work. We have always suspected these as being too large and now Munro's successor does also. Leendert Hartsuijken believes bias in size selection by traps may have warped Munro's estimates. Older fish were excluded by the traps resulting in overestimation of Z, M, and K. Thus, while Pauly's work may provide a convenient citation to support a management scheme, it may also have serious flaws.

Following are tables of our original and Pauly-revised estimates of M and minimum sizes for several species.

	M		Minimum Size in (TL)	
Species	Original	Pauly	Original	Pauly
Red porgy	0.20	0.21	14.5	14.5
White grunt 1/	0.40 & 0.60	0.24	12.0	11.0
Vermilion snapper	0.25	0.37	13.0	11.5
Red snapper 2/	0.30	0.30	16.0	18.0
Lane snapper	0.20	Not recalculated	14.0	-
Yellowtail snapper	0.20	Not recalculated	16.0	-
Black seabass	0.30	0.45	9.0	7.0
Red grouper	0.20	0.23	25.0	25.0
Red hind	0.20	Not recalculated	14.0	-
Gag	0.20	0.22	25.5	25.5

1/ age at entry to grounds changed from 2 to 1,

2/ New growth parameters from R. Nelson.

As you can see, the Pauly method did not change most estimates of M or recommended size limits. However, the new M values for vermilion snapper and black sea bass seem high. The current estimate of M for Atlantic menhaden, an animal which would be expected to have high M, is only about 0.39.

II. Size limit estimates for some additional species.

To furnish material for discussion we have computed proposed maximum yield-minimum size limits for four additional species, speckled hind, snowy grouper, grey snapper, and scamp. While proposals of size limits for deep water groupers is problematic, we have had success in holding at least one speckled hind that we had deflated by stabbing judiciously. Thus, there may be some potential use of size limits for mid-depth and deep water groupers. The proposed size limits (based on Pauly estimates of M) are:

Species	M	Size limit (TL)
grey snapper	.20	15 in
scamp	.23	17.5 (FL)
snowy grouper	.15	23.5
speckled hind	.15	22.0

The yield per recruit models for the snowy grouper, grey snapper, and speckled hind are attached (Figures 1, 2, 3, 4). The scamp model is interesting in that even relatively low recruitment ages furnish a high percentage of the maximum yield/recruit.

III. The third discussion we wish to enter is one concerning the utility of various outputs of yield/recruit models to managers. To date we have only discussed and used the most common output, that which expresses yield per recruit in weight as a surface responding to the variables fishing mortality and age at recruitment to the gear. The version of the yield per recruit model in Beaufort has other response-surface outputs that, used with the yield-in-weight/recruit surface, offer the manager a chance to examine the impact of his choice of fishing conditions on other characteristics of the fishery. Two of the most useful of these secondary outputs are yield in numbers/recruit, and mean weight/captured fish. These outputs are demonstrated in the attached illustrations for red porgy (Figures 5, 6, 7).

As you can see on $Y_{W/R}$ (Figure 5) illustration, a given $Y_{W/R}$ may be obtained with many combinations of age at recruitment (T) and fishing mortality (F). Managers potentially have a choice among these combinations. The surfaces portraying $\bar{W}$ and $Y_{N/R}$ allow examination of the impact on any choice. For instance, if the manager should choose to seek a $Y_{W/R}$ of 275 g, he might choose to do it by operating at the minimum possible recruitment age, about 3.3, and a concomitant F of about 0.6. At that combination of events, the manager could expect to achieve a catch of about 300-400 individuals per 1000 recruits (Figure 6) with a mean weight each of about 500 g (Figure 7). On the other hand 275g/R can be had at high recruitment age, 8.0 for instance, and F's ranging from 0.5 up. At F of .5 and T = 8.0, then only 194 individuals/recruit can be had but with a mean weight of 1500 g. If you want (and can) manage for a trophy fishery, one might set recruitment age very high to achieve this goal. Another choice still giving 275g/recruit would be to allow unlimited increase in effort while maintaining recruitment age at about 4.0, and harvest at about 500 individuals/1000 recruits weighing about 400 g each. Some recreational fisheries might be managed this way.

Examination of alternatives could go on interminably. We urge each of you to examine the illustrations and demonstrate to yourselves the utility of these models.

IV. Management of groupers to deal with protogyny

A subject of longstanding concern is the effect of fishing on the reproductive capacity of protogynous reef fishes, especially groupers because male fish only appear in a cohort after it is "old", 7 to 10 years old in some cases. Because the effect of fishing is to decrease the potential age of cohorts, fishing conceivably could impair or eliminate the reproductive capacity of a stock by removing needed males.

At this stage in reef fish research we are unable to conduct research on reef fish in the wild to determine whether or not fishing really does impair reproduction. We believe, however, that the subject is sufficiently important to grouper management that we should attempt at least preliminary investigations. The most expeditious manner to pursue this investigation is by modelling. Modelling allows us to expose the assumptions necessary to pursue analyses and, because models aren't necessarily constrained by data, allows us to examine numerous alternative schemes by which a system might work, even though we don't know the true way. Often, such examinations reveal that widely varying alternative schemes have the same ultimate impact.

To investigate the interaction of fishing and protogyny, Bill Schaaf and we developed several alternative models using basic biological data for a small grouper, the graysby, Epinephelus cruentatus, from Nagelkerken's work in Curacao. Before examining the models and their implications, let us examine some basic precepts used in our models. First we suggest that given a moderately constant recruitment rate, the ultimate effect of the interaction of protogyny without fishing with constant natural mortality rate is to fix the sex ratio of cohorts and consequently of the stock. We propose given the normal course of evoluntionary events, that M and the transition rate will become established at the level that results in the optimum sex ratio for reproduction. Thus determination of the sex ratio in an unfished stock provides a standard against which the reproductive potential of sex ratios resulting from various levels of fishing can be judged. We posit that negative deviations from the unfished stock-value of the male biomass/population fecundity ratio are related to reproductive potential of the species. However, population fecundity, which also changes in response to fishing is, of course, also related to reproductive potential. Thus, we propose in our models that population reproductive potential can be simulated by the product of population fecundity and the value $\frac{\text{(fished stock sex ratio M/F)}}{\text{(unfished stock sex ratio)}}$.

By following this hypothesis we were able to simulate the effects of fishing on graysby stocks and determine the change in reproductive potential as fishing increased:

We examined the effects of fishing in six models as listed in the attached figure (Figure 8). The first model is for a stock that has all the characteristics of that of the graysby except that it is bisexual (gonochoristic). That is, no sexual transition takes place. The sex ratio remains 1.2:1 (that of an unfished graysby stock) at all levels of fishing.

Thus the only decrease of reproductive potential results from decrease in stock fecundity.

The second model is of a protogynous stock that displays no compensatory mechanism. Three more models are for stocks each of which has a different means of compensating for removal of males from the stock. These models were made in response to observations that in some wild protogynous stocks removal of a breeding male triggers the transition of a female to a breeding male. Two schemes of male-removal compensations are investigated. One hinges on maintenance of a fixed numerical sex ratio. The other mechanism maintains a fixed ratio of male biomass (a proxy for milt production) to population fecundity.

The results of modelling are presented in Figure 9. Interestingly, and unexpectedly, at F=0, Z=M=0.13 the bisexual population seems to have a greater reproductive potential (as a result of having large old females) than the protogynous population. If this result is true we wonder at the evolutionary value of protogyny but will not pursue that question here. As expected all versions of protogyny respond more rapidly (lose reproductive potential) to fishing than does the gonochoristic model. The best protogynous model lost all reproductive potential at an F some 10% less than the F at which the gonochoristic model failed. The worst protogynous model failed at an F that was 30% less. Moreover, the F values at which all of the stocks "fail" (even the gonochoristic stock) are not very large, 0.7 to 1.0, rates that could be realistically expected in an intense fishery. All the protogynous stocks have reproductive potential that is significantly less then the gonochoristic stocks especially at high F values. Thus, within the limits of the asumptions made, we believe we have demonstrated that protogynous stocks do indeed respond to fishing more drastically then bisexual stocks.

Now, after a long departure, we return to discussion of size limits. Schaaf and we wanted to see what impact managing the graysby for maximum yield (in weight) per recruit would have on the ability of the stock to maintain reproductive potential. Examination of the graysby Y/R surface (Figure 10) suggests that recruiting the fish at age 6-7 would protect yield in the face of fishing mortality. To examine the impact of delayed recruitment on reproductive potential, we modified the age specific fishing mortality rates in our models (Figure 11) and found that the impact of delayed recruitment is not only mintained high yield, but also, apparently, high reproductive potential despite the magnitude of F. And most interesting to us is that delayed recruitment (especially if Tp is 7) essentially erases the differences in reproductive potential between protogynous and gonochoristic stocks.

Thus it would appear that size limits would solve two important problems in the management of reef fishes.

V. Modelling to discern the time scale of impact of size limits

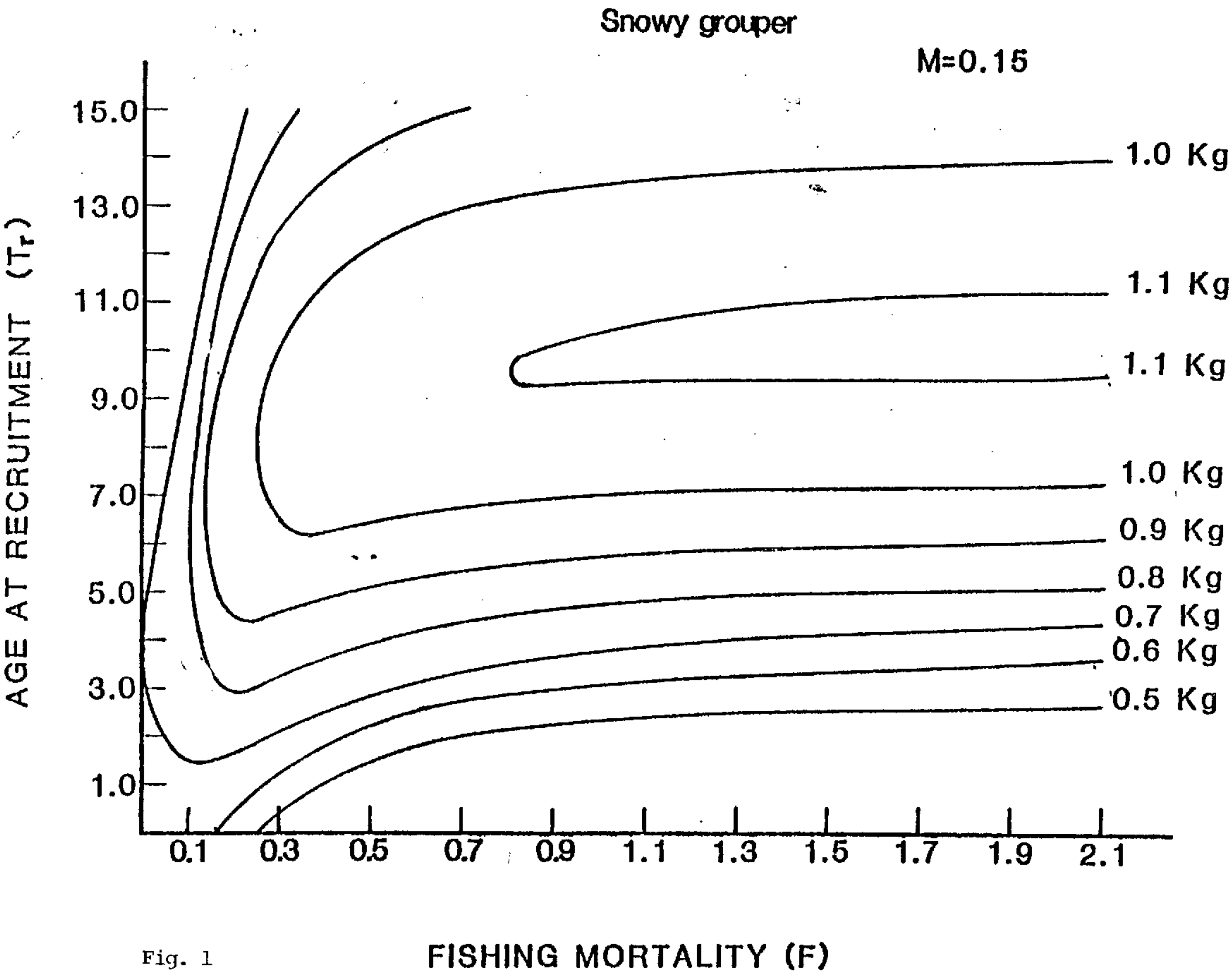
While it seems intuitively obvious that size limits won't have an immediate effect on fish yield, we have been without tools to measure the time required for the beneficial effects of a size limit to accrue.

Jim Waters and Bill Schaaf have constructed a model which allows the required time measurement. The model requires inputs of growth parameters, natural mortality rate, size at birthdays, and age specific F values (which are functions of a size limit or lack of same). The present model only calculates the effects of a one stage change in regulation of a fishery, not incrementally moving to a size limit by several stages. An updated version of the current model will evaluate the incremental approach. The model is generalized, and has, depending on the data supplied, myriads of results.

We chose to supply only one set of results as an example. In this model (Figures 12 and 13) we evaluate the effects on red porgy catches of moving to a minimum size limit of 13 inches (325 mm) from the unregulated fishery where gear selectivity imposes a minimum size of 300 mm. In this model where the size change is small and initial recruitment size large, five years are required to achieve a positive balance of gained vs. lost catch. Fourteen years are required for the population to stabilize. If the initial change had been larger, if the initial recruitment size were smaller, or if growth were faster a positive balance might have been achieved earlier.

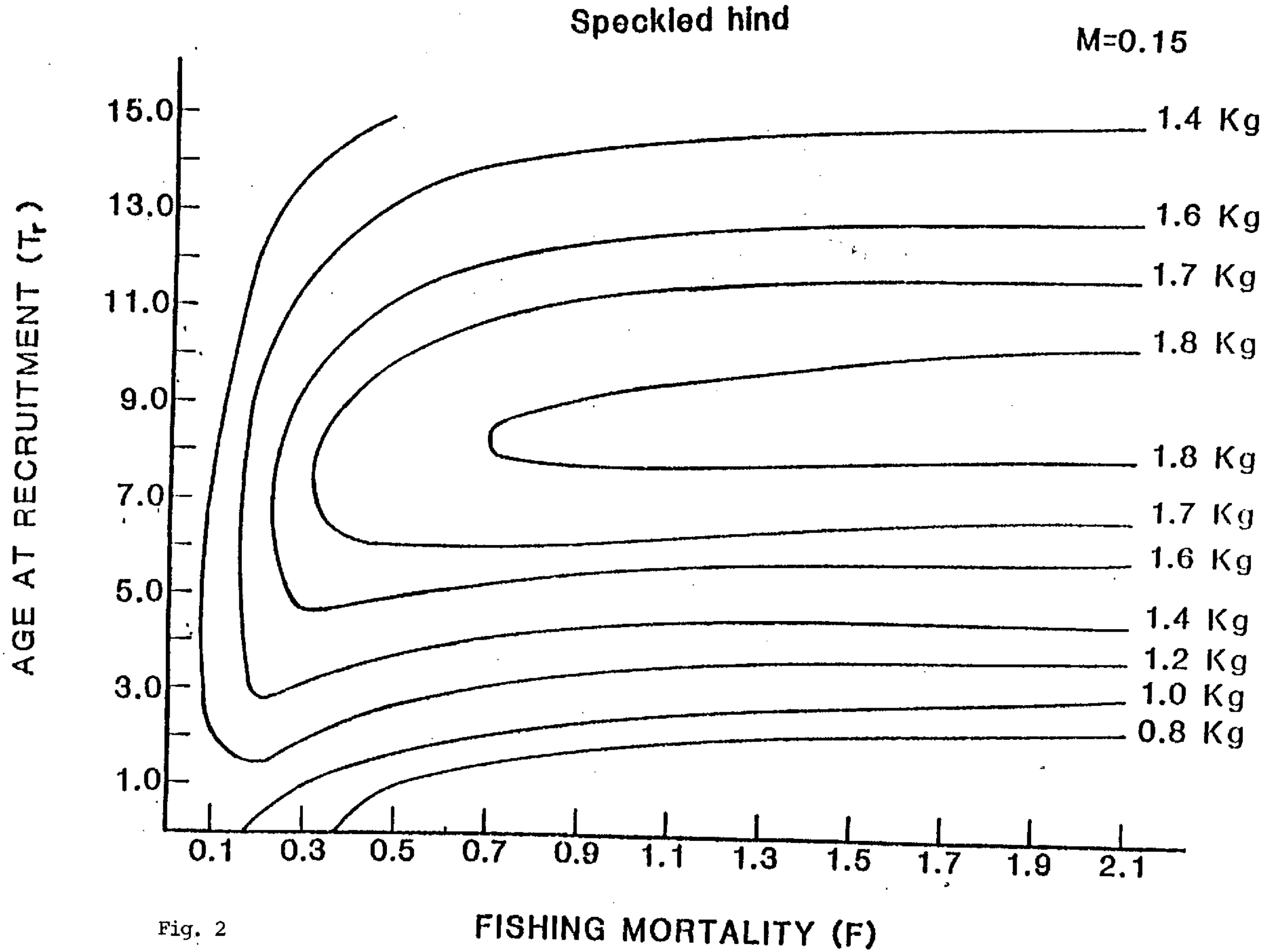
Our only intention here was to demonstrate the existence of our model and the nature of its product. We plan both to refine the model and to use it to answer practical questions on an <u>ad hoc</u> basis. We do not intend to make any particular run unless someone shows serious interest in evaluating a particular set of circumstances.

We want to point out that no discount factor is included in the model. Such a factor would decrement the positivie effects of a model as a function of the amount to time required to achieve those effects. Because the exact form of the decrementing function is unknown to us and is suspected to be highly subjective, we leave decrementing to the managers.



Snowy grouper
M=0.15
1.0 Kg
1.1 Kg
1.1 Kg
1.0 Kg
0.9 Kg
0.8 Kg
0.7 Kg
0.6 Kg
0.5 Kg
15.0
13.0
11.0
9.0
7.0
5.0
3.0
1.0
AGE AT RECRUITMENT (T_r)
0.1
0.3
0.5
0.7
0.9
1.1
1.3
1.5
1.7
1.9
2.1
FISHING MORTALITY (F)

Fig. 1



Speckled hind
M=0.15
AGE AT RECRUITMENT (T_r)
15.0
13.0
11.0
9.0
7.0
5.0
3.0
1.0
1.4 Kg
1.6 Kg
1.7 Kg
1.8 Kg
1.8 Kg
1.7 Kg
1.6 Kg
1.4 Kg
1.2 Kg
1.0 Kg
0.8 Kg
0.1
0.3
0.5
0.7
0.9
1.1
1.3
1.5
1.7
1.9
2.1
FISHING MORTALITY (F)

Fig. 2

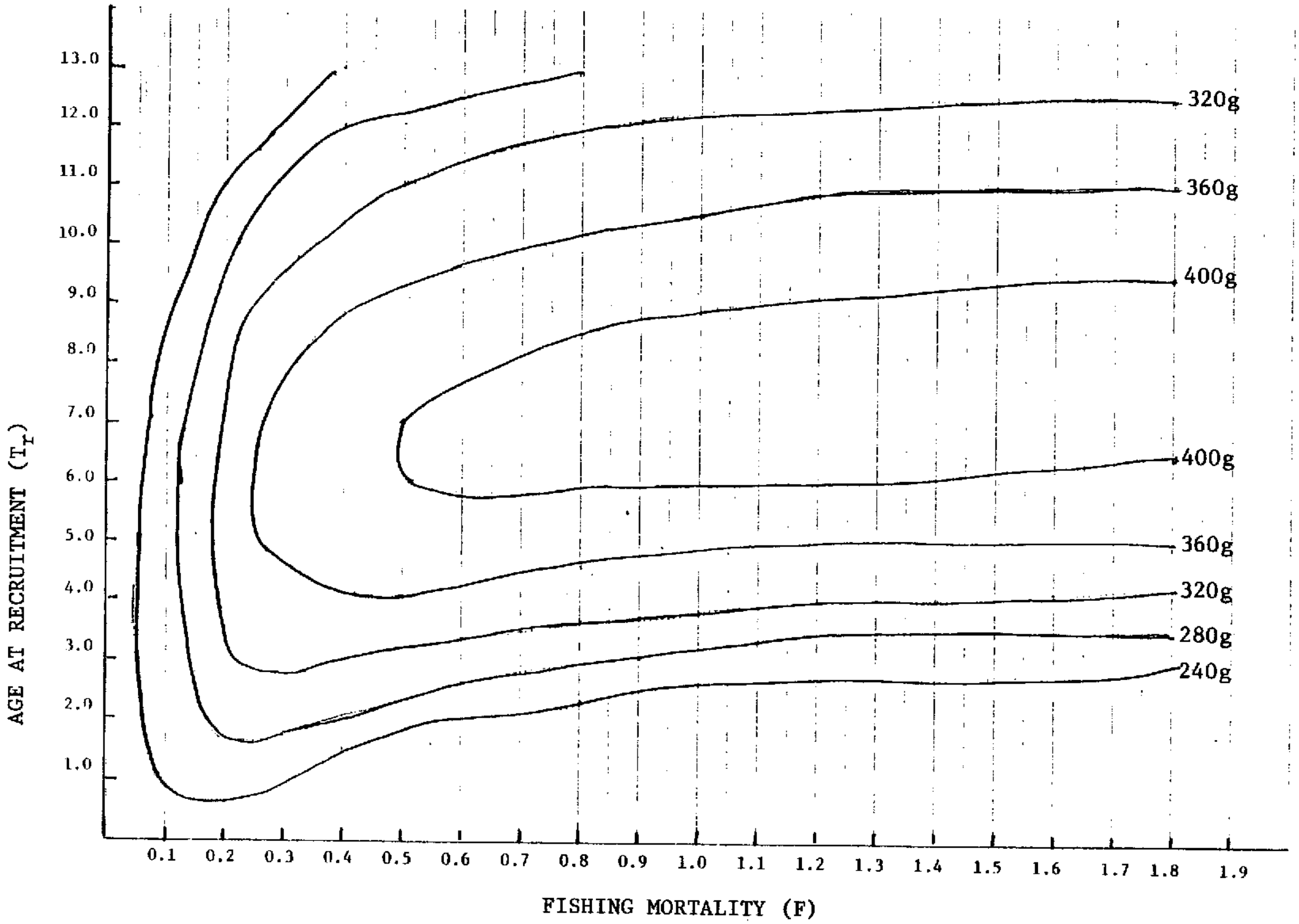


Fig. 3. Gray Snapper M = 0.20

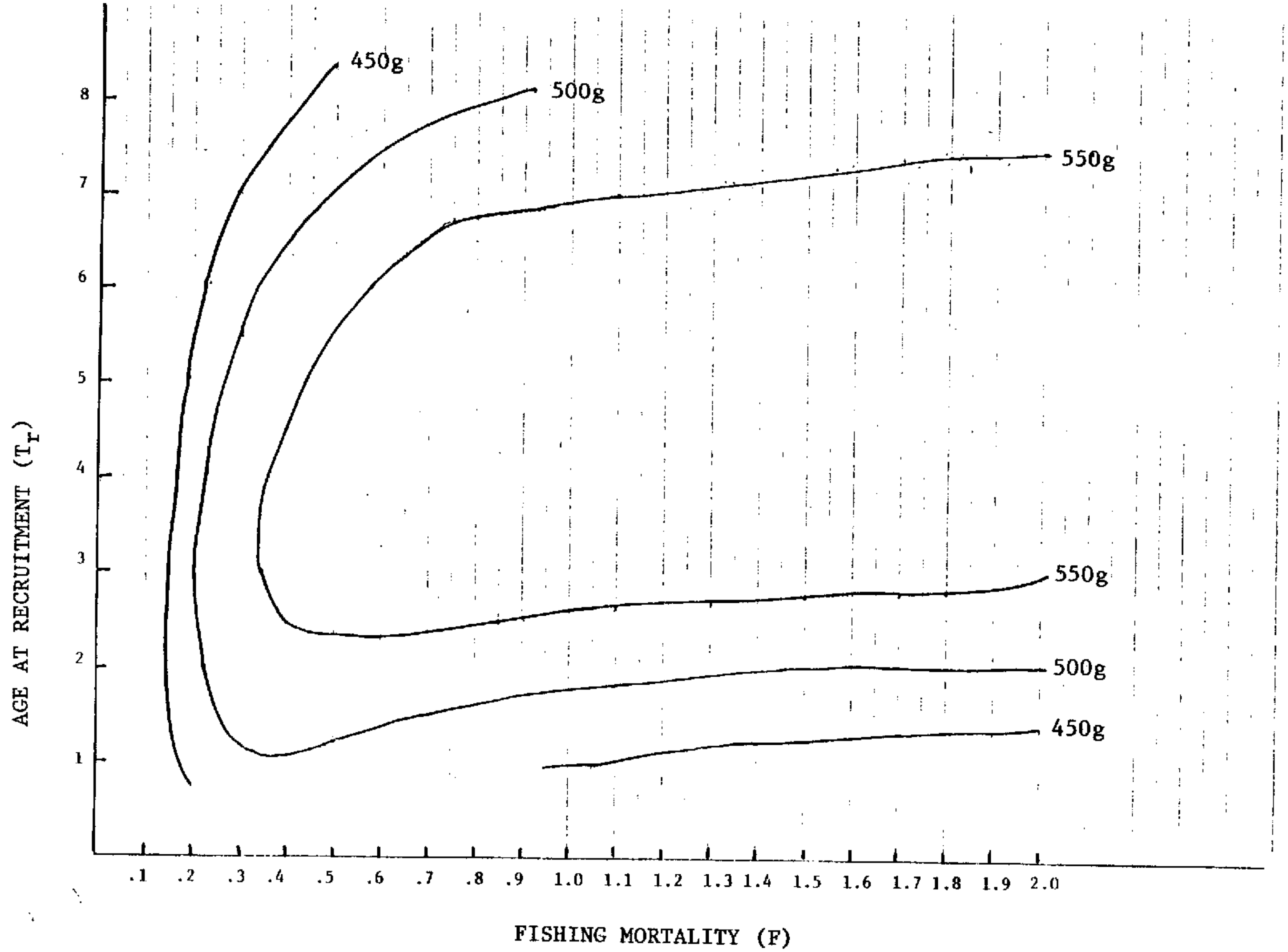


Fig. 4. Scamp M = 0.23

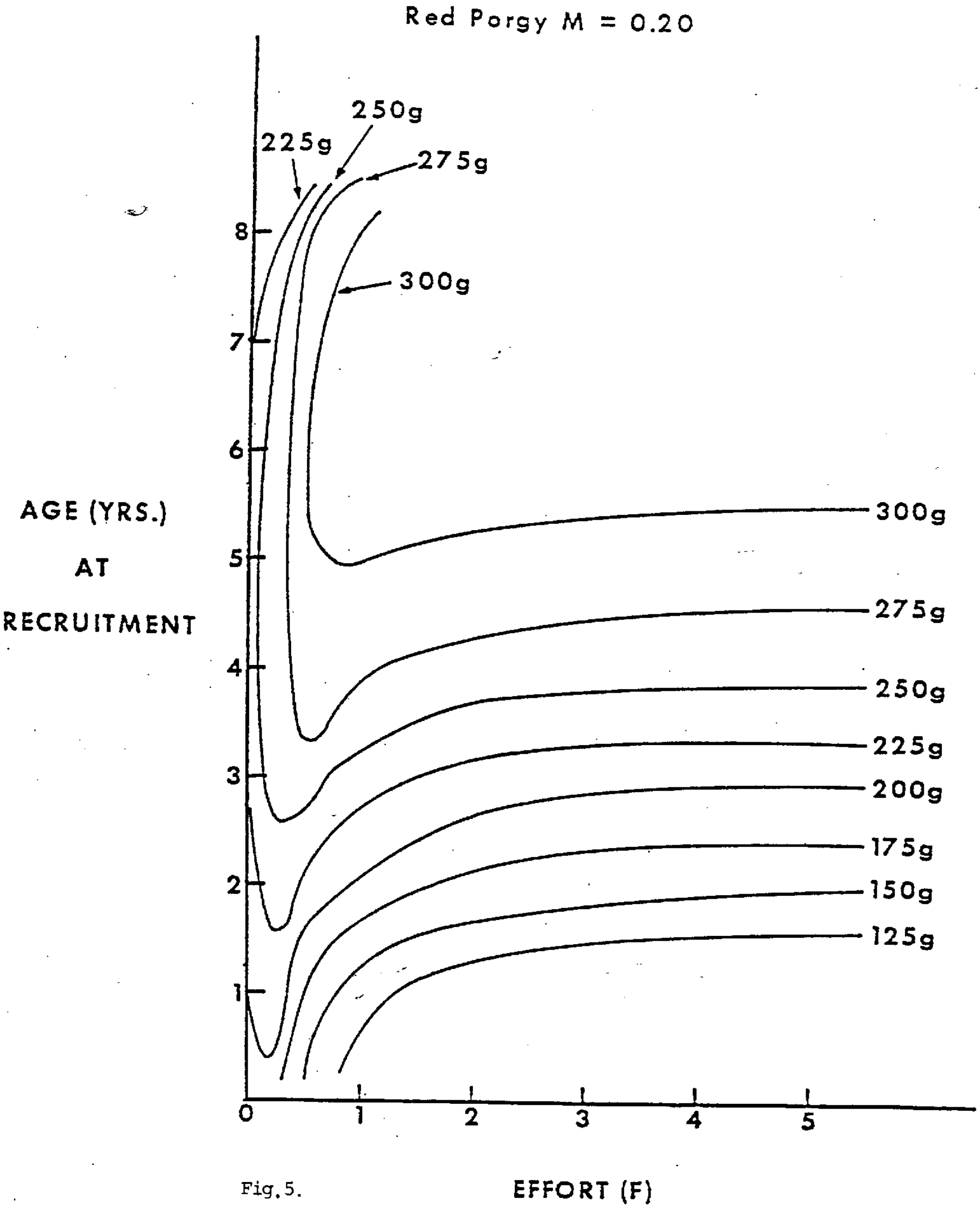

Red Porgy M = 0.20
250g
225g
275g
300g
8
7
6
5
4
3
2
1
0
AGE (YRS.)
AT
RECRUITMENT
300g
275g
250g
225g
200g
175g
150g
125g
1
2
3
4
5
EFFORT (F)

Fig.5.

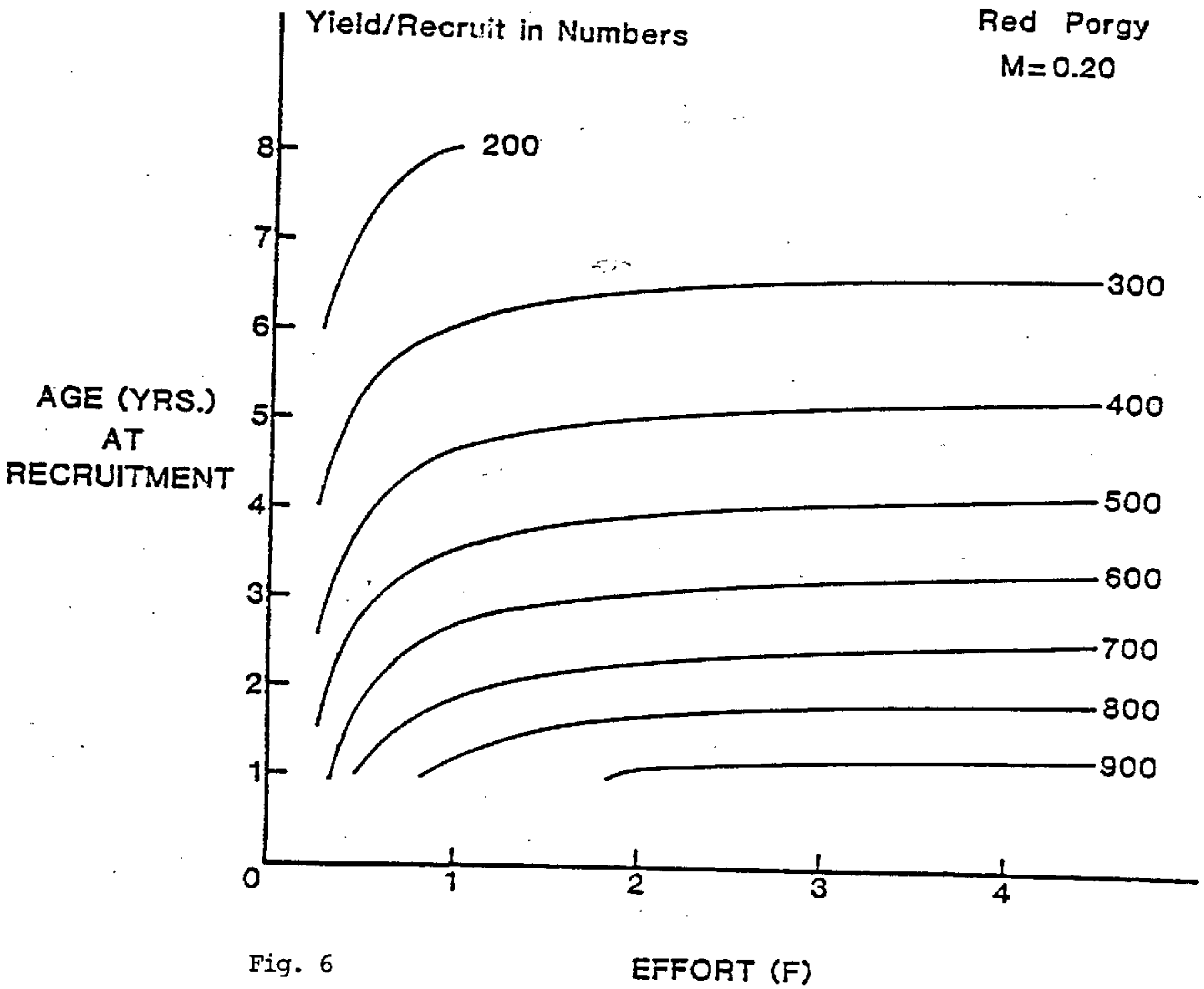

Yield/Recruit in Numbers
Red Porgy
M=0.20
AGE (YRS.) AT RECRUITMENT
0
1
2
3
4
5
6
7
8
200
300
400
500
600
700
800
900
EFFORT (F)

Fig. 6

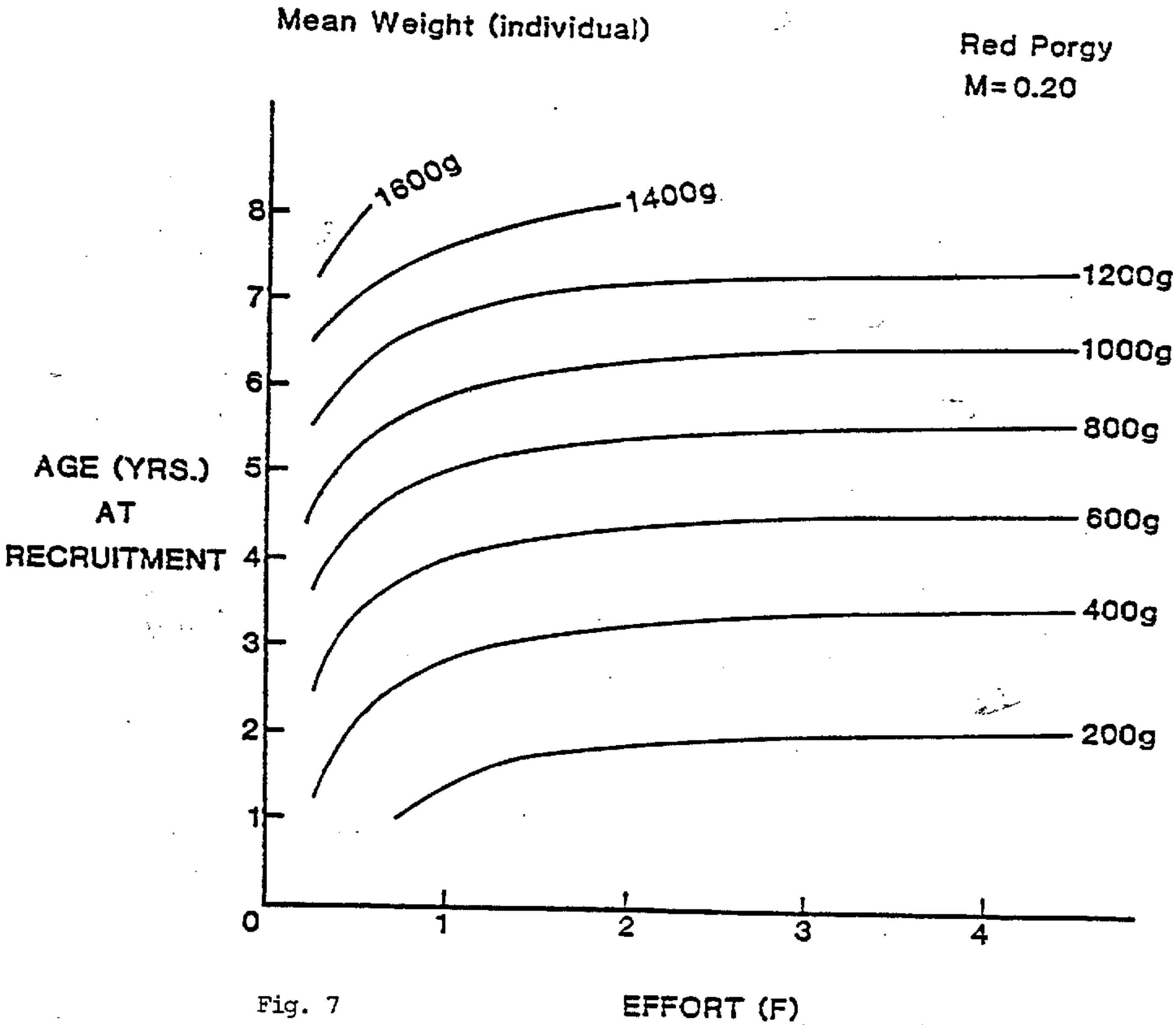

Mean Weight (individual)
Red Porgy
M=0.20
1600g
1400g
1200g
1000g
800g
600g
400g
200g
AGE (YRS.) AT RECRUITMENT
8
7
6
5
4
3
2
1
0
1
2
3
4
EFFORT (F)

Fig. 7

Fig. 8

SIX MODELS COMPARED:

1. BISEXUAL POPULATION, 1.2:1

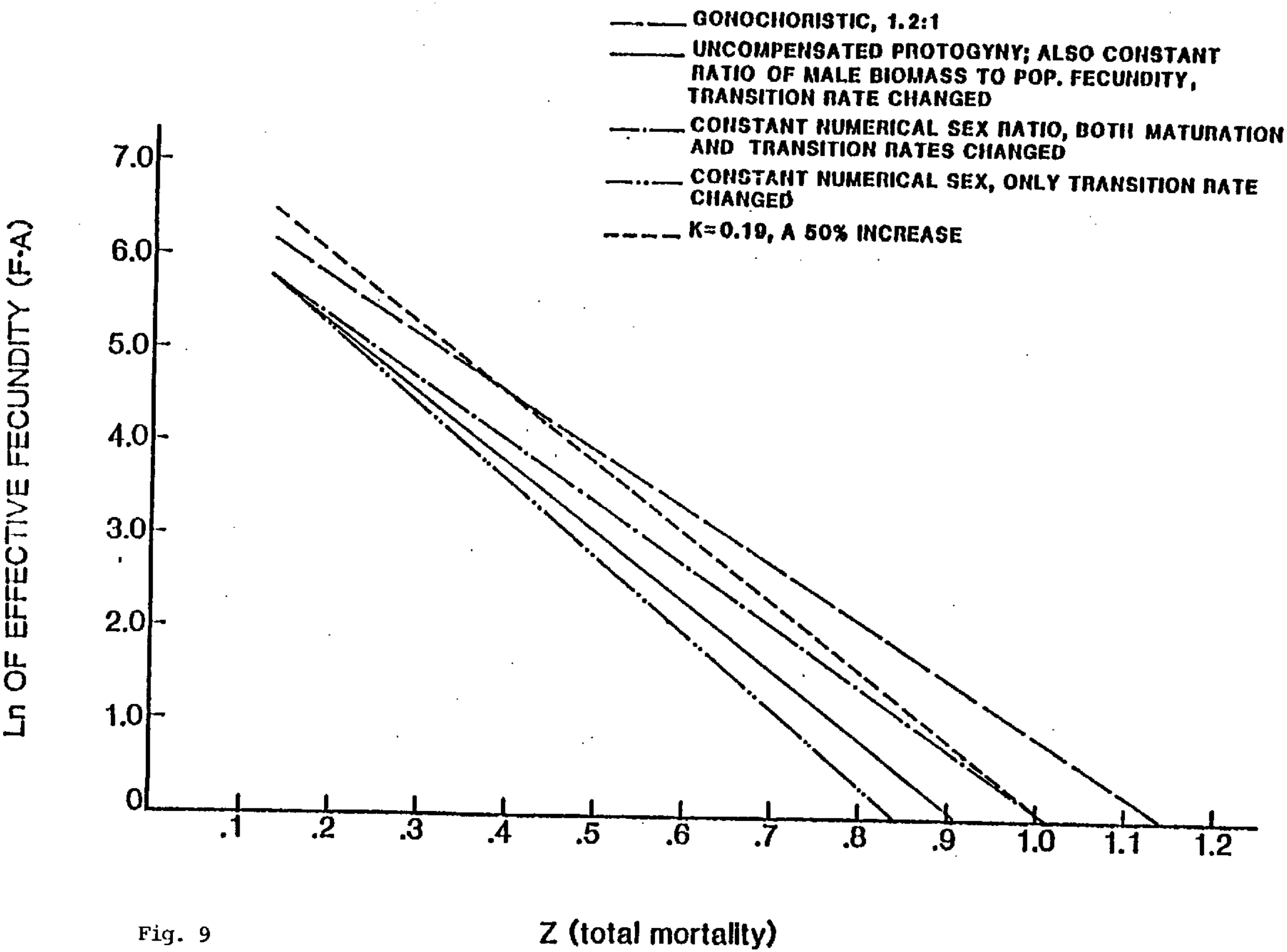
2. UNCOMPENSATED PROTOGYNOUS POPULATION, 1.2:1

3. FOUR TYPES OF COMPENSATED PROTOGYNY:
   a) BOTH MATURATION AND TRANSITION RATES INCREASED TO KEEP NUMERICAL SEX RATIO CONSTANT

   b) ONLY TRANSITION RATE CHANGED TO KEEP NUMERICAL SEX RATIO CONSTANT

   c) ONLY TRANSITION RATE CHANGED TO KEEP RATIO OF MALE BIOMASS TO POPULATION FECUNDITY CONSTANT

   d) THE GROWTH PARAMETER, K, INCREASED



GONOCHORISTIC, 1.2:1
UNCOMPENSATED PROTOGYNY; ALSO CONSTANT RATIO OF MALE BIOMASS TO POP. FECUNDITY, TRANSITION RATE CHANGED
CONSTANT NUMERICAL SEX RATIO, BOTH MATURATION AND TRANSITION RATES CHANGED
CONSTANT NUMERICAL SEX, ONLY TRANSITION RATE CHANGED
K=0.19, A 50% INCREASE
Ln OF EFFECTIVE FECUNDITY (F·A)
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
1.1
1.2
Z (total mortality)

Fig. 9

Graysby

Yield Per Recruit in Weight

Instantaneous Natural Mortality = 0.13

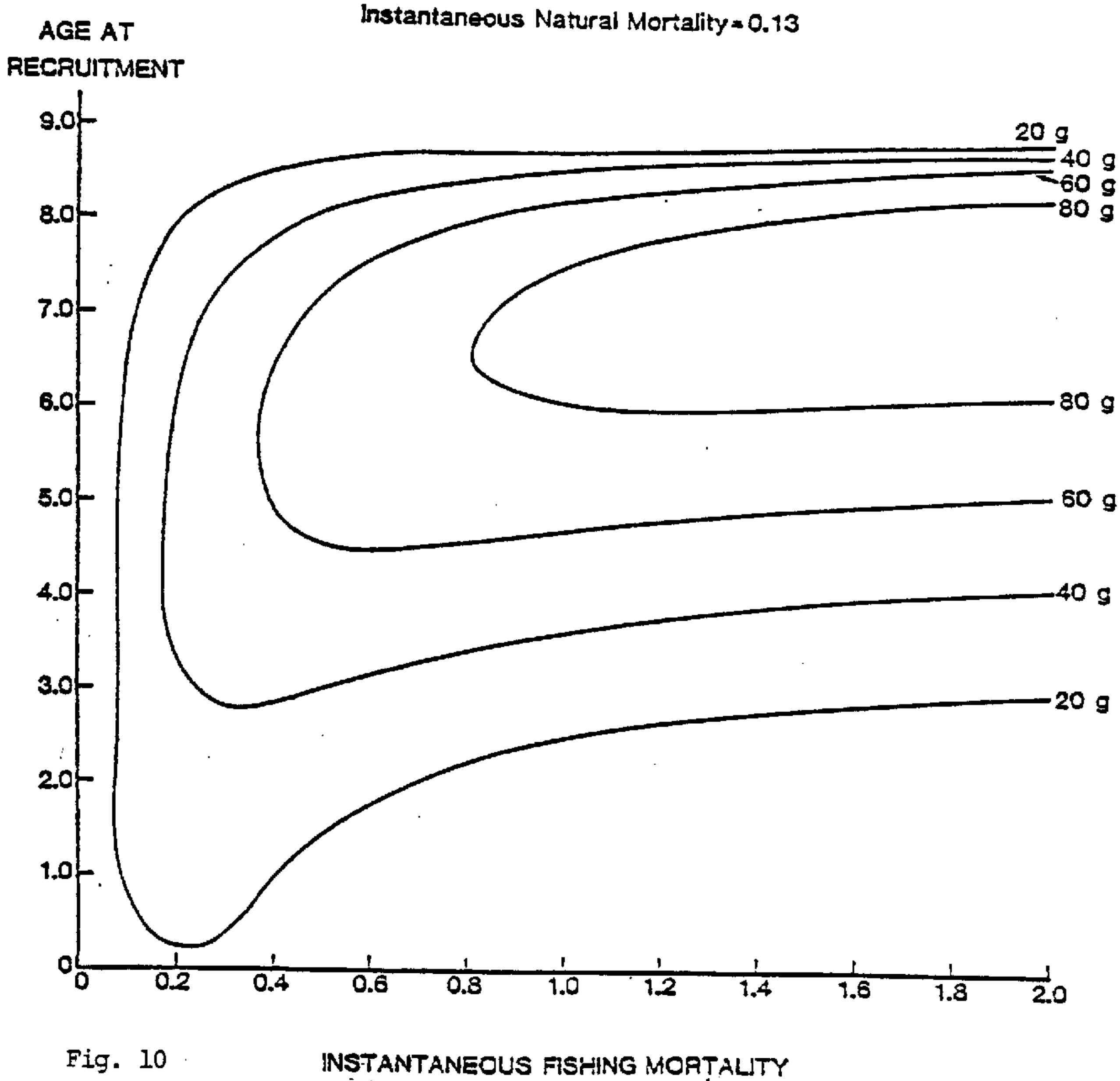


Fig. 10

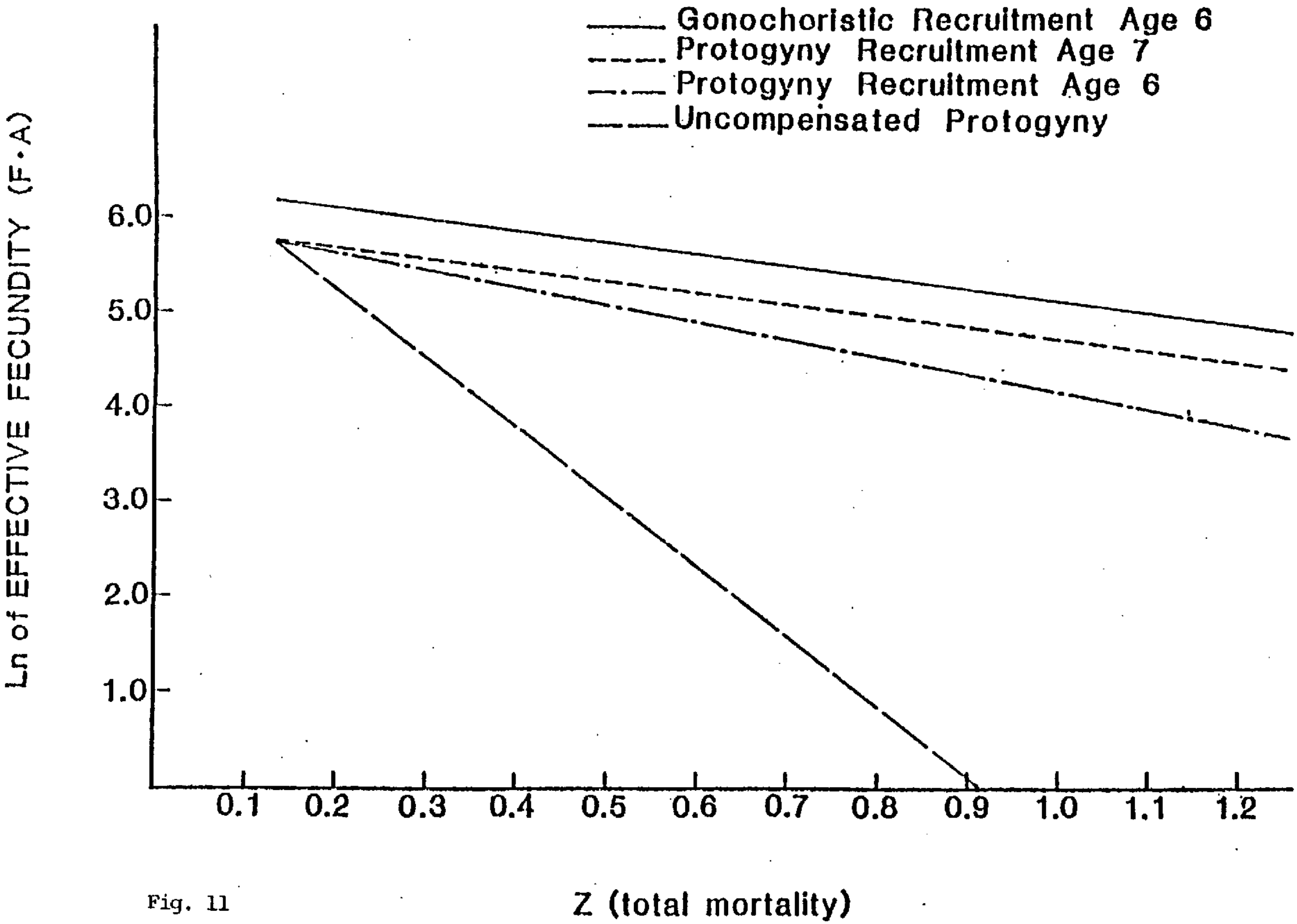

Gonochoristic Recruitment Age 6
Protogyny Recruitment Age 7
Protogyny Recruitment Age 6
Uncompensated Protogyny
Ln of EFFECTIVE FECUNDITY (F·A)
6.0
5.0
4.0
3.0
2.0
1.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
Z (total mortality)

Fig. 11

RED PORGY

YEAR	CATCH W/O POLICY	CATCH W/ POLICY	NET GAIN	ACCUMULATED GAIN
1	364.66	312.46	-52.19	-52.19
2	364.66	331.09	-33.57	-85.76
3	364.66	347.44	-17.22	-102.98
4	364.66	358.33	-6.32	-109.30
5	364.66	365.28	0.62	-108.68
6	364.66	369.57	4.91	-103.77
7	364.66	372.17	7.51	-96.26
8	364.66	373.70	9.05	-87.22
9	364.66	374.60	9.94	-77.27
10	364.66	375.12	10.46	-66.82
11	364.66	375.41	10.75	-56.06
12	364.66	375.57	10.92	-45.15
13	364.66	375.67	11.01	-34.14
14	364.66	375.70	11.05	-23.09
15	364.66	375.71	11.05	-12.04
16	364.66	375.71	11.05	-1.00
17	364.66	375.71	11.05	10.05
18	364.66	375.71	11.05	21.10
19	364.66	375.71	11.05	32.15
20	364.66	375.71	11.05	43.20

STOP IN LINE 2300 PRIOR TO LINE 2520

Fig. 12

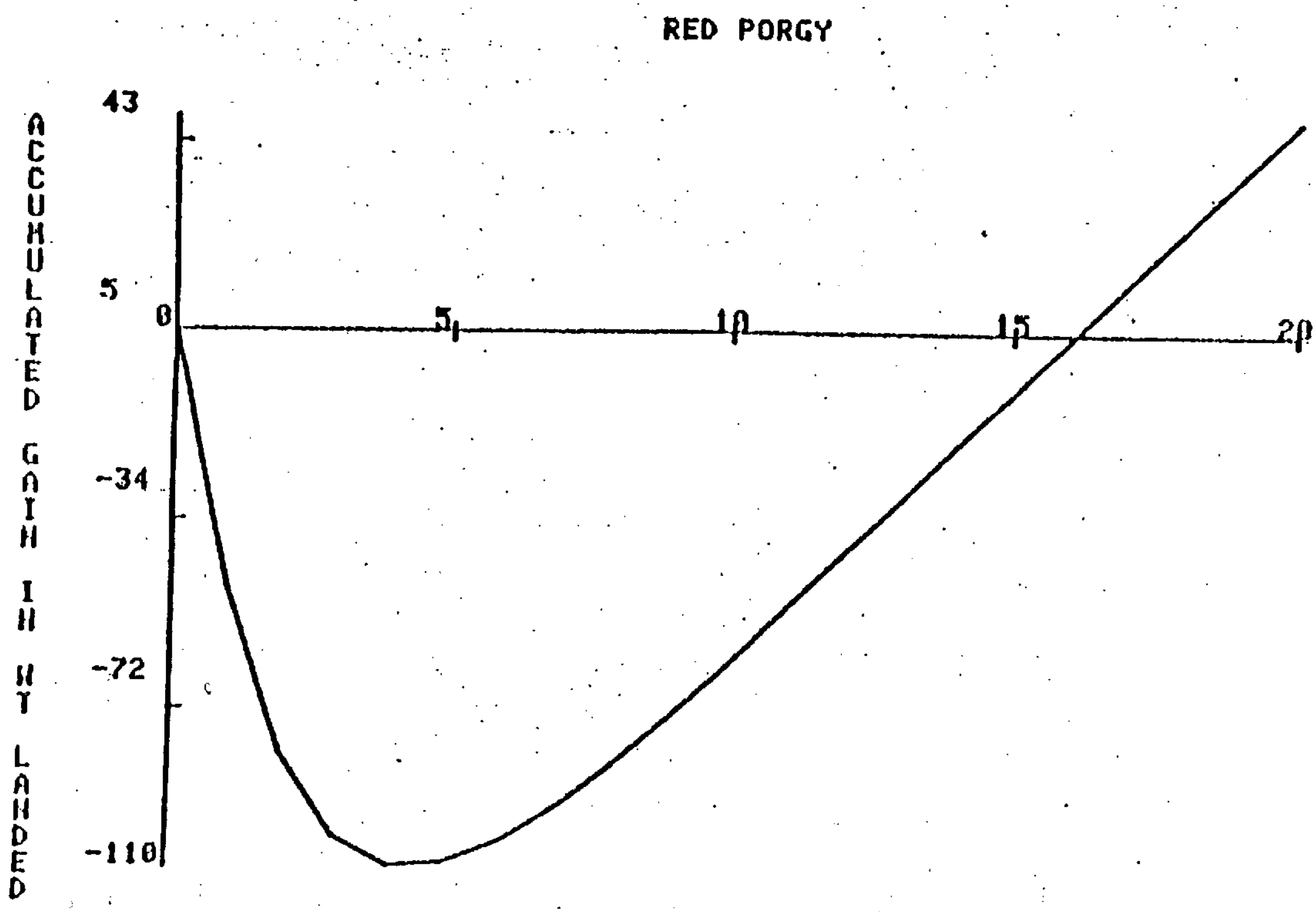

RED PORGY
ACCUMULATED GAIN IN WT LANDED
43
5
0
-34
-72
-110
5
10
15
20
YEARS AFTER BEGINNING NEW POLICY

Fig. 13

APPENDIX C

DYNAMICS OF ESTABLISHING MINIMUM SIZE LIMITS IN THE SOUTH ATLANTIC SNAPPER-GROUPER FISHERY

DRAFT

Dynamics of Establishing Minimum Size Limits in the South Atlantic Snapper-Grouper Fishery

A Summary of
Work Performed for the
South Atlantic Fishery Management Council

James Waters
National Marine Fisheries Service
Southeast Fisheries Center
Beaufort Laboratory
Beaufort, NC 28516

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Abstract

An objective of minimum size limits is to increase biomass landed by harvesting fewer but heavier fish. Biological yield per recruit models adequately predict equilibrium yield per recruit with and without the size limit, but they do not quantify the trade-offs between short run losses and long run gains in yield per recruit during the transition between equilibria. This study quantifies the transition between equilibria and suggests the internal rate of return as a suitable criterion for evaluating the effectiveness of a proposed minimum size limit. In addition, two new variables are introduced into the yield per recruit framework, one representing the probability that undersized fish are caught and released and the other defining the probability that a released fish will survive. Minimum size limits for ten species in the south Atlantic snapper-grouper fishery are evaluated.

Several individuals provided valuable assistance throughout the project and I wish to acknowledge the contributions of each. I thank Bill Schaaf and Gene Huntsman of the National Marine Fisheries Service, Southeast Fisheries Center, Beaufort, N.C., laboratory for bringing the dynamic yield per recruit problem to my attention and for their helpful comments during development of the model. Gene and Chuck Manooch, also of the Beaufort laboratory, assisted in verifying data used in some of the analyses. Bruce Austin of the South Atlantic Fishery Management Council staff suggested the internal rate of return criterion, provided data and encouraged development of the model.
I also thank Beverly Harvey for typing the manuscript and Bill Nicholson for editing it.

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Dynamics of Establishing Minimum Size Limits

The South Atlantic Fishery Management Council advocates minimum size limits as a means of reversing many of the adverse effects of overfishing in the snapper-grouper fishery along the south Atlantic coast. Much of the draft management plan utilizes the concept of yield per recruit (cf. Beverton and Holt 1957, pp. 35-38; Ricker 1975, pp. 235-264) to address problems of growth overfishing in which fish are harvested at too small a size. A minimum size limit postpones the harvest of small fish and increases yield per recruit (Y/R) if growth in weight of those young fish exceeds their mortality. Increasing the minimum legal size may also augment the spawning population and subsequent recruitment,[1] although this expected benefit is not explicity accounted for in Y/R models.

The South Atlantic Council focused on the Y/R model primarily because it has been extensively used in studies of various species in the snapper-grouper fishery (e.g., Huntsman and Manooch 1978; Huntsman, Manooch and Grimes 1983). Results presented in tabular or graphic form illustrate equilibrium Y/R given various combinations of two management parameters: age when fish are first liable to capture and fishing mortality coefficient. Implementation of a minimum size limit corresponds to increasing the age when fish are first liable to capture.

Although it is not often explicitly discussed, biologists recognize that equilibrium Y/R is a long run concept, and that attainment of a new equilibrium is not immediate (Beverton and Holt 1957, pp. 396-404). In the short run, a minimum size limit will reduce total catch by reducing the number of young fish caught, but in the long run, a successful minimum size limit will increase total catch as greater numbers of fish survive to be caught at older ages and heavier

[1] A larger spawning population is expected to increase the size of future year classes, although this outcome may not necessarily occur due to (1) adverse random events in the spawning-recruitment process, (2) population density dependent egg production and (3) environmental carrying capacity constraints.

weights. One shortcoming of the equilibrium Y/R model when applied to the analysis of minimum size limits is that it does not quantify the trade-offs between short run losses and long run gains in Y/R. Moreover, there is no criterion for determining if predicted gains in Y/R are worth incurring the short run losses.

The objective of this study is to quantify the dynamics of establishing minimum size limits for various species in the south Atlantic snapper-grouper complex. The first section of this study describes the core of the dynamic Y/R model, which quantifies the transition between equilibria caused by implementation of a minimum size limit. The second section introduces two new variables into the Y/R framework, one representing the probability that undersized fish are caught and released, and the other defining the probability that a released fish will survive. The third section proposes the internal rate of return as a suitable criterion for evaluating the effectiveness of a proposed minimum size limit. The fourth section presents the results of the dynamic Y/R model applied to ten species in the snapper-grouper complex.

Dynamic Yield Per Recruit Model

The effect of implementing a minimum size limit was studied by simulating the fishery over a 20 year time horizon. During each year, the fish population consisted of I age classes (cohorts), each contributing to total biomass, B. The biomass of each age class, B(i), was defined as the product of the number of survivors in the cohort, N(i), and the average weight per survivor, W(i). Hence

$$B = \sum_{i=a(\rho)}^{I} B(i) = \sum_{i=a(\rho)}^{I} N(i)\, W(i) \qquad (1)$$

In the yield per recruit framework, biomass per recruit is determined by assuming constant recruitment of $N(a(\rho)) = 1$ fish per year.[2] Natural mortality, M, and fishing mortality, F, determined the remaining number of fish in the population.

$$N(i+1) = N(i)e^{-M} \tag{2}$$

for fish younger than age $a(\rho')$, at which age they first become vulnerable to the fishing gear. Similarly,

$$N(i+1) = N(i)e^{-(M+F)} \tag{3}$$

for fish liable to capture. In the likely event that $a(\rho')$ falls between birthdays $a(i)$ and $a(i+1)$, population numbers are defined as

$$N(i+1) = N(i)e^{-M(a(\rho')-a(i))} \; e^{-(M+F)\,(a(i+1)\,-\,a(\rho'))} \tag{4}$$

Hence $N(i)$ for $i = a(\rho) + 1, a(\rho) + 2, \ldots I$ is interpreted as the fraction of the original recruitment that has survived to age $a(i)$.

Over time, the average weight per fish increases according to the von Bertalanffy weight-age relationship.

$$W(a(i)) = W_{max}\left(1-e^{-K(a(i)\,-\,t_o)}\right)^b \tag{5}$$

Variable W_{max} represents the theoretical maximum attainable weight, and parameters K, t_o and b define the rate at which weight asymptotically approaches W_{max}. Beverton and Holt make the convenient assumption that b = 3, which yields, after cubing the expression in parentheses,

$$W(a(i)) = W_{max} \sum_{j=o}^{3} G(j)\, e^{-jk(a(i)-t_o)} \tag{6}$$

[2] Note that ages $a(\rho)$ and $a(\rho')$ correspond to $t\rho$ and $t\rho'$, respectively, in the Beverton-Holt notation. The new notation was adopted to distinguish between calendar time, t, and chronological age, a.

where $G(0) = 1$, $G(1) = -3$, $G(2) = 3$ and $G(3) = -1$. Equation (6) underestimates true weight if b is less than 3, and overestimates true weight if b exceeds 3 (Ricker 1975, p. 256); however, the amount of error caused by assuming $b = 3$ is minor for two reasons. First, the estimated values of b for the species considered here are all relatively close to 3. Second, although there may be errors in calculating weight[3], and hence Y/R, the error in calculating net gain in Y/R (due to implementing a minimum size limit) would be small. Hence the dynamic model uses equation (6) in the Y/R calculations.

Yield per recruit is calculated as the sum over all age classes of biomass landed per recruit

$$Y/R = \sum_{i=a(\rho)}^{I} \int_{a=a(i)}^{a(i+1)} F\, B(a)\, da \tag{7}$$

Parameter F denotes instantaneous fishing mortality; therefore, total catch from age group i is determined as the sum of the instantaneous catches between birthdays a(i) and a(i+1). Substituting (6) into (7) and integrating yields an expression for catch in biomass per recruit. Assume $Z = F + M$.

$$Y/R = \sum_{i=a(\rho')}^{I} F\, W_{max}\, N(a(i)) \sum_{j=o}^{3} \frac{G(j)e^{-jK(a(i)-t_o)}}{(Z+jK)} \left(1-e^{-(Z+jK)(a(i+1)-a(i))}\right) \tag{8}$$

Beverton and Holt note that in equilibrium, the age structure of the population remains unchanged over time. Therefore, yield in biomass from the entire population is equivalent to the yield from a single cohort during its lifetime.

---

3 Most empirical studies do not directly estimate the parameters of equation (5). Instead, they estimate a length-age relationship

$$L(a(i)) = L_{max}\left(1-e^{-K(a(i)-t_o)}\right)$$

and a weight-length curve

$$W(a(i)) = b_o\, L(a(i))^b$$

Since L_{max} is estimated, much of the potential error that would be caused by assuming $b = 3$ is mitigated by calculating $W_{max} = b_o\, L_{max}^b$.

$$Y/R = N(1)e^{-M(a(\rho')-a(1))} \int_{a=a(\rho')}^{a(I+1)} F\, e^{-(M+F)(a-a(\rho'))}\, W(a)\, da \qquad (9)$$

Substituting (6) into (9) and integrating produces the Beverton and Holt equation for equilibrium Y/R[4]. The dynamic model was verified to be computationally correct by comparing equilibrium Y/R with and without minimum size limits as calculated by the dynamic (8) and Beverton and Holt (9) models.

Fisherman Compliance and the Survival of Released Fish

Although it is illegal for fishermen to keep them, some undersized fish are likely to be caught. Therefore, success of the minimum size limit depends on fishermen's cooperation in releasing undersized fish and the survival of released fish.

The free rider theorem explains why fishermen may fail to release undersized fish, even if they had not intended to catch them. A free rider is one who fails to participate when a collectively beneficial agreement is not strictly enforced (Stigler 1974). With special reference to the fishery, the benefit of releasing undersized fish is the increased chance that the quantity and quality of the catch will be enhanced in the long run. However, the individual fisherman can increase his short run utility, with negligible effect on the long run management objective, by keeping his entire catch, provided that all other fishermen abide by the minimum size regulation. But if a significant proportion of fishermen, all acting independently, ignore the minimum size limit, the policy is destined to fail.

The dynamic Y/R model considers the rate of fisherman compliance by introducing a new variable, P_{rele}, that represents the probability that an

---

4

$$Y/R = F\, W_{max} N(1)e^{-M(a(\rho')-a(i))} \sum_{j=o}^{3} \frac{G(j)e^{-jK(a(\rho')-t_o)}}{(Z+jK)} \left(1-e^{-(Z+jK)(a(I+1)-a(\rho'))}\right)$$

undersized fish is released. Then fishing mortality for small fish, F_s, with the minimum size limit is

$$F_s = F\ (1 - P_{rele}) \qquad (10)$$

where F denotes the probability of catching an undersized fish. For simplicity F is the same whether or not a minimum size limit is imposed. According to (10), when $P_{rele} = 0$, fishermen keep all undersized fish and fishing mortality is the same as without the minimum size limit; when $P_{rele} = 1.0$, fishermen fully comply with the regulation.

Fish are often injured during capture and may not survive if released. Deep water fish, for example, often suffer damage from gas expansion as they rise to the surface. Therefore, natural mortality for undersized fish, M_s, was increased to account for those fish that die if caught and released.

$$M_s = M + F\ P_{rele}\ (1 - P_{surv}) \qquad (11)$$

where P_{surv} represents the probability of survival. Total mortality of undersized fish with the minimum size limit

$$M_s + F_s = M + F\ (1 - P_{rele}\ P_{surv}) \qquad (12)$$

is lower than without it by the amount $F\ P_{rele}\ P_{surv}$, which represents the probability that undersized fish survive if incidentally caught and released. When $P_{rele} = P_{surv} = 1.0$, total mortality for small fish is reduced from M + F to M when the minimum size limit is implemented and the policy enjoys its maximum effectiveness. The Beverton and Holt Y/R model assumes P_{rele} and $P_{surv} = 1.0$.

Fishermen who catch undersized fish reduce the potential effectiveness of a minimum size limit by reducing the number of small fish that live to older ages. In the extreme case where no one complies with the regulation (i.e., $P_{rele} = 0$), Y/R is the same as it would be if there were no size limit. A minimum size limit may succeed if fishermen who keep illegal fish are caught and fined. The higher the expected cost of committing a violation, the less likely it is that undersized fish will be kept. Two factors influence the expected cost of keeping undersized fish: the probability of being caught, which depends on the diligence of the enforcement agency, and the amount of the fine.

A potentially more serious problem arises when some released fish do not survive (i.e. $P_{surv} < 1$). Landings of small fish would decline since they would no longer be kept, but the eventual increase in landings of large fish would be less than maximum. In fact, equilibrium Y/R could be reduced. A minimum size limit would be inadvisable if the probability were low that released fish would survive.

Criterion for Evaluating Proposed Minimum Size Limits

The dynamic analysis describes the transition between population equilibria caused by implementing a minimum size limit. The immediate effect is to reduce catches from each cohort with members smaller than the minimum size. Moreover, these short run losses are incurred each year as the size limit continues to save young fish that otherwise would have been caught and landed. Therefore, Y/R initially declines as fewer young fish are caught and catches of older fish remain unchanged. Over time, Y/R gradually increases from its initial low level as the minimum size limit allows greater numbers of young fish to survive and augment population numbers of the older age classes. Eventually all age classes increase in numbers and a new equilibrium is established. The transition requires the same number of years as there are age classes in the fishable population, assuming constant recruitment.

Equilibrium Y/R increases if future landings of older fish exceed the reduced catches of younger fish. However, identification of a minimum size that increases equilibrium Y/R is not sufficient justification for its adoption. Fishery managers need criteria to evaluate the timing and magnitude of losses and gains in Y/R during the transition between equilibria. For example, any net gain in equilibrium Y/R, no matter how small, will eventually offset the short run losses incurred. However, to be warranted, the minimum size limit should generate gains that offset short run losses within a reasonable period of time. The internal rate of return is proposed as a suitable criterion[5] for evaluation of the dynamic trade-offs between short run losses and long run gains in Y/R.

The success or failure of a minimum size limit is attributable to the natural rate of change in fish biomass. Postponement of the harvest of young fish attempts to take advantage of their high natural rate of growth so that future harvests are greater than without the minimum size limit. A natural rate of growth in biomass, g, implies that 1 kg of fish will grow (via growth in weight minus natural mortality) to 1+g Kg in one year. One could also say that 1 Kg of fish one year hence would be produced from $1/(1+g)^{-1}$ Kg of fish today. Similarly, 1 Kg of fish two years hence would be equivalent to $1/(1+g)^{-2}$ Kg today where g is now interpreted as an average annual growth rate. Finally, by extension of this principle, 1 Kg of fish t years hence would be equivalent to $1/(1+g)^{-t}$ Kg today. In the evaluation of minimum size limits, the internal rate of return (IRR) is interpreted as the average annual rate of growth in Y/R, and is calculated to account for the timing and magnitude of losses and gains in Y/R

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[5] From a theoretical perspective, the present value criterion is generally preferred over the internal rate of return criterion. However, the two criteria yield identical results in this application because there is only one sign change in the time sequence of net gains (or losses) in yield per recruit (Hirshleifer 1970, pp. 51-81).

over a 20 year time horizon. The IRR is defined such that (14) is satified.

$$0 = \sum_{t=1}^{20} \frac{NG(t)}{(1+IRR)^{-t}} \tag{14}$$

where NG(t) represents net gain (or loss) in Y/R during year t. In general, the IRR will indicate a high average rate of growth in biomass for species for which positive gains appear relatively early in the sequence of NG(t), and which exhibit large long run gains relative to the magnitude of short run losses.

The IRR criterion predicts that fishery managers are justified[6] in implementing minimum size limits if the IRR exceeds some predetermined minimum acceptable average annual rate of growth in Y/R. The South Atlantic Council chose 3 percent as its minimum acceptable rate of growth[7]. Thus, it is worthwhile to incur short run reductions in Y/R if the anticipated future gains generate an IRR of at least 3 percent. It is emphasized that the IRR criterion cannot be used to rank alternative size limits.[8] The IRR criterion merely states that a proposed minimum size limit is justified if the average annual rate of growth in Y/R satisfies the minimum acceptable growth rate.

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[6] Fishery managers are justified in implementing a minimum size limit policy only with respect to the objective of increasing Y/R. There may also be other management objectives to be considered.

[7] The choice of the minimum acceptable rate of growth is not trivial. If the specified minimum growth rate is relatively high, future gains in Y/R are heavily discounted and the evaluation process favors policies with a fast payoff. On the other hand, if the specified minimum growth rate is relatively low, future gains are not heavily discounted. Hence policies based on a low acceptable growth rate will be conservative, i.e. short run costs will be relatively unimportant. The Council's choice of 3 percent would be considered to be relatively low.

[8] For technical reasons, fishery managers cannot determine the "best" minimum size limit by maximizing IRR. It is stated without proof that the IRR increases as the proposed minimum size limit approaches the unregulated size at which fish are first captured. But since relatively small size limits have little effect on the age structure of the population, they may not be the "best" size limits. Fishery managers may prefer to consider larger minimum sizes, which would have a greater effect on the fish stock, subject to the restriction that the IRR exceeds the minimum acceptable average annual rate of growth in Y/R.

The IRR criterion explains, in part, why fishermen overexploit fishery resources. Most species are common property because it is too costly to exclude others from fishing in a particular fishing ground (Cheung, 1970). Therefore, no one will voluntarily conserve fish for future harvest because the fish he saves will probably be harvested by a competing fisherman. As a result, the IRR realized by fishermen who unilaterally conserve fish is zero; hence unilateral conservation efforts are rarely undertaken.

The Applied Model

The dynamic yield per recruit model was used to evaluate minimum size limits for 10 species (Table 1) in the south Atlantic snapper-grouper fishery. Species and size limits were chosen because biological data are available, and because these species are prominent in recreational and commercial catches. This section presents preliminary results; additional analyses will probably be suggested before the snapper-grouper management plan can be implemented.

A number of analyses using the dynamic Y/R model were performed for each species. In this study relevant growth and mortality data obtained from the South Atlantic Council staff are used in one example for each species. Harvesting situations chosen for analysis correspond to best available estimates of current fishing mortality rates. Each analysis assumes that all fishermen fully comply with the minimum size limits, $P_{rele} = 1.0$, since they would incur a substantial penalty if caught in violation of a regulation. In addition, since little was known about the survival of released fish, it was arbitrarily specified that for a size limit to be considered, the IRR must exceed 3 percent with an assumed survival rate of at least 60-70 percent. Finally, minimum size limits were assumed to be implemented in one step; policies which would gradually approach the desired minimum size were not evaluated, although they may be considered in future analyses.

Table 1. Species for which minimum size limits were evaluated.

Species		Minimum size[a]
Vermilion snapper	R. aurorubens	12 inches
Red snapper	L. campechanus	12
Gray snapper	L. griseus	8
Yellowtail snapper	O. chrysurus	10
Black sea bass	C. striata	8
Speckled hind	E. drummondhayi	18
Red grouper	E. morio	12
Scamp	M. phenax	14
Gag	M. microlepis	18
Red porgy	P. pagrus	14

[a] Minimum size limits were proposed for vermilion snapper (four inch stretch mesh for trawls, no minimum size for hook and line), red snapper, black sea bass and red grouper.

Evaluation of proposed minimum size limits focused on the net gain in Y/R. Hence the key output from the dynamic analyses (Tables 2-11) include Y/R for harvesting strategies without (column 2) and with (column 3) the suggested size limit. Net gain in Y/R (column 4) represents the data used to calculate the internal rate of return. In addition, the accumulated net gain in Y/R (column 5) identifies the payback period, defined as the amount of time required for long run gains to exactly offset short run losses. Payback is achieved when the entries in column 5 switch in sign from negative to positive. The remaining columns provide additional information about average weight per fish landed without (column 6) and with (column 7) the size limit, and the fraction of each recruit landed (columns 8,9). This information (columns 6-9) defines the trade-off between average weight per fish and the number of fish landed required to achieve the eventual increase in equilibrium Y/R. Most of the suggested minimum size limits would result in a relatively large increase in the average weight of fish landed and a large decrease in the number of fish landed. In general, minimum size limits will be actively encouraged by fishermen who prefer to catch fewer but heavier fish rather than a large number of small fish.

As discussed earlier, implemention of a minimum size limit initially decreases Y/R while benefits accrue gradually as the population rebuilds to its new equilibrium level. The dynamic analyses indicate that net gains in Y/R appear within 4-7 years after implementing the size limit (Tables 2-11). The payback period ranges from 9 years for yellowtail snapper (Table 5) to considerably greater than 20 years for black sea bass (Table 10) and red porgy (Table 11). Recall, however, that Tables 2-11 were compiled by assuming arbitrary values for P_{surv}. The actual outcome of a minimum size limit policy would be more favorable if the true value for P_{surv} exceeds the assumed value, but less favorable if P_{surv} is less than the assumed value.

Table 2. Dynamic yield per recruit analysis for vermilion snapper with a 12 inch minimum size limit

VERMILION SNAPPER

YEAR	YIELD/RECRUIT IN GRAMS W/O S-L	W/ S-L	NET GAIN	ACC GAIN	AVE WT/FISH IN GMS W/O S-L	W/ S-L	NO. CAUGHT/RECRUIT W/O S-L	W/ S-L
1	132.37	86.96	-45.41	-45.41	279.43	673.99	0.4737	0.1290
2	132.37	96.52	-35.85	-81.26	279.43	642.66	0.4737	0.1502
3	132.37	112.77	-19.60	-100.87	279.43	626.68	0.4737	0.1799
4	132.37	128.13	-4.24	-105.11	279.43	636.20	0.4737	0.2014
5	132.37	138.82	6.45	-98.66	279.43	653.65	0.4737	0.2124
6	132.37	145.72	13.35	-85.31	279.43	668.46	0.4737	0.2180
7	132.37	149.94	17.57	-67.74	279.43	678.88	0.4737	0.2209
8	132.37	152.18	19.81	-47.93	279.43	684.85	0.4737	0.2222
9	132.37	152.86	20.49	-27.44	279.43	686.71	0.4737	0.2226
10	132.37	152.86	20.49	-6.96	279.43	686.71	0.4737	0.2226
11	132.37	152.86	20.49	13.53	279.43	686.71	0.4737	0.2226
12	132.37	152.86	20.49	34.02	279.43	686.71	0.4737	0.2226
13	132.37	152.86	20.49	54.50	279.43	686.71	0.4737	0.2226
14	132.37	152.86	20.49	74.99	279.43	686.71	0.4737	0.2226
15	132.37	152.86	20.49	95.48	279.43	686.71	0.4737	0.2226
16	132.37	152.86	20.49	115.96	279.43	686.71	0.4737	0.2226
17	132.37	152.86	20.49	136.45	279.43	686.71	0.4737	0.2226
18	132.37	152.86	20.49	156.94	279.43	686.71	0.4737	0.2226
19	132.37	152.86	20.49	177.43	279.43	686.71	0.4737	0.2226
20	132.37	152.86	20.49	197.91	279.43	686.71	0.4737	0.2226

MORTALITY PARAMETERS

W/O S-L	NAT MORT = 0.300	FISH MORT = 0.370
W/ S-L	NAT MORT = 0.374	FISH MORT = 0.000
	P(RELE) = 1.000	P(SURV) = 0.800

GROWTH PARAMETERS

LENGTH	LMAX = 626.50	K = 0.1960	T0 = 0.12770
WEIGHT	B1 = 2.9456	B0 = 0.000017220	

AGE (IN YEARS) PARAMETERS

AGE AT ENTRY TO FISHING GROUNDS	= 1.000	(99.4 MM,	13.2 GMS)
AGE WHEN FIRST LIABLE TO CAPTURE	= 1.500	(149.1 MM,	43.4 GMS)
MAXIMUM AGE IN FISHERY	= 10.000	(537.8 MM,	1902.4 GMS)

MINIMUM SIZE LIMIT = 304.80 MM (12.0 INCHES, 357.2 GMS)

INTERNAL RATE OF RETURN FOR Y/R = 10.7959 PERCENT

Table 3. Dynamic yield per recruit analysis for red snapper with a 12 inch minimum size limit

RED SNAPPER

YEAR	YIELD/RECRUIT IN GRAMS W/O S-L	W/ S-L	NET GAIN	ACC GAIN	AVE WT/FISH IN GMS W/O S-L	W/ S-L	NO. CAUGHT/RECRUIT W/O S-L	W/ S-L
1	501.35	481.21	-20.14	-20.14	1356.07	1566.12	0.3697	0.3073
2	501.35	487.32	-14.02	-34.16	1356.07	1556.58	0.3697	0.3131
3	501.35	493.11	-8.24	-42.40	1356.07	1559.17	0.3697	0.3163
4	501.35	497.84	-3.51	-45.91	1356.07	1565.46	0.3697	0.3180
5	501.35	501.36	0.01	-45.90	1356.07	1571.75	0.3697	0.3190
6	501.35	503.80	2.45	-43.45	1356.07	1576.80	0.3697	0.3195
7	501.35	505.42	4.07	-39.38	1356.07	1580.43	0.3697	0.3198
8	501.35	506.45	5.10	-34.27	1356.07	1582.87	0.3697	0.3200
9	501.35	507.10	5.75	-28.53	1356.07	1584.45	0.3697	0.3200
10	501.35	507.49	6.14	-22.39	1356.07	1585.43	0.3697	0.3201
11	501.35	507.72	6.37	-16.02	1356.07	1586.02	0.3697	0.3201
12	501.35	507.86	6.51	-9.51	1356.07	1586.38	0.3697	0.3201
13	501.35	507.94	6.59	-2.92	1356.07	1586.59	0.3697	0.3201
14	501.35	507.98	6.63	3.71	1356.07	1586.71	0.3697	0.3201
15	501.35	507.98	6.63	10.35	1356.07	1586.71	0.3697	0.3201
16	501.35	507.98	6.63	16.98	1356.07	1586.71	0.3697	0.3201
17	501.35	507.98	6.63	23.61	1356.07	1586.71	0.3697	0.3201
18	501.35	507.98	6.63	30.25	1356.07	1586.71	0.3697	0.3201
19	501.35	507.98	6.63	36.88	1356.07	1586.71	0.3697	0.3201
20	501.35	507.98	6.63	43.52	1356.07	1586.71	0.3697	0.3201

MORTALITY PARAMETERS
W/O S-L NAT MORT = 0.300 FISH MORT = 0.299
W/ S-L NAT MORT = 0.420 FISH MORT = 0.000
P(RELE) = 1.000 P(SURV) = 0.600

GROWTH PARAMETERS
LENGTH LMAX = 975.00 K = 0.1600 T0 = 0.00000
WEIGHT B1 = 2.9530 B0 = 0.000020400

AGE (IN YEARS) PARAMETERS
AGE AT ENTRY TO FISHING GROUNDS = 1.000 (144.2 MM, 48.4 GMS)
AGE WHEN FIRST LIABLE TO CAPTURE = 2.000 (267.0 MM, 298.6 GMS)
MAXIMUM AGE IN FISHERY = 16.000 (899.6 MM, 10788.9 GMS)

MINIMUM SIZE LIMIT = 304.80 MM (12.0 INCHES, 441.5 GMS)

INTERNAL RATE OF RETURN FOR Y/R = 6.0586 PERCENT

Table 4. Dynamic yield per recruit analysis for gray snapper with an 8 inch minimum size limit

GRAY SNAPPER

YEAR	YIELD/RECRUIT IN GRAMS W/O S-L	W/ S-L	NET GAIN	ACC GAIN	AVE WT/FISH IN GMS W/O S-L	W/ S-L	NO. CAUGHT/RECRUIT W/O S-L	W/ S-L
1	141.45	126.33	-15.12	-15.12	250.53	345.06	0.5646	0.3661
2	141.45	131.24	-10.20	-25.32	250.53	336.28	0.5646	0.3903
3	141.45	135.68	-5.77	-31.09	250.53	337.16	0.5646	0.4024
4	141.45	139.18	-2.27	-33.36	250.53	340.70	0.5646	0.4085
5	141.45	141.71	0.26	-33.10	250.53	344.31	0.5646	0.4116
6	141.45	143.42	1.97	-31.12	250.53	347.17	0.5646	0.4131
7	141.45	144.52	3.07	-28.05	250.53	349.18	0.5646	0.4139
8	141.45	145.20	3.75	-24.30	250.53	350.50	0.5646	0.4143
9	141.45	145.61	4.16	-20.13	250.53	351.33	0.5646	0.4145
10	141.45	145.85	4.41	-15.73	250.53	351.83	0.5646	0.4146
11	141.45	145.99	4.55	-11.18	250.53	352.12	0.5646	0.4146
12	141.45	146.07	4.62	-6.56	250.53	352.29	0.5646	0.4146
13	141.45	146.12	4.67	-1.89	250.53	352.39	0.5646	0.4146
14	141.45	146.14	4.69	2.80	250.53	352.44	0.5646	0.4147
15	141.45	146.15	4.71	7.51	250.53	352.47	0.5646	0.4147
16	141.45	146.16	4.71	12.22	250.53	352.48	0.5646	0.4147
17	141.45	146.16	4.72	16.94	250.53	352.49	0.5646	0.4147
18	141.45	146.17	4.72	21.66	250.53	352.50	0.5646	0.4147
19	141.45	146.17	4.72	26.38	250.53	352.50	0.5646	0.4147
20	141.45	146.17	4.72	31.10	250.53	352.50	0.5646	0.4147
21	141.45	146.17	4.72	35.82	250.53	352.50	0.5646	0.4147

MORTALITY PARAMETERS
W/O S-L NAT MORT = 0.300 FISH MORT = 0.389
W/ S-L NAT MORT = 0.456 FISH MORT = 0.000
P(RELE) = 1.000 P(SURV) = 0.600

GROWTH PARAMETERS
LENGTH LMAX = 890.00 K = 0.0878 TO = -1.27450
WEIGHT B1 = 2.9122 B0 = 0.000024000

AGE (IN YEARS) PARAMETERS
AGE AT ENTRY TO FISHING GROUNDS = 1.000 (161.1 MM, 64.2 GMS)
AGE WHEN FIRST LIABLE TO CAPTURE = 1.000 (161.1 MM, 64.2 GMS)
MAXIMUM AGE IN FISHERY = 21.000 (764.1 MM, 5977.4 GMS)

MINIMUM SIZE LIMIT = 203.20 MM (8.0 INCHES, 126.3 GMS)

INTERNAL RATE OF RETURN FOR Y/R = 6.4453 PERCENT

Table 5. Dynamic yield per recruit analysis for yellowtail snapper with a 12 inch minimum size limit

YELLOWTAIL SNAPPER

YEAR	YIELD/RECRUIT IN GRAMS W/O S-L	W/ S-L	NET GAIN	ACC GAIN	AVE WT/FISH IN GMS W/O S-L	W/ S-L	NO. CAUGHT/RECRUIT W/O S-L	W/ S-L
1	335.87	266.54	-69.34	-69.34	489.47	838.58	0.6862	0.3178
2	335.87	290.59	-45.29	-114.62	489.47	801.96	0.6862	0.3623
3	335.87	318.83	-17.04	-131.66	489.47	802.26	0.6862	0.3974
4	335.87	339.08	3.21	-128.46	489.47	817.38	0.6862	0.4148
5	335.87	352.00	16.12	-112.34	489.47	831.18	0.6862	0.4235
6	335.87	359.64	23.76	-88.57	489.47	840.69	0.6862	0.4278
7	335.87	363.94	28.06	-60.51	489.47	846.52	0.6862	0.4299
8	335.87	366.27	30.40	-30.11	489.47	849.87	0.6862	0.4310
9	335.87	367.52	31.64	1.53	489.47	851.71	0.6862	0.4315
10	335.87	368.16	32.29	33.82	489.47	852.69	0.6862	0.4318
11	335.87	368.50	32.62	66.44	489.47	853.21	0.6862	0.4319
12	335.87	368.67	32.79	99.23	489.47	853.47	0.6862	0.4320
13	335.87	368.74	32.87	132.09	489.47	853.59	0.6862	0.4320
14	335.87	368.75	32.88	164.97	489.47	853.61	0.6862	0.4320
15	335.87	368.75	32.88	197.84	489.47	853.61	0.6862	0.4320
16	335.87	368.75	32.88	230.72	489.47	853.61	0.6862	0.4320
17	335.87	368.75	32.88	263.60	489.47	853.61	0.6862	0.4320
18	335.87	368.75	32.88	296.47	489.47	853.61	0.6862	0.4320
19	335.87	368.75	32.88	329.35	489.47	853.61	0.6862	0.4320
20	335.87	368.75	32.88	362.22	489.47	853.61	0.6862	0.4320

MORTALITY PARAMETERS
W/O S-L NAT MORT = 0.200 FISH MORT = 0.500
W/ S-L NAT MORT = 0.400 FISH MORT = 0.000
P(RELE) = 1.000 P(SURV) = 0.600

GROWTH PARAMETERS
LENGTH LMAX = 600.20 K = 0.2880 T0 = -0.30500
WEIGHT B1 = 2.7600 B0 = 0.000061300

AGE (IN YEARS) PARAMETERS
AGE AT ENTRY TO FISHING GROUNDS = 0.800 (163.6 MM, 79.0 GMS)
AGE WHEN FIRST LIABLE TO CAPTURE = 1.000 (188.0 MM, 116.0 GMS)
MAXIMUM AGE IN FISHERY = 14.000 (590.4 MM, 2728.5 GMS)

MINIMUM SIZE LIMIT = 304.80 MM (12.0 INCHES, 439.9 GMS)

INTERNAL RATE OF RETURN FOR Y/R = 14.0508 PERCENT

Table 6. Dynamic yield per recruit analysis for red grouper with a 12 inch minimum size limit

RED GROUPER

YEAR	YIELD/RECRUIT IN GRAMS W/O S-L	W/ S-L	NET GAIN	ACC GAIN	AVE WT/FISH IN GMS W/O S-L	W/ S-L	NO. CAUGHT/RECRUIT W/O S-L	W/ S-L
1	233.00	188.29	-44.71	-44.71	366.14	704.57	0.6364	0.2672
2	233.00	197.29	-35.71	-80.41	366.14	673.93	0.6364	0.2927
3	233.00	212.20	-20.80	-101.21	366.14	655.20	0.6364	0.3239
4	233.00	225.43	-7.57	-108.78	366.14	659.49	0.6364	0.3418
5	233.00	236.15	3.15	-105.63	366.14	670.54	0.6364	0.3522
6	233.00	244.29	11.30	-94.33	366.14	682.09	0.6364	0.3582
7	233.00	250.19	17.19	-77.14	366.14	691.89	0.6364	0.3616
8	233.00	254.29	21.30	-55.84	366.14	699.39	0.6364	0.3636
9	233.00	257.07	24.08	-31.77	366.14	704.81	0.6364	0.3647
10	233.00	258.91	25.91	-5.85	366.14	708.56	0.6364	0.3654
11	233.00	260.10	27.10	21.25	366.14	711.07	0.6364	0.3658
12	233.00	260.86	27.86	49.11	366.14	712.72	0.6364	0.3660
13	233.00	261.33	28.34	77.45	366.14	713.77	0.6364	0.3661
14	233.00	261.63	28.64	106.08	366.14	714.44	0.6364	0.3662
15	233.00	261.81	28.82	134.90	366.14	714.86	0.6364	0.3662
16	233.00	261.93	28.93	163.83	366.14	715.12	0.6364	0.3663
17	233.00	261.99	29.00	192.83	366.14	715.28	0.6364	0.3663
18	233.00	262.04	29.04	221.87	366.14	715.37	0.6364	0.3663
19	233.00	262.06	29.06	250.93	366.14	715.43	0.6364	0.3663
20	233.00	262.07	29.08	280.01	366.14	715.46	0.6364	0.3663
21	233.00	262.08	29.09	309.10	366.14	715.49	0.6364	0.3663
22	233.00	262.09	29.09	338.19	366.14	715.50	0.6364	0.3663
23	233.00	262.09	29.09	367.29	366.14	715.50	0.6364	0.3663
24	233.00	262.09	29.09	396.38	366.14	715.50	0.6364	0.3663
25	233.00	262.09	29.09	425.48	366.14	715.50	0.6364	0.3663

MORTALITY PARAMETERS
W/O S-L NAT MORT = 0.200 FISH MORT = 0.350
W/ S-L NAT MORT = 0.340 FISH MORT = 0.000
P(RELE) = 1.000 P(SURV) = 0.600

GROWTH PARAMETERS
LENGTH LMAX = 928.00 K = 0.1127 T0 = 0.09052
WEIGHT B1 = 2.5895 B0 = 0.000147910

AGE (IN YEARS) PARAMETERS
AGE AT ENTRY TO FISHING GROUNDS = 2.000 (179.6 MM, 101.8 GMS)
AGE WHEN FIRST LIABLE TO CAPTURE = 2.000 (179.6 MM, 101.8 GMS)
MAXIMUM AGE IN FISHERY = 25.000 (871.9 MM, 6086.7 GMS)

MINIMUM SIZE LIMIT = 304.80 MM (12.0 INCHES, 400.3 GMS)

INTERNAL RATE OF RETURN FOR Y/R = 13.6802 PERCENT

Table 7. Dynamic yield per recruit analysis for gag with an 18 inch minimum size limit

GAG

YEAR	YIELD/RECRUIT IN GRAMS W/O S-L	W/ S-L	NET GAIN	ACC GAIN	AVE WT/FISH IN GMS W/O S-L	W/ S-L	NO. CAUGHT/RECRUIT W/O S-L	W/ S-L
1	650.05	500.15	-149.90	-149.90	1514.17	2781.54	0.4293	0.1798
2	650.05	527.39	-122.66	-272.55	1514.17	2664.58	0.4293	0.1979
3	650.05	567.33	-82.72	-355.28	1514.17	2600.08	0.4293	0.2182
4	650.05	600.81	-49.24	-404.52	1514.17	2619.83	0.4293	0.2293
5	650.05	626.44	-23.61	-428.13	1514.17	2660.63	0.4293	0.2354
6	650.05	644.83	-5.22	-433.35	1514.17	2700.19	0.4293	0.2388
7	650.05	657.39	7.34	-426.00	1514.17	2731.69	0.4293	0.2407
8	650.05	665.67	15.62	-410.39	1514.17	2754.45	0.4293	0.2417
9	650.05	670.96	20.91	-389.48	1514.17	2769.96	0.4293	0.2422
10	650.05	674.26	24.21	-365.27	1514.17	2780.09	0.4293	0.2425
11	650.05	676.29	26.24	-339.03	1514.17	2786.50	0.4293	0.2427
12	650.05	677.24	27.19	-311.84	1514.17	2789.60	0.4293	0.2428
13	650.05	677.45	27.40	-284.43	1514.17	2790.28	0.4293	0.2428
14	650.05	677.45	27.40	-257.03	1514.17	2790.28	0.4293	0.2428
15	650.05	677.45	27.40	-229.63	1514.17	2790.28	0.4293	0.2428
16	650.05	677.45	27.40	-202.23	1514.17	2790.28	0.4293	0.2428
17	650.05	677.45	27.40	-174.83	1514.17	2790.28	0.4293	0.2428
18	650.05	677.45	27.40	-147.43	1514.17	2790.28	0.4293	0.2428
19	650.05	677.45	27.40	-120.03	1514.17	2790.28	0.4293	0.2428
20	650.05	677.45	27.40	-92.63	1514.17	2790.28	0.4293	0.2428

MORTALITY PARAMETERS

W/O S-L	NAT MORT = 0.300	FISH MORT = 0.299	
W/ S-L	NAT MORT = 0.390	FISH MORT = 0.000	
	P(RELE) = 1.000	P(SURV) = 0.700	

GROWTH PARAMETERS

LENGTH	LMAX = 1290.00	K = 0.1220	T0 = -1.12700
WEIGHT	B1 = 2.9960	B0 = 0.000012000	

AGE (IN YEARS) PARAMETERS

AGE AT ENTRY TO FISHING GROUNDS	= 0.500	(232.2 MM, 147.1 GMS)
AGE WHEN FIRST LIABLE TO CAPTURE	= 1.000	(294.8 MM, 300.7 GMS)
MAXIMUM AGE IN FISHERY	= 13.000	(1059.8 MM, 13892.0 GMS)

MINIMUM SIZE LIMIT = 457.20 MM (18.0 INCHES, 1119.1 GMS)

INTERNAL RATE OF RETURN FOR Y/R < 1 PERCENT

Table 8. Dynamic yield per recruit analysis for speckled hind with an 18 inch minimum size limit

SPECKLED HIND

YEAR	YIELD/RECRUIT IN GRAMS W/O S-L	W/ S-L	NET GAIN	ACC GAIN	AVE WT/FISH IN GMS W/O S-L	W/ S-L	NO. CAUGHT/RECRUIT W/O S-L	W/ S-L
1	982.25	678.06	-304.19	-304.19	2164.40	2976.44	0.4538	0.2278
2	982.25	777.15	-205.10	-509.30	2164.40	2818.62	0.4538	0.2757
3	982.25	863.18	-119.07	-628.37	2164.40	2810.71	0.4538	0.3071
4	982.25	923.28	-58.97	-687.34	2164.40	2849.74	0.4538	0.3240
5	982.25	963.60	-18.65	-705.99	2164.40	2893.10	0.4538	0.3331
6	982.25	989.81	7.56	-698.43	2164.40	2928.82	0.4538	0.3380
7	982.25	1006.41	24.16	-674.28	2164.40	2954.95	0.4538	0.3406
8	982.25	1016.70	34.45	-639.83	2164.40	2972.84	0.4538	0.3420
9	982.25	1022.97	40.72	-599.10	2164.40	2984.54	0.4538	0.3428
10	982.25	1026.74	44.49	-554.62	2164.40	2991.95	0.4538	0.3432
11	982.25	1028.97	46.72	-507.90	2164.40	2996.54	0.4538	0.3434
12	982.25	1030.20	47.94	-459.95	2164.40	2999.13	0.4538	0.3435
13	982.25	1030.20	47.94	-412.01	2164.40	2999.13	0.4538	0.3435
14	982.25	1030.20	47.94	-364.06	2164.40	2999.13	0.4538	0.3435
15	982.25	1030.20	47.94	-316.12	2164.40	2999.13	0.4538	0.3435
16	982.25	1030.20	47.94	-268.17	2164.40	2999.13	0.4538	0.3435
17	982.25	1030.20	47.94	-220.23	2164.40	2999.13	0.4538	0.3435
18	982.25	1030.20	47.94	-172.28	2164.40	2999.13	0.4538	0.3435
19	982.25	1030.20	47.94	-124.34	2164.40	2999.13	0.4538	0.3435
20	982.25	1030.20	47.94	-76.39	2164.40	2999.13	0.4538	0.3435

MORTALITY PARAMETERS

W/O S-L	NAT MORT = 0.200	FISH MORT = 0.420
W/ S-L	NAT MORT = 0.242	FISH MORT = 0.000
	P(RELE) = 1.000	P(SURV) = 0.900

GROWTH PARAMETERS

LENGTH	LMAX = 1105.00	K = 0.0880	T0 = -1.92000
WEIGHT	B1 = 3.0730	B0 = 0.000011000	

AGE (IN YEARS) PARAMETERS

AGE AT ENTRY TO FISHING GROUNDS	= 1.000	(250.4 MM, 258.4 GMS)
AGE WHEN FIRST LIABLE TO CAPTURE	= 3.000	(388.3 MM, 995.3 GMS)
MAXIMUM AGE IN FISHERY	= 15.000	(855.7 MM, 11283.0 GMS)

MINIMUM SIZE LIMIT = 457.20 MM (18.0 INCHES, 1644.0 GMS)

INTERNAL RATE OF RETURN FOR Y/R < 1 PERCENT

Table 9. Dynamic yield per recruit analysis for scamp with a 14 inch minimum size limit

SCAMP

YEAR	YIELD/RECRUIT IN GRAMS W/O S-L	W/ S-L	NET GAIN	ACC GAIN	AVE WT/FISH IN GMS W/O S-L	W/ S-L	NO. CAUGHT/RECRUIT W/O S-L	W/ S-L
1	502.21	424.74	-77.47	-77.47	999.18	1285.07	0.5026	0.3305
2	502.21	439.29	-62.92	-140.40	999.18	1254.86	0.5026	0.3501
3	502.21	457.33	-44.88	-185.28	999.18	1238.76	0.5026	0.3692
4	502.21	472.77	-29.45	-214.73	999.18	1239.66	0.5026	0.3814
5	502.21	485.43	-16.78	-231.51	999.18	1247.44	0.5026	0.3891
6	502.21	495.47	-6.74	-238.26	999.18	1257.23	0.5026	0.3941
7	502.21	503.21	1.00	-237.26	999.18	1266.73	0.5026	0.3973
8	502.21	509.06	6.84	-230.41	999.18	1274.97	0.5026	0.3993
9	502.21	513.38	11.17	-219.25	999.18	1281.67	0.5026	0.4006
10	502.21	516.53	14.32	-204.93	999.18	1286.90	0.5026	0.4014
11	502.21	518.79	16.58	-188.36	999.18	1290.86	0.5026	0.4019
12	502.21	520.40	18.18	-170.17	999.18	1293.79	0.5026	0.4022
13	502.21	521.53	19.31	-150.86	999.18	1295.91	0.5026	0.4024
14	502.21	522.31	20.10	-130.76	999.18	1297.42	0.5026	0.4026
15	502.21	522.86	20.64	-110.12	999.18	1298.50	0.5026	0.4027
16	502.21	523.23	21.01	-89.10	999.18	1299.24	0.5026	0.4027
17	502.21	523.48	21.27	-67.83	999.18	1299.76	0.5026	0.4028
18	502.21	523.66	21.44	-46.39	999.18	1300.12	0.5026	0.4028
19	502.21	523.77	21.56	-24.83	999.18	1300.36	0.5026	0.4028
20	502.21	523.84	21.62	-3.21	999.18	1300.49	0.5026	0.4028
21	502.21	523.85	21.64	18.43	999.18	1300.53	0.5026	0.4028

MORTALITY PARAMETERS

W/O S-L NAT MORT = 0.200 FISH MORT = 0.250
W/ S-L NAT MORT = 0.225 FISH MORT = 0.000
P(RELE) = 1.000 P(SURV) = 0.900

GROWTH PARAMETERS

LENGTH LMAX = 1090.00 K = 0.0670 T0 = -3.91000
WEIGHT B1 = 2.9100 B0 = 0.000024000

AGE (IN YEARS) PARAMETERS

AGE AT ENTRY TO FISHING GROUNDS = 0.500 (278.8 MM, 313.5 GMS)
AGE WHEN FIRST LIABLE TO CAPTURE = 1.000 (305.6 MM, 409.1 GMS)
MAXIMUM AGE IN FISHERY = 21.000 (884.6 MM, 9020.8 GMS)

MINIMUM SIZE LIMIT = 355.60 MM (14.0 INCHES, 636.1 GMS)

INTERNAL RATE OF RETURN FOR Y/R < 1 PERCENT

Table 10. Dynamic yield per recruit analysis for black sea bass with an 8 inch minimum size limit

BLACK SEA BASS

YEAR	YIELD/RECRUIT IN GRAMS W/O S-L	W/ S-L	NET GAIN	ACC GAIN	AVE WT/FISH IN GMS W/O S-L	W/ S-L	NO. CAUGHT/RECRUIT W/O S-L	W/ S-L
1	76.97	33.55	-43.42	-43.42	162.91	398.95	0.4724	0.0841
2	76.97	41.29	-35.68	-79.10	162.91	378.59	0.4724	0.1091
3	76.97	57.91	-19.05	-98.15	162.91	365.71	0.4724	0.1584
4	76.97	68.88	-8.08	-106.23	162.91	377.52	0.4724	0.1825
5	76.97	74.97	-2.00	-108.23	162.91	388.49	0.4724	0.1930
6	76.97	78.15	1.18	-107.05	162.91	395.56	0.4724	0.1976
7	76.97	79.72	2.75	-104.30	162.91	399.52	0.4724	0.1995
8	76.97	80.30	3.34	-100.96	162.91	401.08	0.4724	0.2002
9	76.97	80.30	3.34	-97.62	162.91	401.08	0.4724	0.2002
10	76.97	80.30	3.34	-94.28	162.91	401.08	0.4724	0.2002
11	76.97	80.30	3.34	-90.95	162.91	401.08	0.4724	0.2002
12	76.97	80.30	3.34	-87.61	162.91	401.08	0.4724	0.2002
13	76.97	80.30	3.34	-84.27	162.91	401.08	0.4724	0.2002
14	76.97	80.30	3.34	-80.94	162.91	401.08	0.4724	0.2002
15	76.97	80.30	3.34	-77.60	162.91	401.08	0.4724	0.2002
16	76.97	80.30	3.34	-74.26	162.91	401.08	0.4724	0.2002
17	76.97	80.30	3.34	-70.93	162.91	401.08	0.4724	0.2002
18	76.97	80.30	3.34	-67.59	162.91	401.08	0.4724	0.2002
19	76.97	80.30	3.34	-64.25	162.91	401.08	0.4724	0.2002
20	76.97	80.30	3.34	-60.91	162.91	401.08	0.4724	0.2002

MORTALITY PARAMETERS

W/O S-L	NAT MORT = 0.300	FISH MORT = 0.530	
W/ S-L	NAT MORT = 0.406	FISH MORT = 0.000	
	P(RELE) = 1.000	P(SURV) = 0.800	

GROWTH PARAMETERS

LENGTH	LMAX = 350.00	K = 0.2220	T0 = 0.18550
WEIGHT	B1 = 3.0237	B0 = 0.000026540	

AGE (IN YEARS) PARAMETERS

AGE AT ENTRY TO FISHING GROUNDS = 1.000	(57.9 MM,	5.7 GMS)
AGE WHEN FIRST LIABLE TO CAPTURE = 2.000	(116.0 MM,	46.4 GMS)
MAXIMUM AGE IN FISHERY = 10.000	(310.4 MM,	909.2 GMS)

MINIMUM SIZE LIMIT = 203.20 MM (8.0 INCHES, 252.6 GMS)

INTERNAL RATE OF RETURN FOR Y/R < 1 PERCENT

Table 11. Dynamic yield per recruit analysis for red porgy with a 14 inch minimum size limit

RED PORGY

YEAR	YIELD/RECRUIT IN GRAMS W/O S-L	W/ S-L	NET GAIN	ACC GAIN	AVE WT/FISH IN GMS W/O S-L	W/ S-L	NO. CAUGHT/RECRUIT W/O S-L	W/ S-L
1	259.37	152.40	-106.97	-106.97	581.85	883.19	0.4458	0.1726
2	259.37	174.01	-85.36	-192.34	581.85	846.09	0.4458	0.2057
3	259.37	206.09	-53.29	-245.63	581.85	831.43	0.4458	0.2479
4	259.37	228.61	-30.76	-276.39	581.85	843.49	0.4458	0.2710
5	259.37	243.84	-15.54	-291.92	581.85	859.35	0.4458	0.2837
6	259.37	253.81	-5.56	-297.49	581.85	873.04	0.4458	0.2907
7	259.37	260.19	0.81	-296.68	581.85	883.34	0.4458	0.2946
8	259.37	264.18	4.81	-291.87	581.85	890.55	0.4458	0.2967
9	259.37	266.64	7.27	-284.60	581.85	895.36	0.4458	0.2978
10	259.37	267.80	8.42	-276.18	581.85	897.73	0.4458	0.2983
11	259.37	267.80	8.42	-267.75	581.85	897.73	0.4458	0.2983
12	259.37	267.80	8.42	-259.33	581.85	897.73	0.4458	0.2983
13	259.37	267.80	8.42	-250.91	581.85	897.73	0.4458	0.2983
14	259.37	267.80	8.42	-242.48	581.85	897.73	0.4458	0.2983
15	259.37	267.80	8.42	-234.06	581.85	897.73	0.4458	0.2983
16	259.37	267.80	8.42	-225.63	581.85	897.73	0.4458	0.2983
17	259.37	267.80	8.42	-217.21	581.85	897.73	0.4458	0.2983
18	259.37	267.80	8.42	-208.79	581.85	897.73	0.4458	0.2983
19	259.37	267.80	8.42	-200.36	581.85	897.73	0.4458	0.2983
20	259.37	267.80	8.42	-191.94	581.85	897.73	0.4458	0.2983

MORTALITY PARAMETERS

```
    W/O S-L   NAT MORT = 0.200    FISH MORT = 0.400
     W/ S-L   NAT MORT = 0.240    FISH MORT = 0.000
              P(RELE)  = 1.000    P(SURV)   = 0.900
```

GROWTH PARAMETERS

```
     LENGTH   LMAX =  763.00     K  =  0.0960        T0 = -1.88000
     WEIGHT   B1   =  2.8939     B0 =  0.000025240
```

AGE (IN YEARS) PARAMETERS

```
     AGE AT ENTRY TO FISHING GROUNDS  =  1.000   ( 184.3 MM,   90.8 GMS)
     AGE WHEN FIRST LIABLE TO CAPTURE =  3.000   ( 285.4 MM,  322.0 GMS)
     MAXIMUM AGE IN FISHERY           = 13.000   ( 580.1 MM, 2508.7 GMS)
```

MINIMUM SIZE LIMIT = 355.60 MM (14.0 INCHES, 608.6 GMS)

INTERNAL RATE OF RETURN FOR Y/R < 1 PERCENT

Results differed for each species, but minimum size limits appear worthwhile for most snappers (Tables 2-5), since undersized fish apparently grow quickly. A four inch stretch mesh, which corresponds to a twelve inch minimum size, was proposed for vermilion snapper (Table 2) since P_{surv} was considered to be relatively high for small fish encountered by trawls. Although there was only a small gain in Y/R for red (Table 3) and gray snapper (Table 4), the suggested minimum size limits were justified when $P_{surv} = 0.6$ since short run losses were small and did not last long. A twelve inch minimum size for yellowtail snapper was also justified (Table 5).

Results for groupers were mixed. A twelve inch minimum size was proposed for red grouper (Table 6) and also for Nassau grouper since both species are similar. The suggested minimum size limit for Gag (Table 7) was not justified although it offered some of the largest potential net gains in equilibrium Y/R. Yet when one considers the timing and magnitude of short run losses and long run gains, the minimum size limit would cause relatively large short run losses and long payback periods. Thus, the average annual rate of growth in Y/R is relatively small after accounting for short run losses. The suggested minimum size limits for speckled hind and scamp produced a net decrease in equilibrium Y/R, assuming $P_{surv} = 0.7$. Additional analyses indicated that approximately 90 percent of undersized speckled hind (Table 8) and scamp (Table 9) would have to survive if caught and released in order to increase Y/R, but the resulting IRR were less than 3 percent.[9]

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[9] Tables 2-11 assume a 20 year time horizon. However, since groupers are relatively long-lived, slow-growing species, additional analyses were performed for gag, speckled hind, and scamp to determine if the suggested minimum size limits wouls generate long run gains in Y/R at a rate sufficient to offset short run losses within a 40 year time horizon. The resulting IRR were:

	P_{surv}	IRR
gag	0.7	3.6%
speckled hind	0.9	4.1
scamp	0.9	5.2

A minimum size limit for gag would be marginally justified with a 40 year time horizon. The IRR were within the acceptable range for speckled hind and scamp, but the assumed values for P_{surv} are higher than the minimum acceptable value of 0.7.

Suggested minimum size limits for black sea bass (Table 10) and red porgy (Table 11) are not justified according to the IRR criterion, although the Council has recommended an 8 inch minimum size limit for black sea bass based on considerations other than IRR.

Summary

This report quantifies the dynamics of establishing minimum size limits for ten species in the snapper-grouper fishery along the south Atlantic coast. Growth and mortality parameters were specified by the South Atlantic Fishery Management Council, and results of the analyses are being used by the Council in the development of a management plan for the snapper-grouper complex.

In summary, minimum size limits attempt to increase biomass landed by harvesting fewer but heavier fish. Biological yield per recruit models adequately predict equilibrium yield per recruit with and without the size limit, but they do not quantify the trade-off between short run losses and long run gains in yield per recruit during the transition between equilibria.

Success of a minimum size limit depends on fisherman cooperation in releasing undersized fish and in the ability of those fish to survive when released. This paper accounts for the rate of fisherman compliance by considering the probability that an undersized fish is released if caught. A second variable represents the probability that a released fish will survive. Both probabilities are exogenously defined in the analyses, although the rate of compliance is actually determined, in part, by the amount of enforcement. Fishermen who catch and keep undersized fish do not sacrifice their landings of small fish, but neither do they enhance future landings of large fish. However, only future landings are reduced when released fish fail to re-enter the population. There is no sense in enforcing a minimum size limit if undersized fish are caught and released, but fail to survive.

The internal rate of return criterion was proposed as a measure of evaluating the timing and magnitude of short run losses and long run gains in yield per recruit. Minimum size limits effectively enhance Y/R if the internal rate of return exceeds the minimum acceptable average annual rate of growth in Y/R. Finally, the internal rate of return criterion reminds us that individual fishermen cannot justify unilateral conservation efforts in the fishery; hence government regulation of the fishery may be warranted.

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