Status Report on the Commercial Snapper-Grouper Fisheries off South Carolina

GLENN F. ULRICH and RAYMOND J. RHODES
Office of Conservation and Management
Division of Marine Resources
S.C. Wildlife and Marine Resources Department
Charleston, S.C. 29412

and

KENNETH J. ROBERTS
Department of Agricultural and Rural Sociology
Clemson University
Clemson, S.C. 29631

ABSTRACT

Shrimp trawlers utilizing roller-rigged trawls fished for snappers and groupers during the closed season for shrimping (January-April) on the continental shelf off South Carolina. A trawler, participating in a South Carolina Marine Advisory Program demonstration of commercial feasibility, produced 35,979 lb of fish from nine trips in 1976. Average catch per vessel-day was 2,106 lb. Species taken and percent of total catch by weight were: red snapper (*Lutjanus campechanus*), 31.0%; vermilion snapper (*Rhomboplites aurorubens*), 25.0%; groupers (*Epinephelus* sp. and *Mycteroperca* sp.), 14.0%; red porgy (*Pagrus sedecim*), 17.0%; whitebone porgy (*Calamus leucosteus*), 10.0%; and black sea bass (*Centropristis striata*), 3.0%.

The majority of commercial hook-and-line vessels fishing South Carolina offshore waters were based in Charleston, South Carolina. Average catch per vessel-day for the May through September 1976 period was 719 lb. The catches taken by commercial hook-and-line fishermen were dominated by the groupers, primarily the gag (*Mycteroperca microlepis*) and scamp (*M. phenax*), with 43% of the catch by weight comprised of these species.

Commercial landings of snappers, groupers and ecologically related species caught by hook-and-line vessels in South Carolina during 1976 were estimated to be 410,000 lb.

INTRODUCTION

Since 1960, commercial landings of snappers (Lutjanidae) and groupers (Serranidae) in South Carolina have generally been incidental to commercial black sea bass (*Centropristis striata*) trapping between shrimp seasons. Before 1976, commercial fishermen from Florida expended a significant amount of fishing effort in waters adjacent to Georgia and the Carolinas, but most of their catches had been landed and reported for the east coast of Florida (J.E. Snell, personal communication). In 1975, snapper and grouper landings (2.2 million lb) from the east coast of Florida comprised 92% of the total landings for the South Atlantic states. Landings from Florida included species caught off the Carolinas and Georgia.

During 1976, a Charleston seafood company began to pay higher prices for species of snapper and grouper than Florida firms. This factor and the facilities to ship large quantities of finfish and supply dockage between fishing trips caused several Florida vessels to land their catches in the Charleston area.

Recent reports by Roberts (1974), Jones, Hubbard, and Roberts (1976), and Calder, Eldridge, and Joseph (1974) have noted the significance of the off-season latent capital and labor resources in the shrimp trawler fishery. There have been a few attempts in the past by resident South Carolina fishermen to utilize these latent resources through demersal fish trawling operations (Prytherch, 1970), but most have been unsuccessful due to costly gear damage and relatively low revenues. Compared to sea bass trapping, fish trawling was considered economically unfeasible (Rhodes and Bearden, 1974).

Recently, fish trawling skills among South Carolina captains and the design of the otter trawl nets have also been considered as factors in past trawling failures. Some South Carolina fishermen renewed their interest in exploring offshore finfish trawling opportunities during 1975. The Sea Grant Marine Advisory Program in South Carolina responded by selecting an experienced, offshore fishing captain and a newly designed fish trawling net (Hillier, 1974) to investigate trawling feasibility.

In 1976, the commercial landings (Table 1) of snappers, groupers, and other demersal species (except black sea bass) increased due to the introduction of the above trawling technology and the increased landings by Florida-owned vessels in Charleston. This report will supply preliminary biological and economic information on the demersal species presently being utilized by both commercial

Table 1. Annual pounds (in thousands) of demersal species landed in South Carolina 1960 to 1975 according to the National Marine Fisheries Service, U.S. Department of Commerce

	(Lutjanidae) *		(Serranidae)		(Sparidae)	
Year Landed	Red Snapper	Vermilion Snapper	Groupers	Sea Bass	Porgies & Scup	(Pomad) Grunts
1960	2	0	7	29	0	0
1961	113	25	6	324	0	21
1962	7	48	0	267	18	21
1963	L+	10	0	265	4	10
1964	8	L	L	234	15	0
1965	16	3	20	83	0	0
1966	0	0	L	136	0	0
1967	3	0	0	66	0	0
1968	37	0	63	204	1	0
1969	16	1	10	722	12	4
1970	12	0	14	773	290	3
1971	8	10	10	514	122	1
1972	15	15	17	547	30	1
1973	17	6	83	289	21	5
1974	13	3	62	134	5	0
1975	6	2	17	147	13	L
1976 †	38	54	179	100	103	1

* Other Lutjanids (e.g. *Lutjanus vivanus, L. buccanella*) were reported as L. *campechanus.*

\+ Less than 500 pounds.

† Preliminary totals for 1976.

trawl and hook-and-line fishermen operating off South Carolina and adjacent states. The feasibility of exploiting lutjanids and serranids in the Carolinas has been investigated by exploratory ground-fish cruises (Cummins et al., 1962; Struhsaker, 1969; Bearden and McKenzie, 1971), but there is no detailed published information on the gear, species composition, or catch per effort for commercial offshore demersal fisheries in this area. In addition, there is only limited information (Rhodes and Bearden, 1974) on the commercial feasibility of winter trawling for offshore demersal species by resident South Carolina commercial fishermen.

The publication of preliminary findings concerning the commercial harvesting of demersal stocks off the South Atlantic states seems especially relevant with the enactment of the Fishery Conservation and Management Act of 1976 (Public Law 94-265). Research by Huntsman (1974; 1976) on the headboat fishery of the Carolinas suggests that fishery resource managers may need to address potential allocation conflicts between domestic and foreign commercial fishing operations and recreational users.

Table 2. A survey of commercial hook and line fishing craft unloading in South Carolina during 1976

	Mean	Mode	Range
Vessel LOA	43	44	26-65
Number of Reels	3	4	1-6
Crew Size *	3	2	1-7
	Electronic Equipment		
	Number	Percent	
LORAN	11	92%	
Radar	0	0	
Depth Recorder	12	100	
2-Way Radio	12	100	
	Florida	South Carolina	
State of Home Port	10	2	

*Includes captain of the fishing craft.

COMMERCIAL FISHING TECHNIQUES AND GEAR

Hook-and-Line

Vessels presently engaged in the fishery off South Carolina range between 26 and 65 ft (LOA) and are of wood or fiberglass construction (Table 2). The majority of the vessels are 44-ft fiberglass boats built by Thompson Trawler Company, Titusville, Florida. Vessels presently using South Carolina as a base of operations have Florida home ports, with two exceptions. All boats are equipped with electric snapper reels and the following electronic equipment: LORAN A,

white-line fathometer (echosounder), VHF and/or CB radio. In addition, two boats have a scope (CRT) scale expander used in conjunction with the white-line fathometer. These "fish scopes" have greater capabilities than the fathometer for detecting fish close to the bottom and also represent the size of the fish within a given depth stratum.

Reels are loaded with 3/64-in diameter stainless steel line which is attached by a large snap swivel to a "triangle" rig (Fig. 1). The lead (usually 3 lb) is attached to the lower point of the triangle. A rubber "snubber" is attached to the opposite side to reduce sudden stress on the gear when a large fish takes the hook. Carpenter (1965) described the tackle used in the Gulf fishery but did not mention the use of the triangle rig. Terminal tackle usually consists of a snap swivel off of the rubber snubber, attached to a short length of heavy monofilament (200-250 lb-test) and two dropper lines connected with a three-way swivel. Hooks used are 8/0 to 10/0 Mustad and No. 5 to 7 tuna circle hooks.

Fishermen operating off the South Carolina coast rarely employ more than two hooks per rig. Carpenter (1965) reports the Gulf of Mexico fishermen utilize from 5 to 15 hooks per rig, and off the Texas coast (Western Ground) where snappers are generally smaller and shallower depths are fished, up to 40 No. 9 hooks may be rigged on a single line.

Commercial vessels which landed their catches in South Carolina fished between Frying Pan Shoals and Savannah, with the majority of their effort north of Charleston. Fishing is concentrated between 20 and 35 fm. The highest

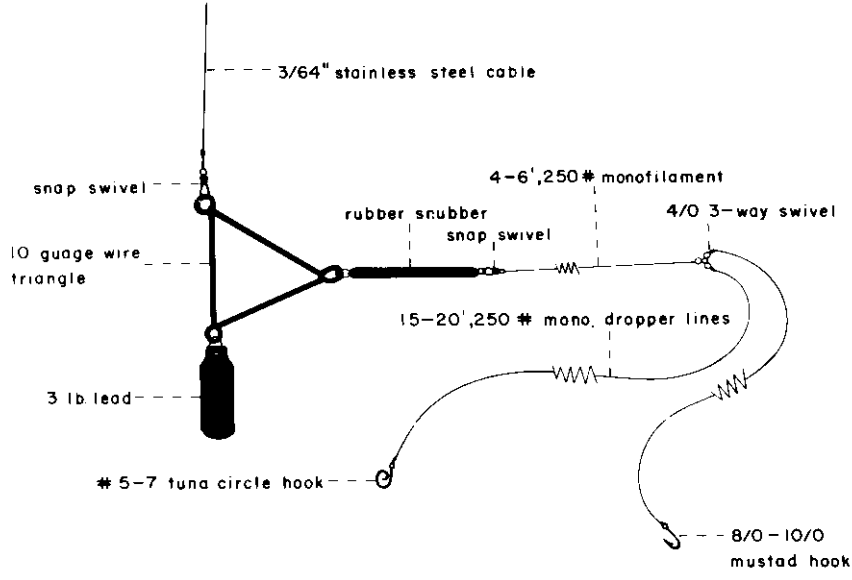

Fig. 1. Typical terminal tackle used by commercial hook-and-line fishermen operating off South Carolina.

priced demersal species, red snapper (*Lutjanus campechanus*), is apparently more numerous in shallower water (less than 35 fm) compared to the lower priced silk snapper (*Lutjanus vivanus*), which is dominant in depths exceeding 32 fm (Rivas, 1969).

Search time is a very critical aspect of commercial demersal fishing off South Carolina. Areas between 20 and 35 fm known from previous trips to be productive are traversed using the white-line fathometer until a promising "mark" of fish is observed. A buoy is often thrown overboard at this point to mark the spot, and a fishing drift is made over the area to determine the type of fish present and their inclination to bite. LORAN A or C bearings are often recorded in notebooks by the captains for future reference. Fishermen employing the fish scope consider this equipment to be useful in assessing the size and possibly species composition of fish marked by the white-line fathometer.

Fish Trawling

The South Carolina Marine Advisory Program's winter fish trawling demonstration involved the purchase of equipment developed by the University of Rhode Island (Hillier, 1974). The commercial gear (i.e. the trawl doors and net) were purchased for $3,890. The owner of the demonstration vessel incurred all other costs including fuel and crew shares.

The vessel **Dixiana**, which provided experimental data, has characteristics common to South Carolina vessels capable of working offshore. The vessel is a V-12 powered, Florida-type shrimp trawler equipped with radar, LORAN A (manual), and a Simrad El white-line fathometer. Since trawling was done from the port outrigger, little additional modification and expense resulted. A towing block was added to the port outrigger, and heavier cable used on the winch. The towing block was positioned slightly inboard of the usual try-net block location and the net was towed by a single cable running through this block. This single-point towing, by putting all the strain on the port boom, did reduce the vessel's maneuverability. The lateral slippage of the vessel also resulted in significant turbulence under the vessel's hull which interfered with reception of the white-line fathometer.

The net used was a 60/80 (60 ft of headrope, 80 ft of footrope) highrise trawl. The URI 60/80 net has a reported vertical mouth opening of 18 ft compared to less than half that amount for the Yankee 36, the net used in a previous trawling feasibility study. Net construction was of 42-thread braided nylon (6-in stretch mesh in the wings and 4-in mesh in the square) and 36-thread (3-in mesh) in the codend. The sweep was constructed of 6-in diameter rubber tire discs, threaded on roller chain backed with wire rope.

Trawling was conducted between 18 and 25 fm. The white-line fathometer was used to locate fish concentrations. When suitable marks of fish appeared on the fathometer, a buoy was set to mark the location, and electric powered 6/0

reels were employed to check species composition and verify the presence of marketable fish. The area around the buoy would usually be checked with the fathometer to determine the extent of fish concentrations and suitability of the bottom for trawling. The net was then set and towed for 20-45 min.

When the net was hauled back, only the bag was pulled into the boat by a lazy line. After lifting and emptying the codend, the net was returned to the water surface where it usually remained between trawling locations.

COMMERCIAL CATCH AND NOMINAL EFFORT

Hook-and-Line

Hook-and-line landings of red snappers, vermilion snappers, and groupers between 1970-1974 averaged approximately 43,500 lb for South Carolina (Table 3). The authors estimate that the 1976 hook-and-line landings of these species (approximately 410,000 lb) will be about nine times larger than this 5-year average. Commercial hook-and-line catches by vessels fishing offshore of the Carolinas and landing their fish in Georgia and Florida ports are estimated at an additional 180,000 lb during 1976.

The commercial catch in the Carolinas is exceeded by recreational fishermen on commercial headboats. Huntsman (1976) estimated the total recreational headboat catch during 1973 in the Cape Romain and Cape Fear region (the same area fished by commercial vessels) at 1,102,499 lb (exclusive of sea bass).

The mean commercial catch (lb) per fishing trip (usually 3 to 10 days), man-day, and vessel-day were calculated by species for each month (April to October, 1976) by the summation of all the fishing trips ending in the sampled months (Table 4). A vessel-day is defined as a 24-h period and includes searching time, traveling time between fishing grounds and time spent traveling to and from the unloading location. Man-days are determined by multiplying the

Table 3. Annual pounds of demersal species caught by commercial hook-and-line and landed in South Carolina 1970-1974* as reported by the National Marine Fisheries Service, U.S. Department of Commerce

Year Landed	Red Snapper	Vermilion Snapper	Grouper	Grunts	Scup & Porgies	Total
1970	9,500		1,200			10,700
1971	7,600	9,900	2,600			20,100
1972	6,400	3,000	6,200	200	2,600	18,400
1973	11,300	600	71,100	600	3,600	87,200
1974	12,400	2,100	62,200		4,400	81,800
5 year average	9,440	3,120	28,660	160	2,280	43,500

*1975 and 1976 catch by fishing gear for these species was not available from the National Marine Fisheries Service at the time of publication

Table 4. Average monthly catch per vessel-day, man-day, and trip for hook-and-line fishing craft unloading in Charleston, S.C. April-October, 1976

	REPORTING MONTHS																				
	May			June			July			August			September			October					
Number Fishing Craft*	1			3			5			8			10			10			10		
Species	C/T†	C/MD‡	C/D§	C/T	C/MD	C/D	C/T	C/MD	C/D	C/T	C/MD	C/D	C/T	C/MD	C/D	C/T	C/MD	C/D	C/T	C/MD	C/D
Red Snapper	503	17	101	643	29	83	460	17	54	286	20	60	189	15	48	136	11	38	520	38	130
Vermilion Sn.	238	8	48	468	21	60	737	27	86	370	26	77	279	22	71	809	64	229	639	47	160
Grouper	3363	112	673	1521	68	196	2382	86	277	2121	148	444	1924	149	489	773	61	219	1381	102	345
Sea Bass	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	19	2	5	51	4	13
Red Porgy	1833	61	367	1269	56	164	1107	40	129	845	59	177	912	70	232	300	24	85	661	49	165
Other	176	6	35	40	13	5	23	1	3	141	10	29	203	16	52	293	23	83	229	17	57
Total	6113	204	1224	3941	187	508	4709	171	549	3763	263	787	3507	272	891	2330	185	659	3481	257	870

* Number of different fishing vessels which unloaded one or more time during the reporting month.

† Mean catch (lb)

‡ Mean catch (lb)

§ Mean catch (lb)

number of vessel-days by the crew size for a given vessel. Since only one hook-and-line vessel unloaded in April, these catch and effort data are excluded from the following discussion.

Groupers (*Mycteroperca* spp. and *Epinephelus* spp.) generally constituted the highest poundage for the above three catch per effort classifications. Grouper catch per man-day ranged from 61 lb in September to 149 lb for August. Grouper catch per vessel-day varied from 196 lb in May to 489 lb in August. During the early 1960s, commercial grouper catches off the Florida east coast were about 35 lb per man-day (Rosen and Robinson, 1961; 1962).

Red porgy was usually the second CPUE. Vermilion snapper was generally the third most abundant species by weight. Average red snapper catch per man-day ranged from 11 lb in September to 38 lb in October. Rosen and Robinson (1961; 1962) reported red snapper landings were 75 lb per man-day for east coast Florida fishermen during 1960 and 1961.

Fish Trawling

Red snapper catch per vessel-day on the **Dixiana** varied between 1001 lb in February and 249 lb in May (Table 5). Vermilion snapper average poundage per vessel-day for February to May was 523, while red porgy catches averaged 352 lb per vessel-day for the same period (Table 5). When trawling with the Yankee 36-ft otter trawl off South Carolina during 1973, the red snapper catch per day did not exceed 60 lb per vessel-day (Rhodes and Bearden, 1974).

The mean monthly catch (all species) per vessel-day for the trawler was 2107 lb (Table 5). Commercial hook-and-line catches averaged 719 lb per vessel-day. In addition to gear selectivity, seasonal, and possible fishing ground differences between hook-and-line operations and winter fish trawling, the captain participating in the Sea Grant deomonstration has above average fish trawling skills and experience.

Table 5. Mean catch per trip and vessel-day for the U.R.I. high-rise otter trawl unloading in South Carolina, 1976

	Feb.		March		April		May		Monthly Average	
Total Fishing Days	8		4		3		2			
Species	C/T*	C/D†	C/T	C/D	C/T	C/D	C/T	C/D	C/T	C/D
Red snapper	2002	1001	625	312	739	492	498	249	1248	661
Vermilion snapper	1293	646	774	387	827	551	515	258	987	523
Grouper	735	367	385	193	261	174	700	350	548	290
Black sea bass	251	126	0	0	14	9	0	0	115	61
Red porgy	1258	629	254	127	193	132	45	23	664	352
Other	741	371	130	65	213	142	88	44	415	220
All species	6280	3140	2168	1084	2247	1500	1846	924	3977	2107

* Mean catch (pounds) per fishing trip.
† Mean catch (pounds) per vessel-day.

PRELIMINARY OBSERVATIONS ON SPECIES AND SIZE COMPOSITION

Species Composition

It should be noted that trawl catches were made during winter and spring and commercial and recreational hook-and-line catches during spring and summer. Parrish (1963) identified three primary factors influencing changes in species and size composition of the commercial catch as: (1) distribution (i.e. spatial and temporal) of fishing operations and fish stock, (2) behavior and habits of fishes in the fished area, and (3) inherent gear selectivity. Differences in species composition between gears are probably due to the interaction of all three of the above factors. The species composition of trawl catches are presented for information purposes, recognizing that seasonal differences preclude direct comparisons on the basis of gear selectivity.

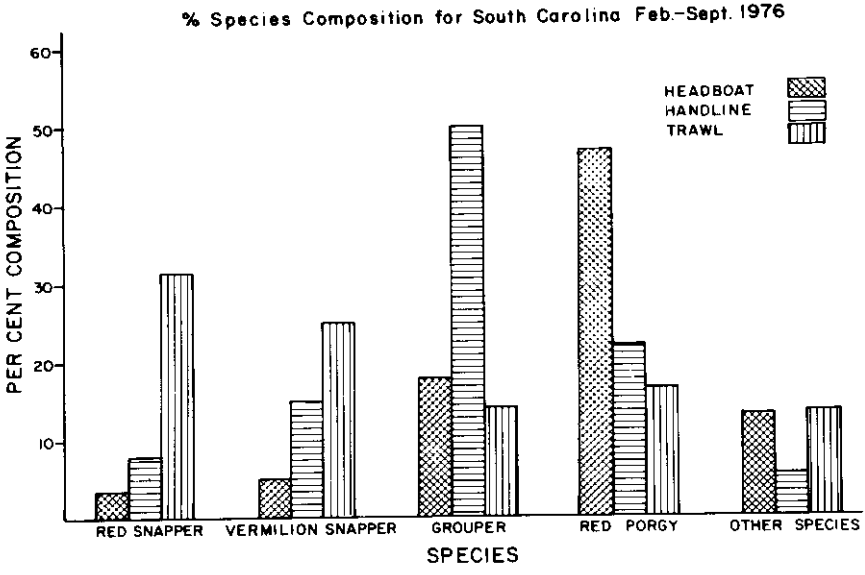

Fig. 2. Percent composition of selected demersal species caught by trawl commercial hook-and-line fishermen (handline), and recreational headboat fishermen (1973 data published by Huntsman, 1976).

The red snapper (*Lutjanus campechanus*) constituted 31% of the trawl catch and 8% of the commercial hook-and-line catch (Fig. 2). Huntsman's data indicate that 3% of the recreational headboat catch was composed of red snappers; however, this includes two other species (*L. vivanus* and *L. buccanella*). The individual contributions of each of these lutjanid species to the headboat catch is not known. *Lutjanus vivanus* contributed 4.8% to the commercial hook-and-line landings (Table 6) but was not observed in trawler catches. The blackfin snapper, *Lutjanus buccanella*, made up less than 1% of the commercial hook-and-line catch and was also absent from trawl catches.

Table 6. Species, percent of catch by weight, and average ex-vessel price for commercial handline catches landed in Charleston, South Carolina, April-September 1976

Common or Market Name	Scientific Name	% Catch by Wt	Ave. Ex-vessel Price/lb
Sea Basses	Serranidae		
Speckled hind or "Kitty Mitchell"	*Epinephelus drummondhayi*	4.7	0.45
Warsaw grouper	*E. nigritus*	L*	0.50
Gag or Gray grouper	*Mycteroperca microlepis*	31.7	0.50
Scamp grouper	*M. phenax*	12.8	0.50
Black sea bass	*Centropristis striata*	L	0.30
Porgies	Sparidae		
Red porgy or "Pink snapper"	*Pagrus sedecim*	21.7	0.40
Knobbed porgy or "Key West" porgy	*Calamus nodosus*	L	0.50
Snappers	Lutjanidae		
Red snapper	*Lutjanus campechanus*	8.1	1.50
Silk or "yelloweye" snapper	*L. vivanus*	4.8	1.20
Cubera snapper	*L. cyanopterus*	L	0.50
Blackfin or "Hambone" snapper	*L. buccanella*	L	1.20
Vermilion snapper	*Rhomboplites aurorubens*	14.7	1.00
Grunts	Pomadasyidae		
White grunt	*Haemulon plumieri*	L	0.25
Tilefish	Branchiostegidae	L	0.25
Gray tilefish	*Caulolatilis microps*	L	0.25
Triggerfishes	Balistidae		
Gray triggerfish	*Balistes capriscus*	L	0.25
Wrasses	Labridae		
Hogfish	*Lachnolaimus maximus*	L	0.50
Mackerels	Scombridae		
King mackerel	*Scomberomorus cavalla*	L	0.60

* Less than one percent by weight of catch

Commercial hook-and-line fishermen have reported that *L. campechanus* catches usually decrease at depths greater than 35 fm with silk (*L. vivanus*) and blackfin snapper (*L. buccanella*) becoming more abundant.

Vermilion snapper (*Rhomboplites aurorubens*) made an important contribution to winter trawl catches with 25% of the landings composed of this species (Fig. 2). Commercial hook-and-line catches were 15% vermilion snapper. Headboat catches of this species for the Cape Romain and Cape Fear regions (area fished by commercial vessels) averaged 6.4% of the catch in 1973 (Huntsman, 1976). Spatial distribution of fishing effort by commercial and recreational fishers may affect the incidence of vermilion snapper in the catch.

Data presented by Huntsman (1976) suggest that this species may be more available to inshore (19-25 fm) fishermen. Commercial fishermen also state that catches of this species increase at night when headboat fishermen would not be fishing.

Groupers (*Mycteroperce* and *Epinephelus*) comprised 14, 50, and 20% of the trawl, commercial hook-and-line and headboat catches (Cape Fear-Cape Romain region), respectively (Fig. 2). The total grouper catch of commercial hook-and-line vessels was comprised of the following species: gag (*Mycteroperca microlepis*), 32%; scamp (*M. phenax*), 13%; and speckled hind (*Epinephelus drummondhayi*), 5% (Table 6). The trawl grouper catches were not marketed by species. The percentage of scamp and gag groupers caught by the headboat fishermen is small in comparison to the commercial hook-and-line fishery. The yellow-edge (*Epinephelus flavolimbatus*) and snowy groupers (*E. niveatus*), which constitute a significant portion of the headboat grouper catches, are rarely observed in the commercial catch. According to Huntsman (1976) these groupers are apparently abundant in 60 to 80 fm where little commercial effort takes place.

The porgies (Sparidae) are an important component of offshore demersal headboat catches. The red porgy (*Pagrus sedecim*) contributed 59% of the total headboat poundage (1.6 million lb) and was one of the most important species to the recreational fishery (Huntsman 1976). Trawl and commercial hook-and-line landings of this species were 17% and 22% respectively (Fig. 2). The whitebone porgy (*Calamus leucosteus*) contributed 10% to the trawler's landings (Table 7) but was absent from the commercial hook-and-line landings. This species was not specifically mentioned in Huntsman's (1976) report on the headboat fishery and its contribution to recreational catches is unknown.

Size Composition

Length-frequency distributions (total length) of red snapper, vermilion snapper, and red porgy in commercial catches were compared (Fig. 3-5). Since trawl catches of vermilion snappers and red porgy were sampled after market (size) grading, it was necessary to adjust the length-frequency groups with a

Table 7. Total catch, average ex-vessel price per pound, percent of total pounds, and ex-vessel dollars for the trawler **Dixiana**, February - May 4, 1976

Species	Pounds	% by Wt	Av. Ex-vessel Price/Lb	% by Dollars*
Red Snapper (*Lutjanus campechanus*)	11,232	31.4	$1.50	53.7
Vermilion Snapper (*Rhomboplites aurorubens*)	8,887	24.8	.90	25.5
Groupers (*Mycteroperca* and *Epinephelus*)	4,930	13.8	.60	9.4
Red Porgy (*Pagrus sedecim*)	5,977	16.7	.40	7.6
Whitebone Porgy (*Calamus leucosteus*)	3,500	9.8	.25	2.8
Black Sea Bass (*Centropristis striata*)	1,033	2.9	.25	.8
Hogfish (*Lachnolaimus maximus*)	85	0.2	.50	.1
Shark	153	0.4	.15	.1
TOTALS	35,797	—		

* Table 9 does not include all revenues (ex-vessel dollars) and pounds reported in this table.

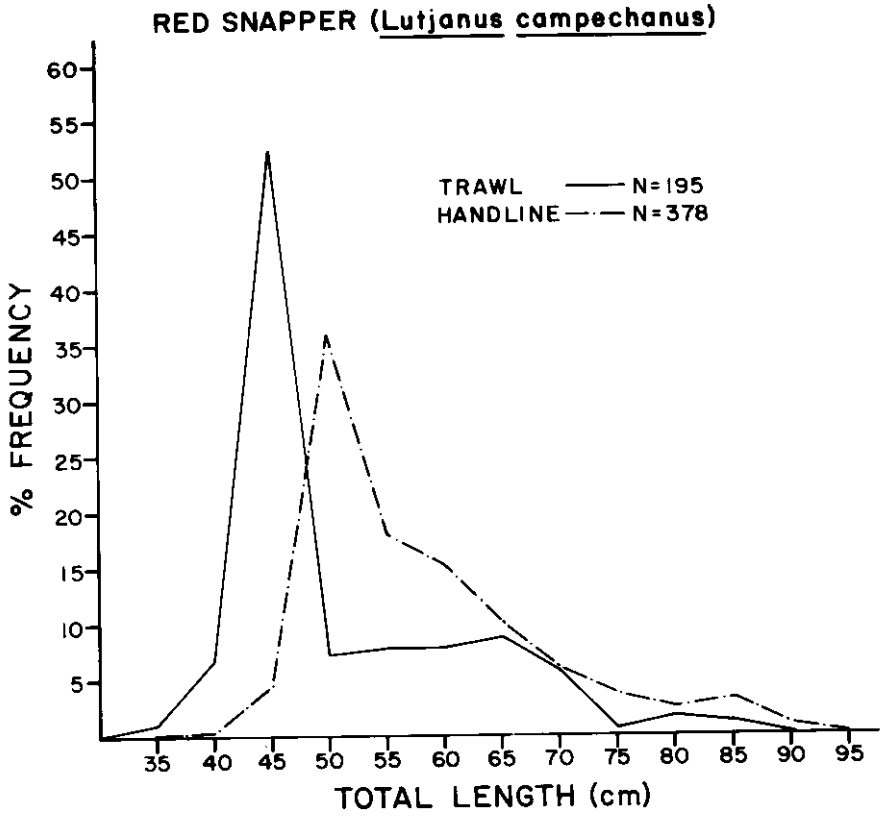

Fig. 3. Size class intervals (cm), for *Lutjanus campechanus* by trawl and hook-and-line gear (handline) from February - September, 1976.

raising factor as discussed in Gulland (1966). The weight of the sample for small vermilion snapper was calculated by using the length-weight equation developed by Grimes (1976). Large vermilion snapper were eviscerated, therefore a preliminary length-eviscerated weight equation was calculated to compute the weight of sampled fish. Sample weights for red porgies were derived using the length-weight equations published by Dias et al. (1972). Due to small samples of gag and scamp groupers from the trawl fishery sampling, no comparisons by gear were possible. Length-frequency distributions for these species taken by commercial hook-and-line vessels are presented in Figures 6 and 7.

Inspection of length-frequency distributions of trawl and commercial hook-and-line catches indicated a significant difference between gear for the vermilion snapper and red porgy. A 2 x C chi-square (X^2) test (Snedecor and Cochran, 1967) was performed on the length-frequency groups of vermilion snapper, red snapper, and red porgy. The results (Table 8) indicate a rejection of the null hypothesis that commercial gear and the associated species length-frequency distributions are unrelated. Although a significant difference in the

size distributions of samples taken by the two gear types exists, it cannot necessarily be attributed to the effects of gear selectivity, due to seasonal difference in the fisheries and the estimating of the raising factor for graded species.

The dominant size class of trawl caught red snapper was the 45-49 cm class (Fig. 3), with 52% of the sample within this class. The dominant size class for the commercial hook-and-line catch was 50-54 cm (Fig. 3). In the northwestern Gulf of Mexico, red snapper enter the commercial hook-and-line fishery at about 20-23 cm (fork length), primarily during the summer months (Bradley and Bryan, 1974).

Size distributions of vermilion snapper (Fig. 4) and red porgies (Fig. 5) captured by the trawl and commercial hook-and-line operations were significantly different (Table 8); the trawl-caught fish being generally smaller than hook-and-line fish. Huntsman (1976) reports that vermilion snapper and red porgy from offshore areas (greater than 25 fm) are usually larger than those taken from inshore waters. Since trawling effort was generally restricted to the 19-25 fm depth strata and commercial hook-and-line fishing was done from 20-35 fm, size selection for the vermilion snapper and red porgy may also be influenced by fish size-dependent schooling and distribution behavior in addition to gear selectivity.

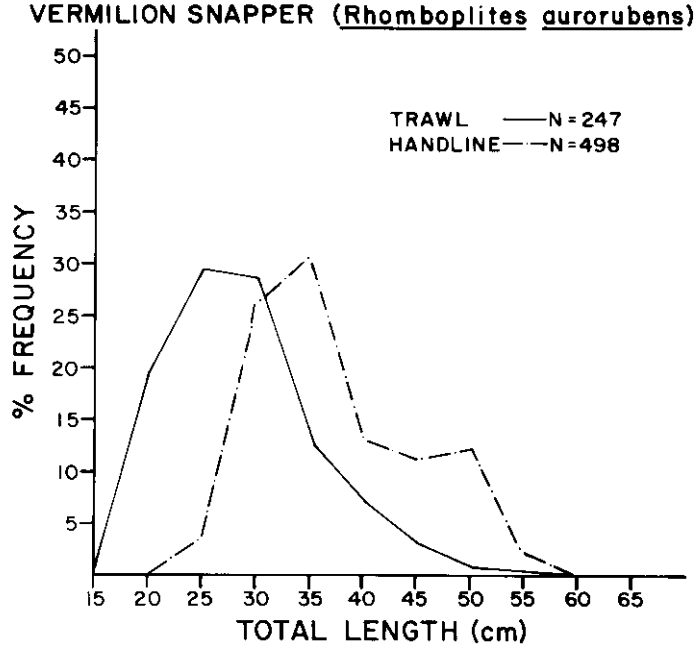

Fig. 4. Size class intervals (cm), for *Rhomboplites aurorubens* by trawl and hook-and-line gear (handline) from February - September, 1976.

ECONOMIC ASPECTS

Marketing Preparation

Commercial hook-and-line fishermen usually eviscerate, wash, and ice their catch while at sea. Eviscerated fish are packed in ice, bellyside down so that fluid will not collect in body cavities. In contrast, trawler fishermen generally will not eviscerate fish on-board because of the short duration of the trips (1 to 3 days), low winter air temperatures, and the large volume of fish that can be caught at one time. When unloaded, the trawl-caught groupers, red snappers, and large vermilion snapper (weighing over 1 lb) are eviscerated. Other species are shipped in the round.

The marketing practice by South Carolina buyers and shippers has been to pack each species separately with a different price paid for each species (Table 6). Camber (1955) and Carpenter (1965) reported that Gulf of Mexico buyers did not make a distinction between various species of snappers, and all were marketed as "red snapper." In addition, price differentials due to owner-operator relationships (Cato and Prochaska, 1975) were not observed in South Carolina.

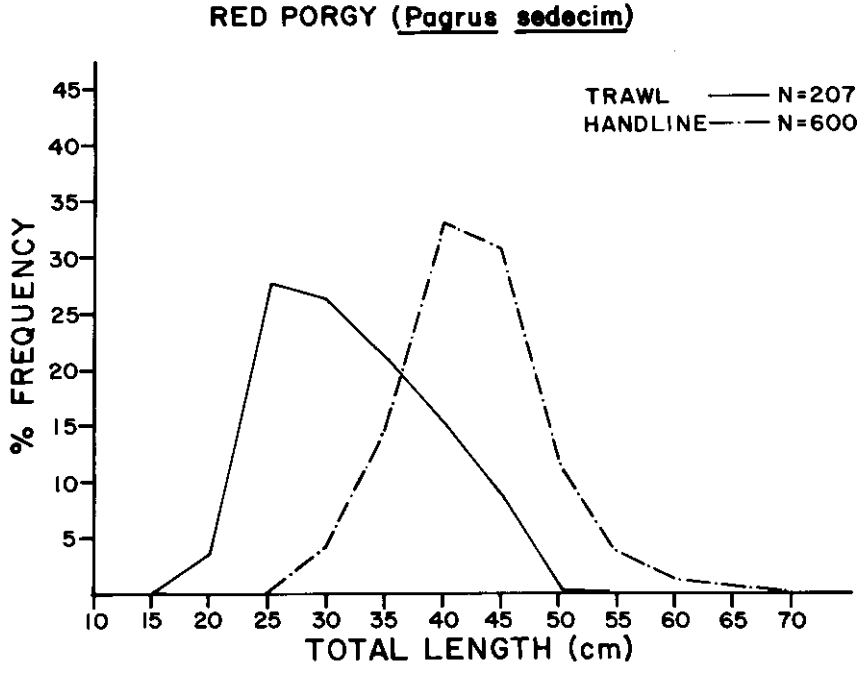

Fig. 5. Size class intervals (cm), for *Pagrus* sedecim by trawl and hook-and-line gear (handline) from May - September, 1976.

Ex-vessel Value

Historically, South Carolina ex-vessel prices for red snapper and vermilion snapper have usually exceeded prices paid for black sea bass and grouper (Fig. 8). Snapper and grouper ex-vessel prices in South Carolina increased substantially during the 1970s compared to 1960s. Research by Cato and Prochaska (1975) suggests that the decline in red snapper and grouper landings in Florida and the other Gulf of Mexico states since 1965 affected the domestic supply of these demersal species resulting in rising prices. Sea bass ex-vessel prices have remained relatively constant in South Carolina since 1971. The lack of significant black sea bass ex-vessel price increases was partially responsible for the decreased commercial sea bass trapping effort and the resulting decline in black sea bass landings after 1972 (Table 1).

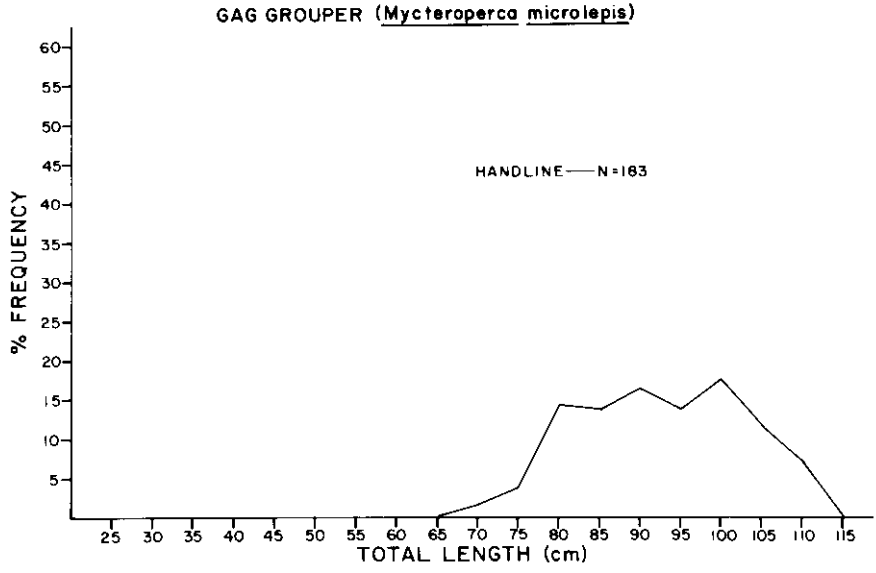

Fig. 6. Length-frequency distribution for *Mycteroperca microlepis*, taken by hook-and-line gear (handline) from May - September, 1976.

Although 1976 grouper ex-vessel prices were lower than red snapper and vermilion snapper prices paid to commercial hook-and-line operations (Table 6) approximately 37% of these fishermen's total gross dollar value (sales) were derived from grouper during April to September, 1976. Vermilion snapper (22%), red snapper (19%), and red porgy (13%), comprised 54% of the total ex-vessel sales from hook-and-line fishermen.

In contrast to the commercial hook-and-line ex-vessel sales, red snapper, not grouper, contributed the most dollars; 54% to the **Dixiana's** total ex-vessel sales (Table 7). The higher red snapper catches compared to the commercial hook-and-line operations and the relatively high price for this species were

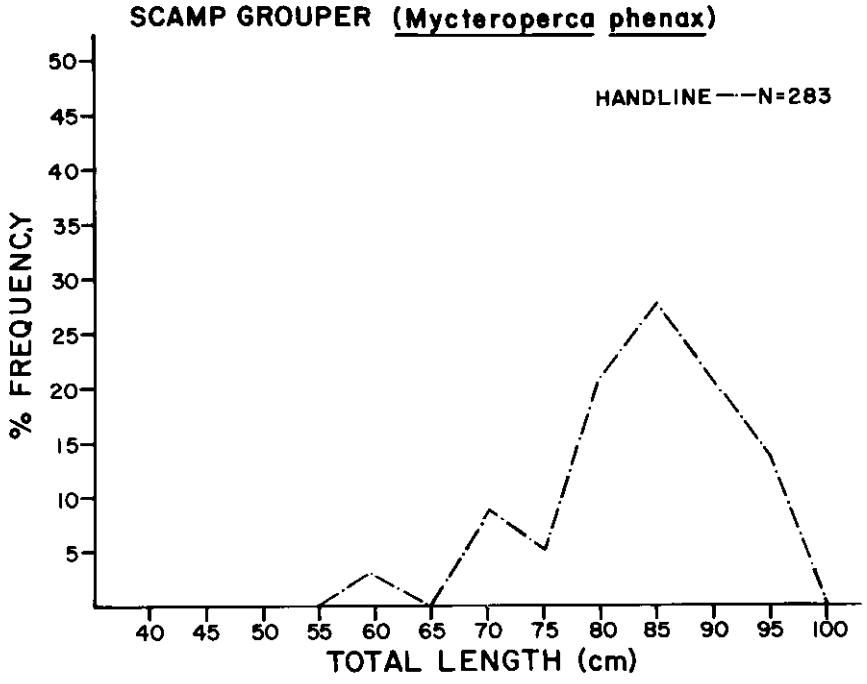

Fig. 7. Length-frequency distribution for *Mycteroperca phenax*, taken by hook-and-line gear (handline) from May - September, 1976.

responsible for the difference. Grouper ex-vessel sales only contributed 9% of the total sales during this trawling demonstration (Table 7). The vermilion snapper ex-vessel sales-percent by the trawler, 26% (Table 7) were near the hook-and-line percent.

Trawling Feasibility

The feasibility of new ventures by an existing firm should be assessed in terms of the profit potential of the venture and its ability to yield greater returns than current uses of the firm's productive factors. In the case of South Carolina shrimp trawlers, the former translates to determining the relationship of gross returns and variable costs for new off-season ventures and also viewing the result in terms of existing off-season utilization of capital and labor.

The calculation of gross and net profit is demonstrated in Table 9. In this instance, winter fish trawling in 1976 clearly meets the first test of feasibility. The break even price after paying all variable costs, fixed costs and a share for the captain was calculated as $0.69 per lb. The net profit represents a 22% increase in profit earned by similar vessels fishing only for shrimp in 1975 (Roberts, 1975). In addition, the profitability (e.g. return to investment) of trawling probably exceeds black sea bass trapping by similar trawlers (Rhodes,

Table 8. Chi-square (X^2) from a 2 x C contingency table (Snedecor and Cochran, 1967) for three demersal fish species and associated commercial gear sampled in South Carolina, 1976

Gear	Red Porgy (*Pagrus sedecim*) Length Frequency										Total
	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65+	
Hook-and-line	0	0	25	88	197	183	70	23	8	6	600
Trawl	88	745	744	568	413	213	14	0	0	0	2785
Total	88	745	769	656	610	396	84	23	8	6	3385
	$X^2 = 1027.12$*, d.f. = 9										

Gear	Red Snapper (*Lutjanus campechanus*) Length Frequency									Total
	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75+	
Hook-and-line	0	1	17	135	68	58	38	23	38	378
Trawl	2	13	102	14	15	15	17	11	6	195
Total	2	14	119	149	83	73	55	34	44	573
	$X^2 = 231.0854$*, d.f. = 8									

Gear	Vermilion Snapper (*Rhomboplites aurorubens*) Length Frequency								Total
	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	
Hook-and-line	0	0	19	130	153	66	57	61	12	498
Trawl	52	1145	1762	1628	672	374	143	44	11	5831
Total	52	1145	1781	1758	825	440	200	105	23	6329
	$X^2 = 922.13$*, d.f. = 8									

* Probability of a greater value less than .5%.

1974). It is risky to generalize about this feasibility demonstration because the generalization would be based upon one set of observations and more importantly the captain's trawling skills are far better than average.

The second test for feasibility proved encouraging. The vessel participating in the fish trawl demonstration was formerly utilized in the off-season (January-April) primarily for trapping sea bass and occasionally hook-and-line fishing for snapper and grouper. This one vessel during 1976 landed nearly the same quantity of snapper and grouper (Table 7) landed for the entire state in 1975 (Table 1). In addition, three other captains chose to equip their vessels with the same type gear based on production early in the demonstration. Based on their 1976 experiences, they will be participating in the trawl fishery again during 1977. Thus it is more by personal observation than data analysis that several vessel owners spending the off season in South Carolina believe fish trawling to be feasible.

MANAGEMENT CONSIDERATIONS

Future Events

It is assumed that recreational fishing effort on demersal stocks in the South Atlantic states will increase during the next 10 years. In 1977, it is anticipated that three to six resident South Carolina shrimp vessels will be employed in trawling for snapper and groupers between January and May. A significant increase in the total number of vessels trawling for demersal species may not occur because of the low fish trawling skills among South Carolina captains and the lack of proper equipment (e.g. LORAN) for trawling offshore. The magnitude of the anticipated 1977 increase of commercial hook-and-line fishermen is unknown. Perhaps the gradual exclusion of U.S. fishermen from Mexican and other foreign fishery economic zones will eventually increase the number of commercial hook-and-line harvesters operating off the South Atlantic states. The activities of both recreational and commercial fishermen may also be significantly altered due to fuel costs in the near future.

Since the present snapper and grouper harvesting off the South Atlantic states is prosecuted beyond the territorial seas, the implementation of the Fisheries Conservation and Management Act of 1976 (P.L. 94-265) on March 1, 1977, will place future management of snappers, groupers, and associated demersal fish

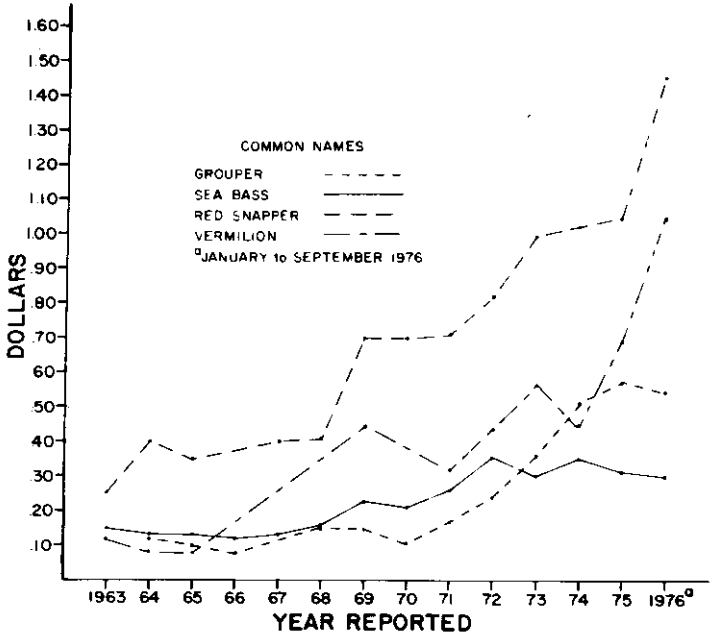

Fig. 8. Trends in South Carolina annual ex-vessel prices for selected demersal species as reported by the National Marine Fisheries Service, U.S. Department of Commerce.

stocks under the jurisdiction of the South Atlantic Fishery Management Council. Under P.L. 94-265 any fishery management plan the Council submits to the Secretary of Commerce must include an estimate of maximum sustainable yield (MSY) and a relatively new concept, optimum yield (OY). The preparation and ultimate implementation of such a plan would seem especially beneficial given the present management vacuum and potential increase of commercial and recreational fishing effort on demersal stocks.

Table 9. Gross and net profit from a fish trawl demonstration conducted in South Carolina, 1976

Gross revenue from 30,711 lb		$26,986*
Variable costs		
Ice	$ 243	
Vessel modification	310	
Social Security tax	631	
Maintenance and repairs	1,571	
Fuel	1,788	
Shares to crew	10,794	
	$15,337	
Gross profit		$11,649
Fixed cost		
Net, doors, floats, sweep†	$ 3,890	
Net profit		$ 7,759

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

† 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.

Management Information

In the Report of the Committee of Conference on H.R. 200 (p. 50) the term, optimum, in the context of OY was defined as " . . . the amount of fish from a fishery which, if produced, will provide the greatest overall benefit to the Nation (especially in terms of food production and recreational opportunities) and which is prescribed for that fishery on the basis of the maximum yield sustainable . . . as modified by any relevant economic, social, or ecological factors." The above definition reflects a legislative mandate for determining MSY; consequently, the various biological yield models used in estimating MSY. The MSY also represents a fundamental concept needed in fishery management (Roedel, 1975).

The MSY concept assumes a knowledge of stock definition, population growth rate in response to exploitation, and accurate estimates of loss rates, particularly due to fishing effort. Also recent work by Lett and Kohler (1976) has demonstrated the importance of examining relationships between species

that interact and are both subjected to exploitation. Although research has been performed on food habits, fecundity, and individual growth of the vermilion snapper (Grimes, 1976) and the red porgy (Manooch, 1975), current information (e.g. catch and effort data) for estimating MSY of demersal fish stocks off the South Atlantic states is inadequate (P.J. Eldridge, personal communication). Moreover, information, particularly estimates for natural mortality rates of some species, is lacking for yield-per-recruit models. The lack of information is unfortunate because investigations in the Gulf of Mexico (Carpenter, 1965, and Bradley and Bryan, 1974) indicate that red snapper stocks have experienced major catch declines under intensive fishing effort.

The pragmatic application of the OY concept will require a new evaluation of information needed for achieving socioeconomic management goals and associated management decisions. Preliminary observations indicate that basic socioeconomic information related to the harvesting sector may be inadequate for determining OY of the snapper and grouper stocks (Table 10). Some of this information (e.g. fishing effort) is necessary for developing conventional yield models for estimating MSY and consequently these deficiencies represent a dual problem in developing a mandatory management tool, MSY, and evaluating socio economic costs and benefits within the harvesting sector. In addition, the scientific investigation of recreational fisheries presents controversial problems in determining recreational fishing values and the ultimate role of these values in fishery management (Stevens, 1969). Although the activities of an important recreational group, headboat fishermen, are being monitored (Huntsman, 1976), additional information will still be needed by the Council when applying the OY concept (Table 10). For instance, factors independent of the actual fishing experience at sea (e.g. traveling distance to the headboats facilities, the recreationalists' income) also strongly influence the satisfaction derived from a fishing trip (Stevens, 1966). A motivation study of British Columbia salt-water recreational fishermen revealed that the most important dimensions of a fishing trip were "... the escapism and out-of-doors aspects of the activity ..." (Bryan, 1974).

User Conflicts

At this time it is useful to discuss potential user conflicts that may occur in the harvesting of South Atlantic snappers, groupers, and associated stocks. In addressing user conflicts, it is important to be specific about what the phrase actually means. Opinions of fishermen toward other fishermen using different techniques to harvest fish may be entirely negative. The problem for the fishery manager is to avoid reacting to these inherent disagreements as conflicts requiring management techniques.

Obviously, user conflicts can arise for reasons other than the common property ownership system and management information problems. Conflicts between recreational and commercial fishermen, as well as between commercial fishermen using different gear types, may reflect differences in the preferred time of harvest and the discount rate for any given species. User groups with the highest discount rate will be more prone to utilize natural resources at higher

Table 10. Harvesting sector basic information typically used in the determination of optimum yield (See Anonymous, 1976) based upon the author's observations

	Description of Information	Status
1.	Commercial catch by major species, time, grounds, vessel type and prices	SC
2.	Vessel type including use (recreational or commercial), size, age, costs, etc.	O
3.	Labor statistics including availability, wages, insurance, fishermen income, etc.	N
4.	Gear description including cost, depreciation, repair and maintenance, etc.	O
5.	Fishing ground distance from port, distance between grounds, etc.	SC
6.	Fishing effort including days fishing, days at sea, trips	SC
7.	Recreational values including estimated number of anglers, the number of angler days, expenditures on goods and services, opportunity cost of time devoted to recreational fishing, etc.	O
8.	Other information including repair and maintenance facilities, processing facilities, utilities (e.g. bait, ice, etc.)	N

SC- Means some data elements are only being collected in South Carolina during 1976 but does not include all data elements.
SC Means all data elements are only being collected in South Carolina during 1976.
N Means none of the data elements are being collected in any South Atlantic state.
O Means some data elements are being collected in the South Atlantic states.

rates. Stier and Bishop (1976) have suggested that the important relationship is between the discount rate and the biological growth potential of the utilized species. If the fecundity and the natural rate of increase of the species is not sufficient to overcome the pressure exerted by a user with a preference for a high present discount rate, the species will soon become unsuitable for use by any group.

In addition to temporal considerations, the methods of harvest are capable of bringing about conflict, whether it be within groups of commercial fishermen or between commercial and recreational fishermen. The fishing gear used will have different efficiencies. Users of less efficient gear may experience catches diminishing to unacceptable levels when more efficient gear is used on the same species and grounds. Radovich (1975) suspects that the catch-per-effort of hook-and-line fishing may not be linearly related to the population level, due to density-dependent factors. It follows that when recreationalists are involved in a fishery, the population may have to be maintained at a level higher than that experienced under a MSY strategy. This phenomenon is reflected in Huntsman's (1976) suggestion of a management strategy directed toward maximizing catch-per-effort in order "... to preserve the present headboat fishery ..." harvesting demersal species off the Carolinas.

Although P.L. 94-265 does not specifically define OY, it does not permit management solely on the basis of economic factors. This is not to be taken as synonymous in ruling out maximum net economic yield (MEY). Certainly, fishery scientists have been successful in establishing the fact that MEY occurs at lower levels of effort (i.e. larger population levels) than MSY. The implication is that fishing effort can be at or near MEY in that the recreationalist's use of less efficient gear and consequent desire for larger population levels may permit MEY management under P.L. 94-265.

ACKNOWLEDGMENTS

We greatly appreciate the information and assistance that was given us by the Sullivan's Island Seafood Company employees and the captains and crews of the commercial fishing vessels. We also wish to thank those who assisted in specific aspects of data collection and preparation without which this report could not have been completed: dock sampling – John Guilds, Paula Keener, Richard McEachern, and Ken Ward; data preparation –Francoise Noe, Cheryl Oswald, and Karen Swanson; manuscript typing, Catherine Roehrig; manuscript review and constructive criticism – Charles Barans, Charles Bearden, David Cupka, Peter Eldridge, Edwin Joseph, and Paul Sandifer.

This is Contribution No. 69 from the South Carolina Marine Resources Center. The trawler demonstrations are a result of extension work partially sponsored by NOAA Office of Sea Grant, Department of Commerce, under Grant No. 04-6-158-44009. Reference to firms in this paper does not imply endorsement of commercial products by the State of South Carolina.

LITERATURE CITED

Anonymous.
1976. Annex K–Typical kinds of socioeconomic information used in the determination of optimum yield. *In* Regional Fisheries Management Council operation manual. Washington, D.C. 141 pp.

Bearden, C.M. and M.D. McKenzie.
1971. An investigation of the offshore demersal fish resources of South Carolina. S.C. Mar. Res. Center Tech. Rpt. No. 2. 19 pp.

Bradley, E. and E.C. Bryan.
1974. Life history and fishery of the red snapper (*Lutjanus campechanus*) in the northwestern Gulf of Mexico. Proc. Gulf Carib. Fish. Inst. 26:77-106.

Bryan, R.C.
1974. The dimensions of a salt-water sport fishing trip or what do people look for in a fishing trip besides fish? Environment Canada, Fish. Mar. Serv., So. Oper. Br., Pac Region, PAC/T-74-1. 35 pp.

Calder, D.R., P.J. Eldridge, and E.B. Joseph, eds.
1974. The shrimp fishery of the southeastern United States. A management planning profile. S.C. Mar. Res. Center Tech. Rpt. No. 5. 229 pp.

Camber, C.
1955. A survey of the red snapper fishery of the Gulf of Mexico, with special reference to the Campeche Banks. Fla. State Bd. Cons. Tech. Series No. 12. 64 pp.

Carpenter, J.S.
1965. A review of the Gulf of Mexico red snapper fishery. U.S. Fish Wildl. Serv. Cir. No. 208. 35 pp.

Cato, J.C. and F.J. Prochaska.
1975. The Gulf of Mexico commercial and recreational red snapper-grouper fishery: An economic analysis of production, marketing and prices. University of Florida, Florida Sea Grant Program. Presented at the Colloquium of Snapper and Grouper Resources of the Western Central Atlantic, Gulf State Mar. Fish. Comm. October 1975.

Cummins, F. Jr., J.B. Rivers, and P. Struhsaker.
1962. Snapper trawling explorations along the Southeastern Coast of the United States. Com. Fish. Rev. 24(12): 1-7.

Dias, R.K., Dias, J.K., and W.D. Anderson, Jr.
1972. Relationships of lengths (Standard, Fork, and Total) and lengths to weight in the Red Porgy, *Pagrus sedecim* (Perciformes, Sparidae), caught off South Carolina. Trans. Amer. Fish. Soc. 101(3): 503-506.

Grimes, C.B.
1976. Certain aspects of the life history of the vermilion snapper *Rhomboplites aurorubens* (Cuvier) from North and South Carolina waters. Ph.D. dissert. U. of N.C., Chapel Hill, N.C. 240 pp. (unpublished).

Gulland, J.A.
1966. Manual of sampling and statistical methods for fisheries biology. Part 1. Sampling methods. FAO Man. Fish. Sci. No. 3 (FRs/M3), Rome, Italy. 87 pp.

Hillier, A.J.
1974. URI high rise series. Bottom trawl manual. U. of Rhode Island, Sea Grant Marine Bull. No. 20 4 pp.

Huntsman, G.R.
1974. Possible effects of foreign fishing on marine sport fishing in the Carolinas. Por. Intern. Gamefish Res. Conf. 16:36-42.

———
1976. Offshore headboat fishing in North Carolina and South Carolina. Mar. Fish. Rev. 38(3): 13-23.

Jones, T.M., J.W. Hubbard, and K.J. Roberts.
1976. Data collected for study. A Productivity and Profitability Analysis of the South Carolina Double Rig Shrimp Fishery: A Case Fishery. Agr. Econ. Rural Sociology Dept. Clemson University. (unpublished).

Lett, P.F. and A.C. Kohler.
1976. Recruitment: a problem of multispecies interaction and environmental perturbations, with special reference to Gulf of St. Lawrence Atlantic herring (*Clupea harengus harengus*) J. Fish. Res. Board Can. 33:1353-1371.

Manooch, C.S.
1975. A study of the taxonomy, exploitation, life history ecology and tagging of the red porgy, *Pagrus pagrus* Linnaeus off the Carolinas. Ph.D. dissert. Dept. Zoology N.C. State U. Raleigh, N.C. 275 pp. (unpublished).

Parrish, B.B.
1963. Some remarks on selection processes in fishing operations in the selectivity of fishing gear. ICNAF Spec. Publi. No. 5:166-170.

Prytherch, H.F.
1970. Trends and conditions of the fisheries of South Carolina, December, 1970. National Marine Fishery Service, Savannah, Georgia. 3 pp. (unpublished).

Radovich, J.
1975. Application of Optimum Sustainable Yield Theory to Marine Fisheries. Pages 21-28 *in* P.M. Roedel, ed. Optimum sustainable yield as a concept in fisheries management. Amer. Fish. Soc. Special Publ. No. 9.

Rhodes, R.J.
1974. Development of an expanded commercial fisheries statistics program for South Carolina. S.C. Mar. Res. Center. Final Completion Rpt. on Project 2-137-D in coop. with NMFS: 149 pp. (unpublished).

———— and C.M. Bearden.
1974. Winter trawling for bottom fish off South Carolina. Coastal Plains Reg. Comm. Contract No. 10240043, S.C. Wildl. and Mar. Res. Center Department. 24 pp. (unpublished).

Rivas, L.R.
1969. Snappers of the Western Atlantic. Fish Wildl. Serv. Sep. No. 860: 41-44.

Roberts, K.J.
1974. Marine Business Aids No. 1-4, S.C. Sea Grant Marine Advisory Program.

———
1975. Revised Marine Business Aids No. 1-4. S.C. Sea Grant Advisory Program.

Roedel, P.M.
1975. A summary and critique of the symposium on optimum sustainable yield. Pages 79-89 *in* P.M. Roedel, ed. Amer. Fish. Soc. Special Publ. No. 9.

Rosen, A. and R.K. Robinson.
1961. Summary of Florida commercial marine landings, 1960, and an analysis of the catch and effort of certain species. Report to Fla. State Bd. Cons., U. of Miami, Miami, Florida. 32 pp.

———
1962. Summary of Florida commercial marine landings 1960, and an analysis of the catch and effort of certain species. Rpt. to Fla. State Bd. Cons., U. of Miami. 32 pp.

Snedecor, G.W. and W.F. Cochran.
1967. Statistical methods. Iowa State U. Press. Ames, Iowa. 593 pp.

Steir, J.C. and R.C. Bishop.
1976. Private property, market trade, and wildlife conservation. Annual meeting of American Agricultural Economics Association, Pennsylvania State U.

Stevens, J.B.
1966. Angler success as a quality determinant of sport fishery recreational values. Trans. Amer. Fish. Soc. 95(4): 357-362.

———
1969. Measurement of economic values in sport fishing: an economist's views on validity, usefulness and propriety. Trans. Amer. Fish. Soc. 98(2): 352-357.

Struhsaker, P.
1969. Demersal fish resources: composition, distribution, and potential of the continental shelf stocks off Southeastern United States. Fish. Indust. Res. 4(7): 261-300.