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Population Assessment of the Scamp, *Mycteroperca phenax*, from the Southeastern United States

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ABSTRACT

Changes in the age structure and population size of scamp, Mycteroperca phenax, from North Carolina through the Florida Keys were examined using records of landings and size frequencies of fish from commercial, recreational, and headboat fisheries from 1986-1996. Population size in numbers at age was estimated for each year by applying separable virtual population analysis (SVPA) to the landings in numbers at age. SVPA was used to estimate annual, age-specific fishing mortality (F) for four levels of natural mortality (M = 0.10, 0.15, 0.20, and 0.25). We believe that the best estimate of M is 0.15-0.20. Landings of scamp for the three fisheries have generally increased in recent years, and minimum fish size regulations have resulted in an increase in the mean size of fish landed. Age at entry and age at full recruitment were age-1 and age-5 for 1986-1988, age-1 and age-3, for 1989-1991, and age-1 and age-5 for 1992-1996. With M = 0.15, levels of fishing mortality (F) ranged from 0.11 to 0.29 for the entire period, 1986-1996. Spawning potential ratio (SPR) was 35% with M = 0.15 for the most recent time period, 1992-1996, and 52% with M = 0.20. If M does equal 0.15, SPR could be raised to 40% by reducing F or increasing the age at entry to the fisheries. We ran the models with release fish mortality, which had no impact on attaining the 40% SPR level.

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INTRODUCTION

The scamp, *Mycteroperca phenax*, is a small to medium sized grouper (Family Serranidae) highly prized by both commercial and recreational fishermen. It is considered to be a seafood delicacy by many fishermen and restauranteurs. The species is found in tropical and warm temperate waters of the western Atlantic from the Campeche Banks in the Gulf of Mexico to North Carolina. Although it occasionally concentrates over high-profile bottom, such as rock outcroppings and wrecks, the preferred habitat is low-profile, live-bottom areas in waters 75 to 300 feet deep from Cape Hatteras to Cape Canaveral (Manooch 1984).

The scamp is believed to be a protogynous hermaphrodite, changing sex from female to male with an increasing size (age). It is reported to live for more than 21 years (Matheson et al. 1986). Off North Carolina and South Carolina, spawning takes place from April through August with a peak in May and June when bottom water temperatures are 22° to 25° C (Matheson et al. 1986). Spawning aggregations of approximately 100 individuals have been observed off the east coast of Florida during September and April (Gilmore and Jones 1992). Eggs and larvae are pelagic and continue this surface-associated existence for days before settling to the bottom to populate favorable habitats (Manooch 1984). Females become sexually mature between the ages of two and five years and lengths of 11 to 16 inches (Bullock and Murphy

1994). Like most groupers, scamp ambush their prey. Major foods are fishes, cephalopods, and crustaceans (Matheson et al. 1986). Dodrill et al. (1993) found that scamp were highly piscivorous compared with 21 other serranids.

In terms of commercial finfish value, the species ranks from 23rd to 28th place for the entire southeastern United States from 1990-1996 (Table 1). Fishermen were able to sell scamp at dockside for $2.00 to $2.43 per pound (Table 1). The species is particularly important to the commercial fisheries of Georgia, where it has ranked fourth or fifth for all finfish from 1990-1996, and in South Carolina (Table 2), where it has ranked fifth, sixth, or seventh for those years (Table 2). By contrast, the scamp is relatively unimportant to commercial fisheries off South Florida (Table 2).

Table 1. Scamp ranking in commercial finfish value ($) for the southeastern U.S.

Year	Rank	Value	$/Lb.
1990	23	1,012,537	2.04
1991	24	883,123	2.16
1992	28	645,789	2.18
1993	26	705,457	2.21
1994	27	769,941	2.26
1995	25	853,121	2.28
1996	24	741,228	2.43

Table 2. Scamp ranking in commercial finfish value ($) by state/area.

	NC		SC		GA		NFL		SFl	
Year	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value
1990	21	217,326	5	518,389	4	90,517	21	175,244	54	11,061
1991	21	199,475	6	487,375	4	83,232	25	87,646	46	25,395
1992	30	149,068	7	319,994	5	51,691	24	105,546	50	19,490
1993	24	215,017	5	312,264	4	65,159	23	99,775	53	13,242
1994	24	244,635	6	330,248	4	71,440	23	109,522	53	14,096
1995	26	236,046	6	334,498	4	104,919	19	167,188	55	10,470
1996	29	185,163	5	367,928	5	56,289	22	118,948	59	12,900

This assessment of the scamp stock from North Carolina (south of Cape Hatteras) through the Florida Keys was conducted to facilitate decision-making by the South Atlantic Fishery Management Council (SAFMC). Although the SAFMC Snapper-Grouper Fishery Management Plan (FMP)(SAFMC 1983) does include discussions of the species, and Huntsman et al. (1992) provided assessments for the species along with the rest of the snapper-grouper complex using data from 1988 and 1990, no separate stock assessment has been made for the scamp along the southeastern United States.

The SAFMC has taken actions to regulate the harvest of the species. The FMP for the snapper-grouper fishery was implemented on August 31, 1983. Amendment 4 to the FMP, effective January 1, 1992, required a 20-inch minimum size for both commercial and recreational fisheries, and a grouper recreational aggregate limit of five grouper per person per day.

In this report we compute and document changes in the age structure and population size for the species. Specifically, given age-specific estimates of instantaneous fishing mortality rates and information on growth, sex ratios, maturity and fecundity, analyses of yield per recruit (YPR) and spawning potential ratio (SPR) are used to determine the status of the southeastern U.S. scamp stock.

METHODS

Landings

For purposes of this report, scamp are landed by three fisheries: commercial, recreational, and headboat. The commercial fishery is principally prosecuted by hydraulically- and manually-operated hook-and-line gear, although a few landings are made by trawls and traps. The recreational fishery includes hook and line fishing from shore or any platform other than headboats. This includes small private boats and charter boats (six passengers or less). Headboats are those usually carrying more than six passengers and charge on a per person basis, thus by the "head", and are considered separate for our analyses from the other recreational vessels. Although landings are available for different years depending on fishery, only data from 1986-1996 were available for all three fisheries. Landings were used with fish length at age information to develop a catch-in-numbers-at-age matrix, which is found under the appropriate heading below.

Landings data were used to describe annual trends in catches, including catch in number, catch in weight, mean fish size, and mean fish age. Catch-per-effort were provided for the headboat data, recreational data, and fishery independent data. Whenever possible, the databases were stratified by state or area: North Carolina, South Carolina, Georgia, North Florida, and South Florida (both East Coast only).

To draw conclusions about the scamp population from fish that were sampled from catches, it is very important that samples were representative of the stock (e.g., size, sex, distribution, etc.), and were adequate in number. Although assumptions must be made for the former, biologists and managers should have some control over the latter. To evaluate the adequacy of sampling intensity for the three fisheries (headboat, recreational, and commercial), we used the informal criterion of 100 fish sampled per 200 metric tons of that species landed (USDOC 1996).

Age/Growth

Growth parameters, length-length conversions, weight-length relationship, and a fish age-fish length key were obtained from a recent study of scamp by Harris (in prep).

Development of Catch-in-Numbers-at-Age Matrix

Data used in the construction of the matrix were derived from several sources and covered the geographical area extending from North Carolina through the Florida Keys. Fishery independent information, including fish age and CPUE data for trap gear were provided by fisheries personnel of the South Carolina Department of Natural Resources, MARMAP (Marine Resources Monitoring, Assessment, and Prediction) Program, Charleston, SC for 1988-1996. Recreational landings and fish lengths and weights were obtained from the Marine Recreational Fisheries Statistics Survey (MRFSS) data base (NMFS, Washington DC) for 1981-1996. Headboat catch estimates, fish length, and fish weight data were obtained from the NMFS for 1972-1996 (NMFS, Beaufort, NC). Commercial fishery data were obtained from two data sets: the General Canvas for catch statistics for 1980-1996, and from the Trip Interview Program (TIP) for length and weight statistics for 1983-1996 (NMFS, Miami, FL).

Derivation of catch in numbers at fish age consisted of multiplying the catch in numbers (n, scalar) by the fish age-fish length key (A, matrix) by a length frequency distribution (L, vector) to obtain the catch in numbers by fish age (N, vector:

$$N_{ax1} = n \cdot A_{axb} \cdot L_{bx1}$$ (Vaughan et al. 1992)),

where a is the number of ages (1 to 27 years), and b is the number of length intervals. Since commercial landings are reported by weight only, the catch of scamp was converted to numbers by dividing the weight landed by the mean weight, stratified by year, geographical area, and gear. The mean weights were estimated from the length samples (TIP) converted to weights by the length-weight equation from Matheson et al.

(1986).

Mortality Estimates

Total Instantaneous Mortality (Z)

Total instantaneous mortality was estimated by analyzing catch curves (Beverton and Holt 1957) based on fully recruited age fish and older. The fish age-fish length key was used to construct catch curves by assigning ages to the landed unaged scamp. Mortality estimates under equilibrium assumption were obtained by regressing the natural log of the catch in numbers against age for fully recruited fish (ages 3 through 20, or 5-20, depending on time period).

Natural Mortality (M)

Natural mortality is often estimated from relatively weak life history and ecological analogies, yet is a very important step in determining that portion of total mortality which may be attributed to fishing. Natural mortality can perhaps be best estimated by using bioprofiles characteristics as demonstrated by Pauly (1979) and later by Hoenig (1983). Pauly (1979) used von Bertalanffy parameters (L_∞, and K, yr^{-1}) as well as mean water temperature (T ^{0}C) for the general habitat:

$$\log_{10}M = 0.0066 - 0.279 \log_{10}L + 0.6543 \log_{10}K + 0.4634 \log_{10}T.$$

Sea surface temperature readings from buoys operated by NOAA's

National Oceanographic Data Center were used to calculate mean annual seawater temperature. Buoys recorded temperature every 30 minutes, and monthly averages were calculated at four different locations throughout the South Atlantic Bight (SAB). These monthly averages were averaged across locations and a SAB-wide value for mean annual temperature obtained. All data were from 1996 for all buoys except Edisto, where 1995 data were used for October through December. Buoys used and their locations are

1) Edisto - 32.5° N 79.1° W
2) Savannah - 31.9° N 80.7° W
3) St. Augustine - 29.9° N 81.3° W
4) Cape Canaveral - 28.5° N 80.2° W

Hoenig (1983) utilizes the maximum age (t_{max}) in an unfished stock of a species:

$$\ln M = 1.46 - 1.01 \ln t_{max}.$$

Because this relationship is based on Z, rather than M, the maximum age in the virgin population (F = 0; M = Z-F) would provide an approximate estimate of natural mortality. Hoenig (1983) also provides an estimate of Z which takes into account the sample size used in the study, the rationale being one has a greater chance of encountering the true maximum age of the fish with increasing sample size. The equation used is

$$Z = \ln (2n + 1)/t_{max} - t_c,$$

where t_c = first age fully represented in the catches.

We also estimated natural mortality using the methods of Roff (1984), using optimal age at maturity, and Rikhter and Efanov

(1977), using age at 50 % maturity. For both methods, we used the logistic function to obtain length at 50 % maturity, and then used the von Bertalanffy growth equation to solve for the corresponding age at 50 % maturity. Another method we used to estimate M was the method of Alverson and Carney (1975), which allows prediction of M from estimates of maximum age and the Brody growth coefficient K.

We also derived estimates of M from the empirical equation of Ralston (1987): $M = 0.0189 + 2.06*K$. This regression equation was developed by surveying the literature for instances in which the von Bertalanffy growth parameter K was jointly estimated with M. Nineteen populations of snapper and grouper species were used, and data were pooled to develop the regression. One final method used to estimate M was the relationship developed by Alagaraja (1984): $S(t_\lambda) = e^{-Mt\lambda}$, where t_λ = maximum age and $S(t_\lambda)$ = survivorship to the maximum age.

Fishing Mortality (F) and Virtual Population Analysis (VPA)

Once natural mortality and total instantaneous mortality have been estimated, it is an easy exercise to obtain fishing mortality, F (e.g., $Z = M + F$; $F = Z - M$). The problem arises from the equilibrium assumption of constant F and recruitment. In this assessment, age-specific fishing mortality rates, and estimates of scamp age-specific population size were obtained by applying an uncalibrated separable virtual population analysis (VPA) technique. However, because of the short time frame of the catch matrix (1986-1996) relative to reported ages for the species (1-27), this was not completely successful. Initially two temporal periods (1986-1991 and 1992-1996) were required, due to the minimum size limits imposed at the beginning of 1992. The VPA method is explained briefly below:

The catch matrix was interpreted using the separable virtual population analysis (VPA) approach to obtain annual age-specific estimates of population size and fishing mortality rates. Virtual population analysis sequentially estimates population size and fishing mortality rates for younger ages of a cohort from a starting value of fishing mortality for the oldest age (Murphy 1965). An estimate of natural mortality, usually assumed constant across years and ages, was also required. The separable method of Doubleday (1976) assumes that age- and year-specific estimates of F can be separated into products of age and year components. There are obvious problems with applying this technique to the full time period, 1986-1996, because of the imposition of a 20-inch size limit for recreational anglers and commercial fishermen which was effective January, 1992. Therefore, the technique was initially applied separately to the two time periods (1986-1991 and 1992-1996). We used the FORTRAN program developed by Clay (1990), based on Pope and Shepherd (1982).

Yield Per Recruit

The yield per recruit model was used to estimate the potential yield in weight for scamp and was based on the method of Ricker (1975). The model estimates total weight of fish taken from a cohort divided by the number of individuals of that cohort that entered the fishing grounds. Unlike the full-dynamic pool model (Beverton and Holt 1957), the Ricker-type model only requires parameters that are relatively easily obtainable: M, F, K, L_∞, t_r (age at recruitment to the fishery), and fishing at ages prior to full recruitment, all shape the response surface (i.e. how the scamp yield per recruit reacts to various levels of fishing effort). The above-mentioned parameters were estimated as discussed previously.

Spawning Potential Ratio

Gabriel et al. (1989) developed maximum spawning potential (%MSP) as a biological reference point. The currently favored acronym for this approach is referred to as equilibrium or static spawning potential ratio (SPR). A recent evaluation of this reference point is given in a report by the Gulf of Mexico SPR Management Strategy Committee (1996) for the Gulf of Mexico Fishery Management Council (see also Mace and Sissenwine (1993), and Mace (1994)). Equilibrium, or static, SPR was calculated as a ratio of spawning stock size when fishing mortality was equal to the observed or estimated F divided by the spawning stock size calculated when F was equal to zero. All other life history parameters were held constant (e.g., maturity schedule and age-specific sex ratios). Hence, the estimate of static SPR increases as fishing mortality decreases. An estimate of released fish mortality was also incorporated into the models.

The SAFMC defines and explains static Spawning Potential Ratio (SPR, also known as Percent Maximum Spawning Potential (%MSP)) as "a measure of an average female's egg production over its lifetime compared to the number of eggs that could be expected if there was no fishing. When there is fishing pressure, a fish's life expectancy is reduced, and so is its average lifetime egg production. A species is considered overfished if its SPR drops below a level beyond which the ability of the stock to produce enough eggs to maintain itself is in jeopardy" (SAFMC 1996). The SAFMC considers a stock to be overfished if the SPR is < 0.30 (< 30%), and is recovering with SPR values ranging from 0.30-0.39 (30-39%). The target is to obtain a SPR of 0.40 or greater (> 39%) (Gregg Waugh, SAFMC, Charleston, SC, pers. comm.). These ranges in SPR values and respective definitions are being debated. Longevity, age-specific fecundity, and age-specific fishing mortality are critical to the derivation of SPR.

In this study, comparisons of age-specific spawning stock biomass were based on mature female biomass and egg production. We derived a sexual maturity schedule for scamp from information provided by Bullock and Murphy (1994). This crude estimate must suffice until SCDNR personnel complete a reproductive study of the species, which is now in progress.

RESULTS

Sampling Adequacy

We used an informal standard developed by the NMFS, Northeast Regional Stock Assessment Workshop (USDOC 1996) to determine the adequacy of biological sampling of scamp landings (Table 3). According to this standard, 100 fish lengths should be recorded for each 200 mt of the species landed. Thus, a value greater than 200 mt/100 samples indicates an inadequate sample. Using 1986-1996 data, we found that recreational (MRFSS) landings of scamp were much less frequently sampled than were headboat or commercial landings (Table 3). Fewer than 100 fish were sampled regionwide for all years except 1996. The problem identified here for scamp holds true for two species for which recent population assessments have been prepared: red snapper, *Lutjanus campechanus*, (Manooch et al. 1998a) and vermilion snapper, *Rhomboplites aurorubens*, (Manooch et al. 1998b) and probably other species of reef fish as well. We encourage an increase of biological sampling intensity of reef fish by MRFSS personnel.

Table 3. Level of sampling per year by fishery (mt/100 length samples) for scamp in the southeastern U.S. Informal criteria is set at 200mt/100 length samples e.g. <200mt/100 length samples, sampling is adequate; >200mt/100 length samples, samplingg is inadequate). (* indicates no samples for that year, but estimated landings.)

Year	MRFSS		Headboat		Commercial	
	mt/#of samples	Level	mt/# of samples	Level	mt/# of samples	Level
1986	3.2/0	*	16.7/360	5	124.2/2154	6
1987	5.3/11	48	24.2/499	5	146.5/3878	4
1988	23.8/43	55	23.6/417	6	136.8/2740	5
1989	9.7/34	29	20.8/303	7	171.5/3321	5
1990	7.8/59	13	27.9/290	10	225.2/2944	8
1991	14.6/23	63	78.2/398	20	184.6/4067	5
1992	15.5/43	36	30.6/271	11	133.3/1798	7
1993	7.8/33	24	24.4/335	7	143.8/2294	6
1994	11.6/41	28	28.5/356	8	152.9/1720	9
1995	0.1/2	5	35.5/350	10	169.4/2818	6
1996	12.6/9	140	25.7/611	4	138.5/2543	5

Trends - Landings

Commercial

Although some commercial landings data are available from 1980 (Table 4), the most reliable and uninterrupted time series begins in 1986. From 1986-1996, landings averaged 355,231 pounds (N = 11) with catches exceeding 400,000 pounds in 1987, 1990, and 1991.

Landings have generally increased since 1980 (Figure 1). The decrease in catches for 1992 may be attributable to regulations imposed in that year (minimum size for recreational and commercial fisheries and bag limit for anglers) rather than abundance of the species. Most scamp were landed at ports in South Carolina and North Carolina (unweighted mean = 77% of the southeastern U.S. catch for 1986-1996). Relatively few scamp were landed in South Florida and the Keys (Table 4).

Headboat

Headboat data are available for all geographical areas for the years 1981 through 1996 (Table 5; Figure 2). For the 16-year period, landings averaged 59,114 pounds. Catches have remained relatively stable since 1981, with the exception of 1991 when headboat landings were unusually high, 172,118 pounds (Table 5; Figure 2). Overall, commercial landings of scamp are five to eight times greater than those reported by headboat anglers for 1986-1996 (Tables 4 and 5).

Most scamp were landed by headboat anglers fishing out of North Carolina, South Carolina, and Northeast Florida ports. Conversely, the species is less frequently caught off Georgia and Southeast Florida.

Table 4. Scamp commercial landings-- weight (lbs) and value ($) from the southeastern U.S.

	NC		SC		GA		FL		Total	
Year	Wt	Value	Wt	Value	Wt	Value	Wt	Value	Wt	Value
1980			36654	31399	1610	1478			38264	32877
1981	59646	53883	52650	49121	3964	3743			116260	106747
1982	84218	70020	120084	113125	259	326			204561	183471
1983	64754	57285	102243	117908	625	819			167622	176012
1984	107087	148483	85357	116904	26897	35339			219341	300726
1985	99452	146052	63274	99735	21771	34951			184497	280738
1986	135612	208561	65944	120701	28242	57993	43423	73826	273221	461081
1987	147607	236803	218716	110881	16938	29664	46803	95943	430064	473291
1988	132154	236211	112659	242318	15626	29233	40578	92630	301017	600392
1989	116703	201699	179358	357968	22441	38908	58800	127155	377302	725730
1990	123570	217326	238908	518389	49971	90517	82949	183576	495398	1009808
1991	109024	199475	208077	487375	44449	83232	44799	105278	406349	875360
1992	74335	149068	142677	319994	26969	51691	49295	119730	293276	640483
1993	106288	215017	138852	312264	30149	35159	41140	106630	316429	669070
1994	113710	244635	146368	330248	32065	71440	44335	115324	336478	761647
1995	111367	236046	147128	334498	46762	104919	67965	176339	373222	851802
1996	83277	185163	147361	367928	25282	56289	48867	131848	304787	741228

Figure 1. Commercial landings (lbs) of scamp from the southeastern U.S.

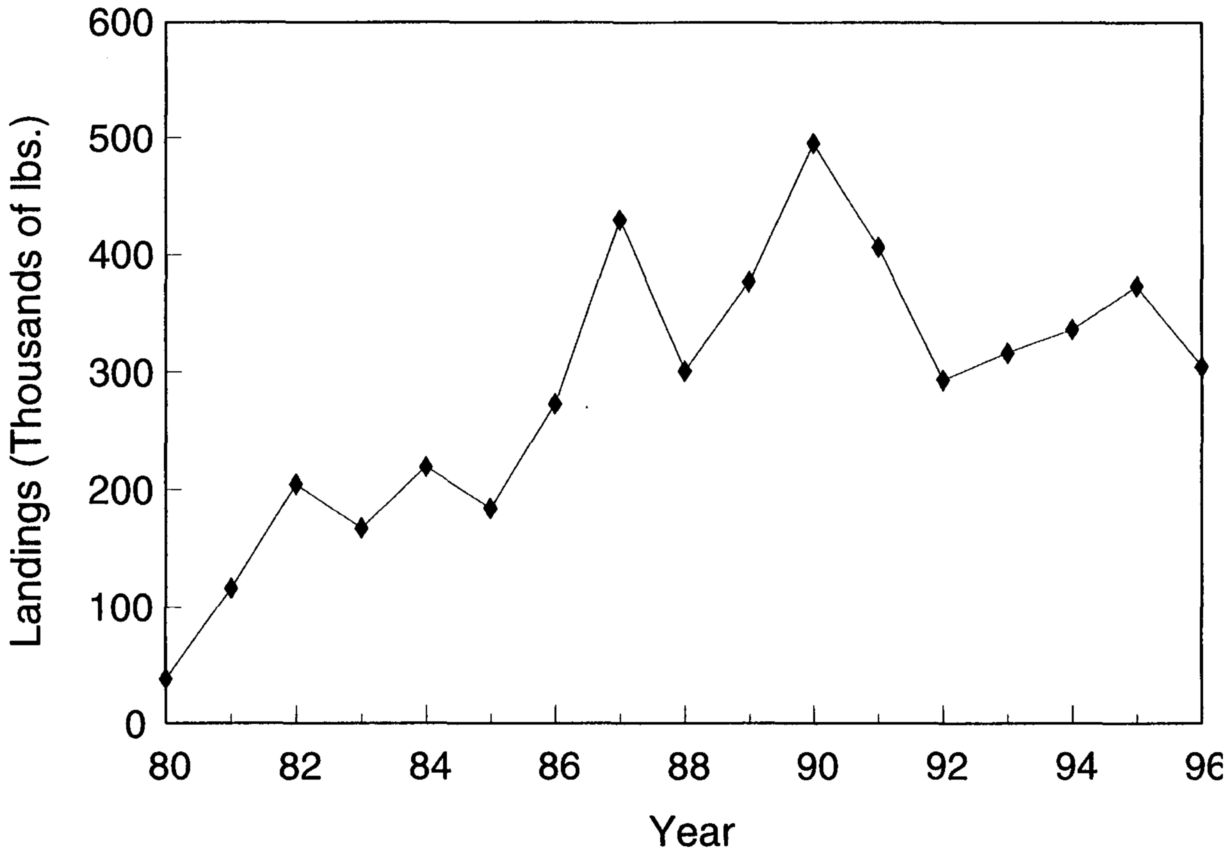
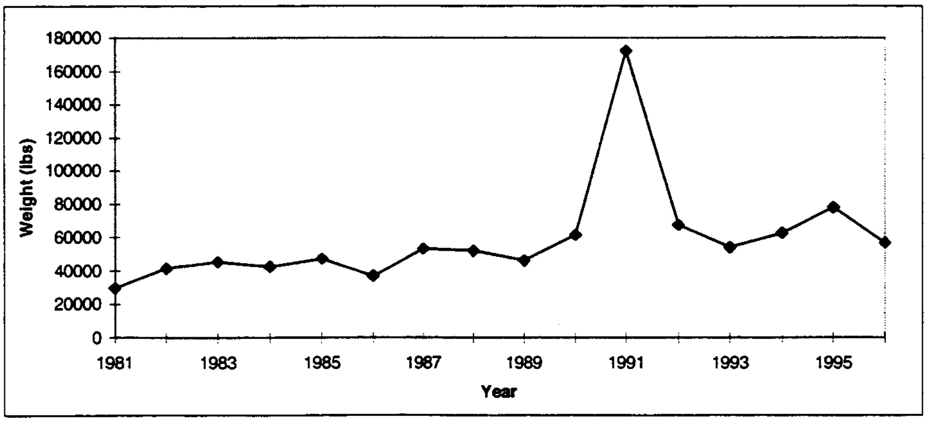


Table 5. Scamp headboat landings -- number and weight (lbs) from the southeastern U.S.

	North Carolina		South Carolina		NE Florida-Georgia		SE Florida		Total	
Year	Number	Weight	Number	Weight	Number	Weight	Number	Weight	Number	Weight
1972	1980	18975	9329	97933					11309	116908
1973	2903	24814	4376	47062					7279	71876
1974	8082	72914	3412	34811					11494	107725
1975	4086	38465	1881	22710					5967	61175
1976	4829	46508	1651	21978					6480	68486
1977	4304	39948	1462	19083					5766	59031
1978	5204	48816	1614	18552					6818	67368
1979	7523	68536	2127	19512					9650	88048
1980	1407	8385	1998	14124					3405	22509
1981	1042	5764	1405	7454	320	2479	4312	13973	7079	29670
1982	2612	17569	2824	13996	415	2939	1679	6938	7530	41442
1983	1548	9654	3375	23371	883	5091	1923	7129	7729	45245
1984	2639	15134	2372	16012	698	4182	1416	6998	7125	42326
1985	2151	11451	4379	25468	1201	7816	610	2603	8341	47338
1986	1801	6291	4610	22229	965	5467	814	2829	8190	36816
1987	4817	14505	7570	30558	774	2770	1540	5386	14701	53219
1988	6111	14055	6635	34485	686	1879	543	1480	13975	51899
1989	4311	11946	6407	29418	514	1314	765	3161	11997	45839
1990	8902	18135	7371	36386	785	3071	898	3832	17956	61424
1991	17215	134799	4820	24526	793	6129	800	6664	23628	172118
1992	1701	11614	9742	48046	727	5258	306	2453	12476	67371
1993	1533	10563	6763	38295	469	2673	432	2198	9197	53729
1994	2408	10710	8890	46812	560	3011	327	2072	12185	62605
1995	772	4858	13460	66660	955	5012	304	1619	15491	78149
1996	1082	6580	7460	45188	653	4109	137	761	9332	56638

Figure 2. Scamp headboat landings by weight (lbs) from the U.S. South Atlantic.



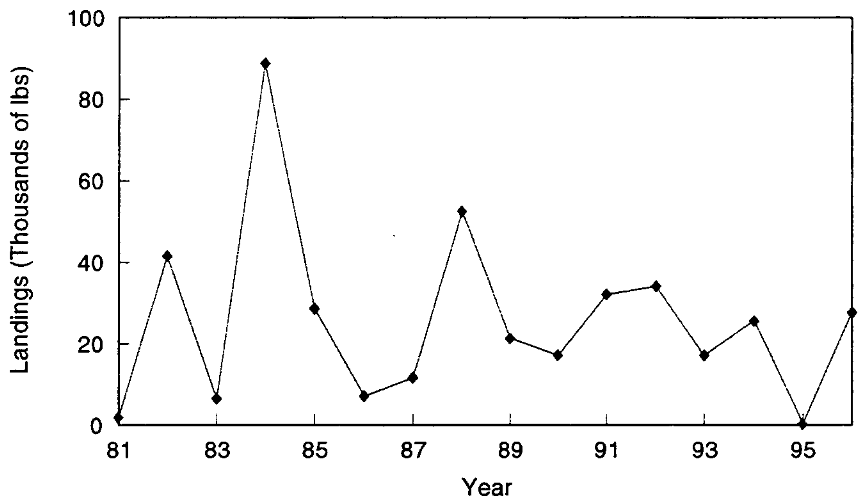
Recreational (MRFSS)

Recreational fishing statistics are available for 1981 through 1996. However, the data fluctuate wildly creating inconsistencies between years and areas, and are of questionable value. Landings of scamp are presented by number and weight (pounds) in Table 6 by year and area. During the 16-year period, the average recreational catch was 25,851 pounds. Landings peaked in 1984 when approximately 89,000 pounds were landed (Table 6; Figure 3). An example of inconsistent estimates was the 277 pounds reported landed in 1995, whereas 26,000 and 28,000 pounds were reported for 1994 and 1996, respectively.

Table 6. Scamp recreational (MRFSS) landings ---number of fish and weight (lbs) from the southeastern U.S.

	NC		SC		GA		FL		Total	
Year	#	lbs	#	lbs	#	lbs	#	lbs	#	lbs
1981							1,175	1,808	1,175	1,808
1982			4,652	27,632			3,207	13,838	7,859	41,470
1983			1,033	6,406					1,033	6,406
1984	2,957	9,434	5,410	24,930			5,590	54,406	13,957	88,770
1985			10,087	1,362	148	1,494	2,548	25,786	12,783	28,642
1986			1,340	7,038					1,340	7,038
1987	1,786	10,505	181	1,126					1,967	11,631
1988	7,296	32,714	3,080	12,775			2,142	6,910	12,518	52,399
1989	6,850	15,451	433	924			1,764	4,963	9,047	21,338
1990	13,087	15,433	777	1,709					13,864	17,142
1991	4,906	16,097	2,140	16,002					7,046	32,099
1992	2,731	13,695	2,958	15,444			858	5,001	6,547	34,140
1993	4,254	17,131							4,254	17,131
1994	5,483	21,861			592	3,738			6,075	25,599
1995	90	277							90	277
1996	1,042	2,798					3,908	24,935	4,950	27,733

Figure 3. MRFSS landings of scamp from the southeastern U.S.



Trends - Catch/Effort

Commercial

Catch per unit effort (CPUE) data are not available for the commercial data base.

Headboat

Catch per unit effort data are available for 1972 through 1996 for North Carolina and South Carolina, and from 1976 through 1996 for North Carolina through the Florida Keys. Annual CPUE values for all areas combined are presented in Table 7 and Figure 4 as weight in pounds of scamp caught per angler day. Catch rates have generally increased slightly since 1981 (Table 7; Figure 4). Relatively high catch rates were recorded from 1972 through 1979, all greater than 0.5 pounds per angler day. Catch rates have increased slightly during the past three years, 1994, 1995, and 1996 (Table 7). CPUE in number of fish and weight are presented by area (NC, SC, NEFL-GA, and SEFL) in Tables 8-11; Figures 5-8). Catch rates have not changed much for North Carolina since 1991 (Figure 5); were up for South Carolina anglers since 1981 (Figure 6); were up for NEFL-GA since 1989 (Figure 7); and were too low for SEFL to be very meaningful (Figure 8). Although the trend in CPUE is downward in SEFL since 1991.

Table 7. Scamp catch-per effort - Headboats - all areas combined.

Year	Cpue-Wt
1972	2.386
1973	1.241
1974	1.276
1975	0.662
1976	0.747
1977	0.638
1978	0.721
1979	1.055
1980	0.256
1981	0.079
1982	0.107
1983	0.124
1984	0.110
1985	0.139
1986	0.089
1987	0.119
1988	0.123
1989	0.121
1990	0.145
1991	0.442
1992	0.183
1993	0.156
1994	0.183
1995	0.250
1996	0.195

Figure 4. Scamp CPUE - headboats - all areas combined.

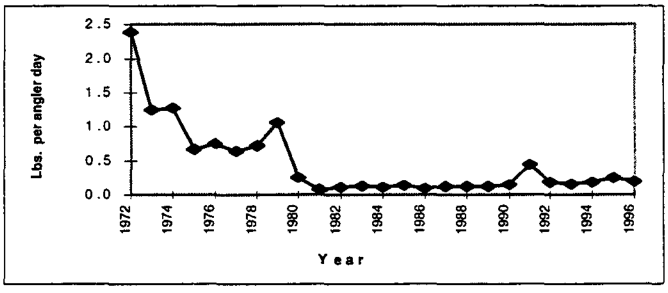


Table 8. North Carolina catch-per-effort
(by number and weight) for scamp.

Year	Number	Weight	Angdays	CPUE-#	CPUE-wt
1972	1980	18975	30659	0.065	0.619
1973	2903	24814	37080	0.078	0.669
1974	8082	72914	32047	0.252	2.275
1975	4086	38465	31225	0.131	1.232
1976	4829	46508	30325	0.159	1.534
1977	4304	39948	22660	0.190	1.763
1978	5204	48816	26032	0.200	1.875
1979	7523	68536	26490	0.284	2.587
1980	1407	8385	23714	0.059	0.354
1981	1042	5764	19372	0.054	0.298
1982	2612	17569	26939	0.097	0.652
1983	1548	9654	21918	0.071	0.440
1984	2639	15134	28865	0.091	0.524
1985	2151	11451	31346	0.069	0.365
1986	1801	6291	31187	0.058	0.202
1987	4817	14505	35261	0.137	0.411
1988	6111	14055	42421	0.144	0.331
1989	4311	11946	38678	0.111	0.309
1990	8902	18135	43240	0.206	0.419
1991	17215	134799	40936	0.421	3.293
1992	1701	11614	41177	0.041	0.282
1993	1533	10563	42785	0.036	0.247
1994	2408	10710	36693	0.066	0.292
1995	772	4858	40294	0.019	0.121
1996	1082	6580	35142	0.031	0.187

Figure 5. Scamp CPUE - North Carolina headboats.

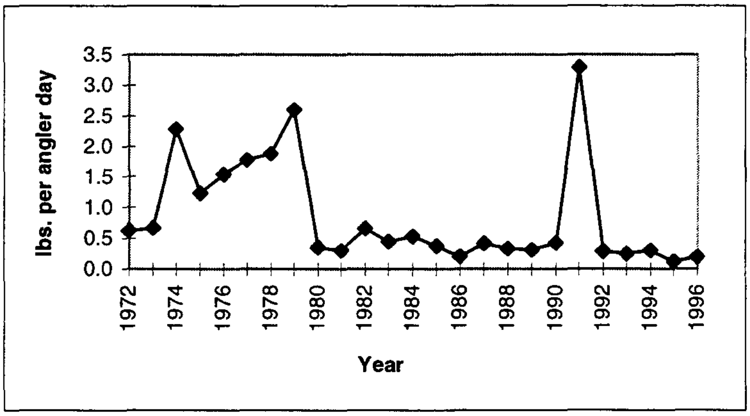


Table 9. South Carolina headboat catch-per-effort (by number and weight) for scamp.

Year	Number	Weight	Angdays	CPUE-#	CPUE-wt
1972	9329	97933	18330	0.509	5.343
1973	4376	47062	20837	0.210	2.259
1974	3412	34811	52384	0.065	0.665
1975	1881	22710	61225	0.031	0.371
1976	1651	21978	61318	0.027	0.358
1977	1462	19083	69910	0.021	0.273
1978	1614	18552	67462	0.024	0.275
1979	2127	19512	56935	0.037	0.343
1980	1998	14124	64244	0.031	0.220
1981	1405	7454	59030	0.024	0.126
1982	2824	13996	67539	0.042	0.207
1983	3375	23371	65713	0.051	0.356
1984	2372	16012	67313	0.035	0.238
1985	4379	25468	28862	0.152	0.882
1986	4610	22229	67227	0.069	0.331
1987	7570	30558	78806	0.096	0.388
1988	6635	34485	76468	0.087	0.451
1989	6407	29418	24861	0.258	1.183
1990	7371	36386	57151	0.129	0.637
1991	4820	24526	67982	0.071	0.361
1992	9742	48046	61790	0.158	0.778
1993	6763	38295	64457	0.105	0.594
1994	8890	46812	63231	0.141	0.740
1995	13460	66660	61739	0.218	1.080
1996	7460	45188	54929	0.136	0.823

Figure 6. Scamp CPUE - South Carolina headboats.

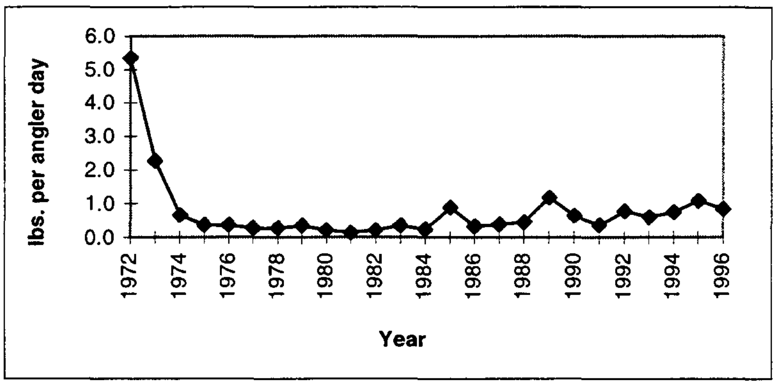


Table 10. Northeast Florida-Georgia headboat catch-per-effort (by number and weight) for scamp.

Year	Number	Weight	Angdays	CPUE-#	CPUE-wt
1976	455	16718	58404	0.008	0.286
1977	242	5397	58330	0.004	0.093
1978	253	1932	78099	0.003	0.025
1979					
1980					
1981	320	2479	72069	0.004	0.034
1982	415	2939	66961	0.006	0.044
1983	883	5091	83499	0.011	0.061
1984	698	4182	95234	0.007	0.044
1985	1201	7816	94446	0.013	0.083
1986	965	5467	113101	0.009	0.048
1987	774	2770	114144	0.007	0.024
1988	686	1879	109156	0.006	0.017
1989	514	1314	102920	0.005	0.013
1990	785	3071	98234	0.008	0.031
1991	793	6129	85111	0.009	0.072
1992	727	5258	90810	0.008	0.058
1993	469	2673	74494	0.006	0.036
1994	560	3011	65745	0.009	0.046
1995	955	5012	59104	0.016	0.085
1996	653	4109	47236	0.014	0.087

Figure 7. Scamp CPUE - NEFL-GA headboats.

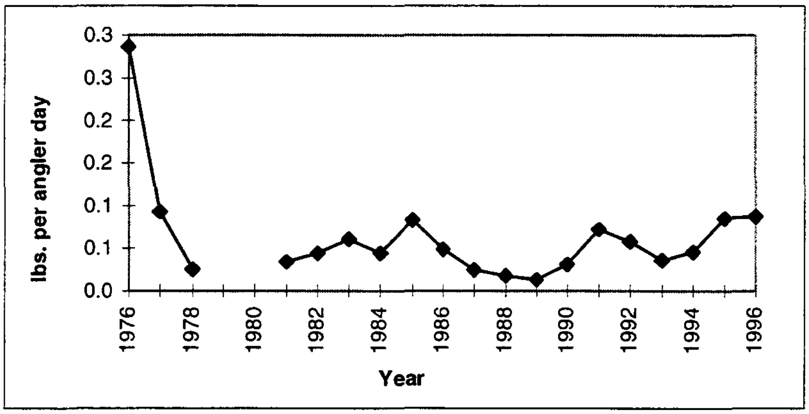
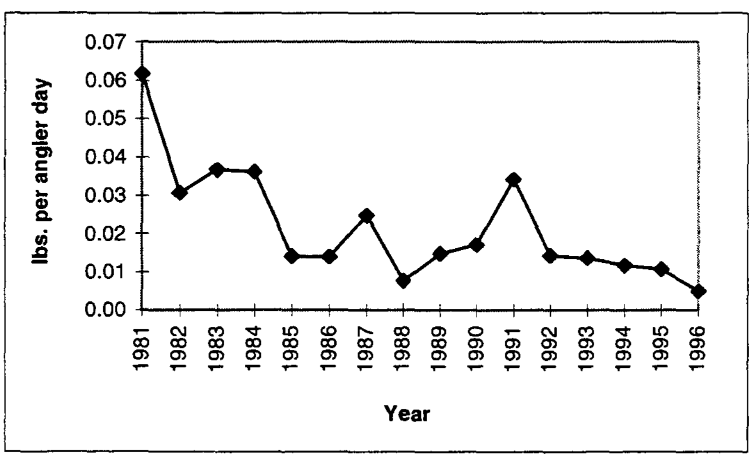


Table 11. Southeast Florida catch-per-effort by number and weight) for scamp.

Year	Number	Weight	Angdays	CPUE-#	CPUE-wt
1981	4312	13973	226456	0.019	0.062
1982	1679	6938	226172	0.007	0.031
1983	1923	7129	194364	0.010	0.037
1984	1416	6998	193760	0.007	0.036
1985	610	2603	186398	0.003	0.014
1986	814	2829	203960	0.004	0.014
1987	1540	5386	218897	0.007	0.025
1988	543	1480	192618	0.003	0.008
1989	765	3161	213944	0.004	0.015
1990	898	3832	224661	0.004	0.017
1991	800	6664	194911	0.004	0.034
1992	306	2453	173714	0.002	0.014
1993	432	2198	162478	0.003	0.014
1994	327	2072	177035	0.002	0.012
1995	304	1619	150957	0.002	0.011
1996	137	761	152617	0.001	0.005

Figure 8. Scamp CPUE - Southeast Florida headboats.



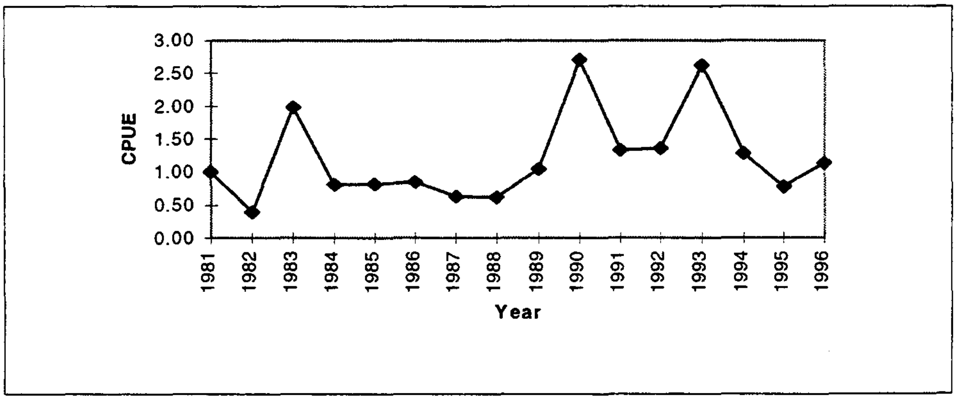
Recreational (MRFSS)

Recreational CPUE data are available for the southeastern United States from 1981 through 1996 (Table 12 and Figure 9). Catch rates were recorded as number of scamp per angler trip. CPUE values were high compared with the headboat CPUE data. Recreational catch rate for scamp peaked in 1990 (2.7 fish/angler trip), and dropped to 1.33 in 1991. CPUE has generally increased slightly since 1988.

Table 12. Recreational (MRFSS) catch per effort data for scamp from the southeastern United States.

Year	Total Catch #	Total Angler Trips	CPUE
1981	1175	1175	1.00
1982	7858	20263	0.39
1983	1033	520	1.98
1984	13957	17227	0.81
1985	2696	3286	0.82
1986	1340	1582	0.85
1987	1967	3112	0.63
1988	12518	20351	0.62
1989	9232	8826	1.05
1990	14228	5272	2.70
1991	7045	5288	1.33
1992	9513	6989	1.36
1993	9265	3532	2.62
1994	11215	8788	1.28
1995	6383	8204	0.78
1996	8512	7555	1.13

Figure 9. Recreational (MRFSS) catch-per-effort for scamp.



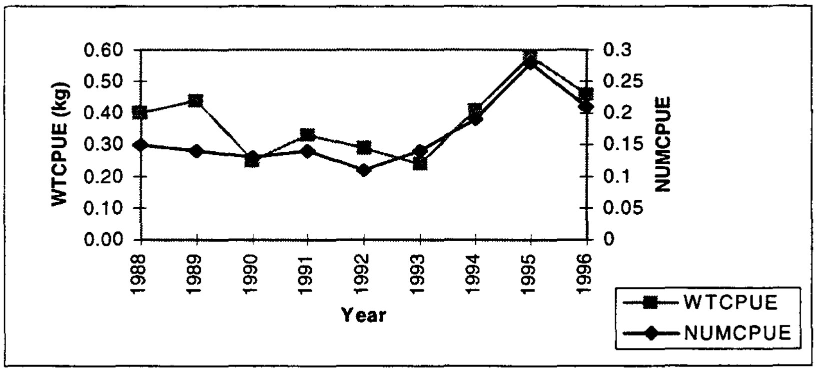
Fishery Independent Data (SCDNR)

From 1988 through 1996 South Carolina Department of Natural Resources personnel used baited chevron traps to capture scamp and other species of reef fish (Table 13; Figure 10). Data were reported as number and weight of scamp caught per trap hour(CPUE). Although sampling efforts were concentrated off South Carolina, collections were also made off North Carolina, Georgia, and northeast Florida. CPUE by weight was relatively high in 1989, and has generally increased since 1993 (Table 13; Figure 10).

Table 13. Fishery independent CPUE in number of fish and weight (kg) of fish for scamp collected by chevron traps in the South Atlantic Bight (SCDNR, MARMAP, Charleston, SC).

Year	N	NUMCPUE	SD	WTCPUE	SD
1988	85	0.15	0.59	0.40	1.46
1989	66	0.14	0.47	0.44	1.68
1990	292	0.13	0.40	0.25	0.86
1991	247	0.14	0.39	0.33	1.00
1992	282	0.11	0.36	0.29	1.26
1993	323	0.14	0.44	0.24	0.85
1994	340	0.19	0.45	0.41	1.07
1995	253	0.28	0.65	0.58	1.57
1996	350	0.21	0.63	0.46	1.60

Figure 10. Fishery independent CPUE for scamp collected by chevron traps in the South Atlantic Bight (SCDNR, MARMAP, Charleston, SC).



Trends - Mean Weights

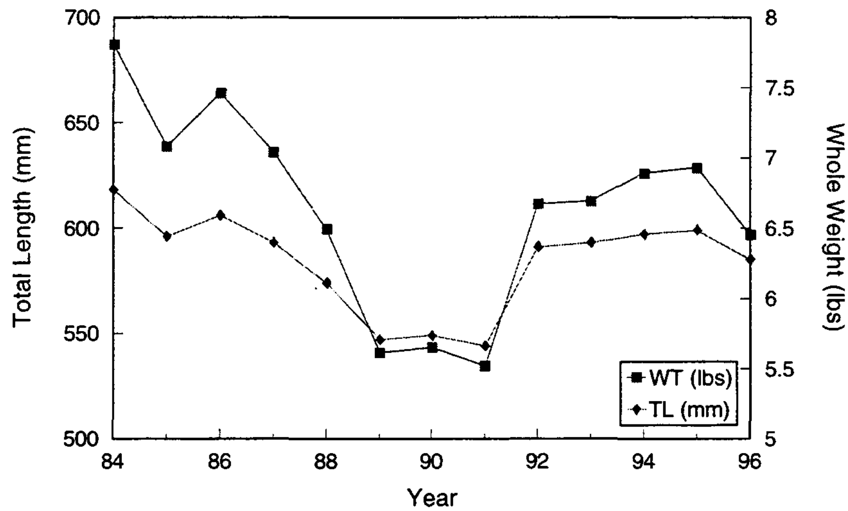
Commercial

Mean size data are available for the commercial fishery from 1984 through 1996 and are presented in Table 14 and Figure 11 by lengths and weights. For all areas combined, mean size for scamp was largest in 1984 (7.8 pounds) and smallest (5.5 pounds) in 1991. Mean sizes were relatively large prior to 1989, were low in 1989, 1990, and 1991, and increased from 1992 through 1996. The minimum size limit has had an impact on commercial landings.

Table 14. Scamp commercial mean total lengths (mm)and whole weights (kg) weighted by sample size of gear types.

	NC/SC		GA/NFL		SFL		Overall Weighted Mean	
Year	TL	lbs.	TL	lbs.	TL	lbs.	TL	lbs.
1984	618	7.81					618	7.81
1985	594	7.06	654	9.15			596	7.08
1986	603	7.33	670	9.92	485	3.67	606	7.46
1987	592	6.97	626	6.75			593	7.04
1988	569	6.31	642	8.76	416	2.31	574	6.49
1989	547	5.61	564	5.94			547	5.61
1990	548	5.65	545	5.43	570	6.07	549	5.65
1991	542	5.46	564	6.12	674	9.24	544	5.52
1992	587	6.51	605	7.17	586	6.36	591	6.67
1993	585	6.42	615	7.52	616	7.50	593	6.69
1994	592	6.71	629	8.05	627	7.70	597	6.89
1995	597	6.84	603	7.13			599	6.93
1996	585	6.45	584	6.38			585	6.45

Figure 11. Mean weight and mean total length of scamp landed commercially in the southeastern U.S.



Headboat

The mean weights of scamp caught by headboat anglers have generally increased since 1991 (Table 15; Figure 12) for all geographic areas combined. This increase is most probably caused by the size restriction intended to reduce the harvest of smaller fish. Mean weight, which had been about 10 pounds through 1978, declined to about five pounds in 1981, was very low from 1987 through 1991, and has increased since 1991 (Table 15; Figure 12).

With the exception of Southeast Florida, the same pattern of moderate increase in mean weights since 1991 prevailed for each geographic area (Tables 16-19; Figures 13-16). These are the areas where most of the scamp were caught.

Even with the increase in mean sizes for recent years, one should wonder what happened to the large scamp (eight pounds and larger) that were caught off North Carolina, South Carolina, Georgia, and northeast Florida (Figures 13-15) during the 1970s.

Table 15. Mean weight (lbs) of scamp from headboats for all areas combined.

Year	Mean Weight	N
1972	10.03	375
1973	9.24	363
1974	9.52	373
1975	9.77	483
1976	10.30	863
1977	10.17	426
1978	9.52	302
1979	7.18	170
1980	5.45	158
1981	4.85	109
1982	5.96	253
1983	5.70	434
1984	5.87	454
1985	5.21	433
1986	4.70	411
1987	3.56	521
1988	3.21	446
1989	3.13	340
1990	3.36	317
1991	3.42	387
1992	5.73	228
1993	5.92	322
1994	5.32	332
1995	5.06	364
1996	5.82	618

Figure 12. Scamp mean weight from headboat landings in the southeastern U.S.

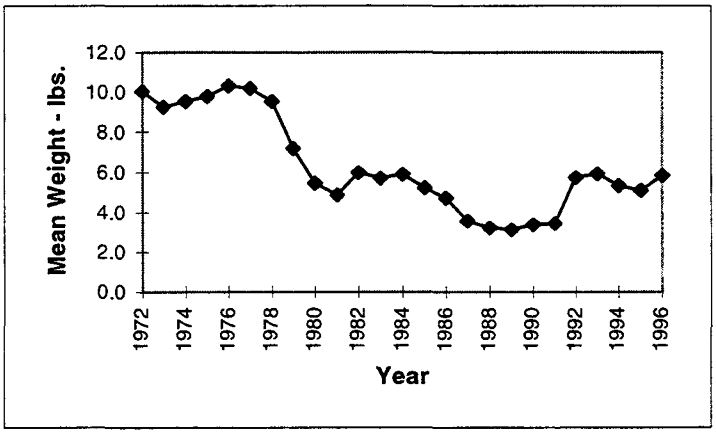


Table 16. Scamp mean weights (lbs) from North Carolina headboats.

Year	Mean Weight	N
1972	10.16	144
1973	8.38	198
1974	8.66	208
1975	8.84	353
1976	9.95	784
1977	9.49	337
1978	9.33	217
1979	8.20	103
1980	6.23	80
1981	5.82	20
1982	6.46	145
1983	6.14	155
1984	5.30	177
1985	5.00	142
1986	4.48	200
1987	2.96	252
1988	2.49	275
1989	2.61	217
1990	2.04	150
1991	2.94	312
1992	6.15	79
1993	6.51	116
1994	4.37	31
1995	6.16	17
1996	6.27	33

Figure 13. Scamp mean weights from North Carolina headboats.

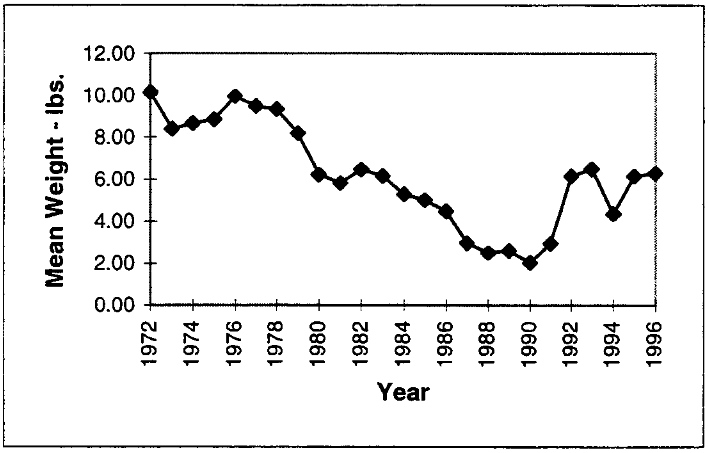


Table 17. Scamp mean weights (lbs) from South Carolina headboats.

Year	Mean Weight	N
1972	9.95	231
1973	10.28	165
1974	10.60	165
1975	12.30	130
1976	13.72	76
1977	13.50	71
1978	12.30	50
1979	9.65	20
1980	6.68	12
1981	4.77	9
1982	5.13	31
1983	6.78	103
1984	6.86	149
1985	5.65	132
1986	5.30	140
1987	4.18	234
1988	4.58	134
1989	4.07	105
1990	4.67	137
1991	5.02	65
1992	5.31	138
1993	5.60	192
1994	5.32	269
1995	5.03	319
1996	5.80	574

Figure 14. Scamp mean weights from South Carolina headboats.

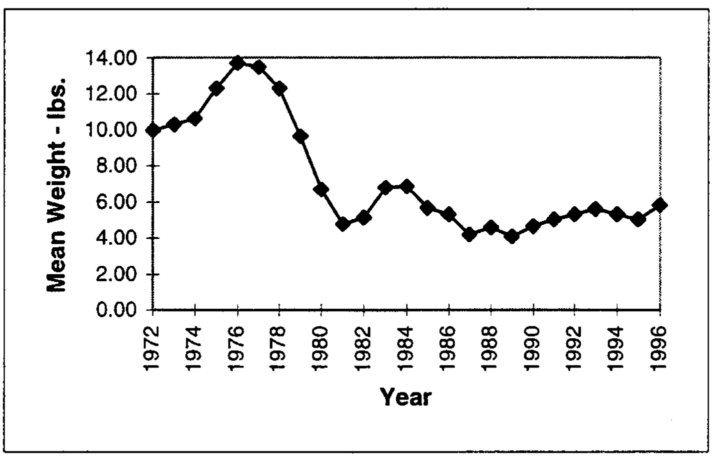


Table 18. Scamp mean weights (lbs) from Northeast Florida-Georgia headboats.

Year	Mean Weight	N
1976	16.67	3
1977	9.67	18
1978	8.66	23
1979	7.86	12
1980	5.08	19
1981	7.84	26
1982	7.09	35
1983	5.59	57
1984	6.44	41
1985	6.30	53
1986	5.97	15
1987	4.27	13
1988	3.73	12
1989	3.04	6
1990	3.83	29
1991	7.84	7
1992	7.27	8
1993	5.86	11
1994	5.69	24
1995	4.79	26
1996	6.56	8

Figure 15. Scamp mean weights from Northeast Florida-Georgia headboats.

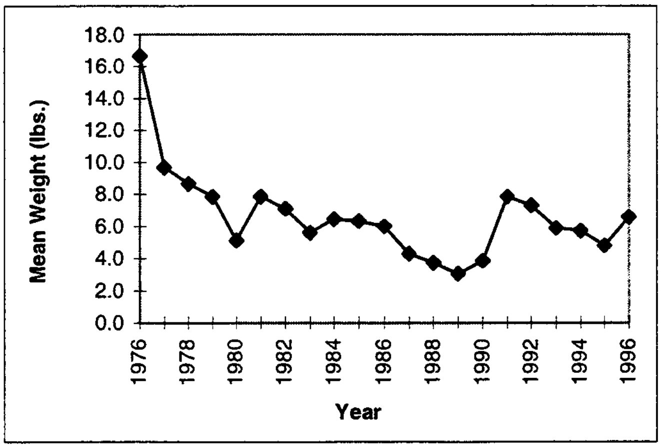
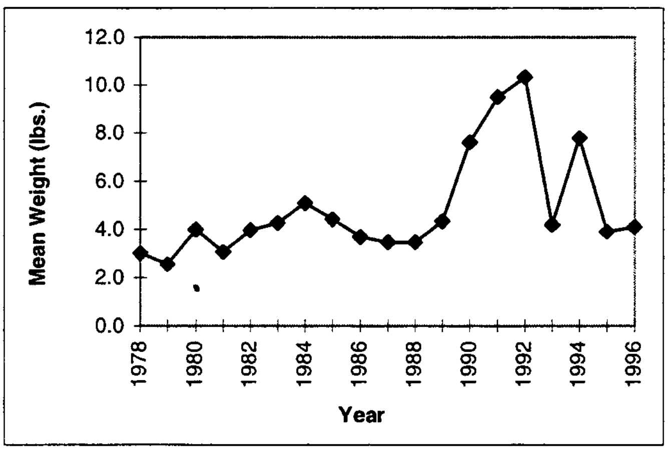


Table 19. Scamp mean weights (lbs) from Southeast Florida headboats.

Year	Mean Weight	N
1978	3.00	12
1979	2.54	35
1980	3.97	47
1981	3.06	54
1982	3.94	42
1983	4.24	119
1984	5.06	87
1985	4.40	106
1986	3.68	56
1987	3.44	22
1988	3.45	25
1989	4.32	12
1990	7.60	1
1991	9.49	3
1992	10.33	3
1993	4.19	3
1994	7.80	8
1995	3.89	2
1996	4.08	3

Figure 16. Scamp mean weights from Southeast Florida headboats.



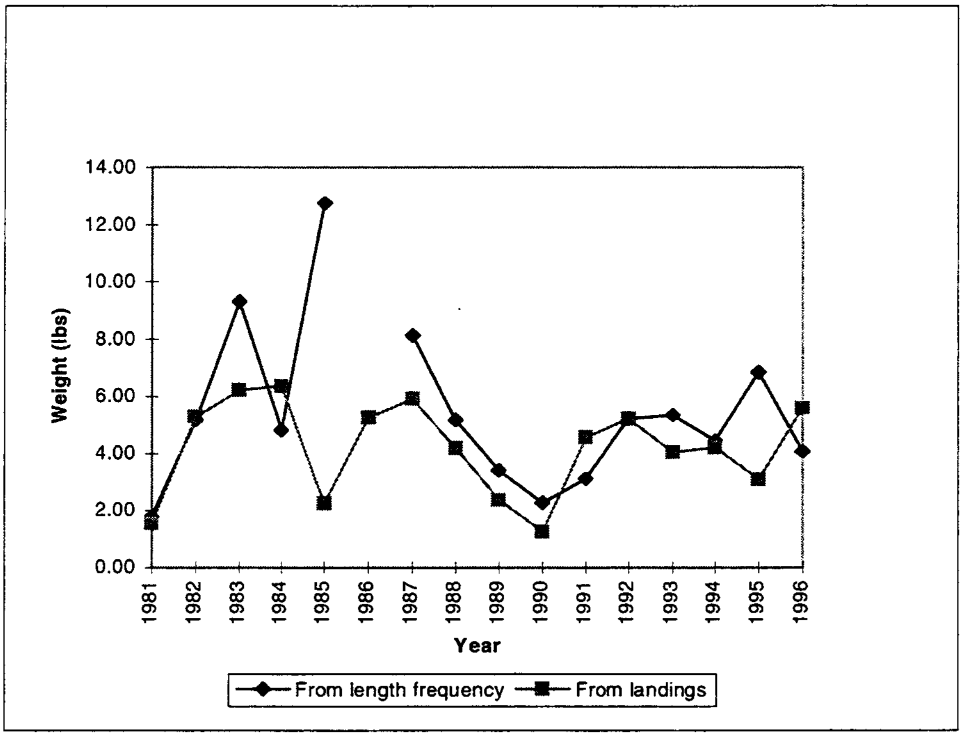
Recreational (MRFSS)

Mean size data are available for the recreational fishery from 1981 through 1996 (Table 20; Figure 17). The data could not be stratified by geographic area because of small sample sizes. Less than 20 scamp were sampled for the entire southeastern United States for each of the years: 1981, 1982, 1983, 1984, 1985, 1986, 1987, 1995, and 1996 (N = 2, 5, 12, 18, 1, 0, 11, 2, and 9, respectively), and less than 100 fish were sampled in all years. Mean size has increased slightly since 1990.

Table 20. Recreational (MRFSS) mean weights of scamp landed in the southeastern United States, generated from the length samples (sample size is in parenthesis)and l-w relationship and from the landings.

	Mean weight (lbs) - Source	
Year	Length samples (N)	Landings
1981	1.78 (2)	1.54
1982	5.17 (5)	5.28
1983	9.31 (12)	6.20
1984	4.81 (18)	6.36
1985	12.76 (1)	2.24
1986	(0)	5.25
1987	8.13 (11)	5.91
1988	5.17 (43)	4.19
1989	3.39 (34)	2.36
1990	2.26 (59)	1.24
1991	3.11 (23)	4.56
1992	5.22 (43)	5.21
1993	5.34 (33)	4.03
1994	4.44 (41)	4.21
1995	6.85 (2)	3.08
1996	4.05 (9)	5.60

Figure 17. Mean weights of scamp landed recreationally (MRFSS) in the southeastern U.S.



Age/Growth

Harris (in prep) conducted an age and growth study of scamp because the previous study was outdated (Matheson et al. 1986). Scamp were aged 1-27 years, although few fish lived longer than 14 years (Harris, in prep.) All back-calculated lengths at ages were used to estimate the von Bertalanffy growth parameters: $L_t = 878 (1-e^{-0.116(t + 2.883)})$ (Harris in prep.)(Figure 18). Fish lengths were converted into fish weights and vice versa using the following equation: $W = 1.25 \times 10-5 (L)^{2.99}$ (Harris in prep.), where W = whole weight in grams, and L = total length in millimeters. When landings data were reported in fork lengths, instead of total lengths, we converted them using an equation presented by Matheson et al (1986): $L_t = 985(1-e^{-0.092(t + 2.45)})$. We used fish total lengths in millimeters at time of capture to create a fish age-fish length key (Table 21).

Figure 18. Comparison of theoretical growth curves for scamp from the southeastern U.S. (Matheson et al. 1986; Harris in prep).

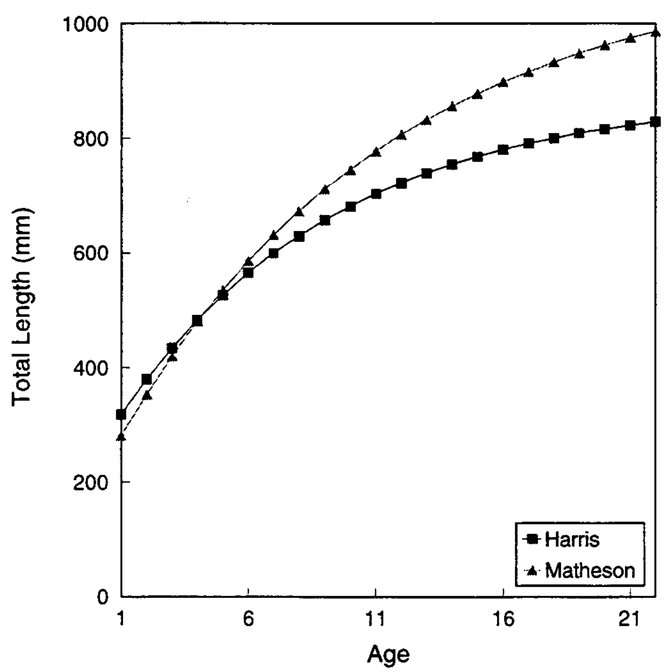


Table 21. Age-length (TL, mm) key in percent of scamp collected from the southeastern United States.

TL	n	Age 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	27
200	1	1.00																						
225	1	1.00																						
250	6	1.00																						
275	3	1.00																						
300	2		1.00																					
325	10	0.30	0.70																					
350	6	0.50	0.17	0.33																				
375	12	0.08	0.42	0.50																				
400	26	0.08	0.50	0.35	0.08																			
425	48		0.23	0.56	0.19	0.02																		
450	54		0.11	0.52	0.30	0.06	0.02																	
475	73		0.03	0.48	0.34	0.15																		
500	192		0.01	0.19	0.39	0.38	0.04																	
525	200		0.01	0.09	0.38	0.43	0.06	0.03		0.01														
550	184			0.04	0.28	0.54	0.06	0.05	0.02						0.01									
575	211				0.14	0.53	0.19	0.07	0.04															
600	152			0.02	0.09	0.47	0.24	0.09	0.07	0.01	0.02													
625	131			0.01	0.08	0.35	0.28	0.15	0.08	0.03	0.02	0.01												
650	108				0.06	0.19	0.24	0.19	0.13	0.12	0.06													
675	117				0.02	0.05	0.14	0.37	0.22	0.08	0.09		0.02	0.01			0.01							
700	106					0.03	0.06	0.23	0.31	0.13	0.15	0.02	0.01		0.01	0.03	0.02	0.01						
725	60						0.08	0.15	0.28	0.17	0.18		0.05	0.05		0.02	0.02							
750	56					0.02		0.07	0.21	0.20	0.20	0.11	0.07	0.02	0.02	0.07		0.02						
775	23					0.04			0.09	0.13	0.26	0.09	0.13		0.13	0.04		0.09						
800	14						0.07		0.07	0.07	0.14	0.14	0.29	0.07					0.07					0.07
825	20								0.05		0.15	0.15	0.15	0.05	0.05	0.10	0.05	0.10	0.05		0.05	0.05		
850	12										0.08		0.08		0.08	0.08	0.08	0.25	0.08	0.08	0.17			
875	1										0.09			0.09	0.09			0.18	0.09	0.09	0.18	0.09	0.09	
900	2																	0.50				0.50		

Development of Catch-in-Numbers-at-Age Matrix

Annual application of the catch-in-numbers-at-age matrix equation (see Methods section) to each fishery (commercial, recreational, and headboat) was performed separately and tabulated for each year to obtain annual estimates of catch in numbers for different ages for 1986-1996. This is the catch matrix.

Mortality Estimates

Total Instantaneous Mortality

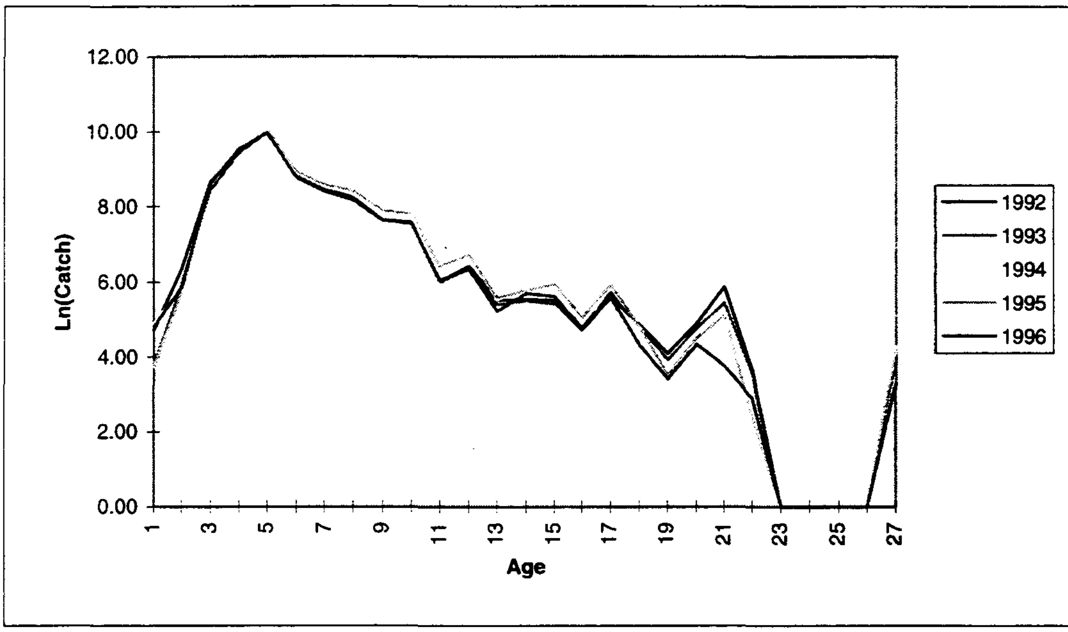
At first inspection, catch curves using data for 1986-1991 were different from those calculated for 1992-1996. We believe this to be mainly attributable to minimum size regulation differences for the two time periods. Smaller (younger) fish could be landed in the earlier period than the later.

Catch curves for 1986-1991 were based on scamp aged 3 and 5-20 years; those produced for 1992-1996 were based on fish aged 5-20 years (Figures 19 and 20). Therefore, total instantaneous mortality estimates were different for the two periods: $Z = 0.32$ for 1986-1991; and $Z = 0.36$ for 1992-1996 computed as means for the two time periods.

We were suspicious of the earlier time period because an examination of trends in mean fish weights indicated <u>three</u> major fish size (<u>thus fish age</u>) time segments instead of two. This was particularly obvious for commercial data (Figure 11), and somewhat evident from the overall headboat data (Figure 12). Therefore we conducted additional analyses of catch curves by dividing the first time segment into two periods: 1986-1988 and 1989-1991. The 1992-1996 period remained intact. Fish ages used in the analyses and the resulting Z for each time segment was: ages 5-20 and Z = 0.28 for 1986-1988; ages 3-20 and Z = 0.36 for 1989-1991; and ages 5-20 and Z = 0.36 for 1992-1996.

Figure 19. Natural log of the catch-at-age for scamp from the southeastern U.S. landed from 1986 through 1991.

Figure 20. Natural log of the catch-at-age for scamp from the southeastern U.S. landed from 1992 through 1996.



Natural Mortality

There is often great uncertainty in deriving a value for natural mortality, M. Yet this is an important parameter input into stock assessment analysis, and ultimately dictates the selection of the initial values of fishing mortality, F, to be used in the analyses. Caution suggests using a range of possible values for M in the analyses, and that is what we have done in this assessment. We estimated natural mortality using several methods, and then four values were chosen as a range to use in the VPA runs. Methods used to estimate M and their resulting values are:

Hoenig (1983) - original equation -		0.15
	adjusted for sample size -	0.32
Pauly (1979) -		0.16
Ralston (1987) -		0.26
Roff (1984) -	using length at 50% maturity -	0.28
	using length at 100% maturity -	0.23
Rikhter and Efanov (1977)-		0.53
Alverson and Carney (1975) -		0.15
Alagaraja (1984) -	survivorship to max age = 1 % -	0.17
	survivorship to max age = 2 % -	0.15
	survivorship to max age = 5 % -	0.11

Both Hoenig (1983) and Alverson and Carney (1975) use maximum age in their equations for calculating M. We used a maximum age of 27 years from the Harris study, although he found only three fish that were older than 21 years. The Hoenig method relates maximum observed age to total mortality and sample size, and assumes random sampling. Since most of the samples from this age-growth study came from the South Atlantic headboat survey and the NMFS commercial sampling program, we feel this assumption is met. The Alverson and Carney (1975) method uses von Bertalanffy growth equation parameters as well as the oldest fish in the population to estimate T_{max}, the age at which a cohort has its maximum biomass in the absence of fishing. Since our data came from a fished stock, the estimate of M = 0.15 seems reasonable.

The Rikhter and Efanov (1977) method produced an estimate of

M that seems unrealistically high (0.53). However, these estimates were not unexpected for an equation that is based solely on age at sexual maturity.

Our value for the Pauly (1979) estimate of M = 0.16 compares favorably with the Alverson and Carney (1975) estimate of M = 0.15. It also compares reasonably well with the estimate of Matheson et al. (1986) for scamp caught from North Carolina and South Carolina of M = 0.21, derived from Pauly (1979). Our mean seawater temperature input into Pauly's (1979) equation was 21.95° C.

Roff (1984) predicts M using the Brody growth coefficient K and the optimal age at maturity. Uncertain as to the true optimal age at maturity, we used ages corresponding to both 50% and 100% maturity. The respective estimates of M = 0.23 and 0.28 seem reasonable, although perhaps slightly high for a species with a lifespan of 27 years.

The empirical equation of Ralston (1987) returned a value of M = 0.26. This seems slightly high but is partly explained by the fact that Ralston used pooled data from 14 snapper stocks and 5 grouper stocks in developing his regression. Sample sizes for the grouper stocks were small by his own admission. An estimate of natural mortality for a serranid derived from a regression developed from a pooled data set, dominated by lutjanid data, could result in artificially high values.

We derived a final estimate of M using the equation of Alagaraja (1984), which used a predetermined survivorship criteria (percent of initial cohort surviving to maximum age). It seems unlikely that survivorship to this maximum age would be 5 %, as recently used by Ault et al. (1998), so we derived estimates of M using three levels of survivorship for comparative purposes: 1, 2, and 5 %. The respective values of M were 0.17, 0.15, and 0.11, and they all agree reasonably well with each other and with our estimates of M derived from other methods for this study.

Our estimates of M generally fall into the range 0.11 to 0.30. It seems unlikely that a long-lived serranid would have an M greater than 0.40, and so we discount the estimate returned by Rikhter and Evanov (1977). We believe that the true value of M for scamp falls between 0.10 and 0.25. Huntsman et al. (1992) used a value of M = 0.17 for scamp in a multispecies stock assessment prepared for the SAFMC. To provide evaluation latitude in our analyses, we choose to run the analyses with a range of values for natural mortality from 0.10 to 0.25.

Fishing Mortality and Virtual Population Analysis

For the separable VPA runs, three catch matrices were analyzed consisting of catch in numbers for ages 1 through 20 for fishing years 1986-1996. Modal ages for the three time segments were age-5 for 1986-1988, age-3 for 1989-1991, and age-5 for 1992-1996. For the SVPA, starting values for F were based on the mean estimates of Z from the three time periods (0.28 yr^{-1} for 1986-1988, and 0.36 yr^{-1} for 1989-1991 and 1992-1996). Sensitivity of estimated F to uncertainty in M was investigated by conducting the above VPAs with alternate values of M (0.10, 0.15, 0.20, and 0.25).

Because of the short duration of the catch matrix and large number of ages, mean values only for the early pre-, late pre-, and post-minimum size limit were considered. Mean values of age-specific estimates of F were obtained from the separable VPA applied to the catch at age data (Table 22) using the uncalibrated separable (SVPA). Estimates of F were averaged over fully-recruited ages (ages 5-20 for 1986-1988, ages 3-20 for 1989-1991, and ages 5-20 for 1992-1996), weighted by catch in numbers for those ages (referred to as full F).

Using the uncalibrated separable approach (SVPA) with M of 0.15, mean estimates of full F were 0.11 for 1986-1988, 0.29 for 1989-1991, and 0.18 for 1992-1996 (Table 23). Note that for the intermediate time period, 1989-1991, SPR was lowest and full F was highest compared with the other time periods, fishing years when larger scamp were being caught. Huntsman et al. (1992) reported fishing mortalities of 0.18 for 1988 and 0.24 for 1990.

Table 22. Catch-at-age for scamp landed in all fisheries operating in the southeastern United States from 1986 to 1996.

Year/Age	1	2	3	4	5	6	7	8	9	10	11
1986	654	2299	5655	6683	10260	3954	3327	3314	1962	2184	547
1987	1935	5125	9464	9390	13610	5117	4050	3709	2185	2369	644
1988	2160	7385	14154	11642	14263	5085	3820	3657	2226	2477	769
1989	2724	9339	19540	16881	18866	6188	4352	3608	2135	1990	466
1990	5102	15271	26802	21486	25201	8006	6136	5039	2669	2550	472
1991	2452	11219	25662	20799	21726	6614	4507	3730	2146	2061	476
1992	110	568	5736	13257	21543	6869	4877	3804	2104	1965	408
1993	44	365	4531	12378	21595	7126	4739	3633	2085	1841	390
1994	134	338	5302	13851	22797	7328	5092	4158	2478	2352	561
1995	41	304	5165	14167	23848	7636	5356	4525	2689	2492	611
1996	122	342	5593	13591	21476	6459	4430	3547	2046	1923	421

Year/Age	12	13	14	15	16	17	18	19	20	21	22	27
1986	822	295	369	395	191	615	184	94	224	474	42	54
1987	982	317	382	420	207	636	227	105	247	335	36	85
1988	1134	346	400	405	156	811	215	59	153	607	34	121
1989	658	232	232	291	134	283	107	25	83	386	11	49
1990	724	289	261	338	199	352	121	40	109	489	20	53
1991	693	254	283	302	147	362	136	52	134	436	30	54
1992	620	245	250	249	127	273	128	59	133	356	37	54
1993	589	220	242	223	111	307	124	51	118	231	34	57
1994	823	247	337	319	131	342	123	31	80	107	14	73
1995	832	263	321	383	155	375	122	34	89	166	11	67
1996	564	183	296	276	112	264	74	30	77	43	18	27

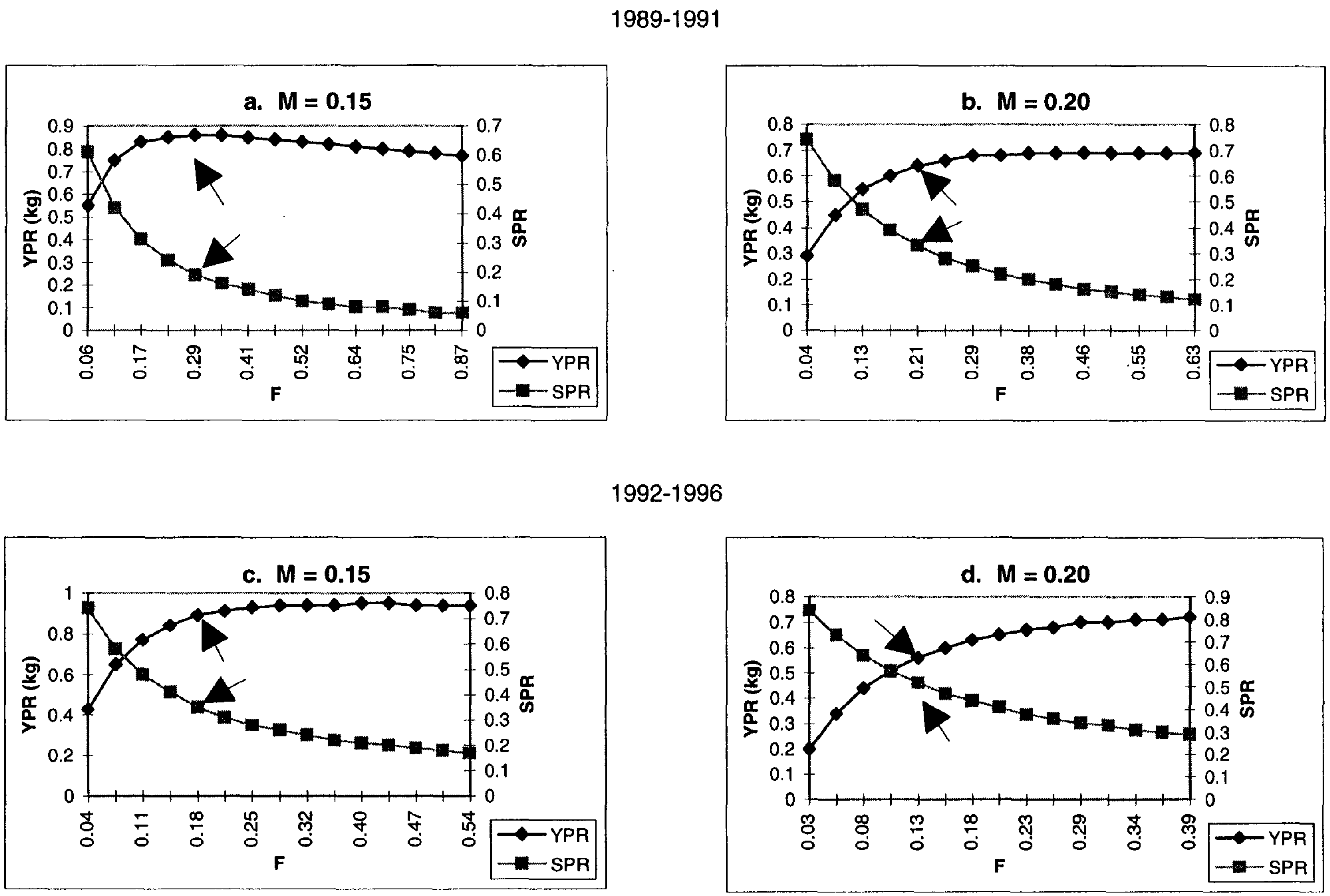
Yield Per Recruit

Yield per recruit increased for the later years due to the imposition of the minimum size limits at the lower estimates of M (0.10 and 0.15). Data are presented graphically in Figure 21a-d. We incorporated an adjustment for released fish mortality to determine what impact this would have on yield at entry to the fishery. The value 22.4%, provided by a NMFS researcher (Bob Dixon, NMFS, Beaufort Laboratory, Beaufort, NC), was used. At this level of release mortality, the age of recruitment to the fishery in order to obtain a 40% SPR (for M = 0.15, 1992-1996) was not impacted. SPR of 40% was projected to be exceeded (52%) with M = 0.20 (Table 23).

Table 23. Spawning potential ratio (SPR) and yield per recruit (YPR) of scamp from the southeastern United States landed during three time periods: 1986-88, 1989-91, and 1992-1996.

		Natural Mortality (M)			
Time Period		0.10	**0.15**	**0.20**	0.25
1986 - 1988	Full F	0.15	**0.11**	**0.07**	0.03
	SPR	0.33	**0.50**	**0.68**	0.88
	YPR	1.23	**0.73**	**0.38**	0.13
1989-1991	Full F	0.34	**0.29**	**0.21**	0.13
	SPR	0.11	**0.19**	**0.33**	0.52
	YPR	1.09	**0.86**	**0.64**	0.41
1992 - 1996	Full F	0.24	**0.18**	**0.13**	0.07
	SPR	0.22	**0.35**	**0.52**	0.69
	YPR	1.29	**0.89**	**0.56**	0.31

Figure 21. Ricker yield-per-recruit and spawning potential ratio for scamp landed in the southeastern U.S. during two time periods: 1989-1991 and 1992-1996, and two levels of M: 0.15 and 0.20.



Spawning Potential Ratio

Reproductive data are very limited for scamp off the southeastern United States. Although the SCDNR is currently studying this aspect of the species' life history, data are not available to us for this assessment report. And, although Matheson et al. (1986) report on very general aspects of scamp reproduction, detailed information was not presented that could be useful to us. Therefore, we relied on a sexual maturity schedule derived for the closely related species, yellowmouth grouper, M. interstitialis, in the Gulf of Mexico (Bullock and Murphy 1994). These authors mention that "female yellowmouth grouper reach sexual maturity at the same age but slightly larger size than scamp...". The schedule we used was 0% mature at age-1; 33% mature at age-2; 50% mature at age-3; and 100% mature at age-4.

Spawning potential ratio, or percent maximum spawning potential, of female scamp was calculated for three time periods (1986-1988, 1989-1991, and 1992-1996) based on mean age specific fishing mortality from separable virtual population analysis using the four different levels of natural mortality (Tables 23 and 24). Released fish mortality of 22% (pers. Comm. Robert Dixon, NMFS, Beaufort Laboratory) was incorporated into the SPR model for the latter time period. Percent maximum spawning potential was greater for the earliest and the more recent time periods: 50% for 1986-1988 and 35% for 1992-1996 with M = 0.15 (Figure 22a-d). These values are slightly higher than those which have been previously presented to the SAFMC (Huntsman et al. 1992): SPR = 0.20-0.28 for data through 1991; and SPR = 0.30-0.42 projected with SAFMC regulations in place.

Estimates of equilibrium spawning potential ratio (static SPR) using estimated F from the separable VPA approach are summarized by time period and assumed level of M. Using separable VPA estimates of F (with different levels of M) for three periods, SPR estimates based on female biomass are compared (Table 23).

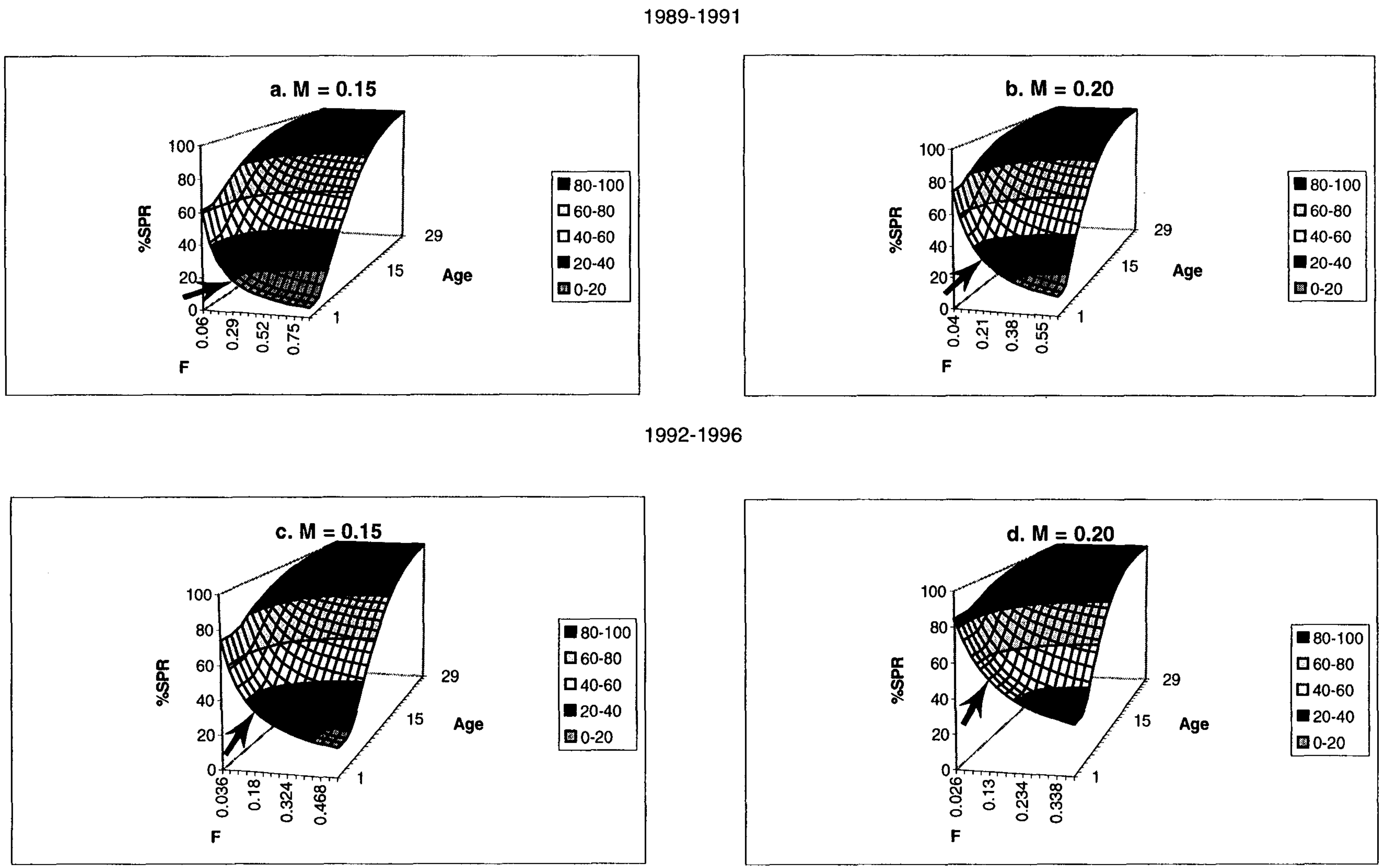
Two management options are evaluated in Table 24 that would each increase SPR to 40%. The two options are reduce F and increase minimum size, thus raising the age at entry to the fisheries. This evaluation would currently apply to the species only if M = 0.15 and M = 0.20.

Table 24. Two management actions that could result in SPR values of scamp to 30% and 40%, based on 1992-1996 data.

Action	Current SPR	Current F	% Reduction in F to Achieve 30%	40%
1. Reduce F				
M = 0.15	35%	0.18	N/A	20% (F=0.14)
M = 0.20	52%	0.13	N/A	N/A

2. Raise Minimum Size (Age)	To Achieve SPR Level 30%	40%
M = 0.15	N/A	20.7" (5yrs)
M = 0.20	N/A	N/A

Figure 22. Spawning potential ratio of the scamp population from the southeastern U.S. during two time periods: 1989-1991 and 1992-1996, and two levels of M: 0.15 and 0.20.



CONCLUSIONS

We believe that our assessment of scamp is flexible enough in its presentation to allow the reader to independently judge the status of the stock. This is because we present different fishing pressure response scenarios based on four different estimates of M.

Landings of scamp have generally increased in recent years, and the mean size of scamp landed, and catch per unit effort have also increased during the past several years. These are positive indications that the minimum size limits are having an effect on landings, and are increasing age at entry to the fishery. Fully recruited age and age at entry are age-5 and age-1 for 1986-1988, age-3 and age-1 for 1989-1991, and age-5 and age-1 for 1992-1996.

SPR values were derived using natural mortality (M) values of 0.10, 0.15, 0.20, and 0.25. We believe that the most accurate estimate of M is between 0.15 and 0.20. An M of 0.15 - 0.20 would result in an SPR ranging from 0.35 to 0.52 for the most recent time period, 1992-1996. The release fish mortality of 22% had no effect on the resulting SPR. SPR could be improved to 40% with a 20% reduction in F with M = 0.15. If M = 0.20, SPR currently exceeds 40%(Table 23). Age-at-entry could be increased if fishermen, particularly recreational, comply fully with the 20-inch minimum size regulation (Mays and Manooch 1997).

We conclude that the scamp stock is in an improved condition. Management actions taken by the SAFMC have been instrumental in the process of rebuilding the stock.

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