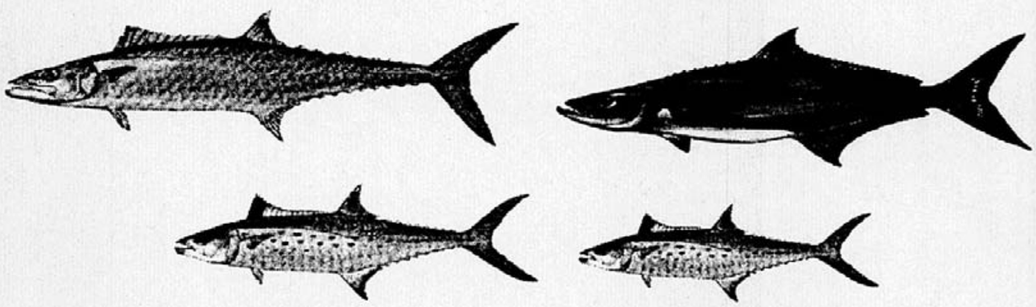
STOCK ASSESSMENT AND FISHERY EVALUATION REPORT FOR KING MACKEREL, SPANISH MACKEREL, AND COBIA

FISHERY MANAGEMENT PLAN FOR COASTAL MIGRATORY PELAGICS

VOLUME I



MAY 1999

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prepared by the
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1.0 INTRODUCTION

The *Guidelines for Fishery Management Plans (602 Guidelines)* published by the National Marine Fisheries Service (NMFS) require that a stock assessment and fishery evaluation (SAFE) report be prepared and reviewed annually for each fishery management plan (FMP). The SAFE reports are intended to summarize the best available scientific information concerning the past, present, and possible future condition of the stocks and fisheries under federal management. Appendix A to the *Guidelines* lists the desired components of SAFE reports as follows: 1) information on which to base harvest specifications; 2) information on which to assess the economic and social condition of persons and businesses that rely on recreational and commercial use of fish resources, including fish processing industries; and 3) any additional economic, social, and ecological information pertinent to the success of management or the achievement of objectives of each FMP.

The SAFE report for the Mackerel/Cobia fishery managed under the Coastal Migratory Pelagics Fishery Management Plan in the South Atlantic and Gulf of Mexico was compiled by South Atlantic Council staff with input from NMFS SERO and NMFS SEFSC. Our goal was to include the most recent information on issues that have been raised or are likely to be raised during the Council's review of the mackerel/cobia stock and fishery. The detailed information is found in the attached reports and we have only attempted to extract a very brief overview for inclusion in Sections 2, 3 and 4.

A very summary overview of stock status is presented in Section 2.0 Overview of Stock Assessment. Overviews of economic and social status of the fishery are presented in Section 3.0 Fishery Evaluation. This section contains material from the Council's Sustainable Fisheries Act Amendment describing fishing communities. Ecosystem considerations are presented in Section 4.0 Ecosystem Considerations using material from the Council's Habitat Plan and Habitat Amendment. These sections rely very heavily on the identified Council documents and the following appendixes:

Appendix A. Results of Literature Search.

A computer search of published literature was conducted. These results, along with the literature cited sections of the papers included in Appendix A through Appendix T, should provide most if not all of the pertinent literature.

Appendix B. List of Contributions to SAFE as Provided by NMFS SERO.

This list includes suggested documents for the SAFE report from the NMFS SERO. Many of these documents are included as Appendixes.

Appendix C. 1998 Report of the Mackerel Stock Assessment Panel (March 23-26,1998).

This is the report of the stock assessment panel which meets yearly at the direction of the Gulf and South Atlantic Councils. The tasks for the panel are specified in Amendment 1 to the FMP for Coastal Migratory Pelagic Resources. This was a full assessment and presents the stock status for mackerels

Appendix D. 1999 Report of the Mackerel Stock Assessment Panel (April 29-April1, 1999).

This is the report of the stock assessment panel which meets yearly at the direction of the Gulf and South Atlantic Councils. The tasks for the panel are specified in Amendment 1 to the FMP for Coastal Migratory Pelagic Resources. This was an update to last year's full assessment and updated the stock status of mackerels.

Appendix E. Updated Projections for King and Spanish Mackerel in the Gulf of Mexico and Atlantic Ocean (MSAP/99).

This paper prepared by Christopher M. Legault from the NMFS Southeast Fisheries Science Center, Sustainable Fisheries Division gives updated projections of the estimated stocks from the 1998 full assessment for mackerel for use in setting the total allowable catch (TAC) for each migratory group for the 1999/2000 fishing year. This was a background document used by the panel to develop their 1999 report.

Appendix F. Simualtion Study of Percentile and Bias Corrected Percentile Confidence Intervals for Allowable Biological Catch (MSAP/99).

This paper prepared by Christopher M. Legault from the NMFS Southeast Fisheries Science Center, Sustainable Fisheries Division presents percentile and bias corrected percentile confidence intervals for use in choosing ABC. This was a background document used by the panel to develop their 1999 report.

Appendix G. Gulf/South Atlantic Mackerel (National Fisherman, October, 1998).

This article from National Fisherman discusses how management affects market prices.

Appendix H. Economic and Social Assessments for Atlantic Mackerels and Cobia.

The NMFS Southeast Fisheries Economics Office intends that Appendixes P through T comprise the "Economic and Social Assessments for Atlantic Mackerels and Cobia". While these documents may contain information useful to conduct an economic and social assessment for Atlantic mackerels and cobia, no such analysis were located.

Appendix I. Report of the 8th. Coastal Migratory Pelagics Socioeconomic Panel Meeting.

This report comes from the 1999 meeting of the Socioeconomic Panel and provides a summary of discussions and recommendations used to advise the Gulf Council in making annual management decisions.

Appendix J. Report of the 7th. Coastal Migratory Pelagics Socioeconomic Panel Meeting.

This report comes from the 1998 meeting of the Socioeconomic Panel and provides a summary of discussions and recommendations used to advise the Gulf Council in making annual management decisions.

Appendix K. What if Mixing Area Fish are Assigned to the Atlantic Migratory Group Instead of the Gulf of Mexico Migratory Group?

This paper prepared by Christopher M. Legault from the NMFS Southeast Fisheries Science Center, Sustainable Fisheries Division evaluates the results of stock assessments and projected allowable biological catches (ABC) for both Atlantic group and the Gulf of Mexico migratory group king mackerel if mixing area fish are assigned to the Atlantic group. This document will be useful as separate FMPs are considered. This was a background document used by the mackerel stock assessment panel to develop their 1998 report.

Appendix L. The Potential Impact of Juvenile King Mackerel (*Scomberomorus cavalla*) and Spanish Mackerel (*S. maculatus*) Shrimp Trawl Bycatch Mortality on Southeast Atlantic Adult Populations (MSAP/98/01).

This paper by Patrick J. Harris (SC Marine Resources Division) and John M. Dean (University of South Carolina) calculates the probability of both king and Spanish mackerel being caught in commercial shrimp tows and estimated the numbers of king and Spanish mackerel harvested by shrimp trawlers in South Carolina and the southeastern United States. This was a background document used by the mackerel stock assessment panel to develop their 1998 report.

Appendix M. Characterization of King Mackerel and Spanish Mackerel Bycatches of South Carolina Shrimp Trawlers.

This paper by Patrick J. Harris and John M. Dean documents the extent and duration of Spanish and king mackerel bycatch during the commercial shrimp trawling season in South Carolina (North American Journal of Fisheries Management, 18:439-453,1998).

Appendix N. Estimates of Bycatch of Mackerel and Cobia in U.S. South Atlantic Shrimp Trawls (MSAP/98/04).

Douglas S. Vaughan (NMFS Beaufort Lab) and James M. Nance (NMFS Galveston Lab) completed this study for use by the South Atlantic and Gulf Councils to incorporate bycatch estimates of king and Spanish mackerel and cobia in the 1998 stock assessment. This was a background document used by the mackerel stock assessment panel to develop their 1998 report.

Appendix O. Commercial Landings Update: Coastal Migratory Pelagic Fish (SER)-ECON-99-06).

This report prepared by John Vondruska (NMFS Fisheries Economics Office) updates summaries of data on commercial landings and exvessel prices for coastal migratory pelagic fish for the Atlantic and Gulf Coast states, with emphasis on the southeast.

Appendix P. An Analysis of the Demand for King Mackerel (SERO-ECON-99-07),

John Vondruska (NMFS Fisheries Economics Office) updates previous work on empirical models of the U.S. market demand for commercially harvested king mackerel and in turn the estimation of net national economic benefits associated with changes in fishery regulations that affect the amount that can be landed.

Appendix Q. U.S. Markets and Trade in King Mackerel and Other Large Mackerel (SERO-ECON-99-08).

This report prepared by John Vondruska (NMFS Fisheries Economics Office) compares the U.S. seafood markets for fresh and frozen mackerel with imports that compete with these products.

Appendix R. Research Activities using the 1997-98 Southeast Recreational Economic Add-on Data (SERO-ECON-99-09).

Stephen G. Holiman (NMFS Fisheries Economics Office) summarizes the internal and external research activities using the 1997-98 Southeast recreational economic add-on data that have currently begun or are planned.

Appendix S. Summary Report of Methods and Descriptive Statistics for the 1997-98 Southeast Region Marine Recreational Economics Survey (SER0-ECON-99-10).

This document prepared by Stephen G. Holiman (NMFS Fisheries Economics Office) is intended to serve as a reference guide to the future contents of the summary report currently in preparation.

Appendix T. Summary Report of Methods and Descriptive Statistics for the 1997-98 Southeast Region Marine Recreational Economics Survey Fishery Management Data (SER0-ECON-99-11).

This document prepared by Stephen G. Holiman (NMFS Fisheries Economics Office) is intended to serve as a reference guide to the future contents of the summary report currently in preparation.

2.0 OVERVIEW OF STOCK ASSESSMENT

2.1 Stock Identification

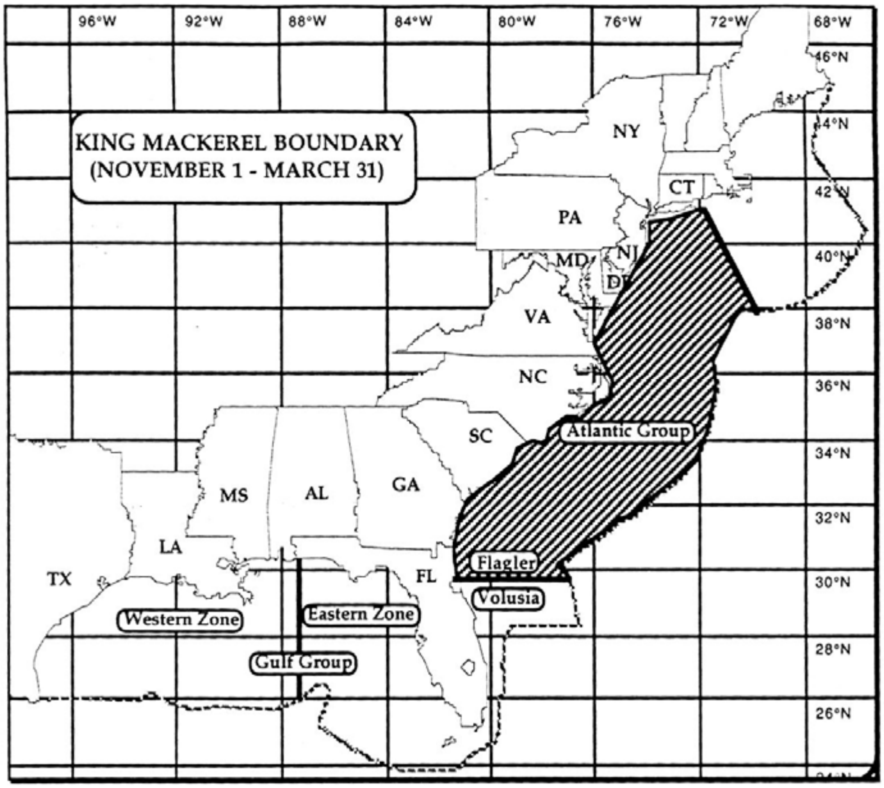
Species in the fishery for Coastal Migratory Pelagics include:

King mackerel	*Scomberomorus cavalla*
Spanish mackerel	*S. maculatus*
Cobia	*Rachycentron canadum*
Cero	*S. regalis*
Little tunny	*Euthynnus alleteratus*
Dolphin	*Coryphaena hippurus*
Bluefish (Gulf of Mexico only)	*Pomatomus saltatrix*

The present management regime for king mackerel recognizes two migratory groups, the Gulf migratory group and the Atlantic migratory group. These groups mix on the east coast of Florida. For management and assessment purposes, a boundary between groups (Figure 1) was specified as the Volusia-Flagler County border on the Florida east coast in the winter (November 1 - March 31) and the Monroe/Collier County border on the Florida southwest coast in the summer (April 1 - October 31).

Spanish mackerel mix in south Florida but abundance trends along each coast of Florida are different indicating sufficient isolation between the two migratory groups. The boundary for Spanish mackerel is fixed at the Dade/Monroe County border on Florida's southeast coast.

The remaining species are managed within the EEZs of the South Atlantic and Gulf of Mexico Council's except for bluefish which is Gulf of Mexico only.



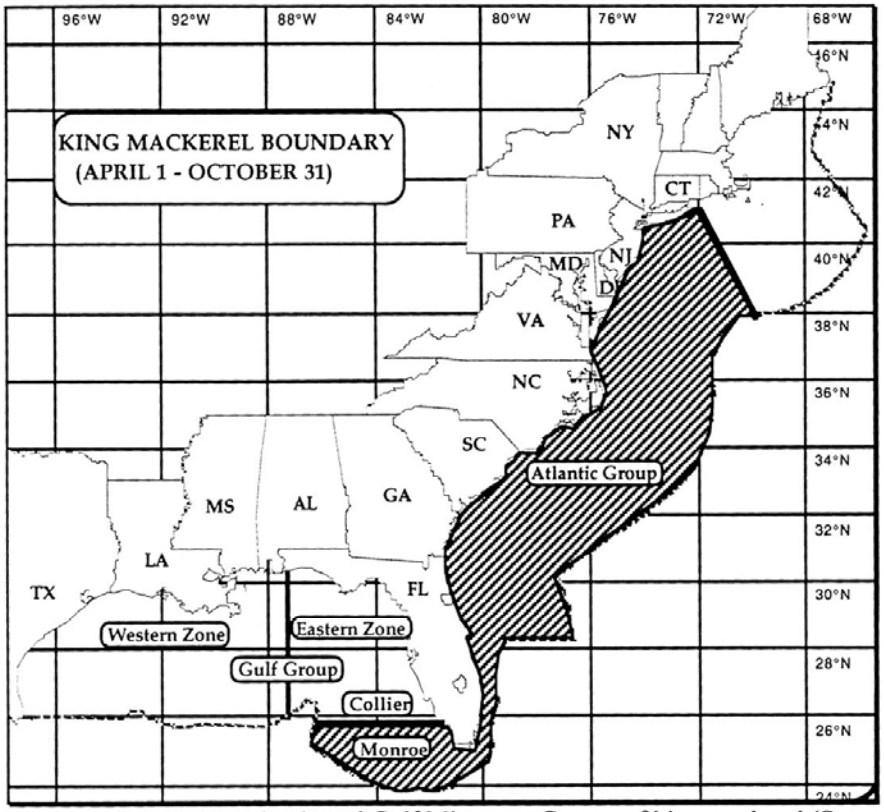


Figure 1. Seasonal boundary between Atlantic and Gulf Migratory Groups of king mackerel (Source: SAFMC Staff).

2.2 Biology

The biology of species in the Coastal Migratory Pelagics is included in the Final Amendment 1 to the Coastal Migratory Pelagics FMP (GMFMC & SAFMC, 1985). Much of this information is outdated and **next year's SAFE report will contain a review of the biology for each species.**

2.3 Catch and Catch Per Unit Effort

King and Spanish mackerel are major target species of important commercial fisheries in Florida and North Carolina, as well as major target species for the private boat and charter boat recreational fishery along widespread areas within the South Atlantic region. Information on recreational and commercial catches are included in Section 3.3 (Status of the Stocks). King mackerel are particularly important to the charter boat and offshore private boat fleets. In addition, smaller amounts of king mackerel are caught as a commercial supplement by the North Carolina charter boat fleet. North Carolina and Virginia follow Florida in commercial production of Spanish mackerel. Small amounts of king and Spanish mackerel are caught as an incidental catch or supplemental commercial target species off Georgia and South Carolina.

Recreational users in general have increased in numbers over time. Many come from outside the management unit as well as areas within it. Increased income, leisure time, and a wide variety of supplies (fishing equipment, etc.) have increased participation. This participation has, in turn, generated significant amounts of economic value and also employment.

Catches of Atlantic migratory group king and Spanish mackerel are shown in Tables 4 and 5.

Next year's SAFE report will contain detailed analyses of catches and CPUE for each species based on the logbook and state trip level data.

2.4 Size Frequency Data

Table 1 in the 1998 Mackerel Assessment Panel Report (Appendix C) presents the ages and length samples for king and Spanish mackerel.

Next year's SAFE report will contain detailed analyses of size frequency data for each species based on available data.

2.5 Age Analysis

Table 1 in the 1998 Mackerel Assessment Panel Report (Appendix C) presents the ages and length samples for king and Spanish mackerel. The aged catch is used in the VPA analyses.

Next year's SAFE report will contain detailed analyses of age data for each species based on available data.

2.6 Stock Status

The following sections are based on information in the 1998/99 Framework prepared by the South Atlantic Council (SAFMC, 1998) and information in the 1999 Assessment Report (Appendix D).

Management Reference Points

The South Atlantic Council's target level or optimum yield (OY) for a mackerel stock or migratory group is 40% static spawning potential ratio (SPR).

The 1998 (Appendix C) and 1999 (Appendix D) Mackerel Assessment Panel Reports are attached. Table 1 shows the 1998 results from the full stock assessment and the Council's recommended changes for the 1998/99 fishing year. The mackerel framework has not been implemented as of this date. The Advisory Panel and committee will be making recommendations to the Council for the 1999/00 fishing year at the upcoming June 1999 meeting based on the 1999 updated assessment (Table 2).

Table 1. Mackerel ABC, TAC, allocations and bag limit specifications.

	Group	ABC (Mlb)	TAC (Mlb)	Com (Mlb)	Rec (Mlb)	Bag Limit
1998/99	King	9.3(8.4-11.9)	8.4	3.12	5.28	3GA-N/2FL
	Spanish	6.6(5.4-8.2)	6.6	3.63	2.97	10 NC-FL
1999/00	King	10(8.9-13.3)				
	Spanish	7.1(5.7-9.0)				

Table 2. Mackerel MSY, OY, Transitional SPR, Static SPR, and Stock Status.

	Group	MSY	OY	Trans. SPR	Static SPR	Status
1998/99	King	7.7 Mlb	40%S.SPR	39%(36-42)	36%	Not*
	Spanish	n/a	40%S.SPR	40%(36-44)	42	Not*
1999/00	King		40%S.SPR	43%(41-48)	54%(50-64)	Not*
	Spanish		40%S.SPR	46%(41-48)	55%(47-63)	Not*

*Note: The "not overfished" recommendations are based on the Councils' overfished criterion of 30% Static SPR for mackerel. Overfishing is judged using 30% Transitional SPR.

The Sustainable Fisheries Act requires Councils to manage fishery resources based on MSY as a limit to OY and maximum fishing mortality threshold (MFMT) as a limit to fishing mortality rate. Stocks should also be maintained above the minimum stock size threshold (MSST). These and other stock status values were calculated in the 1999 assessment and are shown below in Table 3.

Table 3. Sustainable Fisheries Act status determination criteria using the median values from Table 5 in the panel report.

Group	MSY (Mlb)	MFMT (Fmsy)	Bmsy (Mfish)	MSST (Mfish)
Atlantic King	10.4	0.40	5.2	4.4
Atlantic Spanish	6.4	0.40	13.7	9.6
Current Estimates				
Atlantic King		0.15	Spawning Stock=	6.5 Mfish
Atlantic Spanish		0.18	Spawning Stock=	20 Mfish

Based upon the information in Table 3, Atlantic king and Spanish mackerel are not overfished and are not experiencing overfishing. Note that the panel has recommended that assessments for these two species not be done unless there is new information on Atlantic bycatches, catch rates decline over a period of years, catches exceed MSY, or catches exceed those corresponding to MFMT. This can only be done through a plan amendment.

Definition of Overfishing

Currently, king and Spanish mackerel are considered overfished if they are below a transitional Spawning Potential Ratio (SPR) of 30 percent.

Status of the Stocks

The 1999 report of the mackerel stock assessment panel contains the latest information on stock status (Appendix D).

Atlantic Migratory Group King Mackerel

Recreational and commercial catches of Atlantic migratory group king mackerel are shown in Table 4.

The following information is directly from the 1999 Panel Report (see Appendix D for additional information and the referenced tables and figures):

"Discussion of Stock Status

Landings of Atlantic group king mackerel have been below TAC in every year except 1997/98 (Table 1). The transitional SPR has also steadily increased since about 1994, and the current estimate for 1999/2000 is 43 percent. SPR estimates are presented as "conditional on no bycatch" for Atlantic group king mackerel. Although the Panel recognizes that Atlantic group king mackerel are caught in shrimp trawls, the uncertainty of these estimates is too great for meaningful use.

Overfishing

Static SPR was estimated at 54 percent. Consequently, the Panel concludes that the Atlantic group king mackerel fishery was not overfishing the available stock because the fishing mortality rate was less than F30%StaticSPR in 1997-98.

Overfished Status

The Panel concludes that the Atlantic migratory group of king mackerel is not overfished because the transitional SPR is estimated at 43 percent, which is above 30% (Figure ATK-5)"

Table 4. Catches of Atlantic Migratory Group King Mackerel. Source: Mackerel Stock Assessment Panel (1999).

Fishing	Numbers of fish in thousands			Weight of fish in thousands of pounds			Average Com &
Year	Com	Rec	Total	Com	Rec	Total	Rec Weight
1981/82	276	497	772	2,390	4,422	6,812	8.82
1982/83	382	530	911	3,,938	5,246	9,185	10.08
1983/84	235	671	906	2,441	6,253	8,694	9.60
1984/85	182	613	794	1,947	6,131	8,078	10.17
1985/86	233	818	1,051	2,495	7,121	9,616	9.15
1986/87	277	700	977	2,837	5,979	8,816	9.02
1987/88	348	544	892	3,453	3,905	7,357	8.25
1988/89	340	556	897	3,091	4,881	7,972	8.89
1989/90	283	380	664	2,635	3,400	6,036	9.09
1990/91	310	439	750	2,676	3,718	6,394	8.53
1991/92	296	639	934	2,516	5,822	8,338	8.93
1992/93	270	673	943	2,227	6,251	8,477	8.94
1993/94	225	375	600	2,018	4,438	6,456	10.76
1994/95	226	382	607	2,197	3,728	5,925	9.76
1995/96	180	463	644	1,870	4,153	6,023	9.35
1996/97	316	384	700	2,702	4,016	6,718	9.60
1997/98				2,678	5,392*	8,070	
1998/99				2,520	4,565*	7,085	

*Recreational landings, in pounds, were estimated by multiplying number of fish caught by 10.46 lbs/fish.

Atlantic Migratory Group Spanish Mackerel

Recreational and commercial catches of Atlantic migratory group Spanish mackerel are shown in Table 5.

The following information is directly from the 1999 Panel Report (see Appendix D for additional information and the referenced tables and figures):

"Status of the Stock

The transitional SPR has steadily increased since 1995, and the current estimate for 1999/2000 is 46 percent. The Panel attributes the steady increase in transitional SPR since 1995 to the reduction in fishing mortality rates resulting from the elimination of gill nets from Florida state waters (July 1995). SPR estimates however, are presented as "conditional on no bycatch" for Atlantic group Spanish mackerel. Although the Panel recognizes that Atlantic group Spanish mackerel are caught in shrimp trawls, the uncertainty of these estimates is too great for meaningful use.

Overfishing

Static SPR was estimated at 55 percent. Consequently, the Panel concludes that the Atlantic group Spanish mackerel fishery was not overfishing the available stock because the fishing mortality rate was less than F30%StaticSPR.

Overfished Status

The Panel concludes that the Atlantic migratory group Spanish mackerel is not overfished because the transitional SPR is estimated at 46 percent, which is above the 30 percent level (Figure ATS-5)"

Table 5. Catches of Atlantic Migratory Group Spanish Mackerel. Source: Mackerel Stock Assessment Panel (1999).

Fishing	Numbers of fish in thousands			Weight of fish in thousands of pounds			Average Com &
Year	Com	Rec	Total	Com	Rec	Total	Rec Weight
1984/85	2,184	942	3,126	3,292	1,311	4,602	1.47
1985/86	2,346	496	2,842	4,192	747	4,939	1.74
1986/87	1,907	798	2,704	2,565	1,196	3,761	1.39
1987/88	2,446	1,053	3,498	3,559	1,474	5,033	1.44
1988/89	2,647	1,726	4,373	3,524	2,740	6,264	1.43
1989/90	2,234	1,103	3,337	3,963	1,569	5,533	1.66
1990/91	2,067	1,323	3,390	3,560	2,075	5,635	1.66
1991/92	2,913	1,464	4,377	4,736	2,287	7,023	1.60
1992/93	2,274	1,210	3,484	3,716	1,995	5,712	1.64
1993/94	2,525	920	3,445	4,813	1,493	6,306	1.83
1994/95	3,169	1,085	4,254	5,233	1,378	6,611	1.56
1995/96	1,476	785	2,260	2,009	1,089	3,098	1.37
1996/97	2,170	658	2,829	3,096	851	3,946	1.40
1997/98				3,057	1,357*	4,414	
1997/98				3,200	774*	3,974	

*Recreational landings, in pounds, were estimated by multiplying number of fish caught by 1.29 lbs/fish.

3.0 FISHERY EVALUATION

3.1 Economic Status of The Fishery

The Atlantic migratory groups of king mackerel and Spanish mackerel are not considered to be overfished under the Magnuson Act definition of overfishing. However, the Gulf migratory group of king mackerel is currently classified as overfished. This section describes economic aspects of the commercial and recreational sectors that harvest Spanish mackerel (*Scomberomorus maculatus*) and king mackerel (*Scomberomorus cavalla*) in the South Atlantic region. In addition, it discusses the economic implications of measures in the *1998 Framework Seasonal Adjustment of Harvest Levels and Procedures under the FMP for the Coastal Migratory Pelagic Resources in the South Atlantic Region.*

Recreational Fishing in the South Atlantic Region

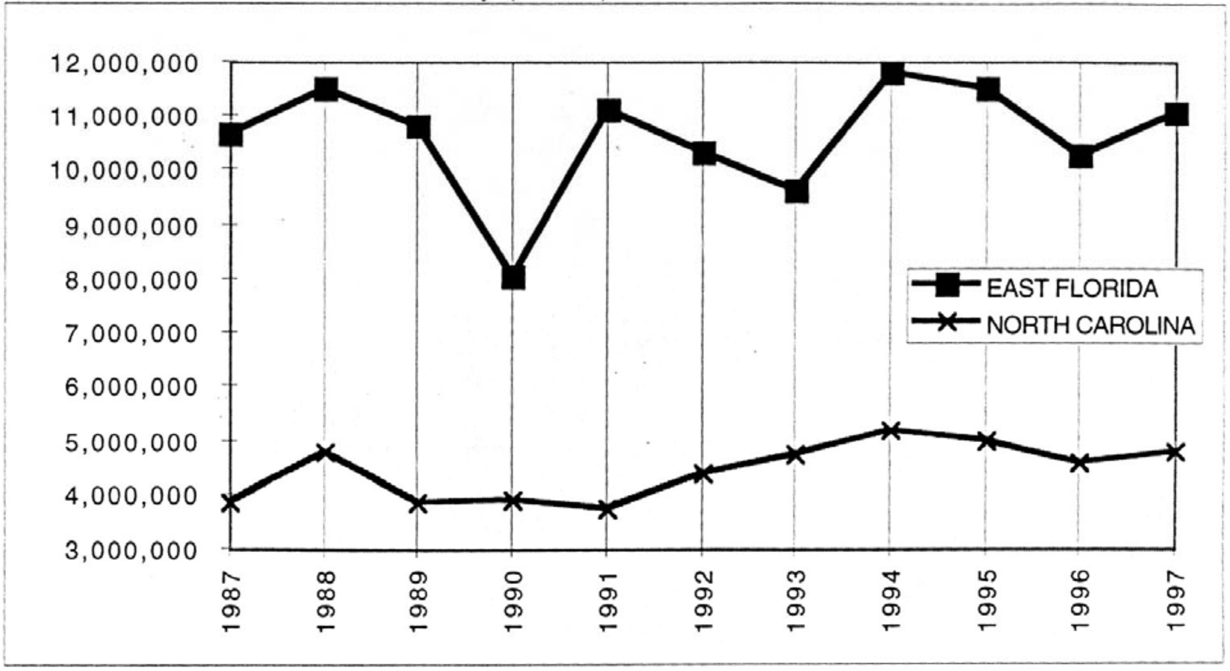
Both king mackerel and Spanish mackerel are important to the recreational fishery in the South Atlantic region. In recent years recreational fishing for king mackerel has grown in popularity, while landings of Spanish mackerel declined. Inferences on the popularity of these species are based on catch and harvest data rather than on information on trips where Spanish and or king mackerel were the targets. The latter data were not available and information on recreational effort in the South Atlantic includes all sport fishing trips. Nearly 90% of all recreational fishing trips occur off Florida and North Carolina (Table 6).

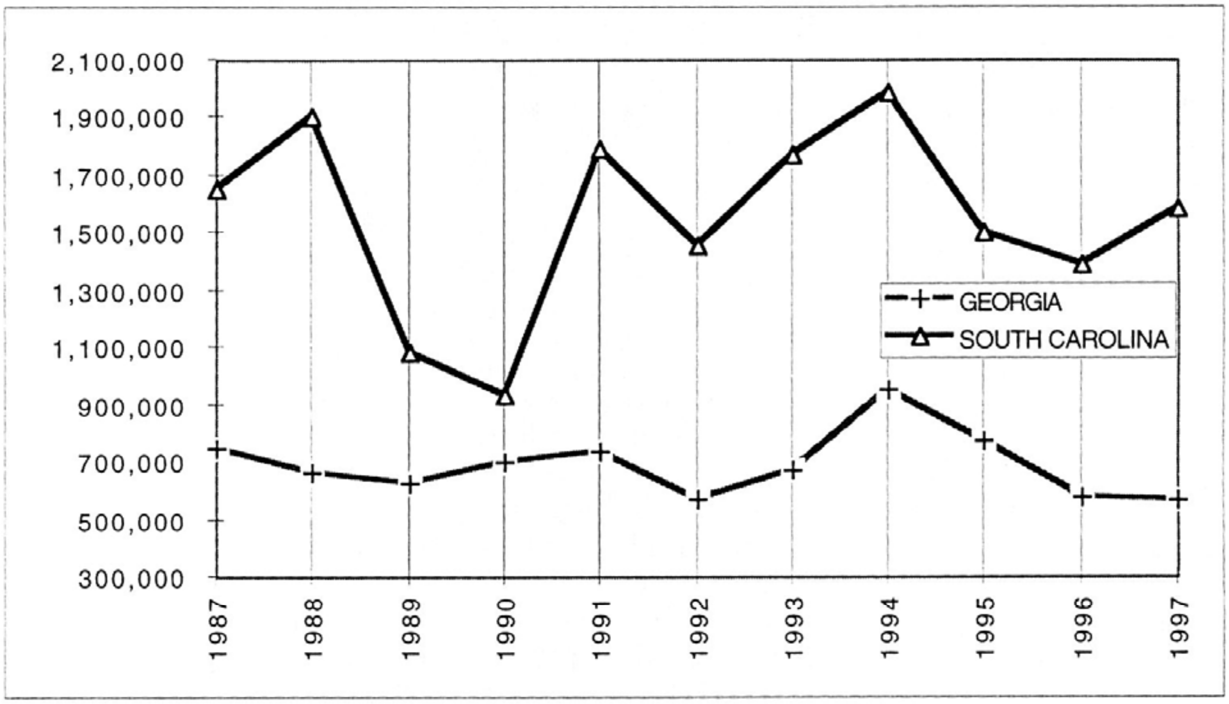
Table 6: The Distribution of Recreational Fishing Trips in the South Atlantic by State. Data from the National Marine Fisheries Service Marine Recreational Fisheries Statistical Survey (MRFSS)

Year	EAST FLORIDA	GEORGIA	NORTH CAROLINA	SOUTH CAROLINA
1992	62%	3%	26%	9%
1993	57%	4%	28%	11%
1994	59%	5%	26%	10%
1995	61%	4%	27%	8%
1996	61%	3%	27%	8%
1997	61%	3%	27%	9%

Recreational fishing effort peaked for most states in 1994 and declined slightly thereafter (Figure 2). The increase in recreational fishing during the early and mid 90s is the result of many factors. However, it is reasonable to speculate that the growth in population in coastal counties, the recovery of the economy from the mild recession in the early 90s (increasing disposable income to spend on leisure activities), and the improvement in some fish stocks are partly responsible for this trend. The slight decline in fishing effort after 1994 may be the result of extreme weather conditions and other episodic events and it remains to be seen whether this is indicative of a long term trend.

Figure 2. Marine Recreational Fishing Trips in the South Atlantic Region (1987-1997). Source: Marine Recreational Statistical Survey (NMFS).





Commercial Fishing for King Mackerel and Spanish Mackerel in the South Atlantic Region

Vondruska(1998) indicates that about 2,124 federal permits were issued in 1997 to vessels with home ports in the South Atlantic region and about 1,411 vessels held commercial mackerel permits (Table 7). The majority of these vessels also held snapper/grouper permits. Most of these vessels were based in North Carolina and East Florida. In 1997 most of these permits were active as 3,421 boats reported selling king mackerel, and to a lesser extent 2,126 boats sold Spanish mackerel.

Table 7. Vessels with federal fishing permits and vessels with mackerel permits in 1997. Source: Taken from Vondruska (1998).

Home Port State/Region	Total Boats*	Mackerel Permits	% of all boats in state/region with mackerel permits
New England	181	22	12.2%
Mid-Atlantic & Chesapeake	272	96	35.3%
North Carolina	654	455	69.6%
South Carolina	163	83	50.9%
Georgia	49	15	30.6%
Florida-East Coast	1,258	863	68.6%
Florida-West Coast	2,371	1,406	59.3%
Florida-Non Coastal	202	141	69.8%
Alabama	194	15	7.7%
Mississippi	63	14	22.2%
Louisiana	380	231	60.8%
Texas	342	70	20.5%
Other States	37	11	29.7%
Total	**6,166**	**3,422**	**55.5%**

*Total number of vessels with federal fishing permits that are administered by the NMFS Southeast Regional Office, except Golden Crab, Wreckfish, and Coral permits.

Spanish mackerel is landed primarily by runaround gill nets, other gill nets and to a lesser extent hook and line. The caches by gear type have remained fairly constant for all gear types from 1994 onward except for runaround gill nets where there was a peak in catches until 1993 and a decline thereafter. In the South Atlantic most of the king mackerel landed are taken by hook and line gear. Since 1985 the run-around gill net fishery declined. Also the landings by the drift gill net fishery did not amount to much and practically disappeared by 1988/89. By 1990 at least 90% of the king mackerel landed came from the hook and line fishery. This remains true today (Vondruska; see Appendix O). Landings in Florida occur throughout the year but fish are more abundant from December through May.

Vondruska (1999-Appendix P) came to the conclusion that demand for king mackerel was very elastic and thus large changes in quantity did not have an appreciable effect on the ex-vessel price. Prices tend to fluctuate throughout the year and examination of monthly price data indicates that seasonal peaks in price occur in June and September for East Florida (Figure 3). Seasonal price fluctuations from North Carolina to Georgia is depicted in Figure 3. The pattern in 1998 appears to be a departure from trends in the earlier years. Prices may vary depending on whether the fish are caught by hook and line or nets.

Imports of both king and Spanish mackerel enter the United States mainly from the Indo West Pacific and the central west Atlantic. These imports increased from about half a million pounds in the mid 80s to nearly several million pounds by the 1990s, and reached a peak of 10.6 million pounds in 1996. By 1998 imports fell to 4.1 million pounds.

Issues in the Spanish Mackerel Fisheries

The 1998 mackerel framework proposed that the TAC for Spanish mackerel be set to 6.6 million pounds, which would be divided 55% commercial and 45% recreational. In the past the commercial/recreational split was 50% to 50%. To date these measures have not been adopted.

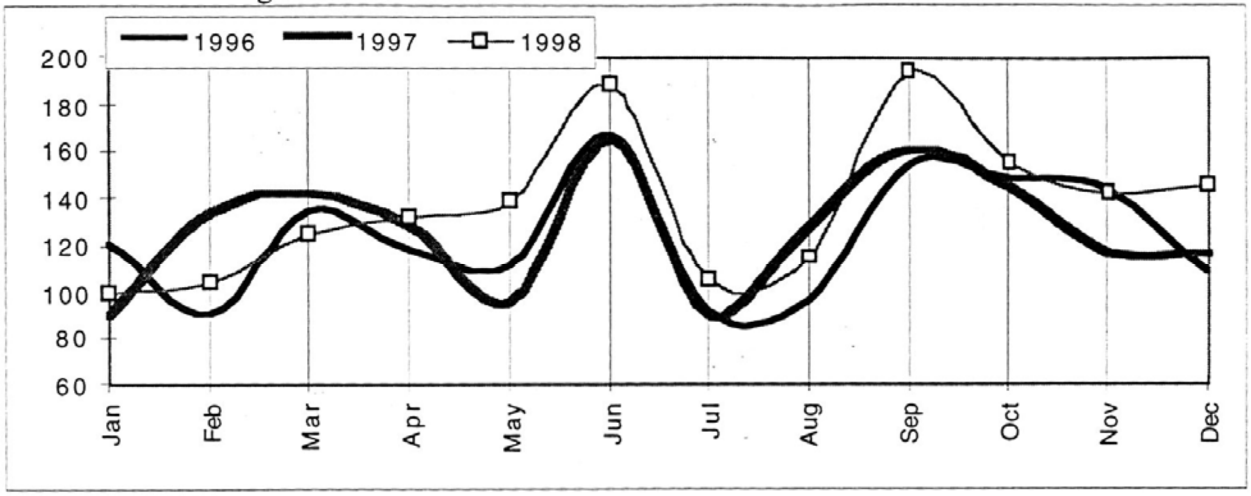
For the commercial sector, harvest in the South Atlantic exceeded their allocation until 1995 when harvest declined to 43% of their total allowable catch. After 1995 total landings increased but was still below the sector's allocation. Preliminary landings data indicate that the harvest of Spanish mackerel may fall short of the allocation proposed in the mackerel framework. Thus, it is expected that there would be no short term change in gross revenue from this framework adjustment.

In the Spanish mackerel fishery, allocations between recreational and commercial sectors have changed over time, and during the past seven years allocation shares have been 50% recreational and 50% commercial. Thus, under the mackerel framework, the recreational share has declined and the overall recreational TAC proposed for 1998/99 has also declined. Harvests within the recreational sector has been on a declining trend since 1992, to the extent that preliminary data for the 1997/98 season indicated that 34% of the allocated TAC was landed in the South Atlantic. This decline could be due to a change in species preference for recreational anglers in the South Atlantic. Data on targeted trips could shed more light on this issue. Since the recreational allocation is more than twice the previous year's landings it is unlikely that this proposed measure would constrain recreational activity and unlikely that short term benefits (consumer surplus) would be reduced.

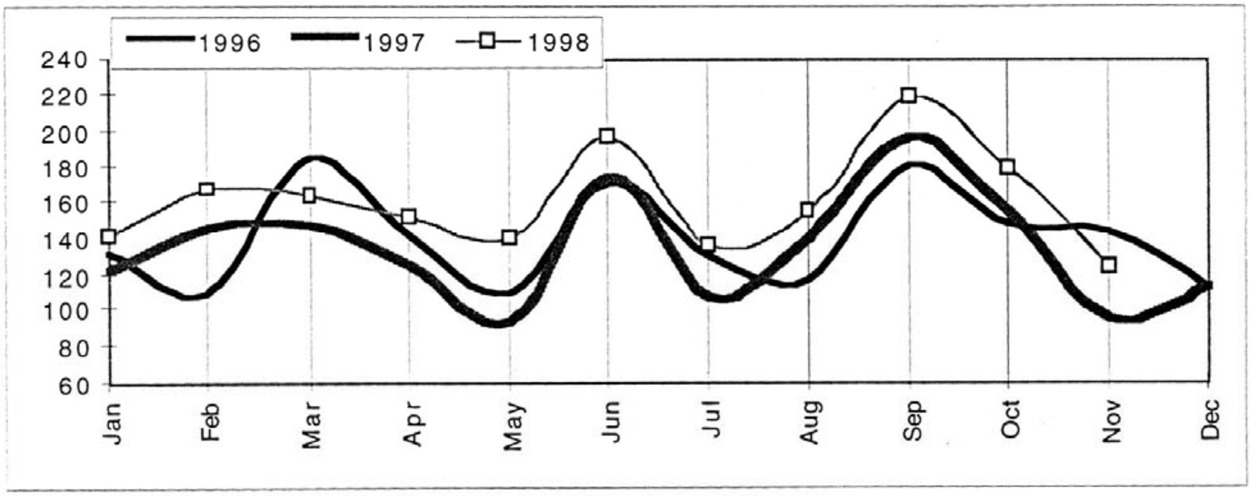
The lower overall harvest proposed would result in higher long terms benefits for this sector as it is expected that population would increase and the catch success rates would improve in the future. However, this reallocation may cause some concern among the recreational sector. There is some speculation that large schools of Spanish mackerel that used to exist attracted many recreational anglers to this fishery, and with the disappearance of this phenomenon recreational interest in this fishery has declined.

Figure 3. Real exvessel monthly prices for king mackerel in 1990 cents (Vondruska, 1999).

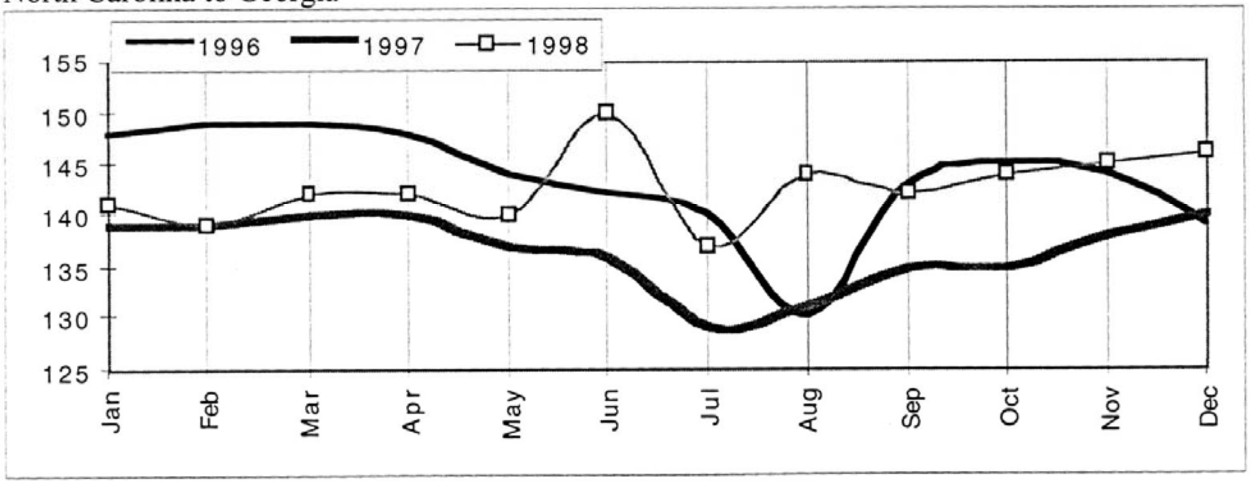
Entire Southeast Region from North Carolina to Texas:



East Florida



North Carolina to Georgia



Issues in the King Mackerel Fisheries

The following is a discussion of the mackerel framework adjustments for king mackerel in the South Atlantic region and other issues that are of interest. Again it must be noted that the framework measures have not been adopted.

1. Establish a TAC of 8.4 million pounds for Atlantic group king mackerel for the 1998/99 fishing year. [Note: Spanish mackerel TAC is less of an issue at this time; allocation and catches are shown in Table 7.]
   This should yield increased benefits for both the recreational and commercial sectors as more fish can now be legally harvested. Both sectors exceeded their allocations in the previous year and preliminary estimates indicate that the framework TAC would not be exceeded (Table 8), however under the status quo it is expected that both sectors will exceed their allocations for the 1998/99 season. An increased allocation will decrease the likelihood of stricter regulations on recreational and commercial fishing in the future. However, in the short term this measure will have little impact on benefits in these sectors.

2. Increase the size limit for Atlantic group king mackerel from 20 inch fork length to 24 inch fork length.
   It is expected that this measure will have little impact on the catches of both commercial and recreational anglers in the South Atlantic. This conclusion is based upon the size composition of the catches. For the commercial sector less than 1% of the fish landed are below 24 inches. The proportion of these sized fish in the recreational catch ranges from 2.3% in Georgia to 7.4% in South Carolina. It is difficult to determine what impact this will have on recreational activity and benefits in the South Atlantic, as the data is not available to determine the response to these types of management measures. Given the low incidence of occurrence in the catch one can assume that it may not significantly impact anglers in the short term.

   The rationale for this measure is to make regulations in the South Atlantic correspond to those in the Gulf of Mexico and the State of Florida. This uniform size limit will aid enforcement of fisheries regulations, and fishermen will not have to contend with a change in regulations as the boundary for Gulf and Atlantic migratory group shifts throughout the year.

3. Revise the trip limit for Gulf migratory king mackerel in the northern area of the eastern subzone (Dade through Volusia County) to 75 fish throughout the entire season (November 1 to March 31).
   This measure would allow fishermen in these areas the opportunity to catch their allocation. It was estimated that there would be an increase of $331,000 in the short term and possible increase in long term economic benefits if the sub-allocation is fully utilized.

4. Lower the 3,500 pound limit for Atlantic group migratory king mackerel north of the South Carolina line year round to 2,000 pounds unless 80% is taken prior to Feb. 1, then reduce this to 1,000 pounds.
   In 1997, seven trips made by gill nets and 58 trips made by other gears other than gill nets landed over 2,000 lb. of king mackerel. Under a trip limit constraint it was estimated that the fishery would experience a drop in revenue of $57,000, or 2.4% of the total revenue to the North Carolina fishery for king mackerel. This trip limit is to ensure that there would not be an early closure of the fishery and to decrease landings in the North Carolina fishery. Should

Table 8. Allocation and catches for South Atlantic Group Spanish Mackerel (Millions of Pounds). Data from the 1999 Mackerel Assessment Panel Report.

	Commercial Fishery			Recreational Fishery		
Year	Allocation	Catch	% Allocation Harvested	Allocation	Catch	% Allocation Harvested
1989/90	3.24	3.963	122%	2.76	1.569	57%
1990/91	3.14	3.560	113%	1.86	2.075	112%
1991/92	3.50	4.736	135%	3.5	2.287	65%
1992/93	3.50	3.716	106%	3.5	1.995	57%
1993/94	4.50	4.813	107%	4.5	1.493	33%
1994/95	4.60	5.233	114%	4.6	1.378	30%
1995/96	4.70	2.009	43%	4.7	1.089	23%
1996/97	3.50	3.096	88%	3.5	0.851	24%
1997/98*	4.00	3.057	76%	4.0	1.357	34%
1998/99**	4.00	3.366	84%	4.00	0.774	19%
1998/99***	3.63	3.366	93%	2.97	0.774	26%

Table 9. Allocation and catches for South Atlantic Group King Mackerel (Millions of Pounds). Data from the 1999 Mackerel Assessment Panel Report.

	Commercial Fishery			Recreational Fishery		
Year	Allocation	Catch	% Allocation Harvested	Allocation	Catch	% Allocation Harvested
1989/90	3.34	2.635	79%	5.66	3.400	60%
1990/91	3.08	2.676	87%	5.22	3.718	71%
1991/92	3.90	2.516	65%	6.60	5.822	88%
1992/93	3.90	2.227	57%	6.60	6.251	95%
1993/94	3.90	2.018	52%	6.60	4.438	67%
1994/95	3.71	2.197	59%	6.29	3.728	59%
1995/96	2.70	1.870	69%	4.60	4.153	90%
1996/97	2.52	2.702	107%	4.28	4.016	94%
1997/98*	2.52	2.678	106%	4.28	5.392	126%
1998/99**	2.52	2.625	104%	4.28	4.565	107%
1998/99***	3.12	2.625	84%	5.28	4.565	86%

*Preliminary estimates only for landings in 1997/98 and 1998/99

**Existing guidelines, since to date the mackerel framework measures have not been adopted.

***Proposed under the 1998 mackerel framework, however these measures have not been approved by the National Marine Fisheries Service .

vessels respond by increasing the number of trips in order to meet some vessel threshold income level then it is expected that net revenue will decrease and landings will not decline.

If additional effort were to enter this area of the king mackerel fishery, this measure should ensure that total harvest would not exceed the allocation, and thus avoid early closures. However, this may impose inefficiency on large vessels that are constrained by the trip limit. In addition, trip limits may avoid market gluts caused by derby style fishing. If this trip limit reduction were to result in higher prices then affected vessels may capture some of their lost revenue.

Other issues not addressed in the framework include: mixing of Atlantic and Gulf king mackerel, beginning the Atlantic migratory group king mackerel season on March 1, and accounting for mackerel by-catch in the shrimp trawl fishery.

There are two migratory groups of king mackerel; one group in the Gulf and another in the Atlantic. During the summer (April 1 to October) the Monroe/Collier county Florida border serves as a demarcation line for landings assigned to the two migratory groups. In the winter (November 1 to March 31) the Flagler/Volusia County border delimits the catches assigned to the two migratory groups. The overlap between these two boundaries is the mixing area and fish caught here are currently distributed to both the Gulf and Atlantic migratory groups depending on the season. However, it has been suggested that some fish caught here in the winter belong to the Atlantic migratory group. This could result in an increase in ABC between 0.9 and 4.6 million pounds depending on the level of by-catch used in the analyses. As both the commercial fishery and recreational fishery exceeded their allocations, such an increase in the ABC and hence the TAC would serve to increase both short term and long term benefits for both groups.

There was some interest expressed in altering the season for king mackerel in the South Atlantic. Fishing starts in April in North Carolina, but recently with the closure of red porgy and gag grouper from January to April fishing for king mackerel in March is becoming more important in North Carolina. This proposed action could impact the Florida fishery, as it may result in early closure.

The mackerel stock assessment panel recognized that there was juvenile Spanish and king mackerel by-catch in the southeast Atlantic shrimp trawl fishery. Most of the data available on this by-catch comes from the South Carolina shrimp fishery. Harris and Dean (1998) observed that king mackerel were found in 21% of the tow samples with peak catches occurring in October and November. While Spanish mackerel were observed in 41% of he samples and peak catches occurred in July. These authors concluded that age 0 king mackerel were vulnerable to the trawl gear for half of the shrimping season and age 0 Spanish mackerel were caught throughout the entire shrimping season (May to December).

These estimates were imprecise and showed too much variability, and to date there is no acceptable method to estimate this by-catch for the entire Southeast. Thus, the panel did not include by-catch estimates in calculating allowable biological catch ranges for king and Spanish mackerel. In the future should by-catch be included in this assessment it would mean wider ABC range for both species. It is important that by-catch in the Southeast shrimp trawl fishery be adequately monitored for at least one year to determine if quantities of these species are large enough to warrant more in-depth studies.

3.2 Social Evaluation - South Atlantic Fishing Communities as Defined in the Sustainable Fisheries Act Amendment (SAFMC, 1998a)

"4.3.3 Fishing Communities - Identify and define fishing communities

Identifying fishing communities provides a basis for analyzing impacts of management measures on fishing communities rather than on a fishery-wide basis. This would be more relevant in situations where impacts are differential because of the location, level of activity and dependency on fishing, availability of alternative job opportunities, etc. in different fishing communities. This measure would allow fishery managers to obtain information on the impacts of future management measures on different fishing communities. It could make for the formulation of management measures that would minimize impacts on fishing communities that have less opportunities to adapt to changes imposed by the measures.

Identification and definition of fishing communities would normally have a positive impact, except that, for the South Atlantic, there are no data collected on fishing communities. National Standard 8 imposes requirements on the council and the fishery management regulatory process that cannot be satisfied given existing data. Current data available do not allow for a meaningful definition of fishing community, moreover, do not provide a measure of dependence upon fishing and will not contribute to useful impact analysis.

At its March meeting, the Gulf of Mexico Fishery Management Council's Socio-economic Panel recommended that further research be initiated and funded by National Marine Fisheries Service as soon as possible to aid in the identification and definition of fishing communities in the Southeast. The panel also recommended the scope of this problem be addressed at a national level, such that impacts upon fishing communities can be analyzed across regions as well as within. A key area for expanded research is ethnographic and survey research to identify, not only communities, but those who provide supporting services to the economy and culture of fishing communities. Especially important in the Southeast is the need to provide a realistic portrayal of recreational fishing, diving, and eco-tourism and their importance to a fishing community.

The Council concluded incorporating all available information at this time will meet the mandates of the recent Magnuson-Stevens Act amendments relative to fishing communities.

With the addition of National Standard 8, FMPs must now identify and consider the impacts upon fishing communities to assure their sustainable participation and minimize adverse economic impacts [MSFCMA section 301 (a) (8)].

The proposed guidelines for this new standard state: *"... fishing communities are considered geographic areas encompassing a specific locale where residents are dependent on fishery resources or are engaged in the harvesting or processing of those resources. The geographic area is not necessarily limited to the boundaries of a particular city or town. No minimum size for a community is specified, and the degree to which the community is 'substantially engaged in' or 'substantially dependent on' the fishery resources must be defined within the context of the geographical area of the FMP. Those residents in the area engaged in the fisheries include not only those actively working in the harvesting or processing sectors, but also ``fishery-support services or industries," such as boat yards, ice suppliers, or tackle shops, and other fishery-dependent industries, such as ecotourism, marine education, and recreational diving."* [Federal Register Volume 62, Number 149 (August 4, 1997)]

"The term 'sustained participation' does not mandate maintenance of any particular level or distribution of participation in one or more fisheries or fishing activities. Changes are inevitable in fisheries, whether they relate to species targeted, gear utilized, or the mix of seasonal fisheries during the year. This standard implies the maintenance of continued access to

fishery resources in general by the community. As a result, national standard 8 does not ensure that fishermen would be able to continue to use a particular gear type, to target a particular species, or to fish during a particular time of the year." [Federal Register Volume 62, Number 149 (August 4, 1997)]

"*The term 'fishing community' means a community that is substantially dependent on or substantially engaged in the harvest or processing of fishery resources to meet social and economic needs, and includes fishing vessel owners, operators, and crew, and fish processors that are based in such communities. A fishing community is a social or economic group whose members reside in a specific location and share a common dependency on commercial, recreational, or subsistence fishing or on directly related fisheries-dependent services and industries (for example, boatyards, ice suppliers, tackle shops)."* [Federal Register Volume 62, Number 149 (August 4, 1997)]

In order to determine a community's "substantial dependence" or "sustained participation" on fishing, those communities must first be identified. Presently, the NMFS has not identified fishing communities, nor their dependence upon fishing in the South Atlantic. Moreover, there are no ongoing data collection programs to gather the necessary information that would allow for the identification of fishing communities in the South Atlantic or other regions. Also, there are no future plans to implement any such data collection program that would determine dependence upon fishing in order to provide the Councils with important information necessary for social and economic impact analysis of fishing communities. This leaves the councils with existing data collected through other agencies, not always specific to fisheries management, i.e., census data, regional economic census, and previous research on specific fisheries. Although this data can be useful, it is often not specific enough to identify or provide a clear representation of a community and its dependence upon fishing. One reason for this difficulty is that fishermen in a specific fishery often do not reside within one particular municipality that can easily be identified as a fishing community or one that is substantially dependent upon fishing. Also, that information is often not provided at the municipality level, but more often at the county level.

Commercial fishermen may have a domicile (home) in one community and dock their boat in another. They may sell their fish in either place or an entirely different location. Recreational fishermen often do not live on the coast, but drive from inland counties and may launch their boats or fish from several different sites. For these reasons, identifying a "fishing community" becomes problematic in that such a community does not fit the normal geographic boundaries or fall within the metes and bounds that would surround a normal incorporated municipality.

The impacts of fisheries management may be minimal in a single community, but, when taken overall may be substantial to an entire county or several county area. Those same measures may have a small impact on a large metropolitan area, but, to a neighborhood where most fishing families live or most fishing activity originates it could be substantial. Therefore, a "fishing community" may encompass a single municipality, a county, several counties or one neighborhood within a major metropolitan area depending upon a variety of demographic, social, economic and ecological factors that one must consider.

One important circumstance to consider when assessing the impacts upon fishing communities is the difference between rural and urban areas, as many fishing communities exist in rural areas on the Southeast coast. There are several ways in which rural areas differ from the more urban or metropolitan as illustrated in *Understanding Rural America* (ERS-USDA, 1993).

Rural areas have consistently lagged behind urban areas with respect to real earnings per job and education levels. Rural areas have also seen a rise in subgroups who are prone to economic disadvantage--families headed by single mothers and minorities. However, these differences vary across the country and are influenced by several factors, one of which is the availability of natural resources. In order to explain and examine some of these differences, counties within the U.S. have been classified as either metropolitan or non-metropolitan. A further subdivision of non-metro counties provides a more clear understanding into each subtype's dependence upon certain economic specialization and the importance of those differences to the residents of those counties (ERS-USDA, 1993). The following classification system may also suggest a possible method for defining an area's dependence upon fishing using the appropriate criteria.

Six types of non-metro counties have been classified, three of which are based upon economic specialization - farming, manufacturing and services. The other three county classifications are based upon their relevance to policy -- retirement-destination; Federal lands; and persistent poverty. Using earned income as a measure of dependence, the classification for counties based upon economic specialization is as follows:

Farming counties - 20% or more earned income from farming
Manufacturing - 30% or more earned income from manufacturing
Services - 50% or more earned income from services industries

Those counties whose classification is based upon economic specialization are mutually exclusive; the other three classification types are not mutually exclusive (ERS-USDA, 1993).

This type of classification system, based upon a percentage of earned income or other measure, might be used to determine a community, county or region's dependence upon fishing. However, like farming counties, those dependent upon fishing have likely seen a decline in the dependence upon fishing over time. This is probably due to significant increases in the population of coastal areas since the 1970's. Much of the population growth has been in the form of immigration of people 60 and older who seek coastal areas for retirement destinations. The increase in this population sector, in turn, brings a greater dependence upon service industries. Choosing such a measure of dependence is not possible at this time and would have to be developed through further analysis and/or research.

Griffith and Dyer developed a typology of fishing community dependence for the Northeast Multi-species Groundfish Fishery (MGF) (Aguirre, 1996). In that typology, they identified critical indicators of dependence which included specific physical-cultural and general social-geographic indicators, i.e., number of repair/supply facilities; number of fish dealers/processors; presence of religious art/architecture dedicated to fishing; presence of secular art/architecture dedcicated to fishing; number of MGF permits; and number of MGF vessels. Using previous results and supplemental research of their own, they were able to develop a fishery dependence index score for the five primary ports in the MGF.

From their research Griffith and Dyer were able to document five variables which best predicted dependence upon the MGF:

1. Relative isolation or integration of fishers into alternative economic sectors, including political participation. To what extent have the fleets involved in the MGF enclaved themselves from other parts of the local political economy or other fisheries? How much have the MGF fleets become, similar to an ethnic enclave, closed communities?

2. Vessel types within the port's fishery. Is there a predominance of large vessels or small vessels, or a mix of small, medium, and large?

3. Degree of specialization. To what extent do fishers move among different fisheries? Clearly, those fishers who would have difficulty moving into alternative fisheries or modifying their vessels with alternative gears are more dependent on the MGF than those who have histories of moving among several fisheries in an opportunistic fashion.

4. Percentage of population involved in fishery or fishery-related industries. Those communities where between five and ten percent of the population are directly employed in MGF fishing or fishing-related industries are more dependent on the MGF than those where fewer than five percent are so employed.

5. Competition and conflict within the port, between different components of the MGF. Extensive competition and conflict between fishers within the same port--as well as between different actors in the MGF, such as boat owners and captains--seem to be associated with intensive fishing effort and consequent high levels of dependence on the MGF. In this case, dependence may have a strong perceptual dimension, with fishers perceiving the resources they are harvesting to be scarce and that one fleet's gain is another fleet's loss.

It is important to understand that these factors are appropriate for the MGF and are not necessarily the best predictors for all fishing communities. Fisheries in the Southeast will differ markedly from those in other regions of the country, especially with regard to their integration into other economies and notably the tourist economy. Recreational fishing is an integral part of the tourism and service economy that has developed for coastal communities in the South Atlantic. For these communities, dependence upon fishing will undoubtedly be tied to commercial and recreational fishing and their associated businesses. Therefore, it is important for fishery dependence models to be developed specifically for the South Atlantic.

Griffith and Dyer (Aguirre 1996) also discuss their description of fishing communities as it relates to the term Natural Resource Community (NRC). Dyer et. al define a NRC as "a population of individuals living within a bounded area whose primary cultural existence is based upon the utilization of renewable natural resources" (1992:106). Natural Resource Communities possess an elementary connection between biological cycles within the physical environment and socio-economic interactions within the community. An adaptation to working on the water by fishermen has important implications for the community as a whole because of the necessary support activities that take place on land, i.e., net hanging & mending; fish handling & preparation; boat building & repair. This important tie to the physical environment not only dictates occupational participation, but structures community interaction and defines social values for those living in Natural Resource Communities. While fishing communities in the MGF are not bounded or set apart from the larger community in which they reside, they still manifest certain recognizable features that would classify them as NRCs (Aguirre 1996). Fishing communities in the South Atlantic will also show signs of being integrated into the larger economy, but may still maintain certain vestiges of an NRC. Fishermen in the South Atlantic, like those in the Northeast MGF, will not likely see their ecological systems being closed, but affected by a host of other forces, both globally and locally. Far more detailed research will need to be conducted among South Atlantic fishing communities to determine changes in integration of the larger economy. One of the most likely changes will be an increasing dependence upon the service sectors as recreational fishing and other recreational activities play an increasing role in the economies of coastal communities. While there will continue to be a connection between the social and physical environments, the nature of that interaction will undoubtedly change.

At this time there is insufficient data to completely identify and define fishing communities in the South Atlantic. The following description of fishing communities provides information to explore ways of defining fishing communities that range from geographical regions to a well bounded municipality. With varied levels of research or data available for each state, descriptions of fishing communities will depend upon the amount of data available and the specific nature and timeliness of that data. In some cases, it may be possible to find a municipality that will clearly fit a definition of fishing community and meet a criterion for dependence upon fishing. In others, it may be a series of communities or counties designated a "fishing community" or possibly a particular sector of a large metropolitan area.

Readily available data will be discussed to allow for public input on the best way to identify fishing communities and determine their dependence upon fishing. Following the discussion of fishing communities in the South Atlantic a discussion of data needs and format will provide possible directions for data collection and analysis. The Council welcomes comments on all aspects of incorporating this new national standard, in order to devise a classification system which will assist in assessing the impacts of fishery management upon fishing communities.

4.3.3.1.1 South Atlantic Fishing Communities

According to NMFS, South Atlantic commercial fishermen have harvested well over 250,000 pounds of seafood in each of the years 1995 and 1996 (Table 1). Those landings have represented over $200,000,000 in harvest value. The value of those landings can become even greater once it diffuses throughout South Atlantic fishing communities as it provides employment and other benefits to other sectors within each community's economic base.

Table 1. U.S. Domestic Commercial Fishing Landings by Region, 1995 and 1996.
Source Fisheries of the United States, 1996

	1995		1996	
Region	**Thousand pounds**	**Thousand dollars**	**Thousand pounds**	**Thousand dollars**
New England	592,665	580,957	641,821	564,169
Middle Atlantic	240,413	179,747	241,936	181,869
Chesapeake	845,632	174,229	728,830	158,736
South Atlantic	**277,035**	**238,112**	**268,990**	**209,407**
Gulf of Mexico	1,464,718	724,619	1,496,875	680,304

Commercial seafood landings also represent other forms of expenditure which have an impact upon fishing communities, such as: fuel, gear, groceries, etc. Support industries like, gas stations, tackle shops, grocery stores all have an investment in the harvesting capability of the local fishing fleet.

As with commercial fishing, recreational fishing activity will also contribute to the economic base of a fishing community as fishermen buy fuel, bait, tackle and food & beverage for fishing trips. Figure 1 demonstrates an increasing trend in recreational fishing trips for most

South Atlantic states, but, also substantial variation in the number of trips over time. Such variation can mean significant economic impacts for those communities that rely upon recreational fishing.

South Atlantic fishing communities will depend upon both recreational fishing and commercial fishing for determining the importance of fishing to their economic base. The supporting role of associated businesses will also need to be incorporated into any measure of dependence. Such businesses as: seafood dealers and processors, marinas, gas stations, bait and tackle shops, dive shops, trucking firms, restaurants and many others, all have some role in determining dependence upon fishing. Unfortunately, data that is robust and/or specific enough does not exist to include in such a determination.

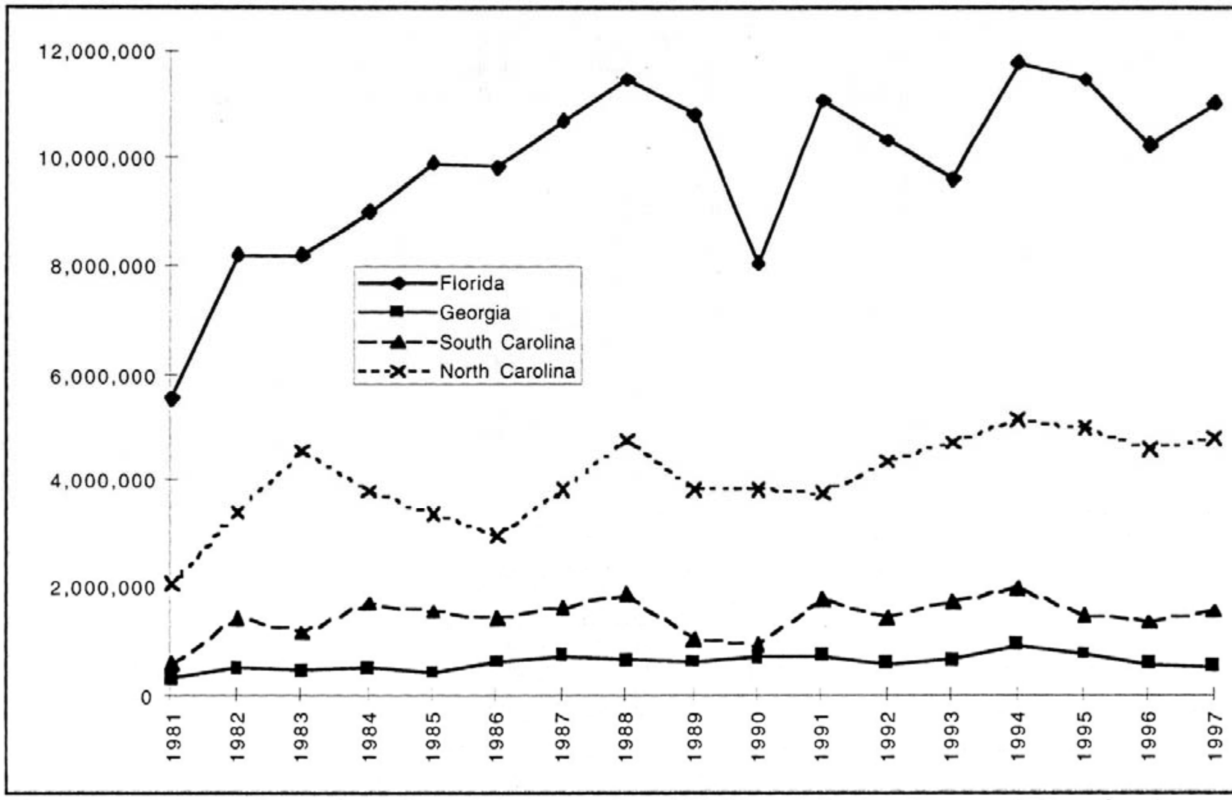


Figure 1. Estimated Number of Marine Recreational Fishing Trips by State and Year for the South Atlantic. Source: Personal communication from the National Marine Fisheries Service, Fisheries Statistics and Economics Division.

To identify fishing communities in the South Atlantic one might begin with the National Oceanic and Atmospheric Administrations publication *Fisheries of the United States* (1996). Among the various statistics listed are commercial landings of major U.S. ports. These ports could be considered to be substantially dependent upon fishing. Table 2 lists the major ports for the South Atlantic in 1996 and 1995 for quantity and value of landings. Some ports are listed as individual communities while others are a combination of several communities over a limited geographical range. This characterization may be useful as we attempt to further delineate fishing communities in each state. Other sources of information helpful in defining fishing communities include the United States Census and Bureau of Economic Research, which include economic information for many areas of the U.S.

Table 2. Quantity, Value and Rank of Commercial Landings for South Atlantic Ports among Major U.S. Ports Source: Fisheries of the United States, 1996.

Port	1995 Quantity*	1995 Rank	1995 Value*	1995 Rank	1996 Quantity*	1996 Rank	1996 Value*	1996 Rank
Key West	23.4	32	66.7	5	23.7	37	62.8	4
Beaufort-Morehead City, NC	87.0	16	35.0	15	75.4	18	20.3	34
Wanchese-Stumpy Point, NC	39.0	25	25.0	24	43.4	24	24.6	27
Charleston-Mt.Pleasant, SC	11.0	58	19.0	32	---	--	---	--
Cape Canaveral, FL	10.1	--	16.9	35	21.2	43	17.7	42
Darien-Bellville, GA	---	--	11.0	50	---	--	---	--
Beaufort, SC	---	--	11.0	51	---	--	---	--
Englehard-Swanquarter, NC	11.0	58	---	--	15.0	50	---	--
Oriental-Vandemere, NC	9.0	--	10.0	--	14.0	53	13.3	50
Bellhaven-Washington, NC	---	--	6.0	--	---	--	11.5	58

*Value and quantity are in millions of dollars and pounds respectively.

4.3.3.1.2 North Carolina

The 1990 Census of Population and Housing provides the following information for North Carolina regarding individuals who reported their occupation as fisher in Table 3. This data will likely include those individuals who commercially fish fresh water areas and others who are not impacted by fisheries management of marine fisheries at the council level. This information does provide data for comparison and could help set parameters for a measure of dependency upon fishing. It is not recommended that these figures be used to determine dependency upon fishing, however. The 1990 Census classifies year-round full-time workers as all persons 16 years old and over who usually worked 35 hours or more per week for 50 to 52 weeks in 1989.

Table 3. Number of Fishers and Mean Annual Income for North Carolina in 1990. Source: U.S. Bureau of the Census.

	Year Round/Full Time	Other	Total
Number of fishers			
Male	989	1,271	2,260
Female	47	105	152
Total	1,036	1,376	2,412
Mean Annual Income ($)			
Male	16,315	13,069	14,489
Female	11,518	4,489	6,662
Total	16,097	12,414	13,996

The 1990 Census also provides the following information for North Carolina regarding individuals who reported their occupation as captain of a fishing vessel in Table 4. It is interesting to note that there were no females listed as captain of fishing vessels. This concurs with the much of the research on the occupation of fishing which finds very few women in this role. Although women often play an important role in the fishing operation, they are rarely in the position of captain of fishing vessels.

Table 4. Number of Captains of Fishing Vessels and other officers and Mean Annual Income for North Carolina in 1990. Source: U.S. Bureau of the Census.

	Year Round/Full Time	Other	Total
Number of Captains			
Male	102	141	243
Female	0	0	0
Total	102	141	243
Mean Annual Income ($)			
Male	26,917	33,640	30,818
Female	0	0	0
Total	26,917	33,640	30,818

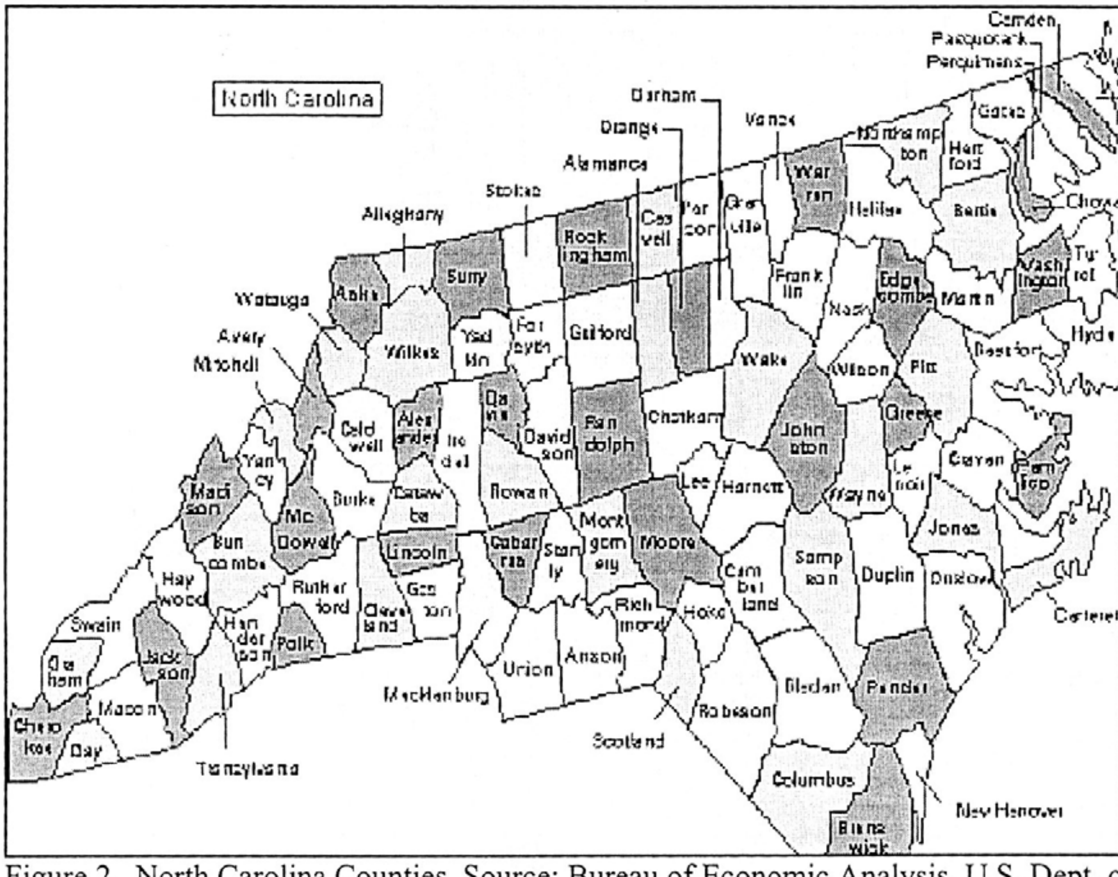


Figure 2. North Carolina Counties. Source: Bureau of Economic Analysis, U.S. Dept. of Commerce.

Johnson and Orbach (1996) have divided North Carolina into six areas for their research on effort management of North Carolina commercial fisheries. Those areas were determined to be distinct with regard to species/gear combinations in addition to sociological, ecological and environmental differences. The areas defined are as follows:

Area 1: Albermarle Area - Currituck, Camden, Pasquotank, Perquimans, Chowan, Bertie, Washington, and Tyrell Counties.

Area 2: Dare County

Area 3: Southern Area - Brunswick, Pender, New Hanover, and Onslow Counties

Area 4: Pamlico Area - Craven, Pamlico, Beaufort, and Hyde Counties.

Area 5: Carteret County

Area 6: Inland Counties.

Area 1: Albermarle Area

The Albermarle area includes the following counties: Currituck, Camden, Pasquotank, Perquimans, Chowan, Bertie, Washington and Tyrell. Johnson and Orbach (1997) found that commercial fishermen in this area had two primary gear types, pots and gill nets. They also concluded that fishermen here move in and out of gill netting on an annual basis.

Table 5. Population and Economic Information for Counties included in Area 1. Source: Bureau of Economic Analysis, U.S. Dept. of Commerce.

Area 1-County		1993	1994	1995
Bertie	Population	20,631	20,665	20,745
	Personal Income (Thousands of $)	291,226	303,292	328,227
	Per Capita Pers Income ($)	14,116	14,677	15,822
	Personal Income Fishing (Thousands of $)	71	75	84
Camden	Population	6,211	6,370	6,399
	Personal Income (Thousands of $)	92,875	100,012	105,636
	Per Capita Pers Income ($)	14,953	15,700	16,508
	Personal Income Fishing (Thousands of $)	0	0	0
Chowan	Population	13,815	13,909	13,958
	Personal Income (Thousands of $)	226,563	234,453	247,428
	Per Capita Pers Income ($)	16,400	16,856	17,727
	Personal Income Fishing (Thousands of $)	128	134	151
Currituck	Population	15,215	15,831	16,285
	Personal Income (Thousands of $)	251,885	269,871	291,055
	Per Capita Pers Income ($)	16,555	17,047	17,873
	Personal Income Fishing (Thousands of $)	358	376	423
Pasquotank	Population	33,220	33,488	33,759
	Personal Income (Thousands of $)	510,623	534,860	574,433
	Per Capita Pers Income ($)	15,371	15,972	17,016
	Personal Income Fishing (Thousands of $)	----	----	----
Perquimans	Population	10,644	10,692	10,737
	Personal Income (Thousands of $)	148,365	162,627	160,912
	Per Capita Pers Income ($)	13,939	15,210	14,987
	Personal Income Fishing (Thousands of $)	----	0	----
Tyrell	Population	3,918	3,875	3,846
	Personal Income (Thousands of $)	56,056	58,138	52,738
	Per Capita Pers Income ($)	14,307	15,003	13,712
	Personal Income Fishing (Thousands of $)	476	500	562
Washington	Population	14,136	14,276	14,138
	Personal Income (Thousands of $)	220,429	229,038	238,124
	Per Capita Pers Income ($)	15,593	16,044	16,843
	Personal Income Fishing (Thousands of $)	225	236	266

Using multidimensional scaling, Johnson and Orbach were able to examine the spatial relationship of various types of fishing in each area. For Area 1, crab potting was the most central fishery. In other words most fishermen in the area do some crab potting. Referring to cliques, they found that for this area fishermen who peeler pot, eel pot, crab pot and gill net flounder differ from those that long haul. Fishermen that long haul will crab pot and gill net flounder but do not engage in peeler pots or eel pots.

In examining the categories which would include fishermen for Area 1 (Table 6) there seems to be no trend regarding either those in Farm/Fish/Forest occupations or the Agriculture, Fishing, Mining Industries. There are both increases and decreases in the number of those within each categories from 1970 to 1990 which varies by county.

Table 6. Number within Farm/Fish/Forest Occupation and Agriculture, Fishing, Mining Industry for North Carolina Coastal Counties included in Area 1 for 1970, 1980, and 1990 Census. Source: MARFIN Sociodemographic Database

County	Occupation/Industry	1970	1980	1990
Bertie County	Farm/Fish/Forest	923	1035	839
	Agri.,Fishing,Mining	1050	1038	884
Camden County	Farm/Fish/Forest	203	220	114
	Agri.,Fishing,Mining	220	181	137
Chatham County	Farm/Fish/Forest	740	904	832
	Agri.,Fishing,Mining	927	934	1286
Currituck County	Farm/Fish/Forest	194	247	316
	Agri.,Fishing,Mining	215	296	309
Pasquotank County	Farm/Fish/Forest	444	491	469
	Agri.,Fishing,Mining	552	478	508
Perquimans County	Farm/Fish/Forest	417	513	299
	Agri.,Fishing,Mining	445	524	316
Tyrrell County	Farm/Fish/Forest	197	249	208
	Agri.,Fishing,Mining	225	273	233
Washington County	Farm/Fish/Forest	408	511	551
	Agri.,Fishing,Mining	462	557	526

Area 2 : Dare County

Within Dare county the following communities have been described through recent research of the snapper grouper fishery and might be considered fishing communities: Manns Harbor, Manteo, Wanchese, Hatteras, Stumpy Point (Iverson 1997). Johnson and Orbach (1997) found that commercial fishermen in this area had two primary gear types, pots and gill nets. In their analysis of fishery networks for Area 2 they again found crab pots to be central. Another interesting difference revealed was that fishermen who shrimp trawl in this area will gillnet for sharks but do not engage in crab potting.

Dare County shows a higher personal income from fishing over the three years listed (Table 7) than most other coastal counties in North Carolina.

Table 7. Population and Economic Information for Counties included in Area 2. Source: Bureau of Economic Analysis, U.S. Dept. of Commerce.

Area 2				
County		**1993**	**1994**	**1995**
Dare				
	Population	24,300	25,106	26,074
	Personal Income (Thousands of $)	429,564	465,011	502,474
	Per Capita Pers Income ($)	17,678	18,522	19,271
	Personal Income Fishing (Thousands of $)	5,426	5,688	6,392

Dare County (Table 8) shows a general increase in the number of individuals in the listed occupations and industries over the twenty years from 1970 to 1990.

Table 8. Number within Farm/Fish/Forest Occupation and Agriculture, Fishing, Mining Industry for Dare County (Area 2) for 1970, 1980, and 1990 Census. Source: MARFIN Sociodemographic Database

County	Occupation/Industry	1970	1980	1990
Dare County	Farm/Fish/Forest	11	376	637
	Agri.,Fishing,Mining	181	446	655

Snapper Grouper Fishing

Most of the snapper grouper permit holders in Area 2 work out of Hatteras and only a small portion of their annual commercial fishing activity is devoted to targeting snapper grouper species. Black sea bass, snowy grouper, and blueline tilefish are the most frequently targeted species by commercial snapper grouper fishermen from this area. Surface longlining for tuna and swordfish is apparently the most productive and profitable style of commercial fishing in the area, and the small towns of Manteo and Wanchese serve as refuge for a large number of both local and non-local longlining boats (Iverson, 1997).

Area 3: Southern Area

The Southern Area includes the following counties and communities (in parenthesis): Brunswick (Southport). Pender, New Hanover, Onslow (Sneads Ferry). Johnson and Orbach (1997) found that commercial fishermen in this area had four primary gear types: hook-and-line, gill net, hand harvest of shellfish, and trawling. Pot fishing was classified as secondary gear but they report that increasing usage over time could possibly make it a primary gear. It is interesting to note that they also reported that pot fishing showed an increase in all five areas over time. Area 3 showed much more complexity in annual rounds of fishing than Areas 1 or 2 with shrimp trawling, hand clamming and crab potting all central to the network (Johnson and Orbach 1997).

Table 9. Population and Economic Information for Counties included in Area 3. Source: Bureau of Economic Analysis, U.S. Dept. of Commerce.

Area 3				
County		**1993**	**1994**	**1995**
Brunswick				
	Population	56,350	58,386	60,697
	Personal Income (Thousands of $)	878,453	941,247	1,024,954
	Per Capita Pers Income ($)	15,589	16,121	16,886
	Personal Income Fishing (Thousands of $)	1,595	1,674	1,885
Pender				
	Population	32,554	33,894	33,759
	Personal Income (Thousands of $)	510,623	534,860	574,433
	Per Capita Pers Income ($)	15,681	16,341	17,253
	Personal Income Fishing (Thousands of $)	----	----	----
New Hanover				
	Population	131,091	135,317	139,906
	Personal Income (Thousands of $)	2,620,539	2,800,024	3,036,665
	Per Capita Pers Income ($)	19,990	20,692	21,705
	Personal Income Fishing (Thousands of $)	----	----	693
Onslow				
	Population	145,638	144,951	144,259
	Personal Income (Thousands of $)	1,962,312	2,030,075	2,149,074
	Per Capita Pers Income ($)	13,474	14,005	14,897
	Personal Income Fishing (Thousands of $)	667	700	787

Counties included in Area 3 (Table 10.) show a general increase in numbers of individuals within the selected occupations and industries, with the exception of Pender County which shows a decline from 1970-1990.

Table 10. Number within Farm/Fish/Forest Occupation and Agriculture, Fishing, Mining Industry for North Carolina Coastal Counties included in Area 3 for 1970, 1980, and 1990 Census. Source: MARFIN Sociodemographic Database.

County	Occupation/Industry	1970	1980	1990
Brunswick County	Farm/Fish/Forest	370	668	1028
	Agri.,Fishing,Mining	505	645	971
Pender County	Farm/Fish/Forest	772	562	627
	Agri.,Fishing,Mining	892	669	690
New Hanover County	Farm/Fish/Forest	289	550	782
	Agri.,Fishing,Mining	564	615	984
Onslow County	Farm/Fish/Forest	754	869	996
	Agri.,Fishing,Mining	906	800	987

Snapper Grouper Fishing

For Area 3, the small community of Sneads Ferry, is unique in that the majority of the commercial reef fishermen fish with sea bass pots. According to the 1993 federal permit list for the South Atlantic region, there were 58 permit holders who indicated that sea bass pots were their primary gear type. Of those, 13 permit holders worked out of Sneads Ferry (Iverson, 1997).

Overall, 72% of fishermen using sea bass pots as their primary gear work out of home ports in North Carolina.

Area 4: Pamlico Area.

The Pamlico area includes these counties and communities (in parenthesis): Craven, Pamlico (Vandemere, Oriental), Beaufort (Bellhaven, Washington), Hyde (Ocracoke, Swanquarter, Englehard). Johnson and Orbach (1997) found that commercial fishermen in this area had three primary gear types, pots, gill nets, and trawls. In terms of annual fishing rounds Area 4 is the simplest to understand where two strategies are employed: gill netting and crab potting or trawling and crab potting. They go on to note that this simple strategy may signify few choices for fishermen in this area in the case of environmental or regulatory change (Johnson and Orbach 1997). Possible fishing communities within Area 4 might be: Vandemere and Oriental.

Table 11. Population and Economic Information for Counties included in Area 4.
Source: Bureau of Economic Analysis, U.S. Dept. of Commerce.

Area 4				
County		**1993**	**1994**	**1995**
Craven				
	Population	83,595	83,851	85,163
	Personal Income (Thousands of $)	1,450,296	1,508,353	1,626,657
	Per Capita Pers Income ($)	17,349	17,988	19,101
	Personal Income Fishing (Thousands of $)	386	405	----
Pamlico				
	Population	11,772	11,948	12,064
	Personal Income (Thousands of $)	179,384	186,131	199,576
	Per Capita Pers Income ($)	15,238	15,578	16,543
	Personal Income Fishing (Thousands of $)	2,714	2,851	3,211
Beaufort				
	Population	43,446	43,815	43,998
	Personal Income (Thousands of $)	674,788	711,961	756,048
	Per Capita Pers Income ($)	15,532	16,249	17,184
	Personal Income Fishing (Thousands of $)	1,339	1,406	1,580
Hyde				
	Population	5,374	5,339	5,362
	Personal Income (Thousands of $)	80,982	90,101	80,300
	Per Capita Pers Income ($)	15,069	16,876	14,976
	Personal Income Fishing (Thousands of $)	1,860	1,973	2,215

Pamlico county had the highest personal income from fishing for Area 4 from 1993 to 1995 with a steady increase over those three years (Table 11). Hyde county followed with Beaufort next; both showing an increase over time. For most counties in Area 4 (Table 12) the general trend seems to be an increase from 1970 to 1980 and then a decrease from 1980 to 1990 within these occupation and industry categories. Beaufort County shows an overall decrease from 1970-1990.

Table 12. Number within Farm/Fish/Forest Occupation and Agriculture, Fishing, Mining Industry for North Carolina Coastal Counties included in Area 4 for 1970, 1980, and 1990 Census. Source: MARFIN Sociodemographic Database

County	Occupation/Industry	1970	1980	1990
Craven County	Farm/Fish/Forest	873	1136	832
	Agri.,Fishing,Mining	1129	1222	860
Pamlico County	Farm/Fish/Forest	245	498	442
	Agri.,Fishing,Mining	502	662	477
Beaufort County	Farm/Fish/Forest	1452	1393	1024
	Agri.,Fishing,Mining	2169	2123	1190
Hyde County	Farm/Fish/Forest	295	509	454
	Agri.,Fishing,Mining	442	579	511

Area 5: Carteret County

In Area 5 Johnson and Orbach (1997) found that commercial fishermen had three primary gear types, gill nets, trawls and hand harvest of shell fish. In terms of annual fishing rounds Area 5 did not show the clear gear stratification found in other areas. Shrimp trawling is the most central fishery, but pound netting, crab potting, and mechanized clamming also occur with shrimp trawling. (Johnson and Orbach 1997). Possible fishing communities within Area 5: Morehead City and Beaufort.

Table 13. Population and Economic Information for Counties included in Area 5. Source: Bureau of Economic Analysis, U.S. Dept. of Commerce.

Area 5 County		1993	1994	1995
Carteret				
	Population	55,747	56,381	57,690
	Personal Income (Thousands of $)	935,032	985,484	1,076,753
	Per Capita Pers Income ($)	16,773	17,479	18,664
	Personal Income Fishing (Thousands of $)	2,783	2,871	3,207

Among North Carolina's coastal counties, Carteret county was second to Dare county (Table 13) in terms of personal income from fishing. In addition, Carteret County (Table 14) shows an marked increase from 1970 to 1980, then a decrease from 1980 to 1990, within the occupations of Farm/Fish/Forest and an overall increase in the number of Agriculture, Fishing and Mining industries.

Table 14. Number within Farm/Fish/Forest Occupation and Agriculture, Fishing, Mining Industry for Carteret County (Area 5) for 1970, 1980, and 1990 Census. Source: MARFIN Sociodemographic Database.

County	Occupation/Industry	1970	1980	1990
Carteret County	Farm/Fish/Forest	225	1200	1158
	Agri.,Fishing,Mining	731	1234	1260

In a recent report on the importance of commercial fishing in Carteret county, Diaby (1997) found that Carteret county ranked first in poundage (96,652,314 lb) and second in dockside value ($20,618,486) in terms of commercial landings for North Carolina coastal counties. Finfish represented the 91% of total landings and 46% of total ex-vessel value. The most important species of finfish were: menhaden, flounder, croaker, weakfish and spot. Shellfish and crustaceans accounted for only 9% of all commercial landings but, represented over half of the value of landings during the period from 1974-1994. Employment by the commercial fishing industry, both full and part time for Carteret county was estimated to be 3,232 people for 1994 (Diaby, 1997). This number varies from those reported in the census data and emphasizes the problems in comparing these types of data. Since 1981 there have been about 105 to 140 licensed seafood dealers in Carteret county. The value of processed seafood peaked for the county in 1981 when scallops accounted for almost half of the value with a total value of $19,737,126. Since that time there has been a general decline in total value of processed seafood attributable to a decline in scallop landings. Menhaden was the most important single processed product over a fifteen year period from 1980 to 1994 (Diaby, 1997).

In estimating the economic impact of Carteret county commercial harvesting sector Diaby (1997) estimated $27 million in sales of goods and services and $11.66 million in value added. Total employment from commercial harvesting activities was estimated to be 3,371.

Sales of goods and services for the wholesaling and processing sector were estimated at $19 million, with $11 million n value added. There were an estimated 1,563 full and part time jobs created earning $6.55 million in wages (Diaby, 1997).

Overall, the activities of the commercial fishing industry created $46 million in sales of goods and services and $24 million in value added. There were 4,934 full and part time jobs which earned $14 million in wages (Diaby, 1997).

The recreational fishery spent approximately $70 million on fishing trips in Carteret county with $25.23 million in employ compensation and $47.61 in value added. There were 1,821 full and part time jobs associated with the recreational fishing industry in Carteret County.

The total impact of the coastal fishing industry on the economy of Carteret County was estimated to be $120.74 million with $71.32 million in value added. The total number of full and part time jobs was estimated at 6,755 with earnings of $38.94 (Diaby, 1997).

Snapper Grouper Fishing

The Morehead City/Beaufort area is located approximately 50 miles south of Ocracoke in Carteret County. This area is known for its sportfishing activity including several major tournaments each year. There is a small population of full time commercial reef fishermen in Morehead, however the majority of fishermen holding commercial permits are primarily part timers. Many of these fishermen divide their time between charter fishing during the peak tourist season (April through September) and commercial fishing in the winter months. Full time fishermen in this area reported fishing approximately 50 miles straight offshore and fishing from Hatteras to as far south as the South Carolina/Georgia line. Trip lengths vary with the size of the vessel, but the average trip length is 7 days and the larger boats carried up to 3 crew members (Iverson, 1997).

King Mackerel Fishery

The king mackerel fishery in North Carolina has grown steadily since 1980 and has leveled with catches repeatedly around one million pounds in recent years. From 1986 to 1990 the number of permits for Atlantic group king mackerel issued in North Carolina ranged from a low of 325 in 1987/88 to a high of 533 in 1989/90. Again, the majority of those permits were granted to hook and line fishermen. Present data indicates there were 448 commercial vessels permitted for king and Spanish mackerel in North Carolina (Vondruska, 1997).

4.3.3.1.3 South Carolina

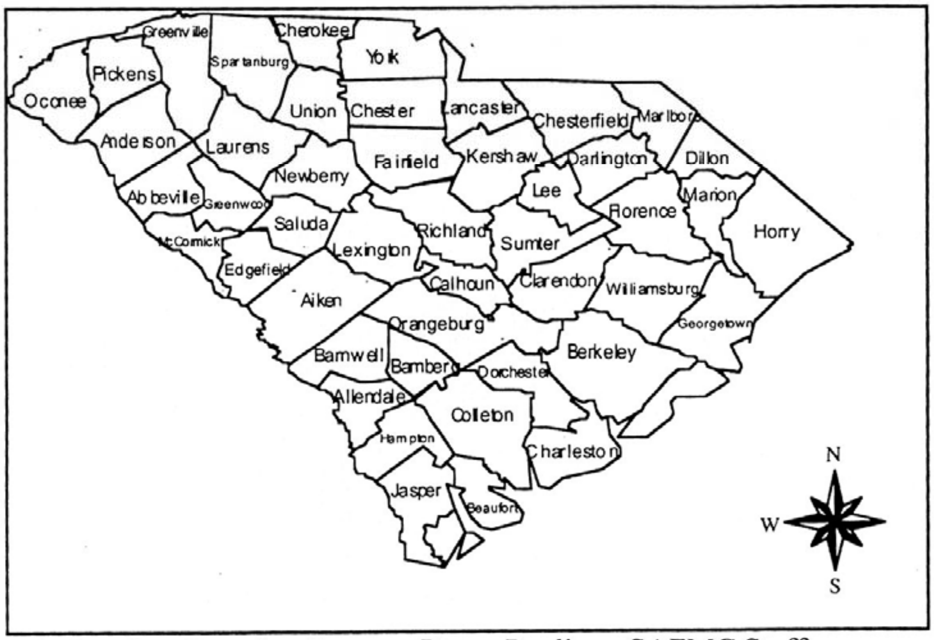


Figure 3. South Carolina Counties Source: Roger Pugliese, SAFMC Staff.

The 1990 Census of Population and Housing provides the following information for South Carolina regarding individuals who reported their occupation as fisher in Table 15. A total of 401 individuals claimed Fisher as their occupational title with less than half indicating it was a year round full time employment. There were few females who indicated such and they had a far lower mean annual income than males in this occupation.

Table 15. Number of Fishers and Mean Annual Income for South Carolina Fishers in 1990. Source: U.S. Bureau of the Census.

	Year Round/Full Time	Other	Total
Number of fishers			
Male	188	193	381
Female	6	14	20
Total	194	207	401
Mean Annual Income ($)			
Male	28,842	14,489	18,946
Female	750	5,000	2,403
Total	23,710	14,269	18,390

There were a total of 69 individuals who indicated their occupation as captain of a fishing vessel in the 1990 census of population and housing. and 7 of them were female according to Table 16 Again, females had a much lower mean annual income when compared to males.

Table 16. Number of Captains of Fishing Vessels and other officers and Mean Annual Income for South Carolina in 1990. Source: U.S. Bureau of the Census

	Year Round/Full Time	**Other**	**Total**
Number of Captains			
Male	17	45	62
Female	7	0	7
Total	24	45	69
Mean Annual Income ($)			
Male	18,765	15,022	16,048
Female	9,000	0	9,000
Total	15,917	15,022	15,333

Horry County

The following descriptions for fishing communities in South Carolina are notes from Kim Iverson of South Carolina Department of Natural Resources. Kim has spent many months interviewing both commercial and recreational fishermen in South Carolina and other parts of the South Atlantic region as part of several research projects. Although the research was not intended to identify fishing communities, her notes represent the best available information on fishing communities for South Carolina.

Little River has a long history of fishing activity, both commercial and recreationally. The headboat operations date back to the 1940's. As of 1996, there were headboats operating in Little River. There are approximately 4 vessels that actively run charters and also commercial fish. Several full time snapper/grouper vessels operate out of the area. Little River also hosts an annual Blue Crab Festival each spring (Kim Iverson, SCDNR pers. comm., 1998).

Murrells Inlet has a large fleet of charter and headboats, with one marina hosting one of the Governor's Cup Billfishing Tournaments. There are several smaller fishing tournaments held in the area. There are fish houses in the community that deal primarily with finfish. There are no shrimp dealers. This area is also noted for it's large number of seafood restaurants that target the tourist market from Myrtle Beach (Kim Iverson, SCDNR pers. comm., 1998).

Major fishing tournaments held in Murrells Inlet are: March of Dimes Annual Flounder Tournament - Voyagers View Marina. Registration was by angler with approximately 200 anglers participating. Local tournament with many family participants. Primarily smaller boats < 25' participating. Tournament date May 17.; and the Marlin Quay Governor's Cup Billfish Tournament - Marlin Quay Marina. The last in the series of SC Gov. Cup. Total of 31 boats registered. July 23-26 (Kim Iverson, SCDNR pers. comm., 1998).

Major tournaments in North Myrtle Beach: Dock Holidays Governor's Cup Billfish Tournament - Dock Holiday's Marina. The first tournament in a series of 6 for the SC Governor's Cup. April 30 - May 3. Total of 25 boats entered; Frantic Atlantic King Mackerel Tournaments - North Myrtle Beach - Blue Marlin Yacht & Fishing Club. A two tournament series consisting of the Spring and Fall Classics. Total purse of $250,000 for the series. Total of 392 paid boat entries with an average of 4.09 anglers per boat. Tournament dates May 9-11, September 26-28; Evinrude Outboard King Mackerel Tournament - Oct. 11-12, Weigh-in stations at Dock Holidays Marina, Marlin Quay Marina and Georgetown Landing. 147 boats were registered; Yamaha Contender King Mackerel Classic - Weigh in stations at Dock Holidays Marina, Marlin Quay Marina and Georgetown Landing. 125 boats registered; Fall Pier King Tournament - September 19-21 (Kim Iverson, SCDNR pers. comm., 1998).

One of the largest concentration of snapper grouper vessels is located in Murrells Inlet, SC. Most of the reef fishermen in this area are full time commercial fishermen and consider bandit reels to be the most effective way of catching snapper grouper. There is a wide variety of snapper grouper species off of Murrells Inlet, with gag grouper, scamp grouper and vermilion snapper being highly targeted. The average trip length is 5 days with some of the larger boats (>40 ft.) fishing up to 10 days. A few smaller bandit boats may stay out for 2-3- days. The Gulf Stream is approximately 62 miles offshore from Murrells Inlet. Most bandit boats fish between the 20-50 fathom line, concentrating on the 25 fathom curve. Winter weather dictates that fishermen fish shallow, in waters 60-90' deep. Several fishermen switch to sea bass trapping during the winter months (Iverson, 1997).

Horry County has shown a small increase in personal income from fishing that follows the general increase in personal income overall (Table 17).

Table 17. Population and Economic Information for Horry County, South Carolina. Source: Bureau of Economic Analysis, U.S. Dept. of Commerce.

County		1993	1994	1995
Horry				
	Population	148,385	152,435	157,834
	Personal Income (Thousands of $)	2,543,793	2,744,260	3,013,059
	Per Capita Pers Income ($)	17,143	18,177	19,220
	Personal Income Fishing (Thousands of $)	81	129	169

Vessels in Murrells Inlet will fish an area from Frying Pan Shoals off southern NC, south to Savannah. The average boat has two crew members. It is interesting to note that fishermen stated a crew of 3 plus the captain was ideal for this area, but decreasing catches and increased costs have made it necessary to cut back on crew members (Iverson, 1997).

<u>Georgetown County</u>

The community of Georgetown has shrimp dealers who also deal in finfish and shellfish. Georgetown is host to the one of the SC Governor's Cup Billfish Tournaments along with several other smaller fishing tournaments. There are no headboats operating from the area and charter activity is limited. Georgetown is known for it's historic waterfront district (Kim Iverson, SCDNR pers. comm., 1998).

Major fishing tournaments in Georgetown County: Georgetown Landing Governor's Cup Billfishing Tournament - May 21-24, Georgetown Landing Marina. The oldest of the series tournaments with 45 boats participating.

Georgetown County shows an increasing personal income from fishing like Horry County in Table 18 but, personal income from fishing tends to be a larger percentage of overall personal income than in Horry County.

Table 18. Population and Economic Information for Georgetown County, South Carolina. Source: Bureau of Economic Analysis, U.S. Dept. of Commerce.

County		1993	1994	1995
Georgetown				
	Population	49,371	49,966	50,835
	Personal Income (Thousands of $)	822,317	885,024	946,898
	Per Capita Pers Income ($)	16,656	17,713	18,627
	Personal Income Fishing (Thousands of $)	246	388	399

Charleston County

McClellanville is a small community with a long history of commercial shrimping. McClellanville has a large shrimp fleet. At any given time (dependent upon the season) there can be as many as 20 shrimp boats at the docks. Shrimp wholesale dealers are also present within the community. McClellanville hosts an annual Blessing of the Fleet Festival each spring. Shem Creek (Mt. Pleasant) hosts a mixture of commercial and recreational fishing activity along with a number of seafood restaurants, a retail seafood market and a waterfront hotel. There are also headboats operating out of Shem Creek along with charter operations. There is a large permanent shrimp fleet and many shrimp boats visit seasonally. At any give time there are an average of 30 shrimp boats along the creek. Shrimp dealers along the creek also buy and sell finfish from the trawlers. There are several offshore fishing boats including longline and snapper/grouper boats. Several shellfishermen and crabbers do business along the creek. Each spring, Mt. Pleasant hosts an Annual Blessing of the Fleet for the shrimp boats.

In Folly Beach there is a concentration of commercial fishing vessels and several fish houses who handle offshore finfish, shellfish, shrimp and crabs. Rockville is a historical small community located at the south end of Wadmalaw Island. There are commercial dealers who handle shrimp, inshore fish, offshore finfish and some shellfish. On Edisto Island there are several commercial seafood dealers. There are approximately 10 shrimp boats that operate there, fluctuating with the season. The dealers handle primarily shrimp and in-shore species along with shellfish and blue crabs. There is also a large "harvest" of horseshoe crabs. These crabs are "bled" for their blood that is used in cancer research and returned to the water. Edisto Island is also host to the annual SC Governor's Cup Billfish Tournament. Charter activity here is limited. Bennett's Point is a small community south of Edisto with shrimping operations in the community. There are 10-15 small boat shrimpers that live in Walterboro and fish out of Bennett's Point (Kim Iverson, SCDNR pers. comm., 1998).

Table 19. Population and Economic Information for Charleston County, South Carolina. Source: Bureau of Economic Analysis, U.S. Dept. of Commerce.

County		1993	1994	1995
Charleston	Population	297,888	287,139	281,068
	Personal Income (Thousands of $)	5,653,489	5,879,506	6,083,636
	Per Capita Pers Income ($)	18,979	20,476	21,645
	Personal Income Fishing (Thousands of $)	3,188	3,809	----

Charleston County (Table 19) has a higher personal income from fishing than the previous two counties, but has a much larger overall dollar value for personal income overall.

Major fishing tournaments in the Charleston County area: SCSSA (South Carolina Saltwater Sportfishing Assoc.) Early Bird - Ashley Marina. Approximately 25 registered boats. April 19. Multi-species tournament; James Island King Mackerel Tournament - James Island Yacht Club, May 24; Wild Dunes Governor's Cup Billfish - June 11-14. Total of 46 registered boats; Bohicket Invitational Governor's Cup Billfish - June 25-28. Total of 48 registered boats. Bohicket Marina on John's Island; Lowcountry Angler's Inshore Tournament - June 28. Multi-species tournament held at the East Cooper Outboard Motor Club on Gold Bug Island in Mt. Pleasant. Registration by angler, with approximately 200 anglers registered; SCSSA Sailfish XV - Ashley Marina in Charleston. Club sponsored tournament with approximately 25 boats registered. Sailfish, tuna, dolphin & wahoo. August 8-10; Fishing For Miracles King Mackerel

Tournament - Ripley's Light Marina. Large King tournament with over 200 boats entered. August 14-16; Alison Oswald, Sr. Memorial Tournament - James Island Yacht Club. Local tournament with approximately 75 boats participating. Multi-species. Aug. 23; Edisto Marina Governor's Cup Billfish Tournament - July 16-19. One of the oldest and largest of the Billfish Series. 46 Boats registered. Edisto Island (Kim Iverson, SCDNR pers. comm., 1998).

Beaufort County

In Frogmore there are 8 commercial dealers which are home to over 50 shrimpers. This does not include the many individuals with shrimp boats in their back yards. The dealers primarily handle shrimp but others may also handle crabs and shellfish. There is a large blue crab industry on nearby Lady's Island. There are several commercial seafood dealers in the Port Royal area with over 30 shrimp boats. There are also commercial crabbers, shad fishermen and offshore finfishermen here. There are a small number of charter vessels operating out of this area also. Hilton Head Island primarily caters to the tourist trade. There are several headboats operating on Hilton Head. These boats make half-day trips and night trips for shark fishing. There are four major marinas that offer charter fishing. Commercially, Hilton Head had 4 seafood dealers and approximately 12-15 shrimp boats (Kim Iverson, SCDNR pers. comm., 1998).

Data on personal income from fishing in Table 20 for Beaufort County may have been excluded due to confidentiality issues.

Table 20. Population and Economic Information for Beaufort County, South Carolina. Source: Bureau of Economic Analysis, U.S. Dept. of Commerce.

County		1993	1994	1995
Beaufort				
	Population	94,375	97,293	100,017
	Personal Income (Thousands of $)	2,057,250	2,194,774	2,373,921
	Per Capita Pers Income ($)	21,799	22,558	23,774
	Personal Income Fishing (Thousands of $)	----	----	----

Major fishing tournaments in Beaufort County: 42nd Annual Beaufort County Water Festival Fishing Tournament - June 28. Held in conjunction with the annual Beaufort Water Festival; Hilton Head Kingfish Classic - Schillings Marina, Hilton Head Island. July 10-12. Registration by angler with a total of 49 registered; Dottie Dunbar Women's Tournament - Palmetto Bay Marina, Hilton Head. Women's only multi-species inshore tournament. Total of 49 anglers registered. October 4 (Kim Iverson, SCDNR pers. comm., 1998).

Possible fishing communities in South Carolina: Charleston, Mt. Pleasant, Hilton Head, Port Royal, Frogmore (St. Helena), Bennett's Point, Edisto Beach, Rockville, Folly Beach, Shem Creek, McClellanville, Georgetown Waterfront, Murrell's Inlet, Little River (most of these locations are designated ports of landing)

Counties in South Carolina have seen a general increase in these occupations and industries over the past three decades (Table 21), with the exception of Horry County which has seen a slight decreasing trend.

Table 21. Number within Farm/Fish/Forest Occupation and Agriculture, Fishing, Mining Industry for South Carolina Coastal Counties for 1970, 1980, and 1990 Census. Source: MARFIN Sociodemographic Database

County	Occupation/Industry	1970	1980	1990
Horry County	Farm/Fish/Forest	2627	2542	2310
	Agri.,Fishing,Mining	2843	2653	2110
Georgetown County	Farm/Fish/Forest	403	558	597
	Agri.,Fishing,Mining	552	856	690
Charleston County	Farm/Fish/Forest	810	1697	2056
	Agri.,Fishing,Mining	1256	1938	2316
Beaufort County	Farm/Fish/Forest	436	938	966
	Agri.,Fishing,Mining	698	1087	1111
Colleton County	Farm/Fish/Forest	532	614	730
	Agri.,Fishing,Mining	787	705	782

For the Charleston, South Carolina MSA (Table 22) there are 113 individuals who indicated fishing as their year round occupation . Another 102 individuals indicated that it is a part time or seasonal occupation for them. This represents over half of those individuals in South Carolina who indicated the occupation as fishing from Table 15. The Charleston, SC MSA includes Berkely, Charleston and Dorchester counties.

Table 22. Number of Individuals in Occupation of Fishing By Work Status and Gender for the Charleston, SC MSA in 1989. Source: 1990 Census Of Population And Housing.

	Year Round Full Time	Other	Total
Male	102	102	204
Female	11	0	11
Total	113	102	215

4.3.3.1.4 Georgia

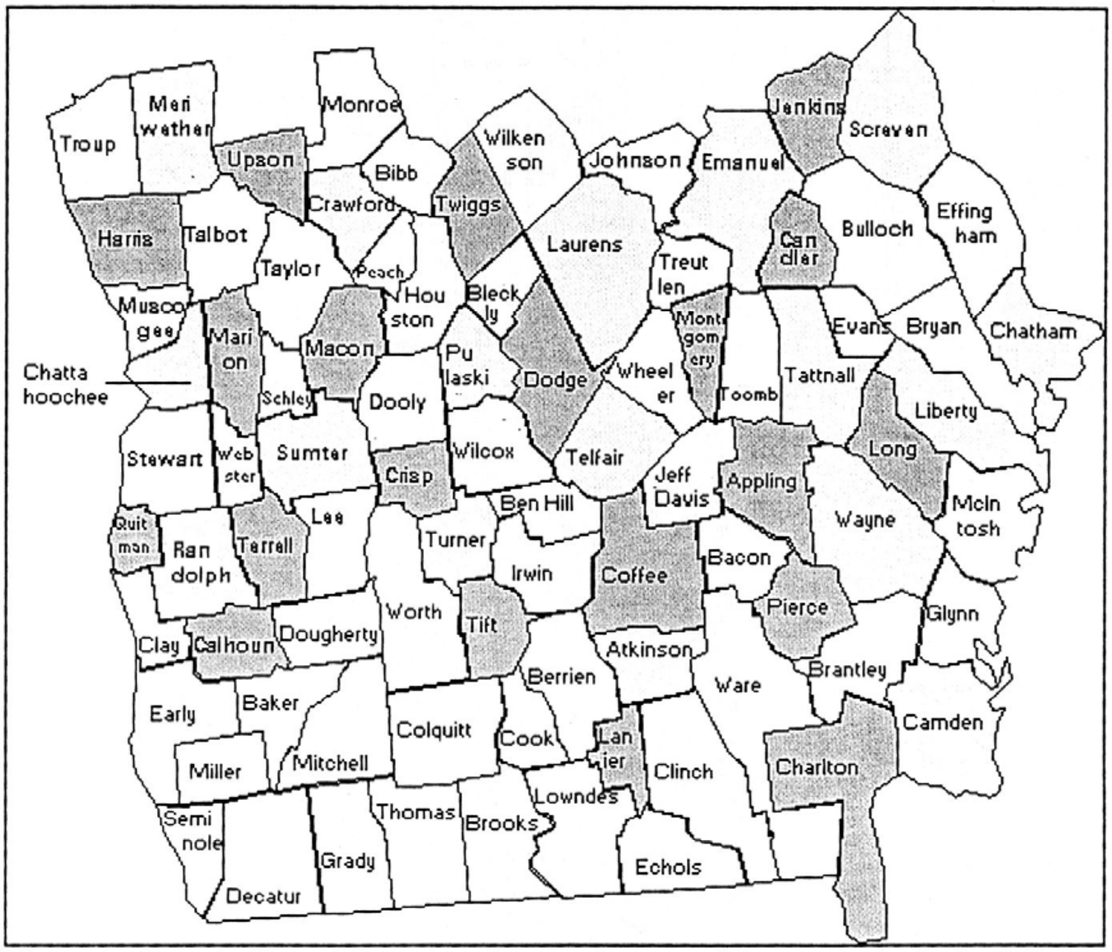


Figure 4. Georgia Coastal Counties. Source: Bureau of Economic Analysis, U.S. Dept. of Commerce.

The 1990 Census of Population and Housing provides the following information for Georgia regarding individuals who reported their occupation as fisher in Table 23. A total of 536 individuals claimed Fisher as their occupational title with less than half indicating it was a year round full time employment. There were few females who indicated such and they had a far lower mean annual income than males who indicated it was a full time occupation. However, females who indicated it was other than full time had a much higher mean income than any other category. This may be due to a low sample size, however.

Table 23. Number of Fishers and Mean Annual Income for Georgia in 1990. Source: U.S. Bureau of the Census.

	Year Round/Full Time	Other	Total
Number of fishers			
Male	222	295	518
Female	11	7	18
Total	234	302	536
Mean Annual Income ($)			
Male	19,139	11,082	15,058
Female	8,600	25,000	20,080
Total	18,813	12,024	15,308

Shrimping

In their 1975 report, Nix et. al., found a total of 32 commercial docks in six Georgia coastal counties. Those docks and shrimp trawlers were distributed as follows: Camden Co. - 5 docks and 33 trawlers; Glynn Co. - 5 docks and 74 trawlers; McIntosh Co. - 12 docks and 111 trawlers; Liberty Co. - 1 dock and 18 trawlers; Bryan Co. - 1 dock and 2 trawlers; and finally Chatham Co. - 8 docks and 69 trawlers. This information is outdated and certainly does not represent the current status and location of shrimp trawlers in Georgia. However, the report does represent the kinds of information that can be extremely helpful in identifying fishing communities.

Snapper Grouper Fishing

The coast of Georgia contains a small concentration of full-time reef fishermen that fish primarily with bandit reels. Their fishing patterns are similar to those found in SC with vessels fishing from northern Florida north to the SC/NC line (Iverson, 1997).

Possible fishing communities in Georgia: Savannah, Brunswick, St. Marys, Jekyll Island, and Darien.

Table 24. Number of Captains of Fishing Vessels and other officers and Mean Annual Income for Georgia in 1990. Source: U.S. Bureau of the Census.

	Year Round/Full Time	Other	Total
Number of Captains			
Male	17	21	38
Female	0	0	0
Total	17	21	38
Mean Annual Income ($)			
Male	25,706	1,976	12,592
Female	0	0	0
Total	25,706	1,976	12,592

Table 25. Population and Economic Information for Chatham County, Georgia. Source: Bureau of Economic Analysis, U.S. Dept. of Commerce.

County		1993	1994	1995
Chatham	Population (number of persons)	224,050	225,779	226,554
	Personal income (thousands of dollar	4,569,113	4,810,530	5,087,638
	Per capita personal income (dollars)	20,393	21,306	22,457
	Personal Income Fishing (Thousands of $)	650	(D)	25

Table 26. Population and Economic Information for Bryan County, Georgia. Source: Bureau of Economic Analysis, U.S. Dept. of Commerce.

County		1993	1994	1995
Bryan				
	Population	18,827	20,008	21,212
	Personal Income (Thousands of $)	274,738	307,258	342,128
	Per Capita Pers Income ($)	14,593	15,357	16,129
	Personal Income Fishing (Thousands of $)	251	359	----

Table 27. Population and Economic Information for Liberty County, Georgia. Source: Bureau of Economic Analysis, U.S. Dept. of Commerce.

County		1993	1994	1995
Liberty				
	Population	56,625	58,827	58,571
	Personal Income (Thousands of $)	636,042	669,454	709,468
	Per Capita Pers Income ($)	11,233	11,380	12,113
	Personal Income Fishing (Thousands of $)	----	90	97

Table 28. Population and Economic Information for McIntosh County, Georgia. Source: Bureau of Economic Analysis, U.S. Dept. of Commerce.

County		1993	1994	1995
McIntosh				
	Population	8,985	9,153	9,372
	Personal Income (Thousands of $)	110,187	116,171	125,645
	Per Capita Pers Income ($)	12,263	12,692	13,406
	Personal Income Fishing (Thousands of $)	3,619	4,486	----

Table 29. Population and Economic Information for Glynn County, Georgia. Source: Bureau of Economic Analysis, U.S. Dept. of Commerce.

County		1993	1994	1995
Glynn				
	Population	64,759	64,956	65,450
	Personal Income (Thousands of $)	1,322,745	1,400,544	1,505,337
	Per Capita Pers Income ($)	20,426	21,558	23,000
	Personal Income Fishing (Thousands of $)	328	343	351

Table 30. Population and Economic Information for Camden County, Georgia. Source: Bureau of Economic Analysis, U.S. Dept. of Commerce.

County		1993	1994	1995
Camden				
	Population	39,712	41,262	40,819
	Personal Income (Thousands of $)	502,639	542,385	556,622
	Per Capita Pers Income ($)	12,657	13,145	13,636
	Personal Income Fishing (Thousands of $)	1,889	2,431	2,484

Georgia coastal counties have seen a general increase in these occupations and industries with the exception of Liberty County which has shown a decrease from 1970-1990.

Table 31. Number within Farm/Fish/Forest Occupation and Agriculture, Fishing, Mining Industry for Georgia Coastal Counties for 1970, 1980, and 1990 Census. Source: MARFIN Sociodemographic Database

County	Occupation/Industry	1970	1980	1990
Bryan County	Agri.,Fishing,Mining	161	100	200
	Farm/Fish/Forest	121	135	136
Chatham County	Agri.,Fishing,Mining	558	686	1103
	Farm/Fish/Forest	228	704	1062
Liberty County	Agri.,Fishing,Mining	332	146	152
	Farm/Fish/Forest	242	205	157
McIntosh County	Agri.,Fishing,Mining	233	266	169
	Farm/Fish/Forest	27	260	193
Glynn County	Agri.,Fishing,Mining	261	482	593
	Farm/Fish/Forest	84	581	712
Camden County	Agri.,Fishing,Mining	209	126	176
	Farm/Fish/Forest	106	110	205

4.3.3.1.5 Florida

Florida's eastern coastline is made up largely of metropolitan counties. This is primarily due to the increases in population for Florida's coastal counties over the past 50 years. Florida's coastline has become a very popular retirement destination and tourist attraction. Because they are largely metropolitan, fishing communities here may be subsumed into these larger metropolitan areas and difficult to identify. Data presented from the most recent Census will also show that in relation to the larger economy, fishing will contribute very little at the county level for most coastal counties. Over the years, with the demographic changes following the inmigration of retirees and tourists and the subsequent economic transition, few fishing communities will have survived as distinct communities.

The data presented in Table 32 shows Florida as having almost 6,000 individuals claiming fisher as their occupation in the 1990 census; 381 of those individuals were female. Mean annual income is highest for those reporting fishing as a full time occupation with women reporting a lower mean annual income in all categories.

Table 32. Number of Fishers and Mean Annual Income for Florida in 1990. Source: U.S. Bureau of the Census.

	Year Round/Full Time	Other	Total
Number of fishers			
Male	2,698	2,844	5,544
Female	111	270	381
Total	2,809	3,116	5,925
Mean Annual Income ($)			
Male	23,288	11,794	17,388
Female	17,285	11,511	13,193
Total	23,051	11,770	17,118

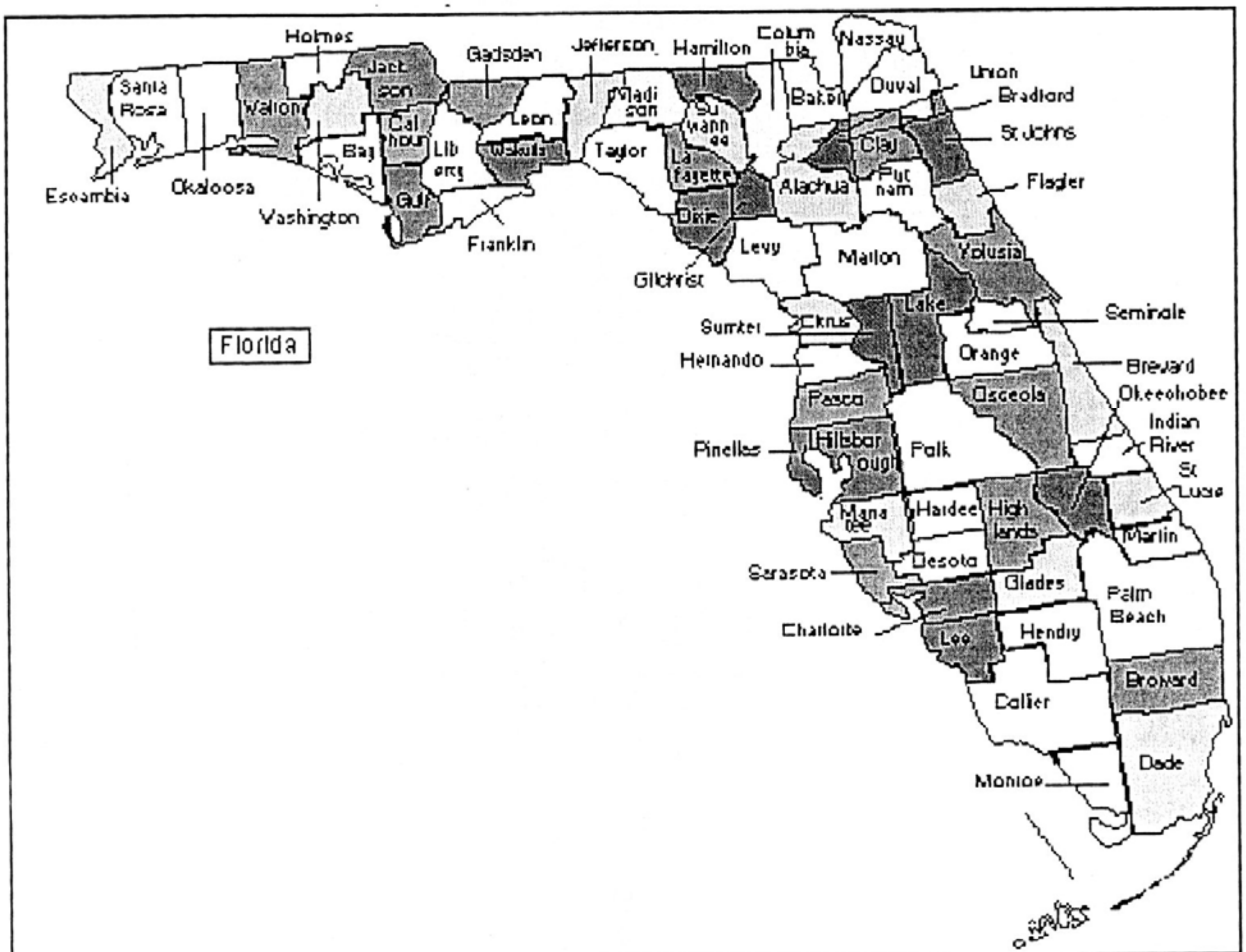


Figure 5. Florida Coastal Counties. Source: Bureau of Economic Analysis, U.S. Dept. of Commerce.

There were over 1100 individuals from Florida who reported their occupation as captain of a fishing vessel during the 1990 census, with 51 of them being female (Table 33). Again, mean annual income was highest for full time workers and females reported lower mean annual income for both full time and other work.

Table 33. Number of Captains of Fishing Vessels and other officers and Mean Annual Income for Florida in 1990 Source: U.S. Bureau of the Census.

	Year Round/Full Time	Other	Total
Number of Captains			
Male	430	633	1,063
Female	26	25	51
Total	456	658	1,114
Mean Annual Income ($)			
Male	25,993	21,274	23,183
Female	8,487	15,420	11,885
Total	24,995	21,052	22,666

Nassau County (Table 34) showed an increase in personal income from fishing over the time period from 1993 to 1995 which reflects the general increase in population and personal income overall for the county.

Table 34. Population and Economic Information for Nassau County, Florida. Source: Bureau of Economic Analysis, U.S. Dept. of Commerce.

County		1993	1994	1995
Nassau				
	Population	48,355	49,565	50,717
	Personal Income (Thousands of $)	954,342	1,003,920	1,089,793
	Per Capita Pers Income ($)	19,736	20,255	21,488
	Personal Income Fishing (Thousands of $)	1,540	1,918	2,068

Duval County (Table 35) shows slow growth in population over the three years listed, but does show growth in personal income from fishing from 1993 to 1994. There was a slight decrease in personal income from fishing reported from 1994 to 1995.

Table 35. Population and Economic Information for Duval County, Florida. Source: Bureau of Economic Analysis, U.S. Dept. of Commerce.

County		1993	1994	1995
Duval				
	Population	701,267	703,152	705,014
	Personal Income (Thousands of $)	14,111,822	14,724,897	15,748,121
	Per Capita Pers Income ($)	20,123	20,941	22,337
	Personal Income Fishing (Thousands of $)	2,272	3,658	3,335

St John's County (Table 36) had some growth in personal income from fishing from 1993 to 1994 but no data were available for 1995 to indicate whether that trend continued.

Table 36. Population and Economic Information for St. John's County, Florida. Source: Bureau of Economic Analysis, U.S. Dept. of Commerce.

County		1993	1994	1995
St. Johns				
	Population	94,480	98,377	101,966
	Personal Income (Thousands of $)	2,394,764	2,612,557	2,869,300
	Per Capita Pers Income ($)	25,347	26,557	28,140
	Personal Income Fishing (Thousands of $)	432	502	----

According to Table 37, Flagler County had no individuals reporting personal income from fishing for the time period 1993 to 1995. Volusia County also has no personal income from fishing listed in Table 38, but data were not included due to confidentiality issues.

Table 37. Population and Economic Information for Flagler County, Florida. Source: Bureau of Economic Analysis, U.S. Dept. of Commerce.

County		1993	1994	1995
Flagler				
	Population	35,868	37,894	40,260
	Personal Income (Thousands of $)	571,528	631,959	692,269
	Per Capita Pers Income ($)	15,934	16,677	17,195
	Personal Income Fishing (Thousands of $)	0	0	0

Table 38. Population and Economic Information for Volusia County, Florida. Source: Bureau of Economic Analysis, U.S. Dept. of Commerce.

County		1993	1994	1995
Volusia				
	Population	397,372	405,515	410,115
	Personal Income (Thousands of $)	6,845,402	7,235,060	7,772,063
	Per Capita Pers Income ($)	17,227	17,842	18,951
	Personal Income Fishing (Thousands of $)	----	----	----

Indian River County saw an increase in personal income from fishing from 1993 to 1994 according to Table 39, but saw a decrease from 1994 to 1995. St. Lucie County (Table 40) may have had a similar trend although data from 1993 are missing and the trend is not clear.

Table 39. Population and Economic Information for Indian River County, Florida. Source: Bureau of Economic Analysis, U.S. Dept. of Commerce.

County		1993	1994	1995
Indian River				
	Population	94,184	95,374	96,263
	Personal Income (Thousands of $)	2,686,514	2,827,427	3,065,533
	Per Capita Pers Income ($)	28,524	29,646	31,845
	Personal Income Fishing (Thousands of $)	1,340	1,826	1,707

Table 40. Population and Economic Information for St. Lucie County, Florida. Source: Bureau of Economic Analysis, U.S. Dept. of Commerce.

County		1993	1994	1995
St. Lucie				
	Population	165,120	169,284	171,914
	Personal Income (Thousands of $)	2,719,602	2,840,752	3,051,018
	Per Capita Pers Income ($)	16,470	16,781	17,747
	Personal Income Fishing (Thousands of $)	----	1,855	1,303

Table 41. Population and Economic Information for Broward County, Florida. Source: Bureau of Economic Analysis, U.S. Dept. of Commerce

County		1993	1994	1995
Broward				
	Population	1,353,279	1,358,585	1,412,942
	Personal Income (Thousands of $)	32,716,045	34,273,950	37,007,667
	Per Capita Pers Income ($)	24,175	24,736	26,192
	Personal Income Fishing (Thousands of $)	658	816	----

The trend in personal income from fishing for Broward County is not clear as data from 1995 are missing from Table 41 because of confidentiality. Brevard County (Table 42) shows a decrease in personal income from fishing during 1994 to 1995, but overall shows a much larger percentage of personal income coming from fishing than most counties previous.

Table 42. Population and Economic Information for Brevard County, Florida. Source: Bureau of Economic Analysis, U.S. Dept. of Commerce.

County		1993	1994	1995
Brevard				
	Population	435,546	443,337	450,238
	Personal Income (Thousands of $)	8,564,204	8,938,218	9,341,030
	Per Capita Pers Income ($)	19,663	20,161	20,747
	Personal Income Fishing (Thousands of $)	3,600	4,690	3,797

Martin County has one of the highest per capita incomes reported over the three year period according to Table 43. There was also a significant increase in personal income from fishing from 1993 to 1994 which decreased in 1995. Palm Beach County, with an even higher per capita income, showed an increase in personal income from fishing from 1993 to 1994 with no data available for 1995 (Table 44).

Table 43. Population and Economic Information for Martin County, Florida. Source: Bureau of Economic Analysis, U.S. Dept. of Commerce.

County		1993	1994	1995
Martin				
	Population	107,238	109,194	110,495
	Personal Income (Thousands of $)	3,406,064	3,521,665	3,815,294
	Per Capita Pers Income ($)	31,762	32,251	34,529
	Personal Income Fishing (Thousands of $)	270	1,658	819

Table 44. Population and Economic Information for Palm Beach County, Florida. Source: Bureau of Economic Analysis, U.S. Dept. of Commerce.

County		1993	1994	1995
Palm Beach				
	Population	933,644	957,522	976,358
	Personal Income (Thousands of $)	30,994,531	32,423,719	35,204,121
	Per Capita Pers Income ($)	33,197	33,862	36,057
	Personal Income Fishing (Thousands of $)	1,464	1,902	----

Dade County shows a steady growth in personal income from fishing for the time period listed in Table 45. Monroe County shows, by far, the highest personal income from fishing for any Florida county and most likely any county in the South Atlantic according to Table 46.

Table 45. Population and Economic Information for Dade County, Florida. Source: Bureau of Economic Analysis, U.S. Dept. of Commerce.

County		1993	1994	1995
Dade				
	Population	1,985,373	2,011,571	2,046,078
	Personal Income (Thousands of $)	39,110,301	40,344,476	43,087,320
	Per Capita Pers Income ($)	19,699	20,056	21,058
	Personal Income Fishing (Thousands of $)	1,247	1,479	1,897

Table 46. Population and Economic Information for Monroe County, Florida. Source: Bureau of Economic Analysis, U.S. Dept. of Commerce.

County		1993	1994	1995
Monroe				
	Population	81,737	81,461	81,152
	Personal Income (Thousands of $)	1,982,209	2,054,326	2,208,152
	Per Capita Pers Income ($)	24,251	25,219	27,210
	Personal Income Fishing (Thousands of $)	13,506	15,558	16,723

Recently, data were compiled from the last three census and placed into a user friendly interface through a MARFIN grant by the Louisiana Population Data Center, Louisiana State University (C. M. Tolbert, et al. 1998). Those data provide a time series of information from the last three census with the ability to compare several variables at the state,. county and place level. Census places are incorporated and Census designated places of 2500 or more persons. The tables presented below incorporate the data included in the MARFIN SocioDemographic Database for the coastal counties outlined above with a focus on the occupational classification of Farm/Fish/Forest and the industry classification of Agriculture, Fishing, and Mining. These classifications are inclusive of those within the occupation and industry of fishing, but not exclusive of others, therefore it is difficult to know the exact number of individuals who have indicated their occupation or business is fishing. We can only assume that whatever trend appears over the time corresponds to the occupation of fishing as well as the others.

Data covering Metropolitan Statistical Areas are provided because it includes a more detailed occupational breakdown, but unfortunately geographic boundaries expand as most MSAs encompass more than one county. In some cases, MSAs were not used because the area covered did not correspond with the coastal areas within the South Atlantic region. As mentioned earlier, these data are what is currently available. Further analysis is constrained by variety of issues relating to data computability and availability at each place level of analysis. As mentioned before more research on fishing communities will be required before a more complete definition and identification can be accomplished.

Examining census data at the level of Metropolitan Statistical area reveals greater detail for occupation, but the scale changes as MSAs often times encompass more than one county. Metropolitan area (MA) is a large population nucleus, together with adjacent communities that have a high degree of economic and social integration with that nucleus. Metropolitan Areas must contain either a place with a minimum population of 50,000 or a Census Bureau-defined urbanized area and a total MA population of at least 100,000. An MA comprises one or more central counties and also may include one or more outlying counties that have close economic and social relationships with the central county. Metropolitan statistical areas (MSA's) are relatively freestanding MA's and are not closely associated with other MA's. These areas typically are surrounded by nonmetropolitan counties. See Appendix ?? for details on the parameters for the coastal MSAs included in this discussion.

When you look at the occupations of farming, fishing and forestry for Florida coastal counties in Table 47, over the past 20 years there is, in general, a steady increase in the number of individuals within these occupations and industries.

Table 47. Number within Farm/Fish/Forest Occupation and Agriculture, Fishing, Mining Industry for East Florida Coastal Counties from 1970, 1980, and 1990 Census. Source: MARFIN Sociodemographic Database

County	Occupation/Industry	1970	1980	1990
Nassau County	Farm/Fish/Forest	371	427	559
	Agri.,Fishing,Mining	501	462	606
Duval County	Farm/Fish/Forest	1237	2782	3729
	Agri.,Fishing,Mining	2536	2959	4324
St.Johns County	Farm/Fish/Forest	794	813	1002
	Agri.,Fishing,Mining	1012	883	976
Flagler County	Farm/Fish/Forest	145	314	408
	Agri.,Fishing,Mining	186	298	403
Volusia County	Farm/Fish/Forest	1308	3150	4917
	Agri.,Fishing,Mining	2511	3407	5606
Indian River County	Farm/Fish/Forest	991	1907	2042
	Agri.,Fishing,Mining	1454	2361	2217
St. Lucie County	Farm/Fish/Forest	2602	2710	3147
	Agri.,Fishing,Mining	3253	3252	3342
Broward County	Farm/Fish/Forest	1982	7358	9425
	Agri.,Fishing,Mining	5354	7756	10317
Brevard County	Farm/Fish/Forest	764	1772	3369
	Agri.,Fishing,Mining	1394	2279	3585
Martin County	Farm/Fish/Forest	964	1838	1983
	Agri.,Fishing,Mining	1268	2032	2086
Palm Beach County	Farm/Fish/Forest	6552	9676	13261
	Agri.,Fishing,Mining	9791	11780	15155
Dade County	Farm/Fish/Forest	4804	11257	14894
	Agri.,Fishing,Mining	9682	13708	16926
Monroe County	Farm/Fish/Forest	163	1769	1729
	Agri.,Fishing,Mining	920	1932	1860

The following table includes only those individuals who reported their occupation as fishing for the following Metropolitan Statistical Areas (MSA) within Florida.

Table 48. Number of Individuals in Occupation of Fishing By Work Status and Gender for Florida MSA in 1989. Source: 1990 Census Of Population And Housing.

Jacksonville		Year Round Full Time	Other	Total
	Male	151	210	361
	Female	15	49	64
	Total	166	259	425
West Palm Beach		Year Round Full Time	Other	Total
	Male	94	47	141
	Female	0	0	0
	Total	94	47	141
Miami		Year Round Full Time	Other	Total
	Male	254	254	508
	Female	0	30	0
	Total	254	284	538

Snapper Grouper Fishery Profile

Concentrations of reef fishermen can be found in the communities of Mayport, Port Orange and New Smyrna, north of Cape Canaveral. Bandit reels are the primary gear used for reef fishing in these areas, although a few bottom longline vessels are present. In northern Florida, bandit fishermen report trips lasting 5-6 days and fish 30-50 miles offshore. They average between 2 to 3 crew members depending on vessel size and gear. Vessels from the Mayport area reported fishing from the Georgia line south to the Daytona area. The larger longline vessels are required by regulations to fish past the 50 fathom line and reported trip lengths of up to 10 days, fishing as far as 100 miles from shore. These bottom long line vessels fish for deep water species such as tilefish in water 600 - 900' deep (Iverson, 1997).

King Mackerel Fishery Profile

McKenna (1994) identified the number of fishermen in Florida reporting landings of king mackerel (based on Saltwater Products Licenses) from 1987 to 1993 as varying from 1,500 to 2,222. From 1986 to 1990 the number of commercial permits for Atlantic migratory group king mackerel ranged from a high of 888 in 1989/90 fishing season to low of 785 in the 1987/88 fishing year. The percentage of those permits which were hook and line fishermen for those years ranged from 89% in 86/87 to 78% in 1990. There were 1654 vessels permitted for commercial king mackerel and Spanish mackerel in Florida for the 1993-94 fishing year. The number of permitted vessels was divided with 846 and 808 allocated to the East and West coasts respectively. How many of those vessels landed king mackerel is unknown at this time. Catch per unit of effort data seems fairly consistent for the southeastern region of the Atlantic group king mackerel with an average CPUE of between 200-300 lbs/trip (McKenna, 1994). Most of the commercial landings of Atlantic group king mackerel are made by hook and line fishermen. In addition, because most landings of Atlantic group king mackerel are in Florida and the most information that exists is on the Florida fishery, the following description will focus primarily on the Florida fishery unless noted otherwise.

King Mackerel Hook and Line Fleet

There were approximately 203 full and part time vessels in the hook and line mackerel fleet in 1980. Vessel size ranged from 22-44 feet in length. Today, the Florida South Atlantic troll fishery is composed of about 100 full-time and 100 part-time operations, about 150 of them are dependent upon king mackerel. Full-time fishermen operate primarily out of Jupiter, Port Salerno, Fort Pierce, Sebastian, and Rivera Beach. Normally, there is one fisherman to a boat. Part-time fishermen operate mostly out of Palm Beach, frequently two or three fishermen per boat. Approximately 40 percent of the full time trollers switch to bottom fishing for various reef fish after the Gulf king mackerel season. The remainder of these full time trollers tie up their boats when the Gulf king mackerel season ends. Some engage in various non-fishing jobs, while the majority reportedly wait for the opening of the Atlantic king mackerel season (GMFMC & SAFMC, 1994).

During the peak season about 75 to 100 troll vessels and 16 to 20 net vessels target king mackerel in the Keys. Net vessels usually start fishing late December, although some of these vessels troll for mackerel before net fishing becomes more practicable. Most king mackerel fishermen in the Keys target other species such as stone crab, spiny lobster, and reef fish throughout the year.

King Mackerel Net Fishing Fleet

There were approximately 89 large gill net vessels in Florida including full and part time in 1980. The vessels ranged in size from 30-65 feet. These vessels fished Spanish and king mackerel during the winter, but also targeted lobster, swordfish and bait fish during other times of the year. Vessels over 40 feet usually employed a power roller to haul nets. The large gill net fleet was primarily located from Florida's central east coast in Ft. Pierce, throughout the Florida Keys to the central west coast as far north as Cortez. There were also a few large boats in the Panhandle area of Port St. Joseph (Centaur Associates, 1981).

Approximately 87% of captains in the large gill net fleet at that time depended entirely upon fishing for their income. Net fishermen, then as they do today, have the options of participating in the Spanish mackerel fishery, trolling for king mackerel, and fishing with nets or hook and line for Atlantic group king mackerel after March (Centaur Associates 1981).

Today, there are twelve large net boats located in the Keys that may fish Atlantic group king mackerel occasionally. These vessels have a capacity of up to 40,000 pounds per trip and have had large catches of king mackerel in the past. There does not seem to be a small gill net boat sector for Atlantic king mackerel. In Monroe County there are 16 to 20 large net boats currently participating in the king mackerel fishery, some with capacity to land up to 50,000 pounds. There are another 6 to 12 small net boats in south-west Florida ready to enter the fishery when the opportunity arises. These vessels are 30 to 40 feet in length with capacities of 5,000 to 10,000 pounds.

There has been a general decline in net catches along the Florida east coast. This may be attributed to regulations like the prohibition of drift nets and purse seines, but also stems from the recent net ban in Florida state waters.

King Mackerel Dealers

McKenna (1994) identified over 200 dealers in Florida who had handled king mackerel since 1987. In 1992 there were 240 who reported landings of king mackerel. Most of those dealers purchased king mackerel ten or fewer times per season and handled less than 5000 pounds. There were over twenty dealers who handled 100,000 pounds or more during the 1992 season (McKenna, 1994) .

Possible fishing communities in Florida: Mayport, Port Orange, New Smyrna, Sebastian, Port Salerno, Rivera Beach, Ft. Pierce, Jupiter, West Palm Beach, Boyton Beaches, The Keys -- Upper Keys: Key Largo, Tavernier; Middle Keys - Islamorada, Marathon; Lower Keys; and Key West.

4.3.3.1.6 Other Community related Analysis

In a recent survey of snapper grouper fishermen in the South Atlantic questions were posed concerning a fishermen's tenure within a community and attitudes towards community change. The results in Table 49 show that the majority of fishermen feel their community has stayed the same or has changed for the better. A larger percentage of inactive than active snapper grouper fishermen feel that their community has changed for the worse. Well over half of fishermen interviewed had been in their present community for twenty years or more. Over sixty percent of inactive fishermen have lived in their community for twenty years or more, while over fifty percent of active fishermen have lived in their communities for 19 years or less. The mean number of years a fishermen had resided in their present community was twenty years or more for North Carolina, South Carolina and Florida. In comparison Georgia snapper grouper fishermen had an average tenure in their communities of 6.5 years. This may be an artifact of the small sample size in Georgia as only seven fishermen from that state were interviewed, but could also be reflective of the nature of snapper grouper fishing in Georgia (Rhodes et al., 1997).

Table 49. Snapper Grouper Fishermen's Tenure and Attitude toward Change in their Present Community. Source: Socio-demographic Assessment of Commercial Reef Fishermen in the South Atlantic Region. 1997.

	Active (%)	Inactive (%)
Feel Your Community has changed?	(N=201)	(N=26)
For the better	41.8	30.8
For the worse	32.1	46.2
Stayed the same	25.9	23.1
	Active (Yrs)	Inactive (Yrs)
Number of Years in Present Community?	(N=201)	(N=26)
2-12	27.6	25.9
13-19	32.0	11.1
20-35	19.5	33.4
36 <	20.9	29.6

These perspectives on an individual's feelings toward a community become important when that person must face significant changes regarding his/her occupation, as is often the case when limited entry or some other form of fisheries management is implemented. An individual's commitment toward their community and sense of belonging will influence decisions on whether to stay in fishing or within a particular community. The impacts become important for the community if many individuals face the same decision. When active fishermen were asked what is the likelihood of moving to a new town in the next 2-3 years most responded that it is was unlikely, however, over 27% indicated they were not sure or it was likely. When both inactive and active fishermen were asked the likelihood of leaving commercial fishing altogether 46% of inactive fishermen said it was likely or very likely, while only 11% of active fishermen indicated such a likelihood. (Rhodes et al., 1997). These type of data at the community level would contribute much to the understanding of possible impacts of future fisheries management.

4.3.3.1.7 Data Needs

As mentioned earlier, the data presented here is what is currently available and readily accessible. It is very limiting and does not provide a sufficient amount of detail needed to define and identify fishing communities. Therefore, the likelihood of realistic impact assessment of future fishing regulations on fishing communities is not good.

At the present the NMFS does not collect data on fishing communities. Therefore, it is impossible to realistically identify fishing communities in this amendment. There is a tremendous need for research to be conducted on a continuous basis to collect this information. Both state and federal government agencies have access to current information which can inform the process of identifying fishing communities. Permit databases for fishing licenses, wholesale and retail licenses, boat registrations, marina permits, boat landing locations, and many others exist now. Putting that information into one database is a monumental task, but should be undertaken soon. Geographic Information System software is now available and being used to compile much of the data regarding habitat. The same type of databases need to be created regarding fishing communities. Spatial analysis of the variables that help identify and define fishing communities can give useful insight into the changes that affect these coastal communities.

It is unlikely that Council Staff would be able to gather these data. Council staff have in the past, with the cooperation of industry, been able to gather important information about a particular fishery, but were criticized for not following OMB guidelines. The difficulty with following OMB guidelines is that approval of data gathering tools is too time consuming. Councils are often on a timeline to develop FMPs which does not allow for a lengthy approval process. The South Atlantic Council staff has sufficient expertise with this type of data collection that design, implementation and analysis can often take place during an extremely short time period with little burden upon the public. In fact, industry is often eager to provide these type of data for consideration during development of an FMP, but don't have the expertise to offer data a form that can be used by Council staff.

Data collection is critical to the future of impact assessment of fishing communities. Standards must be set and data need to be collected. At present, the ACCSP is attempting to set those standards and has included social and economic data in that program. The ACCSP Technical Source Document IV contains detailed social and economic data needs and draft survey instruments. Social and economic data collection projects should at least collect the minimum data elements. Support of ACCSP can be an important step in meeting the future needs of the councils with regard to fishing communities. In addition, another guideline for the types of data needed can be found in the Southeast Social and Cultural Data Analysis Plan (NMFS, 1994). The plan was designed to address many of the current social and cultural information needs for the three councils in the Southeast."

4.0 ECOSYSTEM CONSIDERATIONS

4.1 Introduction

As a result of the Sustainable Fisheries Act Amendment to the Magnuson-Stevens Fishery Conservation and Management Act in 1996 the Councils and the NMFS have been mandated to use an ecosystem approach in managing the Nation's Fisheries. The Council has taken the first step with the submission of the Habitat Plan identifying and describing in detail essential fish habitat (EFH) for species managed by the South Atlantic Council and with the submission of the Comprehensive Habitat Amendment amending all existing FMP's to include descriptions of EFH and EFH-habitat areas of particular concern (EFH-HAPCs). By including an Ecosystems Considerations section in the required SAFE reports, existing data regarding the effects of a fishery on the ecosystem will be provided to the Council on a species by species basis while emphasizing the need for a new level of information. This section will also provide a forum in which to express ecosystem concerns for a specific fishery.

While incorporating ecosystem concerns into stock assessment reports is a new approach for this Council, this approach has been taken by the North Pacific Fishery Management Council for several years. A copy of their ecosystems chapter has been included as Appendix E and is an example of the way the ecosystem approach can be used in annual SAFE reports. Another supporting document detailing new ideas and approaches to holistic management is the report to Congress from the Ecosystem Principles Advisory Panel of the NMFS (Appendix F), appointed by the National Academy of Sciences. Congress charged NMFS with establishing this panel to assess the extent that ecosystem principles are used in fisheries management and research and to recommend how such principles can be used to improve our Nation's management of living marine resources.

Ecosystem considerations presented in the interim final rule to implement the essential fish habitat (EFH) provisions of the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act).

Overview of EFH FMP Amendment Guidelines

The themes of sustainability and risk-averse management are prevalent throughout the Magnuson-Stevens Act, both in the management of fishing practices (e.g., reduction of bycatch and overfishing and consideration of ecological factors in determining optimum yield [OY]) and in the protection of habitats (i.e., prevention of direct and indirect losses of habitats, including EFH). Management of fishing practices and habitat protection are both necessary to ensure long-term productivity of our Nation s fisheries. Mitigation of EFH losses and degradation will supplement the traditional management of marine fisheries. Councils and managers will be able to address a broader range of impacts that may be contributing to the reduction of fisheries resources. Habitats that have been severely altered or impacted may be unable to support populations adequately to maintain sustainable fisheries. Councils should recognize that fishery resources are dependent on healthy ecosystems; and that actions that alter the ecological structure and/or functions within the system can disturb the health or integrity of an ecosystem. Excess disturbance, including over-harvesting of key components (e.g., managed species) can alter ecosystems and reduce their productive capacity. Even though traditional fishery management and FMPs have been mostly based on yields of single-species or multi-species stocks, these regulations encourage a broader, ecosystem approach to meet the EFH requirements of the Magnuson-Stevens Act. Councils should strive to understand the ecological roles (e.g., prey, competitors, trophic *links within food webs, nutrient transfer between ecosystems, etc.) played by managed species within their ecosystems. They should protect, conserve, and enhance adequate quantities of EFH to support a fish population that is capable of fulfilling all of those other contributions that the managed species makes to maintaining a healthy ecosystem as well as supporting a sustainable fishery. Councils must identify in FMPs the habitats used by all life history stages of each managed species in their fishery management units (FMUs). Habitats that are necessary to the species for spawning, breeding, feeding, or growth to maturity will be described and identified as EFH. These habitats must be described in narratives (text and tables) and identified geographically (in text and maps) in the FMP. Mapping of EFH maximizes the ease with which the information can be shared with the public, affected parties, and Federal and state agencies to facilitate conservation and consultation. EFH that is judged to be particularly important to the long-term productivity of populations of one or more managed species, or to be particularly vulnerable to degradation, should be identified as "habitat areas of particular concern" (HAPC) to help provide additional focus for conservation efforts. After describing and identifying EFH, Councils must assess the potential adverse effects of all fishing-equipment types on EFH and must include management measures that minimize adverse effects, to the extent practicable, in FMPs. Councils are also directed to examine non-fishing sources of adverse impacts that may affect the quantity or quality of EFH and to consider actions to reduce or eliminate the effects.*

(ii) EFH determination.
(E) Ecological relationships among species and between the species and their habitat require, where possible, that an ecosystem approach be used in determining the EFH of a managed species or species assemblage. The extent of the EFH should be based on the judgment of the Secretary and the appropriate Council(s) regarding the quantity and quality of habitat that is necessary to maintain a sustainable fishery and the managed species' contribution to a healthy ecosystem.

(11) Review and revision of EFH components of FMPs.
This information should be reviewed as part of the annual Stock Assessment and Fishery Evaluation (SAFE) report prepared pursuant to § 600.315(e).

4.2 Essential Fish Habitat and Essential Fish Habitat -Habitat Areas of Particular Concern Designations

Essential fish habitat is defined in the Act as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." The definition for EFH may include habitat for an individual species or an assemblage of species, whichever is appropriate within each FMP.

For the purpose of interpreting the definition of essential fish habitat: "waters" includes aquatic areas and their associated physical, chemical, and biological properties that are utilized by fish. When appropriate this may include areas used historically. Water quality, including but not limited to nutrient levels, oxygen concentration and turbidity levels is also considered to be a component of this definition. Examples of "waters" that may be considered EFH, include open waters, wetlands, estuarine habitats, riverine habitats, and wetlands hydologically connected to productive water bodies.

"Necessary" , relative to the definition of essential fish habitat, means the habitat required to support a sustainable fishery and a healthy ecosystem. While "spawning, breeding, feeding, or growth to maturity" covers a species full life cycle.

In the context of this definition the term "substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities. These communities could encompass mangroves, tidal marshes, mussel beds, cobble with attached fauna, mud and clay burrows, coral reefs and submerged aquatic vegetation. Migratory routes such as rivers and passes serving as passageways to and from anadromous fish spawning grounds should also be considered EFH. Included in the interpretation of "substrate" are artificial reefs and shipwrecks (if providing EFH), and partially or entirely submerged structures such as jetties.

The Habitat Plan presents the habitat requirements (by life stage where information exists) for species managed by the Council. Available information on environmental and habitat variables that control or limit distribution, abundance, reproduction, growth, survival, and productivity of the managed species is included.

Essential Fish Habitat for Coastal Migratory Pelagic Species

Essential fish habitat for coastal migratory pelagic species includes sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters, from the surf to the shelf break zone, but from the Gulf stream shoreward, including *Sargassum*. In addition, all coastal inlets, all state-designated nursery habitats of particular importance to coastal migratory pelagics (for example, in North Carolina this would include all Primary Nursery Areas and all Secondary Nursery Areas).

For Cobia essential fish habitat also includes high salinity bays, estuaries, and seagrass habitat. In addition, the Gulf Stream is an essential fish habitat because it provides a mechanism to disperse coastal migratory pelagic larvae.

For king and Spanish mackerel and cobia, essential fish habitat occurs in the South Atlantic and Mid-Atlantic Bights.

Essential Fish Habitat - Habitat Areas of Particular Concern for Coastal Migratory Pelagics

Areas which meet the criteria for essential fish habitat-habitat areas of particular concern (EFH-HAPCs) include sandy shoals of Cape Lookout, Cape Fear, and Cape Hatteras from shore to the ends of the respective shoals, but shoreward of the Gulf stream; The Point, The Ten-Fathom Ledge, and Big Rock (North Carolina); The Charleston Bump and Hurl Rocks (South Carolina); The Point off Jupiter Inlet (Florida); *Phragmatopoma* (worm reefs) reefs off the central east coast of Florida; nearshore hard bottom south of Cape Canaveral; The Hump off Islamorada, Florida; The Marathon Hump off Marathon, Florida; The "Wall" off of the Florida Keys; Pelagic *Sargassum*; and Atlantic coast estuaries with high numbers of Spanish mackerel and cobia based on abundance data from the ELMR Program. Estuaries meeting this criteria for Spanish mackerel include Bogue Sound and New River, North Carolina; Bogue Sound, North Carolina (Adults May-September salinity >30 ppt); and New River, North Carolina (Adults May-October salinity >30 ppt). For Cobia they include Broad River, South Carolina; and Broad River, South Carolina (Adults & juveniles May-July salinity >25ppt).

These areas include spawning grounds and habitats where eggs and larvae develop. In addition, the estuarine habitats also provide prey species along migration pathways.

4.3 Description of Habitat

The South Atlantic Council's Habitat Plan

The Council, in developing the Habitat Plan, consolidated the best available information on habitat essential to species managed in the south Atlantic region. The description and distribution of essential fish habitat in this document includes estuarine inshore habitats, mainly focusing on North Carolina, South Carolina, Georgia, and the Florida east coast as well as adjacent offshore marine habitats (e.g. coral, coral reefs, and live/hard bottom habitat, artificial reefs, *Sargassum* habitat and the water column). The structural component of these habitats constitute the basis for the habitat distribution information presented in this document. A primary goal of this document is to relay information on the distribution of managed species and essential fish habitats and provide information to address fishing and non-fishing threats to the watershed or estuarine drainage area.

The Habitat Plan was prepared through a cooperative effort of State, Federal and regional habitat partners on the Councils' Habitat and Coral Advisory Panels, additional technical experts identified during Council EFH workshops, and Council staff. This approach was deemed appropriate and has resulted in a scientifically defensible product that describes the structural characteristics and function by habitat type and presents available information on distribution and use by managed species and their significant prey. The intent of this document is to serve as a source document for all species managed by the Council. It also represents an ecological characterization of the south Atlantic region describing essential fish habitat. The Council is therefore taking a risk-averse approach in describing and protecting essential fish habitat in its area of jurisdiction and making recommendations to protect essential habitat in state waters. The emphasis of the determination is on the interrelationships between habitat and State and Federally managed species and their prey and endangered and threatened species. The vast array of species using these habitats implies that the structural habitats serve such a wide variety of species at different times in different locations that these structural habitats (estuarine, palustrine, coral and live/hard bottom, artificial reefs, and *Sargassum*) are all inclusive as essential to the functioning of a healthy ecosystem in the south Atlantic region. In addition, the water column plays an important role in defining the nature of essential habitat by being the common link.

This document is a living document that will be revised as new information becomes available. New techniques such as Habitat Suitability Index (HSI) modeling being developed may be useful in better identifying these habitats and their use by managed species. In addition, more refined and accurate mapping techniques through geographical information systems (GIS), such as the ones being used in the Coastal Change Analysis Program (C-CAP), under development for south Atlantic states and continued refinement of the SEAMAP bottom mapping effort. These and other activities will provide even more refined information for future Habitat Plan versions.

Habitats Identified in the Habitat Plan Which Constitute the Ecosystem Used by Managed Species including Coastal Migratory Pelagics

A. Estuarine/Inshore Essential Fish Habitat

Estuarine inshore habitats include estuarine emergent vegetation (salt marsh and brackish marsh), estuarine shrub/scrub (mangroves), seagrass, oyster reefs and shell banks, intertidal flats, palustrine emergent and forested (freshwater wetlands), and the estuarine water column. Section 3.1 presents individual detailed descriptions including species use of these habitats.

Estuarine Emergent

Estuarine marshes constitute a complex ecosystem that serves as essential fish habitat but also is vital to wildlife including endangered and threatened species, furbearers and other mammals, waterfowl, wading birds, shore and other birds, reptiles and amphibians, shellfish, and invertebrates. In contrast to freshwater marshes, salt marshes have low species diversity of the higher vertebrates, but high species diversity of invertebrates, including shellfish, and fishes. Optimal estuarine habitat conditions for managed species' spawning, survival, and growth is dependent on protecting the structural integrity as well as the environmental quality of these habitats. In North Carolina, South Carolina, Georgia and Florida, the marsh systems are of principal importance as nursery areas.

More detailed estimates of wetland by county are presented in Appendix A . This compilation of existing wetland habitat may, as refined to hydrological units, begin to serve as a baseline upon which to implement the policy directive and the long-term objective of a net gain of wetland habitats in the South Atlantic region. The Coastal Change Assessment Program (C-CAP) is presently being developed in response to the National Wetlands Policy Forum recommendation to improve inventory, mapping, and monitoring programs by USFWS and NOAA. The program was implemented to develop a nationally standardized geographic information system using ground-based and remote sensing data. It assesses changes in land cover and habitat in US coastal regions to improve understanding of coastal uplands, wetlands, and seagrass beds and their links to distribution, abundance, and health of living marine resources. At this time only South Carolina coastal counties are complete and will represent essential wetland habitat as mapped in that state. The state of Georgia information is under review and as North Carolina and Florida are completed the mapping coverage will be incorporated into the Habitat Plan as the most accurate presentation of inshore essential fish habitat in the South Atlantic region. The ecological value, function and distribution of this essential fish habitat is described in Section 3.1.1.1.

Estuarine Shrub/Scrub Mangroves (from NOAA 1995)

The red mangrove (*Rhizophora mangle*), black mangrove (*Avincennia germinans*), and white mangroves (*Laguncularia erectus*) are the three "true" species found in South Florida (Tomlinson, 1986). Red mangroves have prop roots and viviparous cigar-shaped seedlings, while black mangroves have a pneumataphore root system and gray-green leaves, the undersides of which are encrusted with excreted salt. White mangroves have rounded leaves, with a pair of salt glands on each petiole. Buttonwood (*Conocarpus erectus*), an associated species occurring with mangroves, is found in transitional wetland areas between mangrove and upland areas.

A mangrove classification system has been developed that identifies six major forest types based on geological and hydrological process: riverine, overwash, fringe, basin, dwarf, and hammock (Lugo and Snedaker). Riverine forests do not occur in southeast Florida due to the lack of freshwater rivers and the associated floodplains (Davis, 1943: Minerals Management Service 1990). Fringe forests occur along shorelines inundated by high tides, dominated by red mangroves, and exposed to open water. Tidal flow follows the same directional path along the fringe forest, resulting in sediment and litter accumulation.

Mangrove-related fish communities can be organized along various environmental gradients including salinity, mangrove detritus dependence, and substrate (Odum et al., 1982). The ecological value, function and distribution of this essential fish habitat is described in Section 3.1.1.2

Seagrass Habitat

Seagrass beds in North Carolina and Florida are preferred habitat areas of many managed species including white, brown, and pink shrimp, red drum, and estuarine dependent snapper and grouper species in the larval, juvenile and adult phases of their life cycle. Seagrass meadows provide substrates and environmental conditions which are essential to the feeding, spawning and growth of several managed species. Seagrass meadows are complex ecosystems that are essential habitat because they provide primary productivity, structural complexity, modification of energy regimes, sediment and shoreline stabilization, and nutrient cycling. Section 3.1.1.3 describes the ecological value and function and distribution of this essential fish habitat. The states of North Carolina through CGIA and Florida through FMRI provided geographical information system (GIS) coverage of seagrass habitat. Subsequent reconfiguration of the data was conducted by NMFS SEFSC to create a uniform ArcView format for inclusion into the Councils' essential fish habitat distribution data base and GIS system.

Oyster Reefs and Shell Banks

Oyster and shell essential fish habitat in the South Atlantic can be defined as the natural structures found between (intertidal) and beneath (subtidal) tide lines, that are composed of oyster shell, live oysters and other organisms that are discrete, contiguous and clearly distinguishable from scattered oysters in marshes and mudflats, and from wave-formed shell windrows (Bahr and Lanier 1981). Both intertidal and subtidal populations are found in the tidal creeks and estuaries of the South Atlantic. On the Atlantic coast, the range of the American oyster, *Crassostrea virginica*, extends over a wide latitude (20° N to 54° N). The ecological conditions encountered are diverse and the oyster community is not uniform throughout this range. Where the tidal range is large the oyster builds massive, discrete reefs in the intertidal zone. North of Cape Lookout, in North Carolina, the oyster habitat is dominated by Pamlico Sound and its tributaries. In these wind-driven lagoonal systems, oyster assemblages consist mainly of subtidal beds. Throughout the South Atlantic, oysters are found at varying distances up major drainage basins depending upon typography, salinity, substrate, and other variables.

Several terms used to describe the oyster/shell essential fish habitat are oyster reef, bar, bed, rock, ground and planting. The habitat ranges in size from small scattered clumps to large mounds of living oysters and dead shells. Predation and siltation limit oyster densities at the lower portion and outer regions of the reefs. The vertical elevation of intertidal oyster reefs above mean low water is maximal within the central Georgia coastal zone, where mean tidal amplitude exceeds 2 m (Bahr and Lanier 1981).

Large shell banks or deposits of oyster valves generated by boat wakes are found throughout the South Atlantic, usually along the Atlantic Intracoastal Waterway and heavily traveled rivers. These shell accumulations are usually elongated and conform to the underlying bottom topography from mean low water into the supra littoral zone. Further build-up may result in ridge structures and washovers. In South Carolina, 998 "washed shell" deposits have been located predominantly in the central and southern portion of the State. Washed shell is less resilient, partially abraded oyster shell with a lower specific gravity than recently shucked shells (Anderson 1979).

Intertidal Flats

Variability in the tidal regime along the South Atlantic coast results in considerable regional variability in the distribution and character of the estimated 1 million acres of tidal flat habitat. The coasts of North Carolina and Florida are largely microtidal (0-2m tidal range) with extensive barrier islands and relatively few inlets to extensive sound systems. In these areas wind energy has a strong affect on intertidal flats. In contrast the coasts of South Carolina and Georgia are mesotidal (2-4m) with short barrier islands and numerous tidal inlets so that tidal currents are the primary force effecting the intertidal zone.

Tidal flats are critical structural components of coastal systems that serve as feeding grounds and refuges for a variety of animals. This constantly changing system provides essential fish habitat as; 1) nursery grounds for early stages of development of many benthically oriented estuarine dependent species. 2) refuges and feeding grounds for a variety of forage species of fishes 3) feeding grounds for a variety of specialized predators.

Palustrine Emergent and Forested

Palustrine emergent systems include tidal and non-tidal marshes. A large amount of the energy present in the palustrine emergent vegetation may be exported out of the system. Tidal currents, river currents, and wind energy all act to transport organic carbon downstream to the estuary, which is the nursery area for many of the Council-managed species. Migrating consumers, such as larval and juvenile fish and crustaceans, may feed within the habitat and then move on to the estuary or ocean. These links with managed species demonstrate the essential nature of this habitat type. Section 3.1.2.2 describes the ecological value, function and distribution of this essential fish habitat.

Aquatic Beds

Submersed rooted vascular vegetation in tidal fresh- or freshwater portions of estuaries and their tributaries performs the same functions as those described for seagrasses. Specifically, aquatic bed meadows possess the same four attributes: 1) primary productivity; 2) structural complexity; 3) modification of energy regimes and sediment stabilization; and 4) nutrient cycling. The ecological value, function and distribution of this essential fish habitat is described in Section 3.2.2.3.

Estaurine Water Column

This habitat traditionally comprises four salinity categories: oligohaline (< 8 ppt), mesohaline (8-18 ppt), and polyhaline waters (18-30 ppt) with some euhaline water (>30 ppt) around inlets. Alternatively, a three-tier salinity classification is presented by Schreiber and Gill (1995) in their prototype document developing approaches for identifying and assessing important fish habitats: tidal fresh (0-0.5 ppt), mixing (0.5-25 ppt), and sewater (>25 ppt). Saline environments have moving boundaries, but are generally maintained by sea water transported through inlets by tide and wind mixing with fresh water supplied by land runoff. Particulate materials settle from these mixing waters and accumulate as bottom sediments. Coarser-grained sediments, saline waters, and migrating organisms are introduced from the ocean, while finer-grained sediments, nutrients, organic matter, and fresh water are input from rivers and tidal creeks. The sea water component stabilizes the system, with its abundant supply of inorganic chemicals and its relatively conservative temperatures. Closer to the sea, rapid changes in variables such as temperature are moderate compared to shallow upstream waters. Without periodic additions of sea water, seasonal thermal extremes would reduce the biological capacity of the water column as well as reduce the recruitment of fauna from the ocean. While nearby wetlands contain some assimilative capacity abating nutrient enrichment, fresh water inflow and tidal flushing are primarily important for circulation and removal of nutrients and wastes from the estuary.

The water column is composed of horizontal and vertical components. Horizontaly, salinity gradients (decreasing landward) strongly influence the distribution of biota, both directly (physiologically) and indirectly (e.g., emergent vegetation distribution). Horizontal gradients of nutrients, decreasing seaward, affect primarily the distribution of phytoplankton and, secondarily, organisms utilizing this primary productivity. Vertically, the water column may be stratified by salinity (fresh water runoff overlaying heavier salt water), oxygen content (lower values at the bottom associated with high biological oxygen demand due to inadequate vertical mixing), and nutrients, pesticides, industrial wastes, and pathogens (build up to abnormal levels near the bottom from lack of vertical mixing).

B. Marine/Offshore Essential Fish Habitat

Marine offshore habitats include live/hard bottom, coral and coral reefs, artificial/manmade reefs, pelagic *Sargassum* and water column habitat. Section 3.2 presents individual detailed descriptions including species use of these habitats.

Live/Hard Bottom Habitat

Major fisheries habitats on the Continental Shelf along the southeastern United States from Cape Hatteras to Cape Canaveral (South Atlantic Bight) can be stratified into five general categories: coastal, open shelf, live/hard bottom, shelf edge, and lower shelf based on type of bottom and water temperature. Each of these habitats harbors a distinct association of demersal fishes (Struhsaker 1969) and invertebrates. The description of this essential fish habitat presented in Section 3.2.1.2, segregates the region into two sections: a) Cape Hatteras to Cape Canaveral; and b) Cape Canaveral to the Dry Tortugas. These regions represent temperate, wide-shelf systems and tropical, narrow-shelf systems, respectively. The zoogeographic break between these regions typically occurs between Cape Canaveral and Jupiter Inlet.

Covered by a vast plain of sand and mud underlain at depths of less than a meter by carbonate sandstone is relatively unattractive to fish. Live/hard bottom, usually found near outcropping shelves of sedimentary rock in the zone from 15 to 35 fathoms and at the shelf break, a zone from about 35 to 100 fathoms where the Continental Shelf adjoins the deep ocean basin and is often characterized by steep cliffs and ledges. The live bottom areas constitute essential habitat for warm-temperate and tropical species of snappers, groupers, and associated fishes including 113 species of reef fish representing 43 families of predominately tropical and subtropical fishes off the coasts of North Carolina and South Carolina.

The distribution of live/hard bottom habitat in the south Atlantic region is presented in the hardbottom maps in Section 3.2. These geographic coverage's are a compilation of the four state bottom mapping effort in the South East Monitoring and Assessment Program (SEAMAP). The Florida Marine Research Institute developed uniform ArcView coverage's of hard bottom habitat (including coral, coral reefs, live/hard bottom, and artificial reefs) as a 1998 SEAMAP program and provided it to the Council for inclusion into the south Atlantic essential fish habitat distribution data base and GIS system.

Coral and Coral Reefs

Coral reef communities or solitary specimens exist throughout the south Atlantic region from nearshore environments to continental slopes and canyons, including the intermediate shelf zones. Habitats supporting corals and coral-associated species are discussed below in groupings based on their physical and ecological characteristics. Dependent upon many variables, corals may dominate a habitat, be a significant component, or be individuals within a community characterized by other fauna. Geologically and ecologically, the range of coral assemblages and habitat types is equally diverse. The coral reefs of shallow warm waters are typically, though not always, built upon coralline rock and support a wide array of hermatypic and ahermatypic corals, finfish, invertebrates, plants, and microorganisms. Hard bottoms and hard banks, found on a wider bathymetric and geographic scale, often possess high species diversity but may lack hermatypic corals, the supporting coralline structure, or some of the associated biota. In deeper waters, large elongate mounds called deepwater banks, hundreds of meters in length, often support a rich fauna compared to adjacent areas. Lastly are communities including solitary corals. This category often lacks a topographic relief as its substrate, but instead may use a sandy bottom, for example. Coral habitats (i.e., habitats to which coral is a significant contributor) are divided into five categories - solitary corals, hard bottoms, deepwater banks, patch reefs, and outer bank reefs. The order of presentation approximates the ranking of habitat complexity based upon species diversity (e.g., zonation, topographic relief, and other factors). Although attempts have been made to generalize the discussion into definable types, it must be noted that the continuum of habitats includes many more than these five distinct varieties.

The ecological value, function and distribution of this essential fish habitat is described in Section 3.2.1.2. The distribution of live/hard bottom habitat in the south Atlantic region is presented in the hardbottom maps in Section 3.2.

Artificial/Manmade Reefs

Manmade reefs are defined for this document as any area within marine waters in which suitable structures or materials have intentionally been placed by man for the purpose of creating, restoring or improving long-term habitat for the eventual exploitation, conservation or preservation of the resulting marine ecosystems naturally established on these sites. Manmade hard bottom habitats are formed when a primary hard substrate is available for the attachment and development of epibenthic assemblages. This substrate is colonized when marine algae and larvae of epibenthic animals successfully settle and thrive. Concurrent with the development of the epibenthic assemblage, demersal reef-dwelling finfish recruit to the new hard bottom habitat. Juvenile life stages will use this habitat for protection from predators, orientation in the water column or on the reef itself and as a feeding area. Adult life stages of demersal reef-dwelling finfish including species managed in the snapper grouper plan, will use the habitat for protection from predation, feeding opportunities, orientation in the water column and on the reef and as spawning sites. Pelagic planktivores occur on hard bottom habitats in high densities and use these habitats for orientation in the water column and feeding opportunities. These species provide important food resources to snapper grouper species and coastal migratory pelagics including king and Spanish mackerel and cobia. The pelagic piscivores use the hard bottom habitats for feeding opportunistically. Most of these species do not take up residence on individual hard bottom outcrops, but will transit through hard bottom areas and feed for varying periods of time.

Manmade hard substrates are considered essential fish habitat in the south Atlantic region because of the use of these habitats by species in the snapper grouper complex, coastal migratory pelagics and prey important to those species. The ecological value, function and distribution of this essential fish habitat is described in Section 3.2.2

The State of Florida Marine Research Institute, as part of the 1998 deliverable, provided the Council with uniform Arc View coverage's for inclusion into the south Atlantic essential fish habitat distribution data base and GIS system.

Sargassum

Pelagic brown algae *Sargassum natans* and *S. fluitans* form a dynamic structural habitat within warm waters of the western North Atlantic. Most pelagic *Sargassum* circulates between 20°N and 40°N latitudes and 30°W longitude and the western edge of the Florida Current/Gulf Stream. The greatest concentrations are found within the North Atlantic Central Gyre in the Sargasso Sea. Large quantities of *Sargassum* frequently occur on the continental shelf off the southeastern United States. Depending on prevailing surface currents, this material may remain on the shelf for extended periods, be entrained into the Gulf Stream, or be cast ashore. During calm conditions *Sargassum* may form large irregular mats or simply be scattered in small clumps. Langmuir circulation, internal waves, and convergence zones along fronts aggregate the algae along with other flotsam into long linear or meandering rows collectively termed "windrows".

Pelagic *Sargassum* supports a diverse assemblage of marine organisms including fungi, micro-and macro-epiphytes, at least 145 species of invertebrates, over 100 species of fishes, four species of sea turtles, and numerous marine birds. The fishes associated with pelagic *Sargassum* in the western North Atlantic include juveniles as well as adults of a wide variety of species. The carangids and balistids are the most conspicuous, being represented by 21 and 15 species respectively. Therefore, this habitat is considered essential fish habitat because it provides protection, feeding opportunity and use as a spawning substrate to species managed by the Council. The ecological value, function and distribution of this essential fish habitat is described in Section 3.2.3.

Additional information is contained in the fishery management plan for pelagic *Sargassum* (SAFMC 1998d).

Water Column

Specific habitats in the water column can best be defined in terms of gradients and discontinuities in temperature, salinity, density, nutrients, light, etc. These "structural" components of the water column environment are not static, but change both in time and space. Therefore, there are numerous potentially distinct water column habitats for a broad array of managed species and life-stages within species.

The discussion of the ecological function of water column habitat and importance to managed species is presented in Section 3.2.3.2.

Description of Coastal Migratory Pelagic Habitat

The habitat of adults in the coastal pelagic management unit, except dolphin, is the coastal waters out to the edge of the continental shelf in the Atlantic Ocean. Within the area, the occurrence of these species is governed by temperature and salinity. All species are seldom found in water temperatures less than 20° C. Salinity preference varies, but these species generally prefer high salinity. The scombrids prefer high salinities, but less than 36 ppt. Salinity prefence of little tunny and cobia is not well defined. The larval habitat of all species in the coastal pelagic management unit is the water column. Within the spawning area, eggs and larvae are concentrated in the surface waters.

Estuaries are important habitats for most prey species of coastal pelagics. For this reason, estuarine habitats and factors which affect them should be considered as part of the coastal pelagic management unit. All the coastal pelagic species, move from one area to another and seek prey whatever local resources happen to be abundant. Many of the prey species of the coastal pelagics are estuarine-dependant in that they spend all or a portion of their lives in estuaries. Accordingly, the coastal pelagic species, by virtue of their food source, are to some degree also dependant upon estuaries and, therefore, can be expected to be detrimentally affected if the productive capabilities of estuaries are greatly degraded.

Spatial and Temporal Distribution and Relative Abundance of Spanish Mackerel in Estuarine Habitat

NOAA's Estuarine Living Marine Resource Program (ELMR), through a joint effort of National Ocean Service and NMFS, conducts regional compilations of information on the use of estuarine habitat by select marine fish and invertebrates. A report prepared through the ELMR program (NOAA 1991b) and revised information (NOAA 1998), provided the Council during the Habitat Plan development process, present known spatial and temporal distribution and relative abundance of fish and invertebrates using southeast estuarine habitats. Twenty southeast estuaries selected from the National Estuarine Inventory (NOAA 1985) are included in the analysis which resulted from a review of published and unpublished literature and personal consultations. The resultant information emphasizes the importance and essential nature of estuarine habitat to all life stages of spanish mackerel.

Regional salinity and relative abundance maps for use in determining EFH for two estuarine dependant coastal migratory pelagic species included in the data, Spanish mackerel and Cobia. These map coverages were prepared for the Council by NOAA SEA Division (Appendix F). Figures 43-46 present a representative sample of the distibution maps for juvenile Spanish mackerel. The remainder of the coverages and additional information on species and habitat distribution are available over the Internet on the Council web page under the habitat homepage (www.safmc.noaa.gov). These maps portray salinity and species relative abundances for estuaries and coastal embayments on state and/or regional maps. Depending on data availability, maps were produced at various scales: 1:24K, 1:80K, and 1:250K. For species relative abundances, these maps were developed only for juveniles of estuarine species (Nelson et al. 1991) showing the highest juvenile relative abundance in any salinity zone by season for each estuary. These maps will eventually be provided to the Council as ArcView shape files with associated data for inclusion into the Council's GIS system.

4.4 The Effects of Fishing Gear on the Ecosystem and Prior Council Action

Pursuant the guidelines implementing the essential fish habitat provisions of the Magnuson-Stevens Act, conservation and enhancement measures implemented by the Council may include ones that eliminate or minimize physical, chemical, or biological alterations of the substrate, and loss of, or injury to, benthic organisms, prey species and their habitat, and other components of the ecosystem. The Council has implemented restrictions on fisheries to the extent that no significant activities were identified in the review of gear impact conducted for the NMFS by Auster and Langton (1998) that presented available information on adverse effects of all fishing equipment types used in waters described as EFH. The Council has already prevented, mitigated, or minimized most adverse effects from most fisheries prosecuted in the South Atlantic EEZ.

The Council considered evidence that some fishing practices are having an identifiable adverse effect on habitat, and addressed these in the comprehensive habitat amendment. The Council has already used many of the options recommended in the essential fish habitat guidelines for managing adverse effects from fishing including: fishing equipment restrictions; seasonal and aerial restrictions on the use of specified equipment; equipment modifications to allow the escape of particular species or particular life stages (e.g., juveniles); prohibitions on the use of explosives and chemicals; prohibitions on anchoring or setting equipment in sensitive areas; prohibitions on fishing activities that cause significant physical damage in EFH; time/area closures including closing areas to all fishing or specific equipment types during spawning, migration, foraging, and nursery activities; designating zones for use as marine protected areas to limit adverse effects of fishing practices on certain vulnerable or rare areas/species/life history stages, such as those areas designated as habitat areas of particular concern; and harvest limits.

More specifically, the Council has protected habitat essential to managed species by regulating fisheries to reduce or eliminate the direct or indirect impacts of fishing. With the implementation of the Coral Fishery Management Plan and subsequent amendments to that plan, the Council has protected coral, coral reefs, and live/hard bottom habitat in the south Atlantic region by establishing an optimum yield of zero and prohibiting all harvest or possession of these resources which serve as essential fish habitat to many managed species. Another measure adopted by the Council and implemented through the coral plan was the designation of the Oculina Bank Habitat Area of Particular Concern, a unique and fragile deepwater coral habitat off southeast Florida that is protected from all bottom tending fishing gear damage. The Council has also prohibited the use of the following gears in the snapper grouper fishery management plan to protect habitat: bottom longlines in the EEZ inside of 50 fathoms or anywhere south of St. Lucie Inlet Florida, fish traps, bottom tending (roller-rig) trawls on live bottom habitat, and entanglement gear. Also established under the snapper grouper plan is an Experimental Closed Area (experimental marine reserve) where the harvest or possession of all species in the snapper grouper complex is prohibited. Other actions taken by the Council that directly or indirectly protect habitat or ecosystem integrity include: the prohibition of rock shrimp trawling in a designated area around the Oculina Bank, mandatory use of bycatch reduction devices in the penaeid shrimp fishery, a prohibition of the use of drift gill nets in the coastal migratory pelagic fishery; and a mechanism that provides for the concurrent closure of the EEZ to penaeid shrimping if environmental conditions in state waters are such that the overwintering spawning stock is severely depleted.

4.5 Endangered Species and Marine Mammal Acts

The Sustainable Fisheries Act of 1996 established certain requirements and standards the Councils and the Secretary must meet in managing fisheries under the Magnuson-Stevens Act. Implementing the provisions in the SFA will not have any negative impacts on the listed and protected species under the Endangered Species Act (ESA) and Marine Mammals Protection Act (MMPA) including:

	Whales:	Date Listed
(1)	Northern right whale- *Eubalaena glacialis* (ENDANGERED)	12/2/70
(2)	Humpback whale- *Magaptera novaeangliae* (ENDANGERED)	12/2/70
(3)	Fin whale- *Balaenoptera physalus* (ENDANGERED)	12/2/70
(4)	Sei whale- *Balaenoptera borealis* (ENDANGERED)	12/2/70
(5)	Sperm whale- *Physeter macrocephalus* (ENDANGERED)	12/2/70
(6)	Blue whale- *Balaenoptera musculus* (ENDANGERED)	

	Sea Turtles:	Date Listed
(1)	Kemp's ridley turtle- *Lepidochelys kempii* (ENDANGERED)	12/2/70
(2)	Leatherback turtle- *Dermochelys coriacea* (ENDANGERED)	6/2/70
(3)	Hawksbill turtle- *Eretmochelys imbricata* (ENDANGERED)	6/2/70
(4)	Green turtle- *Chelonia mydas* (THREATENED/ENDANGERED)	7/28/78
(5)	Loggerhead turtle- *Caretta caretta* (THREATENED)	7/28/78

	Other Species Under U.S. Fish and Wildlife Service Jurisdiction:	Date Listed
(1)	West Indian manatee- *Trichechus manatus* (ENDANGERED)	3/67
	(Critical Habitat Designated)	1976
(2)	American crocodile - *Crocodulus acutus* (ENDANGERED)	9/75
	(Critical Habitat Designated)	12/79

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Jerry Ault	Doug Gregory
Jerry Scott (designee for Joe Powers)	Robert Muller
Robert Muller	William Patterson
William Patterson	Joe Powers
	Joe Shepard

6.0 REFERENCES

Adams, J. A. 1960. A contribution to the biology and post-larval development of the *Sargassum* fish, *Histrio histrio* (Linnaeus), with a discussion of the *Sargassum* complex. Bull. Mar. Sci. 10:55-82.

GMFMC and SAFMC. 1985. Final Amendment 1 to the Fishery Management Plan and Final Environmental Impact Statement, for the Coastal Migratory Pelagic Resources (Mackerels). Prepared by the Gulf of Mexico and South Atlantic Fishery Management Councils, April 1985. Available from: SAFMC, 1 Southpark Circle, Suite 306, Charleston, South Carolina 29407-4699.

SAFMC. 1998a. Framework Seasonal Adjusmtne of Harvest Levels and Procedures under the Fishery Management Plan for the Coastal Migratory Pelagic Resources (Mackerels) in the Gulf of Mexico and South Atlantic Region (Including Regulatory Impact Review, Social Impact Assessment/Fishery Impact Statement and Environmental Assessment). Prepared by the South Atlantic Fishery Management Council, August 1998. Available from: SAFMC, 1 Southpark Circle, Suite 306, Charleston, South Carolina 29407-4699.

7.0 APPENDICES

Appendix A. Results of Literature Search

Scomberomorus cavella

TI: Title
A multispecies stock assessment of a pelagic coastal fishery of the south-west Gulf of Mexico.
AU: Author
Arreguin-Sanchez, F; Chavez, EA; Menchaca, JA
AF: Author Affiliation
Cent. Invest. y de Estud. Avanzados del IPN, Km 6 Carreterra Antigua a Progreso, AP 73-Cordemex 97310, Merida, Yucatan, Mexico
SO: Source
AQUACULT. FISH. MANAGE., vol. 23, no. 1, pp. 103-112, 1992
AB: Abstract
Multispecies stock assessment based upon Schaefer's theory was applied to a coastal pelagic fishery (Spanish mackerel, Scomberomorus maculatus ; king mackerel, S. cavalla and the blue runner, Caranx fusus , from the west central Gulf of Mexico. Linear and non-linear systems of equations were estimated by using a multiple stepwise regression technique. The values of interaction parameters show a clear competition between mackerels, and technological interdependences between the blue runner and mackerels. The maximum yield estimation was from 4000 to 5000 tonnes, obtained with 23 and 34 beach seines respectively, depending on the applied model. Two stages were observed from the statistical records; in the first the Spanish mackerel is the most important species while in the second the abundance of this species declines and the others remain at the same level. Significant interactions were found from the first data group.

TI: Title
Population dynamics of the king mackerel (Scomberomorus cavalla) of the Campeche Bank, Mexico
AU: Author
Arreguin-Sanchez, F; Cabrera, MA; Aguilar, FA
AF: Author Affiliation
Cent. Interdiscip. Cienc. Mar. IPN, CICIMAR, Ap. P. 592, 23000 La Paz, Baja California Sur, Mexico
CF: Conference
Int. Symp. on Middle-Sized Pelagic Fish, Las Palmas de Gran Canaria, Gran Canaria, Canary Islands (Spain), 24-28 Jan 1994
ED: Editor
Bas, C; Castro, JJ; Lorenzo, JM (eds)
SO: Source
INTERNATIONAL SYMPOSIUM ON MIDDLE-SIZED PELAGIC FISH HELD IN LAS

PALMAS DE GRAN CANARIA 24-28 JANUARY 1994., 1995, pp. 637-645,
Scientia Marina (Barcelona) [SCI. MAR. (BARC.)], vol. 59, no. 3-4

IS: ISSN
0214-8358

AB: Abstract

The king mackerel (Scomberomorus cavalla) is a migratory pelagic resource which is caught along the coasts of the Gulf of Mexico, where some hypothesis suggest the existence of at least two stocks. In this contribution, the population dynamics of the Campeche Bank stock is analyzed. It is a small scale fishery with limited access to the whole population. Several locations along the coast were sampled around the Peninsula of Yucatan. Size structure of catches indicates a spatial gradient with large fishes found on the northeastern coast of the Yucatan Peninsula, and smaller ones on the southern Gulf of Mexico. This behavior is associated with environmental factors; the southern region, with fluvial influence, probably acting as a nursery area; while in the northeastern region the population dynamics is in syncrony with a seasonal upwelling. The average population parameters estimated were as follows: growth parameters of the von Bertalanffy equation: L sub(arrow left) = 140 cm; K = 0.19 (1/year), and tz = 0.54 years. Total mortality was estimated as Z = 2.16, and natural mortality was estimated to be M = 0.4.
Length-structured-VPA was applied in order to estimate fishing mortality by size, which was more intensive on fishes ranging 60 cm to 80 cm; however, for Campeche, the small length at first catch (Lc) imposes large fishing mortalities on small sizes, and an increment to the Lc was recommended. The Thompson and Bell method suggests the stock is being exploited at the maximum biological production level. Results are discussed within the framework of ecological behavior, stock identity and fish accessibility. The emerging hypothesis is that a well defined stock occurs in the Campeche Bank, with a certain degree of mixing with other stocks from the Northern Gulf of Mexico.

TI: Title
Mackerel workshop report

AU: Author
Austin,C.B.; Browder,J.A.; Brugger,R.D.; Davis,J.C. (eds.)

CA: Corporate Author
Miami Univ., FL (USA). Rosenstiel School of Marine and Atmospheric Science

CF: Conference
Mackerel workshop, Miami, FL (USA), 28 Apr 1977

SO: Source
Sea Grant Spec. Rep. Miami Univ

NT: Notes

Workshop sponsored by US National Marine Fisheries Service, Southeastern Fisheries Center, contract No. 03-6-042-35137

ER: Environmental Regime

Marine

AB: Abstract

The workshops were sponsored by the Southeast Region, National Marine Fisheries Service and were planned to derive descriptive and quantitative socio-economic information for systems modeling. Besides selecting fisheries and participants and arranging logistic support for the workshops, the primary effort of the staff was the preparation of background papers. The information that was assimilated from the literature search and the field trips was brought together into separate croaker and mackerel workshop background papers which provided a starting point for workshops discussions. The croaker workshop was conducted 31 March and 1 April 1977 at the University of Miami's Rosenstiel School of Marine and Atmospheric Science on Virginia Key, Miami, Florida. The mackerel workshop was conducted 28-29 April 1977 at the National Marine Fisheries Service Southeast Fishery Center on Virginia Key, Miami, Florida. this is the workshop's final report on mackerels.

TI: Title

Age and Growth of King Mackerel, Scomberomorus cavalla (Cuvier) of Northeastern Brazil.

OT: Original Title

Edade e Crecimiento da Cavala, Scombermorus cavalla (Cuvier), No Estado do Ceara (Brasil)

AU: Author

Carneiro Ximenes, MO; Ferreira De Menezes, M; Fonteles-Filho, AA

AF: Author Affiliation

Univ. Fed. Ceara, Lab. Cienc. Mar, Fortaleza, Brazil

SO: Source

Arquivos de ciencias do mar. Fortaleza [ARQ. CIENC. MAR.], vol. 18, no. 1/2, pp. 73-81, 1978

IS: ISSN

0041-8854

AB: Abstract

In this paper an analysis is made of the length and age data for king mackerel, Scomberomorous cavalla , with the objective of calculating its growth curves in length and weight and, at the same time, drawing comparisons with previous results obtained for northeastern Brazil in 1966 and for Florida State, in 1973. The data refers to the period from August, 1976 through May, 1978, sampled off Ceara State around positions 3 degree 53'S, 38 degree 21'W and 2 degree 05'S, 40 degree 02'W. The growth curves in length (cm) and weight (g) are given.

TI: Title
Optimizing yields of the king mackerel (Scomberomorus cavalla) fishery in the western and southern Gulf of Mexico
AU: Author
Chavez, EA; Arreguin-Sanchez, F
AF: Author Affiliation
CICIMAR, A.P. 592 La Paz, B.C.S., Mexico
CF: Conference
Int. Symp. on Middle-Sized Pelagic Fish, Las Palmas de Gran Canaria, Gran Canaria, Canary Islands (Spain), 24-28 Jan 1994
ED: Editor
Bas, C; Castro, JJ; Lorenzo, JM (eds)
SO: Source
INTERNATIONAL SYMPOSIUM ON MIDDLE-SIZED PELAGIC FISH HELD IN LAS PALMAS DE GRAN CANARIA 24-28 JANUARY 1994., 1995, pp. 629-636, Scientia Marina (Barcelona) [SCI. MAR. (BARC.)], vol. 59, no. 3-4
IS: ISSN
0214-8358
AB: Abstract
The concept of optimum yield is applied to an age structured simulation model of the Scomberomorus cavalla (Mitchill) fishery in the western and southern Gulf of Mexico. Current yearly catch amounts to 2,600 tonnes and is part of a beach seine multispecies fishery yielding more than 10,000 tonnes annually. Cohort sizes and population parameter changes (fishing mortality and recruit numbers) were analyzed throughout a 39-year period. As a result of recruitment pattern, it was found that optimum yield can be attained when fishing mortality is $F = 0.4$, regardless of the population size. Hypothesizing that the stock fished along the Mexican coasts is independent from others of the same species caught elsewhere, it is concluded that the fishery has been overexploited since 1979. Yields obtained after simulations of the fishery applying several fishing intensities lead to the conclusion that the optimum yield level of about 3,000 tonnes could be achieved in the long term if the former fishing mortality value is applied, but this would imply a reduction of fishing effort to about 40 per cent below the current level.

TI: Title
Larval king mackerel (Scomberomorus cavalla), Spanish mackerel (S. maculatus), and bluefish (Pomatomus saltatrix) off the southeast coast of the United States, 1973-1980.
AU: Author
Collins, MR; Stender, BW
SO: Source
Bulletin of Marine Science [BULL. MAR. SCI.], vol. 41, no. 3, pp. 822-834, 1987

IS: ISSN
0007-4977

AB: Abstract
Surface and subsurface ichthyoplankton collections were made from 9 m to beyond the continental shelf (deepest station 3,940 m) in all seasons from Cape Hatteras, North Carolina to Cape Canaveral, Florida. King mackerel (Scomberomorus cavalla) spawn from April to at least September, primarily at depths > 40 m. Spring spawning activity takes place further offshore than does summer spawning. Spanish mackerel (S. maculatus) spawn from May to September in depths < 40 m. Larvae were less abundant than those of king mackerel, and no areas of concentration were found. Vertical migration to the surface at night is indicated for both king and Spanish mackerels. Bluefish (Pomatomus saltatrix) spawn bimodally from March through at least November in depths > 40 m, with the primary spawning peak in spring and the secondary peak in late summer.

TI: Title
Occurrence of young-of-the-year king, Scomberomorus cavalla , and Spanish, S. maculatus , mackerels in commercial-type shrimp trawls along the Atlantic coast of the Southeast United States.

AU: Author
Collins, MR; Wenner, CA

AF: Author Affiliation
S.C. Wildl. and Mar. Resour. Dep., P.O. Box 12559, Charleston, SC 29412, USA

SO: Source
Fishery Bulletin [FISH. BULL.], vol. 86, no. 2, pp. 394-397, 1988

IS: ISSN
0090-0656

AB: Abstract
King mackerel, Scomberomorus cavalla and Spanish mackerel, S. maculatus , are migratory scombrids that support large recreational and commercial fisheries along the southeast coast of the United States. Recent evidence indicates that both species may be overexploited in portions of thier range, prompting the South Atlantic Fishery Management Council to impose catch limits and landing quotas. Little is known concerning the distribution and occurrence of juvenile (young-of-the-year) mackerels along the Atlantic coast of the southeastern United States, nor does it seem to be widely known that large numbers of these young fishes may be included in the bycatch of a major fishery. This report provides preliminary information on both of these topics.

TI: Title

Fishery-independent recruitment indices for king and Spanish mackerels

AU: Author

Collins, MR; Harris, PJ; Maier, PP

AF: Author Affiliation

South Carolina Department of Natural Resources, Marine Resources Research Institute, Post Office Box 12559, Charleston, SC 29422-2559, USA

SO: Source

North American Journal of Fisheries Management [N. Am. J. Fish. Manage.], vol. 18, no. 1, pp. 181-186, Feb 1998

IS: ISSN

0275-5947

AB: Abstract

We investigated whether the abundance of age-0 mackerels in a fishery-independent trawl survey could be used to predict abundance at age 1 for king mackerel Scomberomorus cavalla and Spanish mackerel S. maculatus. After deletion of inappropriate length-classes and partitioning by season, depth, and stratum, subsets of the data set were compared to landings data and stock assessment results from the National Marine Fisheries Service. Total landings of age-1 Spanish mackerel were closely predicted (r super(2) = 0.91) by catch per unit effort (CPUE) of age-0 fish 11-28 cm in fork length (FL) in samples taken by the Southeast Area Monitoring and Assessment Program-South Atlantic (SEAMAP-SA) during fall from shallow strata in the coastal waters of Georgia and South Carolina (latitudes 30 degree 44'-33 degree 12'N; SEAMAP-SA odd strata 31-49). The best predictor (r super(2) = 0.72) for age-1 king mackerel was CPUE of age-0 fish 9-30 cm FL in SEAMAP-SA's fall samples from shallow strata in the coastal waters of South Carolina and North Carolina (32 degree 04'-35 degree 15'N; SEAMAP-SA odd strata 41-67) collected the previous year. The indices should be used with caution until data from additional years become available for verification and incorporation.

TI: Title

Age, growth, and reproduction of the king mackerel Scomberomorus cavalla (Cuvier) in Trinidad waters.

AU: Author

de L. Sturm, MG; Salter, P

AF: Author Affiliation

Inst. Mar. Aff., P.O. Box 3160, Carenage Post Off., Trinidad

SO: Source

Fishery Bulletin [FISH. BULL.], vol. 88, no. 2, pp. 361-370, 1990

IS: ISSN

0090-0656

AB: Abstract

A study was made of age, growth, and reproduction of the king mackerel Scomberomorus cavalla in Trinidad waters captured by hook-and-line and drift gillnets. Ages, estimated from otolith rings, ranged from 0 to VII in males and from 0 to X in females. Based on gonad examination of 97 males and 224 females, spawning takes place throughout the year around the island, with peak spawning from October through March, a period associated with low salinity. First spawning takes place at ages I-II for both sexes. Females predominated in all size groups, with the proportion of males increasing during the peak spawning season.

TI: Title
Food of king mackerel, Scomberomorus cavalla , in Onslow Bay, North Carolina
AU: Author
DeVane,J.C.,Jr.
AF: Author Affiliation
Natl. Mar. Fish. Serv., Southeast Fish. Cent., Beafort Lab., Beaufort, NC 28516, USA
SO: Source
Trans. Am. Fish. Soc., 107(4), 583-586, (1978)
ER: Environmental Regime
Marine

AB: Abstract
The stomachs of 205 Scomberomorus cavalla collected in Onslow Bay, North Carolina were examined for food items. The stomach contents of the 113 stomachs containing food were composed mainly of fish. The dominant fishes were Atlantic menhaden, Brevoortia tyrannus (35% occurrence) and Atlantic thread herring, Opisthonema oglinum (28% occurrence). Other fishes and invertebrates ranked from 14% to less than 1% in occurrence. Atlantic menhaden and Atlantic thread herring were primarily dominant in the stomachs of king mackerel collected during the spring and summer months. Those collected during the fall months had ingested a wider variety of forage with Atlantic menhaden and Atlantic thread herring being of minor importance.

TI: Title
Age and growth of king and Spanish mackerel larvae and juveniles from the Gulf of Mexico and U.S. South Atlantic Bight.
AU: Author
De Vries, DA; Grimes, CB; Lang, KL; White, D
AF: Author Affiliation
NMFS, Southeast Fish. Cent., 3500 Delwood Beach Rd., Panama City, FL 32407-7499, USA
SO: Source
Environmental biology of fishes. The Hague [ENVIRON. BIOL. FISH.],

vol. 29, no. 2, pp. 135-143, 1990
IS: ISSN
0378-1909

AB: Abstract
Sagtittal otoliths from 50 king mackerel (Scomberomorus cavalla) 2.9-13.0 mm SL and 72 Spanish mackerel (Scomberomorus maculatus) 2.8-22.0 mm SL collected off the southeast U.S. were examined whole at 400 x using a compound microscope-video system. Otoliths of both species had visible, presumably daily, growth increments as well as finer subdaily increments. Otolith growth was directly proportional to growth in standard length for king (r super(2) = 0.91) and Spanish mackerel (r super(2) = 0.86). Spanish mackerel were estimated to be 3-15 d old with a mean absolute growth rate (SL/number of growth increments) and 95% confidence interval of 1.15 plus or minus 0.07 mm/d. The least squares linear equation: SL = - 1.30 + 1.31 (age in days), with r super(2) = 0.67 and p > 0.001, described the relationship between length and age. There was a significant positive relationship between absolute growth rate and fish length. King mackerel were estimated to be 3-15 d old with a mean absolute growth rate of 0.89 plus or minus 0.06 mm/d. Growth rate of king mackerel was slightly higher for fish from the Mississippi River plume than from all other locations combined, while Spanish mackerel growth rates were not significantly different.

TI: Title
Spatial and temporal variation in age and growth of king mackerel, Scomberomorus cavalla, 1977-1992

AU: Author
DeVries, DA; Grimes, CB
AF: Author Affiliation
Panama City Lab., Southeast Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 3500 Delwood Beach Rd., Panama City, FL 32408, USA

SO: Source
Fishery Bulletin [FISH. BULL.], vol. 95, no. 4, pp. 694-708, Oct 1997
IS: ISSN
0090-0656

AB: Abstract
A total of 12,180 king mackerel, Scomberomorus cavalla, collected from 1986 to 1992 from North Carolina to Yucatan, Mexico, and 2,033 collected in 1977 and 1978 from North Carolina to Texas were aged with whole or sectioned sagittal otoliths. Data were analyzed by region - Atlantic Ocean, eastern Gulf of Mexico, and western Gulf - reflecting the currently recognized stocks. Maximum sizes of females aged were 152, 158, and 147 cm FL in the Atlantic, eastern Gulf, and western Gulf, whereas the largest males were

121, 127, and 117 cm FL in those same regions. Maximum ages from the 1986-92 fish were 26, 21, and 24 yr for females and 24, 22, and 23 yr for males in the Atlantic, eastern Gulf, and western Gulf, respectively. Females grew faster and larger than males at every age in each region. A very consistent pattern of greatest growth in the eastern Gulf, intermediate in the western Gulf, and least in the Atlantic was present each year during 1986-92, most noticeably among females. During 1977-78, Atlantic females also had distinctly lower growth than Gulf fish. These consistent regional differences support the current hypothesis that there are three stocks as suggested by previous analyses of other types of data. Within a region and sex, growth was lower in 1977-78 than in 1986-92 in both the Atlantic and eastern Gulf, but higher for western Gulf females.

TI: Title
Possible Temperature Effects on Charter Boat Catches of King Mackerel and Other Coastal Pelagic Species in Northwest Florida.
AU: Author
Fable, WA Jr; Brusher, HA; Trent, L; Finnegan, J Jr
AF: Author Affiliation
Panama City Lab., SE Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 3500 Delwood Beach Rd., Panama City, FL 32407, USA
SO: Source
Marine Fisheries Review [MAR. FISH. REV.], vol. 43, no. 8, pp. 21-26, 1981
IS: ISSN
0090-1830
AB: Abstract
Dramatic changes occurred in the landings, species composition, and sizes of fishes caught in the charter boat fishery for pelagic fishes in northwest Florida in the summers of 1977 and 1978. These changes occurred after two of the coldest winters in 100 years. Catch per hour (CPH) of king mackerel (Scomberomorus cavalla) the target species, declined greatly, while CPH of Atlantic bonito and bluefish increased. Data indicated that warm winters resulted in high CPH, while cool winters resulted in low CPH. The authors concluded that catch rates of king mackerel were related to temperatures of the preceding winter.

TI: Title
Movements of king mackerel, Scomberomorus cavalla , tagged in Southeast Louisiana, 1983-85.
AU: Author
Fable, WA Jr; Trent, L; Bane, GW; Ellsworth, SW
AF: Author Affiliation

Panama City Lab., Southeast Fish. Cent., NMFS, NOAA, 3500 Delwood Beach Rd., Panama City, FL 32407, USA

SO: Source

Marine Fisheries Review [MAR. FISH. REV.], vol. 49, no. 2, pp. 98-101, 1987

IS: ISSN

0090-1830

NT: Notes

Special issue: Marine recreational fisheries and fishing.

AB: Abstract

King mackerel, Scomberomorus cavalla (1,968) caught by hook and line off Grand Isle, Louisiana, were tagged with internal anchor tags and released between 1983 and 1985. Fifty-five tags were recovered, providing an overall return rate of 2.8 percent. King mackerel tagged in winter were returned in every month of the year, but always from the Grand Isle area or westward as far as Veracruz, Mexico. All but one summer-tagged fish were returned in winter months from the Grand Isle area, Key West, Florida, or from Mexico. Winter-tagged fish were mostly large and mostly remained in the northwest Gulf. Summer-tagged fish tended to stay in the northwest Gulf if they they were large, or migrated to south Florida or Mexico if they were small. The data indicate that the northwest Gulf maintains resident large king mackerel year round, and that these fish mix with smaller migrants from south Florida and Mexico to some degree in warmer months.

TI: Title

King mackerel tagging and stock assessment study

CA: Corporate Author

Florida Department of Natural Resources, Tallahassee (USA)

SO: Source

Compl. Rep. Fla. Dep. Nat. Resour

ER: Environmental Regime

Marine

AB: Abstract

A data summary of work performed for a king mackerel (Scomberomorus cavalla) tagging and stock assessment project is presented. During the 45 months of the project, a total of 13,253 king mackerel were tagged to determine migration routes, growth rates, and mortality rates. During the four winters from 1975 to 1978, most tagging was conducted on the Atlantic Coast between Cape Canaveral and Ft. Pierce; tagging was also conducted off Key West during the winters of 1977 and 1978. During each spring from 1975 to 1978, tagging was concentrated in the area of Boynton Beach, Florida. Tagging was conducted a single time off Jacksonville, Islamorada, and Naples, Florida as well as Port Aransas, Texas and Beaufort, North Carolina. By 30 September 1978, 779 tags had been returned. Tags were returned

from as far north as Chincoteague, Virginia and as far west and south as Veracruz, Mexico. These two locations are about 2800 nautical miles apart.

TI: Title
Reproductive biology of king mackerel, Scomberomorus cavalla , from the southeastern United States.
AU: Author
Finucane, JH; Collins, LA; Brusher, HA; Saloman, CH
AF: Author Affiliation
Southeast Fish. Cent., Panama City Lab., NMFS, NOAA, 3500 Delwood Beach Rd., Panama City, FL 32407, USA
SO: Source
Fishery Bulletin [FISH. BULL.], vol. 84, no. 4, pp. 841-850, 1986
IS: ISSN
0090-0656
AB: Abstract
The reproductive biology of king mackerel, Scomberomorus cavalla , was studied from specimens collected off Texas, Louisiana, and northwest Florida in the Gulf of Mexico and off North and South Carolina in the Atlantic Ocean. Gonads were examined from 1,163 females and 595 males obtained in 1977-78. Spawning was prolonged. Most king mackerel were reproductively active from May through September. A few fish were in spawning condition as early as April and as late as October. All females were mature at 850-899 mm fork length (FL). Estimates of fecundity ranged from about 69,000 to 12,207,000 eggs for fish from 446 to 1,489 mm FL, 618 to 25,610 g total weight (TW), and 1 to 13 years of age. Fecundity (F) was usually significantly correlated with FL, TW, and age in each area but TW was the best predictor of fecundity in all areas combined (F = 1.854 x 10 super(1) (TW) super(1.361)) with r super(2) = 0.856.

TI: Title
Diets of young king and Spanish mackerel off the southeast United States.
AU: Author
Finucane, JH; Grimes, CB; Naughton, SP
AF: Author Affiliation
Southeast Fish. Cent., NMFS/NOAA, Panama City Lab., 3500 Delwood Beach Rd., Panama City, FL 32408-7499, USA
SO: Source
NORTHEAST GULF SCI., vol. 11, no. 2, pp. 145-153, 1990
AB: Abstract
The diet of larval and post-larval (n = 95 and 307), and juvenile (n = 489 and 508) king (Scomberomorus cavalla) and Spanish mackerel (S. maculatus) from the Gulf of Mexico and southeastern

Atlantic coastal waters of the U.S. consisted principally of fishes. Carangids, clupeids, and engraulids occurred in 23, 7 and 9% of larval and post-larval king mackerel stomachs and in 20, 40 and 7% of larval and post-larval Spanish mackerel stomachs, respectively. Sciaenids were also common in king mackerel, occurring in 21% of the stomachs. Prey fishes included the genera Cynoscion, Caranx , and Anchoa , and the species Opisthonema oglinum . Invertebrates, principally small crustaceans and nudibranch larvae, occurred infrequently in the diets of both species, but more so in Spanish mackerel than king mackerel. The dominant prey items for juvenile mackerels from the Atlantic were engraulids, clupeids, balistids, and squids, collectively accounting for 73.3% by volume of the diet of king mackerel and 88.8% of Spanish mackerel.

TI: Title
Synopsis of information on king mackerel, Scomberomorus cavalla (Cuvier) and Spanish mackerel, Scomberomorus brasiliensis Collette, Russo and Zavala-Camin (Pisces: Scombridae), off Ceara State, Brazil.

OT: Original Title
Sinopse de informacoes sobre a cavala, Scomberomorus cavalla (Cuvier) e a serra, Scomberomorus brasiliensis Collette, Russo and Zaval-Camin (Pisces: Scombridae), no estado do Ceara, Brasil

AU: Author
Fonteles-Filho, AA

AF: Author Affiliation
Lab. Cienc. Mar, Univ. Fed. Ceara, Fortaleza, Ceara, Brazil

SO: Source
Arquivos de ciencias do mar. Fortaleza [ARQ. CIENC. MAR.], vol. 27, pp. 21-48, 1988

IS: ISSN
0374-5686

AB: Abstract
A review on the biology, fishery and population dynamics of the king mackerel and of the Spanish mackerel is presented. Average values for length and weight are for king mackerel and Spanish mackerel: 71.8 cm, 2851 g and 53.2 cm, 1208g, respectively. King mackerel's females reach their first sexual maturity at 63 cm and 4 years old while Spanish mackerel females reach it at 41 cm fork length and 2.9 years old. Sex ratio is unbalanced in both species with a predominance of females. Based on data of catch/effort, yield per recruit, and fishing mortality it was concluded that the Spanish mackerel is submitted to a higher fishing intensity perhaps because this species is catched with three different gears.

TI: Title
Spawning season, length and age at first maturity of king mackerel and Spanish mackerel, off Ceara State, northeastern Brazil
OT: Original Title
Epoca de reproducao, tamanho e idade na primeira desova da cavala e da serra, na costa do estado do Ceara (Brasil)
AU: Author
Gesteira,T.C.V.; Mesquita,A.L.L.de
AF: Author Affiliation
Lab. Cienc. Mar, Univ. Fed. Ceara, Fortaleza, Ceara, Brazil
SO: Source
Arq. Cienc. Mar, 16(2), 83-86, (1976)
ER: Environmental Regime
Marine
AB: Abstract
This is an investigation of the size and age at first maturity and the spawning season of king mackerel, Scomberomorus cavalla and Spanish mackerel, Scomberomorus maculatus off Ceara State, Brazil. King mackerel's females reach their first sexual maturity at a fork length of 63.0 cm or 4 years of age. Spanish mackerel's females reach their first sexual maturity at a fork length of 4.10 cm or 2.9 years of age. The spawning of both species was found to be total and to take place twice a year. The spawning season of king mackerel spans the period from October to March, with a more intense reproduction in March and November. The spawning season of Spanish mackerel ranges from September to March, with higher reproduction activity in September.

TI: Title
Heavy metal content in otoliths of king mackerel (Scomberomorus cavalla) in relation to body length and age.
AU: Author
Grady, JR; Johnson, AG; Sanders, M
AF: Author Affiliation
NOAA/NMFS, Southeast Fish. Cent., Panama City Lab., 3500 Delwood Beach Rd., Panama City, FL 32407-7499, USA
SO: Source
CONTRIB. MAR. SCI., UNIV. TEXAS., vol. 31, pp. 17-23, 1989
AB: Abstract
The maximum concentrations of heavy metals (zinc, cadmium, copper, and lead) in otoliths of king mackerel (Scomberomorus cavalla) were found in very young fish. The apparent decline in content of metals with age and length in king mackerel otoliths most approximated a negative power curve (y = ax super(-b)). The zinc content of otoliths was found to vary significantly between areas in the southeast U.S. and with the age of the fish.

TI: Title
Delineation of king mackerel (Scomberomorus cavalla) stocks along the U.S. East Coast and in the Gulf of Mexico.
AU: Author
Grimes, CB; Johnson, AG; Fable, WA Jr
AF: Author Affiliation
NOAA/NMFS, Southeast Fish. Cent., Panama City, FL 32406, USA
CF: Conference
Stock Identification Workshop, Panama City Beach, FL (USA), 5-7 Nov 1985
ED: Editor
Kumpf, HE (ed)
SO: Source
PROCEEDINGS OF THE STOCK IDENTIFICATION WORKSHOP, NOVEMBER 5-7, 1985, PANAMA CITY BEACH, FLORIDA., 1987, pp. 186-187, NOAA TECH. MEMO.
NT: Notes
Summary only.
NU: Other Numbers
NOAA-TM-NMFS-SEFC199
AB: Abstract
King mackerel (Scomberomorus cavalla) are widely distributed along the U.S. South Atlantic coast and in the Gulf of Mexico where they support both recreational and mixed-gear commercial fisheries. Because catches are landed within the boundaries of 8 states, 2 regional fishery management jurisdictions and Mexico, management of the fisheries is a problem of both regional and international concern. Biochemical (starch-gel electrophoresis) and mark-recapture techniques are being used to evaluate the stock structure of king mackerel. Preliminary results suggest that at least two breeding groups may exist; a western Gulf of Mexico group, and a second group in the eastern Gulf of Mexico and along the Atlantic coast. Tagging data indicate that mixing of the 2 groups may be occurring in the western and northwestern Gulf of Mexico in summer.

TI: Title
Young king mackerel, Scomberomorus cavalla , in the Gulf of Mexico, a summary of the distribution and occurrence of larvae and juveniles, and spawning dates for Mexican juveniles.
AU: Author
Grimes, CB; Finucane, JH; Collins, LA; DeVries, DA
AF: Author Affiliation
Southeast Fish. Cent., Panama City Lab., 3500 Delwood Beach Rd., Panama City, FL 32408, USA
SO: Source
Bulletin of Marine Science [BULL. MAR. SCI.], vol. 46, no. 3, pp.

640-654, 1990
IS: ISSN
0007-4977
AB: Abstract
To further our understanding of recruitment, spawning areas and times and stock structure we summarized all available published and unpublished information on early life stages of king mackerel. New data, 248 larvae and small juveniles (less than or equal to 50 mm SL) from 676 neuston samples (1 x 2 m 0.947 mm and 0.760 mm mesh net) collected between 1983 and 1986 from west Florida (83 degree W long.) and the U.S. Mexican border (26 degree N lat.), are included. Previously unreported data (mostly large juveniles > 50 mm SL) were collected during over 105,000 h of trawling between 1952 and 1985, and from an almadraba (pound net) and shrimp trawls in Mexico in 1985, 1986 and 1987. Sampling effort appropriate for collecting early life stages of king mackerel has been extensive (> 7,200 collections), but heavily concentrated in U.S. waters during warm months (Apr to Oct). Seasonal occurrences of young stages clearly delineate the spawning season in U.S. waters as May to Oct, with a peak in Sep.

TI: Title
The catch of king mackerel and Spanish mackerel in the commercial shrimp fishery of South Carolina
AU: Author
Harris, PJ; Dean, JM
AF: Author Affiliation
Belle W. Baruch Institute for Marine Biology and Coastal Research, University of South Carolina, Columbia, SC 29208, USA
CF: Conference
Symp. on the Consequences and Management of Fisheries Bycatch, Dearborn, MI (USA), 27-28 Aug 1996
SO: Source
FISHERIES BYCATCH: CONSEQUENCES & MANAGEMENT., 1997, pp. 21-29
IB: ISBN
1-56612-048-9
NU: Other Numbers
AK-SG-97-02
AB: Abstract
The shrimp industry is an extremely important fishery in South Carolina (SC), where an average of 2,383 tons of shrimp worth about $11.8 million were landed between 1978 and 1992. An average of 1,043 commercial permits were issued each year (SAFMC 1993). The commercial and recreational fisheries for king mackerel (Scomberomorus cavalla) and Spanish mackerel (Scomberomorus maculatus) are also important fisheries in South Carolina. Juvenile king and Spanish mackerel were known to be taken as

bycatch off SC. Collins and Wenner (1988) documented that tongue nets, which were being increasingly used (Edwards 1987), appeared to catch more king and Spanish mackerel per hour than semiballoon nets. We hypothesized that the mortality of the juvenile king and Spanish mackerel in SC shrimp trawls had a detrimental effect on the Atlantic group adult mackerel populations. We tested this hypothesis by addressing several objectives: (1) to quantify the number of mackerel taken as bycatch, (2) to estimate the statewide bycatch of mackerels, and (3) to include these data in the estimate of the population size of Atlantic king and Spanish mackerel, and test to see if the sizes of the populations were significantly increased.

TI: Title
Characterization of king mackerel and Spanish mackerel bycatches of South Carolina shrimp trawlers
AU: Author
Harris, PJ; Dean, JM
AF: Author Affiliation
South Carolina Marine Resources Division, Post Office Box 12559, Charleston, SC 29422, USA
SO: Source
North American Journal of Fisheries Management [N. Am. J. Fish. Manage.], vol. 18, no. 2, pp. 439-453, May 1998
IS: ISSN
0275-5947
AB: Abstract
Juvenile king mackerel Scomberomorus cavalla and Spanish mackerel S. maculatus are caught by commercial shrimp trawlers in South Carolina. Our study documented the extent and duration of this bycatch during the commercial shrimp trawling season in South Carolina waters. Sampling was conducted onboard commercial shrimp vessels based in McClellanville, South Carolina, during 1991 and on vessels based in McClellanville, Charleston, and Beaufort in 1992. Eight vessels and 137 trawl tows (mean tow duration, 2.88 h) were sampled; 81 king and 257 Spanish mackerel were collected. The mean annual sample catch per unit effort (CPUE) of king mackerel was 0.244 fish/h; adjusted for trawl footrope length in meters, the mean annual total CPUE was 0.038 fish/(h times m). King mackerel were found in only 21% of the tow samples, and peak catches occurred in October 1991 and September 1992. The mean annual sample CPUE for Spanish mackerel was 0.701 fish/h, and the mean annual total CPUE was 0.109 fish/(h times m). Spanish mackerel were found in 41% of the tow samples, and peak catches occurred in July of both years. Age-0 king mackerel are vulnerable to shrimping gear for at least half of the South Carolina shrimp season, which generally runs from May through December, and age-0

Spanish mackerel are vulnerable for most of the shrimping season.

TI: Title
An analysis of management policies for reducing shrimp by-catch in the Gulf of Mexico
AU: Author
Hendrickson, HM; Griffin, WL
AF: Author Affiliation
Dep. Agricult. Econ., Texas A&M Univ., College Stn., TX 77843-2124, USA
SO: Source
North American Journal of Fisheries Management [N. AM. J. FISH. MANAGE.], vol. 13, no. 4, pp. 686-697, 1993
IS: ISSN
0275-5947
AB: Abstract
Every year the Gulf of Mexico shrimp fleet catches and discards millions of pounds of finfish. Dwindling populations of some commercially and recreationally valuable fish species have raised concern over the effects of shrimp by-catch on fish stocks. The general bioeconomic fisheries simulation model was used to estimate the changes in economic rent and by-catch of red snapper Lutjanus campechanus, king mackerel Scomberomorus cavalla, and Atlantic croaker Micropogonias undulatus that would result under two fishery management policies: by-catch reduction devices (BRDs) and season-area closures. The BRDs were found to be more effective than closures at reducing by-catch and also less costly to shrimpers. Under the BRD scenarios, red snapper discards were reduced 20.2-42.5%, king mackerel discards fell approximately 89%, and Atlantic croaker discards fell about 45%. Under closure policies, the change in discards was a 2.1-15.0% decline for red snapper, a 1.9% increase a 39.3% decrease for king mackerel, and a 0.1-12.9% decline for Atlantic croaker. The BRD policies produced present-value 10-year rent streams (1985 US$) ranging from -$16.434 to -$27.007 million, and closure policies generated 10 year rent streams ranging from -$35.182 to -$54.561 million.

TI: Title
Stock assessment parameters for carite (Scomberomorus brasiliensis kingfish (S. cavalla) and several species of shark
AU: Author
Henry, C; Martin, L
CA: Corporate Author
FAO/UNDP Proj. for the Establ. of Data Collection Syst. and Assessment Programme, Port of Spain (Trinidad)
SO: Source
FAO, PORT OF SPAIN (TRINIDAD), 1992, 29 pp

PB: Publisher
FAO, PORT OF SPAIN (TRINIDAD)
NU: Other Numbers
FAO/UNDP-TRI/91/001/TR2
AB: Abstract
This is a tabular presentation of fisheries biological parameters for stock assessment purposes from existing literature for the Spanish Mackerel Scomberomorus brasiliensis (locally called 'carite'), the king mackerel S. cavalla (locally called 'kingfish') and each of five species of sharks (Carcharhinus limbatus, C. porosus, Rhizoprionodon lalandii, Sphyrna lewini and S. tudes). Carite is the target species of the gill net fishery in Trinidad. The other species are the most important components of the associated catch, which includes up to 30 species.

TI: Title
Preliminary report on the age and growth of king mackerel (Scomberomorus cavalla) from the United States
AU: Author
Johnson,A.G.; Fable,W.A.; Barger,L.E.; Williams,M.L.
AF: Author Affiliation
Address not stated
SO: Source
Collect. Vol. Sci. Pap. ICCAT/Recl. Doc. Sci. CICTA/Colecc. Doc. Cient. CICAA, 9(3), 722-733, (1980)
NT: Notes
ICCAT SCRS/79/91.
ER: Environmental Regime
Marine
AB: Abstract
Preliminary results of a study of the age and growth of king mackerel from the recreational fishery of the south Atlantic and Gulf of Mexico coasts of the United States are presented. The age composition varied between locations. Ages of Texas fish ranged from 1 to 9 years, Louisiana from 1 to 14, northwest Florida from 0 to 10, South Carolina from 1 to 12, and North Carolina from 1 to 12. Generally Louisiana had the majority of the older fish, while northwest Florida had the majority of younger fish. The other areas had intermediate age distributions. The oldest males were 9 years old and the oldest females 14 years old. Theoretical growth varied greatly between locations. Von Bertalanffy growth parameter (K, L infinity in mm FL, and tSUB-o in years) ranges were: males - K = 0.32 to 1.38, L affinity = 757 to 1071, and tSUB-o = -1.39 to 0.44; females - K = 0.04 to 0.62, L affinity = 891 to 3203, and tSUB-o = -3.76 to -0.21. This study revealed differences between regions implying segregation of the population by age.

TI: Title
Age, growth, and mortality of king mackerel, Scomberomorus cavalla , from the southeastern United States.
AU: Author
Johnson, AG; Fable, WA Jr; Williams, ML; Barger, LE
AF: Author Affiliation
Southeast Fish. Cent., Panama City Lab., NMFS, NOAA, 3500 Delwood Beach Road, Panama City, FL 32407, USA
SO: Source
Fishery Bulletin [FISH. BULL.], vol. 81, no. 1, pp. 97-106, 1983
IS: ISSN
0090-0656
AB: Abstract
Age growth, and mortality of king mackerel, S. cavalla , from the southeastern United State were studied. Otoliths from 1,449 fish were used to estimate age composition, growth rates, and mortality rates of this species. Age composition varied between locations (Texas, Louisiana, Florida, South Carolina, and North Carolina. The majority of older fish were found in Louisiana waters. The oldest females were 14+years old and the oldest males were 9+years old. Compensatory growth was found in both sexes. Von Bertalanffy growth equations are presented. The mean annual mortality rate determined by six methods of analysis ranged from 0.32 to 0.42. The length-weight relations of king mackerel. are also presented.

TI: Title
Evidence for distinct stocks of king mackerel, Scomberomorus cavalla, in the Gulf of Mexico
AU: Author
Johnson, AG; Fable, WA Jr; Grimes, CB; Trent, L; Vasconcelos Perez, J
AF: Author Affiliation
Southeast Fish. Sci. Cent., NMFS/NOAA 3500 Delwood Beach Rd., Panama City, FL 32408, USA
SO: Source
Fishery Bulletin [FISH. BULL.], vol. 92, no. 1, pp. 91-101, 1994
IS: ISSN
0090-0656
AB: Abstract
Evidence supporting a two stock hypothesis for king mackerel, Scomberomorus cavalla, in the Gulf of Mexico was developed principally from the results of electrophoretic patterns of one polymorphic dipeptidase locus and supporting evidence from mark-recapture, charterboat catch, and spawning studies. There are two identifiable stocks of king mackerel in the Gulf of Mexico: a western stock and an eastern stock. The western stock migrates northward along the Mexico-Texas coast during the spring and early

summer from its winter grounds in Mexico (Yucatan Peninsula). This stock has a high frequency of the dipeptidase PEPA-2*a allele. The eastern stock migrates at the same time northward along the eastern coast of the Gulf of Mexico from its winter grounds in south Florida (Gulf of Mexico and Atlantic coast). This stock has a high frequency of the dipeptidase PEPA-2*b allele. Both stocks migrate simultaneously into the northern Gulf of Mexico and mix at varying degrees in the northern summering grounds (Texas to northwest Florida).

TI: Title
Use of otolith morphology for separation of king mackerel (Scomberomorus cavalla) and Spanish mackerel (Scomberomorus maculatus)
AU: Author
Johnson, AG
AF: Author Affiliation
Natl. Mar. Fish. Serv., Southeast Fish. Sci. Cent., Panama City Lab., 3500 Delwood Beach Rd., Panama City, FL 32408, USA
SO: Source
Gulf of Mexico Science [GULF MEX. SCI.], vol. 14, no. 1, pp. 1-6, 1996
IS: ISSN
1087-688X
AB: Abstract
Shapes of otoliths (sagittae) of king and Spanish mackerel (Scomberomorus cavalla and S. maculatus) were compared using theta-rho analysis aided by digitized computer methods. Otoliths from three king mackerel groups [Yucatan (Mexico), northwest Florida, and North Carolina] and one Spanish mackerel group were examined. Seven analytical combinations of measurements were tested. Intraspecific separation was highest using two truss systems (66.7-70.0% and 57.7-77.5%) and interspecific separation was highest using length and width radii (91.7%).

TI: Title
[Distribution of larvae of some species of the family Scombridae in the waters of the Gulf of Mexico]
OT: Original Title
Distribucion de las formas larvarias de algunas especies de la familia Scombridae en aguas del Golfo de Mexico
AU: Author
Juarez,M.
AF: Author Affiliation
Address not stated
SO: Source
Rev. Invest. Cent. Invest. Pesq. Inst. Nac. Pesca (Cuba), 2(1), 33-65,

(1976)
ER: Environmental Regime
Marine
AB: Abstract
The data were obtained during three cruises in the Gulf of Mexico, carried out between April and October 1973. The Scombridae larvae found belong to the following species: Auxis thazard, Thunnus thynnus, Euthynnus alletteratus, Katsuwonus pelamis, Thunnus atlanticus, Scomberomorus cavalla. The larvae found were figured and their quantitative temporal and spatial distribution were shown in maps.

TI: Title
Restriction-enzyme-site maps of mitochondrial DNA from red snapper (Lutjanus campechanus) and king mackerel (Scomberomorus cavalla)
AU: Author
Kristmundsdottir, AY; Barber, RC; Gold, JR
AF: Author Affiliation
Cent. for Biosystematics and Biodiversity, Dep. Wildl. and Fish. Sci., Texas A&M Univ., College Station, TX 77843, USA
SO: Source
Gulf of Mexico Science [GULF MEX. SCI.], vol. 14, no. 1, pp. 31-35, 1996
IS: ISSN
1087-688X
AB: Abstract
The red snapper (Lutjanus campechanus) and king mackerel (Scomberomorus cavalla) are two species of considerable economic importance in the Gulf of Mexico (Gulf). Both have experienced population declines over the last decade (GMFMC, 1989; MSAP, 1994), and fisheries for both species are currently regulated to allow stocks to recover. We are using restriction-enzyme-site polymorphism of mitochondrial (mt)DNA to study the spatial and temporal distribution of genetic variability in both species. The purpose of the studies is to determine whether genetic subdivision in either species occurs in the northern Gulf and/or along the Atlantic coast of the southeastern United States (Atlantic). The utility of restriction-site analysis of mtDNA to assess subdivision or stock structure within species has been reviewed extensively (Avise, 1987; Ovenden, 1990; Avise et al., 1987). Part of our work has been published (Camper et al., 1993), and part is in progress.

TI: Title
(Gillnet selectivity for king mackerel (Scomberomorus cavalla) in the southeast zone of Cuba.).
OT: Original Title

Selectividad en redes de enmalle de sierra (Scomberomorus cavalla
en la zona suroriental de Cuba

AU: Author
Leon, MEde; Guardiola, M

AF: Author Affiliation
Cent. Invest. Pesq., Minist. Ind. Pesq., Havana, Cuba

CF: Conference
Meet. of the ICCAT Standing Committee on Research and Statistics,
Madrid (Spain), Oct 1987

SO: Source
Collective volume of scientific papers. International Commission
for the Conservation of Atlantic Tunas/Recueil de documents
scientifiques. Commissio internationale pour la Conservation des
Thonides de l'Atlantique/Coleccion d documentos cientificos
[COLLECT. VOL. SCI. PAP. ICCAT/RECL. DOC. SCI. CICTA/COLECC. DOC.
CIENT. CICAA.], vol. 28, pp. 303-308, 1988

IS: ISSN
1021-5212

NT: Notes
14 ref.

NU: Other Numbers
ICCAT SCRS/87/25

AB: Abstract
A study of the selectivity with polyester gill nets with 50 and 60
mm mesh in the king mackerel (Scomberomorus cavalla) fishery in
the southeast area of Cuba was made during 25 fishing operations
in 1983. The Holt (1963) method was used, resulting in mean
lengths of selection for the two types of nets, 56.11 cm and 67.32
cm, respectively. The mean length of selection for nets with 40 mm
mesh (41.7 cm) was calculated by the Pope (1975) method,
concluding that the 50 and 60 mm nets are ideal for this fishery
as they do not affect the population under the size of first
maturity, while with the 40 mm mesh, 50 percent of the catch are
under this size.

TI: Title
Changes in Serum Androgens and Estrogens During Spawning in
Bluefish, Pomatomus saltator , and King Mackerel, Scomberomorus
cavalla .

AU: Author
MacGregor, R III; Dindo, JJ; Finucane, JH

AF: Author Affiliation
Dept. Biol, Univ. Alabama in Birmingham, Birmingham, AL 35294, USA

SO: Source
CAN. J. ZOOL., vol. 59, no. 9, pp. 1749-1754, 1981

AB: Abstract
Androgens and estrogens were assayed by radioimmunoassay (RIA)
technique in serum of bluefish, Pomatomus saltator , and king

mackerel, Scomberomorus cavalla . Both species were collected in the northeast Gulf of Mexico from August through November 1979. When categorized by stage of ovarian development a significant correlation between gonadosomatic indices (GSI) and serum estrogens was observed among female S. cavalla but not among P. saltator . Among males and females of both species, a significant correlation between GSI and serum androgens occurred. Peak levels of androgens in male king mackerel (38.12 plus or minus 11.21 ng/mL) were not significantly different from peak levels of females (33.14 plus or minus 5.10 ng/mL). However, in female bluefish, androgens peaked at 3.68 plus or minus 0.88 ng/mL, twofold greater than in males (1.66 plus or minus 0.28 ng/mL). Following this peak, a significant reduction in androgens occurred in ripe female bluefish.

TI: Title
Annotated bibliography of four Atlantic scombrids: Scomberomorus brasiliensis, S. cavalla, S. maculatus , and S. regalis
AU: Author
Manooch,C.S.; Nakamura,E.L.; Hall,A.B.
AF: Author Affiliation
US Natl. Mar. Fish. Serv., Southeast Fish. Cent., Panama City, FL, USA
CA: Corporate Author
National Marine Fisheries Service, Seattle, WA (USA). Scientific Publications Staff
SO: Source
Publ. by : NOAA/NMFS; Seattle, WA (USA), Dec 1978, 169 p, NOAA Tech. Rep
NT: Notes
Also as: NMFS Southeast Fisheries Center Contribution No. 77-01B
ER: Environmental Regime
Marine
AB: Abstract
Annotated references are presented on 570 papers published from 1973 to 1977. A subject index is included for each species and cover a variety of topics ranging from taxonomy to commercial and recreational fishing.

TI: Title
Survey of the charter boat troll fishery in North Carolina, 1977
AU: Author
Manooch,C.S.; Laws,S.T.
AF: Author Affiliation
US Natl. Mar. Fish. Serv., Southeast Fish. Cent., Beaufort, NC, USA
SO: Source
Mar. Fish. Rev., 41(4), 15-27, (1979)
ER: Environmental Regime

Marine

AB: Abstract

North Carolina's 127 charter boats made 7,935 trips trolling for pelagic fishes in 1977. The number of boats fishing for pelagic species varied from 65 to 107 depending on the month. Excluding billfishes, 238,413 fish weighing 1.6 million pounds (726 metric tons) were caught, an average of 30 fish and 198 pounds per trip. Major species landed by weight were: king mackerel, Scomberomorus cavalla , 737,680 pounds (344.7t); bluefish, Pomatomus saltatrix , 244,618 pounds (110.0t); dolphin, Coryphaena hippurus , 174,435 pounds (79.3t); amberjack, Seriola spp., 108,998 pounds (49.9t); and wahoo, Acanthocybium solanderi , 76,324 pounds (34.6t). Catch per unit effort varied with season and geographic area and reflected fish migrations. The highest catch rate occurred in October, 4.9 fish per trip, and the lowest in July, 16.3 fish per trip. Boats fishing out of Oregon Inlet and Hatteras Village usually caught a higher percentage of oceanic pelagic species (dolphin, tunas, etc.) and, as a result, had higher mean weights per fish landed.

TI: Title

Age and growth of king mackerel, Scomberomorus cavalla , from the U.S. Gulf of Mexico.

AU: Author

Manooch, CS III; Naughton, SP; Grimes, CB; Trent, L

AF: Author Affiliation

Beaufort Lab., Southeast Fish. Cent., NMFS, NOAA, Beaufort, NC 28516-9722, USA

SO: Source

Marine Fisheries Review [MAR. FISH. REV.], vol. 49, no. 2, pp. 102-108, 1987

IS: ISSN

0090-1830

NT: Notes

Special issue: Marine recreational fisheries and fishing.

AB: Abstract

Whole otoliths of 1,098 king mackerel, Scomberomorus cavalla , 410-1,802 mm fork length (FL) were examined. The fish were sampled from recreational and commercial fisheries operating in the Gulf of Mexico from Key West, Fl., to the Yucatan Peninsula, Mex., from 1980 through 1985. Most fish were collected off Key West, Northwest Florida, and Texas. The oldest fish was 14 years old and measured 1,802 mm FL. Rings formed on most otoliths during the late winter through spring (February-May) and are thus considered to be true annual marks. Back-calculated mean lengths of 947 fish ranged from 420 mm at age 1 to 1,269 mm FL at age 14. Females live longer and attain larger sizes than males. The von Bertalanffy growth equations for both sexes combined, for females, and for

males, are formulated. King mackerel are fully recruited to the gillnet and purse-seine fisheries of south Florida at age 2, to the recreational hook and line fishery off northwest Florida at ages 1 or 2, and to the Texas recreational hook and line fishery at ages 2, or 3.

TI: Title
Distribution, seasonality and abundance of king and Spanish mackerel larvae in the northwestern Gulf of Mexico (Pisces: Scombridae).
AU: Author
McEachran, JD; Finucane, JH; Hall, LS
AF: Author Affiliation
Dep. Wildl. & Fish. Sci., Texas A&M Univ., College Station, TX 77833, USA
SO: Source
NORTHEAST GULF SCI., vol. 4, no. 1, pp. 1-16, 1980
IS: ISSN
: 0148-9836
AB: Abstract
Larvae of king mackerel, Scomberomorus cavalla , and Spanish mackerel, S. maculatus were collected from 1975 through 1977 off the Texas coast. Both species were captured from May through October. S. cavalla was relatively more abundant of the two species and occurred most abundantly over the middle and outer continental shelf (35-183 m). At least 35% of the larvae were captured in September of each year. S. maculatus larvae occurred most abundantly over the inner continental shelf (12 to 50 m). S. cavalla spawned from May through September to early October, with the greatest spawning intensity occurring over the middle and outer continental shelf during September. S. maculatus spawned from May through September to early October over the inner continental shelf, but spawning was less intensive and more irregular than for S. cavalla .

TI: Title
An estimate of harvest by the Texas charter boat fishery.
AU: Author
McEachron, LW; Matlock, GC
AF: Author Affiliation
Texas Parks and Wildl. Dep., Box 1707, Rockport, TX 78382, USA
SO: Source
Marine Fisheries Review [MAR. FISH. REV.], vol. 45, no. 1, pp. 11-17, 1983
IS: ISSN
0090-1830
AB: Abstract

The charter boat fishery in surveyed areas of the Texas coast harvested over 900,000 fish in fiscal year 1979; 71 percent were taken from the Gulf and 29 percent from the bays. Red snapper, Lutjanus campechanus ; king mackerel, Scomberomorus cavalla ; and Spanish mackerel, S. maculatus , constituted the majority (78 percent) of the Gulf catch. Sand seatrout, Cynoscion arenarius : spotted seatrout, C. nebulosus ; Atlantic croaker, Micropogenias undulatus ; and kingfish Menticirrhus sp., constituted the majority of the bay catch. Catch composition within the Gulf and bay varied greatly between party boats (less than or equal to 10 people) and headboats (> 10 people).

TI: Title
Measuring the economic value of anglers' kept and released catches.
AU: Author
Milon, JW
AF: Author Affiliation
Food and Resour. Econ. Dep., Univ. Florida, Gainesville, FL 32611, USA
SO: Source
North American Journal of Fisheries Management [N. AM. J. FISH. MANAGE.], vol. 11, no. 2, pp. 185-189, 1991
IS: ISSN
0275-5947
AB: Abstract
Economic measures of the value of recreational catch typically have been based on the aggregate number of fish caught per unit effort. Fishery management councils, however, regulate recreational catch through bag limits and size restrictions that influence the composition of kept and released fish in the catch, not just the number of fish caught. Statistical tests for pooled site travel cost demand models for anglers of king mackerel Scomberomorus cavalla in the Gulf of Mexico region showed that indicators of kept and released catches outperformed an aggregate indicator. Economic studies of the value of recreational catch in other fisheries should give more consideration to the effects of regulations on the composition of kept and released catches and to the social factors that influence the keep or release decision.

TI: Title
MEXUS-Gulf coastal pelagic fish research, 1977-84.
AU: Author
Nakamura, EL
AF: Author Affiliation
Panama City Lab., Southeast Fish. Cent., NMFS, NOAA, 3500 Delwood Beach Rd., Panama City, FL 32407-7499, USA

SO: Source
Marine Fisheries Review [MAR. FISH. REV.], vol. 49, no. 1, pp. 36-38, 1987
IS: ISSN
0090-1830
AB: Abstract
The major goal of the MEXUS-Gulf Coastal Pelagics Working Group has been to determine whether coastal pelagic fishes, with emphasis on Spanish mackerel, Scomberomorus maculatus , and king mackerel, S. cavalla , fished by both Mexico and the United States, comprise a single stock or separate stocks. Accomplishments to attain this goal during 1977-84 consisted of cooperative tagging studies, cooperative tissue sampling for electrophoretic studies, exchange of data and publications, and consultations between biologists of the two countries. Results of the tagging and electrophoretic studies are summarized briefly below.

TI: Title
Bycatch in the Gulf of Mexico shrimp fishery
AU: Author
Nance, JM; Scott-Denton, E
AF: Author Affiliation
National Marine Fisheries Service, Galveston Laboratory, 4700 Avenue U, Galveston, TX 77551, USA
CA: Corporate Author
Commonwealth Scientific and Industrial Research Organ., Collingwood (Australia)
CF: Conference
2. World Fisheries Congress, Brisbane (Australia), 28 Jul-2 Aug 1996
ED: Editor
Hancock, DA (eds); Smith, DC(eds); Grant, A(eds); Beumer, JP(eds)
SO: Source
Developing and sustaining world fisheries resources. The state of science and management., CSIRO, Collingwood (Australia), 1997, pp. 98-102
IB: ISBN
0-643-05985-7
PB: Publisher
CSIRO, Collingwood (Australia)
AB: Abstract
Over the past 5 years a total of 3653 observer days have been secured by shrimp bycatch observers in the Gulf of Mexico and along the east coast of the United States of America. Analysis revealed that on average about 27 kg of organisms per hour are taken during trawling operations in the Gulf of Mexico.

Examination of the composition of the organisms revealed that about 68% of the catch by weight is composed of finfish (mostly groundfish), 16% by commercial shrimp species. 13% by non-commercial shrimp crustaceans and 3% by non-crustacean invertebrates. Although groundfish species make up the majority of the bycatch taken in shrimp trawls, 3 species (king mackerel, Scomberomorus cavalla, Spanish mackerel, S. maculatus and red snapper, Lutjanus compechanus) have received a great deal of attention because of their commercial and recreational importance and the potential for significant impacts on their population abundance through shrimp trawling activities. Average catch of these 3 species is generally below 0.5 kg per hour.

TI: Title
Biological and fisheries data on king mackerel, Scomberomorus cavalla (Cuvier)
CA: Corporate Author
National Marine Fisheries Service, Highlands, NJ (USA). Northeast Fisheries Center
SO: Source
Publ.by: NOAA/NMFS, Highlands, NJ (USA)., Nov 1977., 46 p., Tech. Ser. Rep. NOAA/NMFS Northeast Fish. Cent.
NT: Notes
Includes bibliography; 75 ref.
PB: Publisher
Publ.by: NOAA/NMFS, Highlands, NJ (USA).
ER: Environmental Regime
Marine
AB: Abstract
This synopsis of biological and fisheries data on the king mackerel, S.cavalla, is based on existing literature. Information is given on the nomenclature, taxonomy, morphology, distribution, bionomics and life history, population structure, exploitation, protection and management of these fish which are found inhabiting tropical and subtropical waters of the western Atlantic Ocean from the Gulf of Maine to Rio de Janiero, Brazil, including the Gulf of Mexico and Caribbean Sea.

TI: Title
Results of a king mackerel (Scomberomorus cavalla) and Atlantic Spanish mackerel (Scomberomorus maculatus) migration study, 1975-79
CA: Corporate Author
National Marine Fisheries Serv., Panama City, FL (USA). Southeast Fisheries Cent.
SO: Source
Publ. by: NOAA/NMFS; Panama City, FL (USA)., Mar 1980., 24 p., NOAA Tech. Memo.

ER: Environmental Regime
Marine
AB: Abstract
The Panama City and Port Aransas Laboratories tagged and released 2,731 king and 745 Atlantic Spanish mackerel in a 1975-78 study of their movements and migration. From those releases, 59 (2.2%) of the king mackerel and 44 (5.9%) of the Atlantic Spanish mackerel were subsequently recaptured. The tagged recoveries revealed an annual migration by king mackerel from south Florida waters north to the northeast coast of the Gulf of Mexico and west to South Texas waters in the spring and return to south Florida in the fall. Mixing of Gulf fish in the winter with Atlantic fish north to Ft. Pierce was disclosed by tagged recaptures. Fragmented evidence was obtained that Atlantic Spanish mackerel made an annual migration from wintering grounds off south Florida and Campeche-Yucatan to summer grounds along the northern Gulf coast and a return migration in the fall.

TI: Title
Stomach contents of juveniles of king mackerel (Scomberomorus cavalla) and Spanish mackerel (S. maculatus).
AU: Author
Naughton, SP; Saloman, CH
AF: Author Affiliation
SEFC, NMFS, NOAA, Panama City Lab., 3500 Delwood Beach Rd., Panama City, FL 32407, USA
SO: Source
NORTHEAST GULF SCI., vol. 5, no. 1, pp. 71-74, 1981
IS: ISSN
: 0148-9836
AB: Abstract
Some trawl-caught king and Spanish mackerel (Scomberomorus cavalla and S. maculatus) were examined as regards their diet. Data indicate both to be carnivorous, primarily piscivorous, as juveniles. Engraulidae (Anchoa sp) and Clupeidae (Brevoortia and Opisthonema oglinum) are the dominant food organisms in the diet of small trawl-caught mackerel.

TI: Title
Analysis of king mackerel stocks using high pressure liquid chromatography (HPLC).
AU: Author
Nieland, D; Bane, GW; Portier, R
AF: Author Affiliation
Coast. Fish. Inst., Cent. Wetland Resour., Louisiana State Univ., Baton Rouge, LA 70803, USA
CF: Conference
Stock Identification Workshop, Panama City Beach, FL (USA), 5-7

Nov 1985

ED: Editor

Kumpf, HE (ed)

SO: Source

PROCEEDINGS OF THE STOCK IDENTIFICATION WORKSHOP, NOVEMBER 5-7, 1985, PANAMA CITY BEACH, FLORIDA., 1987, pp. 176-178, NOAA TECH. MEMO.

NT: Notes

Summary only.

NU: Other Numbers

NOAA-TM-NMFS-SEFC199

AB: Abstract

This report describes HPLC of eye lens nuclear proteins as a new research technique for biochemical analyses of fish populations, and presents data on HPLC investigations of king mackerel (Scomberomorus cavalla) populations in nine areas in the western north Atlantic Ocean and Gulf of Mexico.

TI: Title

Aspects of king mackerel population biology and their effect on fishery management strategies.

AU: Author

Powers, JE; Eldridge, P; Bannerot, SP

AF: Author Affiliation

Miami Lab., Southeast Fish. Cent., NMFS, Miami, FL 33149, USA

CF: Conference

36. Annual Gulf and Caribbean Fisheries Institute, Port of Spain (Trinidad and Tobago), 3 Nov 1983

SO: Source

PROCEEDINGS OF THE THIRTY-SIXTH ANNUAL GULF AND CARIBBEAN FISHERIES INSTITUTE., 1984, pp. 106-116, Proceedings of the Gulf and Caribbean Fisheries Institute [PROC. GULF CARIBB. FISH. INST.]

IS: ISSN

0072-9019

AB: Abstract

King mackerel (Scomberomorus cavalla) are an important fishery resource in the southeastern United States, the Gulf of Mexico and the Caribbean. Recent assessment studies on king mackerel off the southeastern United States have assimilated the available biological information relevant to assessing the status of these king mackerel stocks. In addition, fishery and management implications were derived from these results. Assessing the status of a fishery resource requires an evaluation of how much of the resource is available for a fishery and in what form. This information is needed not just for management of a mature fishery, but for guiding the development of a new fishery. Authors examine the results of the recent assessment studies on king mackerel in the United States, as well as the associated biological information.

TI: Title
Evaluation of stock assessment research for Gulf of Mexico king mackerel: Benefits and costs to management.
AU: Author
Powers, JE; Restrepo, VR
AF: Author Affiliation
Southeast Fish. Cent., Miami Lab., NMFS/NOAA, 75 Virginia Beach Dr., Miami, FL 33149, USA
SO: Source
North American Journal of Fisheries Management [N. AM. J. FISH. MANAGE.], vol. 13, no. 1, pp. 15-26, 1993
IS: ISSN
0275-5947
AB: Abstract
The effect of research programs designed to increase precision in estimates of stock assessment parameters were evaluated for Gulf of Mexico king mackerel Scomberomorus cavalla . Monte Carlo simulations of the entire assessment analysis were used, consisting of separable virtual population analysis (VPA), calibrated VPA, estimation of target fishing mortality rate, and projection of catch at that rate. The distribution of estimates of allowable biological catch (ABC) from the simulations indicated that realistic improvements in research could substantially reduce the uncertainty in ABC estimates from a 40% to a 20% coefficient of variation. Expected yield for risk-averse strategies increased with enhanced research programs. Opportunity losses of forgone yield and lost surplus were diminished as well. Benefits of research combined with risk-averse management strategies to the fishery and to the economy appear to substantially exceed the costs of the research.

TI: Title
Stock assessments for U.S. stocks of king and Spanish mackerels: 1983-1992
AU: Author
Powers, JE; Thompson, NB
AF: Author Affiliation
NOAA/NMFS, Southeast Fish. Sci. Cent., Miami Lab., 75 Virginia Beach Dr., Miami, FL 33249, USA
SO: Source
Collective volume of scientific papers. International Commission for the Conservation of Atlantic Tunas/Recueil de documents scientifiques. Commissio internationale pour la Conservation des Thonides de l'Atlantique/Coleccion d documentos cientificos

[COLLECT. VOL. SCI. PAP. ICCAT/RECL. DOC. SCI. CICTA/COLECC. DOC. CIENT. CICAA], vol. 40, no. 2, pp. 391-398, 1993

IS: ISSN
1021-5212

NU: Other Numbers
ICCAT SCRS/92/25

AB: Abstract
Age-based stock assessment analyses have been completed annually for king (Scomberomorus cavalla) and Spanish mackerel (S. maculatus) for the Gulf of Mexico and Atlantic stocks, respectively. For these analyses, catch-at-age data are integrated into virtual population assessment and are calibrated using CPUE values from selected areas. Results of these analyses are used to determine biological reference points and to project forward in time to determine allowable catch for the upcoming fishing year. Estimates of current spawning stock biomass relative to historical estimates are evaluated to determine which stocks are over-fished.

TI: Title
Prices, marketing margins, and structural change in the king mackerel marketing system

AU: Author
Prochaska,F.J.

AF: Author Affiliation
Florida Univ., Food and Resour. Econ., Gainesville, FL 32611, USA

SO: Source
South. J. Agric. Econ., 10(1), 105-109, (1978)

ER: Environmental Regime
Marine

AB: Abstract
The objective of this article is to determine the functional relationship between the marketing margin and market prices, volume marketed, change in market structure, and the cost of marketing services. The empirical analysis is limited to king mackerel (Scomberomorus cavalla) landed on the Florida Atlantic Coast. US king mackerel comes from the southeastern states from Texas through North Carolina. Florida king mackerel landings were valued at dollar 2.4 million in 1975 and accounted for 93% of United States landings of this species. The Atlantic Coast of Florida produced more than 54% of the US landings. Marketing margins between Florida king mackerel fishermen prices and New York market prices contain a constant percentage margin component but no constant absolute margin component in the total margin. Changes in terminal market prices for fresh king mackerel are shared equally between market middlemen and Florida fishermen. In addition, there is a significant positive relationship between fishermen supply and the size of the marketing margin.

TI: Title
Available data from the 1986 King Mackerel Economic Costs and Returns Study.
AU: Author
Raizin, M
CA: Corporate Author
National Marine Fisheries Serv., St. Petersburg, FL (USA)
SO: Source
NOAA TECH. MEMO., 1989, 16 pp
NT: Notes
NTIS Order No.: PB89-206791/GAR. NOAA-TM-NMFS-SEFC-228.
AB: Abstract
The memorandum informs interested parties of the existence of cost and revenue data for vessels which operated in the Southeast coast of the United States (South Atlantic) king mackerel (Scomberomorus cavalla) fishery in 1986. The data was collected in response to the Gulf of Mexico and South Atlantic Fishery Management Council's need for pertinent economic information on the impact of fisheries management decisions on king mackerel fishermen.

TI: Title
Identification of small (< 3mm) larvae of king and Spanish mackerel, Scomberomorus cavalla and S. maculatus .
AU: Author
Richardson, SL; McEachran, JD
AF: Author Affiliation
Gulf Coast Res. Lab., East Beach Dr., Ocean Springs, MS 39564, USA
SO: Source
NORTHEAST GULF SCI., vol. 5, no. 1, pp. 75-79, 1981
IS: ISSN
: 0148-9836
AB: Abstract
Ichthyoplankton surveys in the Gulf of Mexico off Texas yielded larvae of S. cavalla and S. maculatus as small as 1.8mm standard length. These small larvae are described for the first time with emphasis on diagnostic pigment characters. Data are presented to aid in the practical separation of small larvae of these 2 species in mixed plankton samples.

TI: Title
Use of stable isotopes to assess groups of king mackerel, Scomberomorus cavalla, in the Gulf of Mexico and southeastern Florida
AU: Author
Roelke, LA; Cifuentes, LA
AF: Author Affiliation
Dep. Oceanogr., Texas A&M Univ., College Station, TX 77843, USA

SO: Source
Fishery Bulletin [FISH. BULL.], vol. 95, no. 3, pp. 540-551, Jul 1997
IS: ISSN
0090-0656
AB: Abstract
Stable nitrogen (delta super(15)N) and carbon (delta super(13)C) isotope measurements were used to differentiate groups of king mackerel, Scomberomorus cavalla, in the northwestern Gulf of Mexico and off the southeastern coast of Florida, as well as off the coast of Mexico. Northwestern (+13.1ppt) and southeastern (Mexico=+10.8ppt and Florida=+10.8ppt) groups, as well as the Atlantic group, had significantly different stable nitrogen isotope ratios. These were attributed to isotopic variations at the base of the food chain. Variability in delta super(13)C measurements was too large and did not corroborate the delta super(15)N results. The grouping suggested by the delta super(15)N data can be explained by the influence of the Mississippi River and the Gulf of Mexico Loop Current.

TI: Title
The driftnet fishery in the Fort Pierce-Port Salerno area off Southeast Florida.
AU: Author
Schaefer, HC; Barger, LE; Kumpf, HE
AF: Author Affiliation
Econ. and Stat. Off., Southeast Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 19100 S.E. Federal Highw., Tequesta, FL 33469, USA
SO: Source
Marine Fisheries Review [MAR. FISH. REV.], vol. 51, no. 1, pp. 44-49, 1989
IS: ISSN
0090-1830
AB: Abstract
From May through Sep 1987, observations were made on 38 trips in the driftnet fishery off the Fort Pierce-Port Salerno area off southeast Florida. Of the number and weight of fish landed on observed trips, 91.6 percent consisted of king mackerel, Scomberomorus cavalla , the targeted species. Over 33 species of fishes were observed among the discarded by-catch.

TI: Title
King mackerel, Scomberomorus cavalla, mark-recapture studies off Florida's east coast
AU: Author
Schaefer, HC; Fable, WA Jr
AF: Author Affiliation

Stat. Off., Coast. Resour. Div., Southeast Fish. Sci. Cent., NMFS/NOAA, 19100 S.E. Federal Hwy., Tequesta, FL 33469, USA

SO: Source

Marine Fisheries Review [MAR. FISH. REV.], vol. 56, no. 3, pp. 13-23, 1994

IS: ISSN

0090-1830

AB: Abstract

King mackerel, Scomberomorus cavalla, were tagged and released from eastern Florida between 1985 and 1993. Recapture trends from these studies indicate an increase in tag returns from areas north of the release sites, along with a decrease in recaptures from coastal waters in the Florida Keys and Gulf of Mexico, since earlier king mackerel tagging studies completed in the late 1970's. The data indicate that eastern Florida waters may maintain resident king mackerel. Cyclical tag return patterns were noted along eastern Florida and in North Carolina. The proportion of mixing of presently defined king mackerel stocks along eastern Florida may vary yearly. Comparison of king mackerel tags show internal anchor tags to have a higher percentage of return and lower percentage of tag loss than dorsal dart tags.

TI: Title

Studies of the mackerel fishery of Trinidad. Part 1: The present status of the mackerel fishery of Trinidad.

AU: Author

Sturm, M; Julien, M

SO: Source

RES. REP. INST. MAR. AFF. CHAGUARAMAS., no. 13, 1983, 28 pp

AB: Abstract

This report attempts to establish the status of the mackerel fishery of Trinidad. It is based on data collected by the Fisheries Division, Ministry of Agriculture, Lands and Food Production from 1964 to 1981. This fishery is artisanal in nature and comprises the carite Scomberomorus brasiliensis and the kingfish S. cavalla . The fish are caught by gill nets, trolling, beach and "Italian" seines. Carite are the most important commercial finfish with kingfish approaching it in importance. South coast beaches are the most important landing places for kingfish. Cyclic variation in both stocks indicates that they are not overfished.

TI: Title

Movement patterns and stock affinities of king mackerel in the southeastern United States.

AU: Author

Sutter, FC III; Williams, RO; Godcharles, MF

AF: Author Affiliation

Florida Mar. Res. Inst., Dep. Nat. Resour., 100 Eighth Ave. SE,
St. Petersburg, FL 33701-5095, USA

SO: Source

Fishery Bulletin [FISH. BULL.], vol. 89, no. 2, pp. 315-324, 1991

IS: ISSN

0090-0656

AB: Abstract

King mackerel Scomberomorus cavalla were tagged and released from southeastern Florida, the Florida Keys, and South Carolina from 1975 through 1979 to document spatial and temporal movement patterns. Distance traveled by tagged king mackerel was not significantly related to size (fork length), but was correlated with number of days-at-large. king mackerel show a cyclical pattern of movement along the Atlantic seaboard of the southeastern United States and coastal waters of the Gulf of Mexico. A migratory behavior may exist in which fish return to the area of release over a period of up to 5 years. The number of fish moving away from the area of release and their direction of movement depend on whether the fish are associated with Atlantic or Gulf waters. The seasonal overlap between the two recognized stocks of king mackerel in southeastern Florida is estimated to be as high as 29.4-41.8%.

TI: Title

Growth and mortality of king mackerel Scomberomorus cavalla tagged in the southeastern United States.

AU: Author

Sutter, FC III; Williams, RO; Godcharles, MF

AF: Author Affiliation

Florida Mar. Res. Inst., Dep. Nat. Resour., 100 Eighth Ave. SE,
St. Petersburg, FL 33701-5095, USA

SO: Source

Fishery Bulletin [FISH. BULL.], vol. 89, no. 4, pp. 733-737, 1991

IS: ISSN

0090-0656

AB: Abstract

This report presents estimates of growth and mortality based on mark-recapture data for both the Gulf and Atlantic king mackerel (Scomberomorus cavalla) groups.

TI: Title

Headboat and charterboat finfish catch statistics for the bays and Gulf waters of Texas, September 1978-August 1979

CA: Corporate Author

Texas Parks and Wildlife Dep., Austin (USA). Coastal Fisheries Branch.

SO: Source

Publ. by: TPWD; Austin, TX (USA)., 1980., 42 p., Manage. Data Ser.

Tex. Parks Wildl. Dep.

ER: Environmental Regime

Marine; Brackish

AB: Abstract

From September 1978 through August 1979 headboat and charterboat fishermen were surveyed in the Galveston-Freeport, Aransas-Corpus Christi and lower Laguna Madre areas. During this period 104 headboat and 74 charterboat interviews were conducted. All surveys were separated as to Gulf of Mexico fishing or bay fishing. Reef fishes, mainly red snapper (Lutjanus campechanus), dominated the Gulf headboat catches; sand seatrout (Cynoscion arenarius) dominated the bay headboat catches. Spotted seatrout (C. nebulosus) constituted almost all of the bay charterboat catches; king mackerel (Scomberomorus cavalla), Spanish mackerel (S. maculatus) and red snapper dominated the Gulf charterboat catches. The best time to obtain charterboat and headboat surveys was during late spring, summer and early fall because of increased demand by clients during these periods.

TI: Title

Size and Sex Ratio of King Mackeral, Scomberomorus cavalla , in the Southeastern United States.

AU: Author

Trent, L; Williams, RO; Taylor, RG; Saloman, CH; Manooch, CS III

CA: Corporate Author

National Marine Fisheries Service, Panama City, FL (USA)

SO: Source

NOAA TECH. MEMO., NOAA/NMFS, PANAMA CITY, FL (USA) , 1981, 63 pp

PB: Publisher

NOAA/NMFS, PANAMA CITY, FL (USA)

NU: Other Numbers

NOAA-TM-NMFS-SEFC-62

AB: Abstract

Data from over 54,000 king mackerel, Scomberomorus cavalla , were analyzed to evaluate temporal variations in size and sex composition in seven areas of the southeastern United States. Data were obtained from recreational hook-and-line fishermen of the coastal states from Texas to North Carolina, and from commercial hook-and-line and gill-net fishermen of south Florida. Most of the length-frequency distributions derived from king mackerel catches were uni-modal. This distribution is typical of a species that spawns over a long period each year, has highly variable growth rates among individuals, or both. Size composition in each area varied considerably between months and indicated temporally heterogeneous groups of king mackerel. Females were dominant in the catches in all areas and years except south Florida in 1978.

Annual or ranges of annual estimates by percentage female are given. No explanation for these deviations from a 1:1 sex ratio was attempted. Distinct seasonal changes in sex ratio were observed only in Texas.

TI: Title
Size, sex ratio, and recruitment in various fisheries of king mackerel, Sco mberomorus cavalla , in the southeastern United States.
AU: Author
Trent, L; Williams, RO; Taylor, RG; Saloman, CH; Manooch, CH III
CA: Corporate Author
National Marine Fisheries Serv., Panama City, FL (USA). Panama City Lab
SO: Source
, 1981, 13 pp
NT: Notes
NTIS Order No.: PB85-121853/GAR. Prepared with Fla. Dep. Nat. Resour.
AB: Abstract
Data from over 54,000 king mackerel, Scomberomorus cavalla , were analyzed to evaluate spatial and temporal variations in size and sex composition in seven areas of the southeastern United States. Data were obtained from the recreational hook-and-line fishery of coastal states from Texas to North Carolina and from commercial hook-and-line and gill net fisheries of south Florida. Of the three types of gear, recreational hook and line appeared to be the least selective and gill net the most selective for particular sizes of king mackerel. Size composition in each area varied considerably among months; patterns of size change were discernible in some areas. Females dominated catches in all size groups and in all areas and years, except for south Florida in 1978.

TI: Title
Size, sex ration and groups of king mackerel, Scomberomorus cavalla , in southeastern United States.
AU: Author
Trent, L; Williams, RO; Taylor, RG; Saloman, CH; Manooch, ChS III
AF: Author Affiliation
Natl. Mar. Fish. Service, Southeast Fish. Center, Panama City Lab., 3500 Delwood Beach Road, Panama City, FL 32407, USA
CA: Corporate Author
International Counc. for the Exploration of the Sea, Copenhagen (Denmark)
CF: Conference
Council Meeting, 1981, of the International Council for the

Exploration of the Sea, (Woods Hole, MA (USA)), (5 Oct 1981)
SO: Source
ICES COUNCIL MEETING 1981 (COLLECTED PAPERS)., ICES, COPENHAGEN (DENMARK) , 1981, 14 pp

TI: Title
Abundance of king mackerel, Scomberomorus cavalla , in the southeastern United States based on CPUE data from charterboats, 1982-85.
AU: Author
Trent, L; Palko, BJ; Williams, ML; Brusher, HA
AF: Author Affiliation
Panama City Lab., Southeast Fish. Cent., NMFS, NOAA, 3500 Delwood Beach Rd., Panama City, FL 32407, USA
SO: Source
Marine Fisheries Review [MAR. FISH. REV.], vol. 49, no. 2, pp. 78-90, 1987
IS: ISSN
0090-1830
NT: Notes
Special issue: Marine recreational fisheries and fishing.
AB: Abstract
In 1982, a survey was initiated to obtain daily catch and effort data on fishes commonly caught by charterboats in the southeastern United States. Boat effort and king mackerel, Scomberonmorus cavalla , CPUE data obtained from 1982 through 1985 were analyzed. The offshore fishing zone (> 10 fathoms) received the highest amount of trolling and other fishing (nontrolling) efforts; the nearshore fishing zone (less than or equal to 10 fathoms) received the second highest trolling effort and lowest other fishing effort; the estuarine fishing zone received the lowest trolling effort and the second lowest other fishing effort. Data to evaluate seasonal fluctuations in fishing effort were provided for 15 areas of the southeastern United States and for the U.S. Caribbean. Annual CPUE of king mackerel by other fishing was much lower than trolling for most areas and years. CPUE was higher in the nearshore or offshore zone than in the estuarine zone for all area-year combinations except North Carolina in 1983. CPUE values were highest in the nearshore zone about as often as in the offshore zone. Highest CPUE for king mackerel occurred in 1983 or 1985 when all areas were considered. Evaluation of the historical data bases in northwest Florida indicated cyclical patterns of abundance over a 20-year period.

TI: Title
Variations in size and sex ratio of king mackerel, Scomberomorus cavalla , off Louisiana, 1977-85.

AU: Author
Trent, L; Fable, WA Jr; Russell, SJ; Bane, GW; Palko, BJ

AF: Author Affiliation
Southeast Fish. Cent., Panama City Lab., NMFS, NOAA, 3500 Delwood Beach Rd., Panama City, FL 32407, USA

SO: Source
Marine Fisheries Review [MAR. FISH. REV.], vol. 49, no. 2, pp. 91-97, 1987

IS: ISSN
0090-1830

NT: Notes
Special issue: Marine recreational fisheries and fishing.

AB: Abstract
Data from over 27,000 king mackerel, Scomberomorus cavalla , collected from Grand Isle, Louisiana, during 1977-85 were analyzed to evaluate temporal variations in size and sex compositions. The fish were caught by recreational and commercial hook-and-line fishermen. Groups of king mackerel from Louisiana were composed of a greater portion of large fish than were populations from other areas in the southeastern United States with the possible exception of South Carolina and Georgia. Large (> 120 cm fork length) king mackerel were caught off Louisiana throughout the year. For both males and females, catches were composed of the smallest fish in April through October and the largest fish between November and March. Females dominated catches in most months and comprised a greater portion of the recreational than the commercial landings. Female percentage was usually lower in the warmer than in the colder months. In general, female percentage increased with an increase in fish size.

TI: Title
Size, sex ration and groups of king mackerel, Scomberomorus cavalla , in southeastern United States.

AU: Author
Trent, L; Williams, RO; Taylor, RG; Saloman, CH; Manooch, ChS III

AF: Author Affiliation
Natl. Mar. Fish. Service, Southeast Fish. Center, Panama City Lab., 3500 Delwood Beach Road, Panama City, FL 32407, USA

CA: Corporate Author
International Counc. for the Exploration of the Sea, Copenhagen (Denmark)

CF: Conference
Council Meeting, 1981, of the International Council for the Exploration of the Sea, (Woods Hole, MA (USA)), (5 Oct 1981)

SO: Source
ICES COUNCIL MEETING 1981 (COLLECTED PAPERS)., ICES, COPENHAGEN (DENMARK) , 1981, 14 pp

TI: Title
Catch and bycatch in the shark drift gillnet fishery off Georgia and east Florida
AU: Author
Trent, L; Parshley, DE; Carlson, JK
AF: Author Affiliation
Panama City Lab., Southeast Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 3500 Delwood Beach Rd., Panama City, FL 32408, USA
SO: Source
Marine Fisheries Review [MAR. FISH. REV.], vol. 59, no. 1, pp. 19-28, 1997
IS: ISSN
0090-1830
AB: Abstract
An observer program of the shark drift gillnet fishery off the Atlantic coast of Florida and Georgia was begun in 1993 to define the fishery and estimate bycatch including bottlenose dolphin, Tursiops truncatus, and sea turtles. Boats in the fishery were 12.2-19.8 m long. Nets used were 275-1,800 m long and 3.2-4.1 m deep. Stretched-mesh sizes used were 12.7-29.9 cm. Fishing trips were usually <18 h and occurred within 30 n. mi. of port. Fishing with an observer aboard occurred between Savannah, Ga., and Jacksonville, Fla., and off Cape Canaveral, Fla. Nets were set at least 3 n. mi. offshore. Numbers of boats in the fishery increased from 5 in 1993 to 11 in 1995, but total trips decreased from 185 in 1994 to 149 in 1995. During 1993-95, 48 observer trips were completed and 52 net sets were observed. No marine mammals were caught and two loggerhead turtles, Caretta caretta, were caught and released alive. A total of 9,270 animals (12 shark, 21 teleost, 4 ray, and 1 sea turtle species) were captured. Blacknose, Carcharhinus acronotus; Atlantic sharpnose, Rhizoprionodon terraenovae; and blacktip shark, C. limbatus), were the dominant sharks caught. King mackerel, Scomberomorus cavalla; little tunny, Euthynnus alleteratus; and cownose ray, Rhinoptera bonasus, were the dominant bycatch species. About 8.4% of the total catch was bycatch. Of the totals, 9.4% of the sharks and 37.3% of the bycatch were discarded.

TI: Title
King mackerel.
AU: Author
Wallace, R
CA: Corporate Author
Auburn Univ., AL (USA). Sea Grant Advisory Serv
SO: Source
SEA HARVEST NEWS., 1985, pp. 1-2, .

NT: Notes
Grant No.: NA85AA-D-SG005.
NU: Other Numbers
MASGP-85-005-2
AB: Abstract
The Gulf of Mexico Fishery management Council Council recently approved a new "mackerel plan". The Councils' summary of the plan is given. The overall catch of Gulf group king mackerel is to be reduced by 22% to 14.225 million pounds (M), with recreational and commercial fishermen sharing the reduction in proportion to their historic catches. The commercial catch quota of 4.552 M is to be limited to permit vessels which must cease to fish when the annual quota is filled. Permit applicants must be able to show they derive 10% of their earned income from commercial fishing, and charter boats are not eligible for commercial permits. The Gulf commercial allocation is divided with 2.94 M to an eastern zone (Florida), 1.328 M to a western zone, and 0.284 M for purse seines.

TI: Title
The effect of water temperature and winter air temperature on the springtime migrations of king mackerel in the vicinity of Tampa Bay, Florida
AU: Author
Williams,R.O.; Taylor,R.G.
AF: Author Affiliation
Fla. Dep. Nat. Resour. Mar. Res. Lab., 100 8th Avenue S.E., St. Petersburg, FL 33701, USA
CF: Conference
Presented at: 44. Annual meeting of the Academy, Tampa, FL (USA), 23 Mar 1980
SO: Source
Fla. Sci., 43(suppl. 1), 26, (1980)
NT: Notes
Summary only.
ER: Environmental Regime
Marine
AB: Abstract
This paper reviews the springtime migrations of the king mackerel, Scomberomorus cavalla , in the vicinity of Tampa Bay, Florida during each of the past twenty years and demonstrates that their date of first appearance is directly dependent on offshore water temperature (min. 20 C) and indirectly on prevailing air temperatures during the previous winter. The springtime arrival date of king mackerel to the Tampa Bay area was established by reviewing daily newspaper recreational fishing columns. Offshore water temperatures were compiled from various sources and are available for twelve of the

past twenty years. Air temperatures for Tampa, Florida were available from annual summaries of the U.S. National Weather Service.

Spamish mackerel

TI: Title
A multispecies stock assessment of a pelagic coastal fishery of the south-west Gulf of Mexico.
AU: Author
Arreguin-Sanchez, F; Chavez, EA; Menchaca, JA
AF: Author Affiliation
Cent. Invest. y de Estud. Avanzados del IPN, Km 6 Carreterra Antigua a Progreso, AP 73-Cordemex 97310, Merida, Yucatan, Mexico
SO: Source
AQUACULT. FISH. MANAGE., vol. 23, no. 1, pp. 103-112, 1992
AB: Abstract
Multispecies stock assessment based upon Schaefer's theory was applied to a coastal pelagic fishery (Spanish mackerel, Scomberomorus maculatus ; king mackerel, S. cavalla and the blue runner, Caranx fusus , from the west central Gulf of Mexico. Linear and non-linear systems of equations were estimated by using a multiple stepwise regression technique. The values of interaction parameters show a clear competition between mackerels, and technological interdependences between the blue runner and mackerels. The maximum yield estimation was from 4000 to 5000 tonnes, obtained with 23 and 34 beach seines respectively, depending on the applied model. Two stages were observed from the statistical records; in the first the Spanish mackerel is the most important species while in the second the abundance of this species declines and the others remain at the same level. Significant interactions were found from the first data group.

TI: Title
An investigation of the trophic role of three pelagic fishes in a tropical coastal ecosystem of the western Gulf of Mexico, using the ECOPATH II model
AU: Author
Arreguin-Sanchez, F; Chavez, EA
AF: Author Affiliation
Cent. Interdiscipl. Cienc. Mar. IPN (CICIMAR), Ao., P. 592, 23000 La Paz, Baja California Sur, Mexico
CF: Conference
Int. Symp. on Middle-Sized Pelagic Fish, Las Palmas de Gran Canaria, Gran Canaria, Canary Islands (Spain), 24-28 Jan 1994
ED: Editor
Bas, C; Castro, JJ; Lorenzo, JM (eds)

SO: Source
INTERNATIONAL SYMPOSIUM ON MIDDLE-SIZED PELAGIC FISH HELD IN LAS PALMAS DE GRAN CANARIA 24-28 JANUARY 1994., 1995, pp. 307-315, Scientia Marina (Barcelona) [SCI. MAR. (BARC.)], vol. 59, no. 3-4
IS: ISSN
0214-8358
AB: Abstract
The spanish and king mackerels (Scomberomorus maculatus and S. cavalla) and the blue runner (Caranx fusus) are important pelagic fish resources along the coasts of the Gulf of Mexico. Interdependences between them have been studied through simple multispecies yield models. Simulated changes in fishing effort suggest S. cavalla and C. fusus populations are more stable than S. maculatus. The ecosystem model, previously obtained with ECOPATH II, was used to simulate gradual changes in biomass. Ecosystem response tends to maintain the thermodynamic equilibrium by adjusting the biomass/energy flows. The predator/prey and competence interdependences show impacts of different magnitude, depending on how species are using the ecosystem resources. However, the main variations occurred through respiration and flows into detritus. Spanish and king mackerels share some resources like anchovies, herrings and shrimp; however, the spanish mackerel has a wider trophic spectrum. The blue runner shares some food resources with the above species, but it also uses some others. The specific biomass flows in the prey/predator relationships, the specific foraging index, the niche overlap and the relative population abundance explain the higher variability of the spanish mackerel population.

TI: Title
Simulation of the Spanish mackerel (Scomberomorus maculatus) fishery of the Gulf of Mexico.
OT: Original Title
Simulacion de la pesqueria de sierra (Scomberomorus maculatus) del Golfo de Mexico
AU: Author
Chavez, EA
AF: Author Affiliation
Cent. Invest. Aliment. y Desarrollo A.C., Unid. Mazatlan Acuicult. y Manejo Ambient., Calzada Sabalo-Cerritos y Estero del Yugo, A.P. 711, Mazatlan, Sinaloa 82010, Mexico
SO: Source
Revista de investigaciones marinas. Mexico City [REV. INVEST. MAR.], vol. 15, no. 3, pp. 209-217, 1994
IS: ISSN
0252-1962
AB: Abstract

Spanish mackerel (Scomberomorus maculatus) fishery was analyzed through a 40-year period of catch records. Estimates of population size, exploitation rates and fishing mortality coefficients were obtained for each year once age structure was determined. With these data a simulation model that considers changes in size of each cohort through time was made; this model allowed to assess the consequences of different management options. Results showed that the stock is slightly under exploited.

TI: Title
Fluctuations in abundance of Spanish mackerel in Chesapeake Bay and the mid-Atlantic region
AU: Author
Chittenden, ME Jr; Barbieri, LR; Jones, CM
AF: Author Affiliation
Coll. William and Mary, Virginia Inst. Mar. Sci. Gloucester Point, VA 23062, USA
SO: Source
North American Journal of Fisheries Management [N. AM. J. FISH. MANAGE.], vol. 13, no. 3, pp. 450-458, 1993
IS: ISSN
0275-5947
AB: Abstract
Spanish mackerel Scomberomorus maculatus have shown great fluctuations in abundance in Chesapeake Bay and the Mid-Atlantic Region. Early anecdotal accounts indicate they were very abundant in the later 1600s but were not common in the early-mid-1800s. Both annual landings and anecdotal accounts indicate they were very abundant about 1860-1910 and much less so since. Early patterns may reflect, in part, a natural long-term component in abundance. Large early landings were probably at levels not sustainable in the Chesapeake and Mid-Atlantic Region, because the classical response of a stock to fishing is a process of juvenescence and reduction of the virgin standing stock to a new, lower, equilibrium level. Fluctuations due to recruitment have probably been superimposed on the juvenescence process since the inception of the early fishery about 1865. Repeated lows in Chesapeake Bay landings in 1910-1936, 1947-1960, and 1977-1985 indicate repeated, prolonged series of weak year-classes in that region or poor escapement from fisheries in more southern waters. Two brief periods of high landings in 1937-1938 and 1944-1946 probably each reflected one or two strong year-classes. The nature and duration of the recent period of high landings (1986-1991) is not yet clear.. This apparent increase in abundance may reflect (1) increased survivorship and escapement of adults due to recent management actions in Florida, and (2) possible production of at least one strong year-class at the beginning of, if not

throughout, the period, a phenomenon that may have been enhanced by increased spawning stocks reflecting recent management or earlier voluntary actions.

TI: Title
Fishery-independent recruitment indices for king and Spanish mackerels
AU: Author
Collins, MR; Harris, PJ; Maier, PP
AF: Author Affiliation
South Carolina Department of Natural Resources, Marine Resources Research Institute, Post Office Box 12559, Charleston, SC 29422-2559, USA
SO: Source
North American Journal of Fisheries Management [N. Am. J. Fish. Manage.], vol. 18, no. 1, pp. 181-186, Feb 1998
IS: ISSN
0275-5947
AB: Abstract
We investigated whether the abundance of age-0 mackerels in a fishery-independent trawl survey could be used to predict abundance at age 1 for king mackerel Scomberomorus cavalla and Spanish mackerel S. maculatus. After deletion of inappropriate length-classes and partitioning by season, depth, and stratum, subsets of the data set were compared to landings data and stock assessment results from the National Marine Fisheries Service. Total landings of age-1 Spanish mackerel were closely predicted (r super(2) = 0.91) by catch per unit effort (CPUE) of age-0 fish 11-28 cm in fork length (FL) in samples taken by the Southeast Area Monitoring and Assessment Program-South Atlantic (SEAMAP-SA) during fall from shallow strata in the coastal waters of Georgia and South Carolina (latitudes 30 degree 44'-33 degree 12'N; SEAMAP-SA odd strata 31-49). The best predictor (r super(2) = 0.72) for age-1 king mackerel was CPUE of age-0 fish 9-30 cm FL in SEAMAP-SA's fall samples from shallow strata in the coastal waters of South Carolina and North Carolina (32 degree 04'-35 degree 15'N; SEAMAP-SA odd strata 41-67) collected the previous year. The indices should be used with caution until data from additional years become available for verification and incorporation.

TI: Title
Age and growth of king and Spanish mackerel larvae and juveniles from the Gulf of Mexico and U.S. South Atlantic Bight.
AU: Author
De Vries, DA; Grimes, CB; Lang, KL; White, D
AF: Author Affiliation
NMFS, Southeast Fish. Cent., 3500 Delwood Beach Rd., Panama City,

FL 32407-7499, USA

SO: Source
Environmental biology of fishes. The Hague [ENVIRON. BIOL. FISH.], vol. 29, no. 2, pp. 135-143, 1990
IS: ISSN
0378-1909

AB: Abstract
Sagtittal otoliths from 50 king mackerel (Scomberomorus cavalla) 2.9-13.0 mm SL and 72 Spanish mackerel (Scomberomorus maculatus) 2.8-22.0 mm SL collected off the southeast U.S. were examined whole at 400 x using a compound microscope-video system. Otoliths of both species had visible, presumably daily, growth increments as well as finer subdaily increments. Otolith growth was directly proportional to growth in standard length for king (r super(2) = 0.91) and Spanish mackerel (r super(2) = 0.86). Spanish mackerel were estimated to be 3-15 d old with a mean absolute growth rate (SL/number of growth increments) and 95% confidence interval of 1.15 plus or minus 0.07 mm/d. The least squares linear equation: SL = - 1.30 + 1.31 (age in days), with r super(2) = 0.67 and p > 0.001, described the relationship between length and age. There was a significant positive relationship between absolute growth rate and fish length. King mackerel were estimated to be 3-15 d old with a mean absolute growth rate of 0.89 plus or minus 0.06 mm/d. Growth rate of king mackerel was slightly higher for fish from the Mississippi River plume than from all other locations combined, while Spanish mackerel growth rates were not significantly different.

TI: Title
Selectivity of gill nets used in the commercial Spanish mackerel fishery of Florida.

AU: Author
Ehrhardt, NM; Die, DJ
AF: Author Affiliation
Div. Biol. and Living Resour., Rosenstiel Sch. Mar. and Atmos. Sci., Univ. Miami, 4600 Rickenbacker Causeway, Miami, FL 33149, USA

SO: Source
Transactions of the American Fisheries Society [TRANS. AM. FISH. SOC.], vol. 117, no. 6, pp. 574-580, 1988
IS: ISSN
0002-8487

AB: Abstract
Selection curves of encircling (run-around) and drifting (stab) gill nets used in the winter fishery for Spanish mackerel Scomberomorus maculatus off southern Florida were estimated by use of cumulative probability distributions of retention girth at

length. Selection curves corresponded well with observed size frequencies obtained from each mesh size. Increasing differences between maximum and head girth perimeters as fish grew resulted in selection curves indicating increased selection range and efficiency. Selectivity of Spanish mackerel gill nets will change as the condition of the fish changes with the onset of the spawning season. Apparently, selectivity also changes with twine size.

TI: Title
Size-structured yield-per-recruit simulation for the Florida gill-net fishery for Spanish mackerel.
AU: Author
Ehrhardt, NM; Die, DJ
AF: Author Affiliation
Div. Biol. and Living Resour., Rosenstiel Sch. Mar. and Atmos. Sci., Univ. Miami, 4600 Rickenbacker Causeway, Miami, FL 33149, USA
SO: Source
Transactions of the American Fisheries Society [TRANS. AM. FISH. SOC.], vol. 117, no. 6, pp. 581-590, 1988
IS: ISSN
0002-8487
AB: Abstract
The authors estimated the effects of gill-net mesh size regulations on the yield per recruit of Spanish mackerel Scomberomorus maculatus in Florida. Yield per recruit was calculated with a simulation model that incorporated seasonal fishing rates by sectors (recreational and commercial) and size-varying availabilities of fish to the gear and retention probabilities once fish encountered the gear. Gains in yield (g) per recruit were always obtained by increasing mesh size, gill-net fishing mortality, or both. Adoption of a minimum length above the present enforced minimum 30.5 cm fork length may result in considerable gains in yield per recruit. This, however, depends on the assumption that there is no cryptic mortality of undersized fish in the recreational fishery.

TI: Title
Age and growth of Spanish mackerel, Scomberomorus maculatus , from Florida and the Gulf of Mexico.
AU: Author
Fable, WA Jr; Johnson, AG; Barger, LE
AF: Author Affiliation
Southeast Fish. Cent. Panama City Lab., Natl. Mar. Fish. Serv., NOAA, 3500 Delwood Beach Rd., Panama City, FL 32407-7499, USA
SO: Source

Fishery Bulletin [FISH. BULL.], vol. 85, no. 4, pp. 777-783, 1987
IS: ISSN
0090-0656
AB: Abstract
Otoliths from 1,787 Spanish mackerel, Scomberomorus maculatus , were used to estimate age and growth rates of this species from Florida and the Gulf of Mexico. There was a wide range of lengths within an age group: the oldest male was 7 years old, while the oldest female was 9 years old. Length at age was significantly different for sexes, sampling areas, and collection gear.

TI: Title
The Atlantic Spanish mackerel, Scomberomorus maculatus , new to Nova Scotia and Canada.
AU: Author
Gilhen, J; McAllister, DE
AF: Author Affiliation
Nova Scotia Mus., 1747 Summer St., Halifax, N.S. B3H 3A6, Canada
SO: Source
Canadian field-naturalist. Ottawa ON [CAN. FIELD-NAT.], vol. 103, no. 2, pp. 287-289, 1989
IS: ISSN
0008-3550
AB: Abstract
A single Atlantic Spanish mackerel, Scomberomorus maculatus taken by Victor Kiley off Sauls Island 44 degree 28'25"N, 63 degree 47'00"W, 4 October 1985, is the first record for Canadian waters. The species has previously been taken north as far as Monhegan Island, Maine. Spots on its sides, a black area on the front of the first dorsal fin and high vertebral count distinguish it from other Canadian Scombridae. Its occurrence in Nova Scotian waters does not appear to be explainable by passive transplant in the Gulf Stream as is invoked for northern records of less active swimmers.

TI: Title
Composition and storage stability of Spanish mackerel and related species
AU: Author
Hale,M.; Rasekh,J.
AF: Author Affiliation
U.S. Natl. Mar. Fish. Serv., Southeast Fish. Cent., Charleston, SC 29412, USA
CA: Corporate Author
TAMU-SG-79-101
CF: Conference
Presented at : 3. Annu. Tropical and Subtropical Fisheries

Technological Conference of the Americas, New Orleans, LA (USA), 23 Apr 1978

SO: Source

In : Proceedings of the third annual tropical and subtropical fisheries technological conference of the Americas, Rep. Tex. A and M Univ. Sea Grant Program, Publ. by : Texas A and M University, College Station, TX (USA), Sep 1978, p. 268-277

NT: Notes

En

ER: Environmental Regime

Marine

AB: Abstract

The U.S. commercial landings for Spanish mackerel (Scomberomorus maculatus) set new records in 1976 for both volume and value. Despite this fact, these species have not reached their commercial potential and may be considered underutilized. The major technological barrier to full utilization of the Scomberomorus species is a limited stability in frozen storage due to the development of oxidative rancidity. Preliminary results of a frozen storage study with Spanish mackerel indicate that treatment of fillets with an ascorbic acid solution is beneficial to quality preservation, but the use of carboxymethylcellulose dips does not appear to be worthwhile.

TI: Title

The catch of king mackerel and Spanish mackerel in the commercial shrimp fishery of South Carolina

AU: Author

Harris, PJ; Dean, JM

AF: Author Affiliation

Belle W. Baruch Institute for Marine Biology and Coastal Research, University of South Carolina, Columbia, SC 29208, USA

CF: Conference

Symp. on the Consequences and Management of Fisheries Bycatch, Dearborn, MI (USA), 27-28 Aug 1996

SO: Source

FISHERIES BYCATCH: CONSEQUENCES & MANAGEMENT., 1997, pp. 21-29

IB: ISBN

1-56612-048-9

NU: Other Numbers

AK-SG-97-02

AB: Abstract

The shrimp industry is an extremely important fishery in South Carolina (SC), where an average of 2,383 tons of shrimp worth about $11.8 million were landed between 1978 and 1992. An average of 1,043 commercial permits were issued each year (SAFMC 1993). The commercial and recreational fisheries for king mackerel

(Scomberomorus cavalla) and Spanish mackerel (Scomberomorus maculatus) are also important fisheries in South Carolina. Juvenile king and Spanish mackerel were known to be taken as bycatch off SC. Collins and Wenner (1988) documented that tongue nets, which were being increasingly used (Edwards 1987), appeared to catch more king and Spanish mackerel per hour than semiballoon nets. We hypothesized that the mortality of the juvenile king and Spanish mackerel in SC shrimp trawls had a detrimental effect on the Atlantic group adult mackerel populations. We tested this hypothesis by addressing several objectives: (1) to quantify the number of mackerel taken as bycatch, (2) to estimate the statewide bycatch of mackerels, and (3) to include these data in the estimate of the population size of Atlantic king and Spanish mackerel, and test to see if the sizes of the populations were significantly increased.

TI: Title
Characterization of king mackerel and Spanish mackerel bycatches of South Carolina shrimp trawlers
AU: Author
Harris, PJ; Dean, JM
AF: Author Affiliation
South Carolina Marine Resources Division, Post Office Box 12559, Charleston, SC 29422, USA
SO: Source
North American Journal of Fisheries Management [N. Am. J. Fish. Manage.], vol. 18, no. 2, pp. 439-453, May 1998
IS: ISSN
0275-5947
AB: Abstract
Juvenile king mackerel Scomberomorus cavalla and Spanish mackerel S. maculatus are caught by commercial shrimp trawlers in South Carolina. Our study documented the extent and duration of this bycatch during the commercial shrimp trawling season in South Carolina waters. Sampling was conducted onboard commercial shrimp vessels based in McClellanville, South Carolina, during 1991 and on vessels based in McClellanville, Charleston, and Beaufort in 1992. Eight vessels and 137 trawl tows (mean tow duration, 2.88 h) were sampled; 81 king and 257 Spanish mackerel were collected. The mean annual sample catch per unit effort (CPUE) of king mackerel was 0.244 fish/h; adjusted for trawl footrope length in meters, the mean annual total CPUE was 0.038 fish/(h times m). King mackerel were found in only 21% of the tow samples, and peak catches occurred in October 1991 and September 1992. The mean annual sample CPUE for Spanish mackerel was 0.701 fish/h, and the mean annual total CPUE was 0.109 fish/(h times m). Spanish mackerel were found in 41% of the tow samples, and peak catches

occurred in July of both years. Age-0 king mackerel are vulnerable to shrimping gear for at least half of the South Carolina shrimp season, which generally runs from May through December, and age-0 Spanish mackerel are vulnerable for most of the shrimping season.

TI: Title
Electrophoretic Patterns of Proteins in Spanish Mackerel (Scomberomorus maculatus).
AU: Author
Johnson, AG
CA: Corporate Author
Natl. Marine Fish. Serv., Panama City, FL (USA). Southeast Fish. Center
SO: Source
NOAA TECH. MEMO., NOAA/NMFS, PANAMA CITY, FL (USA) , 1981, 12 pp
PB: Publisher
NOAA/NMFS, PANAMA CITY, FL (USA)
NU: Other Numbers
NOAA-TM-NMFS-SEFC-76
AB: Abstract
The biochemical variations and electrophoretic patterns found in tissues of Spanish mackerel (S. maculatus) using starch gel electrophoresis are reported. The exmination was performed in order to find biochemical variants which may be useful to identify stocks, and to estimate the amount of genetic variation in this species. Ten of the 44 loci studied were found to be polymorphic. The variant systems were alpha-glycerophosphate dehydrogenase, lactate dehydrogenase (B locus), malate dehydrogenase, malic enzyme (two variant systems), glutamic dehydrogenase, esterase, peptidase, adenoside, deaminase, and phosphoglucose isomerase.

TI: Title
Use of otolith morphology for separation of king mackerel (Scomberomorus cavalla) and Spanish mackerel (Scomberomorus maculatus)
AU: Author
Johnson, AG
AF: Author Affiliation
Natl. Mar. Fish. Serv., Southeast Fish. Sci. Cent., Panama City Lab., 3500 Delwood Beach Rd., Panama City, FL 32408, USA
SO: Source
Gulf of Mexico Science [GULF MEX. SCI.], vol. 14, no. 1, pp. 1-6, 1996
IS: ISSN
1087-688X
AB: Abstract
Shapes of otoliths (sagittae) of king and Spanish mackerel

(Scomberomorus cavalla and S. maculatus) were compared using theta-rho analysis aided by digitized computer methods. Otoliths from three king mackerel groups [Yucatan (Mexico), northwest Florida, and North Carolina] and one Spanish mackerel group were examined. Seven analytical combinations of measurements were tested. Intraspecific separation was highest using two truss systems (66.7-70.0% and 57.7-77.5%) and interspecific separation was highest using length and width radii (91.7%).

TI: Title
Management of a Multigear Fishery Exploiting a Highly Migratory Stock: Spanish Mackerel, Scomberomorus maculatus, in the Eastern Gulf of Mexico
AU: Author
Legault, C
AF: Author Affiliation
University Of Miami, FL, USA
SO: Source
Dissertation Abstracts International Part B: Science and Engineering [Diss. Abst. Int. Pt. B - Sci. & Eng.], Feb 1998, vol. 58, no. 8, p. 3981
NT: Notes
Thesis publ. date: 1997, 241pp. Source UMI, 300 N Zeeb Rd, POB 1346, Ann Arbor, MI 48106, USA (800.521.0600) or www.umi.com/hp/Products/Dissertations.html.
NU: Other Numbers
AAT 9805924
AB: Abstract
Three specific problems created by a multigear fishery exploiting a highly migratory population were examined: (1) use of catch per unit effort to reflect population abundance for a migratory stock; (2) seasonal fisheries not adhering to the assumption of a constant annual fishing mortality rate during the year; and (3) the ability to allocate a total quota amongst user groups to achieve a given management goal. The theoretical basis for each problem was examined and simulations incorporating some aspects of uncertainty from the real world were conducted based on the Spanish mackerel, Scomberomorus maculatus, fishery in the eastern Gulf of Mexico. Three catch per unit effort (CPUE) indices were compared in ability to reflect changes in population abundance of a migratory species: whole season, fully available and maximum. An algorithm was developed to correct annual observed catches from seasonal fisheries to meet the assumption of a constant fishing mortality rate during the year. A separate algorithm was developed to allow incorporation of additional constraints to match the allocation scheme when computing a total quota for multiple gears. A migratory age and size based fishery simulation model (MASFISH)

was created to examine these problems and potential solutions for the Spanish mackerel fishery in the eastern Gulf of Mexico. Application of the model consisted of six experiments. Two stock assessment experiments examined the ability of the three CPUE indices and two types of catch (observed and corrected) to estimate population abundance when used in tuned virtual population analysis. Four management experiments examined the ability to recover an overexploited stock under the twelve total combinations comprised of three CPUE indices, two types of catch, and two methods of setting quotas (incorporating or independent of quota allocations). The three CPUE indices performed nearly identically, while the corrected catch outperformed observed catch, and the inclusion of quota allocations when setting the quota produced better management than computing the total quota independent of the quota allocation.

TI: Title
Annotated bibliography of four Atlantic scombrids: Scomberomorus brasiliensis, S. cavalla, S. maculatus , and S. regalis
AU: Author
Manooch,C.S.; Nakamura,E.L.; Hall,A.B.
AF: Author Affiliation
US Natl. Mar. Fish. Serv., Southeast Fish. Cent., Panama City, FL, USA
CA: Corporate Author
National Marine Fisheries Service, Seattle, WA (USA). Scientific Publications Staff
SO: Source
Publ. by : NOAA/NMFS; Seattle, WA (USA), Dec 1978, 169 p, NOAA Tech. Rep
NT: Notes
Also as: NMFS Southeast Fisheries Center Contribution No. 77-01B
ER: Environmental Regime
Marine
AB: Abstract
Annotated references are presented on 570 papers published from 1973 to 1977. A subject index is included for each species and cover a variety of topics ranging from taxonomy to commercial and recreational fishing.

TI: Title
[Biological aspects of Scomberomorus maculatus (Mitchill), caught by gill nets]
OT: Original Title
Aspectos biologicos da serra, Scomberomorus maculatus (Mitchill), capturada por currais-de-pesca
AU: Author
Menezes Ferreira, M.de

AF: Author Affiliation
Lab. Cienc. Mar, Univ. Fed. Ceara, Fortaleza, Ceara, Brazil
SO: Source
Arq. Cienc. Mar., 16(1), 45-48, (1976)
ER: Environmental Regime
Marine
AB: Abstract
This paper gives some information on basic biological characteristics of the population of Spanish mackerel, Scomberomorus maculatus (Mitchill), concerning size distribution, sex-ratio and reproductive activity. Spanish mackerel is caught by gill-nets and fishing-weirs, and the size distribution from each gear has been shown to be different, smaller fish being caught in a lower proportion by fishing-weirs. The size distribution from fishing-weir catch samples is thought to be closer to the population distribution, given the probable non-selectivity of that type of fishing gear. Very little reproductive activity has been observed to take place in the studied area (northwest of Ceara State - Brazil), the reason for that lying probably with the fact that Spanish mackerels spawn outside the catching range of fishing-weirs. Further evidence to this fact is provided by the high sex-ratio in favour of females (1 male: 3 . 3 female) in all seasons of the year. It cannot be known as yet whether the gathered information represent the true facts or there are sampling errors involved, further sampling in offshore areas being needed in order to confirm of deny the data.

TI: Title
Effects of storage time and temperature on the microflora and amine development in Spanish mackerel (Scomberomorus maculatus).
AU: Author
Middlebrooks, BL; Toom, PM; Douglas, WL; Harrison, RE; McDowell, S
AF: Author Affiliation
Dep. Biol. Sci., Univ. Southern Mississippi, Hattiesburg, MS 39406, USA
SO: Source
Journal of Food Science [J. FOOD SCI.], vol. 53, no. 4, pp. 1024-1029, 1988
IS: ISSN
0022-1147
AB: Abstract
Microbial content was characterized and levels of three amines were determined in Spanish mackerel (Scomberomorus maculatus) decomposed at 0 degree C, 15 degree C, and 30 degree C for varying lengths of time. A total of 14 bacterial species with histidine decarboxylase activity were isolated from decomposing fish, including three species (Acinetobacter lwoffi, Pseudomonas putrefaciens , and Aeromonas hydrophila) not previously reported

to have the potential to produce histamine.

TI: Title
Bycatch in the Gulf of Mexico shrimp fishery
AU: Author
Nance, JM; Scott-Denton, E
AF: Author Affiliation
National Marine Fisheries Service, Galveston Laboratory, 4700 Avenue U, Galveston, TX 77551, USA
CA: Corporate Author
Commonwealth Scientific and Industrial Research Organ., Collingwood (Australia)
CF: Conference
2. World Fisheries Congress, Brisbane (Australia), 28 Jul-2 Aug 1996
ED: Editor
Hancock, DA (eds); Smith, DC(eds); Grant, A(eds); Beumer, JP(eds)
SO: Source
Developing and sustaining world fisheries resources. The state of science and management., CSIRO, Collingwood (Australia), 1997, pp. 98-102
IB: ISBN
0-643-05985-7
PB: Publisher
CSIRO, Collingwood (Australia)
AB: Abstract
Over the past 5 years a total of 3653 observer days have been secured by shrimp bycatch observers in the Gulf of Mexico and along the east coast of the United States of America. Analysis revealed that on average about 27 kg of organisms per hour are taken during trawling operations in the Gulf of Mexico. Examination of the composition of the organisms revealed that about 68% of the catch by weight is composed of finfish (mostly groundfish), 16% by commercial shrimp species. 13% by non-commercial shrimp crustaceans and 3% by non-crustacean invertebrates. Although groundfish species make up the majority of the bycatch taken in shrimp trawls, 3 species (king mackerel, Scomberomorus cavalla, Spanish mackerel, S. maculatus and red snapper, Lutjanus compechanus) have received a great deal of attention because of their commercial and recreational importance and the potential for significant impacts on their population abundance through shrimp trawling activities. Average catch of these 3 species is generally below 0.5 kg per hour.

TI: Title
Biological and fisheries data on Spanish mackerel, Scomberomorus maculatus (Mitchill)

CA: Corporate Author
National Marine Fisheries Service, Highlands, NJ (USA). Northeast Fisheries Center
SO: Source
Publ.by: NOAA/NMFS, Highlands, NJ (USA)., Nov 1977., 58 p., Tech. Ser. Rep. NOAA/NMFS Northeast Fish. Cent.
NT: Notes
Includes bibliography; 99 ref.
PB: Publisher
Publ.by: NOAA/NMFS, Highlands, NJ (USA).
ER: Environmental Regime
Marine
AB: Abstract
This synopsis of biological and fisheries data on the Spanish mackerel, S.maculatus, is based on existing literature. Information is given on the nomenclature, taxonomy, morphology, distribution, bionomics and life history, population structure, exploitation, protection and management of these fish which are found from the western Atlantic Ocean from Maine and Bermuda to Santos, Brazil, including the Gulf of Mexico and the water around Cuba, but is absent from the rest of the West Indies.

TI: Title
Results of a king mackerel (Scomberomorus cavalla) and Atlantic Spanish mackerel (Scomberomorus maculatus) migration study, 1975-79
CA: Corporate Author
National Marine Fisheries Serv., Panama City, FL (USA). Southeast Fisheries Cent.
SO: Source
Publ. by: NOAA/NMFS; Panama City, FL (USA)., Mar 1980., 24 p., NOAA Tech. Memo.
ER: Environmental Regime
Marine
AB: Abstract
The Panama City and Port Aransas Laboratories tagged and released 2,731 king and 745 Atlantic Spanish mackerel in a 1975-78 study of their movements and migration. From those releases, 59 (2.2%) of the king mackerel and 44 (5.9%) of the Atlantic Spanish mackerel were subsequently recaptured. The tagged recoveries revealed an annual migration by king mackerel from south Florida waters north to the northeast coast of the Gulf of Mexico and west to South Texas waters in the spring and return to south Florida in the fall. Mixing of Gulf fish in the winter with Atlantic fish north to Ft. Pierce was disclosed by tagged recaptures. Fragmented evidence was obtained that Atlantic Spanish mackerel made an annual migration from wintering grounds off south Florida and Campeche-Yucatan to summer grounds along the northern Gulf coast and a return migration in the fall.

TI: Title
Stomach contents of juveniles of king mackerel (Scomberomorus cavalla) and Spanish mackerel (S. maculatus).
AU: Author
Naughton, SP; Saloman, CH
AF: Author Affiliation
SEFC, NMFS, NOAA, Panama City Lab., 3500 Delwood Beach Rd., Panama City, FL 32407, USA
SO: Source
NORTHEAST GULF SCI., vol. 5, no. 1, pp. 71-74, 1981
IS: ISSN
: 0148-9836
AB: Abstract
Some trawl-caught king and Spanish mackerel (Scomberomorus cavalla and S. maculatus) were examined as regards their diet. Data indicate both to be carnivorous, primarily piscivorous, as juveniles. Engraulidae (Anchoa sp) and Clupeidae (Brevoortia and Opisthonema oglinum) are the dominant food organisms in the diet of small trawl-caught mackerel.

TI: Title
Abundance of Spanish mackerel, Scomberomorus maculatus , in the southeastern United States based on charterboat CPUE data, 1982-85.
AU: Author
Palko, BJ; Trent, PL; Brusher, HA
AF: Author Affiliation
Panama City Lab. Southeast Fish. Cent., NMFS, NOAA, 3500 Delwood Beach Rd., Panama City, FL 32407, USA
SO: Source
Marine Fisheries Review [MAR. FISH. REV.], vol. 49, no. 2, pp. 67-77, 1987
IS: ISSN
0090-1830
NT: Notes
Special issue: Marine recreational fisheries and fishing.
AB: Abstract
Catch per unit effort (CPUE) data for Spanish mackerel, Scomberomorus maculatus , over a broad geographic area were obtained from charterboats. In 1982, a survey was initiated to obtain daily catch and effort data on fishes commonly caught by charterboats in the southeast United States. Boat effort and Spanish mackerel CPUE data obtained from this survey during 1982-85 were analyzed. The offshore fishing zone (> 10 fathoms) received the highest amount of trolling and "other fishing" efforts; the nearshore fishing zone (less than or equal to 10

fathoms) received the second highest trolling effort and lowest "other fishing" effort; the estuarine fishing zone received the lowest trolling effort and the second lowest "other fishing" effort. CPUE of Spanish mackerel by "other fishing" was much lower than trolling for most areas and years. CPUE was highest in the estuarine zone when compared with the nearshore and offshore zones. Significant differences in CPUE among years were detected only in North Carolina and Louisiana.

TI: Title
Daily age and growth of larval and early juvenile Spanish mackerel, Scomberomorus maculatus, from the South Atlantic Bight
AU: Author
Peters, JS; Schmidt, DJ
AF: Author Affiliation
Dep. Biol., Coll. Charleston, 66 George St., Charleston, SC 29424, USA
SO: Source
Fishery Bulletin [FISH. BULL.], vol. 95, no. 3, pp. 530-539, Jul 1997
IS: ISSN
0090-0656
AB: Abstract
Age and growth of larval and juvenile Spanish mackerel, Scomberomorus maculatus, were determined by examining increments of daily growth on the otoliths (lapilli) of specimens collected along the southeastern Atlantic coast, 1983-89. Marginal increment analysis was performed on 152 fish (7.4-97.0 mm SL) to validate the deposition of daily rings. A mean standardized marginal increment (SMI) was calculated by comparing the width of the marginal increment to the adjacent increment on the lapilli of fish captured over a diel cycle. The distribution of mean SMI was unimodal. A nonlinear equation was used to model growth (ln SL = 6.2 - 55.1/Age). Based on this growth equation, predicted absolute growth rates for the first 23 days of life were approximately 1.9 mm/day, followed by a surge of rapid growth approaching 5.0 mm/day over the next 17 days. Absolute growth rates subsequent to 40 days of age were 2.1 mm/day.

TI: Title
Stock assessments for U.S. stocks of king and Spanish mackerels: 1983-1992
AU: Author
Powers, JE; Thompson, NB
AF: Author Affiliation
NOAA/NMFS, Southeast Fish. Sci. Cent., Miami Lab., 75 Virginia Beach Dr., Miami, FL 33249, USA

SO: Source
Collective volume of scientific papers. International Commission for the Conservation of Atlantic Tunas/Recueil de documents scientifiques. Commissio internationale pour la Conservation des Thonides de l'Atlantique/Coleccion d documentos cientificos [COLLECT. VOL. SCI. PAP. ICCAT/RECL. DOC. SCI. CICTA/COLECC. DOC. CIENT. CICAA], vol. 40, no. 2, pp. 391-398, 1993

IS: ISSN
1021-5212

NU: Other Numbers
ICCAT SCRS/92/25

AB: Abstract
Age-based stock assessment analyses have been completed annually for king (Scomberomorus cavalla) and Spanish mackerel (S. maculatus) for the Gulf of Mexico and Atlantic stocks, respectively. For these analyses, catch-at-age data are integrated into virtual population assessment and are calibrated using CPUE values from selected areas. Results of these analyses are used to determine biological reference points and to project forward in time to determine allowable catch for the upcoming fishing year. Estimates of current spawning stock biomass relative to historical estimates are evaluated to determine which stocks are over-fished.

TI: Title
Differences in hemoglobin phenotypes among Spanish mackerel, Scomberomorus maculatus .

AU: Author
Skow, LC; Chittenden, ME Jr

AF: Author Affiliation
Dep. Wildl. and Fish. Sci., Texas A&M Univ., College Station, TX 77843, USA

SO: Source
NORTHEAST GULF SCI., vol. 5, no. 1, pp. 67-70, 1981

IS: ISSN
: 0148-9836

AB: Abstract
Electrophoretic evidence is presented for the existence of at least 2 populations of S. maculatus . Starch-gel electrophoresis of mackerel (Scomberomorus) blood samples show the hemoglobins to resolve into 2 bands thus indicating genetic variation.

TI: Title
Comparison of the catch from tongue and two-seam shrimp nets off South Carolina

AU: Author
Stender, BW; Barans, CA

AF: Author Affiliation

Mar. Resour. Res. Inst., South Carolina Wildl. and Mar. Resour. Dep., PO Box 12559, Charleston, SC 29422-2559, USA

SO: Source

North American Journal of Fisheries Management [N. AM. J. FISH. MANAGE.], vol. 14, no. 1, pp. 178-195, 1994

IS: ISSN

0275-5947

AB: Abstract

Before the gears were used for catch comparisons, a two-seam net and a tongue trawl were evaluated for changes in net dimensions with fishing depth and tow direction. When towed as it would be during catch comparisons, the two-seam net had a width of 16.1 m and was estimated to extend 2.1 m vertically at the center of the headrope. The horizontal spread of the tongue trawl was 13.5 m and its vertical spread was 4.2 m at center. Small, statistically consistent differences in openings (<0.5 m) occurred with depth and direction. The major factor influencing changes in catch (kg/ha) with depth (10-fold increase in shallow water) appeared to be the faunal distribution with depth, independent of towing characteristics. Differences in biomass (kg/tow, kg/ha), and in the biomass (kg/ha) ratios of taxa to shrimp between the two-seam and tongue trawls were documented for eight major biological groups. Major differences in total catch by net occurred between years primarily because of changes in the catch of miscellaneous invertebrates and shrimp. Significant differences in the lengths of nine priority species occurred between the two gears. Mean lengths in the two nets differed by more than 1 cm for spot Leiostomus xanthurus (which was larger in the tongue net), Atlantic croaker Micropogonias undulatus (larger in the two-seam net), and Spanish mackerel Scomberomorus maculatus (larger in the tongue net). Mean ratio of fish to shrimp biomass was 31:1 overall (21:1 for the two-seam net and 41:1 for the tongue trawl). Ratios of total biomass and the biomass of any taxonomic grouping to shrimp biomass did not differ statistically between the two gears. Biomass ratios were recalculated from published data by a standard methodology. Subsequent comparisons indicated increases in the ratios over time and highlighted a need to validate the technique of subsampling heterogenous trawl samples. Finfish by-catch in both gears was dominated by sciaenids (44% by weight of all fish). Red drum Sciaenops ocellatus spotted seatrout Cynoscion nebulosus snappers (Lutjanidae), and groupers (Epinephelinae) were not caught by either net. Catches of Spanish mackerel and king mackerel Scomberomorus cavalla were documented and warrant further investigation to evaluate the effects of by-catch on local populations.

Scomberomorus maculatus

TI: Title
A multispecies stock assessment of a pelagic coastal fishery of the south-west Gulf of Mexico.
AU: Author
Arreguin-Sanchez, F; Chavez, EA; Menchaca, JA
AF: Author Affiliation
Cent. Invest. y de Estud. Avanzados del IPN, Km 6 Carreterra Antigua a Progreso, AP 73-Cordemex 97310, Merida, Yucatan, Mexico
SO: Source
AQUACULT. FISH. MANAGE., vol. 23, no. 1, pp. 103-112, 1992
AB: Abstract
Multispecies stock assessment based upon Schaefer's theory was applied to a coastal pelagic fishery (Spanish mackerel, Scomberomorus maculatus ; king mackerel, S. cavalla and the blue runner, Caranx fusus , from the west central Gulf of Mexico. Linear and non-linear systems of equations were estimated by using a multiple stepwise regression technique. The values of interaction parameters show a clear competition between mackerels, and technological interdependences between the blue runner and mackerels. The maximum yield estimation was from 4000 to 5000 tonnes, obtained with 23 and 34 beach seines respectively, depending on the applied model. Two stages were observed from the statistical records; in the first the Spanish mackerel is the most important species while in the second the abundance of this species declines and the others remain at the same level. Significant interactions were found from the first data group.

TI: Title
An investigation of the trophic role of three pelagic fishes in a tropical coastal ecosystem of the western Gulf of Mexico, using the ECOPATH II model
AU: Author
Arreguin-Sanchez, F; Chavez, EA
AF: Author Affiliation
Cent. Interdiscipl. Cienc. Mar. IPN (CICIMAR), Ao., P. 592, 23000 La Paz, Baja California Sur, Mexico
CF: Conference
Int. Symp. on Middle-Sized Pelagic Fish, Las Palmas de Gran Canaria, Gran Canaria, Canary Islands (Spain), 24-28 Jan 1994
ED: Editor
Bas, C; Castro, JJ; Lorenzo, JM (eds)
SO: Source
INTERNATIONAL SYMPOSIUM ON MIDDLE-SIZED PELAGIC FISH HELD IN LAS PALMAS DE GRAN CANARIA 24-28 JANUARY 1994., 1995, pp. 307-315,

Scientia Marina (Barcelona) [SCI. MAR. (BARC.)], vol. 59, no. 3-4
IS: ISSN
0214-8358
AB: Abstract
The spanish and king mackerels (Scomberomorus maculatus and S. cavalla) and the blue runner (Caranx fusus) are important pelagic fish resources along the coasts of the Gulf of Mexico. Interdependences between them have been studied through simple multispecies yield models. Simulated changes in fishing effort suggest S. cavalla and C. fusus populations are more stable than S. maculatus. The ecosystem model, previously obtained with ECOPATH II, was used to simulate gradual changes in biomass. Ecosystem response tends to maintain the thermodynamic equilibrium by adjusting the biomass/energy flows. The predator/prey and competence interdependences show impacts of different magnitude, depending on how species are using the ecosystem resources. However, the main variations occurred through respiration and flows into detritus. Spanish and king mackerels share some resources like anchovies, herrings and shrimp; however, the spanish mackerel has a wider trophic spectrum. The blue runner shares some food resources with the above species, but it also uses some others. The specific biomass flows in the prey/predator relationships, the specific foraging index, the niche overlap and the relative population abundance explain the higher variability of the spanish mackerel population.

TI: Title
Simulation of the Spanish mackerel (Scomberomorus maculatus) fishery of the Gulf of Mexico.
OT: Original Title
Simulacion de la pesqueria de sierra (Scomberomorus maculatus) del Golfo de Mexico
AU: Author
Chavez, EA
AF: Author Affiliation
Cent. Invest. Aliment. y Desarrollo A.C., Unid. Mazatlan Acuicult. y Manejo Ambient., Calzada Sabalo-Cerritos y Estero del Yugo, A.P. 711, Mazatlan, Sinaloa 82010, Mexico
SO: Source
Revista de investigaciones marinas. Mexico City [REV. INVEST. MAR.], vol. 15, no. 3, pp. 209-217, 1994
IS: ISSN
0252-1962
AB: Abstract
Spanish mackerel (Scomberomorus maculatus) fishery was analyzed through a 40-year period of catch records. Estimates of population size, exploitation rates and fishing mortality coefficients were

obtained for each year once age structure was determined. With these data a simulation model that considers changes in size of each cohort through time was made; this model allowed to assess the consequences of different management options. Results showed that the stock is slightly under exploited.

TI: Title
Fluctuations in abundance of Spanish mackerel in Chesapeake Bay and the mid-Atlantic region

AU: Author
Chittenden, ME Jr; Barbieri, LR; Jones, CM

AF: Author Affiliation
Coll. William and Mary, Virginia Inst. Mar. Sci. Gloucester Point, VA 23062, USA

SO: Source
North American Journal of Fisheries Management [N. AM. J. FISH. MANAGE.], vol. 13, no. 3, pp. 450-458, 1993

IS: ISSN
0275-5947

AB: Abstract
Spanish mackerel Scomberomorus maculatus have shown great fluctuations in abundance in Chesapeake Bay and the Mid-Atlantic Region. Early anecdotal accounts indicate they were very abundant in the later 1600s but were not common in the early-mid-1800s. Both annual landings and anecdotal accounts indicate they were very abundant about 1860-1910 and much less so since. Early patterns may reflect, in part, a natural long-term component in abundance. Large early landings were probably at levels not sustainable in the Chesapeake and Mid-Atlantic Region, because the classical response of a stock to fishing is a process of juvenescence and reduction of the virgin standing stock to a new, lower, equilibrium level. Fluctuations due to recruitment have probably been superimposed on the juvenescence process since the inception of the early fishery about 1865. Repeated lows in Chesapeake Bay landings in 1910-1936, 1947-1960, and 1977-1985 indicate repeated, prolonged series of weak year-classes in that region or poor escapement from fisheries in more southern waters. Two brief periods of high landings in 1937-1938 and 1944-1946 probably each reflected one or two strong year-classes. The nature and duration of the recent period of high landings (1986-1991) is not yet clear. This apparent increase in abundance may reflect (1) increased survivorship and escapement of adults due to recent management actions in Florida, and (2) possible production of at least one strong year-class at the beginning of, if not throughout, the period, a phenomenon that may have been enhanced by increased spawning stocks reflecting recent management or earlier voluntary actions.

TI: Title
Fishery-independent recruitment indices for king and Spanish mackerels
AU: Author
Collins, MR; Harris, PJ; Maier, PP
AF: Author Affiliation
South Carolina Department of Natural Resources, Marine Resources Research Institute, Post Office Box 12559, Charleston, SC 29422-2559, USA
SO: Source
North American Journal of Fisheries Management [N. Am. J. Fish. Manage.], vol. 18, no. 1, pp. 181-186, Feb 1998
IS: ISSN
0275-5947
AB: Abstract
We investigated whether the abundance of age-0 mackerels in a fishery-independent trawl survey could be used to predict abundance at age 1 for king mackerel Scomberomorus cavalla and Spanish mackerel S. maculatus. After deletion of inappropriate length-classes and partitioning by season, depth, and stratum, subsets of the data set were compared to landings data and stock assessment results from the National Marine Fisheries Service. Total landings of age-1 Spanish mackerel were closely predicted (r super(2) = 0.91) by catch per unit effort (CPUE) of age-0 fish 11-28 cm in fork length (FL) in samples taken by the Southeast Area Monitoring and Assessment Program-South Atlantic (SEAMAP-SA) during fall from shallow strata in the coastal waters of Georgia and South Carolina (latitudes 30 degree 44'-33 degree 12'N; SEAMAP-SA odd strata 31-49). The best predictor (r super(2) = 0.72) for age-1 king mackerel was CPUE of age-0 fish 9-30 cm FL in SEAMAP-SA's fall samples from shallow strata in the coastal waters of South Carolina and North Carolina (32 degree 04'-35 degree 15'N; SEAMAP-SA odd strata 41-67) collected the previous year. The indices should be used with caution until data from additional years become available for verification and incorporation.

TI: Title
Age and growth of king and Spanish mackerel larvae and juveniles from the Gulf of Mexico and U.S. South Atlantic Bight.
AU: Author
De Vries, DA; Grimes, CB; Lang, KL; White, D
AF: Author Affiliation
NMFS, Southeast Fish. Cent., 3500 Delwood Beach Rd., Panama City, FL 32407-7499, USA
SO: Source
Environmental biology of fishes. The Hague [ENVIRON. BIOL. FISH.],

vol. 29, no. 2, pp. 135-143, 1990

IS: ISSN

0378-1909

AB: Abstract

Sagtittal otoliths from 50 king mackerel (Scomberomorus cavalla) 2.9-13.0 mm SL and 72 Spanish mackerel (Scomberomorus maculatus) 2.8-22.0 mm SL collected off the southeast U.S. were examined whole at 400 x using a compound microscope-video system. Otoliths of both species had visible, presumably daily, growth increments as well as finer subdaily increments. Otolith growth was directly proportional to growth in standard length for king (r super(2) = 0.91) and Spanish mackerel (r super(2) = 0.86). Spanish mackerel were estimated to be 3-15 d old with a mean absolute growth rate (SL/number of growth increments) and 95% confidence interval of 1.15 plus or minus 0.07 mm/d. The least squares linear equation: SL = - 1.30 + 1.31 (age in days), with r super(2) = 0.67 and p > 0.001, described the relationship between length and age. There was a significant positive relationship between absolute growth rate and fish length. King mackerel were estimated to be 3-15 d old with a mean absolute growth rate of 0.89 plus or minus 0.06 mm/d. Growth rate of king mackerel was slightly higher for fish from the Mississippi River plume than from all other locations combined, while Spanish mackerel growth rates were not significantly different.

TI: Title

Selectivity of gill nets used in the commercial Spanish mackerel fishery of Florida.

AU: Author

Ehrhardt, NM; Die, DJ

AF: Author Affiliation

Div. Biol. and Living Resour., Rosenstiel Sch. Mar. and Atmos. Sci., Univ. Miami, 4600 Rickenbacker Causeway, Miami, FL 33149, USA

SO: Source

Transactions of the American Fisheries Society [TRANS. AM. FISH. SOC.], vol. 117, no. 6, pp. 574-580, 1988

IS: ISSN

0002-8487

AB: Abstract

Selection curves of encircling (run-around) and drifting (stab) gill nets used in the winter fishery for Spanish mackerel Scomberomorus maculatus off southern Florida were estimated by use of cumulative probability distributions of retention girth at length. Selection curves corresponded well with observed size frequencies obtained from each mesh size. Increasing differences between maximum and head girth perimeters as fish grew resulted in

selection curves indicating increased selection range and efficiency. Selectivity of Spanish mackerel gill nets will change as the condition of the fish changes with the onset of the spawning season. Apparently, selectivity also changes with twine size.

TI: Title
Size-structured yield-per-recruit simulation for the Florida gill-net fishery for Spanish mackerel.
AU: Author
Ehrhardt, NM; Die, DJ
AF: Author Affiliation
Div. Biol. and Living Resour., Rosenstiel Sch. Mar. and Atmos. Sci., Univ. Miami, 4600 Rickenbacker Causeway, Miami, FL 33149, USA
SO: Source
Transactions of the American Fisheries Society [TRANS. AM. FISH. SOC.], vol. 117, no. 6, pp. 581-590, 1988
IS: ISSN
0002-8487
AB: Abstract
The authors estimated the effects of gill-net mesh size regulations on the yield per recruit of Spanish mackerel Scomberomorus maculatus in Florida. Yield per recruit was calculated with a simulation model that incorporated seasonal fishing rates by sectors (recreational and commercial) and size-varying availabilities of fish to the gear and retention probabilities once fish encountered the gear. Gains in yield (g) per recruit were always obtained by increasing mesh size, gill-net fishing mortality, or both. Adoption of a minimum length above the present enforced minimum 30.5 cm fork length may result in considerable gains in yield per recruit. This, however, depends on the assumption that there is no cryptic mortality of undersized fish in the recreational fishery.

TI: Title
Age and growth of Spanish mackerel, Scomberomorus maculatus , from Florida and the Gulf of Mexico.
AU: Author
Fable, WA Jr; Johnson, AG; Barger, LE
AF: Author Affiliation
Southeast Fish. Cent. Panama City Lab., Natl. Mar. Fish. Serv., NOAA, 3500 Delwood Beach Rd., Panama City, FL 32407-7499, USA
SO: Source
Fishery Bulletin [FISH. BULL.], vol. 85, no. 4, pp. 777-783, 1987
IS: ISSN
0090-0656

AB: Abstract

Otoliths from 1,787 Spanish mackerel, Scomberomorus maculatus , were used to estimate age and growth rates of this species from Florida and the Gulf of Mexico. There was a wide range of lengths within an age group: the oldest male was 7 years old, while the oldest female was 9 years old. Length at age was significantly different for sexes, sampling areas, and collection gear.

TI: Title

The Atlantic Spanish mackerel, Scomberomorus maculatus , new to Nova Scotia and Canada.

AU: Author

Gilhen, J; McAllister, DE

AF: Author Affiliation

Nova Scotia Mus., 1747 Summer St., Halifax, N.S. B3H 3A6, Canada

SO: Source

Canadian field-naturalist. Ottawa ON [CAN. FIELD-NAT.], vol. 103, no. 2, pp. 287-289, 1989

IS: ISSN

0008-3550

AB: Abstract

A single Atlantic Spanish mackerel, Scomberomorus maculatus taken by Victor Kiley off Sauls Island 44 degree 28'25"N, 63 degree 47'00"W, 4 October 1985, is the first record for Canadian waters. The species has previously been taken north as far as Monhegan Island, Maine. Spots on its sides, a black area on the front of the first dorsal fin and high vertebral count distinguish it from other Canadian Scombridae. Its occurrence in Nova Scotian waters does not appear to be explainable by passive transplant in the Gulf Stream as is invoked for northern records of less active swimmers.

TI: Title

Composition and storage stability of Spanish mackerel and related species

AU: Author

Hale,M.; Rasekh,J.

AF: Author Affiliation

U.S. Natl. Mar. Fish. Serv., Southeast Fish. Cent., Charleston, SC 29412, USA

CA: Corporate Author

TAMU-SG-79-101

CF: Conference

Presented at : 3. Annu. Tropical and Subtropical Fisheries Technological Conference of the Americas, New Orleans, LA (USA), 23 Apr 1978

SO: Source

In : Proceedings of the third annual tropical and subtropical fisheries technological conference of the Americas, Rep. Tex. A and M Univ. Sea Grant Program, Publ. by : Texas A and M University, College Station, TX (USA), Sep 1978, p. 268-277

NT: Notes
En

ER: Environmental Regime
Marine

AB: Abstract
The U.S. commercial landings for Spanish mackerel (Scomberomorus maculatus) set new records in 1976 for both volume and value. Despite this fact, these species have not reached their commercial potential and may be considered underutilized. The major technological barrier to full utilization of the Scomberomorus species is a limited stability in frozen storage due to the development of oxidative rancidity. Preliminary results of a frozen storage study with Spanish mackerel indicate that treatment of fillets with an ascorbic acid solution is beneficial to quality preservation, but the use of carboxymethylcellulose dips does not appear to be worthwhile.

TI: Title
The catch of king mackerel and Spanish mackerel in the commercial shrimp fishery of South Carolina

AU: Author
Harris, PJ; Dean, JM

AF: Author Affiliation
Belle W. Baruch Institute for Marine Biology and Coastal Research, University of South Carolina, Columbia, SC 29208, USA

CF: Conference
Symp. on the Consequences and Management of Fisheries Bycatch, Dearborn, MI (USA), 27-28 Aug 1996

SO: Source
FISHERIES BYCATCH: CONSEQUENCES & MANAGEMENT., 1997, pp. 21-29

IB: ISBN
1-56612-048-9

NU: Other Numbers
AK-SG-97-02

AB: Abstract
The shrimp industry is an extremely important fishery in South Carolina (SC), where an average of 2,383 tons of shrimp worth about $11.8 million were landed between 1978 and 1992. An average of 1,043 commercial permits were issued each year (SAFMC 1993). The commercial and recreational fisheries for king mackerel (Scomberomorus cavalla) and Spanish mackerel (Scomberomorus maculatus) are also important fisheries in South Carolina. Juvenile king and Spanish mackerel were known to be taken as

bycatch off SC. Collins and Wenner (1988) documented that tongue nets, which were being increasingly used (Edwards 1987), appeared to catch more king and Spanish mackerel per hour than semiballoon nets. We hypothesized that the mortality of the juvenile king and Spanish mackerel in SC shrimp trawls had a detrimental effect on the Atlantic group adult mackerel populations. We tested this hypothesis by addressing several objectives: (1) to quantify the number of mackerel taken as bycatch, (2) to estimate the statewide bycatch of mackerels, and (3) to include these data in the estimate of the population size of Atlantic king and Spanish mackerel, and test to see if the sizes of the populations were significantly increased.

TI: Title
Characterization of king mackerel and Spanish mackerel bycatches of South Carolina shrimp trawlers
AU: Author
Harris, PJ; Dean, JM
AF: Author Affiliation
South Carolina Marine Resources Division, Post Office Box 12559, Charleston, SC 29422, USA
SO: Source
North American Journal of Fisheries Management [N. Am. J. Fish. Manage.], vol. 18, no. 2, pp. 439-453, May 1998
IS: ISSN
0275-5947
AB: Abstract
Juvenile king mackerel Scomberomorus cavalla and Spanish mackerel S. maculatus are caught by commercial shrimp trawlers in South Carolina. Our study documented the extent and duration of this bycatch during the commercial shrimp trawling season in South Carolina waters. Sampling was conducted onboard commercial shrimp vessels based in McClellanville, South Carolina, during 1991 and on vessels based in McClellanville, Charleston, and Beaufort in 1992. Eight vessels and 137 trawl tows (mean tow duration, 2.88 h) were sampled; 81 king and 257 Spanish mackerel were collected. The mean annual sample catch per unit effort (CPUE) of king mackerel was 0.244 fish/h; adjusted for trawl footrope length in meters, the mean annual total CPUE was 0.038 fish/(h times m). King mackerel were found in only 21% of the tow samples, and peak catches occurred in October 1991 and September 1992. The mean annual sample CPUE for Spanish mackerel was 0.701 fish/h, and the mean annual total CPUE was 0.109 fish/(h times m). Spanish mackerel were found in 41% of the tow samples, and peak catches occurred in July of both years. Age-0 king mackerel are vulnerable to shrimping gear for at least half of the South Carolina shrimp season, which generally runs from May through December, and age-0

Spanish mackerel are vulnerable for most of the shrimping season.

TI: Title
Electrophoretic Patterns of Proteins in Spanish Mackerel (Scomberomorus maculatus).
AU: Author
Johnson, AG
CA: Corporate Author
Natl. Marine Fish. Serv., Panama City, FL (USA). Southeast Fish. Center
SO: Source
NOAA TECH. MEMO., NOAA/NMFS, PANAMA CITY, FL (USA) , 1981, 12 pp
PB: Publisher
NOAA/NMFS, PANAMA CITY, FL (USA)
NU: Other Numbers
NOAA-TM-NMFS-SEFC-76
AB: Abstract
The biochemical variations and electrophoretic patterns found in tissues of Spanish mackerel (S. maculatus) using starch gel electrophoresis are reported. The exmination was performed in order to find biochemical variants which may be useful to identify stocks, and to estimate the amount of genetic variation in this species. Ten of the 44 loci studied were found to be polymorphic. The variant systems were alpha-glycerophosphate dehydrogenase, lactate dehydrogenase (B locus), malate dehydrogenase, malic enzyme (two variant systems), glutamic dehydrogenase, esterase, peptidase, adenoside, deaminase, and phosphoglucose isomerase.

TI: Title
Use of otolith morphology for separation of king mackerel (Scomberomorus cavalla) and Spanish mackerel (Scomberomorus maculatus)
AU: Author
Johnson, AG
AF: Author Affiliation
Natl. Mar. Fish. Serv., Southeast Fish. Sci. Cent., Panama City Lab., 3500 Delwood Beach Rd., Panama City, FL 32408, USA
SO: Source
Gulf of Mexico Science [GULF MEX. SCI.], vol. 14, no. 1, pp. 1-6, 1996
IS: ISSN
1087-688X
AB: Abstract
Shapes of otoliths (sagittae) of king and Spanish mackerel (Scomberomorus cavalla and S. maculatus) were compared using theta-rho analysis aided by digitized computer methods. Otoliths from three king mackerel groups [Yucatan (Mexico), northwest

Florida, and North Carolina] and one Spanish mackerel group were examined. Seven analytical combinations of measurements were tested. Intraspecific separation was highest using two truss systems (66.7-70.0% and 57.7-77.5%) and interspecific separation was highest using length and width radii (91.7%).

TI: Title
Management of a Multigear Fishery Exploiting a Highly Migratory Stock: Spanish Mackerel, Scomberomorus maculatus, in the Eastern Gulf of Mexico
AU: Author
Legault, C
AF: Author Affiliation
University Of Miami, FL, USA
SO: Source
Dissertation Abstracts International Part B: Science and Engineering [Diss. Abst. Int. Pt. B - Sci. & Eng.], Feb 1998, vol. 58, no. 8, p. 3981
NT: Notes
Thesis publ. date: 1997, 241pp. Source UMI, 300 N Zeeb Rd, POB 1346, Ann Arbor, MI 48106, USA (800.521.0600) or www.umi.com/hp/Products/Dissertations.html.
NU: Other Numbers
AAT 9805924
AB: Abstract
Three specific problems created by a multigear fishery exploiting a highly migratory population were examined: (1) use of catch per unit effort to reflect population abundance for a migratory stock; (2) seasonal fisheries not adhering to the assumption of a constant annual fishing mortality rate during the year; and (3) the ability to allocate a total quota amongst user groups to achieve a given management goal. The theoretical basis for each problem was examined and simulations incorporating some aspects of uncertainty from the real world were conducted based on the Spanish mackerel, Scomberomorus maculatus, fishery in the eastern Gulf of Mexico. Three catch per unit effort (CPUE) indices were compared in ability to reflect changes in population abundance of a migratory species: whole season, fully available and maximum. An algorithm was developed to correct annual observed catches from seasonal fisheries to meet the assumption of a constant fishing mortality rate during the year. A separate algorithm was developed to allow incorporation of additional constraints to match the allocation scheme when computing a total quota for multiple gears. A migratory age and size based fishery simulation model (MASFISH) was created to examine these problems and potential solutions for the Spanish mackerel fishery in the eastern Gulf of Mexico. Application of the model consisted of six experiments. Two stock

assessment experiments examined the ability of the three CPUE indices and two types of catch (observed and corrected) to estimate population abundance when used in tuned virtual population analysis. Four management experiments examined the ability to recover an overexploited stock under the twelve total combinations comprised of three CPUE indices, two types of catch, and two methods of setting quotas (incorporating or independent of quota allocations). The three CPUE indices performed nearly identically, while the corrected catch outperformed observed catch, and the inclusion of quota allocations when setting the quota produced better management than computing the total quota independent of the quota allocation.

TI: Title
Annotated bibliography of four Atlantic scombrids: Scomberomorus brasiliensis, S. cavalla, S. maculatus , and S. regalis
AU: Author
Manooch,C.S.; Nakamura,E.L.; Hall,A.B.
AF: Author Affiliation
US Natl. Mar. Fish. Serv., Southeast Fish. Cent., Panama City, FL, USA
CA: Corporate Author
National Marine Fisheries Service, Seattle, WA (USA). Scientific Publications Staff
SO: Source
Publ. by : NOAA/NMFS; Seattle, WA (USA), Dec 1978, 169 p, NOAA Tech. Rep
NT: Notes
Also as: NMFS Southeast Fisheries Center Contribution No. 77-01B
ER: Environmental Regime
Marine
AB: Abstract
Annotated references are presented on 570 papers published from 1973 to 1977. A subject index is included for each species and cover a variety of topics ranging from taxonomy to commercial and recreational fishing.

TI: Title
[Biological aspects of Scomberomorus maculatus (Mitchill), caught by gill nets]
OT: Original Title
Aspectos biologicos da serra, Scomberomorus maculatus (Mitchill), capturada por currais-de-pesca
AU: Author
Menezes Ferreira, M.de
AF: Author Affiliation
Lab. Cienc. Mar, Univ. Fed. Ceara, Fortaleza, Ceara, Brazil
SO: Source

Arq. Cienc. Mar., 16(1), 45-48, (1976)

ER: Environmental Regime

Marine

AB: Abstract

This paper gives some information on basic biological characteristics of the population of Spanish mackerel, Scomberomorus maculatus (Mitchill), concerning size distribution, sex-ratio and reproductive activity. Spanish mackerel is caught by gill-nets and fishing-weirs, and the size distribution from each gear has been shown to be different, smaller fish being caught in a lower proportion by fishing-weirs. The size distribution from fishing-weir catch samples is thought to be closer to the population distribution, given the probable non-selectivity of that type of fishing gear. Very little reproductive activity has been observed to take place in the studied area (northwest of Ceara State - Brazil), the reason for that lying probably with the fact that Spanish mackerels spawn outside the catching range of fishing-weirs. Further evidence to this fact is provided by the high sex-ratio in favour of females (1 male: 3 . 3 female) in all seasons of the year. It cannot be known as yet whether the gathered information represent the true facts or there are sampling errors involved, further sampling in offshore areas being needed in order to confirm of deny the data.

TI: Title

Effects of storage time and temperature on the microflora and amine development in Spanish mackerel (Scomberomorus maculatus).

AU: Author

Middlebrooks, BL; Toom, PM; Douglas, WL; Harrison, RE; McDowell, S

AF: Author Affiliation

Dep. Biol. Sci., Univ. Southern Mississippi, Hattiesburg, MS 39406, USA

SO: Source

Journal of Food Science [J. FOOD SCI.], vol. 53, no. 4, pp. 1024-1029, 1988

IS: ISSN

0022-1147

AB: Abstract

Microbial content was characterized and levels of three amines were determined in Spanish mackerel (Scomberomorus maculatus) decomposed at 0 degree C, 15 degree C, and 30 degree C for varying lengths of time. A total of 14 bacterial species with histidine decarboxylase activity were isolated from decomposing fish, including three species (Acinetobacter lwoffi, Pseudomonas putrefaciens , and Aeromonas hydrophila) not previously reported to have the potential to produce histamine.

TI: Title

Bycatch in the Gulf of Mexico shrimp fishery
AU: Author
Nance, JM; Scott-Denton, E
AF: Author Affiliation
National Marine Fisheries Service, Galveston Laboratory, 4700 Avenue U, Galveston, TX 77551, USA
CA: Corporate Author
Commonwealth Scientific and Industrial Research Organ., Collingwood (Australia)
CF: Conference
2. World Fisheries Congress, Brisbane (Australia), 28 Jul-2 Aug 1996
ED: Editor
Hancock, DA (eds); Smith, DC(eds); Grant, A(eds); Beumer, JP(eds)
SO: Source
Developing and sustaining world fisheries resources. The state of science and management., CSIRO, Collingwood (Australia), 1997, pp. 98-102
IB: ISBN
0-643-05985-7
PB: Publisher
CSIRO, Collingwood (Australia)
AB: Abstract
Over the past 5 years a total of 3653 observer days have been secured by shrimp bycatch observers in the Gulf of Mexico and along the east coast of the United States of America. Analysis revealed that on average about 27 kg of organisms per hour are taken during trawling operations in the Gulf of Mexico. Examination of the composition of the organisms revealed that about 68% of the catch by weight is composed of finfish (mostly groundfish), 16% by commercial shrimp species. 13% by non-commercial shrimp crustaceans and 3% by non-crustacean invertebrates. Although groundfish species make up the majority of the bycatch taken in shrimp trawls, 3 species (king mackerel, Scomberomorus cavalla, Spanish mackerel, S. maculatus and red snapper, Lutjanus compechanus) have received a great deal of attention because of their commercial and recreational importance and the potential for significant impacts on their population abundance through shrimp trawling activities. Average catch of these 3 species is generally below 0.5 kg per hour.

TI: Title
Biological and fisheries data on Spanish mackerel, Scomberomorus maculatus (Mitchill)
CA: Corporate Author
National Marine Fisheries Service, Highlands, NJ (USA). Northeast Fisheries Center

SO: Source
Publ.by: NOAA/NMFS, Highlands, NJ (USA)., Nov 1977., 58 p., Tech. Ser. Rep. NOAA/NMFS Northeast Fish. Cent.

NT: Notes
Includes bibliography; 99 ref.

PB: Publisher
Publ.by: NOAA/NMFS, Highlands, NJ (USA).

ER: Environmental Regime
Marine

AB: Abstract
This synopsis of biological and fisheries data on the Spanish mackerel, S.maculatus, is based on existing literature. Information is given on the nomenclature, taxonomy, morphology, distribution, bionomics and life history, population structure, exploitation, protection and management of these fish which are found from the western Atlantic Ocean from Maine and Bermuda to Santos, Brazil, including the Gulf of Mexico and the water around Cuba, but is absent from the rest of the West Indies.

TI: Title
Results of a king mackerel (Scomberomorus cavalla) and Atlantic Spanish mackerel (Scomberomorus maculatus) migration study, 1975-79

CA: Corporate Author
National Marine Fisheries Serv., Panama City, FL (USA). Southeast Fisheries Cent.

SO: Source
Publ. by: NOAA/NMFS; Panama City, FL (USA)., Mar 1980., 24 p., NOAA Tech. Memo.

ER: Environmental Regime
Marine

AB: Abstract
The Panama City and Port Aransas Laboratories tagged and released 2,731 king and 745 Atlantic Spanish mackerel in a 1975-78 study of their movements and migration. From those releases, 59 (2.2%) of the king mackerel and 44 (5.9%) of the Atlantic Spanish mackerel were subsequently recaptured. The tagged recoveries revealed an annual migration by king mackerel from south Florida waters north to the northeast coast of the Gulf of Mexico and west to South Texas waters in the spring and return to south Florida in the fall. Mixing of Gulf fish in the winter with Atlantic fish north to Ft. Pierce was disclosed by tagged recaptures. Fragmented evidence was obtained that Atlantic Spanish mackerel made an annual migration from wintering grounds off south Florida and Campeche-Yucatan to summer grounds along the northern Gulf coast and a return migration in the fall.

TI: Title
Stomach contents of juveniles of king mackerel (Scomberomorus

cavalla) and Spanish mackerel (S. maculatus).
AU: Author
Naughton, SP; Saloman, CH
AF: Author Affiliation
SEFC, NMFS, NOAA, Panama City Lab., 3500 Delwood Beach Rd., Panama City, FL 32407, USA
SO: Source
NORTHEAST GULF SCI., vol. 5, no. 1, pp. 71-74, 1981
IS: ISSN
: 0148-9836
AB: Abstract
Some trawl-caught king and Spanish mackerel (Scomberomorus cavalla and S. maculatus) were examined as regards their diet. Data indicate both to be carnivorous, primarily piscivorous, as juveniles. Engraulidae (Anchoa sp) and Clupeidae (Brevoortia and Opisthonema oglinum) are the dominant food organisms in the diet of small trawl-caught mackerel.

TI: Title
Abundance of Spanish mackerel, Scomberomorus maculatus , in the southeastern United States based on charterboat CPUE data, 1982-85.
AU: Author
Palko, BJ; Trent, PL; Brusher, HA
AF: Author Affiliation
Panama City Lab. Southeast Fish. Cent., NMFS, NOAA, 3500 Delwood Beach Rd., Panama City, FL 32407, USA
SO: Source
Marine Fisheries Review [MAR. FISH. REV.], vol. 49, no. 2, pp. 67-77, 1987
IS: ISSN
0090-1830
NT: Notes
Special issue: Marine recreational fisheries and fishing.
AB: Abstract
Catch per unit effort (CPUE) data for Spanish mackerel, Scomberomorus maculatus , over a broad geographic area were obtained from charterboats. In 1982, a survey was initiated to obtain daily catch and effort data on fishes commonly caught by charterboats in the southeast United States. Boat effort and Spanish mackerel CPUE data obtained from this survey during 1982-85 were analyzed. The offshore fishing zone (> 10 fathoms) received the highest amount of trolling and "other fishing" efforts; the nearshore fishing zone (less than or equal to 10 fathoms) received the second highest trolling effort and lowest "other fishing" effort; the estuarine fishing zone received the lowest trolling effort and the second lowest "other fishing"

effort. CPUE of Spanish mackerel by "other fishing" was much lower than trolling for most areas and years. CPUE was highest in the estuarine zone when compared with the nearshore and offshore zones. Significant differences in CPUE among years were detected only in North Carolina and Louisiana.

TI: Title
Daily age and growth of larval and early juvenile Spanish mackerel, Scomberomorus maculatus, from the South Atlantic Bight
AU: Author
Peters, JS; Schmidt, DJ
AF: Author Affiliation
Dep. Biol., Coll. Charleston, 66 George St., Charleston, SC 29424, USA
SO: Source
Fishery Bulletin [FISH. BULL.], vol. 95, no. 3, pp. 530-539, Jul 1997
IS: ISSN
0090-0656
AB: Abstract
Age and growth of larval and juvenile Spanish mackerel, Scomberomorus maculatus, were determined by examining increments of daily growth on the otoliths (lapilli) of specimens collected along the southeastern Atlantic coast, 1983-89. Marginal increment analysis was performed on 152 fish (7.4-97.0 mm SL) to validate the deposition of daily rings. A mean standardized marginal increment (SMI) was calculated by comparing the width of the marginal increment to the adjacent increment on the lapilli of fish captured over a diel cycle. The distribution of mean SMI was unimodal. A nonlinear equation was used to model growth (ln SL = 6.2 - 55.1/Age). Based on this growth equation, predicted absolute growth rates for the first 23 days of life were approximately 1.9 mm/day, followed by a surge of rapid growth approaching 5.0 mm/day over the next 17 days. Absolute growth rates subsequent to 40 days of age were 2.1 mm/day.

TI: Title
Stock assessments for U.S. stocks of king and Spanish mackerels: 1983-1992
AU: Author
Powers, JE; Thompson, NB
AF: Author Affiliation
NOAA/NMFS, Southeast Fish. Sci. Cent., Miami Lab., 75 Virginia Beach Dr., Miami, FL 33249, USA
SO: Source
Collective volume of scientific papers. International Commission for the Conservation of Atlantic Tunas/Recueil de documents

scientifiques. Commissio internationale pour la Conservation des
Thonides de l'Atlantique/Coleccion d documentos cientificos
[COLLECT. VOL. SCI. PAP. ICCAT/RECL. DOC. SCI. CICTA/COLECC. DOC.
CIENT. CICAA], vol. 40, no. 2, pp. 391-398, 1993

IS: ISSN
1021-5212

NU: Other Numbers
ICCAT SCRS/92/25

AB: Abstract
Age-based stock assessment analyses have been completed annually for king (Scomberomorus cavalla) and Spanish mackerel (S. maculatus) for the Gulf of Mexico and Atlantic stocks, respectively. For these analyses, catch-at-age data are integrated into virtual population assessment and are calibrated using CPUE values from selected areas. Results of these analyses are used to determine biological reference points and to project forward in time to determine allowable catch for the upcoming fishing year. Estimates of current spawning stock biomass relative to historical estimates are evaluated to determine which stocks are over-fished.

TI: Title
Differences in hemoglobin phenotypes among Spanish mackerel, Scomberomorus maculatus .

AU: Author
Skow, LC; Chittenden, ME Jr

AF: Author Affiliation
Dep. Wildl. and Fish. Sci., Texas A&M Univ., College Station, TX 77843, USA

SO: Source
NORTHEAST GULF SCI., vol. 5, no. 1, pp. 67-70, 1981

IS: ISSN
: 0148-9836

AB: Abstract
Electrophoretic evidence is presented for the existence of at least 2 populations of S. maculatus . Starch-gel electrophoresis of mackerel (Scomberomorus) blood samples show the hemoglobins to resolve into 2 bands thus indicating genetic variation.

TI: Title
Comparison of the catch from tongue and two-seam shrimp nets off South Carolina

AU: Author
Stender, BW; Barans, CA

AF: Author Affiliation
Mar. Resour. Res. Inst., South Carolina Wildl. and Mar. Resour. Dep., PO Box 12559, Charleston, SC 29422-2559, USA

SO: Source

North American Journal of Fisheries Management [N. AM. J. FISH. MANAGE.], vol. 14, no. 1, pp. 178-195, 1994
IS: ISSN
0275-5947

AB: Abstract
Before the gears were used for catch comparisons, a two-seam net and a tongue trawl were evaluated for changes in net dimensions with fishing depth and tow direction. When towed as it would be during catch comparisons, the two-seam net had a width of 16.1 m and was estimated to extend 2.1 m vertically at the center of the headrope. The horizontal spread of the tongue trawl was 13.5 m and its vertical spread was 4.2 m at center. Small, statistically consistent differences in openings (<0.5 m) occurred with depth and direction. The major factor influencing changes in catch (kg/ha) with depth (10-fold increase in shallow water) appeared to be the faunal distribution with depth, independent of towing characteristics. Differences in biomass (kg/tow, kg/ha), and in the biomass (kg/ha) ratios of taxa to shrimp between the two-seam and tongue trawls were documented for eight major biological groups. Major differences in total catch by net occurred between years primarily because of changes in the catch of miscellaneous invertebrates and shrimp. Significant differences in the lengths of nine priority species occurred between the two gears. Mean lengths in the two nets differed by more than 1 cm for spot Leiostomus xanthurus (which was larger in the tongue net), Atlantic croaker Micropogonias undulatus (larger in the two-seam net), and Spanish mackerel Scomberomorus maculatus (larger in the tongue net). Mean ratio of fish to shrimp biomass was 31:1 overall (21:1 for the two-seam net and 41:1 for the tongue trawl). Ratios of total biomass and the biomass of any taxonomic grouping to shrimp biomass did not differ statistically between the two gears. Biomass ratios were recalculated from published data by a standard methodology. Subsequent comparisons indicated increases in the ratios over time and highlighted a need to validate the technique of subsampling heterogenous trawl samples. Finfish by-catch in both gears was dominated by sciaenids (44% by weight of all fish). Red drum Sciaenops ocellatus spotted seatrout Cynoscion nebulosus snappers (Lutjanidae), and groupers (Epinephelinae) were not caught by either net. Catches of Spanish mackerel and king mackerel Scomberomorus cavalla were documented and warrant further investigation to evaluate the effects of by-catch on local populations.

Rachycentron canadum

TI: Title
Biochemical and histological changes during ovarian development of cobia, Rachycentron canadum, from the northern Gulf of Mexico
AU: Author
Biesiot, PM; Caylor, RE; Franks, JS
AF: Author Affiliation
Dep. Biol. Sci., Univ. South. Mississippi Hattiesburg, MS 39406-5018, USA
SO: Source
Fishery Bulletin [FISH. BULL.], vol. 92, no. 4, pp. 686-696, 1994
IS: ISSN
0090-0656
AB: Abstract
Female cobia, Rachycentron canadum, were sampled on their spawning grounds in the northern Gulf of Mexico to study changes in proximate analysis (protein, lipid, carbohydrate, and ash) of the ovaries during gonadal maturation. Four major stages of oocyte development were studied: stage 1, previtellogenesis; stage 2, vitellogenesis; stage 3, final maturation; and stage 4, postovulation. Cobia are multiple spawning fish; therefore, ovaries engaged in a sequential round of oogenesis were distinguished as stages 1' and 2'. Protein was the major constituent of cobia ovaries and its contribution remained fairly constant (49-55% of the dry weight) throughout all stages of development. Lipid was the second most abundant component but the levels, ranging from 21 to 41%, changed depending on the stage of ovarian development. Lipid concentration increased from stage 1 through 3 and decreased slightly in stage 4; it was lower in stage-1 than in stage-1' ovaries but was the same in stages 2 and 2'. Carbohydrate was the least abundant component (3-4%) whereas ash ranked third (6-20%). Most cobia were in prespawning condition (stages 1-3) when they arrived in the northern Gulf of Mexico in April and May; some prespawning fish (stages 1 and 2) were also observed in August and September about a month or two before migration to the overwintering grounds normally occurs. Cobia undergoing sequential spawning episodes (stages 1' and 2') were captured from April through August. Gonosomatic indices (GSI) were calculated both for ovarian developmental stage and for month of capture. Mean GSI increased as ovarian development proceeded and decreased during postovulation; GSI for month of capture was highest during April and May when the prespawning fish first appeared in northern Gulf of Mexico waters.

TI: Title
Larval development, distribution, and ecology of cobia

Rachycentron canadum (family: Rachycentridae) in the northern Gulf of Mexico

AU: Author

Ditty, JG; Shaw, RF

AF: Author Affiliation

Coast. Fish. Inst., Wetland Resour. Build., Louisiana State Univ., Baton Rouge, LA 70803-7503, USA

SO: Source

Fishery Bulletin [FISH. BULL.], vol. 90, no. 4, pp. 668-677, 1992

IS: ISSN

0090-0656

AB: Abstract

Cobia (Rachycentron canadum) is a highly prized recreational species of worldwide distribution in tropical and subtropical seas, but the development, distribution, and ecology of its early life stages are poorly known. Eggs are spherical, average 1.24 mm in diameter, and have a single oil globule (mean diameter 0.45 mm). The perivitelline space is narrow and the embryo heavily pigmented. Eggs hatch in about 24 h at 29 degree C based on the relationship between egg diameter and water temperature to predict development time in other marine fishes. Larvae hatch at about 2.5 mmSL. Cobia spawn in both estuarine and shelf waters during the day, and eggs and larvae are usually collected in the upper meter of the water column. Larvae are recognized by the large supraorbital ridge with a single spine, laterally swollen pterotics, heavy body pigmentation, minute epithelial spicules covering the body integument, and a pair of moderate-to-large, simple spines on either side of the angle of the posterior preoperculum. Only 70 larvae < 20 mmSL were collected and identified from the Gulf of Mexico between 1967 and 1988; most occurred between June and September at surface temperatures greater than or equal to 25 degree C, salinities > 27 ppt, and within the 100 m depth contour. Similar patterns of head spination provide evidence of a sister-group relationship between cobia (Rachycentron canadum) and dolphinfish rather than that previously hypothesized between cobia and remoras.

TI: Title

A pugheaded cobia (Rachycentron canadum) from the north central Gulf of Mexico

AU: Author

Franks, JS

AF: Author Affiliation

Gulf Coast Res. Lab., P.O. Box 7000, Ocean Springs, MS 39566-7000, USA

SO: Source

Gulf Research Reports [GULF RES. REP.], vol. 9, no. 2, pp.

143-145, 1995
IS: ISSN
0072-9027
AB: Abstract
A pugheaded cobia (Rachycentron canadum) captured in the Northcentral Gulf of Mexico represents the first record of pugheaded in cobia. The specimen, a 4-year-old gravid female, exhibited considerable distortion of the premaxillary and maxillary bones, with the length of the snout 46% shorter than that of a normal cobia of the same length. The anomaly had no apparent effect on feeding, since the stomach contained a substantial amount of food, and the fish was the same length expected of a normal 4-year-old cobia.

TI: Title
Stomach contents of juvenile cobia, Rachycentron canadum, from the northern Gulf of Mexico
AU: Author
Franks, JS; Garber, NM; Warren, JR
AF: Author Affiliation
Gulf Coast Res. Lab., P.O. Box 7000, Ocean Springs, MS 39566-7000, USA
SO: Source
Fishery Bulletin [FISH. BULL.], vol. 94, no. 2, pp. 374-380, 1996
IS: ISSN
0090-0656
AB: Abstract
This paper represents the first study describing specifically the diet of juvenile R. canadum.

TI: Title
Gonadal maturation in the cobia, Rachycentron canadum, from the Northcentral Gulf of Mexico
AU: Author
Lotz, JM; Overstreet, RM; Franks, JS
AF: Author Affiliation
Gulf Coast Res. Lab., P.O. Box 7000, Ocean Springs, MS 39566-7000, USA
SO: Source
Gulf Research Reports [GULF RES. REP.], vol. 9, no. 3, pp. 147-159, 1996
IS: ISSN
0072-9027
AB: Abstract
Gonadal maturation of cobia, Rachycentron canadum, was evaluated by examining 508 specimens from its recreational fishery. Specimens were collected off southeast Louisiana to northwest

Florida by hook-and-line during February through October 1987-1991. Fork lengths (FL) of these fish ranged from 580-1,530 mm, with corresponding weights of 2.0-43.5 kg. The female:male ratio was 1:0.37. Using a combination of oocyte size-frequency and histological assessment of many of the fish, we determined that females were ripe from May through September, with atretic oocytes occurring in some fish from July through October. Degenerating hydrated oocytes in July and October and the presence of resting ovaries in July suggest two major spawning periods; however, monthly gonosomatic indices peaking in May, followed by a steady decline, do not support that finding. Ovaries were placed into undeveloped, early developing, mid-developing, or late developing categories based upon oocyte size-frequency distributions. Developing ovaries had two or three modes of oocytes larger than 30 mu m. Batch fecundity was estimated to be 2.6x10 super(6) to 1.91x10 super(8) oocytes, depending on the size of fish/ovaries. The smallest female with oocytes exhibiting vitellogenesis was 834 mm FL. This fish was 2 years old based its otolith evaluation. The smallest male with an abundance of spermatozoa in its testes was 640 mm FL and 1 year old based on otolith evaluation; smaller males were not examined. Females larger than 840 mm FL had vitellogenic oocytes in March and April. A few fish still had vitellogenic oocytes in early October, but none did by late October. When Gilson's fluid was used to assess ovarian tissue, the fresh weight of the tissue was reduced by 20% after being stored for 3 months. The diameter of oocytes shrunk about 25% in Gilson's fluid which was 11% less than those fixed in formalin, embedded in paraffin, and sectioned. Tissue sections from specific individuals, each demonstrating a variety of different developmental stages, were similar regardless of whether they were obtained from the anterior, middle, or posterior portion of either ovary.

TI: Title
Food of cobia, Rachycentron canadum from the Northcentral Gulf of Mexico
AU: Author
Meyer, GH; Franks, JS
AF: Author Affiliation
Univ. Southern Mississippi, Dep. Biol. Sci., Box 5018, Hattiesburg, MS 39406-5018, USA
SO: Source
Gulf Research Reports [GULF RES. REP.], vol. 9, no. 3, pp. 161-167, 1996
IS: ISSN
0072-9027
AB: Abstract

The stomach contents of 403 cobia, Rachycentron canadum, caught in the Northcentral Gulf of Mexico recreational fishery from April through October of 1987-1990 were examined. Cobia ranged from 373-1,530 mm in fork length. Of the 403 stomachs, 287 (71.2%) contained at least one identifiable prey taxon. Crustaceans, consisting primarily of portunid crabs, were the predominant food. Crustaceans occurred in 79.1% of the stomachs and comprised 77.6% of the total number of identifiable prey. The second most important prey category was fish which was dominated by hardhead catfish, Arius felis, and eels. Fish occurred in 58.5% of the stomachs but only accounted for 20.3% of the total number of prey. The importance of fish as prey increased with increasing size (length) of cobia, with the largest size class of cobia (1,150-1,530 mm FL) showing the highest percent frequency occurrence of fish prey (84.4%). There were no significant differences between the diets of male and female cobia. Species composition of the diet indicated that cobia examined in this study were generalist carnivores in their feeding habits and fed primarily on benthic/epibenthic crustaceans and fishes. However, the occurrence of pelagic prey provided evidence of diversity in the foraging behavior of cobia. Feeding in cobia indicated their dependence upon prey availability rather than upon a few specific food organisms.

TI: Title
Synopsis of biological data on the cobia Rachycentron canadum Pisces: Rachycentridae.

AU: Author
Shaffer, RV; Nakamura, EL
CA: Corporate Author
National Marine Fisheries Serv., Panama City, FL (USA). Southeast Fisheries Cent.
SO: Source
NOAA TECH. MEMO., 1989, 28 pp
NT: Notes
NTIS Order No.: PB90-171513/GAR.
NU: Other Numbers
NOAA-TM-NMFS-82
AB: Abstract
Information on the biology and fisheries of cobia, Rachycentron canadum , is compiled and reviewed in the FAO species synopsis style. Topics include taxonomy, morphology, distribution, reproduction, pre-adult and adult stages, food, growth, migration, population characteristics, and various aspects of exploitation. Data and information were obtained from unpublished as well as published sources. (Also pub. as Food and Agriculture Organization

of the United Nations, Rome (Italy), Fishery Resources and
Environment Div rept. no. FAO-FISHERIES SYNOPSIS-153. Sponsored by
Food and Agriculture Organization of the United Nations, Rome
(Italy). Fishery Resources and Environment Div.).

Appendix B. List of Contributions to SAFE as Provided by NMFS SERO

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE

Southeast Regional Office
9721 Executive Center Drive N.
St. Petersburg, FL 33702
(727) 570-5335; FAX (727) 570-5300

March 24, 1999 F/SERX1:RCR:dcp

Mr. Robert Mahood, Executive Director
South Atlantic Fishery Management Council
1 Southpark Circle, Suite 306
Charlotte, SC 29407

Dear Bob,

Enclosed are lists of contributions to the SAFE reports for the FMPs under your Council's jurisdiction. The lists represents contributions sent directly to our office as of Friday, March 19, 1999, and also includes some items extracted from Council briefing books and other sources.

Dr. Kemmerer recently announced that the responsibility for SAFE reporting is being transferred from the Fisheries Economics Office to the Sustainable Fisheries Division (Dr. James Weaver). The March 19, 1999 cut-off date for this report has been established to avoid confusion during the transition period. The Fisheries Economics Office will temporarily maintain a file of new contributions received after March 19, 1999. These documents will be given to the Sustainable Fisheries Division at the time the transition is completed and they become responsible for maintaining the SAFE files.

Sincerely yours,

Richard C. Raulerson, Chief
Fisheries Economics Office

Attachment: Lists of SAFE Contributions

RECEIVED
MAR 2 9 1999

cc: F/SE - Andrew Kemmerer/Carol Ballew
F/SER2 - James Weaver/Mike Justen
F/SF - George Darcy/Richard Surdi
SEFSC - Brad Brown/Alex Chester
F/SEC7 - John Merriner
F/SEC5 - Tom McIlwayne

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INDEX
Stock Assessment and Fisheries Evaluation Report Contribution
Gulf of Mexico/South Atlantic Fishery Management Councils
Coastal Migratory Pelagics

Title	Contributor	Date
Characterization of the Dolphin Fish (*Coryphaenidae Pices*) Fishery of the United States Western North Atlantic Ocean, MSAP198/03	Nancy Thompson, SEFSC, Miami, FL	February 1998
1998 Report of the Mackerel Stock Assessment Panel	Mackerel Stock Assessment Panel Final Report 4/27/98	Meeting held March 23-
Presentation on Report of the 7th Coastal Migratory Pelagics Socioeconomic Panel March 23-25, 1998 - SERO-ECON-98-08	John Vondruska	Presentation given at meeting in New Orleans April 20-21, 1998
Report of the Seventh Coastal Migratory Pelagics Socioeconomic Panel Meeting	Socioeconomic Panel	March 23-25, 1998 Mee Miami, FL
Commercial Landings of Coastal Migratory Pelagic Fish, East and Gulf Coasts, 1962-1997 - SERO-ECON-98-16	John Vondruska NMFS - SERO	March 20, 1998
Application of a Stochastic Age-Structured Production Model to Gulf of Mexico Spanish Mackerel - MSAP/98/13	C.M. Legualt and V. R. Restrepo	March 1998

Delta Lognormal Estimates of Bycatch for Gulf of Mexico King and Spanish Mackerel and Their Impact on Stock Assessment and Allowable Biological Catch - MSAP/98/12	C.M. Legault and M. Ortiz - NMFS-SEFSC	March 1998
What if Mixing Area Fish are Assigned to the Atlantic Migratory Group Instead of the Gulf of Mexico Migratory Group? MSAP/98/10	Christopher M. Legault - NMFS - SEFSC	March 1998
Stock Assessment Analysis on Atlantic Migratory Group King Mackerel, Gulf of Mexico Migratory Group King Mackerel, Atlantic Migratory Group Spanish Mackerel, and Gulf of Mexico Migratory Group Spanish Mackerel MSAP/98/09	C.M. Legault, N. Cummings, and P. Phares - NMFS - SEFSC	March 1998
The potential impact of juvenile king mackerel (*Scomberomorus cavalla*) and Spanish mackerel (*S. Maculatus*) shrimp trawl bycatch mortality on southeast Atlantic adult populations. MSAP/98/01	P. J. Harris and J.M. Dean, South Carolina Marine Resources Division	February 1998
Characterization of the King mackerel and Spanish mackerel bycatch of South Carolina shrimp trawlers	Patrick J. Harris and John M. Dean	February 1998
Estimates of Bycatch of Mackerel and Cobia in U.S. South Atlantic Shrimp Trawls - MSAP/98/03	Douglas S. Vaughan and James M. Nance	February 19, 1998
Some Discussion on the Methods and Potential Use of Federal Fishing Permits data in Descriptive Fishery Analysis, with Emphasis on Commercial Fishing for Mackerels - SERO-ECON-98-11	John Vondruska	December 9, 1997

3

Updated Projections of Gulf of Mexico Migratory Group King Mackerel and Atlantic Migratory Group Spanish Mackerel - MSAP/97/1	Joseph E. Powers and Patricia Phares	April 1997
Some Discussion of Data on Commercial Landings of Coastal Migratory Pelagic Species and Federal Fishing Permits	John Vondruska, NMFS	Prepared for GOMFMC Fish Fishery Socioecono Panel Meeting on April 2 1997
Report of the Sixth Coastal Migratory Pelagics Socioeconomic panel Meeting	Socioeconomic Panel	May 7, 1997
Some Discussion of Data on Commercial Landings of Coastal Migratory Pelagic Species and Federal Fishing Permits, SERO-ECON-98-05	John Vondruska, SERO	Socioeconomic Assessm Panel of the GOMFMC April 23-25, 1997
Recreational Fishery Data, Coastal Migratory Pelagics Fishery, SERO-ECON-97-02	Stephen G. Holiman, SERO	Prepared for the Gulf of Fishery Management Co Reef Fish Fishery Socio Panel Meeting on April 1997
Recreational Fishery Data Coastal Migratory Pelagics Fishery, SERO-ECON-97-02	Stephen G. Holiman, SERO	April 1997
1997 Report of the Mackerel Stock Assessment Panel	Mackerel Stock Assessment Panel	March 31-April 4, 1997
Description of Boats with Federal Fishing Permits in 1997 - SERO-ECON-98-14	John Vondruska - NMFS-SERO	March 5, 1997
A Compilation of Spanish Mackerel Abundance Indices Developed for the 1996 Mackerel Stock Assessment	Nancie Cummings - NMFS-SEFSC	March 1997

Landings Estimates Under a Zero King Mackerel Bag Limit for Charterboat Captains and Crew in the Gulf of Mexico	Stephen G. Holiman	Florida Marine Fisheries Commission Meeting October 7-9, 1996
Summary Statistics and Discussion on the Recreational King Mackerel Fishery of the Gulf of Mexico, SERO-ECON-96-13	Stephen G. Holiman	June 1996
1996 Report of the Mackerel Stock Assessment Panel	Mackerel Stock Assessment Panel	Meeting held April 15-18
Recreational Fishery Data Gulf of Mexico Coastal Migratory Pelagics Fishery, SERO-ECON-96-12	Stephen G. Holiman	April 1996
Assessment of the Status of Cobia in the Gulf and Atlantic - A Working Paper Presented to the Mackerel Stock Assessment Panel - MSAP/93/9	Nancy R. Thompson	March 1993

Appendix C. 1998 Report of the Mackerel Stock Assessment Panel (March 23-26, 1998)

4/27/98

1998 REPORT OF THE MACKEREL STOCK ASSESSMENT PANEL

Prepared by the Mackerel Stock Assessment Panel
at the Panel Meeting Held March 23 - 26, 1998

Gulf of Mexico Fishery Management Council
The Commons at Rivergate
3018 U.S. Highway 301 North, Suite 1000
Tampa, Florida 33619-2266
813-228-2815

&

South Atlantic Fishery Management Council
Southpark Building, Suite 306
1 Southpark Circle
Charleston, South Carolina 29407-4699
803-571-4366

This is a publication of the Gulf of Mexico Fishery Management Council and South Atlantic Fishery Management Council pursuant to National Oceanic and Atmospheric Administration Award No. NA87FC0003 and NA87FC0004

SUMMARY OF RECOMMENDATIONS

GROUP	ABC (RANGE) of OY= yield	Transitional SPR %	Static SPR %	OVERFISHED/ OVERFISHING
King mackerel: Atlantic migratory group	9.3 (8.4 - 11.9) million lbs @$F_{40\%}$ static SPR	39 (36-42)	36	Not overfished* Not overfishing
King mackerel: Gulf migratory group	8.7 (7.1 - 10.8) million lbs. @$F_{30\%}$ static SPR	23 (20 -27)	21	Overfished Overfishing
Spanish mackerel: Atlantic migratory group	6.6 (5.4 - 8.2) million lbs. @$F_{40\%}$ static SPR	40 (36-44)	42	Not overfished* Not overfishing
Spanish mackerel: Gulf migratory group	10.3 (7.3 - 14.1) million lbs. @$F_{30\%}$ static SPR	35 (30-39)	47	Not overfished* Not overfishing

* The "not overfished" recommendations are based on the Council's overfished criterion of 30% SPR for mackerel.

Notes: Transitional spawning potential ratio (SPR) (calculated from fishing mortality rates by age and year) is used to determine whether a stock is currently in an overfished status.

Static SPR (projected from most recent years fishing mortality rates) is used to determine whether a stock is being fished at a rate that will eventually lead to an overfished status, i.e. overfishing.

Acceptable biological catch (ABC) and Transitional SPR are presented at the 50th percentile mark of probability. The range (in parentheses) is presented for ABC between the 16th percentile and the 84th percentile and for transitional SPR from the 10th percentile to the 90th percentile.

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1998 REPORT OF THE MACKEREL STOCK ASSESSMENT PANEL (MSAP)
March 23 - 26, 1998
MIAMI, FLORIDA

I. INTRODUCTION

At the direction of the Gulf of Mexico and South Atlantic Fishery Management Councils (Councils), the Mackerel Stock Assessment Panel (Panel) met in Miami from March 23 - 26, 1998. The tasks for this Panel are specified by the Councils in Amendment 1 to the Fishery Management Plan (FMP) for the Coastal Migratory Pelagic Resources (Mackerels) dated April, 1985 (and subsequent amendments). Most recently, Amendment 8 includes a modified framework that respecifies the Panel's charge (See Appendix A). Previous Panel reports reflect the actions required by subsequent amendments.

Amendment 6 required full stock assessments every other year, and Amendment 8 requires full stock assessments in even numbered years. Accordingly, this year's assessments for Atlantic and Gulf migratory groups of king and Spanish mackerel are full assessments.

The list of documents that were reviewed by the Panel is included in the Literature Cited section. Copies of documents are available from the Councils or the Southeast Fisheries Science Center (SEFSC).

II. OVERFISHED, OVERFISHING, AND TARGET (OPTIMUM YIELD) CRITERIA

The current definitions of overfished, overfishing, target Optimum Yield (OY), and a rebuilding program, as approved under the Coastal Migratory Pelagics Fishery Management Plan (FMP), as amended, are as follows:

Overfished: A mackerel stock or migratory group is considered to be overfished when the transitional SPR falls below 30%.

Overfishing: When a stock or migratory group is not overfished (transitional SPR equal to or greater than 30%), the act of overfishing is defined as harvesting at a rate that exceeds the fishing mortality rate associated with a threshold static SPR of 30% (i.e., $F_{30\%}$). If fishing mortality rates that exceed the level associated with the static SPR threshold rate are maintained, the stock may become overfished. Therefore, if overfishing is occurring, a program to reduce fishing mortality rates toward management target levels (OY) will be implemented, even if the stock or migratory group is not in an overfished condition (Amendment 8).

For species like cobia, when there is insufficient information to determine whether the stock or migratory group is overfished (transitional SPR), overfishing is defined as a fishing mortality rate in excess of the fishing mortality rate corresponding to a default threshold static SPR of 30%. If overfishing is occurring, a program to reduce fishing mortality rates to at least the level corresponding to management target levels will be implemented (Amendment 8).

Target Optimum Yield (OY): The South Atlantic Council's target level or OY is 40% static SPR. The Gulf Council's target level or OY is 30% static SPR. ABC is calculated relative to the probability of achieving the target level or OY fishing mortality rate in the following fishing year (SAFMC = 40% static SPR and GMFMC = 30% static SPR).

Rebuilding Program: When a stock or migratory group is overfished (transitional SPR less than 30%), a rebuilding program that makes consistent progress towards restoring stock condition must be implemented and continued until the stock is restored beyond the overfished condition. The rebuilding program must be designed to achieve recovery within an acceptable time frame as specified by the Councils. The Councils will continue to rebuild the stock until the stock is restored to the management target (OY) within a unspecified time frame.

III. DATA SOURCES AND ANALYTICAL METHODOLOGY

A. AVAILABLE DATA TO ASSESS MACKEREL STOCKS

Data from a variety of sources were included in these assessments. Revised recreational landings and intercept data for 1995 and 1996, as well as preliminary estimates for 1997 came from the Marine Recreational Fisheries Statistical Survey (MRFSS). Additional recreational landings and catch rate information came from NMFS's Headboat Survey and Texas Parks and Wildlife Department Creel Survey. Commercial landings for 1996 were revised and preliminary estimates for 1997 used in these assessments came from NMFS's General Canvass. Commercial catch rates came from the Trip Interview Program (TIP) and Florida's Marine Fisheries Information System (Trip Ticket Program).

Auxiliary information included size and sex of fish from the commercial fishery, aging from collections of otoliths, numbers of juveniles from Atlantic SEAMAP, and catch rates from numerous directed fisheries. Due to time constraints, updated larval information from Gulf SEAMAP sampling was not available for this year's assessments. Last year, the Panel requested that analyses be performed to quantify the effects that various sampling designs and sample sizes have on assessment results. Although this research activity was considered during operations planning, the Gulf Council placed highest priority on completing full assessments of all mackerel stocks; and under the accelerated delivery schedule for this assessment, evaluations of this nature could not take place. The Panel again requests that these analyses be performed because the results of the analyses and the Panel's subsequent recommendations are highly dependent on these statistics.

Table 1 shows biological sampling and sampling fractions used in various analyses for Atlantic and Gulf migratory groups of king and Spanish mackerel.

'e 1. Spanish mackerel biological samples and sampling fractions

Migratory Group	1987	1988	1989	1990	1991	1992	1993	1994	1995*	1996 *
Age Samples (number of specimens aged for age-length keys):										
ATL	246	174	212	507	625	681	451	200	295	564
GLF	378	276	479	1019	871	987	358	612	422	266
Age Sample Fractions (expressed as # of directed fisheries catch in numbers):										
ATL	0.007	0.004	0.006	0.015	0.014	0.020	0.013	0.005	0.013	0.020
GLF	0.011	0.007	0.020	0.037	0.021	0.026	0.011	0.020	0.023	0.017
Length Samples (number of specimens measured):										
ATL	6724	4165	6159	11194	15619	17609	13295	12927	4684	6997
GLF	12625	18016	9637	5686	10687	8541	7923	4655	4075	2346
Length Sample Fractions (expressed as # of directed fisheries catch in numbers):										
ATL	0.192	0.095	0.185	0.330	0.357	0.505	0.386	0.304	0.207	0.247
GLF	0.375	0.473	0.410	0.209	0.261	0.224	0.246	0.175	0.224	0.149

*Re: 1995-1996 length samples - Spanish mackerel commercial net samples from North Carolina were not available in 1995-1997.

Table 1.(cont.) King mackerel biological samples and sampling fractions

Migratory Group	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Age Samples (number of specimens aged for age-length keys):											
ATL	375	498	440	836	907	746	1246	780	805	410	831
GLF	302	846	660	812	572	1339	1271	1213	972	877	1607
Age Sample Fractions (expressed as # of directed fisheries catch in numbers):											
ATL	0.038	0.056	0.049	0.130	0.121	0.080	0.132	0.130	0.133	0.139	0.119
GLF	0.049	0.201	0.102	0.116	0.080	0.139	0.122	0.127	0.086	0.118	0.154
Length Samples (number of specimens measured):											
ATL	8232	12736	8909	8233	8599	10203	9356	5692	7961	4181	6265
GLF	7807	6287	5570	6215	4164	12726	13055	7581	7614	9267	7013
Length Sample Fractions (expressed as # of directed fisheries catch in numbers):											
ATL	0.842	1.428	0.994	1.241	1.147	1.092	0.993	0.948	1.310	0.650	0.896
GLF	1.270	1.491	0.860	0.891	0.579	1.324	1.253	0.796	0.678	1.000	0.673

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B. ANALYTICAL METHODOLOGY

As in previous assessments, the status of exploitation of Atlantic and Gulf group king and Spanish mackerels is currently evaluated using age-based sequential virtual population analysis (VPA) models. Age-structured models require that the catches by species and migratory group be assigned ages. Catch-at-age data by group through fishing year 1996/97 developed for the 1998 mackerel assessments were used in the population assessments. The VPA models were calibrated with abundance indices from fisheries dependent CPUE data and from fisheries independent resource surveys. In the past, the age-specific selectivities in the most recent year were estimated from a separable VPA; however, this year's analyses used an iterative procedure to estimate those selectivities. Population sizes and fishing mortality rates were estimated using the ADAPT method (Restrepo 1996).

The results of the stock assessment analyses were used to evaluate the status of the stocks relative to specific biological reference points, and project forward in time to determine the ABC ranges for fishing year 1998/99. As in previous assessments, the fishing mortality rates (F's) were estimated in the VPA based on observed catches in 1996/97 and preliminary catch estimates for 1997/98. Catches for the remainder of 1997/98 were based on projected harvest rates. The estimated F's in 1996/97, 1997/98, and the target F's in 1998/99 were used to project stock sizes and catches through 1998/99 and to determine ABC ranges for that year. The projection model estimates future yields from the recreational sector in numbers and from the commercial sector in pounds using $F_{40\%}$ for Atlantic coast species and $F_{30\%}$ for Gulf coast species. Details of these estimates and projections are presented in Legault et al. (1998).

The effects of uncertainty in key parameter estimates and data sources on the ABC ranges for each of the mackerel species and migratory groups were evaluated by using a mixed Monte Carlo/bootstrap method to generate ABC probability distributions. The key parameters of catch at age, natural mortality rate at age, and abundance indices were assumed to be random variables exhibiting either known probability distributions or a distribution of the observed residuals from the original fit. Bootstrap analyses were repeated 400 times, and projections were made using fishing mortality rates corresponding to static spawning potential ratios of 5% to 50%. The probability distributions from the 400 results per each fishing mortality rate were used to construct confidence intervals surrounding the ABC estimates.

Because the distributions are skewed, the upper portion of the ABC ranges are much more difficult to determine and less certain than the central portion (median or 50th percentile mark) of the ABC ranges. Consequently, the Panel strongly recommends that the Councils adopt a more risk adverse approach by choosing the median (50%) of the ABC range, as the upper bound instead of the 84th percentile. At the median, there are about even odds of achieving the Councils' goals ($F_{30\%}$ SPR - Gulf Council and $F_{40\%}$ SPR - South Atlantic Council).

The method of calculating current SPR, called transitional SPR, continues to follow the recent recommendations of Mace et al. (1996). Transitional SPR uses estimated year and age-specific fishing and natural mortality rates as well as average fecundity to calculate SPR on a per recruit basis. Mace et al. (1996) also recommended using static SPR for projections or the evaluation of alternative management options. Static SPRs are calculated by estimating the equilibrium age-structure associated with the most recent fishing mortality rates.

C. REVIEW AND EVALUATION OF SHRIMP TRAWL BYCATCH DATA

1. DELTA METHOD VERSUS GLM

In previous Gulf king and Spanish mackerel stock assessments, a generalized linear model (GLM) approach was used to estimate annual bycatch of mackerels in shrimp trawls (Nichols et al. 1987). In the GLM approach, the raw data are first transformed by adding a constant (1.0) to each CPUE value, and then the log of (CPUE + 1) is used as input data for the analysis. The addition of a constant is necessary because the raw values are mostly of zeros. They must be transformed because the log of zero is undefined. Two problems with using this approach are: 1) transformed data may not meet the GLM assumption of normality, and 2) the constant added to the CPUE values is not an arbitrary scalar because different values of the transformed constant yield different results in the bycatch estimates. To address these problems and consider possible alternative methods to estimate bycatch, the Panel reviewed the delta lognormal method, as presented by Legault and Ortiz (1998).

The delta lognormal method is a two-part process that first estimates the probability of encountering a fish (i.e. a tow with a king or a Spanish mackerel), and then estimates the expected value if a positive value is encountered. The estimated portion of positive tows is multiplied by the estimated CPUE, given that a positive tow has occurred. A stratum is the combinations of data set, year, season, area, and depth zone factors used in the model fitting. Bycatch CPUE is estimated by multiplying the results within each stratum. The approach may prove to be more robust statistically; however, there is a high probability that the delta-method bycatch estimates are biased due to the overwhelming dominance of zero values in the mackerel bycatch data sets (Legault and Ortiz 1998). Because the direction and magnitude of potential biases are unknown, the Panel opted to retain the GLM estimation procedure in the 1998 Gulf king and Spanish mackerel stock assessments. The Panel will review the appropriateness of using the delta method as more data become available.

2. ATLANTIC GROUP KING & SPANISH MACKEREL BYCATCH DATA

The Panel reviewed several estimates of mackerel bycatch in the southeast Atlantic shrimp trawl fisheries. One approach used SEAMAP data and two methods of estimation for the years 1992-1997. The two estimation methods are essentially based upon stratum-by-stratum expansions of bycatch by either shrimp effort expressed as numbers of tows or by the ratio of finfish to shrimp. For the 1996 assessment, the Panel elected to include estimated bycatch for 1992-1994, based on the effort expansion method, with the caveat that the available estimates were both very imprecise and highly variable from year to year. Upon further review of estimates for 1992-1997 using the same methodology, the Panel no longer supports inclusion of these estimates of annual bycatch in the VPA analyses because of the very high variability of the estimates. Furthermore, the number of sampled shrimp trips is very low and has decreased since 1994-1995. For example, in 1996/1997, there were no samples available to characterize nearly 60% of the trips by strata.

For this year's assessment, the Panel reviewed another proposed method of bycatch estimation based on sampling conducted in South Carolina during 1991 and 1992. This approach estimated the total regional bycatch for 1981-1995 by expanding mackerel catch per tow by an estimate of the total number of tows. The Panel does not feel that the limited sampling of this study (137 trips sampled from 3 ports over 2 years) is adequate for use as a regional bycatch estimate in the stock assessment.

Although bycatch of both Spanish and king mackerel is known to occur in southeast Atlantic shrimp trawl fisheries, to-date no acceptable method of estimating the magnitude of that bycatch has been derived. Further, the large variability of the available estimates both between and within years hampers attempts to provide meaningful average estimates. The Panel concluded that the best approach was to estimate ABC ranges without including any bycatch estimates. The Panel noted, however, that this approach could cause overestimation of SPR values if bycatch is occurring.

D. STOCK IDENTIFICATION OF KING MACKEREL

The present management regime specifies two migratory groups for management purposes based on tagging data, growth rate differences, and temporal differences in the fisheries: the Gulf migratory group and the Atlantic migratory group (although fish captured in the eastern Gulf of Mexico off west Florida are genetically indistinguishable from the Atlantic). The Atlantic migratory group that occurs along the U.S. east coast to New York mixes with the Gulf migratory group along southeast Florida in winter. For management and stock assessment purposes, the boundary between migratory groups currently is specified as the Volusia/Flagler county border along the Florida east coast in winter (November 1 - March 31) and the Monroe/Collier county border on the southwest Florida coast in summer (April 1 - October 31). Those boundaries were established based upon the results of mark-recapture studies conducted from 1975-1979.

The 1996 Panel report includes a review of the Working Group's report on stock identity and mixing. After a review of those findings, the Panel concluded that "the biological information supports a zone of mixing on the Florida east coast. The current boundary was specified by the Councils at the Flagler/Volusia county boundary. The Councils should be reminded that the east coast of Florida in the winter is a zone of mixing and that both Gulf and Atlantic migratory group fish occur there at that time. It is our understanding that some of the reasons that the original boundary was chosen was to provide greater biological protection to the overfished Gulf migratory group."

Tagging data from the 1970s indicated that during winter the Atlantic and Gulf migratory groups of king mackerel mix off the southeastern coast of Florida. The extent of mixing is not well-known, but it has been estimated at over 50 %. Both Councils continue to question the extent of mixing between the Gulf and Atlantic migratory groups, particularly in south Florida.. Consequently, investigations to identify fish belonging to each of the migratory groups continues. This year, the Panel reviewed a draft paper by DeVries and Grimes (in prep.) that examined the potential of using otolith shape analysis to distinguish between the Gulf and Atlantic migratory groups in the mixing zone. An image analysis system was developed and used to evaluate otolith shape using otoliths collected from female king mackerel that were caught during summer in the Atlantic (SC, GA, and NE FL) and the Gulf (NW FL). Using otolith shape characteristics as classification variables, a multivariate, discriminate functions analysis was used to classify fish caught in the mixing zone during November-March as belonging to either the Gulf or Atlantic migratory groups. In a preliminary study using females collected from 1986-1993 (n = 355), Atlantic and Gulf fish were correctly classified with a high degree of accuracy (> 80 %), both by resampling the fish used to estimate the discriminate function and by using an independent data set of fish from both areas (n = 105). Next, females were collected (n = 363; FL = 80 - 96 cm) on the spawning grounds of the Atlantic and Gulf during the summer of 1996. Otolith shape data from these fish were used to estimate a discriminate function that correctly classified 77.1 % of Gulf fish and 85 % of Atlantic fish from an independent data set (n = 240). They applied this discriminate function to otolith shape data from fish collected in the mixing zone (Cape Canaveral to West Palm Beach, FL) during December and January 1996-97, and the discriminate function estimated that 88 % of the mixing zone fish belonged to the Atlantic migratory group and 12 % belonged to the Gulf migratory group. The Panel re-estimated the mixing to correct for the proportion not identified correctly. The corrected, preliminary proportions were 70% Atlantic migratory group and 30% Gulf migratory group.

The Panel thinks this work is a unique and useful approach to estimating the dynamics of mixing in the winter fishery of southeast Florida, and it may prove to be a useful management tool in allocating mixing zone fish to either group. Before this technique is routinely utilized in king mackerel stock assessment or management, however, the Panel recommends four issues for further study or clarification: 1) variance estimates of the percent fish classified as belonging to each group are needed; 2) the analysis needs to be adjusted for misclassification errors estimated in the rule discriminate function when estimating percent mixing zone fish belonging to each group; 3) the assumption that differences in growth rates between Atlantic and Gulf migratory group females are driving the signals seen in otolith shapes needs to be tested; and 4) the temporal stability of the signal between years and/or across age classes needs to be tested.

After discussing the mixing issue, the Panel decided not to change their 1996 conclusions. Otolith shape analyses hold promise as a method to estimate rates of mixing; however, more research is needed (See Future Research and Assessment Considerations section). Additionally, this and other methods (e.g., otolith chemical analysis) should continue to be evaluated.

IV. STATUS OF THE STOCKS

1. Atlantic Migratory Group King Mackerel

Landings and History of Management

Catches since 1981/82 have ranged from a low of 5.93 million pounds in 1994/95 to a high of 9.62 million pounds in 1985/86 (Table 2) (Figure ATK -1). Projected fishing year 1997/98 landings were estimated using the recreational estimates from the most recent 12-month period available, current commercial quota monitoring reports or dealer surveys, and personal communications with fisheries statistics personnel. For Atlantic group king mackerel, the 1997/98 projected landings are:

Commercial	=	2.52 million pounds*
Recreational	=	6.00 million pounds (574,000 fish)
Total	=	8.52 million pounds

- the commercial fishery closed on March 27, 1998 following the filling of the commercial allocation of TAC.

Estimates of Fishing Mortality Rates

The pooled fishing mortality rates (F's) on age 3+ adults increased from just below 0.2 in 1982/83 to a high of about 0.3 in 1985/86 and then varied without trend around 0.2 between 1987/88 through 1992/93 (Figure **ATK-2**). From 1992/93 through 1994/95, fishing mortality declined to a low of below 0.1, but it has increased each year since 1994/95. The median pooled F on ages 3+for 1997/98 was 0.11 per year within the 10th percentile to 90th percentile range of 0.08 to 0.13.

Trends in Recruitment

Recruitment for ages 1-2 was low in the 1980s, increased through the early 1990s, and then declined to a low in 1994/95. It subsequently rebounded to its highest level in 1997/98 (Figure **ATK-3**).

Trends in Biomass

Biomass estimates of ages 3+ showed a slight decline during the 1980s and subsequently increased through 1997/98 (Figure **ATK-4**). Total biomass estimates have remained relatively stable (Figure **ATK-5**).

Acceptable Biological Catch (ABC)

For the 1998/99 fishing year, given the South Atlantic Council's objective not to exceed F_{40}% SPR, the Panel recommends the best estimate of yield to be 9.3 million pounds. There is a 50 percent chance that a TAC of 9.3 million pounds will achieve a $F_{40\%}$SPR level, a 16 percent chance that a 11.9 million pound TAC would achieve a $F_{40\%}$SPR level, and an 84 percent chance that a TAC of 8.4 million pounds would achieve a $F_{40\%}$SPR level. Estimated landings for the last five years have averaged 6.7 million pounds.

Discussion of Stock Status

Landings of Atlantic group king mackerel in the last five years have averaged 6.7 million pounds; and total landings have been below TAC in every year except 1997/98 (Table 2). The transitional SPR has also steadily increased since about 1994, and the current estimate for 1998/99 is 39 percent. As previously noted, SPR estimates are presented as "conditional on no bycatch."

Overfishing

Static SPR was estimated at 36 percent based on the F multiplier for 1996-97 of 0.47. Consequently, the Panel concludes that the Atlantic group king mackerel fishery was not overfishing the available stock because the fishing mortality rate was less than F at 30% static SPR in 1996-97.

Overfished Status

The Panel concludes that the Atlantic migratory group of king mackerel is not overfished because the transitional SPR is estimated at 39 percent, which is above 30% (Figure ATK-6).

Table 2. King mackerel Atlantic stock catch summary for numbers in thousands.

Fishing Year	Mid and North (N. of NC) Com	Rec	Total	South (NC - FL) Com	Rec	Total	Combined Com	Rec	Total
1981/82	<0.5	3	3	275	494	769	276	497	772
1982/83	2	<0.5	2	380	530	910	382	530	911
1983/84	1	<0.5	1	234	671	905	235	671	906
1984/85	<0.5	<0.5	<0.5	181	613	794	182	613	794
1985/86	1	<0.5	1	232	818	1050	233	818	1051
1986/87	<0.5	10	10	277	690	967	277	700	977
1987/88	2	7	9	346	537	883	348	544	892
1988/89	2	13	15	339	543	882	340	556	897
1989/90	1	7	8	282	373	655	283	380	664
1990/91	2	2	5	308	437	745	310	439	750
1991/92	3	10	13	293	628	921	296	639	934
1992/93	4	13	17	265	660	925	270	673	943
1993/94	2	17	20	223	358	581	225	375	600
1994/95	0	2	3	226	379	605	226	382	607
1995/96	1	1	2	179	462	641	180	463	644
1996/97	0	1	2	315	383	698	316	384	700
1997/98									

Table 2 (cont.). King mackerel Atlantic stock catch summary for weight in thousands of pounds.

Fishing Year	Mid and North (N. of NC) Com	Rec	Total	South (NC - FL) Com	Rec	Total	Combined Com	Rec	Total
1981/82	3	28	31	2387	4394	6781	2390	4422	6812
1982/83	14	<0.5	14	3924	5246	9170	3938	5246	9185
1983/84	7	<0.5	7	2434	6253	8687	2441	6253	8694
1984/85	3	<0.5	3	1944	6131	8075	1947	6131	8078
1985/86	10	2	12	2485	7119	9604	2495	7121	9616
1986/87	4	78	81	2833	5901	8734	2837	5979	8816
1987/88	16	49	65	3436	3856	7293	3453	3905	7357
1988/89	15	122	137	3076	4759	7835	3091	4881	7972
1989/90	10	72	82	2625	3329	5954	2635	3400	6036
1990/91	15	14	28	2662	3704	6366	2676	3718	6394
1991/92	22	93	115	2494	5730	8224	2516	5822	8338
1992/93	31	100	132	2195	6150	8345	2227	6251	8477
1993/94	20	219	240	1997	4219	6216	2018	4438	6456
1994/95	1	24	25	2196	3703	5900	2197	3728	5925
1995/96	10	13	24	1859	4140	5999	1870	4153	6023
1996/97	5	16	21	2697	4000	6697	2702	4016	6718
1997/98							2520*	6000*	8520*

- 1997/98 landings are preliminary

Table 2. (cont.) King mackerel Atlantic stock management regulations. Pounds are in millions.

Fishing Year	ABC (lbs)	TAC (lbs)	Rec. Alloc./Quota[3] (lbs / numbers)	Rec. Bag Limit	Com. Allocation[4] (lbs)
1986/87	6.9 - 15.4	9.68	6.09	3	3.59 (PS=0.40)
1987/88	6.9 - 15.4	9.68	6.09	3	3.59 (PS=0.40)
1988/89	5.5 - 10.7	7.00	4.40	2 in FL, 3 GA-NC	2.60 (PS=0.40)
1989/90	6.9 - 15.4	9.00	5.66 / 666,000	2 in FL, 3 GA-NC	3.34
1990/91	6.5 - 15.7	8.30	5.22 / 601,000	2 in FL, 3 GA-NY	3.08
1991/92	9.6 - 15.5	10.50	6.60 / 735,000	5 in FL-NY	3.90
1992/93	8.6 - 12.0	10.50	6.60 / 834,000[5]	2 in FL, 5 GA-NY	3.90
1993/94	9.9 - 14.6	10.50	6.60 / 854,000	2 in FL, 5 GA-NY	3.90
1994/95	7.6 - 10.3	10.00	6.29 / 709,000	2 in FL, 5 GA-NY	3.71
1995/96	7.3 - 15.5	7.30	4.60 / 454,000	2 in FL, 3[6] GA-NY	2.70
1996/97	4.1 - 6.8	6.80	4.28 / 438,525	2 in FL, 3 GA-NY	2.52
1997/98	4.1 - 6.8	6.80	4.28 / 438,525	2 in FL, 3 GA-NY	2.52

[1]Fishing year 1979/80 begins on 1 April 1979 and ends on 31 March 1980.
[2]Sums within rows may not appear to equal the Total value shown due to rounding of numbers before printing.
[3]Recreational quota in numbers is the allocation divided by an estimate of annual average weight (not used prior to fishing year 1989).
[4]The commercial allocation includes the purse seine allocations listed.
[5]Bag limit will not be reduced to zero when allocation reached, beginning in fishing year 1992.
[6]Bag limit reduced from 5 to 3 effective 1/1/96.

2. Gulf Migratory Group King Mackerel

Landings and History of Management

Catches since 1981/82 have ranged from a to a high of 12.3 million pounds in 1982/83 to a low of 3.0 million pounds in 1987/88 (Table 3 and Figure GK-1). Since 1986/87, landings have generally increased and have exceeded TAC in most years (Table 4). Preliminary estimates of 1997/98 landings are:

1997/98	
Commercial	3,390,000*
Recreational	8,393,226 (779,319 fish)**
Total	11,783,266

* The total commercial landings for the 1997 fishing year are expected to equal the allocated quota.

** This total was computed based upon 1996/97 average weights in the recreational fishery, plus calendar landings based on 1996 headboat and Texas recreational levels and 1997 MRFSS data.

Estimates of Fishing Mortality Rates

Pooled F's on age 4+ adults generally declined from 1981/82 to their lowest point in 1987/88. The last peak in F was during the 1994/95 fishing year with lower, relatively stable levels since 1995 (Figure GK-2). The median pooled F on ages 4+ for 1997/98 was 0.19 per year within the 10th percentile to 90th percentile range of 0.15 to 0.23.

Trends in Recruitment

Estimates of recruitment for ages 1-3 declined from 1981/82 to a low in 1984/85, then steadily increased to a high in 1996/97 (Figure GK-3). The 1997/98 estimate is somewhat lower, as is the 1998 projection; however, recruitment is still higher than levels that existed prior to 1994.

Trends in Biomass

Biomass estimates of ages 4+ showed a steady decline from 1981/82 to 1987/88 but have since increased to the current levels that are the highest in the time series (Figure GK-4). Total biomass increased from 1981/82 to about 1988/89 and remained relatively stable thereafter (Figure GK-5). The expected biomass at the beginning of the 1998-99 season is the highest in the time series. *A note of caution is that biomass has consistently lagged recruitment with an offset of about 3 years. Since recruitment has remained level or may be declining, continued increases in biomass may not occur in the short-term.*

Acceptable Biological Catch (ABC)

For the 1998/99 fishing year, given the Gulf Council's objective not to exceed F 30% SPR, the Panel recommends the best estimate of TAC to be 8.7 million pounds. There is a 50 percent chance that a TAC of 8.7 million pounds will achieve a $F_{30\%}$ SPR level, a 16 percent chance that a 10.8 million pound TAC would reach a $F_{30\%}$ SPR level, and an 84% that a TAC of 7.1 million pounds would provide a $F_{30\%}$ SPR level. Clearly, the lower the TAC is set, the lower the probability of overfishing during the 1998-99 fishing year. The Panel emphasizes that there are greater uncertainties with regard to estimates above the 50th percentile mark.

Discussion of Stock Status

Landings of Gulf group king mackerel in the last five years have been the highest in the series since 1982/83, and total landings have exceeded TAC in every year since 1986 (Table 4). Since the 1986/87 fishing year, transitional SPR has varied between 20 and 25 percent with a slightly increasing trend since 1995 (Figure GK-6). Transitional SPR for the 1998/99 fishing year is estimated at 23 percent, which is below the Council's objective.

Overfishing

Static SPR was estimated at 21 percent based on the F multiplier for 1996-97 of 1.00. Consequently, the Panel concludes that the Gulf group king mackerel fishery was overfishing the available stock because the fishing mortality rate was greater than F at 30 percent static SPR in 1996/97. If fishing mortality continues at this rate, the fishery will remain overfished and will not be able to recover above the 30 percent transitional SPR level.

Overfished Status

The Panel concludes that the Gulf migratory group of king mackerel is overfished because the transitional SPR is below 30 percent. Although the Panel did not address rebuilding of the stock, NMFS developed various scenarios for the Council's use should it desire to implement a new rebuilding schedule (Appendix B).

Table 3. King Mackerel Gulf Stock catch summary for number in thousands[1,2]. The listings for East and West Gulf represent catch estimates derived by assuming a zone of mixing between these two hypothesized stocks. The assumed mixing zone ranges from Alabama through Texas with variable proportions of the catch attributed to each of the hypothesized stocks as a function of distance along the U.S. Gulf of Mexico coast.

	East Gulf			West Gulf			US Gulf		
Fishing Year	Com	Rec	Total	Com	Rec	Total	Com	Rec	Total
1981/82	654	172	827	<0.5	126	126	654	299	953
1982/83	406	435	841	42	388	430	449	823	1271
1983/84	360	270	630	29	72	101	389	342	731
1984/85	282	317	599	44	81	125	326	398	724
1985/86	335	116	451	42	68	110	377	184	561
1986/87	153	384	538	19	58	77	172	442	615
1987/88	107	257	364	12	46	58	119	303	422
1988/89	103	463	566	19	62	81	122	526	647
1989/90	156	469	625	27	45	73	184	514	698
1990/91	180	436	616	37	66	103	217	502	719
1991/92	195	648	843	28	90	118	223	738	961
1992/93	340	540	881	70	92	162	410	632	1042
1993/94	215	560	775	52	125	177	267	685	952
1994/95	281	709	991	55	83	137	336	792	1128
1995/96	241	569	811	49	65	114	290	634	925
1996/97	328	595	923	49	69	118	378	664	1042
1997/98									

Table 3 (cont.). King Mackerel Gulf Stock catch summary for weight in thousands of pounds[1,2].

	East Gulf			West Gulf			US Gulf		
Fishing Year	Com	Rec	Total	Com	Rec	Total	Com	Rec	Total
1981/82	5646	1425	7071	<0.5	1476	1476	5646	2901	8548
1982/83	3802	3735	7538	837	3958	4795	4640	7693	12333
1983/84	2624	1626	4250	348	812	1161	2972	2439	5411
1984/85	2601	2358	4959	603	751	1354	3205	3109	6313
1985/86	2976	979	3956	574	852	1426	3550	1832	5382
1986/87	1165	2618	3784	308	650	958	1473	3269	4742
1987/88	690	1655	2345	178	490	668	868	2145	3013
1988/89	1103	4515	5618	303	761	1063	1405	5276	6681
1989/90	1521	2856	4377	432	504	937	1954	3360	5314
1990/91	1395	3288	4683	421	664	1084	1816	3951	5767
1991/92	1731	3966	5697	386	808	1194	2117	4773	6890
1992/93	2839	5458	8297	760	800	1560	3599	6258	9857
1993/94	1954	4923	6877	618	1224	1841	2572	6146	8718
1994/95	2330	7205	9535	612	659	1271	2942	7863	10806
1995/96	2101	5663	7764	544	602	1146	2645	6265	8910
1996/97	2328	6454	8782	525	700	1225	2853	7154	10007
1997/98							3390*	8393*	11783*

* 1997/98 landings are preliminary.

Table 3. (cont.) King Mackerel US Gulf Stock management regulations. Weights are in millions of pounds.

Fishing Year	ABC (lbs)	TAC (lbs)	Rec. Alloc./Quota[3] (lbs / numbers)	Rec. Bag Limit[4]	Com. Allocation: East/West[5,6]	
1986/87	1.2 - 2.9	2.9	1.97	2/3 FL-TX	0.93 :	0.60/0.27 + PS=0.06
1987/88	0.6 - 2.7	2.2	1.50	2/3 FL-TX	0.70 :	0.48/0.22
1988/89	0.5 - 4.3	3.4	2.31	2/3 FL-TX	1.09 :	0.75/0.34
1989/90	2.7 - 5.8	4.25	2.89 / 298,000	2/3 FL-TX	1.36 :	0.94/0.42
1990/91	3.2 - 5.4	4.25	2.89 / 301,000	2/3 FL-TX	1.36 :	0.94/0.42
1991/92	4.0 - 7.0	5.75	3.91 / 574,000	2 FL; 2/3 AL-TX	1.84 :	1.27/0.57
1992/93	4.0 -10.7[9]	7.80	5.30 / 715,000[8]	2 FL-TX	2.50+0.259:	1.73+0.259/0.77[7]
1993/94	1.9 - 8.1[9]	7.80	5.30 / 759,000	2 FL-TX	2.50 :	1.73/0.77
1994/95	1.9 - 8.1[9]	7.80	5.30 / 768,000	2 FL-TX	2.50+0.300:	1.73+0.300/0.77[10]
1995/96	1.9 - 8.1[9]	7.80	5.30 / 629,000	2 FL-TX	2.50 :	1.73/0.77
1996/97	4.7 - 8.8	7.80	5.30 / 629,000	2 FL-TX	2.50 :	1.73/0.77
1997/98	6.0 - 13.7	10.60	7.21 /	2 FL-TX	3.39 :	2.34/1.05

[1]Fishing year 1979/80 begins on 1 July 1979 and ends on 30 June 1980.

[2]Sums within rows may not appear to equal the total value shown due to rounding of numbers before printing.

[3]Recreational quota in numbers is the allocation divided by an estimate of annual average weight (not used prior to fishing year 1989).

[4]Bag Limit "2/3" means 2 for private boats; for charterboats: 2 with, or 3 without, captain and crew.

[5]E/W com. allocations apply to all legal gears except purse seine in fishing year 1986 (only H&L and runaround gillnet beginning 1990/91).

[6]For quota monitoring, E/W com. allocations apply to East=(Florida) and West=(Alabama-Texas), not accounting for mixing.

[7]0.259 million pounds added to com. allocation for FL east only, opened 2/18/93 - 3/26/93.

[8]Bag limit will not be reduced to zero when allocation reached, beginning in fishing year 1992/93.

[9]Panel recommended ABC range changed from 16%-84% to 16%-50% and Gulf Council selected TAC accepting greater than 50% risk level.

[10]0.300 million pounds added to hook-and-line quota for Florida West Coast subzone

TABLE 4. Comparison of Gulf group king mackerel TAC and landings by fishing year(million pounds); percent of total l
over allocation for recreational and commercial sectors.

Fishing Year	TAC	Total Landings	Recreational				Commercial		
			Allocation	Landings	% of Landings	% Over Allocation	Allocation	Landings	% C Lan
86/87	2.9	4.74	1.97	3.27	69%	66	.93	1.47	31%
87/88	2.2	3.02	1.50	2.15	71%	43	.70	.87	29%
88/89	3.4	6.69	2.31	5.28	79%	128	1.09	1.41	21%
89/90	4.25	5.31	2.89	3.36	63%	16	1.36	1.95	37%
90/91	4.25	5.77	2.89	3.95	68%	37	1.36	1.82	32%
91/92	5.75	6.89	3.91	4.77	69%	22	1.84	2.12	31%
92/93	7.8	9.86	5.30	6.26	63%	18	2.50	3.60	37%
93/94	7.8	8.72	5.30	6.15	71%	16	2.50	2.57	29%
94/95	7.8	10.8	5.30	7.86	73%	48	2.50	2.94	27%
95/96	7.8	8.92	5.30	6.27	70%	18	2.50	2.65	30%
96/97	7.8	10.0	5.30	7.15	72%	35	2.50	2.85	28%
97/98*	10.6	11.78	7.21	8.39	71%	16	3.39	3.39	29%

* 1997/98 landings are preliminary

3. Atlantic Migratory Group Spanish Mackerel

Landings and History of Management

The Atlantic group Spanish mackerel fishery has been fully regulated since 1986/87. While the commercial quota has been met every year up to 1995/96, the total harvest has not exceeded the TAC since the 1991/92 fishing year (Table 5) (Figure **ATS-1**). Additionally, the recreational sector has not filled their allocation since 1990/1991.

Projected fishing year 1997/98 landings were estimated using the recreational estimates from the most recent 12-month period available, current commercial quota monitoring reports or dealer surveys, and personal communications with fisheries statistics personnel. For Atlantic group Spanish mackerel, the 1997/98 projected landings are:

Commercial	=	4.00 million pounds
Recreational	=	1.35 million pounds (1,047,000 fish)
Total	=	5.35

Estimates of Fishing Mortality

The fishing mortality rate on adults, ages (Age 2+), was slightly above 0.8 for fishing year 1984/85, and declined to about 0.2 in the 1987/88 fishing year. From 1988/89 through 1994/95, F varied around 0.4 and then declined in 1995/96. The trend has been upwards since 1995/96 (Figure **ATS-2**). The median pooled F on ages 2+ for 1997/98 was 0.21 per year within the 10^{th} percentile to 90^{th} percentile range of 0.16 to 0.27.

Trends in Recruitment

Estimates of age-1 recruits has been variable without trend since 1984/85 (Figure **ATS-3**).

Trends in Biomass

Estimates of biomass of age 2+ was low in the mid-1980s and increased in the late 1980s. Biomass was stable from 1988/89 through 1995/96, but recent estimates of biomass have been higher (Figure ATS-4). Total biomass has generally increased since about 1989 (Figure **ATS-5**).

Acceptable Biological Catch (ABC)

For the 1998/99 fishing year, given the Council's objective not to exceed $F_{40\%}$SPR, the Panel recommends the best estimate of yield to be 6.6 million pounds. There is a 50 percent chance that a TAC of 6.6 million pounds will achieve a $F_{40\%}$SPR level, a 16 percent chance that a TAC of 8.2 million pounds would achieve a $F_{40\%}$SPR level, and an 84 percent chance that a TAC of 5.4 million pounds would achieve a $F_{40\%}$SPR level.

Status of the Stock

The Panel believes that the reductions in harvest in recent years reflect the elimination of gill nets from Florida state waters in 1995 and are not due to reduced stock sizes. The current operation of the fishery is expected to harvest less than the estimated median ABC value of 6.6 million pounds.

Overfishing

Static SPR was estimated at 42 percent based on the F multiplier of 0.35 for 1996-97. Consequently, the Panel concluded that the Atlantic migratory group Spanish mackerel fishery was not overfishing the available stock because the fishing mortality rate is above the $F_{30\%\ static}$ rate.

Overfished Status

The Panel concludes that Atlantic migratory group Spanish mackerel are not overfished since the transitional SPR is estimated at 40, which is above the 30 percent level (Figure ATS-6).

Table 5. Spanish mackerel Atlantic stock catch summary for numbers in thousands.

Fishing Year	Mid and North (North of NC) Com	Rec	Total	South (NC - FLA) Com	Rec	Total	Combined Com	Rec	Total
1984/85	10	<0.5	10	2174	942	3116	2184	942	3126
1985/86	38	<0.5	38	2308	496	2804	2346	496	2842
1986/87	246	9	254	1661	789	2450	1907	798	2704
1987/88	578	11	589	1868	1042	2910	2446	1053	3498
1988/89	553	102	655	2094	1624	3718	2647	1726	4373
1989/90	451	97	547	1784	1006	2790	2234	1103	3337
1990/91	540	70	610	1527	1253	2780	2067	1323	3390
1991/92	737	155	893	2176	1308	3484	2913	1464	4377
1992/93	356	88	445	1918	1122	3040	2274	1210	3484
1993/94	63	123	186	2462	797	3258	2525	920	3445
1994/95	476	197	673	2693	887	3580	3169	1085	4254
1995/96	381	113	494	1095	672	1767	1476	785	2260
1996/97	292	71	362	1879	587	2466	2170	658	2829

Table 5 (cont.). Spanish mackerel Atlantic stock catch summary for weight in thousands of pounds.

Fishing Year	Mid and North (North of NC) Com	Rec	Total	South (NC - FLA) Com	Rec	Total	Combined Com	Rec	Total
1984/85	10	<0.5	10	3281	1311	4592	3292	1311	4602
1985/86	15	<0.5	15	4176	747	4923	4192	747	4939
1986/87	176	11	186	2390	1185	3575	2565	1196	3761
1987/88	381	15	396	3179	1458	4637	3559	1474	5033
1988/89	327	153	480	3197	2587	5784	3524	2740	6264
1989/90	423	113	537	3540	1456	4996	3963	1569	5533
1990/91	600	100	699	2960	1975	4935	3560	2075	5635
1991/92	765	217	982	3971	2070	6041	4736	2287	7023
1992/93	396	118	514	3321	1877	5198	3716	1995	5712
1993/94	83	159	242	4731	1333	6064	4813	1493	6306
1994/95	504	231	735	4729	1147	5876	5233	1378	6611
1995/96	392	133	524	1617	957	2574	2009	1089	3098
1996/97	311	86	397	2785	765	3550	3096	851	3946
1997/98							4000*	1350*	5350*

* 1997/98 landings are preliminary

Table 5. (cont). Spanish mackerel Atlantic stock management regulations. Pounds are in millions.

Fishing Year	ABC (lbs)	TAC (lbs)	Rec. Alloc./Quota[3] (lbs / numbers)	Rec. Bag Limit	Com. Alloc. (lbs)
1987/88	1.7 - 3.1	3.1	0.74	4 in FL, 10 GA-NC	2.36
1988/89	1.3 - 5.5	4.0	0.96	4 in FL, 10 GA-NC	3.04
1989/90	4.1 - 7.4	6.0	2.76 / 1,725,000[4]	4 in FL, 10 GA-NC	3.24
1990/91	4.2 - 6.6	5.0	1.86 / 1,216,000	4 in FL, 10 GA-NY	3.14
1991/92	5.5 -13.5	7.0	3.50 / 2,778,000	5 in FL, 10 GA-NY	3.50
1992/93	4.9 - 7.9	7.0	3.50 / 2,536,000[5]	10 FL-NY	3.50
1993/94	7.3 -13.0	9.0	4.50 / 3,214,000	10 FL-NY	4.50
1994/95	4.1 - 9.2	9.2	4.60 / 3,262,000	10 FL-NY	4.60
1995/96	4.9 -14.7	9.4	4.70 / 3,113,000	10 FL-NY	4.70
1996/97	5.0 - 7.0	7.0	3.50 / 2,713,000	10 FL-NY	3.50
1997/98	5.8 - 9.4	8.0	4.00 / 2,564,000	10 FL-NY	4.00

[1]Fishing year 1979 begins on 1 April and ends on 31 March 1980.
[2]Sums within rows may not appear to equal the total value shown due to rounding of numbers before printing.
[3]Recreational quota in numbers is the allocation divided by an estimate of annual average weight (not used prior to fishing year 1989).
[4]Allocations and rec. quota are as revised October 14, 1989.
[5]Bag limit will not be reduced to zero when allocation reached ,beginning fishing year 1992.

4. Gulf Migratory Group Spanish Mackerel

Landings and History of Management

Landings of Spanish mackerel from U.S. catches have ranged from 4.0 to 9.6 million pounds between fishing years 1984/85 and 1994/95 (Table 6) (Figure GS-1). The total U.S. landings for this group in the last two fishing years were substantially less than previous landings, averaging only 2.7 million pounds due to the elimination of gill nets in Florida waters from July 1995.

This fishery has been fully regulated since 1986/87. In 1987/88 and 1988/89, catches were greater than the TAC. Over the period 1989/90 through 1997/98, catches have been below TAC and the mid point of the ABC range.

Estimates of Fishing Mortality Rate

Since the 1995/96 fishing year, the median fishing mortality rates, pooled F on adults ages 2+, were lower than the target of $F_{30\%}$ SPR (Figure GS-2). The reductions came primarily from the commercial sector after gill nets were eliminated from Florida state waters in July 1995. The median pooled F on ages 2+ for 1997/98 was 0.14 per year within the 10^{th} percentile to 90^{th} percentile range of 0.10 to 0.18.

Trends in Recruitment and Biomass

Age 0 recruits have varied between 10 and 20 million fish since the early 1980's (Figure GS-3). The apparent cyclic trends in recruitment during the 1980's are reflected in similar trends in biomass, which is characteristically true among short-lived species (Figure GS-4). However, since the 1993/94 fishing year recruitment has been steady and adult biomass has increased in each year with last year's biomass levels being the highest in the data series. Total biomass has been increasing since about 1992 (Figure GS-5).

Acceptable Biological Catch (ABC)

For the 1997/98 fishing year, given the Council's objective not to exceed $F_{30\%}$ SPR, the Panel recommends the best estimate of yield to be 10.3 million pounds. There is a 50 percent chance that a TAC of 10.3 million pounds will achieve a $F_{30\%}$ SPR level, a 16 percent chance that a 14.1 million pound TAC would reach an $F_{30\%}$ SPR level, and an 84% that a TAC of 7.3 million pounds would provide a $F_{30\%}$ SPR level. As previously noted the lower the TAC is set, the lower the probability of overfishing in the 1998/99 fishing year, and there is much greater uncertainty about estimates above the median level of ABC.

Table 6. Spanish mackerel Gulf stock catch summary.

Fishing Year	US Gulf - thousands of fish Com	Rec	Total	US Gulf - thousands of pounds Com	Rec	Total
1984/85	1857	865	2722	3445	1178	4623
1985/86	1706	1060	2766	3298	1355	4653
1986/87	1250	6334	7584	2053	7520	9573
1987/88	1488	1882	3370	2581	3124	5705
1988/89	2466	1340	3806	3902	2177	6079
1989/90	1101	1250	2351	2145	1856	4001
1990/91	1124	1596	2720	2074	2138	4213
1991/92	2075	2014	4089	4163	2889	7053
1992/93	1804	2008	3812	3113	3130	6243
1993/94	1432	1795	3227	2614	2696	5309
1994/95	1532	1136	2668	2544	1556	4100
1995/96	731	1092	1823	1075	1575	2650
1996/97	316	1260	1576	617	2054	2671
1997/98						

Table 6. (cont.) Spanish mackerel US Gulf stock management regulations. Pounds are in millions. Prior to fishing year 1990, management was based upon a July-June fishing year. The regulations shown for fishing year 1987 and later are relative to the July-June fishing year.

Fishing Year	ABC (lbs)	TAC (lbs)	Rec. Alloc./Quota[4] (lbs / numbers)	Rec. Bag Limit	Com. Alloc. (lbs)
1987/88	1.9 - 4.0	2.50	1.08	3	1.42
1988/89	1.9 - 7.1	5.00	2.15	4 FL, 10 AL-TX	2.85
1989/90	4.9 - 6.5	5.25	2.26 / 1,614,000	4 FL, 10 AL-TX	2.99
1990/91	3.9 - 7.4	5.25	2.26 / 1,569,000	3 TX, 4 FL[5], 10 AL-LA	2.99
1991/92	7.1 -12.2	8.60	3.70 / 2,721,000	3 TX, 5 FL, 10 AL-LA	4.90
1992/93	5.1 - 9.8	8.60	3.70 / 3,274,000[6]	7 TX, 10 FL-LA	4.90
1993/94	4.7 - 8.7	8.60	3.70 / 3,274,000	7 TX, 10 FL-LA	4.90
1994/95	4.4 - 8.7	8.60	3.70 / 2,202,000	7 TX, 10 FL-LA	4.90
1995/96	4.0 -10.7	8.60	3.70 / 2,782,000	7 TX, 10 FL-LA	4.90
1996/97	1.6 - 9.5	7.00	3.01 /	7 TX, 10 FL-LA	3.99
1997/98	5.5 -13.9	7.00	3.01/	7 TX, 10 FL-LA	3.99

[1]Fishing year 1979 begins on 1 April 1979 and ends on 31 March 1980.
[2]Sums within rows may not appear to equal the Total value shown due to rounding of numbers before printing.
[3]Information on Mexico catch and size distributions for some years was not sufficient for inclusion.
[4]Recreational quota in numbers is the allocation divided by an estimate of annual average weight (not used prior to fishing year 1989).
[5]Rec. bag limit in FL changed from 4 to 5 on 1/1/91, and changed from 5 to 10 on 1/1/93.
[6]Bag limit will not be reduced to zero when allocation reached ,beginning fishing year 1992.

Status of the Stock

As with Atlantic migratory group Spanish mackerel, the Panel believes that the reductions in harvest in recent years reflect the elimination of gill nets in Florida state waters in 1995 and are not due to reduced stock sizes. The current operation of the fishery will most likely harvest less than the estimated median ABC value of 10.3 million pounds. The low level of harvest relative to stock size has accelerated the rebuilding of this stock which is reflected in the marked increase in transitional SPR. The Council's definition of optimum yield (OY) is a target of 30% SPR, and this fishery exceeded the OY target in the 1997/98 fishing year (Figure GS-6).

Overfishing

Static SPR was estimated at 47 percent based on the F multiplier of 0.20 for 1996-97. Consequently, the Panel concluded that the Gulf group Spanish mackerel fishery was not overfishing the available stock because the static SPR value is greater than 30 percent.

Overfished Status

The median estimate of transitional SPR is 35 percent (Figure GS-6). Since transitional SPR for Gulf group Spanish mackerel is greater that 30 percent, the Panel concludes that this stock is not overfished.

V. FUTURE RESEARCH AND ASSESSMENT CONSIDERATIONS

During the 1998 mackerel stock assessment review, the Panel identified several areas where additional research is needed to improve the quality, cost-effectiveness, and reliability of future stock assessments. The Panel's research recommendations fall into three categories: (1) theory of sampling strategies; (2) age, growth, and mortality; and, (3) analytical studies and management perspectives. The Panel recommends that in the odd years, when a full assessment is not completed, rather than update the projections, time be spent addressing these analytical items as identified below. In this way, the precision of assessments will improve.

Theory of Sampling Strategies

A simple matrix of survey strategy by fishery type clearly shows that the amount of variance described by GLM multiple regression is low for almost all of the auxiliary stock indices. This is very disconcerting since these GLM models are then used to tune the principal index of stock abundance/biomass in the FADAPT VPA model, and error intrinsic to the data likely exacerbates the extent of uncertainty associated with the recommended ABCs. To ameliorate these problems, we recommend several strategies to improve data collection systems for relative abundance (i.e., CPUE) for Gulf and Atlantic king and Spanish mackerels, particularly in Florida waters. We recommend that analytical research be directed towards optimizing sampling survey designs associated with these indices, and that some effort be applied to identifying and promoting those indices that are both accurate and precise.

There is also an historical component contributing to uncertainty in population estimates. The techniques and methodologies used to generate length compositions in landings may not lead to representative estimates of the stock in question, we recommend an evaluation of the impacts of unbalanced sampling designs on the estimated landings at size (and age). These analyses should address the impacts of varying biostatistical sampling levels on assessment results. Based on these analyses, sampling designs and survey effort levels should be recommended to achieve specified precision bounds.

Annual bycatch estimates also suffer from problems in both accuracy and precision. To improve bycatch estimates, we recommend a program to monitor the Atlantic coast directed shrimp fishery to refine bycatch estimates of Atlantic-group king and Spanish mackerels.

The Panel feels that greater emphasis should be placed on the temporal and spatial resolution of the distribution of nominal fishing effort and its relationship to CPUE estimates. We recommend That a comprehensive program of log-book and trip-intercept survey methodologies be developed for coastal pelagics.

In addition, we recommend development of innovative fishery-independent monitoring methods to assess stock size for both Gulf and Atlantic group king and Spanish mackerels. These methods should examine the feasibility of alternative assessment methods such as aerial surveys in south Florida during winter. These new fishery-independent methodologies should integrate and help to calibrate extant fishery-dependent methodologies.

Age, Growth, and Natural Mortality

Potentially biased length frequencies applied to uncertain catch data may be creating artifacts in the data that could deleteriously affect the results of stock assessments. The Panel notes that stratified age-length keys are not equally sampled (i.e., selected) by all gear types for all ages. In some cases strata are not adequately sampled. These conditions, coupled with natural recruitment effects on age-length keys, need to be systematically evaluated to ensure that they do not deleteriously affect the results and conclusions of stock assessments. Therefore, we recommend an evaluation of the potential biases associated with inappropriate stratifications of data used to generate age-length keys for Atlantic and Gulf group king and Spanish mackerels.

We also recommend an evaluation of the implications of using alternative values of the natural mortality rate (M) on estimates of stock size and attendant ABC recommendations. We suggest that the distribution around the M values be minimized in the Monte Carlo/bootstrap simulations to reflect the certitude of maximum age from relatively extensive age-and-growth studies on mackerels. Overall, we feel this action de facto would reduce the range of ABCs provided.

Analytical Studies and Management Perspectives

The Panel noted several lines of analysis needed to refine the quality of management decision- making advice provided to the Councils.

First, we recommend an analysis of the implications to fishery productivity of changing the minimum size of first capture to protect immature fish for Gulf group king mackerel.

Second, we recommend an evaluation of the effects of gear fishing power standardization using GLM techniques on temporal and spatial trends in bycatch, paying particular attention to before and after the implementation of TEDs in the directed shrimp fisheries.

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Third, we recommend an evaluation of alternative stock assessment methods for Spanish mackerel such as non-equilibrium age-structured production models. Models that aggregate age structure have the added advantage of specifying a recruitment boundary condition, and may be particularly useful when assessments are projected from incomplete or imprecise catch-at-age data.

Finally, we recommend that management invert the onus with respect to the probability of a fishery being in compliance with an established SPR threshold. That is, place the responsibility on the participants in the fishery to demonstrate that no part of the estimated probability range of SPR is below the established minimum.

VI. LITERATURE CITED

DeVries, D.A. and C.B. Grimes. 1998. Using otolith shape analysis to distinguish Eastern Gulf of Mexico from Atlantic Ocean stock king mackerel *Scomberomorus cavalla*. MSAP/98/11. DOC, NMFS, SEFSC. Panama City, Florida. 14 p. + Figures.

Grimes, C.B. and D.A. DeVries. 1998. Discrimination of king mackerel, *Scomberomorus cavalla*, stocks in the U.S. south Atlantic and Gulf of Mexico and assignment of catches from mixed stock fisheries. MSAP/98/08. DOC, NMFS, SEFSC. Panama City, Florida.

Harris, P.J. and J. M. Dean. 1998. The potential impact of juvenile king mackerel (*Scomberomorus cavalla*) and Spanish mackerel (*S. maculatus*) shrimp trawl bycatch mortality on southeast Atlantic adult populations. MSAP/98/01. South Carolina Marine Sources Division and University of South Carolina. 18 p. + Figures.

Harris, P.J. and J. M. Dean. 1998. Characterization of the king mackerel and Spanish mackerel bycatch of South Carolina shrimp trawlers, MSAP/98/02. South Carolina Marine Sources Division and University of South Carolina. 36 p.

Legault, C.M., N. Cummings, and P. Phares. 1998. Stock assessment analyses on Atlantic migratory group king mackerel, Gulf of Mexico migratory group king mackerel, Atlantic migratory group Spanish mackerel, and Gulf of Mexico migratory group Spanish mackerel. MSAP/98/09. DOC, NMFS, SEFSC MIA-97/98-15. Miami, Florida. 90 p. + appendices.

Legault, C.M. 1998. What if mixing area fish are assigned to the Atlantic migratory group instead of the Gulf of Mexico migratory group? DOC, NMFS, SEFSC. MSAP/98/10. Miami, Florida. 40 p.

Legault, C.M. 1998. Application of a stochastic age-structured production model to Gulf of Mexico Spanish mackerel. MSAP/98/13. DOC, NMFS, SEFSC. Miami, Florida. unpaged.

Legault, C.M. and M. Ortiz. 1998. Delta lognormal estimate of bycatch for the Gulf of Mexico king and Spanish mackerel and their impact on stock assessment and acceptable biological Catch. MSAP/98/12. DOC, NMFS, SEFSC. Miami, Florida. unpaged.

Mace, P., L. Botsford, J. Collie, W. Gabiel, P. Goodyear, J. Powers, V. Restrepo, A. Rosenberg, M. Sissenwine, G. Thompson, and J. Witzig. 1996. Scientific review of definitions of overfishing in U.S. fishery management plans: Supplemental report. DOC, NMFS. MSAP 96/15. 20 p.

Nichols, S. 1998. Mackerel and cobia shrimp fleet bycatch. unpaged. DOC, MFS, SEFSC. MSAP/98/05. e-mail February 17, 1998.

Pellegrin, G. 1998. King and Spanish mackerels for the South Atlantic.unpaged. DOC, NMFS, SEFSC. MSAP/98/06. e-mail February 20,1998.

Pellegrin, G. 1998. King and Spanish mackerels for the South Atlantic. unpaged. DOC, NMFS, SEFSC. MSAP/98/07. e-mail February 23, 1998.

Restrepo, V.,R. 1996. FADAPT Version 3.0: A Guide. Unpublished manuscript, available from author. University of Miami RSMAS, 4600 Rickenbacker Causeway, Miami, FL 33149.

Thompson, N. 1998. Characterization of the dolphin fish (Coryphinaenidae, Pisces) fishery of the United States Western North Atlantic Ocean. MSAP/98/03. DOC, NMFS, SEFSC. Miami, Florida. 21 p.

Vaughan, D.S. and J.M. Nance. 1998. Estimates of bycatch of mackerel and cobia in U.S. South Atlantic shrimp trawls. MSAP/98/04. DOC, NMFS, SEFSC. Beaufort, North Carolina and Galveston Texas. 25 p.

VII. LIST OF PANEL MEMBERS AND ATTENDEES

Doug Gregory, Chairman
Gregg Waugh, V. Chairman
Jerry Ault
Jerry Scott (designee for Joe Powers)
Robert Muller
William Patterson

Observers:

Roy Williams - Gulf Council/Florida Marine Fisheries Commission
Rick Leard - Gulf of Mexico Fishery Management Council
Chuck Hawkins - South Atlantic Fishery Management Council, Mackerel AP
Nancie Cummings - NMFS/SEFSC - Miami
Patricia Phares - NMFS/SEFSC -Miami
Michael Schirripa - NMFS/SEFSC - Miami
Mark Godcharles - NMFS/SERO - St. Petersburg
Mauricio Ortiz - University of Miami, RSMAS, Miami, Florida
Chris Legault - NMFS/SEFSC - Miami
John Sanchez - Monroe County Commercial Fishermen, Inc., Marathon, Florida
John Vondruska - NMFS/SERO - St. Petersburg
Guy Davenport - NMFS/SEFSC - Miami-
Tom McIlwain - NMFS - Pascagoula
John Ward - NMFS - Silver Spring
John Poffenberger - NMFS/SEFSC - Miami
John Merriner - NMFS/SEFSC - Beaufort
Joe O'Hop - Florida Department of Environmental Protection - St. Petersburg
John Carmichael - North Carolina Department of Environment and Natural Resources - Morehead City
Dave VanVoorhees - NMFS - Silver Spring
Priscilla Weeks - University of Houston Clear Lake - Houston
Michael Jepson - SAFMC - Charleston
Michael Travis - NMFS/SERO - St. Petersburg

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Atlantic King mackerel

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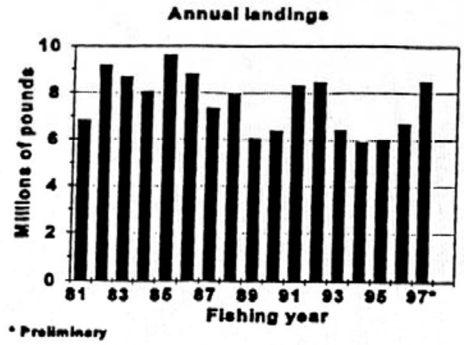

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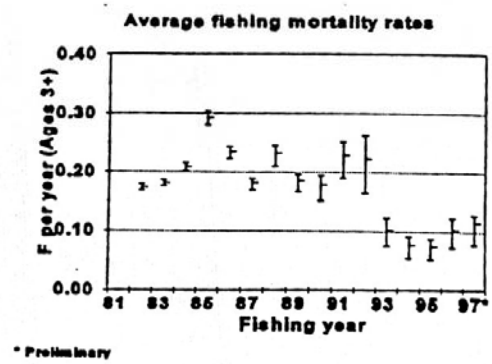

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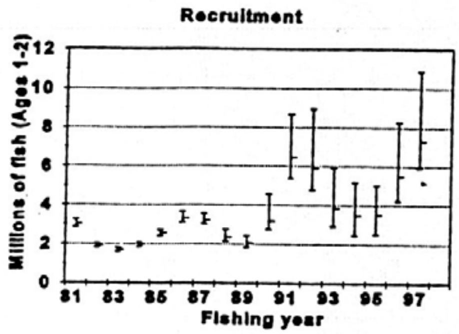

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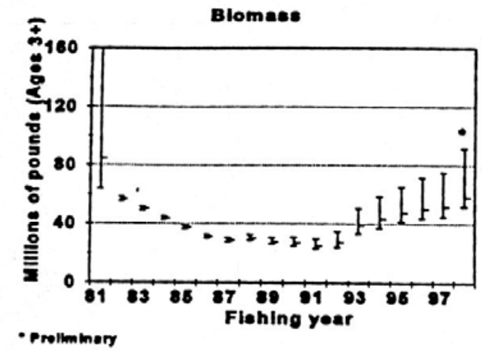

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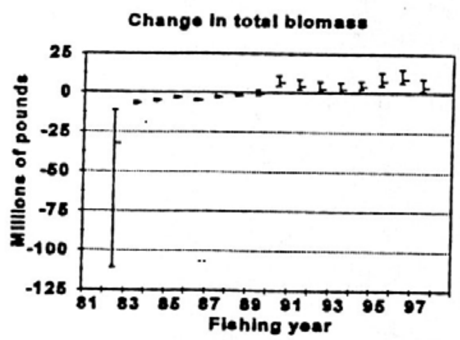

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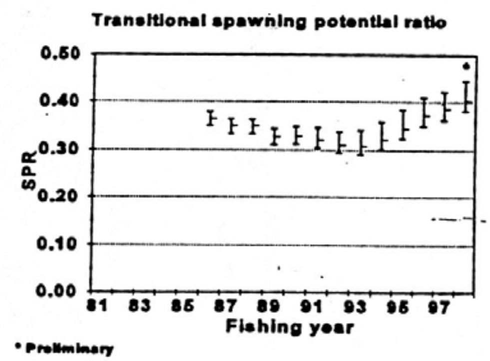

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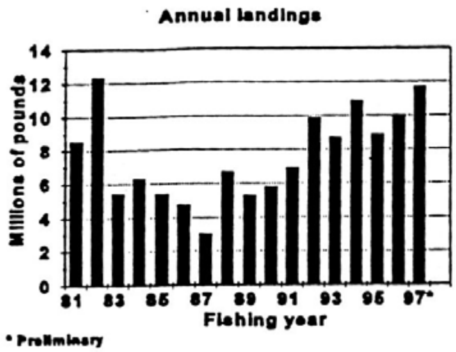
Gulf king mackerel

GK - 1



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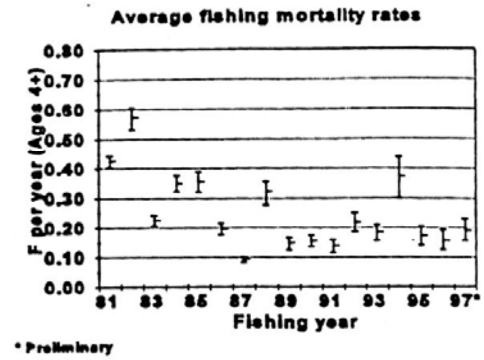

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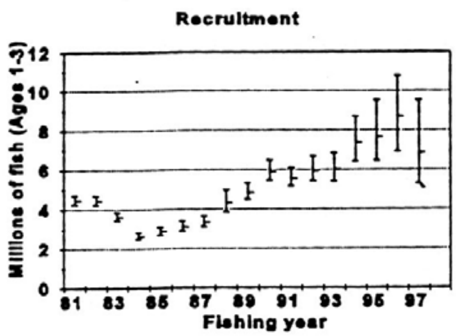

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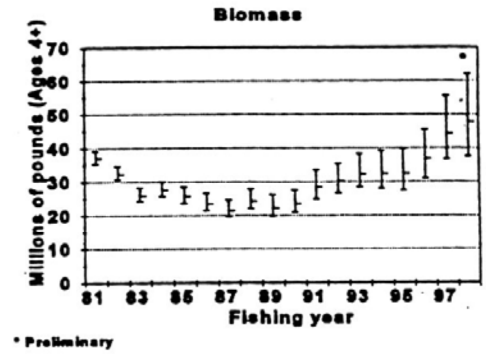

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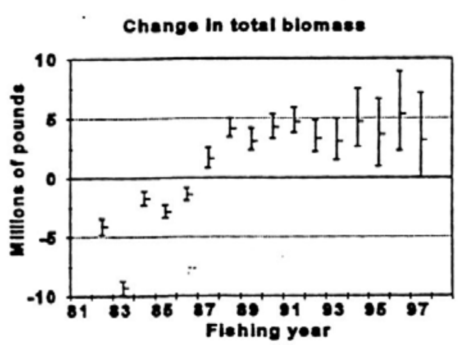

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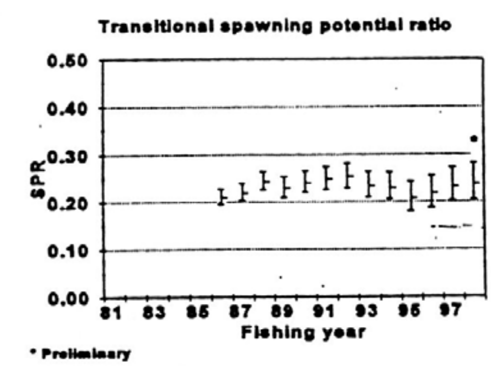
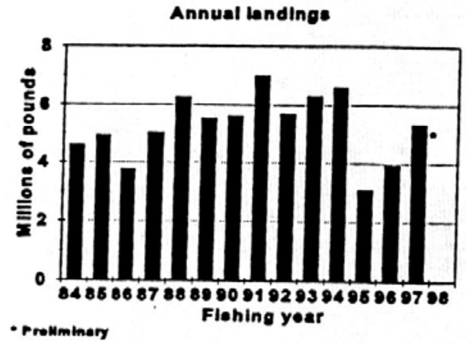


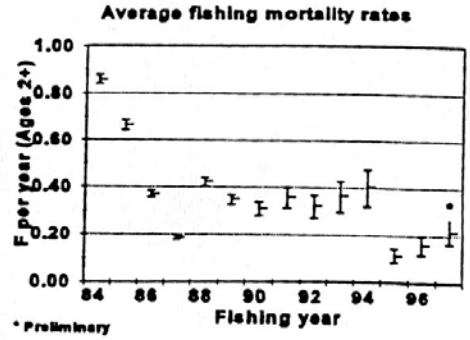
27

Atlantic Spanish mackerel

ATS - 1



ATS - 2



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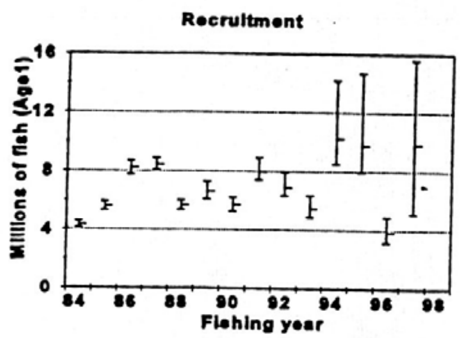

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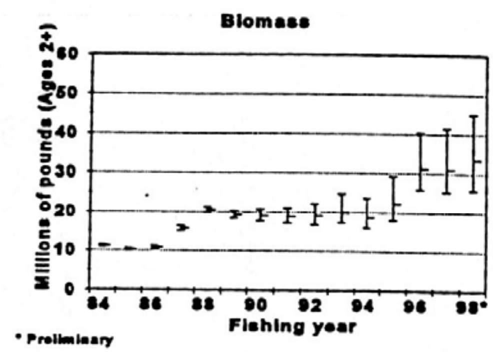

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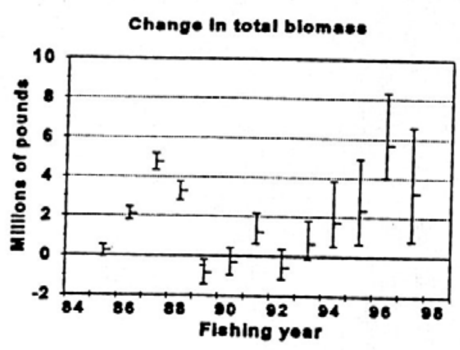

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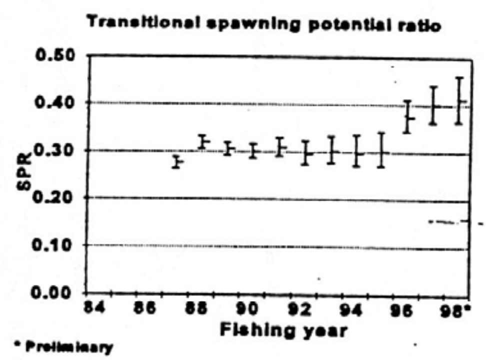
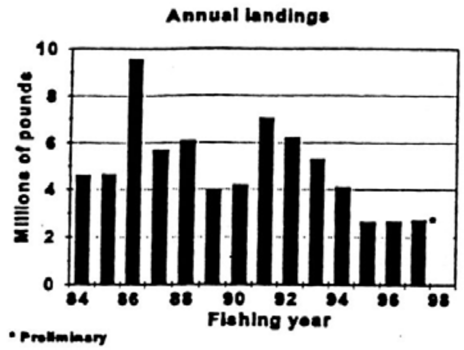


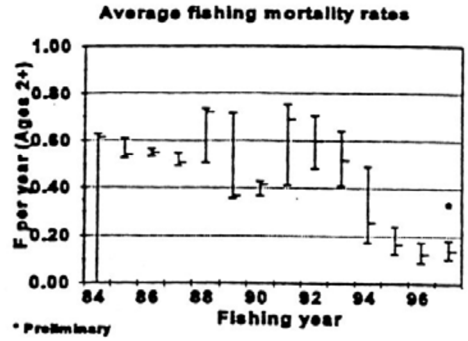
28

Gulf Spanish mackerel

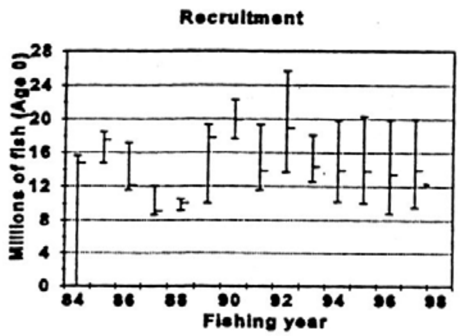
GS - 1



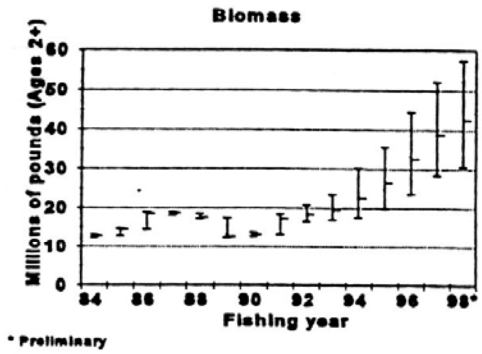
GS - 2



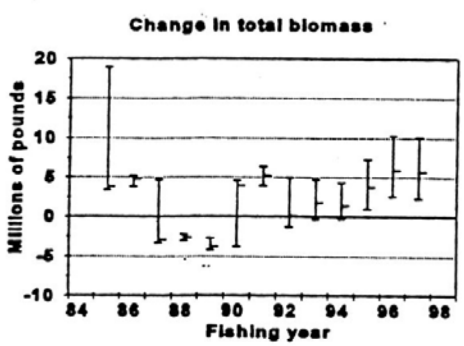
GS - 3



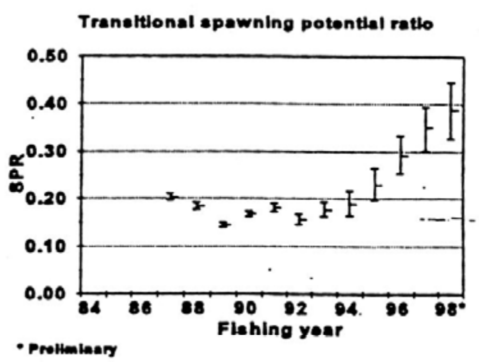
GS - 4



GS - 5



GS - 6



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APPENDIX A

Section 6.1.1: Mechanism for Determination of Framework Adjustments, as modified by this and previous amendments is as follows:

Section 12.6.1.1

A. An assessment panel (Panel) appointed by the Councils will normally reassess the condition of each stock or migratory group of king and Spanish mackerel and cobia in alternate (even numbered) years for the purpose of providing for any needed preseason adjustment of TAC and other framework measures. However, in the event of changes in the stocks or fisheries, the Councils may request additional assessments as may be needed. The Councils, however, may make annual seasonal adjustments based on the most recent assessment. The Panel shall be composed of NMFS scientists, Council staff, Scientific and Statistical Committee members, and other state, university, and private scientists as deemed appropriate by the Councils.

The Panel will address the following items for each stock:

1. Stock identity and distribution. This should include situations where there are groups of fish within a stock which are sufficiently different that they should be managed as separate units. If several possible stock divisions exist, the Panel should describe the likely alternatives.

2. MSY for each identified stock. If more than one possible stock division exists, MSY for each possible combination should be estimated.

3. Condition of the stock(s) or groups of fish within each stock which could be managed separately. For each stock, this should include but not be limited to:

    a. Fishing mortality rate relative to F_{msy} and $F_{0.1}$ as well as $F_{20\%SPR}$, $F_{30\%SPR}$, and $F_{40\%SPR}$.
    b. Spawning potential ratio (SPR).
    c. Abundance relative to an adequate spawning biomass.
    d. Trends in recruitment.
    e. Acceptable Biological Catch (ABC) which will result in long-term yield as near MSY as possible.
    f. Calculation of catch ratios based on catch statistics using procedures defined in the FMP as modified.
    g. Estimate of current mix of Atlantic and Gulf migratory group king mackerel in the mixing zone for use in tracking quotas.

4. Overfishing:

    a. A mackerel stock or migratory group is considered to be overfished when the transitional spawning potential ratio (SPR) is below 30 percent.

b. The South Atlantic Council's target level or optimum yield (OY) is 40 percent static SPR. The Gulf Council's target level or optimum yield (OY) is 30 percent static SPR. ABC is calculated based on the target level or optimum yield (SAFMC = 40 percent static SPR and GMFMC = 30 percent static SPR).
c. When a stock or migratory group is overfished (transitional SPR less than 30 percent), a rebuilding program that makes consistent progress towards restoring stock condition must be implemented and continued until the stock is restored beyond the overfished condition. The rebuilding program must be designed to achieve recovery within an acceptable time frame as specified by the Councils. The Councils will continue to rebuild the stock until the stock is restored to the management target (OY) within an unspecified time frame.
d. When a stock or migratory group is not overfished (transitional SPR equal to or greater than 30 percent), the act of overfishing is defined as a static SPR that exceeds the threshold of 30 percent (i.e., $F_{30\ percent}$). If fishing mortality rates that exceed the level associated with the static SPR threshold are maintained, the stock may become overfished. Therefore, if overfishing is occurring, a program to reduce fishing mortality rates toward management target levels (OY) will be implemented, even if the stock or migratory group is not in an overfished condition.
e. The Councils have requested the Mackerel Stock Assessment Panel (MSAP) provide a range of possibilities and options for specifying an absolute biomass level which could be used to represent a depleted condition or state. In a future amendment, the Councils will describe a process whereby if the biomass is below such a level, the Councils would take appropriate action, including but not limited to, eliminating directed fishing mortality and evaluating measures to eliminate any bycatch mortality in a timely manner through the framework procedure.
f. For species like cobia, when there is insufficient information to determine whether the stock or migratory group is overfished (transitional SPR), overfishing is defined as a fishing mortality rate in excess of the fishing mortality rate corresponding to a default threshold static SPR of 30 percent. If overfishing is occurring, a program to reduce fishing mortality rates to at least the level corresponding to management target levels will be implemented.

5. Management options. If recreational or commercial fishermen have achieved or are expected to achieve their allocations, the Panel may delineate possible options for nonquota restrictions on harvest, including effective levels for such actions as:

a. Bag limits.
b. Size limits.
c. Gear restrictions.
d. Vessel trip limits.
e. Closed season or areas, and
f. Other options as requested by the Councils.

6. Other biological questions as appropriate.

A - 2

B. The Panel will prepare a written report with its recommendations for submission to the Councils each year (even years - full assessment, odd years - mini assessments) by such date as may be specified by the Councils. The report will contain the scientific basis for their recommendations and indicate the degree of reliability which the Council should place on the recommended stock divisions, levels of catch, and options for nonquota controls of the catch.

C. The Councils may take action based on the panel report or may take action based on issues/information that surface separate from the assessment group. The steps are as follows:

1. Assessment panel report: The Councils will consider the report and recommendations of the Panel and such public comments as are relevant to the Panel's report. A public hearings will be held at the time and place where the Councils consider the Panel's report. The Councils will consult their Advisory Panels and scientific and Statistical Committees to review the report and provide advice prior to taking final action. After receiving public input, the Councils will make findings on the need for changes.

2. Information separate from assessment panel reports: The Councils will consider information that surfaces separate from the assessment group. Council staff will compile the information and analyze the impacts of likely alternatives to address the particular situation. The Council staff report will be presented to the Council. A public hearing will be held at the time and place where Councils consider the Council staff report. The Councils consult their Advisory Panels and Scientific and Statistical Committees to review the report and provide advice prior to taking final action. After receiving public input, the Councils will make findings on the need for changes.

D. If changes are needed in the following, the Councils will advise the Regional Administrator (RA) of the Southeast Region of the National Marine Fisheries Service in writing of their recommendations, accompanied by the assessment panel's report, relevant background material, and public comment:

a. MSYs,
b. overfishing levels,
c. TACs,
d. quotas (including zero quotas),
e. trip limits,
f. bag limits (including zero bag limits),
g. minimum sizes,
h. reallocation of Atlantic group Spanish mackerel,
i. gear restriction (ranging from modifying current regulations to a complete prohibition),
j. permit requirements, or
k. season/area closure and reopening (including spawning closure).

Recommendations with respect to the Atlantic migratory groups of king and Spanish mackerel will be the responsibility of the South Atlantic Council, and those for the Gulf migratory groups of king and Spanish mackerel will be the responsibility of the Gulf Council. Except that the SAFMC will have responsibility to set vessel trip limits, closed seasons or areas, or gear restrictions for the northern area of the Eastern Zone (Dade through Volusia Counties, Florida) for the commercial fishery for Gulf group king mackerel. This report shall be submitted by such data as may be specified by the Councils.

E. The RA will review the Councils' recommendation, supporting rationale, public comments and other relevant information, and if he concurs with the recommendation, he will draft regulations in accordance with the recommendation. He may also reject the recommendation, providing written reasons for rejection. In the event the RA rejects the recommendation, existing regulations shall remain in effect until resolved. However, if the RA finds that a proposed recreational bag limit for Gulf migratory group or groups of king mackerels is likely to exceed the allocation and rejects the Councils' recommendation, the bag limit reverts to one fish per person per day.

F. If the RA concurs that the Councils' recommendations are consistent with the goals and objectives of the plan, the National Standards, and other applicable law, he shall implement the regulations by proposed and final rules in the Federal Register prior to the appropriate fishing year or such dates as may be agreed upon with the Councils. A reasonable period for public comment shall be afforded, consistent with the urgency, if any, of the need to implement the management measure.

Appropriate regulatory changes that may be implemented by the RA by proposed and final rules in the Federal Register are:

1. Adjustment of the point estimates of MSY for cobia, for Spanish mackerel within a range of 15.7 million pounds to 19.7 million pounds, and for king mackerel within a range of 21.9 million pounds to 35.2 million pounds. Adjustment of the overfishing level for king and Spanish mackerels.

2. Setting total allowable catches (TACs) for each stock or migratory group of fish which should be managed separately, as identified in the FMP provided:
   a. No TAC may exceed the best point estimate of MSY by more than 10 percent.
   b. No TAC may exceed the upper range of ABC if it results in overfishing as defined in Section 12.6.1.1(A)(4).
   c. Downward adjustments of TAC of any amount are allowed in order to protect the stock and prevent overfishing.
   d. Reductions or increases in allocations as a result of changes in the TAC are to be as equitable as may be practical utilizing similar percentage changes to allocations for participants in a fishery.

3. Adjusting user group allocations in response to changes in TACs according to the formula specified in the FMP.

4. The reallocation of Spanish mackerel between recreational and commercial fishermen may be made through the framework after consideration of changes in the social and/or economic characteristics of the fishery. Such allocation adjustments shall not be greater than a ten percent change in one year to either sector's allocation. Changes may be implemented over several years to reach a desired goal, but must be assessed each year relative to changes in TAC and social and/or economic impacts to either sector of the fishery.

5. Modifying (or implementing for a particular species):
   a. quotas (including zero quotas)
   b. trip limits
   c. bag limits (including zero bag limits)
   d. minimum sizes
   e. re-allocation of Atlantic group Spanish mackerel by no more than 10 percent per year to either the commercial or recreational sector.
   f. gear restriction (ranging from modifying current regulations to a complete prohibition)
   g. permit requirements, or
   h. season/area closures and reopenings (including spawning closure)

Authority is also granted to the RA to close any fishery, i.e., revert any bag limit to zero, and close and reopen any commercial fishery, once a quota has been established through the procedure described above; and such quota has been filled. When such action is necessary, the RA will recommend that the Secretary publish a notice in the Federal Register as soon as possible.

A- 5

APPENDIX B

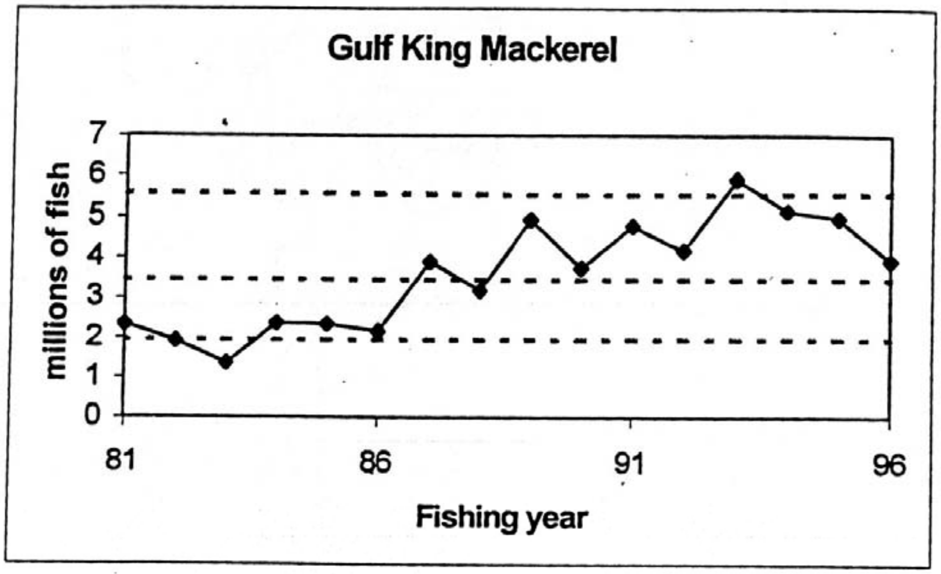
With Amendment 5, the Council approved a definition of "overfished" as a Spawning Stock Biomass Per Recruit (SSBR) target level, but no lower than 20 percent. Amendment 6 changed the basis to an SPR percentage. This target SPR for purposes of determining the "overfished" status is presumed to be a transitional SPR. Since Gulf group king mackerel were considered to be overfished, the Council adopted a rebuilding schedule that required a rebuilding of the stock to the 30 percent transitional SPR in 12 years beginning in 1985.

Mace et al. (1996) recommended that the overfished criterion be changed to a transitional SPR less than 20 percent, and the Gulf Council approved this recommendation as a part of Amendment 8. The NMFS subsequently disapproved this portion of Amendment 8 that would have changed the criterion from 30 percent transitional SPR to 20 percent. Since the current estimate of transitional SPR is only 23 percent, the Gulf Council must revise the rebuilding schedule to reach the 30 percent transitional SPR target level. Additionally, the Sustainable Fisheries Act requires that a stock that is considered to be overfished be rebuilt as soon as possible but within 10 years, unless the biology of the species involved precludes a 10-year rebuilding schedule.

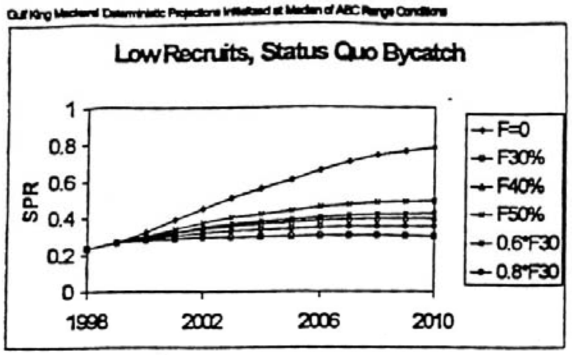
The following tables and figures provide 3 scenarios of recruitment and 4 scenarios of bycatch reduction for use by the Council in projecting a recovery period based on various yields.

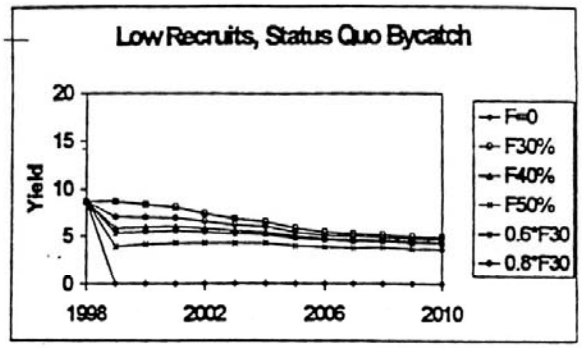
Gulf Group Projections - Deterministic with three levels of assumed constant recruitment.

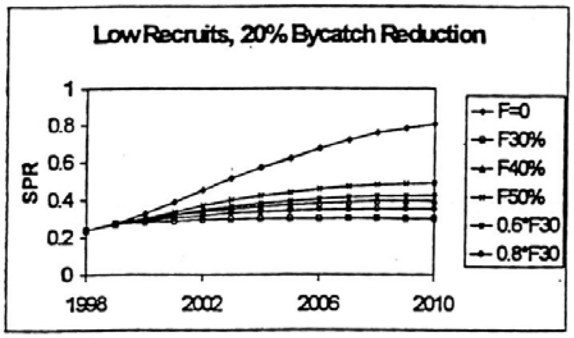
Deterministic recruitment estimates for Gulf King Mackerel - The upper dashed line is the assumed high recruitment level for projections; the center dashed line is the medium assumed recruitment for projections; and the lower dashed line is the low assumed recruitment for projections.

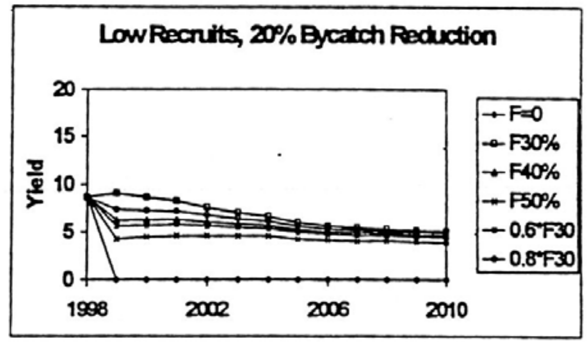

Gulf King Mackerel
millions of fish
0
1
2
3
4
5
6
7
81
86
91
96
Fishing year

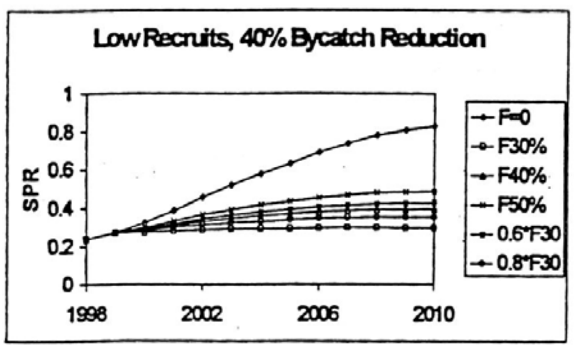
Gulf King Mackerel Deterministic Projections Initialized at Median of ABC Range Conditions

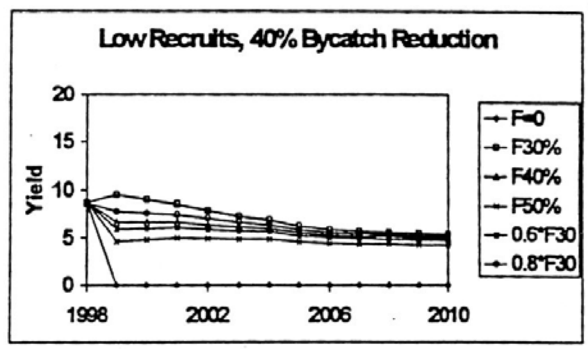


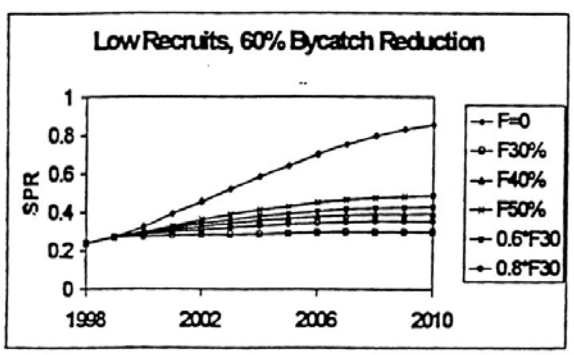


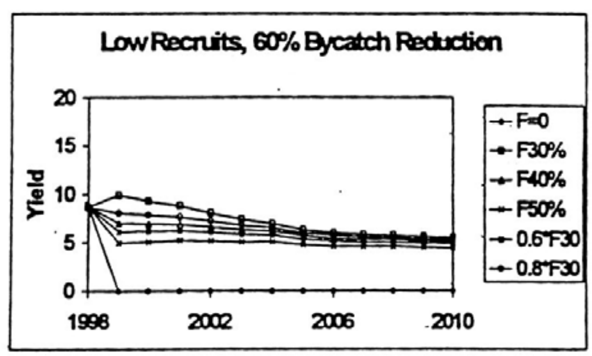




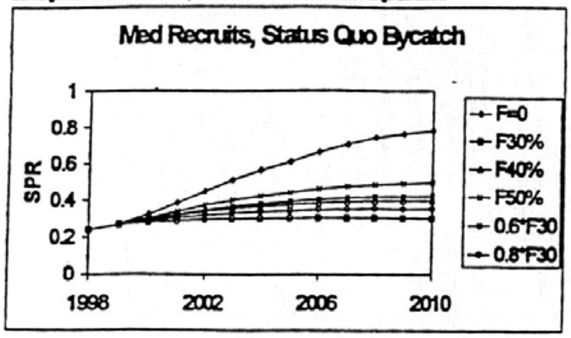


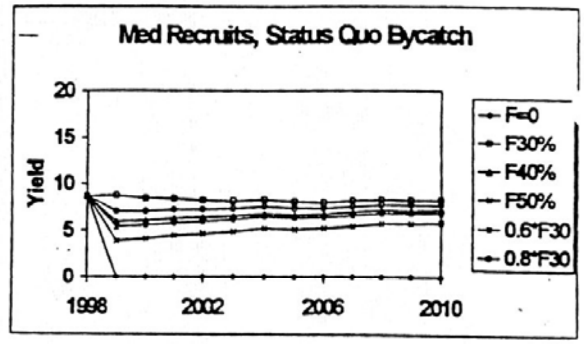


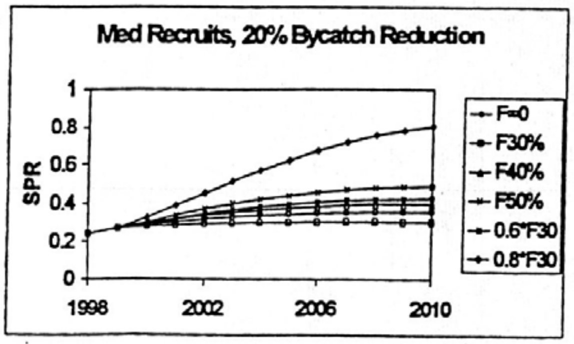


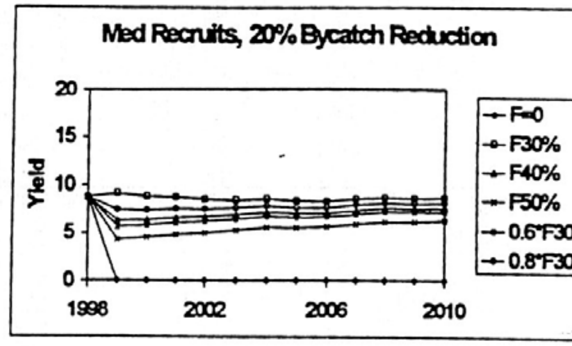


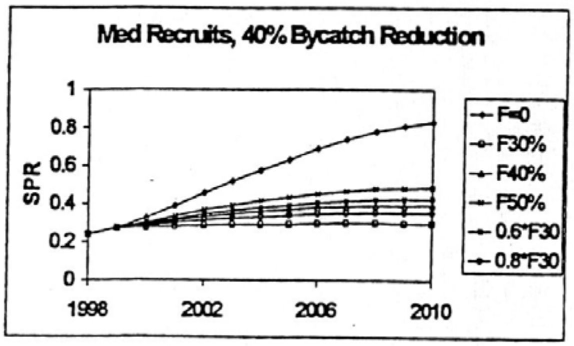
Gulf King Mackerel Deterministic Projections Initialized at Median of ABC Range Conditions

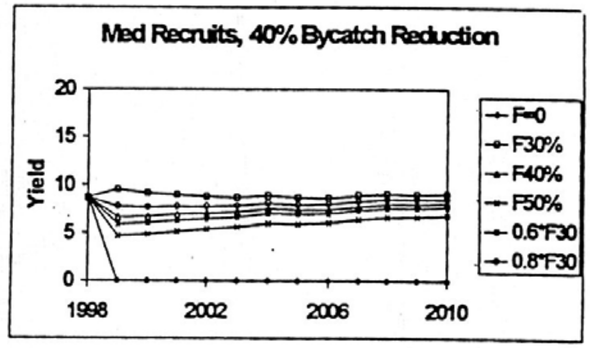


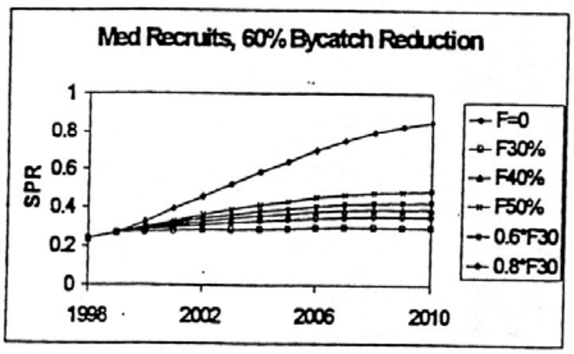


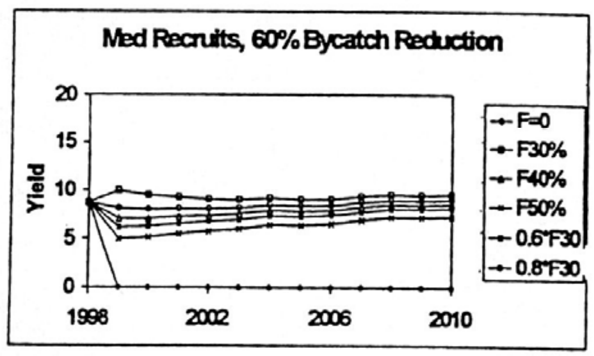












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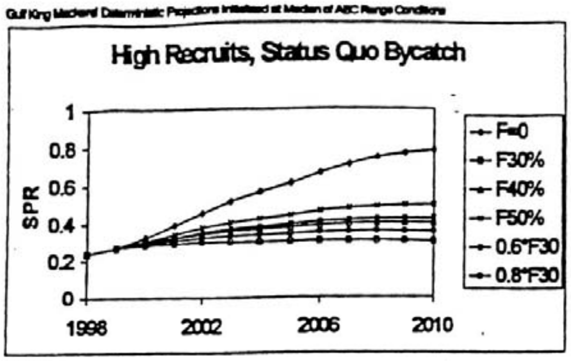
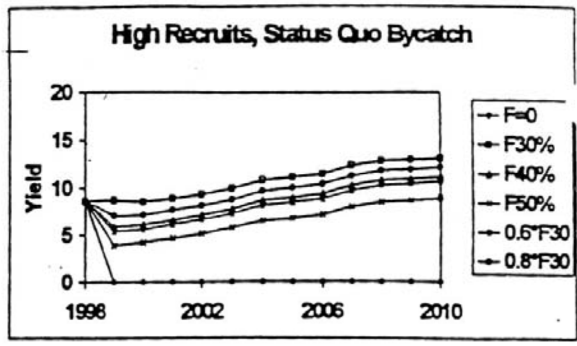
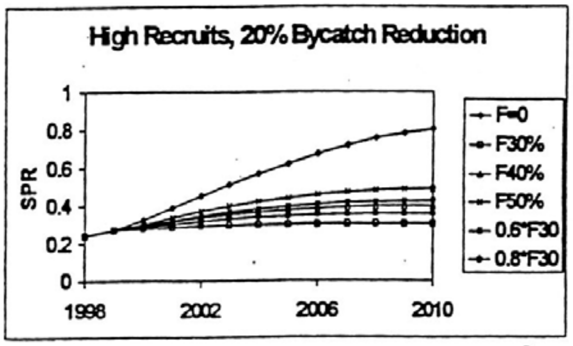
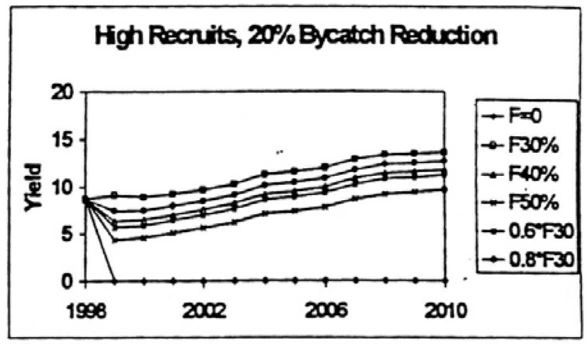
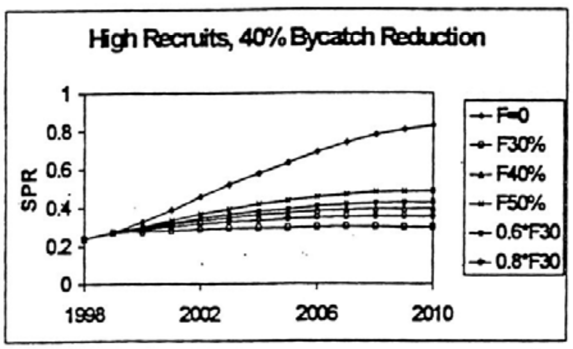
Gulf King Mackerel Deterministic Projections Initialized at Median of ABC Range Conditions

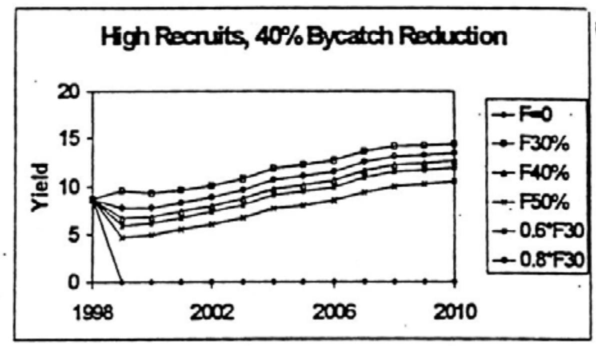


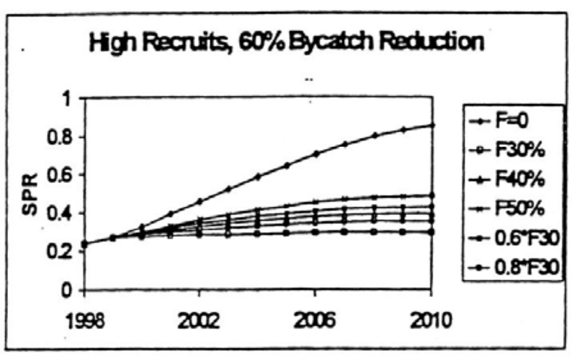


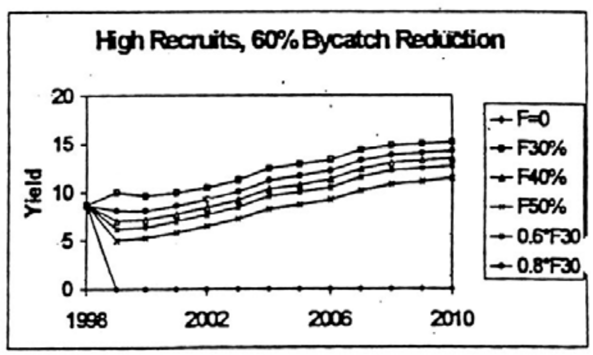












Low Recruits, Status Quo Bycatch

	SPR						Yield					
year	F=0	F30%	F40%	F50%	0.6*F30	0.8*F30	F=0	F30%	F40%	F50%	0.6*F30	0.8*F30
1998	0.2387	0.2387	0.2387	0.2387	0.2387	0.2387	8.66308	8.66308	8.66308	8.66308	8.66308	8.66308
1999	0.2701	0.2701	0.2701	0.2701	0.2701	0.2701	0	8.67055	5.90612	3.94121	5.37315	7.04869
2000	0.3254	0.2789	0.2937	0.3042	0.2965	0.2876	0	8.34305	5.97413	4.12445	5.49404	6.99117
2001	0.3872	0.2883	0.3181	0.3402	0.3239	0.3055	0	8.0087	6.02029	4.29782	5.58941	6.90735
2002	0.4507	0.2958	0.34	0.3743	0.3489	0.3211	0	7.39527	5.82069	4.29173	5.449	6.55109
2003	0.5099	0.2994	0.3563	0.4023	0.3681	0.3316	0	6.83539	5.59497	4.24525	5.27619	6.19339
2004	0.5647	0.3011	0.3688	0.4255	0.3832	0.3391	0	6.44813	5.46907	4.26887	5.1944	5.96118
2005	0.6115	0.3008	0.3767	0.4426	0.3933	0.343	0	5.81983	5.01618	3.96714	4.78067	5.42892
2006	0.6623	0.3027	0.3866	0.4616	0.4053	0.349	0	5.44853	4.77734	3.84336	4.56997	5.12772
2007	0.7049	0.3034	0.393	0.4755	0.4134	0.3525	0	5.24573	4.63382	3.7611	4.43956	4.95368
2008	0.7407	0.3029	0.3968	0.4853	0.4186	0.3541	0	5.1358	4.59491	3.78913	4.4169	4.8797
2009	0.7632	0.3006	0.3967	0.489	0.4193	0.3528	0	4.9631	4.43789	3.6707	4.26927	4.71202
2010	0.7819	0.2993	0.397	0.4921	0.4202	0.3522	0	4.88431	4.38588	3.6588	4.22738	4.64495

Low Recruits, 20% Bycatch Reduction

year	F=0	F30%	F40%	F50%	0.6*F30	0.8*F30	F=0	F30%	F40%	F50%	0.6*F30	0.8*F30
1998	0.2387	0.2387	0.2387	0.2387	0.2387	0.2387	8.66308	8.66308	8.66308	8.66308	8.66308	8.66308
1999	0.2701	0.2701	0.2701	0.2701	0.2701	0.2701	0	9.07467	6.27004	4.27978	5.63233	7.3829
2000	0.3254	0.2769	0.2918	0.3025	0.2952	0.2859	0	8.66999	6.30397	4.45456	5.73535	7.28154
2001	0.3878	0.2847	0.3147	0.3369	0.3216	0.3025	0	8.27794	6.32347	4.62257	5.81842	7.16461
2002	0.4524	0.2913	0.3355	0.3699	0.3462	0.3174	0	7.61695	6.09409	4.60211	5.6631	6.77729
2003	0.5135	0.2948	0.3515	0.3973	0.3654	0.3278	0	7.03072	5.84821	4.54435	5.48194	6.40145
2004	0.5708	0.297	0.3642	0.4206	0.3812	0.3358	0	6.63356	5.71247	4.56378	5.39936	6.16263
2005	0.6205	0.2973	0.3726	0.438	0.3922	0.3404	0	6.00455	5.25031	4.2484	4.98213	5.62722
2006	0.6743	0.2998	0.3829	0.4573	0.4049	0.3471	0	5.63413	5.00486	4.11586	4.76918	5.32413
2007	0.7199	0.3011	0.3899	0.4716	0.4139	0.3513	0	5.44874	4.87281	4.04077	4.65154	5.165
2008	0.7586	0.3011	0.3941	0.4818	0.4198	0.3534	0	5.34421	4.83497	4.06897	4.6325	5.09488
2009	0.7837	0.2992	0.3945	0.486	0.4212	0.3526	0	5.17804	4.68013	3.9487	4.48765	4.93177
2010	0.8048	0.2983	0.3952	0.4896	0.4227	0.3524	0	5.10323	4.62864	3.9352	4.44738	4.86725

Low Recruits, 40% Bycatch Reduction

year	F=0	F30%	F40%	F50%	0.6*F30	0.8*F30	F=0	F30%	F40%	F50%	0.6*F30	0.8*F30
1998	0.2387	0.2387	0.2387	0.2387	0.2387	0.2387	8.66308	8.66308	8.66308	8.66308	8.66308	8.66308
1999	0.2701	0.2701	0.2701	0.2701	0.2701	0.2701	0	9.48502	6.63902	4.62252	5.89637	7.72281
2000	0.3255	0.2748	0.2899	0.3007	0.2939	0.2842	0	8.99644	6.63392	4.7849	5.97897	7.57313
2001	0.3884	0.2811	0.3112	0.3337	0.3193	0.2995	0	8.54345	6.62381	4.94483	6.04838	7.42074
2002	0.4543	0.2869	0.3312	0.3655	0.3434	0.3137	0	7.83456	6.3636	4.90855	5.87789	7.00185
2003	0.5172	0.2903	0.3467	0.3925	0.3628	0.3241	0	7.22358	6.09808	4.83931	5.68897	6.60877
2004	0.5772	0.293	0.3597	0.4158	0.3793	0.3326	0	6.81887	5.95381	4.85496	5.60675	6.36502
2005	0.6298	0.294	0.3688	0.4337	0.3912	0.338	0	6.1917	5.48456	4.52785	5.18751	5.82843
2006	0.6867	0.2972	0.3795	0.4533	0.4048	0.3454	0	5.82425	5.23417	4.38767	4.97343	5.52507
2007	0.7355	0.2991	0.3871	0.4681	0.4147	0.3503	0	5.65789	5.11571	4.32199	4.87026	5.38257
2008	0.7772	0.2995	0.3918	0.4787	0.4212	0.3529	0	5.55968	5.07998	4.35106	4.85561	5.31721
2009	0.8051	0.2981	0.3926	0.4833	0.4232	0.3526	0	5.40048	4.9282	4.23004	4.71415	5.15925
2010	0.8287	0.2975	0.3938	0.4874	0.4253	0.3528	0	5.33002	4.87788	4.2155	4.67592	5.09775

Low Recruits, 60% Bycatch Reduction

year	F=0	F30%	F40%	F50%	0.6*F30	0.8*F30	F=0	F30%	F40%	F50%	0.6*F30	0.8*F30
1998	0.2387	0.2387	0.2387	0.2387	0.2387	0.2387	8.66308	8.66308	8.66308	8.66308	8.66308	8.66308
1999	0.2701	0.2701	0.2701	0.2701	0.2701	0.2701	0	9.90179	7.01321	4.96959	6.16542	8.0686
2000	0.3256	0.2726	0.288	0.299	0.2926	0.2824	0	9.32228	6.96396	5.11547	6.22492	7.86586
2001	0.3891	0.2775	0.3078	0.3304	0.317	0.2965	0	8.8052	6.92134	5.26464	6.27931	7.67567
2002	0.4562	0.2825	0.3268	0.3612	0.3406	0.31	0	8.04835	6.62941	5.21126	6.0934	7.22487
2003	0.5211	0.2859	0.3422	0.3877	0.3603	0.3205	0	7.41441	6.34496	5.13054	5.89751	6.81568
2004	0.5838	0.2892	0.3555	0.4113	0.3775	0.3296	0	7.00478	6.19372	5.14307	5.81694	6.56882
2005	0.6395	0.2909	0.3652	0.4297	0.3904	0.3358	0	6.38199	5.71966	4.80624	5.39725	6.0331
2006	0.6997	0.2948	0.3765	0.4497	0.4048	0.3438	0	6.01961	5.46611	4.65967	5.18323	5.73116
2007	0.7518	0.2974	0.3847	0.465	0.4156	0.3495	0	5.8738	5.36328	4.60567	5.09623	5.60697
2008	0.7965	0.2982	0.3897	0.4759	0.4228	0.3526	0	5.78271	5.33071	4.63639	5.08672	5.54721
2009	0.8273	0.2971	0.391	0.481	0.4254	0.3527	0	5.63085	5.18279	4.51566	4.94926	5.39494
2010	0.8536	0.2968	0.3925	0.4855	0.428	0.3534	0	5.56504	5.13425	4.50066	4.91348	5.33688

Medium Recruits, Status Quo Bycatch

year	F=0	F30%	F40%	F50%	0.6*F30	0.8*F30	F=0	F30%	F40%	F50%	0.6*F30	0.8*F30
1998	0.2387	0.2387	0.2387	0.2387	0.2387	0.2387	8.66308	8.66308	8.66308	8.66308	8.66308	8.66308
1999	0.2701	0.2701	0.2701	0.2701	0.2701	0.2701	0	8.69079	5.91965	3.95012	5.38532	7.0649
2000	0.3254	0.2789	0.2937	0.3042	0.2965	0.2876	0	8.42489	6.02887	4.16053	5.54354	7.0569
2001	0.3872	0.2883	0.3181	0.3402	0.3239	0.3055	0	8.36859	6.26446	4.46023	5.81191	7.1996
2002	0.4507	0.2958	0.34	0.3743	0.3489	0.3211	0	8.16934	6.35794	4.65469	5.94175	7.18884
2003	0.5099	0.2994	0.3563	0.4023	0.3681	0.3316	0	8.08423	6.48528	4.85806	6.097	7.23861
2004	0.5647	0.3011	0.3687	0.4255	0.3832	0.339	0	8.2222	6.77191	5.18481	6.40114	7.47119
2005	0.6115	0.3007	0.3767	0.4426	0.3932	0.343	0	7.9638	6.62655	5.11805	6.27822	7.27744
2006	0.6623	0.3027	0.3865	0.4615	0.4051	0.3489	0	7.88538	6.64279	5.19557	6.30885	7.25059
2007	0.7049	0.3033	0.393	0.4754	0.4133	0.3524	0	8.11674	6.90376	5.44699	6.56581	7.50001
2008	0.7407	0.3028	0.3968	0.4853	0.4184	0.354	0	8.24018	7.10488	5.68647	6.777	7.66745
2009	0.7632	0.3006	0.3967	0.489	0.4192	0.3527	0	8.17833	7.075	5.68809	6.75728	7.62313
2010	0.7819	0.2993	0.397	0.4921	0.4201	0.3521	0	8.19899	7.14124	5.791	6.83467	7.66873

Medium Recruits, 20% Bycatch Reduction

year	F=0	F30%	F40%	F50%	0.6*F30	0.8*F30	F=0	F30%	F40%	F50%	0.6*F30	0.8*F30
1998	0.2387	0.2387	0.2387	0.2387	0.2387	0.2387	8.66308	8.66308	8.66308	8.66308	8.66308	8.66308
1999	0.2701	0.2701	0.2701	0.2701	0.2701	0.2701	0	9.09628	6.28471	4.28966	5.64533	7.40021
2000	0.3254	0.2769	0.2918	0.3025	0.2952	0.2859	0	8.75888	6.36427	4.4952	5.78914	7.35295
2001	0.3878	0.2847	0.3147	0.3369	0.3217	0.3025	0	8.66954	6.59299	4.80595	6.06091	7.48289
2002	0.4524	0.2913	0.3355	0.3699	0.3462	0.3174	0	8.45655	6.68551	5.01093	6.19912	7.47002
2003	0.5135	0.2947	0.3514	0.3973	0.3654	0.3278	0	8.37964	6.82461	5.23217	6.37232	7.5328
2004	0.5708	0.2969	0.3641	0.4205	0.3811	0.3357	0	8.54202	7.13583	5.58824	6.70488	7.79152
2005	0.6205	0.2972	0.3726	0.438	0.3921	0.3404	0	8.30394	7.00471	5.53209	6.59692	7.6161
2006	0.6743	0.2998	0.3829	0.4572	0.4048	0.347	0	8.24161	7.03274	5.62096	6.64369	7.60379
2007	0.7199	0.3011	0.3899	0.4716	0.4138	0.3512	0	8.50777	7.33051	5.91006	6.9372	7.8896
2008	0.7586	0.3011	0.3941	0.4818	0.4197	0.3533	0	8.64203	7.54431	6.16637	7.164	8.06989
2009	0.7837	0.2992	0.3945	0.486	0.4211	0.3526	0	8.58723	7.52084	6.17397	7.15232	8.03302
2010	0.8048	0.2983	0.3953	0.4896	0.4226	0.3524	0	8.61188	7.59097	6.28223	7.23581	8.08335

Medium Recruits, 40% Bycatch Reduction

year	F=0	F30%	F40%	F50%	0.6*F30	0.8*F30	F=0	F30%	F40%	F50%	0.6*F30	0.8*F30
1998	0.2387	0.2387	0.2387	0.2387	0.2387	0.2387	8.66308	8.66308	8.66308	8.66308	8.66308	8.66308
1999	0.2701	0.2701	0.2701	0.2701	0.2701	0.2701	0	9.5081	6.65488	4.63342	5.91025	7.74129
2000	0.3255	0.2748	0.2899	0.3007	0.2939	0.2842	0	9.09285	6.70018	4.83044	6.03735	7.6506
2001	0.3884	0.2811	0.3112	0.3337	0.3193	0.2995	0	8.96903	6.92053	5.15078	6.31232	7.76687
2002	0.4543	0.2869	0.3312	0.3655	0.3434	0.3137	0	8.74397	7.01291	5.36653	6.46017	7.75325
2003	0.5172	0.2902	0.3467	0.3924	0.3628	0.3241	0	8.67846	7.16592	5.60711	6.65348	7.83159
2004	0.5772	0.2929	0.3597	0.4158	0.3792	0.3326	0	8.86892	7.50481	5.99452	7.01712	8.11957
2005	0.6298	0.2939	0.3687	0.4337	0.3911	0.338	0	8.6541	7.39061	5.95181	6.9305	7.96518
2006	0.6867	0.2972	0.3795	0.4533	0.4047	0.3453	0	8.60997	7.4325	6.05372	6.99119	7.96941
2007	0.7355	0.2991	0.3871	0.4681	0.4145	0.3502	0	8.91208	7.76916	6.3832	7.3235	8.29333
2008	0.7772	0.2995	0.3918	0.4787	0.4211	0.3529	0	9.05754	7.99626	6.65674	7.56671	8.48707
2009	0.8051	0.2981	0.3927	0.4833	0.4231	0.3526	0	9.00972	7.97962	6.67102	7.56358	8.45789
2010	0.8287	0.2975	0.3938	0.4874	0.4252	0.3528	0	9.03835	8.05385	6.78474	7.65344	8.51305

Medium Recruits, 60% Bycatch Reduction

year	F=0	F30%	F40%	F50%	0.6*F30	0.8*F30	F=0	F30%	F40%	F50%	0.6*F30	0.8*F30
1998	0.2387	0.2387	0.2387	0.2387	0.2387	0.2387	8.66308	8.66308	8.66308	8.66308	8.66308	8.66308
1999	0.2701	0.2701	0.2701	0.2701	0.2701	0.2701	0	9.92643	7.03032	4.98155	6.18024	8.08834
2000	0.3256	0.2726	0.288	0.299	0.2926	0.2824	0	9.42679	7.03659	5.16627	6.28821	7.94988
2001	0.3891	0.2775	0.3078	0.3304	0.317	0.2965	0	9.2671	7.24727	5.49486	6.56624	8.05164
2002	0.4562	0.2825	0.3268	0.3612	0.3406	0.31	0	9.03206	7.34055	5.72191	6.72518	8.03887
2003	0.5211	0.2859	0.3422	0.3877	0.3603	0.3204	0	8.98142	7.50996	5.98357	6.94092	8.13557
2004	0.5838	0.2891	0.3555	0.4113	0.3775	0.3295	0	9.2038	7.87947	6.40466	7.33857	8.45616
2005	0.6395	0.2909	0.3651	0.4297	0.3903	0.3357	0	9.01524	7.78532	6.3783	7.27377	8.32555
2006	0.6997	0.2948	0.3764	0.4496	0.4047	0.3438	0	8.99149	7.84324	6.49513	7.35219	8.34835
2007	0.7518	0.2974	0.3847	0.465	0.4155	0.3494	0	9.33043	8.22071	6.86753	7.72555	8.71201
2008	0.7965	0.2982	0.3898	0.4759	0.4227	0.3526	0	9.48719	8.46161	7.15879	7.98593	8.91964
2009	0.8273	0.2971	0.391	0.481	0.4253	0.3527	0	9.44637	8.45219	7.18038	7.99178	8.89634
2010	0.8536	0.2968	0.3925	0.4855	0.4279	0.3534	0	9.4789	8.53067	7.29969	8.08826	8.95842

High Recruits, Status Quo Bycatch

							Yields (million lbs)					
year	F=0	F30%	F40%	F50%	0.6*F30	0.8*F30	F=0	F30%	F40%	F50%	0.6*F30	0.8*F30
1998	0.2387	0.2387	0.2387	0.2387	0.2387	0.2387	8.66308	8.66308	8.66308	8.66308	8.66308	8.66308
1999	0.2701	0.2701	0.2701	0.2701	0.2701	0.2701	0	8.71999	5.93918	3.96299	5.40288	7.08829
2000	0.3254	0.2789	0.2937	0.3042	0.2965	0.2876	0	8.54306	6.10795	4.21264	5.61502	7.15183
2001	0.3872	0.2883	0.3181	0.3402	0.3239	0.3055	0	8.88925	6.61771	4.69518	6.13382	7.6224
2002	0.4507	0.2958	0.34	0.3743	0.3489	0.3211	0	9.28356	7.13099	5.17682	6.65067	8.10657
2003	0.5099	0.2993	0.3563	0.4022	0.3681	0.3316	0	9.87298	7.75888	5.73403	7.27082	8.73453
2004	0.5647	0.3011	0.3687	0.4255	0.3831	0.339	0	10.7702	8.63947	6.49606	8.13016	9.63741
2005	0.6115	0.3007	0.3767	0.4426	0.3932	0.3429	0	11.0496	8.93868	6.76749	8.42726	9.93425
2006	0.6623	0.3027	0.3865	0.4615	0.405	0.3488	0	11.4057	9.33271	7.14236	8.81523	10.3142
2007	0.7049	0.3033	0.3929	0.4754	0.4131	0.3524	0	12.2747	10.1889	7.88496	9.64225	11.1863
2008	0.7407	0.3028	0.3967	0.4853	0.4183	0.354	0	12.7371	10.7397	8.43278	10.1943	11.7051
2009	0.7632	0.3006	0.3967	0.489	0.4191	0.3527	0	12.834	10.8928	8.60748	10.3588	11.8381
2010	0.7819	0.2993	0.397	0.4921	0.4201	0.3521	0	12.9977	11.1301	8.87688	10.6089	12.0464

High Recruits, 20% Bycatch Reduction

							Yields)					
year	F=0	F30%	F40%	F50%	0.6*F30	0.8*F30	F=0	F30%	F40%	F50%	0.6*F30	0.8*F30
1998	0.2387	0.2387	0.2387	0.2387	0.2387	0.2387	8.66308	8.66308	8.66308	8.66308	8.66308	8.66308
1999	0.2701	0.2701	0.2701	0.2701	0.2701	0.2701	0	9.12752	6.30589	4.30393	5.66412	7.42523
2000	0.3254	0.2769	0.2918	0.3025	0.2952	0.2859	0	8.8872	6.45135	4.5539	5.86681	7.45609
2001	0.3878	0.2847	0.3146	0.3369	0.3217	0.3025	0	9.2361	6.9829	5.07124	6.41172	7.94331
2002	0.4524	0.2913	0.3355	0.3699	0.3462	0.3174	0	9.66511	7.53644	5.59898	6.97024	8.46686
2003	0.5135	0.2947	0.3514	0.3973	0.3654	0.3278	0	10.3123	8.22156	6.21546	7.64578	9.15228
2004	0.5708	0.2969	0.3641	0.4205	0.3811	0.3357	0	11.2845	9.17729	7.05537	8.57614	10.1293
2005	0.6205	0.2972	0.3726	0.438	0.392	0.3403	0	11.6154	9.52511	7.37289	8.9202	10.4762
2006	0.6743	0.2998	0.3828	0.4572	0.4047	0.3469	0	12.0097	9.95813	7.78887	9.34659	10.8949
2007	0.7199	0.3011	0.3899	0.4715	0.4137	0.3512	0	12.9383	10.8879	8.61384	10.2447	11.8344
2008	0.7586	0.3011	0.3941	0.4818	0.4196	0.3533	0	13.4191	11.468	9.20257	10.8296	12.3788
2009	0.7837	0.2992	0.3946	0.486	0.421	0.3525	0	13.5237	11.6336	9.39452	11.0097	12.5233
2010	0.8048	0.2983	0.3953	0.4896	0.4225	0.3524	0	13.6912	11.8795	9.67924	11.2723	12.7393

High Recruits, 40% Bycatch Reduction

							Yield					
year	F=0	F30%	F40%	F50%	0.6*F30	0.8*F30	F=0	F30%	F40%	F50%	0.6*F30	0.8*F30
1998	0.2387	0.2387	0.2387	0.2387	0.2387	0.2387	8.66308	8.66308	8.66308	8.66308	8.66308	8.66308
1999	0.2701	0.2701	0.2701	0.2701	0.2701	0.2701	0	9.54144	6.67778	4.64915	5.9303	7.768
2000	0.3255	0.2748	0.2899	0.3007	0.2939	0.2842	0	9.23209	6.79585	4.8962	6.12165	7.7625
2001	0.3884	0.2811	0.3112	0.3337	0.3194	0.2995	0	9.58471	7.34982	5.44871	6.69414	8.26781
2002	0.4543	0.2869	0.3311	0.3655	0.3434	0.3137	0	10.053	7.94707	6.02525	7.29782	8.83449
2003	0.5172	0.2902	0.3467	0.3924	0.3628	0.324	0	10.7635	8.69409	6.70489	8.03314	9.5824
2004	0.5772	0.2929	0.3597	0.4158	0.3792	0.3325	0	11.8162	9.73005	7.62714	9.03943	10.6388
2005	0.6298	0.2939	0.3687	0.4337	0.391	0.3379	0	12.2023	10.1305	7.99496	9.43427	11.0396
2006	0.6867	0.2972	0.3795	0.4533	0.4046	0.3452	0	12.6369	10.6051	8.45461	9.9017	11.4995
2007	0.7355	0.2991	0.3871	0.4681	0.4144	0.3502	0	13.6254	11.6103	9.36508	10.8739	12.5079
2008	0.7772	0.2996	0.3918	0.4787	0.421	0.3528	0	14.124	12.2198	9.99478	11.4925	13.0782
2009	0.8051	0.2981	0.3927	0.4834	0.4231	0.3525	0	14.2356	12.3976	10.2041	11.6885	13.234
2010	0.8287	0.2975	0.3938	0.4874	0.4251	0.3528	0	14.4065	12.6517	10.5036	11.9637	13.4572
2011	0.8486	0.2975	0.3951	0.491	0.4271	0.3534	0	14.5054	12.7913	10.6639	12.114	13.5825

High Recruits, 60% Bycatch Reduction

year	F=0	F30%	F40%	F50%	0.6*F30	0.8*F30	F=0	F30%	F40%	F50%	0.6*F30	0.8*F30
1998	0.2387	0.2387	0.2387	0.2387	0.2387	0.2387	8.66308	8.66308	8.66308	8.66308	8.66308	8.66308
1999	0.2701	0.2701	0.2701	0.2701	0.2701	0.2701	0	9.96199	7.05502	4.99883	6.20163	8.11682
2000	0.3256	0.2726	0.288	0.299	0.2926	0.2824	0	9.57766	7.14147	5.23963	6.3796	8.07114
2001	0.3891	0.2775	0.3078	0.3304	0.317	0.2965	0	9.93536	7.71876	5.82792	6.98133	8.59557
2002	0.4562	0.2825	0.3268	0.3612	0.3406	0.31	0	10.4481	8.36366	6.45635	7.63396	9.21019
2003	0.5211	0.2858	0.3421	0.3877	0.3602	0.3204	0	11.228	9.17759	7.20342	8.43374	10.0259
2004	0.5838	0.2891	0.3555	0.4113	0.3774	0.3295	0	12.3669	10.2992	8.21287	9.52123	11.1673
2005	0.6395	0.2909	0.3651	0.4297	0.3902	0.3357	0	12.8116	10.7564	8.6353	9.97075	11.6258
2006	0.6997	0.2948	0.3764	0.4496	0.4046	0.3437	0	13.2887	11.2752	9.1413	10.4819	12.1293
2007	0.7518	0.2974	0.3847	0.465	0.4154	0.3494	0	14.337	12.3576	10.1402	11.5312	13.2082
2008	0.7965	0.2982	0.3898	0.4759	0.4226	0.3525	0	14.8528	12.9961	10.8109	12.1842	13.8041
2009	0.8273	0.2971	0.3911	0.481	0.4253	0.3527	0	14.9706	13.1858	11.0376	12.3964	13.9706
2010	0.8536	0.2968	0.3926	0.4856	0.4279	0.3533	0	15.1443	13.4475	11.3513	12.684	14.201

Appendix D. 1999 Report of the Mackerel Stock Assessment Panel (March 29-April 1, 1999)

1999 REPORT
OF THE MACKEREL STOCK ASSESSMENT PANEL

Prepared by the Mackerel Stock Assessment Panel
at the Panel Meeting Held March 29 - April 1, 1999

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SUMMARY OF RECOMMENDATIONS

GROUP	ABC (RANGE) of OY= yield	Transitional SPR %	Static SPR %	OVERFISHED/ OVERFISHING
King mackerel: Atlantic migratory group	10.0 (8.9 - 13.3) million lbs @$F_{40\%}$ static SPR	43 (41 - 48)	54 (50 - 64)	Not overfished* Not overfishing
King mackerel: Gulf migratory group	10.1 (8.0 - 12.5) million lbs. @$F_{30\%}$ static SPR	25 (21 - 29)	28 (22 - 35)	Overfished Overfishing
Spanish mackerel: Atlantic migratory group	7.1 (5.7 - 9.0) million lbs. @$F_{40\%}$ static SPR	46 (41 - 48)	55 (47 - 63)	Not overfished* Not overfishing
Spanish mackerel: Gulf migratory group	12.9 (9.1 - 17.2) million lbs. @$F_{30\%}$ static SPR	42 (36 - 47)	53 (44 - 59)	Not overfished* Not overfishing

* The "not overfished" recommendations are based on the Councils' overfished criterion of 30% SPR for mackerel.

Notes: Transitional spawning potential ratio (SPR) (calculated from fishing mortality rates by age and year) is used to determine whether a stock is currently in an overfished status.

Static SPR (projected from most recent years fishing mortality rates) is used to determine whether a stock is being fished at a rate that will eventually lead to an overfished status, i.e. overfishing.

Acceptable biological catch (ABC) and transitional SPR are presented at the 50th percentile mark of probability. The range (in parentheses) is presented for ABC between the 16th percentile and the 84th percentile and for transitional SPR from the 10th percentile to the 90th percentile. Static SPR is presented as the median point estimate with the range (in parentheses) being the 80 percent confidence interval.

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1999 REPORT OF THE MACKEREL STOCK ASSESSMENT PANEL (MSAP)
MARCH 29 - APRIL 1, 1999
MIAMI, FLORIDA

I. INTRODUCTION

At the direction of the Gulf of Mexico and South Atlantic Fishery Management Councils (Councils), the Mackerel Stock Assessment Panel (Panel) met in Miami from March 29-April 1, 1999. The tasks for this Panel are specified by the Councils in Amendment 1 to the Fishery Management Plan (FMP) for the Coastal Migratory Pelagic Resources (Mackerels) dated April, 1985 (and subsequent amendments). Most recently, Amendment 8 includes a modified framework that respecifies the Panel's charge. Previous Panel reports reflect the actions required by subsequent amendments.

Amendment 6 required full stock assessments every other year, and Amendment 8 required full stock assessments in even numbered years. Accordingly, this year's assessments for Atlantic and Gulf migratory groups of king and Spanish mackerel were partial assessments in which results of the previous year's stock status were projected ahead based upon the catches that occurred in the ensuing year.

Additionally, the Panel addressed several issues related to the Sustainable Fisheries Act (SFA) Guidelines (50 CFR 600 1998) and Technical Guidance for implementation of the Magnuson-Stevens Act (Restrepo et al. 1998). These issues include estimation of maximum sustainable yield (MSY), the fishing mortality rate that achieves MSY, and the spawning stock that will support that yield. Also, candidates for minimum stock size thresholds (MSST) and control rules (Restrepo et al. 1998) for the mackerel stocks were introduced. The Panel recognized that this is an important first step that the Councils need in their development of management procedures under the SFA Guidelines.

The list of documents that were reviewed by the Panel is included in the Literature Cited section. Copies of documents are available from the Councils or the Southeast Fisheries Science Center (SEFSC).

II. OVERFISHED, OVERFISHING, AND TARGET (OPTIMUM YIELD) CRITERIA

The current definitions of overfished, overfishing, target optimum yield (OY), and a rebuilding program, as approved under the Coastal Migratory Pelagics Fishery Management Plan (FMP), as amended, are as follows:

Overfished: A mackerel stock or migratory group is considered to be overfished when the transitional SPR falls below 30%.

Overfishing: When a stock or migratory group is not overfished (transitional SPR equal to or greater than 30%), the act of overfishing is defined as harvesting at a rate that exceeds the fishing mortality rate associated with a threshold static SPR of 30% (i.e., $F_{30\%}$). If fishing mortality rates that exceed the level associated with the static SPR threshold rate are maintained, the stock may become overfished. Therefore, if overfishing is occurring, a program to reduce fishing mortality rates toward management target levels (OY) will be implemented, even if the stock or migratory group is not in an overfished condition (Amendment 8).

For species like cobia, when there is insufficient information to determine whether the stock or migratory group is overfished (transitional SPR), overfishing is defined as a fishing mortality rate in excess of the fishing mortality rate corresponding to a default threshold static SPR of 30%. If overfishing is occurring, a program to reduce fishing mortality rates to at least the level corresponding to management target levels will be implemented (Amendment 8).

Target Optimum Yield (OY): The South Atlantic Council's target level or OY is 40% static SPR. The Gulf Council's target level or OY is 30% static SPR. ABC is calculated relative to the probability of achieving the target level or OY fishing mortality rate in the following fishing year (SAFMC = 40% static SPR and GMFMC = 30% static SPR).

Rebuilding Program: When a stock or migratory group is overfished (transitional SPR less than 30%), a rebuilding program that makes consistent progress towards restoring stock condition must be implemented and continued until the stock is restored beyond the overfished condition. The rebuilding program must be designed to achieve recovery within an acceptable time frame as specified by the Councils. The Councils will continue to rebuild the stock until the stock is restored to the management target (OY) within a unspecified time frame.

III. STATUS OF THE STOCKS

The current advice relative to ABC , overfished status, and overfishing is based on the management objectives of the FMP itemized in Section II. Note, however, that with the implementation of the Councils' SFA Amendments in the near future, the management objectives will change. Consequently, the advice of the Panel will also be altered. This topic is discussed further in Section IV.

1. Atlantic Migratory Group King Mackerel

Landings and History of Management

Catches since 1981/82 have ranged from a low of 5.93 million pounds in 1994/95 to a high of 9.62 million pounds in 1985/86 (Table 1 and Figure ATK -1). Projected fishing year 1998/99 landings were estimated using the recreational estimates from the most recent 12-month period available, current commercial quota monitoring reports or dealer surveys, and personal communications with fisheries statistics personnel. For Atlantic group king mackerel, projected landings are:

2

Commercial	=	2.52 million pounds
Recreational	=	4.57 million pounds (436,415 fish)
Total	=	7.09 million pounds

Estimates of Fishing Mortality Rates

The pooled fishing mortality rates (F's) per year on age 3+ adults increased from just below 0.2 in 1982/83 to a high of about 0.3 in 1985/86 and then varied without trend around 0.2 between 1987/88 through 1992/93 (Figure **ATK-2**). From 1992/93 through 1994/95, fishing mortality declined to a low of below 0.1 per year, but it has increased each year since 1994/95. The median pooled F on ages 3+for 1998/99 was 0.15 per year within the 10th percentile to 90th percentile range of 0.10 to 0.19.

Trends in Recruitment

No new estimates were available (Figure **ATK-3**).

Trends in Spawning Stock

The spawning stock of Atlantic king mackerel (Figure **AK-4**) continues to increase (current estimate of spawning stock is 6.5 million) after reaching a low of 3.0 million in 1989.

Acceptable Biological Catch (ABC)

For the 1999/2000 fishing year, given the South Atlantic Council's objective not to exceed $F_{40\%SPR}$, the Panel recommends the best estimate of ABC to be 10.0 million pounds. There is a 50 percent chance that a TAC of 10.0 million pounds will exceed $F_{40\%SPR}$; there is an 84 percent chance that a 13.3 million pound TAC will exceed $F_{40\%SPR}$; and, there is a 16 percent chance that a 8.9 million pound TAC would exceed $F_{40\%SPR}$.

Discussion of Stock Status

Landings of Atlantic group king mackerel have been below TAC in every year except 1997/98 (Table 1). The transitional SPR has also steadily increased since about 1994, and the current estimate for 1999/2000 is 43 percent. SPR estimates are presented as "conditional on no bycatch" for Atlantic group king mackerel. Although the Panel recognizes that Atlantic group king mackerel are caught in shrimp trawls, the uncertainty of these estimates is too great for meaningful use.

Overfishing

Static SPR was estimated at 54 percent. Consequently, the Panel concludes that the Atlantic group king mackerel fishery was not overfishing the available stock because the fishing mortality rate was less than $F_{30\%staticSPR}$ in 1997-98.

Overfished Status

The Panel concludes that the Atlantic migratory group of king mackerel is not overfished because the transitional SPR is estimated at 43 percent, which is above 30% (Figure **ATK-5**).

2. <u>Gulf Migratory Group King Mackerel</u>

Landings and History of Management

Catches since 1981/82 have ranged from a high of 12.3 million pounds in 1982/83 to a low of 3.0 million pounds in 1987/88 (Table 2 and Figure **GK-1**). Since 1986/87, landings have generally increased and have exceeded TAC in most years (Table 2). Preliminary estimates of 1998/99 landings are:

Commercial	3.60 million pounds*
Recreational	6.23 million pounds** (578,367 fish)
Total	9.83 million pounds

* The 3.6 million pounds as estimated in February 1999 was used for projections. Subsequent information indicates that catches may exceed 3.9 million pounds.

** This total was computed based upon 1996/97 average weights in the recreational fishery, plus calendar landings based on 1996 headboat and Texas recreational levels and 1997 MRFSS data.

Estimates of Fishing Mortality Rates

Pooled F's per year on age 4+ adults generally declined from 1981/82 to their lowest point in 1987/88. The last peak in F was during the 1994/95 fishing year with lower, relatively stable levels since 1995 (Figure **GK-2**). The median pooled F on ages 4+ for 1998/99 was 0.38 per year within the 10^{th} percentile to 90^{th} percentile range of 0.27 to 0.76.

Trends in Recruitment

Estimates of recruitment declined from 1981/82 to a low in 1983/84, then steadily increased to a high in 1995/96 (Figure **GK-3**). The 1996/97 and 1998/99 shrimp trawl bycatch estimates indicate lower recruitment after 1995/1996.

Trends in Spawning Stock

The spawning stock of Gulf king mackerel (Figure **GK-4**) continues to increase (current estimate of spawning stock is 5.7 million) after reaching a low of 2.7 million in 1987. Spawning stock size on Gulf group king mackerel appears to reflect recruitment, albeit offset by 4-5 years.

Acceptable Biological Catch (ABC)

For the 1999/2000 fishing year, given the Gulf Council's objective not to exceed $F_{30\%SPR}$, the Panel recommends the best estimate of ABC be 10.1 million pounds. Assuming a 50 percent reduction in bycatch, there is a 50 percent chance that a TAC of 10.1 million pounds will exceed $F_{30\%SPR}$; there is an 84% chance that 12.5 million pound TAC would exceed $F_{30\%SPR}$; and, there is a 16 percent chance that an 8.0 million pounds TAC would exceed $F_{30\%SPR}$. Clearly, the lower the TAC is set, the lower the probability of overfishing during the 1999-2000 fishing year. The Panel emphasizes that there are greater uncertainties with regard to estimates above the 50th percentile mark.

Discussion of Stock Status

Landings of Gulf group king mackerel in the last 7 years have been the highest in the series since 1982/83, and total landings have exceeded TAC in every year since 1986 (Table 2). Since the 1986/87 fishing year, transitional SPR has varied between 20 and 25 percent with a slightly increasing trend since 1995 (Figure **GK-5**). Transitional SPR for the 1999/2000 fishing year is estimated at 25 percent, which is below the Council's objective.

Overfishing

Static SPR was estimated at 28 percent. Consequently, the Panel concludes that the Gulf group king mackerel fishery was overfishing the available stock because the fishing mortality rate was greater than $F_{30\%staticSPR}$. If fishing mortality continues at this rate, the fishery will continue to be overfishing and will not recover above the 30 percent transitional SPR level.

Overfished Status

The Panel concludes that the Gulf group king mackerel is overfished because the transitional SPR is estimated at 25 percent, which is below 30 percent. The apparent contradiction between parent stock size and transitional SPR stems from stock size, reflecting the recent increased estimates of recruitment; whereas transitional SPR only considers the fishing mortality rates that have remained relatively stable over the last decade (**GK-2**)

3. <u>Atlantic Migratory Group Spanish Mackerel</u>

Landings and History of Management

The Atlantic group Spanish mackerel fishery has been fully regulated since 1986/87. While the commercial quota has been met every year up to 1995/96, the total harvest has not exceeded TAC since the 1991/92 fishing year (Table 4 and Figure **ATS-1**). Additionally, the recreational sector has not filled their allocation since 1990/1991.

Projected 1998/99 fishing year landings were estimated using the recreational estimates from the most recent 12-month period available, current commercial quota monitoring reports or dealer surveys, and personal communications with fisheries statistics personnel. For Atlantic group Spanish mackerel, the 1998/99 projected landings are:

Commercial	=	3.2 million pounds
Recreational	=	0.8 million pounds (600,720 fish)
Total	=	4.0 million pounds

Estimates of Fishing Mortality

The fishing mortality rate on adults, ages (Age 2+), was slightly above 0.8 for fishing year 1984/85, and declined to about 0.2 in the 1987/88 fishing year. From 1988/89 through 1994/95, F varied around 0.4 per year and then declined in 1995/96. The trend has been upwards since 1995/96 (Figure **ATS-2**). The median pooled F on ages 2+ for 1998/99 was 0.18 per year within the 10th percentile to 90th percentile range of 0.13 to 0.23.

Trends in Recruitment

No new estimates were available (Figure **ATS-3**).

Trends in Spawning Stock

The spawning stock of Atlantic Spanish mackerel (Figure AS-4) was essentially flat at about 12 million until an increase to 18 million in 1996, and the current estimate is 20 million. The increase beginning in 1995 is attributed to the gear restrictions in Florida that were promulgated July 1, 1995.

Acceptable Biological Catch (ABC)

For the 1999/2000 fishing year, given the Council's objective not to exceed $F_{40\%SPR}$, the Panel recommends the best estimate of ABC be 7.1 million pounds. There is a 50 percent chance that a TAC of 7.1 million pounds will exceed a $F_{40\%SPR}$; there is an 84 percent chance that a 9.0 million pound TAC will exceed $F_{40\%SPR}$; and, there is a 16 percent chance that a 5.7 million pound TAC would exceed $F_{40\%SPR}$.

Status of the Stock

The transitional SPR has steadily increased since 1995, and the current estimate for 1999/2000 is 46 percent. The Panel attributes the steady increase in transitional SPR since 1995 to the reduction in fishing mortality rates resulting from the elimination of gill nets from Florida state waters (July 1995).

SPR estimates however, are presented as "conditional on no bycatch" for Atlantic group Spanish mackerel. Although the Panel recognizes that Atlantic group Spanish mackerel are caught in shrimp trawls, the uncertainty of these estimates is to great for meaningful use.

Overfishing

Static SPR was estimated at 55 percent. Consequently, the Panel concludes that the Atlantic group Spanish mackerel fishery was not overfishing the available stock because the fishing mortality rate is below the $F_{30\%\ staticSPR}$.

Overfished Status

The Panel concludes that Atlantic group Spanish mackerel is not overfished since the transitional SPR is estimated at 46 percent, which is above the 30 percent level (Figure **ATS-5**).

4. <u>Gulf Migratory Group Spanish Mackerel</u>

Landings and History of Management

Landings of Spanish mackerel from U.S. catches have ranged from 4.0 to 9.6 million pounds between fishing years 1984/85 and 1994/95 (Table 4 and Figure GS-1). Total U.S. landings (less than 3 million pounds) for this group since prohibiting the use of gill nets in Florida waters (July 1995) were substantially below previous landings.

This fishery has been regulated by TAC since 1986/87. In 1987/88 and 1988/89, catches were greater than the TAC. Over the period 1989/90 through 1997/98, catches have been below TAC and the mid point of the ABC range.

Projected fishing year 1998/99 landings were estimated using the recreational estimates from the most recent 12-month period available, current commercial quota monitoring reports or dealer surveys, and personal communications with fisheries statistics personnel. For Gulf group Spanish mackerel, the 1998/99 projected landings are:

Commercial	=	0.4 million pounds
Recreational	=	1.9 million pounds (1,168,740 fish)
Total	=	2.3 million pounds

Estimates of Fishing Mortality Rate

Since the 1995/96 fishing year, the median fishing mortality rates, pooled F's per year on adults ages 2+, were lower than the target of $F_{30\%SPR}$ (Figure **GS-2**). The reductions came primarily from the commercial sector after gill nets were eliminated from Florida state waters in July 1995. The median pooled F on ages 2+ for 1998/99 was 0.14 per year within the 10^{th} percentile to 90^{th} percentile range of 0.10 to 0.22.

Trends in Recruitment

No new estimates were available (Figure **GS-3**); however, shrimp trawl bycatch estimates indicate that recruitment has been stable.

Trends in Spawning Stock

The spawning stock of Gulf Spanish mackerel (Figure **GS-4**) was essentially flat at about 12 million until it began to increase in 1994 and the current estimate is 24 million. Although the increase began in 1994, the stock received another boost beginning in 1995 with the gear restrictions in Florida that were promulgated July 1, 1995.

Acceptable Biological Catch (ABC)

For the 1999/2000 fishing year, given the Council's objective not to exceed $F_{30\%SPR}$, the Panel recommends the best estimate of ABC to be 12.9 million pounds. There is a 50 percent chance that a TAC of 12.9 million pounds will exceed $F_{30\%SPR}$; there is an 84 percent chance that a 17.2 million pound TAC will exceed $F_{30\%SPR}$; and, there is a 16 percent chance that a 9.1 million pound TAC would exceed $F_{30\%SPR}$. Given Florida's gear restrictions, it is highly unlikely that TAC would be achievable.

Status of the Stock

As with Atlantic group Spanish mackerel, the Panel believes that the steady increase in transitional SPR in recent years reflects the prohibition of gill nets in Florida waters in 1995. The current operation of the fishery will most likely harvest less than the estimated median ABC value of 9.14 million pounds. The Council's definition of optimum yield (OY) is a target of 30% SPR, and this fishery reached OY in the 1997/98 fishing year.

Overfishing

Static SPR was estimated at 53 percent. Consequently, the Panel concluded that the Gulf group Spanish mackerel fishery was not overfishing the available stock because the fishing mortality rate is below the $F_{30\%\ staticSPR}$.

Overfished Status

The median estimate of transitional SPR is 42 percent (Figure **GS-5**). Since transitional SPR for Gulf group Spanish mackerel is greater that 30 percent, the Panel concludes that this stock is not overfished.

IV. CONSIDERATION OF MSY, B_{MSY}, MSST, MFMT, AND CONTROL RULES

MSY, B_{MSY}, MSST, and MFMT:

The Sustainable Fisheries Act requires Councils to manage fishery resources based on maximum sustainable yield (MSY) as a limit to OY, and maximum fishing mortality threshold (MFMT) as a limit to fishing mortality rate. With the data available for mackerels in the southeast US, the Gulf and South Atlantic Councils have adopted $F_{30\%SPR}$ as a proxy for F_{MSY}. However, projecting $F_{30\%}$ to attain MSY depends upon future recruitment. The NMFS analysts together with the Panel used average recruitments that were calculated from ADAPT VPA bootstraps. As a first approximation to identifying the biomass at MSY (B_{MSY}), the average recruitment in recent years (assumed to be constant for current and higher spawning stock levels) was plotted with the $F_{30\%}$ replacement line. The biomass associated with MSY was identified as the spawning stock size where those lines crossed. Maximum sustainable yield was the long-term yield projected from that spawning biomass and $F_{30\%}$. Clearly if future recruitment does not follow these averages then MSY will have to be re-evaluated.

Because of uncertainty in estimates of earlier period spawning stocks (stemming from the tuning index coverage by age, especially in the older plus group), only recruitment from 1987 through 1996 was used to estimated average recruitment for Gulf group king mackerel and from 1985 through 1996 for Gulf group Spanish mackerel. Spanish mackerel are shorter lived and so the Panel was able to include more years. Similarly, only recruitment from 1989 through 1996 was used for Atlantic group king mackerel and Atlantic group Spanish mackerel.

Figure 5 shows annual spawning stock expressed in millions (based on relative fecundity schedules) and recruitment in numbers. The spawning stock is derived using a relative fecundity scale and thus does not have units. Recruitment is assumed to follow an empirically derived spawner-recruit relationship that increases up to some level of spawning stock (here estimated as the average of the five lowest spawning stock values), and then remains at the average recruitment for higher spawning stock values. The straight line in Figure 5 is the number of recruits per spawner at the $F_{30\%}$ replacement line, considered to be the MSY proxy.

Table 5 provides estimated values for a first approximation of MSY, F_{MSY}, stock size at MSY, and MSST from 400 bootstrap outcomes for Gulf and Atlantic group king and Spanish mackerel. These are presented as the median estimate and the upper and lower boundaries of the 80 percent confidence intervals.

Control Rules

The evaluation of the condition of a stock under control rules is based on two common ideas in fishery management: spawning stock biomass at maximum sustainable yield (B_{MSY}) and the long term fishing mortality rate associated that spawning stock level F_{MSY}. If the current spawning biomass is greater than B_{MSY} then the stock is not overfished. Similarly if the current fishing mortality rate is less than F_{MSY}, then the fishery is not overfishing. As shown in Figure 6 the evaluation can be simplified by using ratios instead of the actual values. Gulf Spanish mackerel provide an example of evaluating the status of a stock using control rules (Figure 6). After a few years of management (the cluster of points labeled 89), the spawning stock was less than half of that at MSY; and fishing mortality rates were above F_{MSY}, i.e. the stock was overfished and the fishery was overfishing. There were low landings in 1989 and 1990 and good recruitment, and the stock began to rebuild (the cluster labeled 94). With additional good recruitment in 1992, one would expect more recovery; however, the quota was overrun in some of those years (indicated by the high fishing mortality rates). The stock was increasing but it still was not up to B_{MSY}, and the fishery was still overfishing. After Florida's gear restrictions were implemented in 1995, the spawning stock exceeded B_{MSY}, and the fishery was operating at levels less than F_{MSY} (the cluster labeled 98). Thus, Gulf Spanish mackerel were not overfished, and the fishery was not overfishing. The recent results were below the $F_{40\%}$ line indicating that this fishery is operating in the OY region.

Minimum Stock Size Threshold

While stocks should be managed at levels to ensure that they remain above B_{MSY}, there will be times when the stock falls below this level and fishing mortality rates have to lowered. Thus, the Minimum Stock Size Threshold (MSST) is the spawning stock level below which Councils must take action to reduce fishing mortality. For stocks such as mackerels that can be considered to be data-moderate or data-poor, the NMFS suggested that MSST be (1.0 - natural mortality rate)*BMSY. A determination of "overfishing" is made when most of the points fall above the MFMT, and a determination of "overfished" is made when most of the points fall below (to the left of) MSST. In the example above for 1994, Gulf Spanish mackerel would not have been considered overfished because while the median spawning stock was below B_{MSY} (and B_{OY}), it was above B_{MSST}. However, the fishery was overfishing at that time; thus biomass would need to be increased.

The default control rule decreases the MFMT below $F_{30\%SPR}$ if stock size falls below the MSST (Restrepo et al. 1998). For Atlantic king mackerel, the MSST would be 85% of B_{MSY} (M=0.15); for Gulf king mackerel, the MSST would be 80% of B_{MSY} (M=0.20); and for Spanish mackerel MSST would be 70% B_{MSY} (M=0.3) for both stocks. Figure 7 depicts the status condition of the four stocks relative to the default MSY control rule. Thus using these criteria, none of the stocks would be overfished and only the Gulf king mackerel fishery would be overfishing. For comparison, the Figure 7 also presents a target control rule ("OY") that is similar to the MFMT, but based on the South Atlantic Council's recommended target of $F_{40\%SPR}$.

V. FUTURE RESEARCH AND ASSESSMENT CONSIDERATIONS

The Panel identified several areas where additional research is needed to improve the quality, cost-effectiveness, and reliability of future stock assessments. The Panel recommends that in the odd years when a full assessment is not completed, time be spent addressing the items identified below rather than updating the projections.

Schedule

The Panel discussed the implications of the control rules to stock status and future assessment conditions. It was noted that Gulf Spanish and Atlantic king and Spanish would be above MSST and below MFMT (Note that in the case of the Atlantic sticks, that this status determination will depend upon bycatch estimation). Therefore, it is unlikely that status relative to these criteria will change in the next few years. Therefore, the Panel recommends that assessments of Gulf Spanish and Atlantic king and Spanish not be conducted in the next few years unless there is new information on Atlantic bycatches; catch rates decline over a period of years; catches exceed MSY; or catches exceed those corresponding to MFMT.

Bycatch

Current bycatch estimates in the Atlantic shrimp trawl fishery are contradictory and not complete enough for inclusion in the VPA model. The Atlantic shrimp fishery should be monitored to more completely describe bycatch of Atlantic king and Spanish mackerels.

In the Gulf shrimp fishery, an evaluation of the effects of gear fishing power standardization using GLM techniques on temporal and spatial trends in bycatch is needed to document the effects of TEDs and BRDs on bycatch estimates because the shrimp bycatch estimates are very influential in determining recruitment trends.

Sampling Efforts

Fishery dependent sampling programs should be expanded to provide greater temporal and spatial coverage of king and Spanish mackerel fisheries with respect to nominal fishing effort, CPUE, age-length keys, and reproduction. We also recommend evaluating potential biases associated with inappropriate stratification of data used to generate age-length keys for Atlantic and Gulf group king and Spanish mackerels.

Fishery-independent monitoring is needed to calibrate the VPA. For example, aerial surveys in south Florida during winter and expanded larval sampling could be used to reduce assessment uncertainty.

Environmental Influences on Recruitment

The new fishery control laws required by the Sustainable Fisheries Act depend on estimates of recruitment to determine levels of MSY biomass and the MSST. Stock recruitment models are not easily applied to existing data and at observed levels of stock abundance (especially in Spanish mackerel) environmental influences may be major factors in determining recruitment trends. A special workshop of fishery and oceanographic scientists should be convened to identify and assemble available environmental data and to evaluate which environmental factors may be influencing recruitment.

VI. LITERATURE CITED

Burns, K.M., C. Neidig, J. Lotz, and R. Overstreet. 1998. Cobia (*Rachycentron canadum*) stock assessment study in the Gulf of Mexico and in the South Atiantic. Final Report, MARFIN Award No. NA57FF0294. MSAP/99/05. 108 pp (+Appendices).

CFR 50 Part 600. 5/1/98. Magnuson-Stevens Act Provisions; National Standard Guidelines; Final Rule. Volume 63, No. 84. 24212-24237.

Legault, C.M. 1999. Updated projections for king and Spanish mackerel in the Gulf of Mexico and Atlantic Ocean. MSAP/99/01. DOC, NMFS, SEFSC, Sustainable Fisheries Division Contribution SFD-98/99-49. 33 pp (+Appendix).

Legault, C.M. 1999. Simulation study of percentile and bias corrected percentile confidence intervals for allowable biological catch. MSAP/99/02. DOC, NMFS, SEFSC, Sustainable Fisheries Division Contribution SFD-98/99-48. 9 pp.

Phares, P. 1999. Frequency of length observations for mackerels by fishing year and migratory group. Memorandum to Gerry Scott, 3/26/99. MSAP/99/03. DOC, NMFS, SEFSC, Sustainable Fisheries Division, Miami, Florida. 1 pp.

Restrepo, V.R, G.G. Thompson, P.M. Mace, W.L. Gabriel, L.L. Low, A.D. MacCall, R.D. Methot, J.E. Powers, B.L. Taylor, P.R. Wade, and J.F. Witzig. 1998. Technical guidance on the use of precutionary approaches to implementing National Standard 1 of the Magnuson-Stevens Fishery Conservation and Management Act. DOC, NOAA, NMFS, NOAA Technical Memorandum NMFS-F/SPO-31. 54 pp.

Scott, G.P and P.L. Phares. 1999. Cobia fishery information update. MSAP/99/04. DOC, NMFS, SEFSC, Sustainable Fisheries Division Contribution SFD-98/99-51. 38 pp.

VII. LIST OF PANEL MEMBERS AND ATTENDEES

John Carmichael
Nelson Ehrhardt
Doug Gregory
Robert Muller
William Patterson - Absent (excused)
Joseph Powers
Joe Shepard

Observers:

Roy Williams - Gulf Council/Florida Marine Fisheries Commission
Rick Leard - Gulf of Mexico Fishery Management Council
Gerry Scott - NMFS/SEFSC -Miami
Patricia Phares - NMFS/SEFSC -Miami
Michael Schirripa - NMFS/SEFSC - Miami
Mark Godcharles - NMFS/SERO - St. Petersburg
Mauricio Ortiz - NMFS/SEFSC Miami
Chris Legault - NMFS/SEFSC - Miami
Clay Porch - NMFS/SEFSC - Miami
Tom McIlwain - NMFS-SEFSC - Pascagoula
Diane Rielinger - ReefKeeper International
Bob Zales, II - Charterboat captain, Mackerel AP Chairman

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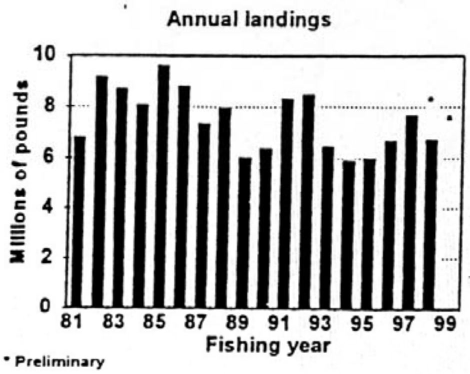
Figure 1. Atlantic king mackerel, status figures. The last 2 years are preliminary projections, and are indicated by asterisk in the graphs.



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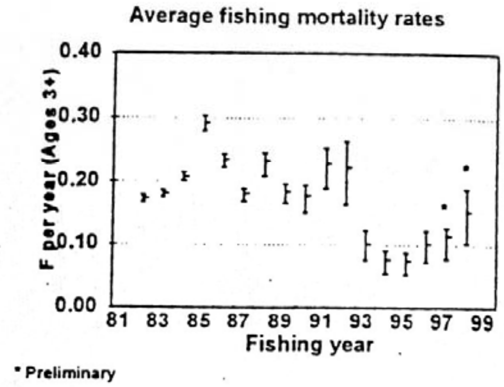

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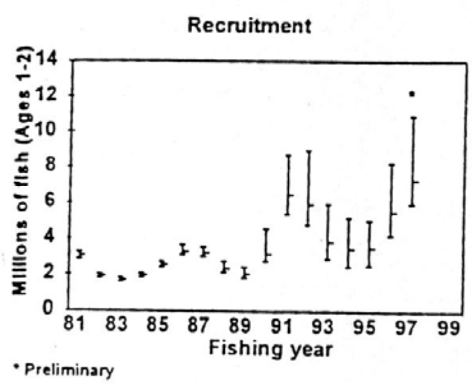

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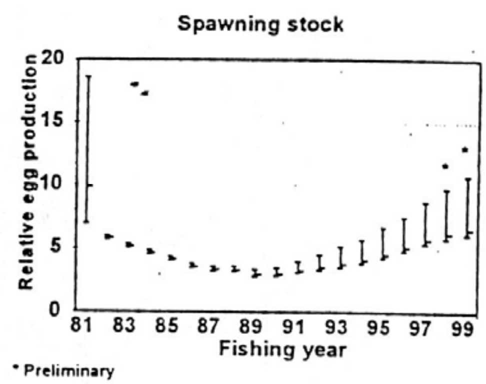

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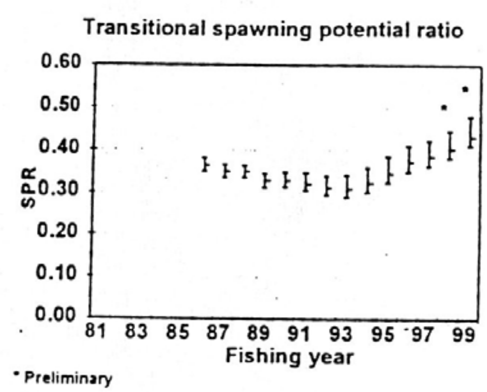

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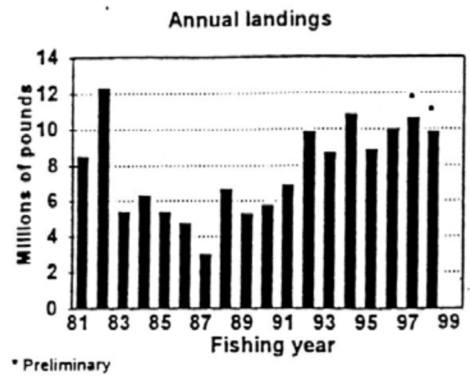
Figure 2. Gulf king mackerel, status figures. The last 2 years are preliminary projections, and are indicated by asterisk in the graphs.



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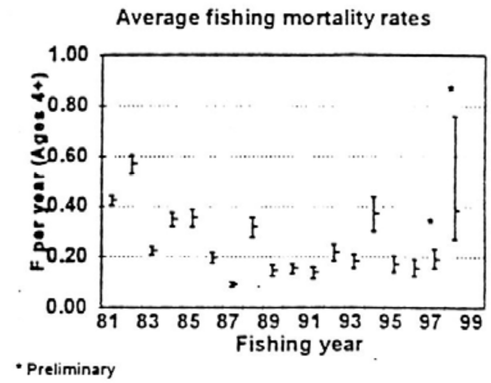

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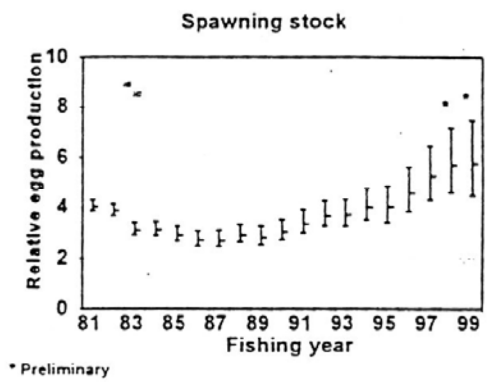

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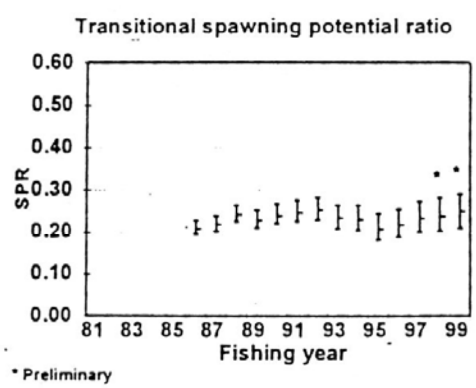

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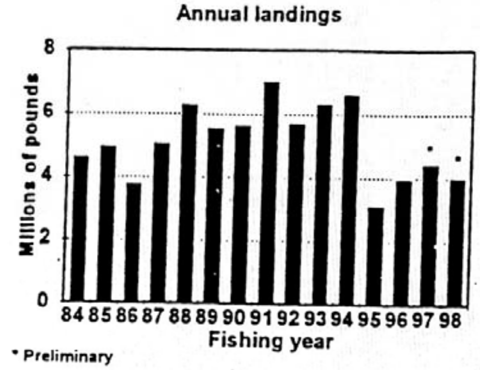
Figure 3. Atlantic Spanish mackerel, status figures. The last 2 years are preliminary projections, and are indicated by asterisk in the graphs.



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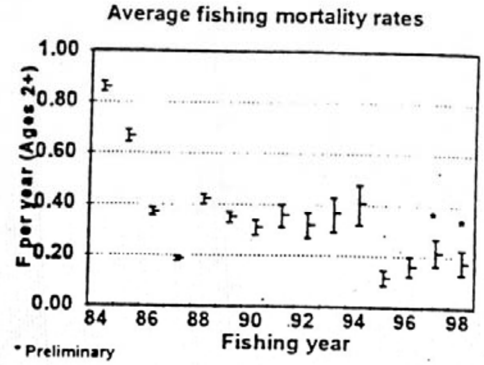

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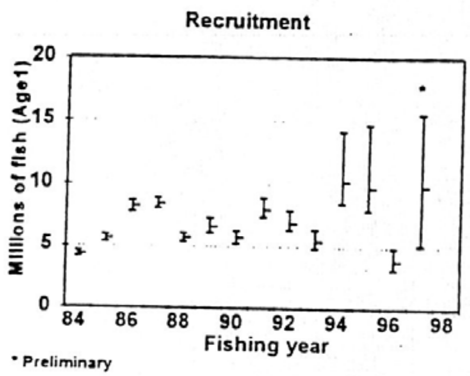

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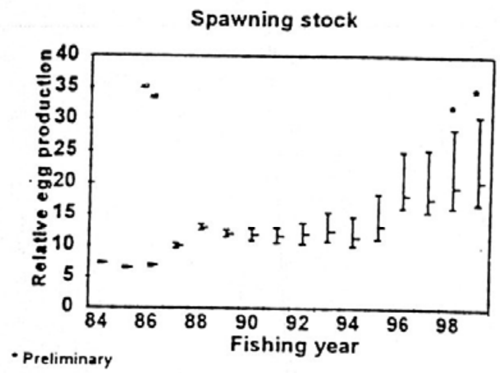

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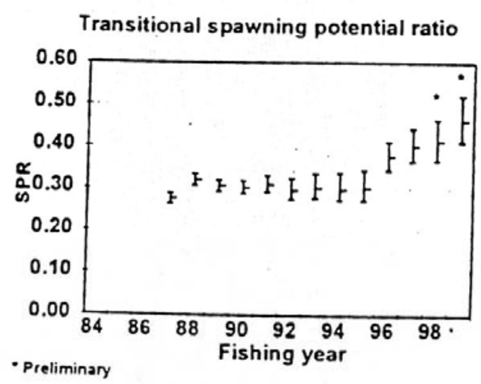

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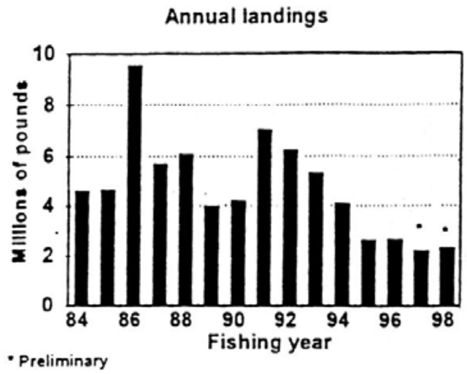
Figure 4. Gulf Spanish mackerel, status figures. The last 2 years are preliminary projections, and are indicated by asterisk in the graphs.



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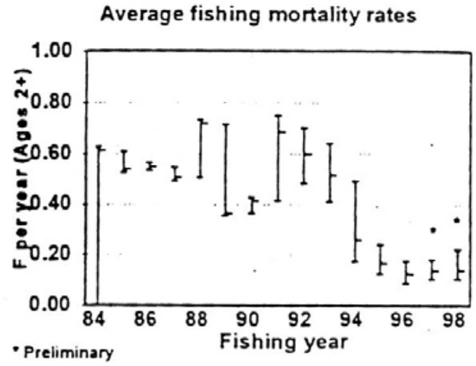

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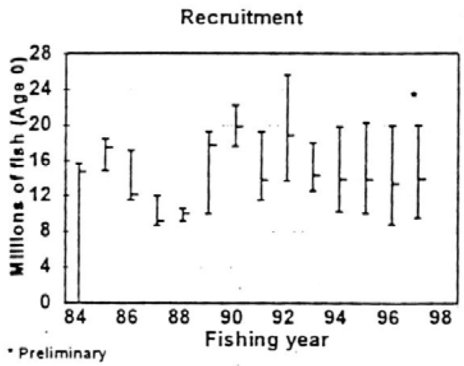

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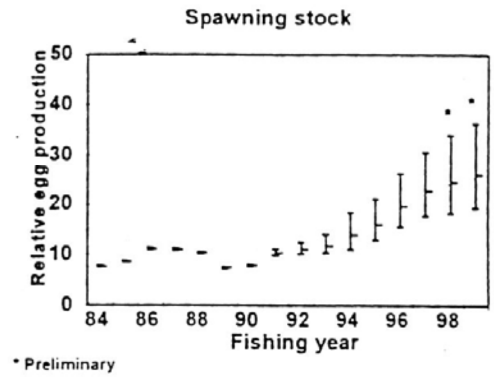

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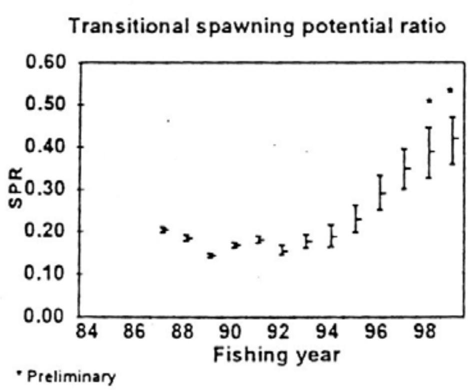

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Figure 5. Annual spawning stock expressed in relative fecundity (millions), recruitment in numbers, and number of recruits per spawner at the $F_{30\%}$ replacement line, considered to be the MSY proxy. (Note: The spawning stock at MSY is approximated by the intersection of the spawner-recruit curve and the $F_{30\%}$ replacement line.)

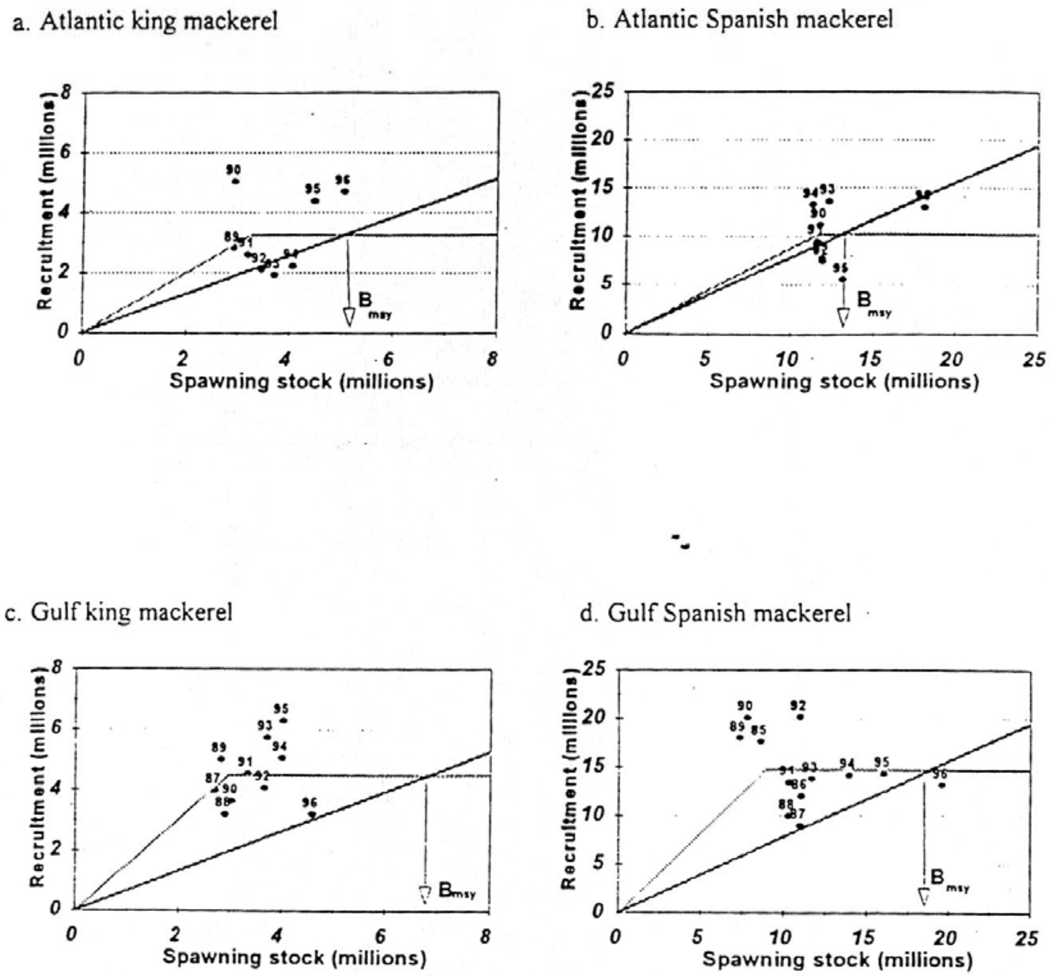

Figure 6. Fishing mortality rates and spawning stock sizes from three previous stock assessments (1989 depicted with crosses, 1994 depicted with open circles, and 1998 depicted with X's) of Gulf group Spanish mackerel plus control rules for the $F_{30\%MSY}$ proxy (MFMT) and for $F_{40\%MSY}$. (Note: Each cluster of points represents 400 bootstrap solutions.)

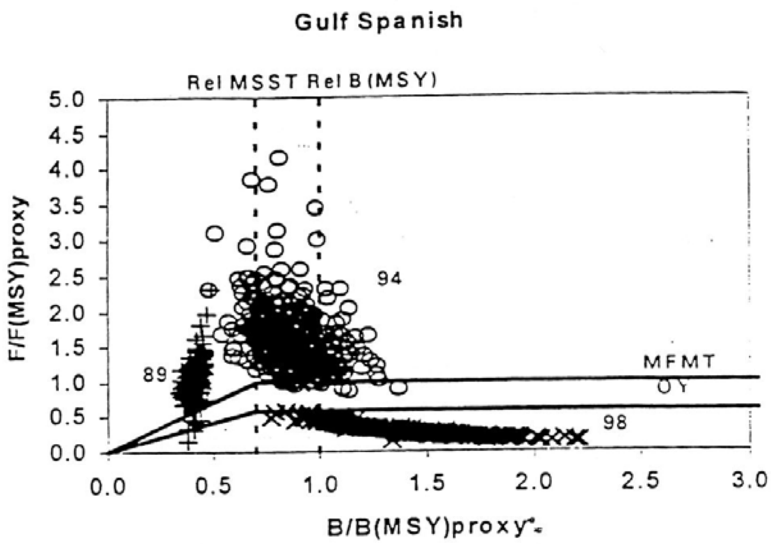

Figure 7. Ratios of spawning stock biomass (B) to spawning stock biomass at MSY (B_{MSY}) and current fishing mortality rates (F) to the fishing mortality rate at MSY ($F_{30\%}$ proxy) from 400 bootstrap runs. Vertical lines illustrate the relative biomass at MSY (Rel MSY) and the relative Minimum Stock Size Threshold (Rel MSST). Based upon the proposed control rules, none of the stocks is overfished based upon the median estimate of current spawning stock but the Gulf king mackerel fishery is currently overfishing.

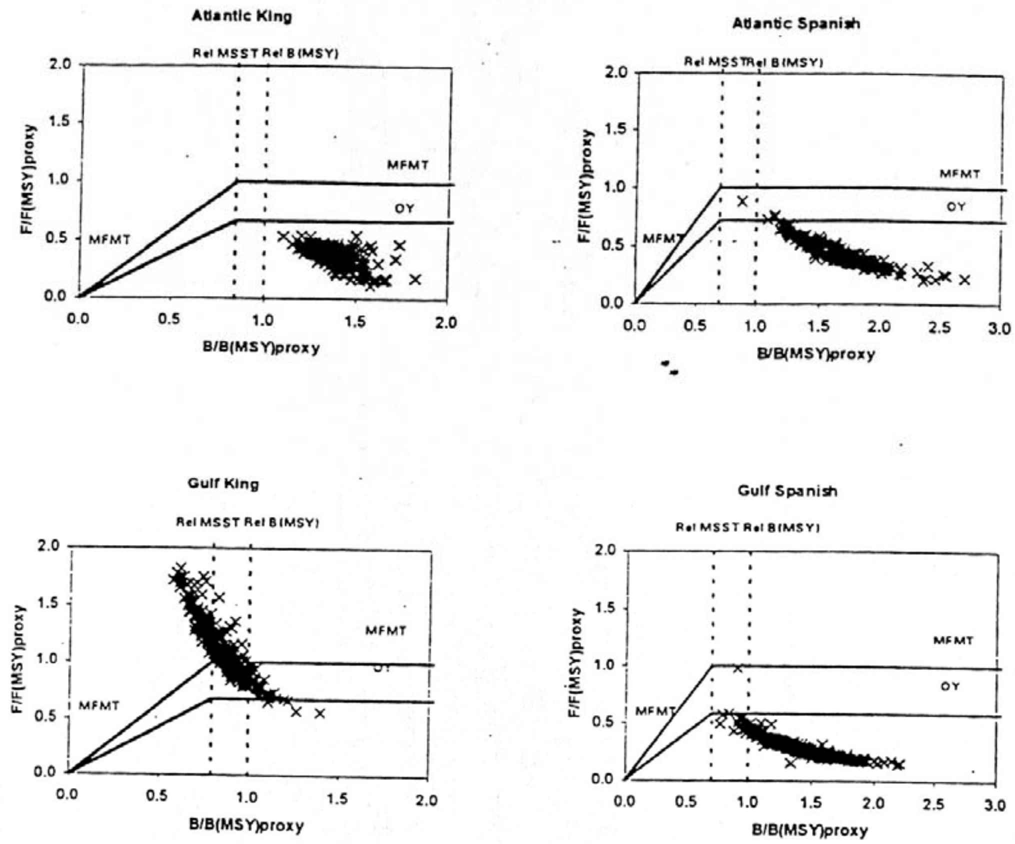

Table 1. Atlantic group king mackerel management regulations and harvest. Pounds are in millions.

Fishing Year	ABC RANGE[8] (lbs)	TAC (lbs)	Rec. Alloc./Quota [3] (lbs / numbers)	Rec. Bag Limit	Commercial Allocation	Annual Harvest Lev	
						Com	Rec
1986/87	6.9 -15.4	9.68		3	3.59 (PS=0.40)	2.840	5.980
1987/88	6.9 -15.4	9.68	6.09	3	3.59 (PS=0.40)	3.453	3.905
1988/89	5.5 -10.7	7.00	4.40	2 in FL, 3 GA-NC	2.60 (PS=0.40)	3.091	4.881
1989/90	6.9 -15.4	9.00	5.66 / 666,000	2 in FL, 3 GA-NC	3.34	2.635	3.400
1990/91	6.5 -15.7	8.30	5.22 / 601,000	2 in FL, 3 GA-NY	3.08	2.676	3.718
1991/92	9.6 -15.5	10.50	6.60 / 735,000	5 in FL-NY	3.90	2.516	5.822
1992/93	8.6 -12.0	10.50	6.60 / 834,000[5]	2 in FL, 5 GA-NY	3.90	2.227	6.251
1993/94	9.9 -14.6	10.50	6.60 / 854,000	2 in FL, 5 GA-NY	3.90	2.018	4.438
1994/95	7.6 -10.3	10.00	6.29 / 709,000	2 in FL, 5 GA-NY	3.71	2.197	3.728
1995/96	7.3 -15.5	7.30	4.60 / 454,000	2 in FL, 3[6] GA-NY	2.70	1.870	4.153
1996/97	4.1 - 6.8	6.80	4.28 / 438,525	2 in FL, 3 GA-NY	2.52	2.702	4.016
1997/98	4.1 - 6.8	6.80	4.28 / 438,525	2 in FL, 3 GA-NY	2.52[4]	2.678	5.392[7]
1998/99	8.4 -11.9	8.40	5.28 / 504,780	2 in FL, 3 GA-NY	3.12	2.520	4.565[7]

[1] Fishing year 1979 begins on 1 April and ends on 31 March 1980.
[2] Sums within rows may not appear to equal the total value shown due to rounding of numbers before printing.
[3] Recreational quota in numbers is the allocation divided by an estimate of annual average weight (not used prior to fishing year 1989).
[4] The commercial allocation includes the purse seine allocations listed.
[5] Bag limit will not be reduced to zero when allocation reached, beginning fishing year 1992.
[6] Bag limit reduced from 5 to 3 effective 1/1/96.
[7] Recreational landings, in pounds were estimated by multiplying number of fish caught by 10.46 lbs/fish
[8] The range has been defined in terms of acceptable risk of achieving the FMP's fishing mortality rate target; the Panel's best estimate of ABC ha to the end-points of this range.

Table 2. Gulf group king mackerel management regulations and harvest levels. Weights are in millions of pounds.

Fishing Year	ABC RANGE[12] (lbs)	TAC (lbs)	Rec. Alloc./Quota [3] (lbs / numbers)	Rec. Bag Limit[4]	Commercial Allocation	East/West [5,6]	Annual Ha	
							Com	R
1986/87	1.2-2.9	2.9	1.97	2/3 FL-TX	0.93 :	0.60/0.27 + PS=0.06	1.473	3.2
1987/88	0.6-2.7	2.2	1.50	2/3 FL-TX	0.70 :	0.48/0.22	0.868	2.1
1988/89	0.5-4.3	3.4	2.31	2/3 FL-TX	1.09 :	0.75/0.34	1.405	5.2
1989/90	2.7-5.8	4.25	2.89 / 298,000	2/3 FL-TX	1.36 :	0.94/0.42	1.954	3.3
1990/91	3.2-5.4	4.25	2.89 / 301,000	2/3 FL-TX	1.36 :	0.94/0.42	1.816	3.9
1991/92	4.0-7.0	5.75	3.91 / 574,000	2 FL; 2/3 AL-TX	1.84 :	1.27/0.57	2.117	4.7
1992/93	4.0-10.79	7.80	5.30 / 715,000[8]	2 FL-TX	2.50+0.259 :	1.73+0.259/0.77[7]	3.599	6.2
1993/94	1.9-8.1[9]	7.80	5.30 / 759,000	2 FL-TX	2.50 :	1.73/0.77	2.572	6.1
1994/95	1.9-8.1[9]	7.80	5.30 / 768,000	2 FL-TX	2.05+0.300 :	1.73+0.300/0.77[10]	2.942	7.8
1995/96	1.9-8.1[9]	7.80	5.30 / 629,000	2 FL-TX	2.50 :	1.73/0.77	2.645	6.2
1996/97	4.7-8.8	7.80	5.30 / 629,000	2 FL-TX	2.50 :	1.73/0.77	2.853	7.1
1997/98	6.0-13.7	10.6	7.21	2 FL-TX	3.39 :	2.34/1.05	3.160	7.45
1998/99	7.1-10.8	10.6	7.21	2 FL-TX	3.39	2.34/1.05	3.600	6.22

[1] Fishing year 1979/80 begins on 1 July 1979 and ends on 30 June 1980.
[2] Sums within rows may not appear to equal the total value shown due to rounding of numbers before printing.
[3] Recreational quota in numbers is the allocation divided by an estimate of annual average weight (not used prior to fishing year 1989).
[4] Bag Limit "2/3" means 2 for private boats; for charterboats: 2 with, or 3 without, captain and crew.
[5] E/W com. Allocations apply to all legal gears except purse seine in fishing year 1986 (only H&L and runaround gillnet beginning 1990/91).
[6] For quota monitoring, E/W com. allocations apply to East=(Florida) and West=(Alabama-Texas), not accounting for mixing.
[7] 0.250 million pounds added to com. allocation for FL east only, opened 2/18/93 - 3/26/93.
[8] Bag limit will not be reduced to zero when allocation reached, beginning in fishing year 1992/93.
[9] Panel recommended ABC range changed from 16%-84% to 16%-50% and Gulf Council selected TAC accepting greater than 50% risk level.
[10] 0.300 million pounds added to hook-and-line quota for Florida West Coast subzone.
[11] Recreational landings, in pounds were estimated by multiplying number of fish caught by 10.77 lbs/fish.
[12] The range has been defined in terms of acceptable risk of achieving the FMP's fishing mortality rate target; the Panel's best estimate of ABC has been intermediate to the end-points of

Table 3. Atlantic group Spanish mackerel management regulations. Pounds are in millions.

Fishing Year	ABC RANGE[6] (lbs)	TAC (lbs)	Rec. Alloc./Quota [3] (lbs / numbers	Rec. Bag Limit	Com. Alloc. (lbs)	Harvest Levels	
						Com	Rec
1987/88	1.7 - 3.1	3.1	0.74	4 in FL, 10 GA-NC	2.36	3.559	1.474
1988/89	1.3 - 5.5	4.0	0.96	4 in FL, 10 GA-NC	3.04	3.524	2.740
1989/90	4.1 - 7.4	6.0	2.76 / 1,725,000 [4]	4 in FL, 10 GA-NC	3.24	3.963	1.569
1990/91	4.2 - 6.6	5.0	1.86 / 1,216,000	4 in FL, 10 GA-NC	3.14	3.560	2.075
1991/92	5.5 - 13.5	7.0	3.50 / 2,778,000	5 in FL, 10 GA-NC	3.50	4.739	2.287
1992/93	4.9 - 7.9	7.0	3.50 / 2,536,000 [5]	10 FL - NY	3.50	3:716	1.995
1993/94	7.3 - 13.0	9.0	4.50 / 3,214,000	10 FL - NY	4.50	4.813	1.493
1994/95	4.1 - 9.2	9.2	4.60 / 3,262,000	10 FL - NY	4.60	5.233	1.378
1995/96	4.9 - 14.7	9.4	4.70 / 3,113,000	10 FL - NY	4.70	2.009	1.089
1996/97	5.0 - 7.0	7.0	3.50 / 2,713,000	10 FL - NY	3.50	3.096	0.851
1997/98	5.8 - 9.4	8.0	4.00 / 2,564,000	10 FL - NY	4.00	3.057	1.357[6]
1998/99	5.4 - 8.2	8.0	4.00 / 2,564,000	10 FL - NY	4.00	3.200	0.774[6]

[1] Fishing year 1979 begins on 1 April and ends on 31 March 1980.
[2] Sums within rows may not appear to equal the total value shown due to rounding of numbers before printing.
[3] Recreational quota in numbers is the allocation divided by an estimate of annual average weight (not used prior to fishing year 1989).
[4] Allocations and rec. quota are as revised October 14, 1989.
[5] Bag limit will not be reduced to zero when allocation reached, beginning fishing year 1992.
[6] Recreational landings, in pounds were estimated by multiplying number of fish caught by 1.29 lbs/fish.
[6] The range has been defined in terms of acceptable risk of achieving the FMP's fishing mortality rate target; the Panel's best estimate of ABC has be to the end-points of this range.

Table 4. Gulf group Spanish mackerel management regulations. Pounds are in millions. Prior to fishing year 1990, management was b
fishing year. The regulations shown for fishing year 1987 and later are relative to the July-June fishing year.

Fishing Year	ABC RANGE[8] (lbs)	TAC (lbs)	Rec. Alloc./Quota[4] (lbs / numbers)	Rec. Bag Limit	Com. Alloc. (lbs)	Annual Harv	
						Com	Re
1987/88	1.9 - 4.0	2.50	1.08	3	1.42	2.581	3.1
1988/89	1.9 - 7.1	5.00	2.15	4 FL, 10 AL-TX	2.85	3.902	2.1
1989/90	4.9 - 6.5	5.25	2.26 / 1,614,000	4 FL, 10 AL-TX	2.99	2.145	1.8
1990/91	3.9 - 7.4	5.25	2.26 / 1,569,000	3 TX, 4 FL[5], 10 AL-LA	2.99	2.074	2.1
1991/92	7.1 - 12.2	8.60	3.70 / 2,721,000	3 TX, 5 FL, 10 AL-LA	4.90	4.163	2.88
1992/93	5.1 - 9.8	8.60	3.70 / 3,274,000[6]	7 TX, 10 FL-LA	4.90	3.113	3.13
1993/94	4.7 - 8.7	8.60	3.70 / 3,274,000	7 TX, 10 FL-LA	4.90	2.614	2.69
1994/95	4.4 - 8.7	8.60	3.70 / 2,202,000	7 TX, 10 FL-LA	4.90	2.544	1.55
1995/96	4.0 - 10.7	8.60	3.70 / 2,782,000	7 TX, 10 FL-LA	4.90	1.075	1.57
1996/97	1.6 - 9.5	7.00	3.01 /	7 TX, 10 FL-LA	3.99	0.617	2.05
1997/98	5.5 - 13.9	7.00	3.01 /	7 TX, 10 FL-LA	3.99	0.331	1.90
1998/99	7.3-14.1	7.00	3.01 /	7 TX, 10 FL-LA	3.99	0.460	1.878

[1] Fishing year 1979 begins on 1 April and ends on 31 March 1980.
[2] Sums within rows may not appear to equal the total value shown due to rounding of numbers before printing.
[3] Information on Mexico catch and size distributions for some years was not sufficient for inclusion.
[4] Recreational quota in numbers is the allocation divided by an estimate of annual average weight (not used prior to fishing year 1989).
[5] Rec. bag limit in Fl changed from 4 to 5 on 1/1/91, and changed from 5 to 10 on 1/1/93.
[6] Bag limit will not be reduced to zero when allocation reached, beginning fishing year 1992.
[7] Recreational landing, in pounds were estimated by multiplying number of fish caught by 1.63 lbs/fish.
[8] The range has been defined in terms of acceptable risk of achieving the FMP's fishing mortality rate target; the Panel's best estimate of ABC ha
to the end-points of this range.

Table 5. A first approximation to estimating MSY, F_{MSY}, stock size at MSY, and MSST for Gulf and Atlantic group king and Spanish mack

Stock	Maximum Sustainable Yield (millions of pounds)			Maximum Fishing Mortality Threshold F_{MSY} per year			Spawning Stock at MSY B_{MSY} (Millions)			Minimum Sto (M	
	Median	Lower 80 CI	Upper 80 CI	Median	Lower 80 CI	Upper 80 CI	Median	Lower 80 CI	Upper 80 CI	Median	Low C
Atlantic King	10.4	9.4	14.5	0.40	0.32	0.48	5.2	4.7	7.1	4.4	
Gulf King	12.1	10.7	13.8	0.35	0.29	0.62	6.8	6.2	7.5	5.4	
Atlantic Spanish	6.4	5.7	7.5	0.40	0.38	0.42	13.7	12.2	15.8	9.6	
Gulf Spanish	8.5	7.1	9.7	0.53	0.41	0.69	19.1	17.5	20.7	13.4	

Appendix E. Updated Projections for King and Spanish Mackerel in the Gulf of Mexico and Atlantic Ocean (MSAP/99)

MSAP/99/

Updated Projections for King and Spanish Mackerel in the Gulf of Mexico and Atlantic Ocean

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Introduction

Updated projections of the estimated stocks from the 1998 full assessment were made such that the total allowable catch (ABC) for each migratory group can be set for the 1999/2000 fishing seasons using procedures previously established by the mackerel stock assessment panel (MSAP). The estimated stocks from the 1998 full assessment contained a deterministic point estimate and 400 mixed bootstrap/Monte Carlo estimates of stock abundance and fishing mortality rates estimated from tuned virtual population analysis with the terminal year the 1996/97 fishing seasons (Legault et al. 1998). The updated projections presented here use these stock abundance and fishing mortality rate matrices first projected to match estimates of total catch (not separated by age) for the commercial and recreational fleets in the 1997/98 and 1998/99 fishing seasons and then estimate allowable biological catches under given management schemes ($F_{30\%SPR}$ or $F_{40\%SPR}$) for the 1999/2000 fishing season. Also available for these projections are estimates of the reduction in shrimp trawl bycatch of mackerels in the Gulf of Mexico due to the implementation of bycatch reduction devices (BRDs). The uncertainty of allowable biological catches is presented in two ways, the historically used percentile method and the bias corrected percentile method, which seems to provide better confidence interval coverage than the percentile method (Legault 1999). Deterministic, long term potential yields, stock recruitment relationships, and estimates of maximum sustainable yield related benchmarks are also provided for all the migratory groups. Recovery of the Gulf of Mexico king mackerel migratory group is treated in more detail.

Updated Landings

Updated landings of mackerel migratory groups for the 1997/98 fishing seasons and estimated landings for the 1998/99 fishing seasons were provided by P. Phares (NMFS, SEFSC, Sustainable Fisheries Division) and are based on currently available commercial and recreational harvest information. The landings were separated as commercial, given in pounds, and recreational, given in numbers of fish (Table 1). The derivations of the 1998/99 estimates are detailed in Appendix A. Applying an approximate average weight of recreational fish (total weight divided by total numbers from tables 1-4 of the 1998 assessment) allows comparison of these updated values with the historical series (Figure 1). All four migratory groups show stability in the recent level of landings, especially considering the approximate nature of these values.

Table 1. *Mackerel landings of commercial (pounds) and recreational (numbers) sectors for the 1997/98 fishing seasons and projected landings for the 1998/99 fishing seasons.*

	1997/98		1998/99	
	Commercial	Recreational	Commercial	Recreational
Atlantic King	2,677,794	515,482	2,520,000	436,415
Gulf King	3,159,578	692,375	3,600,000	578,367
Atlantic Spanish	3,056,845	1,051,550	3,200,000	600,072
Gulf Spanish	331,342	1,168,740	460,000	1,152,305

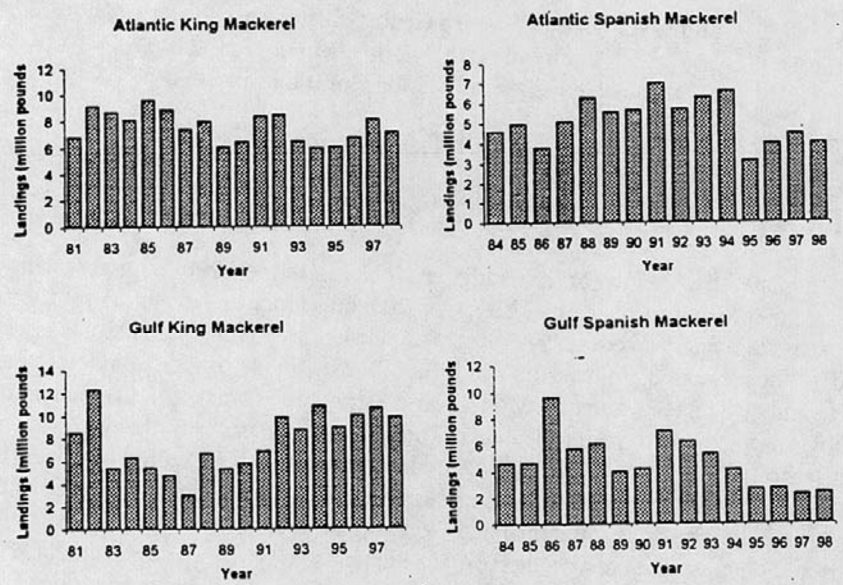

Figure 1. *Total landings in weight for the four mackerel migratory groups. A fishing season is denoted by its first year, for example 84/85 is denoted 84. The 97 and 98 values are preliminary.*

Bycatch

Shrimp trawl bycatch for the Atlantic migratory groups was set to zero when determining the ABC in the 1998 mackerel stock assessment panel report. This was done even though there is known to be bycatch in the shrimp trawl fleet because the data available only allowed a single value to be used for the entire historical time series (see Legault et al. 1998 for further details). No additional information was available for these projections. Since not including bycatch raises estimates of SPR relative to including it, three sets of projections are provided for the Atlantic migratory groups: no bycatch, low bycatch and high bycatch. The low and high bycatch cases correspond to the two Vaughan and Nance (1998) estimates described in Legault et al. (1998).

The implementation of BRDs in the Gulf of Mexico necessitates inclusion of a bycatch reduction multiplier for shrimp trawl bycatch in the projections. The bycatch reduction multiplier modifies the estimated bycatch at age of future years for each bootstrapped VPA projection. This multiplier is defined as 1.0 minus the F that occurs using BRDs divided by the F that would have occurred without BRDs. For example, status quo bycatch has a bycatch reduction multiplier of 0.0 while complete elimination of the shrimp trawl fishery has a bycatch reduction multiplier of 1.0. Estimates of the bycatch reduction multipliers for king and Spanish mackerel in the Gulf of Mexico were provided by S. Nichols (NMFS, SEFSC, Pascagoula Laboratories) (Appendix B). Briefly, the generalized linear model (GLM) used to estimate total bycatch by species had the "dataset" classification modified from two levels (research and commercial) to three levels (research, commercial with BRD and commercial without BRD). This additional level allowed calculation of total bycatch if all boats, or boats fishing in specific areas at specific times, had used BRDs during any year. For 1998, the normal GLM was run to produce the "ALL" estimate while "ACT" estimates were produced by using WithBRD estimates for areas, seasons that had BRD requirement and NoBRD otherwise (Table 2). The 1998 reduction was calculated as 1-ACT/ALL. To estimate potential reductions when all boats use BRDs, the average of the past five years of bycatch reductions was computed from 1-WithBRD/NoBRD. These average bycatch reduction multipliers were used for years 1999 and beyond for long term potential yield projections, and for MSY related calculations. Bycatch reduction multipliers were not used with Atlantic group mackerels, except for calculation of some long term potential yields.

Table 2. Total shrimp trawl bycatch estimates provided by Scott Nichols (pers. comm.) and calculation of bycatch reduction multipliers. See text for description of variables.

				King Mackerel		
Year	ACT	ALL	1-ACT/ALL	WithBRD	NoBRD	1-WithBRD/NoBRD
1994	1.056	0.993		0.654	1.056	0.381
1995	1.087	1.109		0.720	1.087	0.338
1996	0.630	0.623		0.255	0.630	0.595
1997	0.752	0.742		0.362	0.752	0.519
1998	0.301	0.527	**43%**	0.214	0.587	0.635
					average	**49%**

				Spanish Mackerel		
Year	ACT	ALL	1-ACT/ALL	WithBRD	NoBRD	1-WithBRD/NoBRD
1994	3.021	3.005		2.357	3.021	0.220
1995	2.650	2.700		2.056	2.650	0.224
1996	2.722	2.724		2.081	2.722	0.235
1997	2.583	2.568		1.949	2.583	0.245
1998	2.117	2.655	**20%**	1.969	2.611	0.246
					average	**23%**

Current Stock Condition

Transitional unweighted spawning potential ratios calculated from the 400 mixed bootstrap/Monte Carlo assessments and projections of estimated catch show that all migratory groups are either trending upwards or level over the past few years (Figure 2). Using 30%SPR as the overfished definition for Gulf of Mexico migratory groups, king mackerel are overfished and Spanish mackerel are not overfished. Using 40%SPR as the overfished definition for Atlantic migratory groups, both king and Spanish mackerel are not overfished under no bycatch, but both are overfished under either low or high bycatch.

Using a static spawning potential ratio of either 30% or 40% as the definition of overfishing classifies Gulf of Mexico king mackerel and Atlantic Spanish mackerel under high bycatch as undergoing overfishing, while all other migratory groups and bycatch levels are classified as not overfishing in the 1998/99 fishing season (Table 3). Current fishing mortality rates and spawning stock sizes are also provided in Table 3 for comparison with possible management benchmarks provided in subsequent sections.

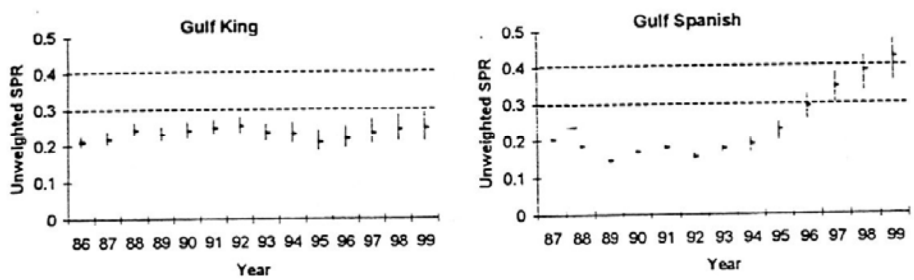

Figure 2a. Gulf migratory group unweighted transitional SPR. Box and whiskers denote median and 80% confidence interval.

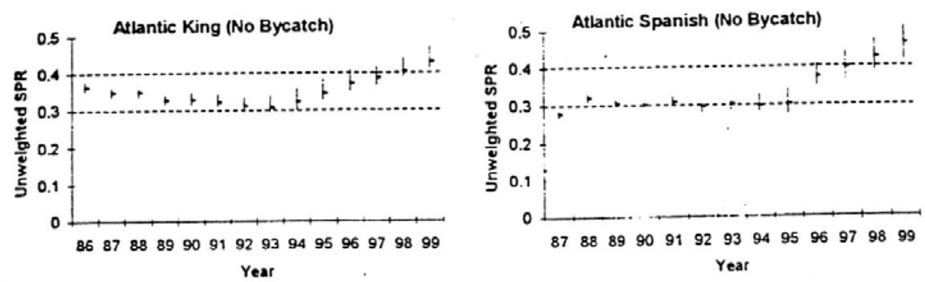

Figure 2b. Atlantic migratory group SPR under no bycatch. Median and 80% CI.

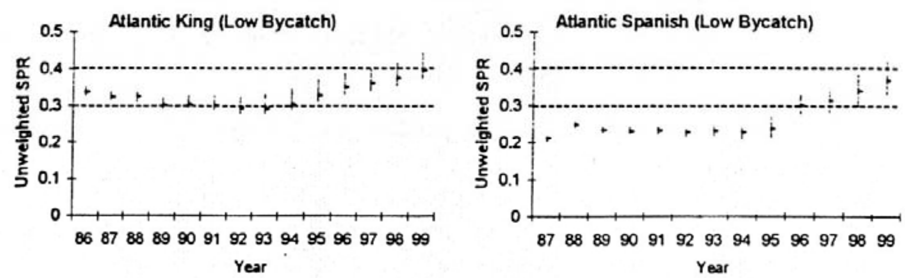

Figure 2c. *Atlantic migratory group SPR under low bycatch. Median and 80% CI.*

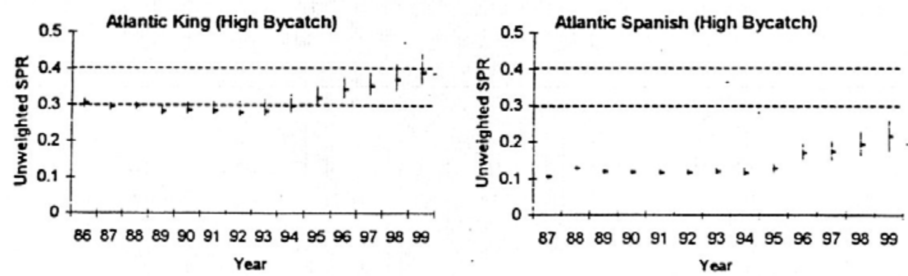

Figure 2d. *Atlantic migratory group SPR under high bycatch_Median and 80% CI.*

Table 3. *Current conditions of the migratory groups. Group code: G=Gulf of Mexico, A=Atlantic, K=king mackerel, S=Spanish mackerel, N=no, L=low, H=high, B=bycatch. SS99=spawning stock in 1999. F98=the maximum directed fishing mortality rate at age in 1998. Static SPR98 is the static spawning potential ratio in 1998.*

	SS99 (millions)				F98				Static SPR98			
Group	Point	Median	80%CI		Point	Median	80%CI		Point	Median	80%CI	
GK	5.75	5.72	4.49	7.47	0.382	0.384	0.270	0.760	0.271	0.278	0.217	0.348
GS	26.04	27.50	19.34	36.33	0.154	0.141	0.104	0.222	0.513	0.529	0.441	0.587
AK NB	6.49	6.86	6.06	10.71	0.174	0.154	0.103	0.190	0.521	0.538	0.501	0.637
AS NB	20.31	22.44	16.76	30.62	0.192	0.175	0.130	0.226	0.523	0.554	0.469	0.634
AK LB	4.98	5.81	4.70	9.53	0.241	0.189	0.130	0.252	0.431	0.479	0.419	0.601
AS LB	20.32	22.86	16.66	31.39	0.192	0.166	0.124	0.222	0.405	0.451	0.363	0.529
AK HB	5.29	6.40	5.02	9.41	0.197	0.153	0.110	0.195	0.426	0.483	0.421	0.586
AS HB	20.23	24.45	17.53	34.69	0.193	0.155	0.111	0.207	0.211	0.283	0.201	0.359

Allowable Biological Catch

Calculation of allowable biological catch followed exactly the mixed bootstrap/Monte Carlo VPA and projection algorithms used in the 1998 stock assessment (Legault et al. 1998). The 1999/2000 fishing season ABC estimates under two management schemes ($F_{30\%SPR}$ and $F_{40\%SPR}$) and two methods to characterize the uncertainty (percentile and bias corrected percentile) are summarized in Table 4 and cumulative frequency plots provided in Figure 3. The bias correction algorithm is described in Legault (1999). Bias correction increased the median ABC for Gulf of Mexico king mackerel, but decreased the median ABC for the other migratory groups. Bias correction narrowed the range contained within the 16-84% confidence intervals in all cases. The decrease in the Atlantic Spanish high bycatch ABCs is extreme due to the point estimate falling almost outside the bootstrap/Monte Carlo distribution. This is most likely an artifact of using a constant value for bycatch in the deterministic case and using Monte Carlo simulation to generate a varying trend in bycatch for the mixed bootstrap/ Monte Carlo simulation projections. It also highlights the possibility that the selection of distributions for the Monte Carlo simulations are not in fact centered on the point estimates when projected ABCs are considered. For example, the Atlantic king mackerel natural mortality point estimate is 0.15 and the Monte Carlo simulation chooses a value from a uniform distribution of (0.1, 0.2). Although the point estimate of M is centered in the distribution assumed for M, the response of ABC to changes in M is non-linear and thus not likely to be centered about the point estimate (see Legault 1999 for further details).

***Table 4.** Allowable biological catches for the 1999/2000 fishing season. Point Est are the deterministic VPA and projection results, Level refers to the per cent confidence level (50 is the median) for the two methods to characterize uncertainty (Percentile and Bias Corrected).*

Allowable Biological Catch (million pounds) for 1999/2000 Fishing Season

	F30%SPR				F40%SPR			
Migratory Group	Point Est	Level	Percentile	Bias Corrected	Point Est	Level	Percentile	Bias Corrected
Gulf King		16	8.03	8.45		16	5.49	5.79
	10.32	50	10.10	10.52	7.17	50	6.96	7.39
		84	12.51	12.93		84	8.73	9.09
Gulf Spanish		16	9.14	8.14		16	5.65	4.80
	12.40	50	12.92	11.94	7.74	50	8.19	7.39
		84	17.18	16.06		84	10.82	10.10
Atlantic King		16	12.80	12.19		16	8.93	8.36
(no bycatch)	13.82	50	14.35	13.44	9.55	50	10.03	9.20
		84	19.30	15.63		84	13.27	10.50
Atlantic Spanish		16	7.64	6.31		16	5.74	4.73
(no bycatch)	8.63	50	9.43	7.93	6.48	50	7.08	5.97
		84	11.91	9.82		84	8.96	7.39
Atlantic King		16	9.51	6.69		16	6.69	4.44
(low bycatch)	10.02	50	11.27	9.07	6.90	50	7.92	6.17
		84	17.26	10.76		84	11.80	7.17
Atlantic Spanish		16	5.89	4.71		16	4.08	3.25
(low bycatch)	6.75	50	7.65	5.89	4.64	50	5.42	4.06
		84	9.91	7.64		84	7.04	5.36
Atlantic King		16	9.32	6.31		16	6.56	3.06
(high bycatch)	9.71	50	11.74	8.65	6.63	50	8.18	5.51
		84	16.67	10.38		84	11.44	6.72
Atlantic Spanish		16	2.32	4.11E-08		16	0.62	4.10E-09
(high bycatch)	2.02	50	3.90	1.01	0.014	50	1.78	4.10E-09
		84	5.53	1.86		84	3.06	2.32E-08

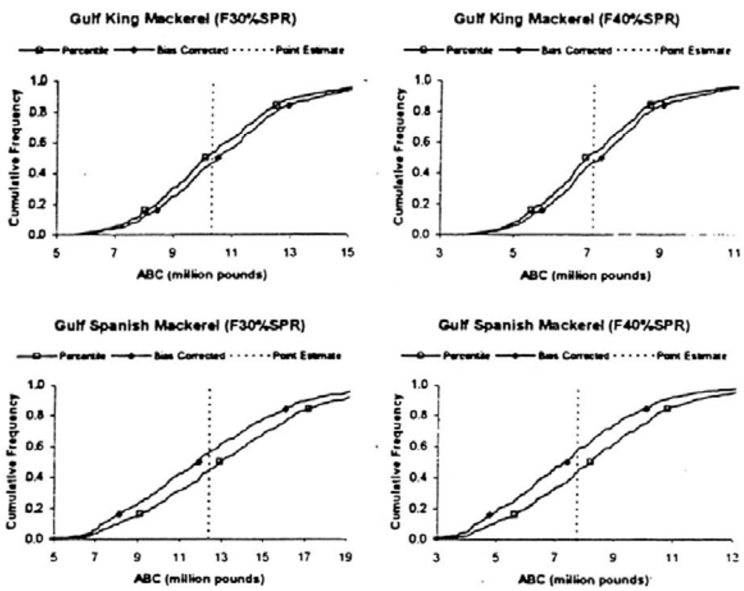

***Figure 3a**. Gulf migratory group mackerel 1999/2000 allowable biological catch.*

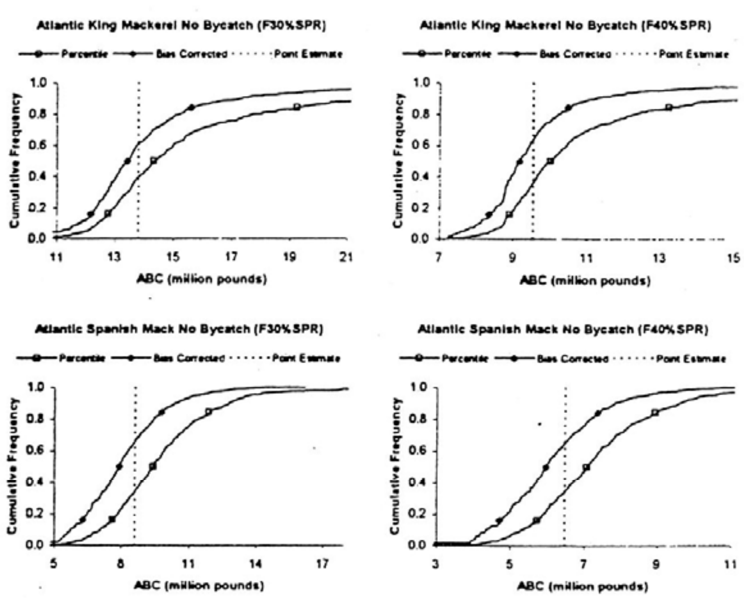

***Figure 3b**. Atlantic migratory group mackerel 1999/2000 allowable biological catch under no bycatch.*

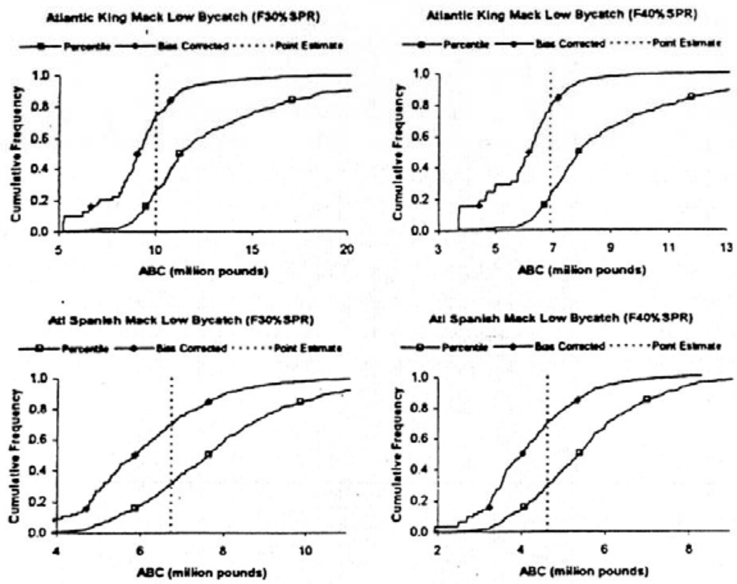

Figure 3c. Atlantic migratory group mackerel 1999/2000 allowable biological catch under low bycatch.

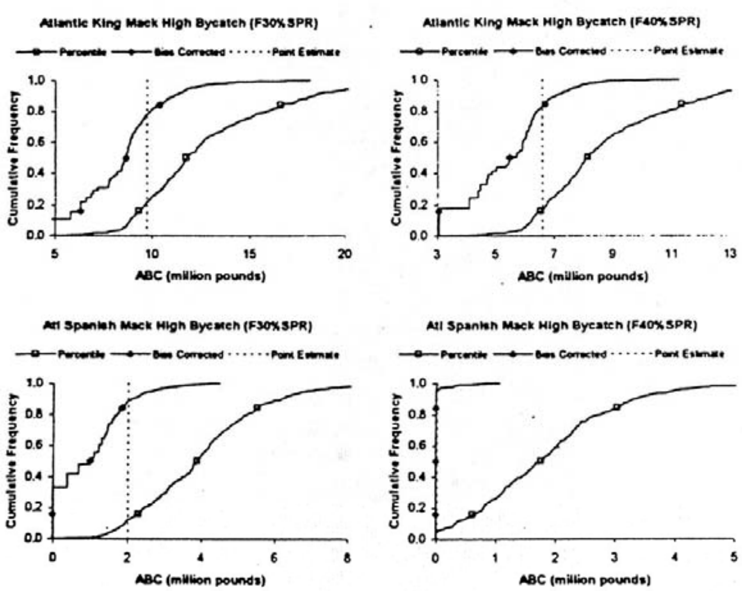

Figure 3d. Atlantic migratory group mackerel 1999/2000 allowable biological catch under high bycatch.

Long Term Potential Yield

Two approaches were taken with regards to long term potential yield: deterministic trends over time and equilibrium conditions for an expanded number of parameter combinations. The deterministic trends from current conditions were computed by applying exactly $F_{30\%SPR}$ or $F_{40\%SPR}$ to the stocks estimated in the deterministic VPAs. For the Gulf of Mexico migratory groups, only one bycatch reduction pattern was examined, the one described in the "Bycatch" section. Future recruitment was held constant at the geometric mean (centered on the mean) from the estimated values of the deterministic VPA. Natural mortality was held constant at its expected value. The resulting unweighted transitional SPR and yield time series followed smooth curves towards the equilibrium values (Table 5 and Figure 4). Note that in some cases the use of $F_{30\%SPR}$ or $F_{40\%SPR}$ caused the unweighted SPR to decrease because the stocks are currently at higher levels. Potential recovery trends of Gulf of Mexico king mackerel are examined further in a separate section.

Long term potential yield was computed for equilibrium conditions by combining per recruit analyses with estimates of future average recruitment levels. Possible future recruitment levels were estimated from historical estimates of recruitment from the VPAs (Table 6 and Figure 5). The per recruit analyses were conducted by solving for the commercial and recreational F multipliers that satisfied two conditions: the desired static SPR and the desired proportion of yield per recruit to the recreational sector. The commercial and recreational selectivity curves were generated from the average F at age during the years 1992 to 1996 by each sector using the VPA estimates. Weight at age, fecundity and the natural mortality were all fixed. The multiplication of the yield per recruit (Y/R) and spawners per recruit (S/R) that result under a given management scheme by a future level of recruitment provides the long term potential yield estimate ($LTPY=R*Y/R$) and the corresponding spawning stock size ($SS_{LTPY}=R*S/R$). This corresponding spawning stock size can be used as a proxy for B_{MSY} when a stock recruitment relationship cannot be calculated for a migratory group. The associated fishing mortality rate allows the definition of a harvest control law based on spawning potential ratio calculations as a proxy for MSY.

Long term potential yield per recruit for each of the migratory groups was examined under two management schemes ($F_{30\%SPR}$ and $F_{40\%SPR}$) as a function of the bycatch reduction multiplier (Table 7). Note that the spawning stock per recruit does not change with changes in bycatch reduction for any group. This is because the exploited spawning stock is the result of both the directed and non-directed fishing while the virgin spawning stock is determined by only natural mortality. Thus, any reduction in shrimp bycatch mortality does not change the health of the stock but rather increases the directed yield, modified by the natural mortality rate and directed selectivity patterns. Multiplying the per recruit values by a future recruitment level allows estimation of proxies for MSY and MSY control laws (Figure 6). Increasing the level of recruitment and increasing the bycatch reduction resulted in higher long term potential yields in all cases except for the Atlantic no bycatch cases which obviously did not change with changes in bycatch reduction.

The 400 mixed bootstrap/Monte Carlo assessments can also be individually compared with long term potential yield parameters. The yield per recruit, spawning stock per recruit and fishing mortality rate under a given management scheme are computed for each of the bootstrap/Monte Carlo simulations. A fixed level of recruitment is then applied over all the bootstrap/Monte Carlo simulations to produce the spawning stock associated with the long term potential yield. Dividing the current conditions of F and SS by the values associated with long term potential yield for each bootstrap/Monte Carlo simulation allows examination of the uncertainty associated with the status of the stock. If F_{98}/F_{LTPY} is greater than 1.0 then overfishing is occurring. If SS_{99}/SS_{LTPY} is less than 1.0 then the stock is overfished. Table 8 summarizes the percentage of bootstrap/Monte Carlo simulations resulting in these classifications. Plotting the ratios shows explicitly the uncertainty associated with these classifications (Figure 7). Note that changing the management scheme impacts both the F and SS long term potential yield values for each bootstrap/Monte Carlo simulation, while changing the bycatch reduction impacts only the F values and changing the future recruitment level impacts only the SS values.

Table 5a. King mackerel time trends in unweighted transitional spawning potential ratio (SPR) and directed yield (millions of pounds) from dete
projections of F30%SPR and F40%SPR.

	Gulf King				Atlantic King (No Bycatch)				Atlantic King (Low Bycatch)				Atlantic King (High Bycatc			
Year	SPR30	Yield30	SPR40	Yield40	SPR30	Yield30	SPR40	Yield40	SPR30	Yield30	SPR40	Yield40	SPR30	Yield30	SPR40	Yi
1998	0.245	11.37	0.245	11.37	0.399	5.89	0.399	5.89	0.359	5.73	0.359	5.73	0.342	5.69	0.342	5
1999	0.247	10.32	0.247	7.17	0.424	13.82	0.424	9.55	0.375	10.02	0.375	6.90	0.359	9.71	0.359	6
2000	0.253	10.17	0.268	7.47	0.391	12.01	0.421	9.02	0.357	8.86	0.381	6.58	0.347	8.78	0.370	6
2001	0.260	9.80	0.290	7.57	0.365	10.85	0.418	8.72	0.342	8.34	0.387	6.57	0.337	8.33	0.378	6
2002	0.267	9.39	0.310	7.57	0.345	9.97	0.415	8.50	0.330	7.99	0.391	6.63	0.328	7.97	0.384	6
2003	0.275	9.40	0.330	7.86	0.331	8.94	0.411	8.00	0.321	7.33	0.394	6.34	0.320	7.40	0.389	6
2004	0.281	8.91	0.346	7.67	0.320	8.36	0.410	7.85	0.315	7.04	0.397	6.34	0.315	7.22	0.394	6
2005	0.285	8.49	0.358	7.39	0.312	7.55	0.406	7.31	0.309	6.83	0.398	6.39	0.310	6.87	0.396	6
2006	0.290	8.45	0.370	7.47	0.308	6.90	0.405	6.82	0.306	6.32	0.398	5.99	0.307	6.46	0.398	5
2007	0.294	8.34	0.379	7.43	0.305	6.53	0.404	6.59	0.304	6.07	0.400	5.91	0.305	6.24	0.400	5
2008	0.296	8.30	0.386	7.46	0.302	6.21	0.402	6.14	0.302	5.84	0.400	5.62	0.303	5.94	0.399	5
2009	0.297	8.24	0.391	7.41	0.301	6.05	0.401	5.92	0.301	5.72	0.399	5.48	0.301	5.80	0.399	5
2010	0.298	8.22	0.394	7.42	0.301	5.96	0.401	5.79	0.301	5.65	0.400	5.40	0.301	5.71	0.400	5
2011	0.299	8.18	0.396	7.38	0.300	5.92	0.400	5.72	0.300	5.62	0.400	5.37	0.301	5.67	0.400	5
2012	0.299	8.19	0.398	7.41	0.300	5.90	0.400	5.74	0.300	5.61	0.400	5.40	0.300	5.68	0.400	5
2013	0.300	8.14	0.399	7.31	0.300	5.88	0.400	5.68	0.300	5.59	0.400	5.35	0.300	5.64	0.400	5
2014	0.300	8.14	0.400	7.31	0.300	5.85	0.400	5.56	0.300	5.56	0.400	5.26	0.300	5.59	0.400	5
2015	0.300	8.14	0.400	7.33	0.300	5.85	0.400	5.55	0.300	5.56	0.400	5.26	0.300	5.59	0.400	5
2016	0.300	8.14	0.400	7.33	0.300	5.85	0.400	5.55	0.300	5.56	0.400	5.26	0.300	5.59	0.400	5
2017	0.300	8.15	0.400	7.33	0.300	5.85	0.400	5.55	0.300	5.56	0.400	5.26	0.300	5.59	0.400	5
2018	0.300	8.15	0.400	7.33	0.300	5.85	0.400	5.55	0.300	5.56	0.400	5.26	0.300	5.59	0.400	5
2019	0.300	8.15	0.400	7.33	0.300	5.85	0.400	5.55	0.300	5.56	0.400	5.26	0.300	5.59	0.400	5
2020	0.300	8.15	0.400	7.33	0.300	5.85	0.400	5.55	0.300	5.56	0.400	5.26	0.300	5.59	0.400	5

***Table 5b**. Spanish mackerel time trends in unweighted transitional spawning potential ratio (SPR) and directed yield (millions of pounds) from a*
projections of F30%SPR and F40%SPR.

	Gulf Spanish				Atlantic Spanish (No Bycatch)				Atlantic Spanish (Low Bycatch)				Atlantic Spanish (High Byca			
Year	SPR30	Yield30	SPR40	Yield40	SPR30	Yield30	SPR40	Yield40	SPR30	Yield30	SPR40	Yield40	SPR30	Yield30	SPR40	Y
1998	0.387	3.77	0.387	3.77	0.418	4.30	0.418	4.30	0.328	4.30	0.328	4.30	0.176	4.30	0.176	
1999	0.421	12.40	0.421	7.74	0.448	8.63	0.448	6.48	0.351	6.75	0.351	4.64	0.188	2.02	0.188	
2000	0.368	10.52	0.414	7.50	0.400	7.65	0.437	6.23	0.339	6.45	0.367	4.78	0.214	2.29	0.229	
2001	0.336	9.29	0.409	7.30	0.363	6.77	0.426	5.85	0.326	6.04	0.378	4.73	0.236	2.44	0.267	
2002	0.318	8.60	0.406	7.17	0.339	6.31	0.418	5.68	0.318	5.84	0.386	4.76	0.255	2.58	0.301	
2003	0.309	8.25	0.404	7.11	0.324	6.02	0.412	5.55	0.312	5.70	0.392	4.77	0.269	2.68	0.329	
2004	0.304	8.08	0.402	7.11	0.314	5.83	0.408	5.45	0.308	5.60	0.396	4.76	0.280	2.75	0.351	
2005	0.302	7.94	0.401	6.99	0.308	5.77	0.405	5.45	0.305	5.59	0.398	4.83	0.288	2.87	0.368	
2006	0.301	7.91	0.400	7.00	0.304	5.67	0.403	5.39	0.303	5.53	0.399	4.82	0.292	2.90	0.380	
2007	0.300	7.89	0.400	6.98	0.302	5.58	0.401	5.29	0.301	5.43	0.399	4.72	0.295	2.85	0.388	
2008	0.300	7.88	0.400	6.97	0.301	5.59	0.401	5.34	0.301	5.47	0.400	4.81	0.299	2.96	0.396	
2009	0.300	7.88	0.400	6.97	0.300	5.56	0.400	5.29	0.300	5.43	0.400	4.77	0.299	2.94	0.398	
2010	0.300	7.88	0.400	6.98	0.300	5.55	0.400	5.29	0.300	5.42	0.400	4.77	0.300	2.95	0.400	

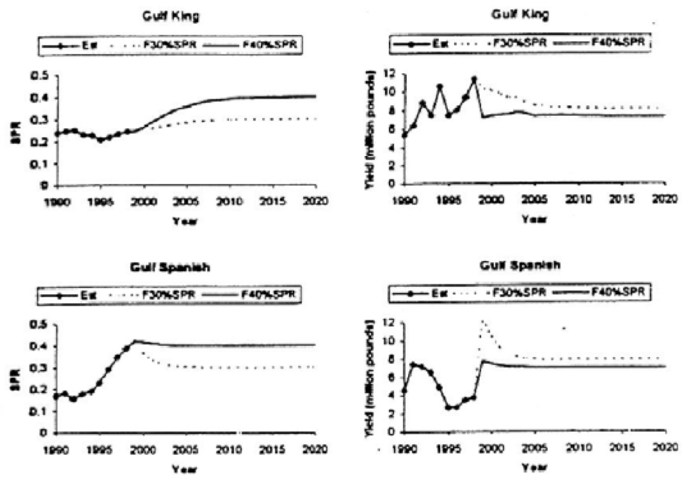

Figure 4a. Gulf deterministic time trends in SPR and yield.

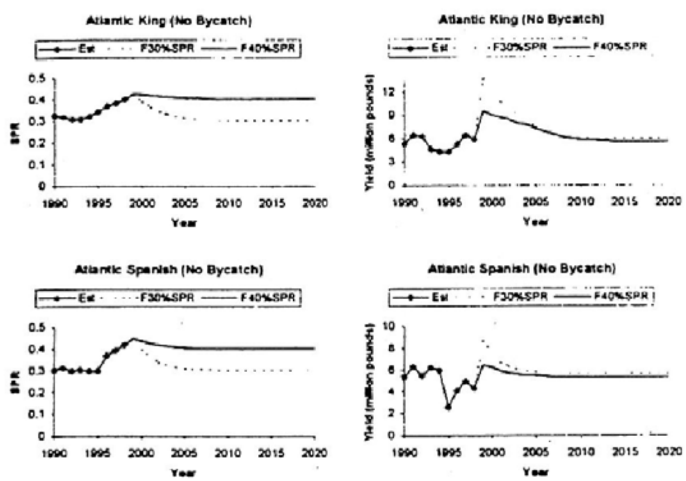

Figure 4b. Atlantic no bycatch deterministic time trends in SPR and yield.

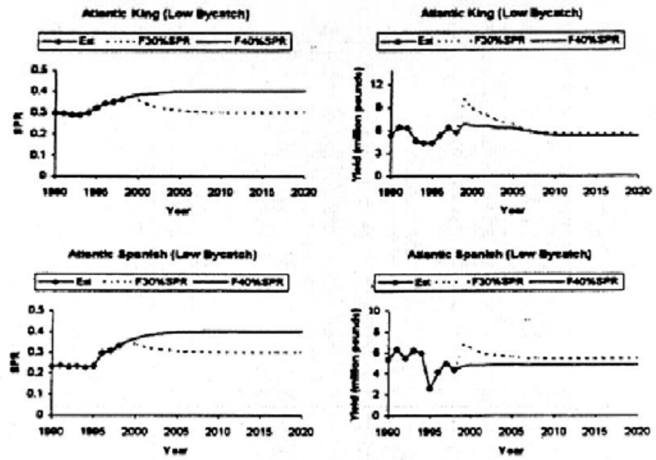

***Figure** 4c. Atlantic low bycatch deterministic time trends.*

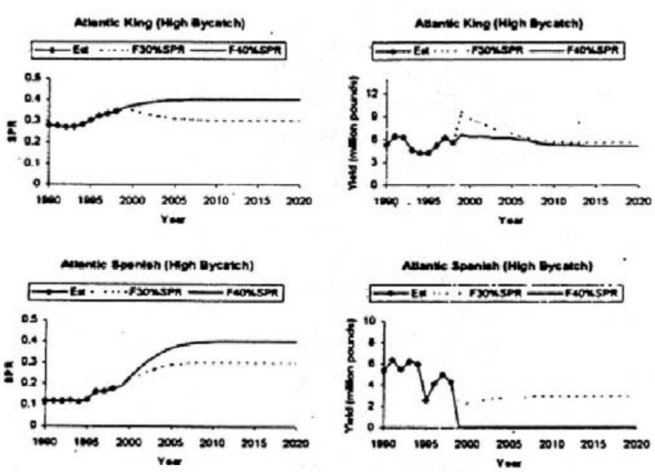

***Figure** 4d. Atlantic high bycatch deterministic time trends.*

***Table 6.** Median recruitment (millions of fish) estimated by VPA for each of the mackerel migratory groups. Group definitions as in table 3. Summary statistics given at the bottom are the arithmetic average over all years (avg all), arithmetic average over the five highest recruitments (avg 5 hi) and maximum recruitment estimated (max).*

Year	GK	GS	AK NB	AS NB	AK LB	AS LB	AK HB	AS HB
81	2.37		1.04		1.12		1.27	
82	1.73		1.10		1.18		1.34	
83	1.35		1.37		1.42		1.61	
84	2.39	14.92	1.79	7.55	1.85	10.26	2.05	21.64
85	2.20	17.70	2.37	11.06	2.38	13.77	2.64	25.19
86	2.13	12.01	1.80	11.44	1.86	14.17	2.06	25.66
87	3.97	8.98	1.40	7.93	1.35	10.64	1.68	22.01
88	3.21	10.02	1.18	9.26	1.94	11.93	1.51	23.32
89	5.02	18.09	2.70	7.82	2.38	10.52	2.87	21.90
90	3.63	20.32	5.11	11.20	4.34	13.92	4.96	25.37
91	4.50	13.32	2.64	9.70	2.34	12.38	2.63	23.81
92	4.08	19.77	2.18	7.38	2.01	10.14	2.09	21.48
93	5.70	14.04	1.99	13.93	1.72	16.72	1.90	28.34
94	4.87	13.93	2.27	13.40	2.06	16.12	2.03	27.74
95	6.09	14.06	4.43	5.62	3.80	8.30	4.33	19.58
96	3.11	13.28	4.73	13.58	4.07	16.39	4.57	27.62
avg all	3.52	14.65	2.38	9.99	2.24	12.71	2.47	24.13
avg 5 hi	5.24	18.16	3.92	12.71	3.39	15.46	3.87	26.94
max	6.09	20.32	5.11	13.93	4.34	16.72	4.96	28.34

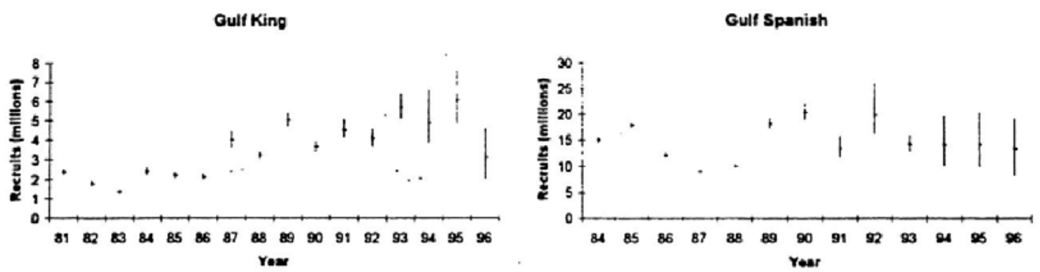

***Figure 5a.** Gulf recruitment, median and 80% confidence intervals.*

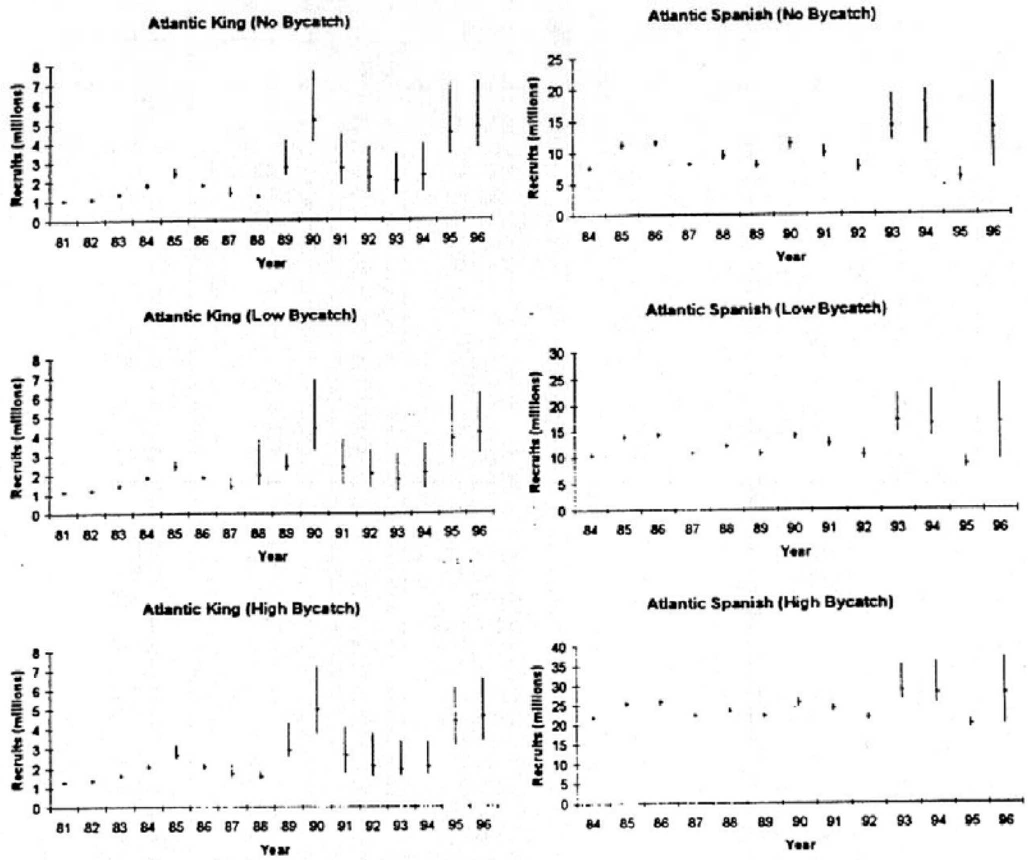

Figure 5b. Atlantic recruitment, median and 80% confidence intervals.

***Table** 7. Long term potential yield per recruit (pounds), associated spawning stock per recruit and directed fishing mortality multiplier under two management schemes ($F_{30\%SPR}$ and $F_{40\%SPR}$) and a range of bycatch reduction levels (0=status quo to 1=no shrimp trawl bycatch).*

		F30%SPR			F40%SPR		
Group	bycreduc	LTPY/R	SS/R	F	LTPY/R	SS/R	F
Gulf King	0	2.4011	1.5207	0.2950	2.0908	2.0275	0.1905
	0.25	2.5783	1.5207	0.3171	2.2854	2.0275	0.2088
	0.5	2.7624	1.5207	0.3402	2.4870	2.0275	0.2278
	0.75	2.9538	1.5207	0.3641	2.6959	2.0275	0.2475
	1	3.1530	1.5207	0.3890	2.9126	2.0275	0.2678
Gulf Spanish	0	0.5045	1.2836	0.4413	0.4246	1.7114	0.2440
	0.25	0.5722	1.2836	0.5222	0.5085	1.7114	0.3048
	0.5	0.6417	1.2836	0.6111	0.5942	1.7114	0.3713
	0.75	0.7132	1.2836	0.7086	0.6819	1.7114	0.4442
	1	0.7867	1.2836	0.8155	0.7718	1.7114	0.5241
Atlantic King (No Bycatch)	0	3.1713	1.5595	0.4179	3.0133	2.0793	0.2758
	0.25	3.1713	1.5595	0.4179	3.0133	2.0793	0.2758
	0.5	3.1713	1.5595	0.4179	3.0133	2.0793	0.2758
	0.75	3.1713	1.5595	0.4179	3.0133	2.0793	0.2758
	1	3.1713	1.5595	0.4179	3.0133	2.0793	0.2758
Atlantic Spanish (No Bycatch)	0	0.5993	1.2836	0.3998	0.5708	1.7114	0.2882
	0.25	0.5993	1.2836	0.3998	0.5708	1.7114	0.2882
	0.5	0.5993	1.2836	0.3998	0.5708	1.7114	0.2882
	0.75	0.5993	1.2836	0.3998	0.5708	1.7114	0.2882
	1	0.5993	1.2836	0.3998	0.5708	1.7114	0.2882
Atlantic King (Low Bycatch)	0	3.0097	1.5595	0.4038	2.8431	2.0793	0.2662
	0.25	3.0423	1.5595	0.4091	2.8791	2.0793	0.2703
	0.5	3.0751	1.5595	0.4144	2.9154	2.0793	0.2744
	0.75	3.1081	1.5595	0.4198	2.9518	2.0793	0.2785
	1	3.1413	1.5595	0.4252	2.9885	2.0793	0.2827
Atlantic Spanish (Low Bycatch)	0	0.4473	1.2836	0.3010	0.3932	1.7114	0.1991
	0.25	0.4842	1.2836	0.3253	0.4364	1.7114	0.2210
	0.5	0.5224	1.2836	0.3503	0.4809	1.7114	0.2434
	0.75	0.5618	1.2836	0.3760	0.5266	1.7114	0.2663
	1	0.6026	1.2836	0.4023	0.5736	1.7114	0.2898
Atlantic King (High Bycatch)	0	2.7768	1.5595	0.3326	2.5817	2.0793	0.2182
	0.25	2.8598	1.5595	0.3442	2.6740	2.0793	0.2274
	0.5	2.9442	1.5595	0.3560	2.7676	2.0793	0.2368
	0.75	3.0302	1.5595	0.3681	2.8627	2.0793	0.2464
	1	3.1177	1.5595	0.3805	2.9592	2.0793	0.2561
Atlantic Spanish (High Bycatch)	0	0.1244	1.2836	0.0833	0.0012	1.7114	0.0006
	0.25	0.2290	1.2836	0.1545	0.1312	1.7114	0.0657
	0.5	0.3426	1.2836	0.2315	0.2682	1.7114	0.1356
	0.75	0.4682	1.2836	0.3153	0.4162	1.7114	0.2109
	1	0.6088	1.2836	0.4071	0.5790	1.7114	0.2929

(18)

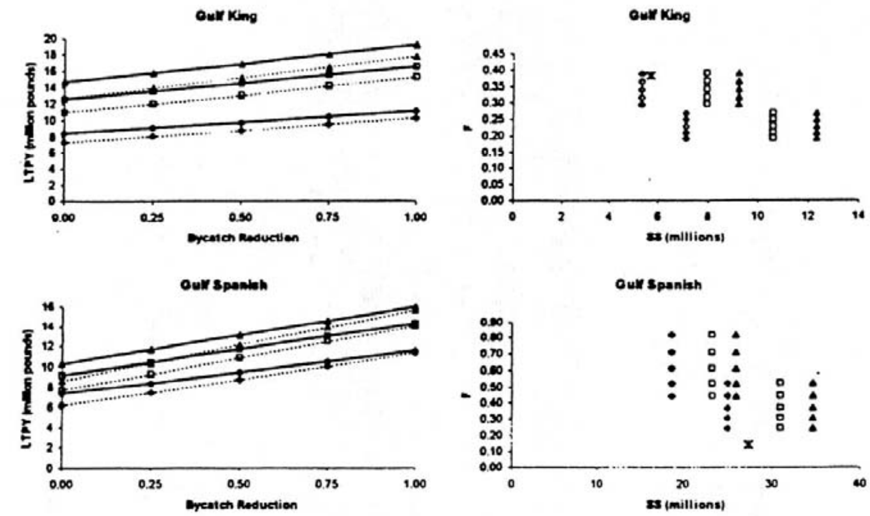

Figure 6a. Gulf long term potential yield and associated fishing mortality rate and spawning stock. Diamonds=average recruitment over all years, squares=average of 5 highest recruitments, triangles=maximum recruitment. Left panel: solid lines=F30%SPR, dashed lines=F40%SPR. Right panel: five vertical symbols show bycatch reduction (lowest F=status quo, highest F=no bycatch); upper left groups of five symbols=F30%SPR, lower right groups of five symbols=F40%SPR; asterick denotes current conditions (F98 and SS99).

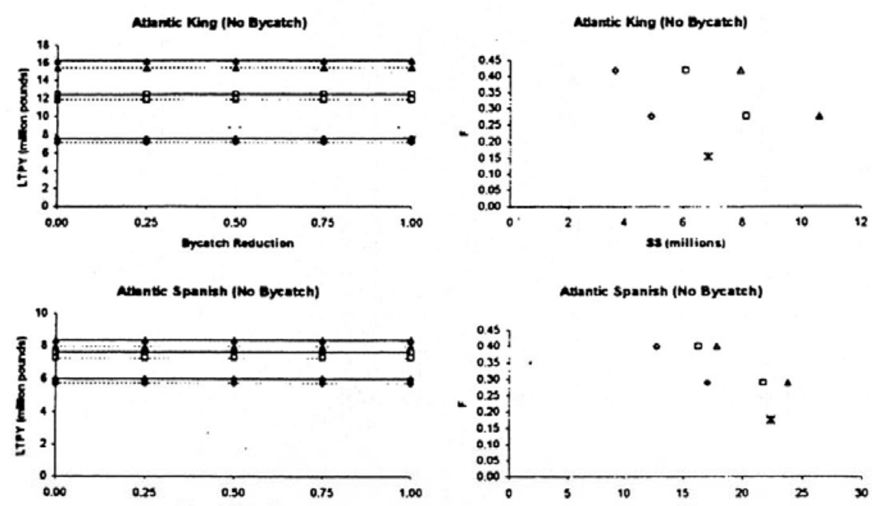

Figure 6b. Atlantic no bycatch long term potential yield, F and spawning stock. Symbols as in figure 6a.

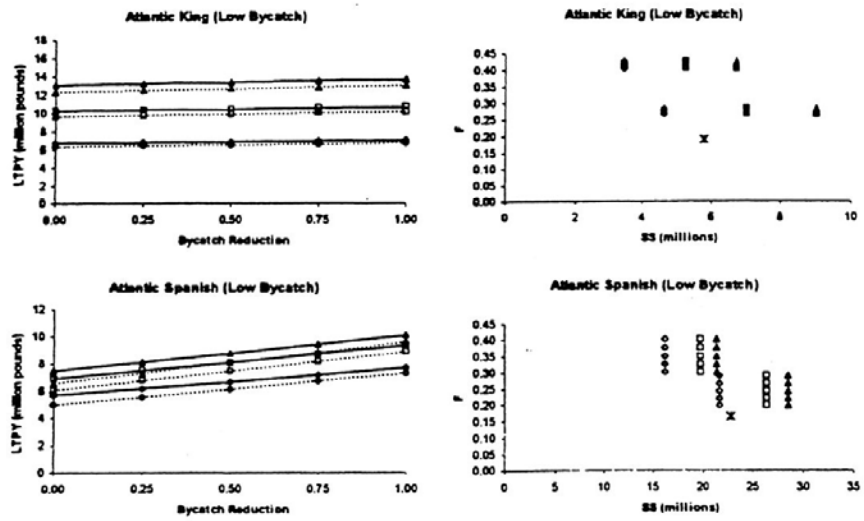

Figure 6c. *Atlantic low bycatch long term potential yield, F and spawning stock. Symbols as in figure 6a.*

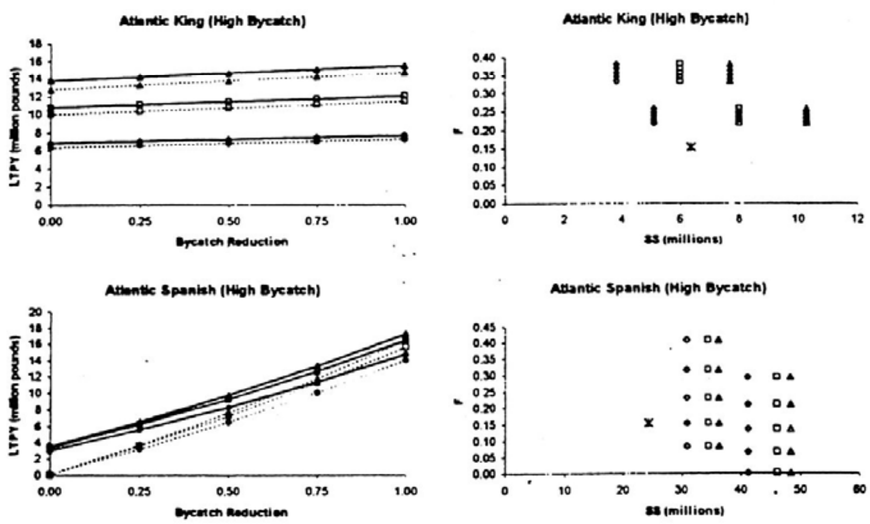

Figure 6d. *Atlantic high bycatch long term potential yield, F and spawning stock. Symbols as in figure 6a.*

Table 8. Percentage of 400 mixed bootstrap/Monte Carlo assessments resulting in classification of stocks as overfishing or overfished under specific long term potential yield calculations. Gulf groups use F30%SPR, Atlantic groups use F40%SPR. Gulf king uses 50% bycatch reduction, gulf Spanish uses 25% bycatch reduction, Atlantic groups with bycatch use 50% bycatch reduction. All use average of 5 highest median recruitments for future recruitment. Group acronyms as in figure 3.

Status	GK	GS	AK NB	AS NB	AK LB	AS LB	AK HB	AS HB
Overfishing	65%	0%	0%	1%	3%	7%	3%	54%
Overfished	93%	25%	78%	45%	73%	74%	78%	99%

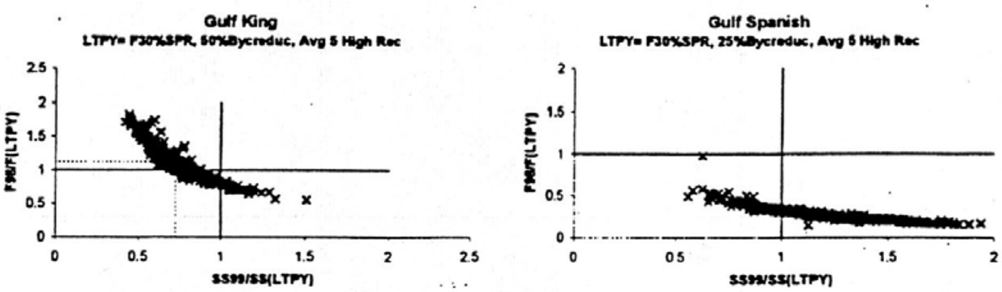

Figure 7a. Gulf ratios of current to long term potential yield fishing mortality and spawning stock from 400 mixed bootstrap/Monte Carlo assessments. Solid lines denote limits for overfishing (F ratio) and overfished (SS ratio). Dotted lines denote point estimate.

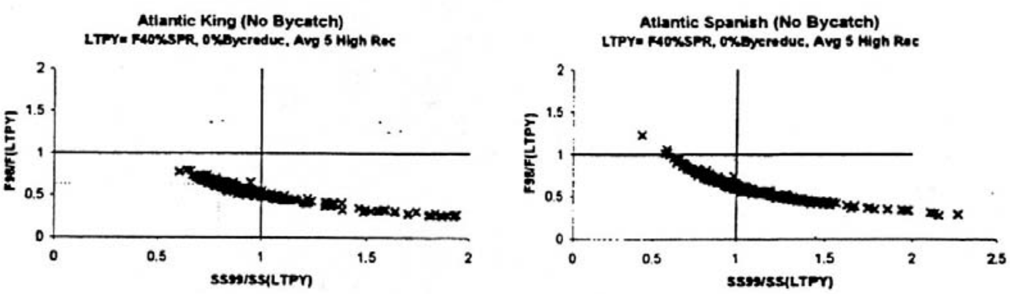

Figure 7b. Atlantic no bycatch current to LTPY ratios of F and SS. Lines as in figure 7a.

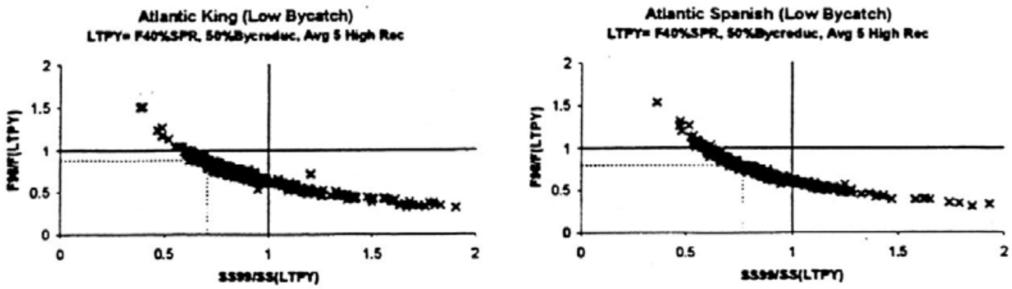

Figure 7c. Atlantic low bycatch current to LTPY ratios of F and SS. Lines as in figure 7a.

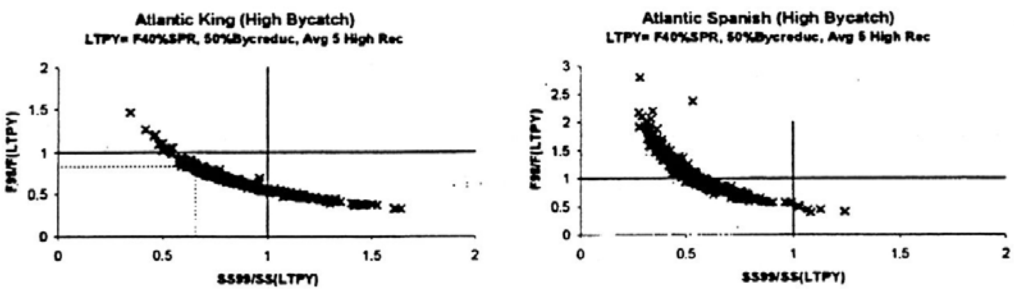

Figure 7d. Atlantic high bycatch current to LTPY ratios of F and SS. Lines as in figure 7a.

Stock Recruitment Relationships

Examination of all stock recruitment plots from the deterministic cases led to the conclusion that there is not enough regression range to fit only one curve through the observations, many highly different curves could provide equally good fits. Spawning stock was defined as the sum of population abundance at age times the relative fecundity at age values that have been used in the past few stock assessments. Since the fecundity functions are relative, the spawning stock has no units. For this reason, a range of possible relationships was examined using the Shepherd (1982) equation

$$R = \frac{\alpha S}{1 + \left(\frac{S}{\kappa}\right)^{\beta}}$$

where R and S denote the recruits and spawning stock values, respectively, and α, β, and κ are parameters to be fit. Note that when β is 1.0, the Beverton and Holt stock recruitment relationship results. When $\beta>1$, recruitment has a maximum then decreases with increasing stock size, as in the Ricker stock recruitment relationship. In order to examine a range of plausible stock recruitment relationships 4 cases were examined by fixing the values of β and κ then solving for the values of α to give the best fit to the observations (Figure 8). The κ values were chosen based on multiples of the maximum observed stock size such that for the Ricker-like stock recruitment relationship, the maximum recruitment occurred at either the maximum observed stock size or twice that amount. These four combinations of β and κ produced curves that either maximized at approximately the maximum observed recruitment levels or else allowed higher values of recruitment to occur as the spawning stocks increased in size. The different levels of bycatch in the Atlantic migratory groups raised or lowered the estimated recruitment levels but did not impact the spawning stock estimates or the trend in the stock recruitment observations.

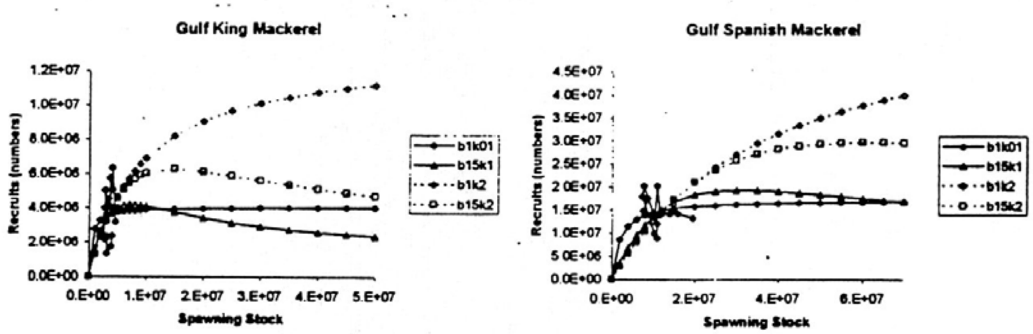

Figure 8a. Gulf stock recruitment relationships. Filled diamonds denote estimated stock and recruitment values from the deterministic VPA, open symbols denote fitted Shepherd curves fixing beta at 1.0 or 1.5 and kappa at the maximum estimated stock size, one tenth this value, or twice the maximum value.

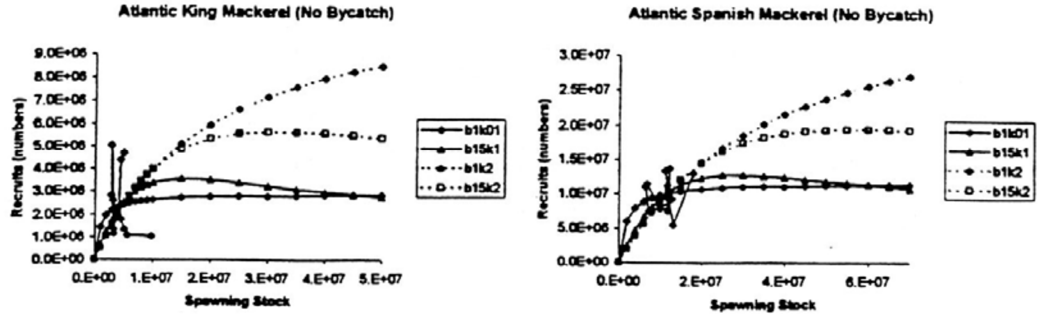

Figure 8b. Atlantic no bycatch stock recruitment relationships. Symbols as in figure 8a.

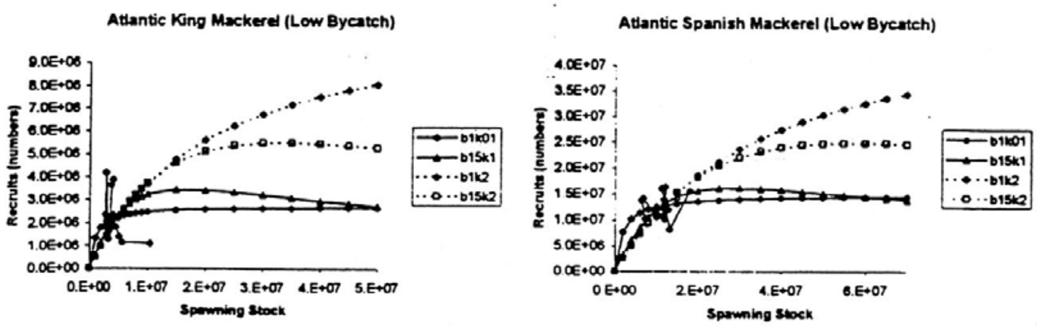

Figure 8c. Atlantic low bycatch stock recruitment relationships. Symbols as in figure 8a.

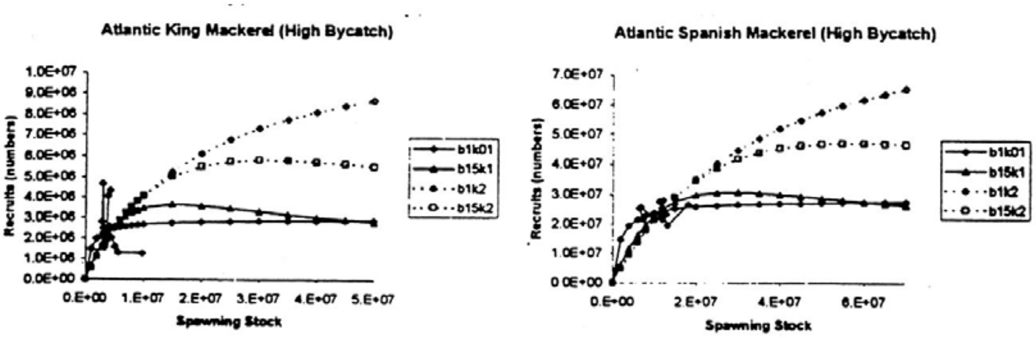

Figure 8d. Atlantic high bycatch stock recruitment relationships. Symbols as in figure 8a.

Maximum Sustainable Yield

Calculation of maximum sustainable yield (MSY) required a slightly different approach than long term potential yield. For any value of recreational fishing mortality multiplier, the commercial fishing multiplier that generated the desired proportion of total yield to the recreational fishery was determined. The recreational fishing mortality multiplier was changed until the maximum equilibrium total yield was achieved. Equilibrium total yield was determined by first determining the yield per recruit (Y/R) and spawners per recruit (S/R) for a given recreational (and associated commercial) F multiplier. This S/R and the stock recruitment relationship (rearranged to make S a function of S/R: $S=\kappa[\alpha(S/R)-1]^{1/\beta}$) determine the equilibrium spawning stock and recruitment. This equilibrium recruitment multiplied by the corresponding equilibrium yield per recruit generated the equilibrium total yield for the particular recreational F multiplier. The fishing mortality rate at MSY (F_{MSY}) was determined by the maximum total directed F at age (commercial plus recreational). Since overall selectivity changes with changes in commercial and recreational F multipliers, the F_{MSY} are not directly comparable among different stock recruitment relationships.

The deterministic VPA results were used along with the four stock recruitment curves described above to generate values of MSY, spawning stock at MSY (SS_{MSY}), and F_{MSY} for each of the mackerel migratory groups. In addition to the natural mortality value used in the deterministic VPA, the minimum and maximum natural mortality rates were applied in the calculation of MSY related parameters for comparison purposes. This use of different M values is not entirely correct because the selectivity patterns estimated in a VPA would change under different M, but are provided here to demonstrate the direction and magnitude of expected changes in MSY related parameters (Table 9 and Figure 9). In all cases, lower M caused increased MSY and SS_{MSY}. In general, the Beverton and Holt curves produced the extreme values for MSY, SS_{MSY} and F_{MSY}, with the Ricker-like curves intermediate, although high M values sometimes broke this pattern. Since all four stock recruitment relationships fit the estimated stock and recruitment points about equally well, there is no statistical basis to choose any one of the four as a "best" fit. In fact, many other stock recruitment relationships could be fit to the data equally well and provide an even wider range for MSY related parameters. Until stock sizes are allowed to increase enough to allow reasonable estimation of the stock recruitment relationship, the calculation of MSY related parameters will be highly uncertain.

As with the long term potential yield calculations, the bootstrap specific ratios of current to MSY fishing mortality and spawning stock can be computed. The choice of stock recruitment relationship determines the overfishing and overfished classification almost completely, even considering the uncertainty in the estimates (Figure 10). For this reason, the ratio graphs for all migratory groups are not shown.

Table 9. *Maximum sustainable yield (MSY), spawning stock at MSY (SS_{MSY}) and fishing mortality rate at MSY (F_{MSY}) under three levels of natural mortality and four stock recruitment relationships for each of the mackerel migratory groups. Stock recruitment curves use same legend as in figure 8.*

	MSY (million pounds)				SS_{MSY} (millions)				F_{MSY}			
M	b1k01	b15k1	b1k2	b15k2	b1k01	b15k1	b1k2	b15k2	b1k01	b15k1	b1k2	b15k2
Gulf King												
0.15	14.90	16.48	36.78	24.18	7.60	7.17	30.09	12.76	0.367	0.431	0.225	0.354
0.20	10.58	11.69	21.47	16.22	4.25	5.51	17.64	9.61	0.468	0.398	0.226	0.315
0.25	7.71	7.89	11.84	10.07	2.64	4.28	10.72	7.23	0.548	0.346	0.206	0.260
Gulf Spanish												
0.25	11.39	13.71	28.72	20.53	24.48	28.32	89.65	48.40	0.525	0.557	0.316	0.461
0.30	9.01	10.79	19.86	15.52	17.82	23.33	64.08	39.41	0.624	0.550	0.322	0.441
0.35	7.23	8.33	13.42	11.37	13.35	19.36	46.23	32.12	0.721	0.523	0.313	0.404
Atlantic King No Bycatch												
0.10	11.40	15.22	30.03	22.99	8.50	12.10	35.75	21.13	0.234	0.215	0.128	0.179
0.15	7.35	8.84	13.36	12.05	4.59	8.27	18.38	13.91	0.312	0.191	0.120	0.148
0.20	4.90	4.40	4.74	4.84	2.78	5.54	8.99	8.55	0.367	0.144	0.091	0.098
Atlantic Spanish No Bycatch												
0.25	7.70	9.10	18.20	13.37	19.97	24.06	75.24	41.40	0.333	0.327	0.209	0.279
0.30	6.14	7.10	12.49	9.99	14.51	19.97	54.05	33.91	0.363	0.307	0.200	0.255
0.35	4.95	5.42	8.34	7.20	10.91	16.68	39.16	27.76	0.386	0.280	0.185	0.224
Atlantic King Low Bycatch												
0.10	9.99	13.80	25.85	20.56	7.84	12.04	33.05	20.82	0.228	0.200	0.123	0.166
0.15	6.32	7.59	10.64	9.99	4.24	8.05	16.44	13.28	0.295	0.170	0.110	0.131
0.20	4.11	3.39	3.17	3.31	2.56	5.16	7.38	7.54	0.338	0.121	0.075	0.077
Atlantic Spanish Low Bycatch												
0.25	7.61	8.98	17.83	13.16	19.61	23.81	73.85	40.94	0.335	0.326	0.208	0.278
0.30	6.06	7.00	12.20	9.80	14.24	19.75	53.00	33.51	0.366	0.306	0.199	0.253
0.35	4.89	5.33	8.11	7.04	10.71	16.48	38.34	27.39	0.389	0.278	0.183	0.222
Atlantic King High Bycatch												
0.10	10.07	13.56	25.93	20.34	7.79	11.55	32.60	20.06	0.216	0.191	0.117	0.159
0.15	6.44	7.63	11.03	10.19	4.21	7.79	16.46	12.97	0.279	0.165	0.106	0.128
0.20	4.25	3.56	3.54	3.67	2.55	5.09	7.69	7.63	0.319	0.120	0.076	0.079
Atlantic Spanish High Bycatch												
0.25	7.57	8.94	17.59	13.06	19.26	23.61	72.68	40.59	0.340	0.328	0.209	0.278
0.30	6.03	6.95	12.00	9.70	13.98	19.59	52.12	33.20	0.371	0.306	0.200	0.253
0.35	4.87	5.28	7.95	6.93	10.51	16.34	37.64	27.10	0.394	0.278	0.183	0.221

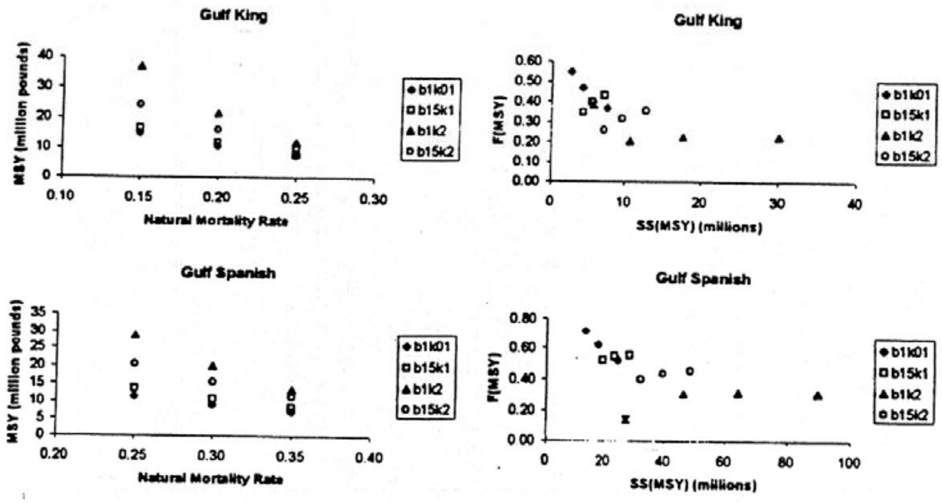

Figure 9a. Gulf maximum sustainable yield (MSY) from deterministic VPA output under different levels of natural mortality (left panels) and F and spawning stock at MSY under three levels of natural mortality (right panels). Symbol legends as in figure 8. Asterisk denotes current location (F98, SS99).

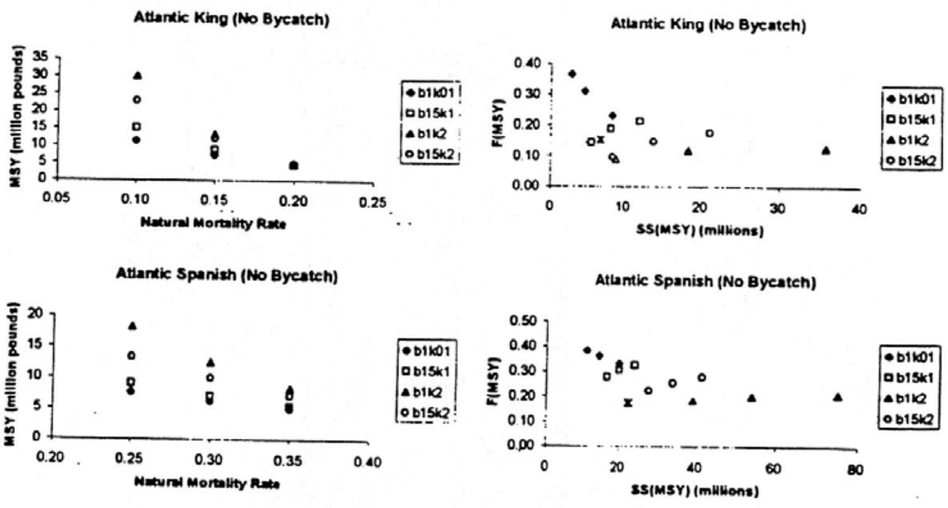

Figure 9b. Atlantic no bycatch MSY related parameters. Symbols as in figure 9a.

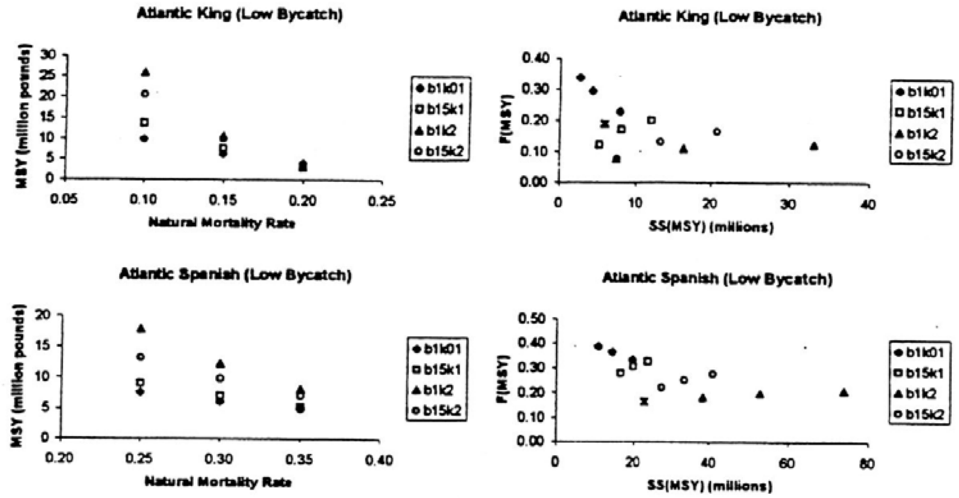

Figure 9c. Atlantic low bycatch MSY related parameters. Symbols as in figure 9a.

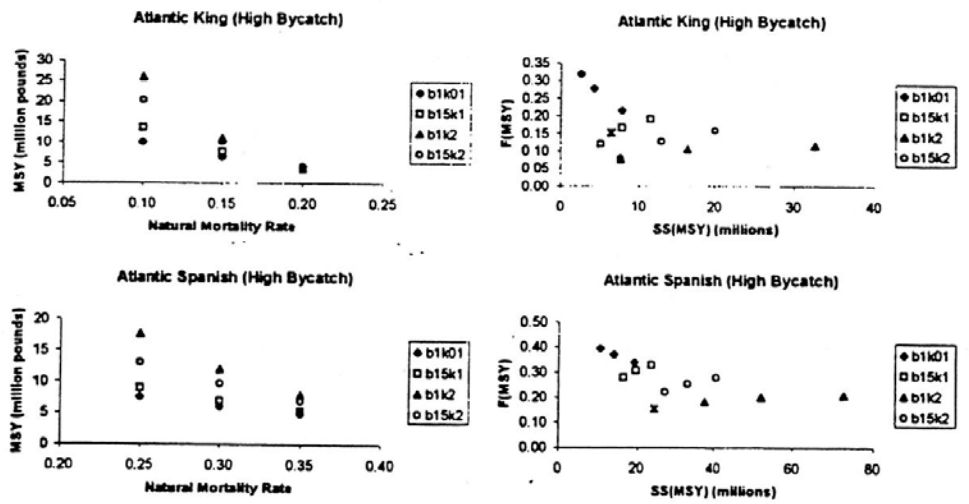

Figure 9d. Atlantic high bycatch MSY related parameters. Symbols as in figure 9a.

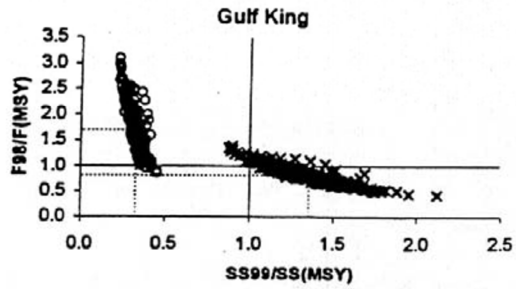

Figure 10. Gulf king mackerel ratios of current F and spawning stock to FMSY and SSMSY under two stock recruitment relationships (circles b1k2, crosses b1k01).

Recovery of Gulf of Mexico King Mackerel

The recovery of Gulf of Mexico king mackerel was examined in further detail using all 400 mixed bootstrap/Monte Carlo assessment results. Future catches were either calculated from the fishing mortality rate to generate a given spawning potential ratio or else held constant. The constant catches corresponded to the 16, 50 and 84 percentiles of the 1999/2000 fishing season bias corrected allowable biological catch distributions under $F_{30\%SPR}$ and $F_{40\%SPR}$. Future recruitment was projected as constant at two separate levels: the arithmetic average of medians over all years and the arithmetic average of the five largest median recruitments. Thus, a total of 16 stochastic recovery trajectories were examined.

The projection of F30%SPR and F40%SPR caused the unweighted transitional SPR to quickly reach the associated static value and had low levels of uncertainty under either recruitment (Figure 11a). Note that in the left panel of figure 11a the lines from the two levels of recruitment are indistinguishable. The associated yield trajectories also reached equilibrium by the year 2020, with low levels of uncertainty at that point, but go through a transitional period of higher levels of uncertainty (Figure 11b). Note that the level of future recruitment has a larger impact on equilibrium yield than does the choice of 30 or 40%SPR in this particular example.

The projection of constant catches greater levels of uncertainty in the unweighted transitional spawning potential ratio, but had zero uncertainty about the annual yield, except when the stock crashed (Figure 12). The year in which the median SPR crossed the 30% line depends upon both the level of constant catch and the level of projected future recruitment (Table 10). Recovery did not occur in two cases, 10.5 and 12.9 million pound catch with average recruitment.

Table 11. *Year in which the median unweighted transitional SPR becomes greater than 0.30 under given constant catches (TAC) and level of recruitment for Gulf king mackerel. The first two columns show how the TAC were chosen: the management scheme used to set the 1999/2000 fishing year ABC and the bias corrected percentile of that ABC distribution.*

%SPR	Percentile	TAC	Avg R	High R
40	16	5.8	2001	2001
40	50	7.4	2002	2002
40	84	9.1	2004	2003
30	16	8.5	2003	2003
30	50	10.5	N/A	2006
30	84	12.9	N/A	2016

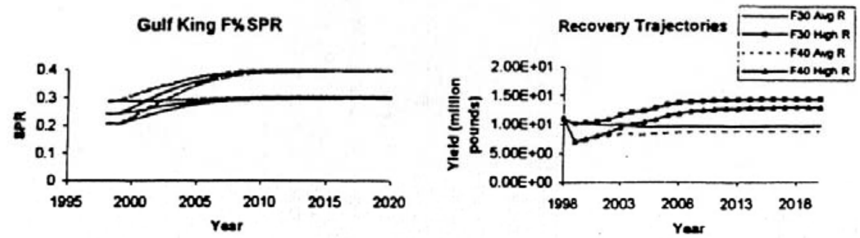

Figure 11a. *Unweighted transitional spawning potential ratio medians and 80% confidence intervals for Gulf king mackerel under projection of F30%SPR and F40%SPR under two levels of recruitment (left panel) and associated median yields (right panel).*

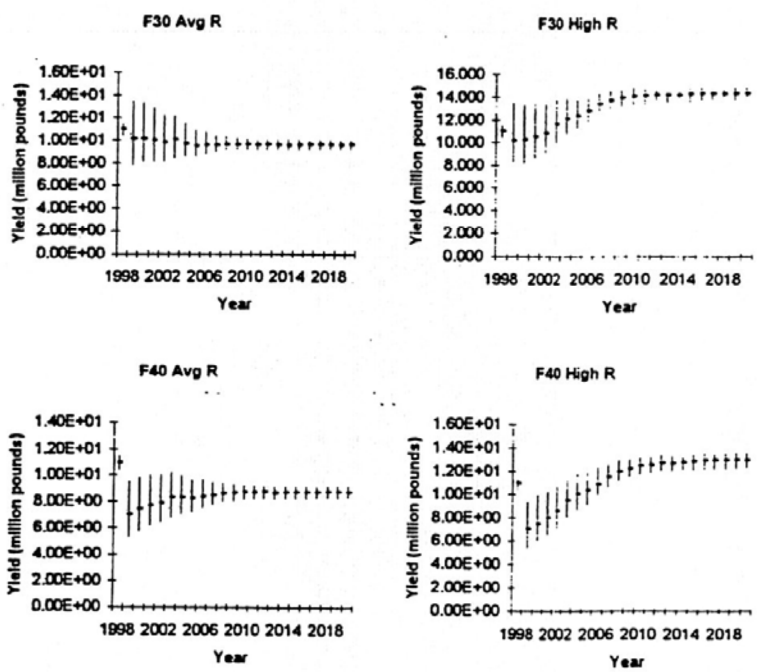

Figure 11b. *Median and 80% confidence intervals for Gulf king mackerel yield under four combinations of projected F%SPR and recruitment level.*

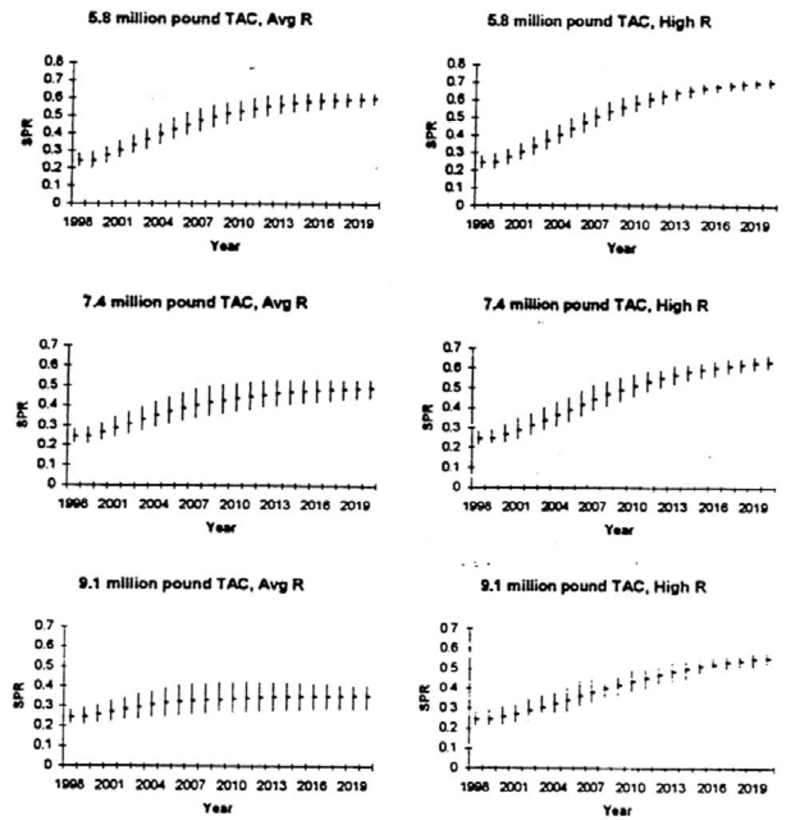

Figure 12a. *Median and 80% confidence intervals for Gulf king mackerel under projections of constant catches associated with $F_{40\%SPR}$ (see table 11) under two levels of recruitment.*

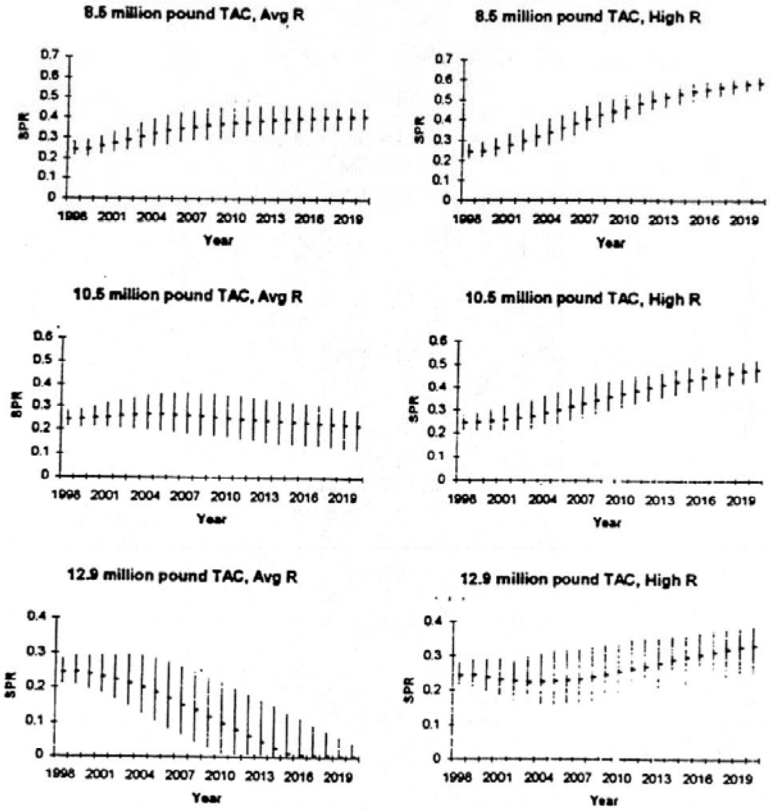

Figure 12b. Median and 80% CI for Gulf king mackerel under projections of constant catches associated with $F_{30\%SPR}$ (see table 11) under two levels of recruitment.

Literature Cited

Legault, C.M. 1999. Simulation study of percentile and bias corrected percentile confidence intervals for allowable biological catch. NMFS-SEFSC-SFD Contribution SFD-98/99-48. MSAP/99/??. 9 p.

Legault, C. M., N. Cummings, and P. Phares. 1998. Stock assessment analyses on Atlantic migratory group king mackerel, Gulf of Mexico migratory group king mackerel, Atlantic migratory group Spanish mackerel, and Gulf of Mexico migratory group Spanish mackerel. MSAP/98/09. NMFS Miami Laboratory Contribution MIA-97/98-15. Miami, Florida. 90 p. + appendices.

Shepherd, J.G. 1982. A versatile new stock-recruitment relationship for fisheries, and the construction of sustainable yield curves. J. Cons. int Explor. Mer. 40: 67-75.

Vaughan, D.S. and J.M. Nance. 1998. Estimates of bycatch of mackerel and cobia in U.S. south Atlantic shrimp trawls. MSAP/98/04. 25p.

Appendix A: **Landings estimates for FY 97/98 and projected FY 98/99**

Recreational landings (numbers of fish)

Note: Estimates for 1998-1999 headboat, 1998-1999 tpwd, and 10/98-6/99 mrfss are not available so substitutes for past and anticipated catches have been made. The available 1998 mrfss estimates are preliminary. TPWD does not estimate shore mode; the substitute used in assessments for Spanish mackerel is: shore=1.02*<boats, wave total>.

(1) king Atlantic FY1997/98

mrfss	4/97 - 12/97:	481749
mrfss	1/98 - 3/98:	15025
Hbt	4/97 - 3/98 (use 1-12/1997 = most recent 12-month est.)	18708
		515482

(2) king Atlantic FY1998/99

mrfss	4/98-12/98:	402682
mrfss	1-3/99 (use 1-3/1998 as sub):	15025
Hbt	4/98 - 3/99 (use 1-12/1997 = most recent 12-month est.)	18708
		436415

(3) king Gulf FY1997/98

mrfss	7-12/97:	334203
mrfss	1-6/98:	282600
Hbt	7/97- 6/98 (use 1-12/97 = most recent 12-month est.):	41833
tpwd	"	33739
		692375

(4) king Gulf FY1998/99

mrfss	7-12/98:	220195
mrfss	1-6/99 (use 1-6/98):	282600
Hbt	7/98- 6/99 (use 1-12/97 = most recent 12-month est.):	41833
tpwd	"	33739
		578367

(5) Spanish Atlantic FY 1997/98

mrfss	4-12/97:	985724
mrfss	1-3/98:	63315
Hbt	4/97- 3/98 (use 1-12/97 = most recent 12-month est.):	2511
		1051550

(6) Spanish Atlantic FY 1998/999

mrfss	4-12/98:	534894
mrfss	1-3/99 (use 1-3/98):	63315
Hbt	4/98- 3/99 (use 1-12/97 = most recent 12-month est.):	2511
		600720

(7) Spanish Gulf FY 1997/98

mrfss	4-12/97:	1076157
mrfss	1-3/98:	68672
Hbt	4/97- 3/98 (use 1-12/97 = most recent 12-month est.):	848
tpwd	4/97- 3/98 (use 1-12/97 = most recent 12-month est., plus shore=1.02*<boats, wave total>):	23063
		1168740

(8) Spanish Gulf FY 1998/99

mrfss	4-12/98:	1059722
mrfss	1-3/99 (use 1-3/98):	68672
Hbt	4/98- 3/99 (use 1-12/97 = most recent 12-month est.):	848
tpwd	4/98- 3/99 (use 1-12/97 = most recent 12-month est., plus shore=1.02*<boats, wave total>):	23063
		1152305

Commercial landings (pounds)
FY1997/98 landings for southeast states are from the Accumulated Landings (on sefhost), as of 2/17/99.
FY1997/98 landings for northeast states are from the NE landings files (accessed by Josh Bennett), as of 2/10/99.
FY1998/99 landings for southeast and northeast states are from quota monitoring reports compiled by Linda Hardy (NMFS Beaufort) for Atlantic groups and Mark Godcharles (NMFS Regional Office) for Gulf groups and/or reports from FL.DEP, as well as personal communication with Linda and Mark.

(1) king Atlantic FY1997/98

southeast 4/97-3/98:	2662223
northeast 4/97-3/98:	15571
	2677794

(2) king Atlantic FY1998/99

4/98-3/99 (96.3% of quota as of 2/16/99, use 100%*quota as estimate):	**2520000**

(3) king Gulf FY1997/98

7/97-6/98:	**3159578**

(4) king Gulf FY1998/99

Report from Mark Godcharles 2/24/99, plus personal communication (to get best guess of what is not yet reported, based on current fishing activity): **3600000**

Western zone =	1.0 (closed 8/25 at 93% = .98)
Western subzone, gillnet =	1.0 (closed at 171% = 1.0)
Western subzone, H&L=	0.6 (quota=0.585, already reached 87% with incomplete reporting)
East coast subzone =	1.0 (quota=1.17, currently 61%=.71 with incomplete reporting)
	3.6

(5) Spanish Atlantic FY1997/98

southeast 4/97-3/98:	2837612
northeast 4/97-3/98:	219233
	3056845

(6) Spanish Atlantic FY1998/99

Personal communication with Linda Hardy, 2/24/99: current total is 3175749. Quota is 4 million.
Unlimited net fishing is over (2/2-2/9)
Fishing with 1500 lb/day limit is going on but landings are low. Quota probably will not be met. Last year's quota monitoring report was several hundred thousand lbs over the figures now in the landings files (for FY 97/98), and last year's estimate of 4 million (=quota) is not supported by the current "official" figures from the landings files.

Guess for 98/99:	**3200000**

(7) Spanish Gulf FY1997/98

4/97-3/98:	**331342**

(8) Spanish Gulf FY1998/99 **460000**

4/98-1/99 from FDEP:	211,529
2-3/98 from FDEP sub for 1999	+30,000
	240,529 for FLW
From ALS (sub previous year if unavailable)	+221,951 AL-LA

Appendix B: **Shrimp trawl bycatch of king and Spanish mackerel in the Gulf of Mexico** (text excerpted from email from S. Nichols to C. Legault dated February 11, 1999, relating to bycatch estimates for Cobia, king mackerel and Spanish mackerel.)

The Excel file contains annual summary statistics for cobia, king mackerel, and Spanish mackerel, each on a separate sheet. The columns are the multiple cases, some of which have been sent in the past, but there are a few new ones. Labels refer to which sets of observer data were used in the estimates. (All GLM estimates use time series of Oregon II data as well.)

OLD — GLM estimates based only on 1972-1982 observer data

NEW — GLM estimates based only on 1992-1998 observer data (nets without BRDs)

ALL — GLM estimates based on both the old and new data

BRD — GLM estimates based on observer data where legal BRDs were in use, ie estimates what bycatch would have been had BRDs been in use throughout the time series. Observer data without BRDs not included in this model.

NoBRD — GLM estimate from model including both BRD and non-BRD data, differentiated as separate data sets, ie 3 sets - research vessel, commerical with BRD, commercial without BRD treated as levels of main effect 'Dataset' in single GLM model. NoBRD is the set of estimates if all vessels fished without BRDs each year.

WithBRD — Estimates from same '3 levels for dataset' model as NoBRD, for case had all vessels fished with BRDs each year.

ACT — Best estimate of actual bycatch. Data from NoBRD estimate prior to 1998. For 1998, WithBRD estimates used for areas, seasons that had BRD requirement, NoBRD otherwise. No allowance is made for incomplete compliance, etc. These should match the numbers in the SAS file.

Red f:e — Reduction fraction comparing BRD and ALL.

Red h:g — Reduction fraction comparing WithBRD to NoBRD

Effort — 'Days' fished from the shrimp statistics

CPUE — Total annual bycatch divided by total annual effort. This became the juvenile index used for king mackerel an assessment or two ago, when we realized that research vessel cpue was so low that tuning was being driven by chance inclusion or exclusion of very few fish. The ALL set was used in the estimate, consistent with past practice.

RAW — Estimates based on using raw cell mean CPUEs of observer data (no Oregon II) when n>5, GLM ALL estimates where n<=5.

RAWBRD Same as RAW, but for cell means of observations with BRDs, GLM BRD estimates where n<=5. RAW and RAWBRD are reported only for those years where there was enough observer data so at least some of the annual total was estimated from cell means.

We're still working on approaches to estimating bycatch reduction by device specific estimates of reduction in paired tests, then acoounting for choices of BRDs in the fleet, degree of compliance, season/areas where BRDs required, extra mortality, etc. We will probably not get to mackerel via that route in time for this assessment, although it may be a better estimation strategy in the long run. However, as the reductions that fell out of this GLM approach are plausible based on performance of individual BRDs in paired tests, I'd go with this for now. If anything, Spanish mackerel usually are reduced better than these GLM estimates indicate, king mackerel a bit worse, and cobia we've never tried to calculate from the paired test. For the actual best estimate for the assessment, you only need that one value from 1998.

Cobia

Year	OLD	NEW	ALL	BRD	No BRD	With BRD	ACT	Red f:e	Red h:g	Effort	CPUE	RAW	RAW
1972	0.146	0.028	0.082	0.014	0.08	0.038	0.08	0.8293	0.5250	168735	0.01012		
1973	0.054	0.002	0.021	0.001	0.02	0.003	0.02	0.9524	0.8500	145976	0.00300	0.012	
1974	0.21	0.082	0.146	0.059	0.144	0.091	0.144	0.5959	0.3681	148330	0.02051	0.096	
1975	0.136	0.041	0.092	0.025	0.091	0.052	0.091	0.7283	0.4286	121603	0.01576	0.058	
1976	0.144	0.028	0.092	0.014	0.09	0.048	0.09	0.8478	0.4667	154654	0.01239	0.097	
1977	0.1	0.01	0.056	0.002	0.054	0.019	0.054	0.9643	0.6481	174140	0.00670	0.037	
1978	0.163	0.022	0.091	0.013	0.087	0.039	0.087	0.8571	0.5517	205848	0.00921	0.025	
1979	0.285	0.096	0.193	0.067	0.191	0.115	0.191	0.6528	0.3979	221961	0.01812	0.191	
1980	0.199	0.055	0.137	0.033	0.135	0.076	0.135	0.7591	0.4370	185707	0.01537	0.191	
1981	0.118	0.014	0.068	0.005	0.067	0.029	0.067	0.9265	0.5672	170527	0.00831	0.059	
1982	0.179	0.047	0.112	0.029	0.11	0.061	0.11	0.7411	0.4455	173911	0.01342	0.104	
1983	0.285	0.122	0.212	0.093	0.209	0.144	0.209	0.5613	0.3110	176841	0.02498		
1984	0.188	0.048	0.114	0.028	0.112	0.061	0.112	0.7544	0.4554	190121	0.01249		
1985	0.197	0.054	0.121	0.032	0.119	0.064	0.119	0.7355	0.4622	191839	0.01314		
1986	0.143	0.018	0.064	0.009	0.062	0.021	0.062	0.8594	0.6613	223793	0.00596		
1987	0.236	0.061	0.128	0.035	0.125	0.062	0.125	0.7266	0.5040	250299	0.01065		
1988	0.119	0.017	0.054	0.006	0.053	0.017	0.053	0.8889	0.6792	218524	0.00515		
1989	0.209	0.058	0.118	0.034	0.115	0.059	0.115	0.7119	0.4870	217697	0.01129		
1990	0.218	0.066	0.13	0.043	0.127	0.069	0.127	0.6692	0.4567	204567	0.01324		
1991	0.303	0.117	0.204	0.086	0.2	0.123	0.2	0.5784	0.3850	219837	0.01933		
1992	0.312	0.181	0.226	0.085	0.222	0.138	0.222	0.6239	0.3784	238367	0.01975	0.957	
1993	0.611	0.261	0.29	0.327	0.281	0.206	0.281	-0.1276	0.2669	202898	0.02978	0.268	
1994	0.349	0.25	0.286	0.168	0.287	0.213	0.287	0.4126	0.2578	197380	0.03019	0.159	
1995	0.311	0.167	0.207	0.125	0.198	0.132	0.198	0.3961	0.3333	177440	0.02430	0.136	
1996	0.386	0.245	0.311	0.176	0.308	0.236	0.308	0.4341	0.2338	194425	0.03332	0.303	
1997	0.5	0.303	0.374	0.283	0.37	0.295	0.37	0.2433	0.2027	197379	0.03948	0.249	
1998	0.227	0.12	0.166	0.087	0.19	0.119	0.139	0.4759	0.3737	199816	0.01731	0.177	

King Mackerel

Year	OLD	NEW	ALL	BRD	No BRD	With BRD	ACT	Red f:e	Red h:g	Effort	CPUE	RAW	RA
1972	0.876	0.686	0.81	0.317	0.814	0.474	0.814	0.6106	0.4177	168735	0.1000		
1973	0.347	0.239	0.303	0.013	0.306	0.079	0.306	0.9575	0.7418	145976	0.0432	0.148	
1974	0.421	0.297	0.367	0.038	0.372	0.119	0.372	0.8978	0.6801	148330	0.0515	0.693	
1975	0.316	0.206	0.284	0.013	0.288	0.083	0.288	0.9549	0.7118	121603	0.0487	0.271	
1976	0.359	0.222	0.321	0.008	0.326	0.082	0.326	0.9755	0.7485	154654	0.0432	1.523	
1977	0.354	0.22	0.302	0.007	0.306	0.054	0.306	0.9771	0.8235	174140	0.0361	0.08	
1978	0.584	0.386	0.547	0.02	0.54	0.174	0.54	0.9630	0.6778	205848	0.0554	1.836	
1979	0.729	0.504	0.623	0.089	0.632	0.218	0.632	0.8592	0.6551	221961	0.0585	0.632	
1980	0.422	0.308	0.374	0.016	0.379	0.082	0.379	0.9578	0.7836	185707	0.0420	0.101	
1981	0.41	0.255	0.369	0.008	0.374	0.089	0.374	0.9786	0.7620	170527	0.0451	0.632	
1982	0.414	0.269	0.366	0.012	0.369	0.086	0.369	0.9675	0.7669	173911	0.0438	0.352	
1983	0.388	0.249	0.339	0.009	0.341	0.063	0.341	0.9736	0.8152	176841	0.0399		
1984	0.576	0.411	0.518	0.048	0.523	0.175	0.523	0.9082	0.6654	190121	0.0568		
1985	0.563	0.384	0.49	0.044	0.497	0.155	0.497	0.9115	0.6881	191839	0.0532		
1986	0.486	0.266	0.377	0.008	0.381	0.06	0.381	0.9790	0.8425	223793	0.0351		
1987	0.988	0.729	0.862	0.223	0.872	0.384	0.872	0.7443	0.5596	250299	0.0717		
1988	0.77	0.529	0.649	0.119	0.66	0.246	0.66	0.8197	0.6273	218524	0.0619		
1989	1.448	1.189	1.316	0.74	1.328	0.878	1.328	0.4428	0.3389	217697	0.1259		
1990	0.987	0.767	0.88	0.344	0.888	0.479	0.888	0.6126	0.4606	204567	0.0896		
1991	1.223	0.973	1.099	0.516	1.109	0.663	1.109	0.5347	0.4022	219837	0.1041		
1992	0.688	0.523	0.59	0.042	0.602	0.174	0.602	0.9302	0.7110	238367	0.0516	0.448	
1993	1.287	1.017	1.06	0.534	1.021	0.611	1.021	0.4770	0.4016	202898	0.1088	5.642	
1994	1.109	0.937	0.993	0.616	1.056	0.654	1.056	0.4167	0.3807	197380	0.1048	16.336	
1995	1.313	1.049	1.109	0.673	1.087	0.72	1.087	0.3809	0.3376	177440	0.1302	1.937	
1996	0.753	0.538	0.623	0.18	0.63	0.255	0.63	0.7143	0.5952	194425	0.0668	0.532	
1997	0.887	0.648	0.742	0.283	0.752	0.362	0.752	0.6237	0.5186	197379	0.0783	0.506	
1998	0.701	0.466	0.527	0.188	0.587	0.214	0.301	0.6797	0.6354	199816	0.0549	0.492	

Spanish Mackerel

Year	OLD	NEW	ALL	BRD	No BRD	With BRD	ACT	Red f:e	Red h:g	Effort	CPUE	RAW	RAV
1972	2.218	2.691	2.421	1.752	2.404	1.845	2.404	0.2763	0.2325	168735	0.2989		
1973	1.881	2.405	2.043	1.582	2.026	1.546	2.026	0.2256	0.2369	145976	0.2916	1.134	
1974	1.553	1.824	1.59	1.2	1.559	1.116	1.559	0.2453	0.2842	148330	0.2233	0.963	
1975	1.406	1.705	1.5	1.087	1.483	1.1	1.483	0.2753	0.2583	121603	0.2570	2.093	
1976	2.136	2.595	2.28	1.759	2.262	1.747	2.262	0.2285	0.2277	154654	0.3071	5.359	
1977	2.441	2.827	2.737	1.758	2.731	2.141	2.731	0.3577	0.2160	174140	0.3274	20.449	
1978	3.006	3.641	3.36	2.227	3.329	2.626	3.329	0.3372	0.2112	205848	0.3401	10.377	
1979	3.075	3.724	3.403	2.437	3.388	2.641	3.388	0.2839	0.2205	221961	0.3194	3.388	
1980	3.89	4.336	4.175	3.107	4.158	3.463	4.158	0.2558	0.1671	185707	0.4684	9.459	
1981	2.255	2.809	2.515	1.775	2.502	1.936	2.502	0.2942	0.2262	170527	0.3073	2.286	
1982	2.537	3.121	2.799	2.066	2.781	2.189	2.781	0.2619	0.2129	173911	0.3353	2.411	
1983	2.24	2.759	2.523	1.714	2.503	1.926	2.503	0.3207	0.2305	176841	0.2972		
1984	2.426	2.998	2.732	1.876	2.716	2.089	2.716	0.3133	0.2309	190121	0.2994		
1985	2.085	2.681	2.427	1.552	2.416	1.814	2.416	0.3605	0.2492	191839	0.2636		
1986	2.374	3.142	2.856	1.738	2.849	2.139	2.849	0.3915	0.2492	223793	0.2659		
1987	2.837	3.645	3.319	2.153	3.305	2.506	3.305	0.3513	0.2418	250299	0.2763		
1988	3.343	4.139	3.832	2.713	3.828	3.066	3.828	0.2920	0.1991	218524	0.3653		
1989	3.565	4.396	4.089	2.922	4.088	3.315	4.088	0.2854	0.1891	217697	0.3913		
1990	3.254	3.964	3.674	2.651	3.663	2.946	3.663	0.2784	0.1957	204567	0.3742		
1991	3.572	4.404	4.093	2.915	4.088	3.31	4.088	0.2878	0.1903	219837	0.3879		
1992	3.44	5.17	5.039	2.751	5.038	4.162	5.038	0.4541	0.1739	238367	0.4404	18.299	
1993	3.592	4.775	4.717	3.166	4.713	3.944	4.713	0.3288	0.1632	202898	0.4843	84.857	
1994	2.576	3.068	3.005	2.053	3.021	2.357	3.021	0.3168	0.2198	197380	0.3172	1.757	
1995	2.704	2.804	2.7	2.026	2.65	2.056	2.65	0.2496	0.2242	177440	0.3170	3.427	
1996	2.443	2.923	2.724	1.953	2.722	2.081	2.722	0.2830	0.2355	194425	0.2919	2.349	
1997	2.184	2.782	2.568	1.695	2.583	1.949	2.583	0.3400	0.2455	197379	0.2711	2.054	
1998	2.593	2.823	2.655	2.027	2.611	1.969	2.117	0.2365	0.2459	199816	0.2768	2.371	

Appendix F. Simulation Study of Percentile and Bias Corrected Percentile Confidence Intervals for Allowable Biological Catch (MSAP/99)

MSAP/99/

Simulation Study of Percentile and Bias Corrected Percentile Confidence Intervals for Allowable Biological Catch

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Sustainable Fisheries Division Contribution SFD-98/99-48

March 16, 1999

Introduction

For the past few years, the Mackerel Stock Assessment Panel (MSAP) has provided the Gulf of Mexico and South Atlantic Fishery Management Councils (Councils) distributions of allowable biological catch (ABC) that correspond to given management schemes, for example the fishing mortality rate that causes a static spawning potential ratio of 30% ($F_{30\%SPR}$). From these distributions of ABC the Councils select a total allowable catch (TAC) or quota. These distributions of ABC have been generated by a mixed bootstrap/Monte Carlo simulation approach using virtual population analysis (VPA) to estimate the current condition of the stock followed by a short term projection into the quota year. The VPAs bootstrap residuals about index fits and randomly chosen from a priori defined distributions, values of catch and bycatch by age and year (lognormal), natural mortality rate by age and year (uniform), and recruitment for projected years (lognormal) (see Legault et. al 1998 for further details). A total of 400 ABCs are generated for each mackerel management unit and the distributions truncated at the 16% and 84% cumulative frequency levels to develop a range from which the Councils select the TAC. The MSAP historically has recommended the risk neutral median (50% cumulative frequency) for the quota, while identifying the 16th and 84th percentiles as relatively resource risk-adverse and resource risk-prone alternatives.

Point estimates of the ABC have also been computed each year for the mackerel management units. These point estimates have never exactly matched the median of the ABC distributions created through the mixed bootstrap/Monte Carlo simulations. The difference between the point estimates and the median of the distributions is a measure of the statistical bias inherit in this highly non-linear estimation and projection algorithm. This statistical bias can be taken into account in the determination of uncertainty for the ABCs through the use of bias corrected percentile confidence intervals (Efron 1982). Bias correction can shift the distribution of ABCs either lower or higher depending upon the relative position of the point estimate and the median of the percentile ABCs. When the point estimate is lower than the median, the bias corrected ABC distribution is shifted to lower values, while a higher point estimate causes the distribution to shift upwards (Figure 1). The median of the bias corrected percentile distribution is thus shifted to the other side of the point estimate from the median of the percentile distribution.

One can think of this as a reflection of the point estimate itself being statistically biased in the same direction that the percentile median is biased relative to the point estimate.

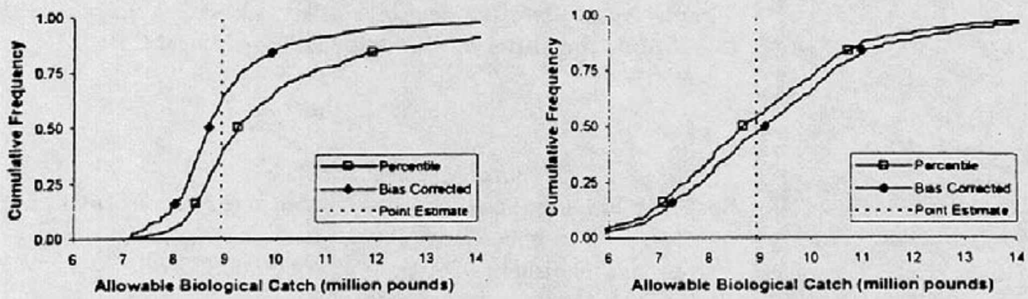


***Figure 1**. Examples of point estimate position relative to median of percentile distribution determining position of bias corrected percentile distribution. Symbols denote the 16, 50 and 84% cumulative frequencies for the distributions.*

Efron (1982) introduced the bias corrected percentile method to account for this statistical bias in bootstrapping. Numerous (bootstrapping only) examples have demonstrated the superiority of bias corrected percentile over percentile confidence intervals (see Efron and Tibshirani 1993). In a fisheries context, Gavaris (1999) showed through simulation that the bias corrected percentile confidence intervals had better coverage (explained below) than the percentile method when only bootstrapping was used in a VPA. In this study, I extend the results of Gavaris (1999) to a mixed bootstrap/Monte Carlo simulation approach similar to the one employed for creating allowable biological catch distributions for mackerels. A nested simulation approach is employed whereby random realizations about a data set without error are generated and the mixed bootstrap/Monte Carlo approach used for each of the realizations. The distribution of where the true ABC falls within the percentile and bias corrected percentile cumulative frequency distributions (coverage) are used to compare the two methods for setting confidence intervals.

Methods

Bias Correction

The percentile method (Efron 1982) has historically been used to generate confidence intervals for allowable biological catch due to its ease of implementation and superiority over delta method approaches. The ABCs are sorted into ascending order and the desired confidence level found according to the percentage of results less than or equal to the given probability. For example, if the 16% confidence level is desired from 400 mixed boostrap/Monte Carlo results, the 64^{th} (=0.16*400) lowest value is chosen.

The bias corrected percentile method (Efron 1982) takes into account the difference between the point estimate and the median of the bootstrap distribution to modify the confidence level associated with each point. The process is range preserving, only values that are present in the original bootstrap distribution can be found in the bias corrected distribution. Thus, the bias correction process can be thought of as holding the tails and shifting the middle of the distribution to take into account the statistical bias due to non-linear estimation. The statistical bias is measured as the inverse standard normal function of the fraction of bootstraps that are less than the point estimate

$$z_0 = \Phi^{-1}\left(\frac{\#\{\theta^b < \theta\}}{B}\right)$$

where Φ^{-1} denotes the inverse of the standard normal cumulative distribution function, θ^b is a bootstrap ABC, θ is the point estimate of ABC, and B is the number of bootstraps. If the point estimate equals the median of the ABC distribution, then half of the bootstraps will be below the point estimate and the bias will be zero [$=\Phi^{-1}(0.5)$]. If the point estimate is greater than the median then z_0 will be positive, while if the point estimate is less than the median then z_0 will be negative. This measure of median bias in the distribution is used to modify the distribution of ABCs by setting new confidence levels for each bootstrap ABC as

$$\alpha_{BC} = \Phi[2z_0 + \Phi^{-1}(\alpha)]$$

where α_{BC} is the bias corrected confidence level and α is the percentile confidence level. (Note when z_0 is zero, $\alpha_{BC}=\Phi[\Phi^{-1}(\alpha)]=\alpha$.)

As an example, in the left panel of Figure 1, 151of the 400 bootstrap/Monte Carlo ABCs were less than the point estimate. The median bias (z_0) is calculated as $\Phi^{-1}(151/400) = \Phi^{-1}(0.3775) = -0.312$. The bias corrected 16% confidence level corresponds to $\Phi[2(-0.312)+\Phi^{-1}(0.16)] = \Phi[-0.624-0.9945] = 0.0528$. Thus, in this case, the bias corrected 16% confidence level corresponds to the 21st (=0.0528*400) smallest ABC instead of the 64th smallest ABC, as it is in the percentile method. The bias corrected cumulative frequency distribution is shifted to the left relative to the percentile method because the point estimate is less than the median of the percentile distribution (Figure 1, left panel).

Simulation Experiment

In order to examine the properties of the percentile and the bias corrected percentile confidence intervals in a process similar to that used to estimate mackerel ABCs, a nested bootstrap/Monte Carlo experiment was conducted. The outer loop created a data set for use in VPA with noise in the catch at age and tuning indices. Each of these data sets were then used to determine a point estimate and a distribution of 400 ABCs through a mixed bootstrap/Monte Carlo approach similar to the one used in the mackerel stock assessments. The outer loop was repeated 1000 times such that 401,000 (=401*1000) ABCs were estimated. The point estimate and distribution of 400 ABCs of each inner loop were used to generate both the percentile and the bias corrected percentile cumulative frequency distributions.

The true data underlying the simulation was loosely based on the 1998 Gulf of Mexico king mackerel stock assessment and had a single true ABC of 6.9 million pounds. Some simplifications of the estimation and projection algorithm were made to reduce the amount of time necessary to conduct the simulation experiment. These simplifications include treating bycatch as directed catch, not splitting the quota for projections, and a slight modification to the calculation of spawning potential ratio to set the quota. These simplifications caused the simulated true ABC to be lower than that of the 1998 stock assessment, but for the purposes of this simulation experiment should not favor either the percentile or bias corrected percentile methods.

The location of the true ABC from the simulation experiment within both the percentile and the bias corrected percentile cumulative frequency distributions was determined for each of the 1000 outer loops in order to examine the coverage of the two methods. Figure 2 shows the results of one outer loop of the simulation experiment to demonstrate the process. In this particular example, the point estimate is below the median of the percentile distribution and thus the bias corrected distribution is shifted to the left. The true ABC corresponds to the 19.25% and 29.57% cumulative frequency of the percentile and the bias corrected percentile distributions, respectively. The distribution of the true ABC locations within the 1000 percentile and 1000 bias corrected percentile ABC cumulative frequency distributions was used to measure the coverage of each method. Under perfect coverage, the true ABC location cumulative frequency distribution would exactly match the fraction of runs. For example, 10 out of 1000 distributions would have a true ABC location of 1% or lower, 500 would have a true ABC location of 50% or lower, and 990 would have a true ABC location of 99% or lower. Additionally, the true ABC would fall within the successive 10% of cumulative frequency 100 times each under perfect coverage. Most importantly for this particular application, a desired confidence interval with perfect coverage would contain exactly that fraction of true ABC locations, with the fraction above and below the confidence interval matching as well. For example, when the 16% to 84% confidence interval is chosen, 160 (=0.16*1000) of the 1000 true ABC locations would be below the range, 680 would be within the range, and 160 would be above the range.

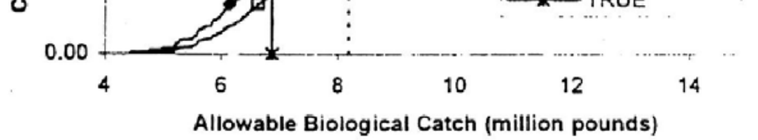


Figure 2. Results from one outer loop of the simulation experiment.

(4)

Results and Discussion

The confidence interval coverage was not exact for either the percentile or the bias corrected percentile methods, but was better for the bias corrected percentile than the percentile method. The cumulative frequency of true ABC location was closer to the exact values for the bias corrected percentile method than the percentile method (Figure 3). The number of times the true ABC fell within each decile was closer to the expected value (100) for the bias corrected percentile than the percentile method (Figure 4). However, both distributions were highly significantly different from the expected uniform distribution using the chi square test. The number of true ABC locations below, within, and above the 16% to 84% confidence interval was more symmetric for the bias corrected percentile than the percentile method, although the percentile method had closer to the expected number of within interval results (Table 1). These simulation results show that the true ABC fell in the lower end of percentile method ABC distributions much more often than in the corresponding bias corrected percentile method ABC distributions. This result indicates that the 16-84% range of the percentile method normally presented by the MSAP to the Councils will result many more times than expected in a TAC that is too high, relative to the implied or stated resource risk level, regardless of where within the distribution the TAC is chosen. The range usually presented by the MSAP to the Councils will result in a TAC that is almost never too low, relative to the implied or stated resource risk level. The bias corrected method is more risk neutral in that the probability of providing too high of an ABC range is almost the same as the probability of providing too low of an ABC range for selection of a TAC.

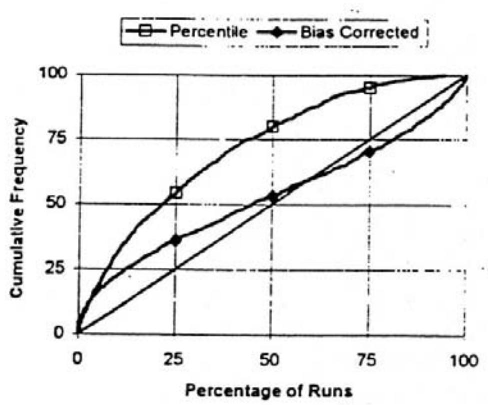


Figure 3. Cumulative frequency distribution of the true ABC location within the percentile and bias correct percentile distributions.

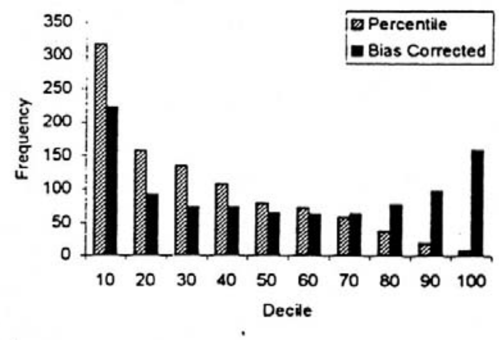


Figure 4. Frequency of true ABC within successive 10% intervals of the cumulative frequency distribution of the percentile and bias correct percentile distributions.

(5)

Table 1. *Frequency of true ABC relative to 16-84% confidence interval for percentile and bias correct percentile methods.*

	True Value Relative to ABC Range (16-84%)		
	Percentile	Bias Corrected	Expected
Below	422	281	160
Within	558	497	680
Above	20	222	160

There are other methods to produce confidence intervals from bootstrapping, such as the bootstrap-t and the bias corrected and accelerated method (BCA) (Efron and Tibshirani 1993). The BCA method is the most highly recommended method in Efron and Tibshirani (1993), due to its being range preserving, transformation respecting and second order accurate. Both the percentile and bias corrected percentile methods are range preserving and transformation respecting while the bootstrap-t is neither. Transformation respecting means that applying any monotone transformation to the distribution of ABCs does not change the confidence level associated with any individual ABC. However, the percentile method is only first order accurate and the bias corrected percentile method lies somewhere between the percentile and BCA methods in terms of accuracy. First order accuracy means errors approach zero at the rate of one over the square root of the sample size, while second order accuracy means errors approach zero at the rate of one over the sample size.

The acceleration part of the BCA method measures the rate of change of the standard error of the point estimate with respect to the true parameter. Inclusion of the acceleration (a) produces confidence levels as

$$\alpha_{BCA} = \Phi\left(z_0 + \frac{z_0 + \Phi^{-1}(\alpha)}{1 - a[z_0 + \Phi^{-1}(\alpha)]} \right)$$

and thus when acceleration is zero $\alpha_{BCA}=\alpha_{BC}$. However, the BCA method most commonly uses a jacknife of each bootstrap result to estimate the acceleration. Jacknifing is not possible in a mixed bootstrap/Monte Carlo simulation analysis and I was unable to determine another approach to estimating the acceleration in the time available. By analogy to some examples in Efron and Tibshirani (1993), I expect the acceleration to be in the range (-0.1,0.1). Including the acceleration changes the tails of the cumulative frequency distributions, but not the median (at all when z_0 is zero and not much otherwise). Positive accelerations shift both tails to the right, while negative a shift both tails to the left. To demonstrate the impact of larger than expected accelerations, application of accelerations of -0.2 and 0.2 to a single outer loop result shifted the tails of the distribution below 25% and above 75% cumulative frequency, but did not shift the median (Figure 5). Not including the acceleration constant may explain the excessive number of trials resulting in the true ABC being in the tails of the bias corrected percentile distribution. However, the high degree of similarity between the BCA and bias corrected percentile medians relative to the percentile median further supports the selection of the bias corrected percentile over the percentile method due to the demonstrated theoretical superiority of the BCA method over the percentile method.

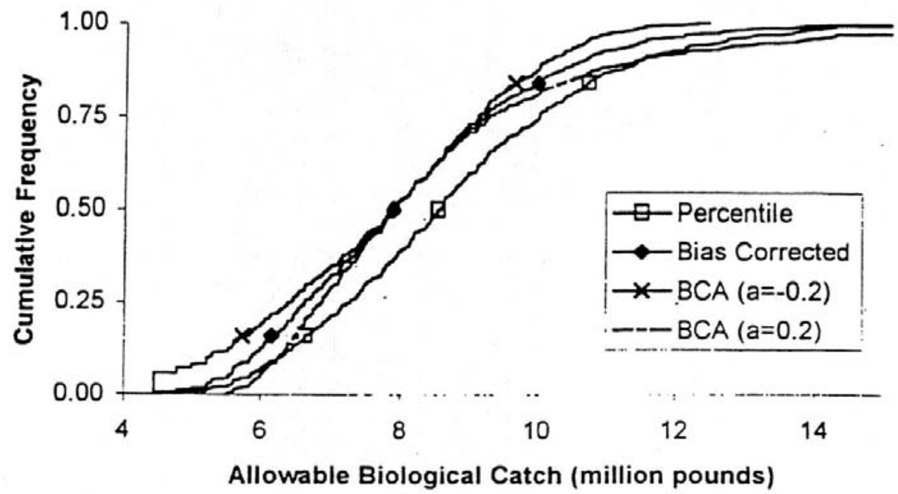


Figure 5. Four cumulative frequency distributions from a single inner loop of the simulation experiment.

Another potential cause of the excessive number of results in the tails of the bias corrected percentile method is that not enough bootstrap/Monte Carlo simulations were conducted. A general rule of thumb given by Efron and Tibshirani (1993) is that 1000 bootstraps are required to estimate confidence intervals well using the bias corrected and accelerated method. Time did not permit conducting this nested simulation experiment with 1000 mixed bootstrap/Monte Carlo simulations per each data set. Instead, the consistency of results was checked when only 50, 100 or 200 inner loops were used to produce ABC distributions for each outer loop (Figure 6). The changes seen increasing from 50 to 400 ABCs per outer loop are in the direction towards the expected uniform distribution for deciles. The relative change from 200 to 400 ABCs per outer loop is smaller than the preceding differences, suggesting that there is not much to gain from increasing the number of bootstrap/Monte Carlo simulations above 400 for either method.

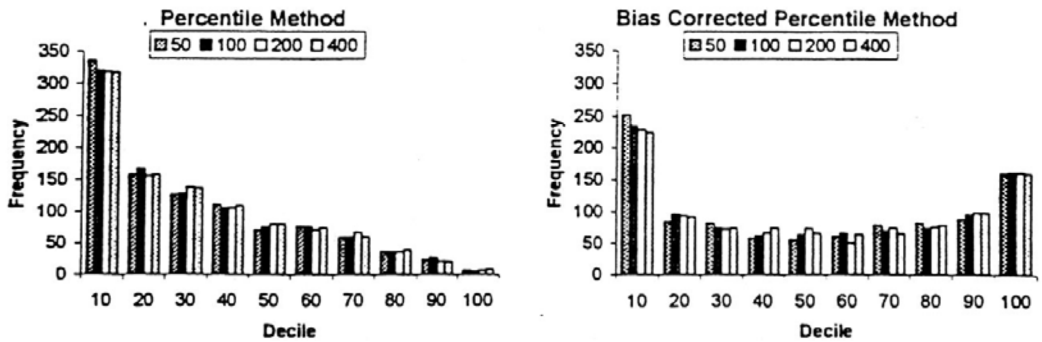


Figure 6. *Number of times that the true ABC fell within successive 10% cumulative frequencies of the percentile and bias corrected percentile method under four different levels of inner mixed boostrap/Monte Carlo simulations.*

The development of the bias corrected percentile method was done for bootstrapping only, not mixed bootstrap/Monte Carlo applications. Although in this simulation example the bias corrected percentile method performed better than the percentile method, this may not always be the case. The distributions used for the Monte Carlo simulation may in fact conflict with the bias correction algorithm. This could happen if the distribution for a parameter to be Monte Carlo sampled was highly skewed and resulted in ABCs that were highly skewed. The bias correction algorithm would attempt to "correct" for these deviations form the point estimate when they are in fact due to the subjective selection of the pdf types for Monte Carlo generation of input. This conflict can also arise when the Monte Carlo distribution is centered on the point estimate, but the ABCs respond non-linearly to the parameter. One possible solution to this problem would be to modify the sampling to make it nested such that Monte Carlo samples would be created and then multiple bootstraps performed for each Monte Carlo realization. The bias correction algorithm could be applied to each Monte Carlo realization and then combined to create the total ABC distribution. This approach would require significantly more computing time, but would allow the BCA method to be used to produce a distribution of ABCs that most appropriately defines the amount of uncertainty in the process.

Conclusions

Due to its theoretical superiority and better performance in a simulation experiment specific to the methods used, the bias corrected percentile method is recommended over the percentile method for producing confidence statements about allowable biological catches. The bias corrected and accelerated method should be examined to determine if further improvement in ABC recommendations is possible. The nested bootstrap/Monte Carlo approach should also be examined to determine if the extra computing time is compensated by significantly improved ABC recommendations.

Literature Cited

Efron, B. 1982. The jacknife, the bootstrap and other resampling plans. CBMS Monograph #38, Society for Industrial and Applied Mathematics, Philadelphia.

Efron, B. and R. J. Tibshirani. 1993. An introduction to the bootstrap. Chapman & Hall. New York. 436 pp.

Gavaris, S. 1999. Comparison of confidence statements for a fisheries assessment problem from two bootstrap methods. ICES Comprehensive Fisheries Evaluation Working Paper 99/1. Key Largo, Florida. 11 p.

Legault, C. M., N. Cummings, and P. Phares. 1998. Stock assessment analyses on Atlantic migratory group king mackerel, Gulf of Mexico migratory group king mackerel, Atlantic migratory group Spanish mackerel, and Gulf of Mexico migratory group Spanish mackerel. MSAP/98/09. NMFS Miami Laboratory Contribution MIA-97/98-15. Miami, Florida. 90 p. + appendices.

NATIONAL FISHERMAN OCTOBER 1998

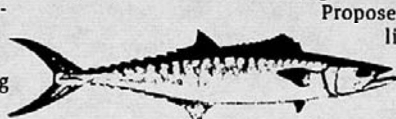
GULF/SOUTH ATLANTIC
MACKEREL

Many say trip limits are the answer to concerns about quality, prices.

Take two oceans — the Gulf of Mexico and the South Atlantic — with two populations of the same fish, neither of which stays at home much.

Add conflicting user groups — handliners, trollers, gillnetters, rod-and-reel fishermen and others.

Mix in two regional management councils overseeing at least half a dozen zones and sub-zones and almost too many different quotas and subquotas to count, and you've got the management and marketing nightmare called king mackerel fishing.



"It's almost incomprehensible to most people," says Michael Jepson, a biologist with the South Atlantic Fisheries Management Council.

Despite the biological and management complexities, proposed 3,000-pound trip limits in the western Gulf offer hope of higher prices, while a proposed increase in the commercial quota in the Atlantic could boost earnings there.

Prices generally have been on a downward slide in the South Atlantic, from a high of $1.57 per pound in 1993 to a low of $1.44 in 1997. In the Gulf, kings brought $1.09 overall in 1997, the best price since 1990, except for 1994, when fishermen got $1.12.

But ex-vessel price reports from the Gulf during the July opening this year weren't good.

"The price has dropped out on us," said Carol Torrence, two weeks after the western-zone derby-style opening. Carol and her husband, Tom, who sits on a Gulf council advisory panel, fish the 43-foot handliner SeaQuest out of Grand Isle, La.

On her first trip, which began July 1, the SeaQuest landed 909 pounds of small kings worth $1,363.50 at $1.50 per pound. By the end of her second trip, the price had dropped to $1, so the Torrences made less profit on 1,928 pounds of small kings.

Proposed western-zone trip limits enjoy strong support from the industry, and supporters have high hopes that the limits will even out wild, derby-driven price fluctuations.

South Atlantic king fishermen, primarily in Florida and North Carolina, would be able to market a share of the proposed overall Atlantic quota of 3.12 million pounds, an increase from 2.52 million pounds that would allow some fishermen to fish more of the year and help even out price swings.

The changes are likely too late for this king mackerel season, however.

In July, New York's Fulton Street Fish Market prices mirrored the derby price swings in the Gulf. On June 29, kings brought $3.25 per pound. Two weeks after the western-Gulf opening, prices had plummeted to $1.70 for Gulf fish.

Fishermen in the western Gulf believe the 3,000-pound trip limits also would solve a quality problem that in recent years has driven prices down.

Traditional hook-and-line fishermen blame big offshore boats, which stay at sea a long time and land 10,000 to 12,000 pounds or more at a time, of glutting the market with poor fish, Carol Torrence says.

"They just hold 'em too long," she says "They're not edible."

A Gulf council statement recommending the trip limits acknowledged a "vastly accelerating derby" and "very-poor-quality fish."

If summer 1998 blends into fall with higher-than-normal temperatures, look for the kings to hang around longer in their upper Gulf and Florida panhandle spawning grounds, as they did in 1997, producing an Indian-summer run, says Mark Godcharles, a biologist with the National Marine Fisheries Service.

The North Carolina fishery cranks up in autumn, so who gets the better price — Carolina or Gulf of Mexico fishermen — probably depends on who gets to market first.

Around December, most of the action should shift back to s

The southern tip west coasts, accounts of Southeast king la percent or more in m

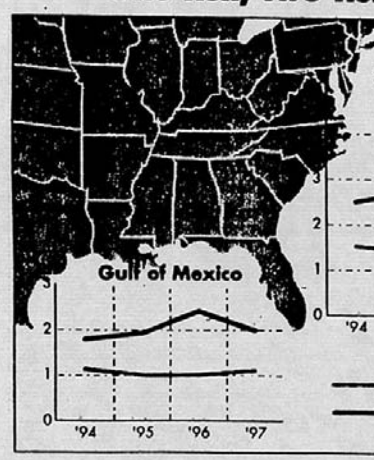
When a lot of fish there, ex-vessel pric beating.

"Once more than on the market, you're good dip in the pric Fla., hook-and-line Hawkins, a South A sory panel member

Beyond that, he catching fish in the going to go down.

"Once it goes belo no real interest in fish

One fish, two fish



Appendix H. Economic and Socail Assessments for Atlantic Mackerels and Cobia

NOTE: THE NMFS SOUTHEAST FISHERIES ECONOMICS OFFICE INTENDS THAT APPENDIXES P. THROUGH T. COMPRISE THE "ECONOMIC AND SOCIAL ASSESSMENTS FOR ATLANTIC MACKERELS AND COBIA". WHILE THESE DOCUMENTS MAY CONTAIN INFORMATION USEFUL TO CONDUCT AN ECONOMIC AND SOCIAL ASSESSMENT FOR ATLANTIC MACKERELS AND COBIA, NO SUCH ANALYSES WERE LOCATED.

Appendix I. Report of the 8th. Coastal Migratory Pelagics Socioeconomic Panel Meeting

REPORT OF THE EIGHTH COASTAL MIGRATORY PELAGICS SOCIOECONOMIC PANEL MEETING

Prepared by the

Socioeconomic Panel

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April 15-16, 1999
Tampa, Florida

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INTRODUCTION

At the direction of the Gulf of Mexico Fishery Management Council, the Socioeconomic Panel (SEP) met to consider the social and economic implications of the 1999 stock assessments for king and Spanish mackerel. The meeting was held on April 15-16, 1999 in Tampa, Florida. A list of attendees is found at the end of this report.

PURPOSE

The SEP was formed to advise the Council on the social and economic implications of the current regulatory structure and potential changes in management for fisheries under the jurisdiction of the Gulf Council. The short-run task specifically calls for recommending a TAC (total allowable catch) within the ABC (acceptable biological catch) range estimated by the Mackerel Stock Assessment Panel (MSAP), analyzing the consequences of changing the TAC, and reviewing the economic and social assessments for the fishery conducted by NMFS (National Marine Fisheries Service). The long-run function involves proposing or recommending data and analyses that should be included in future social and economic assessments.

PRESENTATIONS

Dr. Robert Muller, FDEP-FMRI, presented the 1999 MSAP report. He indicated that of the four stocks analyzed, only the Gulf group of king mackerel is considered overfished and is undergoing overfishing. The transitional SPR for this stock is estimated at 25 percent, which is below the 30 percent SPR threshold. The stock's static SPR is estimated at 28 percent, indicating a fishing mortality greater than $F_{30\%SPR}$. In particular the case of Gulf king mackerel, he noted a decline in recruitment after 1995/1996 which could show up as a decline in spawning stock 4 years later. He also presented the MSAP's first attempt at estimating various stock indicators required under the SFA to manage fishery resources. The MSAP estimated, among others, an MSY for the Gulf group of king mackerel at a range of 10.7 million pounds (MP) to 13.8 MP, with the median estimate at 12.1 MP.

Dr. John Vondruska, Fisheries Economics Office, NMFS, summarized reports on commercial fishery production, markets and foreign trade, and models of demand. According to industry sources and a survey of seafood consumers in Florida, there are several more or less ethnically-based target markets for king mackerel. Imports of king and other large mackerel have increased since the mid-1980s when the conditions of the U.S. stocks and landings reached a low point (Vondruska and Antozzi, 1999). The imports are said to compete more or less directly with the king mackerel from commercial fisheries in the southeastern coastal states (North Carolina to Texas). And to the extent that they still occur, shipments from the southeastern fisheries to target markets in Puerto Rico and foreign countries are now much smaller. Imports were estimated using available information; during 1993-97, they compared in amount with southeast landings which were 4-6 MP.

Models of the U.S. market demand for king mackerel were specified, using monthly data for 1977-97 and annual data for 1972-98, including imports (Vondruska, 1999). Mostly, the estimated parameters in the several models had the expected signs and were statistically significant. Selected demand models were used to show the effects of hypothetical changes in southeast commercial landings on exvessel price, consumer surplus, exvessel revenue and producer surplus, recognizing that survey data is needed to better estimate producer surplus. A crude proxy for producer surplus was estimated as being 8 percent of exvessel revenue. The model-based estimates of the effects on price and consumer surplus were relatively small, because the own-price elasticities of demand were relatively high, numerically about the same as reported by Easley et. al. (1993). Further work is planned on the specification and estimation of demand models, and there are plans to collect cost and earnings information needed for a full determination of producer surplus.

Dr. Stephen Holiman, Fisheries Economics Office, NMFS, presented summary catch and effort data for the king mackerel, Spanish mackerel, cobia, dolphin and wahoo recreational fisheries. Primary discussion centered on the king mackerel fishery. Summarized by calendar year, while 1997 harvest was stable relative to 1996, preliminary 1998 data showed a 24 percent reduction in numbers of fish and a 31 percent reduction in pounds over 1997. Trip level data was unavailable at the time of analysis, so it was not possible to determine the degree effort and catch per trip influenced the reduction. Performance this low has not been seen in this fishery since 1992. Examination of effort trends prior to 1998 provided no insights portending expected reductions in 1998. Unlike some fisheries, such as the red snapper fishery, which are dominated by incidental harvest effort (individual angler trips that catch the species without indicating a target preference), king mackerel is primarily a target fishery with target effort averaging 70 percent greater than catch effort since 1990. While king mackerel target effort has been quite variable since 1990, ranging from 350,000 to 760,000 trips, catch effort has remained more stable ranging from 250,000 to 425,000 trips, with the number of catch trips in 1996 and 1997 virtually equal at approximately 337,000 angler trips. Finally, the proportion of catch trips that harvested 2 fish was unchanged in 1997 over 1996.

Dr. Holiman also presented a summary of the results of 1997-98 Southeast economic survey. This survey contained several questions addressing angler attitudes and behavior relative to coastal migratory pelagic species. As seen in Figure 1, when asked their behavioral response to a zero bag limit for king mackerel, approximately 80 percent of anglers indicated their fishing patterns would not change since they either did not fish for king mackerel, they practiced catch and release, or the bag limit did not restrict their participation. Approximately 12 percent indicated they would cease fishing for king mackerel while less than 2 percent would cease fishing entirely. Less than 7 percent of respondents indicated they fished for king mackerel some portion of the year (4 target species responses accepted per angler) (Figure 2). Over 50 percent of king mackerel anglers expected to catch and keep the legal king mackerel harvest limit (Figure 3). A series of questions addressed whether angler behavior had changed over the past 2 years. Over 90 percent of respondents indicated they had neither changed the number of annual fishing trips nor targeted new species in response to king mackerel regulations or catch rates. Given the constancy of management and the stability of harvests, these responses were not unexpected.

Dr. Holiman further discussed other research activities utilizing the 1997-98 recreational economic data. To date, the data have been distributed to 15 academic, state, federal and consulting groups. Two research projects, the first at East Carolina University and the second at Texas A&M University, specifically involve recreational demand estimation that may be applicable to the king mackerel recreational fishery. The first project is scheduled to be completed in October 1999 while the second project will not be completed until January 2001. Upon completion of final data summary reports, NMFS will begin assessment of the king mackerel contingent valuation data collected through the survey. This exercise is scheduled for completion after September 1999.

Dr. Stephen Holland of the University of Florida gave a progress report on the MARFIN project to interview charter captains in the Gulf and South Atlantic states. Results are still being analyzed and report written (due in June 1999). In Florida, interviews were conducted with 340 captains (all three coasts). Dr. Holland showed a table which indicated that the number of charter and head boats in Florida appear to have increased in the last ten years by about 18%, despite the promulgation of many regulations on sportfish during that time frame. There are now about 856 charterboats and 68 headboats in the Florida Gulf of Mexico. There are also about 430 charterboats and 23 headboats in the other Gulf States for a U.S. Gulfwide total of 1,286 charterboats and 91 headboats. In addition, charts were shown indicating the number of boats targeting selected species (Figures 4 and 5). In the Keys, the species targeted by the most boats are Dolphin, King Mackerel, Snapper and Grouper (with 31% indicating they do not target any particular species). In the Gulf, the species targeted by the most boats are Snapper, Grouper, King Mackerel and Cobia/Ling (with 67% indicating they do not target any particular species).

SUMMARY OF DISCUSSIONS AND RECOMMENDATIONS

The SEP reviewed the interim year assessment report from the MSAP and notes that Gulf-group Spanish mackerel has continued the recovery predicted and that the stock is neither overfished nor is overfishing a problem. The TAC recommended for Gulf-group Spanish mackerel will more than fulfill current user group demand while leading to achieving the optimum yield goal established by the Council. Recent landings information clearly shows that the commercial quota for Spanish mackerel will not be met as a direct result of the Florida net ban. In addition, information on recreational landings of Spanish mackerel indicates the demand for Spanish mackerel trips is not sufficient to fully utilize the recreational allocation. **Accordingly, this report makes no recommendations concerning Spanish mackerel. Although the SEP received additional information from the Fisheries Economics Office of NMFS regarding cobia, wahoo and dolphin, no issues relative to these species were raised in the MSAP's report, so the SEP has no recommendations regarding these species.**

As can be gathered from the previous section, NMFS has continued to update and expand the commercial fishery model for king mackerel and presented a progress report on research designed to develop demand models and other information pertaining to recreational fishing trips. Given this year's report from NMFS and the expectation of a recreational demand model next year, NMFS may be able to model specific commercial and recreational scenarios for next year's full assessment. For this year the SEP used the commercial demand model in developing expectations about the level of net revenues under differing assumptions and management rules. In the future, the SEP would like for NMFS to develop a simultaneous model of supply and demand for the commercial sector, since it would provide accurate estimates of producer and consumer surplus from which net benefits can be estimated. In addition, recreational demand models along the lines developed by Haab and Whitehead could be estimated to allow determination of angler consumer surplus. These two analyses will allow the determination of the change in net benefits from different TAC levels for each user group.

The deliberations of the SEP focused on Gulf-group king mackerel. The stock assessment continues to reflect both the effects of overfishing and of being overfished. However, the SEP notes that a new assessment approach, explained by the presenter of the SAP report, indicates that the new approach would mean that the stocks are not overfished but are still undergoing overfishing. The SEP believes that two points should be emphasized: 1) overruns of allocation have been the rule, not the exception, and 2) the stock assessment indicated that recruitment is trending downward (MSAP 1999, Figure 2, GK-3) and landings for the 1998/99 fishing year are estimated to be 93 percent of TAC (MSAP 1999, Table 2) due to a substantial drop in recreational catch (15%) and landings (20%). In other words, the preliminary data on recreational landings indicates that the recreational catch was down 17 percent from the prior year's level and 14 percent below the allocation. The commercial fishery experienced a small (6%) overage of allocation as the result of an administrative problem. The SEP was unable to determine the reasons for this preliminary result, except to note that the most recent fishing year was characterized by adverse weather patterns that may have limited the number of trips or the success of those trips.

The SEP believes that next year's technical information, which should consist of enhanced economics information and a new, full stock assessment, will provide the opportunity to address a number of management considerations, with quantification of their economic implications. For example, the biological assessment for next year may have to be based on a new biological optimum of a 40 percent SPR rather than the current 30 percent goal. The SEP understands that the current transitional SPR is on the order of 28 percent and moving from 28 percent to 40 percent is a more daunting task than moving from 28 percent to 30 percent. This scenario may result in the need for substantial reductions in fishing mortality and the economic implications may be pronounced.

The SEP spent a considerable amount of time debating the appropriate king mackerel TAC for the coming fishing season. A large part of the debate took into account the fact that last year the Gulf Council recommended, but NMFS has not yet implemented, a number of framework actions designed to reduce king mackerel landings and thereby help achieve the goals for stock rebuilding while maintaining the TAC at the status quo level of 10.6 MP. These changes include a provision to set the bag limit for captain and crew of for-hire vessels at zero, to impose a trip limit of 3,000 pounds for the western subgroup and to increase the minimum size limit from 20 to 24 inches for the commercial and recreational sectors.

The SEP recommends that the 1999/2000 TAC for Gulf group king mackerel be set no higher than the current TAC of 10.6 MP. The SEP recognizes that last year's framework measures designed to control the overall catches of king mackerel have not yet been implemented. However, given the future higher SPR target and future effects of a reduction in recruitment in more recent years, a lower TAC may eventually have to be adopted. The full set of SEP findings and recommendations is as follows:

- The ABC range for Gulf group of king mackerel is 8.0 - 12.5 with 10.1 MP representing a 50 percent probability of achieving a 30 percent SPR value (MSAP 1999, p. 5)

- Discussions on the implications of possible management strategies for Gulf group king mackerel resulted in the consensus that the Council should set a TAC no greater than the status quo of 10.6 MP.

- The Council has been managing the king mackerel fishery for an optimum yield, represented by a 30 percent SPR. A proposed (via Amendment 8) lower SPR level of 20 percent representing overfishing threshold for the Gulf group king mackerel was rejected by NMFS. Under the Sustainable Fisheries Act generic amendment, the target optimum is proposed to be changed to a 40 percent SPR level, and this may dictate the need for a lower TAC in the near future.

- The preliminary estimate of 1998/1999 landings is 9.83 MP. The TAC was 10.6 MP or 8 percent greater than landings. The estimate for 1997/98 was 11.8 MP but the final estimate was 10.61 MP. The fishery did not reach TAC, in spite of a small commercial overage, because of a substantial (1.2 million pound) reduction in recreational landings from the prior year. This is the first time, since the 1986/87 fishing year that TAC has not been exceeded.

- The SEP again recommends that the Council explore limited access management for all sectors of the coastal migratory pelagics FMP.

- The SEP strongly applauds the NMFS response to their past recommendation that an economic assessment be prepared. Next year's assessment will include a model that incorporates commercial and recreational economic components capable of estimating the economic implications of various TAC levels and accompanying regulatory measures, such as bag limits, size limits, closed seasons, and other management measures. Dr. Holiman will develop a recreational model that incorporates a number of related analyses using data from the MRFSS add-on economic survey. NMFS already presented a model of demand for the commercial sector that was developed by Dr. Vondruska. These models will provide the SEP with better information upon which to base expectations about the economic effects on the commercial, recreational, and final consumers of various TAC levels and accompanying management measures.

- The SEP reiterates its recommendation that NMFS should begin providing social and cultural data and analyses for consideration by the SEP. (See the social data needs section for specific data needs). Of immediate concern is the information needed to address the SFA requirements regarding fishing communities.

- To alleviate the problems of insufficient time for the development of the economic assessment of the management implications and recommendations of the MSAP and to provide increased regulatory stability, the SEP recommends that the TAC be set at 2-year intervals coinciding with the year of the full stock assessment.

ECONOMIC AND SOCIAL IMPLICATIONS OF TAC CHOICES

From an economic perspective, an evaluation of alternative TACs entails maximization of the present value of commercial and recreational catches over a fairly long time horizon. For regulation to be effective in rebuilding an overfished stock, catches must be reduced in the short-term, and later may be increased when the fish population increases in size. Assuming that the open access management of this common property fishery were replaced with a bioeconomically rational management program, a smaller TAC would yield smaller commercial and recreational economic benefits in the short term, but would also lead to a faster realization of the economic benefits of a larger king mackerel resource in the future made possible by faster recovery of the fish stock. Conversely, a higher TAC would generate larger short-term benefits at the expense of a slower stock recovery. Thus, the economic problem is characterized as a tradeoff in the value of catches over time.

In general, if management continues with a permit moratorium and the setting of an annual TAC, short-run economic benefits from maintaining a higher TAC will be dissipated by increasing fishing effort by existing participants in the fishery, causing harvest costs to increase as the length of the fishing season continues to be abbreviated. The alternative of cutting TAC now would incur costs from lost production and redirect effort to other commercial and recreational fisheries, imposing costs on these other fisheries. Increases in TAC in the future would attract new effort into the commercial and recreational fisheries and result in increased operating costs. Intuitively, maintaining the TAC at its present level would minimize these costs under the present management institution.

Three alternative TACs, 10.6, 10.1 and 8.0 MP, are considered here for comparative analysis of impacts. The first alternative is the current TAC, the second alternative is the median ABC estimated by the MSAP, and the last alternative is the lower bound of the ABC estimated by the MSAP. The upper end of ABC is predicated on a high probability of exceeding $F_{30\%SPR}$, and thus would appear to be less of a viable TAC alternative especially if the 40 percent static SPR, proposed under the SFA generic amendment, becomes effective as the biological optimum yield. In fact, this new provision would require lower TACs in future years.

One of the annual demand models estimated by Dr. Vondruska was re-run in terms of 1998 dollars and used to estimate exvessel revenues, producer surplus, and consumer surplus for the commercial fisheries on Gulf group king mackerel associated with possible choices of one stream of yields over another (for 23 fishing years, 1998/99 to 2020/2021, from Legault, 1999). The one stream of yields is associated with achieving 30% SPR by 2013/2014 (after which the annual TAC stabilizes at about 8.4 MP) and the other stream of yields is associated with achieving 40% SPR by 2014/2015 (after which the annual TAC stabilizes at about 7.3 MP). The net present values (in 1998 dollars) for the differences between the 23-year streams were about $6.2 million for exvessel revenue, $493,000 for producer surplus, and $435,000 for consumer surplus. Considering that no similar stream of yields was available for the TAC alternatives considered here, only a one-year estimation is done (presented below) for the commercial sector corresponding to the three TAC alternatives.

An unresolved issue in the recreational king mackerel fishery is the impact of provisions contained in the 1998 regulatory amendment to the Coastal Migratory Pelagics FMP. In an attempt to contain recreational harvest overages, this amendment specified a minimum legal size increase from the current 20 inches fork length to 24 inches fork length and reduced the for-hire vessel captain and crew bag limit to zero fish. These regulations have not yet been implemented and therefore would not have affected the harvest performance in 1998. Further, while estimates of expected impacts of these rules were made given previous fishery conditions, the reduction in harvest in 1998 in the absence of regulatory change may be an indication of fundamental stock or angler behavioral change. It is therefore difficult to predict the additional impact these rules may have on future harvests. In addition, the absence of an empirical model for the recreational fishery precludes estimation of the economic impacts of changes in harvests resulting from the mentioned proposed regulatory measures.

As a general guide to determining the consequences of the various TAC levels on the recreational fishery, it may be instructive to present here some MRFSS data presented by Holiman. In particular, this data indicated that the changes in landings from the prior year had the following characteristics:

	Percentage and pounds change between 1998 and 1997
By mode	
charter	minus 13 percent (422,973)
private/rental	minus 57 percent (1,154,464)
By state	
FL	minus 20 percent (848,739)
AL	minus 51 percent (336,930)
MS	minus 89 percent (350,742)
LA	minus 70 percent (122,022)
TX	unknown
By wave	
Jan-Feb	minus 44 percent (816,019)
Mar-Apr	PLUS 28 percent (151,069)
May-Jun	minus 42 percent (240,605)
Jul-Aug	minus 11 percent (92,648)
Sep-Oct	minus 62 percent (593,107)
Nov-Dec	minus 10 percent (67,121)

The succeeding discussion considers the implications of each TAC alternative separately. It has to be recognized that should there be a need to reduce TAC, a phased-in approach may be adopted. The discussions under each TAC alternative provides the general direction and magnitude of effects at least over the short run of implementing this approach to TAC setting.

TAC = 10.6 MP

Commercial Sector Impacts: At this TAC level and using the 32 percent commercial allocation, the commercial sector is expected to generate about $4.252 million dollars of exvessel revenues, of which $0.340 million is an approximation of producer surplus (data in 1998 dollars). For the current purpose, producer surplus is assumed to be 8 percent of exvessel revenues. Using an estimated annual demand model, consumer surplus is estimated at $0.216 million.

Recreational Sector Impacts: Since this is the status quo TAC, no short-term consequences occur in the recreational sector. Current bag and size limits can be maintained and, since quota management does not exist for this fishery, total harvest will be determined by the effort applied, the availability of stock, and the degree to which existing bag and size limits restrict harvest.

Long term consequences may occur if substantial allocation overruns occur (and perhaps even if allocation overruns do not occur; see Legault 1999, Figure 12b) requiring future decreases in TAC greater than those currently anticipated in order to bring the stock to the "not overfished" level, thus requiring greater size, bag or seasonal closure adjustments than would be normally required. Such adjustments would be accompanied with additional loss in economic value to the fishery. Given the uncertainty of harvest and required adjustments, as well as the current lack of specific economic information on trip demand for this fishery, these values cannot currently be estimated.

Social Impacts: At this time, there exist few specific data with which to address short and long term consequences of changes in TAC. Other studies of resource dependent industries lead the SEP to believe that as harvest restrictions increase, commercial fishermen and other stakeholders (marina owners, the for-hire sector) will be penalized proportionately, at least in the short run and perhaps in the long run. More restrictive TACs also have the potential to seriously affect economic well-being, living conditions and the immediate future of people living in those communities that depend on fishing. However, without better data, the magnitude of these effects cannot be estimated.

TAC = 10.1 MP

Commercial Sector Impacts: At this TAC level, exvessel revenues and producer surplus are estimated at $4.063 million and $0.325 million, respectively. These are about 4 percent below those estimated under a higher TAC. Consumer surplus is estimated at $0.2 million, or about 7 percent lower than that under a 10.6 million-pound TAC.

Recreational Sector Impacts: This TAC is a 500,000-pound reduction from the status quo TAC. Under the current 68 percent recreational allocation of TAC for this fishery, this equals a 340,000 pound reduction, or 4.72 percent, in the recreational allocation. As previously discussed, the 1998 regulatory amendment established a 24-inch king mackerel minimum size and a zero-fish bag limit for captain and crew on for-hire vessels. Individually, the minimum size limit increase (from the current 20-inch limit) is projected to produce up to a 10 percent reduction in recreational harvest, while the captain and crew limit is projected to produce up to a 12 percent reduction in recreational harvest. Although not yet implemented, the proposed measures are expected to go into effect in the near future and thus can be characterized as establishing status quo management regulations for the fishery. Since the allocation reduction implied under a 10.1 million pound TAC is easily accommodated by either the size limit increase or the bag limit decrease, no further adjustments should be required to contain the recreational sector to its allocation, thus producing no short-term economic effects. Clarification should be made that, although the proposed measures will in fact result in short term economic losses, these losses are not attributable to the TAC changes currently being discussed.

Long term consequences under a 10.1 million-pound TAC are similar to those described under a 10.6 million pound TAC, except it modestly prepares the fishery for possible future TAC reductions, a first step in a possible phased reduction in TAC needed to comply with the higher SPR target. Despite the pending implementation of the minimum size and bag limit changes, the recreational sector is subject to harvesting whatever circumstances dictate. As such, regardless of the TAC, the potential exists for allocation overruns, with subsequent deleterious effects.

Social Impacts: See the discussion for the first TAC alternative.

TAC = 8.0 MP

Commercial Sector Impacts: At this TAC level, exvessel revenues and producer surplus are estimated at $3.256 million and $0.261 million, respectively. These are about 23 percent below those estimated under a 10.6 million pound TAC. Consumer surplus is estimated at $0.139 million, or about 36 percent lower than that under a 10.6 million pound TAC.

Recreational Sector Impacts: Under the current 68 percent recreational allocation of TAC for this fishery, an 8.0 million pound TAC equates to a 5.44 million pound recreational allocation. The average harvest has been 6.766 MP since the 1992/93 fishing season under constant bag and size limits and uncontrolled recreational effort levels (MSAP 1999)[1]. With the 1992-99 average harvest used as the expected harvest level, an 8.0 million pound TAC equates to a 1.326 million pound reduction in the expected recreational harvest, or 19.6 percent. Although in functional application,

[1]The 1992/93 season was selected as the initial year for comparison because this season experienced a 65 percent harvest increase over the previous 6-year average. This harvest level has been approximately maintained or exceeded each year since.

expected harvest savings from simultaneous bag and size limit changes will not be directly additive, the expected harvest reduction potential of the pending regulatory measures, as discussed above, exceed the estimated 19.6 percent recreational harvest reduction required under an 8.0 million pound TAC. Thus, as with the previous TAC scenarios, no additional harvest restrictions should be required and no short-term economic losses should accrue. This determination could change, however, depending on when the mentioned proposed measures become effective. It is not possible at this time, however, to determine either the effective date of implementation or the resultant effect in reducing expected harvest savings.

Long term consequences under an 8 million pound TAC are similar to those described under both scenarios above. Despite the implementation of the minimum size and bag limit changes, the recreational sector is subject to harvesting whatever circumstances dictate. As such, regardless of the TAC, the potential exists for allocation overruns, with subsequent deleterious effects.

This TAC level will preserve more stock for the future with moderate biological gains (i.e., increases in SPR) (See Legault 1999, Figure 12b). It also accelerates recovery of the stock that will likely be required in 2001; implementing this in 1999/2000 achieves MSY sooner.

Social Impacts: See the discussion for the first TAC alternative.

FISHING COMMUNITIES

With the addition of National Standard 8, fishery management plans must now identify and consider the impacts on fishing communities to assure their sustained participation and minimize adverse economic impacts [MSFCMA section 301 (a) (8)]. According to the proposed guidelines, a fishing community is a social or economic group whose members reside in a specific location and share a common dependency on commercial, recreational, or subsistence fishing or on directly related fisheries-dependent services and industries (for example, boatyards, ice suppliers, tackle shops) [Federal Register volume 62, Number 149 (August 4, 1997)].

There remains an immediate need for programs and data collection protocols in order to identify and define fishing communities in the Gulf region. Data that are presently collected through other agencies are not specific to fisheries management, e.g. census data and case studies on particular fisheries. Although this data can be useful, they are often not specific enough to identify fishing communities nor can they characterize the nature of dependence upon fishing. In addition, these data do not allow for the determination of the impacts of proposed management regulations such as TACs and trip limits on fishing communities through their effects on employment levels in the fishery or related support industries. Therefore, the lack of such data greatly hinders the potential analysis of the social and economic impacts of proposed regulations. At this time, we can only allude to possible community impacts.

A MARFIN proposal to identify and define fishing communities in Florida is presently underway. Other Gulf states will need similar projects to assist them in identifying dependence and substantial engagement in fishing. However, initial work to identify and define fishing communities should begin soon. The Atlantic Coast Cooperative Statistical Program (ACCSP) is developing a protocol for identifying fishing communities and other Fishery Management Councils are beginning to update previous Fishery Impact Statements to reflect this new National Standard. As stated last year in a letter to the Council, the SEP reiterates the need for coordination and overview by the National Marine Fisheries Service to ensure consistency throughout the nation.

OTHER SOCIAL DATA NEEDS

As mackerel stocks recover, the management of these fisheries will increasingly focus on allocation of the catch and less on the biology of the stock. This development makes it even more important that some minimum set of socioeconomic data be collected to allow for as complete an analysis of the impacts as possible. The economic add-on for the MRFSS survey will provide important economic and socio-demographic data for the recreational angler. It is imperative that similar data be collected for the commercial and for-hire owners, vessel captains, and crew and included in the economic modeling. The panel recommends the following data at a minimum be collected for the commercial and for-hire sectors:

1. Number of participants and their age, education, and marital status.
2. Years fishing, family history of fishing participation.
3. Percent of total household income from commercial fishing (include total household income).
4. Effort by species and month and gear type (include all species fished and location to assess multispecies nature of mackerel fishermen).
5. Job skills and employment history (job training).
6. Perceived opportunities for alternative employment.

POTENTIAL NEED FOR EFFORT MANAGEMENT

This report discussed several disturbing trends in the approach to the management of king mackerel. At present there are several occurrences within the fishery that signal potential problems. While much of the success of management to date has been based on quotas to limit the amount of total catch, this has ultimately led to a derby fishery. Attempts to resolve some of the problems created by the derby have involved gear regulations designed to maintain suballocation shares at historical percentages. These suballocations lock in market distortions caused by the open access management of domestic common property resources and ensure that net benefits will be less than could be obtained in the fishery under some form of rational management. Using history as a guide, even more regulation will be necessary as the stock continues to recover. An analogous situation developed in the red snapper fishery and the Council eventually chose to limit fishing effort as a way to resolve the derby problems in that fishery. The SEP recognizes that the Congress has limited the ability of councils to introduce ITQ or IQ programs per se, but that intent does not extend to other methods of limiting effort. Considering that fishers in the coastal pelagic fisheries also participate in other fisheries, there is a need to take into account the multi-species nature of the participants in these fisheries as it relates to effort limitation programs and impact of shifting effort to these species.

In addition, with the recent emphasis upon ecosystem management that is evident through the reauthorization the Magnuson-Stevens Act, the SEP emphasizes the need to include humans within the ecosystem. Present paradigms, such as the recent efforts to identify essential fish habitat do not adequately encompass the human dimensions of fisheries management. A more holistic approach to fisheries management which includes the full range of behavior by those who utilize fisheries' resource and incorporation of that behavior into the ecosystems approach is essential to fully realize such a shift in management paradigms.

DOCUMENTS REVIEWED OR CITED

Easely, J. E., Jr. Chuck Adams, Walter N. Thurman and Joel Kincaid. 1993. The derived demand for commercially harvested Gulf and South Atlantic king mackerel: partial equilibrium and general equilibrium models. Project report to the Gulf of Mexico Fishery Management Council, 42 pp. + appendices, March 29, 1993.

Holiman, S.G. 1999. Recreational Fishery Data Gulf of Mexico Coastal Migratory Pelagics Fishery 1982-98. National Marine Fisheries Service, Fisheries Economics Office, 9721 Executive Center Drive N., St. Petersburg, FL 33702-2432, 167 pp., SERO-ECON-99-04. M 99

Holiman, S.G. 1999. Research Activities Using the 1997-98 Southeast Recreational Economic Add-On Data. National Marine Fisheries Service, Fisheries Economics Office, 9721 Executive Center Drive N., St. Petersburg, FL 33702-2432, 8 pp., SERO-ECON-99-09.

Holiman, S.G. 1999. Summary Report of Methods and Descriptive Statistics for the 1997098 Southeast Region Marine Recreational Economics Survey. National Marine Fisheries Service, Fisheries Economics Office, 9721 Executive Center Drive N., St. Petersburg, FL 33702-2432, 18 pp., SERO-ECON-99-10.

Holiman, S.G. 1999. Summary Report of Methods and Descriptive Statistics for the 1997098 Southeast Region Marine Recreational Economics Survey Fishery Management Data. National Marine Fisheries Service, Fisheries Economics Office, 9721 Executive Center Drive N., St. Petersburg, FL 33702-2432, 29 pp., SERO-ECON-99-11.

Legault, C.M. 1999. Updated projections for king and Spanish mackerel in the Gulf of Mexico and Atlantic Ocean. MSAP/99/01. DOC, NMFS, SEFSC, Sustainable Fisheries Division Contribution SFD-98/99-49. 33 pp (+Appendix).

Mackerel Stock Assessment Panel (MSAP). 1999. 1999 report of the mackerel stock assessment panel. Gulf of Mexico Fishery Management Council, 3018 U.S. Highway 301 North, Suite 1000, Tampa, FL 33619 and South Atlantic Fishery Management Council, 1 Southpark Circle, Charleston, SC 29407, 25 pp.

Vondruska, John. 1999. Commercial landings update, coastal migratory pelagic fish. National Marine Fisheries Service, Fisheries Economics Office, 9721 Executive Center Drive N., St. Petersburg, FL 33702-2432, SERO-ECON-99-06, April 1999.

Vondruska, John. 1999. An analysis of the demand for king mackerel. National Marine Fisheries Service, Fisheries Economics Office, 9721 Executive Center Drive N., St. Petersburg, FL 33702-2432, SERO-ECON-99-07, April 1999.

Vondruska, John and W. Antozzi. 1999. U.S. markets and trade in king mackerel and other large mackerel. National Marine Fisheries Service, Fisheries Economics Office, 9721 Executive Center Drive N., St. Petersburg, FL 33702-2432, SERO-ECON-99-08, April 1999.

LIST OF ATTENDEES

Stephen Holland, Chairman
David Lavergne, Vice-chairman
Joselito Estrada, Member
Michael Jepson, Member
Robert Palmer, Member
Richard Raulerson, Member
Robin Riechers, Member
Deborah Tootle, Member
John Ward, Member

Roy Williams, Council member
Chris Dorsett, GRN
Stephen Holiman, NMFS-SERO
Antonio Lamberte, Council staff
Robert Muller, FDEP-FMRI
Mike Travis, NMFS-SERO
John Vondruska, NMFS-SERO

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Figure 1. Distribution of Recreational Anglers' Stated Reaction to a Zero Bag Limit for King Mackerel, All Anglers, by Subregion

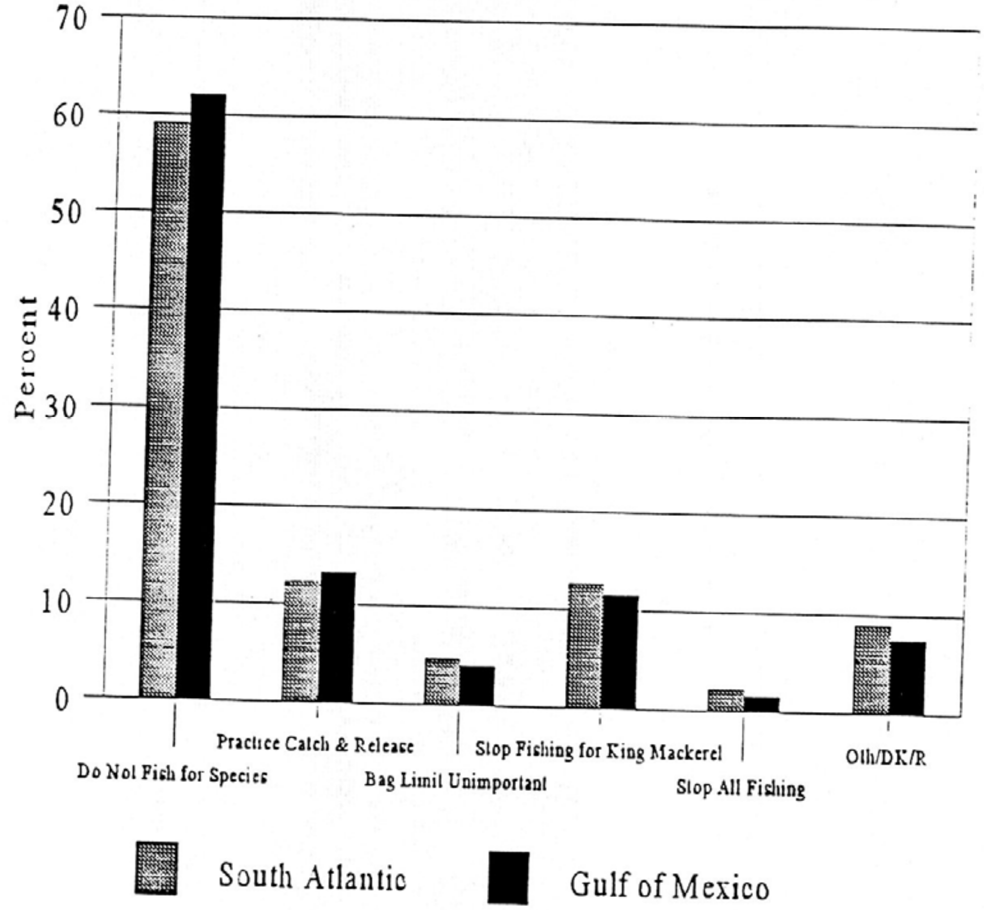

Figure 2. Distribution of Recreational Anglers' General Target Species, by Subregion

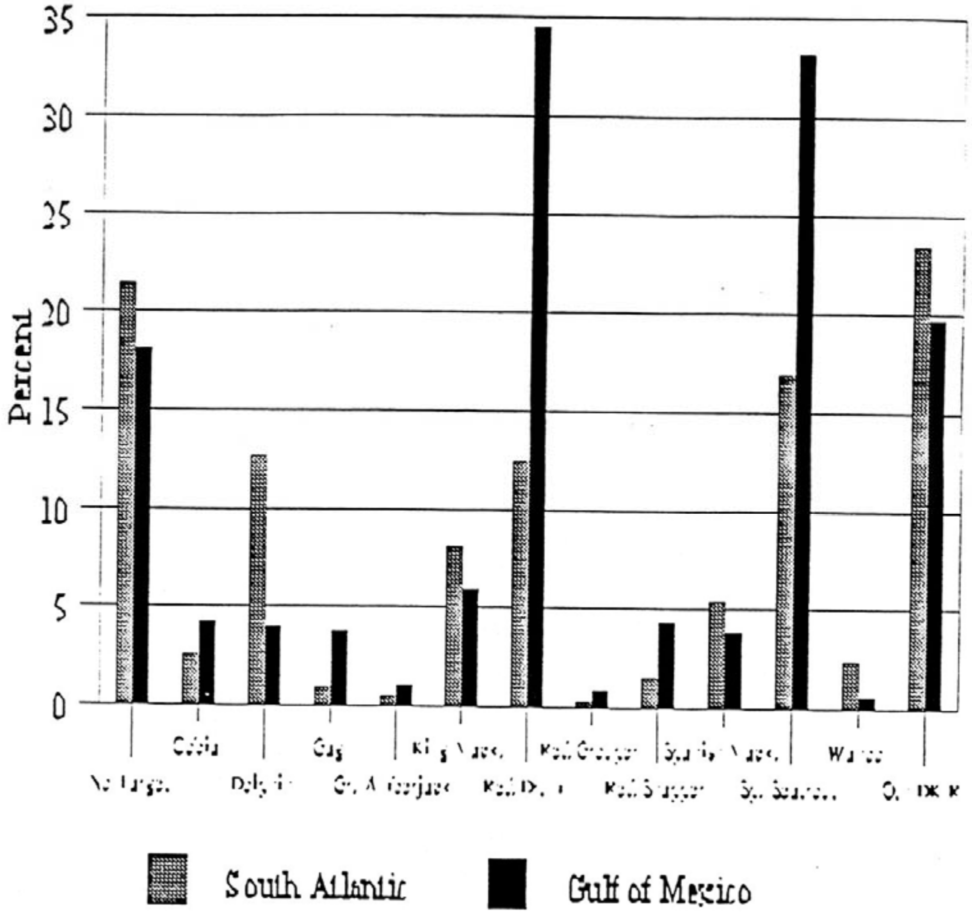

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Figure 3. Distribution of Recreational Anglers' Expectations of Catching and Keeping the Legal King Mackerel Limit, by Subregion

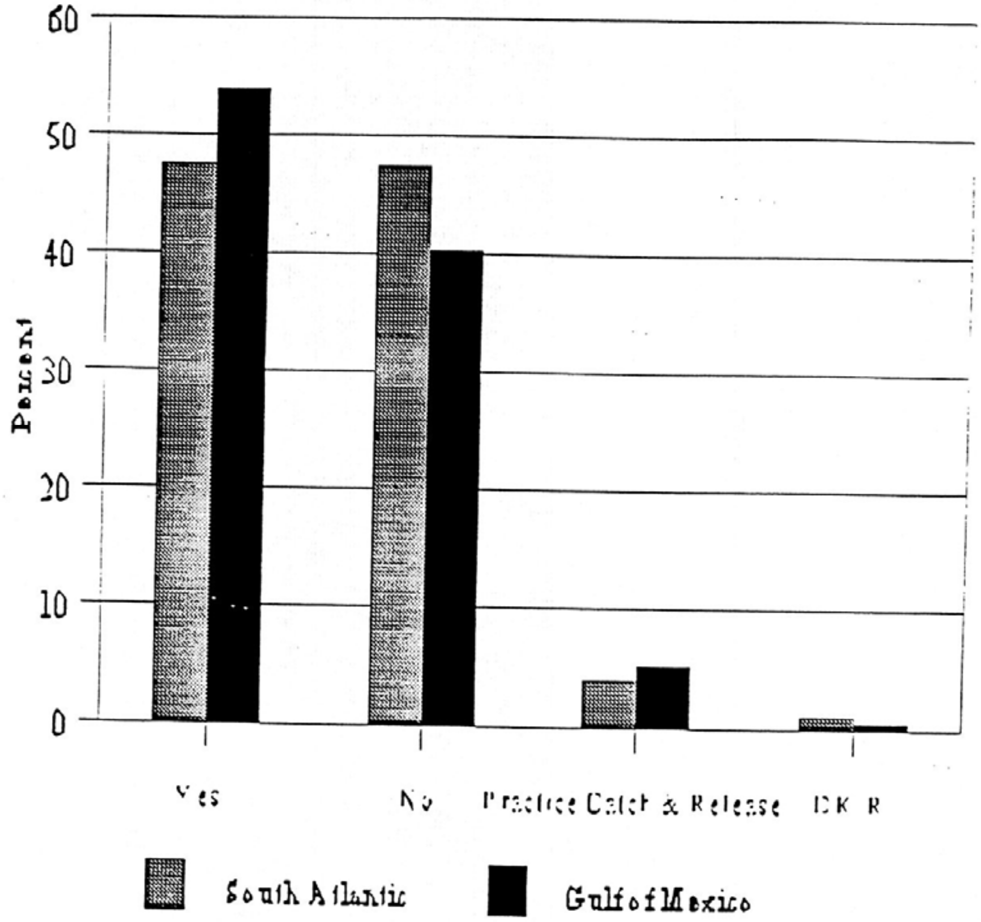

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Figure 4. **Gulf Charter and Head Boats**
Percent Targeting Species in the Gulf

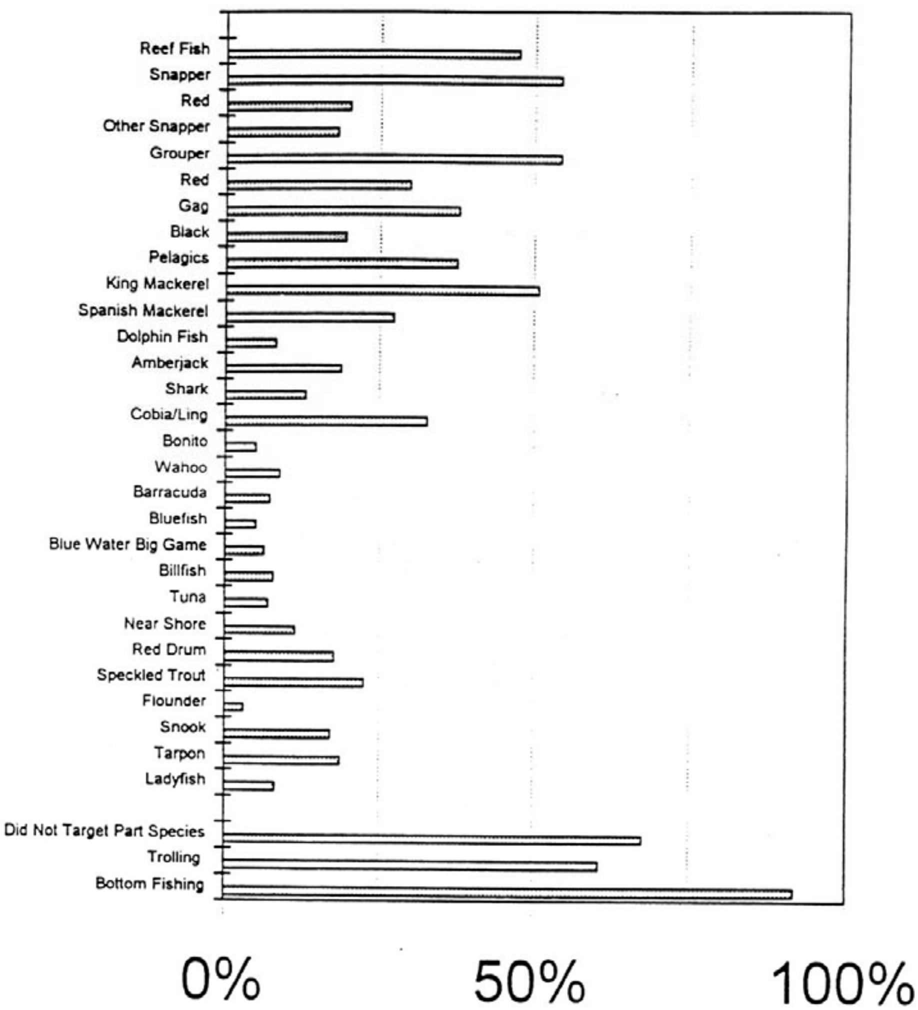

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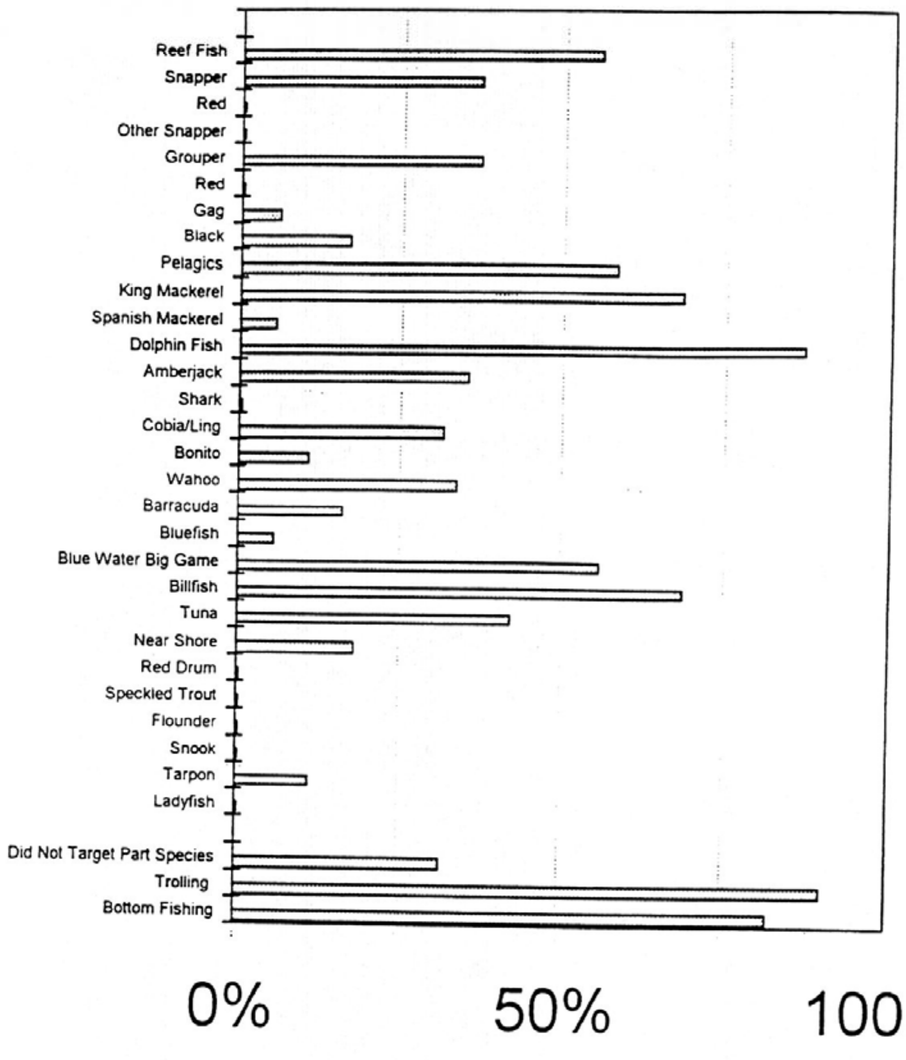
Figure 5. **Keys Charter and Headboats**
Percent Targeting Species in the Keys



The following figures and tables are not cited in the text but were used by the SEP in their discussions.

COMMERCIAL FISHERY

Figure 1.--U.S. Supplies of Large Mackerel

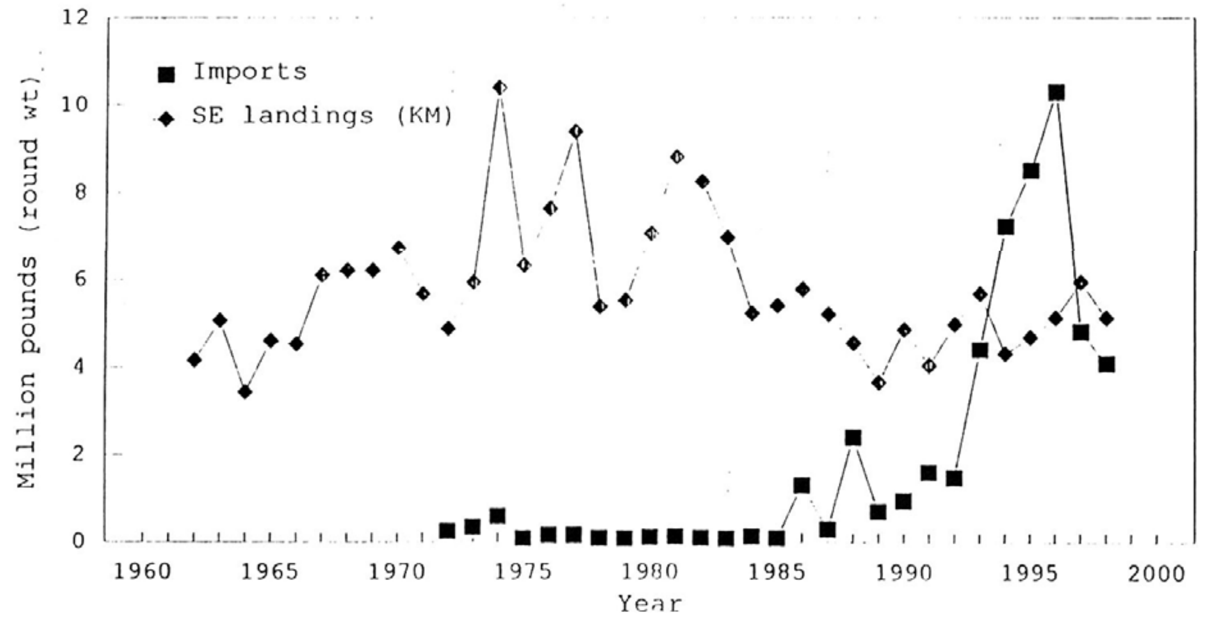


Figure 1.--U.S. Supplies of Large Mackerel

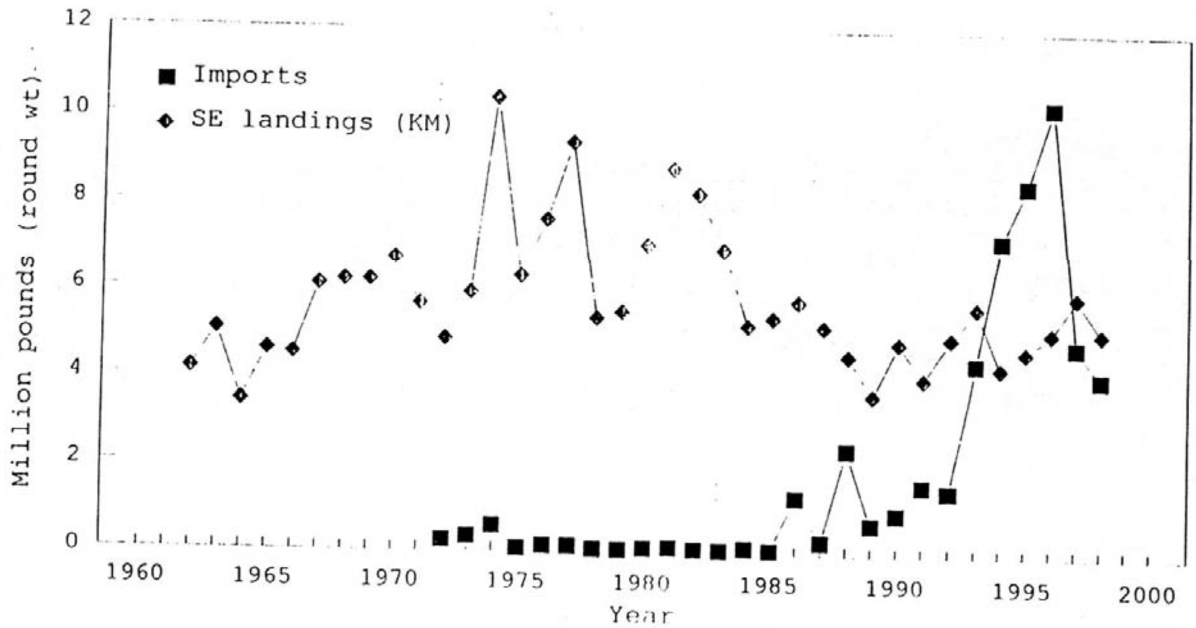


Figure 2.--Real Prices of Large Mackerel

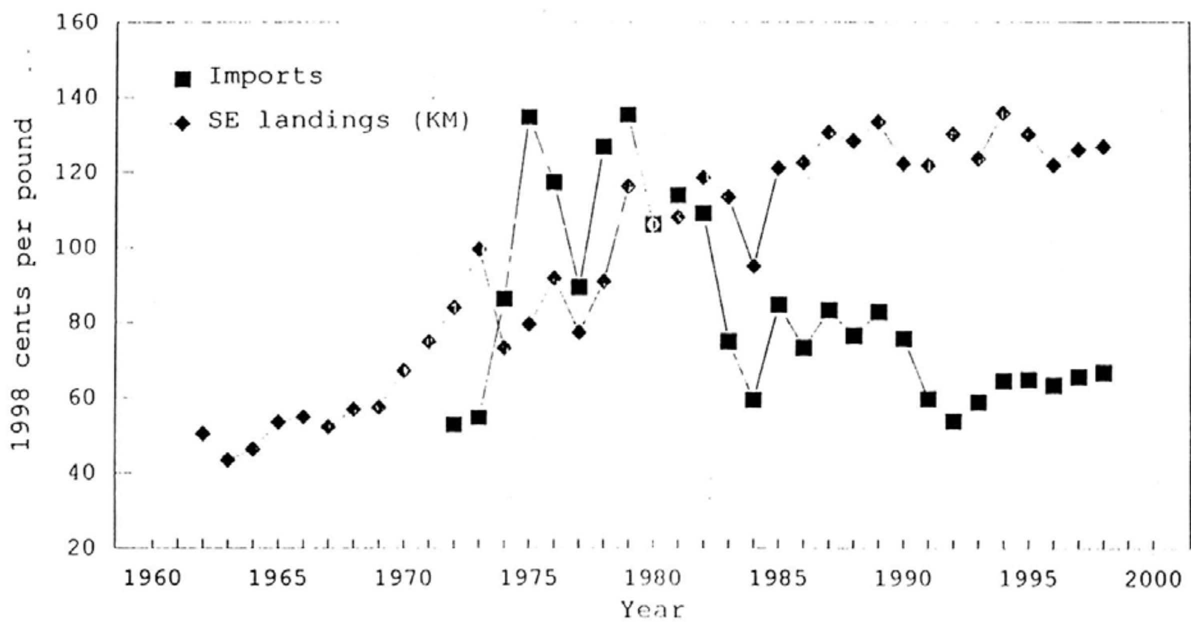


Figure 2.--Real Prices of Large Mackerel

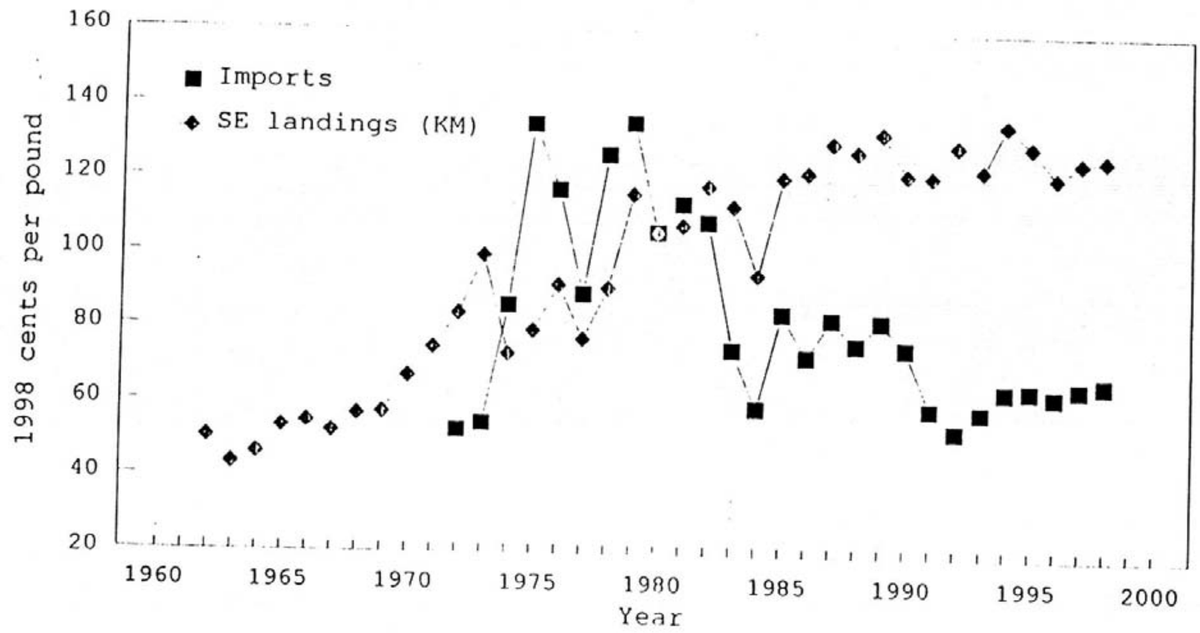


Table 1.--Variables used in the annual demand model for king mackerel model,

YR	MQ	MP	CONS	LQSE	LPSE	DPI92	PPI
1960							
1961							
1962			4149	4149	50	1913	317
1963			5048	5048	43	1983	316
1964			3423	3423	46	2125	316
1965			4586	4586	53	2259	323
1966			4513	4513	55	2379	333
1967			6096	6096	52	2482	334
1968			6198	6198	57	2595	342
1969			6202	6202	57	2679	356
1970			6723	6723	67	2783	369
1971			5660	5660	75	2895	381
1972	243	53	5111	4867	84	3027	398
1973	337	55	6265	5929	100	3241	450
1974	586	86	10987	10401	73	3217	535
1975	81	135	6400	6319	79	3273	584
1976	148	117	7770	7622	92	3401	611
1977	146	89	9534	9388	77	3511	649
1978	80	127	5448	5367	91	3692	699
1979	78	135	5593	5515	116	3793	787
1980	110	106	7178	7068	106	3816	898
1981	126	114	8938	8813	108	3905	980
1982	89	109	8331	8242	119	3935	1000
1983	74	75	7037	6963	113	4039	1013
1984	128	59	5345	5217	95	4339	1037
1985	84	85	5476	5392	121	4464	1032
1986	1290	73	7058	5768	123	4595	1002
1987	291	83	5490	5199	130	4683	1028
1988	2384	76	6926	4542	128	4875	1069
1989	693	83	4342	3649	133	4972	1122
1990	934	76	5782	4848	122	5060	1163
1991	1585	60	5616	4031	122	5053	1165
1992	1467	54	6435	4968	130	5190	1172
1993	4388	59	10052	5664	124	5260	1189
1994	7224	64	11518	4294	136	5380	1205
1995	8496	65	13169	4674	130	5530	1248
1996	10295	63	15407	5112	122	5684	1277
1997	4804	66	10738	5934	126	5842	1276
1998	4078	67	9192	5114	127	6026	1244
1999							
2000							

Data on landings for 1998 is incomplete.
CONS US consumption, 1000 lb, live wt
DPI98 US disposable personal inc, billion 98$
LPSE SE exvessel price, KM-cero, 1998 cts/lb
LQSE SE landings, KM-cero, 1000 lb live wt
MP Import price, 1998 cents/lb, live wt
MQ Imports, large mackerel, 1000 lb live wt
PPI PPI, all commodities, 1982=1000
YR 1962-98 (range used in model is 1972-98)
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1963			5048	5048	43	1983	316
1964			3423	3423	46	2125	316
1965			4586	4586	53	2259	323
1966			4513	4513	55	2379	333
1967			6096	6096	52	2482	334
1968			6198	6198	57	2595	342
1969			6202	6202	57	2679	356
1970			6723	6723	67	2783	369
1971			5660	5660	75	2895	381
1972	243	53	5111	4867	84	3027	398
1973	337	55	6265	5929	100	3241	450
1974	586	86	10987	10401	73	3217	535
1975	81	135	6400	6319	79	3273	584
1976	148	117	7770	7622	92	3401	611
1977	146	89	9534	9388	77	3511	649
1978	80	127	5448	5367	91	3692	699
1979	78	135	5593	5515	116	3793	787
1980	110	106	7178	7068	106	3816	898
1981	126	114	8938	8813	108	3905	980
1982	89	109	8331	8242	119	3935	1000
1983	74	75	7037	6963	113	4039	1013
1984	128	59	5345	5217	95	4339	1037
1985	94	85	5476	5392	121	4464	1032
1986	1290	73	7058	5768	123	4595	1002
1987	291	83	5490	5199	130	4683	1028
1988	2384	76	6926	4542	128	4875	1069
1989	693	83	4342	3649	133	4972	1122
1990	934	76	5782	4848	122	5060	1163
1991	1585	60	5616	4031	122	5053	1165
1992	1467	54	6435	4968	130	5190	1172
1993	4388	59	10052	5664	124	5260	1189
1994	7224	64	11518	4294	136	5380	1205
1995	8496	65	13169	4674	130	5530	1248
1996	10295	63	15407	5112	122	5684	1277
1997	4804	66	10738	5934	126	5842	1276
1998	4078	67	9192	5114	127	6026	1244
1999							
2000							

Data on landings for 1998 is incomplete.

CONS US consumption, 1000 lb, live wt
DPI98 US disposable personal inc, billion 98$
LPSE SE exvessel price, KM-cero, 1998 cts/lb
LQSE SE landings, KM-cero, 1000 lb live wt
MP Import price, 1998 cents/lb, live wt
MQ Imports, large mackerel, 1000 lb live wt
PPI PPI, all commodities, 1982=1000
YR 1962-98 (range used in model is 1972-98)
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Table 13a.--Estimated consumer and producer surplus, option 1 (Gulf king to 30% SPR by FY2013/2014, Legault, 1999, Table 5a, p.12)

Variable:	LPSE	INTERCEPT	LQSE	MQ	DPI98
Coefficient (a):	na	45.940539	-0.00223	-0.001485	0.018519
Means, 1993-97:	127.356	na	5,135.48	7,041.33	5,538.99

FY1993/94 to FY1997/98 means, commercial landings (1000 lbs., round wt)	
Atlantic group	2,279
Gulf group	2,826
Overall	5,105

Year	Fishing year	- - Gulf group - - total yield, thousand pounds round weight 1	comm. alloc., thousand pounds round weight 2	Southeast (North Carolina-Texas) Modeled LQSE (b), thousand pounds, round wt 3	Model estimate, LPSE (c), 1998 cents per pound 4	LQSE (d) thousand pounds, round wt 5	Model estimate, LPSE (c), 1998 cents per pound 6	- - - Allocated effects for Gulf group king mac[…] Total exvessel revenue (3*4) *(2/3), thousand 1998$ 7	Producer surplus (7*0.08) *(2/3), thousand 1998$ 8	Consumer surplus (3-5)* (6-4)*0.5 *(2/3), thousand 1998$ 9	Present […] year […] Exvessel revenue, thousand 1998$ 10	Pro[…] su[…]
0	1998/1999	11,370	3,638	5,948	125	0	138	4,541	363	241	4,541	
1	1999/2000	10,320	3,302	5,612	126	0	138	4,146	332	207	3,875	
2	2000/2001	10,170	3,254	5,564	126	0	138	4,089	327	202	3,572	
3	2001/2002	9,800	3,136	5,445	126	0	138	3,949	316	190	3,223	
4	2002/2003	9,390	3,005	5,314	126	0	138	3,792	303	178	2,893	
5	2003/2004	9,400	3,008	5,317	126	0	138	3,796	304	178	2,707	
6	2004/2005	8,910	2,851	5,161	127	0	138	3,608	289	164	2,404	
7	2005/2006	8,490	2,717	5,026	127	0	138	3,446	276	152	2,146	
8	2006/2007	8,450	2,704	5,013	127	0	138	3,431	274	151	1,997	
9	2007/2008	8,340	2,669	4,978	127	0	138	3,388	271	148	1,843	
10	2008/2009	8,300	2,656	4,965	127	0	138	3,373	270	147	1,715	
11	2009/2010	8,240	2,637	4,946	127	0	138	3,350	268	145	1,591	
12	2010/2011	8,220	2,630	4,940	127	0	138	3,342	267	145	1,484	
13	2011/2012	8,180	2,618	4,927	127	0	138	3,326	266	144	1,380	
14	2012/2013	8,190	2,621	4,930	127	0	138	3,330	266	144	1,291	
15	2013/2014	8,140	2,605	4,914	127	0	138	3,311	265	143	1,200	
16	2014/2015	8,140	2,605	4,914	127	0	138	3,311	265	143	1,121	
17	2015/2016	8,140	2,605	4,914	127	0	138	3,311	265	143	1,048	
18	2016/2017	8,140	2,605	4,914	127	0	138	3,311	265	143	980	
19	2017/2018	8,150	2,608	4,917	127	0	138	3,315	265	143	917	
20	2018/2019	8,150	2,608	4,917	127	0	138	3,315	265	143	857	
21	2019/2020	8,150	2,608	4,917	127	0	138	3,315	265	143	801	
22	2020/2021	8,150	2,608	4,917	127	0	138	3,315	265	143	748	
Sum		200,930	64,298	117,416				81,409	6,513	3,680	44,333	

(a) Equation 1, Table 6, estimated using 1972-98 annual data (27 obs.). (b) Landings (LQSE) @ 1993-97 means after adjustment for chang[…] from base. (c) Estimated @ LQSE in preceding col.; 1993-97 means for other ind. variables. (d) Near-zero value for LQSE (0.1 lb / yr.[…]
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Table 13a.--Estimated consumer and producer surplus, option 1 (Gulf king to [illegible] SPR by FY2013/2014, Legault, 1999, Table 5a, p.12)

Variable:	LPSE	INTERCEPT	LQSE	MQ	DPI98
Coefficient (a):	na	45.940539	-0.00223	-0.001485	0.018519
Means, 1993-97:	127.356	na	5,135.48	7,041.33	5,538.99

FY1993/94 to FY1997/98 means, commercial landings (1000 lbs., round wt)	
Atlantic group	2,279
Gulf group	2,826
Overall	5,105

		- - Gulf group - -		Southeast (North Carolina-Texas)				- - - Allocated effects for Gulf group king ma			
		total yield	comm. alloc.	Modeled LQSE (b), thousand pounds, round wt	Model estimate, LPSE (c), 1998 cents per pound	LQSE (d) thousand pounds, round wt	Model estimate, LPSE (c), 1998 cents per pound	Total exvessel revenue (3*4) *(2/3)	Producer surplus (7*0.08) *(2/3)	Consumer surplus (3-5)* (6-4)*0.5 *(2/3)	Present year: Exvessel revenue
		thousand pounds round weight						- - - - - - - - - - thousand 1998$ - - - - - -			
Year	Fishing year	1	2	3	4	5	6	7	8	9	10
0	1998/1999	11,370	3,638	5,948	125	0	138	4,541	363	241	4,541
1	1999/2000	10,320	3,302	5,612	126	0	138	4,146	332	207	3,875
2	2000/2001	10,170	3,254	5,564	126	0	138	4,089	327	202	3,572
3	2001/2002	9,800	3,136	5,445	126	0	138	3,949	316	190	3,223
4	2002/2003	9,390	3,005	5,314	126	0	138	3,792	303	178	2,893
5	2003/2004	9,400	3.008	5,317	126	0	138	3,796	304	178	2,707
6	2004/2005	8,910	2,851	5,161	127	0	138	3,608	289	164	2,404
7	2005/2006	8,490	2,717	5,026	127	0	138	3,446	276	152	2,146
8	2006/2007	8,450	2,704	5,013	127	0	138	3,431	274	151	1,997
9	2007/2008	8,340	2,669	4,978	127	0	138	3,388	271	148	1,843
10	2008/2009	8,300	2,656	4,965	127	0	138	3,373	270	147	1,715
11	2009/2010	8,240	2,637	4,946	127	0	138	3,350	268	145	1,591
12	2010/2011	8,220	2,630	4,940	127	0	138	3,342	267	145	1,484
13	2011/2012	8,180	2,618	4,927	127	0	138	3,326	266	144	1,380
14	2012/2013	8,190	2,621	4,930	127	0	138	3,330	266	144	1,291
15	2013/2014	8,140	2,605	4,914	127	0	138	3,311	265	143	1,200
16	2014/2015	8,140	2,605	4,914	127	0	138	3,311	265	143	1,121
17	2015/2016	8,140	2,605	4,914	127	0	138	3,311	265	143	1,048
18	2016/2017	8,140	2,605	4,914	127	0	138	3,311	265	143	980
19	2017/2018	8,150	2,608	4,917	127	0	138	3,315	265	143	917
20	2018/2019	8,150	2,608	4,917	127	0	138	3,315	265	143	857
21	2019/2020	8,150	2,608	4,917	127	0	138	3,315	265	143	801
22	2020/2021	8,150	2,608	4,917	127	0	138	3,315	265	143	748
Sum		200,930	64,298	117,416				81,409	6,513	3,680	44,333

(a) Equation 1, Table 6, estimated using 1972-98 annual data (27 obs.). (b) Landings (LQSE) @ 1993-97 means after adjustment for cha
from base. (c) Estimated @ LQSE in preceding col.; 1993-97 means for other ind. variables. (d) Near-zero value for LQSE (0.1 lb / y
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Table 13b.--Estimated consumer and producer surplus, option 2 (Gulf king to 40% SPR by FY2014/2015--Legault, 1999, Table 5a, p. 12)

Variable:	LPSE	INTERCEPT	LQSE	MO	DPI92
Coefficient (a):	na	45.940539	-0.00223	-0.001485	0.018519
Means, 1993-97:	127.356	na	5,135.48	7,041.33	5,538.99

FY1993/94 to FY1997/98 means, commercial landings (1000 lbs., round wt)	
Atlantic group	2,279
Gulf group	2,826
Overall	5,105

		- - Gulf group - -		Southeast (North Carolina-Texas)				- - - Allocated effects for Gulf group king mac[kerel]			
		total yield	comm. alloc.	Modeled LQSE (b), thousand pounds, round wt	Model estimate, LPSE (c), 1998 cents per pound	LQSE (d) thousand pounds, round wt	Model estimate, LPSE (c), 1998 cents per pound	Total exvessel revenue (3*4) *(2/3)	Producer surplus (7*0.08) *(2/3)	Consumer surplus (3-5)* (6-4)*0.5 *(2/3)	Present year: Exvessel revenue
		thousand pounds round weight						- - - thousand 1998$ - - -			
Year	Fishing year	1	2	3	4	5	6	7	8	9	10
0	1998/1999	11,370	3,638	5,948	125	0	138	4,541	363	241	4,541
1	1999/2000	7,170	2,294	4,604	128	0	138	2,932	235	118	2,740
2	2000/2001	7,470	2,390	4,700	128	0	138	3,050	244	125	2,664
3	2001/2002	7,570	2,422	4,732	128	0	138	3,089	247	128	2,521
4	2002/2003	7,570	2,422	4,732	128	0	138	3,089	247	128	2,356
5	2003/2004	7,860	2,515	4,825	127	0	138	3,202	256	135	2,283
6	2004/2005	7,670	2,454	4,764	127	0	138	3,128	250	130	2,084
7	2005/2006	7,390	2,365	4,674	128	0	138	3,018	241	123	1,880
8	2006/2007	7,470	2,390	4,700	128	0	138	3,050	244	125	1,775
9	2007/2008	7,430	2,378	4,687	128	0	138	3,034	243	124	1,650
10	2008/2009	7,460	2,387	4,697	128	0	138	3,046	244	125	1,548
11	2009/2010	7,410	2,371	4,681	128	0	138	3,026	242	124	1,438
12	2010/2011	7,420	2,374	4,684	128	0	138	3,030	242	124	1,345
13	2011/2012	7,380	2,362	4,671	128	0	138	3,014	241	123	1,251
14	2012/2013	7,410	2,371	4,681	128	0	138	3,026	242	124	1,174
15	2013/2014	7,310	2,339	4,649	128	0	138	2,987	239	121	1,083
16	2014/2015	7,310	2,339	4,649	128	0	138	2,987	239	121	1,012
17	2015/2016	7,330	2,346	4,655	128	0	138	2,995	240	122	948
18	2016/2017	7,330	2,346	4,655	128	0	138	2,995	240	122	886
19	2017/2018	7,330	2,346	4,655	128	0	138	2,995	240	122	828
20	2018/2019	7,330	2,346	4,655	128	0	138	2,995	240	122	774
21	2019/2020	7,330	2,346	4,655	128	0	138	2,995	240	122	723
22	2020/2021	7,330	2,346	4,655	128	0	138	2,995	240	122	676
Sum		174,650	55,888	109,006				71,218	5,697	2,971	38,180

(a) Equation 1, Table 6, estimated using 1972-98 annual data (27 obs.). (b) Landings (LQSE) @ 1993-97 means after adjustment for char[...] from base. (c) Estimated @ LQSE in preceding col.; 1993-97 means for other ind. variables. (d) Near-zero value for LQSE (0.1 lb / y[...]
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Table 13b.--Estimated consumer and producer surplus, option 2 (Gulf king to 40% SPR by FY2014/2015--Legault, 1999, Table 5a, p. 12)

Variable:	LPSE	INTERCEPT	LQSE	MQ	DPI92
Coefficient (a):	na	45.940539	-0.00223	-0.001485	0.018519
Means, 1993-97:	127.356	na	5,135.48	7,041.33	5,538.99

FY1993/94 to FY1997/98 means, commercial landings (1000 lbs., round wt)	
Atlantic group	2,279
Gulf group	2,826
Overall	5,105

Year	Fishing year	- - Gulf group - - total yield	comm. alloc.	Southeast (North Carolina-Texas) Modeled LQSE (b), thousand pounds, round wt	Model estimate, LPSE (c), 1998 cents per pound	LQSE (d) thousand pounds, round wt	Model estimate, LPSE (c), 1998 cents per pound	- - - Allocated effects for Gulf group king ma[…] Total exvessel revenue (3*4) *(2/3)	Producer surplus (7*0.08) *(2/3)	Consumer surplus (3-5)* (6-4)*0.5 *(2/3)	Present […] year […] Exvessel revenue
		thousand pounds round weight						- - - - - - - - - - thousand 1998$ - - - - - - -			
		1	2	3	4	5	6	7	8	9	10
0	1998/1999	11,370	3,638	5,948	125	0	138	4,541	363	241	4,541
1	1999/2000	7,170	2,294	4,604	128	0	138	2,932	235	118	2,740
2	2000/2001	7,470	2,390	4,700	128	0	138	3,050	244	125	2,664
3	2001/2002	7,570	2,422	4,732	128	0	138	3,089	247	128	2,521
4	2002/2003	7,570	2,422	4,732	128	0	138	3,089	247	128	2,356
5	2003/2004	7,860	2,515	4,825	127	0	138	3,202	256	135	2,283
6	2004/2005	7,670	2,454	4,764	127	0	138	3,128	250	130	2,084
7	2005/2006	7,390	2,365	4,674	128	0	138	3,018	241	123	1,880
8	2006/2007	7,470	2,390	4,700	128	0	138	3,050	244	125	1,775
9	2007/2008	7,430	2,378	4,687	128	0	138	3,034	243	124	1,650
10	2008/2009	7,460	2,387	4,697	128	0	138	3,046	244	125	1,548
11	2009/2010	7,410	2,371	4,681	128	0	138	3,026	242	124	1,438
12	2010/2011	7,420	2,374	4,684	128	0	138	3,030	242	124	1,345
13	2011/2012	7,380	2,362	4,671	128	0	138	3,014	241	123	1,251
14	2012/2013	7,410	2,371	4,681	128	0	138	3,026	242	124	1,174
15	2013/2014	7,310	2,339	4,649	128	0	138	2,987	239	121	1,083
16	2014/2015	7,310	2,339	4,649	128	0	138	2,987	239	121	1,012
17	2015/2016	7,330	2,346	4,655	128	0	138	2,995	240	122	948
18	2016/2017	7,330	2,346	4,655	128	0	138	2,995	240	122	886
19	2017/2018	7,330	2,346	4,655	128	0	138	2,995	240	122	828
20	2018/2019	7,330	2,346	4,655	128	0	138	2,995	240	122	774
21	2019/2020	7,330	2,346	4,655	128	0	138	2,995	240	122	723
22	2020/2021	7,330	2,346	4,655	128	0	138	2,995	240	122	676
Sum		174,650	55,888	109,006				71,218	5,697	2,971	38,180

(a) Equation 1, Table 6, estimated using 1972-98 annual data (27 obs.). (b) Landings (LQSE) @ 1993-97 means after adjustment for chan[…] from base. (c) Estimated @ LQSE in preceding col.: 1993-97 means for other ind. variables. (d) Near-zero value for LQSE (0.1 lb / yr[…]
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Table 13d.--Estimated commercial fishery consumer and producer surplus, selected Gulf migratory group king TACs for fishin
1999/2000

Variable:	LPSE	INTERCEPT	LQSE	MQ	DI198
Coefficient (a):	na	45.940539	-0.00223	-0.001485	0.018519
Means, 1993-97:	127.356	na	5,135.48	7,041.33	5,518.99

FY1993/94 to FY1997/98 means, commercial landings (1000 lbs., round wt)	
Atlantic group	2,279
Gulf group	2,826
Overall	5,105

Fishing year	- - Gulf group - - total yield (TAC) thousand pounds round weight	comm. alloc. (.32*TAC)	Southeast (North Carolina-Texas) Modeled LQSE (b), thousand pounds, round wt	Model estimate, LPSE (c), 1998 cents per pound	LQSE (d) thousand pounds, round wt	Model estimate, LPSE (c), 1998 cents per pound	- - - Allocated effects for Gulf group king ma Total exvessel revenue (3*4) *(2/3)	Producer surplus (7*0.08) *(2/3)	Consumer surplus (3-5)* (6-4)*0.5 *(2/3)	Effect of chan quo (TAC=1 Exvessel revenue	Pro su
							- - - - - - - - - thousand 1998$				
	1	2	3	4	5	6	7	8	9	10	
1999/2000	10,600	3,392	5,701	125	0	138	4,252	340	216	0	
1999/2000	10,100	3,232	5,541	126	0	138	4,063	325	200	-189	
1999/2000	8,000	2,560	4,869	127	0	138	3,256	261	139	-995	

(a) Equation 1, Table 6, estimated using 1972-98 annual data (27 obs.). (b) Landings (LQSE) @ 1993-97 means after adjustme change from base. (c) Estimated @ LQSE in preceding col.; 1993-97 means for other ind. variables. (d) Near-zero value for (0.1 lb / yr).

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Table 13d.--Estimated commercial fishery consumer and producer surplus, selected Gulf migratory group king TACs for fishing y
1999/2000

Variable:	LPSE	INTERCEPT	LQSE	MQ	DPI98
Coefficient (a):	na	45.940539	-0.00223	-0.001485	0.018519
Means, 1993-97:	127.356	na	5,135.48	7,041.33	5,538.99

FY1993/94 to FY1997/98 means, commercial landings (1000 lbs., round wt)	
Atlantic group	2,279
Gulf group	2,826
Overall	5,105

	- - Gulf group - -		Southeast (North Carolina-Texas)				- - - Allocated effects for Gulf group king macke				
	total yield (TAC)	comm. alloc. (.32*TAC)	Modeled LQSE (b), thousand pounds, round wt	Model estimate, LPSE (c), 1998 cents per pound	LQSE (d) thousand pounds, round wt	Model estimate, LPSE (c), 1998 cents per pound	Total exvessel revenue (3*4) *(2/3)	Producer surplus (7*0.08) *(2/3)	Consumer surplus (3-5)* (6-4)*0.5 *(2/3)	Effect of change quo (TAC=10. Exvessel revenue	Produ surpl
Fishing year	thousand pounds round weight						- - - - - - - - thousand 1998$ - - - - - - - - -				
	1	2	3	4	5	6	7	8	9	10	
1999/2000	10,600	3,392	5,701	125	0	138	4,252	340	216	0	
1999/2000	10,100	3,232	5,541	126	0	138	4,063	325	200	-189	
1999/2000	8,000	2,560	4,869	127	0	138	3,256	261	139	-995	

(a) Equation 1, Table 6, estimated using 1972-98 annual data (27 obs.). (b) Landings (LQSE) @ 1993-97 means after adjustment change from base. (c) Estimated @ LQSE in preceding col.; 1993-97 means for other ind. variables. (d) Near-zero value for l (0.1 lb / yr).
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RECREATIONAL FISHERY

TABLE 9. GULF OF MEXICO RECREATIONAL KING MACKEREL LANDINGS, MRFSS, HEADBOAT AND TPWD DATA. 1998 DATA ARE PRELIMINARY.

	MRFSS		HEADBOAT		TPWD		TOTAL	
YEAR	#	POUNDS	#	POUNDS	#	POUNDS	#	POUNDS
1982	733,984	5,755,328						
1983	262,421	2,092,327						
1984	303,334	3,132,773						
1985	140,136	1,105,768						
1986	162,161	1,722,951	8,804	107,321	16,813	178,637	187,778	2,008,909
1987	411,268	2,878,343	9,643	111,797	33,160	232,077	454,071	3,222,217
1988	323,001	2,918,861	9,483	110,044	22,217	200,768	354,701	3,229,673
1989	263,220	2,630,318	10,456	114,356	18,558	185,447	292,234	2,930,121
1990	372,508	3,167,732	11,265	131,767	27,616	234,841	411,389	3,534,340
1991	596,320	4,325,060	12,860	127,752	27,703	200,928	636,883	4,653,740
1992	349,675	3,134,947	17,928	159,638	54,980	492,913	422,583	3,787,498
1993	446,829	4,118,916	15,511	157,415	74,734	688,905	537,074	4,965,236
1994	538,502	4,633,703	19,419	171,535	17,121	147,323	575,042	4,952,561
1995	493,275	4,696,549	21,731	212,590	14,361	136,733	529,367	5,045,872
1996	579,391	5,699,958	19,820	193,918	19,680	193,561	618,891	6,087,437
1997	519,834	5,416,267	21,458	177,679	33,739	348,673	575,031	5,942,619
1998	396,790	3,757,798						

Figure 4 Distribution of Recreational Anglers' Behavioral Change in Response to King Mackerel Regulations, by Subregion

Figure 5 Distribution of Recreational Anglers' Behavioral Change in Response to King Mackerel Catch Rates, by Subregion

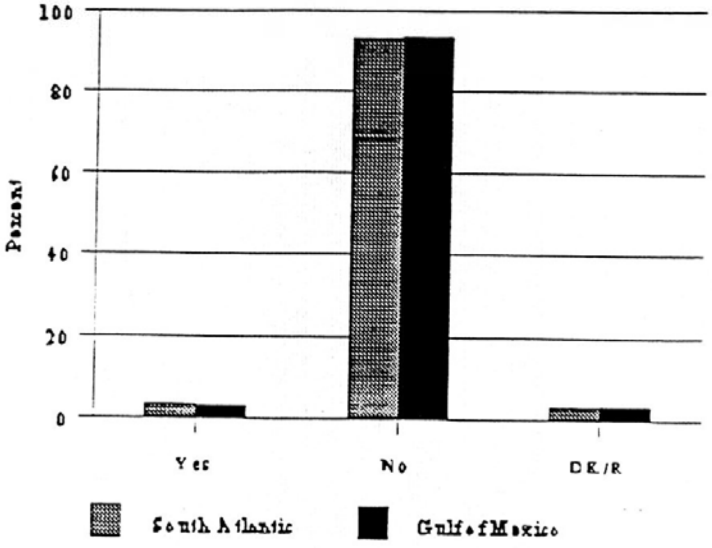
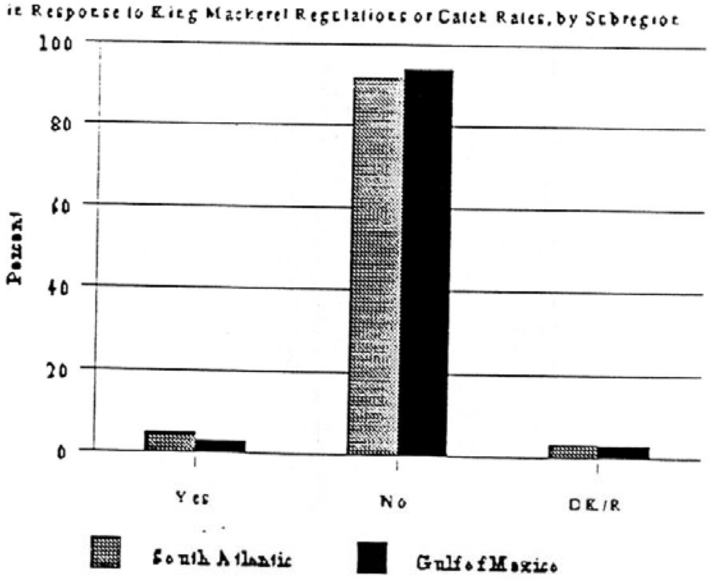


Figure 6 Distribution of Recreational Anglers Targeting New Species in Response to King Mackerel Regulations or Catch Rates, by Subregion



Appendix J. Report of the 7th. Coastal Migratory Pelagics Socioeconomic Panel Meeting (March 23-25, 1998)

REPORT OF THE SEVENTH COASTAL MIGRATORY PELAGICS SOCIOECONOMIC PANEL MEETING

Prepared by the

Socioeconomic Panel

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March 23-25, 1998
Miami, Florida

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INTRODUCTION

At the direction of the Gulf of Mexico Fishery Management Council, the Socioeconomic Panel (SEP) met to consider the social and economic implications of the 1998 stock assessments for king and Spanish mackerel. The meeting was held on March 23-25, 1998 in Miami, Florida. A list of attendees is found at the end of this report.

PURPOSE

The SEP was formed to advise the Council on the social and economic implications of the current regulatory structure and potential changes in management for fisheries under the jurisdiction of the Gulf Council. The short-run task specifically calls for recommending a TAC (total allowable catch) within the ABC (acceptable biological catch) range estimated by the Mackerel Stock Assessment Panel (MSAP), analyzing the consequences of changing the TAC, and reviewing the economic and social assessments for the fishery conducted by NMFS (National Marine Fisheries Service). The long-run function involves proposing or recommending data and analyses that should be included in future social and economic assessments.

PRESENTATIONS

The SEP has recently been restructured into three subgroups, namely, Reef Fish, Coastal Pelagics and Controlled Access. Under this restructuring, a subgroup is scheduled to meet in conjunction with the stock assessment panel and then with the entire SEP. Subgroup meetings for reef fish and coastal pelagics are to be held jointly with the appropriate stock assessment panel. In the recent mackerel meeting, the Coastal Migratory Subgroup jointly met with the MSAP on March 23-24, 1998. The full SEP met on March 25, 1998. Presentations at the joint meeting are detailed in 1998 MSAP report.

Dr. Charles Tolbert of Louisiana State University presented results of a recently completed MARFIN study. This study assembled socio-demographic information in coastal states in the southeastern United States based on data from the 1970, 1980 and 1990 census. The resulting data base contains more refined groupings than readily available in census reports, and is easier to use.

Michael Jepson of the South Atlantic Fishery Management Council staff and SEP member presented his preliminary work on description of fishing communities in the SAFMC area of jurisdiction. This work is part of the SAFMC's generic amendment addressing Sustainable Fisheries Act (SFA) requirements. He reported on recent works on fishing communities completed for North Carolina, the Northeast Multi-species Groundfish Fishery and the North Pacific Fishery Management Council. He indicated that the necessary information to identify and define fishing communities in the South Atlantic, similar to that provided in the aforementioned reports, was severely lacking. The available information presented in his discussion was provided by the Bureau of Economic Research and used the last census data. He noted that although this type of information was useful, it was limited to county level data and did not give a realistic portrayal of fishing communities within the South

Atlantic. It was his concern that unless the NMFS began funding research to help identify and define fishing communities in the South Atlantic and the Gulf, council staff would be severely limited in their ability to conduct realistic impact assessments upon fishing communities for future management alternatives.

Dr. John Vondruska of NMFS-SERO presented a brief description of two papers he prepared for the SEP. The first one tabulates the commercial landings of coastal migratory pelagic fish in the east and Gulf coasts for the period 1962-1997. The second paper provides descriptive statistics for about 6000 boats that had federal fishing permits in 1997, as administered by the NMFS-SERO. According to qualitative data (permits held, fish sold and gear deployed), most boats engage in 3 or 4 fishing activities. The boats vary considerably, but most represent relatively small fishing businesses judging by frequency distributions of permits data related to boat income and expense totals for fishing.

Dr. Stephen Holiman of NMFS-SERO indicated that there were no new available catch and effort recreational data. NMFS is in the process of revising the 1996 estimates and has not released either preliminary 1997 Wave 5 and 6 or final 1997 data. Final data collection has been completed for the 1997-98 Southeast economic add-on survey. The data is currently being checked and processed and final data is expected to be available in May. Summary analysis and modeling will begin at this point.

SUMMARY OF DISCUSSIONS AND RECOMMENDATIONS

- The ABC range for Gulf group of king mackerel is 7.1 - 10.8 with 8.7 million pounds representing a 50 percent probability of achieving a 30 percent SPR value. (See page 11 of the 1998 MSAP Report)

- The SEP does not provide a TAC recommendation. Discussions on the implications of possible management strategies for Gulf king mackerel are provided below (See the section "Other Matters").

- The Council has determined the optimum yield for this fishery is represented by a 30 percent SPR. A proposed (via Amendment 8) lower SPR level of 20 percent representing overfishing threshold for the Gulf group king mackerel was rejected by NMFS.

- Preliminary estimates of 1997/1998 harvest puts the commercial landings at 3,390,000 pounds and recreational harvests at 8,393,226 pounds (or 779,319 fish), or a total harvest of 11,783,266 pounds. This total harvest exceeded the TAC of 10.6 million pounds, with practically all the overages coming from the recreational sector.

- In the absence of new recreational data, previous analyses on various combinations of bag and size limits and on limiting the captain and crew of for-hire vessels to a bag limit of zero are maintained in this report.

- The SEP again recommends that the Council explore limited access management for all sectors of the coastal migratory pelagics FMP. Substantial potential exists for increasing net benefits to the nation generated primarily by substantial improvements in stock size under some forms of limited entry. A bioeconomic model of the coastal migratory pelagics fisheries could be used to provide the Council with information as to the forms of management capable of generating maximum net benefits to the nation given the prescribed stock recovery periods.

- The SEP has no TAC recommendations for Gulf groups of king and Spanish mackerel. With respect to Spanish mackerel, it is clear that neither the commercial nor the recreational sectors will take their quota unless TAC is substantially reduced. With respect to king mackerel, the SEP notes that as long as the recreational sector is allowed a 2-fish bag limit without closure, any reduction in TAC would adversely affect mainly the commercial sector in the short-run. More importantly the SEP notes that unless TAC overruns are minimized, the long-term social and economic impacts on fishing participants could be severe.

- The SEP strongly recommends that NMFS provide an economic assessment that incorporates commercial and recreational economic models capable of estimating the economic implications of various TAC levels and accompanying regulatory measures, such as bag limits, size limits, closed seasons, etc. As an integral part of this modeling activity, NMFS should estimate economic models using data from the recently completed MRFSS add-on economic survey in time for the information to be used at the next SEP meeting for coastal migratory pelagics. Within the same time frame, NMFS should also estimate supply and demand models for the commercial sector using data from the data set assembled by Dr. Vondruska that was presented at the SEP meeting. These analyses could provide an indication of the economic impacts on the commercial, recreational, and final consumers of changes in proposed TAC levels.

- The SEP reiterates its recommendation that NMFS should begin providing social and cultural data and analyses for consideration by the SEP. (See the social data needs section for specific data needs). Of immediate concern is the information needed to address the SFA requirements regarding fishing communities. The SEP is asking the Council to send a letter to Dr. Schmitten for this latter purpose.

DISCUSSION

Stock Assessment Panel Report

Due to the current meeting set-up in which the SEP's Coastal Migratory Subgroup meets jointly with the MSAP, no MSAP report was available to the SEP. While an ABC range for the Gulf king mackerel was provided to the SEP, model re-estimations not available at that time show a different potential ABC range. Biological assessments have determined ranges of ABC for Gulf migratory stocks of king and Spanish mackerel. The continuing level of information provided for either the calculation of net benefits or the analysis of a social impact assessment is inadequate for further recommendations concerning management alternatives. However, in the case of Gulf group king mackerel, additional management controls will be necessary to contain total catch even at the current TAC of 10.6 MP. Therefore, our analysis will summarize some of the characterization data available to highlight the social and economic issues with specific reference to Gulf king mackerel. This report cannot provide any guidance about the optimal allocation of the resource within the biological constraint.

Management Trends Affecting Recovery

Since allocation management began, recreational and commercial landings have exceeded the plan allocations. As recovery has progressed TAC has risen from a low of 2.2 MP in 1987-1988 to 10.6 MP in 1997-1998. A TAC of 7.8 MP had been maintained for the period 1992-1993 to 1996-1997. Since the 1986-1987 fishing year, total harvests have exceeded the TAC. More details are found in Table 1.

By selecting the TAC near the upper end of the ABC range, the Council has basically opted for a risk-prone strategy. MSAP reports, on the other hand, have recommended the adoption of a more risk averse strategy which implies selection of TAC such that there would be a 50 percent chance that current fishing mortality would result in an SPR greater than or equal to the target SPR. According to the most recent MSAP report, the result has been a relatively flat SPR that is below the overfishing threshold of 30 percent. This is apparently due to the fact that the increase in landings since fishing year 1989-1990 have kept pace with the increase in biomass (ages 3+).

The MSAP has currently recommended an ABC range of 7.1 to 10.8 MP, with 8.7 MP representing the 50/50 probability of reaching the SPR level of 30 percent. The upper limit of ABC is lower than the current TAC of 10.6 MP. Last year's increase in TAC may have been dependent on one or more strong recruitment classes and thus not sustainable in subsequent years. Adjusting TAC's from year to year based on the recruitment class entering the fishable population may require year-to-year adjustments, lowering and raising the TAC as necessary. This type of actions may slow recovery of the stock to the target level of SPR 30%, and resistance to lower TAC after it has been raised in previous years may be difficult and perceived as the result of poor or erratic past predictions. In reality this attempt to set TAC as a rate of biomass does bring forth the question:

> **Should a constant TAC strategy be maintained until the risk of lowering in subsequent years is lessened, or is a TAC strategy based on a constant rate of biomass acknowledging that TAC may be lowered and raised from year-to-year be the most appropriate strategy?**

Another trend is the disparity between the risk neutral TAC (median ABC) recommended by the MSAP and the more risk prone level of TAC (upper end of ABC) selected by the Council. TAC decisions have been set at or above the 84th percentile of probability of exceeding the 30 percent SPR since the 1992-1993 analysis.

The decision to select risk prone values in previous years suggests a skepticism about the utility of the modeling methods. These cumulative decisions could also be the cause of the declines in SPR estimates leading to the need for draconian action especially if the overfishing threshold is increased to a level above 30 percent SPR. In spite of the skepticism, absent an alternative assessment technique, the current assessment shows a static or equilibrium SPR which is below the overfishing definition.

One other trend to keep in mind is the growth in effort and landings by the for-hire sector. Since 1993, landings of king mackerel in the charter and headboat sector (excluding Texas due to lack of information) have grown by an average annual rate of 23.9% (1993-1996; using unrevised estimates for 1996). Previous analysis showed that a zero bag limit for charter crew would reduce landings in this sector by 18%, if landings growth in 1997 and 1998 were approximately the same as those in previous recent years. Without the zero bag limit for crew, recent evidence suggested that not only will TAC be exceeded due to the crew catch but also landings growth may further exacerbate the overage.

The SEP recognizes the possible substitution of effort between Gulf king and Spanish mackerel in the commercial fishery. However given the history of overruns of kingfish and forgone catches of Spanish mackerel this possibility is not reflected by reality. Although the resulting changes in overall cost and returns to the commercial fishermen cannot be calculated at this time, there may be some possible gains in benefits. Indications of the possibility that revenue losses in the king mackerel fishery can be offset by potential revenue gains in the Spanish mackerel fishery were covered in the 1994 SEP report.

Gulf King Mackerel

King mackerel, *Scomberomorus cavalla*, is characterized as a coastal pelagic, one which migrates along the coastal margin of the open sea and so is independent of inshore or nearshore habitats. The species ranges from the Yucatan Peninsula around the Gulf of Mexico and up along the Atlantic coast to the middle Atlantic states of the U.S.A. There is a predictable seasonal pattern to the migration of the fish which has resulted in its regional/seasonal exploitation by human population. Fishing occurs in both state and federal waters, consequently the exploitation of the species is controlled primarily by the federal authority of fishery management councils. King mackerel occurring off the Southeastern U.S. are considered to be a single species comprising two migratory groups: an Atlantic group and a Gulf group.

In a previous analysis of king mackerel, the MSAP concluded that SPR for the U.S. Gulf king mackerel was slowly declining. The most recent MSAP report indicates that relative to the 30 percent SPR overfishing threshold, Gulf king mackerel is considered overfished. At the current landings level, it does not appear likely that SPR will reach 30 percent. To ensure a 50 percent probability of reaching the SPR goal, the 1997/1998 TAC would have to be set at 8.7 MP, a 1.94 MP (18 percent) decrease from the current TAC of 10.6 MP and a 3.12 MP (26 percent) reduction from the estimated actual catch of 11.78 MP.

The Gulf Council's action applies only to the Gulf group king mackerel. The range of this migratory group, however, extends into the South Atlantic Council's area of jurisdiction at certain time of the year. Off Florida, this group is always present north of the Monroe/Collier county line in the Gulf of Mexico and its range extends into state and federal waters off Monroe County through Volusia County between November 1st to March 31st. Figure 1 displays the relevant boundaries of the fishery off Florida. Table 2 summarizes the commercial seasons and quotas from 1990-1991 through 1997-1998.

The migratory pattern of the fish, combined with the twin stock management of the species makes management one of the most complex. Most of the commercial and recreational harvests of Gulf group king mackerel are caught by Florida-based fishermen. In Florida, the commercial fishery consists of an east coast hook-and-line (H&L) component and west coast, largely Monroe County, H&L and gill net components. The gill net component occurs in federal waters. The east and west coast fisheries are regulated by different trip limits to extend the quota. During the 1995/96 fishing year the east coast subregion continued to land the 50 fish commercial trip limit until March 15th when the limit was reduced to 25 fish until April. A similar situation occurred in the 1996/1997 season but this time the reduction in trip limit from 50 to 25 fish occurred for the whole month of March. Primarily because of an increase in quota, the trip limit for the 1997/1998 season was revised to 50 fish from November 1 through March 31. The increased quota was not reached. Starting in the 1995/1996 season, the west coast H&L subquota was based on split 125/50 fish trip limits which were designed to extend the season. The west coast H&L fishermen have always fished their allocation. The west coast gill net fishery has been limited to a trip limit of 30,000 pounds, and this fishery has always taken its allocation.

The recreational fishery includes guide boats, head boats, charter boats, privately operated boats and shore-based, beach and pier catches. Table 3 shows the recreational landings of king mackerel in the Gulf, using three data sources. The spatial distribution of total recreational landings of king mackerel can been seen by looking at Figure 2. This chart shows landings by Florida west coast and compares those with the landings of other Gulf states. Note that other Gulf states have landed less than 30 percent of the total Gulf landings in recent years. Most recreational information comes from a national saltwater fishing survey, the Marine Recreational Fisheries Statistical Survey (MRFSS) conducted by the NMFS.

If we ignore the groupings of the species we can see an increasing trend in both landings and effort (trips) by Florida based anglers. Figure 2 shows, among others, the trend in landing of king mackerel by Florida anglers. Fish caught or landed are a result of legal fish being available (large enough year classes) and of either their abundance or of the number of trips.

We can use several measures for analysis to focus on recreational effort originating from the gulf coast of Florida. First, the trend in trips where the person interviewed said that king mackerel was either the first or second species they sought: target trips. Second, the trend in trips catching king mackerel whether targeted or not and finally trips either targeting or catching. These three categories are graphed in Figure 3. Note that the third category, target or catch, was not graphed for 1986 or 1987, hence the zero values. Catch trips, aside from the jumps in 1991 and 1987, are roughly constant at 200,000, with an increasing trend during the last three years shown. The year 1995 continued that trend, to over 300,000. The largest category comprises the target trips and mirrors the peaks and recent trend of catch trips.

Figure 4 graphs the landings for the GOM/MRFSS states by mode of fishing. Mode refers the how we get to the fish: shore (beach, dock, pier), charter boats and the combination of private boats and boats which are rented by individuals. The graph shows first, that shore based landings are a usually small proportion of total landings. More importantly, the figure reflects a reversal in share from private boats to charter boats during the last ten years. Certainly there are some recreational fisheries where catches have always been dominated by charter boats; the bill fishes are an obvious example, but king mackerel seems to have become more important to charter boats probably as other species have declined or have been placed under more stringent regulations..

You should also note Figure 5, which depicts the landings of king mackerel from head boats, a separate survey. While the other recreational modes landed nearly five million pounds during 1995, headboats in the GOM reported 200,000 pounds.

Using MRFSS estimates of trips by mode in the GOM, we can again look at effort but now with respect to mode rather than state. Figure 6 shows the trend in MRFSS trips for the GOM between 1986 and 1994. Three trends are charted: 1) charter boat trips targeting king mackerel, 2) private/rental boat trips targeting king mackerel and 3) total charter boat trips. For example, during 1994 there were 825,632 charter boat trips of which 90,762, or eleven percent, listed king mackerel as their first or second target species. During 1994, 341,097 private boats targeted king mackerel while 9.4 million total trips occurred. If we compare 1990 with 1994, the number of charterboat trips targeting king mackerel grew by 307 percent while total charterboat trips grew by 113 percent. The comparable percentages for private boats are 25 percent and 30 percent, respectively.

The trend is the steady and substantial growth in king mackerel landings by charter/headboats. Table 4 shows that king mackerel figures prominently as a target species by charter boat captains. While shore based landings have shown a steady decline (56% decline in pounds since 1990) and king mackerel landings for the private/rental mode have remained flat since 1990, charter king mackerel landings have more than doubled since 1990 (see Figure 4). Since about 85% of Gulf charter boats are based in Florida (Holland, Ditton, and Gill, 1992), the vast proportion of these landings are on Florida charter boats. While the number of charter boats over this period has increased, the number of directed effort charter trips has increased from 41,000 in 1990 to 134,000 in 1994. Given the need to reduce landings to reach a proposed lower TAC, these increased charter landings should be addressed.

Potential Economic Consequences of a Change in TAC for Gulf King Mackerel

In the absence of an estimated economic model that integrates the various sectors of the coastal migratory pelagic (CMP) fishery inclusive of the shrimp fishery interacting with the CMP fishery mainly through the bycatch of juvenile CMP fish, it is not possible to adequately assess the economic implications of various possible TAC levels within the ABC range estimated by the MSAP. In this section, however, an attempt is made to explore the short-term economic effects of a change in TAC. The benchmark TAC is the current TAC of 10.6 MP while the new TAC selected for purposes of comparison is 8.7 MP. This is the median of the ABC range recently estimated by the MSAP.

Commercial Sector

Following the 68:32 division of TAC, the commercial sector's allocation would fall about 18%, from 3.39 MP (1997/98) to 2.78 MP (1998/99). Using an own-price elasticity of demand of 8 from the several reported by Easley et al. (1993, p. 21) and the 18% decline in landings, one obtains a price increase of about 2.2%. For the east and Gulf coasts, the exvessel price averaged $1.37 a pound for king mackerel in 1997 (Vondruska, 1998b), and a 2.2% increase would mean a price of about $1.40. Using these two prices, one obtains exvessel values of about $4,647,000 (1997/98) and $3,998,000 (1998/99), or a decline of about $649,000. A crude approximation of the change in consumer surplus is $93,000 [(2,780,000 pounds * $0.03 per pound) + (610,000 pounds * $0.03) / 2) = $92,550]. Using the medians, net income from fishing represented about 20% of the gross income from fishing, according summaries of data for boats with permits for commercial mackerel fishing in 1997 (Vondruska, 1998a, p. 38), and 20% of the change in exvessel value of $649,000 results in a change in net income from fishing of about $130,000, a crude approximation of the change in producer surplus.

Recreational Sector NO - REWRITE

Considering that in recent years the commercial sector has been generally restricted to its quota while the recreational sector has continued to exceed its allocation, a slightly different benchmark, namely, estimated recreational harvest, is used to assess the short-term effects of a change in TAC on the recreational sector.

The 1997/98 estimated harvest by the recreational sector, as reported in the MSAP report, is 8.39 MP. A TAC of 8.7 MP therefore requires a 29 percent reduction in recreational landings from the 1997/98 season. Bag and size limit analyses were previously conducted by Holiman (1996). These analyses have not been updated due to ongoing revision of more current data. Nevertheless, the results from the 1996 analysis provide insight to the magnitude of regulatory change required to achieve the proscribed 29 percent recreational harvest reduction. The results of the analysis, as seen in Table 5, show that under the current 20 inch fork length minimum size, a uniform 1-fish bag limit is required to achieve the necessary reduction. If the size limit is increased to 26 inches, a 1-fish for-hire bag and a 2-fish private bag should be sufficient, assuming the reduced bag does not result in high-grading of retained fish (Tables 5 and 6). Of the results presented in Holiman (1996), none of the combinations presented support maintenance of the current 2-fish for-hire bag (Tables 5, 6 and 7).

Holiman (1997) provides additional information to relate these bag or size limit reductions to the number of potentially affected angler trips. The following assessment is based solely on MRFSS data. Utilizing the same base time frame incorporated in the bag and size limit analysis (1995 data), there were approximately 301,000 angler trips that caught king mackerel in the Gulf in 1995. Approximately 37 percent of these trips landed greater than 1 fish, therefore, approximately 111,000 trips would be affected by a uniform reduction in the bag limit to 1 fish. Under the 1-fish for-hire:2-fish private scenario, there were 168,000 king mackerel for-hire catch trips in 1995 of which 52 percent landed in excess of 1 fish per trip. Therefore, approximately 87,000 for-hire angler trips would be affected by the reduction in the bag limit. It is not possible to generate a similar statistic for the size limit increase because the size distribution of landed fish will not be uniform over all trips. Further, an attempt to combine bag-limit affected trips with size limit affected trips will result in double counting of some trips.

Existing data does not support estimation of the impact per affected trip of proposed bag or size limit changes. Results from recreational demand studies for various Gulf species (Green, 1989; Greene et al., 1994; Leeworthy, 1990; Milon, 1993) have shown either statistically insignificant results (do not support a relationship between catch rates and trip demand) or have shown results that are inconsistent with logic (show a negative relationship between catch rates and trip demand). Nor does existing data support differential limits for the different sectors. It is therefore, currently not possible to estimate consumer surplus losses as a result of these management changes. Future analysis of recently collected recreational economic data acquired through an add-on the MRFSS in 1997-98 should allow estimation of this information.

It should be cautioned that, given the precedent of quota management of the recreational red snapper fishery, the existence of continued overruns by the recreational sector increase the risk of not only jeopardizing stock recovery goals, but also the imposition of quota management upon the king recreational mackerel fishery, thereby potentially requiring closed seasons. Logic holds that consumer surplus losses associated with a canceled trip exceed those of a trip taken under a lower bag or more restrictive size limit. It is therefore the preferred economic outcome that, in the absence of more direct effort controls (such that the rights to harvest are allocated to those individuals who value the fish the most), the fishery should be managed through reduced uniform bag and/or size limits such that no closure is required.

Angler Attitudes

In 1994, surveys of recreational anglers have been conducted in Florida, Louisiana, and Texas. Modified Dillman techniques were used in all of the surveys. In these surveys, questions regarding management options based on general support or opposition to certain types of management tools are asked. These responses can be useful to identify generally which management tools may be faced with greater support or opposition. Table 8 represents a summary of responses from the three different surveys, and includes the responses for anglers from Florida, Louisiana, and Texas who indicated that king mackerel is their preferred species.

The SEP recognizes that as additional restrictions are placed on the recreational fishery, substitution into like fisheries may occur. Table 9 suggests that cobia, Spanish mackerel, red drum, spotted seatrout, and dolphin are all considered as acceptable substitutes by the majority of those individuals who now target king mackerel in the Florida study.

Anglers participating in the Louisiana and Texas studies were asked to list their preferred saltwater species in order of preference. Responses suggest that red drum, snapper, spotted seatrout would be the specific alternative species targeted. Cobia was also an important species listed by Louisiana king mackerel anglers, although Texas anglers slightly preferred sharks, dolphin, and flounder to cobia, as substitutes for king mackerel.

In addition to the above information on species substitution, data from the MRFSS for the Gulf of Mexico for the year 1988-1994 also indicate that Spanish mackerel, red snapper, and other snappers are probable substitute species for those who target and catch king mackerel.

The SEP recognizes that the Council may be considering changes in regulations to more evenly spread the existing commercial quota so that all geographical sectors can participate in the fishery. While the SEP did not fully address the subject, the panel repeats a point made in last year's report. From an economics standpoint, the imposition of trip limits would likely result in a decline in net economic benefits because the inference is that efficiency would be affected. For example, if the introduction of trip limits means that twice as many trips will be required to catch a particular subquota, this implies an approximate doubling of the cost associated with the harvest of that subquota. This year's experience of increased costs without the realization of price increases is an example of this issue.

Fishing Communities

With the addition of National Standard 8, fishery management plans must now identify and consider the impacts upon fishing communities to assure their sustained participation and minimize adverse economic impacts [MSFCMA section 301 (a) (8)]. According to the proposed guidelines,

A fishing community is a social or economic group whose members reside in a specific location and share a common dependency on commercial, recreational, or subsistence fishing or on directly related fisheries-dependent services and industries (for example, boatyards, ice suppliers, tackle shops) [Federal Register volume 62, Number 149 (August 4, 1997)].

In order to determine a community's dependence on fishing, those communities must first be identified. Presently, the NMFS has not identified fishing communities, nor their dependence upon fishing in the Gulf of Mexico. There are no ongoing data collection programs to gather the necessary information that would allow for the identification of fishing communities and no future plans to implement any such data collection program to determine communities' dependence on fishing. This leaves the Council with existing data collected through other agencies which is not specific to fisheries management, e.g. census data and case studies on particular fisheries. Although this data can be useful, it is often not specific enough to identify fishing communities and characterize the nature of their dependence. In addition, it does not allow the determination of the impacts of proposed management regulations such as TACs and trip limits on the fishing communities through their effects on employment levels in the fishery or related support industries. The lack of such data greatly hinders the analysis of the social and economic impacts of proposed regulations.

Fisheries in the Gulf of Mexico will differ markedly from those in other regions of the country, especially with regard to their integration into other economies and notably the tourist economy. Recreational fishing is an integral part of the tourism and service economy for coastal communities that has developed in the Gulf. For these communities, dependence upon fishing will undoubtedly be tied to commercial and recreational fishing and their associated businesses. Therefore, it is important for fishery dependence models to be developed specifically for the Gulf of Mexico.

Documentation of fishing communities and an extensive collection of baseline data are needed to satisfy requirements of National Standard 8. At this time, we can only allude to possible community impacts. Because the Council must amend all Fishery Management Plans in accordance with the new standard, the SEP might assist the Council in developing a plan for identifying fishing dependent communities, provide guidelines for measuring impacts upon communities of proposed regulations, and identify alternate measures for determining community level economic and social impacts given various levels of data availability. This assistance, however, would not be as productive if the necessary information useful in addressing fishing community issues is not collected. (See attached letter to the Council which formally requests action by NMFS regarding gathering of community level data).

Other Social Data Needs

As mackerel stocks recover, the management of these fisheries will increasingly focus on allocation of the catch and less on the biology of the stock. This development makes it even more important that some minimum set of socioeconomic data be collected to allow for as complete an analysis of the impacts as possible. The economic add-on for the MRFSS survey will provide important economic and socio-demographic data for the recreational sector. It is imperative that similar data be collected for the commercial and for-hire sectors and included in the economic modeling. The panel recommends the following data at a minimum be collected for the commercial and for-hire sectors:

1. Number of participants and their age, education, and marital status.
2. Years fishing, family history of fishing participation.
3. Percent of total household income from commercial fishing (include total household income).
4. Effort by species and month and gear type (include all species fished and location to assess multispecies nature of mackerel fishermen)

5. Job skills and employment history (job training).
6. Perceived opportunities for alternative employment.

Potential Need for Effort Management

This report discussed several disturbing trends in the approach to the management of king mackerel. At present there are several occurrences within the fishery that signal potential problems. While much of the success of management to date has been based on quotas to limit the amount of total catch, this has ultimately led to a derby fishery. Attempts to resolve some of the problems created by the derby have involved gear regulations designed to maintain suballocation shares at historical percentages. These suballocations lock in market distortions caused by the open access management of domestic common property resources and ensure that net benefits will be less than could be obtained in the fishery under some form of rational management. Using history as a guide, even more regulation will be necessary as the stock continues to recover. An analogous situation developed in the red snapper fishery and the Council eventually chose to limit fishing effort as a way to resolve the derby problems in that fishery. The SEP recognizes that the Congress has limited the ability of councils to introduce ITQ or IQ programs per se, but that intent does not extend to other methods of limiting effort. Considering that fishers in the coastal pelagic fisheries also participate in other fisheries, there is a need to take into account the multi-species nature of the participants in these fisheries as it relates to effort limitation programs.

OTHER MATTERS

Given the current MSAP recommended ABC range, the historical overruns of Gulf king mackerel harvests, and the new SFA guidelines, several issues are worth noting in the management of the Gulf king mackerel fishery.

1. Based on the most recent stock assessment for Gulf king mackerel and MSAP discussions (Legault et al., 1998; MSAP, 1998), the stock will remain overfished, that is, below the overfishing threshold of 30 percent SPR, if the current TAC of 10.6 MP is maintained.

2. In order to provide for a 50:50 chance of reaching the 30 percent SPR, a TAC of 8.7 MP would have to be selected.

3. If the recent SFA requirement necessitates a higher SPR as an overfishing threshold and/or that the stock be rebuilt within 10 years, the TAC may need to be reduced even further below 8.7 MP.

4. The choice of TAC at the higher end of ABC coupled with substantial overruns would lengthen the recovery period.

Therefore, the Council is faced with policies to set a lower TAC and effectively control the recreational sector within its allocation. These restrictions on harvesting activity would impose costs on both commercial and recreational fishermen and consumers, but long-term economic gains usually are possible if regulation effectively rebuilds the fish population. The economic problem is to evaluate the tradeoff between short-term losses and long-term gains, but additional research is needed to specify the theoretical long-term sustainable yields under the various management alternatives.

The following table outlines some key biological information necessary to conduct an economic analysis of king mackerel management.

Constant Catch Policies

Bycatch Reduction	Minsize Rec/Com	TAC	SPR 1998	SPR 2007	Equilibrium SPR in Year		Sustainable Yield
?%	20/20	11.8 MP	?	?	?%	?	? MP
?	24/24	11.8	?	?	?	?	?
?	26/26	11.8	?	?	?	?	?
?%	20/20	10.8 MP	?	?	?%	?	? MP
?	24/24	10.8	?	?	?	?	?
?	26/26	10.8	?	?	?	?	?
?%	20/20	10.6 MP	?	?	?	?	?MP
?%	24/24	10.6	?	?	?	?	?
?%	26/26	10.6	?	?	?	?	?
?%	20/20	8.7 MP ?	?	?	?		?MP
?	24/24	8.7	?	?	?	?	?
?	26/26	8.7	?	?	?	?	?
?	20/20	7.1 MP ?	?	?	?		?MP
?	24/24	7.1	?	?	?	?	?
?	26/26	7.1	?	?	?	?	?

In addition, the Council must address the issue of how best to implement its policies. For the red snapper assessment, Schirripa and Legault (1997) considered two types of policies for the directed red snapper fishery: constant catch policies and constant F policies. A similar analysis may be done for king mackerel. A constant catch policy would hold TAC constant from 1998 until the SPR goal is achieved. It is presumed that TAC would increase, perhaps by a substantial amount, when and if the SPR goal is achieved, but estimates of the long-term equilibrium SPR and corresponding sustainable yields were not available. Constant F policies are modeled with constant fishing mortality rates over time, but as a practical matter could be implemented as a series of TACs that initially would decline substantially and then would increase over time as king mackerel become more abundant due to stock recovery. Neither of these policies would improve net benefits generated by the fishery and would probably lead to a more severe race for fish at present or in the future as stocks recover. Unless long-term entry into the fishery or the expansion of existing fisher operations can be controlled, benefits from stock conservation will be dissipated and political pressure will mount as more fishermen petition the Councils to expand TAC.

Constant catch policies have an advantage in the short-term because TACs would be larger than under constant F policies. Hence, short-term economic disruptions to commercial and recreational fishermen, their support industries and to consumers would be minimized. In the short-term, commercial fishermen would continue to experience derby fishing, low prices and seasonal closures. Consumers would continue to enjoy low prices during the brief open seasons and then would switch to imports. Recreational fishermen would be subject to lower bag limits and seasonal closures if TAC were substantially reduced below its current level of 10.6 MP.

Over time with a constant catch policy, each year's TAC would be harvested within an ever-shorter season because fish would become easier to catch as the king mackerel population recovered and they become more abundant. Dockside prices to be received by commercial fishermen would become more depressed because the length of season required to harvest the commercial share of the TAC would become shorter. In addition, consumers of king mackerel would become more reliant on imports as a source of supply because the availability of domestic king mackerel would be limited by the shorter commercial seasons. Similarly, regulations on recreational fishermen would need to become more restrictive to prevent overruns of the recreational share of the TAC. Implementation of lower bag limits as king mackerel become more abundant and easier to catch is counterintuitive to recreational fishermen. On the other hand, constant bag limits and ever-shorter recreational seasons would create economic disruptions to recreational fishermen and their support industries.

Constant F policies generally entail large short-term losses for the directed fisheries and subsequent negative impacts on fishing communities. Losses would be determined as the change in commercial profits and value of recreational enjoyment as the TAC is lowered. Furthermore, the extra fishing effort may be applied to other species leading to problems in other fisheries.

The possibility for constant F policies to generate large long-term harvests for commercial and recreational king mackerel fishermen is linked to the desired target SPR and the percentage reduction in bycatch of juvenile king mackerel. A low biological goal for SPR (assuming it provides for long-term viability of the stock) and large percentage reductions in bycatch offer large long-term catches to the directed commercial and recreational king mackerel fisheries. One issue worth noting here is that the reduction in shrimp trawl bycatch of king mackerel is not as much of a determining factor in the recovery of the king mackerel stock as it is with red snapper.

Additional policies could be devised to combine a constant catch policy in the short-term while SPR recovered to some intermediate level (as yet undetermined) followed by a constant F policy during the remainder of the recovery period. This hybrid policy would reduce short-term economic losses at the cost of a longer recovery period before the target SPR would be achieved. However, to meet the objectives in the Magnuson-Stevens Act to increase benefits from living marine resources and reduce impacts on fishing communities, a new approach needs to be considered and adopted. Sole ownership, territorial use rights, co-management, or some other form of rational management for this fishery resource needs to replace the reliance of management on constant catch or F policies.

The SEP discussed the need for an economic model to evaluate the potential benefits and costs of management, including the effects on participants of the commercial king mackerel, recreational king mackerel, for-hire king mackerel, and shrimp fisheries. Several data collections have been completed recently or are underway that will provide information needed to estimate economic models.

Based on the presentation on commercial landings by Dr. Vondruska, there is enough data to attempt to estimate a supply and demand model for the commercial CMP fisheries. Preferably, the development of a simultaneous equation model of supply and demand for these fisheries should be attempted. An estimated simultaneous equation model of supply and demand for the CMP fisheries would allow the short-term impacts on consumer and producer surplus to be estimated for different potential TAC levels or proposed regulatory measures. It would also be the first step toward developing the same type of integrated analysis of the CMP fisheries that was recommended for the red snapper fishery at the "Peer Review of the Science and Management of Red Snapper in the Gulf of Mexico."

The SEP recognizes possible limitations of existing information to estimate a simultaneous equation model of supply and demand for the commercial CMP fisheries. It may be recalled that recent work for the Council using such commercial landings data involved several specifications of partial equilibrium and general equilibrium inverse (price dependent) demand equations (Easely, et al., 1993), not a simultaneous supply and demand model. What has been provided for Council use, notably on shrimp, is based on the use of cost and returns data for the supply (production) side of the economic models. The cost and returns data was collected via traditional surveys. Nevertheless, an attempt should be made to estimate a simultaneous equation model using existing data. In the meantime, other data collection effort should be pursued. Several options have been mentioned in the Gulf Operations Plan for fiscal year 1998, such as inclusion of cost and returns information in logbook reporting, NMFS' funding of a cost and return survey for the CMP fisheries, and the MARFIN program. In particular, given the recent decision to include CMP species in the Southeast Logbook, cost and earnings data could be collected following the same approach as used in the Pelagic logbook developed for the Highly Migratory Species Management Division. It may be noted, though, that the add-on sheet for economics data in the Pelagic logbook is voluntary and, as reported in the Operations Plan, "the results of the experiment will be used in discussions regarding acceptable methods of collecting economic and social data." This logbook data collection program could also be expanded to collect demographic and socio-cultural data. One SEP member suggested that this data in conjunction with the biological data on landings and effort could be combined into a simultaneous equation, indirect cost model of a vessel operating in the CMP fisheries, that it could also be used to determine employment levels and shares to labor for use in community impact analysis, and that logbooks could provide information to determine how fleet size changes once data has been collected for at least three years. This fully integrated bio-socio-economic model could also be used to determine how stock size would change over time under different TAC levels and by treating effort endogenously, instead of as a constant as in present stock assessments, predictions will be greatly improved.

Recreational fisheries models are planned based on data from the MRFSS economics add-on and funds to support analysis of the data. Random utility models and participation models following the work of McConnell and Strand (1994) and that of Milon (1993) will be developed to determine how recreational fishermen's demand for trips might vary under different proposed management regulations.

It was suggested that an overall objective in modeling could be to develop an integrated bio-economic model. Some of the steps involve the development of a simultaneous model of supply and demand, collecting cost and earnings data, and contracting for the analysis of the recreational data. Once supply and demand model analyses are completed and cost and earnings data become available they could be used in conjunction with biological and demographic data necessary to estimate indirect cost or profit functions. Recreational participation models of fishing frequency by active and inactive anglers could also be developed in the second year. Finally, sufficient logbook information on participants would be available by the end of the third year to determine fleet dynamics as a function of biomass, profits, and socio-cultural characteristics of the fishers.

These separate analyses could be incorporated into a single integrated model of the CMP fishery in conjunction with the biological model of the fishery estimated by the stock assessment biologists using off-the-shelf spread sheet programs or SAS software. Once combined into a single model, harvest and travel costs, exvessel prices, and commercial fleet and recreational participation, and stock size would be determined simultaneously and endogenously in the model for different proposed management regulations. Most importantly, the costs and benefits to the nation could be estimated for different proposed management regulations and their impacts on the fishing communities determined.

LIST OF DOCUMENTS REVIEWED AT THE SEP MEETING

1. Commercial landings of coastal migratory pelagic fish, east and Gulf coasts, 1962-1997. (Dr. John Vondruska).
2. Description of boats with federal fishing permits in 1997. (Dr. John Vondruska).
3. Some discussion on the methods and potential use of federal fishing permits data in descriptive fishery analysis, with emphasis on commercial fishing for mackerels. (Dr. John Vondruska).
4. Fishing communities - identify and define fishing communities. (Michael Jepson).
5. Community profiles developed for the social impact assessment of the inshore/offshore amendment proposal. (Impact Assessment, Inc.).
6. Stock assessment analysis on Atlantic migratory group king mackerel, Gulf of Mexico migratory group king mackerel, Atlantic migratory group Spanish mackerel, and Gulf of Mexico migratory group Spanish mackerel. (Christopher Legault, Nancie Cummings, and Patricia Phares).
7. Various background information materials for the MSAP meeting.
8. Report of the sixth coastal migratory pelagics SEP meeting. (SEP).
9. SPRs, ABCs, and TACs for king and Spanish mackerel in the 1990's. (Lamberte).

LIST OF CITED LITERATURE

Easely, J. E., Jr. Chuck Adams, Walter N. Thurman and Joel Kincaid. 1993. The derived demand for commercially harvested Gulf and South Atlantic king mackerel: partial equilibrium and general equilibrium models. Project report to the Gulf of Mexico Fishery Management Council, 42 pp. + appendices, March 29, 1993.

Green, T.G. 1989. The Economic Value and Policy Implications of Recreational Red Drum Success Rate in the Gulf of Mexico. Final Report National Marine Fisheries Service Grant No. NA87WC-H-06146.

Greene, G., C.B. Moss, and E.M. Thunberg. 1994. Estimation of Recreational Anglers' Value of Reef Fish in the Gulf of Mexico. Final Report National Marine Fisheries Service Grant No. NA37FF0054.

Holiman, S.G. 1996. Landings Reduction Options for the Recreational King Mackerel Fishery of the Gulf of Mexico. Report prepared for the Gulf of Mexico Fishery Management Council Socioeconomic Panel meeting on July 15-18, 1996.

Holiman, S.G. 1997. Recreational Fishery Data Coastal Migratory Pelagics Fishery. Report prepared for the Gulf of Mexico Fishery Management Council Socioeconomic Panel meeting on April 23-25, 1997.

Holland, S.M. and J.W. Milon. 1989. The Structure and Economics of the Charter and Party Boat Fishing Fleet on the Gulf Coast of Florida. Final Report National Marine Fisheries Service Grant No. NA87WC-H-06141.

Leeworthy, V.R. 1990. An Economic Allocation of Fishery Stocks Between Recreational and Commercial Fishermen: the Case of the King Mackerel. Doctoral Dissertation at Florida State University, Department of Economics, Tallahassee, FL.

McConnell, K.E. and I.E. Strand. 1994. The economic value of Mid- and South Atlantic sportfishing. Vol. 2, Report on cooperative agreement No. CR-811043-01-0 between the University of Maryland, the Environmental Protection Agency, the National Marine Fisheries Service and the National Oceanic Atmospheric Administration.

Milon, J.W. 1993. A Study of the Recreational Demand for Gulf of Mexico Group King Mackerel Using 1990 and 1991 MRFSS Data. Final Report Prepared for the Gulf of Mexico Fishery Management Council, Tampa, FL 33619.

Vondruska, John. 1998. Description of boats with federal fishing permits in 1997. National Marine Fisheries Service, Fisheries Economics Office, 9721 Executive Center Drive N., St. Petersburg, FL 33702-2432, 46 pp., SERO-ECON-98-14, March 5, 1998.

Vondruska, John. 1998. Commercial landings of coastal migratory pelagic fish, east and Gulf coasts, 1962-97. National Marine Fisheries Service, Fisheries Economics Office, 9721 Executive Center Drive N., St. Petersburg, FL 33702-2432, 42 pp., SERO-ECON-98-16, March 20, 1998.

LIST OF ATTENDEES

J. Walter Milon, Chairman
Stephen Holland, Vice-chairman
F. Andrew Deseran, Member
Michael Jepson, Member
David Johnson, Member
David Lavergne, Member
Robin Riechers, Member
John Ward, Member
Priscilla Weeks, Member

Stephen Holiman, NMFS
Antonio Lamberte, Council staff
Charles Tolbert, LSU
Mike Travis, NMFS-SERO
John Vondruska, NMFS-SERO

Table 1

GULF GROUP KING MACKEREL
1996/97 RECOMMENDATIONS AND HISTORICAL SPECIFICATION OF TAC AND ALLOCATIONS, AND LANDINGS ESTIMATES.
MILLIONS OF POUNDS
(NMFS SERO11.MFG; 08/18/96,LOTUS/GKINSPEC)

					ALLOCATIONS							CATCH (Incomplete *)							
					RECREATIONAL				COMMERCIAL (LBS)	ZONES		RECREATIONAL				COMMERCIAL		TOTAL	
FISHING YEAR	MSY**	ABC RANGE	MOST LIKELY	TAC	POUND (68% TAC)	N	MEAN SIZE POUNDS	BAG LIMITS	TOTAL (32% TA	WEST (TX-AL) (31%)	EAST (FL) (69%)	N	POUNDS	% ALLOC.	CLOSED	POUNDS	% ALLOC.	POUNDS	% TA
79/80																			
80/81												599,000	4.328			4.509		8.835	[illegible]
81/82												1,070,000	13.709			6.154		19.863	[illegible]
82/83	37.0			37.0	28.0				9.00	3.88 H&L	5.12 net	299,000	2.901			5.646		8.547	[illegible]
83/84												823,000	7.693			4.640		12.333	[illegible]
84/85												342,000	2.438			2.972		5.411	[illegible]
85/86	20.2	10.7 - 14.0	14.23	14.2	9.67			2/3 TX-FL	4.55	1.41	3.14	398,000	3.109			3.205		6.314	[illegible]
86 EMERGENCY March 11, 1986																			
	20.2	0.88 - 2.34		5.20	3.54			2/3 TX-FL	1.66	0.48	1.08	164,000	1.832	52		3.550	213	5.382	[illegible]
86/87	20.2	1.2 - 2.8		2.90	1.97			2/3 TX-FL	0.93	0.27	0.60	442,000	3.269	166		1.473	159	4.742	[illegible]
87/88	20.2	0.8 - 2.7		2.20	1.50			2/3 TX-FL	0.70	0.22	0.48	303,000	2.145	143	12/18/87	0.868	123	3.013	[illegible]
88/89	20.2	0.5 - 4.3		3.40	2.31			2/3 TX-FL	1.09	0.34	0.75	520,000	5.276	228	12/17/88	1.405	129	6.681	[illegible]
89/90	20.2	2.7 - 5.8		4.25	2.89	298,000	9.70	2/3 TX-FL	1.36	0.42	0.94	/ 514,000	3.360	116	05/21/90	1.954	144	5.314	[illegible]
90/91	20.2	3.2 - 5.4	3.90	4.25	2.89	301,000	9.81	2/3 TX-FL	1.36	0.42	0.94	502,000	3.951	137	12/20/90	1.816	134	5.767	[illegible]
91/92	20.2	4.0 - 7.0	4.90	5.75	3.91	574,000	6.81	2/3 TX-AL 2 FL	1.84	0.57	1.27	738,000	4.773	122	01/13/92	2.117	115	6.890	[illegible]
92/93	20.2	3.8 - 6.1	4.50	7.80	5.30	715,000	7.42	2 TX-FL	2.50	0.77	1.73	832,000	6.258	118		3.599	144	9.857	[illegible]
GMFMC		4.0 - 10.7	5.10																
93/94	20.2	1.9 - 4.5	4.00																
GMFMC		1.9 - 8.1	4.00	7.80	5.30	750,000	6.96	2 TX-FL	2.50	0.77	1.73	685,000	6.146	118		2.572	103	8.718	[illegible]
*94/95	20.2	3.8 - 5.7																	
GMFMC		1.9 - 8.1	5.70	7.80	5.30	788,000	6.90	2 TX-FL	2.50	0.77	1.73	782,000	7.863	148		2.942	118	10.805	[illegible]
*95/96	20.2	2.0 - 5.5	3.70																
GMFMC		1.9 - 8.1		7.80	5.30	829,000	8.42	2 TX-FL	2.50	0.77	1.73		6.28	118		2.64	106	8.922	[illegible]
96/97	20.2	4.7 - 8.8	8.80	7.80	5.30			2 TX-FL	2.50	0.77	1.73								
97/98	20.2	8.0 - 13.7	8.90																
								1 TX-FL											
								2 TX-FL	2.50	0.77	1.73								

* Incomplete
** MSY for Atlantic/Gulf combined
le = less than or equal to

COMMERCIAL CATCH GULF ZONES

	WEST			EAST		
FISHING YEAR	POUNDS	% QUOTA	CLOSED	POUND	% QUOTA	CLO…
82/83	Commercial hook-and-line fishery closed 2400 hrs May 6 throu…					
85/86						
86 EMER	0.872	182	03/12/86	2.577	239	03/… [illegible]
86/87	0.468	173	02/04/87	0.955	159	02/… [illegible]
87/88	0.270	124	11/02/87	0.387	83	12/… [illegible]
88/89	0.457	135	12/03/88	0.828	124	12/… [illegible]
89/90	0.657	156	10/25/89	1.177	125	01/… [illegible]
90/91	0.636	151	10/18/90	1.011	108	01/… [illegible]
91/92	0.587	103	09/29/91	1.324	104	01/… [illegible]
92/93	1.136	148	10/18/92	2.306	133	01/… [illegible]
92/93 EMERGENCY				Reopen FEC:2/18 - 3/2…		
93/94	0.892	116	10/01/93	1.663	96	01/… [illegible]
94/95	0.840	109	09/24/94	2.163	125	12/… [illegible] 02/… [illegible]
94/95 EMERGENCY				Reopen FWH&L:2/01 - 2…		
95/96		0	09/05/95		ERR	02/… [illegible] 02/… [illegible]
96/97			06/26/96			01/… [illegible]

Table 2. King mackerel quotas by migratory group and fishing year.

Fishing Year	Migratory Group and Florida Sub-Zone					
	Gulf Group, Eastern Zone				Atlantic Group	
	FL West Coast Sub-Zone		FL East Coast Sub-Zone			
	Season	Quota (lbs)	Season	Quota (lbs)	Season	Quota (lbs)
1990/91	July-June	470,000	Nov-March	470,000	April-March	3,080,000
1991/92	July-June	635,000	Nov-March	635,000	April-March	3,900,000
1992/93	July-June	635,000	Nov-March	635,000	April-March	3,900,000
1993/94	July-June	865,000	Nov-March	865,000	April-March	3,900,000
1994/95	July-June	865,000	Nov-March	865,000	April-March	3,900,000
1995/96	July-June	865,000	Nov-March	865,000	April-March	3,900,000
1996/97	July-June	865,000	Nov-March	865,000	April-March	3,900,000
1997/98	July-June	1,170,000	Nov-March	1,170,000	April-March	3,900,000

Table 3. Gulf of Mexico recreational king mackerel landings, MRFSS, Headboats and TPWD data.

	MRFSS		HEADBOAT		TPWD		TOTAL	
YEAR	#	POUNDS	#	POUNDS	#	POUNDS	#	POUNDS
1982	733,984	5,755,328						
1983	262,421	2,092,327						
1984	303,334	3,132,773						
1985	140,136	1,105,768						
1986	162,161	1,722,951	8,804	107,321	16,813	178,637	187,778	2,008,909
1987	411,268	2,878,343	9,643	111,797	33,160	232,077	454,071	3,222,217
1988	323,001	2,918,861	9,483	110,044	22,217	200,768	354,701	3,229,673
1989	263,220	2,630,318	10,456	114,356	18,558	185,447	292,234	2,930,121
1990	372,508	3,167,732	11,265	131,767	27,616	234,841	411,389	3,534,340
1991	596,320	4,325,060	12,860	127,752	27,703	200,928	636,883	4,653,740
1992	349,675	3,134,947	17,928	159,638	54,980	492,913	422,583	3,787,498
1993	446,829	4,118,916	15,511	157,415	74,734	688,905	537,074	4,965,236
1994	538,502	4,633,703	19,419	171,535	17,121	147,323	575,042	4,952,561
1995	493,275	4,696,549	21,731	212,590	14,361	136,733	529,367	5,045,872
1996*	574,689	5,650,105	19,820	193,918	19,680	193,486	614,189	6,037,509

*Preliminary.

Table 4a. Distribution of charter boat captains operating from the Florida Keys by species targeted by quarter (1987-1988), sorted by annual number of boats targeting each species.

Species	April-June		July-September		October-December		January-March		Annual	
	N	%	N	%	N	%	N	%	N	%
Dolphin	31	81.6	32	84.2	7	18.4	4	10.5	35	92
Sailfish	10	26.3	4	10.5	23	60.5	24	63.2	33	87
Blue marlin	14	36.8	15	39.5	7	18.4	1	2.6	29	76
Blackfin tuna	14	36.8	9	23.7	9	23.7	12	31.6	27	71
Wahoo	15	39.5	14	36.8	11	28.9	9	23.7	26	68
King mackerel	2	5.3	1	2.6	15	39.5	23	60.5	26	68
Amberjack	13	34.2	11	28.9	6	15.8	8	21.1	25	66
Barracuda	13	34.2	12	31.6	15	39.5	15	39.5	24	63
White marlin	10	26.3	9	23.7	5	13.2	2	5.3	24	63
Grouper	7	18.4	4	10.5	8	21.1	14	36.8	23	61
Bonito	14	36.8	13	34.2	11	28.9	10	26.3	22	58
Snapper	8	21.1	7	18.4	10	26.3	11	28.9	21	55
Shark	7	18.4	8	21.1	7	18.4	11	28.9	20	53
Cobia/Ling	1	2.6	1	2.6	8	21.1	13	34.2	19	50
Yellowfin tuna	4	10.5	2	5.3	2	5.3	4	10.5	9	24
Spanish mackerel	0	0.0	0	0.0	2	5.3	5	13.2	8	21
Swordfish	3	7.9	5	13.2	0	0.0	0	0.0	7	18
Ladyfish	2	5.3	2	5.3	2	5.3	3	7.9	3	8
Bluefin tuna	1	2.6	1	2.6	1	2.6	0	0.0	2	5
Bluefish	1	2.6	0	0.0	0	0.0	1	2.6	2	5
Flounder	1	2.6	1	2.6	1	2.6	2	5.3	1	3
Speckled trout	1	2.6	1	2.6	1	2.6	1	2.6	1	3
Tarpon	1	2.6	1	2.6	0	0.0	1	2.6	1	3
Red drum	0	0.0	0	0.0	1	2.6	0	0.0	1	3
Triggerfish	0	0.0	0	0.0	0	0.0	0	0.0	0	0

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Table 4b. Distribution of charterboat captains operating from the Florida Peninsula West Coast by species targeted by quarter, sorted by annual number of boats targeting each species.

Species	April-June		July-September		October-December		January-March		Annual	
	N	%	N	%	N	%	N	%	N	%
Grouper	29	76.3	30	78.9	31	81.6	27	71.1	33	87
Snapper	19	50.0	18	47.4	20	52.6	15	39.5	30	79
King mackerel	12	31.6	7	18.4	12	31.6	3	7.9	28	74
Spanish mackerel	15	39.5	14	36.8	10	26.3	6	15.8	26	68
Amberjack	15	39.5	14	36.8	18	47.4	16	42.1	24	63
Shark	18	47.4	18	47.4	10	26.3	5	13.2	23	61
Bonito	13	34.2	14	36.8	11	28.9	7	18.4	20	53
Cobia/Ling	10	26.3	11	28.9	10	26.3	8	21.1	19	50
Barracuda	13	34.2	13	34.2	10	26.3	6	15.8	18	47
Dolphin	7	18.4	9	23.7	4	10.5	1	2.6	13	34
Speckled trout	7	18.4	7	18.4	8	21.1	9	23.7	11	29
Blue marlin	6	15.8	9	23.7	6	15.8	0	0.0	10	26
Ladyfish	8	21.1	9	23.7	8	21.1	8	21.1	10	26
Red drum	6	15.8	5	13.2	7	18.4	7	18.4	9	24
Tarpon	9	23.7	5	13.2	4	10.5	2	5.3	9	24
Sailfish	6	15.8	7	18.4	5	13.2	1	2.6	9	24
White marlin	6	15.8	8	21.1	5	13.2	0	0.0	9	24
Blackfin tuna	5	13.2	4	10.5	4	10.5	0	0.0	8	21
Wahoo	4	10.5	6	15.8	3	7.9	0	0.0	8	21
Bluefish	3	7.9	4	10.5	2	5.3	2	5.3	8	21
Yellowfin tuna	4	10.5	4	10.5	2	5.3	0	0.0	6	16
Flounder	3	7.9	2	5.3	2	5.3	3	7.9	6	16
Bluefin tuna	3	7.9	3	7.9	2	5.3	1	2.6	4	11
Swordfish	1	2.6	1	2.6	0	0.0	0	0.0	1	3
Triggerfish	0	0.0	0	0.0	0	0.0	1	2.6	1	0

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Table 4c. Distribution of Florida Panhandle coast charterboat captains by species targeted by quarter (1987-1988), sorted by annual number of boats targeting each species.

Species	April-June		July-September		October-December		January-March		Annual	
	N	%	N	%	N	%	N	%	N	%
Grouper	35	70.0	36	72.0	36	72.0	28	56.0	42	84
Snapper	40	80.0	39	78.0	40	80.0	33	69.5	41	82
Amberjack	31	62.0	31	62.0	29	58.0	22	44.0	40	80
King mackerel	28	56.0	34	68.0	19	38.0	1	2.0	40	80
Bonito	20	40.0	23	46.0	13	26.0	10	20.0	40	80
Spanish mackerel	32	64.0	19	38.0	7	14.0	6	12.0	38	76
Dolphin	21	42.0	26	52.0	12	24.0	2	4.0	38	76
Cobia/Ling	23	46.0	10	20.0	7	14.0	6	12.0	36	72
Wahoo	15	30.0	16	32.0	10	20.0	1	2.0	36	72
Shark	15	30.0	18	36.0	12	24.0	6	12.0	34	68
White marlin	13	26.0	21	42.0	12	24.0	1	2.0	28	56
Blue marlin	12	24.0	20	40.0	11	22.0	1	2.0	27	54
Blackfin tuna	9	18.0	12	24.0	10	20.0	2	4.0	27	54
Bluefish	11	22.0	5	10.0	3	6.0	4	8.0	27	54
Sailfish	13	26.0	19	38.0	13	26.0	1	2.0	25	50
Yellowfin tuna	9	18.0	11	22.0	9	18.0	0	0.0	24	48
Barracuda	5	10.0	6	12.0	4	8.0	1	2.0	20	40
Ladyfish	4	8.0	4	8.0	2	4.0	0	0.0	19	38
Flounder	6	12.0	5	10.0	6	12.0	4	8.0	17	34
Swordfish	6	12.0	7	14.0	5	10.0	1	2.0	11	22
Triggerfish	9	18.0	9	18.0	8	16.0	7	14.0	9	18
Bluefin tuna	2	4.0	3	8.7	2	4.0	0	0.0	8	16
Red drum	2	4.0	3	6.0	6	12.0	3	6.0	7	14
Speckled trout	3	6.0	2	2.0	4	8.0	3	6.0	3	6
Tarpon	2	4.0	2	4.0	1	2.0	1	2.0	2	4

TABLE 5. GULF OF MEXICO KING MACKEREL RECREATIONAL PROJECTED LANDINGS (THOUSANDS OF POUNDS) AS DERIVED FROM A BAG LIMIT ANALYSIS. TARGET = 12.87 PERCENT REDUCTION.

BAG LIMIT		NON-MRFSS/MRFSS RATIO YEARS			% REDUC.
CHARTER	NON-CHARTER	1986-94	1990-94	1994	USING 1994
2	2	5,219	5,234	4,917	-
2	1	4,792	4,805	4,514	8.2
1	2	4,048	4,059	3,813	22.5
1	1	3,620	3,631	3,410	30.6

TABLE 6. GULF OF MEXICO KING MACKEREL RECREATIONAL PROJECTED LANDINGS (THOUSANDS OF POUNDS) AS DERIVED FROM A SIZE LIMIT ANALYSIS. TARGET = 12.87 PERCENT REDUCTION.		
UNIFORM MINIMUM SIZE		
MINIMUM SIZE (INCHES)	LANDINGS	PERCENT REDUCTION
26	4.508	8.32
27	4.385	10.82
28	4.193	14.72
UNIFORM MAXIMUM SIZE		
MAXIMUM SIZE (INCHES)	LANDINGS	PERCENT REDUCTION
43	4.202	14.54
44	4.234	13.89
45	4.297	12.61
24-INCH MINIMUM AND UNIFORM MAXIMUM SIZE		
MAXIMUM SIZE (INCHES)	LANDINGS	PERCENT REDUCTION
NO MAXIMUM	4.727	3.86
47	4.260	13.36
48	4.378	10.96

BLE 7. GULF OF MEXICO KING MACKEREL RECREATIONAL PROJECTED LANDINGS (THOUSANDS OF POUNDS) AS DERIVED FROM A 2-FISH FORHIRE AND 1-FISH PRIVATE BAG AND UNIFORM MINIMUM SIZE LIMIT ANALYSIS. TARGET = 12.87 PERCENT REDUCTION.

MINIMUM SIZE (INCHES)	LANDINGS	PERCENT REDUCTION
24	4.339	11.76
25	4.262	13.32

Table 8. Percent of king mackerel anglers by support of opposition to management tools as reported in Florida, Louisiana, and Texas surveys of recreational anglers.

Management Options	Support or Opposition				
	1	2	3	4	5
Catch & release area for specific saltwater fish	6.2	12.5	31.3	25.0	25.0
Releasing fish below a certain length (minimum size limit)	0.0	6.2	6.2	43.7	43.7
Releasing fish above a certain length (maximum size limit)	0.0	37.5	0.0	31.3	31.3
Releasing fish within a certain length range, but keeping the fish below and above this range (slot limit)	12.5	18.8	12.5	43.7	12.5
Keeping fish within a certain length range, but releasing fish below and above this range	6.2	37.5	12.5	25.0	18.8
Being allowed to keep only a certain number of fish you catch in a day (daily bag limit)	0.0	12.5	0.0	43.7	43.7
Not being allowed to fish in certain restricted areas	12.5	12.5	25.0	43.7	6.2
Having certain fishing areas closed during part of the year (closed season)	6.7	6.7	46.7	33.3	6.7
Prohibiting the use of certain types of sport fishing gear	6.2	25.0	43.7	12.5	12.5
Prohibiting the use of certain types of bait	12.5	43.7	18.8	25.0	0.0
Not being allowed to keep certain species of fish in certain areas	6.2	18.8	50.0	25.0	0.0
Not being allowed to keep certain species of fish during certain times of the year	6.2	6.2	37.5	37.5	12.5
A voluntary catch and release program	0.0	6.2	6.2	75.0	12.5
Stocking fish in saltwater	0.0	0.0	18.8	12.5	68.7
A mandatory stamp to retain a specific species	25.0	25.0	18.8	25.0	6.2

Legend: 1 = strongly oppose, 2 = oppose, 3 = neutral, 4 = support, 5 = strongly support

Source: Steve Holland, 1994

Table 9. Percentage of anglers in Florida who responded that these species would be acceptable substitutes for king mackerel.

Species	Percent who found substitutable
Cobia	81.2
Spanish mackerel	73.3
Red drum	64.3
Spotted sea trout	56.2
Dolphin	42.9
Other species	< 40.0

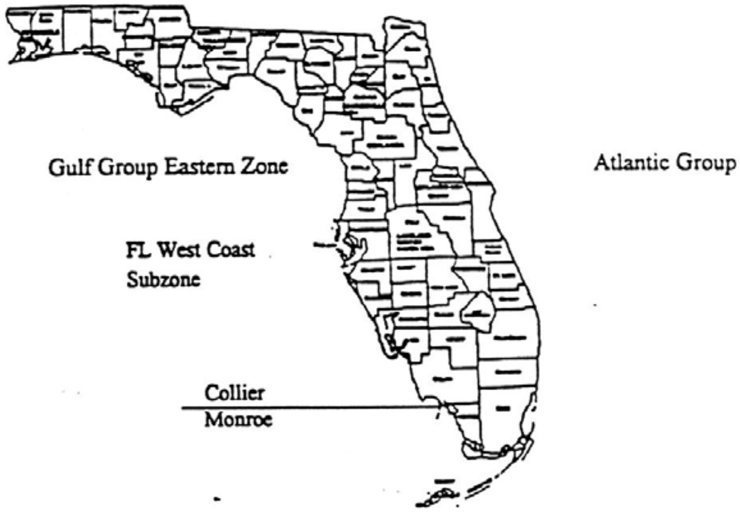
Other species includes grouper, snapper, amberjack, mullet, bonefish, pompano, sailfish, sheepshead.

Source: Steve Holland, 1994

FIGURE 1

Boundaries for King Mackerel

April 1-October 31



November 1- March 31

FIGURE 2

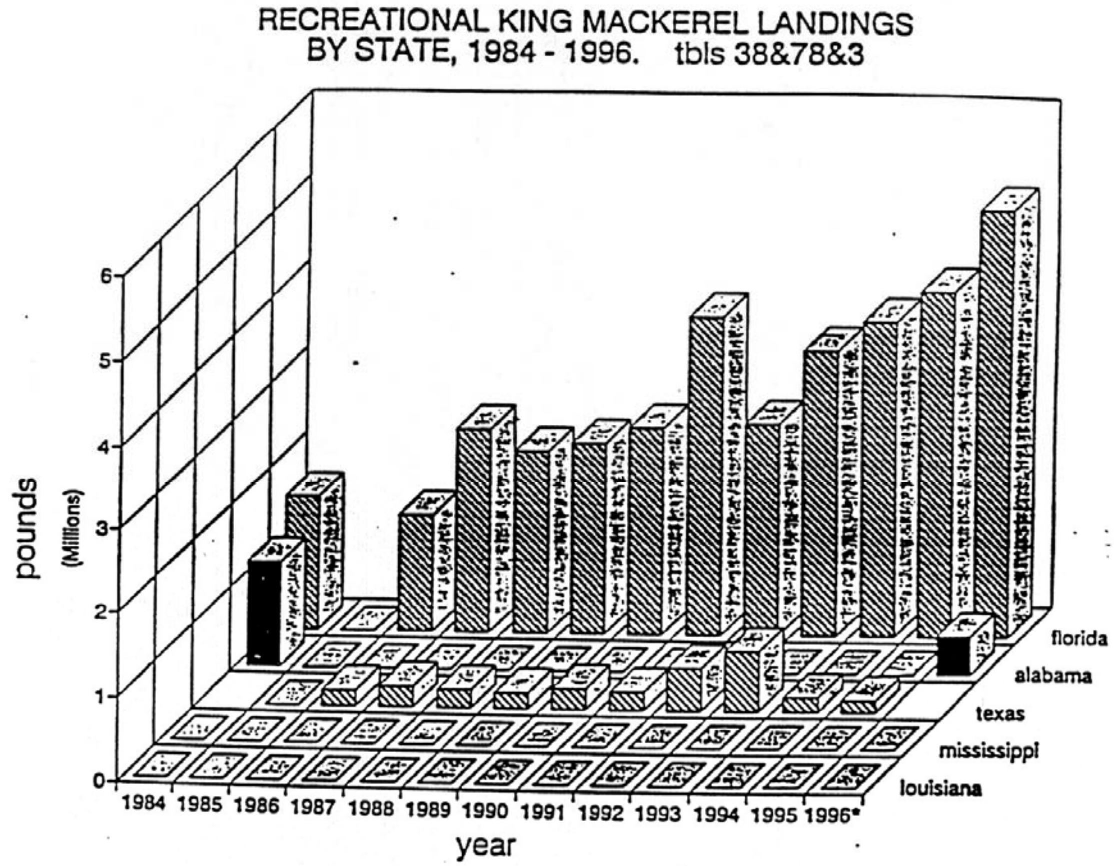

RECREATIONAL KING MACKEREL LANDINGS
BY STATE, 1984 - 1996. tbls 38&78&3
pounds
(Millions)
0
1
2
3
4
5
6
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996*
year
florida
alabama
texas
mississippi
louisiana

FIGURE 3

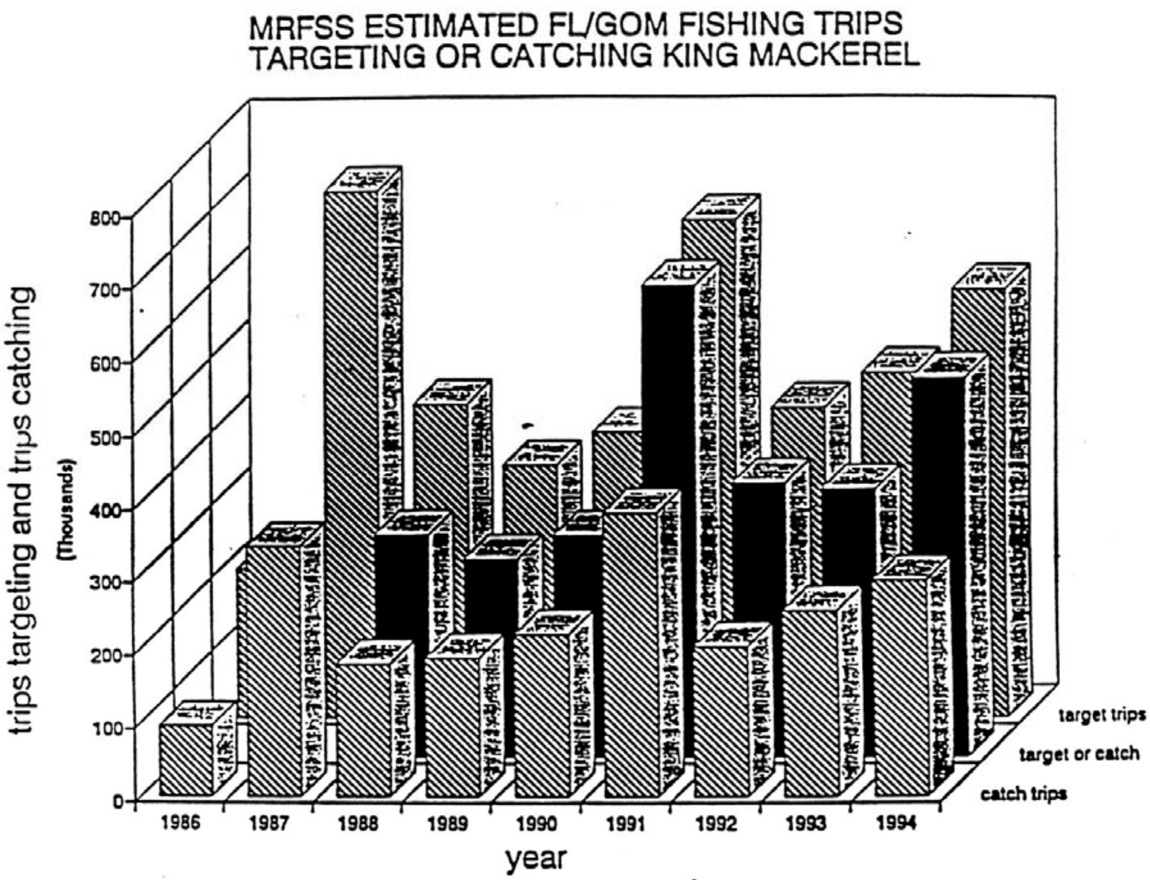

MRFSS ESTIMATED FL/GOM FISHING TRIPS
TARGETING OR CATCHING KING MACKEREL
trips targeting and trips catching
(Thousands)
0
100
200
300
400
500
600
700
800
1986
1987
1988
1989
1990
1991
1992
1993
1994
year
target trips
target or catch
catch trips

FIGURE 4

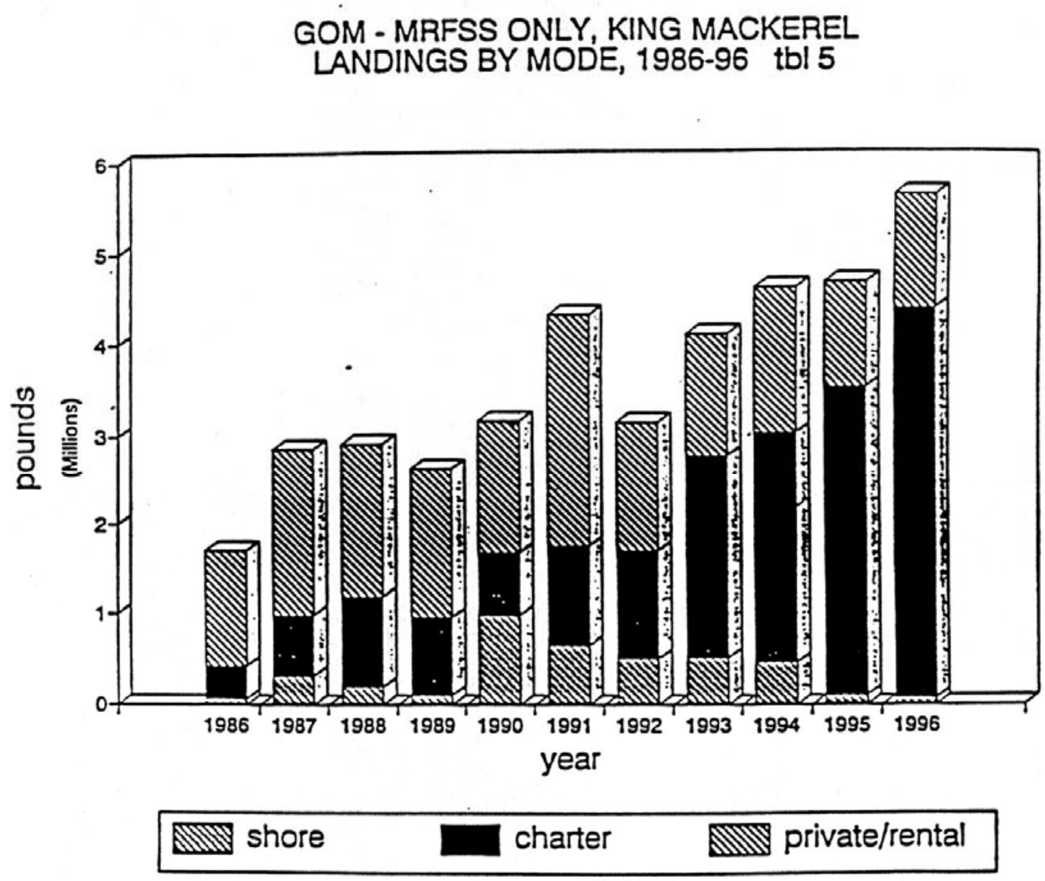

GOM - MRFSS ONLY, KING MACKEREL
LANDINGS BY MODE, 1986-96 tbl 5
pounds
(Millions)
0
1
2
3
4
5
6
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
year
shore
charter
private/rental

FIGURE 5

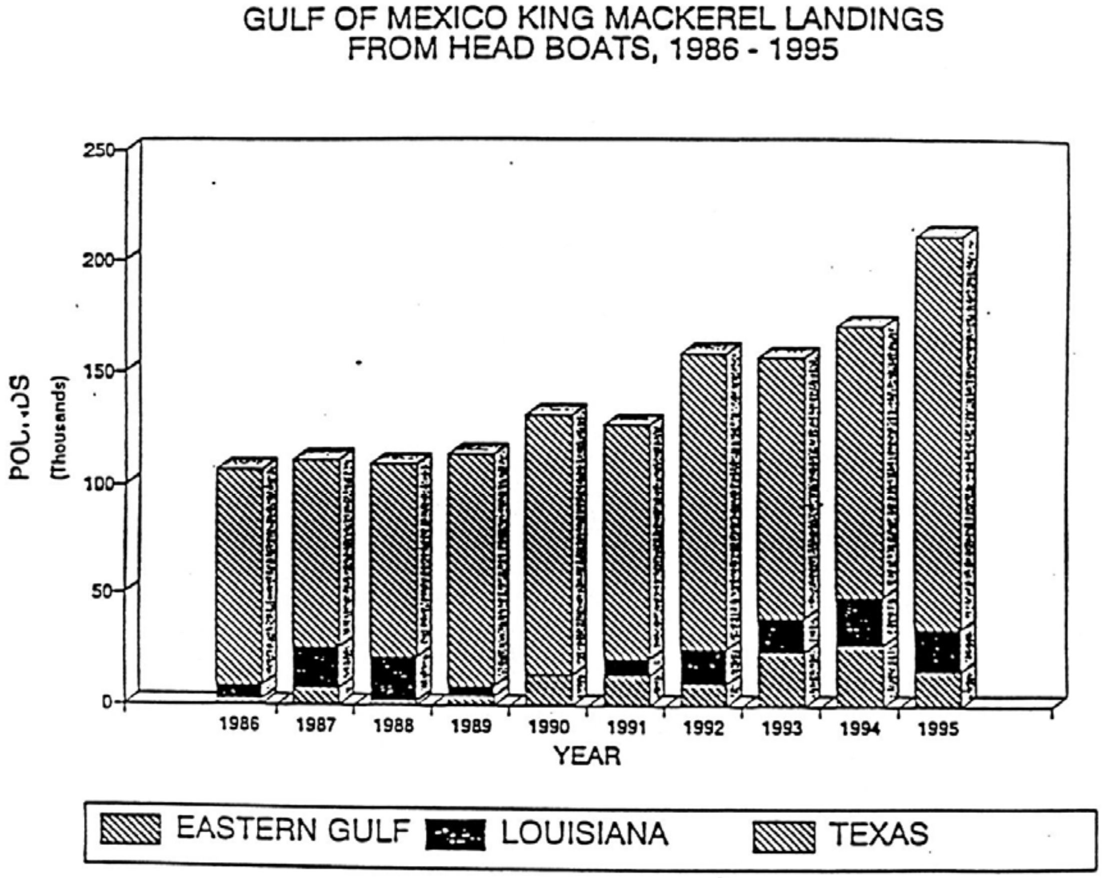
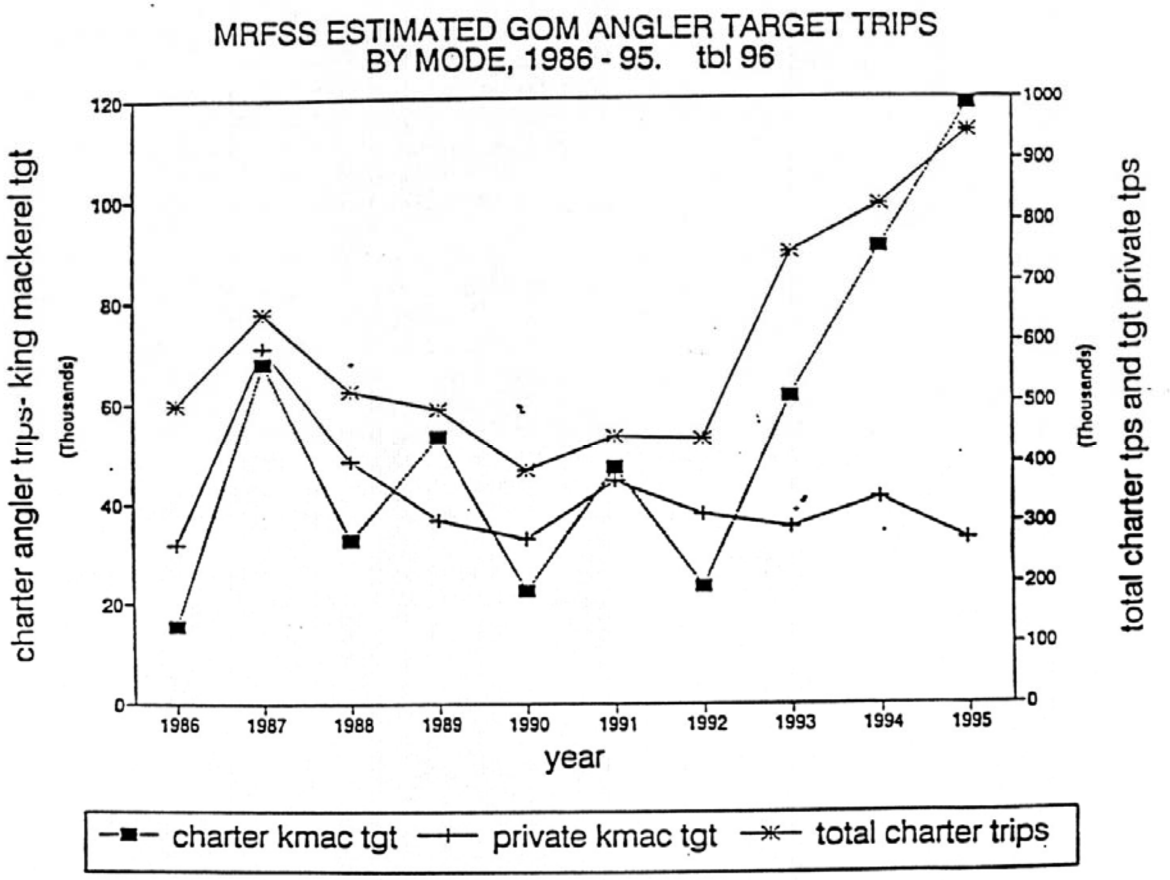

GULF OF MEXICO KING MACKEREL LANDINGS
FROM HEAD BOATS, 1986 - 1995
POUNDS
(Thousands)
0
50
100
150
200
250
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
YEAR
EASTERN GULF
LOUISIANA
TEXAS

FIGURE 6


MRFSS ESTIMATED GOM ANGLER TARGET TRIPS
BY MODE, 1986 - 95. tbl 96
charter angler trips- king mackerel tgt
(Thousands)
total charter tps and tgt private tps
(Thousands)
0
20
40
60
80
100
120
0
100
200
300
400
500
600
700
800
900
1000
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
year
charter kmac tgt
private kmac tgt
total charter trips

GULF OF MEXICO FISHERY MANAGEMENT COUNCIL
The Commons at Rivergate
3018 U.S. Highway 301 North, Suite 1000 • Tampa, Florida 33619-2266
(813) 228-2815 • FAX (813) 225-7015
e-mail: gulf.council@noaa.gov

April 23, 1998

TAB C NO. 9(a)

Dr. Maumus F. Claverie, Jr., Chairman
Gulf of Mexico Fishery Management Council
3018 U.S. Highway 301 North, Suite 1000
Tampa, Florida 33619-2266

Dear Dr. Claverie:

At its March 1998 meeting the Socioeconomic Panel (SEP) discussed the Council's capability to address National Standard 8 of the recently amended Magnuson-Stevens Act. The SEP concluded that National Standard 8 imposes requirements on the council and the fishery management regulatory process that cannot be satisfied given existing data. It is the Panel's recommendation that further research be initiated and funded by National Marine Fisheries Service as soon as possible to aid in the identification and definition of fishing communities in the Southeast. The panel would also recommend the scope of this problem be addressed at a national level, such that impacts upon fishing communities can be analyzed across regions as well as within.

It is the opinion of the Panel that current data available do not allow for a meaningful definition of fishing community. Moreover, current data provide no measure of dependence upon fishing and will not contribute to useful impact analysis. The SEP noted that although recent research has expanded the available information, there is a substantial amount of research that is required before fishing communities can realistically be identified and defined in the Southeast region. Fishing communities in this region are most likely dependent upon both commercial and recreational fishing and support industries for both sectors contribute to that dependence. The Panel emphasized that more ethnographic and survey research is required in order to identify, not only communities, but those who provide supporting services to the economy and culture of fishing communities. Especially important in the Southeast is the need to provide a realistic portrayal of recreational fishing, diving, and eco-tourism and their importance to a fishing community.

Finally, the Panel would also recommend that the NMFS review and consider implementing the "Southeast Social and Cultural Data and Analysis Plan" as this would address many of the current data needs for all the three councils in the Southeast.

Sincerely,

Members of the GMFMC Socioeconomic Panel:

J. Walter Milon, Ph.D., Chairman
F. Andrew Deseran, Ph.D.
G. David Johnson, Ph.D.
Robert Palmer
Robin Riechers
Priscilla Weeks, Ph.D

Stephen Holland, Ph.D., Vice-Chairman
Michael Jepson
David R. Lavergne
Richard Raulerson
John Ward, Ph.D.

cc: SAFMC
CMFC

mackerel\sepletter98.wpd

Appendix K. What if Mixing Area Fish are Assigned to the Atlantic Migratory Group Instead of the Gulf of Mexico Migratory Group (MSAP/98/10)

MSAP/98/10

What if Mixing Area Fish are Assigned to the Atlantic Migratory Group Instead of the Gulf of Mexico Migratory Group?

Christopher M. Legault

National Marine Fisheries Service
Southeast Fisheries Science Center
Sustainable Fisheries Division
75 Virginia Beach Drive
Miami, FL 33149

March 1998
Sustainable Fisheries Division Contribution MIA-97/98-18

Summary

Currently there are two migratory groups of king mackerel recognized for assessment and management purposes, the Atlantic migratory group and the Gulf of Mexico migratory group. The boundary between these groups changes during the year. During the summer, the Monroe-Collier County, FL, border separates the landings assigned to the migratory groups while during the winter the Flagler-Volusia County, FL, border delimits the landings assigned to the migratory groups. The overlap between these two boundaries is known as the mixing area. It has been suggested that some king mackerel in the mixing area during the winter belong to the Atlantic group. In this document, all mixing area king mackerel landings are assigned to the Atlantic group and provides a basis for evaluating the results of stock assessments and projected allowable biological catches (ABC) for both the Atlantic group and the Gulf of Mexico migratory group king mackerel under this alternative. Results of the analysis indicated that under this scenario, the estimated Atlantic group population is larger, has a similar spawning potential ratio (SPR), and would support a larger ABC than if landings of mixing area fish are distributed between the Atlantic and Gulf of Mexico migratory groups as in the currently accepted assessment procedure. In contrast, the estimated Gulf of Mexico group population is smaller, has a more pessimistic trend in SPR and a lower ABC than when the mixing area fish are distributed between the Atlantic and Gulf of Mexico groups as in the currently accepted assessment procedure. The total ABC for king mackerel in the Atlantic and Gulf of Mexico combined, can either increase or decrease slightly depending upon which group is assigned the mixing area fish and which bycatch level is chosen for the Atlantic group. These results are consistent with results presented to previous MSAP meetings examining this question. Due to time constraints, a full analysis of the mixing area problem could not be conducted. Specifically, the catch per unit effort (CPUE) indices used to tune the virtual population analysis (VPA) were not recomputed based on the new group assignments relative to the two migratory groups and the ageing of fish caught in the mixing area was maintained in its current form.

Introduction

Currently there are two migratory groups of king mackerel recognized for management purposes, the Atlantic migratory group and the Gulf of Mexico migratory group. The boundary used for assigning landings to migratory groups changes during the year. During the summer (April 1 to October 31) the Monroe-Collier county line separates landings assigned to the groups while during the winter (November 1 to March 31) the Flagler-Volusia county line delimits the landings assigned to each group. The overlap caused by shifting the boundary is known as the mixing area. It has been suggested that at least some king mackerel in the mixing area during the winter actually belong to the Atlantic group, but the proportion has not been specified (see *i.e.* Sutter *et al.* 1991, Anonymous 1996). New research using otolith shape analysis has suggested there is a significant proportion of Atlantic migratory group fish caught in the mixing during the winter (Grimes and DeVries 1998). This work assigns mixing area fish to the Atlantic group and examines the results of the stock assessments and projected allowable biological catches (ABC) for both the Atlantic group and the Gulf of Mexico migratory group king mackerel under this alternative landings assignment scenario.

Methods

Due to time constraints only a simple approach to the problem could be considered. The fish caught in the mixing area were subtracted from the Gulf of Mexico group catch (Legault *et al.* 1998, MSAP/98/09) and added to the Atlantic group catch. The partial catch at age used to generate the selectivity patterns for the were also subtracted from the Gulf group and added to the Atlantic group as necessary. The number of fish caught in the mixing area is considerable relative to the number caught outside the mixing area (Table 1). The mixing area fish contribute approximately 25% of the total catch to whichever group they are assigned when averaged over all years and ages. Stock assessments were conducted using tuned virtual population analysis and projections made to estimate the allowable biological catch for the 1998/99 fishing season for the two groups following the standard procedure (see Legault *et al.* 1998, MSAP/98/09).

This simple approach ignores two issues potentially important to the interpretation of the results: 1) the ageing of fish in the mixing area and 2) the tuning indices used in the virtual population analyses. The ageing of fish in the mixing area is not a problem when sufficient age-length keys are available. The problem arises when the stochastic ageing procedure must be used due to missing or limited age-length keys (see Cummings 1989). The stochastic ageing procedure requires a growth equation and associated confidence interval to probabilistically assign fish lengths to ages. The different growth equations for the two groups means this assigning of ages will differ depending upon which growth equation is used. The tuning indices used in the virtual population analyses were not recomputed to reflect the change in group designation for the mixing area fish. Specifically, the Atlantic group FDEP, MRFSS and headboat CPUE indices and the Gulf of Mexico group charterboat in southwest Florida, MRFSS and headboat CPUE indices were not recomputed.

Results

Atlantic Group King Mackerel Including Mixing Area Fish

The Atlantic king mackerel virtual population tuning results using the Vaughan and Nance low bycatch estimates are given in Table 2a including parameter standard errors and coefficients of variation, index fits, index selectivities, residual analyses, diagnostics, abundance at age and fishing mortality at age estimates. Tables 2b and 2c contain partial results from the other bycatch scenarios. Comparison of the observed and predicted indices are given in Figure 1. Population trends and unweighted transitional SPR from the Monte Carlo/bootstrap analyses are given in Figure 2. Probabilities of exceeding given SPR conditions under various yields in the 1998/99 fishing year are given in Table 3 and Figure 3. The allowable biological catches for the deterministic case and the median of the stochastic simulations under a range of management objectives (%SPR) are given in Tables 6-7.

Inclusion of mixing area fish in the Atlantic group caused estimates of population abundance to increase while estimates of fishing mortality rates remained about the same compared to analyses using the currently accepted procedure (see Legault *et al.* 1998, MSAP/98/09). Spawning potential ratio shows a slightly greater increasing trend when mixing area fish are included compared to the accepted procedure, but the uncertainty about the point estimates is much greater than the difference between the two lines. The 1998/99 fishing season projected allowable biological catch at 30% SPR increases between approximately 0.9 and 4.6 million pounds when the mixing area fish are included in the Atlantic group depending upon the level of bycatch used in the analyses.

Gulf of Mexico Group King Mackerel Without Mixing Area Fish

The Gulf of Mexico king mackerel virtual population tuning results are given in Table 4 including parameter standard errors and coefficients of variation, index fits, index selectivities, residual analyses, diagnostics, abundance at age and fishing mortality at age estimates. Comparison of the observed and predicted indices are given in Figure 4. Population trends and unweighted transitional SPR from the Monte Carlo/bootstrap analysis are given in Figure 5. Probabilities of exceeding given SPR conditions for this analysis under various yields in the 1998/99 fishing year are given in Table 5 and Figure 6. The projected allowable biological catches for the deterministic case and the median of the stochastic simulations under a range of management objectives (%SPR) are given in Tables 6-7.

Removal of mixing area fish from the Gulf of Mexico group caused estimates of population abundance to decrease while estimates of fishing mortality remained about the same. Spawning potential ratio shows a flatter, possibly even decreasing, trend when mixing area fish are removed, but the uncertainty about the point estimate is again much greater than the difference between the two lines. The 1998/99 fishing season projected allowable biological catch at 30% SPR decreases approximately 1.2 million pounds when mixing area fish are removed from the Gulf of Mexico group compared to the presently accepted assessment procedure (see Legault *et al.* 1998. MSAP/98/09). Thus, under this scenario, the total ABC (sum of projected ABC for both the Atlantic and Gulf of Mexico groups) can decrease 0.3 or increase 3.4 million pounds compared to the currently accepted procedure (see Legault *et al.* 1998. MSAP/98/09) depending upon the level of bycatch used in the analyses.

Literature Cited

Anonymous. 1996. Overview of southeastern U.S. king mackerel mark-recapture data: 1985-1996. Miami Laboratory Contribution MIA-95/96-35. Mackerel Stock Assessment Panel Report MSAP/96/06.

Grimes, C.B. and D.A. DeVries. 1998. Discrimination of king mackerel, *Scomberomorus cavalla*, stocks in the U.S. south Atlantic and Gulf of Mexico and assignment of catches from mixed stock fisheries. Mackerel Stock Assessment Panel Report MSAP/98/08.

Legault, C.M., N. Cummings, and P. Phares. 1998. Stock assessment analyses on Atlantic migratory group king mackerel, Gulf of Mexico migratory group king mackerel, Atlantic migratory group Spanish mackerel, and Gulf of Mexico migratory group Spanish mackerel. NMFS SEFSC Sustainable Fisheries Division Contribution MIA-97/98-15. Mackerel Stock Assessment Panel Report MSAP/98/09.

Sutter III, F.C., R.O. Williams, and M.F. Godcharles. 1991. Movement patterns and stock affinities of king mackerel in the southeastern United States. Fish. Bull. 89:315-324.

Table 1. Number of king mackerel caught in the mixing area and number caught outside the mixing area and assigned to the Atlantic group and the Gulf of Mexico group.

Catch in Mixing Area

age	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92
0	22	10	21	5	8	5	137	4	0	488	2
1	1066	15474	179	5404	3288	10949	13957	9315	44139	20148	11767
2	2913	23415	21936	6533	8449	10857	55252	17651	42921	37932	50455
3	22252	46194	113848	17242	14814	44627	34912	16267	16099	104293	61063
4	361364	108755	42831	85631	42410	47953	20767	76691	10077	27677	31076
5	55520	112733	11534	58733	45858	15890	6311	37340	6744	1148	6636
6	9527	983	14911	12680	15885	4267	2037	11069	4230	7728	13267
7	12928	6615	9349	19306	1743	3043	4858	3626	2149	2599	3760
8	3766	3136	4761	187	222	350	189	3562	1371	947	1192
9	1547	343	514	3	877	57	19	1310	1165	224	1100
10	1289	808	869	652	556	35	85	5	2433	225	1272
11+	1110	1158	836	701	2015	174	93	1768	3450	2764	5938
sum	473304	319624	221588	207077	136125	138207	138617	178607	134779	206173	187529

age	92/93	93/94	94/95	95/96	96/97
0	2	0	10	339	7
1	11761	23717	9125	17318	4010
2	28255	36175	19008	48509	118821
3	52618	22679	38080	43429	62716
4	41537	24263	31772	8591	27693
5	27634	14037	43622	39784	33745
6	6489	7409	18894	14379	3262
7	7722	5670	2663	19537	4048
8	14828	7200	6608	1691	9963
9	10594	3451	7294	2734	2489
10	4093	2330	1901	1257	162
11+	14589	3609	4393	3372	2500
sum	220122	150541	183372	200940	269417

Table 1. Number of king mackerel caught in the mixing area and number caught outside the mixing area and assigned to the Atlantic group and the Gulf of Mexico group (cont.).

Atlantic Group Catch (no mixing area fish)

age	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92
0	589	2809	3693	1175	1117	1441	6151	1757	997	608	243
1	5854	5519	29287	4165	86459	118293	197819	19394	69084	134813	95988
2	14335	5750	60259	10079	126498	221907	212012	217480	101676	162794	321248
3	55954	20653	100524	19651	25568	115697	139893	192579	137946	78594	103736
4	154113	72035	70141	102212	64835	141440	95072	113240	98881	91287	70365
5	131163	170070	138440	135161	98826	63702	73755	60041	69187	81532	99802
6	101579	168341	72811	119135	133340	62910	40807	60993	45231	60087	83573
7	134702	163125	128809	143957	168219	92827	33794	62595	31705	26524	45919
8	52511	154633	137135	54025	201313	56918	23014	22416	16741	15597	30852
9	72985	27181	68940	67192	59323	17873	13912	46998	9812	27181	11985
10	21095	2197	31200	57805	18480	26756	11902	21218	41949	14470	8084
11+	27268	119087	64689	79610	67229	57397	43636	77820	40376	56011	62225
sum	772148	911400	905928	794167	1051206	977160	891765	896530	663585	749500	934019

age	92/93	93/94	94/95	95/96	96/97
0	546	1081	3	59	941
1	77386	48764	90443	114194	33373
2	259453	85149	140721	154476	153885
3	279931	129163	64185	90254	133296
4	70900	110448	75289	59067	100942
5	43701	32380	88968	48155	65170
6	52411	34361	42433	85887	49648
7	46267	34026	15378	10216	65256
8	18954	42321	20874	18488	31835
9	18360	18569	32298	24794	27903
10	12191	17947	13322	19049	6759
11+	62402	45917	23653	18985	30655
sum	942501	600127	607567	643625	699663

Table 1. Number of king mackerel caught in the mixing area and number caught outside the mixing area and assigned to the Atlantic group and the Gulf of Mexico group (cont.).

Gulf of Mexico Group Catch (no mixing area fish)

age	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92
0	43	9431	61	33	489	3571	1230	766	2292	6517	2216
1	380	7048	189	1265	7358	66716	50778	30058	176419	58381	203774
2	4329	159858	107410	3853	33178	167990	112448	105530	148181	161481	257304
3	43125	89753	144717	166613	24251	55896	43922	65386	81335	119201	127469
4	210747	216219	123278	201255	148419	84596	22828	114025	61939	50854	93770
5	132014	174323	37869	68777	104485	22488	20674	30004	30858	38547	26645
6	38601	90752	54189	41126	64685	29323	13769	50927	11000	26921	21064
7	19291	58019	19479	16079	16217	17176	5769	25747	18865	12002	9721
8	11725	35166	11081	11441	8567	9800	3640	8645	11458	11107	4452
9	5911	72923	5305	1911	5449	6146	1825	8647	5039	14487	12750
10	2818	19069	1228	1293	4144	1273	1595	7524	4393	2703	4534
11+	10514	19180	4398	3326	7674	11393	4445	21462	11198	10375	9764
sum	479497	951741	509203	516972	424916	476368	282922	468722	562977	512577	773465

age	92/93	93/94	94/95	95/96	96/97
0	2236	5768	2748	1076	1649
1	77347	144386	160711	91792	55670
2	219291	176328	120813	222637	278575
3	264165	168094	110214	155959	167504
4	81798	138381	169471	65050	97089
5	63496	63985	184867	64790	61187
6	40082	23016	78549	51925	26797
7	21096	22691	12400	33821	27437
8	18025	18245	41243	12544	32928
9	4935	12324	27603	5974	8285
10	7395	2150	10471	6225	1939
11+	22231	26181	19732	12035	13363
sum	822096	801551	938822	723827	772422

Table 2a. Atlantic king mackerel tuned virtual population analysis results (Vaughan and Nance low bycatch).

STOCK AT AGE AT BEGINNING OF YEAR

age	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92
0	1361121	1384770	1733198	2186342	2586446	2124006	6679362	7947624	4316374	7661050	3980609
1	1656056	1098335	1116646	1415699	1808059	2152478	1754161	5670480	6766275	3641546	6520236
2	2132555	1418968	925892	933805	1209635	1473084	1732963	1313871	4854020	5718867	2990762
3	1482445	1819522	1194292	720834	788340	916263	1052653	1244415	913502	4043925	4736316
4	1960722	1203519	1504150	829771	586257	641128	640420	744401	877983	643833	3311230
5	1138472	1211793	868676	1190034	540687	405465	377110	444135	465370	654877	444192
6	833077	807278	781818	609025	844987	331833	275433	250609	292312	330338	487162
7	836824	614254	538388	591740	402418	589338	223537	197447	149215	205866	221664
8	313312	583785	372052	335853	358651	189998	418602	156667	108905	97161	150253
9	104394	217647	356857	189562	238943	123977	110709	338804	110825	76989	68331
10	282237	12595	161866	242963	101244	150081	90124	82400	246930	85228	41015
11+	357806	503891	330726	333790	368272	322522	328787	309018	243833	340865	298817

age	92/93	93/94	94/95	95/96	96/97
0	1487789	2947311	3415812	6674751	7141443
1	3353248	1207412	2463113	2867342	5671968
2	5512166	2803569	972104	2027786	2346126
3	2230267	4477888	2300669	689007	1557457
4	3923910	1612049	3713481	1885475	469487
5	2756018	3273166	1262790	3097031	1560164
6	284030	2306032	2774225	964183	2584162
7	329814	190046	1946113	2330971	737083
8	144900	233953	126897	1658316	1978714
9	99719	93518	155612	83832	1408625
10	46720	59117	60155	97385	46777
11+	220897	144386	110825	107216	136684

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Table 2a. Atlantic king mackerel tuned virtual population analysis results (Vaughan and Nance low bycatch) (cont.).

F AT AGE DURING YEAR

age	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92
0	0.0645	0.0652	0.0523	0.0400	0.0337	0.0413	0.0137	0.0109	0.0200	0.0112	0.0215
1	0.0045	0.0208	0.0288	0.0073	0.0549	0.0668	0.1390	0.0055	0.0182	0.0469	0.0180
2	0.0087	0.0224	0.1003	0.0193	0.1278	0.1860	0.1812	0.2134	0.0326	0.0385	0.1434
3	0.0584	0.0403	0.2142	0.0567	0.0567	0.2082	0.1965	0.1988	0.1998	0.0499	0.0382
4	0.3312	0.1760	0.0842	0.2783	0.2187	0.3807	0.2160	0.3197	0.1432	0.2212	0.0335
5	0.1938	0.2882	0.2051	0.1924	0.3382	0.2367	0.2586	0.2683	0.1927	0.1458	0.2972
6	0.1547	0.2551	0.1286	0.2644	0.2103	0.2451	0.1829	0.3685	0.2006	0.2490	0.2401
7	0.2101	0.3514	0.3219	0.3507	0.6005	0.1921	0.2055	0.4450	0.2790	0.1649	0.2751
8	0.2143	0.3422	0.5243	0.1904	0.9123	0.3901	0.0615	0.1962	0.1968	0.2020	0.2600
9	1.9648	0.1461	0.2344	0.4772	0.3150	0.1689	0.1453	0.1663	0.1126	0.4797	0.2302
10	0.0892	0.2958	0.2392	0.2986	0.2255	0.2128	0.1543	0.3233	0.2145	0.2048	0.2808
11+	0.0892	0.2958	0.2392	0.2986	0.2255	0.2128	0.1543	0.3233	0.2145	0.2048	0.2808

age	92/93	93/94	94/95	95/96	96/97
0	0.0588	0.0295	0.0250	0.0128	0.0120
1	0.0290	0.0668	0.0445	0.0506	0.0071
2	0.0578	0.0477	0.1942	0.1139	0.1335
3	0.1746	0.0372	0.0490	0.2336	0.1454
4	0.0313	0.0942	0.0315	0.0394	0.3478
5	0.0283	0.0154	0.1198	0.0310	0.0707
6	0.2518	0.0197	0.0241	0.1186	0.0223
7	0.1934	0.2539	0.0100	0.0138	0.1066
8	0.2879	0.2578	0.2646	0.0132	0.0230
9	0.3728	0.2912	0.3187	0.4334	0.0235
10	0.4671	0.4577	0.3167	0.2534	0.1732
11+	0.4671	0.4577	0.3167	0.2534	0.3014

Table 2a. Atlantic king mackerel tuned virtual population analysis results (Vaughan and Nance low bycatch) (cont.).

INDEX RESULTS

Fit results for index = NC Com
Index Fitted to Mid-Year Stock Size in BIOMASS

	Scaled	Obj.Function	Predicted	Residual	Scaled resid
81/82	0.8627	0.8627	0.6523	0.2104	0.8283
82/83	0.9199	0.9199	1.0566	-0.1367	-0.5381
83/84	0.5814	0.5814	0.8463	-0.2650	-1.0432
84/85	0.7254	0.7254	0.9796	-0.2542	-1.0008
85/86	0.9258	0.9256	0.8159	0.1099	0.4329
86/87	1.2100	1.2100	1.3262	-0.1162	-0.4575
87/88	1.3804	1.3804	1.5038	-0.1234	-0.4860
88/89	1.0693	1.0693	0.6206	0.4487	1.7664
89/90	0.9892	0.9892	0.7830	0.2062	0.8119
90/91	1.0836	1.0836	0.4840	0.5995	2.3605
91/92	1.1177	1.1177	1.1986	-0.0809	-0.3185
92/93	1.3648	1.3648	1.1351	0.2297	0.9042
93/94	1.1556	1.1556	1.2104	-0.0548	-0.2159
94/95	0.8949	0.8949	0.5950	0.2999	1.1809
95/96	0.7622	0.7622	0.8998	-0.1377	-0.5420
96/97	0.9572	0.9572	1.0955	-0.1383	-0.5446

ML estimate of catchability: 0.80642E-07
Index ML estimate of the variance: 0.0645 (S.E.: 0.2540)
Pearsons (parametric) correlation: 0.514 P= 0.0013
Kendalls (nonparametric) Tau: 0.350 P= 0.0053

Selectivity at age from Partial Catches

year	2	3	4	5	6	7	8	9	10	11
81/82	0.007	0.031	0.137	0.108	0.451	0.061	0.027	1.000	0.069	0.192
82/83	0.013	0.039	0.135	0.181	0.064	0.538	0.090	0.001	0.193	1.000
83/84	0.024	0.018	0.057	0.112	0.274	0.571	0.112	0.452	1.000	0.135
84/85	0.025	0.051	0.027	0.036	0.571	0.315	0.330	1.000	0.294	0.770
85/86	0.031	0.119	0.065	0.132	0.137	0.667	0.689	0.581	1.000	0.271
86/87	0.234	0.248	0.491	0.335	0.279	0.711	0.301	0.947	1.000	0.772
87/88	0.262	0.551	0.708	0.827	0.697	1.000	0.239	0.904	0.720	0.660
88/89	0.083	0.077	0.108	0.589	0.550	1.000	0.258	0.088	0.345	0.237
89/90	0.048	0.346	0.231	0.496	0.581	1.000	0.211	0.116	0.235	0.231
90/91	0.038	0.033	0.211	0.184	0.270	0.206	0.273	1.000	0.301	0.096
91/92	0.308	0.069	0.065	1.000	0.506	0.550	0.712	0.492	0.192	0.274
92/93	0.103	0.339	0.081	0.052	1.000	0.242	0.196	0.746	0.356	0.427
93/94	0.114	0.137	0.262	0.029	0.060	0.724	0.878	0.719	0.789	1.000
94/95	0.159	0.031	0.028	0.136	0.044	0.019	0.498	1.000	0.337	0.439
95/96	0.130	0.359	0.089	0.072	0.316	0.020	0.066	1.000	0.584	0.404
96/97	0.056	0.229	1.000	0.170	0.065	0.272	0.032	0.116	0.385	0.336

Table 2a. Atlantic king mackerel tuned virtual population analysis results (Vaughan and Nance low bycatch) (cont.).

Fit results for index = FDEP
Index Fitted to Beginning Stock Size in BIOMASS

	Scaled	Obj.Function	Predicted	Residual	Scaled resid
85/86	0.9664	0.9664	0.7363	0.2301	0.9474
86/87	1.0285	1.0285	0.6510	0.3775	1.5544
87/88	1.1379	1.1379	1.0753	0.0626	0.2576
88/89	1.3583	1.3583	1.1815	0.1768	0.7279
89/90	1.1854	1.1854	1.0141	0.1713	0.7054
90/91	0.9808	0.9808	0.8516	0.1292	0.5319
91/92	0.8687	0.8687	1.2849	-0.4163	-1.7136
92/93	0.8996	0.8996	1.2708	-0.3712	-1.5283
93/94	0.8990	0.8990	0.8249	0.0741	0.3051
94/95	0.8557	0.8557	0.9224	-0.0667	-0.2746
95/96	0.8539	0.8539	0.5462	0.3076	1.2665
96/97	0.9659	0.9659	1.0908	-0.1249	-0.5141

ML estimate of catchability: 0.42533E-07
Index ML estimate of the variance: 0.0590 (S.E.: 0.2429)
Pearsons (parametric) correlation: 0.262 P= 0.1472
Kendalls (nonparametric) Tau: 0.091 P= 0.3964

Selectivity at age from Partial Catches

year	2	3	4	5	6	7	8	9	10	11
85/86	0.005	0.094	0.522	0.839	0.361	0.280	1.000	0.185	0.494	0.203
86/87	0.142	0.285	1.000	0.621	0.421	0.282	0.511	0.096	0.239	0.292
87/88	0.632	0.807	0.861	1.000	0.635	0.861	0.226	0.442	0.541	0.562
88/89	0.645	0.644	0.702	0.814	0.583	1.000	0.727	0.632	0.819	0.932
89/90	0.096	0.728	0.566	0.636	0.702	0.673	0.923	0.523	0.989	1.000
90/91	0.075	0.181	0.859	0.316	0.826	0.484	0.512	1.000	0.438	0.527
91/92	0.395	0.185	0.178	0.940	1.000	0.978	0.912	0.621	0.628	0.709
92/93	0.186	0.575	0.196	0.180	0.592	0.450	0.654	0.786	1.000	0.890
93/94	0.236	0.154	0.343	0.057	0.059	0.591	0.575	0.775	1.000	0.680
94/95	0.689	0.297	0.162	0.407	0.077	0.038	0.605	0.608	1.000	0.504
95/96	0.224	0.500	0.085	0.081	0.300	0.014	0.022	1.000	0.437	0.346
96/97	0.832	0.734	1.000	0.221	0.046	0.210	0.032	0.031	0.312	0.420

Table 2a. Atlantic king mackerel tuned virtual population analysis results (Vaughan and Nance low bycatch) (cont.).

Fit results for index = MRFSS
Index Fitted to Mid-Year Stock Size in NUMBERS

	Scaled	Obj.Function	Predicted	Residual	Scaled resid
81/82	1.0028	1.0028	0.1402	0.8627	2.3424
82/83	1.3502	1.3502	1.0512	0.2990	0.8117
83/84	0.8722	0.8722	0.6906	0.1815	0.4929
84/85	1.1059	1.1059	1.0784	0.0276	0.0749
85/86	0.7577	0.7577	0.4478	0.3099	0.8413
86/87	1.0191	1.0191	1.1773	-0.1582	-0.4294
87/88	1.1574	1.1574	1.3595	-0.2020	-0.5486
88/89	0.8103	0.8103	1.0224	-0.2121	-0.5759
89/90	0.7020	0.7020	1.3298	-0.6278	-1.7045
90/91	0.7831	0.7831	0.9399	-0.1568	-0.4256
91/92	1.5500	1.5500	1.3996	0.1503	0.4082
92/93	1.5427	1.5427	0.7917	0.7511	2.0392
93/94	0.7417	0.7417	0.4592	0.2825	0.7671
94/95	0.7572	0.7572	0.7139	0.0433	0.1176
95/96	0.8544	0.8544	0.7965	0.0579	0.1572
96/97	0.9932	0.9932	1.0690	-0.0758	-0.2057

ML estimate of catchability: 0.39533E-06
Index ML estimate of the variance: 0.1356 (S.E.: 0.3683)
Pearsons (parametric) correlation: 0.347 P= 0.0335
Kendalls (nonparametric) Tau: 0.300 P= 0.0155

Selectivity at age from Partial Catches

year	2	3	4	5	6	7	8	9	10	11
81/82	0.004	0.024	0.056	0.060	0.020	0.092	0.079	1.000	0.056	0.035
82/83	0.093	0.141	0.192	0.529	0.597	1.000	0.855	0.335	0.004	0.619
83/84	0.199	0.312	0.130	0.428	0.198	0.501	1.000	0.133	0.215	0.347
84/85	0.074	0.190	0.728	0.541	0.779	1.000	0.358	0.847	0.994	0.870
85/86	0.196	0.032	0.172	0.288	0.196	0.703	1.000	0.351	0.068	0.209
86/87	0.786	0.823	1.000	0.529	0.557	0.408	0.914	0.269	0.384	0.436
87/88	1.000	0.808	0.793	0.974	0.632	0.511	0.204	0.349	0.424	0.462
88/89	0.587	0.523	1.000	0.527	0.727	0.700	0.361	0.340	0.549	0.711
89/90	0.208	1.000	0.723	0.773	0.792	0.738	0.906	0.546	0.979	0.942
90/91	0.136	0.159	0.522	0.413	0.601	0.402	0.528	1.000	0.515	0.688
91/92	0.590	0.144	0.075	0.797	0.702	0.954	0.831	0.810	0.934	1.000
92/93	0.116	0.328	0.045	0.044	0.380	0.386	0.702	0.779	1.000	0.949
93/94	0.082	0.058	0.157	0.026	0.029	0.441	0.499	0.572	0.780	1.000
94/95	0.572	0.107	0.073	0.340	0.063	0.019	0.699	0.743	0.840	1.000
95/96	0.368	0.717	0.104	0.080	0.263	0.052	0.024	1.000	0.644	0.661
96/97	0.405	0.414	1.000	0.220	0.063	0.313	0.066	0.036	0.558	0.873

Table 2a. Atlantic king mackerel tuned virtual population analysis results (Vaughan and Nance low bycatch) (cont.).

Fit results for index = Headboat

Index Fitted to Mid-Year Stock Size in NUMBERS

	Scaled	Obj.Function	Predicted	Residual	Scaled resid
81/82	1.0468	1.0468	0.5395	0.5073	1.7072
82/83	0.9987	0.9987	0.9555	0.0432	0.1454
83/84	0.9571	0.9571	0.5888	0.3683	1.2396
84/85	1.0713	1.0713	0.9615	0.1098	0.3696
85/86	0.9027	0.9027	0.3385	0.5642	1.8987
86/87	0.8872	0.8872	0.9597	-0.0725	-0.2440
87/88	0.8629	0.8629	1.0006	-0.1377	-0.4633
88/89	0.8932	0.8932	1.2937	-0.4005	-1.3479
89/90	0.9704	0.9704	1.3217	-0.3514	-1.1825
90/91	0.9475	0.9475	0.7245	0.2230	0.7505
91/92	1.2101	1.2101	1.4121	-0.2021	-0.6801
92/93	0.9746	0.9746	1.0024	-0.0278	-0.0934
93/94	0.9295	0.9295	0.4207	0.5088	1.7124
94/95	1.0036	1.0036	0.9272	0.0764	0.2573
95/96	0.9448	0.9448	0.8890	0.0557	0.1875
96/97	1.3997	1.3997	1.2577	0.1420	0.4780

ML estimate of catchability: 0.42754E-06
Index ML estimate of the variance: 0.0883 (S.E.: 0.2971)
Pearsons (parametric) correlation: 0.414 P= 0.0112
Kendalls (nonparametric) Tau: 0.183 P= 0.1140

Selectivity at age from Partial Catches

year	2	3	4	5	6	7	8	9	10	11
81/82	0.011	0.065	0.282	0.176	0.168	0.210	0.712	1.000	0.005	0.141
82/83	0.095	0.118	0.050	0.475	0.499	0.827	1.000	0.394	0.002	0.325
83/84	0.169	0.337	0.120	0.204	0.253	0.008	1.000	0.167	0.007	0.339
84/85	0.031	0.079	0.866	0.630	0.802	0.494	0.002	0.118	1.000	0.404
85/86	0.086	0.029	0.110	0.210	0.332	0.205	1.000	0.050	0.003	0.042
86/87	0.329	0.761	1.000	0.533	0.523	0.337	0.747	0.157	0.275	0.360
87/88	0.435	0.667	0.665	1.000	0.587	0.366	0.194	0.314	0.355	0.361
88/89	0.732	0.804	0.681	0.385	0.814	1.000	0.578	0.575	0.847	0.905
89/90	0.149	1.000	0.749	0.783	0.793	0.682	0.861	0.536	0.973	0.840
90/91	0.085	0.069	0.441	0.388	0.555	0.378	0.496	1.000	0.511	0.671
91/92	0.555	0.119	0.069	0.886	0.708	1.000	0.880	0.751	0.753	0.753
92/93	0.151	0.401	0.045	0.046	0.485	0.468	0.504	0.618	0.986	1.000
93/94	0.080	0.048	0.123	0.018	0.022	0.345	0.421	0.457	0.672	1.000
94/95	0.875	0.142	0.090	0.329	0.061	0.021	0.636	0.706	0.979	1.000
95/96	0.471	0.729	0.118	0.049	0.277	0.017	0.024	1.000	0.692	0.639
96/97	0.462	0.490	1.000	0.190	0.074	0.358	0.057	0.040	0.701	0.996

Table 2a. Atlantic king mackerel tuned virtual population analysis results (Vaughan and Nance low bycatch) (cont.).

Fit results for index = Res Surv
Index Fitted to Mid-Year Stock Size in NUMBERS

	Scaled	Obj.Function	Predicted	Residual	Scaled resid
86/87	0.1935	0.1935	0.4202	-0.2267	-1.7976
87/88	1.3390	1.3390	1.3393	-0.0003	-0.0024
88/89	1.5953	1.5953	1.5958	-0.0005	-0.0040
89/90	0.8578	0.8578	0.8629	-0.0051	-0.0402
90/91	1.5378	1.5378	1.5381	-0.0003	-0.0021
91/92	0.7951	0.7951	0.7952	-0.0001	-0.0010
92/93	0.6434	0.6434	0.2919	0.3515	2.7569
93/94	0.5858	0.5858	0.5865	-0.0007	-0.0053
94/95	0.6800	0.6800	0.6812	-0.0012	-0.0096
95/96	1.3390	1.3390	1.3390	0.0000	0.0000
96/97	1.4332	1.4332	1.4332	0.0000	0.0000

ML estimate of catchability: 0.21738E-06
Index ML estimate of the variance: 0.0159 (S.E.: 0.1261)
Pearsons (parametric) correlation: 0.961 P= 0.0000
Kendalls (nonparametric) Tau: 0.917 P= 0.0000

Selectivities set to 1.0

year	0
86/87	1.000
87/88	1.000
88/89	1.000
89/90	1.000
90/91	1.000
91/92	1.000
92/93	1.000
93/94	1.000
94/95	1.000
95/96	1.000
96/97	1.000

Table 2a. Atlantic king mackerel tuned virtual population analysis results (Vaughan and Nance low bycatch) (cont.).

```
Run name: Atl King low bycatch w/ mixing area fish
No. index values:  71  Parameters: 12
Mean Squared Error (rss/df) =  0.93188E-01
Rsquared = -0.1978
Loglikelihood = -0.36613E+01

Program termination OK

Parameter      Estimate     S.E.        % C.V.
F age   0      0.0120      0.00316      26.25
F age   1      0.0071      0.00190      26.75
F age   2      0.1335      0.04680      35.06
F age   3      0.1454      0.06066      41.73
F age   4      0.3478      0.05085      14.62
F age   5      0.0707      0.02557      36.20
F age   6      0.0223      0.00703      31.55
F age   7      0.1066      0.06488      60.86
F age   8      0.0230      0.00728      31.64
F age   9      0.0235      0.00769      32.70
F age  10      0.1732      0.04245      24.52
F age  11      0.3014      0.09894      32.82
```

Table 2b. Atlantic king mackerel tuned virtual population analysis results (Vaughan and Nance high bycatch).

STOCK AT AGE AT BEGINNING OF YEAR

age	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92
0	1510275	1533903	1882347	2335488	2735382	2273378	6980152	8291805	4536072	7995472	4189368
1	1655994	1098298	1116591	1415588	1807882	2152085	1754186	5800670	6933798	3701978	6679360
2	2132431	1418915	925861	933757	1209540	1472931	1732625	1313893	4966075	5863055	3042775

age	92/93	93/94	94/95	95/96	96/97
0	1635739	3120903	3605265	6975507	7458157
1	3404275	1206310	2483916	2901772	5802126
2	5649125	2847488	971155	2045691	2375759

F AT AGE DURING YEAR

age	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92
0	0.1685	0.1675	0.1350	0.1061	0.0898	0.1093	0.0351	0.0289	0.0532	0.0299	0.0575
1	0.0045	0.0208	0.0288	0.0073	0.0549	0.0668	0.1390	0.0053	0.0177	0.0461	0.0175
2	0.0087	0.0224	0.1004	0.0193	0.1278	0.1861	0.1812	0.2134	0.0318	0.0375	0.1408

age	92/93	93/94	94/95	95/96	96/97
0	0.1545	0.0783	0.0671	0.0342	0.0320
1	0.0286	0.0668	0.0441	0.0500	0.0070
2	0.0564	0.0469	0.1944	0.1128	0.1317

Table 2b. Atlantic king mackerel tuned virtual population analysis results (Vaughan and Nance high bycatch) (cont.).

```
Run name: Atl King high bycatch w/ mixing area fish
No. index values:  71  Parameters: 12
Mean Squared Error (rss/df) =  0.93120E-01
Rsquared = -0.1969
Loglikelihood = -0.35577E+01

Program termination OK
```

Parameter	Estimate	S.E.	% C.V.
F age 0	0.0320	0.00828	25.86
F age 1	0.0070	0.00185	26.62
F age 2	0.1317	0.04618	35.06
F age 3	0.1438	0.06059	42.13
F age 4	0.3484	0.05090	14.61
F age 5	0.0694	0.02515	36.26
F age 6	0.0217	0.00676	31.22
F age 7	0.1030	0.06177	59.98
F age 8	0.0223	0.00697	31.22
F age 9	0.0229	0.00740	32.38
F age 10	0.1731	0.04262	24.62
F age 11	0.3019	0.09906	32.81

Table 2c. Atlantic king mackerel tuned virtual population analysis results (Harris bycatch).

STOCK AT AGE AT BEGINNING OF YEAR

age	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92
0	2900336	2923984	3274401	3729310	4129187	3668517	9661483	1134693	6523799	10966544	6084589
1	1655647	1098093	1116282	1414966	1806883	2149873	1754537	6901280	8355613	4207333	8028924
2	2131735	1418616	925684	933491	1209005	1472072	1730721	1314194	5913379	7086818	3477728

age	92/93	93/94	94/95	95/96	96/97
0	3019789	4721567	5338104	9656651	10276506
1	3830418	1200148	2658425	3189039	6902555
2	6810701	3214269	965852	2195888	2623005

F AT AGE DURING YEAR

age	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92
0	0.8213	0.8129	0.6890	0.5746	0.5027	0.5876	0.1864	0.1560	0.2886	0.1618	0.3128
1	0.0045	0.0208	0.0288	0.0073	0.0549	0.0669	0.1390	0.0045	0.0147	0.0404	0.0146
2	0.0088	0.0224	0.1004	0.0193	0.1278	0.1862	0.1814	0.2134	0.0267	0.0310	0.1221

age	92/93	93/94	94/95	95/96	96/97
0	0.7727	0.4244	0.3652	0.1858	0.1736
1	0.0254	0.0672	0.0411	0.0454	0.0058
2	0.0465	0.0415	0.1956	0.1047	0.1186

Table 2c. Atlantic king mackerel tuned virtual population analysis results (Harris bycatch) (cont.)

```
Run name: Atl King Harris bycatch w/ mixing area fish
No. index values:  71  Parameters: 12
Mean Squared Error (rss/df) =  0.92732E-01
Rsquared = -0.1919
Loglikelihood = -0.29433E+01

Program termination OK
```

Parameter		Estimate	S.E.	% C.V.
F age	0	0.1736	0.04145	23.88
F age	1	0.0058	0.00155	26.52
F age	2	0.1186	0.04449	37.53
F age	3	0.1322	0.06072	45.94
F age	4	0.3520	0.05144	14.61
F age	5	0.0602	0.02254	37.44
F age	6	0.0174	0.00520	29.82
F age	7	0.0802	0.04455	55.51
F age	8	0.0179	0.00532	29.70
F age	9	0.0186	0.00579	31.19
F age	10	0.1728	0.04219	24.42
F age	11	0.3046	0.10033	32.94

Table 3a. Probability of exceeding given spawning potential ratio under various yields (million pounds) in the 1998/99 fishing season for Atlantic king mackerel using Vaughan and Nance low bycatch.

	% Spawning Potential Ratio								
Yield	50	45	40	35	30	25	20	15	10
5	4.50	2.29	0.95	0.34	0.21	0.17	0.14	0.11	0.08
6	13.28	4.76	2.17	0.95	0.30	0.21	0.17	0.13	0.10
7	27.15	11.83	4.24	1.81	0.87	0.24	0.19	0.15	0.11
8	40.69	20.99	8.88	3.67	1.35	0.48	0.22	0.17	0.13
9	52.94	33.18	15.19	5.35	2.68	0.93	0.25	0.19	0.15
10	63.50	43.98	24.17	10.67	3.75	1.42	0.47	0.21	0.16
11	70.41	53.93	34.66	15.75	5.52	2.56	0.85	0.24	0.18
12	76.26	62.18	42.76	21.71	9.34	3.42	1.08	0.31	0.19
13	78.26	68.44	51.53	30.34	12.59	4.83	1.89	0.49	0.21
14	79.94	74.30	58.30	37.53	18.51	6.86	2.83	0.81	0.23
15	82.67	76.62	63.59	44.44	22.96	9.18	3.35	0.98	0.24
16	85.71	78.45	69.29	51.68	29.44	12.30	4.55	1.52	0.32
17	86.70	79.82	73.85	57.20	34.97	15.44	5.37	2.00	0.44
18	87.89	81.84	75.92	62.31	40.49	19.49	7.15	2.81	0.64
19	89.19	83.91	77.10	64.89	45.85	22.79	8.37	3.32	0.89
20	90.47	86.03	78.48	69.87	51.70	26.80	11.50	3.90	1.12
21	91.38	86.80	79.96	72.55	55.28	31.69	13.18	4.46	1.35
22	92.33	88.02	81.27	75.25	58.68	36.66	15.70	5.41	1.72
23	93.37	89.04	83.04	76.18	62.40	40.81	18.46	7.07	2.16
24	94.41	90.34	84.76	77.23	65.37	44.51	21.23	7.61	2.90
25	95.29	90.99	86.04	78.14	69.25	48.49	24.38	8.76	3.22

Table 3b. Probability of exceeding given spawning potential ratio under various yields (million pounds) in the 1998/99 fishing season for Atlantic king mackerel using Vaughan and Nance high bycatch.

	% Spawning Potential Ratio								
Yield	50	45	40	35	30	25	20	15	10
5	5.47	2.55	0.62	0.31	0.21	0.18	0.14	0.11	0.08
6	11.94	5.49	2.77	0.62	0.30	0.21	0.17	0.13	0.10
7	23.84	10.77	4.31	1.65	0.57	0.25	0.20	0.16	0.12
8	38.10	20.48	8.50	3.49	0.92	0.46	0.23	0.18	0.13
9	51.25	30.29	13.15	6.46	2.91	0.64	0.28	0.20	0.15
10	61.21	42.33	21.75	9.47	3.48	1.31	0.45	0.22	0.17
11	67.54	53.03	30.86	14.00	6.58	2.82	0.63	0.24	0.18
12	71.43	60.47	39.88	20.56	9.04	3.47	0.94	0.34	0.20
13	75.38	64.97	48.92	28.44	11.35	5.13	1.49	0.46	0.22
14	79.71	70.62	55.63	35.58	15.73	6.49	3.01	0.65	0.23
15	82.61	72.87	62.37	41.97	21.76	8.73	3.53	0.88	0.25
16	85.32	76.37	64.89	49.29	27.30	11.25	4.42	1.18	0.34
17	87.29	79.57	69.46	53.61	32.94	13.78	5.62	1.51	0.43
18	88.31	82.02	71.94	60.19	38.29	17.22	6.65	2.67	0.56
19	89.07	83.80	74.66	63.51	43.43	21.99	8.06	3.40	0.77
20	90.69	85.46	77.18	64.52	47.72	26.32	10.85	4.03	0.92
21	91.50	87.34	78.71	68.61	51.68	30.42	12.31	4.74	1.09
22	91.88	88.23	81.16	70.96	54.74	35.02	14.06	5.59	1.28
23	93.21	88.82	82.39	72.93	60.70	37.50	16.77	6.16	1.81
24	94.56	89.97	84.54	75.23	62.66	42.70	20.48	7.14	2.66
25	94.81	91.04	85.75	77.28	64.13	45.15	23.00	8.43	3.29

Table 3c. Probability of exceeding given spawning potential ratio under various yields (million pounds) in the 1998/99 fishing season for Atlantic king mackerel using Harris bycatch.

	% Spawning Potential Ratio								
Yield	50	45	40	35	30	25	20	15	10
5	2.28	1.03	0.22	0.18	0.15	0.12	0.10	0.08	0.06
6	5.63	2.34	1.02	0.22	0.18	0.15	0.12	0.09	0.07
7	10.59	4.87	1.83	0.77	0.21	0.17	0.14	0.11	0.08
8	20.59	9.09	3.47	1.39	0.24	0.20	0.16	0.12	0.09
9	29.81	15.04	6.56	2.60	1.04	0.22	0.18	0.14	0.10
10	38.79	22.73	10.25	4.32	1.54	0.24	0.20	0.15	0.11
11	49.18	31.21	16.37	6.65	2.59	0.95	0.22	0.17	0.13
12	58.39	37.96	21.70	9.84	3.82	1.31	0.23	0.18	0.14
13	63.74	46.65	29.58	13.49	5.75	2.06	0.76	0.20	0.15
14	68.14	54.17	34.49	19.12	8.02	2.89	0.94	0.21	0.16
15	72.02	60.88	41.14	23.18	10.77	3.71	1.20	0.23	0.17
16	76.20	64.26	46.84	28.87	13.61	5.33	1.67	0.24	0.18
17	78.60	67.70	53.57	33.07	17.19	6.71	2.57	0.77	0.19
18	81.09	70.94	58.46	38.50	20.99	8.87	2.99	0.90	0.21
19	82.98	74.95	63.36	44.10	24.57	10.70	3.78	1.06	0.22
20	85.18	77.47	65.51	47.27	28.51	13.61	4.77	1.50	0.23
21	86.81	79.26	67.51	51.28	31.18	15.69	5.91	1.78	0.24
22	87.56	81.46	70.74	57.26	36.41	17.96	7.12	2.54	0.32
23	88.42	82.50	74.26	61.23	39.69	21.04	8.55	2.86	0.79
24	89.29	84.39	76.26	63.17	44.37	24.14	10.39	3.17	0.88
25	90.13	85.74	78.27	64.51	45.89	26.66	12.47	3.84	0.97

Table 4. Gulf of Mexico king mackerel tuned virtual population analysis results.

STOCK AT AGE AT BEGINNING OF YEAR

age	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92
0	2101863	1483316	910512	1952190	1893027	1798354	3011539	2525502	4294529	3142749	3498872
1	1487943	1385989	874446	439161	1130351	1151235	1131884	1694285	1484867	2335056	1778039
2	971752	1217881	1128385	715765	358412	918807	882352	880877	1360020	1056713	1859069
3	752555	791693	853087	826995	582539	263525	601070	621085	626097	979918	719738
4	777712	577226	567287	568169	527204	455053	165485	452494	449558	439321	694868
5	380247	447474	278970	353598	284848	298385	296437	114923	268020	312268	313852
6	299260	193008	210327	194286	227621	139626	224012	224052	67139	191625	220927
7	161039	210233	77006	123520	122080	128289	87943	170982	137653	45065	132639
8	158638	114462	120027	45546	86642	85340	89560	66797	116800	95706	26116
9	119906	119305	62162	88277	27010	63213	61038	70040	46899	85297	68347
10	27213	92836	32958	46110	70549	17213	46213	48325	49552	33856	56793
11+	101520	93378	118055	118561	130651	154065	128806	137840	126317	129929	122299

age	92/93	93/94	94/95	95/96	96/97
0	3320311	4526405	4108029	5108994	2603516
1	1874150	2188978	2752403	2472061	3188235
2	1272072	1464609	1661919	2108463	1941091
3	1290284	844083	1040214	1251682	1525562
4	474539	818775	539854	752301	884253
5	484430	314887	545779	289972	557268
6	232930	339408	200250	281127	179156
7	161886	154626	257120	93649	183438
8	99826	113533	106160	199321	46374
9	17374	65507	76525	49999	151872
10	44484	9794	42543	37925	35552
11+	133733	119240	80169	73326	74645

Table 4. Gulf of Mexico king mackerel tuned virtual population analysis results (cont.).

F AT AGE DURING YEAR

age	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92
0	0.2164	0.3284	0.5291	0.3464	0.2973	0.2630	0.3752	0.3311	0.4093	0.3696	0.4243
1	0.0003	0.0056	0.0002	0.0032	0.0072	0.0660	0.0507	0.0198	0.1402	0.0280	0.1349
2	0.0049	0.1560	0.1107	0.0060	0.1075	0.2244	0.1511	0.1414	0.1278	0.1840	0.1652
3	0.0652	0.1333	0.2064	0.2502	0.0470	0.2653	0.0839	0.1232	0.1543	0.1437	0.2165
4	0.3527	0.5271	0.2727	0.4905	0.3692	0.2286	0.1646	0.3237	0.1644	0.1363	0.1607
5	0.4781	0.5550	0.1618	0.2405	0.5130	0.0867	0.0800	0.3375	0.1355	0.1460	0.0982
6	0.1531	0.7188	0.3323	0.2647	0.3734	0.2623	0.0701	0.2871	0.1987	0.1679	0.1109
7	0.1414	0.3605	0.3252	0.1546	0.1580	0.1594	0.0750	0.1811	0.1635	0.3455	0.0842
8	0.0849	0.4105	0.1072	0.3225	0.1153	0.1352	0.0458	0.1536	0.1143	0.1367	0.2076
9	0.0559	1.0865	0.0987	0.0242	0.2506	0.1132	0.0335	0.1461	0.1259	0.2067	0.2295
10	0.1211	0.2557	0.0419	0.0314	0.0669	0.0850	0.0388	0.1878	0.1027	0.0921	0.0921
11+	0.1211	0.2557	0.0419	0.0314	0.0669	0.0850	0.0388	0.1878	0.1027	0.0921	0.0921

age	92/93	93/94	94/95	95/96	96/97
0	0.2166	0.2975	0.3079	0.2715	0.3023
1	0.0466	0.0755	0.0665	0.0418	0.0194
2	0.2102	0.1422	0.0835	0.1236	0.1718
3	0.2548	0.2470	0.1240	0.1475	0.1288
4	0.2101	0.2056	0.4215	0.1001	0.1288
5	0.1558	0.2526	0.4634	0.2815	0.1288
6	0.2097	0.0777	0.5600	0.2269	0.1798
7	0.1548	0.1761	0.0546	0.5028	0.1798
8	0.2213	0.1945	0.5529	0.0719	1.4502
9	0.3732	0.2317	0.5020	0.1410	0.0620
10	0.2019	0.2759	0.3149	0.1991	0.0620
11+	0.2019	0.2759	0.3149	0.1991	0.2191

Table 4. Gulf of Mexico king mackerel tuned virtual population analysis results (cont.).

INDEX RESULTS

Fit results for index = FDEP NW
Index Fitted to Beginning Stock Size in BIOMASS

	Scaled	Obj.Function	Predicted	Residual	Scaled resid
85/86	0.5318	0.5318	0.7866	-0.2548	-1.7056
86/87	0.7917	0.7917	0.9049	-0.1132	-0.7577
87/88	0.7203	0.7203	0.3875	0.3328	2.2280
88/89	0.5593	0.5593	0.6539	-0.0946	-0.6333
89/90	0.6945	0.6945	0.6896	0.0049	0.0329
90/91	0.8529	0.8529	0.8192	0.0338	0.2262
91/92	1.1802	1.1802	1.0804	0.0998	0.6679
92/93	1.1410	1.1410	1.2801	-0.1391	-0.9312
93/94	1.1314	1.1314	1.2167	-0.0854	-0.5715
94/95	1.3186	1.3186	1.2651	0.0536	0.3586
95/96	1.0779	1.0779	1.0816	-0.0037	-0.0248
96/97	2.0004	2.0004	1.8282	0.1723	1.1535

ML estimate of catchability: 0.94959E-07
Index ML estimate of the variance: 0.0223 (S.E.: 0.1494)
Pearsons (parametric) correlation: 0.924 P= 0.0000
Kendalls (nonparametric) Tau: 0.697 P= 0.0000

Selectivity at age from Partial Catches

year	3	4	5	6
85/86	0.037	1.000	0.702	0.314
86/87	0.797	1.000	0.940	0.361
87/88	0.270	1.000	0.355	0.083
88/89	0.298	1.000	0.191	0.399
89/90	1.000	0.508	0.248	0.224
90/91	0.749	0.150	0.116	1.000
91/92	0.648	1.000	0.346	0.208
92/93	1.000	0.201	0.507	0.342
93/94	1.000	0.565	0.562	0.186
94/95	0.328	1.000	0.624	0.766
95/96	0.241	0.461	0.670	1.000
96/97	1.000	0.836	0.184	0.437

Fit results for index = FDEP SW
Index Fitted to Mid-Year Stock Size in BIOMASS

	Scaled	Obj.Function	Predicted	Residual	Scaled resid
85/86	0.4595	0.4595	0.3600	0.0996	0.3243
86/87	0.4548	0.4548	0.6956	-0.2408	-0.7844
87/88	0.6192	0.6192	0.5278	0.0914	0.2977
88/89	0.8817	0.8817	0.4913	0.3903	1.2713
89/90	0.8268	0.8268	1.1360	-0.3092	-1.0070
90/91	1.0753	1.0753	1.1270	-0.0517	-0.1683
91/92	1.0553	1.0553	1.1491	-0.0938	-0.3054
92/93	2.0982	2.0982	1.2889	0.8093	2.6358
93/94	1.2998	1.2998	1.4848	-0.1850	-0.6026
94/95	0.7294	0.7294	1.0552	-0.3258	-1.0611
95/96	1.1178	1.1178	1.1130	0.0048	0.0156
96/97	1.3822	1.3822	1.3974	-0.0151	-0.0493

Table 4. Gulf of Mexico king mackerel tuned virtual population analysis results (cont.).

```
ML estimate of catchability:  0.11357E-06
Index ML estimate of the variance:    0.0943  (S.E.:      0.3070)
Pearsons (parametric) correlation:  0.722 P= 0.0000
Kendalls (nonparametric) Tau:       0.576 P= 0.0002
```

Selectivity at age from Partial Catches

year	3	4	5	6	7	8
85/86	0.002	0.000	1.000	0.311	0.005	0.026
86/87	0.500	1.000	0.603	0.100	0.024	0.018
87/88	0.314	1.000	0.150	0.664	0.000	0.000
88/89	0.013	1.000	0.949	0.007	0.002	0.059
89/90	0.689	1.000	0.616	0.476	0.901	0.234
90/91	0.902	1.000	0.021	0.468	0.684	0.000
91/92	0.619	1.000	0.115	0.422	0.382	0.354
92/93	1.000	0.026	0.747	0.074	0.003	0.386
93/94	1.000	0.640	0.644	0.186	0.636	0.332
94/95	0.423	1.000	0.371	0.330	0.023	0.476
95/96	0.626	0.254	1.000	0.091	0.237	0.199
96/97	1.000	0.260	0.121	0.329	0.067	0.693

Fit results for index = MRFSS
Index Fitted to Beginning Stock Size in NUMBERS

	Scaled	Obj.Function	Predicted	Residual	Scaled resid
86/87	0.2148	0.2148	0.8491	-0.6343	-1.2224
87/88	0.8052	0.8052	0.7095	0.0957	0.1845
88/89	0.4756	0.4756	0.9209	-0.4453	-0.8583
89/90	0.8034	0.8034	0.9179	-0.1145	-0.2206
90/91	1.8332	1.8332	0.5513	1.2819	2.4707
91/92	2.2057	2.2057	1.5504	0.6553	1.2630
92/93	1.3793	1.3793	1.4975	-0.1182	-0.2278
93/94	0.7956	0.7956	1.2658	-0.4702	-0.9063
94/95	1.0140	1.0140	1.0353	-0.0213	-0.0410
95/96	0.4614	0.4614	0.2877	0.1736	0.3346
96/97	1.0119	1.0119	1.0046	0.0073	0.0141

```
ML estimate of catchability:  0.50866E-06
Index ML estimate of the variance:    0.2692  (S.E.:      0.5189)
Pearsons (parametric) correlation:  0.458 P= 0.0189
Kendalls (nonparametric) Tau:       0.382 P= 0.0147
```

Selectivity at age from Partial Catches

year	2	3	4	5	6	7	8
86/87	0.991	1.000	0.709	0.267	0.434	0.194	0.081
87/88	1.000	0.454	0.524	0.326	0.160	0.126	0.102
88/89	0.705	0.518	0.993	0.456	1.000	0.601	0.577
89/90	0.544	0.749	0.722	0.328	0.291	1.000	0.224
90/91	0.418	0.409	0.189	0.167	0.238	1.000	0.152
91/92	1.000	0.706	0.813	0.234	0.127	0.079	0.130
92/93	0.927	1.000	0.142	0.403	0.587	0.077	0.623
93/94	0.582	1.000	0.546	0.514	0.157	0.551	0.388
94/95	0.378	0.398	1.000	0.472	0.495	0.055	0.773
95/96	0.052	0.111	0.043	0.574	0.063	1.000	0.037
96/97	0.404	0.285	0.256	0.413	0.631	0.758	1.000

Table 4. Gulf of Mexico king mackerel tuned virtual population analysis results (cont.).

Fit results for index = TPWD
Index Fitted to Beginning Stock Size in NUMBERS

	Scaled	Obj.Function	Predicted	Residual	Scaled resid
81/82	1.0808	1.0808	0.7659	0.3149	0.6577
82/83	0.9143	0.9143	0.7385	0.1759	0.3673
83/84	1.1792	1.1792	0.3160	0.8632	1.8032
84/85	1.1177	1.1177	0.6041	0.5136	1.0729
85/86	1.0266	1.0266	0.3798	0.6468	1.3511
86/87	0.7471	0.7471	0.8777	-0.1305	-0.2727
87/88	0.9084	0.9084	0.4852	0.4232	0.8839
88/89	0.7760	0.7760	0.5261	0.2499	0.5221
89/90	0.9094	0.9094	0.4621	0.4473	0.9344
90/91	0.8760	0.8760	0.4826	0.3934	0.8218
91/92	1.1393	1.1393	0.5979	0.5414	1.1309
92/93	1.0356	1.0356	1.4004	-0.3648	-0.7620
93/94	1.0965	1.0965	1.4633	-0.3668	-0.7661
94/95	0.9890	0.9890	1.6461	-0.6571	-1.3726
95/96	1.1190	1.1190	1.3358	-0.2167	-0.4527
96/97	1.0848	1.0848	0.4091	0.6757	1.4115

ML estimate of catchability: 0.74526E-06
Index ML estimate of the variance: 0.2292 (S.E.: 0.4787)
Pearsons (parametric) correlation: 0.118 P= 0.3662
Kendalls (nonparametric) Tau: -0.050 P= 0.4967

Selectivity at age from Partial Catches

year	2	3	4	5	6	7	8
81/82	0.002	0.065	0.461	1.000	0.528	0.488	0.013
82/83	0.021	0.009	0.497	1.000	0.290	0.577	0.400
83/84	0.004	0.018	0.190	0.285	0.648	1.000	0.029
84/85	0.001	0.087	0.398	0.999	0.244	0.537	1.000
85/86	0.028	0.021	0.213	0.680	0.245	1.000	0.040
86/87	0.127	0.835	0.677	0.694	0.958	1.000	0.748
87/88	0.142	0.315	1.000	0.227	0.228	0.257	0.332
88/89	0.106	0.252	0.409	1.000	0.378	0.302	0.292
89/90	0.056	0.220	0.303	0.450	1.000	0.375	0.269
90/91	0.099	0.108	0.313	0.432	0.444	1.000	0.361
91/92	0.090	0.399	0.188	0.269	0.296	0.312	1.000
92/93	0.226	0.496	0.687	0.480	0.739	0.743	1.000
93/94	0.321	0.496	0.636	0.885	0.189	1.000	0.490
94/95	0.335	0.737	0.394	0.688	1.000	0.282	0.231
95/96	0.278	0.336	0.372	0.690	0.652	1.000	0.144
96/97	0.087	0.088	0.090	0.092	0.236	0.147	1.000

Table 4. Gulf of Mexico king mackerel tuned virtual population analysis results (cont.).

Fit results for index = Headboat
Index Fitted to Mid-Year Stock Size in NUMBERS

	Scaled	Obj.Function	Predicted	Residual	Scaled resid
81/82	1.0758	1.0758	0.5239	0.5519	1.7300
82/83	0.7533	0.7533	0.5362	0.2171	0.6804
83/84	1.2663	1.2663	0.8573	0.4090	1.2820
84/85	0.6375	0.6375	0.4971	0.1404	0.4402
85/86	0.7560	0.7560	0.4056	0.3505	1.0987
86/87	0.9245	0.9245	0.3740	0.5506	1.7259
87/88	0.7519	0.7519	0.6060	0.1459	0.4574
88/89	0.4943	0.4943	0.4014	0.0929	0.2911
89/90	1.1189	1.1189	1.3488	-0.2299	-0.7206
90/91	1.2202	1.2202	1.1264	0.0938	0.2939
91/92	1.0760	1.0760	1.1062	-0.0302	-0.0946
92/93	1.1366	1.1366	1.4124	-0.2758	-0.8645
93/94	1.0107	1.0107	1.2557	-0.2450	-0.7680
94/95	1.1293	1.1293	0.5512	0.5781	1.8123
95/96	1.0033	1.0033	1.2437	-0.2404	-0.7537
96/97	1.6451	1.6451	1.8526	-0.2074	-0.6502

ML estimate of catchability: 0.71972E-06
Index ML estimate of the variance: 0.1018 (S.E.: 0.3190)
Pearsons (parametric) correlation: 0.756 P= 0.0000
Kendalls (nonparametric) Tau: 0.500 P= 0.0001

Selectivity at age from Partial Catches

year	2	3	4	5	6
81/82	0.035	0.120	1.000	0.001	0.080
82/83	0.020	0.415	1.000	0.007	0.259
83/84	0.001	1.000	0.646	0.756	0.124
84/85	0.008	0.095	1.000	0.459	0.515
85/86	1.000	0.016	0.375	0.445	0.029
86/87	0.116	0.661	0.476	0.021	1.000
87/88	0.413	0.431	1.000	0.373	0.378
88/89	0.156	0.142	1.000	0.156	0.000
89/90	1.000	0.831	0.490	0.280	0.502
90/91	0.371	1.000	0.924	0.006	0.398
91/92	0.250	1.000	0.864	0.068	0.194
92/93	0.424	0.714	1.000	0.635	0.685
93/94	0.378	0.646	0.721	1.000	0.328
94/95	0.048	0.080	0.260	0.955	1.000
95/96	0.353	0.456	0.285	1.000	0.848
96/97	0.605	0.504	0.476	1.000	0.699

Table 4. Gulf of Mexico king mackerel tuned virtual population analysis results (cont.).

Fit results for index = Chart NWF
Index Fitted to Beginning Stock Size in NUMBERS

	Scaled	Obj.Function	Predicted	Residual	Scaled resid
88/89	0.9278	0.9278	0.6454	0.2824	1.3183
89/90	0.9164	0.9164	1.0402	-0.1238	-0.5777
90/91	0.9148	0.9148	0.8323	0.0825	0.3850
91/92	0.9883	0.9883	1.2929	-0.3046	-1.4216
92/93	1.0380	1.0380	0.9800	0.0580	0.2705
93/94	0.9670	0.9670	1.0557	-0.0887	-0.4142
94/95	1.2478	1.2478	0.9081	0.3397	1.5857

ML estimate of catchability: 0.43112E-06
Index ML estimate of the variance: 0.0459 (S.E.: 0.2142)
Pearsons (parametric) correlation: 0.054 P= 0.6020
Kendalls (nonparametric) Tau: 0.143 P= 0.3705

Selectivity at age from Partial Catches

year	2	3	4	5	6
88/89	0.568	0.482	1.000	0.492	0.843
89/90	0.901	1.000	0.886	0.464	0.569
90/91	1.000	0.578	0.358	0.291	0.308
91/92	1.000	0.704	0.764	0.230	0.136
92/93	1.000	0.575	0.307	0.129	0.218
93/94	0.653	1.000	0.542	0.466	0.167
94/95	0.449	0.413	1.000	0.501	0.586

Fit results for index = Chart SWF
Index Fitted to Mid-Year Stock Size in NUMBERS

	Scaled	Obj.Function	Predicted	Residual	Scaled resid
88/89	0.7913	0.7913	0.8342	-0.0429	-0.1093
89/90	1.0462	1.0462	0.9927	0.0535	0.1365
90/91	0.8940	0.8940	0.2942	0.5999	1.5293
91/92	0.7323	0.7323	0.7053	0.0270	0.0689
92/93	0.9435	0.9435	1.1257	-0.1822	-0.4645
93/94	1.0652	1.0652	1.4668	-0.4016	-1.0239
94/95	1.5274	1.5274	0.8082	0.7192	1.8336

ML estimate of catchability: 0.10697E-05
Index ML estimate of the variance: 0.1539 (S.E.: 0.3923)
Pearsons (parametric) correlation: 0.192 P= 0.3547
Kendalls (nonparametric) Tau: 0.333 P= 0.0969

. Selectivity at age from Partial Catches

year	3	4	5	6	7	8
88/89	0.407	0.790	1.000	0.519	0.516	0.552
89/90	1.000	0.608	0.295	0.453	0.373	0.364
90/91	0.112	0.156	0.169	0.259	1.000	0.032
91/92	0.579	0.229	0.152	0.488	0.259	1.000
92/93	0.478	0.456	0.358	0.391	0.565	1.000
93/94	0.615	0.717	1.000	0.338	0.278	0.861
94/95	0.074	0.247	0.917	1.000	0.066	0.923

Table 4. Gulf of Mexico king mackerel tuned virtual population analysis results (cont.).

Fit results for index = Bycatch Index

Index Fitted to Beginning Stock Size in NUMBERS

	Scaled	Obj.Function	Predicted	Residual	Scaled resid
81/82	0.6148	0.6148	0.7221	-0.1072	-0.6529
82/83	0.5980	0.5980	0.5096	0.0884	0.5363
83/84	0.5450	0.5450	0.3128	0.2322	1.4139
84/85	0.7723	0.7723	0.6706	0.1017	0.6191
85/86	0.6508	0.6508	0.6503	0.0005	0.0030
86/87	0.4723	0.4723	0.6178	-0.1455	-0.8860
87/88	0.9661	0.9661	1.0346	-0.0685	-0.4169
88/89	0.8357	0.8357	0.8676	-0.0319	-0.1941
89/90	1.7011	1.7011	1.4753	0.2258	1.3747
90/91	1.2110	1.2110	1.0796	0.1314	0.7998
91/92	1.4128	1.4128	1.2020	0.2108	1.2833
92/93	0.6929	0.6929	1.1406	-0.4478	-2.7261
93/94	1.4655	1.4655	1.5550	-0.0895	-0.5451
94/95	1.4122	1.4122	1.4113	0.0009	0.0055
95/96	1.7551	1.7551	1.7551	0.0000	0.0000
96/97	0.8944	0.8944	0.8944	0.0000	0.0000

ML estimate of catchability: 0.34354E-06
Index ML estimate of the variance: 0.0270 (S.E.: 0.1643)
Pearsons (parametric) correlation: 0.920 P= 0.0000
Kendalls (nonparametric) Tau: 0.817 P= 0.0000

Selectivities set to 1.0

year	0
81/82	1.000
82/83	1.000
83/84	1.000
84/85	1.000
85/86	1.000
86/87	1.000
87/88	1.000
88/89	1.000
89/90	1.000
90/91	1.000
91/92	1.000
92/93	1.000
93/94	1.000
94/95	1.000
95/96	1.000
96/97	1.000

Fit results for index = SEAMAP

Index Fitted to Beginning Stock Size in NUMBERS

	Scaled	Obj.Function	Predicted	Residual	Scaled resid
86/87	0.5928	0.5928	0.9100	-0.3172	-1.1438
87/88	0.6676	0.6676	0.8946	-0.2270	-0.8185
88/89	0.5928	0.5928	0.9629	-0.3701	-1.3345
89/90	1.1165	1.1165	0.9380	0.1785	0.6436
90/91	0.9381	0.9381	1.0004	-0.0622	-0.2244
91/92	0.9554	0.9554	1.0850	-0.1296	-0.4674
92/93	1.5137	1.5137	1.1886	0.3251	1.1722
93/94	1.6230	1.6230	1.2131	0.4099	1.4779

Table 4. Gulf of Mexico king mackerel tuned virtual population analysis results (cont.).

```
ML estimate of catchability:  0.40661E-06
Index ML estimate of the variance:    0.0769  (S.E.:       0.2774)
Pearsons (parametric) correlation:  0.881 P= 0.0000
Kendalls (nonparametric) Tau:       0.618 P= 0.0017
```

Selectivities input

year	1	2	3	4	5	6	7	8	9	10	11
86/87	0.015	0.121	0.308	0.612	1.037	1.425	1.829	2.247	2.667	3.079	3.853
87/88	0.015	0.121	0.308	0.612	1.037	1.425	1.829	2.247	2.667	3.079	3.853
88/89	0.015	0.121	0.308	0.612	1.037	1.425	1.829	2.247	2.667	3.079	3.853
89/90	0.015	0.121	0.308	0.612	1.037	1.425	1.829	2.247	2.667	3.079	3.853
90/91	0.015	0.121	0.308	0.612	1.037	1.425	1.829	2.247	2.667	3.079	3.853
91/92	0.015	0.121	0.308	0.612	1.037	1.425	1.829	2.247	2.667	3.079	3.853
92/93	0.015	0.121	0.308	0.612	1.037	1.425	1.829	2.247	2.667	3.079	3.853
93/94	0.015	0.121	0.308	0.612	1.037	1.425	1.829	2.247	2.667	3.079	3.853

```
Run name: Gulf King Mackerel without mixing area fish
No. index values: 105   Parameters:  8
Mean Squared Error (rss/df) =  0.12475E+00
Rsquared =  0.1065
Loglikelihood = -0.18222E+02
```

Program termination OK

Parameter		Estimate	S.E.	% C.V.
F age	0	0.3023	0.06827	22.59
F age	1	0.0194	0.00292	15.00
F age	2	0.1718	0.03523	20.50
F age	3	0.1288	0.01597	12.39
F age	6	0.1798	0.03359	18.68
F age	8	1.4502	0.64564	44.52
F age	9	0.0620	0.01490	24.03
F age	11	0.2191	0.11176	51.00

Table 5a. Probability of exceeding given spawning potential ratio under various yields (million pounds) in the 1998/99 fishing season for Gulf king mackerel using updated low 1997 catch.

	% Spawning Potential Ratio								
Yield	50	45	40	35	30	25	20	15	10
2	4.66	1.94	0.42	0.23	0.18	0.14	0.11	0.08	0.06
3	30.96	16.31	7.80	2.38	0.38	0.21	0.17	0.12	0.09
4	71.13	51.55	30.00	14.24	5.16	0.49	0.22	0.17	0.13
5	92.84	80.33	62.93	42.16	21.95	8.27	0.49	0.21	0.16
6	97.67	93.99	84.76	66.90	46.39	22.97	7.45	0.25	0.19
7	99.31	98.07	94.43	86.77	67.86	45.62	19.38	2.17	0.22
8	99.81	99.25	98.01	94.35	85.87	65.91	37.42	13.16	0.32

Table 5b. Probability of exceeding given spawning potential ratio under various yields (million pounds) in the 1998/99 fishing season for Gulf king mackerel using high 1997 catch.

	% Spawning Potential Ratio								
Yield	50	45	40	35	30	25	20	15	10
2	4.99	2.03	0.44	0.23	0.18	0.15	0.11	0.08	0.06
3	32.57	18.15	8.08	2.50	0.41	0.22	0.17	0.13	0.10
4	73.19	52.23	30.47	15.90	5.87	0.64	0.22	0.17	0.13
5	93.30	81.94	64.64	42.84	22.83	9.28	0.66	0.21	0.16
6	97.93	94.37	86.25	69.10	48.29	24.94	8.47	0.33	0.19
7	99.36	98.18	94.78	86.93	69.37	48.04	21.05	3.26	0.22
8	99.81	99.30	98.11	94.47	86.78	66.56	40.56	14.92	0.63

Table 6. Deterministic allowable biological catch (millions of pounds) in the 1998/99 fishing season for the four migratory groups and a range of choices for spawning potential ratio (SPR).

		% Spawning Potential Ratio				
		50	40	30	20	10
Atlantic King	low bycatch	5.67	8.41	13.18	22.29	39.42
Without Mixing	high bycatch	7.29	10.89	17.38	30.20	54.35
Area Fish	Harris bycatch	8.93	13.45	21.79	38.49	69.54
Atlantic King	low bycatch	7.65	11.32	17.79	30.67	55.31
Including Mixing	high bycatch	7.86	11.63	18.32	31.68	57.14
Area Fish	Harris bycatch	9.58	14.30	22.87	40.33	72.97
Gulf King	low 97 catch	3.04	4.08	5.48	7.59	11.64
Without Mixing	high 97 catch	3.00	4.03	5.41	7.50	11.50
Area Fish	updated low 97	3.03	4.06	5.46	7.56	11.60
	updated high 97	2.99	4.01	5.39	7.47	11.46
Gulf King	low 97 catch	3.57	4.88	6.72	9.68	15.96
Including Mixing	high 97 catch	3.54	4.83	6.66	9.60	15.82
Area Fish	updated low 97	3.56	4.86	6.70	9.66	15.92
	updated high 97	3.53	4.82	6.64	9.58	15.78

Table 7. Stochastic simulation median allowable biological catch (millions of pounds) in the 1998/99 fishing season for the four migratory groups and a range of choices for spawning potential ratio (SPR).

		% Spawning Potential Ratio				
		50	40	30	20	10
Atlantic King	low bycatch	7.11	10.60	16.14	26.47	46.55
Without Mixing	high bycatch	8.52	12.69	19.93	32.80	58.97
Area Fish	Harris bycatch	10.38	15.42	24.54	42.10	74.50
Atlantic King	low bycatch	8.73	12.69	19.77	33.76	60.53
Including Mixing	high bycatch	8.89	13.06	20.41	35.57	63.87
Area Fish	Harris bycatch	11.03	16.60	26.66	46.38	83.30
Gulf King	low 97 catch	3.43	4.61	6.19	8.53	13.08
Without Mixing	high 97 catch	3.40	4.55	6.10	8.45	12.93
Area Fish	updated low 97	3.42	4.59	6.17	8.51	13.03
	updated high 97	3.39	4.53	6.07	8.42	12.89
Gulf King	low 97 catch	3.83	5.24	7.23	10.54	17.39
Including Mixing	high 97 catch	3.80	5.20	7.17	10.46	17.24
Area Fish	updated low 97	3.82	5.23	7.21	10.52	17.35
	updated high 97	3.79	5.18	7.15	10.43	17.20

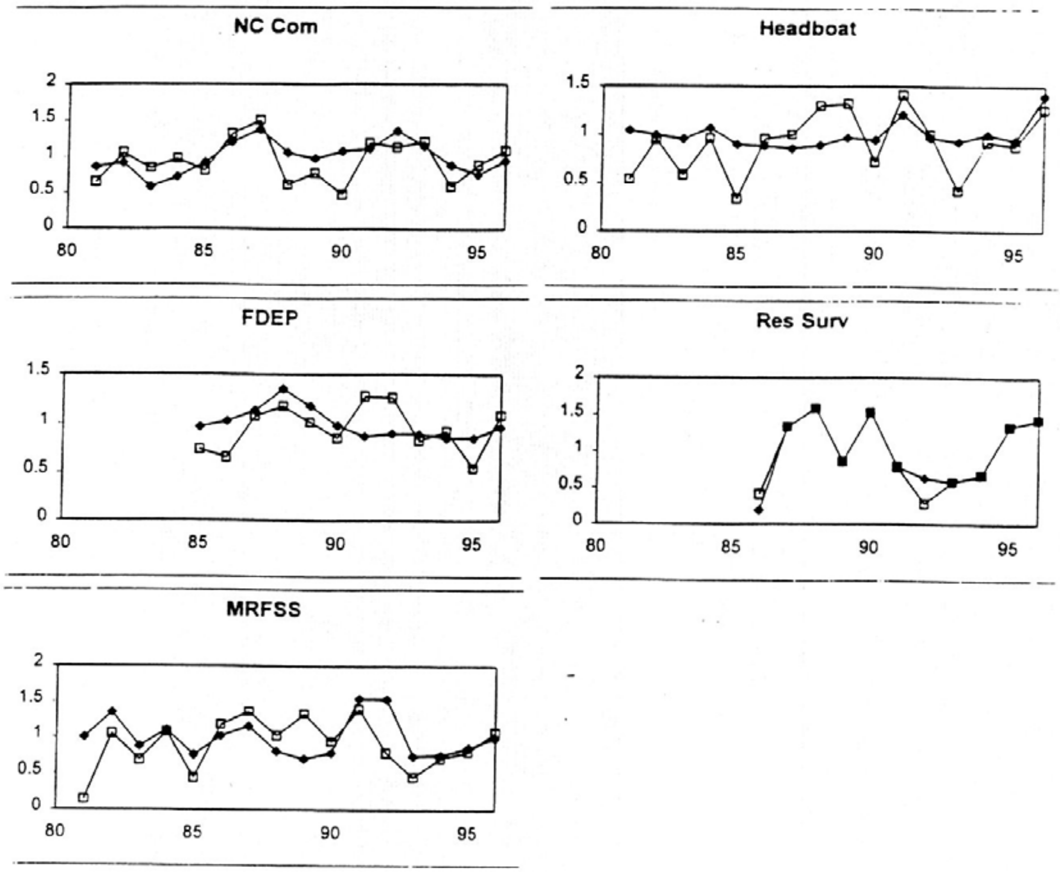

Figure 1a. Comparison of observed (filled diamonds) and predicted (open squares) indices for Atlantic king mackerel using Vaughan and Nance low bycatch.

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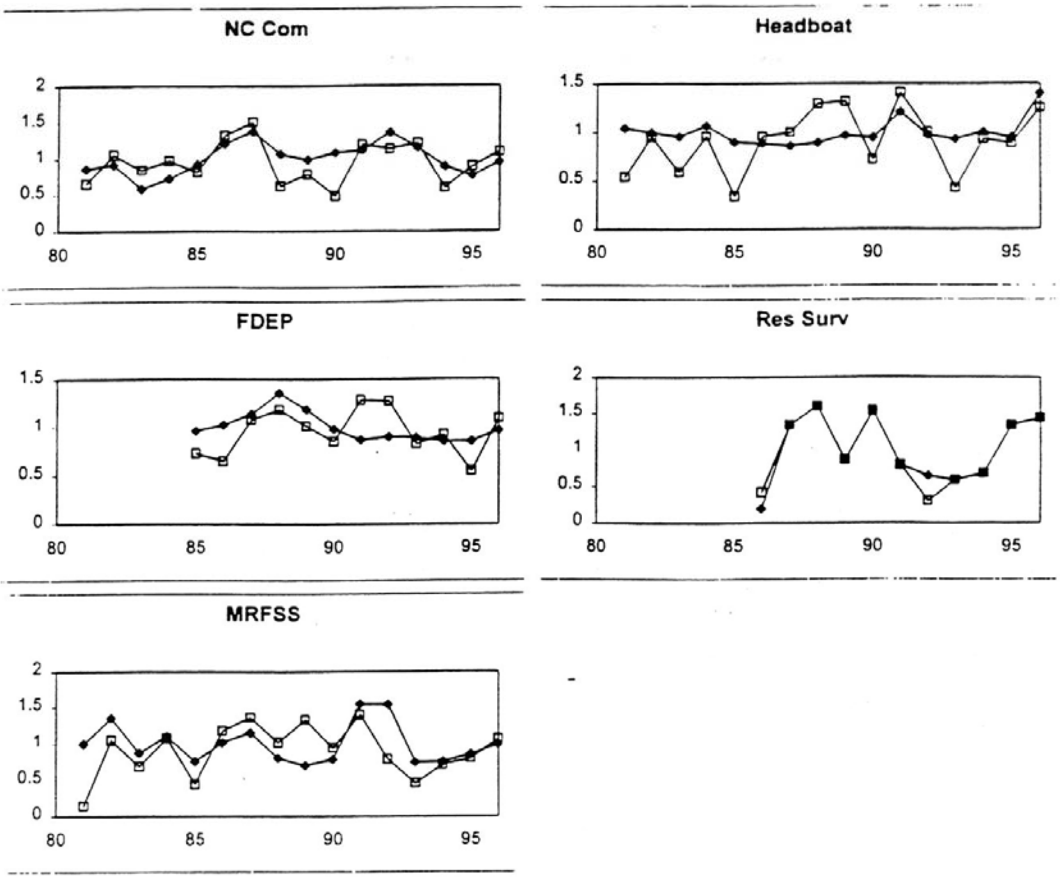


Figure 1b. Comparison of observed (filled diamonds) and predicted (open squares) indices for Atlantic king mackerel using Vaughan and Nance high bycatch.

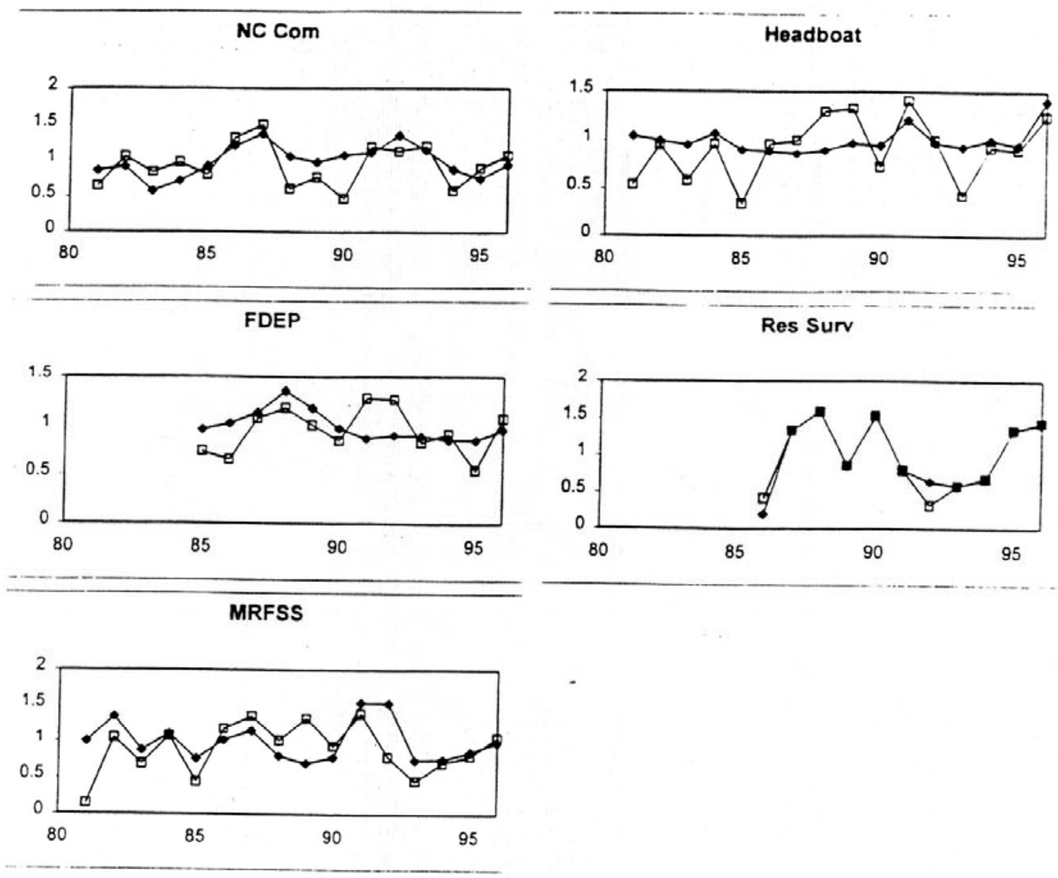


Figure 1c. Comparison of observed (filled diamonds) and predicted (open squares) indices for Atlantic king mackerel using Harris bycatch.

34

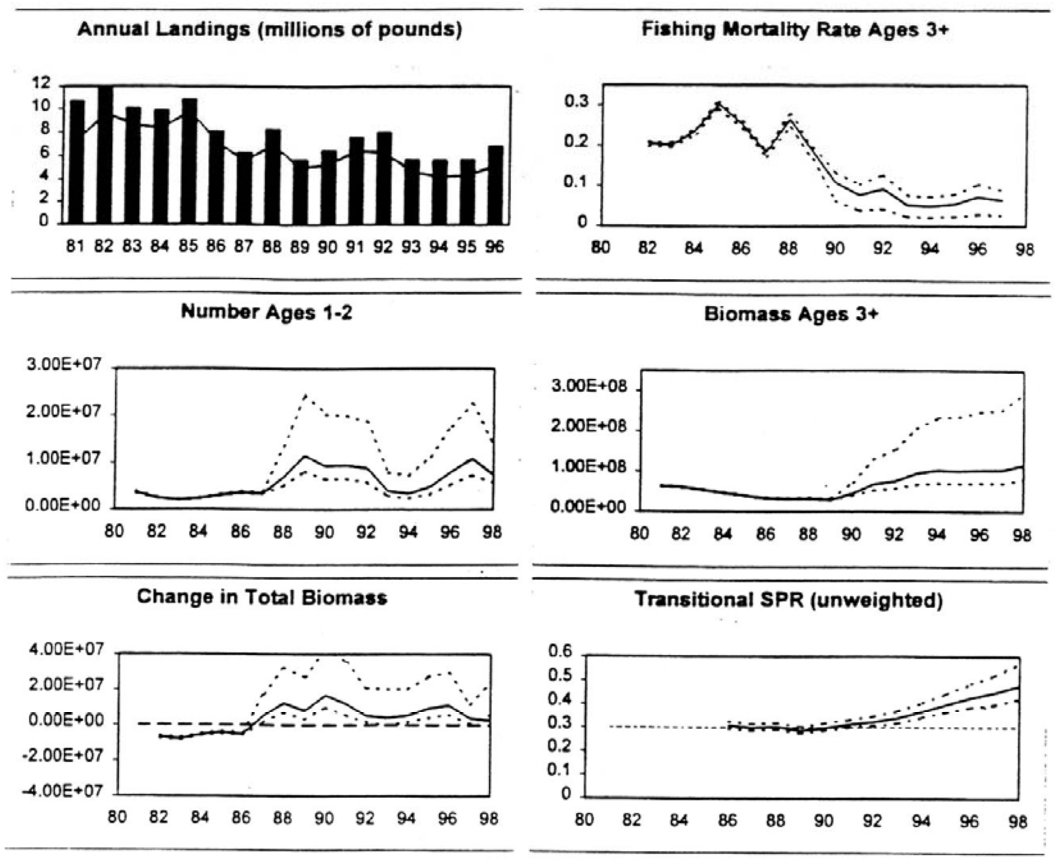


Figure 2a. Atlantic king mackerel catch and population trends with 80% bootstrap confidence intervals using Vaughan and Nance low bycatch.

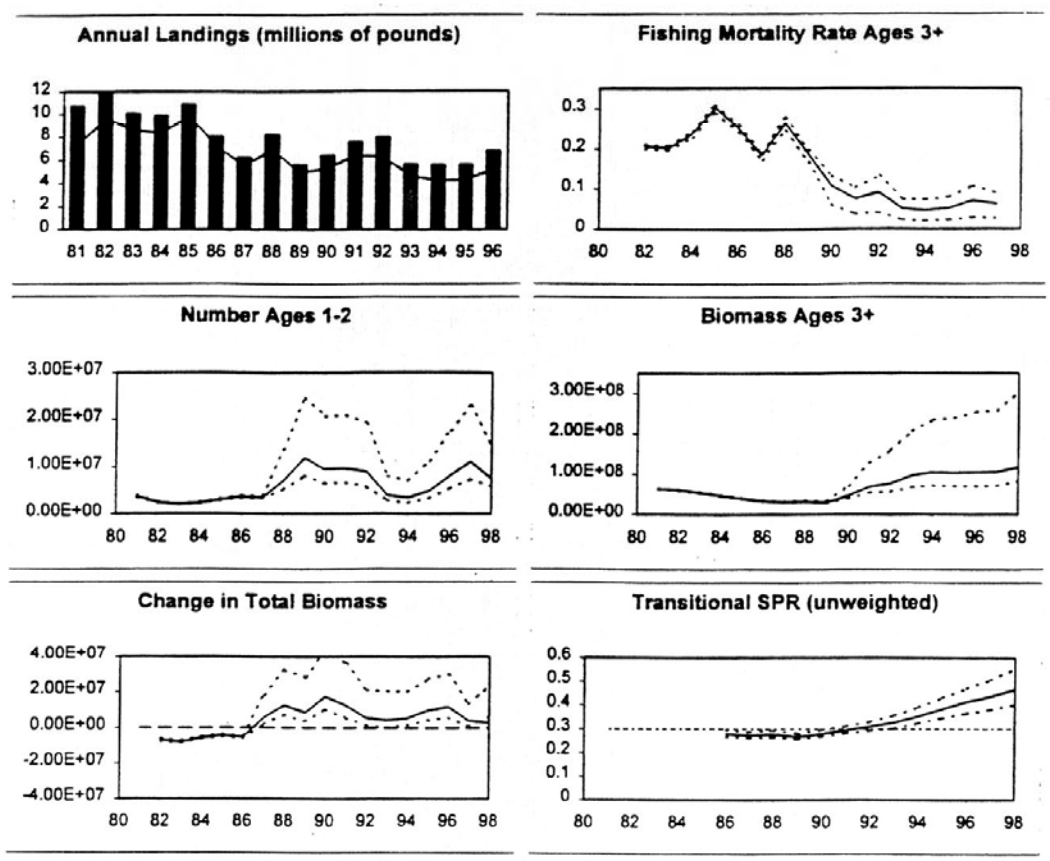


Figure 2b. Atlantic king mackerel catch and population trends with 80% bootstrap confidence intervals using Vaughan and Nance high bycatch.

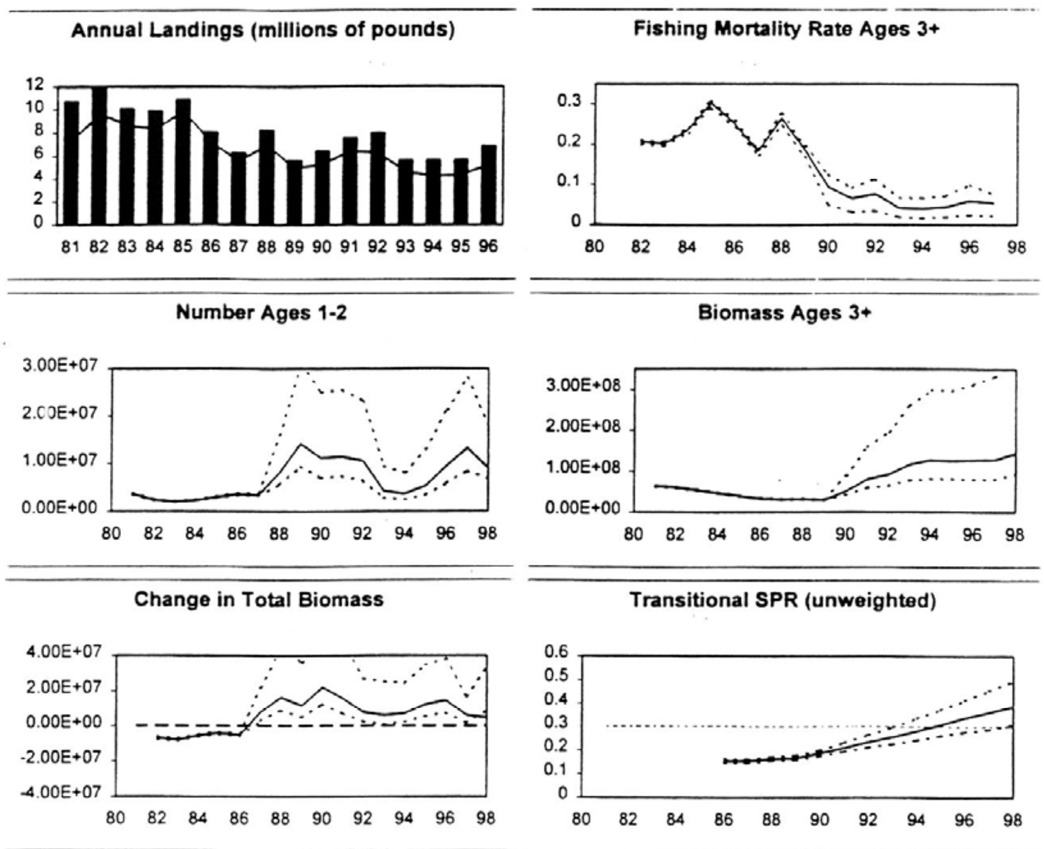


Figure 2c. Atlantic king mackerel catch and population trends with 80% bootstrap confidence intervals using Harris bycatch.

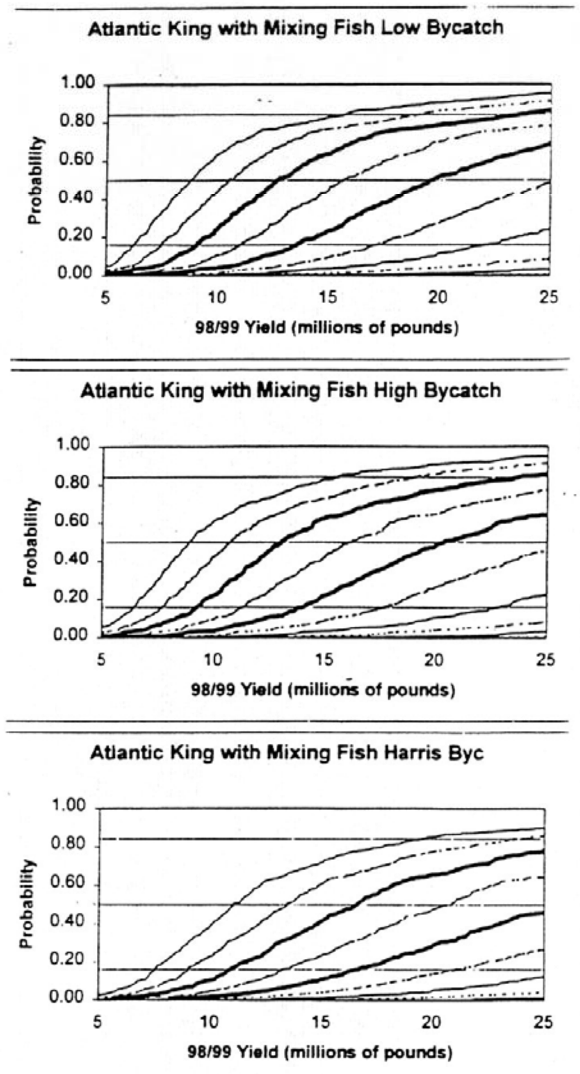


Figure 3. Probability of exceeding various spawning potential ratios under range of yields in the 1998/99 fishing season for Atlantic king mackerel. The spawning potential ratios range from 50% (the leftmost curve) to 5% (the rightmost curve, if visible at all) in increments of 5%. The two bolded lines are 40% SPR and 30% SPR. The horizontal lines denote the 16%, 50% and 84% risks.

Appendix K. What if Mixing Area Fish are Assigned to the Atlantic Migratory Group Instead of the Gulf of Mexico Migratory Group (MSAP/98/10)

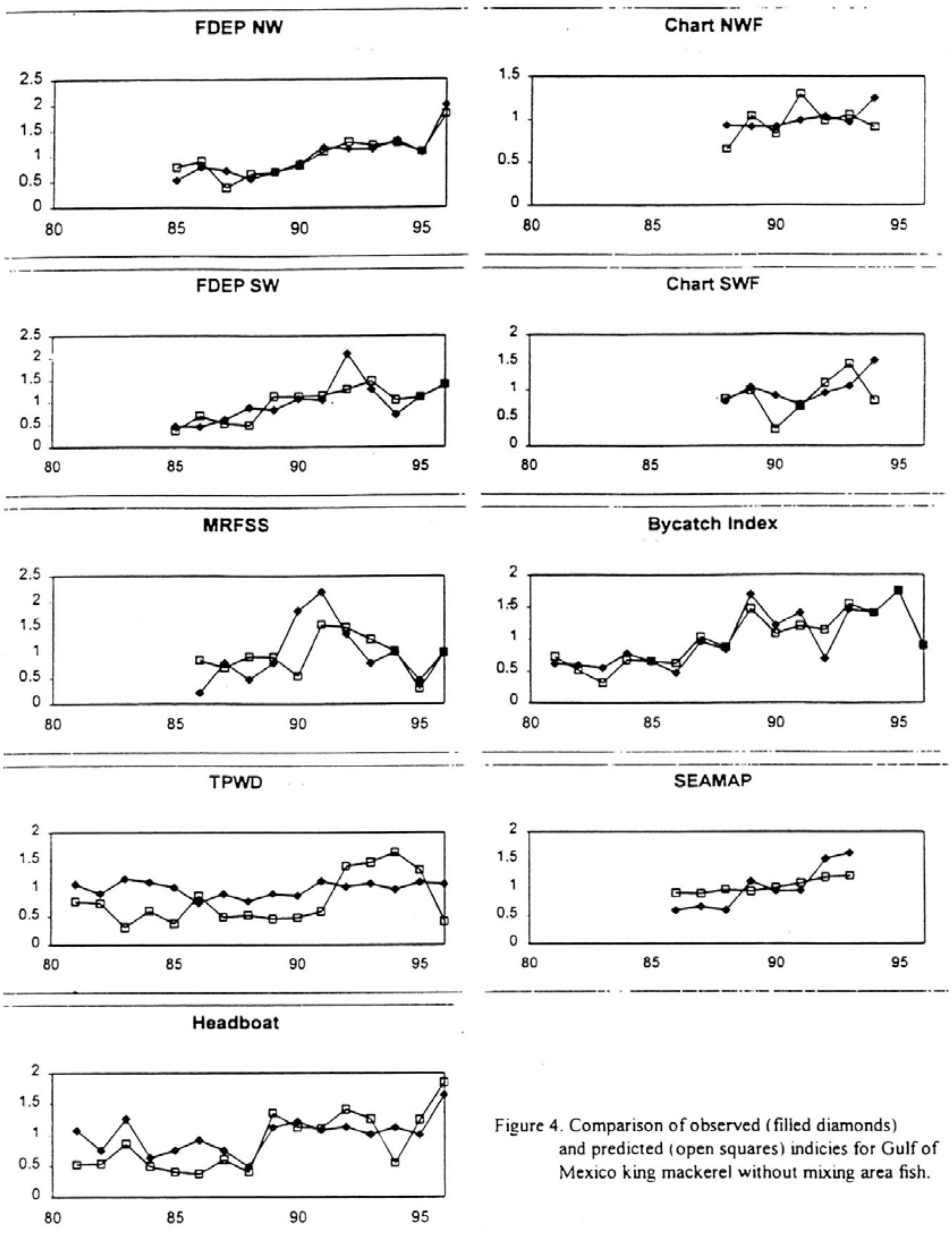


Figure 4. Comparison of observed (filled diamonds) and predicted (open squares) indicies for Gulf of Mexico king mackerel without mixing area fish.

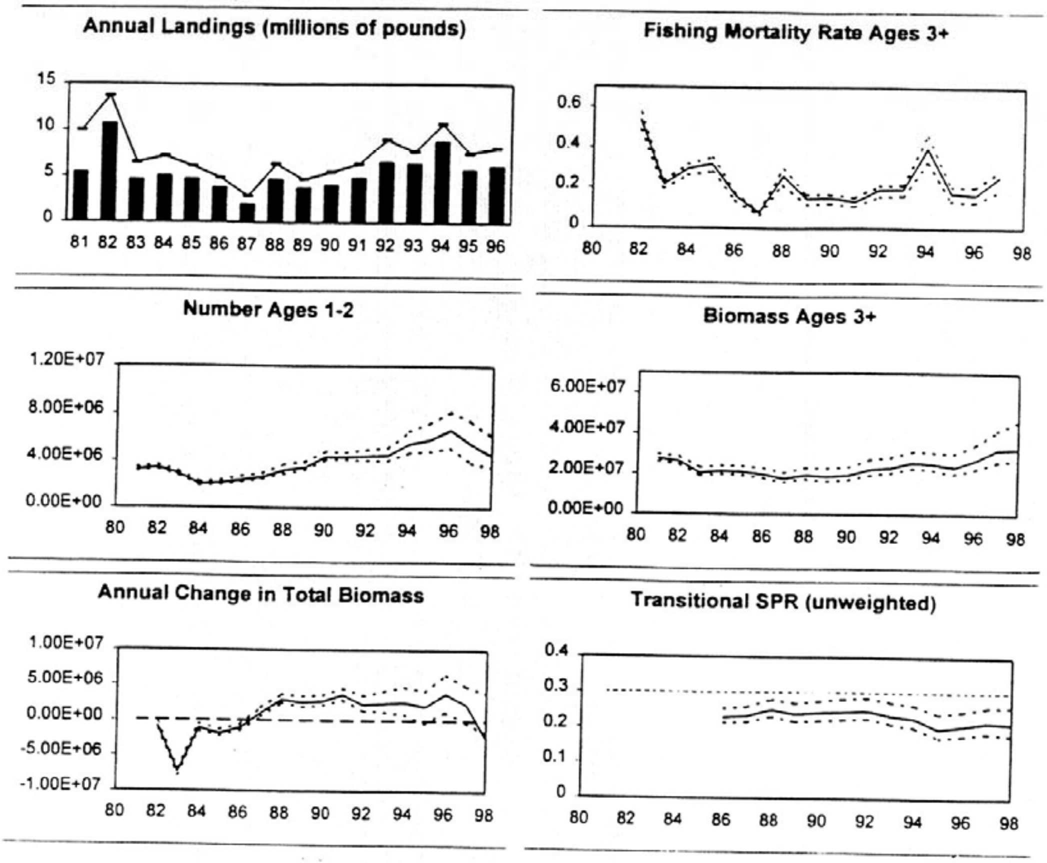
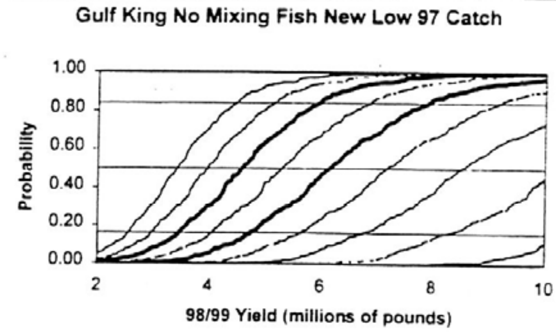


Figure 5. Gulf of Mexico king mackerel catch and population trends with 80% bootstrap confidence intervals.



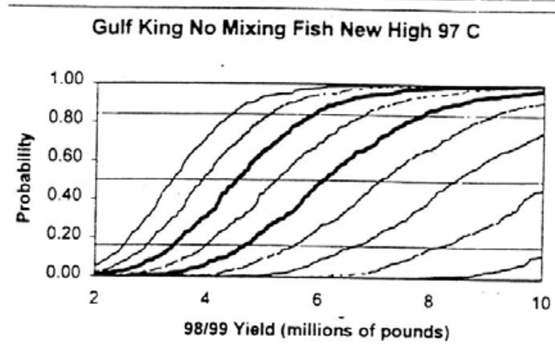


Figure 6. Probability of exceeding various spawning potential ratios under range of yields in the 1998/99 fishing season for Gulf of Mexico king mackerel. The spawning potential ratios range from 50% (the leftmost curve) to 5% (the rightmost curve, if visible at all) in increments of 5%. The two bolded lines are 40% SPR and 30% SPR. The horizontal lines denote the 16%, 50% and 84% risks.

Appendix L. The Potential Impact of Juvenile King Mackerel (*Scomberomorus cavalla*) and Spanish Mackerel (*S. maculatus*) Shrimp Trawl By-Catch Mortality on Southeast Atlantic Adult Populations (MSAP/98/01)

MSAP/98/01

February 1998 MSAP/98/01

*Do NOT CITE WITHOUT PRIOR Reference to authors

The potential impact of juvenile king mackerel (*Scomberomorus cavalla*) and Spanish mackerel (*S. maculatus*) shrimp trawl bycatch mortality on southeast Atlantic adult populations.

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Abstract

We monitored the bycatch of juvenile king and Spanish mackerel aboard commercial shrimp vessels in South Carolina during 1991 and 1992. A total of 81 king mackerel and 257 Spanish mackerel were collected from 137 tows sampled. The sample catches of both king and Spanish mackerel were described by a negative binomial distribution. The probability of juvenile king and Spanish mackerel being caught in a tow was calculated for each species, and used to estimate the total number of juvenile king and Spanish mackerel harvested by shrimp trawlers in South Carolina and the southeastern United States. When the estimated SC bycatch was added to the number of age-0 mackerel as estimated by virtual population analysis, the average size of the age-0 year class of king mackerel increased by 7.8% and Spanish mackerel by 3.5%. Inclusion of the estimated SC statewide mackerel bycatch and all subsequent generations between 1980 and 1995 resulted in an increase in mean annual Atlantic population size of 8.5% for king mackerel, and 6% for Spanish mackerel. These increases in population size were significant ($P<0.01$; RM ANOVA). When the region-wide estimated bycatch and all subsequent generations produced by the bycatch fish were included, the population of king mackerel increased by 34.6% for the unadjusted estimates of bycatch, and by 49.6% for the adjusted estimates. Spanish mackerel estimates of population size increases by 27.4% for the unadjusted estimates of bycatch, and by 41.7% for the adjusted estimates. These increases in population size were significant ($P<0.01$; RM ANOVA). This study demonstrates that while the annual impact of bycatch may be relatively insignificant on a per boat basis, it does seem to have a significant long-term effect in reducing the size of a population also exploited by other means.

Introduction

The otter trawl used in the penaied shrimp throughout the southeast Atlantic to harvest penaeid shrimp (SAFMC 1993). Two species commonly caught as bycatch by commercial trawlers in South Carolina during normal shrimping operations are juvenile king and Spanish mackerel (Keiser 1976; Harris and Dean, in press).

Important commercial and recreational fisheries for Atlantic group king mackerel (*Scomberomorus cavalla*) and Spanish mackerel (*S. maculatus*) exist in the southeast Atlantic states (North Carolina, South Carolina, Georgia, and the east coast of Florida; GMFMC and SAFMC 1992). While Keiser (1976) and Harris and Dean (in press) documented the magnitude and seasonality of the king and Spanish mackerel bycatch in South Carolina, neither attempted to extrapolate the bycatch beyond the vessels sampled, or to postulate as to the effect of the bycatch mortality on adult population.

These issues were addressed by estimating the bycatch of juvenile king and Spanish mackerel taken by commercial shrimp trawlers in South Carolina and the southeastern United States. Estimates of mackerel bycatch for the southeastern United States were expanded from sampling done in South Carolina in 1991 and 1992 (Harris and Dean, in press). Bycatch estimates were incorporated into the age structured stock assessment for each species. We then tested the hypothesis that the inclusion of juvenile king and Spanish mackerel removed as bycatch causes a significant increase in the size of the age-0 year class of each species, and the population sizes of the parent populations.

Methods

Sampling of mackerel bycatch onboard commercial vessels was conducted over a two-year period, from June through December 1991, and May through December 1992, thereby covering the bulk of the South Carolina 1991 and 1992 shrimping seasons. In 1991, sampling was restricted to McClellanville, SC, with Charleston and Beaufort, SC, added in 1992 (Figure 1).

The sampling period for 1991 was divided into a series of seven-day periods with one randomly chosen day sampled per period. If a sample day was missed, sampling was done on the first subsequent day possible. The boat sampled each sample day was randomly chosen from twelve in McClellanville, SC, whose captains had agreed to cooperate during 1991. All tows performed by the selected vessel were treated as separate samples. A tow was defined as the catch of all nets deployed, excluding the trynet. Tow duration was measured as the time from when the trawl doors entered the water on setting the nets until the doors emerged from the water on net retrieval. Sampling periodicity was maintained at one sample day per seven-day period for each location in 1992. If the same day was chosen for sampling in different locations, the more southerly location was sampled the following day. Due to limited cooperation from shrimpers in 1991, sampling was restricted to one or two consistently cooperative vessels at each location in 1992.

A 10 – 25% portion of the total catch from each tow made was randomly sub-sampled (see Harris and Dean (in press) for a complete description of sampling methodology). The shrimp, finfish and invertebrates were separated from each sub-sample, and weight for each group was measured using a Pelouze top pan spring balance accurate to fifty grams. The total shrimp catch from each tow was weighed. King and Spanish mackerel were separated from the sample, measured (mm fork length) and kept on ice for weighing onshore.

The start time and duration of each tow were recorded. Tow location was recorded when the study first began, but was discontinued as towing occurred in such a limited area at each location sampled (Figure 1). Tow speed was measured using Loran-C, which measures speed over the bottom, not through the water. Net type, number, turtle excluder device (TED) type, and footrope length were recorded for each tow.

The mackerel to shrimp ratio in each sample was calculated:

$$MSR_{k:s} = \frac{M_{sk:ss}}{S_s}$$

where $MSR_{k:s}$ = king (k) or Spanish (s) mackerel to shrimp ratio for each tow;

S_s = sample shrimp weight (kg);

$M_{sk:ss}$ = the number of king (sk) or Spanish (ss) mackerel in the sample.

The total mackerel catch was estimated for each tow:

$$EM_{tk:ts} = S_t \times MSR_{k:s}$$

where $EM_{tk:ts}$ = estimated total mackerel catch (king (tk) or Spanish (ts));

S_t = total shrimp weight (kg).

Three methods were tested as potential predictors of the statewide bycatch of king and Spanish mackerel in South Carolina. First, the sample and estimated total catch of king or Spanish mackerel per tow were correlated to the sample shrimp catch, total shrimp catch and tow duration. Significant correlations were tested for with Spearman's rank order correlation coefficient. Second, backward stepwise multiple regressions with estimated total king or Spanish mackerel catch as the dependent variable were done with location, month, tow duration, total shrimp catch, and net size as initial independent variables. Third, the probability distribution that best fit the bycatch of king and Spanish mackerel sampled during the study was used to estimate the statewide number of mackerel caught based on the statewide shrimping effort each year. The goodness of fit for each probability distribution was tested with χ^2 goodness of fit test.

Analyses were performed for the method that best estimated the statewide mackerel catch, based on a readily measurable parameter to describe shrimping effort. Statewide shrimp landings data were used to estimate statewide effort, based on the relationship between shrimp catch and effort for the tows sampled during 1991 and 1992 determined with linear regression. The statewide number of tows per year was estimated from the statewide effort using the mean tow time sampled in 1991 and 1992. The probability distribution was used to predict how many juvenile mackerel of each species were taken as bycatch each year by calculating the number of tows likely to catch x mackerel (where x=0, 1, 2, 3.....10+). The statewide mackerel catch for South Carolina was calculated by multiplying the number of tows by the number of mackerel those tows caught, and summing the results.

Beginning in 1981, the estimated South Carolina king and Spanish mackerel bycatch taken each year was added to the number of age-0 mackerel of each species recruiting to the population for that year (e.g. mackerel bycatch caught in 1981 was added to the age-0 year class of the '81/'82 fishing year). The number of age-0 Atlantic king and Spanish mackerel were taken from the most recent virtual population analysis (VPA) performed for each species (Powers et al. 1995; 1996). Changes in year class size were tested for significance with repeated measures analysis of variance (RM ANOVA).

An annual survival rate of 70% was calculated from the VPA for king mackerel from approximately 180 days (the approximate age of age-0 mackerel in the VPA) to eleven years old and 58% for Spanish mackerel from 180 days to age seven. These estimates of survival were used to estimate the survival of the bycatch portion of each year class. Age-specific fecundities from the literature were used to estimate the egg production of the bycatch fish (Finucane et al. 1986; Schmidt et al. 1993). The survival rate for eggs to 180 day old fish was estimated for each species by calculating the percent survival from the number of eggs produced one year and the number of age-0 surviving to recruit to the population that year as estimated by VPA (i.e. the spawning stock in fishing year '81/'82 was assumed to produce the age-0 fish for fishing year '81/'82). For each year from 1981 through 1995, the bycatch fish, their surviving offspring, and resultant generations of mackerel were added to the population estimated by VPA. The period 1981-1995 was chosen as that was the time span covered by the most recent VPA for king mackerel. Any differences in population size were tested for significance with RM ANOVA.

The bycatch of juvenile king and Spanish mackerels was also estimated for the southeast Atlantic region from Fort Pierce, FL, to Oregon Inlet, NC, using the procedures described for estimating SC bycatch. Our estimates of the region-wide bycatch of king and Spanish mackerels assume all factors affecting bycatch stayed constant over time and space. To partially address this problem, the estimates of bycatch calculated for each state using our catch data were adjusted using the mean sample size of king and Spanish mackerel from Southeast Area Monitoring and Assessment Program, South Atlantic (SEAMAP-SA) trawls between 1990 and 1994. The mean SEAMAP-SA catch per tow for king and Spanish mackerel was calculated for each state, using only the summer and fall sampling periods and only the inshore strata (< 9m), and divided by the mean SEAMAP-SA catch for SC. This gave the catch of the remaining states relative to the SC catch. The bycatch as estimated from our data was then multiplied by this calibration term. Differences in age-0 year class size and population size of Atlantic king and Spanish mackerels were tested for using unadjusted and adjusted estimates of region-wide bycatch with RM ANOVA.

Results

A total of 137 tows were sampled during the two year study period. Tow duration ranged from 1 h to 7.25 h. The average tow duration (± one standard deviation) for all three areas and both years was 2.88 ±0.99 h (Table 1). A total of 81 king mackerel and 251 Spanish mackerel were collected from 137 samples during the 1991 and 1992 shrimp seasons (see Harris and Dean (in review) for a complete description of sampling data).

The correlation between Spanish mackerel sample catch and effort (h) was extremely poor ($r=-0.005$, $P=0.95$, Figure 2), as was the correlation between king ($r=-0.02$, $P=0.78$) and Spanish mackerel sample catch ($r=0.11$, $P=0.9$) and sample shrimp catch (Figure 3). The correlation between king mackerel sample catch and effort was significant, but negative ($r=-0.19$, $P=0.03$, Figure 2), as was the correlation between estimated total king mackerel catch per meter of footrope and effort (h) ($r=-0.17$, $P=0.05$, Figure 4). The estimated total catch per meter of footrope of Spanish mackerel showed no correlation to effort ($r=0.03$, $P=0.73$, Figure 4) and there were no significant correlations between the estimated total catches per meter of footrope of king or Spanish mackerel and total shrimp catch ($r<0.08$, $P>0.32$, Figure 5).

The backward stepwise regressions of the estimated total catch of king and Spanish mackerel found that most of the initial variables included in the model did not contribute significantly to the ability of the equation to predict the total catch of either king or Spanish mackerel. For king mackerel, total shrimp catch ($P=0.75$), effort ($P=0.77$), start time ($P=0.87$), footrope length ($P=0.47$), and month ($P=0.89$) were all removed from the model, leaving location (McClellanville, Charleston, or Beaufort) as the only significant variable ($P=0.028$, $r^2=0.04$, df=1). For Spanish mackerel, total shrimp catch ($P=0.2$), effort ($P=0.81$), start time ($P=0.83$), and location ($P=0.84$) were removed from the model, leaving footrope length and month ($P<0.002$, $r^2=0.14$, df=2) as the only significant variables. However, the catch data for king and Spanish mackerel were not normally distributed (Kolmogorov-Smirnov normality test, $P>0.05$), and variances were heteroscedastic.

The distributions of the sample catches of king mackerel and Spanish mackerel did not differ significantly from negative binomial distributions (king mackerel - $\chi^2=2.84$, $P<0.1$; Spanish mackerel $\chi^2=3.37$, $P<0.25$). The mean number of king mackerel sampled per tow was 0.59, with a variance of 3.00 and $k = 0.145$, and 1.83 with a variance of 15.82 and $k = 0.24$ for Spanish mackerel (variances and k calculated according to Krebs 1989).

Shrimp catch (kg) proved to be good predictor of effort (hours). The relationship was adequately described with a least squares linear regression

Effort (hours) = 2.236 + 0.0129 x total shrimp catch (kg)

($P<0.001$, $r^2 = 0.16$, Figure 6). This equation was solved for effort for each year from 1981 to 1995 using annual SC shrimp landings (Table 1).

The highest estimated bycatch of age-0 king mackerel for SC was 282,139 caught in 1995, and the lowest was 61,854 in 1984. An average of 157,132 (±55,587) king mackerel was estimated to have been caught each year between 1981 and 1995 (Table 1). An average of 437,453 (±154,754) Spanish mackerel was estimated caught as bycatch off SC between 1981 and 1995, with a high of 785,468 captured in 1995, and a low of 172,199 in 1984 (Table 1). The mean annual estimated bycatch of age-0 king mackerel for the southeast Atlantic region was 662,036 fish, with a high of 1.07 million fish in 1991, and a low of 321,344 fish in 1984 (Table 1). When the regional estimated bycatch of age-0 king mackerel was adjusted by state using SEAMAP-SA data, the mean estimated annual bycatch increased to 1.5 million fish (Table 2). Similarly, the mean annual estimated bycatch of age-0 Spanish mackerel for the southeast Atlantic was 1.84 million fish (1981-1995), with a high of 2.99 million fish in 1991, and a low of 0.89 million fish in 1984 (Table 1). When the regional estimated bycatch of age-0 Spanish mackerel was adjusted by state using SEAMAP data, the mean estimated annual bycatch increased to 3.13 million fish (Table 2).

Adding the fish harvested incidentally in SC to the age-0 year class of each species each year increased cohort size by an average of 7.8% for king mackerel and 3.5% for Spanish mackerel (Figure 7). The difference between the VPA and VPA plus the SC bycatch age-0 year class sizes were significant (P<0.01; RM ANOVA).

Inclusion of the estimated SC statewide mackerel bycatch and all subsequent generations between 1980 and 1995, resulted in an increase in mean annual Atlantic population size of 8.5% for king mackerel, and 6% for Spanish mackerel (Figure 8, 9). These increases in population size were significant (P<0.01; RM ANOVA). When the region-wide estimated bycatch and all subsequent generations produced by the bycatch fish were included in, the population of king mackerel increased by 34.6% for the unadjusted estimates of bycatch, and by 49.6% for the adjusted estimates (Figure 8). Spanish mackerel estimates of population size increases by 27.4% for the unadjusted estimates of bycatch, and by 41.7% for the adjusted estimates (Figure 9). These increases in population size were significant (P<0.01; RM ANOVA).

DISCUSSION

Tow duration did not seem to have an impact on the bycatch of king and Spanish mackerel. Sample size per hour or estimated total catches of king and Spanish mackerel did not show biologically significant trends relative to effort. Similarly, the poor relationships between the estimated total mackerel catch and shrimp catch show that total shrimp landings cannot be used to directly predict total mackerel bycatch. Most studies that have attempted to estimate bycatch of fish in shrimp trawls have assumed a relationship between catch of a species and effort (Gutherz and Pellegrin 1988; Nichols 1990; Nichols et al. 1987, 1990; Vaughan and Nance 1996[1]) or shrimp catch (Vaughan and Nance 1996[1]). Mackerel size, swimming speed, and the number of schools present in the shrimping grounds may have a greater impact on mackerel bycatch than tow duration (Harris and Dean, in press).

It would be extremely difficult to derive data for location and net size from landings data as currently recorded in South Carolina for use in a multiple linear regression. A more fundamental problem of using linear regression (either simple or multiple) is that these

[1] Vaughan, D.S. and J.M. Nance. (1996). Estimates of bycatch of mackerel and cobia in U.S. south Atlantic shrimp trawls. Unpublished manuscript 23p.

analyses require data to be normally distributed. The sample catches and estimated total catches of king and Spanish mackerel were not normally distributed, and had heterogeneous variances. Linear regression models are robust tests and can provide acceptable results with slight departures from the assumptions (Zar 1984). However, large deviations from the assumptions can lead to spurious conclusions (Zar 1984). The degree of deviation of king and Spanish mackerel sample and estimated total catch from a normal distribution, and the inability to transform the data to achieve normality precludes the use of linear or multiple regressions in analyses of these data.

The relationship between tow duration and shrimp catch is adequate for estimation of the total number of hours of towing required to land the total annual South Carolina shrimp catch. The shrimp fishery has been fished at maximum sustainable yield for many years (SAFMC 1993) and the relationship between effort and catch from 1991 and 1992 is probably applicable to the shrimp landings from 1981 to 1995. The shrimpers who participated in the study all maintained that, apart from some gear modifications, they were fishing in essentially the same manner in 1992 as in 1982. Therefore, it is unlikely that fishing techniques have changed sufficiently since 1981 to significantly alter the catch and effort relationship from what it was in 1991-1992. If anything, a shift to more efficient gear types or gear usage would result in an underestimate of tows from previous years, thereby underestimating the mackerel catches. Similarly, if king and Spanish mackerel bycatch had been reduced by Turtle Excluder Devices (TEDs), then our estimates would be an underestimate of mackerel bycatch for those years prior to the widespread use of TEDs.

Using the mean tow time measured in 1991 and 1992 to estimate the number of tows from the total annual effort of any given year probably provides a relatively accurate measure of the true number of tows made. Under or overestimating the mean tow time would result in an under or over estimate of the total number of tows and would impact the estimated mackerel bycatch. The quality of shrimp landed from a long tow is often poor, and most shrimpers are reluctant to tow for extended periods, although there was a positive correlation between tow time and shrimp catch. Therefore, no changes in technique or technology should impact the mean tow time, which can therefore be applied back to 1981 with a high degree of confidence.

Annual variations in shrimp landings affect the number of tows derived each year, which in turn influences the estimates of mackerel bycatch for that year. However, between year differences in shrimp landings are due primarily to differences in annual shrimp abundance (shrimp is an annual crop), while effort may be relatively constant between years. However, in years of high shrimp abundance tow times may be shorter, as nets are filling faster. For example, shrimp landings were 28% higher in 1991 than in 1992 and tow times were significantly shorter than in any location sampled in 1992 (Harris and Dean, in press). The number of tows for that year would increase, however, the total number of hours fished may not. The opposite effect would occur in years of low abundance, although the effect would not be as great as shrimpers would still limit tow times to maintain the quality of the catch. Therefore, although the number of tows derived from shrimp landings may be an over- or underestimate for any year, this error is probably balanced over time.

Our methodology does not take into account the abundance of age-0 king and Spanish mackerels. A strong year class of either species would have a greater number lost as bycatch than a weak year class, regardless of the abundance of shrimp. Thus, a strong mackerel year class occurring with a weak shrimp year class could severely underestimate the mackerel bycatch for that year. Annual monitoring of mackerel bycatch onboard commercial vessels could provide an indicator of abundance to fine-tune region-wide estimates of mackerel bycatch. Alternatively, the catch of juvenile king and Spanish mackerel by SEAMAP could be used to predict year class strength (Collins et al. 1997) and to fine-tune region-wide estimates of bycatch.

A total of 2.06 million age-0 king between 1981 and 1994 and 3.74 million age-0 Spanish mackerel between 1984 and 1992 were estimated to have been harvested as incidental bycatch by shrimp trawlers in South Carolina. The unadjusted estimated region-wide catch for the same periods were 8.99 million age-0 king mackerel, and 15.89 million age-0 Spanish mackerel. Between 1981 and 1994, Powers et al. (1996), used a bycatch estimate of 3.17

million (shrimp to fish ratio expansion; Vaughan and Nance (1996[1])) juvenile king mackerel. The estimate for Spanish mackerel bycatch provided by Powers et al. (1995) between 1984 - 1992 was 526,716 individuals, considerably smaller than the 15.89 million individuals we estimated for the same period. Expansion models based directly on measures of effort or shrimp catch to the shrimp fishery of South Carolina or the southeast region could result in spurious estimates of bycatch. Our procedure makes no direct assumptions of a relationship between effort and mackerel bycatch, and may therefore provide better estimates of mackerel bycatch.

Between 1981 and 1995, the king mackerel harvested in SC as incidental bycatch and subsequent generations could have contributed 12 million fish to the Atlantic population (this number counts an age-0 fish once in 1981, once as an age-1 in 1982, etc). Including our unadjusted region-wide estimate of juvenile king mackerel bycatch and their subsequent generations increases the Atlantic king mackerel population by 49 million fish over the same period. Much greater changes are evident in the Spanish mackerel population where the number of bycatch fish in the population between 1981 and 1992 would be 39 million fish for the SC bycatch, and 164 million fish for the unadjusted region-wide bycatch.

Our calculated estimates of juvenile mackerel bycatch far exceed previous estimates, and the implications of these differences are quite broad. The higher numbers of mackerel bycatch estimated using our technique indicates that fewer age-0 fish may be surviving to age-1 and greater than is currently believed. In the absence of a shrimp fishery, Atlantic king and Spanish mackerel populations may have been more abundant and the time required for the stocks to recover from overfishing reduced. Current legislation dictates that king mackerel recover from overfishing in no longer 12 years (seven years for Spanish mackerel) (GMFMC and SAFMC 1992). The estimated king mackerel stock in 1993 was 8.8 million fish (Powers et al. 1996); the estimated total loss of king mackerel between 1980 and 1992 was 8 million (based on SC bycatch only) to 33 million fish (based on unadjusted region-wide bycatch estimates). Therefore, in a 12-year period, over 100% of the potential stock was lost as a result of bycatch. A similar scenario exists for Spanish mackerel, with a 1993 stock size of 45.5 million fish

(Powers et al. 1995), and a loss to bycatch of approximately 18-76 million fish between 1986 and 1992. The recovery time of king and Spanish mackerel populations could be reduced considerably if bycatch mortality were eliminated, and these populations could sustain heavier fishing pressure if bycatch mortality was reduced or eliminated.

Otter trawls have been used in the southeast US shrimp fishery since the 1920's (SAFMC 1981), and bycatch has presumably been taken for as long as the otter trawl has been used. Therefore, estimates of the virgin stock size of king and Spanish mackerel calculated after the advent of the shrimp trawl fishery are in all likelihood too low. This means that estimates of the spawning stock biomass per recruit may be low for both species in the Atlantic. Consequently, the current populations may be managed at an unknown level of spawning stock biomass per recruit instead of the 30% or 40% as is currently thought as the virgin spawning stock biomass may have been underestimated.

The issue of bycatch in shrimp trawls has become increasingly controversial, and the impacts of bycatch on various other species are largely unknown. This study demonstrates that while the annual impact of bycatch may be relatively insignificant on a per boat basis, it does seem to have a significant long-term effect in reducing the size of a population also exploited by other means.

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LITERATURE CITED

Collins M.R., P.J. Harris, and P. Maier. In press. Fishery-independent recruitment indices for king and Spanish mackerels. North American Journal of Fisheries Management.

Finucane, J.H, L.A. Collins, H.A. Brusher, and C.H. Saloman. 1986. Reproductive biology of king mackerel, *Scomberomorus cavalla*, from the southeastern United States. Fisheries Bulletin 84:841-850.

GMFMC and SAFMC. 1992. Final amendment 6 to the fishery management plan and final environmental impact statement for the coastal migratory pelagic resources (mackerels). Prepared by the Gulf of Mexico and South Atlantic Fishery Management Councils, June 1992.

Gutherz, E. J. and G. J. Pellegrin. 1986. Estimate of the catch of red snapper, *Lutjanus campechanus*, by shrimp trawlers in the U.S. Gulf of Mexico. Marine Fisheries Review 50(1):17-25.

Harris, P.J. and J.M. Dean. In press. Characterization of the king mackerel (*Scomberomorus cavalla*) and Spanish mackerel (*S. maculatus*) bycatch of South Carolina shrimp trawlers. North American Journal Fisheries Management.

Keiser, R. K. 1976. Species composition, magnitude and utilization of the incidental catch of the South Carolina shrimp fishery. South Carolina Marine Resources Center, Technical Report No. 16. 94 p.

Krebs, C. J. 1989. Ecological Methodology. HarperCollins, New York. 654 p.

Nichols, S. 1990. The spatial and temporal distribution of the bycatch of red snapper by the shrimp fishery in the offshore waters of the US Gulf of Mexico. Data report of the National Marine Fisheries Service Mississippi Laboratory, 52 p.

Nichols, S., Shah, A., Pellegrin Jr., G.J., and K. Mullin. 1987. Estimates of annual shrimp fleet bycatch for thirteen finfish species in the offshore waters of the Gulf of Mexico. Report to the Gulf of Mexico Fishery Management Council.

Nichols, S., Shah, A., Pellegrin Jr., G.J., and K. Mullin. 1990. Updated estimates of shrimp fleet bycatch in the offshore waters of the US Gulf of Mexico 1972 - 1989. Report to the Gulf of Mexico Fishery Management Council, 22 p.

Powers, J.E., N. Parrack, and P. Phares. 1995. Projections of the status of Gulf of Mexico and Atlantic king mackerel and Spanish mackerel. National Marine Fisheries Service, Southeast Fisheries Science Center, Miami Laboratory MIA-94/95-28, 36 p.

Powers, J.E. N. Parrack, and P. Phares. 1996. Stock assessment analysis on Gulf of Mexico migratory group king mackerel and Atlantic migratory group king mackerel. National Marine Fisheries Service, Southeast Fisheries Science Center, Miami Laboratory MIA-95/96-32 MSAP 96/12. 131pp + notes.

SAFMC (South Atlantic Fishery Management Council). 1981. Profile of the Penaeid shrimp fishery in the south Atlantic. South Atlantic Fishery Management Council, 1 South Park Circle, Charleston, S.C. 190 p.

SAFMC (South Atlantic Fishery Management Council). 1993. Fishery Management Plan for the shrimp fishery of the South Atlantic Region. South Atlantic Fishery Management Council, 1 South Park Circle, Charleston, S.C. 182 p.

Schmidt, D.J., Collins, M.R. and Wyanski, D.M. 1993. Age, growth maturity and spawning of Spanish mackerel, Scomberomorus maculatus (Mitchill), from the Atlantic coast of the southeastern United States. Fishery Bulletin 91:526-533.

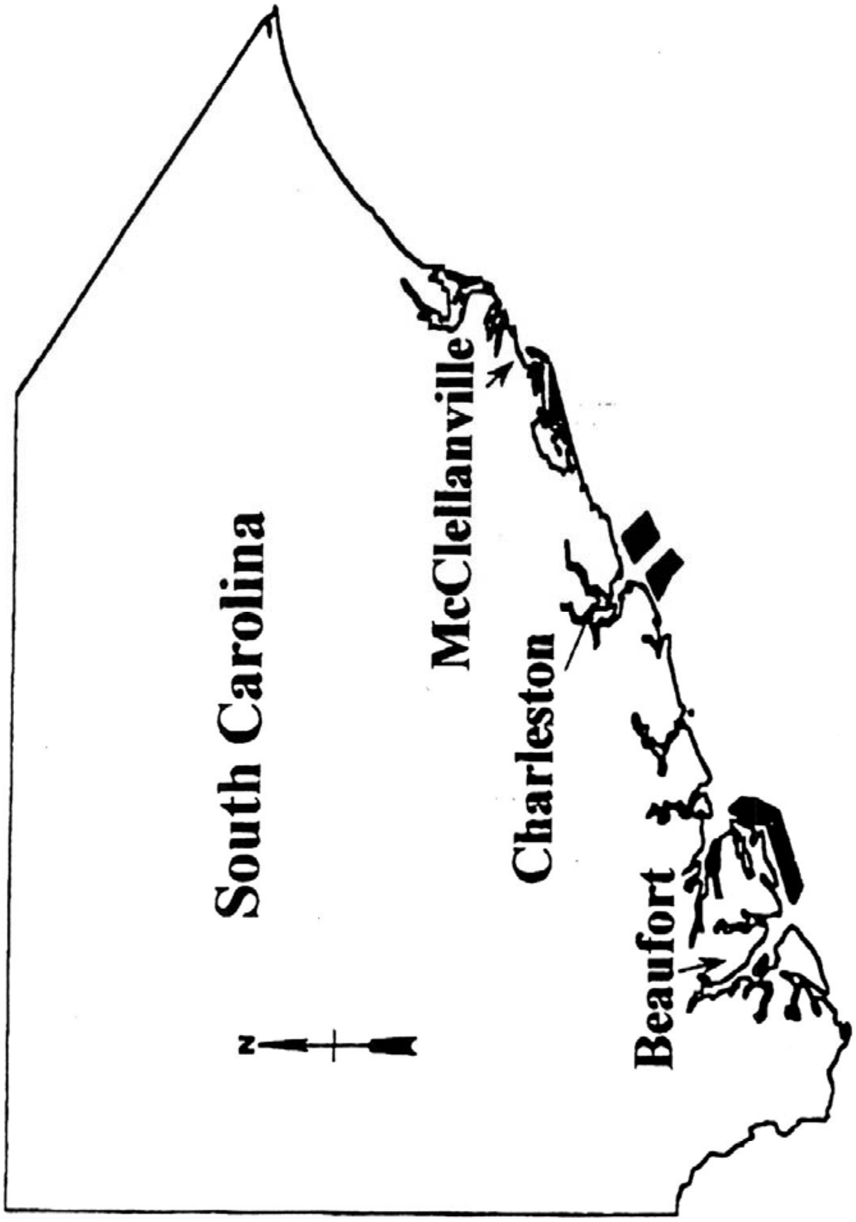
Zar, J. H. (1984). Biostatistical analysis. Prentice Hall, New Jersey,718 p.

Table 1. Estimated number of age-0 king and Spanish mackerel incidentally harvested as bycatch by South Carolina shrimp trawlers, 1981 – 1995.

Year	Shrimp catch (kg)	Estimated effort (hours)	Number of drags	King mackerel age-0	Spanish mackerel age-0
1981	1,331,270	378,613	131,463	77,771	216,512
1982	2,407,364	684,651	237,726	140,634	391,522
1983	2,448,759	696,424	241,814	143,052	398,254
1984	1,058,803	301,124	104,557	61,854	172,199
1985	1,538,125	437,442	151,889	89,855	250,153
1986	2,758,115	784,404	272,363	161,124	448,566
1987	2,582,149	734,360	254,986	150,845	419,947
1988	1,966,604	559,300	194,201	114,886	319,839
1989	3,297,190	937,716	325,596	192,616	536,238
1990	2,627,996	747,398	259,513	153,523	427,404
1991	4,184,475	1,190,058	413,215	244,449	680,541
1992	3,003,504	854,192	296,594	175,459	488,474
1993	3,758,410	1,068,886	371,141	219,559	611,248
1994	2,461,389	700,016	243,061	143,790	400,308
1995	4,829,650	1,373,544	476,925	282,139	785,468

Table 2. Estimated number of age-0 king and Spanish mackerel incidentally harvested as bycatc
Atlantic shrimp trawlers, 1981 – 1995.

Year	Shrimp catch (kg)	Estimated effort (hours)	Number of drags	Unadjusted King mackerel age-0	Adjusted King mackerel age-0	Unadjusted Spanish mackerel age-0
1981	5,943,847	1,690,419	586,951	347,230	804,256	966,679
1982	9,355,302	2,660,630	923,830	546,520	951,400	1,521,499
1983	9,635,867	2,740,422	951,535	562,910	1,004,807	1,567,127
1984	5,500,770	1,564,409	543,198	321,346	664,953	894,619
1985	10,996,508	3,127,385	1,085,898	642,397	1,164,441	1,788,416
1986	9,620,567	2,736,070	950,024	562,017	961,487	1,564,641
1987	8,544,061	2,429,914	843,720	499,129	898,664	1,389,562
1988	9,693,795	2,756,896	957,256	566,294	1,044,436	1,576,548
1989	11,693,430	3,325,588	1,154,718	683,109	1,182,496	1,901,759
1990	9,226,780	2,624,078	911,138	539,013	876,191	1,500,598
1991	18,369,988	5,224,387	1,814,023	1,073,141	2,938,658	2,987,597
1992	14,093,202	4,008,078	1,391,694	823,299	2,590,767	2,292,045
1993	16,338,918	4,646,755	1,613,456	954,489	3,026,268	2,657,275
1994	14,980,889	4,260,534	1,479,352	875,315	2,945,085	2,436,857
1995	15,996,950	4,549,500	1,579,687	934,512	1,795,500	2,601,658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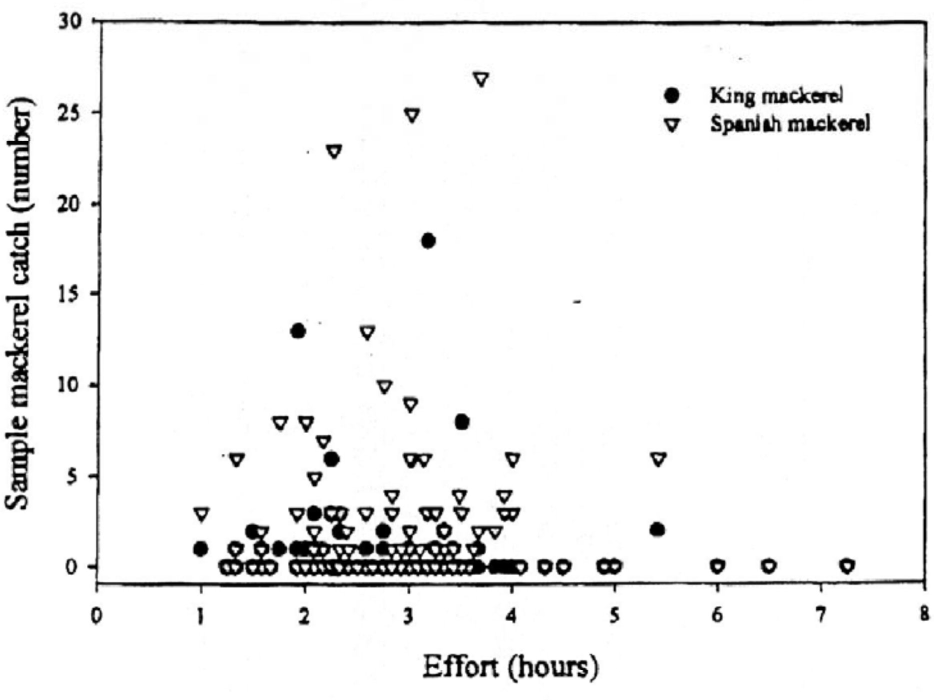

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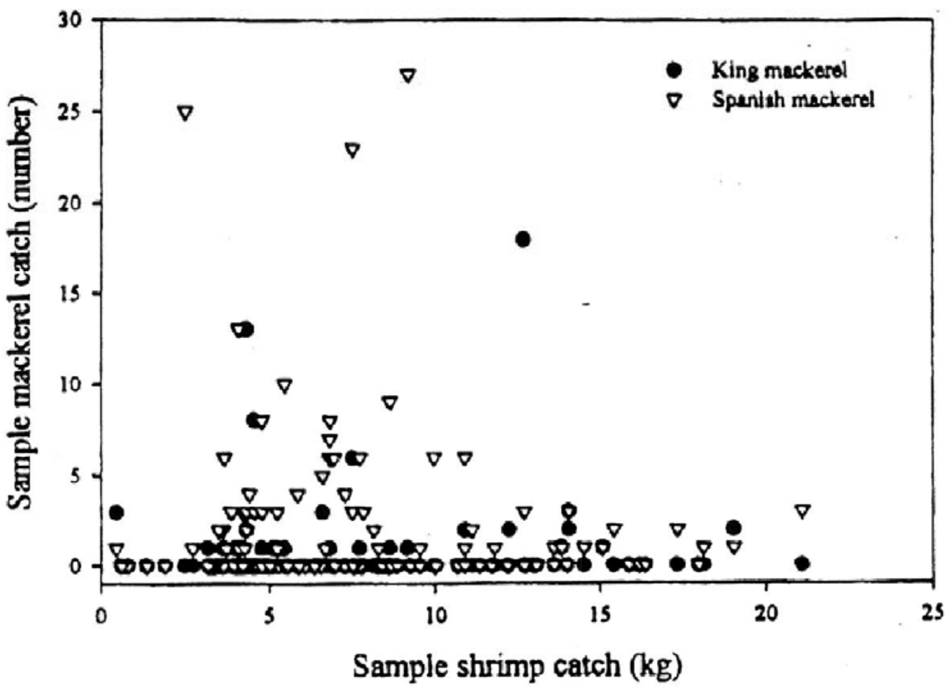

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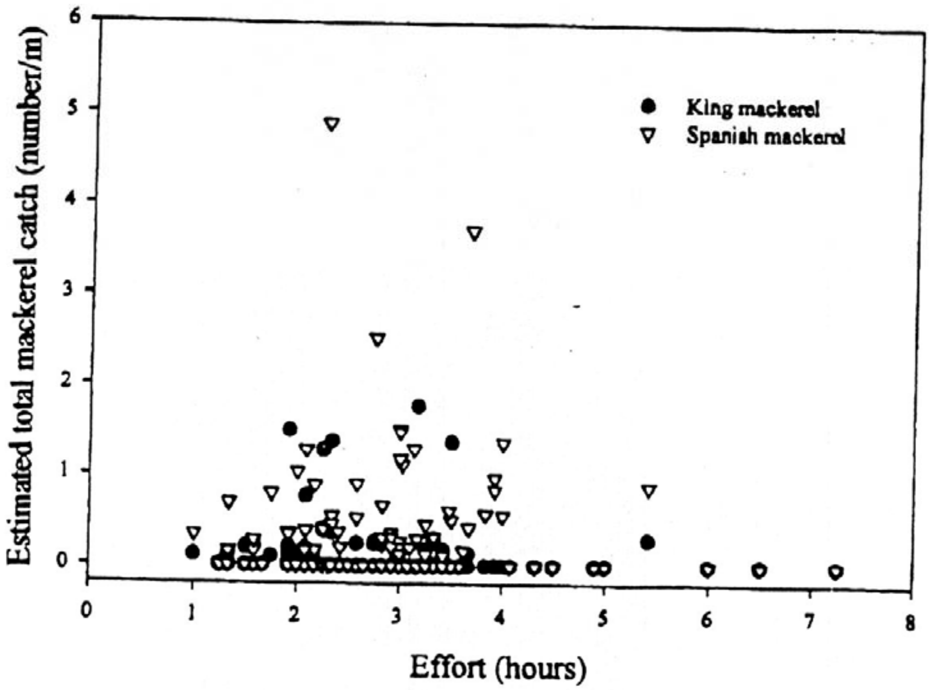
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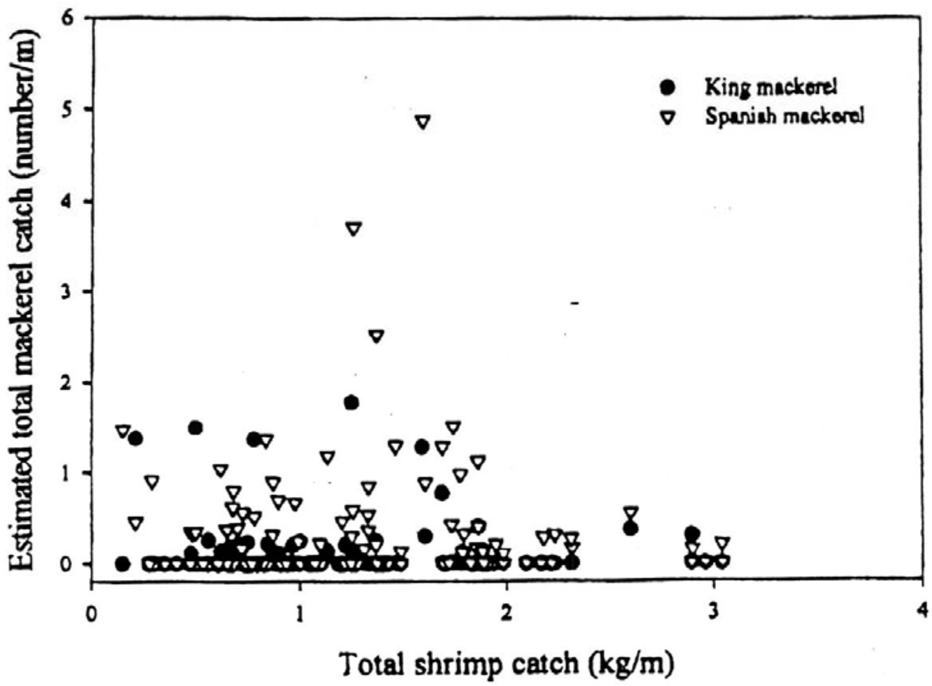

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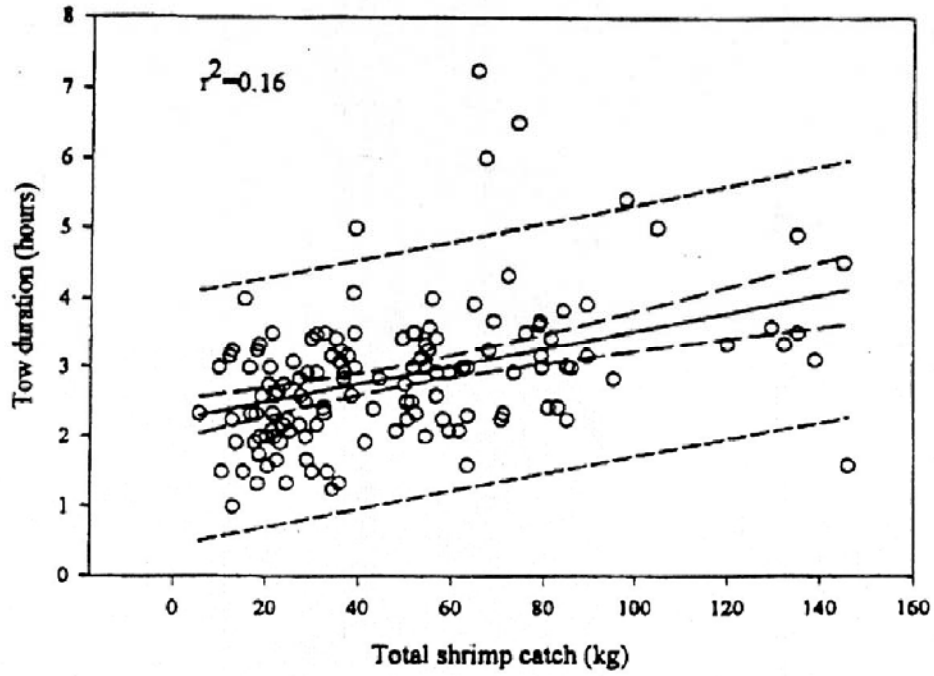

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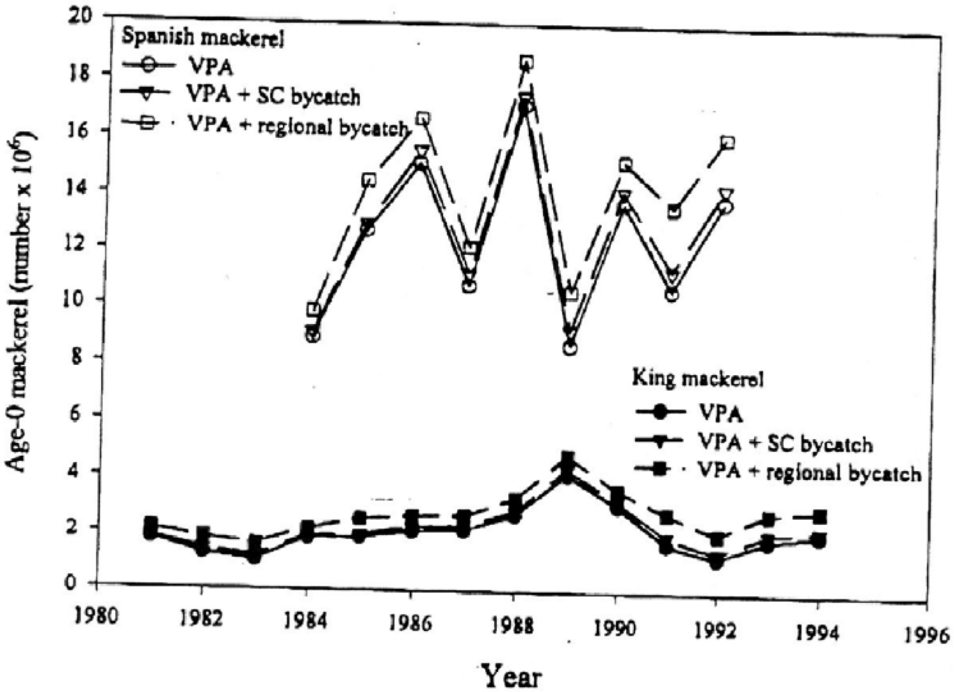

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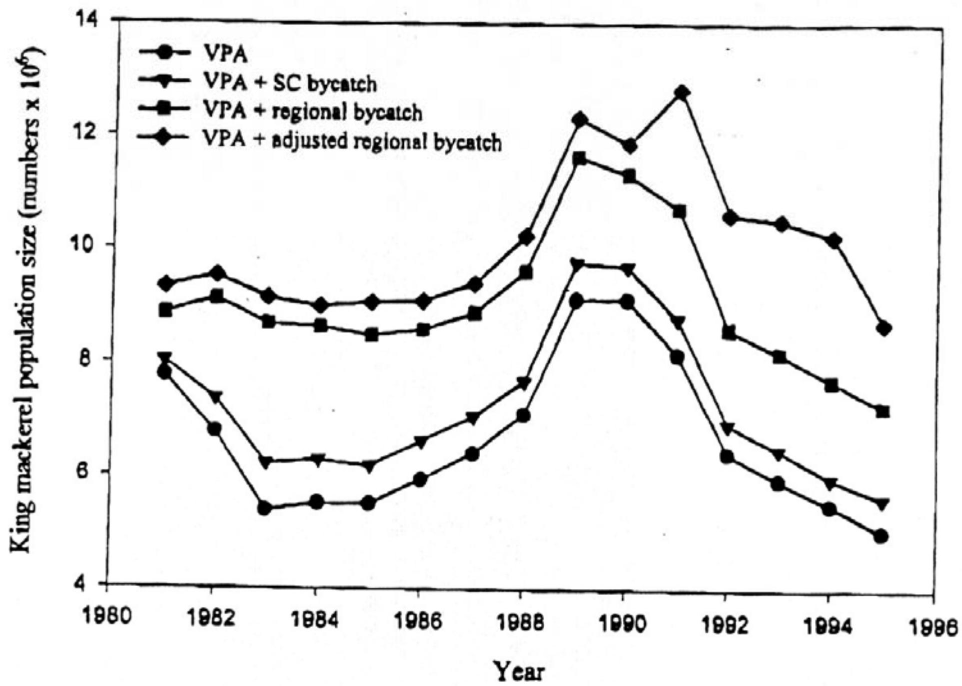

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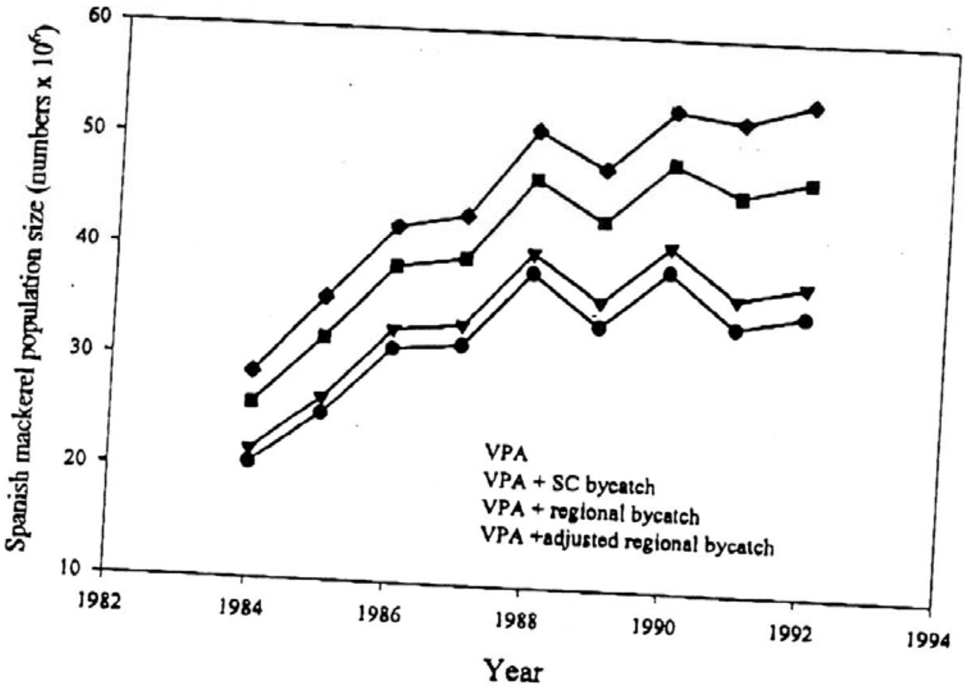

List of Figures

Appendix M. Characterization of King Mackerel and Spanish Mackerel By-Catches of South Carolina Shrimp Trawlers (North American Journal of Fisheries Management, 1998)

North American Journal of Fisheries Management 18:439–453, 1998

Characterization of King Mackerel and Spanish Mackerel Bycatches of South Carolina Shrimp Trawlers

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Abstract.—Juvenile king mackerel *Scomberomorus cavalla* and Spanish mackerel *S. maculatus* are caught by commercial shrimp trawlers in South Carolina. Our study documented the extent and duration of this bycatch during the commercial shrimp trawling season in South Carolina waters. Sampling was conducted onboard commercial shrimp vessels based in McClellanville, South Carolina, during 1991 and on vessels based in McClellanville, Charleston, and Beaufort in 1992. Eight vessels and 137 trawl tows (mean tow duration, 2.88 h) were sampled; 81 king and 257 Spanish mackerel were collected. The mean annual sample catch per unit effort (CPUE) of king mackerel was 0.244 fish/h; adjusted for trawl footrope length in meters, the mean annual total CPUE was 0.038 fish/(h·m). King mackerel were found in only 21% of the tow samples, and peak catches occurred in October 1991 and September 1992. The mean annual sample CPUE for Spanish mackerel was 0.701 fish/h, and the mean annual total CPUE was 0.109 fish/(h·m). Spanish mackerel were found in 41% of the tow samples, and peak catches occurred in July of both years. Age-0 king mackerel are vulnerable to shrimping gear for at least half of the South Carolina shrimp season, which generally runs from May through December, and age-0 Spanish mackerel are vulnerable for most of the shrimping season.

King mackerel *Scomberomorus cavalla* and Spanish mackerel *S. maculatus* are widely distributed pelagic species in the western Atlantic Ocean (Collette et al. 1978; Collette and Russo 1984; Robins and Ray 1986). King mackerel ranges from the Gulf of Maine to southern Brazil, including the northern Gulf of Mexico and most of the West Indies (Erdman 1949). Spanish mackerel is found from Cape Cod, Massachusetts, to southern Florida and throughout the Gulf of Mexico, but is absent from the Bahamas and West Indies except for Cuba and Haiti (Robins and Ray 1986). Both species are highly migratory (GMFMC and SAFMC 1985; Fable et al. 1987; Sutter et al. 1991) and therefore vulnerable to exploitation in several jurisdictions. A single stock of each species, referred to as the Atlantic group king mackerel and Atlantic group Spanish mackerel, is thought to exist off the east coast of the United States (GMFMC and SAFMC 1985; Sutter et al. 1991). The Atlantic stocks of both king and Spanish mackerels are heavily exploited, and the Spanish mackerel stcok was classified as overfished by the South Atlantic Fishery Management Council (SAFMC) during 1983–1990 (MSAP 1992). Successful management since 1983 brought the spawning stock ratio (the spawner biomass ratio of current to unexploited stocks) of this species above 30% (SAFMC's criterion for overfishing) in 1992, and the ratio has since remained above this level for both species.

Commercially important white shrimp *Penaeus setiferus*, brown shrimp *P. duorarum*, and pink shrimp *P. aztecus* likewise are widely distributed through the northwest Atlantic Ocean and Gulf of Mexico (Upton et al. 1992). They are important fishery resources throughout their range; however, a variety of finfish and invertebrate species are caught as bycatch in the otter trawls used for commercial harvesting of shrimp in the southeastern United States.

Juvenile king and Spanish mackerels are among the fish species taken as bycatch in shrimp trawls (Keiser 1976; Collins and Wenner 1988). Juveniles of both mackerel species commonly are found near shore in depths less than 25 m (Grimes et al. 1990), which also are the primary penaeid shrimping areas (SAFMC 1981). The spawning season for Atlantic group mackerels extends from May through at least September (Finucane et al. 1986; Schmidt et al. 1993), suggesting that juvenile mackerels could be present in shrimping areas as early as

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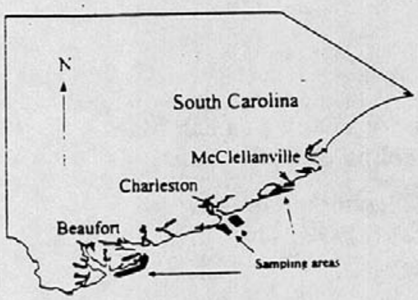

FIGURE 1.—South Carolina shrimping grounds sampled during 1991 and 1992.

May and as late as November. The South Carolina nearshore (<10 m depths) commercial shrimp season usually runs from May to December (Keiser 1976; Collins and Wenner 1988). Collins and Wenner (1988) reported that a greater number of juvenile king and Spanish mackerels were taken as bycatch in tongue nets than in flat (two-seam) nets (see Stender and Barans 1994 for a complete description of these gear types). Tongue nets have essentially replaced the traditional flat and semi-balloon trawl nets during the spring and fall white shrimp seasons, and some vessels use them for the summer brown shrimp season (Edwards 1987; personal observations). The growing use of tongue nets in areas where juvenile mackerels occur could be increasing the premature harvest of these fish. However, no recent study has characterized the mackerel bycatch of the commercial shrimp fleet in the South Atlantic Bight (Cape Hatteras, North Carolina, to Cape Canaveral, Florida).

This paper describes the mackerel bycatches in South Carolina commercial shrimp trawls during 1991–1992, when we examined the age and size frequency of the bycatch to determine when and where juvenile mackerel are most vulnerable to shrimp gear. Our results obtained are compared with those of previous studies to identify any trends in the bycatch of king and Spanish mackerel off the coast of South Carolina.

Methods

The study covered most of the South Carolina shrimping seasons of 1991 and 1992. Sampling was conducted 1 June–31 December 1991 and 15 May–31 December 1992. Sampling was restricted to McClellanville in 1991, but was extended to Charleston and Beaufort in 1992 (Figure 1). All fish sampling was done on the water.

Only commercial boats that returned to the dock each day after shrimping were sampled. The 1991 sampling period was divided into a series of 7-d periods and one sampling day was randomly chosen within each period. If a sample day was missed for any reason, sampling was done on the first subsequent day on which it could be performed.

In 1991, the intent was to randomly select a boat each sample day from among 12 based in McClellanville whose captains had agreed to cooperate. Each boat was to have an equal chance of being chosen every sample day. However, some of the promised cooperation did not materialize, and the available pool of boats was much less than 12 in practice. All tows performed by the selected vessel were treated as separate samples. A tow was defined as the catch of all nets deployed except the trynet. Tow duration was measured from the time the trawl doors entered the water on a set until the doors emerged from the water on net retrieval.

In 1992 sampling periodicity was maintained at one sample day per 7-d period for each location. If the same day was chosen for sampling in different locations, the more southerly location was sampled the following day. Due to limited cooperation from shrimpers in 1991, sampling was restricted to two or three consistently cooperative vessels at each location in 1992.

Eight different commercial shrimp boats were sampled during the study. The size of the boats ranged from 14 to 22 m and engines ranged from 180 to 365 horsepower (Table 1). Four boats were sampled in McClellanville (two in 1991 and three in 1992; one boat was sampled both years). Two boats were sampled in Charleston and two boats in Beaufort.

Two vessel types were encountered during the study: so-called table boats and deck boats. Different sampling methods were required for each. On table boats, the catch is released onto a waist-high table (generally 3–6 m^2), which usually opens over the stern of the boat. The crew standing at the table sorts the catch and unwanted bycatch is discarded. To obtain a sample, a portion of the catch in a corner of the table was separated from the remainder of the catch with two 61- × 15-cm boards fixed in an 'L' shape, thereby isolating a 0.37-m^2 square of catch (Figure 2). The 'L' boards were positioned after the catch from all nets had been released onto the table, but not sorted. This sample was then processed while the crew sorted the remainder of the catch.

On deck boats, the catch is released onto and

TABLE 1.—Details of South Carolina shrimp vessels sampled during the 1991 and 1992 study periods. Turtle excluder devices (TEDs) were Morrison Soft (MS) or Georgia Jumper (GJ).

			White shrimp gear			Brown shrimp gear		
Boat	Length (m)	Boat type	Net type, number	Footrope length (m)	TED type	Net type, number	Footrope length (m)	TED type
1	15.2	Table	Tongue, 2	30.5	MS	Flat, 2	30.5	MS
2	14	Deck	Tongue, 2	30.5	GJ	Flat, 4	37	GJ
3	21.9	Deck	Tongue, 2	45.7	MS	Flat, 2	45.7	MS
4	20.7	Deck	Tongue, 4	61	GJ	Not sampled		
5	20.7	Table	Tongue, 4	67	MS	Tongue, 4	67	GJ
6	17.7	Deck	Tongue, 4	54.9	MS	Tongue, 4	54.9	MS
7	15.2	Deck	Tongue, 4	30.5	MS	Flat, 2	34	MS
8	15	Deck	Tongue, 4	28	MS	Flat, 2	32	MS

sorted on the deck. Unwanted bycatch is pushed overboard after all shrimp and other desirable species have been removed. An open-ended wooden rectangle (183 × 61 × 15 cm) was placed on the deck and pushed into the unsorted catch pile until it was one-third to one-half full (Figure 2). Organisms lying at the opening of the rectangle were moved into the rectangle if more than 50% of their bodies lay within the rectangle; a board was then used to close off the rectangle from the remainder of the catch. The isolated sample was then sorted. We compared weights of fish and shrimp obtained by the two sampling methods at each location with two-tailed t-tests ($\alpha = 0.05$).

All boats used tongue nets during the spring and fall white shrimp seasons. Most boats used flat nets during the summer brown shrimp season (July and August). Both boats in Beaufort used tongue nets throughout the season. Only two types of turtle excluder device (TED) were encountered: the Morrison Soft (a large-mesh panel with a top-opening escape slot, Christian et al. 1989) and the Georgia Jumper (a rigid grid with a bottom-opening escape panel; Renuad et al. 1992). Most vessels used the same TED regardless of net type (Table 1). Three of the boats sampled used two nets throughout the season and three boats used four nets throughout the season. One boat towed four flat nets during the brown shrimp season, and two tongue nets during the white shrimp seasons. Footrope lengths ranged from 25.4 to 55.8 m. Tow speed was generally 1–1.5 m/s.

Shrimp, other invertebrates, and fish were separated from each sample, and each group was weighed on a Pelouze top pan spring balance accurate to 50 g. King and Spanish mackerel were separated from the sample, measured (mm fork length, FL) and kept on ice for weighing onshore. When time permitted, mackerel also were collected from the remainder of the catch for age and growth analyses. The total shrimp catch from each tow was weighed.

Several aspects of the fishing operation were recorded for each tow including start time and duration of each tow. All tows were made during daylight hours because South Carolina allows shrimping between 0500 and 2100 hours from opening day until 16 September and between 0600 and 1900 hours from 16 September until the season is closed. Tow locations were recorded when the study first began but this was discontinued because towing occurred in limited areas near the ports (Figure 1). Tow speeds were calculated from loran-C coordinates and represent speed over the bottom, not through the water. Net type and number, TED type, and net footrope length were recorded for each tow.

For each mackerel species, the mackerel-to-shrimp ratio in each sample (MSR_s) was calculated as

$$MSR_s = M_s/S_s;$$

S_s = sample shrimp weight;
M_s = the number of king or Spanish mackerel in the sample.

The total catch (number of fish) of each mackerel spcies (M_t) in each tow was estimated from the total shrimp weight in the tow (S_t):

$$M_t = S_t \cdot MSR_s$$

The accuracy and precision of estimating the total mackerel catch was indirectly tested by weighing the total fish catch taken (all species) in 25 tows and then comparing the estimated fish weight to the actual fish weight via simple least-squares linear regression and single-factor analysis of variance (ANOVA).

FIGURE 2.—Sampling techniques employed on (top) table boats and (bottom) deck boats. The hatched area on the table depicts the portion of the catch sampled.

The sample mackerel catch per unit effort (CPUE, fish per hour) was calculated for each species separately for each tow as:

$$\text{CPUE}_s = M_s/h;$$

h = the tow duration in hours.

The CPUE for the estimated total mackerel catch per tow (CPUE_t, each species separately) was partially standardized for net size by including the total footrope length (f, meters) in the formula, giving catch per hour per meter of footrope:

$$\text{CPUE}_t = M_t/(h \cdot f).$$

Mean sample and estimated total CPUEs were calculated for each month. Mean monthly sample and estimated total CPUEs for king and Spanish mackerel were tested for differences among months at each location for each year of the study—and between locations by month and year—with Kruskal–Wallace tests ($\alpha = 0.05$). Mean annual CPUEs (sample and total catch) were tested for differences among locations with a Kruskal–Wallace test and between net types (tongue and flat) with a Mann–Whitney rank sum test.

For purposes of comparing our data with those of earlier years, the sample catches of king and Spanish mackerel were combined for each month by year and location. The merged monthly value was converted to a percentage of the sum of all sample weights over the 2-year study. These data were compared to the percentage of sample king and Spanish mackerel reported for 1974 and 1975 by Keiser (1976).

Mackerel removed from the shrimp vessel were weighed in the laboratory (0.1 g), and remeasured (FL) to determine if shrinkage had occurred. Sagittal otoliths were removed from each king mackerel, cleaned with a dilute solution of sodium hypochlorite (one-tenth-strength household bleach), and stored dry in individual vials. Otoliths were mounted in epoxy resin and hand polished to thin transverse sections (about 2 μm) at the core as described by Secor et al. (1992).

Prepared king mackerel otoliths were examined for daily growth increments under a Nikon Labophot microscope and an Olympus BK-12 microscope at 400× and 1,000× (oil immersion) magnification. Each otolith was read twice by two readers. If counts differed by more than five increments, each reader recounted the otolith, and if the difference persisted, that otolith was discarded from further analysis. Individual growth rates were estimated from the age and length at capture. Larval hatch dates were back-calculated from age estimates and date of capture for each fish, and data from both years were pooled to determine periods of king mackerel spawning activity.

TABLE 2.—Number and duration of the trawl tows sampled during the 1991 and 1992 South Carolina shrimp seasons. The asterisk denotes a mean tow time significantly different from the others (Kruskal–Wallace test, $P < 0.05$).

Location	Year	Tows sampled (number)	Time of sampled tows (h)	
			Total	Mean (SD)
McClellanville	1991	60	137.13	2.285 (0.619)*
McClellanville	1992	17	54.33	3.195 (0.425)
Charleston	1992	47	163.23	3.473 (1.088)
Beaufort	1992	13	39.14	3.010 (0.942)
All		137	393.83	2.88 (0.99)

Results

The durations of 137 tows sampled during the study ranged from 1.0 to 7.25 h. The average tow duration (±1 SD) for all three areas and both years was 2.88 ± 0.99 h (Table 2).

In McClellanville, the table sample size averaged 26.5% of the catch (SD = 6.5%, N = 48; percentages were based on the ratio of shrimp sample weight to shrimp total catch weight) with a range of 11.1% to 50.7%. The table method was used on two boats in McClellanville and one boat in Beaufort. In Beaufort, where the total catches were larger, the sample size averaged 9.9% of the catch (SD = 6.4%, N = 12), ranging from 3.3% to 25.3%. The deck method was used on the remaining boats. The deck sample size averaged 18.5% (SD = 6.5%, N = 26, range = 7.9–29.4%) in McClellanville and 13.2% (SD = 4.9%, N = 47, range = 1.5–27.3%) in Charleston.

A comparison of the two sampling methods used in McClellanville in 1991 indicated that sample weights of shrimp and finfish (standardized to an hour of towing) did not differ significantly between the methods (t-test of $\log_{10}$-transformed weights, $P > 0.05$). The two sampling methodologies were therefore considered similar enough to allow direct comparisons of all tows sampled.

Multiplying the sample mackerel-to-shrimp ratio by the total shrimp catch provided a valid estimate of the total mackerel catch for each tow. The r^2 value for the relationship of estimated total fish weight to actual fish weight was high (0.87), and the ANOVA for the regression was highly significant ($P < 0.0001$). A single-factor ANOVA

TABLE 3.—King and Spanish mackerel catches in shrimp trawls by location for 1991 and 1992. Standard deviations are in parentheses; CPUE is catch per unit effort (total CPUE is standardized to a meter of net footrope). Within a column (species independently), mean locational CPUEs with a letter in common are not significantly different (P > 0.05; Kruskal–Wallace tests with Dunn's pairwise or Tukey's multiple comparisons).

Location	Tows sampled (number)	Tows with mackerel (number)	Mackerel sampled (number)	Estimated total catch	Total catch per tow	Sample CPUE (number/h)	Total CPUE (number/(h·m))
				King mackerel			
McClellanville 1991	60	20	60	284	4.73	0.45 (1.19) z	0.07 (0.03) z
McClellanville 1992	17	2	10	49	2.88	0.18 (0.57) zy	0.03 (0.01) y
Charleston	47	6	10	68	1.45	0.07 (0.23) zy	0.01 (0.001) y
Beaufort	13	1	1	8	0.62	0.02 (0.08) y	0.003 (0.0001) y
All	137	29	81	409	2.99	0.24 (0.84)	0.04 (0.01)
				Spanish mackerel			
McClellanville 1991	60	19	99	591	5.97	0.79 (1.73) z	0.13 (0.11) z
McClellanville 1992	17	4	8	36	4.50	0.14 (0.28) z	0.02 (0.003) z
Charleston	47	22	60	477	7.95	0.41 (0.66) z	0.07 (0.01) z
Beaufort	13	11	84	641	7.63	2.08 (2.87) y	0.24 (0.07) y
All	137	56	251	1,745	12.74	0.70 (1.56) z	0.11 (0.06) z

showed no significant differences between measured total fish weight and predicted fish weight ($P = 0.51$).

The 81 king mackerel collected appeared in 21% of the 137 tows sampled (Table 3). Most were collected in McClellanville in 1991 (74.1%, Table 3), but were present in only 20 of the 60 tows sampled there. In 1992, only 21 king mackerel were collected, of which 47.6% were caught in Charleston. The grand mean sample CPUE (SD in parentheses) was 0.24 fish/h (0.84), and the grand mean total CPUE was 0.04 fish/(h·m) (0.01) (Table 3). The mean annual sample CPUE was significantly higher in McClellanville in 1991 than in Beaufort and no other significant differences in this index between locations were apparent (Table 3). However, the mean annual total CPUE for McClellanville 1991 was significantly greater than that recorded in any other locations.

Monthly king mackerel CPUEs varied by year. Off McClellanville in 1991, sample and total CPUEs peaked in October after lows in September (Figure 3). In 1992, sample and total CPUEs appeared to peak in September in McClellanville and Charleston (Figure 3). No king mackerel were collected in May, June, November, or December in any location during either year. There were no significant differences in sample or total CPUEs between any months ($P > 0.05$).

The 251 Spanish mackerel collected appeared in 41% of the 137 tows sampled (Table 3). More (39%) were collected in McClellanville in 1991 than in any other location. The grand mean annual sample CPUE was 0.70 fish/h (1.56), and the grand mean annual total CPUE was 0.11 fish/(h·m) (0.06). Mean annual sample and total CPUEs were significantly higher for Beaufort than for any other location (Table 3).

Monthly Spanish mackerel CPUEs varied by location. Both sample and total CPUEs peaked in July off McClellanville (1991) and Beaufort (1992) but in September off Charleston (1992) and McClellanville 1992 (Figure 4). Some Spanish mackerel were sampled in all months of the fishing season except December. The two July CPUEs in Beaufort were respectively the highest recorded; they were significantly larger than those for November and December in Charleston and for June in McClellanville in 1991 ($P < 0.01$, Dunn's pairwise comparison). In McClellanville 1991 and Beaufort, the high catches in July were followed by a gradual decline until the end of sampling in December (Figure 4). The catch pattern for Charleston was quite different, small numbers of Spanish mackerel being caught during all months.

No significant differences were detected among months for king mackerel when sample or total CPUE data were pooled over 1991 and 1992 (Table 4). Catches of king mackerel peaked in October. Presence–absence analysis did not identify any seasonal trends in the bycatch of juvenile king mackerel. The pooled monthly sample CPUE for Spanish mackerel was significantly larger in July than in October (Table 4), but no significant differences were apparent in the pooled monthly total CPUEs. Presence–absence analysis suggested that the bycatch of Spanish mackerel increased until

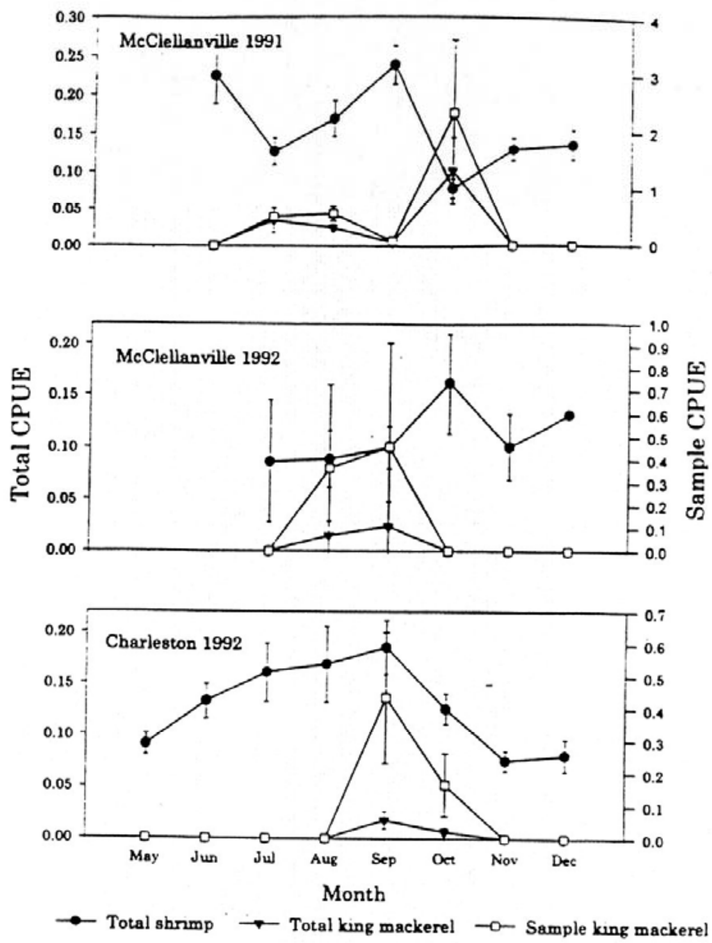

FIGURE 3.—Mean monthly sample catches per unit effort (CPUE, number/h) and estimated total CPUE (number/[h·m], adjusted for net footrope length) of king mackerel and total shrimp CPUE by month off McClellanville and Charleston during 1991 and 1992. Error bars are SEs.

July, was constant through summer and fall, and declined with the approach of winter.

No significant differences in CPUE—sample or total, either species—between net types emerged ($P > 0.05$, Table 5). This was true within locations and for all locations combined (Table 5).

We collected 188 king mackerel, ranging from 80 to 180 mm FL, for age and growth analysis, including 107 specimens from the portion of the catch not sampled. The mean length was 130.2 mm FL (SD, 6.3), with a peak between 145 and 150 mm FL. King mackerel greater than 150 mm FL were rare in the catches (only 22 fish), and none larger than 180 mm FL were sampled. Larger juvenile king mackerel were caught during July and August than in September and October (Figure 5). Mean fork lengths were larger in July (139 mm) than in September (115 mm). These were the only months in which the mean fork lengths were significantly different ($P < 0.01$, Tukey comparison).

The mean age of the 126 king mackerel successfully aged was 36 d (SD, 6.3 d); the range was 23–55 d (Figure 6). The trend in the age-frequency distribution was similar to that of the length fre-

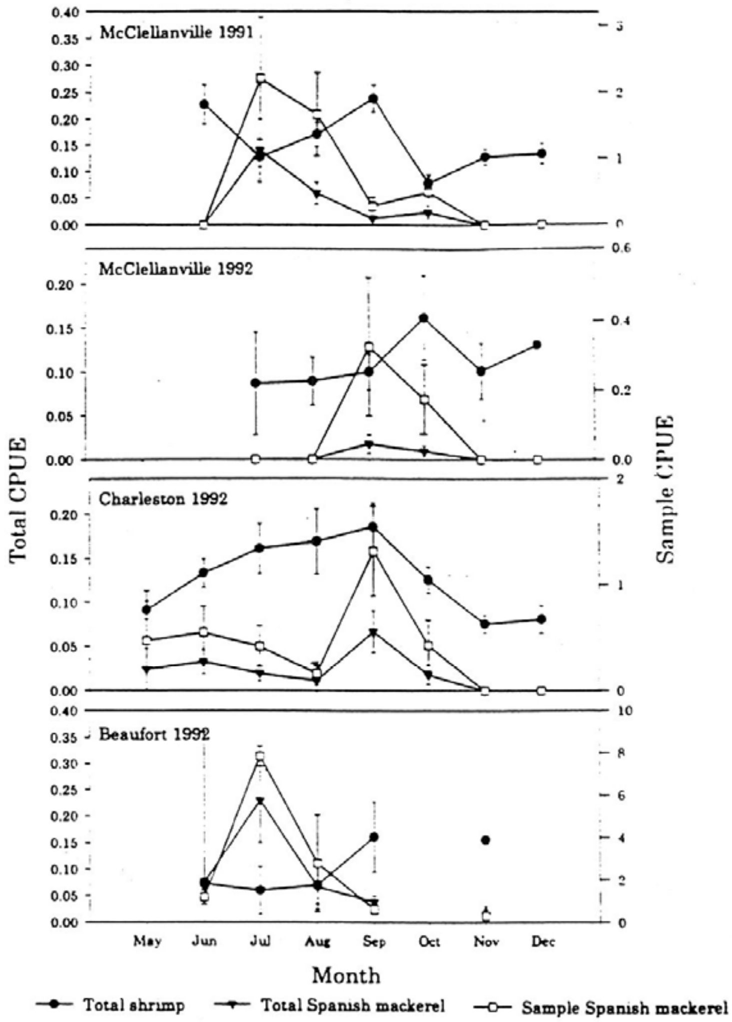

FIGURE 4.—Mean monthly sample catches per unit effort (CPUE, number/h) and estimated total CPUE (number/[h·m], adjusted for net footrope length) of Spanish mackerel and total shrimp CPUE by month at four South Carolina locations during 1991 and 1992. Error bars are SEs.

quency distribution. King mackerel became more vulnerable to the gear with age up to ages 35–37 d old. Catches of king mackerel became progressively smaller as the fish aged further, although the decline appeared more gradual than for length distributions. The mean estimated daily growth rate was 3.5 mm/d (SD, 0.7 mm); the range was 2.7–6.1 mm/d.

Based on the hatch dates, king mackerel spawned throughout the summer, beginning in early May and ending in mid-September. Peak spawning in May–June was indicated, but a smaller resurgence occurred in August–September (Figure 7).

We collected 456 Spanish mackerel, ranging from 95 to 380 mm FL, including 205 specimens from the portion of the catch not sampled. The mean length was 161.8 mm FL (SD, 46.9); the

TABLE 4.—Mean monthly sample and total catches per unit effort (CPUE) of king and Spanish mackerel caught in South Carolina shrimp trawls, pooled over 1991 and 1992 (SDs are in parentheses). Sample CPUE is fish/h. Total CPUE is adjusted for net footrope length: (fish/[h·m]). Within a CPUE column, values without a letter in common are not significantly different ($P > 0.05$, Kruskal–Wallace tests with Dunn's pairwise comparisons).

Month	Tows sampled (number)	King mackerel: Tows with mackerel (percent)	King mackerel: Sample CPUE	King mackerel: Total CPUE	Spanish mackerel: Tows with mackerel (percent)	Spanish mackerel: Sample CPUE	Spanish mackerel: Total CPUE
May	3	0			33	0.471 (0.82) zy	0.078 (0.02) z
June	17	0			41	0.394 (0.62) zy	0.079 (0.02) z
July	22	32	0.273 (0.63) z	0.058 (0.02) z	59	1.944 (2.99) z	0.319 (0.26) z
August	21	43	0.315 (0.420) z	0.043 (0.01) z	52	1.106 (1.77) zy	0.126 (0.03) z
September	29	24	0.208 (0.50) z	0.033 (0.01) z	55	0.052 (0.73) zy	0.093 (0.02) z
October	14	43	1.052 (2.23) z	0.148 (0.08) z	57	0.381 (0.49) y	0.059 (0.01) z
November	19	0			5	0.032 (0.14) zy	0.005 (0.01) z
December	12	0			0		

peak was between 140 and 145 mm and the median was 148 mm. There were no statistically significant trends in the monthly catch patterns (Figure 8).

Spanish mackerel constituted a smaller percentage of the total sample in 1991–1992 than in 1974 (Keiser 1976), whereas the percentage of king mackerel in the sample was similar between studies (Figure 9). Catch patterns showed a peak in July for Spanish mackerel in both studies, but the peak catch of king mackerel shifted to October in the 1990s from September in the 1970s.

Discussion

Limited cooperation from area shrimpers resulted in few boats participating in the study. Although we only sampled two or three vessels in each location per year, the rapport and good working routine established aboard these vessels resulted in samples being collected easily and efficiently. In limiting sampling to a few vessels, however, some bias was introduced because other shrimpers may have fished with slightly different gears which could have yielded different catches (Rulifson et al. 1992). However, as long as the bias was constant aboard a vessel, we were able to identify trends in the data. In both years we were able to sample the bulk of the shrimp season, which typically is open from 15 May to sometime in January (SAFMC 1997). We were unable to maintain our sampling schedule for Beaufort and McClellanville in 1992; we collected no samples off McClellanville in May and June or off Beaufort in October and December.

In our extrapolation of sampling catch per tow to total catch, we assumed that the catch was randomly sampled and that both species of mackerel occurred randomly in the catch. The good correlation between the estimated total fish catch and the actual total fish catch suggests the sample was representative of the entire catch. Once entrained by the fishing gear, mackerel may swim at the mouth of the net, maintaining their school, until they are exhausted or the gear is retrieved (Wardle

TABLE 5.—Mean catches per unit effort (CPUE) of king and Spanish mackerel by shrimp net type (tongue or flat) for McClellanville 1991 and Charleston 1992, South Carolina. Sample CPUE is fish/h; total CPUE (adjusted for footrope length) is fish/(h·m). Beaufort and McClellanville 1992 were excluded from the regional analysis because fewer than five tows with flat nets were sampled in each location. "Overall" includes all tows sampled from all locations. Standard deviations are shown in parentheses.

Location	King mackerel: Sample CPUE: Tongue	King mackerel: Sample CPUE: Flat	King mackerel: Total CPUE: Tongue	King mackerel: Total CPUE: Flat	Spanish mackerel: Sample CPUE: Tongue	Spanish mackerel: Sample CPUE: Flat	Spanish mackerel: Total CPUE: Tongue	Spanish mackerel: Total CPUE: Flat
McClellanville, 1991	0.479 (1.33)	0.359 (0.72)	0.068 (0.03)	0.077 (0.03)	0.526 (1.16)	1.510 (2.69)	0.067 (0.04)	0.317 (0.32)
Charleston, 1992	0.102 (0.27)	0	0.014 (0.001)	0	0.480 (0.76)	0.271 (0.39)	0.081 (0.02)	0.051 (0.005)
Overall	0.272 (0.94)	0.170 (0.51)	0.045 (0.18)	0.04 (0.01)	0.545 (1.14)	1.107 (2.33)	0.076 (0.02)	0.188 (0.182)

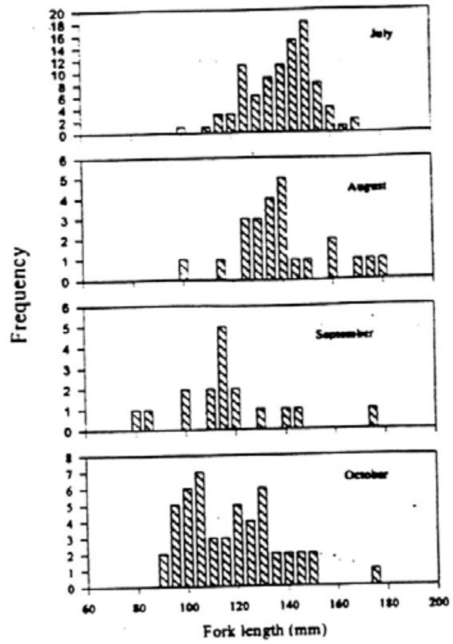

FIGURE 5.—Monthly length frequencies of king mackerel collected at all South Carolina locations by month pooled over 1991 and 1992.

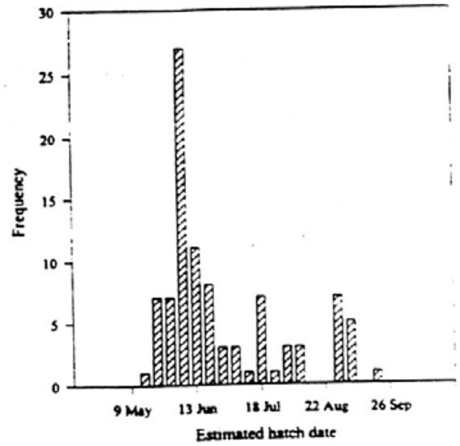

FIGURE 7.—Estimated hatch dates for king mackerel sampled from South Carolina shrimp trawls during 1991 and 1992.

1993). At either time, mackerel would be swept through to the codend of the net, where they would be layered in the catch. Thus, if the codend were held up vertically, the mackerel would be randomly distributed horizontally, but not necessarily vertically. The sampling methodology used specifically addressed the problem of the potential lack

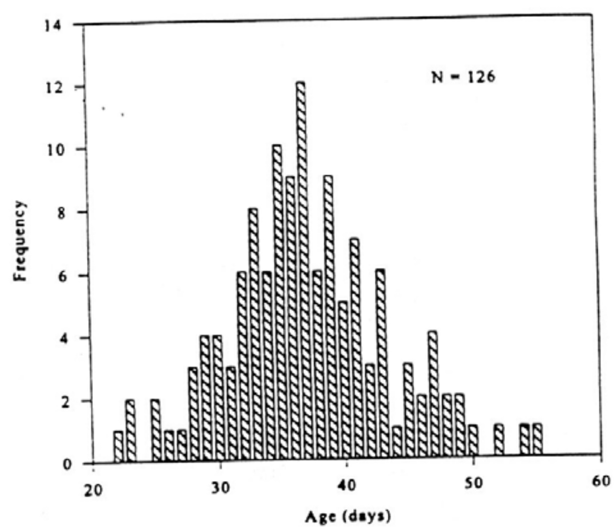

FIGURE 6.—Age frequency of king mackerel collected at all South Carolina locations during 1991 and 1992.

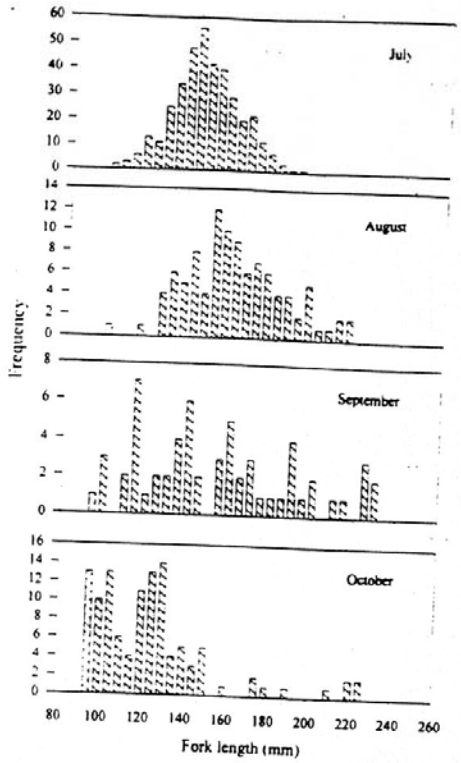

FIGURE 8.—Monthly length frequencies of Spanish mackerel collected at all South Carolina locations by month pooled over 1991 and 1992.

of vertical mixing by taking a vertical sample through the entire catch ("pie slice"). Therefore, the sample was a random sample of the catch, and although the mackerel may not have been randomly distributed in the catch, the sampling methodology specifically addressed this problem.

The estimated total mackerel bycatch was derived from the shrimp catch for each tow, which may introduce bias into the estimate. The sample catch per hour provided a "shrimp-catch-independent" measure of bycatch. By comparing trends of the sample and total CPUEs, we were able to determine whether a trend was a function of shrimp catch bias or a potentially real trend of mackerel bycatch. By analyzing the catch data as either catch per hour (sample CPUE) or estimated total catch per hour per length of footrope (total CPUE), we could partly eliminate the variable of vessel size from the study. Different types of nets, TEDs, and towing speeds, which may each have introduced some variability (Rulifson et al. 1992), were not directly addressed in our study. However, because a variety of vessels were sampled within and between locations, it could be argued that our data may reflect an average mackerel bycatch of the shrimp fleet in South Carolina and that individual vessel variability was countered by sampling more than one vessel type.

Collins and Wenner (1988) reported an approximately 10-fold greater catch of juvenile (age-0) king and Spanish mackerel in tongue nets than in flat nets, whereas Stender and Barans (1994) showed no significant differences between flat and tongue nets for king and Spanish mackerel catches. Collins and Wenner (1988) used different net types in different years, and the increased catch in tongue nets may have reflected differences in the annual abundance of age-0 mackerels. Stender and Barans (1994) used a double rig that had one tongue and one flat net. Both of these investigations were conducted aboard research vessels and neither incorporated TEDs. We found no significant differences in sample or total CPUE for either mackerel species between the two net types. However, we were unable to collect samples from the two net types on the same day or even the same week on vessels fishing a single location. Therefore, any lack of significance in catch rates between the two net types may not reflect potential differences in catch rates of the two net types. Furthermore, low catches of king and Spanish mackerel, high variability, and nonnormal catch distributions all reduced the power of between-net comparisons. The similarity of the presence–absence data for king and Spanish mackerel from July through October, when gear is changed from tongue to flat and back to tongue, supports the suggestion that the bycatch of these species may not differ between these different gear types.

Small changes in net speed could have affected the capture of king and Spanish mackerel. Atlantic mackerel *Scomber scombrus* can cruise at speeds between 0.31 and 1.1 m/s (size range, 275–380 mm FL; Wardle and He 1988). They can sustain a speed of 1.1 m/s for about 200 min (3.33 h). They have a burst speed of 5.5 m/s, which (for 305-mm fish) can be sustained for 5–6 min. The speed of the nets we sampled was 1–1.5 m/s. If entrained in a net moving at 1 m/s, larger mackerel should be able to maintain position at the front of the net for the duration of the average tow (2.88 h), and might use their burst speed capabilities to escape as net retrieval began (Wardle and He 1988;

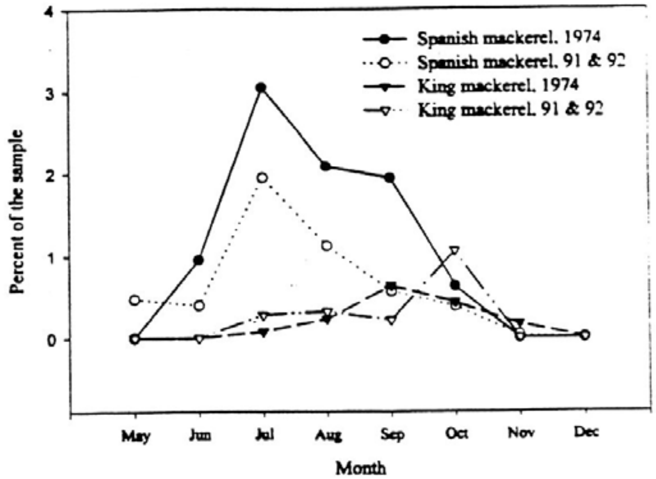

FIGURE 9.—Mean monthly king and Spanish mackerel catches calculated as percentages of the samples in 1991–1992 or in 1974 (1974 data are from Keiser 1976).

Wardle 1993). If net speed increased even slightly above 1 m/s, the maximum cruising speed of even the larger mackerel would be exceeded. Smaller king and Spanish mackerel sampled during 1991 and 1992 were unlikely to escape at a net speed of 1 m/s, and they would be even more vulnerable to changes in net speed above that rate (Wardle and Videler 1980).

However, larger king mackerel (up to 1 m FL) are occasionally captured in research trawls made by the Southeast Area Monitoring, Assessment and Prediction program (SEAMAP, which uses two 26-m tongue trawls towed at about 1.28 m/s without TEDs), suggesting that larger fish can still be captured by shrimp gear (R. Beatty, South Carolina Deptartment of Natural Resources, personal communication). Since 1990, SEAMAP has conducted 34 tows per season (April–May, July–August, and October–November) in a series of strata to a depth of 9.1 m off the South Carolina coast. Between 1990 and 1994, 100% (N = 34) of king mackerel captured in spring, 38% (43) captured in summer, and 5% (490) captured in fall SEAMAP trawls off South Carolina were larger than 180 mm FL (R. Beatty, personal communication). The complete absence of king mackerel greater than 180 mm FL in our samples and these SEAMAP data suggest that king mackerel may leave the shrimping grounds on attaining a specific size or in response to environmental changes as the season progresses, and thus they are no longer available to the shrimping gear.

The estimated growth rate of 3.5 mm/d for king mackerel compares well to other estimates of juvenile growth rates for king mackerel in the South Atlantic Bight (2.9 mm/d: Collins et al. 1988). Although we did not validate the periodicity of increment formation, Peters and Schmidt (1997) used marginal increment analysis to show daily increment formation in Spanish mackerel, and DeVries et al. (1990) used circumstantial evidence for daily increment formation. We therefore assumed daily increment formation for our study. If peak spawning occurred during late May and early September, as suggested by back-calculated hatch dates, a growth rate of 3.5 mm/d would mean that king mackerel at the minimum size captured would be available to the shrimp trawls 23 d after hatching. King mackerel would reach the most commonly captured size (145–150 mm FL) after 41 d and would be unavailable to the shrimp trawls after 51 d. The youngest king mackerel we captured was 23 d old, the peak capture occurred at 37 d, and the oldest king mackerel was 55 d old. This growth rate means that king mackerel are only vulnerable to shrimp gear for 28 d (80–180 mm FL; 33 d vulnerability observed) and have a peak vulnerability period (100–160 mm FL) of only 17 d (22 d observed). Therefore, king mackerel spawned in late May would be most frequently captured in mid-July, and those spawned in early September would be most frequently captured mid-October, when sample catches of king mackerel peaked in 1991. The catch patterns and catch rates of king mackerel in 1991 appear to be a direct result of their early life history and migration patterns (Sutter et al. 1991).

The difference in the catches of king mackerel between 1991 and 1992 are difficult to explain. Most of the king mackerel (two-thirds) sampled were collected during the first year of the study. Sampling effort during the first year was restricted to one location, and 60 tows were sampled, whereas in 1992, three locations and 77 tows were sampled. The abundance of age-0 king mackerel estimated from virtual population analysis (VPA; Powers et al. 1995) decreased about 25% from 1991 to 1992. This decline may partially explain the difference in the number of age-0 king mackerel sampled between the two years of the study, but is not enough to explain all of the difference. The catch patterns of king mackerel were very different in 1992. Not only were far fewer king mackerel collected, the peak catches varied from August in McClellanville to September in Charleston. The weaker year-class in 1992 (relative to 1991) might have been produced more sporadically, without periods of peak spawning as appeared to have occurred in 1991. The abundance of spawning adults was slightly higher in 1992 than in 1991, so the decrease in juvenile mackerel catch by shrimp trawlers may reflect poor survival of eggs, larvae, and juveniles before juvenile king mackerel appeared on the shrimping grounds.

Spanish mackerel catches were more evenly distributed between years and locations than the king mackerel catches. The spawning season of Spanish mackerel is protracted, running at least from May to September (Schmidt et al. 1993) with no apparent peak. Therefore, juvenile Spanish mackerel could occur in shrimp trawls throughout the shrimp season. During 1991 and 1992, the only month with a significantly higher catch occurred in Beaufort in July, and Spanish mackerel were caught in all months except December. This suggests that, although spawning is protracted, the highest survival might have occurred for individuals spawned at the beginning of the spawning season (May).

The smallest Spanish mackerel sampled was 95 mm FL. Because Spanish mackerel spawn in nearshore areas, often near or on the shrimping grounds, it was surprising to see so few small (<100 mm FL) individuals caught. The growth rate of young Spanish mackerel has been estimated at 4.1 mm/d for juveniles up to 37 d (Peters and Schmidt 1997). Over 80% of Spanish mackerel sampled were between 110 and 190 mm FL, corresponding to approximately 20 d of vulnerability. Therefore, peak vulnerability of juvenile Spanish mackerel should be from ages 27 to 47 d. However, because of their protracted spawning season, Spanish mackerel juveniles could be continuously recruiting to the shrimp fishery during much of the season. Monthly length-frequency data (Figure 7) show catches of small Spanish mackerel in all months except May and June without evidence of a cohort developing.

Data from 1974 (Keiser 1976) suggest that the incidental harvest of mackerel by shrimp trawlers has not changed over time. Keiser (1976) found that the bycatch of Spanish mackerel peaked in July and that of king mackerel peaked in September, results that correspond well to ours. We were unable to compare the sizes of the mackerel catches between the two studies except in terms of percentage of the overall sample. Spanish mackerel averaged 1.08% and king mackerel 0.19% of the sample in 1974 (Keiser 1976) and 0.61% and 0.23%, respectively, for 1991–1992. These changes, if comparable, probably reflect changes in population size (i.e., in year-class fluctuations) rather than in catch rates by the shrimp fleet, although exclusion of mackerels by TEDs could be a factor. The peak catches of juvenile king mackerel appear to be taken during July and October, coinciding with the northerly spring and southerly fall migratory pattern of king mackerel in the South Atlantic Bight (Sutter et al. 1991). The catch of Spanish mackerel peaked in July in both studies, but catches in 1991–1992 appear to have declined relative to those in 1974–1975. The bycatch of king and Spanish mackerel in shrimp trawls is probably a function of the size of the year-class; however, a comparison of catches between these two studies may be affected by the different methods used to sample the catch. Nevertheless, the similar monthly catch patterns between the two studies confirm the period of maximum bycatch of juvenile king and Spanish mackerel.

This study increased our understanding of factors influencing the bycatch of juvenile king and Spanish mackerel by commercial shrimp trawlers in South Carolina waters. However, it did not identify any easy management strategy that could minimize the bycatch of these two species. The relatively low but highly variable catch rates, wide distribution, and seasonality of the bycatches of juvenile king and Spanish mackerel suggest by-catch reduction devices may be the best available management tool for reducing this unintentional exploitation.

Acknowledgments

This study would have been impossible without the cooperation of participating shrimpers in McClellanville, Charleston, and Beaufort, and our thanks go to them. We also thank Charlie Barans and Jack McGovern and three anonymous reviewers for many comments that greatly improved the manuscript. This research was performed as part of P.J.H.'s doctoral research and was funded by the Saltonstall-Kennedy program, project NA27FD0067-01. This is contribution number 400 of the South Carolina Marine Resources Center.

References

Christian, P., J. Rivers, and S. Morrison. 1989. Morrison soft TED installation instructions. University of Georgia, Sea Grant College Program, Athens.

Collette, B. B., and J. L. Russo. 1984. Morphology, systematics and biology of the Spanish mackerels, (*Scomberomorus*, Scombridae). Fishery Bulletin 82: 545–692.

Collette, B. B., J. L. Russo, and L. A. Zavala-Camin. 1978. Scoberomorus brasiliensis, a new species of Spanish mackerel from the western Atlantic. Fishery Bulletin 76:273–280.

Collins, M. R., D. J. Schmidt, C. W. Waltz, and J. L. Pickney. 1988. Age and growth of king mackerel, *Scomberomorus cavalla*, from the Atlantic coast of the United States. Fishery Bulletin 87:49–61.

Collins, M. R., and C. A. Wenner. 1988. Occurrence of young-of-the-year king, *Scomberomorus cavalla*, and Spanish, *S. maculatus*, mackerels in commercial-type shrimp trawls along the Atlantic coast of the southeast United States. Fishery Bulletin 86: 394–397.

DeVries, D. A., C. B. Grimes, K. L. Lang, and D. B. White. 1990. Age and growth of king and Spanish mackerel larvae and juveniles from the Gulf of Mexico and U.S. South Atlantic Bight. Environmental Biology of Fishes 29:135–143.

Edwards, M. L. 1987. The shrimp trawl. National Fisherman 67(13):89–92.

Erdman, D. S. 1949. Does the Spanish mackerel *Scomberomorus maculatus* (Mitchill) occur throughout the West Indies? Copeia 1949:301.

Fable, W. A., A. G. Johnson, and L. E. Barger. 1987. Age and growth of Spanish mackerel, *Scomberomorus maculatus*, from Florida and the Gulf of Mexico. Fishery Bulletin 85:777–783.

Finucane, J. H., L. A. Collins, H. A. Brusher, and C. H. Saloman. 1986. Reproductive biology of king mackerel, *Scomberomorus cavalla*, from the southeastern United States. Fishery Bulletin 84:841–850.

GMFMC and ASAFMC (Gulf of Mexico Management Council and South Atlantic Fishery Management Council). 1985. Final amendment 1 to the fishery management plan and final environmental impact statement for the coastal migratory pelagic resources (mackerels). GMFMC, Tampa, Florida. (Also SAFMC, Charleston, South Carolina.)

Grimes, G. B., J. H. Finucane, L. A. Collins, and D. A. DeVries. 1990. Young king mackerel, *Scomberomorus cavalla*, in the Gulf of Mexico, a summary of the distribution and occurrence of larvae and juveniles, and spawning dates for Mexican juveniles. Bulletin of Marine Science 46:640–654.

Keiser, R. K. 1976. Species composition, magnitude and utilization of the incidental catch of the South Carolina shrimp fishery. South Carolina Marine Resources Center, Technical Report 16.

MSAP (Mackerel Stock Assessment Panel). 1992. 1992 report of the mackerel stock assessement panel. U.S. National Marine Fisheries Service, Southeast Fisheries Center, Miami Laboratory MIA-91/92-47, Miami.

Peters, J. S. and D. J. Schmidt. 1997. Daily age and growth of larval and early juvenile Spanish mackerel (*Scomberomorus maculatus*) from the South Atlantic Bight. Fishery Bulletin 95:530–537.

Powers, J. E., N. Parrack, and P. Phares. 1995. Projections of the status of Gulf of Mexico and Atlantic king mackerel and Spanish mackerel. U.S. National Marine Fisheries Service, Southeast Fisheries Science Center, Miami Laboratory MIA-94/95-28, Miami.

Renuad, M., and five coauthors. 1992. Loss of shrimp by turtle excluder devices (TEDs) in coastal waters of the United States, North Carolina to Texas: March 1988–August 1990. Fishery Bulletin 91:129–137.

Robins, C. R., and G. C. Ray. 1986. A field guide to Atlantic coast fishes, North America. Houghton Mifflin, Boston.

Rulifson, R. A., J. D. Murray, and J. J. Bahen. 1992. Finfish catch reduction in south Atlantic shrimp trawls using three designs of by-catch reduction devices. Fisheries 17(1):9–20.

SAFMC (South Atlantic Fishery Management Council). 1981. Profile of the Penaeid shrimp fishery in the south Atlantic. SAFMC, Charleston, South Carolina.

SAFMC (South Atlantic Fishery Management Council). 1997. Shrimp fishery management plan for the South Atlantic region. SAFMC, Charleston, South Carolina.

Schmidt, D. J., M. R. Collins, and D. M. Wyanski. 1993. Age, growth maturity and spawning of Spanish mackerel, *Scomberomorus maculatus* (Mitchill), from the Atlantic coast of the southeastern United States. Fishery Bulletin 91:526–533.

Secor, D. H., J. M. Dean, and E. H. Laban. 1992. Otolith removal and preparation for microstructural examination. Pages 19–57 *in* D. K. Stevenson and S. E. Campana, editors. Otolith microstructure examination and analysis. Canadian Special Publication of Fisheries and Aquatic Sciences 117.

Stender, B. W., and C. A. Barans. 1994. Comparison of the catch from tongue and two-seam shrimp nets of South Carolina. North American Journal of Fisheries Management 14:178–195.

Sutter, F. C., III, R. O. Williams, and M. F. Godcharles. 1991. Movement patterns and stock affinities of king mackerel in the southeastern United States. Fishery Bulletin 89:315–324.

Upton, H. F., P. Hoar, and M. Upton. 1992. The Gulf of Mexico shrimp fishery: profile of a valuable national resource. Center for Marine Conservation, Washington, D.C.

Wardle, C. S. 1993. Fish behaviour and fishing gear. Pages 463–495 *in* T. J. Pitcher, editor. Behaviour of teleost fishes, second edition. Chapman and Hall, London.

Wardle, C. S., and P. He. 1988. Burst swimming speeds of mackerel, *Scomber scombrus* L. Journal of Fish Biology 32:471–478.

Wardle, C. S., and J. J. Videler. 1980. Fish swimming. Pages 12–18 *in* H. Y. Elder and E. R. Trueman, editors. Aspects of animal movement. Cambridge University Press, Cambridge, UK.

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Appendix N. Estimates of Bycatch of Mackerel and Cobia in U.S. South Atlantic Shrimp Trawls (MSAP/98/03)

MSAP/98/04

MSAP/98/04

ESTIMATES OF BYCATCH OF MACKEREL AND COBIA IN U.S. SOUTH ATLANTIC SHRIMP TRAWLS

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Report for:

Gulf of Mexico and
South Atlantic Fishery Management Councils

February 19, 1998

INTRODUCTION

Estimates of the bycatch of king and Spanish mackerel and cobia were requested to be made for inclusion in the 1998 stock assessments of these species by the Gulf and South Atlantic Fishery Management Councils. As in Vaughan and Nance (1996), two approaches are used in this report to expand bycatch finfish samples with shrimp trawl catch and effort information to obtain estimates of total finfish bycatch within larger temporal/geographic strata. One, based on expansion by trips, follows that approach outlined in SEAMAP-SA Shrimp Bycatch Working Group (1996). The other approach, based on finfish:shrimp catches within strata, was suggested by a reviewer (through the Marine Fisheries Section, AFS) of that report.

EXPANSION FACTORS BASED ON SHRIMP TRAWL CATCH AND TRIPS

Historical catch, trips, and catch-per-trip are summarized for inside (inlets and internal bays and sounds), outside (0+ miles offshore, ocean), and combined for each U.S. south Atlantic state (FL-NC) in Tables 1-4. Expansion factors based on catch are summarized in Tables 5-7 and based on trips in Tables 8-10. Modification of strata from the SEAMAP-SA Shrimp Bycatch Working Group (1996) report are summarized by state below. All shrimp trawl catch and effort data for 1997 should be considered preliminary, and probably incomplete for the fall season (i.e., Oct.-Dec. 1997). A major data edit was conducted by the NMFS Galveston Laboratory of the bycatch data between this analysis and the previous (Vaughan and Nance 1996). Furthermore, expansion of tows to trips based on number of nets was done for this analysis as follows: Florida (south of 30° north latitude) was 2.5 for vessels; Florida (north of 30° north latitude) through Georgia was 2.6 for vessels; North Carolina was 1.04 for boats, 2.6 for vessels (non-Fall), and 2.3 for vessels (Fall). These factors were applied to the bycatch characterization tows, as was an expansion for unsampled tows within trips, to expand tow information to trip level for comparison with shrimp effort data at trip level.

<u>Florida:</u> New shrimp catch and effort data were recently provided by Martha Norris (FL DEP, St. Petersburg, FL) from Florida Trip Ticket Program (1986-97) for the east coast of Florida where each record in the computer file represented one trip (Table 1). At this time no shrimp catch and effort data for November and December 1997 were available. Because of large numbers of trips with unknown type (boat or vessel), strata based on this variable were

not used as a basis of stratification in this report.

Although there were also considerable numbers of trips for distance (inside/outside) and latitude (north/south of Jacksonville - 30° N latitude) that were unknown, these stratifying variables were retained. Trips for which these variables (distance and latitude) were known were used to proportion out trips that were unknown. Independently, catches for which these variables (distance and latitude) were known were also used to proportion out catches that were unknown. This way both trips and catches sum to the observed total trips and total catches, including those which are unknown. Outside shrimp trawl trips north of Jacksonville are combined with outside shrimp trawl trips from Georgia and South Carolina to form a single geographic stratum (with four seasonal substrata).

Seasonal definitions for stratification were modified from the SEAMAP Shrimp Bycatch report to allow for fishing year based on April 1 - March 31 (King and Spanish mackerel) and calendar year (cobia). Hence, winter includes Jan-Mar, spring includes Apr-Jun, summer includes Jul-Aug, and fall includes Sep-Dec. Rock shrimp trips were defined as those trips for which rock shrimp were the most abundant in the landings (always outside vessel trips when known and almost entirely south of Jacksonville). Catches associated with rock shrimp trips include all shrimp species landed in those trips.

Stratum expansion factors are summarized for Florida/Inside and Florida/Outside/South for catch (Table 5) and trips (Table 8). Stratum expansion factors are summarized for Florida/Outside/North for catch (Table 6) and for trips (Table 9).

<u>Georgia:</u> NMFS detailed shrimp trawl data were available from 1978-97, of which late season 1997 information are incomplete and therefore preliminary (Table 2). With increasing numbers of trips with unknown distance from shore for recent years, and the historical precedence that boat trips were almost completely inside and vessel trips were almost completely outside, all boat trips were defined as inside and all vessel trips as outside.

Seasonal definitions for stratification were the same as for Florida. Also, as with Florida, rock shrimp trips were defined as those trips for which rock shrimp were the most abundant in the landings (always outside vessel trips).

Stratum expansion factors are summarized for Georgia/Inside for catch

(Table 5) and trips (Table 8). Stratum expansion factors are summarized for Georgia/Outside for catch (Table 6) and for trips (Table 9).

South Carolina: NMFS detailed shrimp data were available from 1979-97, of which late season 1997 information are preliminary (Table 2). Boat trips have not been separated from vessel trips since 1991, but represent a very small level of effort.

Seasonal definitions for stratification were the same as for Florida. Again, rock shrimp trips were defined as those trips for which rock shrimp were the most abundant in the landings (always outside vessel trips).

Stratum expansion factors are summarized for South Carolina (outside) for catch (Table 6) and for trips (Table 9). The negligible inside trips were pooled with the outside trips.

North Carolina: NMFS detailed shrimp data were available from 1978-92 (trip information from 1992 are highly suspect). Only catch information was available for 1993 from the General Canvas data set (Linda Hardy, NMFS Beaufort). NC trip ticket data were made available for 1994-97 by Dee Willis (NC DMF, Morehead City, NC). No shrimp catch and effort data from December 1997 were available. Mean catch per trip for 1988-91 was used to estimate trips from catch for 1992 and 1993. These data are all summarized in Table 4. The trip ticket information could not be used to separate trips into type (boat/vessel) and shrimp species (i.e,, to allow for post-stratification of Fall trips into Fall Pink or Fall White trips).

Seasonal strata were modified as follows: Winter includes Jan.-Mar., spring includes Apr.-May, summer includes Jun.-Sep., and fall includes Oct.-Dec. No rock shrimp strata was defined for North Carolina.

Stratum expansion factors are summarized for North Carolina (Inside and Outside) for catch (Table 7) and for trips (Table 10).

CHARACTERIZATION/BRD SAMPLES AND STRATA ESTIMATES OF FINFISH BYCATCH

Data available from characterization and BRD studies are summarized by strata in Table 11. Expansion estimates of finfish bycatch numbers will not be made for strata containing only one sampled characterization/BRD trip (or tow) (e.g., FSO (Florida-South-Outside) area during fall 1992-93, and NCI

(North Carolina-Inside) during spring 1994-95). Because no bycatch data was available from the 1997-98 fishing year, no estimates of bycatch were made for king and Spanish mackerel and cobia for that fishing year.

Expansion by Catch: This approach is modified in two ways from Vaughan and Nance (1996). Because of a few occasions when finfish catch in numbers are available but not corresponding catch in weight, and because the finfish catch in weight theoretically drops out of the expansion equation ((W/S)/(W/N) where W is finfish weight, S is shrimp weight, and N is finfish number). This approach calculates finfish catch in number to shrimp catch in weight ratio by tow. The mean finfish:shrimp ratio is then calculated from all tows for each stratum. We do not use strata containing a single tow. Based on the mackerel fishing year (April 1 - March 31), expansion for king and Spanish mackerel bycatch numbers based on catch are summarized in Tables 12-13, and by calendar year for cobia in Table 14.

To assess adequacy of coverage across strata, catches from strata for which there were at least two trips sampled compared to total penaeid shrimp trawl catches (total catch of all shrimp from penaeid trips) were 81% (18.4 million pounds from sampled strata divided by 22.6 million pounds for all penaeid shrimp strata) in 1992-93, 85% (20.8 million pounds from 24.6 million pounds) in 1993-94, 72% (17.4 million pounds from 24.1 million pounds) in 1994-95, 71% (23.7 million pounds from 33.4 million pounds) in 1995-96, and 60% (12.1 million pounds from 20.1 million pounds) in 1996-97.

Expansion by Trips: This approach calculates the number of finfish caught per trip (CPE) and multiplies by trips within a strata to obtain an estimate of bycatch in numbers for that strata. As described in SEAMAP-SA Shrimp Bycatch Working Group (1996) report, finfish caught per trip must by expanded up from individually sampled tows to all tows and for multiple nets pulled during a tow. Expansion for king and Spanish mackerel bycatch numbers based on trips are summarized in Tables 15-16, and cobia in Table 17..

To assess adequacy of coverage across strata, trips from strata for which there were at least two trips sampled are compared to total penaeid shrimp trawl trips (total were 63% (32021 trips from all penaeid shrimp trips of 50488) in 1992-93, 69% (34777 from 50879) in 1993-94, 61% (33779 from 55195) in 1994-95, 45% (24789 from 55211) in 1995-96, and 41% (19320 from 47216) in 1996-97.

Length frequency distributions in 10 mm total length intervals are summarized by fishing year (April 1 - March 31) for 1992-95 data for Spanish mackerel (Fig. 1) and combined across fishing years (1992-95) for both king and Spanish mackerel (Fig. 2). A total of 4,542 Spanish mackerel were measured for length, none since the 1995 fishing year. During the same period 172 king mackerel were measured for length, again none since the 1995 fishing year. Only 2 cobia were measured for length, 1 each in 1993 and 1994.

DISCUSSION

An advantage of expanding by catch, rather than trip, is primarily associated with allowing use of characterization and BRD data at the tow level. Expansion of sampled tows to account for unsampled tows, as well as expansion for multiple nets may not be needed. But it should be noted the 2-stage sampling underlying data at the tow level. That is tow based samples are nested within a trip, and trips are nested within strata. Covariances among tows within a given trip should be expected. Hence, the CV and PSE presented for expansion by catch at the tow level may not accurately reflect the true uncertainty. However, not all sources of variance are included in the effort (trip) expansion. Additional error is associated with adjusting for unsampled tows and multiple nets. In both expansion methods, the shrimp data (catch or trips) is assumed known without error. Another concern with catch expansion is concerned with lack of data for rock shrimp fishery and increased importance in expansion (few trips, large catches, especially in 1996 with 22.0 million pounds landed in Florida). Further, there was at least one characterization/BRD trips for which bycatch was counted but not weighed. Thus one trip dropped out of the F:S ratio approach.

In considering these strata estimates for expansion to annual estimates for the U.S. south Atlantic coast several factors must by considered. First, are within-strata sample sizes adequate? We have deleted sample sizes of one from consideration, but are sample sizes of 2 or 3 sufficient? Estimates of strata-specific coefficients of variation (CV) and percent standard error ($PSE = CV/\sqrt{n}$) are included at the strata-level to evaluate this concern, but note these are generally quite large. Only the PSE values for Spanish mackerel might by of an acceptable level (e.g., PSE values of 20-40% for Spanish mackerel in Tables 13 and 16).

A second concern is expansion of strata estimates for which samples are available to strata for which no data is available. This would imply one of two assumptions. Either the finfish:shrimp ratio for sampled strata can be applied to unsampled strata or catch-per-effort for sampled strata can be applied to unsampled strata. Also, does a sufficiently large percentage of catch or trips associated with sampled strata outway concerns about deviations from the above assumptions when expanding bycatch estimates to unsampled strata?

No characterization/BRD data were available for use in this analysis for inside waters for Florida through South Carolina and outside waters from North Carolina. Inside trips have been quite significant in Florida and Georgia, especially since 1988 (Tables 1 and 2), and outside trips are by no means trivial in North Carolina (Table 4).

Finally, only one rock shrimp sampled trip (off Florida in winter 1995) was available to characterize rock shrimp trips. Rock shrimp trips varied by fishing years with 322 in 1992-93, 423 in 1993-94, 557 in 1994-95, 400 in 1995-96, and 882 in 1996-97. Total shrimp catches from rock shrimp trips were 3.1 million pounds in 1992-93, 6.1 million pounds in 1993-94, 6.9 million pounds in 1994-95, 6.0 million pounds in 1995-96, and 23.0 million pounds in 1996-97.

LITERATURE CITED

SEAMAP-South Atlantic Shrimp Bycatch Working Group. 1996. Estimates of Finfish Bycatch in the South Atlantic Shrimp Fishery. ASMFC, Washington, DC, 64 p.

Vaughan, D.S., and J.M. Nance. 1996. Estimates of bycatch of mackerel and cobia in U.S. south Atlantic shrimp trawls. Report to Gulf of Mexico and South Atlantic Fishery Management Councils, 23 p.

Table 1. Annual catch (1000 pounds), effort (trips), and catch per effort (CPE, pounds per tri boats, vessels, and combined from Florida Trip Ticket database (source: Martha Norri Department of Environmental Protection), 1986-97.

Year	Inside			Outside			Combined		
	Catch	Trips	CPE	Catch	Trips	CPE	Catch	Trips	CPE
1986	895.8	6741	132.9	4560.8	3496	1304.5	5456.6	10237	533.0
1987	694.5	7356	94.4	5656.7	3509	1612.0	6351.1	10865	584.6
1988	1271.1	8179	155.4	4465.1	2961	1507.7	5736.2	11141	514.9
1989	1623.8	8139	199.5	6756.8	2852	2369.2	8380.6	10991	762.5
1990	1297.1	8302	156.2	6061.7	2634	2301.2	7358.7	10936	672.9
1991	1272.7	8122	156.7	4001.1	3029	1320.9	5273.7	11151	472.9
1992	1499.8	7810	192.0	5203.4	2668	1950.5	6703.2	10478	639.7
1993	1264.5	7203	175.6	7299.2	2512	2905.5	8563.7	9715	881.5
1994	1345.5	9585	150.8	9252.8	3917	2362.4	10698.4	13502	792.3
1995	948.5	7782	121.9	9605.9	4336	2215.2	10554.4	12118	871.0
1996	743.7	6943	107.1	25515.0	5099	5004.1	26258.7	12042	2180.6
1997[a]	686.0	5100	134.5	3351.9	3597	931.9	4037.8	8697	464.3

[a] Preliminary, no catch and effort from November and December 1997.

Note: Catch and trips for unknown distance (inside and outside) were partitioned separately base catch and trips (distance and/or latitude).

Table 2. Annual catch (1000 pounds), effort (trips), and catch per effort (CPE, pounds per tr inside, outside, and combined for Georgia from NMFS Detailed Shrimp database, 1978-9

Year	Inside			Outside			Combined		
	Catch	Trips	CPE	Catch	Trips	CPE	Catch	Trips	CPE
1978	72.9	931	77.4	5248.7	9781	536.6	5320.8	10712	496.7
1979	172.7	1049	164.7	9540.1	13598	701.6	9712.8	14647	663.1
1980	72.9	735	99.2	8329.3	12427	670.3	8402.3	13162	638.4
1981	25.2	288	87.7	4899.9	6436	761.3	4925.2	6724	732.5
1982	50.5	371	136.0	6684.0	10878	614.5	6734.4	11249	598.7
1983	39.4	282	139.6	7649.4	12031	635.8	7688.8	12313	624.5
1984	7.9	116	68.3	3469.7	5567	623.3	3477.6	5683	611.9
1985	79.1	449	176.2	7088.4	7075	1001.9	7167.5	7524	952.6
1986	70.1	494	142.0	7419.0	9531	778.4	7489.1	10025	747.0
1987	15.9	162	98.0	7255.9	9083	798.9	7271.8	9245	786.6
1988	115.0	4166	27.6	6915.5	8519	811.7	7030.2	12685	554.2
1989	135.5	4400	30.8	7645.2	7639	1000.8	7780.7	12039	646.3
1990	98.3	3462	28.4	5982.9	6236	959.4	6081.2	9698	627.1
1991	117.9	4256	27.7	9053.5	10129	893.8	9171.3	14385	637.6
1992	109.8	3721	29.5	7855.9	8919	880.8	7965.7	12640	630.2
1993	112.0	3802	29.5	7694.4	8963	858.5	7806.4	12765	611.5
1994	120.1	3645	32.9	7094.5	8473	837.3	7214.6	12118	595.4
1995	179.5	3418	52.5	11148.0	9542	1168.3	11327.5	12960	874.0
1996	129.7	3162	41.0	6395.2	7505	852.1	6524.9	10667	611.7
1997[a]	136.4	3264	41.8	6394.2	8742	731.4	6530.6	12006	543.9

[a] Preliminary.

Table 3. Annual catch (1000 pounds), effort (trips), and catch per effort (CPE, pounds per tri
inside, outside, and combined for South Carolina from NMFS Detailed Shrimp database,

Year	Inside			Outside			Combined		
	Catch	Trips	CPE	Catch	Trips	CPE	Catch	Trips	CPE
1979	626.9	1255	499.5	6034.8	10035	601.4	6661.7	11290	590.1
1980	1042.8	2780	375.1	5926.7	11892	498.4	6969.5	14672	475.0
1981	571.3	1599	357.3	2352.6	7281	323.1	2923.8	8880	329.3
1982	807.5	1900	424.9	4203.3	12021	349.7	5010.7	13921	359.9
1983	735.7	1658	443.8	4572.0	8962	510.2	5307.7	10620	499.8
1984	113.3	493	229.9	3001.6	5134	584.7	3115.0	5627	553.6
1985	240.2	728	329.9	3162.8	4724	669.5	3403.0	5452	624.1
1986	26.4	140	188.7	5776.9	9742	593.0	5803.3	9882	587.3
1987	29.4	55	533.8	5190.7	11383	456.0	5220.1	11438	436.4
1988	32.6	36	906.3	4275.4	8351	511.9	4308.1	8387	513.6
1989	35.5	56	633.6	7177.5	10169	705.8	7213.0	10225	705.4
1990	2.6	21	125.8	5503.9	9634	571.3	5506.6	9655	570.3
1991	11.0	18	613.0	8985.3	14375	625.1	8996.3	14393	625.0
1992	0.7	1	716.1	6486.1	12984	499.5	6486.8	12985	499.5
1993	6.3	15	422.7	7914.9	12219	647.8	7921.3	12234	647.5
1994	20.0	113	177.3	5181.2	10838	478.1	5201.2	10951	475.0
1995	87.8	229	383.5	10358.9	12935	800.8	10446.7	13164	793.6
1996	21.5	108	199.5	5216.9	9598	543.6	5238.4	9706	539.7
1997[a]	71.5	318	224.7	5450.2	10564	515.9	5521.7	10882	507.4

[a] Preliminary.

Table 4. Annual catch (1000 pounds), effort (trips), and catch per effort (CPE, pounds per tr inside, outside, and combined for North Carolina, 1978-97.

Year	Inside			Outside			Combined		
	Catch	Trips	CPE	Catch	Trips	CPE	Catch	Trips	CPE
1978[a]	1809.7	11462	157.9	1070.5	2101	509.5	2880.2	13563	212.3
1979	3131.8	13721	228.3	1481.6	2851	519.7	4613.4	16572	278.4
1980	7628.5	29477	258.8	1582.4	3260	485.4	9210.9	32737	281.4
1981	1940.5	22645	85.7	491.6	1824	269.5	2432.1	24469	99.4
1982	5065.1	34378	147.3	1601.1	3612	443.2	6666.2	37991	175.5
1983	4282.6	32516	131.7	1602.0	4043	396.2	5884.7	36560	161.0
1984	3027.3	22856	132.5	1655.2	4473	370.0	4682.5	27329	171.3
1985	10013.1	21896	457.3	1384.2	2310	599.1	11397.3	24206	470.8
1986	4768.5	21743	219.3	1199.9	2444	491.0	5968.4	24187	246.8
1987	3036.9	16588	183.1	1170.3	2721	430.1	4207.2	19310	217.9
1988	6015.1	20928	287.4	1854.7	3996	464.1	7869.9	24924	315.8
1989	6569.8	25834	254.3	2073.4	4273	485.2	8643.1	30107	287.1
1990	6145.9	17097	359.5	1392.9	2482	561.2	7538.7	19579	385.0
1991	8812.5	21945	401.6	1351.3	2848	474.5	10163.8	24793	410.0
1992[b]	4233.0	13871	305.2	967.8	1854	522.0	5200.8	15105	344.3
1993[c]	4345.0	12876	337.4	1799.2	3493	515.1	6144.2	16369	375.4
1994[d]	5244.6	14612	358.9	1643.6	3770	436.0	6888.2	18382	374.7
1995	5733.9	15527	369.3	2181.9	3982	547.9	7915.8	19509	405.7
1996	3056.7	11040	276.9	1812.5	3239	559.6	4869.2	14279	341.0
1997[e]	4895.4	12702	385.4	1448.9	3135	462.2	6344.3	15837	400.6

[a] 1978-91 from NMFS Detailed Shrimp Database.
[b] 1992 based on catch from 1992 NMFS Detailed Shrimp database and trips estimated from mean cat for 1988-91.
[c] 1993 based on catch from General Canvas and trips from mean catch-per-trip for 1988-91 adjust season and inside/outside landings.
[d] 1994-97 from North Carolina trip ticket database (provided by Dee Willis, NC DMF).
[e] Preliminary, no catch and effort from December 1997.

Table 5. Florida trips (catch expansion factors) estimated from Florida Trip Ticket database f inside and for outside south of 30° N latitude and Georgia catches (catch expansion f censused from NMFS Detailed Shrimp database for inside for 1992-97.

Year	Penaeid Shrimp[a] Winter	Spring	Summer	Fall	Rock Shrimp	T
			Florida: Inside			
1992	330.2	188.5	212.7	768.4	0.0	149
1993	278.0	177.6	234.4	574.5	0.0	126
1994	384.3	271.8	348.1	441.3	0.0	144
1995	164.7	184.4	190.9	408.5	0.0	94
1996	257.8	132.4	122.2	230.2	0.0	74
1997	265.5	194.0	137.7	88.7	0.0	68
			Florida (South): Outside			
1992	465.5	186.3	131.9	1587.1	2619.2	499
1993	536.2	235.8	303.5	787.1	5338.7	720
1994	263.9	113.9	154.9	621.6	6556.1	771
1995	396.0	141.9	117.9	660.6	5867.5	718
1996	296.7	308.5	148.7	883.1	21964.3	2360
1997	536.9	126.2	109.2	29.1	1516.2	231
			Georgia: Inside			
1992	14.4	21.5	20.3	53.6	0.0	10
1993	10.7	30.2	23.6	47.5	0.0	11
1994	10.3	21.3	31.7	56.8	0.0	12
1995	16.5	30.7	29.8	102.5	0.0	17
1996	11.0	21.1	29.8	67.8	0.0	12
1997	13.6	16.0	31.2	75.6	0.0	13

[a] Seasonal definitions in text. [b] Preliminary.

Table 6. Florida (north of 30° N latitude) through South Carolina catches (catch expansion fact estimated from Florida Trip Ticket and censused NMFS Detailed Shrimp databases for out season for 1992-97.

Year	Penaeid Shrimp[a] Winter	Spring	Summer	Fall	Rock Shrimp	Total
1992:						
SC	441.4	1129.9	1401.6	3513.9	0.0	6486.8
GA	647.5	2309.9	941.6	3390.8	566.1	7855.9
FL (North)	120.2	40.2	22.8	30.2	0.0	213.4
Total	1209.1	3480.1	2366.0	6934.8	566.1	14556.1
1993:						
SC	231.0	2156.7	2564.6	2969.0	0.0	7921.3
GA	403.6	2215.9	1730.3	2951.2	393.4	7694.4
FL (North)	3.9	59.2	23.1	11.7	0.0	97.9
Total	638.5	4431.8	4318.0	5931.9	393.4	15713.6
1994:						
SC	203.8	790.4	1386.8	2819.8	0.4	5201.2
GA	497.8	1088.9	1223.4	3841.7	442.7	7094.5
FL (North)	4.7	174.8	362.4	1000.6	0.0	1542.5
Total	706.2	2054.1	2972.7	7662.1	443.1	13838.2
1995:						
SC	428.7	2551.4	1747.6	5718.9	0.0	10446.6
GA	876.1	3386.4	1430.7	5089.5	365.3	11148.0
FL (North)	50.9	521.7	723.7	1125.7	0.0	2422.0
Total	1355.7	6459.5	3902.1	11934.2	365.3	24016.6
1996:						
SC	139.1	688.7	1446.4	2961.3	3.0	5238.5
GA	522.4	647.1	1220.5	3355.6	649.8	6395.4
FL (North)	165.1	170.3	438.3	1139.9	0.0	1913.6
Total	826.6	1506.1	3105.2	7456.7	652.8	13547.5
1997[b]:						
SC	32.3	941.4	1379.9	3167.3	0.8	5521.7
GA	138.0	1117.6	1181.9	3792.4	164.3	6394.2
FL (North)	177.7	517.6	323.6	15.3	0.0	1034.2

Total	348.0	2576.6	2885.4	6975.1	164.3	12950.1

[a] Seasonal definitions in text. [b] Preliminary.

Table 7. North Carolina catches (catch expansion factors) by strata censused from General Canvas for 1992-93 and from trip ticket database for 1994-97.

Year	Strata	Seasons[a] Winter	Spring	Summer	Fall	Total
1992	Inside	20.1	340.6	3382.8	489.6	4233.0
	Outside	3.1	55.7	716.6	192.3	967.8
	Total	23.2	396.3	4099.4	681.9	5200.8
1993	Inside	7.0	125.9	2868.4	1343.6	4345.0
	Outside	16.8	30.8	1414.4	337.3	1799.2
	Total	23.8	156.7	4282.8	1680.9	6144.2
1994	Inside	12.4	223.4	3767.0	1241.8	5244.6
	Outside	20.5	125.3	936.0	561.8	1643.6
	Total	33.5	373.7	4923.4	1935.6	6888.2
1995	Inside	47.4	338.9	3558.2	1789.4	5733.9
	Outside	58.7	112.0	1184.3	826.9	2181.9
	Total	106.7	483.8	5280.6	2768.1	7915.8
1996	Inside	0.5	40.8	2511.9	503.6	3056.7
	Outside	29.5	14.7	1094.0	674.3	1812.5
	Total	33.5	373.7	4923.4	1935.6	4869.2
1997	Inside	23.3	94.1	3574.3	1203.8	4895.4
	Outside	77.7	106.6	742.7	521.8	1448.9
	Total	106.7	483.8	5280.6	2768.1	6344.3

[a] Seasonal definitions in text. [b] Preliminary.

Table 8. Florida trips (trip expansion factors) estimated from Florida Trip Ticket database f inside and for outside south of 30° N latitude and Georgia trips (trip expansion fact censused from NMFS Detailed Shrimp database for inside for 1992-97.

Year	Penaeid Shrimp[a]				Rock Shrimp
	Winter	Spring	Summer	Fall	
			Florida: Inside		
1992	2025	1471	1604	2710	0
1993	1630	1465	1363	2744	0
1994	2550	2229	1800	3005	0
1995	1939	1554	1110	3177	0
1996	1805	1495	1118	2524	0
1997[b]	2049	1583	989	478	0
			Florida (South): Outside		
1992	751	197	262	964	273
1993	678	214	332	562	348
1994	557	174	204	467	494
1995	572	188	157	506	417
1996	479	136	198	562	769
1997[b]	887	220	113	31	218
			Georgia: Inside		
1992	488	886	726	1621	0
1993	398	919	782	1703	0
1994	390	797	958	1500	0
1995	494	878	676	1370	0
1996	262	734	780	1386	0
1997[b]	432	698	799	1335	0

[a] Seasonal definitions in text. [b] Preliminary.

Table 9. Florida (north of 30° N latitude) through South Carolina trips (trip expansion facto estimated from Florida Trip Ticket and censused NMFS Detailed Shrimp databases for c season for 1992-97.

Year	Penaeid Shrimp[a] Winter	Spring	Summer	Fall	Rock Shrimp
1992:					
SC	797	2262	2869	7058	0
GA	1027	2197	1540	4098	57
FL (North)	65	46	30	81	0
Total	1889	4505	4439	11237	57
1993:					
SC	736	2538	3016	5943	0
GA	758	2287	1976	3910	32
FL (North)	27	214	73	64	0
Total	1521	5039	5065	9917	32
1994:					
SC	343	1453	3011	6135	8
GA	592	1737	1865	4235	44
FL (North)	28	463	473	1058	0
Total	963	3653	5349	11428	52
1995[b]:					
SC	929	3072	2729	6433	0
GA	900	2523	1812	4269	38
FL (North)	159	634	671	1033	0
Total	1988	6229	5212	11735	38
1996:					
SC	128	1383	2582	5609	3
GA	359	1304	1807	3981	54
FL (North)	302	417	760	1477	0
Total	789	3104	5149	11067	57
1997[b]:					
SC	143	2211	3109	5416	4
GA	295	2115	2054	4259	19
FL (North)	434	916	730	48	0

				17		
Total	872	5242	5893	9723		23

[a] Seasonal definitions in text. [b] Preliminary.

Table 10. North Carolina trips (trip expansion factors) by strata estimated for 1992-93 and censused from trip ticket database for 1994-97.

Year	Strata	Seasons[a] Winter	Spring	Summer	Fall	Total
1992	Inside	252	2713	9355	1551	13871
	Outside	5	175	1337	337	1854
	Total	257	2888	10692	1888	15725
1993	Inside	91	813	8019	3853	12776
	Outside	80	96	2707	610	3493
	Total	171	909	10726	4563	16369
1994	Inside	170	2127	9855	2460	14612
	Outside	46	510	2283	931	3770
	Total	238	3231	22387	7970	18382
1995	Inside	368	2845	9859	2455	15527
	Outside	104	502	2104	1272	3982
	Total	552	4107	24576	9196	19509
1996	Inside	5	996	8587	1452	11040
	Outside	42	118	1987	1092	3239
	Total	238	3231	22387	7970	14279
1997[b]	Inside	293	1612	8969	1828	12702
	Outside	198	366	1743	828	3135
	Total	552	4107	24576	9196	15837

[a] Seasonal definitions in text. [b] Preliminary.

Table 11. Summary of characterization and BRD study samples used to estimate bycatch in the U.S. south Atlantic shrimp trawl fishery with strata expansion factors based on shrimp trawl catch (1000 lbs) and trips by fishing year (April-March).

Area[a]	Season	Trips	Tows	Hours	Stratum Expansion Catch	Stratum Expansion Trips
				1992-93		
FSO	**Fall**	**1**	**14**	**39.6**	**1587.1**	**964**
FGS	Spring	9	15	46.6	3480.1	4505
FGS	Summer	6	14	45.2	2366.0	4439
FGS	Fall	26	43	130.8	6934.9	11237
FGS	Winter	5	8	21.8	638.5	1501
NCI	Summer	21	30	39.4	3382.7	9355
	Total:	68	124	323.4	18389.3	32001
				1993-94		
FSO	**Spring**	**1**	**1**	**3.1**	**235.8**	**214**
FSO	**Summer**	**1**	**2**	**7.4**	**303.5**	**332**
FSO	Fall	3	52	128.4	787.1	562
FGS	Spring	3	37	131.4	4431.8	5039
FGS	Summer	8	115	338.7	4318.0	5065
FGS	Fall	11	61	206.8	5931.9	9917
FGS	**Winter**	**1**	**8**	**30.5**	**706.2**	**963**
NCI	Spring	11	28	49.2	125.9	813
NCI	Summer	62	112	143.8	2868.4	8019
NCI	Fall	3	6	4.2	1343.6	3853
	Total:	104	422	1043.5	21052.3	34777
				1994-95		
FSO	Winter	4	46	228.8	396.0	572
FGS	Summer	13	51	160.1	2972.7	5349
FGS	Fall	18	87	299.1	7662.1	11428
FGS	Winter	2	24	78.3	1355.7	1988
NCI	**Spring**	**1**	**1**	**0.5**	**223.4**	**2127**
NCI	Summer	61	409	375.4	3767.0	9855
NCI	Fall	16	82	118.7	1241.8	2460
	Total:	115	700	1260.9	17618.7	33779
				1995-96		
FSO	**Spring**	**1**	**7**	**32.8**	**141.9**	**188**
FSO	Summer	2	4	6.0	117.9	157
FSO	**Winter**	**1**	**4**	**16.7**	**296.7**	**479**
FGS	Spring	10	44	147.6	6459.5	6229
FGS	Summer	11	47	162.6	3902.1	5212
FGS	Fall	21	113	398.0	11934.2	11735
FGS	Winter	5	37	162.6	826.6	789
	Total:	51	256	926.3	23678.9	24789
				1996-97		
FGS	Spring	7	14	33.6	1506.1	3104
FGS	Summer	2	5	17.2	3105.2	5149
FGS	Fall	1	6	17.1	7456.7	11067
	Total:	10	25	67.9	12068.0	19320

[a] FSO - Florida (South of 30° N latitude, Outside); FGS - Florida (North) to South Carolina (Outside); NCI - North Carolina (Inside).

Table 12. Expanded estimates (1000) of bycatch of king mackerel in the U.S. south Atlantic shrimp trawl fishery based on within-strata expansion by finfish in numbers to shrimp in weight ratio and shrimp catch (1000 lbs) at the tow level by fishing year.

Area[a]	Season	Shrimp Catch	Tows	F#:Shr Ratio	Finfish Catch	CV	PSE
				1992-93			
FSO	Fall	1587.1	14	0.057	90.3	279.5	74.7
FGS	Spring	3480.0	15	0.0	0.0	-	-
FGS	Summer	2366.0	14	0.186	440.5	166.3	44.5
FGS	Fall	6934.9	43	0.0013	8.8	655.7	100.0
FGS	Winter	638.5	6	0.0	0.0	-	-
NCI	Summer	3382.8	30	0.0	0.0	-	-
	Total:	18389.3	124		539.6		
				1993-94			
FSO	Summer	303.5	2	0.0	0.0	-	-
FSO	Fall	787.1	52	0.0	0.0	-	-
FGS	Spring	4431.8	37	0.0	0.0	-	-
FGS	Summer	4318.0	115	0.0	0.0	-	-
FGS	Fall	5931.9	61	0.009	53.4	433.6	55.5
FGS	Winter	706.2	8	0.0	0.0	-	-
NCI	Spring	125.9	28	0.0	0.0	-	-
NCI	Summer	2868.4	112	0.0	0.0	-	-
NCI	Fall	1343.6	6	0.0	0.0	-	-
	Total:	20816.4	421		53.4		
				1994-95			
FSO	Winter	396.0	46	0.0	0.0	-	-
FGS	Summer	2972.7	51	0.047	140.0	314.7	44.1
FGS	Fall	7662.1	87	0.003	19.5	516.3	55.3
FGS	Winter	1355.7	24	0.0	0.0	-	-
NCI	Summer	3767.0	409	0.048	182.5	1281.7	63.4
NCI	Fall	1241.8	82	0.002	2.1	905.5	100.0
	Total:	17395.3	699		344.1		
				1995-96			
FSO	Spring	141.9	7	0.0	0.0	-	-
FSO	Summer	117.9	4	0.0	0.0	-	-
FSO	Winter	296.7	4	0.0	0.0	-	-
FGS	Spring	6459.5	43	0.0	0.0	-	-
FGS	Summer	3902.1	47	0.0	0.0	-	-
FGS	Fall	11934.2	112	0.001	13.8	642.4	60.7
FGS	Winter	626.6	37	0.0	0.0	-	-
	Total:	23678.9	254		13.8		
				1996-97			
FGS	Spring	1506.1	14	0.090	135.9	334.0	89.3
FGS	Summer	3105.2	5	0.0	0.0	-	-
FGS	Fall	7456.7	6	0.0	0.0	-	-
	Total:	12068.0	25		135.9		

Table 13. Expanded estimates (1000) of bycatch of Spanish mackerel in the U.S. south Atlantic shrimp trawl fishery based on within-strata expansion by finfish in numbers to shrimp in weight ratio and shrimp catch (1000 lbs) at the tow level by fishing year.

Area[a]	Season	Shrimp Catch	Tows	F#:Shr Ratio	Finfish Catch	CV	PSE
				1992-93			
FSO	Fall	1587.1	14	0.045	72.1	374.2	100.0
FGS	Spring	3480.0	15	0.162	564.8	131.8	34.0
FGS	Summer	2366.0	14	0.848	2006.5	206.3	55.1
FGS	Fall	6934.9	43	0.096	664.3	140.1	21.4
FGS	Winter	638.5	8	0.0	0.0	-	-
NCI	Summer	3382.8	30	3.018	10209.2	109.6	20.0
	Total:	18389.3	124		13516.9		
				1993-94			
FSO	Summer	303.5	2	0.169	51.2	141.4	100.0
FSO	Fall	787.1	52	0.012	9.6	371.1	51.5
FGS	Spring	4431.8	37	5.764	25543.2	512.8	84.3
FGS	Summer	4318.0	115	0.148	639.2	273.1	25.5
FGS	Fall	5931.9	61	0.121	719.1	368.6	47.2
FGS	Winter	706.2	8	0.0	0.0	-	-
NCI	Spring	125.9	28	0.047	6.0	221.7	41.9
NCI	Summer	2868.4	112	0.059	169.5	573.9	54.2
NCI	Fall	1343.6	6	0.0	0.0	-	-
	Total:	20816.4	421		27137.7		
				1994-95			
FSO	Winter	396.0	46	0.065	25.6	106.2	15.7
FGS	Summer	2972.7	51	0.949	2821.6	228.6	32.0
FGS	Fall	7662.1	87	0.069	530.3	376.4	40.4
FGS	Winter	1355.7	24	0.0	0.0	-	-
NCI	Summer	3767.0	409	2.542	9577.4	906.5	44.8
NCI	Fall	1241.8	82	0.065	81.1	436.1	48.2
	Total:	17395.3	699		13036.1		
				1995-96			
FSO	Spring	141.9	7	0.042	6.0	172.1	65.1
FSO	Summer	117.9	4	0.067	8.0	191.0	95.5
FSO	Winter	296.7	4	0.0	0.0	-	-
FGS	Spring	6459.5	43	0.175	1133.1	274.3	41.8
FGS	Summer	3902.1	47	0.115	447.3	270.7	39.5
FGS	Fall	11934.2	112	0.026	315.6	189.8	17.9
FGS	Winter	826.6	37	0.0	0.0	-	-
	Total:	23678.9	254		1909.9		
				1996-97			
FGS	Spring	1506.1	14	1.641	2471.4	220.1	58.8
FGS	Summer	3105.2	5	1.420	4410.8	135.9	60.8
FGS	Fall	7456.7	6	0.0	0.0	-	-
	Total:	12068.0	25		6882.3		

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Table 14. Expanded estimates (1000) of bycatch of cobia in the U.S. south Atlantic shrimp trawl fishery based on within-strata expansion by finfish in numbers to shrimp in weight ratio and shrimp catch (1000 lbs) at the tow level by calendar year.

Area[a]	Season	Shrimp Catch	Tows	F#:Shr Ratio	Finfish Catch	CV	PSE
				1992			
FSO	Fall	1587.1	14	0.0	0.0	-	-
FGS	Spring	3480.0	15	0.0	0.0	-	-
FGS	Summer	2366.0	14	0.0	0.0	-	-
FGS	Fall	6934.9	43	0.0	0.0	-	-
NCI	Summer	3382.8	30	0.0	0.0	-	-
	Total:	17750.9	116		0.0		
				1993			
FSO	Summer	303.5	2	0.0	0.0	-	-
FSO	Fall	787.1	52	0.0	0.0	-	-
FGS	Winter	638.5	8	0.0	0.0	-	-
FGS	Spring	4431.8	37	0.0	0.0	-	-
FGS	Summer	4318.0	115	0.0004	1.7	1072.4	100.0
FGS	Fall	5931.9	61	0.0	0.0	-	-
NCI	Spring	125.9	28	0.0	0.0	-	-
NCI	Summer	2868.4	112	0.0	0.0	-	-
NCI	Fall	1343.6	6	0.0	0.0	-	-
	Total:	20748.7	421		1.7		
				1994			
FGS	Winter	706.2	8	0.0	0.0	-	-
FGS	Summer	2972.7	51	0.0	0.0	-	-
FGS	Fall	7662.1	87	0.0	0.0	-	-
NCI	Summer	3767.0	409	0.001	3.5	2022.4	100.0
NCI	Fall	1241.8	82	0.0	0.0	-	-
	Total:	16349.7	637		3.5		
				1995			
FSO	Winter	396.0	46	0.0	0.0	-	-
FSO	Spring	141.9	7	0.0	0.0	-	-
FSO	Summer	117.9	4	0.0	0.0	-	-
FGS	Winter	1355.7	24	0.0	0.0	-	-
FGS	Spring	6459.5	43	0.0	0.0	-	-
FGS	Summer	3902.1	47	0.0	0.0	-	-
FGS	Fall	11934.2	112	0.0	0.0	-	-
	Total:	24307.3	283		0.0		
				1996			
FSO	Winter	296.7	4	0.0	0.0	-	-
FGS	Winter	826.6	37	0.0	0.0	-	-
FGS	Spring	1506.1	14	0.424	637.9	369.5	98.7
FGS	Summer	3105.2	5	0.0	0.0	-	-
FGS	Fall	7456.7	6	0.0	0.0	-	-
	Total:	13191.3	66		637.9		

Table 15. Expanded estimates (1000) of bycatch of king mackerel in the U.S. south Atlantic shrimp trawl fishery based on within-strata expansion by effort as trips by fishing year.

Area[a]	Season	Trips	Finfish CPE	Finfish Catch	CV	PSE
			1992-93			
FGS	Spring	4505	0.0	0.0	-	-
FGS	Summer	4439	22.3	98.8	103.4	42.2
FGS	Fall	11237	0.4	4.1	509.9	100.0
FGS	Winter	1521	0.0	0.0	-	-
NCI	Summer	9355	0.0	0.0	-	-
	Total:	31057		102.9		
			1993-94			
FSO	Fall	562	0.0	0.0	-	-
FGS	Spring	5039	0.0	0.0	-	-
FGS	Summer	5065	0.0	0.0	-	-
FGS	Fall	9917	5.2	51.9	252.8	76.2
NCI	Spring	813	0.0	0.0	-	-
NCI	Summer	8019	0.0	0.0	-	-
NCI	Fall	3853	0.0	0.0	-	-
	Total:	33268		51.9		
			1994-95			
FSO	Winter	572	0.0	0.0	-	-
FGS	Summer	5349	24.3	130.2	360.6	100.0
FGS	Fall	11428	6.0	69.0	366.2	86.3
FGS	Winter	1988	0.0	0.0	-	-
NCI	Summer	9855	1.3	12.7	463.7	59.4
NCI	Fall	2460	0.6	1.5	400.0	100.0
	Total:	31652		213.3		
			1995-96			
FSO	Summer	157	0.0	0.0	-	-
FGS	Spring	6229	0.0	0.0	-	-
FGS	Summer	5212	0.0	0.0	-	-
FGS	Fall	11735	0.9	10.2	273.9	59.8
FGS	Winter	789	0.0	0.0	-	-
	Total:	24122		10.2		
			1996-97			
FGS	Spring	3104	4.4	13.8	157.2	59.4
FGS	Summer	5149	0.0	0.0	-	-
	Total:	8253		13.8		

Note: C_f = T*CPE, where C_f = finfish catch, T is number of trips, and CPE is finfish catch per trips in the shrimp trawl fishery.

Table 16. Expanded estimates (1000) of bycatch of Spanish mackerel in the U.S. south Atlantic shrimp trawl fishery based on within-strata expansion by effort as trips by fishing year.

Area[a]	Season	Trips	Finfish CPE	Finfish Catch	CV	PSE
			1992-93			
FGS	Spring	4505	27.2	122.5	79.0	26.3
FGS	Summer	4439	93.7	416.0	59.3	24.2
FGS	Fall	11237	24.4	274.6	179.5	35.2
FGS	Winter	1521	0.0	0.0	-	-
NCI	Summer	9355	96.6	903.3	99.9	19.6
	Total:	31057		1716.5		
			1993-94			
FSO	Fall	562	31.2	17.5	112.0	64.6
FGS	Spring	5039	861.1	4339.0	90.4	52.2
FGS	Summer	5065	312.8	1584.5	212.1	75.0
FGS	Fall	9917	44.5	440.8	228.9	69.0
NCI	Spring	813	9.3	7.6	122.9	37.0
NCI	Summer	8019	5.3	42.8	396.3	50.3
NCI	Fall	3853	0.0	0.0	-	-
	Total:	33268		6432.2		
			1994-95			
FSO	Winter	572	83.7	47.9	48.0	24.0
FGS	Summer	5349	386.9	2069.4	208.7	57.9
FGS	Fall	11428	37.7	430.3	183.0	43.1
FGS	Winter	1988	0.0	0.0	-	-
NCI	Summer	9855	101.5	1000.1	147.5	18.9
NCI	Fall	2460	6.9	16.9	236.5	59.1
	Total:	31652		3564.7		
			1995-96			
FSO	Summer	157	6.3	1.0	84.9	60.0
FGS	Spring	6229	44.6	277.7	112.7	35.6
FGS	Summer	5212	88.3	460.3	202.5	61.1
FGS	Fall	11735	30.8	361.6	272.1	59.4
FGS	Winter	789	0.0	0.0	-	-
	Total:	24122		1100.6		
			1996-97			
FGS	Spring	3104	34.4	106.7	104.0	39.3
FGS	Summer	5149	105.5	543.3	141.4	100.0
	Total:	8253		650.0		

Note: C_f = T*CPE, where C_f = finfish catch, T is number of trips, and CPE is finfish catch per trips in the shrimp trawl fishery.

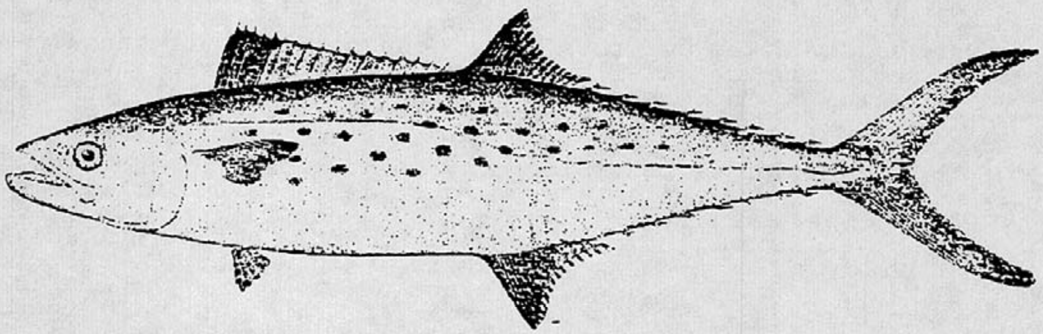
Table 17. Expanded estimates (1000) of bycatch of cobia in the U.S. south Atlantic shrimp trawl fishery based on within-strata expansion by effort as trips by calendar year.

Area[a]	Season	Trips	Finfish CPE	Finfish Catch	CV	PSE
			1992			
FGS	Spring	4505	0.0	0.0	-	-
FGS	Summer	4439	0.0	0.0	-	-
FGS	Fall	11237	0.0	0.0	-	-
NCI	Summer	9355	0.0	0.0	-	-
	Total:	31057		0.0		
			1993			
FSO	Fall	562	0.0	0.0	-	-
FGS	Winter	1521	0.0	0.0	-	-
FGS	Spring	5039	0.0	0.0	-	-
FGS	Summer	5065	4.7	24.0	282.8	100.0
FGS	Fall	9917	0.0	0.0	-	-
NCI	Spring	813	0.0	0.0	-	-
NCI	Summer	8019	0.0	0.0	-	-
NCI	Fall	3853	0.0	0.0	-	-
	Total:	33268		24.0		
			1994			
FGS	Summer	5349	0.0	0.0	-	-
FGS	Fall	11428	0.0	0.0	-	-
NCI	Summer	9855	0.04	0.4	781.0	100.0
NCI	Fall	2460	0.0	0.0	-	-
	Total:	31652		0.4		
			1995			
FSO	Winter	572	0.0	0.0	-	-
FSO	Summer	157	0.0	0.0	-	-
FGS	Winter	1988	0.0	0.0	-	-
FGS	Spring	6229	0.0	0.0	-	-
FGS	Summer	5212	0.0	0.0	-	-
FGS	Fall	11735	0.0	0.0	-	-
	Total:	24122		0.0		
			1996			
FGS	Winter	789	0.0	0.0	-	-
FGS	Spring	3104	2.0	6.3	174.7	66.0
FGS	Summer	5149	0.0	0.0	-	-
	Total:	8253		6.3		

Note: C_i = T*CPE, where C_i = finfish catch, T is number of trips, and CPE is finfish catch per trips in the shrimp trawl fishery.

Appendix O. Commercial Landings Update: Coastal Migratory Pelagic Fish

Commercial Landings Update
Coastal Migratory Pelagic Fish



John Vondruska
National Marine Fisheries Service
Fisheries Economics Office

April 2, 1999

SERO-ECON-99-06

Commercial Landings Update,
Coastal Migratory Pelagic Fish
April 2, 1999

This report updates summaries of data on commercial landings and exvessel prices for coastal migratory pelagic fish for the Atlantic and Gulf coast states (Maine to Texas), with emphasis on the southeast (North Carolina to Texas). The data is preliminary for recent years and not complete for 1998.

Methods, Data and Caveats

This report is based mostly on data obtained in early March 1999 from the Northeast (Woods Hole) and Southeast (Miami) Fisheries Science Centers of the National Marine Fisheries Service (NMFS). The southeast data has been collected under a cooperative state-federal program since the late 1970s. Most of the source files for this report consist of confidential, monthly data records that are identified by dealer (first buyer in the marketing chain going from fisherman to consumer). This affects what can be shown in tables.

In so far as possible, consistent annual time series are shown for individual states or groups of states in Table 4 for each of seven fish for 1962-98, and exceptions are footnoted. The seven fish are bluefish, bonito, cobia, dolphin fish, king mackerel and cero, Spanish mackerel, and wahoo. Monthly landings and real exvessel prices for each are shown for the southeast as a whole for 1977-98 (Tables 7-8). For king mackerel and cero, annual landings are shown for groups of Florida counties (Table 6), and monthly landings and real exvessel prices are shown for groups of southeastern states (Tables 9-10). Annual landings by fish and gear are shown in Table 5 for two regions, the South Atlantic (North Carolina to Dade County on the east coast of Florida) and Gulf of Mexico (Monroe County on the west coast of Florida to Texas). However, gear is not specified in all data records, including those for some Gulf states for 1991-98. Also, totals in Table 5 and other tables may differ. On the other hand, data on landings by gear for Florida became monthly and more timely for 1997 onward, based on Florida trip tickets.[1]

In this report, real prices are expressed in terms of 1990 cents per pound (whole or live weight). They are computed from the current dollar value of landings divided by the quantity of landings. The Bureau of Labor Statistics (BLS) Producer Price Index for all commodities is used as a deflator.

It is difficult to ascertain annual landings for 1998 with the data used in this report (obtained in early March 1999). While the annual data in Table 1 may suggest shortfalls for 1998, that is less clear from monthly data in Table 7. December landings in Florida are normally quite important to the annual totals for king and Spanish mackerel, but observations are

[1]Historically, breakouts of landings (by gear, water body, etc.) in Florida were not part of the ongoing collection of data from dealer records by port agents, and the data was managed by NMFS in separate annual files for Florida. The breakouts of Florida landings were based on an annual general canvass of Florida dealers and port agent records on fishing craft.

missing for Florida for December 1998. For cobia, dolphin fish and wahoo, the monthly numbers seem low for about August 1998 onward (Table 7).

Data for bonito (here combined with data for little tuna or little tunny) has not been entered separately in the source data files for Florida since 1994. For reasons of confidentiality, relatively small landings for other Gulf states are not shown.

Trends

Spanish mackerel

Commercial landings of Spanish mackerel on Florida's west coast appear to have been affected from July 1995 onward by the implementation of an Amendment to that State's Constitution that was intended to restrict the use of net gear (Tables 4, 6 and 7). Florida's "net ban" took effect in July 1995 and it extends to 9 nautical miles from shore on Florida's west coast compared with 3 nautical miles for Florida's east coast. However, as the term coastal migratory pelagic fish implies, it is also possible that changes in availability of harvestable concentrations of Spanish mackerel over time and space, weather, or other factors could have affected landings in Florida in recent years. Regardless of the precise effect of new state regulations on net gear, landings of Spanish mackerel for Florida's west coast and Louisiana were notably less in 1996-98 than in previous years. Consequently lower fishing mortality allowed stock conditions to improve for Gulf group Spanish mackerel especially in terms of biomass and transitional spawning potential ratio (MSAP, 1998).

Because the harvest occurred in federal waters (more than 3 nautical miles from shore), landings of Spanish mackerel have remained well within the range that had prevailed since the mid-1980s in southeast Florida (Volusia-Dade Counties in Table 6). That area has been the leading harvest area for Spanish mackerel since 1995. Whether that situation will continue is unclear. Roughly similar amounts of Spanish mackerel are now being landed in North Carolina, Alabama, the Florida west coast and the northeast (Table 4).

King mackerel

Among the seven coastal migratory pelagic fish considered in this report, king mackerel-cero now leads in terms of tonnage as well as value in the southeast, given the drop for Spanish mackerel that began in 1995. While bluefish does account for more tonnage than king mackerel and cero for the U.S. Atlantic and Gulf coasts as a whole, it is landed mostly in the northeast and North Carolina, and its low price means that the total exvessel value for bluefish was similar to that for Spanish mackerel in 1996-98 (Tables 1-3).

Total landings of king mackerel in recent years have been roughly the same as in the early 1960s, prior to most of the expansion attributable to fishing with gill nets. However, more of the total is now being landed in North Carolina-Georgia and Louisiana-Texas, while less is being landed in Florida (Tables 4 and 5).

The landings in North Carolina-Georgia tend to be concentrated in October-November, though large monthly amounts have been landed sporadically during January-April in recent years (monthly percentages, Table 9). Reportedly, there was a rumor that the landings in November 1998 could have been high enough to trigger events leading to closure for commercial fishing activity prior to the end of the (April-March) 1998/99 fishing year for Atlantic group king mackerel.[2] While quota closures have not been as much of a concern as for Gulf group king mackerel, the TAC has been reduced.[3]

Fishing for king mackerel in Alabama-Texas (mostly in Louisiana) began to be notable in 1982. It is now limited by a quota for the western zone for Gulf group king mackerel. Most of that quota has been landed in as little as the first two months of the fishing year for the Gulf group, which begins in July, and further fishing is curtailed (e.g., closure occurred on August 25, 1998). Reportedly, the fish landed in Alabama-Texas tend to be larger in size. This could help explain why the exvessel price per pound for them has tended to be lower than for king mackerel landed elsewhere (Table 10).

Landings of king mackerel in Florida once accounted for most of what was landed commercially in the Atlantic and Gulf coastal states, but they have been relatively flat in trend since the mid-1980s and appear to be a bit below their historical norm for the 1950s and earlier years (Table 4 and NMFS, 1990). Compared with the past, regulation of commercial fishing on the two stocks of king mackerel in Florida has become quite complex, more so than for any other state, given the Councils' response to the annual stock assessments that began in the mid-1980s. Also, recreational fishing activity today is much greater than in the past, and the Councils have allocated larger percentages of the total allowable catch (TAC) to recreational fishing than commercial fishing. Although allocations have been exceeded for both the commercial and recreational fishing on Gulf group king mackerel, the Councils have moved away from the idea of

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[2]Although preliminary, the data in this report is more complete than whatever was available prior to March 1999, and it indicates that 482,000 pounds of king mackerel-cero were landed in November 1998 in North Carolina, South Carolina and Georgia, taken together. The November 1998 amount is higher than that for November 1997 (346,000 pounds) and it exceeds the previous record for a month (407,000 pounds in November 1987).

[3]If the cumulative landings estimated through November 1998 under the quota-monitoring program were high enough, it is possible that this could have led to a chain of events that closed the commercial fishery for Atlantic group king mackerel early. The allocation was reduced (in proportion to the reduction in total allowable catch) from 3.9 million pounds (for fishing years 1991/92 to 1993/94) to 2.52 million pounds (for fishing years 1996/97 onward). The number for 1996/97 cited by the Mackerel Stock Assessment Panel in April 1998, 2.702 million pounds, did exceed the quota (MSAP, 1998, p. 10). Atlantic group king mackerel has not been considered to be overfished, although overfishing was said to be occurring during fishing year 1996/97, because the rate of fishing mortality (F) was greater than the rate necessary to achieve a target of 30% static spawning potential ratio in 1996/97 (MSAP, 1998, p. 9).

recreational fishery closure, to the extent that closure may be said to occur with a zero bag limit.[4]

For the South Atlantic region as a whole, landings by hook-and-line gear are higher than in the early 1960s, and they approached the peak levels of 1980-81 in 1997. On the other hand, for the Gulf region as a whole, landings by hook-and-line gear were well below those for runaround gill nets even in the hey day for gill nets.[5] Landings in the Gulf region via hook-and-line gear do not appear to be much different than in the early 1960s.[6] Today, differences along the Florida coast in "winter" (November-March) harvestable concentrations and differences in viable fishery practice for gill-net and hook-and-line boats are reflected in complex regulations that involve different trip limits and stepped quotas.[7]

Cobia, dolphin fish, and wahoo

Cobia, dolphin fish and wahoo are landed commercially in much smaller amounts than bluefish or Spanish mackerel, but they have higher prices, roughly similar to those for king mackerel-cero, and the value for dolphin fish is second to that for king mackerel-cero (Tables 1-3). As for king mackerel, landings for recreational fishing exceed those for commercial fishing. The South Atlantic Fishery Management Council hosted a workshop on May 6-8, 1998, respecting the biological characteristics and management options for dolphin fish and wahoo (SAFMC, 1998).

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[4]That is, even if a zero bag limit were imposed on all individuals on a fishing trip (e.g., all crew members, customers and passengers on for-hire boats), catch-and-release recreational fishing could continue.

[5]After a period of relatively high landings from the mid-1960s to 1983, a drop in the commercial landings of king mackerel via runaround gill net began in 1984 in both the South Atlantic and Gulf regions for several reasons. Perhaps the harvestable concentrations may not have been high enough in the normally peak months in south Florida (for viable gill net fishing). Also, the State of Florida implemented regulations on the use of net gear, which apparently applied to federal as well as state waters by default (lack of federal regulation). Later, a short-lived (1986-89) shift to drift gill nets was curtailed by Council action (Table 5, South Atlantic Region).

[6]Landings by hook and line gear for Gulf region as a whole may be understated in their amount for 1991 onward (Table 5) to the extent that they occur in states other than Florida. That is, significant amounts of landings have not been broken out by gear since 1991 for some of the Gulf states other than Florida.

[7]During the months of November-March, landings in Florida from the border with Alabama to the Flagler-Volusia County line on the east coast are said to consist of Eastern Zone fish of the Gulf group of king mackerel for purposes of stock assessment and commercial fishery regulation. On the east coast of Florida (from the Flagler-Volusia County line to the Dade-Monroe County line), a 50-fish trip limit applied in fishing year 1998/99 from November 1 until the quota for that area was reached (1,170,000 pounds, with a formal closure on March 13, 1999). On the west coast of Florida (through the Dade-Monroe County line), equal quotas were assigned for gill-net and hook-and-line fishing, 585,000 pounds each. With a 25,000 pound trip limit, the gill-net quota was reached earlier in fishing year 1998/99 (January 1, 1999) than the hook-and-line fishing quota (1250 pound trip limits until 438,750 pounds was reached, and then 500 pounds per trip until 585,000 pounds was reached, and formal closure occurred on March 16, 1999).

Cobia is landed under a two-fish bag limit, whether by commercial, charter, or private recreational fishing boats. While this has restrained commercial landings, the record amount, about 428,000 pounds in 1996, is several times that for 1966, about 55,000 pounds. Cobia went from being the lowest priced coastal migratory pelagic fish to being the highest priced (20 cents a pound in 1966 and 171 cents in 1998, both in terms of 1990 dollars, Table 3). If an individual fish is 15-30 pounds, it may have an exvessel value of about $25 to $50 (size data from Scott and Phares, 1999). Landings occur throughout the Atlantic and Gulf coast states, but they are highest for the west coast of Florida (Table 4). Hook-and-line gear accounts for much of what is landed commercially, though it is not as dominant as for king mackerel (Table 5).

Without the restraint of a 2-fish (recreational) bag limit, commercial landings of dolphin fish have grown more rapidly than landings of cobia. As for cobia, real prices of dolphin fish have advanced considerably since the 1960s (Table 3). Landings of dolphin fish surpassed a million pounds in 1989, and the record of 2.57 million pounds of 1995 is two orders of magnitude greater than the 32,000 pounds of 1965, when virtually all landings occurred in Florida. Significant landings began to occur in North Carolina-Georgia in the mid-1970s, and a bit later in Alabama-Texas and the northeast (Maine-Virginia) (Table 4). The most important commercial fishing gear types are hook-and-line, and long and trot lines gear (landings for the latter two are shown together in Table 5).

So far as could be determined for this report from NMFS-managed data files, the first separately reported commercial landings of wahoo on the Atlantic and Gulf coasts occurred in Florida in 1974 when they amounted to about a thousand pounds (Table 4). Landings now occur elsewhere, but to a large extent in Louisiana, where they are now much less than in 1992-93. In 1994-98, the landings total has been in the middle of the range of about 0.14 million pounds (1987) to 0.37 million pounds (1993). As for dolphin fish, the most important commercial fishing gear types are hook-and-line, long and trot lines (landings for the latter two are shown together in Table 5).

Selected References

Gulf of Mexico Fishery Management Council (GMFMC) and South Atlantic Fishery Management Council (SAFMC). 1998. 1998 Report of the Mackerel Stock Assessment Panel (meeting of March 23-26, 1998).

National Marine Fisheries Service (NMFS). 1990. Historical catch statistics, Atlantic and Gulf coast states, 1879-89. U.S. Dept. of Commerce, NOAA, NMFS Fisheries Statistics Division, 1335 East West Highway, Silver Spring, MD 20910, current fishery statistics no. 9010, historical series numbers 5-9 revised (October 1990), 107 p.

Scott, Gerald P. and Patty L. Phares. 1999. Cobia fishery information update. NMFS Southeast Fisheries Science Center, Sustainable Fisheries Division, 75 Virginia Beach Drive, Miami, FL 33149, Contribution SFD-98/99-51, 38 pages.

South Atlantic Fishery Management Council (SAFMC). 1998. SAFMC Dolphin/Wahoo Workshop Proceedings (Town and Country Inn, Charleston, South Carolina, May 6-8, 1998).

List of tables on commercial landings, coastal migratory pelagic fish

Table 1.--Landings by fish, east & Gulf coasts
(thousands of pounds, whole weight)
(Data for 1998 is not complete)

Year	Bluefish	Bonito	Cobia	Dolphin fish	King mackerel & cero	Spanish mackerel	Wahoo	Total
1962	5,938	168	81	24	4,157	9,601	.	19,968
1963	5,595	212	95	9	5,058	7,794	.	18,762
1964	4,651	63	53	28	3,460	6,072	.	14,326
1965	5,031	182	45	32	4,593	8,012	.	17,896
1966	5,532	124	55	77	4,520	9,471	.	19,779
1967	4,295	50	61	189	6,099	7,885	.	16,578
1968	5,417	94	101	97	6,201	11,776	.	23,686
1969	5,993	217	85	61	6,204	10,918	.	23,477
1970	7,456	183	129	84	6,729	12,140	.	26,719
1971	6,328	198	125	60	5,667	10,391	.	22,770
1972	6,258	52	135	70	4,869	10,615	.	21,997
1973	8,598	578	125	88	5,937	9,711	.	25,037
1974	8,365	205	149	85	10,416	10,926	1	30,147
1975	8,260	325	139	133	6,333	11,350	5	26,546
1976	9,276	190	153	110	7,640	18,012	5	35,386
1977	11,542	493	116	135	9,406	13,693	7	35,392
1978	11,931	453	116	164	5,376	7,258	13	25,312
1979	13,521	868	105	111	5,527	7,023	15	27,170
1980	16,451	450	128	173	7,088	11,856	23	36,169
1981	17,446	855	161	132	8,816	7,940	26	35,376
1982	16,791	457	158	307	8,255	7,419	30	33,416
1983	16,787	565	169	321	6,969	8,265	34	33,109
1984	12,658	354	174	444	5,220	6,043	30	24,923
1985	14,245	241	165	422	5,398	6,457	39	26,967
1986	15,371	214	221	687	5,772	7,155	52	29,472
1987	15,244	387	274	648	5,211	7,178	160	29,101
1988	16,881	515	262	780	4,557	6,163	312	29,469
1989	10,494	594	337	1,561	3,657	6,985	300	23,928
1990	11,072	621	285	1,848	4,864	5,639	203	24,532
1991	11,141	879	318	2,430	4,053	7,819	252	26,892
1992	9,786	1,565	373	1,136	4,999	6,932	365	25,157
1993	8,874	864	392	1,242	5,687	7,518	335	24,912
1994	7,084	1,773	399	1,417	4,299	6,804	249	22,024
1995	8,081	227	399	2,570	4,680	5,220	264	21,440
1996	7,704	263	428	1,646	5,117	3,655	231	19,043
1997	8,387	332	361	1,995	5,949	3,812	256	21,093
1998	7,168	191	298	941	5,118	1,944	228	15,888

Table 2.--Real value by fish, east & Gulf coasts
(1990 dollars)
(Data for 1998 is not complete)

Year	Bluefish	Bonito	Cobia	Dolphin fish	King mackerel & cero	Spanish mackerel	Wahoo	Total
1962	2,372	75	17	7	1,955	3,435	.	7,862
1963	2,281	74	25	3	2,046	2,652	.	7,081
1964	2,107	35	12	9	1,494	2,077	.	5,734
1965	2,098	72	11	11	2,288	3,253	.	7,734
1966	2,274	39	11	25	2,314	3,789	.	8,452
1967	1,846	23	15	66	2,972	2,742	.	7,664
1968	2,452	45	29	41	3,296	4,127	.	9,990
1969	2,317	78	23	26	3,325	4,062	.	9,830
1970	2,420	168	36	37	4,219	4,635	.	11,515
1971	2,214	53	33	29	3,960	3,631	.	9,920
1972	2,244	31	36	36	3,819	3,865	.	10,031
1973	2,640	126	35	51	5,522	4,064	.	12,438
1974	2,075	57	37	47	7,121	4,225	0	13,562
1975	2,003	92	45	66	4,698	3,894	4	10,802
1976	1,904	60	60	63	6,543	6,203	5	14,838
1977	2,339	172	51	88	6,794	4,510	6	13,961
1978	2,800	414	61	113	4,564	2,368	10	10,330
1979	3,361	261	49	88	6,001	2,410	13	12,183
1980	3,360	160	64	133	7,027	4,070	19	14,833
1981	4,059	218	91	116	8,899	2,955	21	16,359
1982	4,374	102	95	280	9,149	2,769	25	16,794
1983	2,929	122	118	298	7,386	2,826	33	13,711
1984	2,633	93	132	449	4,632	1,966	30	9,935
1985	2,769	67	151	504	6,109	2,207	44	11,853
1986	3,076	76	220	801	6,612	2,573	64	13,423
1987	3,716	99	304	879	6,352	2,820	190	14,360
1988	3,263	208	312	1,031	5,465	2,642	348	13,270
1989	2,271	195	408	1,766	4,556	2,786	290	12,272
1990	1,501	95	368	1,949	5,565	2,246	245	11,970
1991	1,346	185	430	2,771	4,619	3,049	276	12,676
1992	2,041	282	538	1,250	6,076	2,422	382	12,991
1993	2,013	150	581	1,505	6,580	2,796	376	14,001
1994	1,149	409	605	1,971	5,455	2,816	287	12,693
1995	1,512	57	628	3,214	5,686	2,164	357	13,618
1996	1,132	55	687	2,158	5,830	1,588	303	11,752
1997	1,601	42	577	2,086	6,989	1,799	343	13,436
1998	1,231	61	510	1,234	6,063	1,129	306	10,536

Table 3.--Real exvessel prices by fish, east & Gulf coasts
(1990 cents/pound, whole weight)
(Data for 1998 is not complete)

Year	Bluefish	Bonito	Cobia	Dolphin fish	King mackerel & cero	Spanish mackerel	Wahoo
1962	40	45	22	28	47	36	.
1963	41	35	27	36	40	34	.
1964	45	56	24	33	43	34	.
1965	42	40	25	35	50	41	.
1966	41	31	20	33	51	40	.
1967	43	46	25	35	49	35	.
1968	45	48	29	42	53	35	.
1969	39	36	27	42	54	37	.
1970	32	92	28	44	63	38	.
1971	35	27	26	49	70	35	.
1972	36	59	27	52	78	36	.
1973	31	22	28	58	93	42	.
1974	25	28	25	55	68	39	62
1975	24	28	33	50	74	34	73
1976	21	31	39	57	86	34	86
1977	20	35	44	65	72	33	79
1978	23	91	52	69	85	33	73
1979	25	30	46	80	109	34	88
1980	20	36	50	77	99	34	84
1981	23	25	57	88	101	37	80
1982	26	22	60	91	111	37	84
1983	17	22	70	93	106	34	97
1984	21	26	76	101	89	33	100
1985	19	28	92	119	113	34	112
1986	20	36	100	117	115	36	122
1987	24	26	111	136	122	39	119
1988	19	40	119	132	120	43	112
1989	22	33	121	113	125	40	97
1990	14	15	129	105	114	40	121
1991	12	21	135	114	114	39	109
1992	21	18	144	110	122	35	105
1993	23	17	148	121	116	37	112
1994	16	23	152	139	127	41	115
1995	19	25	158	125	121	41	135
1996	15	21	161	131	114	43	131
1997	19	13	160	105	117	47	134
1998	17	32	171	131	118	58	134

Table 4.--Landings by fish, region and state
(thousands of pounds, whole weight, NE=Maine-Virginia)
(Data for 1998 is not complete)

Bluefish

Year	Northeast		South Atlantic				Gulf				
	NE	Region total	NC	SC-GA	FL ec	Region total	FL wc	AL-MS	LA-TX	Region total	Total
1962	2,638	2,638	955	5	1,393	2,352	944	4	.	949	5,938
1963	2,408	2,408	813	114	1,363	2,289	889	8	.	898	5,595
1964	1,813	1,813	515	316	1,202	2,033	779	26	.	804	4,651
1965	2,452	2,452	704	84	855	1,643	859	78	.	937	5,031
1966	2,489	2,489	821	159	1,354	2,333	584	126	.	711	5,532
1967	1,417	1,417	888	48	1,347	2,282	513	83	.	596	4,295
1968	1,967	1,967	872	24	1,911	2,807	556	87	.	644	5,417
1969	2,450	2,450	871	5	2,080	2,957	529	57	0	586	5,993
1970	4,211	4,211	496	9	2,046	2,550	650	44	0	694	7,456
1971	3,579	3,579	578	13	1,625	2,216	510	22	.	533	6,328
1972	3,834	3,834	.	.	1,876	1,876	511	36	0	548	6,258
1973	6,485	6,485	.	.	1,583	1,583	493	38	0	530	8,598
1974	6,556	6,556	.	.	1,273	1,273	501	25	11	536	8,365
1975	6,708	6,708	.	.	1,021	1,021	436	83	12	531	8,260
1976	7,290	7,290	.	.	1,380	1,380	528	77	1	606	9,276
1977	6,889	6,889	2,342	.	1,373	3,715	902	35	.	938	11,542
1978	7,763	7,763	1,961	.	1,336	3,297	850	21	0	871	11,931
1979	7,663	7,663	3,419	.	1,489	4,908	900	50	.	950	13,521
1980	7,551	7,551	5,532	4	2,167	7,703	1,155	42	.	1,197	16,451
1981	7,792	7,792	6,627	4	2,158	8,789	777	88	0	865	17,446
1982	9,167	9,167	4,308	12	2,008	6,328	1,158	'139	.	1,296	16,791
1983	7,692	7,692	6,802	12	1,499	8,313	725	57	0	782	16,787
1984	6,801	6,801	3,633	2	1,586	5,221	588	48	0	636	12,658
1985	9,345	9,345	3,679	2	638	4,319	564	15	2	581	14,245
1986	10,099	10,099	3,528	11	1,165	4,704	458	108	3	568	15,371
1987	8,397	8,397	4,710	8	1,548	6,266	445	115	21	581	15,244
1988	9,447	9,447	5,146	9	1,316	6,470	709	243	12	963	16,881
1989	5,410	5,410	3,396	6	998	4,401	513	135	35	683	10,494
1990	4,594	4,594	4,709	4	1,077	5,790	388	119	181	688	11,072
1991	4,987	4,987	4,030	6	1,482	5,519	378	111	146	635	11,141
1992	4,287	4,287	3,014	6	1,090	4,109	303	56	1,031	1,390	9,786
1993	3,996	3,996	2,852	6	1,197	4,055	172	64	586	823	8,874
1994	3,833	3,833	1,988	8	933	2,930	239	10	72	322	7,084
1995	3,818	3,818	3,193	1	701	3,895	299	45	24	368	8,081
1996	3,659	3,659	3,433	17	258	3,708	277	43	19	338	7,704
1997	3,096	3,096	4,374	1	462	4,838	281	74	99	454	8,387
1998	2,894	2,894	3,537	4	448	3,990	141	31	112	284	7,168

Bluefish: NC includes SC & GA in 1977-79. AL-MS includes LA in 1977.

Table 4.--Landings by fish, region and state
(thousands of pounds, whole weight, NE=Maine-Virginia)
(Data for 1998 is not complete)

Bonito

Year	Northeast		South Atlantic			Gulf		
	NE	Region total	NC	FL ec	Region total	FLwc-TX	Region total	Total
1962	163	163	.	2	2	3	3	168
1963	210	210	.	1	1	1	1	212
1964	63	63	.	0	0	.	.	63
1965	182	182	.	0	0	.	.	182
1966	31	31	.	4	4	89	89	124
1967	40	40	.	6	6	4	4	50
1968	82	82	.	6	6	6	6	94
1969	206	206	.	3	3	8	8	217
1970	141	141	.	7	7	34	34	183
1971	65	65	.	6	6	127	127	198
1972	45	45	.	3	3	4	4	52
1973	78	78	.	10	10	491	491	578
1974	101	101	.	5	5	99	99	205
1975	193	193	.	11	11	121	121	325
1976	46	46	.	21	21	123	123	190
1977	180	180	.	18	18	295	295	493
1978	360	360	.	6	6	87	87	453
1979	527	527	0	30	30	311	311	868
1980	179	179	17	81	98	173	173	450
1981	244	244	4	79	83	528	528	855
1982	102	102	31	70	101	254	254	457
1983	201	201	11	28	40	324	324	565
1984	235	235	1	38	39	80	80	354
1985	138	138	1	5	6	97	97	241
1986	114	114	1	4	5	95	95	214
1987	151	151	7	29	35	201	201	387
1988	197	197	3	56	59	259	259	515
1989	268	268	4	148	153	172	172	594
1990	179	179	4	18	22	420	420	621
1991	187	187	5	17	22	670	670	879
1992	499	499	12	51	63	1,003	1,003	1,565
1993	206	206	16	91	107	552	552	864
1994	280	280	37	81	119	1,374	1,374	1,773
1995	192	192	35	.	35	.	.	227
1996	246	246	16	.	16	.	.	263
1997	290	290	42	.	42	.	.	332
1998	160	160	31	.	31	.	.	191

Bonito: NC includes GA in 1982. Gulf coast landings not shown for 1995-98.

Table 4.--Landings by fish, region and state
(thousands of pounds, whole weight, NE=Maine-Virginia)
(Data for 1998 is not complete)

Cobia

Year	Northeast		South Atlantic				Gulf				
	NE	Region total	NC	SC-GA	FL ec	Region total	FL wc	AL-MS	LA-TX	Region total	Total
1962	21	21	20	.	3	23	17	6	14	37	81
1963	33	33	17	.	7	24	10	4	25	38	95
1964	13	13	12	.	2	14	11	1	14	26	53
1965	10	10	10	.	4	14	11	1	11	22	45
1966	3	3	10	.	5	15	28	2	8	38	55
1967	3	3	10	.	9	19	24	4	12	40	61
1968	4	4	7	.	9	16	41	14	26	81	101
1969	3	3	6	.	4	11	45	10	17	72	85
1970	2	2	7	.	14	21	60	13	33	106	129
1971	4	4	11	.	7	18	77	8	18	104	125
1972	4	4	.	.	14	14	74	15	29	117	135
1973	2	2	.	.	11	11	77	15	21	113	125
1974	4	4	.	.	12	12	89	14	30	133	149
1975	6	6	.	.	14	14	84	8	28	119	139
1976	3	3	.	.	13	13	104	6	27	137	153
1977	2	2	.	.	11	11	80	22	.	102	116
1978	1	1	.	.	11	11	87	3	14	104	116
1979	1	1	.	.	11	11	80	6	8	94	105
1980	1	1	5	2	20	27	90	3	7	100	128
1981	1	1	5	11	25	41	100	2	17	118	161
1982	2	2	11	19	17	46	85	26	.	110	158
1983	1	1	4	13	18	35	111	3	18	132	169
1984	2	2	7	5	18	30	115	11	16	142	174
1985	3	3	7	2	17	26	105	8	23	136	165
1986	1	1	18	6	34	59	94	21	45	161	221
1987	0	0	33	7	58	98	111	17	48	175	274
1988	6	6	16	7	71	94	106	10	47	163	262
1989	11	11	15	7	92	114	128	20	64	212	337
1990	18	18	22	3	77	103	109	8	47	164	285
1991	15	15	23	6	97	126	132	2	44	177	318
1992	9	9	19	9	101	128	159	3	73	235	373
1993	7	7	20	12	91	124	171	4	86	261	392
1994	8	8	31	8	88	127	149	4	111	264	399
1995	25	25	35	8	90	133	158	1	82	241	399
1996	23	23	33	5	103	142	179	2	81	262	428
1997	16	16	42	4	91	137	136	4	69	208	361
1998	10	10	30	4	66	100	130	.	58	188	298

Cobia: FL ec includes NC-GA in 1977-79. AL-MS includes LA-TX in 1977 and 1982.
LA-TX includes AL-MS in 1998.

Table 4.--Landings by fish, region and state
(thousands of pounds, whole weight, NE=Maine-Virginia)
(Data for 1998 is not complete)

Dolphin fish

Year	Northeast		South Atlantic					Gulf				
	NE	Region total	NC	SC	GA	FL ec	Region total	FL wc	AL-LA	TX	Region total	Total
1962	.	.	.	.	.	8	8	16	.	.	16	24
1963	.	.	.	.	.	4	4	5	.	.	5	9
1964	.	.	.	.	.	6	6	22	.	.	22	28
1965	0	0	.	.	.	14	14	18	.	.	18	32
1966	.	.	.	.	.	16	16	61	.	.	61	77
1967	.	.	.	.	.	35	35	154	.	.	154	189
1968	.	.	.	.	.	21	21	76	.	.	76	97
1969	0	0	.	.	.	12	12	49	.	.	49	61
1970	.	.	.	.	.	21	21	63	.	.	63	84
1971	.	.	.	.	.	22	22	38	.	.	38	60
1972	.	.	.	.	.	14	14	55	.	.	55	70
1973	.	.	.	.	.	18	18	70	.	.	70	88
1974	.	.	.	.	.	15	15	70	.	.	70	85
1975	.	.	.	.	.	26	26	106	.	.	106	133
1976	.	.	.	.	.	27	27	84	.	.	84	110
1977	0	0	.	.	.	71	71	64	.	.	64	135
1978	1	1	13	.	.	57	70	93	.	.	93	164
1979	.	.	10	.	.	35	45	66	.	.	66	111
1980	1	1	24	7	.	47	78	95	.	.	95	173
1981	.	.	6	8	0	45	59	73	.	.	73	132
1982	0	0	41	21	1	80	144	162	.	.	162	307
1983	2	2	30	35	0	62	128	191	.	.	191	321
1984	2	2	47	20	10	82	159	283	0	.	283	444
1985	10	10	42	18	14	68	143	260	10	.	270	422
1986	4	4	36	11	15	127	190	448	44	.	493	687
1987	15	15	71	19	8	115	213	342	78	.	421	648
1988	44	44	56	28	11	117	212	351	172	.	523	780
1989	97	97	99	67	8	251	425	634	327	78	1,039	1,561
1990	83	83	96	70	12	329	508	858	326	73	1,257	1,848
1991	101	101	141	95	14	401	650	1,064	562	54	1,679	2,430
1992	81	81	72	58	8	188	327	368	321	39	728	1,136
1993	121	121	149	91	13	267	520	403	188	9	600	1,242
1994	115	115	161	107	9	342	619	556	118	9	683	1,417
1995	210	210	356	288	27	496	1,166	926	247	21	1,194	2,570
1996	52	52	127	144	8	268	547	743	294	11	1,047	1,646
1997	120	120	230	296	.	364	889	717	262	7	986	1,995
1998	96	96	199	51	.	189	439	337	68	1	406	941

Dolphin fish: FL ec includes SC in 1977. NC includes SC & GA in 1978-79. SC includes GA in 1980, 1997 and 1998. AL-LA includes TX in 1984-87.

Table 4.--Landings by fish, region and state
(thousands of pounds, whole weight, NE=Maine-Virginia)
(Data for 1998 is not complete)

King mackerel & cero

Year	Northeast		South Atlantic					Gulf				
	NE	Region total	NC	SC	GA	FL ec	Region total	FL wc	AL-MS	LA-TX	Region total	Total
1962	8	8	49	3	0	2,076	2,128	2,021	.	.	2,021	4,157
1963	10	10	53	4	1	2,173	2,231	2,817	.	.	2,817	5,058
1964	37	37	89	0	0	2,020	2,109	1,314	.	.	1,314	3,460
1965	6	6	139	.	.	2,549	2,688	1,898	.	.	1,898	4,593
1966	7	7	95	4	.	1,782	1,880	2,633	.	.	2,633	4,520
1967	3	3	24	.	.	2,988	3,012	3,084	.	.	3,084	6,099
1968	3	3	8	0	.	2,586	2,594	3,604	.	.	3,604	6,201
1969	2	2	16	2	.	2,943	2,960	3,242	.	.	3,242	6,204
1970	5	5	12	0	1	4,338	4,352	2,372	.	.	2,372	6,729
1971	7	7	9	6	1	2,907	2,923	2,738	.	.	2,738	5,667
1972	2	2	.	.	.	3,489	3,489	1,378	.	.	1,378	4,869
1973	8	8	.	.	.	3,712	3,712	2,217	.	.	2,217	5,937
1974	15	15	.	.	.	4,267	4,267	6,134	.	.	6,134	10,416
1975	14	14	.	.	.	3,697	3,697	2,622	.	.	2,622	6,333
1976	18	18	.	.	.	4,821	4,821	2,801	.	.	2,801	7,640
1977	18	18	256	.	.	3,915	4,171	5,217	.	.	5,217	9,406
1978	9	9	220	.	.	3,402	3,622	1,745	0	.	1,746	5,376
1979	11	11	478	.	.	3,346	3,824	1,691	.	0	1,691	5,527
1980	20	20	769	208	17	3,073	4,067	3,002	.	.	3,002	7,088
1981	3	3	736	135	11	4,858	5,739	3,073	.	.	3,073	8,816
1982	13	13	1,207	186	4	4,647	6,045	1,968	.	229	2,197	8,255
1983	6	6	843	179	2	3,108	4,132	1,340	2	1,490	2,832	6,969
1984	3	3	758	138	38	2,437	3,370	1,095	4	749	1,847	5,220
1985	6	6	833	82	96	2,636	3,647	768	3	973	1,744	5,398
1986	4	4	1,006	95	202	2,421	3,724	1,707	1	336	2,044	5,772
1987	12	12	1,349	128	72	2,573	4,121	543	4	531	1,078	5,211
1988	15	15	886	124	30	2,461	3,502	577	9	453	1,040	4,557
1989	8	8	720	175	8	1,801	2,705	286	4	653	944	3,657
1990	16	16	1,131	162	18	1,881	3,191	1,018	2	637	1,657	4,864
1991	22	22	1,103	266	24	1,641	3,034	413	1	583	997	4,053
1992	31	31	1,035	256	13	1,413	2,716	1,108	11	1,132	2,251	4,999
1993	23	23	888	162	10	1,614	2,674	2,088	2	900	2,990	5,687
1994	4	4	850	92	7	1,557	2,506	904	5	878	1,788	4,299
1995	6	6	1,013	83	11	1,618	2,725	1,190	3	755	1,948	4,680
1996	5	5	794	95	4	1,817	2,710	1,665	4	733	2,402	5,117
1997	16	16	1,559	61	8	2,536	4,164	976	5	789	1,770	5,949
1998	4	4	1,438	42	8	1,513	3,001	1,151	.	962	2,113	5,118

*King mackerel & cero: NC includes SC and GA in 1977-79. LA-TX includes AL-MS in 1998.

Table 4.--Landings by fish, region and state
(thousands of pounds, whole weight, NE=Maine-Virginia)
(Data for 1998 is not complete)

Spanish mackerel

Year	Northeast		South Atlantic				Gulf				
	NE	Region total	NC	SC-GA	FL ec	Region total	FL wc	AL-MS	LA-TX	Region total	Total
1962	15	15	83	14	2,578	2,675	6,869	41	1	6,911	9,601
1963	79	79	135	9	2,123	2,268	5,405	41	2	5,447	7,794
1964	33	33	78	3	2,002	2,083	3,880	75	2	3,956	6,072
1965	75	75	117	14	2,901	3,032	4,883	18	5	4,906	8,012
1966	142	142	79	3	2,181	2,262	7,004	59	3	7,066	9,471
1967	30	30	73	5	1,802	1,879	5,867	101	8	5,976	7,885
1968	60	60	69	9	4,407	4,484	7,066	153	13	7,231	11,776
1969	124	124	89	4	2,359	2,451	8,175	97	70	8,342	10,918
1970	202	202	63	2	3,574	3,640	8,100	169	29	8,298	12,140
1971	52	52	95	4	2,582	2,681	7,383	235	40	7,658	10,391
1972	23	23	.	.	3,369	3,369	6,532	576	114	7,222	10,615
1973	50	50	.	.	3,203	3,203	6,194	174	89	6,458	9,711
1974	26	26	.	.	2,346	2,346	8,267	95	192	8,554	10,926
1975	68	68	.	.	5,145	5,145	5,621	316	200	6,138	11,350
1976	82	82	.	.	9,589	9,589	7,783	424	135	8,341	18,012
1977	22	22	48	.	10,987	11,035	2,393	243	.	2,636	13,693
1978	2	2	41	.	5,511	5,551	1,600	105	.	1,705	7,258
1979	1	1	15	.	4,886	4,901	1,946	143	33	2,122	7,023
1980	9	9	75	8	9,811	9,895	1,770	126	55	1,952	11,856
1981	5	5	52	1	4,174	4,227	3,550	91	68	3,709	7,940
1982	14	14	189	2	3,759	3,950	3,287	153	15	3,456	7,419
1983	9	9	41	1	5,947	5,989	2,087	104	74	2,266	8,265
1984	10	10	127	1	2,397	2,526	3,476	12	18	3,506	6,043
1985	15	15	173	1	3,245	3,419	2,915	76	32	3,023	6,457
1986	174	174	232	8	4,004	4,244	2,577	139	22	2,738	7,155
1987	321	321	504	1	3,497	4,002	2,665	129	61	2,855	7,178
1988	335	335	438	2	3,072	3,512	2,138	156	22	2,316	6,163
1989	422	422	589	2	2,853	3,444	2,991	104	24	3,119	6,985
1990	240	240	839	1	1,979	2,819	2,385	181	13	2,579	5,639
1991	531	531	859	1	2,987	3,846	3,262	144	36	3,442	7,819
1992	396	396	738	2	2,023	2,763	3,564	151	58	3,773	6,932
1993	413	413	590	1	3,892	4,482	2,475	127	20	2,623	7,518
1994	392	392	531	0	3,100	3,632	2,420	279	83	2,781	6,804
1995	196	196	402	0	3,065	3,467	1,160	377	20	1,557	5,220
1996	345	345	402	0	2,245	2,646	409	245	9	663	3,655
1997	211	211	767	0	2,269	3,036	211	350	4	565	3,812
1998	128	128	519	0	919	1,438	156	218	4	378	1,944

Spanish mackerel: NC includes SC & GA in 1977-79. AL-MS includes LA-TX in 1977-78.

Table 4.--Landings by fish, region and state
(thousands of pounds, whole weight, NE=Maine-Virginia)
(Data for 1998 is not complete)

Wahoo

Year	Northeast		South Atlantic				Gulf				
	NE	Region total	NC	SC-GA	FL ec	Region total	FL wc	AL-LA	TX	Region total	Total
1974	.	.	.	.	1	1	0	.	.	0	1
1975	.	.	.	.	4	4	1	.	.	1	5
1976	.	.	.	.	4	4	1	.	.	1	5
1977	.	.	.	.	6	6	1	.	.	1	7
1978	.	.	.	.	9	9	4	.	.	4	13
1979	.	.	.	.	12	12	3	.	.	3	15
1980	.	.	2	2	16	20	3	.	.	3	23
1981	0	0	1	4	12	17	9	0	.	9	26
1982	0	0	3	6	12	21	9	.	.	9	30
1983	0	0	7	7	11	25	9	.	.	9	34
1984	0	0	9	5	8	22	8	.	.	8	30
1985	0	0	9	5	12	27	8	4	.	12	39
1986	1	1	6	5	10	21	21	9	.	30	52
1987	0	0	16	7	17	40	53	66	.	119	160
1988	1	1	20	8	17	44	58	208	.	266	312
1989	1	1	10	13	12	35	35	193	37	265	300
1990	2	2	17	8	19	43	68	74	16	158	203
1991	1	1	19	8	22	48	45	137	21	203	252
1992	3	3	14	16	22	52	46	232	31	310	365
1993	3	3	24	12	21	57	56	214	5	275	335
1994	20	20	20	13	15	48	40	136	5	181	249
1995	7	7	41	14	23	78	44	125	10	179	264
1996	2	2	26	10	24	60	42	123	4	169	231
1997	2	2	21	10	29	60	61	130	3	194	256
1998	2	2	26	5	23	54	31	138	2	171	228

Wahoo: FL ec includes NC in 1978-79 and SC in 1979. AL-LA includes TX in 1984-87.

Table 5.--Landings by region, fish and gear (thousands of pounds, whole weight)
(Data is not complete for 1998. Breakout not available for some states in 1991-98)

South Atlantic
Bluefish

Year	Haul seines	Purse seines	Trawls	Pound, fyke & hoop nets	Pots & traps	Drift gill nets	Run-around gill nets	Other gill nets	Hook & line gear	Long & trot lines	Other or unknown gear
1962	652	.	5	.	.	.	1,254	185	208	.	48
1963	682	.	6	.	.	.	1,324	137	99	.	40
1964	707	.	3	3	.	.	1,167	63	75	.	13
1965	564	.	4	10	.	.	850	120	95	.	.
1966	926	.	23	2	.	.	1,137	130	112	.	2
1967	835	.	15	6	.	34	1,271	10	109	.	1
1968	960	.	16	3	.	.	1,557	68	204	.	.
1969	941	.	21	1	.	.	1,662	187	145	.	.
1970	768	.	27	4	.	.	1,543	72	135	.	2
1971	833	.	52	3	.	.	1,168	78	83	.	.
1972	728	.	1	.	.	.	1,076	.	70	.	.
1973	568	.	29	.	.	.	859	.	127	.	.
1974	434	.	32	.	.	.	715	.	92	.	.
1975	418	.	21	.	.	.	508	.	74	.	.
1976	580	.	51	.	.	.	655	.	94	.	.
1977	940	.	1,257	44	1	0	1,118	121	234	.	.
1978	503	.	1,105	56	.	0	1,161	227	243	.	.
1979	704	.	1,792	71	.	1	1,380	521	438	.	.
1980	661	.	3,003	325	.	1	1,834	1,217	654	.	.
1981	535	.	4,439	142	.	2	1,843	1,391	437	.	.
1982	547	.	1,798	227	.	2	1,737	1,498	518	3	.
1983	449	.	3,857	87	.	3	1,277	2,339	300	0	.
1984	406	.	1,164	93	.	1	1,320	1,930	306	0	0
1985	588	.	1,017	135	2	.	522	1,944	108	.	1
1986	546	.	773	80	0	3	1,101	2,133	67	.	.
1987	627	.	538	125	0	.	1,459	3,349	169	0	.
1988	565	.	1,267	91	.	.	1,246	3,217	85	.	.
1989	364	.	674	41	.	10	1,017	2,172	123	0	.
1990	607	.	307	58	0	.	1,209	3,495	112	1	1
1991	684	.	314	61	0	.	1,391	2,908	160	0	0
1992	510	.	762	29	.	1	996	1,671	138	0	1
1993	186	.	377	18	.	0	1,165	2,201	108	1	0
1994	226	.	47	14	4	18	877	1,683	55	6	0
1995	166	.	401	14	3	3	525	2,646	130	7	2
1996	182	.	221	7	2	0	92	2,958	122	2	11
1997	237	18	314	18	2	3	362	3,731	138	3	12
1998	150	21	220	7	6	30	351	3,046	135	3	20

Table 5.--Landings by region, fish and gear (thousands of pounds, whole weight)
(Data is not complete for 1998. Breakout not available for some states in 1991-98)

South Atlantic
Bonito

Year	Haul seines	Purse seines	Trawls	Pound, fyke & hoop nets	Pots & traps	Drift gill nets	Run-around gill nets	Other gill nets	Hook & line gear	Long & trot lines	Other or unknown gear
1962	.	.	.	.	.	.	.	.	2	.	.
1963	.	.	.	.	.	.	.	.	1	.	.
1964	.	.	.	.	.	.	.	.	0	.	.
1965	.	.	.	.	.	.	.	.	0	.	.
1966	.	.	.	.	.	.	.	.	4	.	.
1967	.	.	.	.	.	.	.	.	6	.	.
1968	.	.	.	.	.	.	.	.	6	.	.
1969	.	.	.	.	.	.	.	.	3	.	.
1970	.	.	.	.	.	.	.	.	7	.	.
1971	.	.	.	.	.	.	.	.	6	.	.
1972	.	.	.	.	.	.	.	.	3	.	.
1973	.	.	.	.	.	.	.	.	10	.	.
1974	.	.	.	.	.	.	.	.	5	.	.
1975	.	.	.	.	.	.	.	.	11	.	.
1976	.	.	.	.	.	.	.	.	21	.	.
1977	.	.	.	.	.	.	.	.	18	.	.
1978	.	.	.	.	.	.	.	.	6	.	.
1979	.	.	.	.	.	.	.	.	30	.	.
1980	0	.	.	.	.	.	.	.	98	.	.
1981	.	.	0	.	.	.	.	3	80	.	.
1982	1	.	1	.	.	.	.	15	84	0	.
1983	1	.	.	.	.	.	.	9	29	0	.
1984	0	.	0	.	.	.	.	0	38	.	.
1985	0	.	.	.	.	.	0	1	5	.	.
1986	0	.	0	.	.	.	1	0	3	.	.
1987	.	.	0	.	.	12	9	1	14	.	.
1988	.	.	.	.	.	37	1	0	21	.	.
1989	.	.	1	.	.	57	56	2	36	0	.
1990	.	2	0	.	.	.	3	3	14	.	.
1991	10	.	0	.	.	.	1	3	8	.	.
1992	2	4	5	.	.	.	1	4	48	0	0
1993	.	.	1	.	.	.	6	5	95	1	.
1994	1	.	0	.	.	0	34	31	53	.	.
1995	0	.	.	0	0	.	.	30	5	.	.
1996	0	.	0	0	.	.	.	6	10	0	.
1997	.	.	0	0	0	.	0	36	6	0	.
1998	0	.	0	.	0	0	0	25	5	.	.

Table 5.--Landings by region, fish and gear (thousands of pounds, whole weight)
(Data is not complete for 1998. Breakout not available for some states in 1991-98)

South Atlantic
Cobia

Year	Haul seines	Purse seines	Trawls	Pound, fyke & hoop nets	Pots & traps	Drift gill nets	Run-around gill nets	Other gill nets	Hook & line gear	Long & trot lines	Other or unknown gear
1962	18	.	.	.	.	.	.	0	3	.	2
1963	13	.	1	.	.	.	.	2	6	.	2
1964	11	.	.	1	.	.	.	.	2	.	.
1965	8	.	.	2	.	.	.	.	4	.	.
1966	8	.	.	1	.	.	.	1	5	.	.
1967	10	.	0	.	.	0	.	.	9	.	.
1968	7	.	.	.	.	.	.	1	9	.	.
1969	6	.	.	.	.	.	.	.	4	.	.
1970	6	.	.	1	.	.	.	.	14	.	.
1971	10	.	.	0	.	.	.	.	7	.	.
1972	.	.	.	.	.	.	.	.	14	.	.
1973	.	.	1	.	.	.	.	.	10	.	.
1974	.	.	.	.	.	.	.	.	12	.	.
1975	.	.	.	.	.	.	.	.	14	.	.
1976	.	.	.	.	.	.	.	.	13	.	.
1977	1	.	.	.	.	.	.	.	10	.	.
1978	2	.	0	.	.	.	.	.	10	.	.
1979	1	.	0	0	.	.	.	.	10	.	.
1980	.	.	5	0	.	.	.	.	22	.	.
1981	.	.	13	.	.	.	.	.	29	.	.
1982	0	.	18	0	.	.	.	1	27	0	.
1983	0	.	9	0	.	.	.	0	26	0	.
1984	0	.	4	1	.	.	.	1	24	0	.
1985	0	.	1	0	.	.	.	1	43	.	.
1986	1	.	3	1	.	4	.	1	47	1	.
1987	1	.	3	2	.	17	.	1	74	1	.
1988	0	.	4	1	.	27	0	2	57	2	0
1989	0	.	3	1	.	26	1	4	73	3	3
1990	1	.	3	1	.	.	2	4	87	5	0
1991	1	.	2	1	.	2	4	2	87	7	21
1992	1	0	2	1	.	0	4	3	84	9	25
1993	0	.	4	1	.	1	4	6	84	10	14
1994	1	.	3	0	0	0	6	10	80	6	19
1995	1	.	3	1	1	.	10	12	76	10	19
1996	0	.	4	1	0	.	14	13	76	13	11
1997	1	.	5	0	0	.	12	26	59	8	26
1998	1	.	7	0	0	2	11	8	49	3	17

Table 5.--Landings by region, fish and gear (thousands of pounds, whole weight)
(Data is not complete for 1998. Breakout not available for some states in 1991-98)

South Atlantic
Dolphin fish

Year	Trawls	Pots & traps	Drift gill nets	Run-around gill nets	Other gill nets	Hook & line gear	Long & trot lines	Other or unknown gear	Total
1962	.	.	.	.	.	8	.	.	8
1963	.	.	.	.	.	4	.	.	4
1964	.	.	.	.	.	6	.	.	6
1965	.	.	.	.	.	14	.	.	14
1966	.	.	.	.	.	16	.	.	16
1967	.	.	.	.	.	35	.	.	35
1968	.	.	.	.	.	21	.	.	21
1969	.	.	.	.	.	12	.	.	12
1970	.	.	.	.	.	21	.	.	21
1971	.	.	.	.	.	22	.	.	22
1972	.	.	.	.	.	14	.	.	14
1973	.	.	.	.	.	18	.	.	18
1974	.	.	.	.	.	15	.	.	15
1975	.	.	.	.	.	26	.	.	26
1976	.	.	.	1	.	26	.	.	27
1977	.	.	.	.	.	71	.	.	71
1978	.	.	.	.	.	70	.	.	70
1979	.	.	.	.	.	45	.	.	45
1980	.	.	.	.	.	72	5	.	78
1981	0	.	.	.	.	57	1	.	59
1982	.	.	.	.	.	135	9	.	144
1983	0	.	.	.	.	118	10	.	128
1984	.	.	.	.	.	152	7	.	159
1985	.	.	.	.	.	138	5	0	143
1986	0	.	.	.	.	186	3	.	190
1987	.	.	1	.	.	195	17	.	213
1988	.	.	1	.	.	160	51	0	212
1989	.	.	3	.	.	360	63	.	425
1990	.	0	.	.	.	374	133	0	508
1991	0	0	.	0	.	485	164	0	650
1992	0	.	.	0	.	212	114	1	327
1993	0	.	.	.	.	367	153	0	520
1994	.	0	.	.	0	364	254	0	619
1995	0	0	.	0	.	520	643	1	1,164
1996	0	0	.	.	.	263	262	0	525
1997	.	1	.	0	.	355	532	1	889
1998	32	1	0	0	0	214	183	9	439

Table 5.--Landings by region, fish and gear (thousands of pounds, whole weight)
(Data is not complete for 1998. Breakout not available for some states in 1991-98)

South Atlantic
King mackerel & cero

Year	Haul seines	Purse seines	Trawls	Pound, fyke & hoop nets	Pots & traps	Drift gill nets	Run-around gill nets	Other gill nets	Hook & line gear	Long & trot lines	Other or unknown gear
1962	8	.	.	.	.	.	126	.	1,995	.	.
1963	3	.	.	.	.	.	531	.	1,697	.	.
1964	9	.	0	.	.	.	446	.	1,654	.	.
1965	6	.	1	.	.	.	902	.	1,779	.	.
1966	4	.	.	.	.	.	770	0	1,106	.	.
1967	0	.	1	.	.	.	1,900	.	1,111	.	.
1968	.	.	0	.	.	.	1,483	.	1,111	.	.
1969	1	.	0	.	.	.	1,756	.	1,203	.	.
1970	.	.	1	.	.	.	2,354	1	1,995	.	.
1971	5	.	1	.	.	.	1,630	0	1,286	.	.
1972	.	.	.	.	.	.	1,291	.	2,199	.	.
1973	.	.	.	.	.	.	1,176	.	2,536	.	.
1974	.	.	.	.	.	.	1,593	.	2,674	.	.
1975	.	.	.	.	.	.	1,198	.	2,499	.	.
1976	.	.	.	.	.	.	2,069	.	2,752	.	.
1977	.	.	0	0	.	.	1,204	0	2,966	.	.
1978	.	.	2	.	.	.	1,225	0	2,395	.	.
1979	.	.	9	.	.	14	1,039	14	2,748	.	.
1980	.	.	14	.	.	.	683	90	3,280	.	.
1981	.	.	46	.	.	.	1,151	130	4,413	0	.
1982	.	.	13	.	.	.	1,277	401	4,352	1	.
1983	.	.	9	6	.	.	1,036	133	2,948	0	.
1984	0	.	7	0	.	0	824	59	2,480	0	.
1985	.	.	4	.	.	.	739	19	2,885	0	.
1986	0	.	4	.	.	221	.	19	3,480	0	.
1987	0	.	4	0	.	859	.	39	3,219	0	.
1988	.	113	2	.	.	777	212	74	2,323	.	1
1989	0	8	3	.	.	757	.	12	1,925	.	.
1990	.	.	7	.	0	0	3	46	3,135	0	0
1991	1	.	1	.	0	0	13	8	3,011	.	0
1992	.	.	2	.	.	.	12	7	2,696	0	0
1993	0	.	10	.	0	0	14	6	2,642	0	0
1994	1	.	3	0	2	0	32	61	2,401	2	5
1995	0	.	0	0	2	.	104	58	2,556	4	1
1996	0	.	0	0	1	0	131	53	2,219	1	.
1997	0	1	1	0	1	0	226	168	3,763	4	0
1998	0	.	1	0	1	17	22	64	2,847	7	42

Table 5.--Landings by region, fish and gear (thousands of pounds, whole weight)
(Data is not complete for 1998. Breakout not available for some states in 1991-98)

South Atlantic
Spanish mackerel

Year	Haul seines	Purse seines	Trawls	Pound, fyke & hoop nets	Pots & traps	Drift gill nets	Run-around gill nets	Other gill nets	Hook & line gear	Long & trot lines	Other or unknown gear	T
1962	62	.	.	.	.	.	2,475	5	126	.	7	
1963	89	.	2	.	.	.	2,043	45	76	.	14	
1964	50	.	1	9	.	.	1,955	4	65	.	.	
1965	72	.	10	16	.	.	2,787	1	145	.	.	
1966	19	.	5	1	.	25	2,021	15	177	.	.	
1967	45	.	8	1	.	3	1,690	0	131	.	.	
1968	57	.	17	26	.	.	4,219	13	152	.	.	
1969	102	.	7	0	.	.	2,240	3	100	.	.	
1970	40	.	10	12	.	.	3,457	15	106	.	.	
1971	58	.	8	3	.	.	2,416	61	135	.	.	
1972	40	.	3	.	.	.	3,221	.	104	.	.	
1973	7	.	21	.	.	.	3,020	.	155	.	.	
1974	7	.	7	.	.	.	2,164	.	168	.	.	
1975	16	.	1	.	.	.	4,754	.	374	.	.	
1976	34	.	0	.	.	.	8,731	.	822	.	.	
1977	20	.	2	9	.	.	10,665	18	321	.	.	
1978	8	.	1	1	.	.	5,486	30	25	.	.	
1979	1	.	3	0	.	1	4,843	4	50	.	.	
1980	8	.	9	4	.	0	9,745	56	73	.	.	
1981	4	.	4	1	.	1	4,148	24	45	.	.	
1982	5	.	4	11	.	1	3,733	115	83	.	.	
1983	11	.	1	10	.	1	5,923	11	32	.	.	
1984	18	.	4	14	.	0	2,365	69	56	.	.	
1985	17	.	15	33	13	.	3,214	99	29	.	.	
1986	34	.	45	38	.	.	3,921	132	73	.	.	
1987	47	.	48	231	.	4	3,420	152	101	.	.	
1988	53	.	38	176	.	3	3,013	171	57	.	0	
1989	80	.	38	163	.	156	2,678	293	37	.	.	
1990	32	.	53	56	.	1	2,021	546	110	.	0	
1991	54	.	60	114	.	.	2,918	558	141	.	0	
1992	44	1	20	203	.	1	1,967	478	49	.	1	
1993	44	.	13	86	.	.	3,823	420	97	.	.	
1994	27	.	14	30	3	9	3,037	455	55	0	0	
1995	15	.	6	49	2	0	2,840	336	204	.	15	
1996	10	.	8	45	1	0	683	330	82	.	37	
1997	18	1	13	61	1	1	1,960	672	92	0	217	
1998	8	.	3	27	1	2	793	466	67	0	72	

Table 5.--Landings by region, fish and gear (thousands of pounds, whole weight)
(Data is not complete for 1998. Breakout not available for some states in 1991-98)

South Atlantic
Wahoo

Year	Trawls	Drift gill nets	Run-around gill nets	Other gill nets	Hook & line gear	Long & trot lines	Other or unknown gear	Total
1974	.	.	.	.	1	.	.	1
1975	.	.	.	.	4	.	.	4
1976	.	.	.	.	4	.	.	4
1977	.	.	.	.	6	.	.	6
1978	.	.	.	.	9	.	.	9
1979	.	.	.	.	12	.	.	12
1980	0	.	.	.	19	1	.	20
1981	0	.	0	.	13	3	.	17
1982	0	.	.	.	16	4	.	21
1983	0	.	.	.	21	4	.	25
1984	.	.	.	.	19	2	.	22
1985	.	.	.	.	25	2	.	27
1986	.	.	.	.	20	1	.	21
1987	.	1	.	.	37	2	.	40
1988	.	1	.	.	35	8	0	44
1989	.	1	.	.	25	8	.	35
1990	.	.	.	.	35	8	.	43
1991	.	.	0	.	39	9	0	48
1992	0	.	0	.	42	10	0	52
1993	.	.	0	.	44	14	.	57
1994	.	.	.	0	39	9	.	48
1995	.	.	0	0	63	15	0	78
1996	.	.	0	.	43	14	.	57
1997	.	.	0	.	49	11	.	60
1998	.	.	0	0	46	7	2	54

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Table 5.--Landings by region, fish and gear (thousands of pounds, whole weight)
(Data is not complete for 1998. Breakout not available for some states in 1991-98)

Gulf
Bluefish

Year	Haul seines	Purse seines	Trawls	Pots & traps	Drift gill nets	Run-around gill nets	Other gill nets	Hook & line gear	Long & trot lines	Other or unknown gear	Total
1962	230	.	0	.	.	497	11	86	.	125	9
1963	220	.	.	.	.	449	29	70	.	129	8
1964	271	.	0	.	41	356	.	46	.	91	8
1965	368	.	1	.	5	400	.	49	.	114	9
1966	362	16	.	.	.	243	.	26	.	64	7
1967	303	.	1	.	.	236	.	16	.	40	5
1968	267	.	2	.	.	299	.	30	.	46	6
1969	318	.	13	.	.	197	.	21	.	38	5
1970	295	.	5	.	.	292	4	55	.	43	6
1971	209	.	3	.	.	241	8	23	.	48	5
1972	223	.	17	.	.	218	12	21	.	57	5
1973	209	.	9	.	.	232	.	45	.	35	5
1974	243	.	10	.	.	209	.	30	.	44	5
1975	202	.	11	.	.	255	.	33	.	30	5
1976	267	.	1	.	0	276	.	25	.	37	6
1977	265	.	1	.	.	603	.	33	.	35	9
1978	417	0	1	.	.	389	.	19	.	46	8
1979	491	1	0	.	.	394	9	18	.	37	9
1980	557	.	0	.	.	559	2	36	.	43	1,1
1981	261	74	0	.	.	471	4	18	.	37	8
1982	543	121	.	.	.	556	2	28	.	47	1,2
1983	320	54	0	.	.	383	1	7	.	16	7
1984	199	46	0	.	202	164	0	11	.	14	6
1985	214	13	0	.	206	125	0	10	0	11	5
1986	2	167	0	.	97	290	0	11	0	1	5
1987	128	169	1	.	62	172	17	30	1	2	5
1988	155	113	1	.	58	327	83	62	160	3	9
1989	101	102	0	.	26	235	66	139	11	1	6
1990	95	101	5	.	11	279	1	10	105	80	6
1991	79	78	.	.	36	234	13	14	0	181	6
1992	53	4	0	.	23	212	0	42	24	1,030	1,3
1993	46	.	0	.	2	111	0	64	0	600	8
1994	40	1	0	0	8	172	1	7	.	92	3
1995	27	34	6	0	1	218	.	23	0	57	3
1996	15	169	0	0	.	78	0	33	0	36	3
1997	2	215	2	0	.	95	1	25	0	113	4
1998	5	113	4	0	.	28	0	13	0	120	2

Table 5.--Landings by region, fish and gear (thousands of pounds, whole weight)
(Data is not complete for 1998. Breakout not available for some states in 1991-98)

Gulf
Bonito

Year	Haul seines	Purse seines	Trawls	Pots & traps	Run-around gill nets	Other gill nets	Hook & line gear	Long & trot lines	Other or unknown gear	Total
1962	.	.	.	.	.	.	3	.	.	3
1963	.	.	.	.	.	.	1	.	.	1
1966	13	58	.	.	14	.	4	.	.	89
1967	3	.	.	.	.	.	2	.	.	4
1968	2	.	.	.	.	.	4	.	.	6
1969	5	.	.	.	.	.	3	.	.	8
1970	17	15	.	.	1	.	2	.	.	34
1971	64	53	.	.	.	.	9	.	.	127
1972	2	1	.	.	.	.	1	.	.	4
1973	13	475	1	.	0	.	1	.	.	491
1974	25	70	.	.	0	.	5	.	.	99
1975	28	86	.	.	.	.	7	.	.	121
1976	11	110	.	.	0	.	3	.	.	123
1977	119	87	.	.	46	.	36	.	6	294
1978	28	44	.	.	6	.	9	.	1	88
1979	73	220	.	.	7	.	11	.	1	311
1980	40	83	.	.	1	.	15	.	32	173
1981	23	88	.	.	2	.	53	.	363	528
1982	35	107	.	.	18	.	33	.	60	254
1983	76	224	.	.	3	.	8	.	14	324
1984	17	53	.	.	2	.	6	.	1	80
1985	47	15	.	.	3	.	27	0	4	97
1986	.	2	.	.	4	.	90	.	.	95
1987	16	49	.	.	1	.	34	.	.	100
1988	10	160	0	.	2	1	84	2	.	259
1989	4	141	.	.	8	.	20	0	.	172
1990	9	186	135	.	16	.	68	.	6	420
1991	28	605	.	.	17	.	14	3	4	670
1992	25	930	16	.	15	.	17	.	1	1,003
1993	0	208	322	.	8	.	12	0	2	552
1994	48	1,265	0	0	3	.	18	0	40	1,374

Table 5.--Landings by region, fish and gear (thousands of pounds, whole weight)
(Data is not complete for 1998. Breakout not available for some states in 1991-98)

Gulf
Cobia

Year	Haul seines	Purse seines	Trawls	Pots & traps	Drift gill nets	Run-around gill nets	Other gill nets	Hook & line gear	Long & trot lines	Other or unknown gear	Total
1962	1	.	5	.	.	0	.	31	.	.	37
1963	0	.	1	.	.	0	.	37	.	.	38
1964	.	.	0	.	.	0	.	25	.	.	26
1965	.	.	2	.	.	1	.	19	.	.	22
1966	0	.	5	.	.	2	.	30	.	.	38
1967	0	.	7	.	.	5	.	27	.	.	40
1968	1	.	16	.	.	11	.	53	.	.	81
1969	0	.	15	.	.	12	.	45	.	.	72
1970	0	.	31	.	.	15	.	60	.	.	106
1971	.	.	17	.	.	20	.	66	.	.	104
1972	0	.	27	.	.	23	.	66	.	.	117
1973	1	.	23	.	.	20	.	69	.	1	113
1974	.	.	28	.	.	25	.	80	.	.	133
1975	.	.	14	.	.	37	.	69	.	.	119
1976	0	.	16	.	.	34	.	87	.	.	137
1977	.	.	9	.	.	25	.	69	.	.	102
1978	.	.	6	.	.	20	.	64	.	14	104
1979	.	.	8	.	.	21	.	57	.	8	94
1980	0	.	9	.	.	6	.	68	.	15	99
1981	0	.	18	.	.	6	.	80	.	14	118
1982	1	.	25	.	.	4	.	73	.	8	110
1983	0	.	21	.	.	5	.	96	.	11	132
1984	.	.	6	1	8	2	.	122	.	4	142
1985	0	.	15	1	2	1	.	114	0	2	136
1986	.	.	5	0	2	5	.	143	4	.	160
1987	.	.	7	.	3	3	.	154	9	0	175
1988	0	.	2	.	2	3	0	139	13	0	161
1989	.	.	2	.	.	11	0	182	12	3	210
1990	.	.	0	.	.	9	0	106	7	39	161
1991	.	.	1	.	.	14	.	97	15	50	177
1992	.	.	2	1	.	17	.	121	16	79	235
1993	.	.	1	0	.	13	.	131	17	98	261
1994	0	.	1	1	.	11	.	116	15	119	264
1995	0	.	1	1	.	8	.	131	7	93	241
1996	.	.	0	0	.	1	.	149	17	85	252
1997	0	.	0	1	.	1	.	117	17	72	208
1998	2	0	0	1	.	1	.	108	11	66	188

Table 5.--Landings by region, fish and gear (thousands of pounds, whole weight)
(Data is not complete for 1998. Breakout not available for some states in 1991-98)

Gulf
Dolphin fish

Year	Trawls	Pots & traps	Run-around gill nets	Hook & line gear	Long & trot lines	Other or unknown gear	Total
1962	.	.	.	16	.	.	16
1963	.	.	.	5	.	.	5
1964	.	.	.	22	.	.	22
1965	.	.	.	18	.	.	18
1966	.	.	.	61	.	.	61
1967	.	.	.	154	.	.	154
1968	.	.	.	76	.	.	76
1969	.	.	.	49	.	.	49
1970	.	.	.	63	.	.	63
1971	.	.	.	38	.	.	38
1972	.	.	.	55	.	.	55
1973	.	.	.	70	.	.	70
1974	.	.	.	70	.	.	70
1975	.	.	.	106	.	.	106
1976	.	.	.	84	.	.	84
1977	.	.	.	64	.	.	64
1978	.	.	.	94	.	.	94
1979	.	.	.	66	.	.	66
1980	.	.	.	94	0	.	95
1981	.	.	.	73	0	.	73
1982	.	.	.	162	0	.	162
1983	.	.	.	191	0	.	191
1984	.	.	.	283	0	.	283
1985	.	.	.	265	4	.	270
1986	.	.	0	386	107	.	492
1987	.	.	.	302	102	.	404
1988	.	.	.	300	199	.	499
1989	.	.	.	607	423	.	1,030
1990	.	.	.	838	261	.	1,099
1991	.	.	.	920	194	561	1,675
1992	.	0	0	289	105	334	728
1993	.	0	.	347	53	200	600
1994	.	0	.	505	48	130	683
1995	0	0	.	811	95	287	1,194
1996	.	0	.	601	128	305	1,034
1997	.	1	.	600	116	269	986
1998	.	.	.	261	22	123	406

Table 5.--Landings by region, fish and gear (thousands of pounds, whole weight)
(Data is not complete for 1998. Breakout not available for some states in 1991-98)

Gulf
King mackerel & cero

Year	Haul seines	Purse seines	Trawls	Pots & traps	Drift gill nets	Run-around gill nets	Other gill nets	Hook & line gear	Long & trot lines	Other or unknown gear	Total
1962	48	.	.	.	.	1,159	.	809	.	5	2,0
1963	20	.	.	.	.	2,134	.	656	.	8	2,8
1964	31	.	.	.	25	1,032	.	226	.	.	1,3
1965	62	.	.	.	20	1,542	.	264	.	10	1,8
1966	52	.	.	.	24	2,262	.	280	.	15	2,6
1967	42	282	.	.	45	2,399	.	303	.	13	3,0
1968	78	333	.	.	15	2,881	.	296	.	1	3,6
1969	63	116	.	.	45	2,389	.	628	.	1	3,2
1970	97	.	.	.	19	1,796	.	459	.	.	2,3
1971	51	.	.	.	52	2,294	.	340	.	1	2,7
1972	46	.	.	.	.	978	.	354	.	.	1,3
1973	74	.	.	.	.	1,747	.	395	.	0	2,2
1974	33	.	.	.	.	5,109	.	991	.	.	6,1
1975	81	.	.	.	.	1,895	.	646	.	.	2,6
1976	42	.	.	.	.	2,355	.	405	.	.	2,8
1977	4	.	.	.	.	4,687	.	526	.	.	5,2
1978	4	.	.	.	.	1,199	.	542	.	0	1,7
1979	14	.	.	.	.	1,088	.	590	.	0	1,6
1980	36	.	.	.	.	2,303	.	663	.	.	3,0
1981	8	.	.	.	.	2,278	.	788	.	.	3,0
1982	3	.	.	.	.	1,469	.	725	.	.	2,1
1983	5	.	2	.	.	1,003	.	1,822	.	.	2,8
1984	4	0	0	.	.	822	.	1,020	.	.	1,8
1985	1	.	0	.	.	536	.	1,207	0	.	1,7
1986	.	37	0	.	.	1,292	.	715	0	.	2,0
1987	0	1	0	.	.	270	.	806	0	.	1,0
1988	.	0	0	.	.	340	.	698	1	.	1,0
1989	.	14	.	.	.	52	.	877	.	.	[illegible]
1990	.	1	.	.	.	600	.	1,049	1	.	1,0
1991	1	.	0	.	.	59	0	352	1	582	[illegible]
1992	6	.	0	0	.	371	.	783	1	1,091	2,
1993	2	.	0	0	.	1,401	.	683	1	900	2,
1994	.	0	0	0	.	70	.	834	1	880	1,
1995	.	0	0	24	.	430	.	689	0	802	1,
1996	.	.	.	.	.	559	.	824	3	733	2,
1997	.	0	0	0	.	389	.	591	1	789	1,
1998	0	3	0	.	.	626	.	507	1	976	2,

Table 5.--Landings by region, fish and gear (thousands of pounds, whole weight)
(Data is not complete for 1998. Breakout not available for some states in 1991-98)

Gulf
Spanish mackerel

Year	Haul seines	Purse seines	Trawls	Pots & traps	Drift gill nets	Run-around gill nets	Other gill nets	Hook & line gear	Long & trot lines	Other or unknown gear	Total
1962	376	.	2	.	.	5,644	516	302	.	72	6,9
1963	222	.	2	.	.	4,538	325	298	.	62	5,4
1964	289	.	1	.	42	3,437	.	160	.	27	3,9
1965	400	.	6	.	101	4,058	.	258	.	83	4,9
1966	593	.	4	.	97	5,973	.	302	.	97	7,0
1967	655	195	25	.	70	4,675	.	236	.	120	5,9
1968	824	199	24	.	70	5,777	.	218	.	120	7,2
1969	890	.	84	.	113	6,966	.	190	.	98	8,3
1970	1,226	.	52	.	98	6,511	41	248	.	121	8,2
1971	1,320	.	71	.	67	5,677	165	220	.	140	7,6
1972	1,541	.	77	0	.	4,595	473	336	.	200	7,2
1973	602	.	114	.	.	5,505	.	121	.	115	6,4
1974	486	.	190	.	.	7,066	.	647	.	165	8,5
1975	266	.	126	.	.	4,914	.	740	.	92	6,1
1976	286	.	86	.	10	7,078	0	791	.	90	8,3
1977	146	.	64	.	.	1,806	.	580	.	39	2,6
1978	154	5	28	.	.	964	0	512	.	43	1,7
1979	235	0	58	.	.	1,654	59	58	.	57	2,1
1980	308	.	69	.	.	1,431	4	76	.	64	1,9
1981	633	4	37	.	.	2,750	23	157	.	104	3,7
1982	282	76	29	.	.	2,820	4	155	.	90	3,4
1983	294	0	43	.	.	1,736	17	124	.	52	2,2
1984	136	1	17	.	325	2,956	0	49	.	21	3,5
1985	205	5	22	.	233	2,475	0	58	6	19	3,0
1986	2	147	17	.	586	1,947	1	35	.	3	2,7
1987	5	7	31	.	613	1,115	842	225	.	16	2,8
1988	50	55	18	.	359	1,794	3	24	.	12	2,3
1989	33	97	7	.	457	2,384	5	53	67	15	3,1
1990	163	32	13	.	622	1,682	8	16	.	42	2,5
1991	193	13	2	.	58	2,877	38	145	0	115	3,4
1992	182	2	4	.	246	3,139	2	34	.	164	3,7
1993	133	82	2	1	112	2,191	6	26	0	70	2,6
1994	45	2	1	0	159	2,338	14	22	.	200	2,7
1995	64	0	1	3	.	1,362	2	25	0	99	1,5
1996	3	3	0	0	.	559	3	41	0	22	6
1997	0	3	0	0	.	488	0	66	0	7	5
1998	7	16	3	.	.	272	0	38	0	41	3

Table 5.--Landings by region, fish and gear (thousands of pounds, whole weight)
(Data is not complete for 1998. Breakout not available for some states in 1991-98)

Gulf
Wahoo

Year	Trawls	Pots & traps	Run-around gill nets	Hook & line gear	Long & trot lines	Other or unknown gear	Total
1974	.	.	0	.	.	.	0
1975	.	.	1	.	.	.	1
1976	.	.	1	.	.	.	1
1977	.	.	1	0	.	.	1
1978	.	.	4	.	.	.	4
1979	.	.	0	3	.	.	3
1980	.	.	1	2	.	.	3
1981	.	.	0	9	0	.	9
1982	.	.	2	7	.	.	9
1983	.	.	.	9	.	.	9
1984	.	.	2	7	.	.	8
1985	.	.	2	9	2	.	12
1986	.	.	4	19	7	.	30
1987	.	.	6	22	74	.	101
1988	.	.	3	16	217	.	236
1989	.	.	3	18	230	.	251
1990	.	.	1	20	33	74	128
1991	.	.	.	20	44	137	201
1992	0	.	.	22	54	234	310
1993	.	.	.	23	33	219	275
1994	.	.	.	26	14	141	181
1995	.	0	.	31	12	136	179
1996	.	.	.	25	14	127	166
1997	.	.	.	43	18	133	194
1998	.	.	.	16	13	142	171

Table 6.--Florida landings by fish and area
(thousands of pounds, whole weight)
(1998 data may be incomplete)

King mackerel & cero

Year	Northeast (Nassua-Flagler)	Southeast (Volusia-Dade)	Monroe County	West (Collier-Wakulla)	Northwest (Franklin-Escambia)	Other	Total
1977	119	3,796	4,885	291	40	.	9,132
1978	34	3,367	1,328	383	34	.	5,147
1979	36	3,310	1,490	53	148	.	5,038
1980	50	3,023	2,184	635	183	.	6,075
1981	52	4,806	2,946	69	57	.	7,931
1982	78	4,569	1,837	107	24	.	6,615
1983	61	3,047	1,282	21	36	.	4,448
1984	42	2,395	1,030	32	32	.	3,531
1985	60	2,576	710	45	13	.	3,404
1986	63	2,358	1,601	56	49	.	4,128
1987	39	2,533	472	49	21	1	3,115
1988	51	2,410	534	21	23	0	3,038
1989	47	1,755	216	46	23	0	2,087
1990	84	1,796	942	38	32	6	2,898
1991	132	1,509	259	66	88	1	2,054
1992	70	1,343	933	111	65	0	2,521
1993	35	1,580	1,890	89	109	.	3,702
1994	42	1,515	438	75	390	1	2,461
1995	44	1,574	997	83	88	21	2,808
1996	56	1,762	1,271	168	225	0	3,482
1997	49	2,487	659	59	259	.	3,513
1998	51	1,461	1,025	26	99	0	2,663

Spanish mackerel

Year	Northeast (Nassua-Flagler)	Southeast (Volusia-Dade)	Monroe County	West (Collier-Wakulla)	Northwest (Franklin-Escambia)	Other	Total
1977	10	10,977	1,735	441	217	.	13,381
1978	4	5,506	1,023	151	426	.	7,111
1979	3	4,883	1,278	127	541	.	6,832
1980	6	9,805	1,054	103	613	.	11,581
1981	4	4,170	2,213	218	1,119	.	7,724
1982	3	3,755	2,284	321	683	.	7,046
1983	11	5,936	1,317	192	579	.	8,035
1984	13	2,384	3,099	121	256	.	5,873
1985	16	3,229	2,137	346	432	.	6,160
1986	36	3,967	1,832	256	489	0	6,581
1987	38	3,459	1,822	377	465	0	6,162
1988	34	3,038	1,011	665	462	1	5,210
1989	20	2,834	2,285	463	243	1	5,845
1990	39	1,941	1,151	749	484	1	4,364
1991	50	2,937	1,456	1,380	425	0	6,249
1992	56	1,967	1,344	1,570	650	0	5,587
1993	16	3,876	374	1,486	616	0	6,367
1994	26	3,074	318	1,661	439	2	5,519
1995	12	3,053	207	571	381	1	4,225
1996	6	2,239	324	76	9	.	2,654
1997	7	2,262	169	37	4	.	2,480
1998	1	918	35	114	7	0	1,076

Table 7.--Southeast landings by fish and month
thousands of pounds, whole weight
(1998 data may not be complete)

Bluefish

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1977	800	567	772	503	130	142	113	110	291	418	340	467	4653
1978	432	611	468	519	296	145	78	173	242	313	223	668	4168
1979	590	1196	863	817	447	247	133	136	130	462	474	363	5858
1980	1236	1030	1065	1264	362	187	260	331	302	949	686	1228	8900
1981	1912	1526	1234	1009	507	185	166	289	350	507	576	1394	9653
1982	1143	647	1064	836	230	269	324	393	751	662	462	844	7624
1983	1250	2207	1392	1823	256	205	188	226	199	300	382	668	9095
1984	927	895	862	986	339	225	162	212	229	247	284	489	5857
1985	410	655	585	626	305	167	212	325	331	332	300	653	4900
1986	624	826	862	495	172	92	153	326	425	442	281	573	5272
1987	700	853	1141	990	371	149	238	196	329	402	577	901	6847
1988	1108	1223	1294	1093	359	220	170	186	269	364	444	703	7433
1989	539	345	824	506	180	99	138	234	254	414	463	1089	5084
1990	882	582	1085	619	268	206	179	262	380	386	670	958	6478
1991	891	698	862	971	433	132	146	224	367	517	320	593	6154
1992	904	576	534	798	532	398	192	208	263	273	247	574	5499
1993	600	614	817	501	433	164	340	120	152	285	176	.676	4878
1994	455	528	783	487	93	49	51	107	165	233	84	216	3251
1995	871	635	842	515	380	82	77	81	127	113	99	441	4263
1996	476	663	599	478	259	76	54	96	215	104	371	656	4046
1997	557	1109	538	443	270	126	103	99	271	166	608	1001	5292
1998	1003	398	505	572	320	150	85	49	74	134	111	415	3814

Bonito

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1977	0	.	0	0	11	69	33	45	150	4	0	.	312
1978	0	0	2	1	1	12	-0	7	17	51	1	.0	93
1979	0	1	8	7	89	79	0	8	20	123	2	3	341
1980	0	0	2	0	47	38	36	71	43	22	4	6	271
1981	19	24	64	165	158	58	32	19	13	39	11	9	611
1982	1	4	18	33	19	134	52	24	6	52	8	3	355
1983	5	6	2	5	11	126	117	31	38	15	6	1	364
1984	0	0	32	0	54	6	5	6	3	4	4	3	119
1985	5	0	4	5	9	2	12	3	1	23	40	1	103
1986	1	1	2	64	4	1	1	2	4	20	1	1	100
1987	1	1	3	10	47	28	119	5	16	2	1	4	236
1988	1	4	2	8	91	17	94	34	25	35	4	4	318
1989	4	4	45	61	21	48	46	36	6	6	22	25	325
1990	6	2	7	104	27	13	165	11	38	55	13	2	442
1991	11	3	7	3	55	123	39	160	262	13	11	4	692
1992	2	9	17	96	24	229	72	198	334	61	13	11	1067
1993	26	62	13	23	9	30	67	111	294	11	3	9	658
1994	16	7	24	18	28	4	53	159	877	229	48	31	1493

Table 7.--Southeast landings by fish and month
thousands of pounds, whole weight
(1998 data may not be complete)

Cobia

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1977	6	4	3	12	6	8	10	5	7	11	14	6	113
1978	8	8	21	17	4	11	17	11	6	2	2	9	116
1979	5	21	8	8	7	9	9	9	6	5	11	6	105
1980	14	17	13	12	6	10	12	12	8	5	6	12	127
1981	22	19	16	13	11	7	15	15	9	5	8	18	160
1982	17	21	15	13	14	8	19	11	6	15	9	10	156
1983	15	21	18	14	16	15	21	10	9	8	9	11	168
1984	25	22	19	11	12	10	10	14	8	8	11	22	172
1985	18	19	24	17	13	9	12	12	5	13	8	13	162
1986	25	18	13	22	20	21	20	25	15	14	11	14	219
1987	18	27	23	28	27	32	34	19	18	12	16	21	273
1988	14.	20	22	29	29	25	27	26	13	20	15	16	256
1989	24	23	34	46	40	33	29	20	16	20	26	14	326
1990	29	21	29	37	25	23	18	16	13	11	19	25	266
1991	30	31	35	36	19	29	26	23	13	12	21	29	303
1992	31	36	43	46	41	30	25	15	16	23	20	38	363
1993	32	29	44	62	54	26	27	19	16	26	21	31	385
1994	23	31	47	73	46	26	27	24	26	25	19	24	391
1995	32	35	45	75	46	23	25	16	16	15	19	26	374
1996	32	61	39	84	51	22	18	19	20	22	17	20	404
1997	23	29	44	63	38	25	23	17	18	28	22	15	345
1998	24	21	28	81	40	22	17	9	7	23	6	2	280

Cobia: Total for 1977 includes 20 thousand pounds for which month is not identified.

Dolphin fish

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1977	1	2	6	6	47	32	12	14	3	5	3	3	135
1978	2	4	7	16	47	43	19	9	5	2	2	7	163
1979	0	0	2	9	31	32	15	8	5	4	2	4	111
1980	2	3	4	11	24	78	24	15	6	2	1	1	173
1981	1	2	2	10	25	35	26	13	9	3	2	3	132
1982	1	2	3	12	47	73	71	47	28	11	6	4	306
1983	3	2	2	9	86	130	33	20	12	11	8	4	319
1984	2	4	20	21	143	152	34	21	13	9	13	10	442
1985	4	3	11	22	57	109	110	54	21	9	7	5	412
1986	4	8	13	33	149	147	137	64	53	29	27	18	682
1987	12	7	6	18	95	218	111	79	30	15	21	22	633
1988	12	8	12	63	103	234	141	59	50	22	12	18	735
1989	20	37	32	86	197	286	367	186	134	61	34	22	1464
1990	32	25	36	82	318	526	353	185	108	42	31	28	1765
1991	33	22	88	75	295	656	546	291	151	64	60	49	2330
1992	45	31	27	42	191	253	248	88	63	28	18	20	1055
1993	22	17	24	32	254	276	262	102	53	28	30	21	1121
1994	16	21	36	87	270	294	208	151	93	56	35	34	1301
1995	27	28	53	270	829	514	332	144	76	33	33	20	2360
1996	13	19	17	57	490	424	312	152	45	22	19	24	1594
1997	16	16	51	109	591	560	274	127	59	24	30	19	1876
1998	14	18	13	47	160	250	167	77	18	21	6	5	796

Table 7.--Southeast landings by fish and month
thousands of pounds, whole weight
(1998 data may not be complete)

King mackerel & cero

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1977	2282	2465	1934	206	150	143	234	308	168	235	305	958	9388
1978	928	1132	668	525	506	206	140	272	139	161	205	485	5367
1979	394	1701	669	207	510	259	183	377	107	240	175	694	5515
1980	1012	1012	1171	327	572	197	164	573	449	317	424	850	7068
1981	1377	1790	1555	323	451	183	228	419	181	391	324	1591	8813
1982	1581	646	1529	443	1091	188	378	581	261	400	551	591	8242
1983	1045	1223	1493	251	729	224	170	403	279	317	418	412	6963
1984	1000	761	369	170	328	162	182	389	281	286	312	976	5217
1985	513	463	901	310	780	193	286	304	98	210	530	805	5392
1986	726	1283	472	378	616	138	299	478	340	393	302	344	5768
1987	558	392	143	429	660	285	388	414	381	518	449	583	5199
1988	62	38	96	825	803	142	247	382	270	310	503	865	4542
1989	71	45	35	476	555	154	310	507	247	396	496	357	3649
1990	790	47	230	461	507	166	323	402	340	323	592	668	4848
1991	316	94	122	346	382	138	310	525	381	290	382	743	4031
1992	839	124	149	365	228	212	554	392	370	605	280	851	4968
1993	1380	274	288	328	524	108	511	458	352	208	342	893	5664
1994	407	212	227	427	372	144	594	392	388	275	390	467	4294
1995	626	660	399	278	374	155	621	299	148	234	388	492	4673
1996	406	947	174	439	412	211	561	494	153	349	347	618	5112
1997	774	438	684	428	524	169	913	292	139	425	663	484	5934
1998	663	618	498	477	302	162	663	385	121	323	533	68	4814

Spanish mackerel

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1977	5305	3005	670	182	117	46	41	62	144	292	938	2869	13672
1978	2914	929	270	156	32	6	7	46	198	260	226	2212	7256
1979	1393	3029	194	322	117	41	60	146	56	198	130	1336	7023
1980	4711	1417	110	289	105	34	41	72	210	184	160	4513	11847
1981	2004	224	63	717	172	44	38	81	282	234	733	3345	7936
1982	1046	254	2589	419	181	43	126	139	211	221	717	1459	7405
1983	4184	248	62	321	289	42	56	46	87	209	520	2191	8255
1984	1814	606	815	142	98	21	22	133	57	105	391	1829	6032
1985	1713	1812	405	316	53	66	38	51	58	232	211	1488	6442
1986	2370	2376	217	380	118	44	74	124	150	283	158	686	6982
1987	1328	816	280	671	171	131	104	139	151	205	98	2762	6858
1988	621	210	497	430	317	73	125	77	97	296	318	2766	5828
1989	1853	556	192	217	97	83	146	86	95	448	298	2493	6563
1990	723	595	406	437	142	143	145	184	330	343	428	1520	5398
1991	1013	152	197	430	194	175	167	190	425	566	399	3380	7288
1992	1057	641	510	648	292	126	158	156	239	496	309	1904	6537
1993	838	526	742	701	238	136	90	92	249	349	441	2703	7105
1994	544	1008	793	744	114	107	90	143	353	450	236	1830	6413
1995	1473	1054	692	599	149	62	62	75	176	150	219	314	5024
1996	254	490	144	262	136	72	44	124	90	271	139	1285	3310
1997	512	252	220	272	137	124	103	117	261	412	577	613	3601
1998	322	144	101	196	140	70	66	43	71	354	162	1	1670

Table 7.--Southeast landings by fish and month
thousands of pounds, whole weight
(1998 data may not be complete)

Wahoo

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1977	0	1	0	0	1	1	1	1	0	0	0	0	7
1978	0	2	1	1	1	2	1	1	3	0	0	2	13
1979	1	0	1	0	1	1	4	4	1	1	1	0	15
1980	3	3	0	1	1	2	4	6	2	0	1	1	23
1981	1	1	1	2	2	4	6	4	2	1	1	1	26
1982	1	1	1	2	3	3	6	4	1	5	1	1	30
1983	1	2	1	1	3	7	6	5	5	2	1	1	34
1984	0	0	2	2	4	4	5	7	2	1	1	1	30
1985	1	1	2	4	5	5	7	7	3	2	1	1	39
1986	1	1	1	2	5	5	10	9	8	4	3	1	51
1987	7	3	4	6	9	31	31	26	15	11	9	8	159
1988	10	14	9	7	21	47	72	60	20	28	14	10	311
1989	32	14	10	16	29	46	68	38	28	7	5	7	299
1990	9	7	8	7	18	34	45	34	19	8	7	6	201
1991	7	8	9	11	17	37	57	55	24	9	7	9	252
1992	12	11	28	23	30	55	75	73	22	12	9	13	362
1993	11	16	16	22	26	35	63	87	29	11	7	8	332
1994	9	11	16	12	22	31	41	33	23	10	8	15	229
1995	10	9	15	17	27	41	57	31	20	11	7	11	257
1996	8	13	5	12	19	43	44	40	20	9	9	6	229
1997	7	10	15	17	22	28	37	50	34	13	10	11	254
1998	14	12	15	17	22	25	47	41	10	12	5	3	222

Table 8.--Southeast real exvessel prices by fish and month
1990 cents/pound, whole weight
(1998 data may not be complete)

Bluefish

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1977	22	24	19	18	19	17	21	18	19	16	24	25
1978	26	31	26	24	18	21	21	21	18	16	18	25
1979	44	34	30	27	21	18	21	20	22	20	20	21
1980	20	20	26	23	20	17	17	21	19	13	16	18
1981	19	21	32	26	21	17	14	16	17	18	16	26
1982	24	34	40	47	18	18	16	18	16	17	17	21
1983	20	13	16	15	20	21	19	17	17	16	14	16
1984	18	17	25	18	20	20	19	18	16	14	14	13
1985	35	25	19	18	18	17	20	15	14	14	14	16
1986	20	18	19	20	19	19	20	18	18	15	13	16
1987	27	25	24	31	17	19	18	18	16	15	14	13
1988	18	18	19	19	19	20	18	18	17	17	15	15
1989	17	33	25	23	23	28	21	21	22	19	16	16
1990	27	28	26	31	25	22	19	22	15	17	12	12
1991	20	22	25	18	20	26	23	24	19	22	13	13
1992	20	32	29	30	48	65	41	44	32	37	28	42
1993	43	42	36	42	44	56	39	64	37	28	70	15
1994	34	33	34	32	23	24	25	26	26	36	27	29
1995	32	34	37	33	27	25	25	25	26	27	23	35
1996	25	25	26	23	23	23	26	24	27	26	27	26
1997	27	26	28	42	24	24	22	24	32	26	26	26
1998	28	30	29	28	26	24	25	29	27	28	25	28

Bonito

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1977	20	.	21	18	12	14	14	14	14	14	13	.
1978	8	9	7	16	13	9	36	25	13	13	11	16
1979	16	23	14	12	13	11	13	12	12	11	10	14
1980	14	7	19	16	14	23	14	12	10	22	11	26
1981	20	18	18	17	16	10	10	10	10	10	11	19
1982	8	17	13	9	8	11	10	13	12	13	12	11
1983	10	11	14	14	15	9	9	11	10	12	23	17
1984	11	21	6	39	9	11	15	14	10	11	13	11
1985	9	15	17	15	22	15	11	12	23	12	12	17
1986	14	28	11	12	12	27	19	11	13	14	22	13
1987	17	31	21	14	10	10	10	13	12	12	26	27
1988	20	23	24	17	15	38	23	20	17	15	19	21
1989	14	17	17	12	27	16	19	25	36	28	19	15
1990	29	16	15	11	12	16	17	18	18	24	17	15
1991	10	20	12	18	24	21	27	23	21	23	17	19
1992	23	26	13	13	21	19	17	36	27	18	16	20
1993	19	23	19	15	32	15	20	21	15	31	28	24
1994	18	30	27	20	21	23	32	23	25	23	28	30
1995	19	19	19	19	23	20	25	17	19	27	18	19
1996	22	22	21	22	22	23	25	24	30	22	21	21
1997	24	20	20	20	21	20	34	21	20	20	20	35
1998	22	21	21	21	21	21	21	22	21	21	21	21

Table 8.--Southeast real exvessel prices by fish and month
1990 cents/pound, whole weight
(1998 data may not be complete)

Cobia

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1977	27	44	53	43	39	46	46	30	47	53	53	47
1978	62	64	50	53	51	50	52	46	44	68	70	55
1979	44	50	55	50	48	45	43	41	48	51	37	50
1980	53	50	47	57	48	43	47	54	50	50	51	48
1981	70	68	58	58	45	62	57	56	47	45	49	47
1982	80	55	57	68	59	60	65	59	46	55	54	51
1983	82	81	65	76	71	60	68	57	63	65	70	74
1984	78	67	71	80	84	74	76	65	66	68	84	92
1985	91	99	96	104	83	85	80	86	98	92	92	95
1986	98	119	106	115	95	91	96	85	94	91	106	113
1987	123	115	120	119	108	112	107	108	89	91	114	119
1988	109	119	131	131	128	110	119	122	114	104	117	128
1989	132	133	127	131	123	115	111	116	111	110	122	126
1990	131	133	145	150	131	126	117	113	109	113	128	138
1991	129	135	144	145	126	117	130	139	130	132	150	146
1992	155	156	158	155	141	131	133	125	141	143	142	146
1993	149	152	153	153	142	142	143	144	142	133	147	162
1994	161	163	163	166	145	145	145	145	147	143	147	149
1995	159	176	168	158	151	152	154	158	151	134	158	162
1996	158	172	171	174	159	153	149	160	151	129	157	184
1997	175	169	170	177	160	144	156	165	147	133	156	179
1998	184	175	179	189	173	159	168	167	165	141	158	136

Dolphin fish

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1977	84	81	64	67	60	64	70	56	77	94	78	78
1978	75	64	85	69	67	66	69	68	66	105	94	66
1979	87	76	95	89	82	72	81	85	76	88	90	74
1980	95	92	81	86	83	77	70	70	78	85	75	87
1981	76	106	112	88	87	87	79	88	91	85	105	119
1982	91	93	98	92	91	90	88	93	93	94	100	100
1983	97	101	123	119	94	88	95	97	100	93	85	110
1984	103	122	124	114	100	88	106	112	108	118	122	130
1985	116	134	142	132	117	108	119	128	119	126	139	142
1986	141	142	128	125	104	111	118	122	119	123	159	127
1987	140	142	146	138	137	139	132	137	135	114	117	120
1988	130	138	142	130	128	119	115	114	110	443	127	128
1989	128	123	139	120	118	114	105	104	103	116	112	104
1990	106	132	124	113	103	103	108	109	110	115	124	120
1991	124	123	96	121	123	113	109	111	121	121	114	111
1992	96	98	105	115	112	108	106	98	115	117	120	119
1993	119	118	122	126	124	128	110	126	126	128	130	124
1994	131	132	131	139	141	138	141	160	157	149	133	122
1995	143	139	144	139	120	129	134	154	154	154	150	146
1996	141	135	169	146	124	123	138	135	134	148	153	157
1997	121	132	143	126	105	102	107	112	125	135	124	132
1998	129	117	134	131	130	128	143	149	148	168	121	112

Table 8.--Southeast real exvessel prices by fish and month
1990 cents/pound, whole weight
(1998 data may not be complete)

King mackerel & cero

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1977	76	62	66	82	112	111	100	92	123	115	82	63
1978	68	67	77	69	88	98	129	122	136	141	118	105
1979	107	99	93	153	125	146	133	129	121	105	111	100
1980	92	94	93	103	100	107	111	113	106	102	113	100
1981	100	98	101	106	98	113	109	102	118	103	102	103
1982	108	113	113	115	105	105	121	112	121	120	102	111
1983	111	110	109	133	113	109	120	116	104	85	73	81
1984	64	74	90	106	100	123	120	125	121	98	87	82
1985	108	128	107	126	108	126	128	127	150	131	112	93
1986	114	105	123	131	118	127	141	99	131	101	102	113
1987	129	118	163	155	117	127	139	135	108	96	99	117
1988	152	182	193	103	114	149	117	129	129	125	126	109
1989	160	206	202	126	102	152	155	128	127	111	112	116
1990	108	136	148	121	114	151	131	128	122	103	95	96
1991	103	143	216	138	123	153	114	98	100	127	100	96
1992	102	168	188	156	157	158	102	112	121	112	125	113
1993	87	165	181	158	129	184	102	103	83	140	125	111
1994	127	137	176	132	119	161	102	124	114	134	131	125
1995	124	101	144	154	122	182	88	107	114	148	138	119
1996	121	91	134	119	111	167	92	96	154	148	143	108
1997	90	134	142	129	96	166	90	129	162	145	118	116
1998	100	104	126	132	139	189	105	115	194	155	142	146

Spanish mackerel

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1977	33	33	33	34	35	36	34	34	34	35	36	32
1978	31	31	32	36	34	32	37	37	41	39	39	34
1979	31	33	35	41	45	34	53	46	42	42	41	37
1980	30	41	35	37	36	37	37	48	39	38	46	35
1981	36	34	37	36	35	42	57	44	39	44	38	38
1982	38	37	38	37	36	50	38	34	42	38	39	34
1983	35	40	38	37	31	37	42	42	37	36	31	32
1984	30	33	32	33	38	40	45	42	34	39	36	33
1985	32	31	31	34	39	26	41	40	39	36	41	39
1986	35	34	35	37	42	34	40	38	39	40	43	38
1987	36	43	39	41	43	29	36	34	33	38	42	41
1988	46	33	70	41	39	36	34	38	36	41	46	39
1989	42	42	41	42	43	33	35	42	39	42	45	37
1990	48	45	46	43	41	37	36	42	40	39	48	32
1991	51	57	51	40	38	41	40	38	39	36	40	37
1992	31	35	37	36	39	37	37	41	36	42	43	36
1993	36	45	37	41	40	42	42	45	39	47	46	35
1994	45	40	49	41	41	43	49	43	43	48	47	40
1995	41	38	41	34	35	39	48	48	52	65	69	50
1996	56	49	70	62	47	45	41	46	56	56	57	33
1997	49	38	71	50	51	59	53	58	54	59	40	35
1998	61	88	74	75	64	60	54	62	68	48	46	59

Table 8.--Southeast real exvessel prices by fish and month
1990 cents/pound, whole weight
(1998 data may not be complete)

Wahoo

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1977	84	81	83	78	63	73	86	80	84	82	88	74
1978	60	62	76	84	93	73	76	71	69	69	84	72
1979	93	91	102	100	83	86	87	86	102	80	97	89
1980	108	106	99	86	85	77	76	77	69	71	84	85
1981	87	81	75	82	88	83	77	74	81	74	84	83
1982	89	100	77	86	92	86	82	83	82	71	92	107
1983	103	79	107	106	104	103	100	104	77	99	103	80
1984	71	78	86	91	84	101	104	105	110	101	123	109
1985	115	96	121	115	102	111	108	120	112	110	114	115
1986	108	118	117	135	142	120	129	118	120	121	131	119
1987	92	132	121	126	116	120	115	119	125	124	121	114
1988	108	98	123	142	124	113	107	105	115	109	111	124
1989	113	112	102	110	95	93	88	87	82	121	117	135
1990	125	138	122	148	141	119	112	116	114	114	126	133
1991	120	110	120	140	123	107	98	101	117	120	132	111
1992	131	113	107	101	120	107	98	87	109	121	118	115
1993	112	97	112	108	129	118	105	105	107	140	151	132
1994	110	144	117	152	124	120	111	108	127	148	149	131
1995	134	133	123	159	152	125	124	122	135	175	170	148
1996	142	154	142	158	141	105	109	125	134	177	183	180
1997	208	186	137	144	137	123	114	107	133	168	160	163
1998	124	153	127	147	150	120	110	122	166	187	152	117

Table 9.--Southeast monthly landings of king mackerel and cero by state
monthly=% of total, total=thousands of pounds, whole weight
(1998 data is not complete)

North Carolina-Georgia

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1977	0	0	0	1	9	1	2	1	2	37	41	6	256
1978	0	.	0	1	6	4	6	3	5	25	41	9	220
1979	0	0	0	6	7	2	5	8	8	23	24	18	478
1980	0	0	0	3	5	2	4	9	9	24	36	8	993
1981	0	1	1	3	6	5	6	3	7	40	24	3	882
1982	0	0	1	6	9	5	4	4	9	26	24	11	1398
1983	1	1	0	2	11	4	5	5	9	23	28	12	1024
1984	1	1	5	14	7	5	4	3	6	25	19	9	933
1985	1	0	3	10	9	6	4	5	6	13	36	7	1012
1986	2	1	3	7	8	5	5	6	17	25	13	7	1303
1987	1	1	6	3	8	4	5	4	13	25	26	4	1549
1988	5	3	8	5	7	4	4	4	12	22	22	3	1041
1989	4	4	3	15	4	3	6	7	6	18	24	6	903
1990	2	1	16	18	2	4	5	5	10	10	25	4	1311
1991	14	5	7	7	4	4	4	6	6	15	18	10	1393
1992	9	7	10	9	4	7	4	3	4	17	16	10	1303
1993	11	12	8	7	13	4	4	3	2	10	21	4	1060
1994	5	5	10	14	3	3	3	3	5	17	16	15	949
1995	11	3	16	6	3	2	4	1	3	17	20	14	1107
1996	10	4	6	14	2	2	1	3	2	23	27	7	893
1997	1	11	29	8	1	2	2	1	3	15	21	6	1627
1998	8	3	11	8	3	2	1	1	2	14	41	6	1189

Florida, east coast

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1977	17	17	18	1	3	3	5	8	4	2	4	18	3915
1978	10	19	16	4	14	6	4	8	3	3	3	10	3402
1979	4	22	17	5	13	7	4	9	1	3	1	13	3346
1980	11	5	4	4	17	6	4	15	9	2	2	20	3073
1981	13	11	14	5	8	3	3	8	2	1	2	30	4858
1982	10	5	25	8	21	3	7	11	3	1	2	6	4647
1983	17	7	26	6	18	5	2	6	4	1	3	5	3108
1984	8	22	12	1	10	4	3	13	9	0	2	16	2437
1985	10	7	19	7	25	3	7	8	1	1	2	10	2636
1986	10	9	8	9	20	3	9	15	4	1	4	8	2421
1987	9	2	0	13	20	9	10	12	5	0	1	20	2573
1988	0	0	0	29	29	4	4	11	5	1	4	13	2461
1989	1	0	0	16	28	7	9	17	2	1	7	10	1801
1990	4	0	0	9	25	6	5	9	3	2	13	25	1881
1991	1	1	1	15	20	5	6	10	5	3	5	27	1641
1992	15	0	1	14	12	8	5	8	8	3	3	22	1413
1993	3	8	12	15	24	4	4	10	4	3	4	11	1614
1994	10	7	7	11	21	7	6	9	5	2	5	11	1557
1995	10	7	10	11	21	8	4	4	1	2	8	14	1618
1996	8	12	3	7	22	11	5	10	4	3	3	15	1817
1997	10	7	8	11	19	5	5	7	2	3	9	13	2536
1998	13	10	7	12	17	9	9	8	5	6	2	.	1513

Table 9.--Southeast monthly landings of king mackerel and cero by state
monthly=% of total, total=thousands of pounds, whole weight
(1998 data is not complete)

Florida, west coast

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1977	31	35	24	3	0	0	0	0	0	1	1	5	5217
1978	33	28	8	22	0	0	0	0	1	1	0	7	1745
1979	15	57	6	2	2	0	0	3	2	1	1	10	1691
1980	22	28	35	6	0	0	0	0	2	1	0	5	3002
1981	24	40	28	2	0	0	0	0	0	0	0	4	3073
1982	57	20	19	0	0	0	0	0	1	1	1	1	1968
1983	11	45	36	1	0	0	0	1	1	1	1	2	1340
1984	70	18	2	2	1	0	0	0	0	2	3	2	1095
1985	16	34	45	1	0	0	1	0	0	0	0	1	768
1986	23	57	12	3	2	0	0	0	0	0	0	1	1707
1987	40	30	8	8	3	0	1	1	2	1	1	4	543
1988	0	0	0	10	2	1	1	1	1	2	1	81	577
1989	7	1	3	18	2	1	1	1	3	10	13	40	286
1990	69	3	1	6	1	0	0	1	2	1	2	14	1018
1991	25	2	1	2	1	1	4	4	5	6	10	38	413
1992	46	2	1	4	1	0	2	1	2	2	2	36	1108
1993	58	1	1	1	0	0	1	1	1	2	3	32	2088
1994	22	7	2	14	1	1	5	3	3	8	18	17	904
1995	28	43	5	3	1	0	2	1	2	1	3	10	1190
1996	10	42	4	12	0	0	1	1	3	6	3	18	1665
1997	52	9	1	2	1	0	3	1	4	12	9	6	976
1998	33	31	8	17	1	0	1	2	1	5	2	.	1151

Alabama-Texas

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1978	.	.	.	.	.	.	.	.	.	100	.	.	0
1979	.	.	.	.	.	.	100	.	.	.	.	.	0
1982	.	.	.	.	.	.	.	.	.	.	42	58	229
1983	24	27	13	1	3	2	4	10	4	3	1	7	1492
1984	4	4	0	0	0	2	8	6	2	4	6	64	752
1985	11	1	3	1	4	5	5	5	1	6	10	48	976
1986	17	19	5	0	0	0	5	9	6	14	9	15	338
1987	20	30	0	0	0	0	9	10	7	22	2	.	535
1988	0	.	0	.	0	0	23	14	5	12	34	11	463
1989	0	0	.	.	.	0	13	20	22	29	17	.	658
1990	.	0	.	.	.	0	27	26	23	22	.	2	639
1991	.	.	.	0	0	0	22	45	33	0	.	.	584
1992	.	.	0	0	0	0	36	20	16	28	0	0	1143
1993	.	.	0	0	0	0	42	28	28	1	0	.	902
1994	0	.	0	.	.	0	49	23	27	1	0	.	884
1995	.	.	0	0	0	0	64	27	9	0	0	0	759
1996	.	.	.	.	0	0	59	38	3	.	.	.	737
1997	.	.	.	.	0	0	91	9	0	0	0	.	793
1998	.	7	17	0	0	0	51	24	0	.	.	.	962

Table 10.--Southeast monthly real exvessel prices of king mackerel & cero by state
1990 cents/pound, whole weight
(1998 data may not be complete)

King mackerel & cero
North Carolina-Georgia

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1977	107	128	90	80	94	91	145	122	112	140	44	82
1978	90	.	93	88	82	87	109	122	101	128	98	88
1979	101	102	92	101	108	94	101	116	128	83	109	110
1980	89	78	133	122	93	95	110	110	101	100	113	95
1981	110	115	115	120	100	102	106	106	115	103	102	109
1982	97	94	108	130	101	97	101	105	124	121	96	111
1983	111	107	108	108	110	108	105	96	93	85	65	68
1984	96	129	100	103	88	98	107	116	134	101	85	79
1985	115	113	117	114	104	100	110	107	138	146	119	112
1986	132	127	133	105	72	111	111	103	120	100	91	103
1987	136	152	183	161	98	119	122	116	94	97	97	112
1988	155	190	196	98	98	127	121	129	129	127	129	151
1989	181	231	232	122	108	153	171	134	148	129	108	122
1990	183	214	148	110	132	154	142	138	120	125	85	92
1991	99	156	235	128	119	148	147	125	110	127	95	96
1992	138	190	202	160	176	157	140	135	143	142	124	122
1993	174	176	191	159	123	162	137	136	138	143	122	162
1994	151	150	148	147	144	136	142	142	136	141	144	141
1995	149	148	148	147	143	141	136	147	148	144	145	144
1996	148	149	149	148	144	142	140	130	143	145	144	139
1997	139	139	140	140	137	136	129	131	135	135	138	140
1998	141	139	142	142	140	150	137	144	142	144	145	146

King mackerel & cero
Florida, east coast

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1977	98	66	78	140	120	121	105	92	127	119	111	62
1978	80	73	81	103	88	99	133	123	143	158	135	115
1979	122	108	92	176	135	150	142	141	160	133	124	103
1980	105	130	121	115	100	109	114	114	116	115	116	103
1981	104	97	100	105	99	118	113	102	123	106	106	103
1982	112	126	114	112	105	110	126	113	122	123	112	112
1983	115	128	114	142	114	117	147	126	113	114	97	77
1984	87	82	89	130	103	145	154	128	117	114	111	101
1985	120	163	109	133	109	151	134	135	186	158	120	122
1986	140	151	137	146	126	140	153	98	160	142	134	129
1987	145	150	138	155	123	129	150	150	138	140	126	117
1988	135	139	160	104	115	159	132	133	135	137	125	112
1989	144	105	131	131	102	153	166	127	169	138	121	123
1990	148	161	149	136	113	151	169	174	156	146	108	93
1991	104	106	160	146	123	162	118	115	128	144	114	98
1992	117	116	115	169	154	160	148	147	154	135	134	134
1993	127	163	182	161	131	201	158	132	135	164	141	137
1994	134	138	203	120	117	169	167	167	159	132	132	120
1995	148	142	150	160	121	191	119	148	164	181	129	108
1996	131	110	185	141	110	170	129	116	181	147	143	112
1997	122	145	147	125	94	174	108	140	197	155	95	113
1998	141	167	163	151	140	196	135	154	218	179	124	.

Table 10.--Southeast monthly real exvessel prices of king mackerel & cero by state
1990 cents/pound, whole weight
(1998 data may not be complete)

King mackerel & cero
Florida, west coast

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1977	66	60	59	62	64	44	45	65	82	60	63	62
1978	61	59	61	57	55	70	68	65	89	90	89	82
1979	99	93	95	71	15	86	77	66	76	85	84	88
1980	86	87	90	89	85	83	76	73	67	78	87	91
1981	97	98	102	103	82	81	72	75	76	77	84	104
1982	106	105	109	100	92	86	86	89	82	84	83	99
1983	111	111	109	113	87	89	78	71	67	83	84	68
1984	58	50	74	100	83	80	88	85	109	86	88	99
1985	107	103	103	107	99	102	100	92	109	114	97	100
1986	102	95	112	112	135	111	105	126	121	126	119	126
1987	116	116	122	143	111	119	116	103	112	122	111	118
1988	124	138	164	94	97	107	98	103	100	108	108	105
1989	132	144	104	107	103	96	85	94	101	103	107	104
1990	102	106	126	127	115	121	114	105	111	114	114	108
1991	110	99	90	50	104	71	110	104	89	99	102	90
1992	87	92	90	93	97	103	102	97	101	97	119	93
1993	77	106	111	110	104	110	104	98	110	114	119	100
1994	116	125	166	131	119	121	136	101	110	124	120	115
1995	103	89	117	145	106	97	96	122	109	147	128	107
1996	98	82	91	86	107	95	102	94	155	156	140	98
1997	73	103	113	112	100	102	101	110	154	161	99	98
1998	69	74	110	107	108	108	107	109	165	150	116	.

King mackerel & cero
Alabama-Texas

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1978	.	.	.	.	.	.	.	.	.	65	.	.
1979	.	.	.	.	.	.	176	.	.	.	.	.
1982	.	.	.	.	.	.	.	.	.	.	110	110
1983	104	100	93	86	110	69	115	114	114	71	57	107
1984	56	69	67	83	110	81	84	111	120	78	67	66
1985	79	140	112	137	89	119	128	113	110	91	84	73
1986	76	93	88	25	96	107	118	101	107	84	68	73
1987	119	106	76	66	57	68	109	77	81	88	76	.
1988	133	.	133	.	88	145	104	117	111	119	123	107
1989	105	105	.	.	.	86	126	127	108	95	109	.
1990	.	122	.	.	.	90	108	81	112	71	.	78
1991	.	.	.	85	29	39	95	78	85	52	.	.
1992	.	.	120	80	82	60	89	90	98	90	94	80
1993	.	.	20	29	158	81	87	82	63	96	33	.
1994	78	.	39	.	.	139	83	97	95	115	53	.
1995	.	.	47	56	70	54	79	90	85	55	90	93
1996	.	.	.	.	91	84	82	81	79	.	.	.
1997	.	.	.	.	91	86	84	104	83	68	73	.
1998	.	94	96	47	93	103	95	93	94	.	.	.

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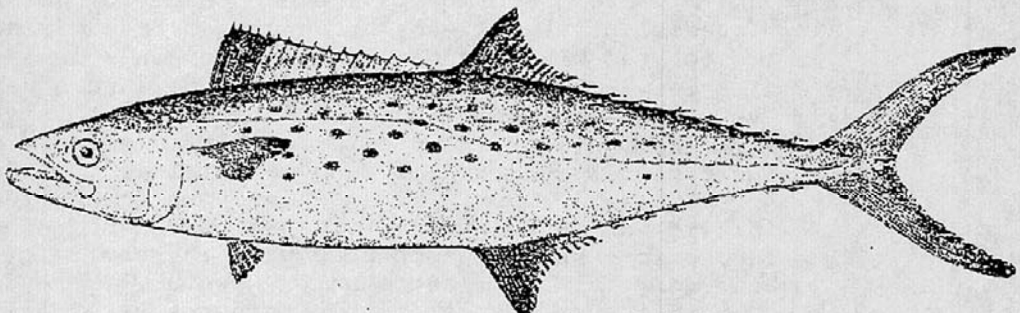
Appendix P. An Analysis of the Demand for King Mackerel (SERO-ECON-99-07)

An Analysis of the Demand for King Mackerel



John Vondruska, Ph.D.
National Marine Fisheries Service
Fisheries Economics Office

April 13, 1999

SERO-ECON-99-07

An Analysis of the Demand for King Mackerel[1]

April 13, 1999

Introduction and Summary

This report updates previous work on empirical models of the U.S. market demand for commercially harvested king mackerel and in turn the estimation of net national economic benefits associated with changes in fishery regulation that affect the amount that can be landed. Clearly, the analysis of market demand and supply requires much more work. Progress towards improving the empirical estimates for net national economic benefits, notably producer surplus, will depend on the availability of results of economic surveys of the fisheries.

In this report, results of estimating several annual and monthly demand models are provided (Tables 5 and 6; Appendices A and B). Selected models are then used to show the effects on exvessel price, exvessel revenue and consumer surplus that are associated with hypothetical changes in southeast landings (Tables 7-11). Finally, based on one annual demand model, 22-year sums for consumer surplus and 22-year sums for proxies for producer surplus are provided for two recovery patterns for the Gulf migratory group of king mackerel (Table 12; annual yields from Legault, 1999). The differences in the respective sums provide an indication of the two components of net national economic benefits associated with the choice of one fish stock recovery path over the other. However, these indicators of consumer and producer surplus are not necessarily additive nor are they necessarily comparable with what might be estimated for recreational fishing activity.

Demand Models

Several linear, mostly price-dependent, single-equation monthly and annual models of the U.S. commercial-fishery market demand for king mackerel were specified and then estimated using ordinary least squares. Data for 1977-97 was used to estimate the monthly models, and data for 1972-98 was used to estimate the annual models. The values for adjusted R-square ranged from about 0.38 to 0.52 for 12 monthly models, and they were about 0.7 for 4 annual models, as depicted in Tables 5 and 6 (monthly

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[1]Prepared by John Vondruska, National Marine Fisheries Service, 9721 Executive Center Drive, North, St. Petersburg, FL 33702-2432. This is file c:\reports\mack99\kmdend.wpd.

models 13-16 and 18 are shown in Appendix A only). For the most part, the estimated coefficients in the models had the expected signs and exhibited statistical significance.

The price-dependent models suggest that market demand is quite elastic with respect to price, about as previously reported by Easley et. al. (1993) for their 1977-91 monthly models. Two specifications for quantity-dependent demand models, one annual and one monthly, suggest lower price elasticities of demand, but they have problems with serial correlation of residuals that could not be addressed by the author at this time (monthly model 11 and annual model 4).[2]

"What-if" Scenarios

Second, based on results for selected monthly and annual models of U.S. market demand, "what-if" scenarios are depicted for changes in commercial landings of king mackerel in southeastern coastal states (North Carolina to Texas) to show the effect on real exvessel prices, exvessel revenue, a related proxy for producer surplus, and consumer surplus for a single year (Tables 7-11). Given the relatively high elasticity of demand, changes in exvessel price are quite small. If, for example, the commercial landings were reduced by 1 million pounds annually (enough to reduce Gulf group landings by about a third from their average for the five fishing years 1993/94 to 1997/98), one annual model suggests only a 2 cent increase in exvessel price to $1.21 a pound (in 1992 dollars).

National Economic Benefits

Finally, based on one of the annual models and two yields (total allowable catches) for each of 22 fishing years (1998/99 to 2020/2021, from Legault, 1999), the 22-year sums of present values of southeast commercial fishery exvessel revenue, producer surplus, and consumer surplus are depicted using a 7% discount rate (Table 12). The difference in the 22-year sums for consumer surplus represents one component of net national benefits. The difference in 22-year sums for the proxy for producer surplus represents another component of net national benefits. Recovery to 40% SPR by 2014/2015 rather than recovery to 30% SPR by 2013/2014 results in a sum of estimated commercial landings for

[2]Easley et. al. (1993) found serial correlation of residuals to be a problem with most of their models, and chose to use an autoregression estimation procedure to address this problem. Apart from limitations of time, this was not possible for the author, given the incomplete version of SAS 6.12 that is available (i.e., the SAS/ETS module is not available).

the 22 years that is about 8.4 million pounds lower. The present value for the 22 years of exvessel revenue is $5.5 million less (in 1992 dollars), that for the proxy for producer surplus is $444,000 less, and that for consumer surplus is about $53,000 less.

Selected References

Easley, J.E., Chuck Adams, Walter N. Thurman and Joel Kincaid. 1993. The derived demand for commercially harvested Gulf and South Atlantic king mackerel: partial and general equilibrium, a project report to the Gulf of Mexico Fishery Management Council, March 29, 1993, 42 p. + appendices.

Legault, Christopher M. 1999. Updated projections for king and Spanish mackerel in the Gulf of Mexico and Atlantic Ocean. National Marine Fisheries Service, Southeast Fisheries Science Center, Sustainable Fisheries Division, 75 Virginia Beach Drive, Sustainable Fisheries Division Contribution SFD-98/99-49, March 16, 1999, 33 p. + appendices A and B.

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Table 5.--Flexibilities, elasticities and other selected results of linear, single-equation, 1977-97 monthly demand or price models for king mackerel (t-statistic in parentheses below coefficients)

No	Price dependent models	Inter-cept	Quantity coeff.	Price-quantity flex.	Approx. quantity-price elast.	Income coeff.	Price-income flexib.	Adj R-sq	D-W*	Othe si st s
1	LPSE=f(LQSE,MQ, DPI92)	75.61879 (6.917)	-0.031897 (-8.621)	-0.125903	-7.942622	0.014646 (5.703)	0.126592	0.3779	1.191	
2	LPSE=f(LQSE,MP, DPI92)	76.391114 (5.604)	-0.031882 (-8.657)	-0.125844	-7.946359	0.014618 (5.708)	0.126350	0.3779	1.190	
3	LPSE=f(CONS,DPI92)	40.636301 (4.263)	-0.016780 (-6.222)	-0.090940	-10.996241	0.022123 (9.498)	0.191220	0.3013	1.214	
4	LPSE=f(LQSE,MQ, DPI92,D1-D11)	65.536971 (6.075)	-0.035958 (-9.168)	-0.141932	-7.045604	0.015834 (6.780)	0.136861	0.4960	1.203	
5	LPSE=f(LQSE,MP, DPI92,D1-D11)	64.780673 (4.816)	-0.035588 (-9.105)	-0.140472	-7.118855	0.015284 (6.574)	0.132107	0.4949	1.204	
6	LPSE=f(CONS,DPI92, D1-D11)	31.059974 (3.132)	-0.019889 (-6.315)	-0.107790	-9.277335	0.023178 (10.735)	0.200339	0.4177	1.154	
7	LPSE=f(CONS,SQ, DPI92,D1-D11)	40.797222 (3.789)	-0.019001 (-6.033)	-0.102977	-9.710906	0.022432 (10.349)	0.193891	0.4272	1.198	
8	LPSE=f(CONS,SP, DPI92,D1-D11)	-10.21124 (-0.691)	-0.020817 (-6.760)	-0.112819	-8.863761	0.025579 (11.615)	0.221092	0.4471	1.219	
9	LPSE=f(LQSE,MQ,SQ, DPI92,D1-D11)	82.634066 (7.095)	-0.036081 (-9.410)	-0.142418	-7.021585	0.014122 (6.039)	0.122063	0.5184	1.273	
10	LPSE=f(LQSE,MP,SP, DPI92,D1-D11)	28.407412 (1.761)	-0.036371 (-9.559)	-0.143563	-6.965600	0.016933 (7.362)	0.146360	0.5227	1.278	

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Table 5.--Flexibilities, elasticities and other selected results of linear, single-equation, 1977-97 monthly demand or price models for king mackerel (t-statistic in parentheses below coefficients)

	Quantity dependent models	Inter-cept	Price coeff.	Approx. price-quantity flex.	Quantity-price elast.	Income coeff.	Income elasticity	Adj R-sq	D-W	Ot
11	CONS=f(LPSE,DPI92, D1-D11)	578.131701 (3.058)	-7.215396 (-6.315)	-0.751110	-1.331363	0.315321 (6.894)	1.985016	0.4698	0.899	
12	MQ=f(LQSE,MP,DPI92, D1-D11)	-525.67080 (-2.408)	-1.032039 (-1.455)	-2.036712	-0.490987	0.269087 (7.130)	6.235147	0.3637	0.626	

Means of monthly variable used in models, 252 observations for 1977-97

MQ	MP	SQ	SP	CONS	LQSE
177.992	84.6788	1821.68	224.864	655.154	477.162
LPSE	DPI92				
120.887	4124.34				

Flexibility of price with respect to quantity
Flexibility, F = (% change in price) / (% change in quantity)
E.g., F = coefficient for LQSE * (average LQSE) / (average LPSE)
F = coefficient for CONS * (average CONS) / (average LPSE)

Elasticity of quantity with respect to price
E = 1 / F, approximately, or directly
Elasticity, E = (% change in quantity) / (% change in price)
E.g., E = coefficient for LPSE * (average LPSE) / (average CONS)

Flexibility of price respecting income, F
Flexibility, F = (% change in price) / (% change in income)
E.g., F = coefficient for DPI92 * (average DPI92) / (average LPSE)

Elasticity of quantity with respect to income
Elasticity, E = (% change in quantity) / (% change in income)
E.g., E = coefficient for DPI92 * (average DPI92) / (average CONS)

*Note: except for equations 11 & 12, the Durbin-Watson test is inconclusive.
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Table 6.--Flexibilities, elasticities and other selected results of linear, single-equation, 1972-98 annual demand or price models for king mackerel (t-statistic in parentheses below coefficients)

No	Price dependent models	Inter-cept	Quantity coeff.	Price-quantity flex.	Approx. quantity-price elast.	Income coeff.	Price-income flexib.	Adj R-sq	D-W*	Ot
1	LPSE=f(LQSE,MQ,DPI92)	43.281601 (2.182)	-0.002101 (-1.527)	-0.118590	-8.432386	0.019665 (5.046)	0.012991	0.7148	1.457	
2	LPSE=f(LQSE,MP,DPI92)	46.781927 (2.249)	-0.002553 (-1.795)	-0.144103	-6.939460	0.016971 (5.348)	0.011211	0.7006	1.345	
3	LPSE=f(CONS,DPI92)	36.337776 (3.867)	-0.001638 (-2.244)	-0.121325	-8.242322	0.020842 (8.314)	0.013769	0.7248	1.467	

	Quantity dependent models		Price coeff.	Approx. price-quantity flex.	Quantity-price elast.	Income coeff.	Income elasticity	Adj R-sq	D-W	Ot
4	CONS=f(LPSE,DPI92)	5855.830 (2.903)	-105.858 (-2.244)	-0.699702	-1.429179	3.337783 (3.166)	1.680346	0.2469	0.972	

Means of annual variable used in models, 27 observations for 1972-98

MQ	MP	SQ	SP	CONS	LQSE
1860.71	77.8828	na	na	7819.91	5959.21
LPSE	DPI92				
105.576	3936.79				

*Note: except for equation 4, the Durbin-Watson test is inconclusive.
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Table 7.--Estimated consumer and producer surplus using 1993-97 means for variables (a):
option: base for this model

Month	Variable	Coeffi-cient (a)	Means for 60 obs.	1993-97 means (5 obs. per month) (CONS not used in this model) LQSE	MQ	CONS	SQ
	LPSE	na	133.374				
	INTERCEPT	82.634066	na				
	LQSE	-0.036081	421.252				
	MQ	-0.000556	586.777				
	SQ	-0.005565	2002.71				
	DPI92	0.014112	4914.37				
Jan	D1	10.375594		718	1067	1785	2390
Feb	D2	20.443209		506	1458	1965	2110
Mar	D3	33.684962		354	943	1297	2531
Apr	D4	17.022013		379	430	810	2965
May	D5	9.876466		441	142	583	2897
Jun	D6	18.557651		157	132	289	2261
Jul	D7	-4.977988		601	98	698	1239
Aug	D8	-4.932345		386	126	513	776
Sep	D9	-2.743502		237	60	296	935
Oct	D10	-1.776801		315	293	607	1434
Nov	D11	-5.492161		412	933	1344	2101
Dec	na	0		550	1359	1909	2393

Month	Change in LQSE from 1993-97 average	Modeled LQSE (b), thousand pounds, round wt	Model estimate, LPSE (c), 1992 cents per pound	LQSE (d) thousand pounds, round wt	Model estimate, LPSE (c), 1992 cents per pound	Total exvessel revenue 1992$ (2x3)	Producer surplus, 1992$ (e) (6*0.08)	Consumer surplus, 1992$ (2-4)*(5-3)/2
Col-->	1	2	3	4	5	6	7	8
Jan	na	718	123	0	148	879,991	70,399	9,300
Feb	na	506	142	0	160	716,593	57,327	4,619
Mar	na	354	158	0	171	560,342	44,827	2,261
Apr	na	379	139	0	152	525,270	42,022	2,591
May	na	441	130	0	146	572,196	45,776	3,509
Jun	na	157	152	0	158	238,990	19,119	445
Jul	na	601	118	0	140	711,425	56,914	6,516
Aug	na	386	129	0	143	496,927	39,754	2,688
Sep	na	237	135	0	144	321,027	25,682	1,013
Oct	na	315	131	0	142	411,706	32,936	1,790
Nov	na	412	119	0	134	491,999	39,360	3,062
Dec	na	550	118	0	138	649,377	51,950	5,457
Total		5,056		0		6,575,841	526,067	43,252
Mean		421	130			547,987	43,839	3,604
Changes from base in total:		0				0	0	(0)
		0%				0%	0%	-0%

(a) Equation 9, Table 5, estimated using 1977-97 data (252 obs.).
(b) Landings (LQSE) @ 1993-97 means after adjustment for change from base.
(c) Estimated @ LQSE in preceding col.; 1993-97 means for other ind. variables.
(d) Near-zero value for LQSE (LQSE = 0.1 pound per month).
(e) 8% of total revenue (1/3 of net revenue, which averaged 24% of total revenue for federal- 1344 permit boats in 1997 with applicant qualitative indication of sales of mackerel & expected gear--Table 6c., Vondruska, 1997).

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Table 7.--Estimated consumer and producer surplus using 1993-97 means for variables (a): option: reduce landings by 400,000 pounds per year from base for this model

Month	Variable	Coeffi- cient (a)	Means for 60 obs.	LQSE	MQ	CONS	SQ
				1993-97 means (5 obs. per month) (CONS not used in this model)			
	LPSE	na	133.374				
	INTERCEPT	82.634066	na				
	LQSE	-0.036081	421.252				
	MQ	-0.000556	586.777				
	SQ	-0.005565	2002.71				
	DPI92	0.014112	4914.37				
Jan	D1	10.375594		718	1067	1785	2390
Feb	D2	20.443209		506	1458	1965	2110
Mar	D3	33.684962		354	943	1297	2531
Apr	D4	17.022013		379	430	810	2965
May	D5	9.876466		441	142	583	2897
Jun	D6	18.557651		157	132	289	2261
Jul	D7	-4.977988		601	98	698	1239
Aug	D8	-4.932345		386	126	513	776
Sep	D9	-2.743502		237	60	296	935
Oct	D10	-1.776801		315	293	607	1434
Nov	D11	-5.492161		412	933	1344	2101
Dec	na	0		550	1359	1909	2393

Month	Change in LQSE from 1993-97 average	Modeled LQSE (b), thousand pounds, round wt	Model estimate, LPSE (c), 1992 cents per pound	LQSE (d) thousand pounds, round wt	Model estimate, LPSE (c), 1992 cents per pound	Total exvessel revenue 1992$ (2x3)	Producer surplus, 1992$ (e) (6*0.08)	Consumer surplus, 1992$ (2-4)*(5-3)/2
Col-->	1	2	3	4	5	6	7	8
Jan	-100	618	126	0	148	779,728	62,378	6,890
Feb	-100	406	145	0	160	589,622	47,170	2,974
Mar	-100	254	162	0	171	411,218	32,897	1,164
Apr		379	139	0	152	525,270	42,022	2,591
May		441	130	0	146	572,196	45,776	3,509
Jun		157	152	0	158	238,990	19,119	445
Jul		601	118	0	140	711,425	56,914	6,516
Aug		386	129	0	143	496,927	39,754	2,688
Sep		237	135	0	144	321,027	25,682	1,013
Oct		315	131	0	142	411,706	32,936	1,790
Nov		412	119	0	134	491,999	39,360	3,062
Dec	-100	450	122	0	138	547,545	43,804	3,653
Total		4,656		0		6,097,651	487,812	36,295
Mean		388	131			508,138	40,651	3,025
Changes from base in total:		-400 -8%				-478190 -7%	-38255 -7%	-6957 -16%

(a) Equation 9, Table 5, estimated using 1977-97 data (252 obs.).
(b) Landings (LQSE) @ 1993-97 means after adjustment for change from base.
(c) Estimated @ LQSE in preceding col.; 1993-97 means for other ind. variables.
(d) Near-zero value for LQSE (LQSE = 0.1 pound per month).
(e) 8% of total revenue (1/3 of net revenue, which averaged 24% of total revenue for 1344 federal permit boats in 1997 with applicant qualitative indication of sales of mackerel & expected gear--Table 6c., Vondruska, 1997).

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Table 7.--Estimated consumer and producer surplus using 1993-97 means for variables (a):
option: decrease landings by 400,000 pounds per year from base for this model

Month	Variable	Coeffi-cient (a)	Means for 60 obs.	1993-97 means (5 obs. per month) (CONS not used in this model) LQSE	MQ	CONS	SQ
	LPSE	na	133.374				
	INTERCEPT	82.634066	na				
	LQSE	-0.036081	421.252				
	MQ	-0.000556	586.777				
	SQ	-0.005565	2002.71				
	DPI92	0.014112	4914.37				
Jan	D1	10.375594		718	1067	1785	2390
Feb	D2	20.443209		506	1458	1965	2110
Mar	D3	33.684962		354	943	1297	2531
Apr	D4	17.022013		379	430	810	2965
May	D5	9.876466		441	142	583	2897
Jun	D6	18.557651		157	132	289	2261
Jul	D7	-4.977988		601	98	698	1239
Aug	D8	-4.932345		386	126	513	776
Sep	D9	-2.743502		237	60	296	935
Oct	D10	-1.776801		315	293	607	1434
Nov	D11	-5.492161		412	933	1344	2101
Dec	na	0		550	1359	1909	2393

Month	Change in LQSE from 1993-97 average	Modeled LQSE (b), thousand pounds, round wt	Model estimate, LPSE (c), 1992 cents per pound	LQSE (d) thousand pounds, round wt	Model estimate, LPSE (c), 1992 cents per pound	Total exvessel revenue 1992$ (2x3)	Producer surplus, 1992$ (e) (6*0.08)	Consumer surplus, 1992$ (2-4)*(5-3)/2
Col-->	1	2	3	4	5	6	7	8
Jan		718	123	0	148	879,991	70,399	9,300
Feb		506	142	0	160	716,593	57,327	4,619
Mar		354	158	0	171	560,342	44,827	2,261
Apr		379	139	0	152	525,270	42,022	2,591
May		441	130	0	146	572,196	45,776	3,509
Jun		157	152	0	158	238,990	19,119	445
Jul	-200	401	126	0	140	503,615	40,289	2,901
Aug	-200	186	136	0	143	252,874	20,230	624
Sep		237	135	0	144	321,027	25,682	1,013
Oct		315	131	0	142	411,706	32,936	1,790
Nov		412	119	0	134	491,999	39,360	3,062
Dec		550	118	0	138	649,377	51,950	5,457
Total		4,656		0		6,123,978	489,918	37,573
Mean		388	132			510,332	40,827	3,131
Changes from base in total:		-400 -8%				-451863 -7%	-36149 -7%	-5679 -13%

(a) Equation 9, Table 5, estimated using 1977-97 data (252 obs.).
(b) Landings (LQSE) @ 1993-97 means after adjustment for change from base.
(c) Estimated @ LQSE in preceding col.; 1993-97 means for other ind. variables.
(d) Near-zero value for LQSE (LQSE = 0.1 pound per month).
(e) 8% of total revenue (1/3 of net revenue, which averaged 24% of total revenue for 1344 federal permit boats in 1997 with applicant qualitative indication of sales of mackerel & expected gear--Table 6c., Vondruska, 1997).

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Table 7.--Estimated consumer and producer surplus using 1993-97 means for variables (a):
option: reduce landings by 400,000 pounds per year from base for this model

Month	Variable	Coeffi- cient (a)	Means for 60 obs.	1993-97 means (5 obs. per month) (CONS not used in this model) LQSE	MQ	CONS	SQ
	LPSE	na	133.374				
	INTERCEPT	82.634066	na				
	LQSE	-0.036081	421.252				
	MQ	-0.000556	586.777				
	SQ	-0.005565	2002.71				
	DPI92	0.014112	4914.37				
Jan	D1	10.375594		718	1067	1785	2390
Feb	D2	20.443209		506	1458	1965	2110
Mar	D3	33.684962		354	943	1297	2531
Apr	D4	17.022013		379	430	810	2965
May	D5	9.876466		441	142	583	2897
Jun	D6	18.557651		157	132	289	2261
Jul	D7	-4.977988		601	98	698	1239
Aug	D8	-4.932345		386	126	513	776
Sep	D9	-2.743502		237	60	296	935
Oct	D10	-1.776801		315	293	607	1434
Nov	D11	-5.492161		412	933	1344	2101
Dec	na	0		550	1359	1909	2393

Month	Change in LQSE from 1993-97 average	Modeled LQSE (b), thousand pounds, round wt	Model estimate, LPSE (c), 1992 cents per pound	LQSE (d) thousand pounds, round wt	Model estimate, LPSE (c), 1992 cents per pound	Total exvessel revenue 1992$ (2x3)	Producer surplus, 1992$ (e) (6*0.08)	Consumer surplus, 1992$ (2-4)*(5-3)/2
Col-->	1	2	3	4	5	6	7	8
Jan	-33	685	124	0	148	847,372	67,790	8,457
Feb	-33	473	143	0	160	675,071	54,006	4,030
Mar	-33	321	159	0	171	511,436	40,915	1,855
Apr	-33	346	140	0	152	483,229	38,658	2,156
May	-33	408	131	0	146	533,849	42,708	2,998
Jun	-33	124	153	0	158	189,736	15,179	276
Jul	-33	568	120	0	140	678,794	54,304	5,813
Aug	-33	353	130	0	143	458,256	36,660	2,244
Sep	-33	204	137	0	144	278,325	22,266	748
Oct	-33	282	132	0	142	371,527	29,722	1,431
Nov	-33	379	121	0	134	456,748	36,540	2,587
Dec	-33	517	119	0	138	616,234	49,299	4,816
Total		4,656		0		6,100,577	488,046	37,411
Mean		388	131			508,381	40,671	3,118
Changes from base in total:		-400				-475264	-38021	-5841
		-8%				-7%	-7%	-14%

(a) Equation 9, Table 5, estimated using 1977-97 data (252 obs.).
(b) Landings (LQSE) @ 1993-97 means after adjustment for change from base.
(c) Estimated @ LQSE in preceding col.; 1993-97 means for other ind. variables.
(d) Near-zero value for LQSE (LQSE = 0.1 pound per month).
(e) 8% of total revenue (1/3 of net revenue, which averaged 24% of total revenue for 1344 federal permit boats in 1997 with applicant qualitative indication of sales of mackerel & expected gear--Table 6c., Vondruska, 1997).

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Table 7.--Estimated consumer and producer surplus using 1993-97 means for variables (a): option: reduce landings by 400,000 pounds per year from base for this model

Month	Variable	Coeffi- cient (a)	Means for 60 obs.	LQSE	MQ	CONS	SQ
	LPSE	na	133.374				
	INTERCEPT	82.634066	na	1993-97 means (5 obs. per month) (CONS not used in this model)			
	LQSE	-0.036081	421.252				
	MQ	-0.000556	586.777				
	SQ	-0.005565	2002.71				
	DPI92	0.014112	4914.37				
Jan	D1	10.375594		718	1067	1785	2390
Feb	D2	20.443209		506	1458	1965	2110
Mar	D3	33.684962		354	943	1297	2531
Apr	D4	17.022013		379	430	810	2965
May	D5	9.876466		441	142	583	2897
Jun	D6	18.557651		157	132	289	2261
Jul	D7	-4.977988		601	98	698	1239
Aug	D8	-4.932345		386	126	513	776
Sep	D9	-2.743502		237	60	296	935
Oct	D10	-1.776801		315	293	607	1434
Nov	D11	-5.492161		412	933	1344	2101
Dec	na	0		550	1359	1909	2393

Month	Change in LQSE from 1993-97 average	Modeled LQSE (b), thousand pounds, round wt	Model estimate, LPSE (c), 1992 cents per pound	LQSE (d) thousand pounds, round wt	Model estimate, LPSE (c), 1992 cents per pound	Total exvessel revenue 1992$ (2x3)	Producer surplus, 1992$ (e) (6*0.08)	Consumer surplus, 1992$ (2-4)*(5-3)/2
Col-->	1	2	3	4	5	6	7	8
Jan	-120	598	127	0	148	758,809	60,705	6,451
Feb	na	506	142	0	160	716,593	57,327	4,619
Mar	na	354	158	0	171	560,342	44,827	2,261
Apr	na	379	139	0	152	525,270	42,022	2,591
May	na	441	130	0	146	572,196	45,776	3,509
Jun	na	157	152	0	158	238,990	19,119	445
Jul	na	601	118	0	140	711,425	56,914	6,516
Aug	na	386	129	0	143	496,927	39,754	2,688
Sep	na	237	135	0	144	321,027	25,682	1,013
Oct	na	315	131	0	142	411,706	32,936	1,790
Nov	na	412	119	0	134	491,999	39,360	3,062
Dec	na	550	118	0	138	649,377	51,950	5,457
Total		4,936		0		6,454,659	516,373	40,403
Mean		411	131			537,888	43,031	3,367
Changes from base in total:		-120 -2%				-121182 -2%	-9694 -2%	-2849 -7%

(a) Equation 9, Table 5, estimated using 1977-97 data (252 obs.).
(b) Landings (LQSE) @ 1993-97 means after adjustment for change from base.
(c) Estimated @ LQSE in preceding col.; 1993-97 means for other ind. variables.
(d) Near-zero value for LQSE (LQSE = 0.1 pound per month).
(e) 8% of total revenue (1/3 of net revenue, which averaged 24% of total revenue for 1344 federal permit boats in 1997 with applicant qualitative indication of sales of mackerel & expected gear--Table 6c., Vondruska, 1997).

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Table 8.--Estimated consumer and producer surplus using 1993-97 means for variables (a): option: base for this model

Month	Variable	Coeffi-cient (a)	Means for 60 obs.	1993-97 means (5 obs. per month) (CONS not used in this model) LQSE	MP	CONS	SP
	LPSE	na	133.374				
	INTERCEPT	44.179847	na				
	LQSE	na	421.252				
	MP	0.011064	61.0158				
	SP	0.104890	2002.71				
	DPI92	0.018656	4914.37				
Jan	LQSE1	-0.038985		718	59	1785	229
Feb	LQSE2	-0.032442		506	59	1965	234
Mar	LQSE3	-0.025285		354	61	1297	216
Apr	LQSE4	-0.048205		379	60	810	198
May	LQSE5	-0.051641		441	66	583	195
Jun	LQSE6	-0.023793		157	61	289	197
Jul	LQSE7	-0.085280		601	59	698	217
Aug	LQSE8	-0.071196		386	50	513	232
Sep	LQSE9	-0.085443		237	76	296	208
Oct	LQSE10	-0.072105		315	59	607	204
Nov	LQSE11	-0.082507		412	64	1344	223
Dec	LQSE12	-0.053634		550	59	1909	244

Month	Change in LQSE from 1993-97 average	Modeled LQSE (b), thousand pounds, round wt	Model estimate, LPSE (c), 1992 cents per pound	LQSE (d) thousand pounds, round wt	Model estimate, LPSE (c), 1992 cents per pound	Total exvessel revenue 1992$ (2x3)	Producer surplus, 1992$ (e) (6*0.08)	Consumer surplus, 1992$ (2-4)*(5-3)/2
Col-->	1	2	3	4	5	6	7	8
Jan	na	718	133	0	161	951,664	76,133	10,049
Feb	na	506	145	0	161	731,897	58,552	4,153
Mar	na	354	150	0	159	531,859	42,549	1,584
Apr	na	379	139	0	157	526,904	42,152	3,462
May	na	441	134	0	157	592,141	47,371	5,022
Jun	na	157	153	0	157	240,940	19,275	293
Jul	na	601	108	0	159	649,218	51,937	15,402
Aug	na	386	133	0	161	514,416	41,153	5,304
Sep	na	237	138	0	159	327,701	26,216	2,400
Oct	na	315	135	0	158	425,879	34,070	3,577
Nov	na	412	126	0	160	518,988	41,519	7,003
Dec	na	550	133	0	162	729,353	58,348	8,112
Total		5,056		0		6,740,959	539,277	66,360
Mean		421	133			561,747	44,940	5,530
Changes from base in total:		0 0%				(0) -0%	(0) -0%	0 0%

(a) Equation 17, estimated using 1977-97 data (252 obs.).
(b) Landings (LQSE) @ 1993-97 means after adjustment for change from base.
(c) Estimated @ LQSE in preceding col.; 1993-97 means for other ind. variables.
(d) Near-zero value for LQSE (LQSE = 0.1 pound per month).
(e) 8% of total revenue (1/3 of net revenue, which averaged 24% of total revenue for federal- 1344 permit boats in 1997 with applicant qualitative indication of sales of mackerel & expected gear--Table 6c., Vondruska, 1997).

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Table 8.--Estimated consumer and producer surplus using 1993-97 means for variables (a): option: increase landings by 400,000 pounds per year from base for this model

Month	Variable	Coeffi- cient (a)	Means for 60 obs.	1993-97 means (5 obs. per month) (CONS not used in this model) LQSE	MP	CONS	SP
	LPSE	na	133.374				
	INTERCEPT	44.179847	na				
	LQSE	na	421.252				
	MP	0.011064	61.0158				
	SP	0.104890	2002.71				
	DPI92	0.018656	4914.37				
Jan	LQSE1	-0.038985		718	59	1785	229
Feb	LQSE2	-0.032442		506	59	1965	234
Mar	LQSE3	-0.025285		354	61	1297	216
Apr	LQSE4	-0.048205		379	60	810	198
May	LQSE5	-0.051641		441	66	583	195
Jun	LQSE6	-0.023793		157	61	289	197
Jul	LQSE7	-0.085280		601	59	698	217
Aug	LQSE8	-0.071196		386	50	513	232
Sep	LQSE9	-0.085443		237	76	296	208
Oct	LQSE10	-0.072105		315	59	607	204
Nov	LQSE11	-0.082507		412	64	1344	223
Dec	LQSE12	-0.053634		550	59	1909	244

Month	Change in LQSE from 1993-97 average	Modeled LQSE (b), thousand pounds, round wt	Model estimate, LPSE (c), 1992 cents per pound	LQSE (d) thousand pounds, round wt	Model estimate, LPSE (c), 1992 cents per pound	Total exvessel revenue 1992$ (2x3)	Producer surplus, 1992$ (e) (6*0.08)	Consumer surplus, 1992$ (2-4)*(5-3)/2
Col-->	1	2	3	4	5	6	7	8
Jan	100	818	129	0	161	1,052,318	84,185	13,043
Feb	100	606	141	0	161	856,881	68,550	5,957
Mar	100	454	148	0	159	670,622	53,650	2,606
Apr	na	379	139	0	157	526,904	42,152	3,462
May	na	441	134	0	157	592,141	47,371	5,022
Jun	na	157	153	0	157	240,940	19,275	293
Jul	na	601	108	0	159	649,218	51,937	15,402
Aug	na	386	133	0	161	514,416	41,153	5,304
Sep	na	237	138	0	159	327,701	26,216	2,400
Oct	na	315	135	0	158	425,879	34,070	3,577
Nov	na	412	126	0	160	518,988	41,519	7,003
Dec	100	650	127	0	162	827,100	66,168	11,330
Total		5,456		0		7,203,107	576,249	75,398
Mean		455	132			600,259	48,021	6,283
Changes from base in total:		400 8%				462,148 7%	36,972 7%	9,038 14%

(a) Equation 17, estimated using 1977-97 data (252 obs.).
(b) Landings (LQSE) @ 1993-97 means after adjustment for change from base.
(c) Estimated @ LQSE in preceding col.; 1993-97 means for other ind. variables.
(d) Near-zero value for LQSE (LQSE = 0.1 pound per month).
(e) 8% of total revenue (1/3 of net revenue, which averaged 24% of total revenue for federal- 1344 permit boats in 1997 with applicant qualitative indication of sales of mackerel & expected gear--Table 6c., Vondruska, 1997).

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Table 8.--Estimated consumer and producer surplus using 1993-97 means for variables (a): option: reduce landings by 400,000 pounds per year from base for this model

Month	Variable	Coefficient (a)	Means for 60 obs.	1993-97 means (5 obs. per month) (CONS not used in this model) LQSE	MP	CONS	SP
	LPSE	na	133.374				
	INTERCEPT	44.179847	na				
	LQSE	na	421.252				
	MP	0.011064	61.0158				
	SP	0.104890	2002.71				
	DPI92	0.018656	4914.37				
Jan	LQSE1	-0.038985		718	59	1785	229
Feb	LQSE2	-0.032442		506	59	1965	234
Mar	LQSE3	-0.025285		354	61	1297	216
Apr	LQSE4	-0.048205		379	60	810	198
May	LQSE5	-0.051641		441	66	583	195
Jun	LQSE6	-0.023793		157	61	289	197
Jul	LQSE7	-0.085280		601	59	698	217
Aug	LQSE8	-0.071196		386	50	513	232
Sep	LQSE9	-0.085443		237	76	296	208
Oct	LQSE10	-0.072105		315	59	607	204
Nov	LQSE11	-0.082507		412	64	1344	223
Dec	LQSE12	-0.053634		550	59	1909	244

Month	Change in LQSE from 1993-97 average	Modeled LQSE (b), thousand pounds, round wt	Model estimate, LPSE (c), 1992 cents per pound	LQSE (d) thousand pounds, round wt	Model estimate, LPSE (c), 1992 cents per pound	Total exvessel revenue 1992$ (2x3)	Producer surplus, 1992$ (e) (6*0.08)	Consumer surplus, 1992$ (2-4)*(5-3)/2
Col-->	1	2	3	4	5	6	7	8
Jan	-33	685	134	0	161	916,380	73,310	9,137
Feb	-33	473	146	0	161	688,794	55,104	3,624
Mar	-33	321	151	0	159	484,481	38,758	1,300
Apr	-33	346	141	0	157	486,116	38,889	2,880
May	-33	408	136	0	157	554,401	44,352	4,291
Jun	-33	124	154	0	157	190,766	15,261	182
Jul	-33	568	111	0	159	629,347	50,348	13,741
Aug	-33	353	136	0	161	478,363	38,269	4,427
Sep	-33	204	141	0	159	287,411	22,993	1,772
Oct	-33	282	138	0	158	387,582	31,007	2,860
Nov	-33	379	129	0	160	487,413	38,993	5,915
Dec	-33	517	134	0	162	694,386	55,551	7,159
Total		4,656		0		6,285,440	502,835	57,289
Mean		388	135			523,787	41,903	4,774
Changes from base in total:		-400				-455519	-36442	-9071
		-8%				-7%	-7%	-14%

(a) Equation 17, estimated using 1977-97 data (252 obs.).
(b) Landings (LQSE) @ 1993-97 means after adjustment for change from base.
(c) Estimated @ LQSE in preceding col.; 1993-97 means for other ind. variables.
(d) Near-zero value for LQSE (LQSE = 0.1 pound per month).
(e) 8% of total revenue (1/3 of net revenue, which averaged 24% of total revenue for federal- 1344 permit boats in 1997 with applicant qualitative indication of sales of mackerel & expected gear--Table 6c., Vondruska, 1997).

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Table 8.--Estimated consumer and producer surplus using 1993-97 means for variables (a): option: reduce landings by 400,000 pounds per year from base for this model

Month	Variable	Coefficient (a)	Means for 60 obs.	1993-97 means (5 obs. per month) (CONS not used in this model)			
				LQSE	MP	CONS	SP
	LPSE	na	133.374				
	INTERCEPT	44.179847	na				
	LQSE	na	421.252				
	MP	0.011064	61.0158				
	SP	0.104890	2002.71				
	DPI92	0.018656	4914.37				
Jan	LQSE1	-0.038985		718	59	1785	229
Feb	LQSE2	-0.032442		506	59	1965	234
Mar	LQSE3	-0.025285		354	61	1297	216
Apr	LQSE4	-0.048205		379	60	810	198
May	LQSE5	-0.051641		441	66	583	195
Jun	LQSE6	-0.023793		157	61	289	197
Jul	LQSE7	-0.085280		601	59	698	217
Aug	LQSE8	-0.071196		386	50	513	232
Sep	LQSE9	-0.085443		237	76	296	208
Oct	LQSE10	-0.072105		315	59	607	204
Nov	LQSE11	-0.082507		412	64	1344	223
Dec	LQSE12	-0.053634		550	59	1909	244

Month	Change in LQSE from 1993-97 average	Modeled LQSE (b), thousand pounds, round wt	Model estimate, LPSE (c), 1992 cents per pound	LQSE (d) thousand pounds, round wt	Model estimate, LPSE (c), 1992 cents per pound	Total exvessel revenue 1992$ (2x3)	Producer surplus, 1992$ (e) (6*0.08)	Consumer surplus, 1992$ (2-4)*(5-3)/2
Col-->	1	2	3	4	≈ 5	6	7	8
Jan	na	718	133	0	161	951,664	76,133	10,049
Feb	-100	406	148	0	161	600,425	48,034	2,674
Mar	-300	54	158	0	159	85,227	6,818	37
Apr	na	379	139	0	157	526,904	42,152	3,462
May	na	441	134	0	157	592,141	47,371	5,022
Jun	na	157	153	0	157	240,940	19,275	293
Jul	na	601	108	0	159	649,218	51,937	15,402
Aug	na	386	133	0	161	514,416	41,153	5,304
Sep	na	237	138	0	159	327,701	26,216	2,400
Oct	na	315	135	0	158	425,879	34,070	3,577
Nov	na	412	126	0	160	518,988	41,519	7,003
Dec	na	550	133	0	162	729,353	58,348	8,112
Total		4,656		0		6,162,855	493,028	63,334
Mean		388	132			513,571	41,086	5,278
Changes from base in total:		-400 -8%				-578104 -9%	-46249 -9%	-3026 -5%

(a) Equation 17, estimated using 1977-97 data (252 obs.).
(b) Landings (LQSE) @ 1993-97 means after adjustment for change from base.
(c) Estimated @ LQSE in preceding col.; 1993-97 means for other ind. variables.
(d) Near-zero value for LQSE (LQSE = 0.1 pound per month).
(e) 8% of total revenue (1/3 of net revenue, which averaged 24% of total revenue for federal- 1344 permit boats in 1997 with applicant qualitative indication of sales of mackerel & expected gear--Table 6c., Vondruska, 1997).

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Table 8.--Estimated consumer and producer surplus using 1993-97 means for variables (a):
option: reduce landings by 120,000 pounds per year from base for this model

Month	Variable	Coeffi- cient (a)	Means for 60 obs.	LQSE	MP	CONS	SP
				1993-97 means (5 obs. per month) (CONS not used in this model)			
	LPSE	na	133.374				
	INTERCEPT	44.179847	na				
	LQSE	na	421.252				
	MP	0.011064	61.0158				
	SP	0.104890	2002.71				
	DPI92	0.018656	4914.37				
Jan	LQSE1	-0.038985		718	59	1785	229
Feb	LQSE2	-0.032442		506	59	1965	234
Mar	LQSE3	-0.025285		354	61	1297	216
Apr	LQSE4	-0.048205		379	60	810	198
May	LQSE5	-0.051641		441	66	583	195
Jun	LQSE6	-0.023793		157	61	289	197
Jul	LQSE7	-0.085280		601	59	698	217
Aug	LQSE8	-0.071196		386	50	513	232
Sep	LQSE9	-0.085443		237	76	296	208
Oct	LQSE10	-0.072105		315	59	607	204
Nov	LQSE11	-0.082507		412	64	1344	223
Dec	LQSE12	-0.053634		550	59	1909	244

Month	Change in LQSE from 1993-97 average	Modeled LQSE (b), thousand pounds, round wt	Model estimate, LPSE (c), 1992 cents per pound	LQSE (d) thousand pounds, round wt	Model estimate, LPSE (c), 1992 cents per pound	Total exvessel revenue 1992$ (2x3)	Producer surplus, 1992$ (e) (6*0.08)	Consumer surplus, 1992$ (2-4)*(5-3)/2
Col-->	1	2	3	4	5	6	7	8
Jan	-120	598	137	0	161	820,587	65,647	6,971
Feb	na	506	145	0	161	731,897	58,552	4,153
Mar	na	354	150	0	159	531,859	42,549	1,584
Apr	na	379	139	0	157	526,904	42,152	3,462
May	na	441	134	0	157	592,141	47,371	5,022
Jun	na	157	153	0	157	240,940	19,275	293
Jul	na	601	108	0	159	649,218	51,937	15,402
Aug	na	386	133	0	161	514,416	41,153	5,304
Sep	na	237	138	0	159	327,701	26,216	2,400
Oct	na	315	135	0	158	425,879	34,070	3,577
Nov	na	412	126	0	160	518,988	41,519	7,003
Dec	na	550	133	0	162	729,353	58,348	8,112
Total		4,936		0		6,609,882	528,791	63,282
Mean		411	134			550,824	44,066	5,274
Changes from base in total:		(120)				(131,077)	(10,486)	(3,078)
		-2%				-2%	-2%	-5%

(a) Equation 17, estimated using 1977-97 data (252 obs.).
(b) Landings (LQSE) @ 1993-97 means after adjustment for change from base.
(c) Estimated @ LQSE in preceding col.; 1993-97 means for other ind. variables.
(d) Near-zero value for LQSE (LQSE = 0.1 pound per month).
(e) 8% of total revenue (1/3 of net revenue, which averaged 24% of total revenue for federal- 1344 permit boats in 1997 with applicant qualitative indication of sales of mackerel & expected gear--Table 6c., Vondruska, 1997).

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Table 9.--Estimated consumer and producer surplus using 1993-97 means for variables (a): option: base for this model

Month	Variable	Coeffi-cient (a)	Means for 60 obs.	1993-97 means (5 obs. per month) (SQ not used in this model)			
				LQSE	MQ	CONS	SQ
	LPSE	-7.215396	133.374				
	INTERCEPT	578.131701	na				
	LQSE	na	421.252				
	MQ	na	586.777				
	CONS	na	1008.03				
	DPI92	0.315321	4914.37				
Jan	D1	43.010841		718	1067	1785	2390
Feb	D2	192.350157		506	1458	1965	2110
Mar	D3	29.092810		354	943	1297	2531
Apr	D4	-456.975328		379	430	810	2965
May	D5	-468.666128		441	142	583	2897
Jun	D6	-627.748695		157	132	289	2261
Jul	D7	-636.571842		601	98	698	1239
Aug	D8	-567.301277		386	126	513	776
Sep	D9	-698.532935		237	60	296	935
Oct	D10	-591.989294		315	293	607	1434
Nov	D11	-431.331046		412	933	1344	2101
Dec	na	0.		550	1359	1909	2393

Month	Change in LQSE from 1993-97 average	Modeled CONS (b), thousand pounds, round wt	Model estimate, LPSE (c), 1992 cents per pound	CONS (d) thousand pounds, round wt	Model estimate, LPSE (c), 1992 cents per pound	Total exvessel revenue 1992$	Producer surplus, 1992$ (e) (6*0.08)	Consumer surplus, 1992$ (2-4)*(5-3)/2
Col-->	1	2	3	4	5	6	7	8
Jan	na	1785	53	0	301	383,854	30,708	220,793
Feb	na	1965	49	0	322	249,014	19,921	267,568
Mar	na	1297	119	0	299	421,847	33,748	116,571
Apr	na	810	119	0	232	452,128	36,170	45,465
May	na	583	149	0	230	657,686	52,615	23,553
Jun	na	289	168	0	208	263,499	21,080	5,788
Jul	na	698	110	0	207	660,659	52,853	33,761
Aug	na	513	145	0	216	560,343	44,827	18,237
Sep	na	296	157	0	198	372,217	29,777	6,071
Oct	na	607	129	0	213	405,460	32,437	25,532
Nov	na	1344	49	0	235	201,224	16,098	125,172
Dec	na	1909	30	0	295	166,733	13,339	252,535
Total	0	12,096		0		4,794,664	383,573	1,141,048
Mean		1,008	40			399,555	31,964	95,087
Changes from base in total:	0	0				-0	0	-0
	0%	0%				-0%	0%	-0%

(a) Equation 11, estimated using 1977-97 data (252 obs.).
(b) Consumption (CONS) @ 1993-97 means after adjustment for change in LQSE from base.
(c) Estimated @ CONS in preceding col.; 1993-97 means for other ind. variables.
(d) Near-zero value for CONS (CONS = 0.1 pound per month).
(e) 8% of total revenue (1/3 of net revenue, which averaged 24% of total revenue for 1344 federal permit boats in 1997 with applicant qualitative indication of sales of mackerel & expected gear--Table 6c, Vondruska, 1997).

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Table 9.--Estimated consumer and producer surplus using 1993-97 means for variables (a): option: reduce landings by 400,000 pounds per year from base for this model

Month	Variable	Coeffi- cient (a)	Means for 60 obs.	1993-97 means (5 obs. per month) (SQ not used in this model)			
				LQSE	MQ	CONS	SQ
	LPSE	-7.215396	133.374				
	INTERCEPT	578.131701	na				
	LQSE	na	421.252				
	MQ	na	586.777				
	CONS	na	1008.03				
	DPI92	0.315321	4914.37				
Jan	D1	43.010841		718	1067	1785	2390
Feb	D2	192.350157		506	1458	1965	2110
Mar	D3	29.092810		354	943	1297	2531
Apr	D4	-456.975328		379	430	810	2965
May	D5	-468.666128		441	142	583	2897
Jun	D6	-627.748695		157	132	289	2261
Jul	D7	-636.571842		601	98	698	1239
Aug	D8	-567.301277		386	126	513	776
Sep	D9	-698.532935		237	60	296	935
Oct	D10	-591.989294		315	293	607	1434
Nov	D11	-431.331046		412	933	1344	2101
Dec	na	0		550	1359	1909	2393

Month	Change in LQSE from 1993-97 average	Modeled CONS (b), thousand pounds, round wt	Model estimate, LPSE (c), 1992 cents per pound	CONS (d) thousand pounds, round wt	Model estimate, LPSE (c), 1992 cents per pound	Total exvessel revenue 1992$	Producer surplus, 1992$ (e) (6*0.08)	Consumer surplus, 1992$ (2-4)*(5-3)/2
Col-->	1	2	3	4	5	6	7	8
Jan	-100	1685	67	0	301	416,043	33,283	196,748
Feb	-100	1865	63	0	322	256,070	20,486	241,028
Mar	-100	1197	133	0	299	337,884	27,031	99,288
Apr	na	810	119	0	232	452,128	36,170	45,465
May	na	583	149	0	230	657,686	52,615	23,553
Jun	na	289	168	0	208	263,499	21,080	5,788
Jul	na	698	110	0	207	660,659	52,853	33,761
Aug	na	513	145	0	216	560,343	44,827	18,237
Sep	na	296	157	0	198	372,217	29,777	6,071
Oct	na	607	129	0	213	405,460	32,437	25,532
Nov	na	1344	49	0	235	201,224	16,098	125,172
Dec	-100	1809	44	0	295	198,785	15,903	226,771
Total	-400	11,696		0		4,781,997	382,560	1,047,415
Mean		975	41			398,500	31,880	87,285
Changes from base in total:	-400	-400				-12667	-1013	-93633
	-8%	-3%				-0%	-0%	-8%

(a) Equation 11, estimated using 1977-97 data (252 obs.).
(b) Consumption (CONS) @ 1993-97 means after adjustment for change in LQSE from base.
(c) Estimated @ CONS in preceding col.; 1993-97 means for other ind. variables.
(d) Near-zero value for CONS (CONS = 0.1 pound per month).
(e) 8% of total revenue (1/3 of net revenue, which averaged 24% of total revenue for 1344 federal permit boats in 1997 with applicant qualitative indication of sales of mackerel & expected gear--Table 6c, Vondruska, 1997).

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Table 9.--Estimated consumer and producer surplus using 1993-97 means for variables (a):
option: increase landings by 400,000 pounds per year from base for this model

Month	Variable	Coeffi-cient (a)	Means for 60 obs.				
	LPSE	-7.215396	133.374				
	INTERCEPT	578.131701	na	1993-97 means (5 obs. per month) (SQ not used in this model)			
	LQSE	na	421.252				
	MQ	na	586.777				
	CONS	na	1008.03	LQSE	MQ	CONS	SQ
	DPI92	0.315321	4914.37				
Jan	D1	43.010841		718	1067	1785	2390
Feb	D2	192.350157		506	1458	1965	2110
Mar	D3	29.092810		354	943	1297	2531
Apr	D4	-456.975328		379	430	810	2965
May	D5	-468.666128		441	142	583	2897
Jun	D6	-627.748695		157	132	289	2261
Jul	D7	-636.571842		601	98	698	1239
Aug	D8	-567.301277		386	126	513	776
Sep	D9	-698.532935		237	60	296	935
Oct	D10	-591.989294		315	293	607	1434
Nov	D11	-431.331046		412	933	1344	2101
Dec	na	0		550	1359	1909	2393

Month	Change in LQSE from 1993-97 average	Modeled CONS (b), thousand pounds, round wt	Model estimate, LPSE (c), 1992 cents per pound	CONS (d) thousand pounds, round wt	Model estimate, LPSE (c), 1992 cents per pound	Total exvessel revenue 1992$	Producer surplus, 1992$ (e) (6*0.08)	Consumer surplus, 1992$ (2-4)*(5-3)/2
Col-->	1	2	3	4	5	6	7	8
Jan	100	1885	40	0	301	323,947	25,916	246,225
Feb	100	2065	35	0	322	214,239	17,139	295,495
Mar	100	1397	105	0	299	478,092	38,247	135,239
Apr	na	810	119	0	232	452,128	36,170	45,465
May	na	583	149	0	230	657,686	52,615	23,553
Jun	na	289	168	0	208	263,499	21,080	5,788
Jul	na	698	110	0	207	660,659	52,853	33,761
Aug	na	513	145	0	216	560,343	44,827	18,237
Sep	na	296	157	0	198	372,217	29,777	6,071
Oct	na	607	129	0	213	405,460	32,437	25,532
Nov	na	1344	49	0	235	201,224	16,098	125,172
Dec	100	2009	16	0	295	106,963	8,557	279,685
Total	400	12,496		0		4,696,456	375,717	1,240,224
Mean		1,041	38			391,371	31,310	103,352
Changes from base in total:	400 8%	400 3%				-98208 -2%	-7856 -2%	99176 9%

(a) Equation 11, estimated using 1977-97 data (252 obs.).
(b) Consumption (CONS) @ 1993-97 means after adjustment for change in LQSE from base.
(c) Estimated @ CONS in preceding col.; 1993-97 means for other ind. variables.
(d) Near-zero value for CONS (CONS = 0.1 pound per month).
(e) 8% of total revenue (1/3 of net revenue, which averaged 24% of total revenue for 1344 federal permit boats in 1997 with applicant qualitative indication of sales of mackerel & expected gear--Table 6c, Vondruska, 1997).

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Table 10.--Estimated consumer and producer surplus--annual demand model and 1993-97 means for variables (a)

Variable	LPSE	INTERCEPT	LQSE	MQ	DPI92
Coefficient (a)	na	43.281601	-0.002101	-0.001399	0.019665
Means, 1993-97	119.985	na	5,135.48	7,041.33	4,914.37

Option	Change in LQSE from 1993-97 average 1	Modeled LQSE (b), thousand pounds, round wt 2	Model estimate, LPSE (c), 1992 cents per pound 3	LQSE (d) thousand pounds, round wt 4	Model estimate, LPSE (c), 1992 cents per pound 5	Total exvessel revenue (2x3) 6	Producer surplus (e) (6*0.08) 7	Consumer surplus (2-4)*(5-3)/2 8
						- - - - thousand 1992$		- - - -
Base	na	5,135	119	0	130	6,126	490	28
1	-400	4,735	120	0	130	5,688	455	24
2	400	5,535	118	0	130	6,556	525	32
3	-1000	4,135	121	0	130	5,020	402	18
4	1000	6,135	117	0	130	7,190	575	40
5	-2000	3,135	123	0	130	3,872	310	10
6	2000	7,135	115	0	130	8,212	657	53

	Landings group (f) thousand pounds, round wt	- - - - - - Change from base in					- - - - - -
		Landings Gulf group	Landings NC-TX (LQSE)	Price NC-TX (LPSE)	Total revenue	Producer surplus	Consumer surplus
					- - - - thousand 1992$		- - - -
Base	2,826	0%	0%	0%	0	0	0
1	2,426	-14%	-8%	1%	-437	-35	-4
2	3,226	14%	8%	-1%	431	34	4
3	1,826	-35%	-19%	2%	-1106	-88	-10
4	3,826	35%	19%	-2%	1064	85	12
5	826	-71%	-39%	4%	-2254	-180	-17
6	4,826	71%	39%	-4%	2086	167	26

(a) Equation 1, Table 6, estimated using 1972-98 annual data (27 obs.).
(b) Landings (LQSE) @ 1993-97 means after adjustment for change from base.
(c) Estimated @ LQSE in preceding col.; 1993-97 means for other ind. variables.
(d) Near-zero value for LQSE (LQSE = 0.1 pound per year).
(e) 8% of total revenue (1/3 of net revenue, which averaged 24% of total revenue for 1344 federally-permit boats in 1997 with applicant qualitative indication of sales of mackerel & expected gear--Table 6c., Vondruska, 1997).
(f) Average landings for Gulf group in fishing years 1993/94 to 1997/98.

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Table 11.--Estimated consumer and producer surplus--annual demand model and 1993-97 means for variables (a)

Variable	LPSE	INTERCEPT	LQSE	MP	DPI92
Coefficient (a)	na	46.781927	-0.002553	0.092359	0.016971
Means, 1993-97	119.985	na	5,135.48	59.6557	4,914.37

Option	Change in LQSE from 1993-97 average 1	Modeled LQSE (b), thousand pounds, round wt 2	Model estimate, LPSE (c), 1992 cents per pound 3	LQSE (d) thousand pounds, round wt 4	Model estimate, LPSE (c), 1992 cents per pound 5	Total exvessel revenue (2x3) 6	Producer surplus (e) (6*0.08) 7	Consumer surplus (2-4)*(5-3)/2 8
						- - - - thousand 1992$ - - - -		
Base	na	5,135	123	0	136	6,295	504	34
1	-400	4,735	124	0	136	5,853	468	29
2	400	5,535	122	0	136	6,729	538	39
3	-1000	4,135	125	0	136	5,175	414	22
4	1000	6,135	120	0	136	7,364	589	48
5	-2000	3,135	128	0	136	4,004	320	13
6	2000	7,135	117	0	136	8,383	671	65

	Landings group (f) thousand pounds, round wt	- - - - - Change from base in					- - - - -
		Landings Gulf group	Landings NC-TX (LQSE)	Price NC-TX (LPSE)	Total revenue	Producer surplus	Consumer surplus
					- - - - thousand 1992$		- - - -
Base	2,826	0%	0%	0%	0	0	0
1	2,426	-14%	-8%	1%	-442	-35	-5
2	3,226	14%	8%	-1%	434	35	5
3	1,826	-35%	-19%	2%	-1120	-90	-12
4	3,826	35%	19%	-2%	1069	86	14
5	826	-71%	-39%	4%	-2292	-183	-21
6	4,826	71%	39%	-4%	2087	167	31

(a) Equation 2, Table 6, estimated using 1972-98 annual data (27 obs.).
(b) Landings (LQSE) @ 1993-97 means after adjustment for change from base.
(c) Estimated @ LQSE in preceding col.; 1993-97 means for other ind. variables.
(d) Near-zero value for LQSE (LQSE = 0.1 pound per year).
(e) 8% of total revenue (1/3 of net revenue, which averaged 24% of total revenue for 1344 federally-permit boats in 1997 with applicant qualitative indication of sales of mackerel & expected gear--Table 6c., Vondruska, 1997).
(f) Average landings for Gulf group in fishing years 1993/94 to 1997/98.

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Table 12a.--Estimated consumer and producer surplus, option 1 (Gulf king to 30% SPR by FY2013/2014, Legault, 1999, Table 5a, p.12)

Variable:	LPSE	INTERCEPT	LQSE	HQ	DPI92	FY1993/94 to FY1997/98 means, commercial landings (1000 lbs., round wt)		
Coefficient (a):	na	43.281601	-0.002101	-0.001399	0.019665	Atlantic group	2,279	
Means, 1993-97:	119.985	na	5,135.48	7,041.33	4,914.37	Gulf group	2,826	Discount rate
						Overall	5,105	7.00%

Year	Fishing year	Gulf group total yield (thousand pounds round weight)	Gulf group comm. alloc. (thousand pounds round weight)	Modeled LQSE (b), thousand pounds, round wt	Model estimate, LPSE (c), 1992 cents per pound	LQSE (d) thousand pounds, round wt	Model estimate, LPSE (c), 1992 cents per pound	Total exvessel revenue (3x4)	Producer surplus (7*0.08)	Consumer surplus (3-5)*(6-4)/2	Present value in year zero for: Exvessel revenue	Present value in year zero for: Producer surplus	Present value in year zero for: Consumer surplus
								- - - thousand 1992$ - - -					
		1	2	3	4	5	6	7	8	9	10	11	12
0	1998/1999	11,370	3,638	5,948	118	0	130	6,993	559	37	6,993	559	37
1	1999/2000	10,320	3,302	5,612	118	0	130	6,638	531	33	6,204	496	31
2	2000/2001	10,170	3,254	5,564	118	0	130	6,587	527	33	5,753	460	28
3	2001/2002	9,800	3,136	5,445	119	0	130	6,460	517	31	5,273	422	25
4	2002/2003	9,390	3,005	5,314	119	0	130	6,319	506	30	4,821	386	23
5	2003/2004	9,400	3,008	5,317	119	0	130	6,322	506	30	4,508	361	21
6	2004/2005	8,910	2,851	5,161	119	0	130	6,153	492	28	4,100	328	19
7	2005/2006	8,490	2,717	5,026	120	0	130	6,007	481	27	3,741	299	17
8	2006/2007	8,450	2,704	5,013	120	0	130	5,993	479	26	3,488	279	15
9	2007/2008	8,340	2,669	4,978	120	0	130	5,955	476	26	3,239	259	14
10	2008/2009	8,300	2,656	4,965	120	0	130	5,941	475	26	3,020	242	13
11	2009/2010	8,240	2,637	4,946	120	0	130	5,920	474	26	2,812	225	12
12	2010/2011	8,220	2,630	4,940	120	0	130	5,913	473	26	2,625	210	11
13	2011/2012	8,180	2,618	4,927	120	0	130	5,899	472	26	2,448	196	11
14	2012/2013	8,190	2,621	4,930	120	0	130	5,902	472	26	2,289	183	10
15	2013/2014	8,140	2,605	4,914	120	0	130	5,885	471	25	2,133	171	9
16	2014/2015	8,140	2,605	4,914	120	0	130	5,885	471	25	1,993	159	9
17	2015/2016	8,140	2,605	4,914	120	0	130	5,885	471	25	1,863	149	8
18	2016/2017	8,140	2,605	4,914	120	0	130	5,885	471	25	1,741	139	8
19	2017/2018	8,150	2,608	4,917	120	0	130	5,888	471	25	1,628	130	7
20	2018/2019	8,150	2,608	4,917	120	0	130	5,888	471	25	1,522	122	7
21	2019/2020	8,150	2,608	4,917	120	0	130	5,888	471	25	1,422	114	6
22	2020/2021	8,150	2,608	4,917	120	0	130	5,888	471	25	1,329	106	6
Sum		200,930	64,298	117,416				140,093	11,207	632	74,945	5,996	346

(a) Equation 1, Table 6, estimated using 1972-98 annual data (27 obs.). (b) Landings (LQSE) @ 1993-97 means after adjustment for change from base. (c) Estimated @ LQSE in preceding col.; 1993-97 means for other ind. variables. (d) Near-zero value for LQSE (LQSE = 0.1 lb / yr).
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Table 12b.--Estimated consumer and producer surplus, option 2 (Gulf king to 40% SPR by FY2014/2015--Legault, 1999, Table 5a, p. 12)

Variable:	LPSE	INTERCEPT	LQSE	MQ	DPI92
Coefficient (a):	na	43.281601	-0.002101	-0.001399	0.019665
Means, 1993-97:	119.985	na	5,135.48	7,041.33	4,914.37

FY1993/94 to FY1997/98 means, commercial landings (1000 lbs., round wt)	
Atlantic group	2,279
Gulf group	2,826
Overall	5,105

Discount rate 7.00%

Year	Fishing year	- Gulf group - - total yield (thousand pounds round weight)	comm. alloc. (thousand pounds round weight)	Modeled LQSE (b), thousand pounds, round wt	Model estimate, LPSE (c), 1992 cents per pound	LQSE (d) thousand pounds, round wt	Model estimate, LPSE (c), 1992 cents per pound	Total exvessel revenue (3x4)	Producer surplus (7*0.08)	Consumer surplus (3-5)*(6-4)/2	Present value in year zero for: Exvessel revenue	Producer surplus	Consumer surplus
								- - - thousand 1992$					
		1	2	3	4	5	6	7	8	9	10	11	12
0	1998/1999	11,370	3,638	5,948	118	0	130	6,993	559	37	6,993	559	37
1	1999/2000	7,170	2,294	4,604	120	0	130	5,543	443	22	5,180	414	21
2	2000/2001	7,470	2,390	4,700	120	0	130	5,649	452	23	4,934	395	20
3	2001/2002	7,570	2,422	4,732	120	0	130	5,684	455	24	4,640	371	19
4	2002/2003	7,570	2,422	4,732	120	0	130	5,684	455	24	4,337	347	18
5	2003/2004	7,860	2,515	4,825	120	0	130	5,786	463	24	4,126	330	17
6	2004/2005	7,670	2,454	4,764	120	0	130	5,720	458	24	3,811	305	16
7	2005/2006	7,390	2,365	4,674	120	0	130	5,621	450	23	3,500	280	14
8	2006/2007	7,470	2,390	4,700	120	0	130	5,649	452	23	3,288	263	14
9	2007/2008	7,430	2,378	4,687	120	0	130	5,635	451	23	3,065	245	13
10	2008/2009	7,460	2,387	4,697	120	0	130	5,646	452	23	2,870	230	12
11	2009/2010	7,410	2,371	4,681	120	0	130	5,628	450	23	2,674	214	11
12	2010/2011	7,420	2,374	4,684	120	0	130	5,631	451	23	2,500	200	10
13	2011/2012	7,380	2,362	4,671	120	0	130	5,617	449	23	2,331	186	10
14	2012/2013	7,410	2,371	4,681	120	0	130	5,628	450	23	2,183	175	9
15	2013/2014	7,310	2,339	4,649	120	0	130	5,593	447	23	2,027	162	8
16	2014/2015	7,310	2,339	4,649	120	0	130	5,593	447	23	1,894	152	8
17	2015/2016	7,330	2,346	4,655	120	0	130	5,600	448	23	1,773	142	7
18	2016/2017	7,330	2,346	4,655	120	0	130	5,600	448	23	1,657	133	7
19	2017/2018	7,330	2,346	4,655	120	0	130	5,600	448	23	1,548	124	6
20	2018/2019	7,330	2,346	4,655	120	0	130	5,600	448	23	1,447	116	6
21	2019/2020	7,330	2,346	4,655	120	0	130	5,600	448	23	1,352	108	5
22	2020/2021	7,330	2,346	4,655	120	0	130	5,600	448	23	1,264	101	5
Sum		174,650	55,888	109,006				130,899	10,472	544	69,395	5,552	293

(a) Equation 1, Table 6, estimated using 1972-98 annual data (27 obs.). (b) Landings (LQSE) @ 1993-97 means after adjustment for change from base. (c) Estimated @ LQSE in preceding col.; 1993-97 means for other ind. variables. (d) Near-zero value for LQSE (LQSE = 0.1 lb / yr).
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Appendix A: Monthly demand models

Alphabetic List of Variables

Variable	Label
CONS	US consumption, live wt
D1	Jan 0-1 variable
D2	Feb 0-1 variable
D3	Mar 0-1 variable
D4	Apr 0-1 variable
D5	May 0-1 variable
D6	Jun 0-1 variable
D7	Jul 0-1 variable
D8	Aug 0-1 variable
D9	Sep 0-1 variable
D10	Oct 0-1 variable
D11	Nov 0-1 variable
D12	Dec 0-1 variable
DPI92	US DPI, saa, billion 1992$
LAGCONS	Consumption (t-1)
LAGLPSE	SE exvessel price KM-cero (t-1)
LAGLQSE	SE landings, KM-cero (t-1)
LPSE	SE price, KM-cero, 1992 cts/lb
LQSE	SE landings, KM-cero, live wt
LQSE1	SE landings, KM-cero, Jan
LQSE2	SE landings, KM-cero, Feb
LQSE3	SE landings, KM-cero, Mar
LQSE4	SE landings, KM-cero, Apr
LQSE5	SE landings, KM-cero, May
LQSE6	SE landings, KM-cero, Jun
LQSE7	SE landings, KM-cero, Jul
LQSE8	SE landings, KM-cero, Aug
LQSE9	SE landings, KM-cero, Sep
LQSE10	SE landings, KM-cero, Oct
LQSE11	SE landings, KM-cero, Nov
LQSE12	SE landings, KM-cero, Dec
MO	Month
MP	Import price, 1992 cents/lb, live wt
MQ	Imports, large mackerel, live weight
PPIALL	PPI, all commodities, 1982=1000
SP	SE price, pink shrimp 92 cts/lb
SQ	SE landings, pink shrimp, live wt
YR	Year (4-digit, 1960 onward)

Means of selected variables for 1977-97:

MQ	MP	SQ	SP	CONS	LQSE
177.992	84.6788	1821.68	224.864	655.154	477.162

LPSE	DPI92	PPIALL
120.887	4124.34	1048.12

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Model: MODEL 1
Dependent Variable: LPSE   SE exvessel price, KM-cero, 1992 c

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value
Model	3	69753.53228	23251.17743	51.829
Error	248	111256.66611	448.61559	
C Total	251	181010.19839		

Root MSE	21.18055	R-square	0.3854
Dep Mean	120.88701	Adj R-sq	0.3779
C.V.	17.52095		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	75.618790	10.93262874	6.917	0.0001
LQSE	1	-0.031897	0.00370004	-8.621	0.0001
MQ	1	0.000477	0.00398464	0.120	0.9049
DPI92	1	0.014646	0.00256813	5.703	0.0001

Variable	DF	Variable Label
INTERCEP	1	Intercept
LQSE	1	SE landings, KM-cero, live wt
MQ	1	Imports, large mackerel, live weight
DPI92	1	US DPI, saa, billion 1992$

Durbin-Watson D	1.191
(For Number of Obs.)	252
1st Order Autocorrelation	0.400

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Model: MODEL 2
Dependent Variable: LPSE SE exvessel price, KM-cero, 1992 cts/lb

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	3	69756.23893	23252.07964	51.832	0.0001
Error	248	111253.95946	448.60468		
C Total	251	181010.19839			

Root MSE	21.18029	R-square	0.3854
Dep Mean	120.88701	Adj R-sq	0.3779
C.V.	17.52073		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	76.391114	13.63197739	5.604	0.0001
LQSE	1	-0.031882	0.00368267	-8.657	0.0001
MP	1	-0.006859	0.04809053	-0.143	0.8867
DPI92	1	0.014618	0.00256090	5.708	0.0001

Variable	DF	Variable Label
INTERCEP	1	Intercept
LQSE	1	SE landings, KM-cero, live wt
MP	1	Import price, 1992 cents/lb, live wt
DPI92	1	US DPI, saa, billion 1992$

Durbin-Watson D	1.190
(For Number of Obs.)	252
1st Order Autocorrelation	0.400

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Model: MODEL 3
Dependent Variable: LPSE   SE exvessel price, KM-cero, 1992 cts/lb

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	2	55543.79552	27771.89776	55.116	0.0001
Error	249	125466.40287	503.88114		
C Total	251	181010.19839			

Root MSE	22.44730	R-square	0.3069
Dep Mean	120.88701	Adj R-sq	0.3013
C.V.	18.56882		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	40.636301	9.53158491	4.263	0.0001
CONS	1	-0.016780	0.00269689	-6.222	0.0001
DPI92	1	0.022123	0.00232916	9.498	0.0001

Variable	DF	Variable Label
INTERCEP	1	Intercept
CONS	1	US consumption, live wt
DPI92	1	US DPI, saa, billion 1992$

Durbin-Watson D	1.214
(For Number of Obs.)	252
1st Order Autocorrelation	0.392

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Model: MODEL 4
Dependent Variable: LPSE SE exvessel price, KM-cero, 1992 cts/lb

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	14	94876.34285	6776.88163	18.647	0.0001
Error	237	86133.85554	363.43399		
C Total	251	181010.19839			

Root MSE	19.06394	R-square	0.5241
Dep Mean	120.88701	Adj R-sq	0.4960
C.V.	15.77005		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	65.536971	10.78849122	6.075	0.0001
LQSE	1	-0.035958	0.00392202	-9.168	0.0001
MQ	1	-0.003295	0.00397926	-0.828	0.4085
DPI92	1	0.015834	0.00233543	6.780	0.0001
D1	1	9.248083	5.91415021	1.564	0.1192
D2	1	21.339021	5.88945426	3.623	0.0004
D3	1	31.467632	5.92526383	5.311	0.0001
D4	1	10.286854	6.16318411	1.669	0.0964
D5	1	3.660350	6.12623641	0.597	0.5508
D6	1	17.360120	6.45496636	2.689	0.0077
D7	1	-0.374507	6.26569682	-0.060	0.9524
D8	1	1.068608	6.19740963	0.172	0.8632
D9	1	2.284136	6.37612285	0.358	0.7205
D10	1	1.304417	6.23516000	0.209	0.8345
D11	1	-4.158618	6.05840116	-0.686	0.4931

Variable	DF	Variable Label
INTERCEP	1	Intercept
LQSE	1	SE landings, KM-cero, live wt
MQ	1	Imports, large mackerel, live weight
DPI92	1	US DPI, saa, billion 1992$
D1	1	Jan 0-1 variable
D2	1	Feb 0-1 variable
D3	1	Mar 0-1 variable
D4	1	Apr 0-1 variable
D5	1	May 0-1 variable
D6	1	Jun 0-1 variable
D7	1	Jul 0-1 variable
D8	1	Aug 0-1 variable
D9	1	Sep 0-1 variable
D10	1	Oct 0-1 variable
D11	1	Nov 0-1 variable

Durbin-Watson D	1.203
(For Number of Obs.)	252
1st Order Autocorrelation	0.391

Model: MODEL 5
Dependent Variable: LPSE SE exvessel price, KM-cero, 1992 cts/lb

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	14	94677.00837	6762.64345	18.565	0.0001
Error	237	86333.19003	364.27506		
C Total	251	181010.19839			

Root MSE	19.08599	R-square	0.5230
Dep Mean	120.88701	Adj R-sq	0.4949
C.V.	15.78829		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	64.780673	13.45035771	4.816	0.0001
LQSE	1	-0.035588	0.00390856	-9.105	0.0001
MP	1	0.016155	0.04369024	0.370	0.7119
DPI92	1	0.015284	0.00232479	6.574	0.0001
D1	1	9.621025	5.91133264	1.628	0.1049
D2	1	21.408916	5.90282004	3.627	0.0004
D3	1	31.991535	5.89952812	5.423	0.0001
D4	1	11.432560	6.03237395	1.895	0.0593
D5	1	4.937455	5.93129286	0.832	0.4060
D6	1	18.767471	6.23428804	3.010	0.0029
D7	1	0.987129	6.04574406	0.163	0.8704
D8	1	2.396090	5.99668720	0.400	0.6898
D9	1	3.661843	6.13796310	0.597	0.5514
D10	1	2.566371	6.06115088	0.423	0.6724
D11	1	-3.576638	6.01445157	-0.595	0.5526

Variable	DF	Variable Label
INTERCEP	1	Intercept
LQSE	1	SE landings, KM-cero, live wt
MP	1	Import price, 1992 cents/lb, live wt
DPI92	1	US DPI, saa, billion 1992$
D1	1	Jan 0-1 variable
D2	1	Feb 0-1 variable
D3	1	Mar 0-1 variable
D4	1	Apr 0-1 variable
D5	1	May 0-1 variable
D6	1	Jun 0-1 variable
D7	1	Jul 0-1 variable
D8	1	Aug 0-1 variable
D9	1	Sep 0-1 variable
D10	1	Oct 0-1 variable
D11	1	Nov 0-1 variable

Durbin-Watson D	1.204
(For Number of Obs.)	252
1st Order Autocorrelation	0.391

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Model: MODEL 6
Dependent Variable: LPSE        SE exvessel price, KM-cero, 1992 cts/lb
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Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	13	81069.66188	6236.12784	14.851	0.0001
Error	238	99940.53651	419.91822		
C Total	251	181010.19839			

Root MSE	20.49191	R-square	0.4479
Dep Mean	120.88701	Adj R-sq	0.4177
C.V.	16.95129		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	31.059974	9.91608468	3.132	0.0020
CONS	1	-0.019889	0.00314958	-6.315	0.0001
DPI92	1	0.023178	0.00215905	10.735	0.0001
D1	1	5.793034	6.32852232	0.915	0.3609
D2	1	20.732623	6.32971326	3.275	0.0012
D3	1	30.134351	6.36484270	4.735	0.0001
D4	1	10.624995	6.62456741	1.604	0.1101
D5	1	0.245923	6.55813674	0.037	0.9701
D6	1	19.509700	6.92833313	2.816	0.0053
D7	1	-1.197597	6.73349133	-0.178	0.8590
D8	1	-0.487491	6.65608908	-0.073	0.9417
D9	1	2.665379	6.85339604	0.389	0.6977
D10	1	1.543383	6.70206746	0.230	0.8181
D11	1	-2.394053	6.50492325	-0.368	0.7132

Variable	DF	Variable Label
INTERCEP	1	Intercept
CONS	1	US consumption, live wt
DPI92	1	US DPI, saa, billion 1992$
D1	1	Jan 0-1 variable
D2	1	Feb 0-1 variable
D3	1	Mar 0-1 variable
D4	1	Apr 0-1 variable
D5	1	May 0-1 variable
D6	1	Jun 0-1 variable
D7	1	Jul 0-1 variable
D8	1	Aug 0-1 variable
D9	1	Sep 0-1 variable
D10	1	Oct 0-1 variable
D11	1	Nov 0-1 variable

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Durbin-Watson D              1.154
(For Number of Obs.)           252
1st Order Autocorrelation    0.421
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Model: MODEL 7
Dependent Variable: LPSE SE exvessel price, KM-cero, 1992 cts/lb

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	14	83111.74929	5936.55352	14.372	0.0001
Error	237	97898.44910	413.07362		
C Total	251	181010.19839			

Root MSE	20.32421	R-square	0.4592
Dep Mean	120.88701	Adj R-sq	0.4272
C.V.	16.81257		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	40.797222	10.76591733	3.789	0.0002
CONS	1	-0.019001	0.00314928	-6.033	0.0001
SQ	1	-0.003849	0.00173121	-2.223	0.0271
DPI92	1	0.022432	0.00216751	10.349	0.0001
D1	1	6.363585	6.28197672	1.013	0.3121
D2	1	20.076209	6.28485252	3.194	0.0016
D3	1	31.587355	6.34649152	4.977	0.0001
D4	1	15.304434	6.89919817	2.218	0.0275
D5	1	4.338905	6.75994179	0.642	0.5216
D6	1	20.468346	6.88514883	2.973	0.0033
D7	1	-4.431869	6.83497085	-0.648	0.5173
D8	1	-4.732866	6.87219897	-0.689	0.4917
D9	1	-0.789311	6.97263502	-0.113	0.9100
D10	1	-0.573522	6.71506012	-0.085	0.9320
D11	1	-3.209574	6.46210851	-0.497	0.6199

Variable	DF	Variable Label
INTERCEP	1	Intercept
CONS	1	US consumption, live wt
SQ	1	SE landings, pink shrimp, live wt
DPI92	1	US DPI, saa, billion 1992$
D1	1	Jan 0-1 variable
D2	1	Feb 0-1 variable
D3	1	Mar 0-1 variable
D4	1	Apr 0-1 variable
D5	1	May 0-1 variable
D6	1	Jun 0-1 variable
D7	1	Jul 0-1 variable
D8	1	Aug 0-1 variable
D9	1	Sep 0-1 variable
D10	1	Oct 0-1 variable
D11	1	Nov 0-1 variable

Durbin-Watson D	1.198
(For Number of Obs.)	252
1st Order Autocorrelation	0.401

Model: MODEL 8
Dependent Variable: LPSE SE exvessel price, KM-cero, 1992 cts/lb

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	14	86503.58095	6178.82721	15.495	0.0001
Error	237	94506.61745	398.76210		
C Total	251	181010.19839			

Root MSE	19.96903	R-square	0.4779
Dep Mean	120.88701	Adj R-sq	0.4471
C.V.	16.51875		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	-10.211236	14.77736424	-0.691	0.4902
CONS	1	-0.020817	0.00307949	-6.760	0.0001
SP	1	0.132849	0.03598804	3.691	0.0003
DPI92	1	0.025579	0.00220225	11.615	0.0001
D1	1	6.505682	6.17006272	1.054	0.2928
D2	1	21.275343	6.16995423	3.448	0.0007
D3	1	33.174059	6.25685700	5.302	0.0001
D4	1	13.378186	6.49847366	2.059	0.0406
D5	1	3.256345	6.44261921	0.505	0.6137
D6	1	22.581891	6.80264797	3.320	0.0010
D7	1	0.665016	6.58104890	0.101	0.9196
D8	1	-0.460997	6.48625426	-0.071	0.9434
D9	1	6.695674	6.76717523	0.989	0.3235
D10	1	5.912278	6.63742280	0.891	0.3740
D11	1	-0.599128	6.35756292	-0.094	0.9250

Variable	DF	Variable Label
INTERCEP	1	Intercept
CONS	1	US consumption, live wt
SP	1	SE exv price, pink shrimp 92 cts/lb
DPI92	1	US DPI, saa, billion 1992$
D1	1	Jan 0-1 variable
D2	1	Feb 0-1 variable
D3	1	Mar 0-1 variable
D4	1	Apr 0-1 variable
D5	1	May 0-1 variable
D6	1	Jun 0-1 variable
D7	1	Jul 0-1 variable
D8	1	Aug 0-1 variable
D9	1	Sep 0-1 variable
D10	1	Oct 0-1 variable
D11	1	Nov 0-1 variable

Durbin-Watson D	1.219
(For Number of Obs.)	252
1st Order Autocorrelation	0.389

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Model: MODEL 9
Dependent Variable: LPSE SE exvessel price, KM-cero, 1992 cts/lb

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	15	99038.07429	6602.53829	19.009	0.0001
Error	236	81972.12411	347.33951		
C Total	251	181010.19839			

Root MSE	18.63705	R-square	0.5471
Dep Mean	120.88701	Adj R-sq	0.5184
C.V.	15.41691		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	82.634066	11.64618184	7.095	0.0001
LQSE	1	-0.036081	0.00383436	-9.410	0.0001
MQ	1	-0.000556	0.00396980	-0.140	0.8887
SQ	1	-0.005565	0.00160758	-3.461	0.0006
DPI92	1	0.014112	0.00233670	6.039	0.0001
D1	1	10.375594	5.79088324	1.792	0.0745
D2	1	20.443209	5.76338531	3.547	0.0005
D3	1	33.684962	5.82789123	5.780	0.0001
D4	1	17.022013	6.33156051	2.688	0.0077
D5	1	9.876466	6.25249217	1.580	0.1155
D6	1	18.557651	6.31989689	2.936	0.0036
D7	1	-4.977988	6.26810091	-0.794	0.4279
D8	1	-4.932345	6.30178860	-0.783	0.4346
D9	1	-2.743502	6.40032804	-0.429	0.6686
D10	1	-1.776801	6.16018893	-0.288	0.7733
D11	1	-5.492161	5.93525217	-0.925	0.3557

Variable	DF	Variable Label
INTERCEP	1	Intercept
LQSE	1	SE landings, KM-cero, live wt
MQ	1	Imports, large mackerel, live weight
SQ	1	SE landings, pink shrimp, live wt
DPI92	1	US DPI, saa, billion 1992$
D1	1	Jan 0-1 variable
D2	1	Feb 0-1 variable
D3	1	Mar 0-1 variable
D4	1	Apr 0-1 variable
D5	1	May 0-1 variable
D6	1	Jun 0-1 variable
D7	1	Jul 0-1 variable
D8	1	Aug 0-1 variable
D9	1	Sep 0-1 variable
D10	1	Oct 0-1 variable
D11	1	Nov 0-1 variable

Durbin-Watson D	1.273
(For Number of Obs.)	252
1st Order Autocorrelation	0.359

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Model: MODEL 10
Dependent Variable: LPSE SE exvessel price, KM-cero, 1992 cts/lb

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	15	99775.41052	6651.69403	19.324	0.0001
Error	236	81234.78787	344.21520		
C Total	251	181010.19839			

Root MSE	18.55304	R-square	0.5512
Dep Mean	120.88701	Adj R-sq	0.5227
C.V.	15.34742		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	28.407412	16.13295025	1.761	0.0796
LQSE	1	-0.036371	0.00380486	-9.559	0.0001
MP	1	-0.000002661	0.04267726	-0.000	1.0000
SP	1	0.129041	0.03352947	3.849	0.0002
DPI92	1	0.016933	0.00230013	7.362	0.0001
D1	1	10.329244	5.74921148	1.797	0.0737
D2	1	21.819599	5.73898293	3.802	0.0002
D3	1	35.079942	5.79066439	6.058	0.0001
D4	1	14.363156	5.91316160	2.429	0.0159
D5	1	8.241929	5.82925037	1.414	0.1587
D6	1	22.174650	6.12452647	3.621	0.0004
D7	1	3.223095	5.90557147	0.546	0.5857
D8	1	2.792774	5.83014800	0.479	0.6324
D9	1	8.093069	6.07664597	1.332	0.1842
D10	1	7.148939	6.01101382	1.189	0.2355
D11	1	-1.497794	5.87140457	-0.255	0.7989

Variable	DF	Variable Label
INTERCEP	1	Intercept
LQSE	1	SE landings, KM-cero, live wt
MP	1	Import price, 1992 cents/lb, live wt
SP	1	SE exv price, pink shrimp 92 cts/lb
DPI92	1	US DPI, saa, billion 1992$
D1	1	Jan 0-1 variable
D2	1	Feb 0-1 variable
D3	1	Mar 0-1 variable
D4	1	Apr 0-1 variable
D5	1	May 0-1 variable
D6	1	Jun 0-1 variable
D7	1	Jul 0-1 variable
D8	1	Aug 0-1 variable
D9	1	Sep 0-1 variable
D10	1	Oct 0-1 variable
D11	1	Nov 0-1 variable

Durbin-Watson D	1.278
(For Number of Obs.)	252
1st Order Autocorrelation	0.355

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Model: MODEL 11
Dependent Variable: CONS US consumption, live wt

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	13	35701963.39	2746304.8762	18.028	0.0001
Error	238	36256056.899	152336.37353		
C Total	251	71958020.29			

Root MSE	390.30293	R-square	0.4961
Dep Mean	655.15404	Adj R-sq	0.4686
C.V.	59.57422		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	578.131701	189.04358355	3.058	0.0025
LPSE	1	-7.215396	1.14259463	-6.315	0.0001
DPI92	1	0.315321	0.04574037	6.894	0.0001
D1	1	43.010841	120.71719651	0.356	0.7219
D2	1	192.350157	122.61512344	1.569	0.1180
D3	1	29.092810	126.79555420	0.229	0.8187
D4	1	-456.975328	123.34931019	-3.705	0.0003
D5	1	-468.666128	121.16065464	-3.868	0.0001
D6	1	-627.748695	127.82153821	-4.911	0.0001
D7	1	-636.571842	121.44055395	-5.242	0.0001
D8	1	-567.301277	121.32765343	-4.676	0.0001
D9	1	-698.532935	122.47399319	-5.704	0.0001
D10	1	-591.989294	121.76299030	-4.862	0.0001
D11	1	-431.331046	120.73754162	-3.572	0.0004

Variable	DF	Variable Label
INTERCEP	1	Intercept
LPSE	1	SE exvessel price, KM-cero, 1992 cts/lb
DPI92	1	US DPI, saa, billion 1992$
D1	1	Jan 0-1 variable
D2	1	Feb 0-1 variable
D3	1	Mar 0-1 variable
D4	1	Apr 0-1 variable
D5	1	May 0-1 variable
D6	1	Jun 0-1 variable
D7	1	Jul 0-1 variable
D8	1	Aug 0-1 variable
D9	1	Sep 0-1 variable
D10	1	Oct 0-1 variable
D11	1	Nov 0-1 variable

Durbin-Watson D	0.899
(For Number of Obs.)	252
1st Order Autocorrelation	0.523

Model: MODEL 12
Dependent Variable: MQ Imports, large mackerel, live weight

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	14	15114133.276	1079580.9483	11.247	0.0001
Error	237	22748790.488	95986.457755		
C Total	251	37862923.764			

Root MSE	309.81681	R-square	0.3992
Dep Mean	177.99216	Adj R-sq	0.3637
C.V.	174.06205		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	-525.670799	218.33536957	-2.408	0.0168
LQSE	1	-0.101737	0.06344634	-1.604	0.1102
MP	1	-1.032039	0.70920976	-1.455	0.1469
DPI92	1	0.269087	0.03773757	7.130	0.0001
D1	1	-98.471659	95.95677862	-1.026	0.3058
D2	1	3.697385	95.81859626	0.039	0.9693
D3	1	-156.642068	95.76515967	-1.636	0.1032
D4	1	-332.545755	97.92160354	-3.396	0.0008
D5	1	-391.085560	96.28078651	-4.062	0.0001
D6	1	-427.202468	101.19921065	-4.221	0.0001
D7	1	-418.760639	98.13863636	-4.267	0.0001
D8	1	-400.482609	97.34231204	-4.114	0.0001
D9	1	-438.456532	99.63559870	-4.401	0.0001
D10	1	-376.862432	98.38873040	-3.830	0.0002
D11	1	-205.696616	97.63067534	-2.107	0.0362

Variable	DF	Variable Label
INTERCEP	1	Intercept
LQSE	1	SE landings, KM-cero, live wt
MP	1	Import price, 1992 cents/lb, live wt
DPI92	1	US DPI, saa, billion 1992$
D1	1	Jan 0-1 variable
D2	1	Feb 0-1 variable
D3	1	Mar 0-1 variable
D4	1	Apr 0-1 variable
D5	1	May 0-1 variable
D6	1	Jun 0-1 variable
D7	1	Jul 0-1 variable
D8	1	Aug 0-1 variable
D9	1	Sep 0-1 variable
D10	1	Oct 0-1 variable
D11	1	Nov 0-1 variable

Durbin-Watson D	0.626
(For Number of Obs.)	252
1st Order Autocorrelation	0.683

```
Model: MODEL 13
Dependent Variable: LPSE        SE exvessel price, KM-cero, 1992 cts/lb
```

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	14	81618.70588	5829.90756	14.129	0.0001
Error	236	97377.16759	412.61512		
C Total	250	178995.87347			

Root MSE	20.31293	R-square	0.4560
Dep Mean	121.06546	Adj R-sq	0.4237
C.V.	16.77847		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	27.991280	9.91167692	2.824	0.0051
CONS	1	-0.015591	0.00377363	-4.132	0.0001
LAGCONS	1	-0.008839	0.00370506	-2.386	0.0178
DPI92	1	0.024113	0.00218677	11.027	0.0001
D1	1	10.006433	6.67913614	1.498	0.1354
D2	1	24.847159	6.50279130	3.821	0.0002
D3	1	35.835340	6.76168069	5.300	0.0001
D4	1	15.694581	6.95197822	2.258	0.0249
D5	1	1.390948	6.53713275	0.213	0.8317
D6	1	22.835047	7.07079758	3.229	0.0014
D7	1	-1.671239	6.69248973	-0.250	0.8030
D8	1	0.177674	6.62503876	0.027	0.9786
D9	1	4.762283	6.89663093	0.691	0.4905
D10	1	1.469789	6.66109202	0.221	0.8256
D11	1	-2.236202	6.45824652	-0.346	0.7295

Variable	DF	Variable Label
INTERCEP	1	Intercept
CONS	1	US consumption, live wt
LAGCONS	1	Consumption (t-1)
DPI92	1	US DPI, saa, billion 1992$
D1	1	Jan 0-1 variable
D2	1	Feb 0-1 variable
D3	1	Mar 0-1 variable
D4	1	Apr 0-1 variable
D5	1	May 0-1 variable
D6	1	Jun 0-1 variable
D7	1	Jul 0-1 variable
D8	1	Aug 0-1 variable
D9	1	Sep 0-1 variable
D10	1	Oct 0-1 variable
D11	1	Nov 0-1 variable

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Durbin-Watson D               1.151
(For Number of Obs.)            251
1st Order Autocorrelation     0.424
```

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Model: MODEL 14
Dependent Variable: LPSE SE exvessel price, KM-cero, 1992 cts/lb

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	16	101378.04231	6336.12764	19.102	0.0001
Error	234	77617.83116	331.70013		
C Total	250	178995.87347			

Root MSE	18.21264	R-square	0.5664
Dep Mean	121.06546	Adj R-sq	0.5367
C.V.	15.04363		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	81.933499	13.43558020	6.098	0.0001
LQSE	1	-0.032346	0.00423637	-7.635	0.0001
LAGLQSE	1	-0.013180	0.00414203	-3.182	0.0017
MP	1	0.025108	0.04183604	0.600	0.5490
SQ	1	-0.004383	0.00158309	-2.769	0.0061
DPI92	1	0.013795	0.00225516	6.117	0.0001
D1	1	12.812914	5.81730753	2.203	0.0286
D2	1	25.981205	5.87150420	4.425	0.0001
D3	1	38.182858	5.83117539	6.548	0.0001
D4	1	20.206955	6.11394561	3.305	0.0011
D5	1	9.251651	5.84749074	1.582	0.1150
D6	1	22.254164	6.13116043	3.630	0.0003
D7	1	-5.269501	5.98906532	-0.880	0.3798
D8	1	-2.828127	6.08628422	-0.465	0.6426
D9	1	0.385790	6.21886444	0.062	0.9506
D10	1	-1.205472	5.90487334	-0.204	0.8384
D11	1	-4.983264	5.78171913	-0.862	0.3896

Variable	DF	Variable Label
INTERCEP	1	Intercept
LQSE	1	SE landings, KM-cero, live wt
LAGLQSE	1	SE landings, KM-cero (t-1)
MP	1	Import price, 1992 cents/lb, live wt
SQ	1	SE landings, pink shrimp, live wt
DPI92	1	US DPI, saa, billion 1992$
D1	1	Jan 0-1 variable
D2	1	Feb 0-1 variable
D3	1	Mar 0-1 variable
D4	1	Apr 0-1 variable
D5	1	May 0-1 variable
D6	1	Jun 0-1 variable
D7	1	Jul 0-1 variable
D8	1	Aug 0-1 variable
D9	1	Sep 0-1 variable
D10	1	Oct 0-1 variable
D11	1	Nov 0-1 variable

Durbin-Watson D	1.226
(For Number of Obs.)	251
1st Order Autocorrelation	0.383

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Model: MODEL 15
Dependent Variable: LPSE SE exvessel price, KM-cero, 1992 cts/lb

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	16	103410.48387	6463.15524	20.009	0.0001
Error	234	75585.38960	323.01449		
C Total	250	178995.87347			

Root MSE	17.97260	R-square	0.5777
Dep Mean	121.06546	Adj R-sq	0.5489
C.V.	14.84536		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	37.765875	15.79202378	2.391	0.0176
LQSE	1	-0.031699	0.00417035	-7.601	0.0001
LAGLQSE	1	-0.015506	0.00401044	-3.866	0.0001
MP	1	0.002152	0.04146147	0.052	0.9587
SP	1	0.123265	0.03275175	3.764	0.0002
DPI92	1	0.015685	0.00225693	6.950	0.0001
D1	1	13.564012	5.74663668	2.360	0.0191
D2	1	27.895135	5.76965137	4.835	0.0001
D3	1	40.586848	5.80579431	6.991	0.0001
D4	1	19.260108	5.92123171	3.253	0.0013
D5	1	8.489359	5.65690949	1.501	0.1348
D6	1	26.344028	6.12080148	4.304	0.0001
D7	1	1.269861	5.74688832	0.221	0.8253
D8	1	3.332601	5.66266569	0.589	0.5567
D9	1	10.080818	5.96930380	1.689	0.0926
D10	1	6.472248	5.84751057	1.107	0.2695
D11	1	-1.257808	5.70681438	-0.220	0.8257

Variable	DF	Variable Label
INTERCEP	1	Intercept
LQSE	1	SE landings, KM-cero, live wt
LAGLQSE	1	SE landings, KM-cero (t-1)
MP	1	Import price, 1992 cents/lb, live wt
SP	1	SE exv price, pink shrimp 92 cts/lb
DPI92	1	US DPI, saa, billion 1992$
D1	1	Jan 0-1 variable
D2	1	Feb 0-1 variable
D3	1	Mar 0-1 variable
D4	1	Apr 0-1 variable
D5	1	May 0-1 variable
D6	1	Jun 0-1 variable
D7	1	Jul 0-1 variable
D8	1	Aug 0-1 variable
D9	1	Sep 0-1 variable
D10	1	Oct 0-1 variable
D11	1	Nov 0-1 variable

Durbin-Watson D	1.246
(For Number of Obs.)	251
1st Order Autocorrelation	0.371

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Model: MODEL 16
Dependent Variable: LPSE SE exvessel price, KM-cero, 1992 cts/lb

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	16	113669.63698	7104.35231	25.448	0.0001
Error	234	65326.23649	279.17195		
C Total	250	178995.87347			

Root MSE	16.70844	R-square	0.6350
Dep Mean	121.06546	Adj R-sq	0.6101
C.V.	13.80116		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	31.955106	14.57325067	2.193	0.0293
LQSE	1	-0.036874	0.00356725	-10.337	0.0001
LAGLPSE	1	0.366168	0.04980807	7.352	0.0001
MP	1	0.001668	0.03854203	0.043	0.9655
SP	1	0.079059	0.03101140	2.549	0.0114
DPI92	1	0.009227	0.00232948	3.961	0.0001
D1	1	10.999327	5.23775756	2.100	0.0368
D2	1	22.109338	5.16888852	4.277	0.0001
D3	1	29.149011	5.27390131	5.527	0.0001
D4	1	2.772708	5.54235090	0.500	0.6174
D5	1	1.038985	5.33592027	0.195	0.8458
D6	1	18.835244	5.55855002	3.389	0.0008
D7	1	-9.037910	5.56106994	-1.625	0.1055
D8	1	0.008291	5.26767130	0.002	0.9987
D9	1	3.945520	5.51970524	0.715	0.4754
D10	1	0.523319	5.49252035	0.095	0.9242
D11	1	-5.672414	5.32278427	-1.066	0.2877

Variable	DF	Variable Label
INTERCEP	1	Intercept
LQSE	1	SE landings, KM-cero, live wt
LAGLPSE	1	SE exvessel price KM-cero (t-1)
MP	1	Import price, 1992 cents/lb, live wt
SP	1	SE exv price, pink shrimp 92 cts/lb
DPI92	1	US DPI, saa, billion 1992$
D1	1	Jan 0-1 variable
D2	1	Feb 0-1 variable
D3	1	Mar 0-1 variable
D4	1	Apr 0-1 variable
D5	1	May 0-1 variable
D6	1	Jun 0-1 variable
D7	1	Jul 0-1 variable
D8	1	Aug 0-1 variable
D9	1	Sep 0-1 variable
D10	1	Oct 0-1 variable
D11	1	Nov 0-1 variable

Durbin-Watson D	2.017
(For Number of Obs.)	251
1st Order Autocorrelation	-0.013

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Model: MODEL 17
Dependent Variable: LPSE SE exvessel price, KM-cero, 1992 cts/lb

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	15	93791.14266	6252.74284	16.919	0.0001
Error	236	87219.05573	369.57227		
C Total	251	181010.19839			

Root MSE	19.22426	R-square	0.5182
Dep Mean	120.88701	Adj R-sq	0.4875
C.V.	15.90267		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	44.179847	15.40090896	2.869	0.0045
LQSE1	1	-0.038985	0.00511599	-7.620	0.0001
LQSE2	1	-0.032442	0.00488060	-6.647	0.0001
LQSE3	1	-0.025285	0.00565538	-4.471	0.0001
LQSE4	1	-0.048205	0.01242035	-3.881	0.0001
LQSE5	1	-0.051641	0.00880977	-5.862	0.0001
LQSE6	1	-0.023793	0.02741950	-0.868	0.3864
LQSE7	1	-0.085280	0.01261423	-6.761	0.0001
LQSE8	1	-0.071196	0.01201684	-5.925	0.0001
LQSE9	1	-0.085443	0.01780178	-4.800	0.0001
LQSE10	1	-0.072105	0.01440393	-5.006	0.0001
LQSE11	1	-0.082507	0.01220808	-6.758	0.0001
LQSE12	1	-0.053634	0.00665419	-8.060	0.0001
MP	1	0.011064	0.04430885	0.250	0.8030
SP	1	0.104890	0.03409386	3.076	0.0023
DPI92	1	0.018656	0.00239330	7.795	0.0001

Variable	DF	Variable Label
INTERCEP	1	Intercept
LQSE1	1	SE landings, KM-cero, Jan
LQSE2	1	SE landings, KM-cero, Feb
LQSE3	1	SE landings, KM-cero, Mar
LQSE4	1	SE landings, KM-cero, Apr
LQSE5	1	SE landings, KM-cero, May
LQSE6	1	SE landings, KM-cero, Jun
LQSE7	1	SE landings, KM-cero, Jul
LQSE8	1	SE landings, KM-cero, Aug
LQSE9	1	SE landings, KM-cero, Sep
LQSE10	1	SE landings, KM-cero, Oct
LQSE11	1	SE landings, KM-cero, Nov
LQSE12	1	SE landings, KM-cero, Dec
MP	1	Import price, 1992 cents/lb, live wt
SP	1	SE exv price, pink shrimp 92 cts/lb
DPI92	1	US DPI, saa, billion 1992$

Durbin-Watson D	1.251
(For Number of Obs.)	252
1st Order Autocorrelation	0.365

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Model: MODEL 18

Dependent Variable: CONS US consumption, live wt

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	14	42262578.448	3018755.6034	26.366	0.0001
Error	236	27020740.416	114494.66278		
C Total	250	69283318.864			

Root MSE	338.37060	R-square	0.6100
Dep Mean	648.65124	Adj R-sq	0.5869
C.V.	52.16526		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	497.584505	164.71996113	3.021	0.0028
LPSE	1	-4.326343	1.04712709	-4.132	0.0001
LAGCONS	1	0.448843	0.05520325	8.131	0.0001
DPI92	1	0.192196	0.04305886	4.464	0.0001
D1	1	-271.739064	110.37980302	-2.462	0.0145
D2	1	-82.494691	111.49394714	-0.740	0.4601
D3	1	-310.285199	117.42520763	-2.642	0.0088
D4	1	-643.045059	109.30846273	-5.883	0.0001
D5	1	-437.776534	105.11087038	-4.165	0.0001
D6	1	-707.309019	111.20455635	-6.360	0.0001
D7	1	-490.024880	106.83733775	-4.587	0.0001
D8	1	-492.777695	105.59472685	-4.667	0.0001
D9	1	-677.039124	106.21935072	-6.374	0.0001
D10	1	-478.743746	106.50558414	-4.495	0.0001
D11	1	-354.158171	105.10960166	-3.369	0.0009

Variable	DF	Variable Label
INTERCEP	1	Intercept
LPSE	1	SE exvessel price, KM-cero, 1992 cts/lb
LAGCONS	1	Consumption (t-1)
DPI92	1	US DPI, saa, billion 1992$
D1	1	Jan 0-1 variable
D2	1	Feb 0-1 variable
D3	1	Mar 0-1 variable
D4	1	Apr 0-1 variable
D5	1	May 0-1 variable
D6	1	Jun 0-1 variable
D7	1	Jul 0-1 variable
D8	1	Aug 0-1 variable
D9	1	Sep 0-1 variable
D10	1	Oct 0-1 variable
D11	1	Nov 0-1 variable

Durbin-Watson D	1.944
(For Number of Obs.)	251
1st Order Autocorrelation	0.008

Appendix B: Annual Demand Models

Model: ANNUAL MODEL 1
Dependent Variable: LPSE   SE exvessel price, KM-cero, 1992 cts/lb

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	3	6162.01040	2054.00347	22.726	0.0001
Error	23	2078.80525	90.38284		
C Total	26	8240.81565			

Root MSE	9.50699	R-square	0.7477
Dep Mean	105.57630	Adj R-sq	0.7148
C.V.	9.00485		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	43.281601	19.83609785	2.182	0.0396
LQSE	1	-0.002101	0.00137576	-1.527	0.1404
MQ	1	-0.001399	0.00095492	-1.465	0.1565
DPI92	1	0.019665	0.00389683	5.046	0.0001

Variable	DF	Variable Label
INTERCEP	1	Intercept
LQSE	1	SE landings, KM-cero, 1000 lb live wt
MQ	1	Imports, large mackerel, 1000 lb live wt
DPI92	1	US disposable personal inc, billion 92$

Durbin-Watson D	1.457
(For Number of Obs.)	27
1st Order Autocorrelation	0.223

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Model: ANNUAL MODEL 2
Dependent Variable: LPSE   SE exvessel price, KM-cero, 1992 cts/lb

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	3	6058.29984	2019.43328	21.281	0.0001
Error	23	2182.51581	94.89199		
C Total	26	8240.81565			

Root MSE	9.74125	R-square	0.7352
Dep Mean	105.57630	Adj R-sq	0.7006
C.V.	9.22674		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	46.781927	20.79684831	2.249	0.0344
LQSE	1	-0.002553	0.00142184	-1.795	0.0858
MP	1	0.092359	0.09472294	0.975	0.3397
DPI92	1	0.016971	0.00317357	5.348	0.0001

Variable	DF	Variable Label
INTERCEP	1	Intercept
LQSE	1	SE landings, KM-cero, 1000 lb live wt
MP	1	Import price, 1992 cents/lb, live wt
DPI92	1	US disposable personal inc, billion 92$

Durbin-Watson D	1.345
(For Number of Obs.)	27
1st Order Autocorrelation	0.293

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Model: ANNUAL MODEL 3
Dependent Variable: LPSE   SE exvessel price, KM-cero, 1992 cts/lb

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	2	6147.57872	3073.78936	35.243	0.0001
Error	24	2093.23693	87.21821		
C Total	26	8240.81565			

Root MSE	9.33907	R-square	0.7460
Dep Mean	105.57630	Adj R-sq	0.7248
C.V.	8.84580		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	36.337776	9.39654885	3.867	0.0007
CONS	1	-0.001638	0.00073009	-2.244	0.0343
DPI92	1	0.020842	0.00250685	8.314	0.0001

Variable	DF	Variable Label
INTERCEP	1	Intercept
CONS	1	US consumption, 1000 lb, live wt
DPI92	1	US disposable personal inc, billion 92$

Durbin-Watson D	1.467
(For Number of Obs.)	27
1st Order Autocorrelation	0.218

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Model: ANNUAL MODEL 4
Dependent Variable: CONS US consumption, 1000 lb, live wt

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	2	59301333.809	29650666.904	5.261	0.0127
Error	24	135249801.19	5635408.3828		
C Total	26	194551135			

Root MSE	2373.90151	R-square	0.3048
Dep Mean	7819.91315	Adj R-sq	0.2469
C.V.	30.35713		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEP	1	5855.830087	2798.4067130	2.093	0.0471
LPSE	1	-105.857871	47.17293728	-2.244	0.0343
DPI92	1	3.337783	1.05417910	3.166	0.0042

Variable	DF	Variable Label
INTERCEP	1	Intercept
LPSE	1	SE exvessel price, KM-cero, 1992 cts/lb
DPI92	1	US disposable personal inc, billion 92$

Durbin-Watson D	0.972
(For Number of Obs.)	27
1st Order Autocorrelation	0.494

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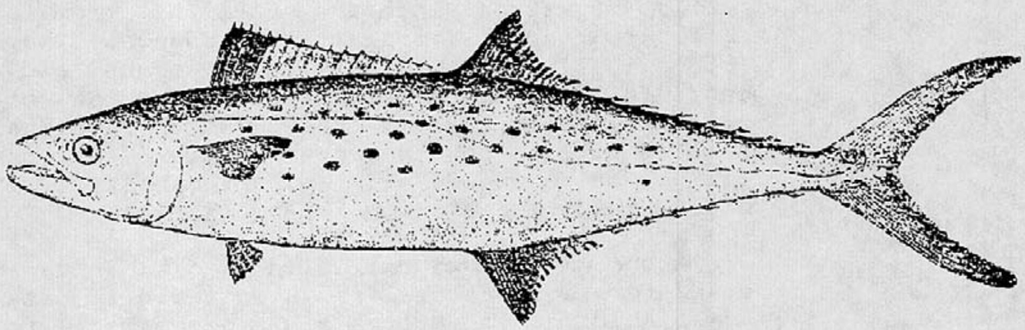
Appendix Q. U.S. Markets and Trade in King Mackerel and Other Large Mackerel (SERO-ECON-99-08)

U.S. Markets and Trade in King Mackerel and Other Large Mackerel



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Fisheries Economics Office

April 13, 1999

SERO-ECON-99-08

U.S. Markets and Trade in King Mackerel and other Large Mackerel[1]

April 13, 1999

Introduction and Summary

Imports that compete more or less directly in the U.S. seafood market with the king mackerel were estimated. Data on U.S. imports of fresh and frozen mackerel was selected to represent imports of king mackerel and other large mackerel based on information from industry sources (Antozzi, 1999), Collette and Nauen (1983), and landings by species of fish and country (FAO, 1998).

Imports of large mackerel include the narrow-barred Spanish mackerel (*Scomberomorus commerson*) from fisheries in warmer waters of the Indo-West Pacific, as well as king mackerel (*S. cavalla*) from fisheries in the central Western Atlantic. The imports of large mackerel are estimated to have increased by an order of magnitude since the mid-1980s, from less a half a million pounds to several million pounds. They reached a peak in 1996 of 10.3 million pounds (round weight) and were 4.1 million pounds in 1998. Commercial fishery landings of king mackerel in the southeastern coastal states (North Carolina to Texas) have been 4-6 million pounds since the mid-1980s, compared with 5-10 million pounds in 1967-83, and shipments to Puerto Rico and foreign countries are now far smaller.

Along with other variables used in annual models of the demand for king mackerel shown in Table 1, data on estimated U.S. market supplies and prices of large mackerel for 1962-98 is also shown in Figures 1-2. Data used in monthly models of demand for 1977-97 is shown in Table 2. The models and results are discussed in a separate report. Note that the more recently obtained annual data on landings is not complete for 1998 (Table 1), while the previously obtained monthly data on landings may not be complete through 1997 (Table 2), and that the two sets of data may differ for recent years.

Markets for King Mackerel

Industry sources indicate that there are market niches for

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king mackerel which have ethnic dimensions, notably Hispanic, Asian and black, and that target markets now include Miami, New York, New Jersey, New England, California, Washington and Canada (Antozzi, 1999). Some of the target markets have larger numbers of Hispanics, one of the fastest growing and increasingly affluent segments of the nation's population.[2] In the 1970s, when U.S. landings of king mackerel were larger, target markets are reported to have included Puerto Rico, New York, Miami, Canada and Venezuela.[3]

In trying to trace Hispanic consumer tastes and preferences for seafood items, one must recognize variation among countries of the Caribbean and Latin America in terms of such factors as continental shelf area, fishery resources, fisheries, cuisine and income. For example, although Mexico has abundant fishery resources, the per-capita consumption of seafood is lower than in the United States (FAO data in NMFS, 1998), in part because much of the population has lived inland. In turn, the large proportion of people with Mexican heritage among Hispanics in California and Texas may suggest lesser markets for king mackerel in both States, but California is reported to be a key market (Antozzi, 1999; McGovern, 1999).

In comparison with some Caribbean and Latin American countries, Florida has relatively wide continental shelf areas, abundant fishery resources, and high per-capita consumption of seafood, roughly twice the United States average. Based on their survey, Degner et al. (1994) indicate that per-capita consumption of seafood in Florida is roughly similar for the state sample and the white, black and Hispanic sub-groups in that sample, but about a third higher for the Asian and American Indian sub-groups. King mackerel was a separate item (in addition to mackerel) and it accounted a small fraction of the per-capita consumption of seafood for survey respondents, depending on sub-group.[4] Whites have lower per-capita consumption of king

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[2]In order of size, California, Texas, New York, Florida and Illinois account for about 70% of the growing, diverse and increasingly affluent number of people with a Hispanic heritage (McGovern, 1999). At 30 million, they represent about 11.3% of the nation's population today, and demographers expect that they may account for about a fourth in 2050.

[3]An estimated three fourths of the landings from Florida's southwest coast and the Keys were marketed frozen to Puerto Rico, and the fish were mostly net caught (GMFMC & SAFMC, 1982, p. 10-1). The remainder was sold fresh primarily via New York's Fulton Fish Market. The local Florida market was attributed largely to the Cuban-American population in Miami. A survey of Florida's Atlantic coast fish dealers showed that 65% of their king mackerel was shipped fresh to the Fulton Fish Market in 1974 (Prochaska and Cato, 1979).

[4]King mackerel represents 0.28% of the seafood consumed by all survey respondents, 0.16% for whites, 0.68% for blacks, and 0.97% for Hispanics (Degner et al., 1994).

mackerel than blacks or Hispanics, but the relative numbers of people suggest that the three sub-groups consume roughly similar amounts in total. Overall, Floridians appear to consume an amount of king mackerel that about equals most or all of what is landed commercially in their State.[5]

U.S. Exports and Imports

Industry sources indicate that king mackerel from southeastern United States fisheries experiences market competition especially from imports of king mackerel from Mexico and lower-priced imports from India and Taiwan of the similarly large, narrow-barred Spanish mackerel, *S. commerson* (Antozzi, 1999). Other mackerels are landed, imported and exported in much larger amounts by the United States and other countries, but the individual fish are smaller (Collette and Nauen; FAO, 1998).

The United States has exported 30-80 million pounds a year of fresh and frozen mackerel in the 1990s, and steady, leading buyers include Japan, South Korea, Canada, Jamaica, and Australia. Even exports of fresh and frozen mackerel to the Caribbean and Latin America are large when compared with United States landings of king mackerel of 4-6 million pounds in the 1990s, and the export prices are low when compared with the exvessel prices of king mackerel. Among countries of the Caribbean and Latin America, Jamaica has been the leading buyer at 2-4 million pounds a year. For smaller amounts, Mexico has a been a steady buyer (0.03 to 0.7 million pounds), while Venezuela has been a more sporadic buyer along with other countries.

In comparison with what is now published monthly by the U.S. Bureau of Census and maintained by NMFS in data files for fishery research for 1972 onward, sometimes more detailed data on U.S. imports of some fishery products was collected and published

[5]An estimate of annual consumption of king mackerel in Florida is 1.427 million pounds, edible raw meat weight, or perhaps 2-3 million pounds, live weight. The estimate was developed as follows. The Florida population was 13.711 million in 1993 [Survey of Current Business, 78:10 (October 1998): 28-29]. Per-capita annual consumption of king mackerel was 47 grams (about 0.10 pound), raw edible meat weight, for randomly selected adult respondents for the state sample (age 18 an older) (Degner et al., 1994). A table of conversion factors from several sources was transmitted for review in a memo by Mark C. Holliday, NMFS, Fishery Statistics Division (June 22, 1990). At p. 25, that table gives factors to convert product weight to live weight for king mackerel, 1.54 or 1.82 for raw steaks, and 1.82 or 2.86 for raw fillets. The factors for raw fillets and steaks of the smaller Spanish, Atlantic and Pacific mackerel (steaks, 1.75; fillets, 3.03) are larger than one source's factors for king mackerel, albacore tuna and light meat tuna (steaks, 1.54; fillets, 2.86).

weekly by the NMFS in the past.[6] The NMFS-published data for southeastern U.S. ports of entry for 1983-87 was compiled from the NMFS *New Orleans Market News Report* and analyzed by Adams and Lawlor (1989), and that for 1984-87 was used by Easley et al. (1993) in some of their single-equation models of the U.S. market demand for king mackerel. Otherwise, Easley et al. (1993) used monthly data for 1977-91. The selection of Census-published data for 1972-98 in this report gives smaller annual totals (in pounds) for imports that compete with U.S. landed king mackerel than the NMFS-published data for 1983-87, the only period for which the two sets of data can be compared.

Estimating U.S. Imports of King Mackerel and Cero

Stocks of king mackerel (*S. cavalla*) occur in the Western Atlantic Ocean from Massachusetts to Rio de Janeiro, Brazil, and the individual fish may attain a maximum size of 173 cm fork length and 45 kg in weight (more commonly up to 70 cm fork length) (Collette and Nauen). During 1987-96, reported landings of 7-12 kt occurred mostly in the United States, Mexico, Venezuela and Brazil (FAO, 1998). Compared with king mackerel, Cero (*S. regalis*) is a smaller fish that occurs in somewhat the same area (maximum size, 83.5 cm fork length and 4.9 kg) (Collette and Nauen). U.S. landings of cero are reported inseparably with landings of king mackerel. To the extent of separate reporting, FAO's (1998) total for cero is about 0.2 to 0.5 kt a year in 1987-96, mostly for Caribbean countries.

In this paper, imports of fresh and frozen mackerel from countries of the Caribbean, Central America and the east coast of South American down to Brazil are assumed to be king mackerel, excepting imports from Mexico into Arizona, California, Oregon and Washington. U.S. imports of mackerel into Arizona and southern California are reported to consist of the smaller jack mackerel and chub mackerel (Donley, 1999),[7] and Mexico does not

[6]Data on the quantity of imports had been obtained for many years by NMFS port agents from offices of the U.S. Customs Service and published weekly in the NMFS *Fishery Market News Reports* (printed regionally in reports for Boston, New York, New Orleans, San Pedro and Seattle). The data was collected by species, port of entry, country of origin and product form and required manual compilation by users.

[7]During 1972-98, imports of fresh and frozen mackerel from Mexico into the four states (Arizona, California, Oregon and Washington) entered largely via the U.S. Customs District of San Diego. The chub mackerel (also called Pacific mackerel, *Scomberomorus japonicus*) is landed in many parts of the world, with a total of about 1.2-2.2 million metric tons in 1987-96 (FAO, 1998). United States landings occur on the Pacific coast and they declined from about 45 kt to 10 kt during 1987-96, while Mexico's landings have been nearer the lower end of their 1987-96 range of about 4-40 kt recently (FAO,

land king mackerel on its west coast (FAO, 1998).

Estimating U.S. Imports of Other Large Mackerel

Stocks of the narrow-barred Spanish mackerel (*S. commerson*) are widespread in the Indo-West Pacific Oceans from South Africa and the Red Sea east through the Indo-Australian Archipelago to Australia and Fiji and north to China and Japan (Collette and Nauen). Individual fish may reach a maximum size of about 220 cm fork length and 44.9 kg, with individuals being commonly 90 cm; i.e., apparently a bit larger than king mackerel (*S. cavalla*, maximum 173 cm, commonly 70 cm). Likely suppliers of U.S. imports may be identified on the basis of their landings during 1987-96, which were in the range of 115 to 152 kt worldwide, about ten times the 7-12 kt for king mackerel (FAO, 1998). The leading harvesters are Indonesia (43-68 kt in 1987-96), India (16-39 kt), Philippines (10-18 kt), Oman (3-28 kt), and Pakistan (6-12 kt). Smaller amounts are landed in the Mideast (Bahrain to Yemen), Kenya, South Africa, Australia, Fiji and Taiwan. Except for Kenya and South Africa, U.S. imports of fresh and frozen mackerel from all of these countries are assumed to consist of the narrow-barred Spanish mackerel (*S. commerson*). It is recognized that Australia,[8] Indonesia[9] and India[10] land lesser amounts of medium-sized mackerel, while Taiwan lands varying amounts of other mackerel[11]. The FAO does not report separately

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1998). Jack (horse) mackerel could include many *Trachurus* species; FAO group B-34, items under FAO number 1,70(23)004. Landings of just one, the Chilean jack mackerel (*Trachurus murphyi*) occur mostly in Chile and the worldwide totals were in the range of about 2.6-5.0 million metric tons in 1987-96.

[8]Australia lands smaller amounts of medium sized mackerel for which commonly landed individuals appear to be smaller in size than king mackerel (*S. cavalla*) in the United States. They are the Australian spotted mackerel (*S. munroi*, maximum, 100 cm fork length and 8 kg; commonly, 50-80 cm, 4.5 kg); Qeensland school mackerel (*S. Queenslandicus*, maximum, 100 cm fork length and 8 kg; commonly, 50 cm to 80 cm); and broad barred king mackerel (*S. semifasciatus*, maximum 120 cm fork length and 10 kg; commonly, 1.3 kg to 2.7 kg) (Collette and Nauen).

[9]Besides the narrow-barred Spanish mackerel (*S. commerson*), Indonesia has landed smaller amounts of Indo-Pacific king mackerel (*S. guttatus*) in 1991-96 (FAO, 1998, p. 596).

[10]Besides growing amounts of narrow-barred Spanish mackerel (*S. commerson*), India has landed steadier amounts of Indo-Pacific king mackerel (*S. guttatus*) in 1991-96, and much smaller amounts of streaked seerfish (*S. lineolatus*) (FAO, 1998, p. 595).

[11]Besides the narrow-barred Spanish mackerel (*S. commerson*), Taiwan lands smaller amounts of Indo-Pacific king mackerel (*S. guttatus*), larger amounts of Japanese Spanish mackerel (*S. niphonius*), and even larger amounts of chub mackerel (also called Pacific mackerel, *S.japonicus*).

the landings for another large mackerel (Chinese seerfish, *S. sinensis*, maximum size, 200 cm fork length and 80 kg) (FAO, 1998; Collette and Nauen).

Japan's Market and Imports

The United States and Japan represent major markets for Asia's major producer-exporters of shrimp, and one might suppose that the same could apply to major producer-exporters in the Indo-West Pacific of the narrow-barred Spanish mackerel (*S. commerson*), given a substantial shift from landings to imports of mackerel. Japan has been a leading producer, consumer, exporter and importer of mackerel. It is reported that "larger mackerel" with higher fat content are preferred for the most popular mackerel dish which is broiled, and whole frozen fish over 600 grams (1.3 pounds) bring the highest price (Sonu). However, it appears that Japan does not import much in the way of large mackerel, meaning primarily king mackerel (*S. cavalla*) from fisheries in the warmer waters of the western Central Atlantic Ocean and the narrow-barred Spanish mackerel (*S. commerson*) from fisheries in the warmer waters of the Indo-West Pacific Oceans.

Japan's consumer tastes and preferences for mackerel likely reflect what was landed traditionally, mostly from Japan's fisheries in colder waters of the Northwest Pacific Ocean. Japan's landings of mackerel declined sharply starting in the late 1970s, and the imports were sharply higher by the early 1990s (Sonu). The imports come mostly from Norway and other countries with fisheries in colder waters, countries that are not noted for much in the way of landings of large mackerel.[12]

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[12]Among the countries that have landings and exports of the large, narrow-barred Spanish mackerel (*S. commerson*) to the United States, one country, India, supplied a small amount of fresh "Spanish mackerel" to Japan. However, China and South Korea were the leading suppliers of that item in 1997 (Japan Marine Products Importers Association, 1998, item 0302.69-092). What is translated as "Spanish mackerel" in Japan's trade statistics likely refers to what is called elsewhere Japanese Spanish mackerel (*S. niphonius*), and not to the large narrow-barred Spanish mackerel (*S. commerson*) (Collette and Nauen; FAO, 1998).

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References

Adams, Charles M. and Frank J. Lawlor. 1989. Trends in the importation of selected fresh and frozen seafood products into the southeastern United States. University of Florida, Food and Resource Economics Department, Gainesville, FL Florida Sea Grant College Program Technical Paper TP-59, November 1989, xii + 70 p.

Antozzi, William O., 1999. King mackerel sources and markets. National Marine Fisheries Service, 9721 Executive Center Drive, North, St. Petersburg, FL 33702-2432, preliminary draft, January 14, 1999, 2 p.

Collette, Bruce B. and Cornelia E. Nauen. 1983. FAO Species Catalogue, Vol. 2, Scombrids of the World, An Annotated and Illustrated Catalogue of Tunas, Mackerels, Bonitos and Related Species Known to Date. United Nations Development Programme, Food and Agriculture Organization of the United Nations, FIR/S125 vol 2, 00100 Rome, Italy, 137 p.

Degner, Robert L., Charles M. Adams, Susan D. Moss and Stephanie K. Mack. 1994. Per Capita Fish and Shellfish Consumption in Florida. A report submitted to the Florida Department of Environmental Protection under contract WM-475. University of Florida, Florida Agricultural Market Research Center, a part of the Food and Resource Economics Department, Institute of Food and Agricultural Sciences, Gainesville, FL 32611-0240, August 31, 1994, FAMRC Industry Report 94-2, xxviii + 409 pages.

Easley, J.E., Chuck Adams, Walter N. Thurman and Joel Kincaid. 1993. The derived demand for commercially harvested Gulf and South Atlantic king mackerel: partial and general equilibrium, a project report to the Gulf of Mexico Fishery Management Council, March 29, 1993, 42 p. + appendices.

Food and Agriculture Organization of the United Nations (FAO). 1998. FAO Yearbook of Fishery Statistics, capture production, vol. 82, 1996. FAO, 00100 Rome, Italy.

Japan Marine Products Importers Association. 1998. Japanese Imports of Marine Products (Statistics), calendar year 1997. Japan Marine Products Importers Association, Kamakurabashi Bldg., 1F, 7-1, 1-Chome, Uchikanda, Chiyoda-ku, Tokyo, 1998.

McGovern, Dan. 1999. Marketing to Hispanic Americans. Seafood Business, January 1999, p. 36.

National Marine Fisheries Service (NMFS). 1998. Fisheries of the United States, 1997. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, F/ST1, 1315 East West Highway, Silver Spring, MD 20910-3282.

Prochaska, Fred J. And James C. Cato. 1979. Analysis of Florida Atlantic king mackerel monthly dockside prices. In Eugene L. Nakamura and Harvey R. Bullis, Jr., Proceedings of the Mackerel Colloquium, sponsored by the Gulf States Marine Fisheries Commission (twenty-eighth annual spring meeting, Brownsville, Texas, March 16, 1978), March 1979, no. 4, pp. 67-70.

Smith, Gary G. 1995. South Florida: Guidelines for Canadian Fish Exporters. Canada, Sectoral Liaison Secretariat, Department of Foreign Affairs and International Trade, 125 Sussex Drive, Ottawa, Canada K1A0G2, April 1995, 25 pages in English plus 25 pages in French.

8

Sonu, Sunee. 1992. Japan's mackerel market. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Region, 501 West Ocean Blvd., Suite 4200, Long Beach, CA 90802, NOAA-TM-NMFS-SWR-027, September 1992, 19 p.

Table 1.--Variables used in the annual demand model for king

YR	MQ	MP	CONS	LQSE	LPSE	DPI92	PPI
1962			4,149	4,149	47	1,698	317
1963			5,048	5,048	41	1,759	316
1964			3,423	3,423	43	1,886	316
1965			4,586	4,586	50	2,004	323
1966			4,513	4,513	52	2,111	333
1967			6,096	6,096	49	2,202	334
1968			6,198	6,198	54	2,302	342
1969			6,202	6,202	54	2,377	356
1970			6,723	6,723	63	2,469	369
1971			5,660	5,660	70	2,568	381
1972	243	50	5,111	4,867	79	2,686	398
1973	337	51	6,265	5,929	94	2,875	450
1974	586	81	10,987	10,401	69	2,854	535
1975	81	127	6,400	6,319	75	2,904	584
1976	148	111	7,770	7,622	86	3,018	611
1977	146	84	9,534	9,388	73	3,115	649
1978	80	119	5,448	5,367	86	3,276	699
1979	78	127	5,593	5,515	109	3,365	787
1980	110	100	7,178	7,068	100	3,386	898
1981	126	107	8,938	8,813	102	3,465	980
1982	89	103	8,331	8,242	112	3,491	1000
1983	74	70	7,037	6,963	107	3,584	1013
1984	128	56	5,345	5,217	89	3,850	1037
1985	84	80	5,476	5,392	114	3,960	1032
1986	1,290	69	7,058	5,768	115	4,077	1002
1987	291	78	5,490	5,199	123	4,155	1028
1988	2,384	72	6,926	4,542	121	4,325	1069
1989	693	78	4,342	3,649	126	4,412	1122
1990	934	71	5,782	4,848	115	4,490	1163
1991	1,585	56	5,616	4,031	115	4,484	1165
1992	1,467	51	6,435	4,968	122	4,605	1172
1993	4,388	55	10,052	5,664	116	4,667	1189
1994	7,224	61	11,518	4,294	128	4,773	1205
1995	8,496	61	13,169	4,674	122	4,906	1248
1996	10,295	60	15,407	5,112	115	5,043	1277
1997	4,804	62	10,738	5,934	119	5,183	1276
1998	4,078	63	9,192	5,114	119	5,346	1244

Data on landings for 1998 is incomplete.
CONS US consumption, 1000 lb, live wt
DPI92 US disposable personal inc, billion 92$
LPSE SE exvessel price, KM-cero, 1992 cts/lb
LQSE SE landings, KM-cero, 1000 lb live wt
MP Import price, 1992 cents/lb, live wt
MQ Imports, large mackerel, 1000 lb live wt
PPI PPI, all commodities, 1982=1000
YR range used in annual model is 1972-98

Figure 1.--U.S. Supplies of Large Mackerel

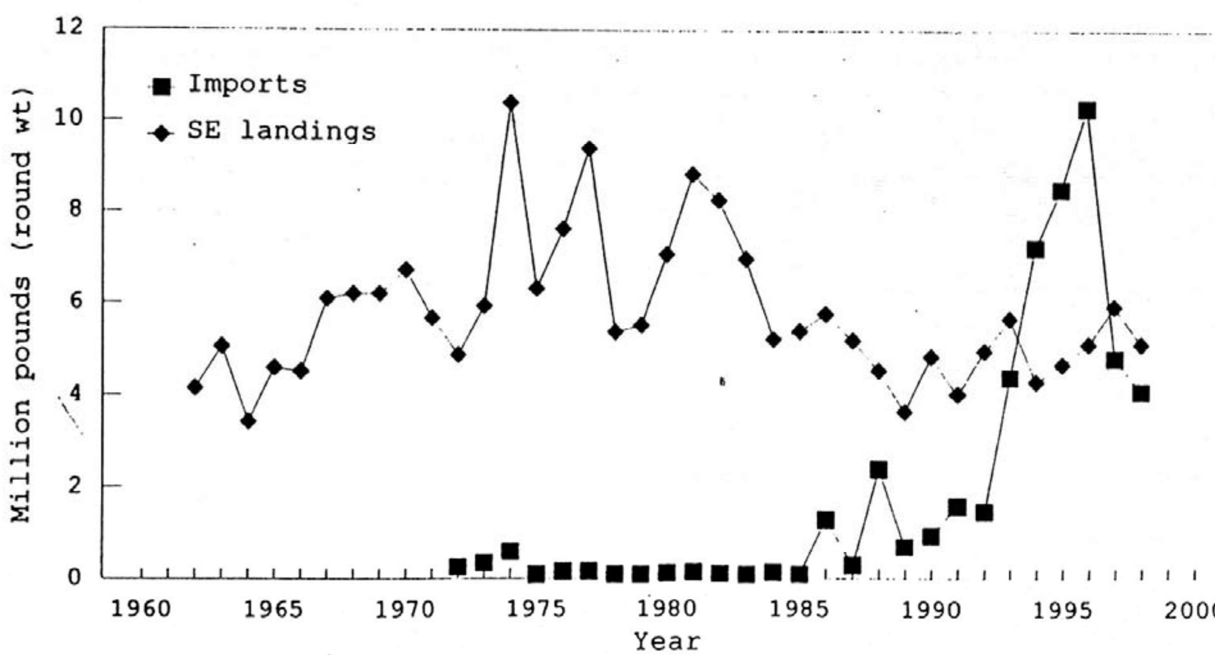


Figure 2.--Real Prices of Large Mackerel

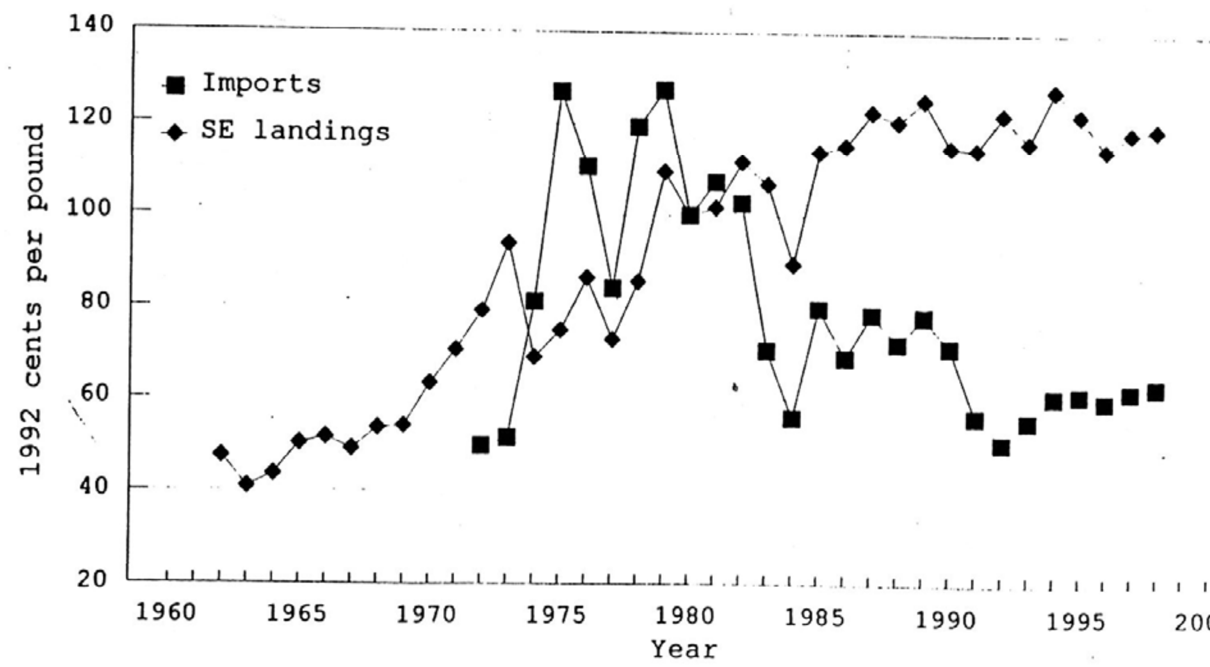


Table 2.--Selected variables for monthly mackerel model

Variable	Label
CONS	US consumption, large mackerel live wt
D1	January 0-1 variable
D2	February 0-1 variable
D3	March 0-1 variable
D4	April 0-1 variable
D5	May 0-1 variable
D6	June 0-1 variable
D7	July 0-1 variable
D8	August 0-1 variable
D9	September 0-1 variable
D10	October 0-1 variable
D11	November 0-1 variable
DPI92	US disposable income, saa, billion 92$
LAGCONS	U.S. consumption, lagged one month
LPSE	SE exvessel price, KM-cero, 1992 cts/lb
LQSE	SE landings, KM-cero, live wt
MO	Month
MP	Import price, 1992 cents/lb, live wt
MQ	Imports, large mackerel, live weight
PPIALL	PPI, all commodities, 1982=1000
SP	SE exvessel price, pink shrimp 92 cts/lb
SQ	SE landings, pink shrimp, live wt
YR	Year (4-digit, 1960 onward)

Table 2.--Selected variables for monthly mackerel model
(thousands of pounds, live weight basis)
(1997 data may not be complete)

Year	SE landings, KM-cero, live wt											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1977	2,282	2,465	1,934	206	150	143	234	308	168	235	305	958
1978	928	1,132	668	525	506	206	140	272	139	161	205	485
1979	394	1,701	669	207	510	259	183	377	107	240	175	694
1980	1,012	1,012	1,171	327	572	197	164	573	449	317	424	850
1981	1,377	1,790	1,555	323	451	183	228	419	181	391	324	1,591
1982	1,581	646	1,529	443	1,091	188	378	581	261	400	551	591
1983	1,045	1,223	1,493	251	729	224	170	403	279	317	418	412
1984	1,000	761	369	170	328	162	182	389	281	286	312	976
1985	513	463	901	310	780	193	286	304	98	210	530	805
1986	726	1,283	472	378	616	138	299	478	340	393	302	344
1987	558	392	143	429	660	285	388	414	381	518	449	583
1988	62	38	96	825	803	142	247	382	270	310	503	865
1989	71	45	35	476	555	154	310	507	247	396	496	357
1990	790	47	230	461	507	166	323	402	340	323	592	668
1991	316	94	122	346	382	138	310	525	381	290	382	743
1992	839	124	149	365	228	212	554	392	370	605	280	851
1993	1,380	274	288	328	524	108	511	458	352	208	342	893
1994	407	212	227	427	372	144	594	392	388	275	390	467
1995	626	660	399	278	374	155	621	299	148	234	388	492
1996	406	947	174	439	412	211	561	494	153	349	347	618
1997	773	438	682	426	520	167	717	288	142	507	593	278
Total	17,089	15,746	13,305	7,937	11,070	3,773	7,401	8,656	5,473	6,965	8,309	14,521

Table 2.--Selected variables for monthly mackerel model
(thousands of pounds, live weight basis)
(1997 data may not be complete)

Year	Imports, live weight											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1977	5	50	4	22	1	13	10	3	9	11	2	17
1978	3	9	4	24	11	4	11	3	3	4	6	5
1979	3	3	4	3	12	4	11	9	5	2	17	9
1980	14	5	14	4	6	5	3	9	10	12	9	18
1981	39	6	2	7	3	21	7	6	1	8	16	9
1982	7	3	2	1	2	46	4	4	11	5	2	1
1983	6	2	2	1	15	4	19	1	1	11	5	8
1984	20	6	18	6	14	2	10	29	11	7	3	2
1985	6	7	7	17	11	18	7	4	9	1	1	2
1986	1	1	2	1	2	4	8	27	26	34	37	1,152
1987	84	4	10	6	1	6	48	25	17	5	67	17
1988	235	884	428	180	7	3	26	136	132	186	109	58
1989	14	50	139	5	2	4	7	241	33	73	67	125
1990	8	119	158	9	8	10	9	9	54	55	167	329
1991	491	262	57	40	25	178	67	43	2	18	4	397
1992	147	113	57	39	186	30	144	35	26	105	155	431
1993	687	1,162	444	405	71	38	113	241	60	105	412	651
1994	818	1,360	907	77	96	90	74	104	29	782	827	2,059
1995	1,132	1,758	1,256	417	20	232	41	120	85	133	1,421	1,881
1996	1,459	1,998	1,160	1,018	375	202	145	153	93	237	1,655	1,802
1997	1,237	1,015	950	234	147	100	116	13	31	208	348	403
Total	6,417	8,814	5,626	2,517	1,019	1,015	879	1,216	647	2,001	5,330	9,373

Table 2.--Selected variables for monthly mackerel model
(thousands of pounds, live weight basis)
(1997 data may not be complete)

Year	U.S. consumption, live wt											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1977	2,287	2,514	1,938	228	151	156	244	311	177	246	307	97
1978	931	1,141	672	549	517	210	151	275	142	165	212	49
1979	396	1,704	673	210	522	263	193	386	112	242	192	70
1980	1,026	1,016	1,185	331	578	203	168	582	459	329	433	86
1981	1,416	1,796	1,557	330	454	203	234	425	182	399	341	1,59
1982	1,588	650	1,531	444	1,093	234	382	585	273	405	554	59
1983	1,051	1,224	1,494	252	743	228	189	404	280	329	423	42
1984	1,020	767	387	175	342	164	193	418	292	293	315	97
1985	519	469	909	326	791	211	293	307	107	212	531	80
1986	728	1,285	473	379	618	142	307	505	366	427	339	1,49
1987	643	396	153	436	662	290	436	439	397	523	515	60
1988	298	921	524	1,004	810	145	273	519	402	496	612	92
1989	85	95	175	481	558	158	317	748	280	468	563	48
1990	798	166	387	470	515	176	331	411	394	377	759	99
1991	807	356	180	386	407	316	378	568	383	308	386	1,14
1992	986	236	207	404	414	242	698	427	395	709	436	1,28
1993	2,066	1,435	732	733	595	145	623	699	412	313	754	1,54
1994	1,225	1,572	1,134	504	468	234	668	496	417	1,057	1,217	2,52
1995	1,758	2,418	1,655	695	394	387	661	419	233	367	1,809	2,37
1996	1,865	2,945	1,334	1,457	788	413	706	647	246	586	2,002	2,41
1997	2,011	1,453	1,632	660	668	267	834	301	173	715	941	68
Total	23,505	24,560	18,931	10,454	12,089	4,788	8,280	9,872	6,120	8,966	13,640	23,89

Table 2.--Selected variables for monthly mackerel model
(Prices in 1992 cents per pound, live weight basis)
(1997 data may not be complete)

Year	SE exvessel price, KM-cero, 1992 cts/lb											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	De
1977	76	62	66	83	113	112	101	92	124	116	83	
1978	69	67	78	70	88	99	130	123	137	142	119	
1979	108	100	94	154	126	147	135	130	122	106	112	
1980	93	95	94	104	100	107	112	114	106	103	114	
1981	101	98	102	107	99	114	110	102	119	103	103	
1982	109	114	114	116	106	106	122	113	122	121	102	
1983	112	111	110	134	114	110	121	117	105	86	74	
1984	64	75	90	107	101	124	121	126	122	99	88	
1985	109	129	108	127	108	126	129	128	151	132	113	
1986	115	106	124	132	119	128	142	100	132	101	103	
1987	130	119	165	156	118	128	140	136	109	97	99	
1988	153	183	194	104	114	150	118	130	131	126	127	
1989	161	208	203	127	103	153	156	129	128	112	112	
1990	109	137	149	122	115	152	132	129	123	104	96	
1991	103	144	217	139	123	154	115	98	101	128	101	
1992	106	170	190	161	163	162	104	115	124	114	127	
1993	90	169	187	164	134	190	104	106	84	143	128	
1994	132	142	182	136	124	168	104	128	116	137	135	
1995	130	122	148	157	134	191	89	109	117	151	146	
1996	125	95	137	123	116	174	94	99	160	152	146	
1997	95	141	149	135	101	174	96	134	170	155	127	

Table 2.--Selected variables for monthly mackerel model
(Prices in 1992 cents per pound, live weight basis)
(1997 data may not be complete)

Year	Import price, 1992 cents/lb, live wt											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	De
1977	79	71	117	99	111	114	111	111	75	46	114	
1978	118	119	119	119	126	118	114	115	120	107	120	
1979	119	118	116	134	119	91	112	117	113	112	139	
1980	122	86	92	94	95	109	99	100	79	112	116	
1981	89	92	103	129	111	128	120	118	113	126	102	
1982	127	98	89	63	109	99	128	92	98	116	98	
1983	100	97	106	142	51	88	32	111	105	97	93	
1984	48	71	68	82	47	76	60	31	57	79	102	
1985	21	29	37	86	58	107	106	104	64	98	183	
1986	98	108	82	81	77	82	88	101	94	122	42	
1987	72	100	186	49	106	89	57	98	49	100	90	
1988	74	69	78	65	79	45	79	75	78	78	72	
1989	96	83	73	96	113	170	226	79	106	97	72	
1990	167	95	81	71	79	56	98	76	65	76	59	
1991	50	61	64	55	146	45	60	75	204	55	165	
1992	38	60	60	63	44	82	32	112	94	27	38	
1993	59	52	58	51	61	80	59	46	60	44	65	
1994	55	63	58	70	69	45	75	46	112	65	61	
1995	62	61	61	59	86	66	64	65	65	56	65	
1996	60	58	62	57	48	59	47	41	50	64	63	
1997	57	63	66	62	68	54	48	51	95	64	65	

Table 2.--Selected variables for monthly mackerel model
(thousands of pounds, live weight basis)
(1997 data may not be complete)

Year	SE landings, pink shrimp, live wt											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1977	851	896	2,146	6,015	4,389	1,706	1,184	779	952	1,302	2,808	2,901
1978	3,092	1,829	2,760	5,177	5,332	2,040	877	800	692	798	1,277	1,409
1979	3,035	2,804	2,770	2,747	2,729	1,604	987	999	691	1,959	1,784	1,815
1980	1,962	1,443	1,679	2,500	2,786	2,331	1,099	995	1,383	1,982	1,524	2,499
1981	2,669	1,521	4,598	6,169	4,740	2,763	1,262	877	1,368	1,456	1,836	1,652
1982	2,152	1,614	2,179	2,642	2,328	1,871	1,000	927	1,343	1,155	1,655	1,516
1983	1,645	1,525	2,354	3,509	4,263	2,811	1,196	702	1,012	1,366	1,284	1,296
1984	1,767	1,560	2,159	3,663	4,176	2,870	1,094	693	606	1,267	1,536	3,436
1985	3,434	2,843	2,367	3,392	2,516	1,705	887	747	1,434	1,837	2,381	3,312
1986	2,796	2,632	3,129	2,865	2,084	1,722	848	926	910	959	834	1,142
1987	1,787	1,676	1,759	2,293	2,035	2,294	914	791	1,014	1,345	2,054	1,835
1988	1,434	1,234	1,549	1,887	2,551	2,230	621	479	675	1,320	1,382	2,061
1989	2,162	2,054	2,101	1,989	2,284	1,947	628	354	412	776	1,202	1,299
1990	1,732	1,625	1,707	1,745	1,019	672	468	575	709	1,092	1,084	1,278
1991	1,439	1,424	1,425	1,688	2,134	1,487	357	437	557	529	954	1,104
1992	1,170	1,356	1,415	1,307	1,639	1,344	963	450	397	434	785	1,066
1993	1,231	1,181	1,616	1,889	2,539	2,046	733	527	616	726	1,562	2,132
1994	2,352	1,745	2,628	2,268	1,744	1,055	411	353	380	635	1,073	1,634
1995	2,281	1,884	2,250	2,721	2,000	2,145	1,271	872	1,099	1,570	2,834	1,947
1996	2,474	2,067	2,072	4,575	4,094	2,773	2,294	1,054	1,240	2,088	2,972	3,427
1997	3,613	3,673	4,090	3,370	4,110	3,284	1,486	1,074	1,342	2,151	2,063	2,825
Total	45,078	38,587	48,754	64,411	61,494	42,699	20,581	15,411	18,831	26,748	34,884	41,586

Table 2.--Selected variables for monthly mackerel model
(Prices in 1992 cents per pound, live weight basis)
(1997 data may not be complete)

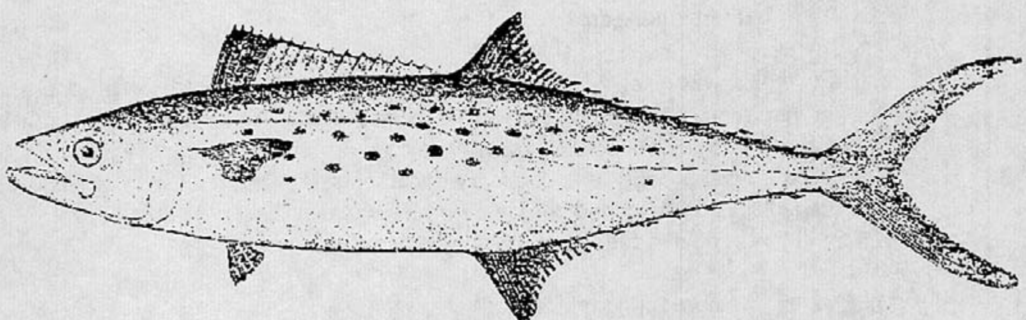
Year	SE exvessel price, pink shrimp 1992 cts/lb											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	De
1977	327	271	272	224	225	219	218	267	217	205	176	
1978	201	204	194	192	185	202	211	279	285	236	292	
1979	288	287	303	343	343	324	345	337	225	245	270	
1980	286	263	248	222	205	218	224	218	176	170	205	
1981	198	221	166	180	206	196	187	178	187	201	239	
1982	256	262	265	259	277	270	243	217	210	254	266	
1983	293	270	206	242	238	256	242	261	208	211	236	
1984	209	217	167	187	205	212	199	229	215	187	195	
1985	211	218	210	205	192	192	197	222	139	179	234	
1986	262	294	232	251	266	272	293	300	268	243	253	
1987	271	266	233	244	249	193	223	243	186	193	202	
1988	210	228	214	212	205	199	212	286	214	203	252	
1989	259	259	228	243	208	186	197	213	173	176	180	
1990	186	190	188	213	226	209	222	182	168	172	184	
1991	220	229	218	218	194	194	225	187	189	211	223	
1992	205	208	195	184	172	181	197	242	253	213	235	
1993	240	235	215	187	194	214	216	221	181	183	198	
1994	216	218	194	203	195	211	262	293	295	274	282	
1995	245	258	227	206	205	188	197	198	172	180	192	
1996	202	212	177	152	154	146	167	191	173	173	204	
1997	243	249	269	243	226	228	243	254	220	211	239	

Table 2.--Selected variables for monthly mackerel model
(billions of 1992 dollars, seasonally adjusted annual rate)

Year	US disposable income, saa, billion 92$											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1977	3,056	3,027	3,073	3,080	3,084	3,097	3,120	3,134	3,151	3,166	3,192	3,204
1978	3,194	3,216	3,250	3,265	3,266	3,266	3,278	3,291	3,297	3,319	3,327	3,343
1979	3,350	3,357	3,372	3,354	3,351	3,347	3,367	3,372	3,363	3,374	3,385	3,394
1980	3,424	3,405	3,380	3,350	3,331	3,334	3,364	3,364	3,380	3,415	3,429	3,453
1981	3,453	3,441	3,446	3,423	3,424	3,439	3,495	3,502	3,493	3,499	3,492	3,473
1982	3,454	3,459	3,467	3,520	3,508	3,482	3,499	3,494	3,490	3,497	3,508	3,516
1983	3,511	3,509	3,527	3,539	3,551	3,551	3,599	3,585	3,614	3,643	3,670	3,705
1984	3,731	3,765	3,792	3,823	3,827	3,854	3,870	3,896	3,921	3,892	3,911	3,918
1985	3,943	3,905	3,881	3,949	4,041	3,949	3,957	3,959	3,960	3,988	3,982	4,011
1986	4,022	4,038	4,075	4,078	4,078	4,075	4,094	4,098	4,096	4,086	4,087	4,095
1987	4,115	4,141	4,148	3,989	4,154	4,151	4,150	4,165	4,166	4,205	4,218	4,255
1988	4,272	4,307	4,311	4,283	4,307	4,327	4,336	4,337	4,337	4,353	4,354	4,379
1989	4,389	4,415	4,429	4,381	4,388	4,411	4,413	4,417	4,408	4,413	4,436	4,441
1990	4,473	4,487	4,489	4,508	4,492	4,501	4,519	4,495	4,497	4,467	4,466	4,481
1991	4,450	4,447	4,461	4,477	4,487	4,509	4,487	4,489	4,495	4,487	4,491	4,522
1992	4,539	4,565	4,572	4,581	4,593	4,601	4,590	4,583	4,601	4,622	4,634	4,781
1993	4,596	4,588	4,572	4,654	4,677	4,669	4,666	4,690	4,682	4,678	4,690	4,836
1994	4,645	4,697	4,709	4,716	4,787	4,779	4,787	4,791	4,808	4,845	4,844	4,867
1995	4,878	4,883	4,888	4,845	4,886	4,897	4,899	4,903	4,925	4,939	4,958	4,972
1996	4,964	5,002	5,010	4,970	5,028	5,057	5,058	5,075	5,085	5,076	5,088	5,102
1997	5,114	5,131	5,148	5,153	5,172	5,178	5,181	5,203	5,211	5,221	5,240	5,246

Appendix R. Research Activities Using the 1997-98 Southeast Recreational Economic Add-On Data (SERO-ECON-99-09)

Research Activities Using the 1997-98 Southeast Recreational Economic Add-On Data



Stephen G. Holiman, Ph.D.
National Marine Fisheries Service
Fisheries Economics Office

Prepared for the Gulf of Mexico Fishery Management Council Coastal Migratory Pelagics Fishery Socioeconomic Panel Meeting on April 15-16, 1999

SERO-ECON-99-09

RESEARCH ACTIVITIES USING THE 1997-98 SOUTHEAST RECREATIONAL ECONOMIC ADD-ON DATA

Stephen G. Holiman
NMFS, SERO
Prepared for the Gulf of Mexico Fishery Management Council
Coastal Migratory Pelagic Fishery
Socioeconomic Panel Meeting on April 15-16, 1999

This report summarizes the internal and external research activities using the 1997-98 Southeast recreational economic add-on data that have currently begun or are planned. The internal research activities are those activities that will be conducted by NMFS staff. The external research activities are those activities that will be conducted by non-NMFS researchers and include, but are not limited to, cooperative Federally funded projects. This report will include a description of the project and expected product, identification of the primary investigators, and the expected date of completion.

1. Internal Research Activities

Final data was received in October 1998. The survey covered recreational shore, charter and private/rental boat anglers in North Carolina through Louisiana from March 1997 through February 1999. Data summarization is now substantially complete. The data summarization exercise will produce two summary documents, the first consisting of socio-demographic variables and the second consisting of management/fishery related variables. Demand analysis will be conducted following the full data summarization.

A. Socio-demographic Data

The variables to be included in the socio-demographic document are (in no particular order) age, gender, ethnicity, Spanish origin, Spanish group, household income, fishing experience, fishing experience in the state intercepted, boat ownership, fishing license, expenditures, single-day vs. multi-day trip, number of days on trip, number of days fished, employment status, full vs. part time employment, and reason for unemployment. The data will be summarized by subregion, subregion by mode, subregion by state, and subregion by state and mode. The results of the first three levels of analysis will be presented in graphical form and the fourth level of analysis will be provided in tabular form as appendices. The report will additionally contain, as derived from supplementary data sources, 1986-97 time series estimates of total fishing participants, total angler trips, and total fish caught.

B. Fishery Management Data

The variables to be included in the fishery management document are (in no particular order) mode fished, primary target species, number of days fished in the past two months, number of days fished in the past two months with intercepted mode, number of days fished in the past two months and intercepted mode for primary target species, number of days fished in the past two months at the intercepted site, number of days fished in the past two months at the intercepted site and intercepted mode, number of days fished in the past two months at the intercepted site and mode and fishing for the primary target species, number of overnight trips in the past two months, fishing experience, fishing experience in the state intercepted, general target species, success expectations, reason for not targeting any species, fishing behavioral changes in response to management or fishing condition changes, response to zero bag limits for certain species, encounters with enforcement, preference for dolphin management, and preferences for reef fish management. The data will be summarized in a manner similar to that in the first document. The report will also contain, similar to the first document, 1986-97 time series estimates of total fishing participants, total angler trips, and total fish caught.

C. Demand Analysis

Upon completion of the data summaries, recreational demand analysis is planned to begin utilizing the contingent valuation questions (red snapper, king mackerel, and gag). Upon completion of this exercise, and possibly in conjunction of such as methodologies exist for simultaneous estimation of both models, initiation of travel cost modeling will begin covering those species or species groups not covered through current external efforts. The contingent valuation exercise is scheduled for completion after September 1999.

2. Data Distribution

As of 4/14/99, 15 copies of the 1997-98 Southeast Economic Add-on Data have been distributed. A full list of the recipients is included as an attachment. The list also contains a brief description of the intended use, as expressed by the requestee, of the data. The distribution list includes 1 Council, 5 universities, 6 state departments, 1 federal agency (NOS), and 1 consulting firm. Only two of the recipients are known with certainty to be actively using the data at this time (both in conjunction with Federally funded research projects).

3. External Research Activities

As noted in (2), the attached list of data recipients contains a brief description of the expected use of the data. The following presents expanded details of the two federally funded projects currently known to be actively using the data.

A. "An Assessment of the Recreational Demand for Gulf of Mexico Red Snapper", to be conducted by the Texas Agricultural Experiment Station under the direction of Dr. Teofilo Ozuna. This is a two-year MARFIN funded project begun January 1, 1999 with a 2-year project length. This project has the following objectives:

1. To determine the recreational demand for Gulf of Mexico red snapper.
2. To assess the effect of red snapper or substitute species regulations on the recreational demand for Gulf of Mexico red snapper.
3. To assess the effect of mode on the recreational demand for Gulf of Mexico red

snapper.
4. To ascertain whether the recreational demand for Gulf of Mexico red snapper is statistically different from the recreational demand of related species.

Status: This project will build upon red snapper recreational demand estimation conducted under the MARFIN Project "Shrimp Bycatch Reduction Impacts on the Shrimp and Red Snapper Harvesting Sectors in the Gulf of Mexico" under the direction of Dr. Wade L. Griffin and Dr. Teofilo Ozuna. This project was scheduled to be completed March 31, 1999. Problems in the modeling processes of the project were identified, however, during a February briefing, requiring additional programming adjustments. These adjustments are understood to be complete and a draft final report is expected to be available soon for review by NMFS. A final report should be available by June 1999. No further current communications have been received specifically with respect to the latest project.

B. "The Economic Value of Marine Recreational Fishing in the Southeast United States 1997-1998 Southeast Economic Data Analysis", to be conducted by East Carolina University under the direction of Dr. Timothy C. Haab. This is a one-year project begun October 1, 1998 and is scheduled to be completed in one year. The project has the following objectives:

1. To estimate the total value of access to marine recreational fisheries in the Southeast (North Carolina - Louisiana) by state, wave, fishing mode, and species/species group.
2. To estimate the change in value associated with changes in fishery conditions and policy.
3. To determine required modifications for future data collection and analysis.

Status: Dr. John Whitehead (co-PI) visited the SERO on March 18 and provided a status report. The discussion focused on data summary efforts, trial regressions (catch, trips, etc.) and species groupings were discussed. The project was felt to be approximately on schedule by the investigators.

1997/98 SOUTHEAST ECONOMIC ADD-ON DATA DISTRIBUTION LIST

10/1/98

3. Tim Haab
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East Carolina University
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John Whitehead
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RUM travel cost recreational demand modeling.

11/20/98

4. Bob Palmer
Florida Marine Fisheries Commission
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Data to be used for the development of ongoing economic assessments of marine fishery regulations in Florida.

11/24/98

5. Herb Holloway
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Used for comparison with results generated from data collected in Summer 1998. Expected report titled "Attitudes, Characteristics, and Expenditures of Louisiana Recreational Anglers", Summer 1999.

11/25/98

6. Tony Lamberte
Gulf of Mexico Fishery Management Council
The Commons at Rivergate
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Unspecified use.

11/30/98

7. E.Jane Luzar
101 Agricultural Administration Building
Department of Agricultural Economics and Agribusiness
Louisiana State University
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225-388-2763
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Conducting expenditure analysis of coastal marine fishing activities.

12/3/98

6. Clark Evans
Georgia Department of Natural Resources
Coastal Resources Division
One Conservation Way
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Comparison with similar surveys conducted in Georgia (attitudinal survey 1997, participation survey 1994 and 1998). Comparison of expenditure data with data to be collected.

8. Rebecca R. Shortland
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Unspecified data assessment for Georgia recreational anglers.

12/21/98

9. Rob Hudson
Department of Environmental Protection

Florida Marine Research Institute
Division of Marine Resources
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Used for various non-specified research projects.

10. Mike Liffmann
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Used for ongoing outreach project as part of the Louisiana Sea Grant work with coastal tourism and recreation audiences.

11. Rahul Swani
Abt Associates Inc.
55 Wheeler Street
Cambrridge, MA 02138-1168
617-492-7100
Rahul_Swani@abtassoc.com

Assess the recreational fishing benefits associated with regulation of cooling water intake structures.

12. Raymond Palmquist
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James E. Easley
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Daniel Phaneuf
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Raleigh, NC 27695
919-515-4672
dan_phaneuf@ncsu.edu

Data exploration. Used to refine previous estimates of recreational demand, specifically species-specific demand and substitution-in-target-species effects.

13. William "Corky" Perret
Mississippi Department of Marine Resources
1141 Bayview Avenue, Suite 101
Biloxi, MS 39530
228-374-5000
jjewell@datasync.com (Joe Jewell)

Generic management assessment of red drum and spotted seatrout for Mississippi.

14. Skip Lazauski
Department of Conservation and Natural Resources
Alabama Marine Resources
P.O. Drawer 458
Gulf Shores, AL 36547
334-968-7576
hlazausk.amrdgs@gulftel.com

Summary of angler stats and profiles to compared Alabama with other states.

1/25/99

15. Dr. Semoon Chang
University of South Alabama
College of Business, Room 13
Mobile, AL 36688
334-460-6156
schang@jaguar1.usouthal.edu

Gathering data on coastal variables to be used in assessment of Mobile Bay National Estuary Program. Specifically interested in for-hire socio-econ data.

2/19/99

16. Dr. Teofilo Ozuna
Department of Agricultural Economics
Texas A&M University
College Station, TX 77843-2124
409-845-3225
tozuna@tamu.edu

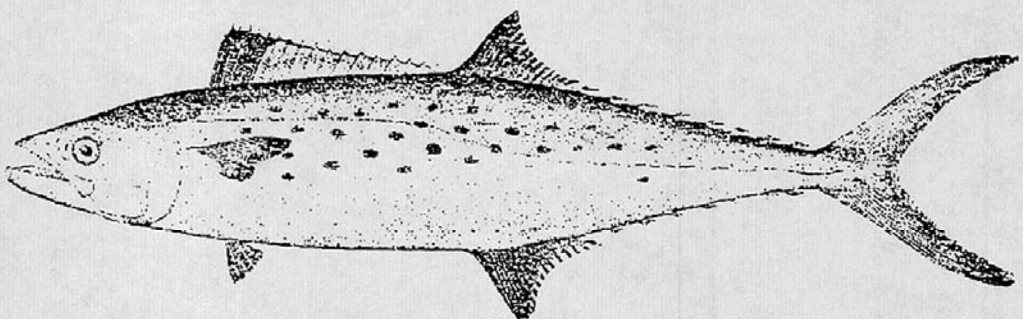
For use in ongoing MARFIN project to estimate red snapper and other species recreational demand curves.

3/1/99

17. Souleymane Diaby, Ph.D.
Statistics Section
NC Division of Marine Fisheries
P.O. Box 769
Morehead City, NC 28557
souleymane_diaby@mail.enr.state.nc.us
919-726-7021, ext. 285

Appendix S. Summary Report of Methods and Descriptive Statistics for the 1997-98 Southeast Region Marine Recreational Economics Survey (SERO-ECON-99-10)

Summary Report of Methods and Descriptive Statistics for the 1997-98 Southeast Region Marine Recreational Economics Survey



Stephen G. Holiman, Ph.D.
National Marine Fisheries Service
Fisheries Economics Office

Prepared for the Gulf of Mexico Fishery Management Council Coastal Migratory Pelagics Fishery Socioeconomic Panel Meeting on April 15-16, 1999

SERO-ECON-99-10

SUMMARY REPORT OF METHODS AND DESCRIPTIVE STATISTICS

FOR THE

1997-98 SOUTHEAST REGION MARINE RECREATIONAL ECONOMICS SURVEY

STEPHEN G. HOLIMAN, PH.D.
FISHERIES ECONOMICS OFFICE
NMFS, ST. PETERSBURG, FL

PREPARED FOR THE GULF OF MEXICO FISHERY
MANAGEMENT COUNCIL COASTAL MIGRATORY PELAGIC FISHERY
SOCIOECONOMIC PANEL MEETING ON
APRIL 15-16, 1999

This document is intended to serve as a reference guide to the future contents of the summary report currently in preparation. It is being distributed to inform people of the types of information soon to be available and to support the development of independent lines of research and inquiry.

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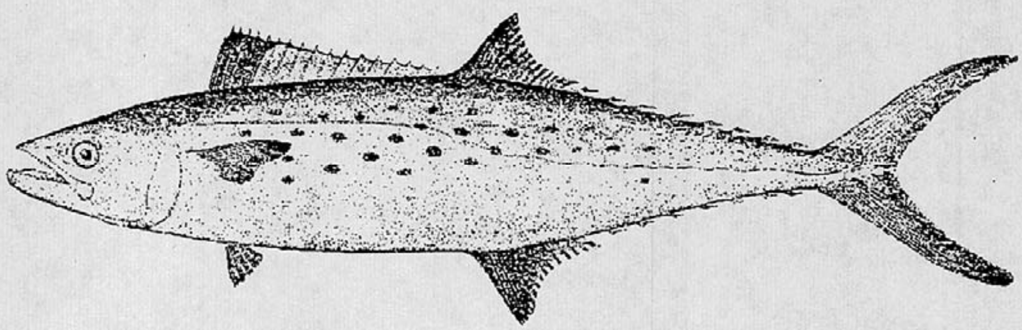
Summary Report of Methods and Descriptive Statistics for the 1997-98 Southeast Region Marine Recreational Economics Survey Fishery Management Data



Stephen G. Holiman, Ph.D.
National Marine Fisheries Service
Fisheries Economics Office

Prepared for the Gulf of Mexico Fishery Management Council Coastal Migratory Pelagics Fishery Socioeconomic Panel Meeting on April 15-16, 1999

SERO-ECON-99-11

SUMMARY REPORT OF METHODS AND DESCRIPTIVE STATISTICS

FOR THE

1997-98 SOUTHEAST REGION MARINE RECREATIONAL ECONOMICS SURVEY

FISHERY MANAGEMENT DATA

STEPHEN G. HOLIMAN, PH.D.
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PREPARED FOR THE GULF OF MEXICO FISHERY MANAGEMENT COUNCIL COASTAL MIGRATORY PELAGIC FISHERY SOCIOECONOMIC PANEL MEETING ON APRIL 15-16, 1999

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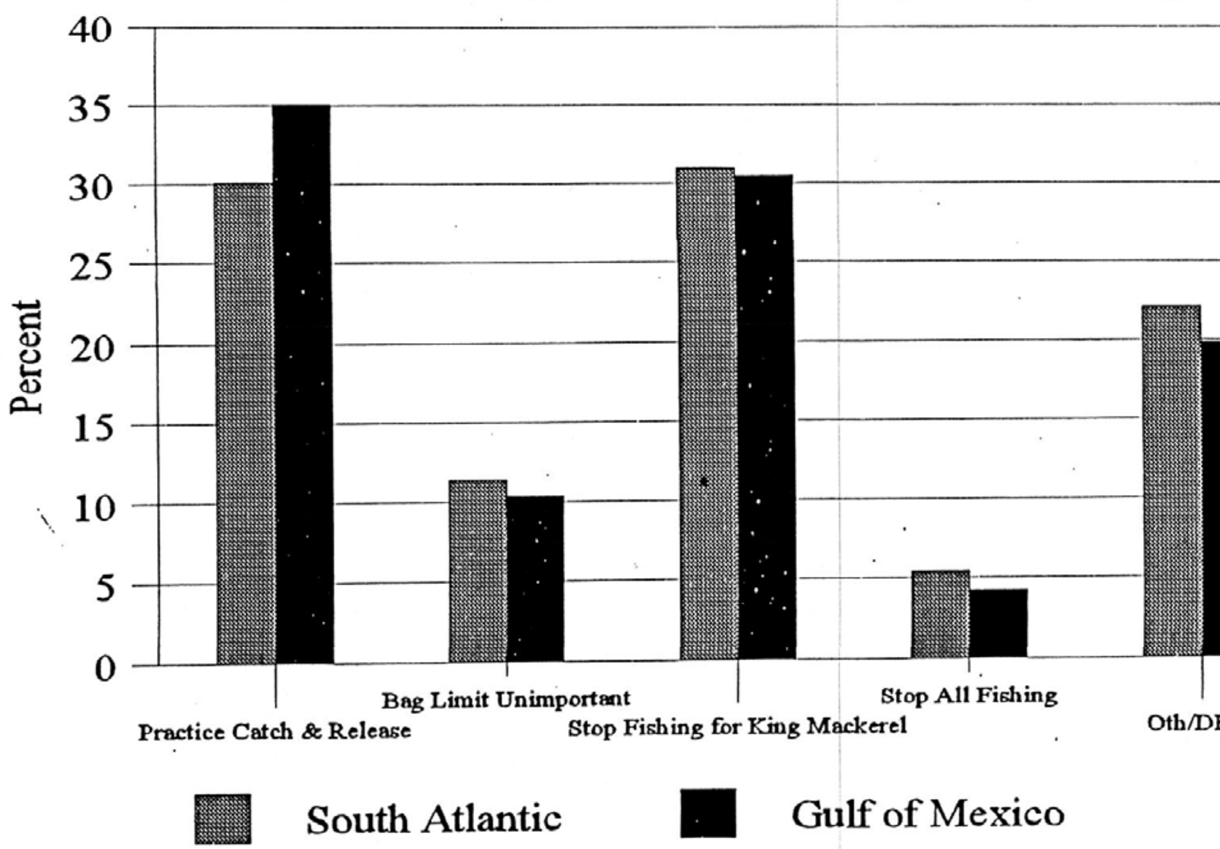

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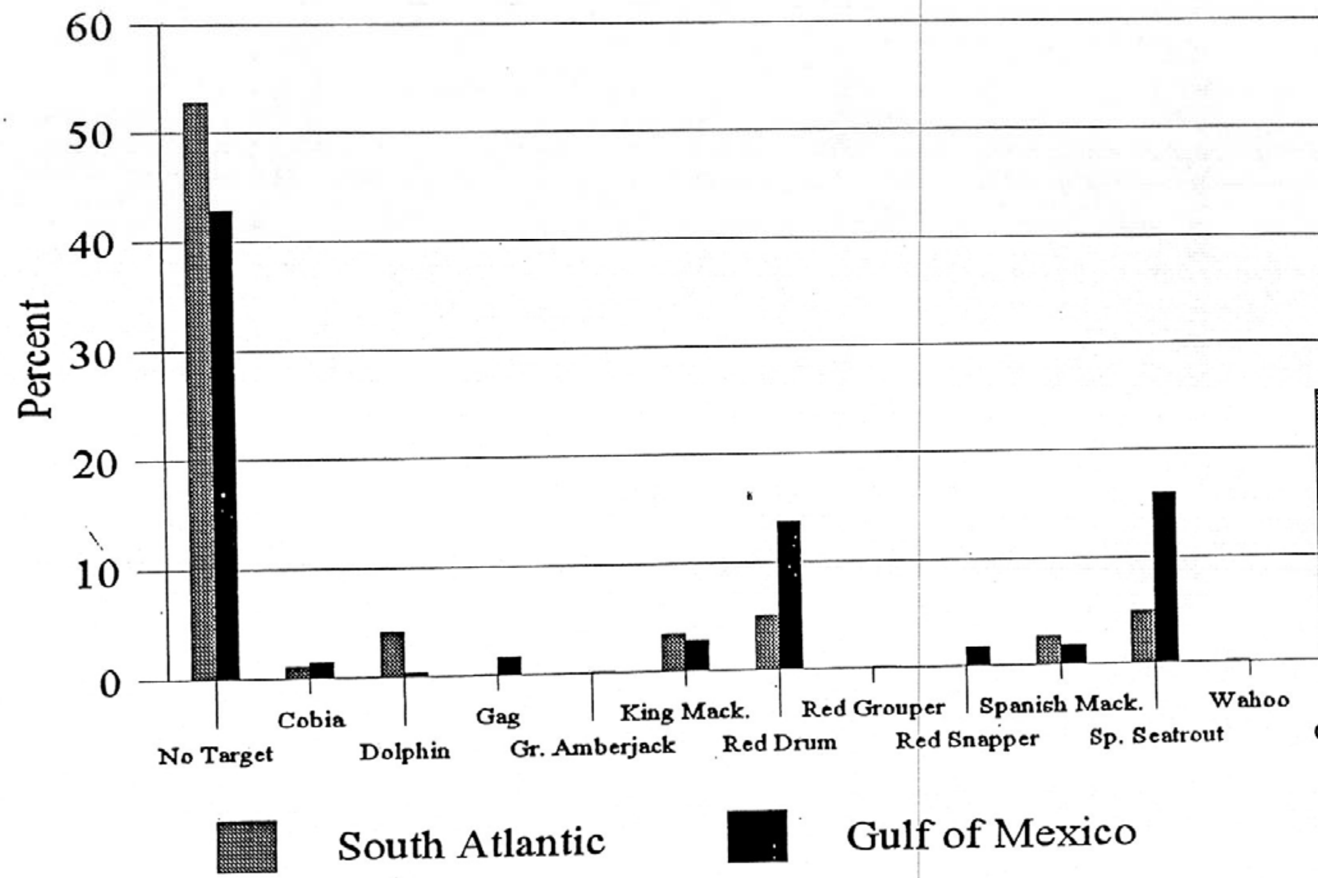

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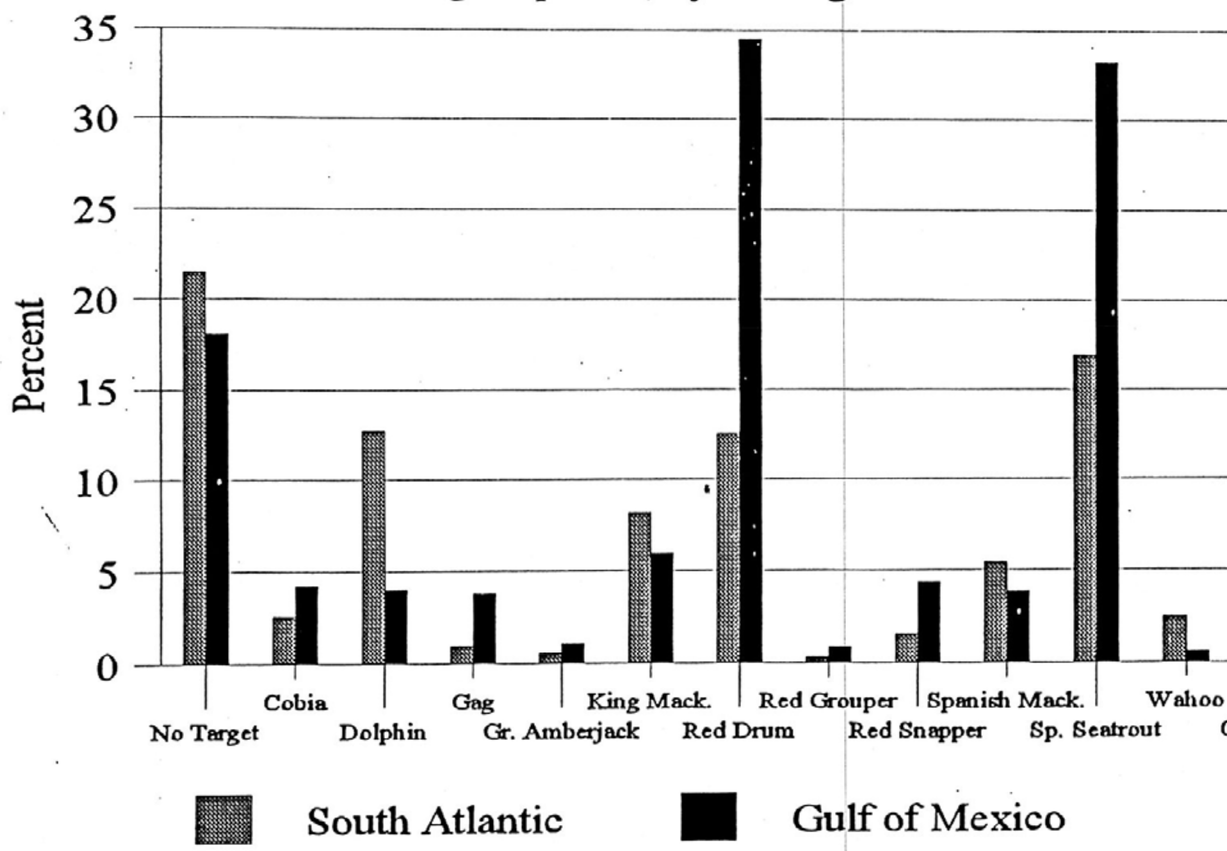

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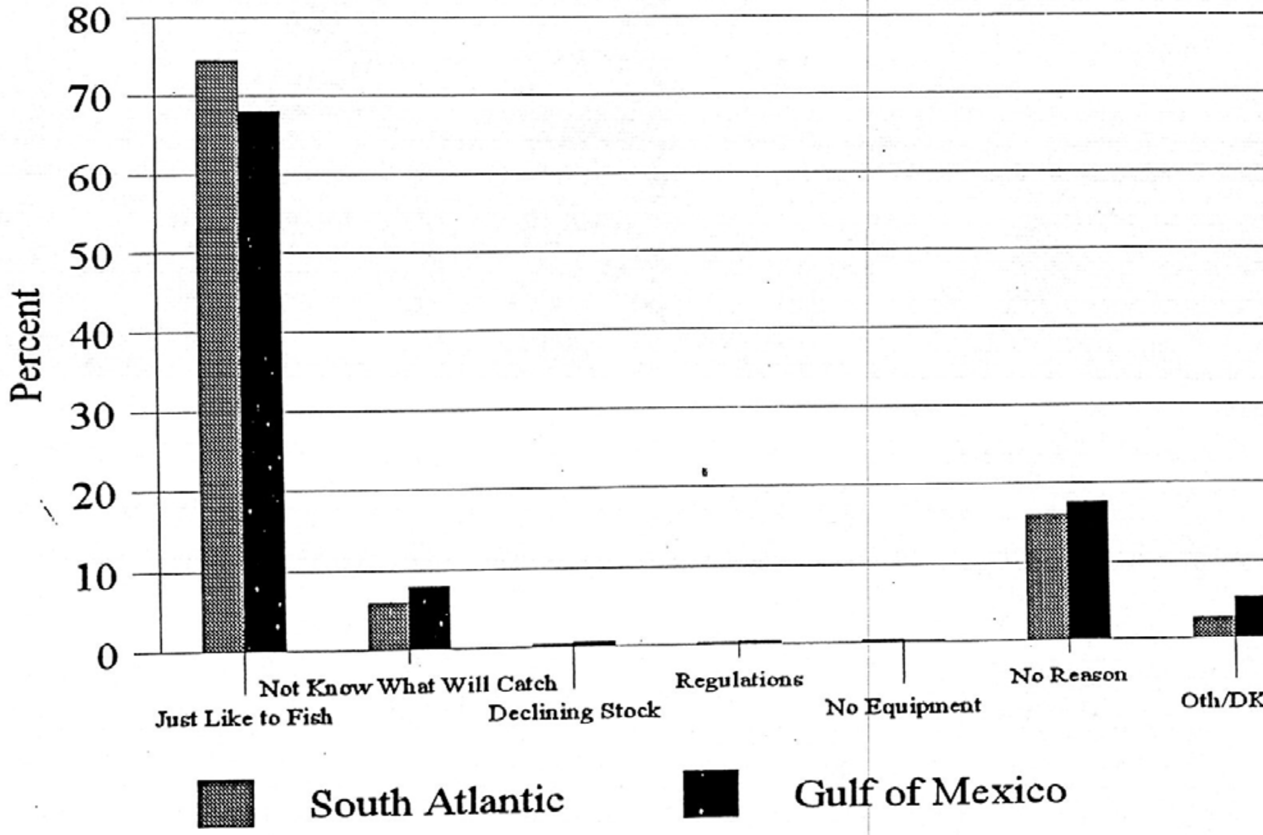

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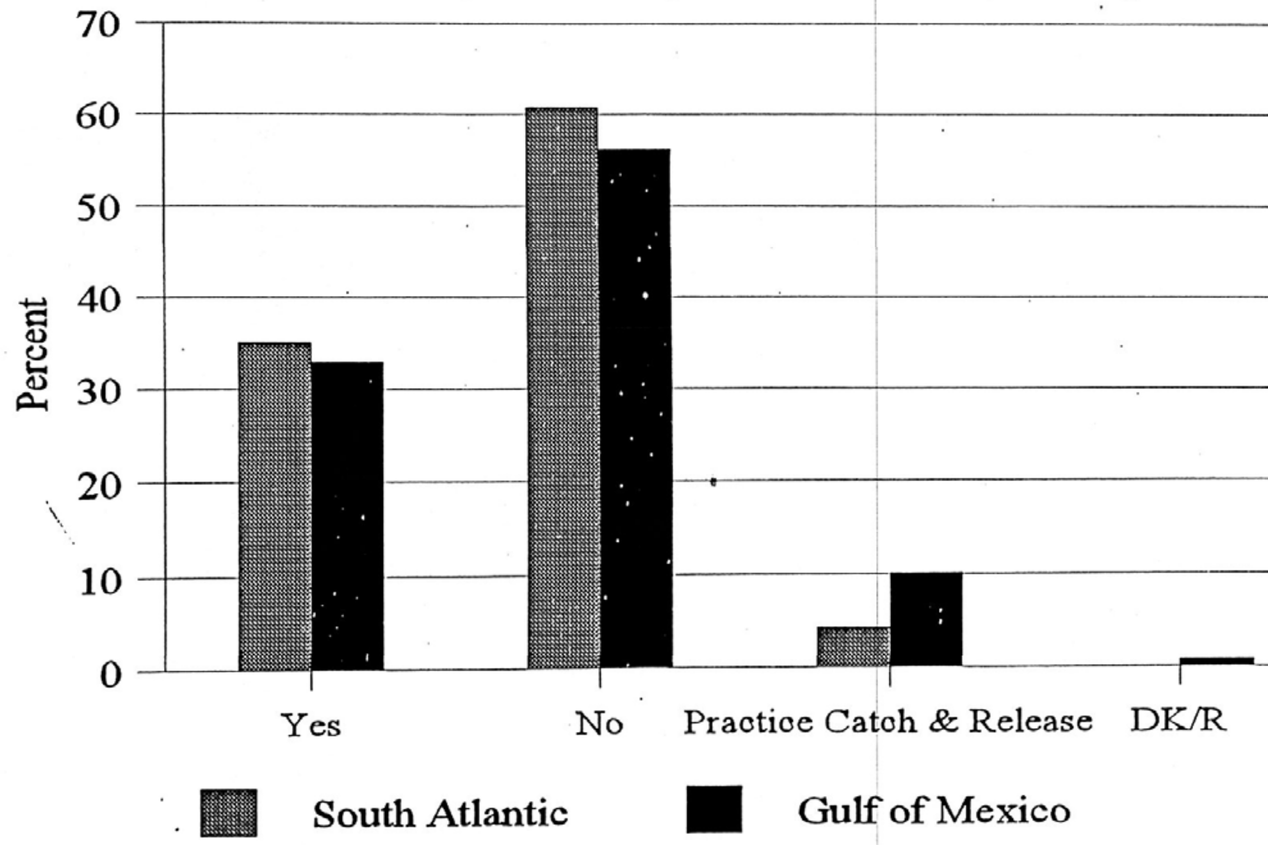

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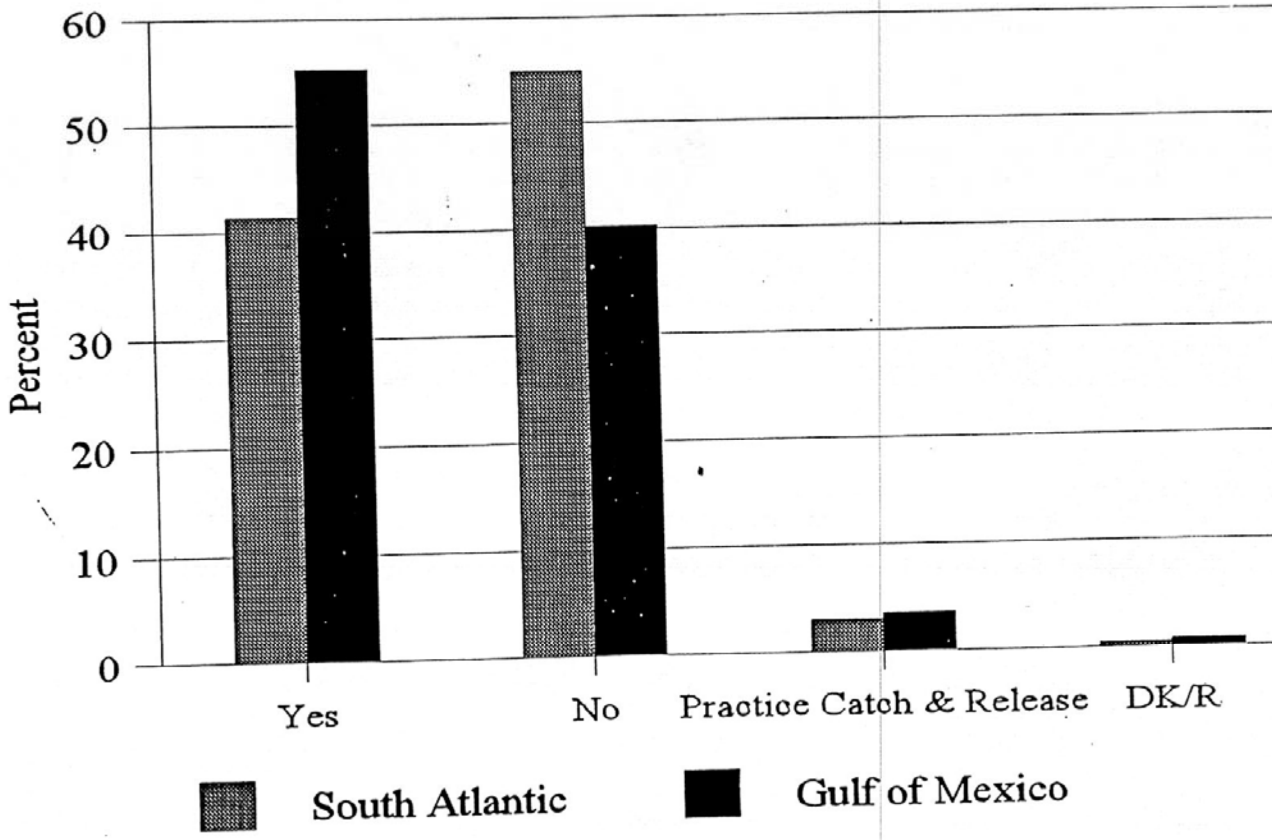

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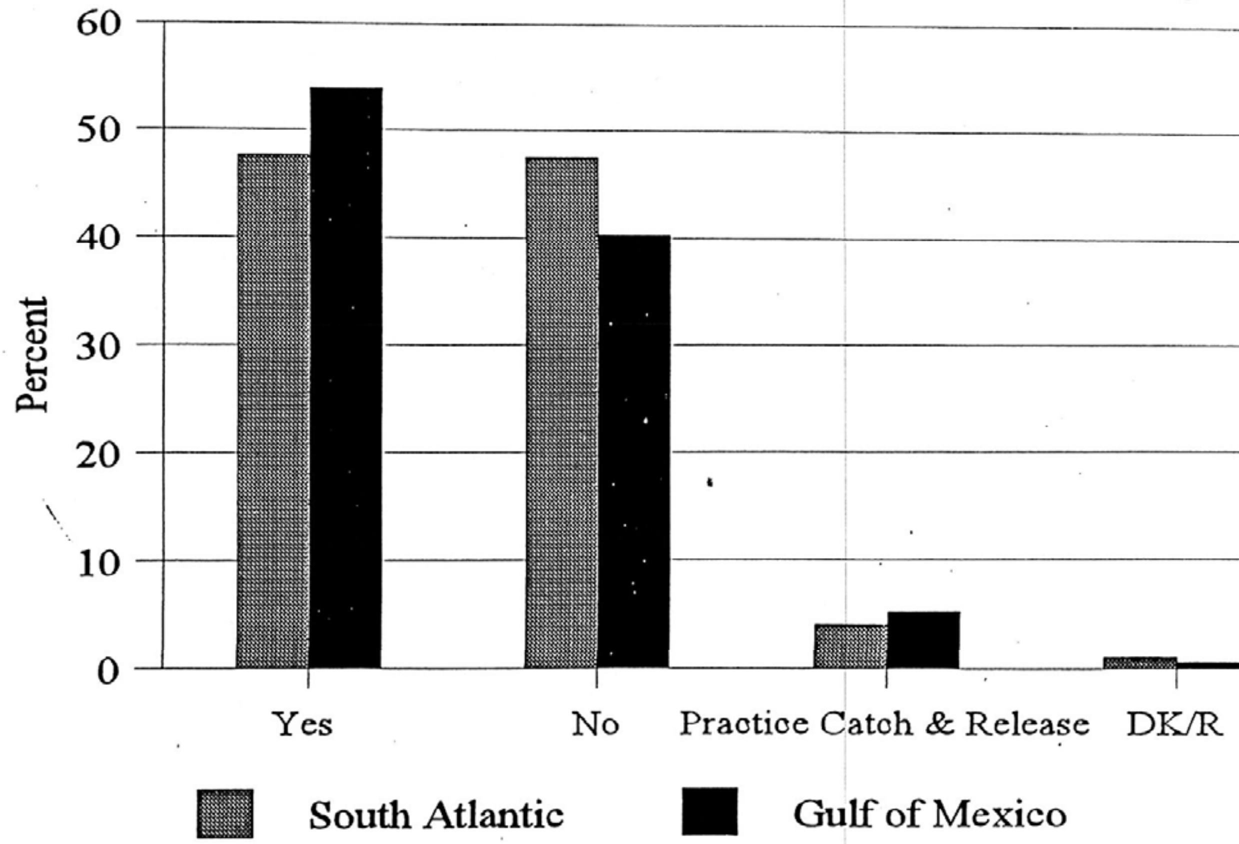

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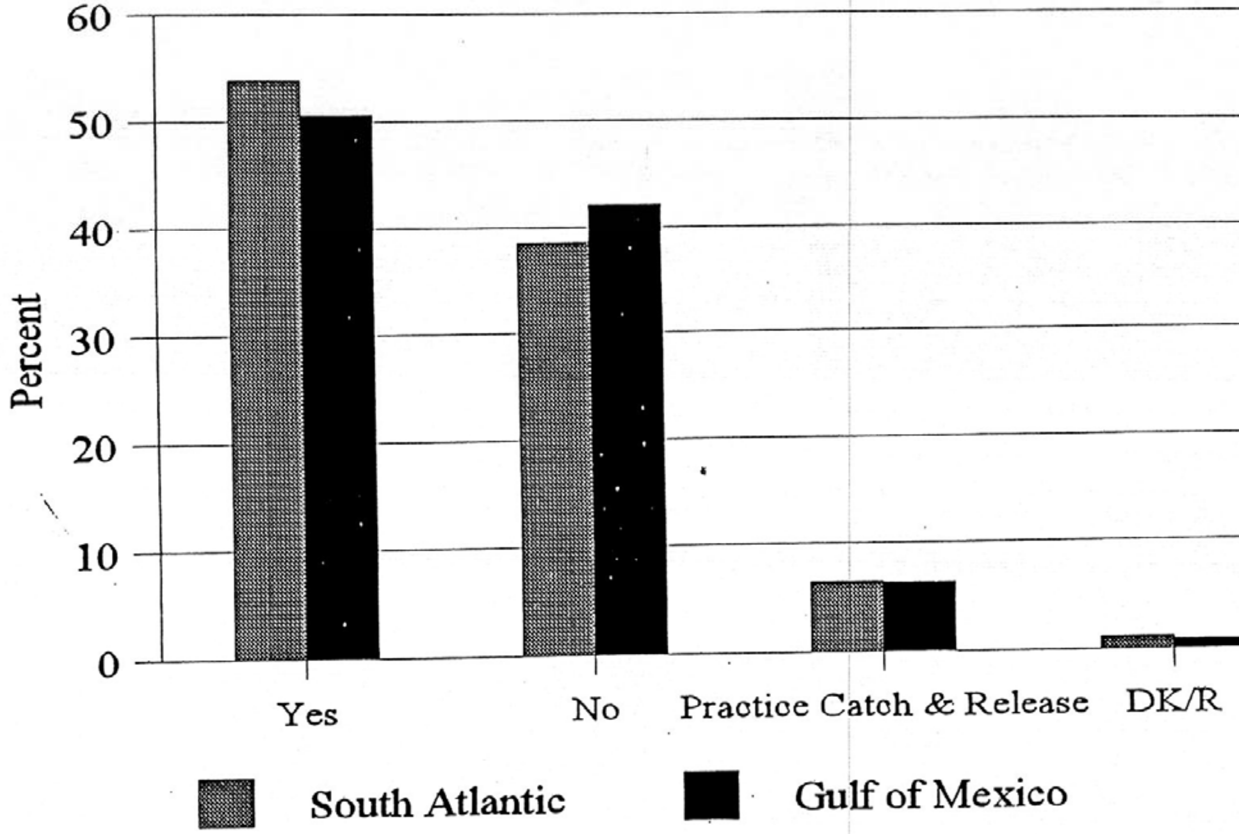

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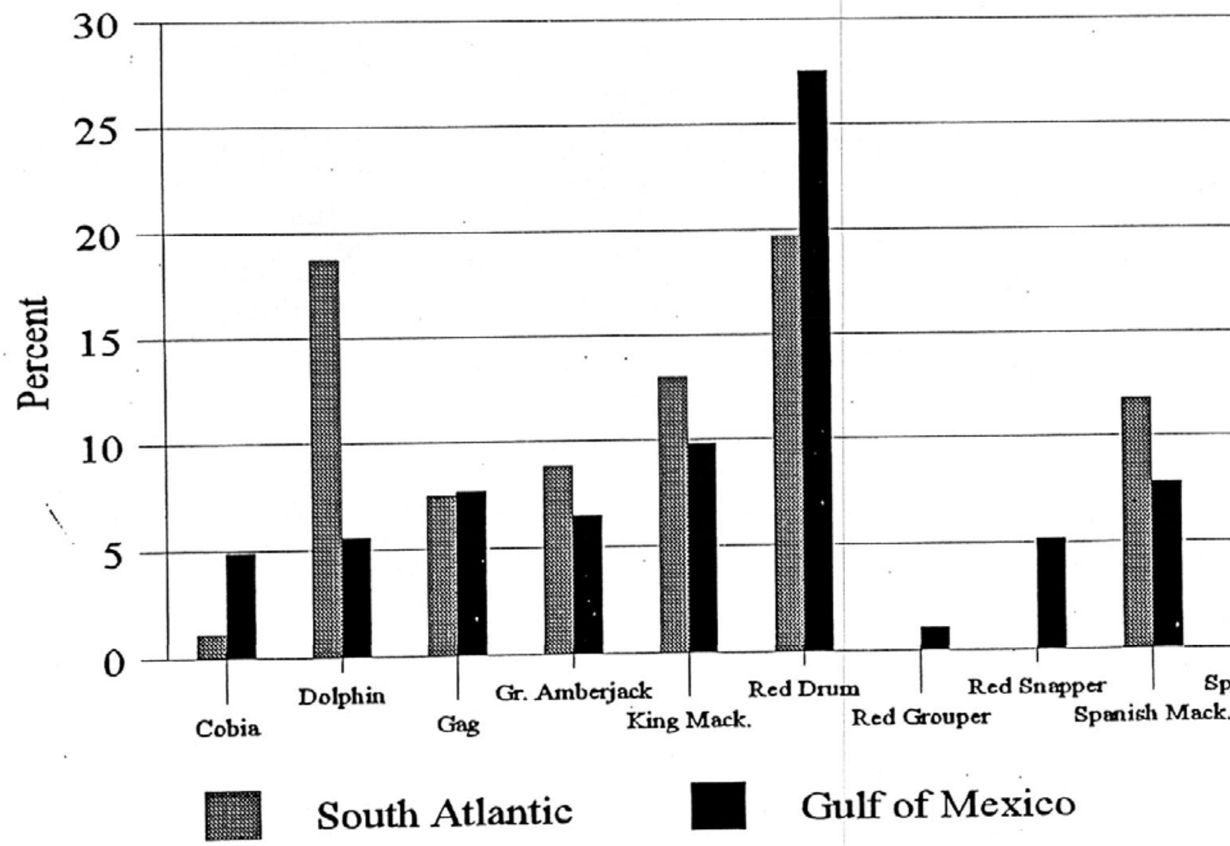

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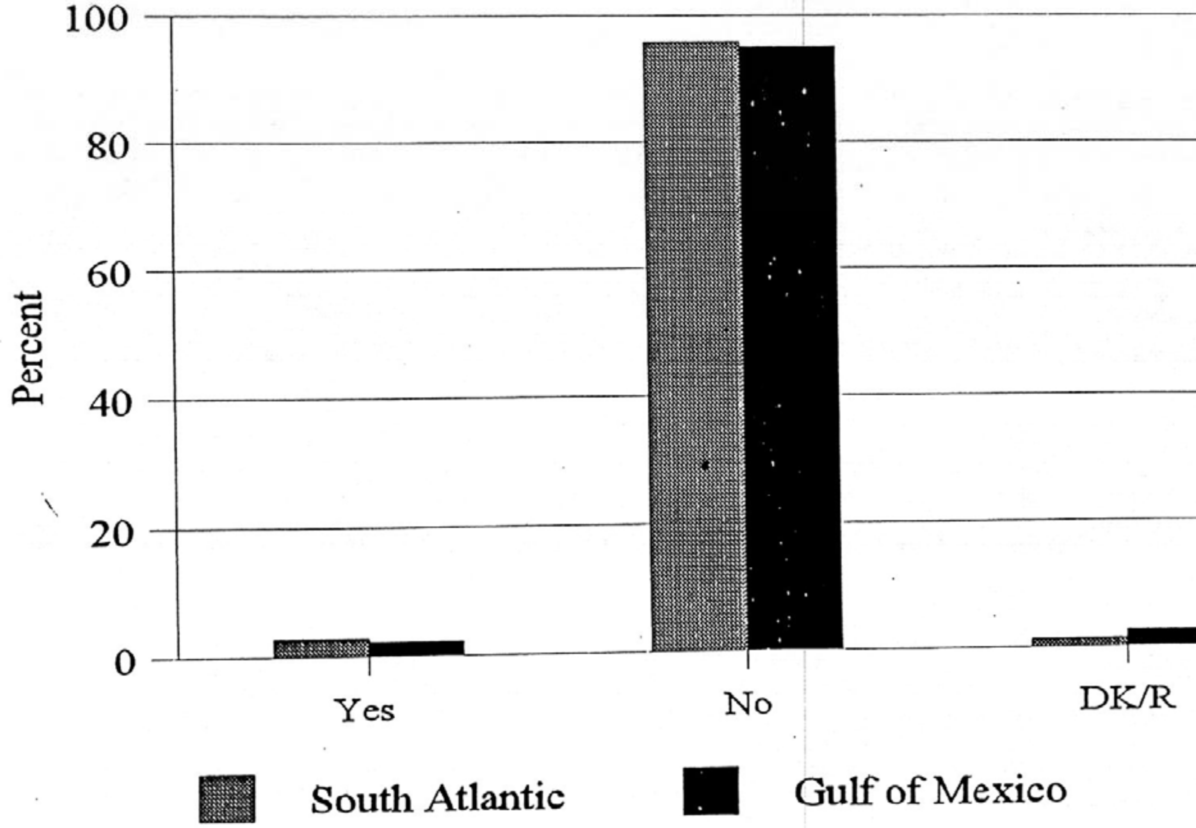

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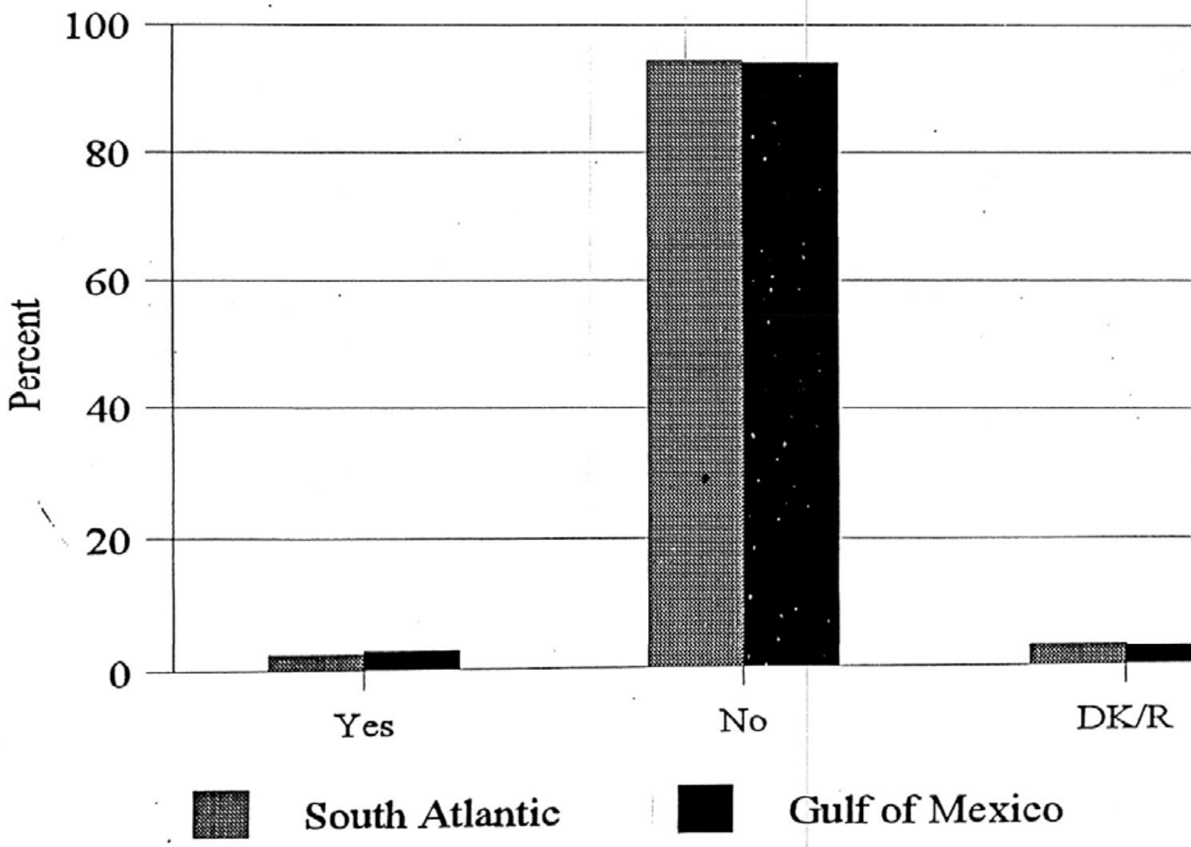

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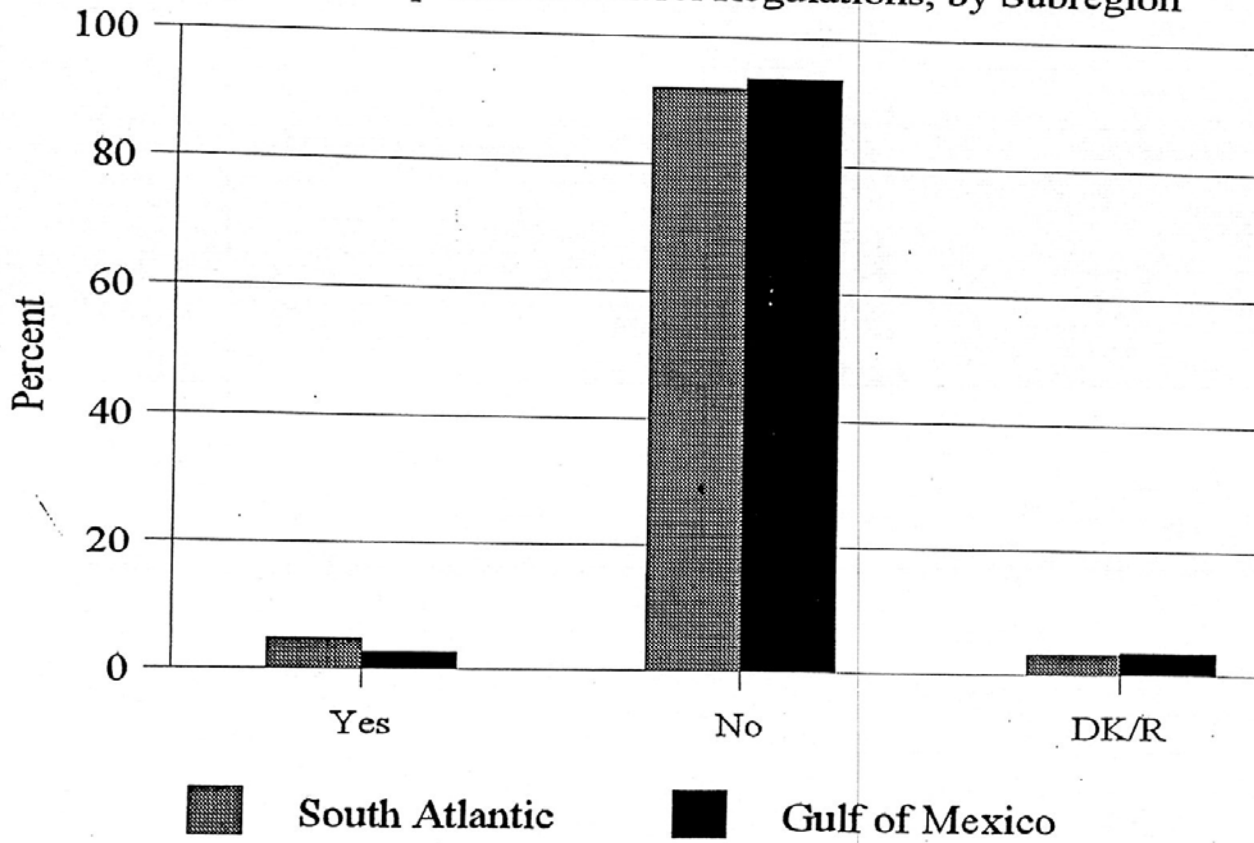

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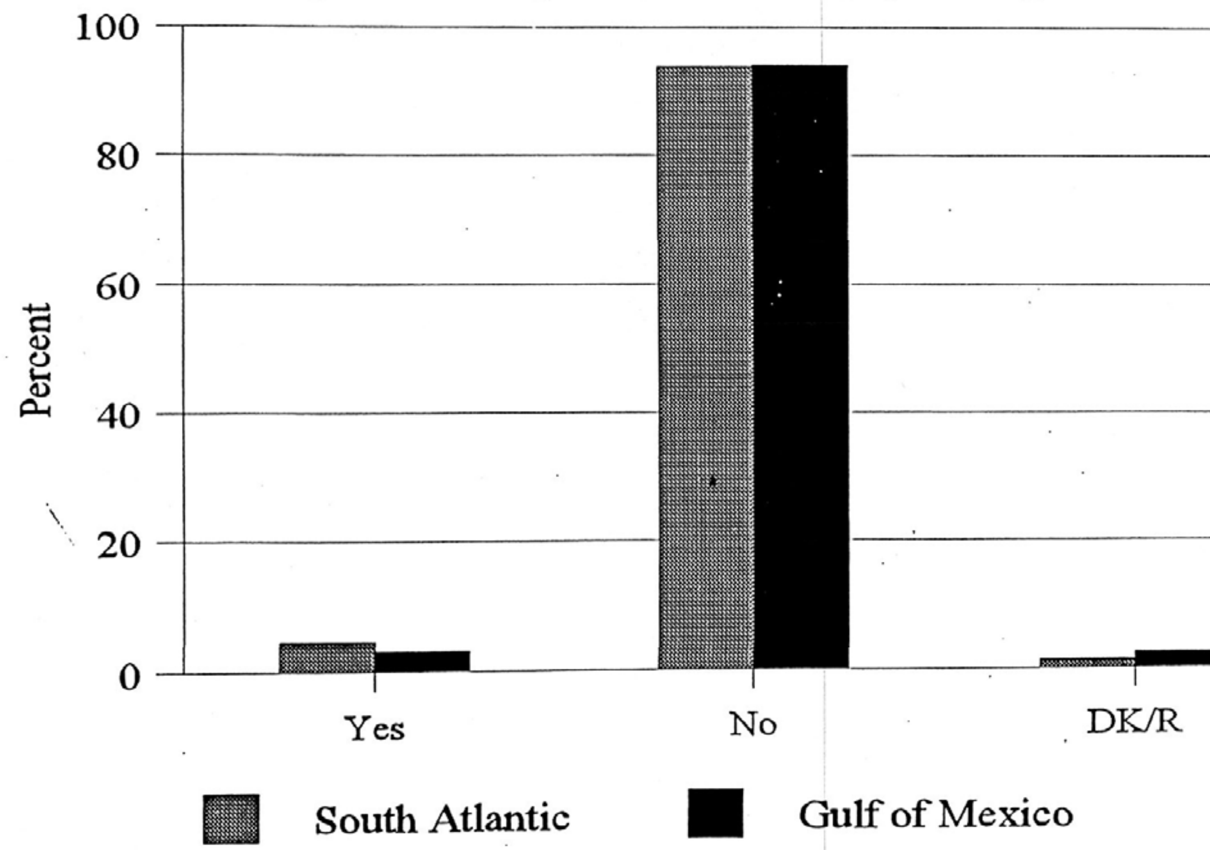

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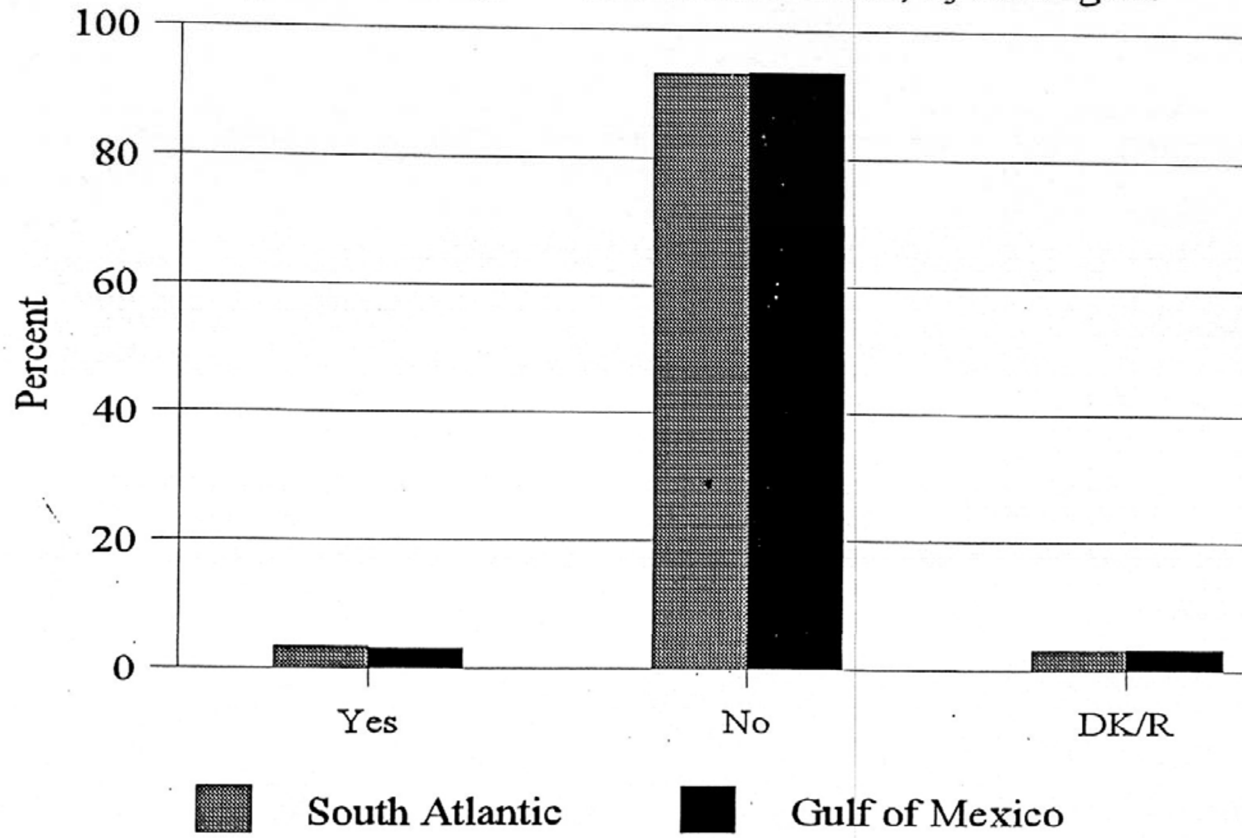

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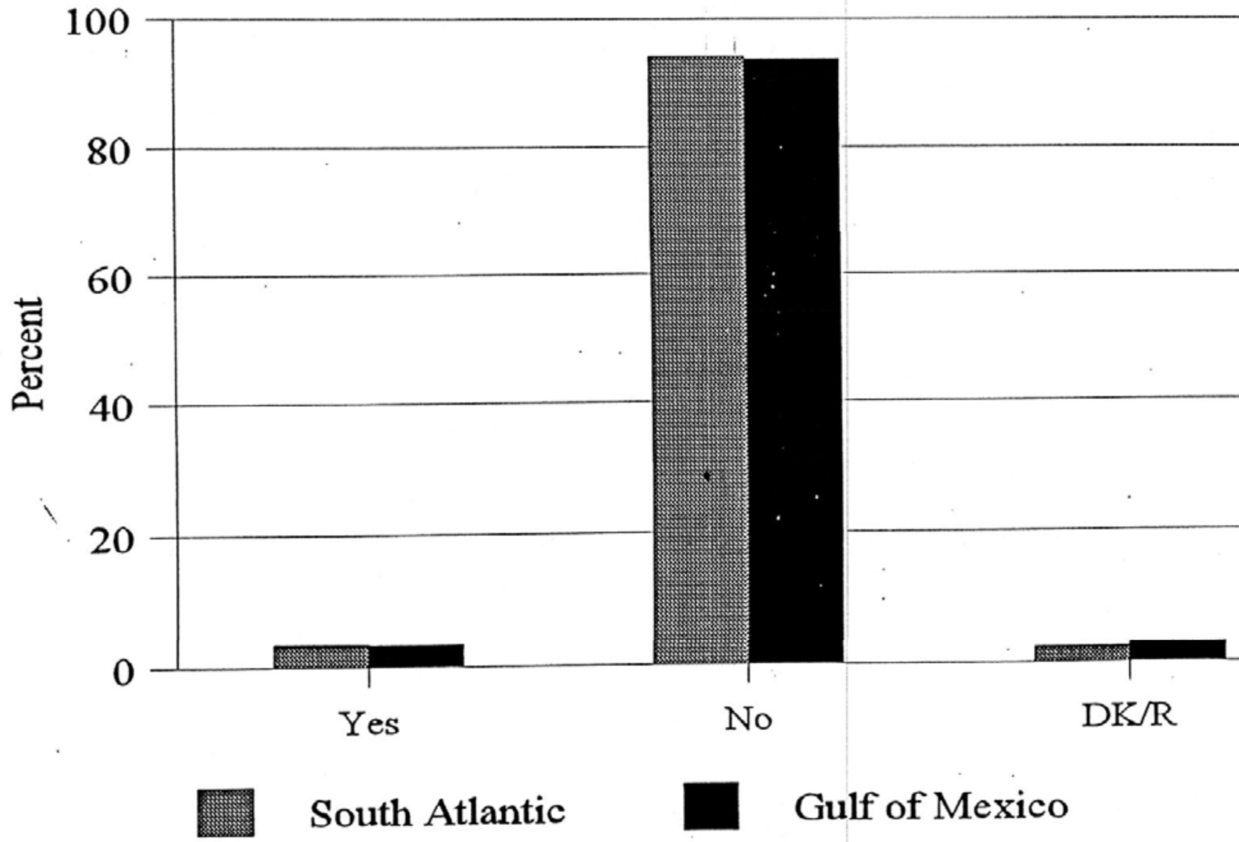

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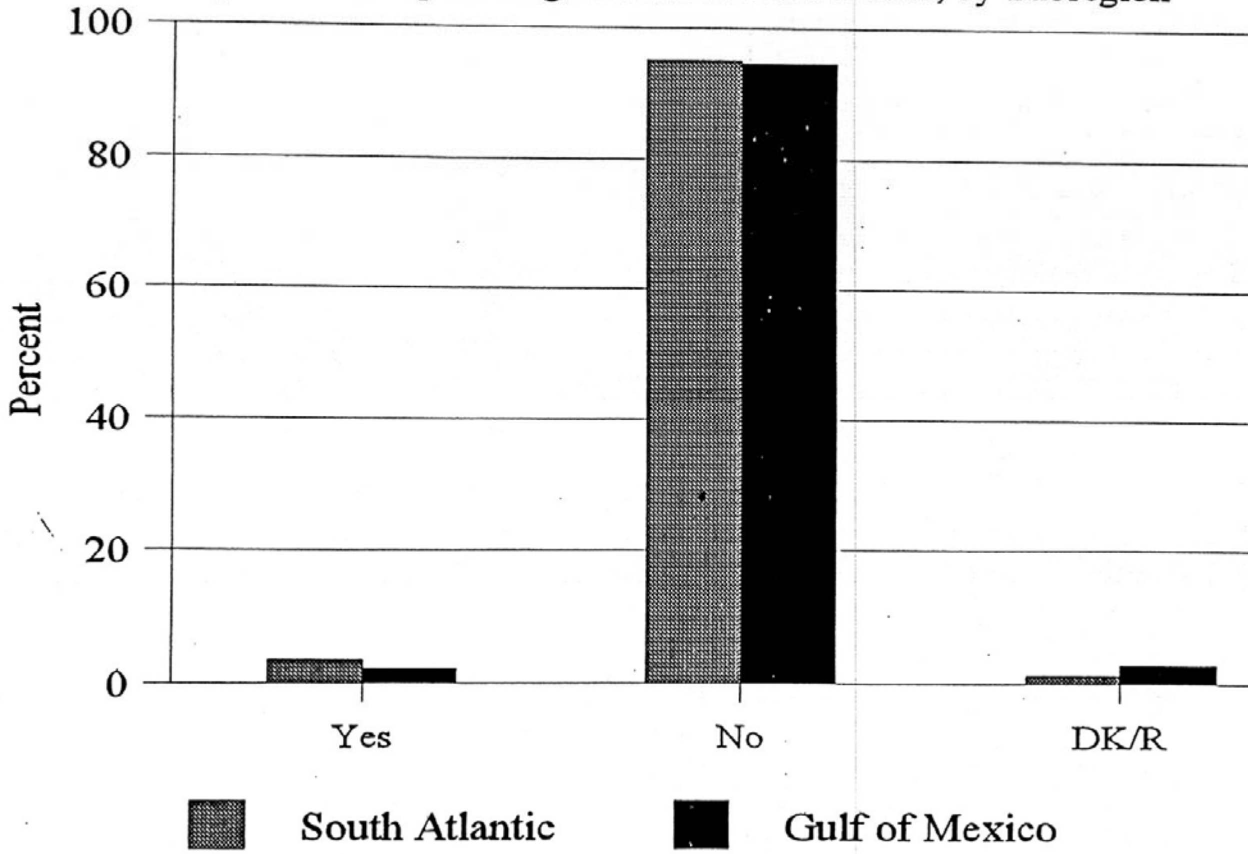

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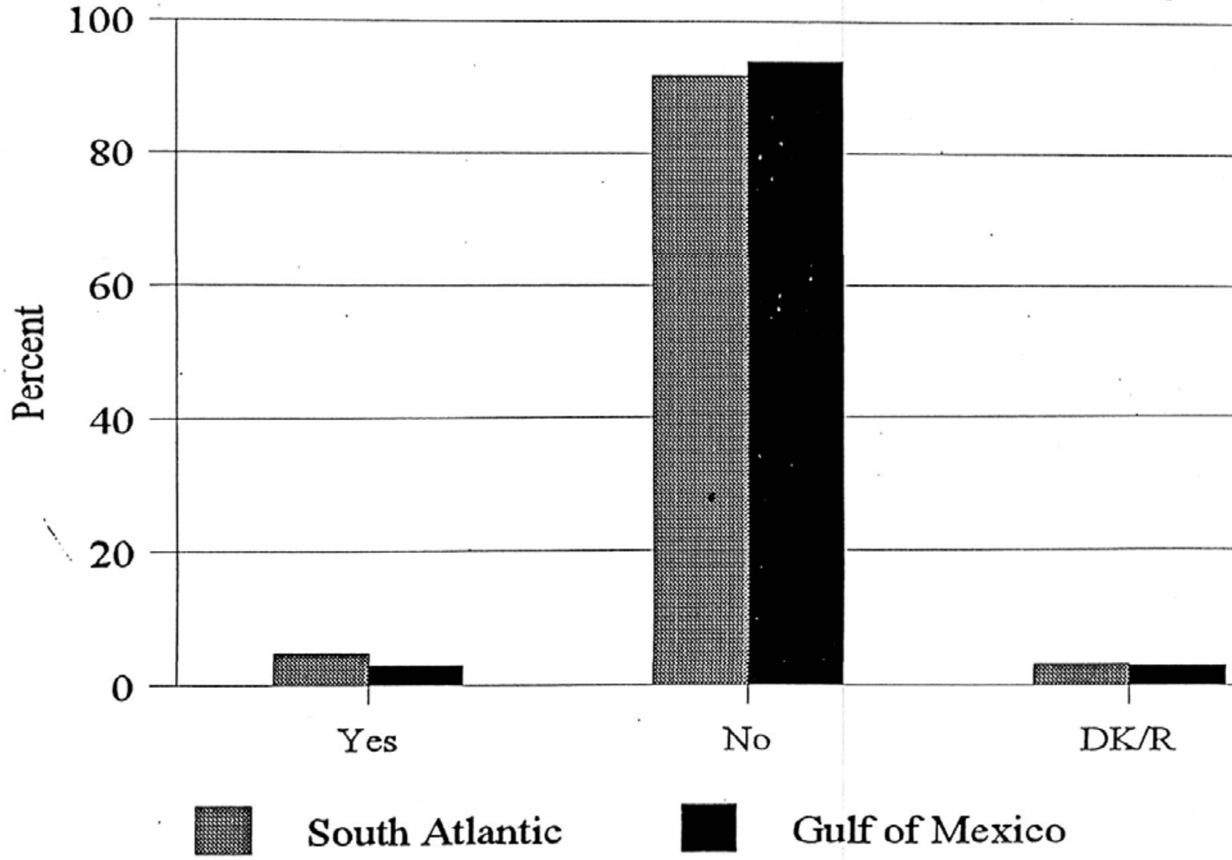

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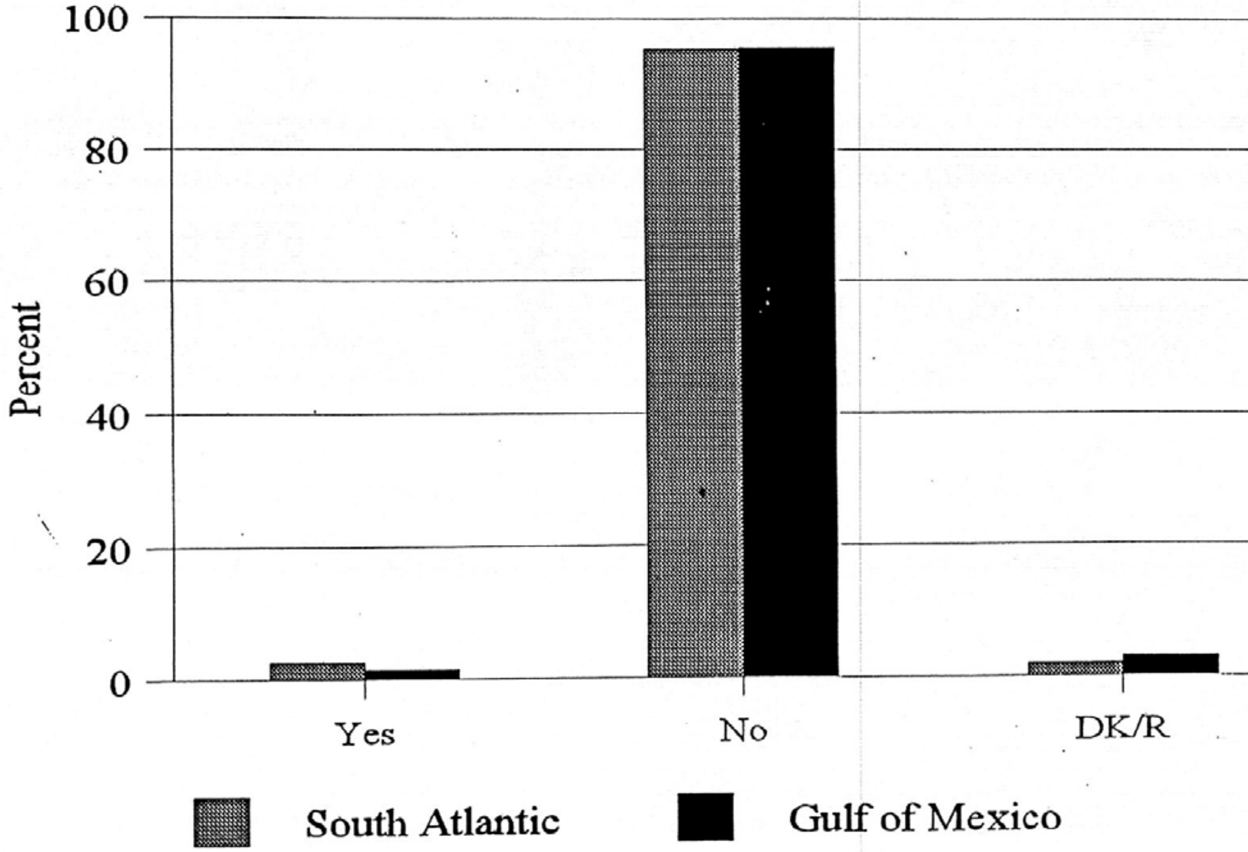

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