Estimation of king mackerel bycatch in the shrimp trawl fishery in the US Gulf of Mexico (GOM) and South Atlantic (SA)

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Summary

Shrimp bycatch estimates for the king mackerel assessment are required. For the GOM, observer data are available from 1972-2006. The mixing zone for king mackerel included shrimp zones 1 and 2. Zones 1 and 2 have observer coverage, but the occurrence of king mackerel data is very low. Effort data are available for the GOM from the NMFS-Galveston laboratory and from each state for the SA. Estimates of king mackerel bycatch in the shrimp fishery were calculated using a delta-GLM model. The catch rate derived from the delta-GLM was then scaled by the number of nets per vessel and the average effort for the entire GOM. The delta-lognormal model fit better than the delta-gamma method and bycatch estimates are provided. For the SA, no observer information was available, therefore an index was used as a proxy. The index is the SEAMAP shallow water trawl survey, and it is a very good proxy for shrimping considering the size of the king mackerel caught and the gear deployed. The state-specific effort is used to scale the SEAMAP index to derive a bycatch series for the SA. The mixing zone has very little data from the observer program and the SEAMAP survey does not gather data in this region. A very cursory bycatch estimate for the mixing zone is provided using the SEAMAP survey and the Florida-specific effort data, although, little confidence is placed in this estimate.

Background

Estimates of bycatch of king mackerel (*Scomberomorus cavalla*) are required for the 2008 stock assessment. The regions of interest for the assessment are the Gulf of Mexico (GOM, statistical zones 1-21) and the South Atlantic (SA, 24-35). For the purposes of this report, we focus on the king mackerel bycatch in the shrimp trawl fishery.

The Data

Gulf of Mexico (GOM)

The Shrimp Fishery Observer Program (Scott-Denton 2004)

NOAA Fisheries is conducting a multi-year shrimp trawl bycatch research program to identify and minimize the impacts of shrimp trawling on federally-managed species in the US Gulf of Mexico and southeastern Atlantic.

One component of the multi-year research program involves the deployment of fishery observers on commercial shrimping vessels. NOAA Fisheries and the Foundation began placing observers on commercial shrimp vessels in February 1992 to collect fishery-specific catch and BRD evaluation data. Other organizations including Texas Shrimp Association, North Carolina Division of Marine Fisheries, and Georgia Department of Natural Resources also placed observers.

Improvement in data to assess bycatch in the shrimp fishery, better shrimp effort estimates, statistically designed data collection programs to avoid opportunistic samplings, and non-reported landings are specific goals of the program. The observers are needed on all vessels involved with the fishery to quantify catch and associated bycatch, and release mortality of bony fish.

In May 1998, the NOAA Fisheries component of the regional observer program intensified coverage of the shrimp fishery operating in the western Gulf of Mexico. This increased effort was in response to Gulf Council's recommendation to maintain the 1998 red snapper TAC of 9.12 million pounds. The Gulf Council based this decision on the 1998 proposed legislation that mandatory BRDs in the shrimp fishery should reduce red snapper mortality by 60%. Through legislative measures in May 1998, mandatory BRDs (Amendment 9 to Gulf shrimp FMP), observers, logbooks and vessel monitoring systems (VMS) units were required for the western Gulf of Mexico shrimp fishery. Efforts to place observers, logbooks and VMS units on randomly-selected shrimp vessels were met with a high refusal rate from the fishing industry. Based on safety concerns and the lack of an enforcement mechanism for a non-permitted fishery, the mandatory observer program became a voluntary charter program.

The commercial shrimp industry is the largest and most valuable fishery in the US southeast region, and until recently, one of only a few commercial fisheries not required to have a federal permit. Amendment 11 to the Gulf shrimp FMP required all commercial shrimp vessels operating in federal waters of the Gulf of Mexico to obtain a renewable federal permit. That permit requirement became effective December 5, 2002.

Observers

Through a cooperative effort among several organizations, standardized observer training, sampling protocols, and data forms were established in 1992. A detailed description of at-sea collection methods and data requirements are presented in NOAA Fisheries Galveston Laboratory's observer manual entitled "Characterization of the US Gulf of Mexico and Southeastern Atlantic Otter Trawl and Bottom Reef Fish Fisheries" May 2002.

Vessel Selection

NOAA Fisheries-approved observers were placed year-round on cooperating shrimping vessels. Placement was based on vessel availability and current commercial effort trends by area and season. From February 1992 through May 1998 vessel operators were solicited to participate through phone and mail correspondence, port agents, and the Foundation. In May 1998, the NOAA Fisheries component of the program became mandatory following federal requirements for mandatory observer coverage, BRDs and VMS units in the Gulf of Mexico. Federal regulations in June 17, 1998, required vessels to have a current US Coast Guard (USCG) Safety Decal prior to taking an observer. Under the mandatory selection process, vessels were randomly selected based on the previous complete year of effort stratified by statistical area, depth and season. These data were derived from NOAA Fisheries shrimp landings file and cross-referenced with USCG documentation records. This yielded a list of active vessels with owner names and addresses. Port agents, when possible, obtained the contact informationfor selected vessels; the Internet was also used. Efforts to place observers randomly, through mandatory measures, were met with a high rate of refusal from industry. Observer safety, inadequate sleeping facilities, liability insurance concerns, combined with the lack of an enforcement mechanism for a non-permitted fishery, ultimately resulted in the program becoming a voluntary charter program in June 1998. Since that time, efforts to randomize the selection of charter vessels have been based on selecting vessels from the previous complete year of shrimp effort as described above. Similarly, port agents, when possible, provided owner contact information. In May 2003, a portion of the shrimp permit file (vessel name, documentation number, vessel owner's name and phone number) was obtained from SERO, and used to facilitate contacting selected vessels. Vessel operators who volunteered to participate were used if vessels, selected under the randomized process, were not available.

From the available vessel contact information, efforts were made to quantify and categorize recorded responses related to the random selection for the NOAA Fisheries component for Gulf of Mexico vessels from 1998 through 2003. Using recorded attempts, ten categories were established. From a list of approximately 315 randomly selected vessels, 21% were contacted by phone and a message was left; 18% did not have a phone, did not answer, reported a wrong phone number, or had a disconnected phone number; 17% did not have a federal shrimp permit as of May 2003; 13% expressed interest, but did not return the information package; 13% responded positively and took an observer; 6% used other types of gear or fished in non-federal waters; 5% each expressed no interest or could not speak English; and 1% each hung up, or had nonfunctional vessels. Collectively, throughout the study period (1992 through 2003), the majority of vessel operators volunteered to participate; vessel selection, for the most part, was non-random.

At-Sea Data Collection Methods

Vessel and Gear Characteristics

For all projects specific data relative to vessel and gear characteristics were recorded. Vessel length, hull construction material, gross tonnage, engine horsepower and crew size information were obtained for each vessel. Characteristics related to BRD, TED, net type and other associated gear were recorded at the start of each trip, or when changes were

made. For each tow, bottom time, vessel speed and operational aspects relative to each net were documented.

Bycatch Characterization

Onboard data collection for the purpose of bycatch characterization consisted of sampling trawl catches taken from commercial shrimp vessels operating in the US Gulf of Mexico and south Atlantic. The first characterization trips occurred in April 1992 in the Gulf of Mexico, and in June 1992 off the east coast. Fishery-specific data were collected from one randomly-selected net for each tow. Nets trailing behind the try net were not selected for sampling. The catch from the selected net was placed into a partitioned area (e.g., separated from the catch from the remaining nets). The catch was then mixed to ensure randomness, shoveled into baskets, and a total weight obtained. A subsample (approximately 20% of the total catch weight) was processed for species composition. Species weight and number were obtained from the subsample. Length frequencies for 30 specimens were recorded for selected species.

Bycatch characterization efforts involved identifying all species in the subsample to species level. During modified characterization trips, 20 selected species of finfish, including king mackerel, were processed with the remaining subsamples grouped into one of the following categories: non-shrimp crustaceans, fish, other non-crustacean invertebrates, or debris (e.g., rocks, logs, trash).

Sampling Effort

Trips and Sea Days

Rick Hart at the Galveston Lab provided estimates of shrimping effort in the GOM, including the standard error (Figures 1 and 2).

Observer data summary

Data were provided by the NMFS-Galveston Laboratory. The data include tow- and trip-level data. They are divided into control tows and experimental tows, depending on the use of a Bycatch Reduction Device (BRD).

CPUE index

The Oregon II trawl is used as an additional source of survey data for the bycatch estimation. Walter Ingram provided the OII index for use in the analysis.

The South Atlantic (SA)

The shrimping effort data are maintained by the individual states. The shrimp fishery observer program is operated mainly by the National Marine Fisheries Service (NMFS) Galveston Laboratory, however there are very few data available in this region for analysis.

Shrimping Effort Data by State

North Carolina
The data are collected through the North Carolina Division of Marine Fisheries Trip Ticket Program. Since 1994, all of the seafood dealers in NC are required to submit trip tickets by state statute. The trip tickets report the species landed, waterbody fished, gear used, license information, and catch for each trip. Commercial fishermen can only sell their product legally to a licensed seafood dealer. In July 1999, the trip ticket program in NC modified its reporting procedures to be consistent with Atlantic Coastal Cooperative Statistics program (ACCSP) standards and started to collect data such as the trip start date.

South Carolina
The shrimp data housed in the South Atlantic Shrimp (SAS) database is a census of all shrimp landings in SC. The data are collected by the state of SC from seafood dealers in the form of trip tickets submitted monthly. The data are entered by South Carolina Department of Natural Resources (SCDNR) into their landings database, then reformatted and sent to the NMFS-SEFSC to be loaded in the NMFS database. The data collected include dealer number, date, state of landing, county of landing, area fished, gear used, shrimp species, shrimp size, number of trips by CG registered vessels, number of trips by vessels registered with the state only, vessel ID number, days fishing, pounds landed and price per pound. The data provided were a summary by year and month of trips by CG registered vessels and state registered vessels combined and the corresponding pounds of shrimp landed for 1999-2005.

Florida
In 1983, Florida Statute (FS) Chapter 370 established the Marine Resources Information System to conserve and manage Florida's marine fisheries. It required wholesale dealers to report each purchase of saltwater products from licensed commercial fishers on a monthly basis. Trip tickets are used to quantify commercial landings of fish and shellfish. Approximately 110,000,000 pounds of catch are reported on 260,000 trip tickets annually. From 1985-1989, the marine fisheries trip ticket required the following information: Saltwater Products License (SPL), dealer license, unloading date, time fished, county landed, number of nets, traps pulled, soak time, species code, and amount of catch. On the trip ticket, there were fields available for area fished, depth, unit price and dollar value, but the data were not yet mandatory. In 1990, gear fished and size code fields were added, and imprinters were required for recording SPL numbers. In January of 1995, area fished, depth, unit price and dollar value became mandatory fields.

Georgia
Coastal Resources Division's (CRD) Statistics Project is part of the Research and Surveys Program within the Marine Fisheries Section. Project staff is comprised of one full-time statistics coordinator and two full-time port agents. Historically, the project has been funded by the National Marine Fisheries Service (NMFS) Cooperative Statistics Program. In 1999, the project received additional funding through the Atlantic Coast Fisheries Cooperative Management Act (ACFCMA) to implement a commercial fisheries trip ticket program which would comply with the Atlantic Coastal Cooperative Statistics Program (ACCSP).

Commercial landings data are collected via trip tickets tailored to each fishery. These trip ticket forms are designed for specific fisheries in order to streamline and simplify the reporting process for the dealer and harvester. The Georgia Department of Natural Resources (GADNR) provides each seafood dealer with trip ticket forms and postage paid envelopes.

At the time a transaction occurs between a seafood dealer and harvester, a trip ticket must be completed. The harvester is obligated to supply the dealer with the required effort information and the dealer is responsible for providing the species, quantity, and value data. Ideally, the harvester should fill out the effort section of the form himself. The ticket, which is a four part NCR form, is separated with one copy for the dealer, one for the harvester, and two for the Department. These tickets are due to the Department by the 10th of the subsequent month; however, while the shrimp season is open dealers are encouraged to submit tickets semi-monthly thereby allowing us to avoid data entry bottlenecks at the beginning of each month.

It should be noted that space for recording Hazard Analysis Critical Control Point HACCP) related information has been included on Georgia's trip ticket forms. This was included at the request of dealers who wanted to use the forms to help them fulfill their HACCP data requirements. The Georgia Department of Natural Resources (GDNR) has no direct interest in this information nor is the Department a custodian of these data.

CPUE index
The SEAMAP shallow water trawl is used as an additional source of survey data for the bycatch estimation. Walter Ingram provided the SEAMAP index for use in the analysis.

Methods

For the GOM, similar to Ortiz (2000, 2002) we used a delta generalized linear model to estimate the index and then the total number of king mackerel caught as bycatch. The details can be found in the documents referenced above. Briefly, the concept of the delta-glm is a very intuitive one: first calculate the probability that the organism in question is encountered by the fishing vessel, and second, calculate the average catch of that organism given it is encountered during fishing. After the index is determined, calculate the bycatch in that year by multiplying the CPUE by the relevant fishing effort and the average number of nets used per vessel. The number of nets has changed over time, and is currently at an average of 3.1 nets used per vessel (Nichols 2004). For the SA, the SEAMAP shallow water trawl index is used as a proxy for the catch rate in the shrimping industry. The SEAMAP survey is described in S13-DW-01 and operates under similar conditions and in similar seasons to the shrimping industry in that region. Since the index is already standardized to a catch rate, the estimates are calculated by multiplying the catch rates by the state-specific effort. The number of nets per vessel is 2 in the survey, and as there is no better information to make a more informed estimate, 2 nets per vessel is used for the estimates in the SA.

Results

Shrimping effort data are available from the GOM and all four states in the SA region and are illustrated in Figures 1-8. Although observer and CPUE data may be available down to the per tow level for some states, the shrimping effort data were at the per trip level, therefore the expanded estimates are calculated at the per trip level. The AIC is 3096 for the lognormal model, and 3250 for the gamma model. Therefore the lognormal model is the better model for the data. Interactions were considered, but similarly to Ortiz (2002) no significant interactions were observed. The expanded estimates are provided for each state by year in the SA (Table 3). The indices for the GOM and the SA are shown in Figures 9-12, and the catch series for the GOM is shown in Table 2.

The mixing zone presented particular problems for estimating total bycatch in the region. The vast majority of observer effort is allocated to shrimping zones 1 and 2 which are located in the extreme western section of the mixing zone. Very few king mackerel are recorded in zones 1 and 2 and it is not a representative sample for the mixing zone as a whole. The nominal values from the observer program are listed in Table 5. The only estimate for the mixing zone is attained by applying the SEAMAP shallow water trawl index to the Florida county-specific effort data in the mixing zone. As the SEAMAP index does not cover this region, it is probably an inappropriate application of the index. It will be up for discussion within the commercial statistics working group.

Acknowledgements
Data and support were provided by Julie Califf (GA), Alan Bianchi (NC), Steve Brown (FL), Rick Hart (TX), Elizabeth Scott-Denton (Observer program), Jim Nance, Enric Cortés, and Dave Gloeckner (SC).

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Table 1. Summarized observed bycatch of king mackerel in the GOM shrimp trawl fishery.

Year	Number of king mackerel caught as bycatch in observed trips	Number of observed trips	Total trips
1972	45	644	-
1973	2	1219	-
1974	46	2013	-
1975	53	1875	-
1976	31	1945	-
1977	6	1561	-
1978	68	1363	-
1979	18	745	-
1980	5	1776	-
1981	133	1737	176726.8
1982	30	1552	173893.8
1983	0	1180	171310.7
1984	49	1455	191739
1985	12	661	196628.2
1986	3	434	226797.7
1987	24	395	241902.4
1988	20	417	205811.6
1989	137	420	221164.8
1990	77	493	211859.8
1991	116	488	223388.4
1992	157	476	216668.9
1993	730	500	204482
1994	542	477	195742.1
1995	459	435	176588.5
1996	56	464	189653
1997	54	433	207912.1
1998	75	1583	216998.6
1999	37	821	200474.7
2000	59	1946	192072.9
2001	72	3267	197644.4
2002	45	5200	206620.5
2003	144	2501	168135.5
2004	227	2985	146696.1
2005	20	2349	102839.8
2006	82	1883	92372.45

Table 2. The GOM king mackerel shrimp bycatch catch series.

Year	Numbers
1981	148925
1982	73007
1983	0
1984	409775
1985	286260
1986	132365
1987	645067
1988	558991
1989	1643210
1990	1250951
1991	1453860
1992	525262
1993	1653275
1994	1539115
1995	1858265
1996	686776
1997	1009554
1998	989183
1999	853640
2000	959050
2001	1795203
2002	942965
2003	2584018
2004	2554041
2005	488343
2006	1031632

Table 3. The estimates for king mackerel bycatch in the south Atlantic shrimp trawl fishery. The red values are taken from the South Atlantic Shrimping System. The blue values are derived by taking the geometric mean of the previous 4 years because it was a missing year.

SA estimates					
Year	SC	NC	FL no mix	GA	Total
1989	55,336	25,547	26,894	88,398	196,175
1990	154,851	41,567	33,680	210,877	440,976
1991	54,455	12,530	23,860	85,348	176,193
1992	90,674	7,003	20,430	91,761	209,868
1993	59,294	17,472	4,014	49,403	130,184
1994	85,561	3,875	5,525	6,069	101,030
1995	172,680	4,027	10,124	12,176	199,007
1996	230,468	3,295	21,221	17,575	272,559
1997	65,643	3,316	4,520	4,767	78,246
1998	174,151	3,605	15,331	14,168	207,255
1999	13,049	4,228	9,522	8,727	35,526
2000	8,958	3,198	6,091	4,330	22,577
2001	3,142	2,748	3,201	1,401	10,492
2002	4,194	2,654	3,352	2,001	12,201
2003	7,438	2,994	5,473	3,485	19,389
2004	3,695	2,971	3,360	1,737	11,762
2005	3,027	1,625	3,729	1,815	10,196
2006	4,055	2,438	3,198	5,203	14,893

Table 4. The estimates for king mackerel bycatch in the mixing zone from the shrimp trawl fishery.

Year	Number of king mackerel in the mixing zone.
1993	11,425
1994	14,843
1995	13,864
1996	14,025
1997	15,538
1998	15,325
1999	14,017
2000	13,332
2001	12,751
2002	11,826
2003	9,882
2004	9,694
2005	9,165
2006	7,853

Table 5. Observed bycatch on shrimping vessels in shrimping zones 1 and 2. These are the only observed values in the mixing zone from the shrimp fishery.

Shrimp bycatch in zone 1 and 2		
Year	Occurrences	Num of king mackerel
1993	0	0
1994	0	0
1995	0	0
1996	0	0
1997	0	0
1998	0	0
1999	4	4
2000	3	3
2001	7	8
2002	6	33
2003	0	0
2004	0	0
2005	0	0
2006	0	0

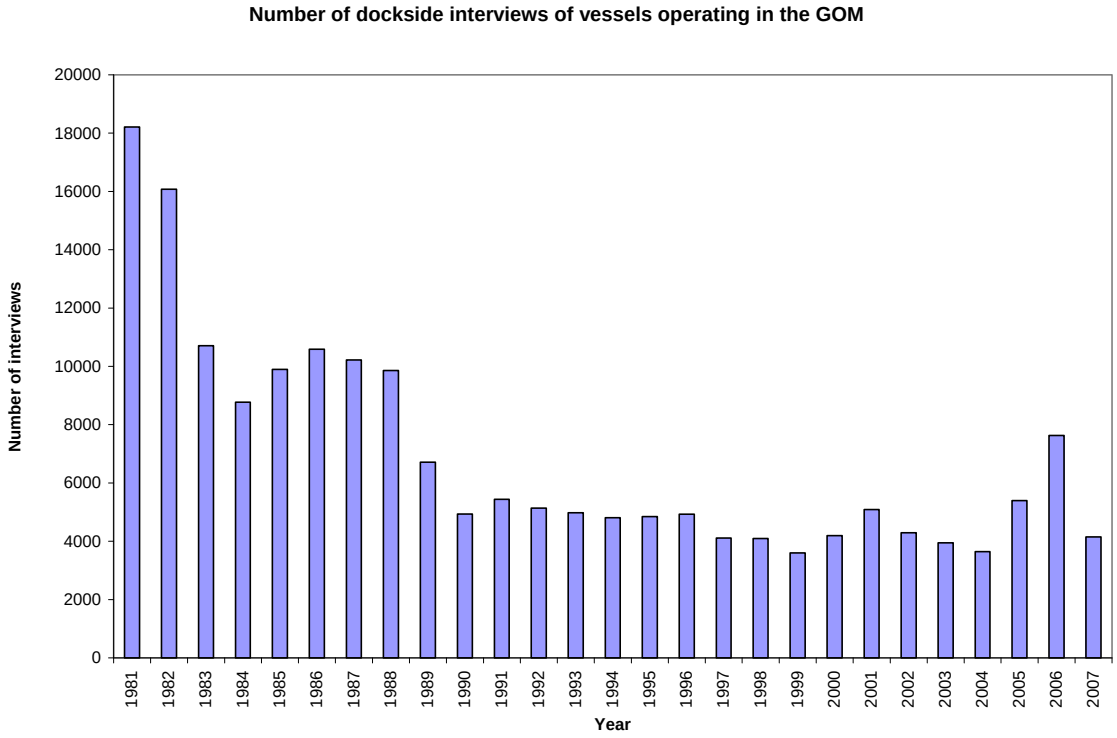

Figure 1. The number of observations of effort in the Gulf of Mexico shrimp trawl fishery.

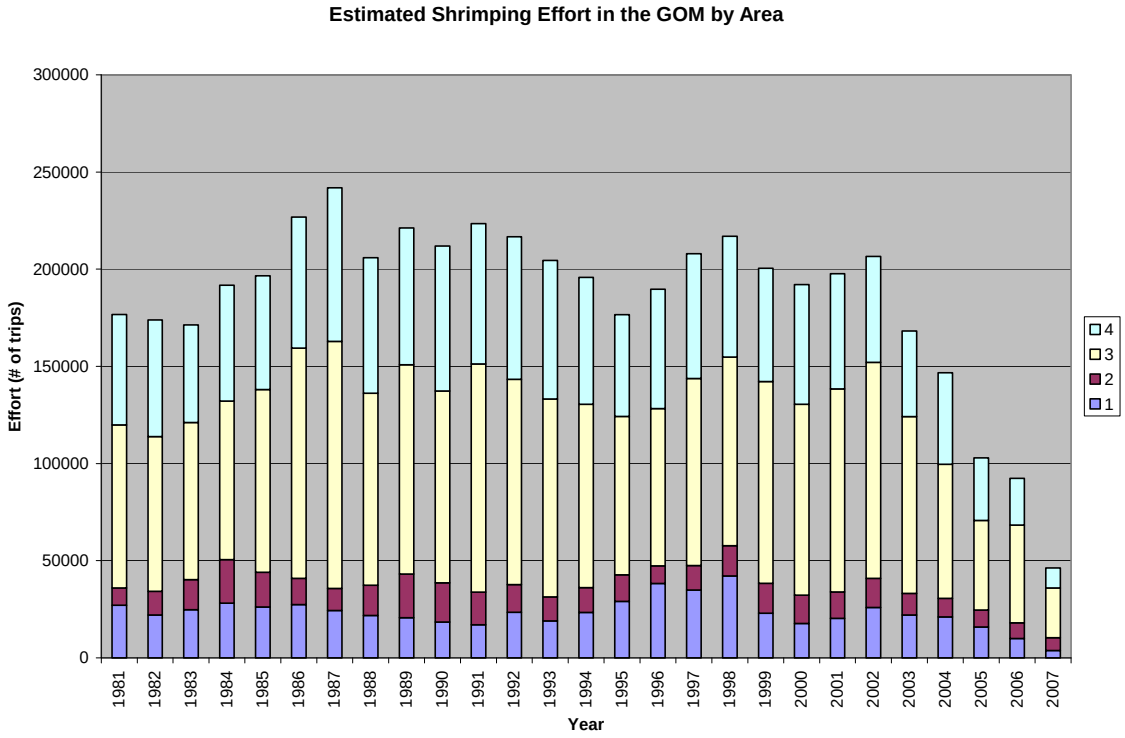

Figure 2. The estimates of shrimping effort in the GOM fishery. The colored sections of the columns represent the statistical areas in the gulf (area: 1 = Stat

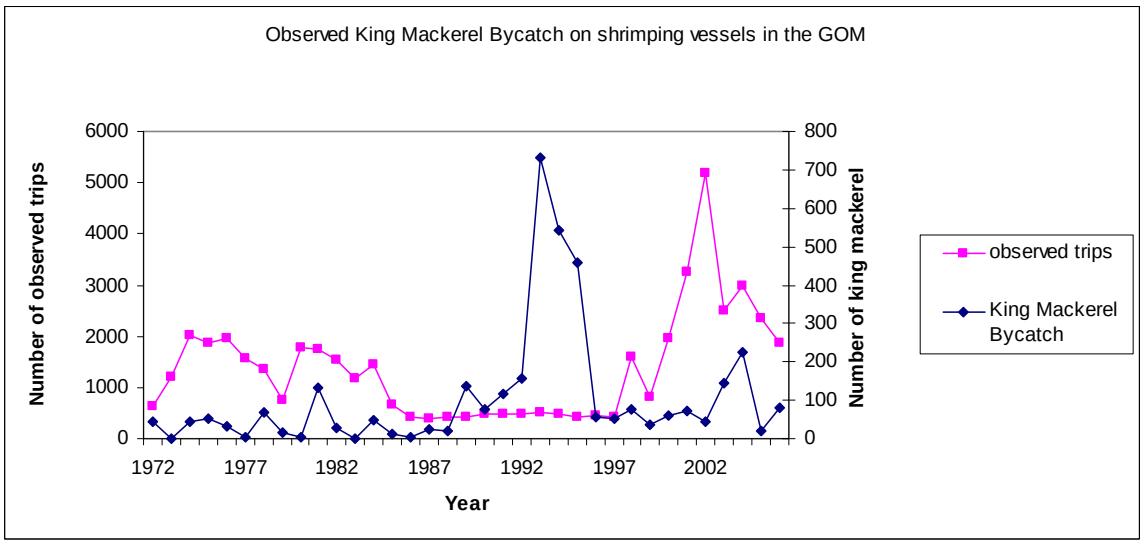

Figure 3. The observed number of king mackerel caught as bycatch in the GOM shrimp fishery.

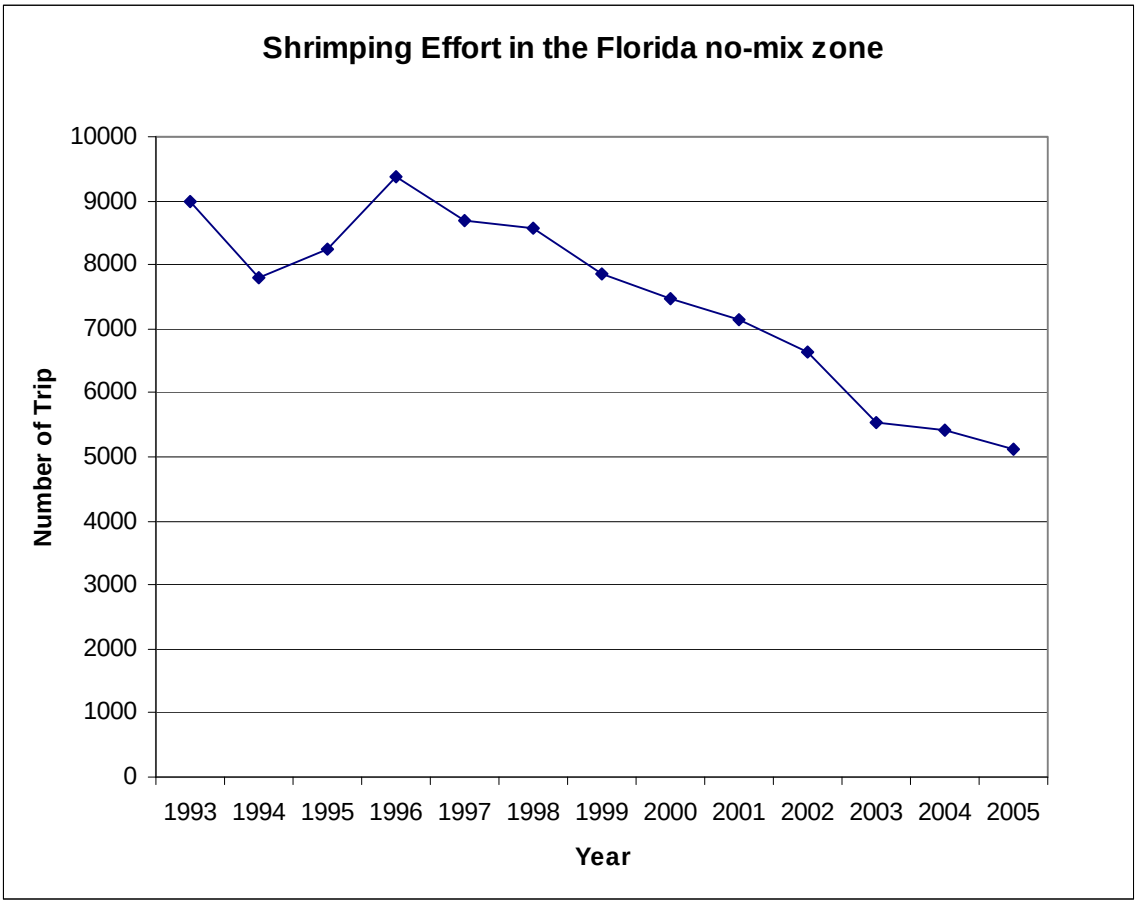

Figure 4. Shrimping effort (# of trips) in the atlantic waters off Florida taken from trip tickets. This does not include the mixing zone from November 1-March 31. Data provided by the Florida Fish and Wildlife Conservation Commission (FWC), Fish and Wildlife Research Institute (FWRI) Fishery Dependent Monitoring program.

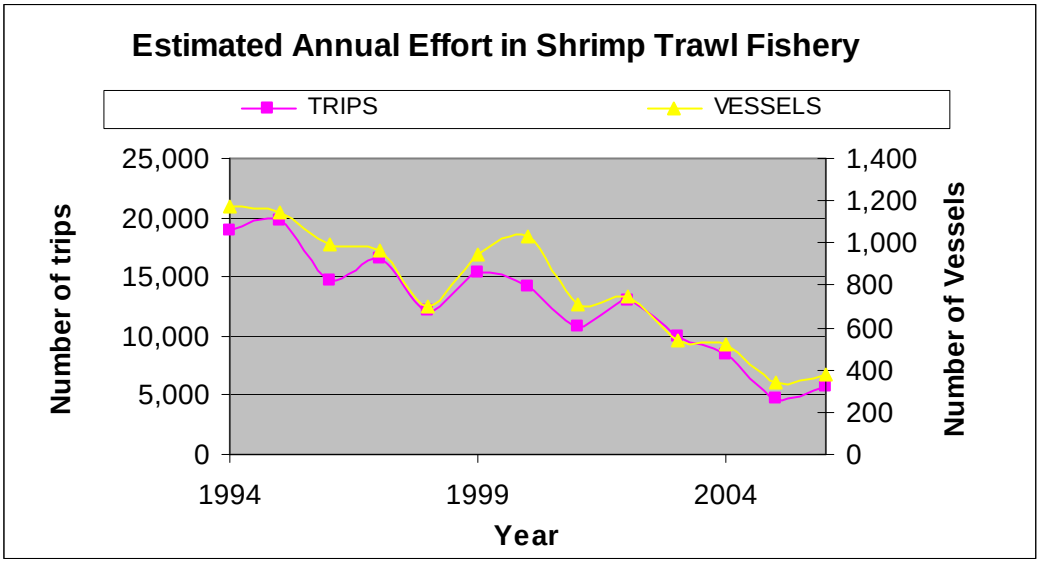

Figure 5. Shrimping effort (# of trips) and numbers of vessels operating in the statistical zones off North Carolina. Data provided by North Carolina Division of Marine Fisheries' trip ticket program.

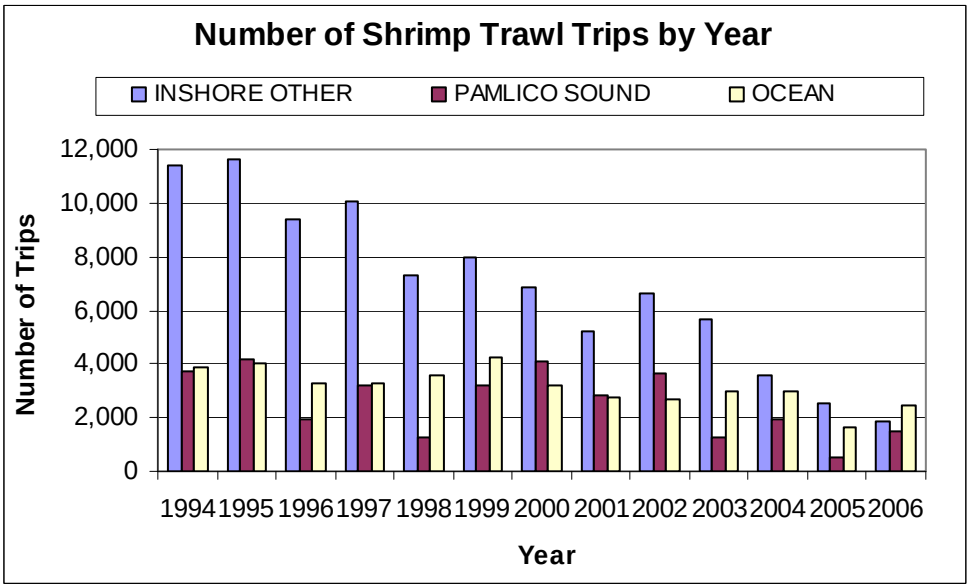

Figure 6. Shrimp trawl data from North Carolina are divided into three aquatic regions, inshore, ocean, and Pamlico Sound. Only ocean effort is used for the SA estimates.

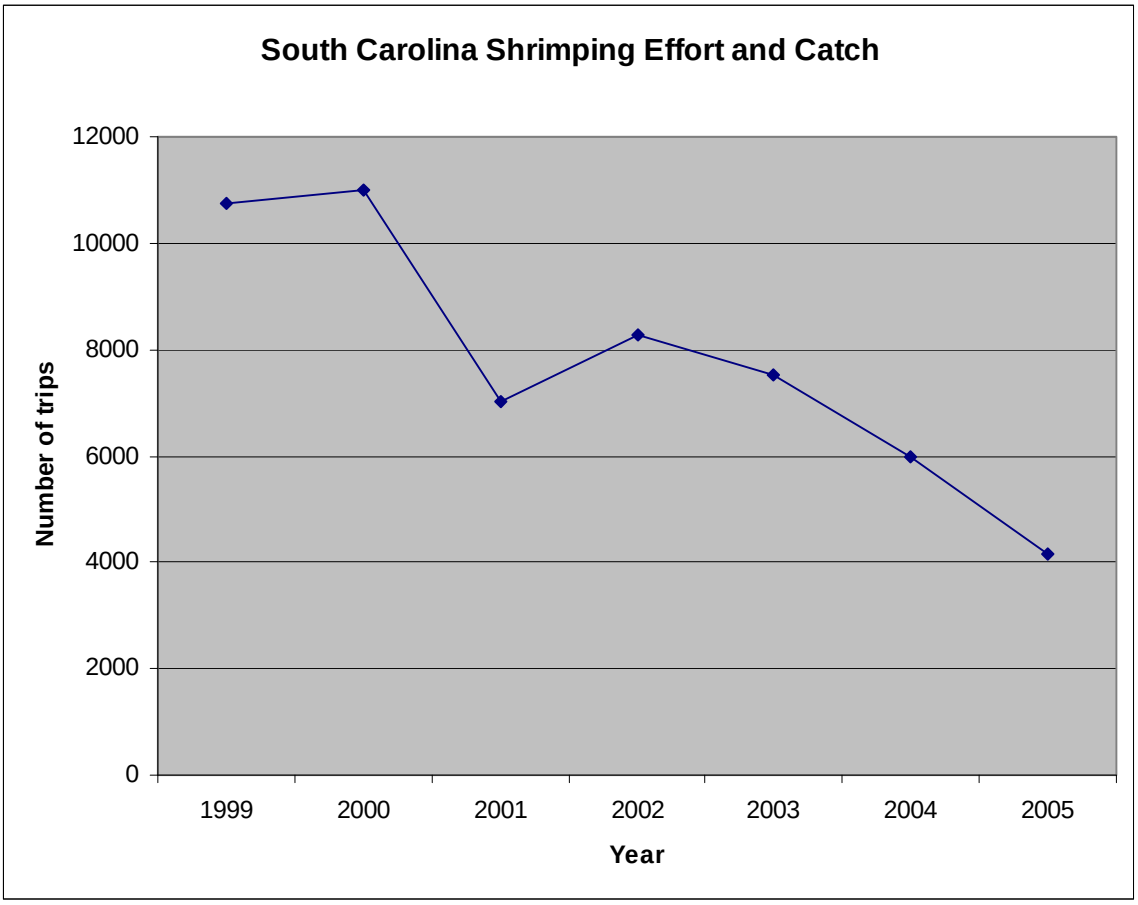

Figure 7. Shrimping effort (# of trips) in the statistical zones off South Carolina.

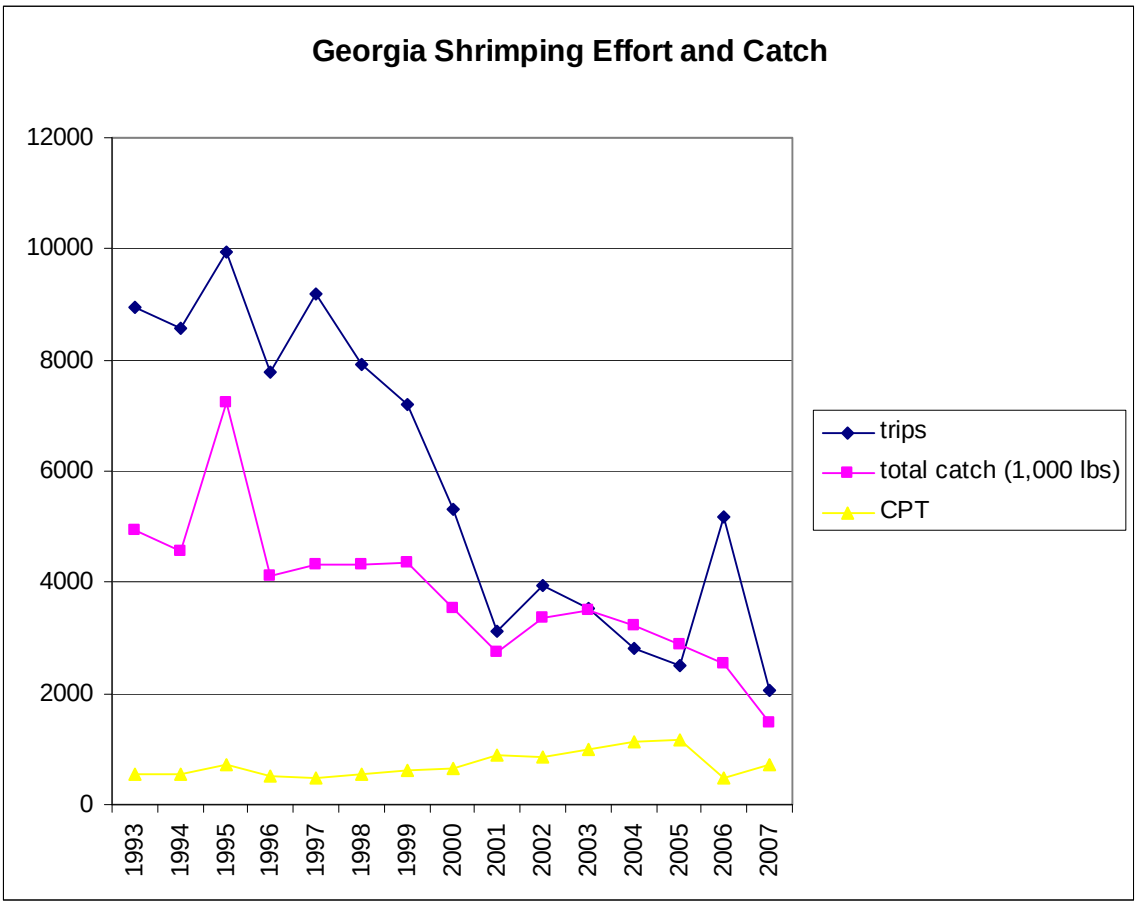

Figure 8. Shrimping effort (# of trips), catch (1000 lbs.), and bycatch per trip (CPT, # of 1000s of pounds of shrimp) in the statistical zones off Georgia. Data provided by the Georgia Department of Natural Resources Coastal Resources Division.

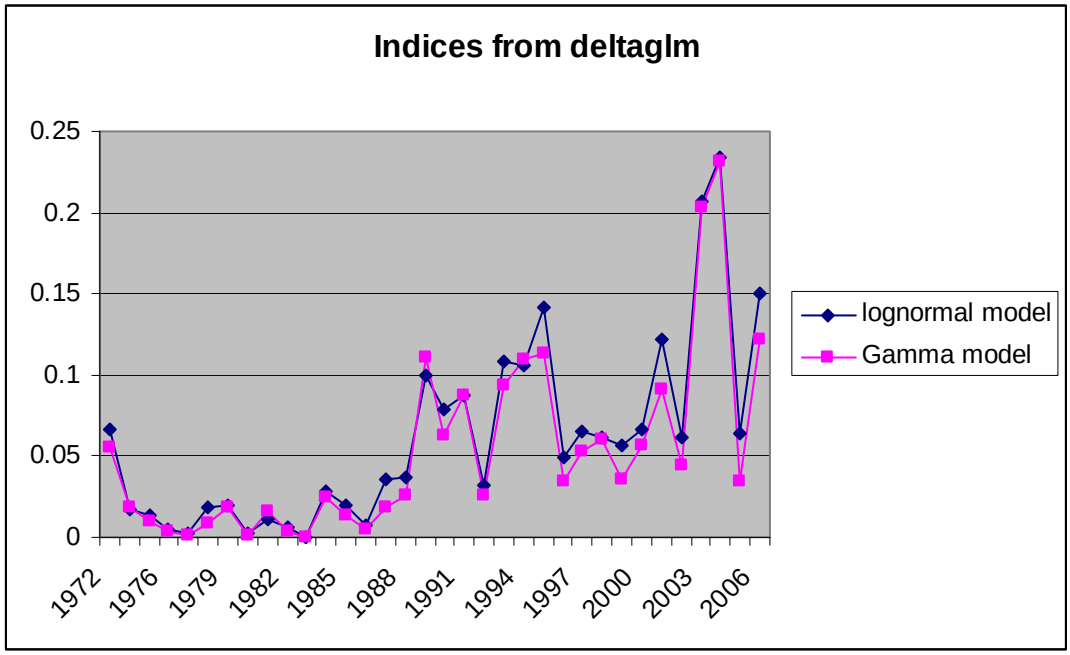

Figure 9. The indices produced for the GOM using the delta-GLM method. The diamond line is the lognormal results while the box results are the gamma results. The lognormal model was determined the best by comparing the AIC values between the models.

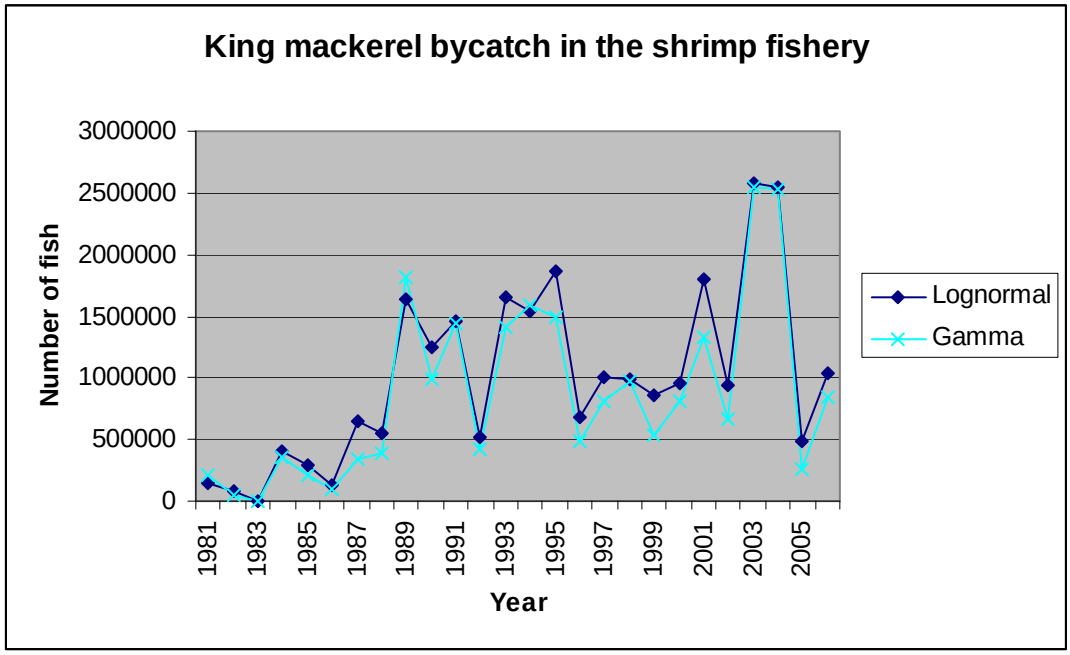

Figure 10. The number of king mackerel bycatch from the GOM shrimp trawl fishery.

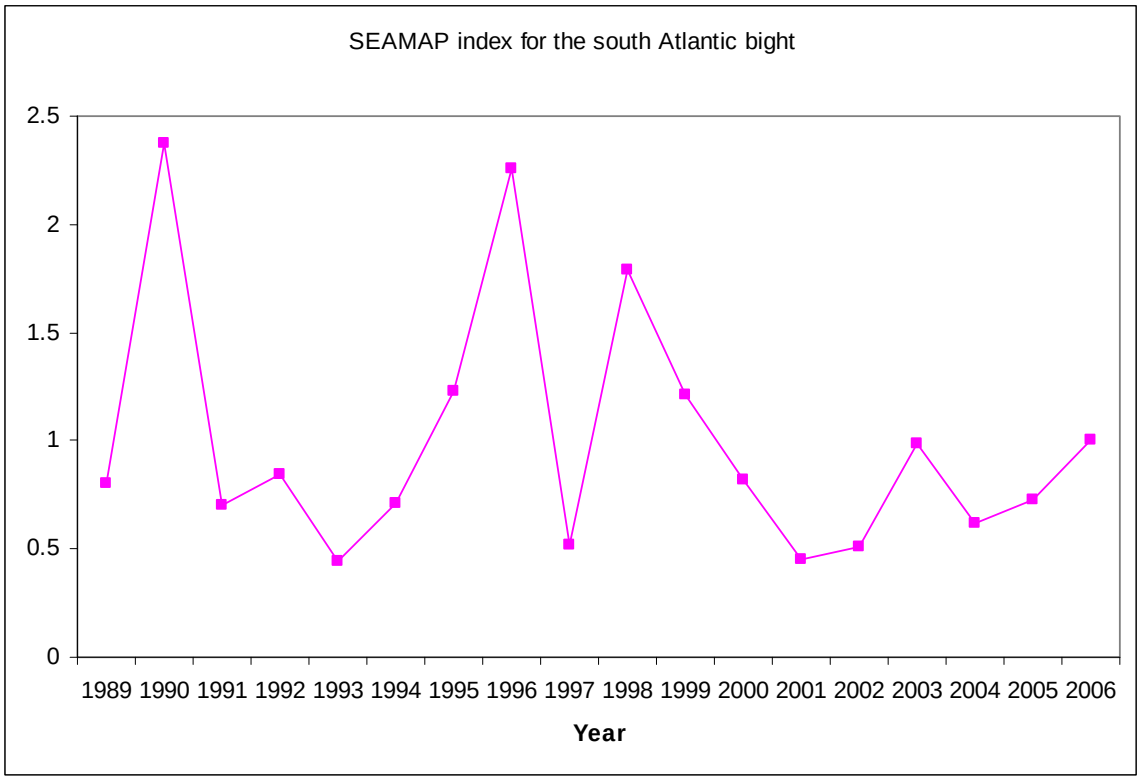

Figure 11. The index used to estimate year-0 king mackerel in the south Atlantic bight. Adapted from Ingram's SEDAR16-DW-09

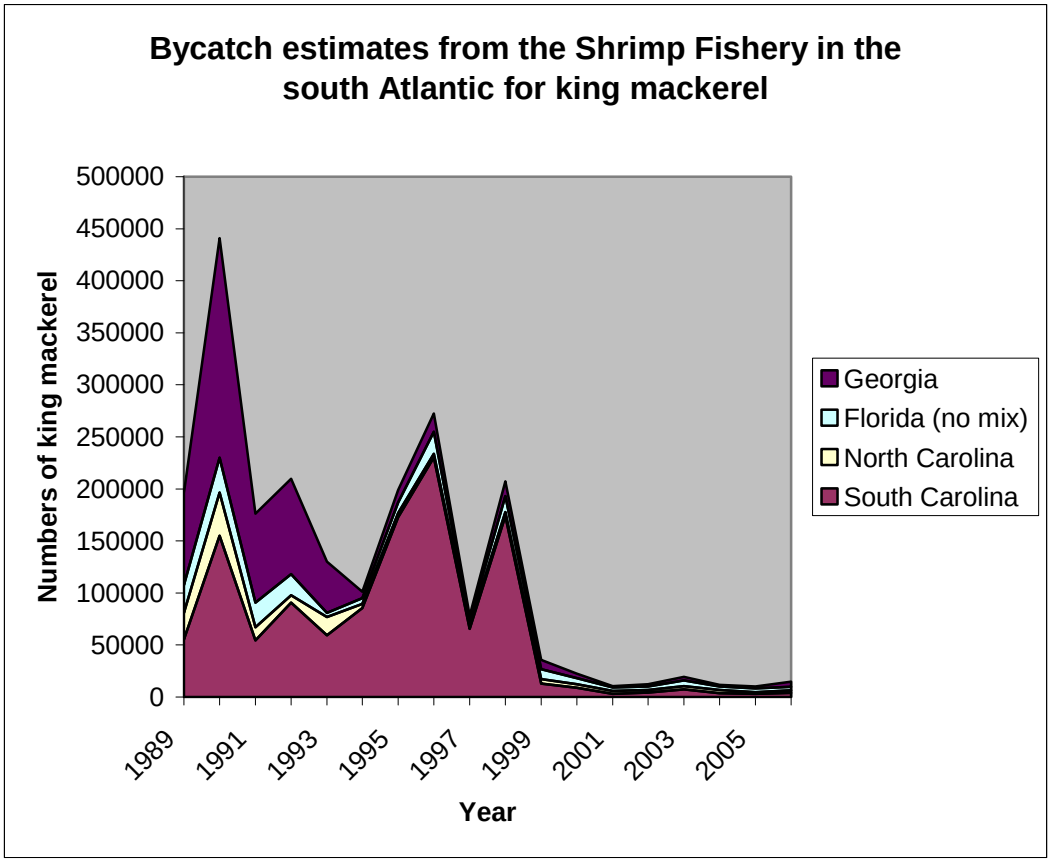

Figure 12. The estimates of king mackerel bycatch in the south Atlantic shrimp trawl fishery. The state-specific estimates are shown in the different colors, purple for GA, light blue for FL, yellow for NC, and magenta for SC. Additional data were received at the SEDAR data workshop from the South Atlantic Shrimp System to update the effort estimates.