Estimation of Spanish mackerel and vermilion snapper bycatch in the shrimp trawl fishery in the South Atlantic (SA)

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Summary

Estimates of Spanish mackerel bycatch in the shrimp trawl fishery was requested for the current SEDAR. Observer data are available, but sparse for the SA region. Effort data are available from representatives of each state (FL, GA, SC, and NC) and from the South Atlantic Shrimping System (SAS). The observer data were fit using a delta GLM model with a lognormal distribution. The resulting index was then scaled to an estimate of the number of fish caught using the average number of nets (from the observer data) and the effort in the SA. The estimates and methods are detailed in the following document. Due to the extreme lack of occurrences of vermilion snapper in the shrimp trawl fishery in the SA, it was not possible to produce an index or calculate estimates. The bycatch is presumed to be negligible for the region.

Background

Estimates of bycatch of Spanish mackerel (*Scomberomorus maculatus*) have been requested for the 2008 stock assessment. The region of interest for the assessment is the South Atlantic (statistical areas 24-35). For the purposes of this report, we focus on the Spanish mackerel bycatch as there are not enough occurrences of vermilion snapper in the SA shrimp fishery to create an index and an estimate.

The Data

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 south 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.

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 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 Spanish mackerel and vermilion snapper, 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

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).

The South Atlantic (SA)

The shrimping effort data are maintained by the individual states and the South Atlantic Shrimping System (SAS). 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, water body 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.

Methods

We used a delta GLM, similar to Ortiz (2000, 2002), to estimate the index and then the total number of Spanish mackerel caught as bycatch. Briefly, the concept of the delta-glm is an 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.

In more detail:
In the case of the delta model approach the first component is the proportion of tows (*y*) per stratum that encounter the organism of interest is assumed to follow a binomial distribution, such as

$$f(y) = \binom{n}{r} p^r (1-p)^{n-r}$$

where *n* is the total number of tows per stratum, *r* is the number of tows that caught Spanish mackerel (i.e positive tows), and *p* the probability to estimate. For the positive tows, estimated catch rates were assumed to follow a lognormal distribution of a linear function of the same fixed factors.

$$\log\left(CPUE'_{ikm}\right) = Year_i + Season_k + Depth\,zone_m + \varepsilon_{ikm}$$

Then the estimated mean bycatch rate per stratum is estimated as the product of the predicted proportion of positive tows times the mean catch rate for positive tows. The estimation of bycatch in numbers of Spanish mackerel follows:

$$Bycatch_i = 24 * \sum_{km} \hat{p}_{ikm} * \hat{CPUE}'_{ikm} * f_{ikm} * 3.7$$

where 24 scales the tow hours to days, $\hat{p}_{ikm}$ is the proportion of positive tows, $\hat{CPUE}'_{ikm}$ is the conditional mean bycatch rate, f_{ikm} is the fishing effort, and 3.7 is the average number of nets deployed on observed vessels over the last 10 years.

Results
The model results are listed in detail in Table 1. There were historical data available (1972-1997) but there were so few occurrences of Spanish mackerel that the model threw those years out due to a model constraint (at least two positive tows in one year). The year 1980 had an inordinately large amount of Spanish mackerel caught that year in observed tows (19,000+), but the other years were incredibly small or non-existent. In fact the model threw out all years except 1979-1981 and 1984. The model then produced output too variable to create estimates, so the historical data bore no further investigation. Figure 1 shows the proportion of occurrences in each of the statistical zones. There is no apparent pattern to where the Spanish mackerel were observed. The resulting index and estimates run from 1998-2006, with a missing year at 2005 (Table 3 and Figure 3). Although there were not two positive tows in 2005 it is unlikely there were no Spanish mackerel caught in the shrimp fishery, but the model was unable to estimate a value for that year.

Shrimping effort data are available from all four states in the SA region and are illustrated in Table 2 and Figure 2. Although observer data may be available down to the per tow level, the shrimping effort data available were at the per trip level, therefore the expanded estimates are calculated at the per trip level. The lognormal model performed better than the gamma model based on AIC scores, so the lognormal model is presented

here. Interactions were considered, but no significant interactions were observed. The expanded estimates are provided for each state by year in the SA (Table 3).

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Table 1. The delta lognormal model results for the SA shrimp trawl fishery.

binomial.formula

Formula for binomial GLM: NUMBER ~ YEAR + DPTHZONE + SEASON

positive.formula

Formula for gaussian GLM: log(NUMBER) ~ YEAR + DPTHZONE + SEASON

deltaGLM.index

	index	jack.mean	jack.se	jack.cv
1998	0.18	0.18	0.08	0.46
1999	2.99	2.99	0.85	0.28
2000	3.17	3.17	0.68	0.21
2001	0.99	0.99	0.50	0.51
2002	0.18	0.18	0.07	0.37
2003	0.26	0.26	0.11	0.41
2004	0.11	0.11	0.09	0.78
2006	0.10	0.10	0.06	0.55

Effects

DPTHZONE

1	0.732615
2	0.286742

SEASON

1	0.204151
2	0.625669
3	0.769174

Data filter

Data filter threshold set at 2 positive observations.

levels deleted by filter

YEAR

2005 2007

AIC.binomial	803.35
AIC.lognormal	943.3606
sigma.mle	0.951508

Table 2. South Atlantic shrimp trawl fishery effort in trips listed by year. Na indicates that effort was not available.

	STATE				
YEAR	FL	GA	NC	SC	Grand Total
1978	Na	10,666	2,211	Na	12,877
1979	Na	14,552	3,397	10,035	27,984
1980	Na	13,103	4,227	11,908	29,238
1981	4,766	6,541	3,684	7,288	22,279
1982	4,972	11,154	5,134	12,169	33,429
1983	4,989	11,580	5,615	8,962	31,146
1984	4,668	5,680	5,796	5,134	21,278
1985	4,946	6,958	3,055	4,724	19,684
1986	4,158	9,634	3,377	9,742	26,912
1987	4,069	9,164	3,325	11,384	27,942
1988	4,812	9,422	5,290	8,352	27,875
1989	5,112	7,580	5,982	10,296	28,970
1990	6,186	6,244	4,923	9,638	26,991
1991	5,802	10,125	5,231	15,431	36,589
1992	4,688	8,925	4,553	14,010	32,176
1993	3,462	8,977	4,553	13,245	30,237
1994	5,197	8,575	3,875	12,080	29,727
1995	4,665	9,893	4,027	14,152	32,737
1996	5,071	7,771	3,295	10,193	26,330
1997	5,309	8,960	3,316	12,725	30,310
1998	5,252	8,009	3,605	9,749	26,615
1999	4,624	7,276	4,228	10,257	26,385
2000	3,760	5,411	3,198	10,166	22,535
2001	2,995	3,411	2,748	6,903	16,057
2002	2,767	3,946	2,654	7,385	16,752
2003	2,474	3,064	2,994	7,026	15,558
2004	2,236	3,354	2,971	4,664	13,225
2005	2,042	2,772	1,625	3,476	9,915
2006	2,697	2,610	2,438	5,299	13,044

Table 3. The catch index and estimated number of Spanish mackerel bycatch in the SA shrimp trawl fishery by year.

Year	Index	CV	Estimates
1998	0.176485	0.46121	417111.3
1999	2.989763	0.283653	7004988
2000	3.168612	0.214095	6340696
2001	0.992848	0.507144	1415705
2002	0.178549	0.37182	265599.6
2003	0.262509	0.41411	362659.8
2004	0.110062	0.782997	129257.4
2005	.	.	.
2006	0.099587	0.552902	115352
2007	.	.	.

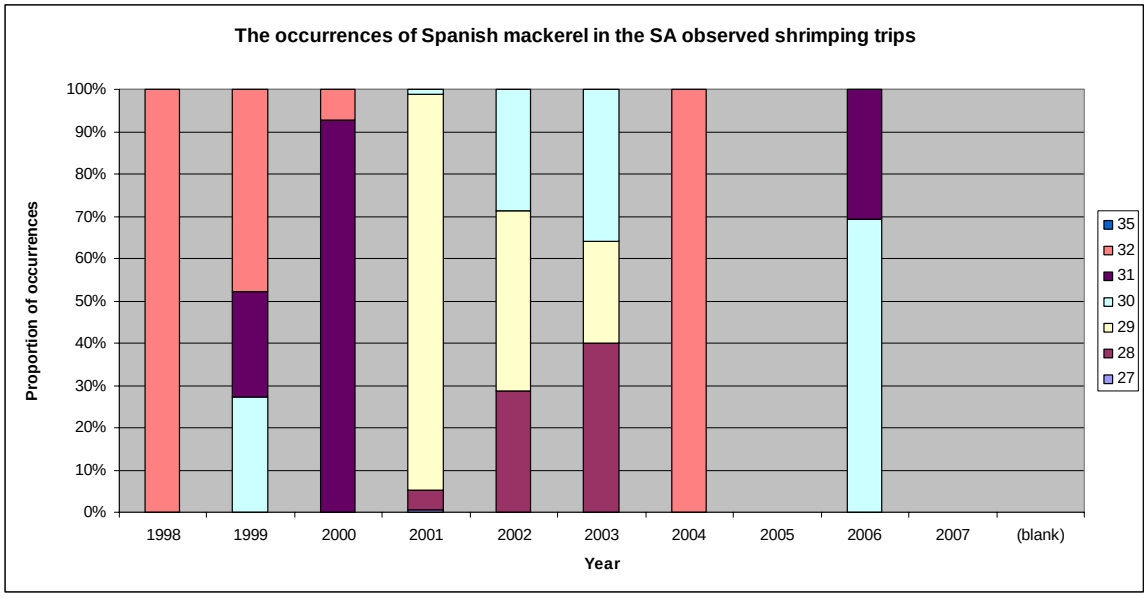

Figure 1. Observed occurrences of Spanish mackerel in the SA shrimp trawl fishery. The statistical zones are the logbook stat zones and the blank option is a data proofing measure to make sure there were no records listed without statistical zone.

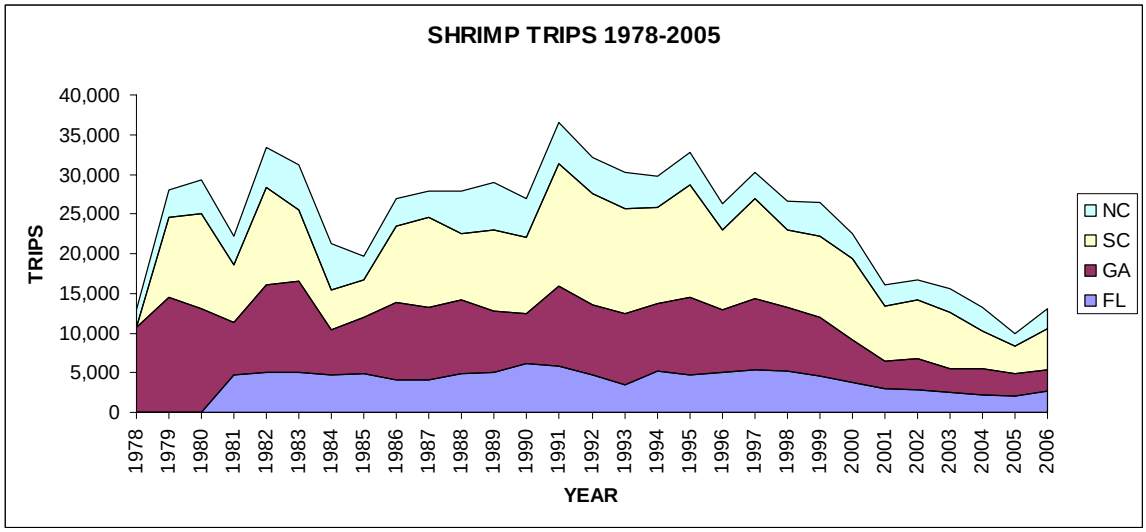

Figure 2. The estimates of shrimping effort in the SA shrimping fishery by state.

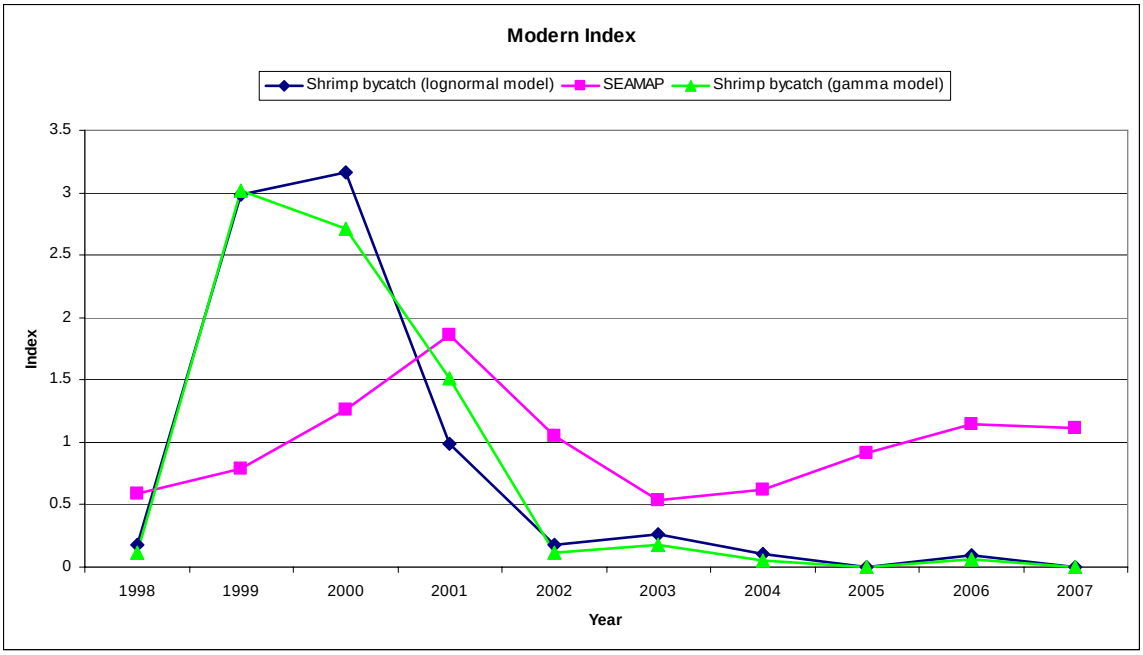

Figure 3. The indices produced for the SA using the delta-GLM method. The lognormal model was determined the best by comparing the AIC values between the models. The SEAMAP index is shown to display the index used for the recruitment of age-0s. Since the trends are not similar, the comparison shows that the shrimp bycatch data have very high levels of uncertainty.