Estimation of bycatch of small coastal sharks in the shrimp trawl fishery in the US South Atlantic

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Background

Estimates of bycatch of the small coastal shark complex, *C. isodon, C. acronotus, S. tiburo, and R. terraenovae,* are required for the 2007 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), however this report focuses on the South Atlantic. For the purposes of this report, we focus on the shark bycatch in the shrimp trawl fishery. See Nichols (2007) for the analysis of data from the GOM.

The Data

The SA includes North Carolina, South Carolina, Georgia, and Florida. 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. In this analysis, we will use Observer data to determine the number of small coastal sharks caught as bycatch in the shrimp trawl fishery, and then extrapolate those values to the entire SA using shrimping effort data from the states.

The Shrimp Fishery Observer Program

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 southeastern 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 (or taxa) of finfish were processed with the remaining subsample 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

A total of 1, 310 trips was completed in the US Gulf of Mexico and southeastern Atlantic from February 1992 through December 2003 during 12,749 sea days of observations. More than 117,000 hours of trawling were observed. 637 trips (11,147 sea days) operated in the Gulf of Mexico, with an average trip length of 17.5 days. 668 (1,475 sea days) occurred off the east coast, with average trip length of 2.2 days. Five trips (127 sea days) targeted waters off both the east coast and in the Gulf of Mexico, and averaged 25.4 days. Annual observer coverage levels were less than 1% of the total shrimp effort in all years, except in 2002. The number of sea days varied from 1992 through 2003 (Figure 1), and were directly correlated to the amount of funding received. Coverage levels were highest in 2002 with 3,063 sea days, followed by 1998 with 1,472 sea days. In 1994 and 1993, coverage levels were 1,235 and 1,228 sea days, respectively. In all other years during the study period, coverage was less than 1000 sea days. The lowest coverage occurred in 1996 with 300 sea days.

Observer data summary

Data were provided by the NMFS-Galveston Laboratory. The data include tow- and trip-level data, including 563 trips and 1077 observed tows. They are divided into control tows and experimental tows, depending on the use of a Bycatch Reduction Device (BRD). Within the control group, we found 29 occurrences of shark bycatch, and withing the experimental group we found 137 occurrences (Table 1 and 2). There were very few observed trips in the statistical zone for North Carolina, and of those, there were no observed bycatch events.

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.

Methods

Similar to Cortés (2002) we expanded the number of sharks caught per trip in the observer data to the entire SA. First we calculated the number of sharks caught per tow using the following equation

$$Bycatch\ per\ tow = number\ of\ sharks * \frac{Total\ weight}{Sample\ weight} * number\ of\ nets. \quad (1)$$

The bycatch units are number of sharks, total weight is the weight of the catch, sample weight is the fraction of the total the observer sampled from that tow, and number of nets is general 2 or 4. Sharks per tow are then summed across the trip to give us the total number of sharks per trip. The number of sharks caught per trip is averaged, and the mean is then multiplied by the total shrimping effort for that state to give us an estimate of total bycatch.

Results

Shrimping effort data are available from all four states in the SA region and are illustrated in Figures 2-6. Observer data were available down to the per tow level, but since the shrimping effort data were at the per trip level, the expanded estimates are calculated at the per trip level. The expanded estimates are provided for each state, both by species and by year (Tables 3-5), as well as for all species for the entire SA region (Table 6).

Acknowledgements

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Scott-Denton (2004). Observer Coverage of the US Gulf of Mexico and Southeastern Atlantic Shrimp Fishery, February 1992-December 2003-Methods, SEDAR**:** 13.

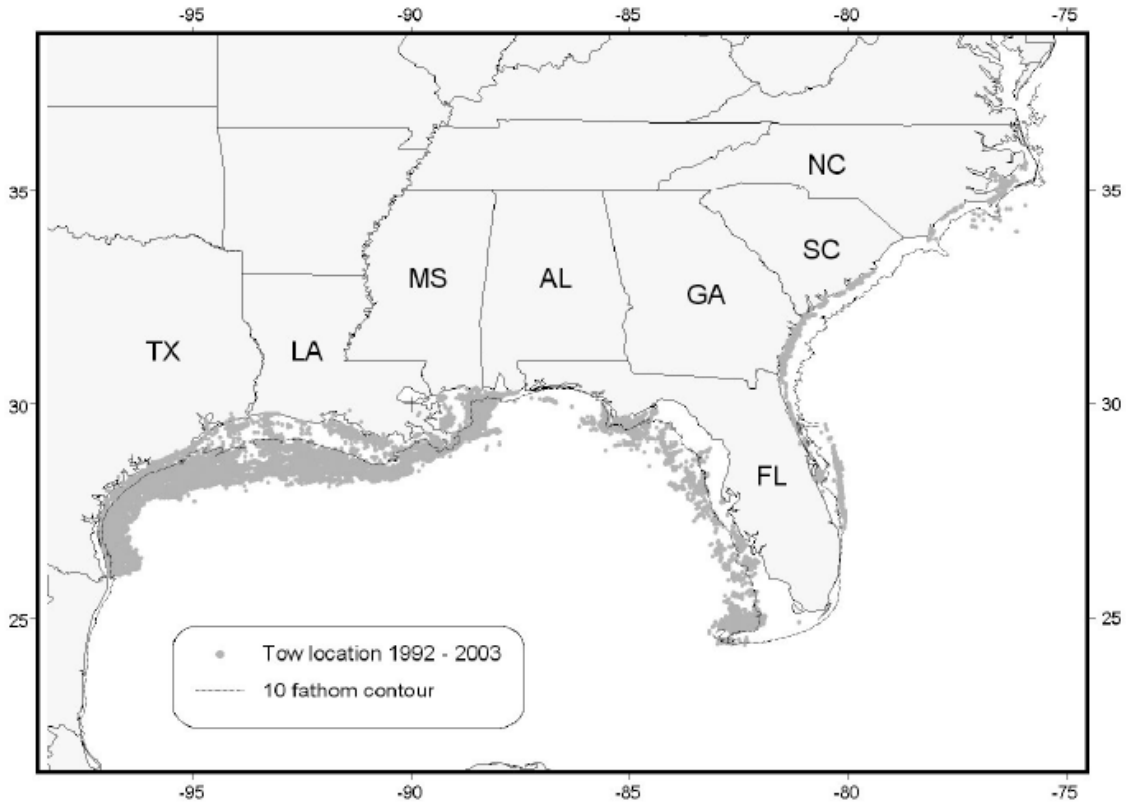

Figure 1. The observed tows in the Gulf of Mexico and South Atlantic Shrimp Trawl Fishery from 1992-2003. (adapted from (Scott-Denton 2004))

Table 1. Summarized observed bycatch of small coastal sharks in the SA shrimp trawl fishery

Total *S. tiburo*	42
Total *C. isodon*	74
Total *R. terraenovae*	34
Total unspecified *Carcharhinids*	209
Total	359

Table 2. Shrimping trips and number of tows per trip with observed small coastal bycatch

	Trip # with observed shark bycatch	Number of tows in that trip
	95	47
	96	10
	98	16
	111	10
	112	41
	113	61
	123	52
	129	20
	224	18
	227	36
	251	41
	257	16
	261	1
	300	15
	306	14
	309	38
	315	54
	416	2
	418	2
	420	2
	448	2
	486	9
	491	8
	511	1
	513	1
	514	2
	530	2
	531	2
	532	2
	533	1
	534	2
	535	2
	538	2
	539	2
	540	1
	543	2
	550	3
	551	3
	552	2
	554	2
	560	2
	561	2
	563	2
Total	42 trips	553 tows

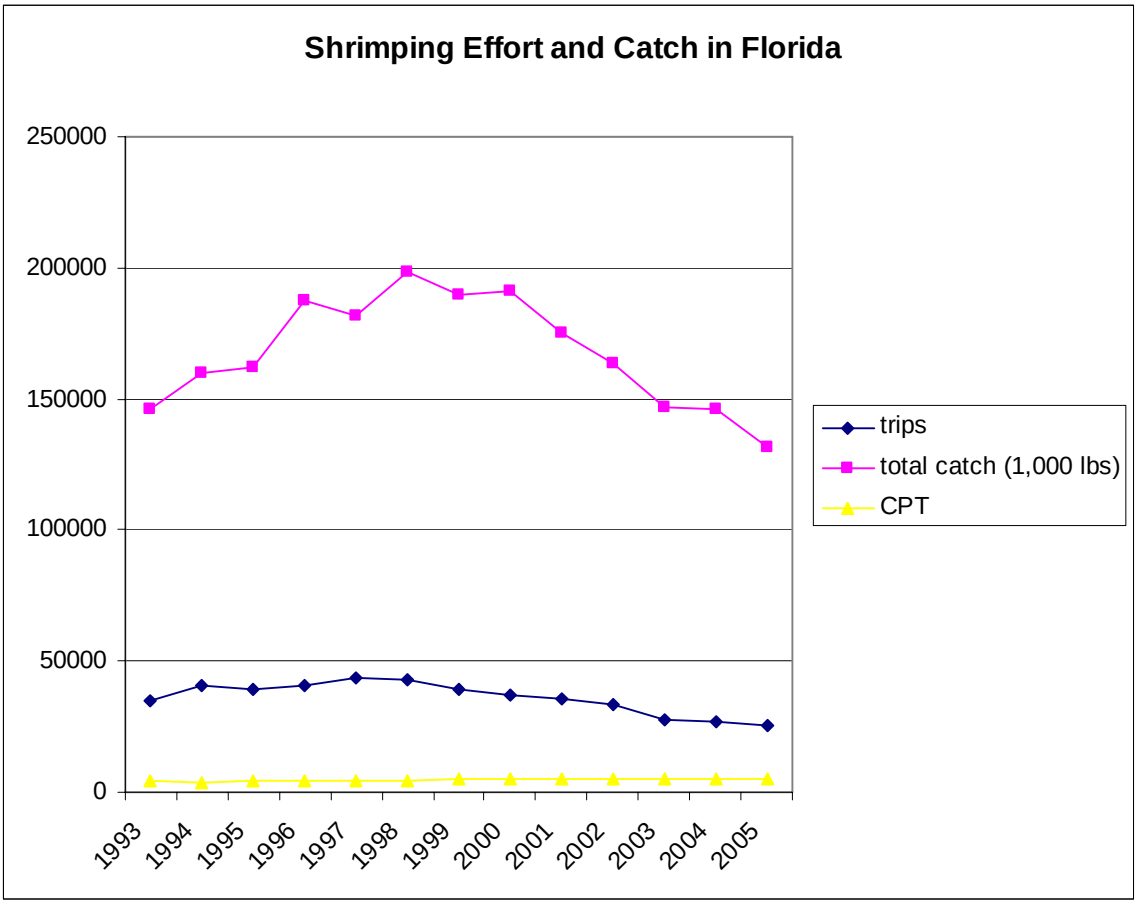

Figure 2. Shrimping effort (# of trips), catch (1000 lbs.), and bycatch per trip (CPT, # of sharks) in the statistical zones off Florida. Data provided by the Florida Fish and Wildlife Conservation Commission (FWC), Fish and Wildlife Research Institute (FWRI) Fishery Dependent Monitoring program.

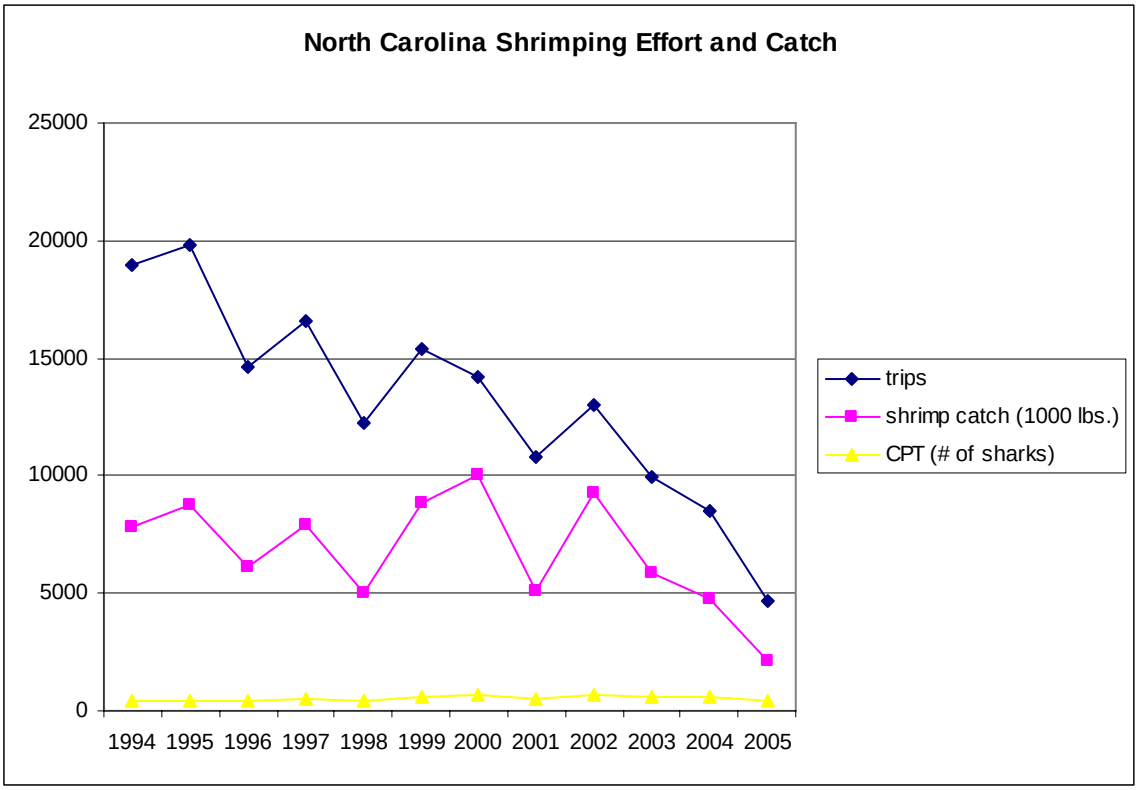

Figure 3. Shrimping effort (# of trips), catch (1000 lbs.), and bycatch per trip (CPT, # of sharks) in the statistical zones off North Carolina. Data provided by North Carolina Division of Marine Fisheries' trip ticket program.

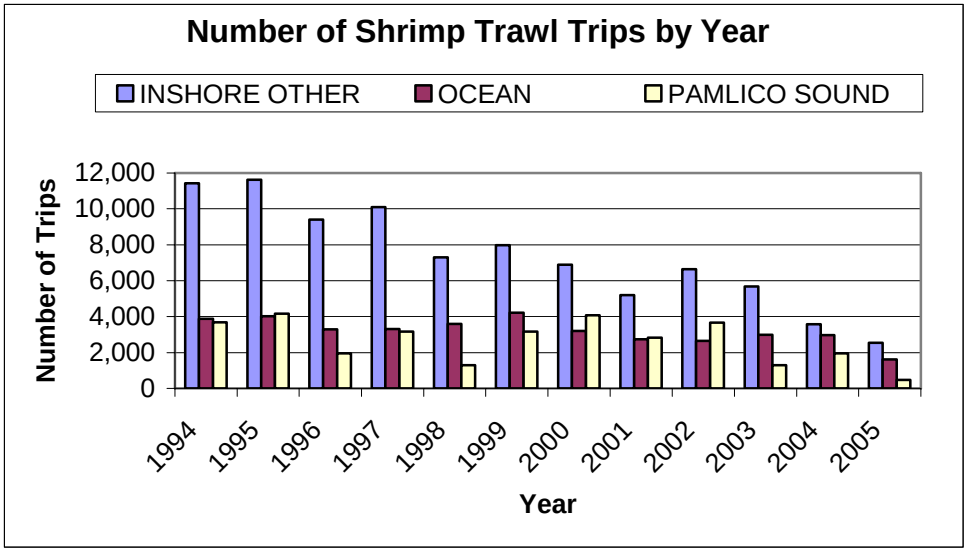

Figure 4. Shrimp trawl data from North Carolina are divided into three aquatic regions, inshore, ocean, and Pamlico Sound.

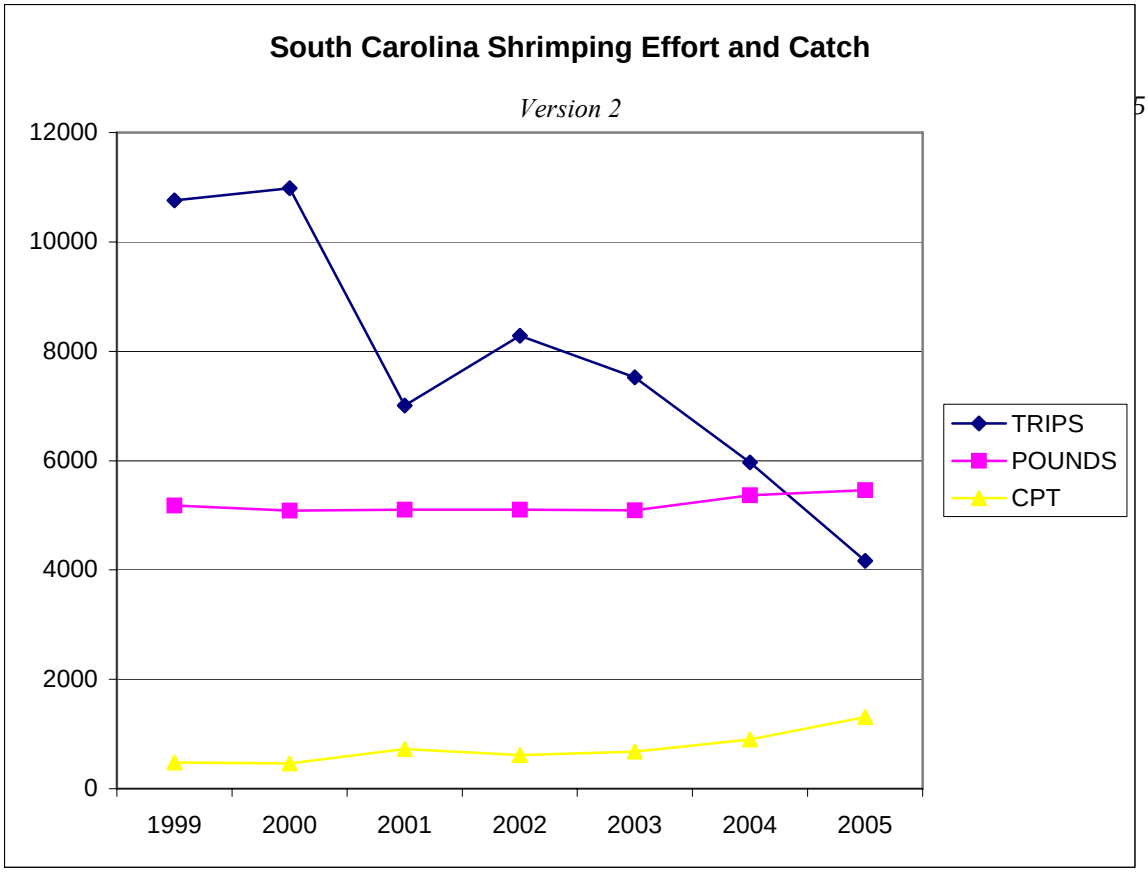

Figure 5. Shrimping effort (# of trips), catch (1000 lbs.), and bycatch per trip (CPT, # of sharks) in the statistical zones off South Carolina. Data provided by the NMFS Sustainable Fisheries Division.

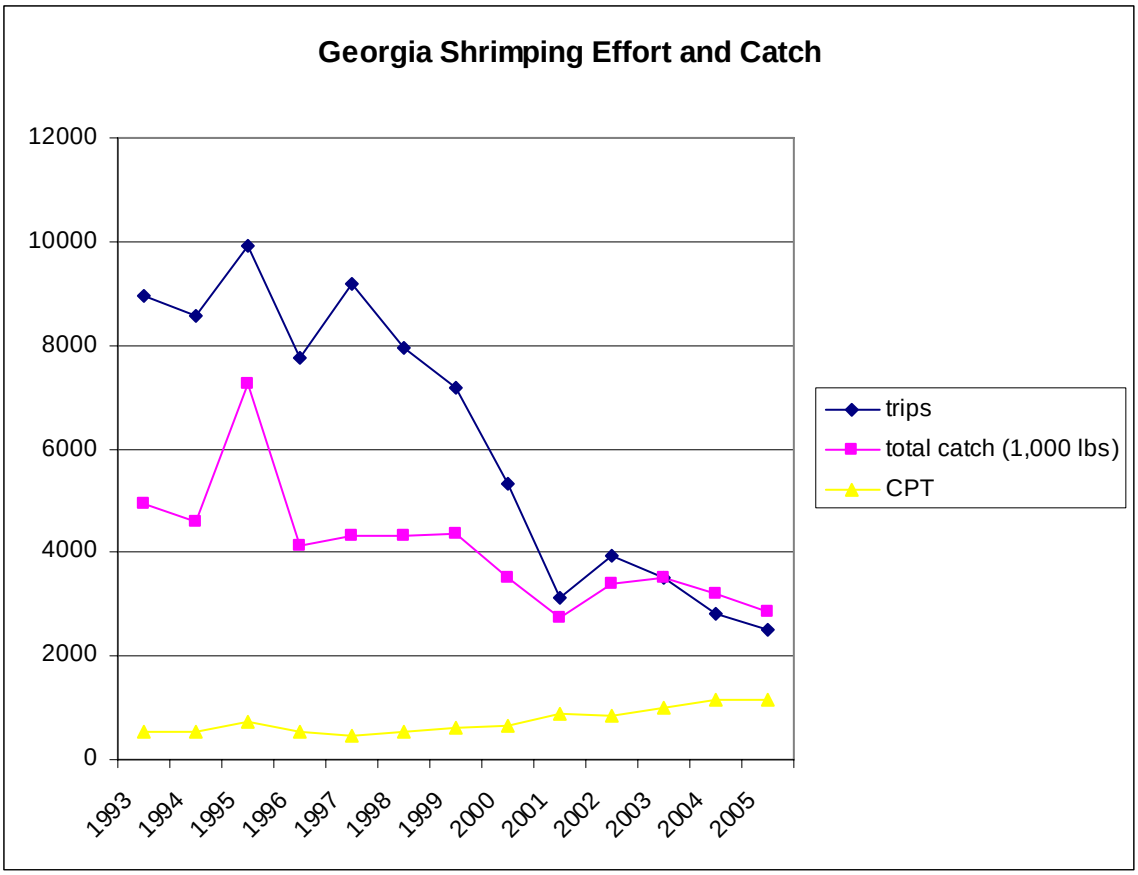

Figure 6. Shrimping effort (# of trips), catch (1000 lbs.), and bycatch per trip (CPT, # of sharks) in the statistical zones off Georgia. Data provided by the Georgia Department of Natural Resources Coastal Resources Division.

Table 3. South Carolina shrimp trawl fishery expanded shark bycatch estimates. Sample size (N), mean, standard deviation (SD), and standard error (SE) are provided. The complex includes all four species of sharks and unspecified carcharhinids. The unspecified are likely small coastal species, therefore they were included in the estimates for the complex as well as estimated independently.

Complex		1999	2000	2001	2002	2003	2004	2005
Catch/Trip	N	1					4	20
	Mean	83					25	81
	SD						9	70
	SE						4	16
Total SC trips		10758	10982	7008	8286	7522	5970	4167
estimated catch		896735	0	0	0	0	148223	339244

Unspecified		1999	2000	2001	2002	2003	2004	2005
Catch/Trip	N	1					4	2
	Mean	83					25	20
	SD						9	2
	SE						4	2
Total SC trips		10758	10982	7008	8286	7522	5970	4167
estimated catch		896735	0	0	0	0	148223	82338

R. terraenovae		1999	2000	2001	2002	2003	2004	2005
Catch/Trip	N							1
	Mean							27
	SD							
	SE							
Total SC trips		10758	10982	7008	8286	7522	5970	4167
estimated catch		0	0	0	0	0	0	113104

C. isodon		1999	2000	2001	2002	2003	2004	2005
Catch/Trip	N							24
	Mean							82
	SD							72
	SE							15
Total SC trips		10758	10982	7008	8286	7522	5970	4167
estimated catch		0	0	0	0	0	0	342479

Table 4. Georgia shrimp trawl fishery expanded shark bycatch estimates. Sample size (N), mean, standard deviation (SD), and standard error (SE) are provided. The unspecified are likely small coastal species, therefore they were included in the estimates for the complex as well as estimated independently.

Complex		1999	2000	2001	2002	2003	2004	2005
Catch/Trip	N	1	2					3
	mean	12.28	98.42					81.64
	SD		91.41					5
	SE		64.64					10.25
Total GA trips		7195	5309	3125	3953	3524	2806	2499
Estimated catch		88365	522508.34	0	0	0	0	204017

Unspecified		1999	2000	2001	2002	2003	2004	2005
Catch/Trip	N	1	2					2
	mean	12.28	98.42					48.39
	SD		91.41					23.13
	SE		64.64					16.35
Total GA trips		7195	5309	3125	3953	3524	2806	2499
Estimated catch		88365	522508	0	0	0	0	120932

S. tiburo		1999	2000	2001	2002	2003	2004	2005
Catch/Trip	N	1	2					2
	mean	12.28	98.42					22.01
	SD							2.84
	SE		64.64					2.01
Total GA trips		7195	5309	3125	3953	3524	2806	2499
Estimated catch		88365	522508	0	0	0	0	54999

R. terraenovae		1999	2000	2001	2002	2003	2004	2005
Catch/Trip	N	1	2					2
	mean	12.28	98.42					52.05868
	SD		91.41					39.70378
	SE		64.64					28.07481
Total GA trips		7195	5309	3125	3953	3524	2806	2499
Estimated catch		88365	522508	0	0	0	0	130095

Table 5. Florida shrimp trawl fishery expanded shark bycatch estimates. Sample size (N), mean, standard deviation (SD), and standard error (SE) are provided. The unspecified are likely small coastal species, therefore they were included in the estimates for the complex as well as estimated independently.

Complex		1999	2000	2001	2002	2003	2004	2005
Catch/Trip	N	1		3	5	4		
	mean	6.57		493.47	39.24	1500.94		
	SD			756.67	7.58	2543.18		
	SE			436.86	3.39	1271.59		
Total FL trips		39253	37336	35708	33118	27674	27146	25667
		258081	0	17620772	1299470	41537060	0	0

Unspecified		1999	2000	2001	2002	2003	2004	2005
Catch/Trip	N	1				3		
	mean	6.57				1500.94		
	SD					2543.18		
	SE					1271.59		
Total FL trips		39253	37336	35708	33118	27674	27146	25667
Estimated catch		258081	0	0	0	41537060	0	0

R. terraenovae		1999	2000	2001	2002	2003	2004	2005
Catch/Trip	N			2	1	1		
	mean			56.84	36.70	22.05		
	SD			35.17				
	SE			24.87				
Total FL trips		39253	37336	35708	33118	27674	27146	25667
Estimated catch		0	0	2029755	1215594	610212	0	0

S. tiburo		1999	2000	2001	2002	2003	2004	2005
Catch/Trip	N			1	4			
	mean			1366.72	39.87			
	SD				8.85			
	SE				4.43			
Total FL trips		39253	37336	35708	33118	27674	27146	25667
Estimated catch		0	0	48802806	1320439	0	0	0

Table 6. Shrimp trawl fishery expanded shark bycatch estimates for the entire SA region. Sample size (N), mean, standard deviation (SD), and standard error (SE) are provided. The unspecified are likely small coastal species, therefore they were included in the estimates for the complex as well as estimated independently.

Species Complex	1999	2000	2001	2002	2003	2004	2005
# of observed trips with bycatch	4	3	3	5	7	4	21
mean shark bycatch	102.21	65.61	484.14	39.24	857.68	24.83	84.33
SD	20.13	37.87	765.32	7.79	1662.98	8.79	67.41
SE	10.06	21.86	441.86	3.49	628.55	4.40	14.71
Trips in the SA	72586	67790	56607	58325	48689	44430	36979
Estimated total bycatch	7419120	4447899	27405952	2288532	41759629	1103104	3118565

R. terraenovae	1999	2000	2001	2002	2003	2004	2005
# of observed trips with bycatch	0	0	2	2	1	0	3
mean shark bycatch			85.71	32.55	22.05		52.06
SD			54.95	5.88	0.00		0.06
SE			38.86	4.16	0.00		0.04
Trips in the SA	72586	67790	56607	3	48689	44430	36979
Estimated total bycatch	0	0	4851988	96	1073592	0	1925078

S. tiburo	1999	2000	2001	2002	2003	2004	2005
# of observed trips with bycatch	0	0	1	3	0	0	3
mean shark bycatch			1366.72	43.70			29.75
SD				5.45			13.56
SE				3.14			7.83
Trips in the SA	72586	67790	56607	58325	48689	44430	36979
Estimated total bycatch	0	0	77365868	2548631	0	0	1100184

C. isodon	1999	2000	2001	2002	2003	2004	2005
# of observed trips with bycatch	0	0	0	0	0	0	11
mean shark bycatch							88.94
SD							73.38
SE							22.12
Trips in the SA		67790	56607	58325	48689	44430	36979
Estimated total bycatch	0	0	0	0	0	0	3288768

Unspecified	1999	2000	2001	2002	2003	2004	2005
# of observed trips with bycatch	4	3	0	0	6	4	3
mean shark bycatch	102.21	65.61			856.46	24.83	23.85
SD	20.13	37.87			1663.70	8.79	7.28
SE	10.06	21.86			679.20	4.40	4.20
Trips in the SA	72586	67790	56607	58325	48689	44430	36979
Estimated total bycatch	7419120	4447899	0	0	41700233	1103104	882036