Age Sampling of the Commercial Snapper Grouper Fishery and Age Description of the Black Sea Bass Fishery in North Carolina

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ABSTRACT

The snapper grouper fishery prosecuted off the coast of North Carolina is an important commercial fishery. The South Atlantic Fishery Management Council manages the snapper grouper fishery and the seventy-three species included in the management unit through the Snapper Grouper Fishery Management Plan. Many of the species lack sufficient data to determine sustainable harvest levels. Data were collected from 1,388 trips targeting various species in the snapper/grouper or king mackerel fishery throughout North Carolina from April 2006 through September 2010 to assist in the determining of fishery's sustainability in future assessments. General effort information, species composition, and total count were recorded for each trip. Over the sampling period, 107 species were observed. Lengths were taken from 61,841 fish. Aging structures, otoliths or dorsal spines, were taken from 62 species and 29,510 fish. All aging structures were sent to NOAA aging lab in Beaufort, NC for processing and analysis except for black sea bass, which were aged by the NC Division of Marine Fisheries. Most of the sampled trips fished in Onslow Bay or south of Cape Fear, NC, representing greater than 5% of the number of trips that landed snapper grouper species and 10.2% of the weight for all trips landing in North Carolina based on North Carolina Trip Ticket Program. A majority of the boats sampled fished with bandit reels. Electromate rod and reels were the second most commonly sampled gear followed by fish pots. The three different gears had different median depths fished, which likely contributed to different median sizes for black sea bass (*Centropristis striata),* snowy grouper (*Ephinephelus niveatus*), gag grouper (*Mycteroperca microlepis*), red porgy (*Pagrus pagrus*), and gray triggerfish (*Balistes capriscus*). These distinct harvest selectivity patterns indicate that electromate rod and reel and bandit gears should be separated in future SEDAR landings data.

A total of 6,149 black sea bass otoliths was read to determine the age structure for black sea bass from the North Carolina pot and hook and line fisheries. Overall precision between reads and readers was good with a mean CV from 1.02% to 2.70% between three different reads. Potential influences on the between reader differences in age estimation included: inability to distinguish the first annulus, check marks, otolith readability, and edge type. The maximum between-reader difference was three years. The majority of the black sea bass landed were between ages 4 and 5, with 10 being the oldest observed age. Younger black sea bass were predominantly caught in shallower waters less than 40 m for both electromate rod and reel and manual hook and line gears and less than 30 m for fish pots. Younger black sea bass were also caught more frequently caught at shallow depths during the spring and early fall, and at deeper depths in winter. The South Atlantic black sea bass commercial closure in 2009 and 2010 may have resulted in shifting the harvest toward younger fish and protected the larger black sea bass in deeper water.

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INTRODUCTION

The South Atlantic snapper grouper complex is managed by the South Atlantic Fishery Management Council (SAFMC). Data are typically limited for the 73 species in this management unit which may impact the reliability of stock assessments. Data needed for accurate and reliable assessments include: size and/or age structure of the harvest, weight and number of harvest, selectivity of the gear fished, and effort in the fishery. Age data are critical for sustainable management of species in the snapper grouper complex because they are typically long lived (NMFS 2005), have considerable overlap in age at length (SEDAR 1 2002; 2 2003; 10 2006; 15 2009; 19 2010; 24 2010), and have complex spawning behaviors including protogyny (NMFS 2005). The maximum age for species in the snapper grouper complex has been reported to range between 10 years for black sea bass (*Centropristis striata*) and up to 85 years for yellowedge grouper (*Epinephelus flavolimbatus)* (NMFS 2005). Length at age plots for black sea bass, vermilion snapper (*Rhomboplites aurorubens*), gag grouper (*Mycteroperca microlepis*), and red porgy (*Pagrus pagrus)* all have significant overlap in length at age, particularly for sizes vulnerable to the recreational and commercial fisheries. For example, a black sea bass 300 mm total length can be between 3 and 10 years old. Since length is not a good predictor of age, an accurate age distribution of the catch could provide a more precise estimate of the age structure of the harvested population rather than age distributions based on expanded length frequencies. Additionally, if differences in fish growth occur among gears or areas such as with black sea bass, vermilion snapper, and white grunt (*Haemulon plumeiri*) (Potts and Manooch 2001; Murie and Parkyn 2005; Allman 2007); then applying a single length at age key can produce biased estimates for the age distribution of the catch (Quinn and Deriso 1999).

Stock assessments have been conducted by the SAFMC for black sea bass, gag, red grouper (*E. morio)*, snowy grouper (*E. niveatus)*, vermilion snapper, and red porgy. In the assessments of these species, age data were limited due to limited resources to collect aging samples from ports in the South Atlantic. Black sea bass age samples from the commercial fishery were not included in the assessment update due to limited age data in the benchmark assessment (Black Sea Bass Assessment Update 2005); gag age samples from the commercial fishery were sporadically available from 1977 to 1982, 1994 to 1995, and 2004 to 2005 off the Carolinas (SEDAR 10 2006); red grouper had less than 60 age samples per year until 2004 in the South Atlantic (SEDAR 19 2010); the snowy grouper assessment did not include age data off North Carolina until after 1995 (SEDAR 4 2004); vermilion snapper had less than 100 age samples per year from North Carolina (usually 0) prior to 2004 (SEDAR 17 2008); and red porgy age samples from the commercial fishery were only available for six years of the assessment period and averaged less than 300 age samples per year for years with any commercial age data collected (SEDAR Red Porgy Update Assessment 2006). A consistent age sampling program is needed to accurately track changes in a population's age structure.

The black sea bass fishery is of particular importance to North Carolina. Commercial fishing for black sea bass started in the 1800s when fishermen would sail out to the fishing grounds (Earll 1887). Most of the crew members would fish the rocks with hook and line gear while one crew member attempted to maintain position on the fishing location by rowing. Anchoring was believed to disturb the fishing operation. The Black Fish Rocks off of southeastern North Carolina are still targeted by recreational and commercial fishermen.

The stock assessment for South Atlantic black sea bass used an age-implied biomass model (SEDAR 2 2008). Due to the considerable overlap in size at age, year class strength cannot be detected by length frequency plots alone. Additionally, black sea bass have seasonal migration patterns some of which are based on the age of the fish (Musick and Mercer 1977; Wenner et al. 1986; Low and Waltz 1991). The commercial fishery, which opens in June, closed in December 2009 and October 2010 when the total allowable catch was reached. This closure could cause a shift in the age structure of the harvest due a change in the fishing season which typically operated in the winter or due to a change in depth typically fished. Understanding changes in the commercial fishery for parameters such as fishing depth, gear fished, effort, length/age of harvest, and harvest seasonality can provide stock assessment scientists with needed supporting data for model development. After the data have been analyzed on a fine scale, then data on different fisheries/gear can be grouped based on selectivity patterns, effort, or seasonality to reduce variability in the stock assessment model.

According to the SAFMC statistics, North Carolina fishermen landed 27% of the South Atlantic commercial snapper grouper landings from 2001 to 2005 (SAFMC 2008). In North Carolina, hook and line fisheries are typically grouped based on gear; however, commercial snapper grouper fishermen use different gear to target different species. Fishermen that use electromate rod and reel typically fish in shallower water targeting grouper while those that use bandit reels typically fish in deeper water targeting vermilion snapper and red porgy but will target grouper as well. The differences in fishing area may result in distinct selectivities between gears. An understanding of what species are harvested by different gear will give an indication of the species and sizes of individuals available to the gear.

Therefore, the objectives of this project are to:

- Collect otoliths and spines from the snapper/grouper management complex caught by commercial fishermen of North Carolina according to Trip Interview Program (TIP) protocol.
- Send otoliths and spines to the National Marine Fisheries Service (NMFS) Laboratory at Beaufort, NC for processing and analysis.
- Determine the age structure for black sea bass from the pot and hook and line fisheries.

METHODS

FISH HOUSE SAMPLING

Commercial vessels were sampled to collect trip information and aging structures for various species in the snapper/grouper complex throughout North Carolina by the NC Division of Marine Fisheries (NCDMF) from April 2006 through September 2010 (Figure 1). Fish houses were sampled from Manteo, NC southward to Holden Beach, NC (Figure 2). General fishing location, days at sea, days fished, number of fishermen, type of gear, count of hooks and/or pots, and depth fished were documented for each trip sampled. Some trips had two depths recorded and some trips had a single depth. The primary depth referred to in this study will be either the depth where most fish were caught or the shallowest depth of the range fished. Species composition and total count were recorded, giving a detailed make up of each market category.

The diversity and relative abundance of the catch were used to determine the number of samples collected for each species. Fish were measured to the centerline measurement and randomly selected individuals chosen for age sampling. Sagittal otoliths were removed from under the operculum and stored dry in coin envelopes (Figure 3). Dorsal spines were collected from gray and queen triggerfish. Biological samples were collected from major target species as well as uncommon and rare species. Aging structures were coded and sent to the NOAA aging lab in Beaufort, NC except black sea bass otoliths, which were kept for further analysis by the NCDMF.

In addition to fish house sampling, the NCDMF collected a census of commercial fishing through the North Carolina Trip Ticket Program (NCTTP). Commercial fishermen are required to complete a trip ticket report at the point of landing, which includes information such as number of days fished, crew size, gear used, general area fished (north or south of Cape Hatteras), and the weight in each market category. The NCTTP uses a hand line category and groups bandit reels, electromate rod and reel, and manual hook and line, which were noted during this study.

The port sampler in the Wilmington Regional Office also assisted a federal port sampler to collect trip and biological information. Age samples collected by both samplers were generally combined into one sample either reported by the federal port sampler or the port sampler supported by this study. A summary of samples reported by the federal port sampler is recorded as an appendix to this study. Additionally supplemental aging structures and biological data were also collected from the recreational fishery and regional king mackerel and spearfishing tournaments. General location, time fished, number of fishermen, type of gear, count of hooks, depth range, and centerline lengths were collected using the same sampling protocol used for the commercial fishery. The samples collected from fishing tournaments are likely biased toward larger fish because typically the largest fish brought to the weigh stations.

LENGTH AND AGE DESCRIPTION

In addition to the biological samples, number of fish per species per market category was determined by counting the number of individuals in a market category. In some instances, sub-sampling was required. The sub-sample was expanded to the total sample by dividing the total weight per market category by the number per pound sampled. The number per length bin (either 10 or 25 mm size bins depending on the maximum observed size) or age class was expanded by using the observed length or age frequency in the sample and expanded to the total number of fish in each size bin or age class. If a species was separated into different market categories, the length or age distribution was calculated for each market category separately.

OTOLITH MACRO-STRUCTURE ANALYSIS OF BLACK SEA BASS OTOLITHS

In August 2009, the primary otolith reader attended the SC Department of Natural Resources Marine Resources Monitoring, Assessment, and Prediction Program's (SCDNR/ MARMAP) aging workshop for black sea bass. Methodology for preparing samples for aging, interpretation of otolith macro-structure, and conversion of increment counts to calendar ages were discussed. The assignment of the first increment and the interpretation of check marks were also investigated at the workshop. An inter-lab calibration was conducted generating an aging error matrix for the 2010 SEDAR update. After the aging workshop, the primary reader taught a secondary reader to age black sea bass according to the aging determination methodology developed at the workshop.

Black sea bass otoliths were examined with reflective light in a Petri dish of water against a black background at 10-12x magnification using a dissecting microscope by two independent readers with no knowledge of fish size and date of capture. When examined with reflective light, alternating translucent and opaque bands can be seen around an opaque core (primordium). Continuous opaque bands extending out from the primordium to the edges were recorded as annuli. While all orientations and directions were taken into account, most counts were taken along the anterior and posterior edges of the otoliths. Marginal increments (edge type) and readability (Table 1) were assigned using the SCDNR/MARMAP/ codes.

Mercer (1978) noted that the formation of hyaline zones (translucent) occur from June to the following January for black sea bass. Otoliths with opaque zones on their edges were classified as edge type 1 (Figure 4). If any amount of an opaque zone appeared on the edge, it was considered an increment and counted. Edge type 2 was assigned to otoliths with a small translucent zone on the edge equivalent to <30% of the previous translucent zone (Figure 5). Edge type 3 was assigned to otoliths where there was a moderate translucent zone on the edge equivalent to 30%-60% of the previous translucent zone (Figure 6). Otoliths with a wide translucent zone on the edge equivalent to >60% of the previous translucent zone were classified as edge type 4 (Figure 7). In a previous study, the SCDNR/MARMAP aging lab observed opaque zones as early as January, with a majority of the formation occurring in March (Figure 8). By May, wide translucent zones (edge type 3 and 4) began forming; however, a large portion of the otoliths were observed having opaque zones on the edge (edge type 1). Based on these observations, otoliths with translucent zones (edges type 3 and 4) were converted to a calendar age by advancing the increment count by one for fish captured between January 1st and April 30th (the month of increment formation). However, fish captured between July 1st and December 31st with translucent zones (edges) 3 and 4 were assigned ages based on increment count alone. Otoliths interpreted as having edge types 1 and 2 were assigned ages corresponding to increment count regardless of date of capture.

Parametric t-test and simple linear regression were later used to detect systematic differences between the primary reader's first and second reads, as well as the second reader's ages. Age bias plots were constructed to visually identify differences where one reader underestimates age at one end of an age range and then overestimates age at the other end. Mean coefficient of variation (CV), percent agreement, and average percent error (APE) were also analyzed to determine the degree of precision among reads and readers. The primary reader's second reads were conducted after attending the SCDNR /MARMAP aging workshop and were used as the baseline age for all comparison and subsequent analysis.

RESULTS

A total of 1,388 trips targeting fish in the snapper grouper or king mackerel fishery was sampled throughout the grant period (Table 2a and 2b). Most of the sampled trips landed from Morehead City, NC south to Holden Beach, NC. Most of the trips fished in Onslow Bay and south of Cape Fear although fishing occurred from north of Cape Hatteras, NC to Jacksonville, FL. Snapper and grouper species were targeted on 1,302 of the trips sampled and king mackerel were targeted on 86 of the trips sampled. The sampled trips were not selected using a random design. Therefore the sampled trips cannot be used to describe all trips across North Carolina. Although the samples were not random, the samples do represent greater than 5% of the number of trips that landed snapper grouper species and 10.2% of the landed snapper grouper weight in North Carolina based on NCTTP data (excluding trips targeting spadefish (*Chaetodipterus faber)* and sheepshead (*Archosargus probatocephalus)* or fishing inshore of 3 miles). Generally, the percent of total weight sampled is greater than 10% of the total weight for trips reporting landings from south of Cape Hatteras (general fishing area for snapper grouper species except black sea bass, scup, and tilefishes) and all trips landing in North Carolina (Table 3).

GEAR AND HARVEST AREAS SAMPLED

North Carolina fishermen used: bandit reel (also called Miami reels), electromate rod and reel, longline, manual hook and line, fish pot, spear, and trolling (Table 4). Most trips sampled fished with bandit reels (n=894). Electromate rod and reel was the second most commonly sampled gear used to target snapper grouper species (n=189). Fish pots, usually targeting black sea bass, were sampled third most (n=165). Other gears sampled included: long line (n=26), manual hook and line (n=32), and spear (n=6).

Most of the boats using bandit reels fished in Onslow Bay (n=564) and south of Cape Fear (n=236) bays. Seventy-eight trips fishing with bandit reels were sampled from Raleigh Bay. Boats fishing with bandit reels north of Cape Hatteras (n=12) or south of Cape Fear (n=1) were sampled but encountered on very few occasions.

Electromate rod and reel (n=189) and fish pot (165) trips typically fished in Onslow Bay. Ninety-six percent of the trips using electromate rod and reel gear fished in Onslow Bay. Less than ten trips using electromate rod and reel gear were sampled from Raleigh Bay and south of Cape Fear. Eighty-three percent of the trips using fish pots fished in Onslow Bay. Twenty-four trips using fish pots were sampled from south of Cape Fear. Less than ten trips using fish pots that fished north of Cape Hatteras and Raleigh Bay were sampled.

Trips using long line gear fished north of Cape Hatteras (n=19), in Raleigh Bay (n=6), and south of Cape Fear (n=1). Dive trips were observed in both Onslow Bay and south of Cape Fear but samples were limited (<10 overall) and only occurred in 2010. Trips using manual hook and line gear were sampled from Raleigh (n=1) and Onslow (n=18) bays and south of Cape Fear (n=12).

TRIP LENGTH

The length of trips varied among area fished and gear used (Table 5). Trips that fished with bandit reels typically fished for two to four days with a median of three days (range 1 to 12 days). The median trip length for boats that fished south of Cape Fear (4 days, average 4.6 days) was longer than for boats fishing in Raleigh or Onslow bays (3 days, average 3.3 and 2.9 days, respectively).

The median length of trips using electromate rod and reel was one day (average 1.3 days) with a range of one to six days. Most of the trips were conducted in Onslow Bay (96%) and too few trips were observed from other areas to quantify the median trip length (<10 trips).

Trips that fished with fish pots typically fished from one to three days with a median of 1.5 days (range 1 to 5 days). The median length of fish pot trips conducted south of Cape Fear (2 days, average 2.0) was longer than the median length of fish pot trips conducted in Onslow Bay (1 day, average 1.7). There were less than five trips that reported trip length from the other areas.

Other gears had very few observed trips. Longline trips lasted from one to five days. Dive boats fished for one to six days. Manual hook and line trips fished for one to three days.

DEPTH FISHED

Fishing depth varied by gear and area (Table 6, Figure 9 A-C). As expected, long line trips tended to fish in the deepest waters. Fish pot trips fished in the shallowest waters.

Longline trips fished in water deeper than 91 m. This corresponds to the minimum allowable fishing depth for longline gear in the SAFMC’s management area (SEDAR 19). Most of the trips were observed in a narrow depth range (91 m to 110 m) with the exception of one trip that fished in over 200 m of water.

Bandit reels were fished at depths ranging from 18 m to 274 m. The median of the primary depth fished decreased with decreasing latitude of fishing area. The median of the primary depth fished was 91 m north of Cape Hatteras with a range of 27 m to 183 m. Bandit reels fished in Raleigh Bay had a median primary depth fished of 57 m and a range of 18 m to 274 m. Bandit reels fished in Onslow Bay had a median primary depth of 42 m with a range of 18 m to 274 m. Bandit reels fished south of Cape Fear had the shallowest median primary depth (38 m) with a range of 18 m to 219 m.

Electromate rod and reels were typically fished in waters shallower than bandit reels. The median primary depth in Raleigh (36 m) and Onslow (32 m) bays and south of Cape Fear (35.5 m) were shallower than the median primary depth for trips that fished with bandit reels. Electromate rod and reels were fished from 18 m to 161 m.

Fish pots were fished in the shallowest water of all the gears. The median depth for trips that fished pots was 23 m with a range of depths from 9 m to 73 m. Eighty-three percent of the fish pot trips fished in Onslow Bay (n=137) where the median depth fished was 24 m with a range of 9 m to 46 m. Trips south of Cape Fear had a median depth of 18 m with a range of 9 m to 46 m. A few trips (n=3) were sampled from north of Cape Hatteras using pots that fished in deeper water (37 m to 73 m).

Manual hook and line trips reported depths ranging from 21 m to 168 m. Dive trips were reported between 24 m and 45 m. The dive trips also fished with hook and line gear, which may have been fished at deeper depths.

CREW SIZE

Crew size on commercial vessels that targeted snapper grouper species varied by gear. Boats that fished with bandit reels or electromate rod and reel typically had two to three crew members with a range of crew size from one to six fishermen. Few dive boat trips were observed, but the typical trip had four crew members. Longline trips typically fished with three crew members with a range of two to four fishermen. Boats that fished pots typically had two crew members with a range of one to three crew members.

SPECIES SAMPLED

The snapper grouper fishery encounters a variety of species. Over the sampling period, 107 species were observed. Lengths were taken from 61,841 fish (Table 7). Otoliths or dorsal spines were taken from 62 species and 29,510 fish (Table 8). All length measurement and effort information was shared with the NMFS TIP. Otoliths and spines taken from this survey were archived by the NMFS Beaufort Ageing Lab. In addition to collections listed in this document, the port sampler in the Wilmington Regional Office assisted in the collection of otoliths and sampling of boats with a federal port sampler. Attached as an appendix are the yearly totals for number of otoliths/spines collected and boats sampled.

SPECIES BY GEAR

The percent each species contributed to the commercial landings varied by gear. Trips fishing with bandit reel gear had the most diverse landings with 105 species being observed. Vermilion snapper accounted for 37.1% of the landings caught with bandit gear (Figure 10). Gray triggerfish (*Balistes capriscus)* and red grouper accounted for 15.5% and 13.4%, respectively. No other species accounted for greater than 5% of the landings.

Trips fishing with electromate hook and line had 51 species observed in the catch. The top two species were red grouper (34.8%) and gag grouper (26.2%) (Figure 11). The next three species in descending order of percent of total landings were vermilion snapper (8.6%), greater amberjack (*Seriola dumerili*) (6.7%), and black sea bass (5.0%).

The fish pot fishery had 41 species observed in the catch. The dominant species in the pot fishery was black sea bass (86.7%) (Figure 12). No other species made up greater than 5% of the catch.

Longline, trolling, and manual hook and line gears all targeted just a few species (Figures 13 to 15). Longline trips targeted blueline tilefish (*Caulolatilus microps*) (63.2%). Eighteen other species were observed from longline trips. Other abundant species included smooth dogfish (*Mustelus canis*) (13.3%), bluefish (*Pomatomus saltatrix*) (9.2%), and dolphin (*Coryphaena hippurus*) (7.6%). Trolling trips targeted king mackerel (*Scomberomorus cavalla*) (77.3%). The only other species that accounted for greater than 5% of the landings was little tunny (*Euthynnus alletteratus*) (13.7%). Manual hook and line gear targeted king mackerel (67.7%). The only other species that accounted for greater than 5% of the landings was gag grouper (6.2%).

SPECIES COMPOSITION BY MARKET CATEGORY

Snapper grouper species landed in North Carolina are packed and labeled by market categories as opposed to species categories. Market categories can be sized based and/or contain a mixture of species. Some of the market categories typically have only one species, such as yellowtail snapper (*Ocyurus chrysurus*), while other market categories were observed to have as many as 32 species. A sample weight for each market category was calculated and compared to NCTTP landings data. The NCTTP data are a complete census of the landings where as the sampling conducted here provides data on a finer scale to estimate percent contribution by each species of a market category and to identify additional gear categories, which are combined in the NCTTP. In this program, manual hook and line, electromate rod and reel, and bandit reel gears were separated although they are combined in the NCTTP data.

The landings presented in this section refer to landings from April 2006 through December 2009. NCTTP landing data for 2010 have not been finalized. Also landing data are broken up to all of North Carolina and south of Cape Hatteras. This is done for two reasons: 1) the snapper grouper fishery typical operates south of Cape Hatteras and 2) the NCTTP records area fished as north and south of Cape Hatteras. The snapper grouper landings from North Carolina were 10,415,352 lb. Snapper grouper landings south of Cape Hatteras were 8,036,791 lb. The total weight sampled over the same time period was 1,066,739 lb.

The black sea bass market category had the highest landings for all the species in the snapper grouper management complex. This species is split into two different management units in North Carolina with a break at Cape Hatteras. The landings of black sea bass from trips that fished south of Cape Hatteras from April 2006 through December 2009 accounted for 62.4% of the statewide landings (2,056,336 lb). The port samplers sampled trips that accounted for 6.8% of the catch by weight south of Cape Hatteras (87,878 lb). There were seven species observed in the black sea bass market category including: black sea bass, bank sea bass(*Centropristis ocyurus*), rock sea bass (*Centropristis philadelphica*), horse-eye jack (*Caranx latus*), tomtate (*Haemulon aurolineatum*), white grunt (*Haemulon plumieri*), and spottail pinfish (*Diplodus holbrooki*). Dive, manual hook and line, and fish pot trips only had black sea bass observed in the black sea bass category. Bank sea bass (0.5%) and rock sea bass (<0.1%) were observed in the black sea bass market category for electromate rod and reel trips. Bandit reel trips included six species (listed above) other than black sea bass in the market category but the combined weight of those species accounted for an insignificant amount (<0.3% of the market category landings).

Most of the black sea bass sampled were separated into size categories (98.8% sampled and >99.9% NCTTP) or lumped into a mixed grade (1.2% sampled and <0.1% NCTTP). A majority of black sea bass were harvested using fish pots based on trip ticket reported landings (87.7%). Black sea bass captured with fish pots were grouped into small (28.1% sampled and 43.0% NCTTP), medium (46.1% sampled and 40.7% NCTTP), large (20.7% sampled and 13.9% NCTTP), or jumbo (4.9% sampled and 2.2% NCTTP) size categories. Only 0.2% of the black sea bass captured with fish pots were not classified in a size category.

Black sea bass harvested with bandit reels were classified into mixed (8.9% sampled and 0.3% NCTTP), small (16.6% sampled and 16.6% NCTTP), medium (32.8% sampled and 43.6% NCTTP), large (29.8% sampled and 29.1% NCTTP), or jumbo (11.9% sampled and 10.5% NCTTP) categories. The weight of bank sea bass, rock sea bass, horse-eye jack, spottail pinfish, and white grunt accounted for 0.1% of the mixed category. Tomtate accounted for 0.2% of the large category.

Black sea bass harvested with electromate rod and reel were classified into mixed (1.5%), small (4.0%), medium (30.4%), large (38.1%), or jumbo (26.1%) categories. Horse-eye jack accounted for <0.1% of the mixed category. Bank sea bass accounted for <0.1% of the medium category and 0.5% of the jumbo category.

Similar to black sea bass, the majority of vermilion snapper (0.9% sampled and <0.1% NCTTP), or beeliners as they are marketed, are grouped into size categories based on weight. The majority of vermilion snapper (>99.9%) were caught using hand line gears (bandit reel, manual hook and line, and electromate) based on NCTTP data. The landings by size categories were ¾ to 1 lb (13.2% NCTTP), 1 to 2 lb (57.0% NCTTP), 2 to 4 lb (28.4% NCTTP), and >4 lb (1.4%). The sampled trips (19.3% of the total landings) reported the various hand line gears separately including: bandit reel, manual hook and line, and electromate rod and reel, which had slightly different distributions of landings for each size category. Bandit reel catches accounted for 96.8% vermilion snapper. The size distribution was 9.1% in ¾ lb to 1 lb, 51.9% in 1 lb to 2 lb, 36.2% in 2 lb to 4 lb, and 1.9% in >4 lb. Electromate rod and reel accounted for 2.5% of the sampled vermilion snapper. The size distribution shifted slightly to 1 lb to 2 lb fish. The electromate catches were 5.6% in ¾ lb to 1 lb, 74.8% in 1 lb to 2 lb, 19.5% in 2 lb to 4 lb, and <0.5% in >4 lb.

Species other than vermilion snapper observed in the vermilion snapper market category included: graysby (*E. cruentatus*), coney grouper (*E. fulvus*), creolefish (*Paranthias furcifer*), blackfin snapper (*Lutjanus buccanella*), silk snapper (*L. vivanus*), yellowtail snapper, red porgy, spotfin hogfish (*Bodianus pulchellus*), and yellowcheek wrasse (*Halichoeres cyanocephalus*). These species combined for 0.5% of the sampled weight. Silk snapper accounted for 0.25% of the sample weight and creolefish accounted for 0.2% of the sample weight.

Red grouper had the highest landings of all grouper species from April 2006 through December 2009. All landings were reported south of Cape Hatteras and a total of 10.5% of the red grouper landings were sampled. Hand lines accounted for 99.6% of the total landings based on NCTTP data. The sampled trips observed red grouper landings for bandit reels, manual hook and line, and electromate rod and reel. Bandit reels accounted for 80.9% of the red grouper landings and electromate rod and reel accounted for 17.5% of the landings. Species observed in the red grouper market category other than red grouper included: rock hind (*E. adscensionis*), red hind (*E. guttatus*), warsaw grouper (*E. nigritus*), and snowy grouper. These species only accounted for 0.2% of the sampled red grouper landings.

Combination of black and gag grouper landings ranked fifth in landings of the snapper grouper management complex. The species were grouped due to the common practice of labeling gag grouper as black grouper (*E. bonaci*). One hundred percent of this species grouping occurred south of Cape Hatteras. Hand lines were used to harvest most of the gag/black grouper (97.9%). Based on observed trips, bandit reels accounted for 60.9%, electromate rod and reel accounted for 35.0%, dive trips accounted for 2.6%, and other gear accounted for 0.1%. The gag/black grouper market category included eight species of grouper. Gag grouper accounted for 97.3% of the observed weight. Yellowfin grouper (*M. venenosa*) accounted for 1.5%, black grouper accounted for 0.7%, scamp (*M. phenax*) accounted for 0.3%, and the remaining species accounted for 0.1% of the observed weight or less.

Triggerfish ranked sixth in landings of the snapper grouper management complex. The majority of triggerfish was harvested south of Cape Hatteras (99.2%) and caught with hand lines (97.6%). Bandit reel trips accounted for 97.0% of the sampled weight. The remaining 3.0% were caught on trips using electromate rod and reel, manual hook and line, fish pots, and spears.

The triggerfish market category had nine different species observed. Gray triggerfish accounted for 99.3% of the market category. Queen triggerfish (*B. vetula)* accounted for 0.5% of the landings. The remaining 0.2% of the triggerfish market category was made up of almaco jack (*Seriola rivoliana*), bigeye (*Priacanthus arenatus*), blue angelfish (*Holocanthus bermudensis*), blueline tilefish (*Caulolatilus microps*), gray snapper (*L. griseus*), knobbed porgy (*Calamus nodosus*), and white grunt.

Amberjack ranked eighth in landings of the snapper grouper management complex. Most of the landings of amberjack were caught south of Cape Hatteras using rod and reel based on the NCTTP data (81.7%). Other significant gears used to harvest amberjack included trolling rod and reel (13.1%) and spears (5.1%). The rod and reel gear used to harvest amberjack was dominated by trips that used bandit reels (88.7% of the hook and line gear) with a minor contribution caught using electromate rod and reel (11.1%) and manual hook and line (0.2%).

Amberjack were broken into different market categories including mixed (33.6% sampled and 84.3% NCTTP), small (2.7% sampled and 1.9% NCTTP), medium (10.1% sampled and 2.0% NCTTP), and large (53.6% sampled and 11.9% NCTTP). The species composition of amberjack included twelve species. Almaco jack made up the highest percent of the amberjack landings (49.9%). Greater amberjack accounted for 46.4% of the sampled amberjack landings. The remaining 3.7% of the sampled landings included lesser amberjack (*Seriola fasciata*), banded rudderfish (*S. zonata*), blue runner (*Caranx crysos*), horse-eye jack, yellow jack (*C. bartholomaei*), bluefish, graysby, and misty grouper (*Epinephelus mystacinus*).

Almaco jack is a closely related species to greater amberjack and the two species can be difficult to distinguish. Almaco jack ranked 13th in the landings of snapper grouper management complex. Most of the catch of almaco jack was reported south of Cape Hatteras (99.0%) using rod and reel gear (97.4%). Similar to greater amberjack, bandit reels were the dominant gear used to harvest almaco jack (92.4%). The species composition of the almaco jack market category included: almaco jack (95.7%), banded rudderfish (1.9%), blue runner (<0.1%), crevalle jack (*C. hippos)* (<0.1%), greater amberjack (1.6%), horse-eye jack (<0.1%), lesser amberjack (0.4%), Atlantic bonito (*Sarda sarda)* (0.1%), little tunny (0.2%), and bluefish (0.1%).

The grunt market category ranked ninth in landings of the snapper grouper management complex. The majority of the grunt market category was harvested south of Cape Hatteras (99.9%) using hook and line gears (82.3%). Fish pots accounted for 17.6% of the landings. Bandit reels accounted for 97.0% of the sampled weight for gear classified as hook and line gear.

The grunt market category included 26 different species observed. White grunt accounted for 97.3% of the sampled weight. Knobbed porgy accounted for an additional 1.4% of the sampled weight. The remaining 24 species accounted for 1.3% of the sampled weight.

Scamp, or broomtails, ranked tenth in landing of the snapper grouper management complex. All scamp were harvested south of Cape Hatteras. Scamp were mostly harvested using hook and line gears (98.8%) with some of the catch being reported with spears (1.2%). The hook and line landings were observed using bandit reels (96.0%), electromate rod and reel (4.0%), and manual hook and line (<0.1%).

The scamp market category had seven species observed. Scamp accounted for 98.1% of the sampled weight. Other species observed in the scamp market category include gag grouper (0.3%), graysby (<0.1%), rock hind (<0.1%), snowy grouper (<0.1%), yellowfin grouper (0.1%), and yellowmouth grouper (*Mycteroperca interstitialis*) (1.5%).

Red porgy, also called pink snapper, ranked 11th in landings of the snapper grouper management complex. The majority of red porgy landings was harvested south of Cape Hatteras (>99.9%) and caught using hand lines (99.7%). Bandit reel gear accounted for 94.9% of the sampled weight of red porgy. Electromate rod and reel accounted for 3.7% of the sampled weight. All other gears accounted for less than 0.5% of the sample weight. Red porgy were separated into mixed (94.1% sample and 87.9% NCTTP), small (0.2% sample and 0.5% NCTTP), medium (1.1% sample and 7.4% NCTTP), and large (4.7% sample and 4.2% NCTTP) size categories.

Four species were observed in the red porgy market category including red porgy, knobbed porgy, whitebone porgy (*Calamus leucosteus*), and creolefish. Red porgy accounted for greater than 99.9% of the sample weight.

Snowy grouper ranked 12th in landings of the snapper grouper management complex. The majority of the landings were harvested south of Cape Hatteras (80.8%) using hook and line gear (99.8%). Based on sample trips, the hook and line gear used to capture snowy grouper was bandit reels (88.9% of sampled weight for all gear) with a small percentage captured with electromate rod and reel and manual hook and line (2.4% combined).

Snowy grouper landings were separated into size based market categories including: mixed (8.6% sampled and 0.2% NCTTP), small (5.5% sampled and 5.9% NCTTP), medium (20.9% sampled and 32.2% NCTTP), large (62.2% sampled and 60.7% NCTTP), and jumbo (2.8% sampled and 1.1% NCTTP). The species composition included: snowy grouper (98.6%), graysby (<0.1%), misty grouper (0.1%), warsaw grouper (0.1%), wreckfish (*Polyprion americanus*) (0.7%), and yellowedge grouper (0.5%).

The hinds, or strawberry grouper, market category ranked 14th in landings of the snapper grouper management complex. All hinds were harvested south of Cape Hatteras. Most of the landings were harvested with rod and reel gears (99.8%). Bandit reels accounted for a majority of the sampled weight for the hinds (95.8%). Electromate rod and reel (2.8%) and spears (1.0%) accounted for a small portion of the sampled weight.

The species composition of the hinds was diverse consisting of 21 species. Four species made up 96.4% of the sampled weight. Rock hind accounted for the highest percent of the sampled weight (48.4%). Red hind accounted for 26.3% of the sampled weight, graysby 13.6%, and coney grouper 8.1%.

The jolthead porgy market category ranked 16th in landings of the snapper grouper management complex. The majority of jolthead porgy landings were harvested south of Cape Hatteras (97.5%) using rod and reel gears (99.6%). The rod and reel landings of jolthead porgy were mostly harvested with bandit reels (97.7%). Electromate rod and reel accounted for 2.3% of the rod and reel landings.

The jolthead porgy was a diverse market category including 19 species. The most commonly observed species on the sampled trips was knobbed porgy (91.5%). Other porgies observed in the jolthead market category included: jolthead porgy (*Calamus bajonado*) (2.2%), whitebone porgy (2.0%), scup (*Stenotomus chrysops)* (1.2%), and spottail pinfish (1.1%). No other species accounted for greater than 0.5% of the sampled weight.

The hogfish or hog snapper category ranked 17th in landings of the snapper grouper management complex. All landings of the hogfish market category were reported south of Cape Hatteras. The landings were nearly equally split between rod and reel (50.4%) and spear (49.3%) gears. Sampling observed a similar split of rod and reel (49.5%, all bandit) and spear (50.3%). The species composition of the hogfish market category consisted of two species: hogfish (*Lachnolaimus maximus*) (99.9%) and spotfin hogfish (0.1%).

Red snapper ranked 18th in landings of the snapper grouper management complex. All landings of the red snapper were reported south of Cape Hatteras. Most of the landings were harvested with rod and reel gear (99.6%). Bandit reels (87.3%) and electromate rod and reel (12.2%) accounted for almost all of the landings in the red snapper category.

The species composition of the red snapper market category included five species of snapper. Red snapper (*Lutjanus campechanus*) accounted for 98.8% of the sampled weight. Vermilion snapper (0.5%), mutton snapper (*Lutjanus analis*) (0.5%), silk snapper (0.1%), and blackfin snapper (0.1%) accounted for the remainder of the sampled weight.

SIZE COMPOSITION

All fish were measured to the nearest millimeter; however, species were grouped into size bins for easier depiction of the length frequency data. Species with an observed maximum centerline measurement of less than 600 mm were grouped in 10 mm size bins. Species with an observed maximum centerline measurement greater than 600 mm were grouped in 25 mm size bins.

Black sea bass length measurements ranged from 218 mm to 590 mm total length (TL). The median length of black sea bass was 295 mm. Length frequency plots indicated that fish pots harvested smaller fish than both bandit reel and electromate rod and reel gears (Figure 16). Fish landed with fish pots had the sharpest increase near the minimum commercial limit of 10 inches (254 mm). In addition to shift in length by gear, there is an indication of a shift in length composition by area fished. The most northern samples had the largest median size (385 mm TL). There was a decrease in median size from north of Cape Hatteras to Onslow Bay for black sea bass caught with bandit reel and fish pot gears (Table 9). The median size south of Cape Fear increased or was similar to Onslow Bay depending on gear.

Vermilion snapper measurements ranged from 248 mm to 550 fork length (FL) with a median size of 345 mm. Expanded length frequency plots indicated that a higher percentage of larger fish were caught with bandit reels as compared to electromate rod and reel (Figure 17). Similar to black sea bass a clinal pattern was observed in median size with larger fish being found in more northern regions (Table 9). The largest median size for bandit reels and electromate rod and reel was found in Raleigh Bay. The smallest median size for both gears was found south of Cape Fear.

Red grouper length measurements ranged from 370 mm to 860 mm FL with a median size of 663 mm. Expanded length frequency plots indicated that a higher percentage of larger fish were caught with electromate rod and reels compared to bandit reel (Figure 18). Red grouper caught with bandit reels had a declining median size with latitude for fish caught from Raleigh Bay to south of Cape Fear (Table 9). However, red grouper caught with electromate rod and reel had an increase in size from Raleigh Bay to Onlsow Bay.

Gag grouper measurements ranged from 456 mm to 1,207 mm FL with a median size of 813 mm. Expanded length frequency plots indicated that a higher percent of larger fish are caught with bandit reels compared to electromate rod and reel (Figure 19). Gag grouper caught with electromate rod and reel had a much sharper increase in the percent of fish at length near the minimum size limit (24 inches) compared to bandit reel caught fish. The largest median size for gag grouper was observed south of Cape Fear and the smallest was observed in Onslow Bay for both electromate rod and reel and bandit reels (Table 9).

Gray triggerfish length measurements ranged from 201 mm to 556 mm FL with a median size of 385 mm. Expanded length frequency plots indicated that a greater percentage of smaller fish are caught in fish pots (Figure 20). Electromate rod and reel had a higher percentage of slightly larger fish than those caught in fish pots, but the length frequency distribution was skewed toward smaller fish when the distribution was compared to fish caught by bandit reels (Figure 20). The median size of gray triggerfish was similar among all areas when compared among the same gear (Table 9).

Greater amberjack length measurements ranged from 322 mm to 1,538 mm FL with a median size of 938 mm. Expanded length frequency plots indicated that the size distribution of fish landed with bandit reels was much broader than the size distribution for fish caught by electromate rod and reel (Figure 21). The median size when compared among gears in the same area fished was the same in Onslow Bay and slightly larger (one size bin) in Raleigh Bay for fish caught by electromate rod and reel as compared to fish caught by bandit reels (Table 9). The median size of greater amberjack was largest south of Cape Fear for fish caught by bandit reels. The smallest median size was observed in Onslow Bay for all gears.

Almaco jack length measurements ranged from 210 mm to 1,080 mm FL with a median size of 588 mm. Expanded length frequency plots indicated that the size distribution of landed fish was wider for fish caught by bandit reels compared to fish caught by electromate rod and reel (Figure 22). The largest median size of almaco jack was in Onslow Bay across all gears (Table 9). The smallest median size for almaco jack was observed south of Cape Fear caught with bandit gear.

White grunt length measurements ranged from 200 to 490 mm FL with a median size of 315 mm. Expanded length frequency plots indicated that the size distribution of landed fish was similar for fish caught by bandit reels, electromate rod and reel, and fish pots (Figure 23). The median size for white grunt was similar among all gear (295 mm to 325 mm FL) and areas fished with the exception of trolling gear, which had few fish measured (n=10).

Scamp length measurements ranged from 373 mm to 892 mm FL with a median size of 538 mm. Expanded length frequency plots indicated that the size distribution of fish caught with bandit reels and electromate rod and reel were similar (Figure 24). Both gears had a sharp increase in percent of fish caught near the 20 inch minimum size limit (508 mm). The median size of scamp varied by area fished (Table 9). Scamp caught with bandit gear had a smaller median size with a decrease in latitude fished with the smallest median size south of Cape Fear. The smallest median size for scamp caught with electromate rod and reel was observed in Onslow Bay.

Red porgy length measurements ranged from 220 mm to 565 mm FL with a median size of 345 mm. Expanded length frequency plots indicated that the electromate rod and reel harvested smaller fish compared to fish caught by bandit reels (Figure 25). The median size of red porgy was smaller with decreasing latitude (Table 9). The largest fish were observed in Raleigh Bay for bandit reel and electromate rod and reel gears.

Snowy grouper length measurements ranged from 250 mm to 1,248 mm TL with a median size of 538 mm. Expanded length frequency plots indicated a shift in the size distribution for the three gears that landed snowy grouper (Figure 26). Snowy grouper caught with electromate rod and reel had the narrowest size distribution. Fish caught with bandit reels had a slightly broader length frequency distribution but the largest fish were rarely observed on trips with this gear. Snowy caught with longline gear had a larger size distribution when compared to the other two gears. The median size of snowy grouper by gear and area also had similar results (Table 9). Fish with the smallest median size were caught south of Cape Fear and the median size increased with latitude for bandit reels and longline gears.

Hinds include four different species of grouper; rock hind, red hind, graysby, and coney grouper. The lengths of the hinds ranged from 185 mm to 590 mm centerline. The size distribution for coney and graysby were similar (Figure 27). Rock hind had a larger size distribution compared to coney and graysby. The size distribution of red hind was the largest of four species. The median sizes for the hinds did not have any trends due to area fished (Table 9).

Knobbed porgy length measurement ranged from 252 mm to 492 mm FL with a median size of 335 mm. The size distribution of knobbed porgy was domed shaped for fish caught with bandit reels (Figure 28). There was not sufficient data from other gears for knobbed porgy. The median size of knobbed porgy was smaller with decreasing latitude (Table 9). Raleigh Bay had the highest median size and the smallest median size was observed south of Cape Fear.

Hogfish length measurements ranged from 402 mm to 792 mm FL with a median size of 613 mm. The size distribution of hogfish was similar between dive trips and trips fishing with bandit reels (Figure 29). The median size was different between Onslow Bay and south of Cape Fear (Table 9).

Red snapper length measurements ranged from 437 mm to 912 mm FL with a median size of 538 mm. The size distribution of red snapper was similar for fish caught with bandit reel and electromate rod and reel gears (Figure 30). The median size of red snapper was smaller with decreasing latitude (Table 9). This trend was observed on trips that had the primary gear as bandit reel, electromate rod and reel, and fish pots.

READER COMPARISON

Parametric paired t-tests comparing age of black sea bass revealed slight differences between reads and readers (Table 10). A significant difference between the primary reader's first and second reads was observed for all readability scenarios. Paired t-tests also indicated that the primary reader's first ages and second reader's ages were significantly different. Age bias plots and their resulting slopes did not appear to detect differences where the primary reader underestimated ages at one end of the age range and then overestimated ages at the other end. Visually comparing the pair-wise linear regression between primary reader's first reads and second reads indicated that ages 3 and 4 were periodically overestimated by as much 3 years, whereas ages 5+ were underestimated by as much as 3 years (Figure 31). A directional bias was found when the linear relationship between the primary reader's first and second read for otoliths with readabilities E (excellent) and D (good) (Figure 32) and readabilities E (Figure 33). This indicates that primary reader's first read overestimated ages 3 and 4.

A plot of the linear regression between primary reader's first ages and second reader's ages also indicated that second reader over-aged ages 3 and 4, and under-aged ages 5 and 6 by as much as three years (Figure 34). Removing otoliths with readabilities of A (unreadable), B (difficult to read), and C (fair) (Figure 35) and otoliths with readabilities of D (Figure 26) from the analysis indicated that the second reader overestimated ages 3 and 4. Comparing the primary reader's second ages to reader two's ages further displayed this bias, indicating that reader two typically overestimated ages 3 and 4 and underestimated ages 5+ (Figures 37, 38, and 39).

Overall precision between reads and readers was high, mean CV ranged from 1.02% to 2.70%, percent agreement ranged from 85.06% to 94.18%, and APE ranged from 0.72% to 1.91% (Table 10). Precision dropped slightly when all three reads were compared, mean CV was 2.79%, percent agreement was 80.74%, and APE was 3.19%. Removing otoliths with moderate to poor readabilities (D, C, B, A) slightly increased the level of precision between reads and readers. Using only otoliths with excellent readabilities (E), the highest level of precision was observed between reader one's first and second reads (mean CV=1.02%, percent agreement = 94.18%, APE=0.72%).

Between-reader bias was also observed in the distribution of edge type by month. The primary reader indicated that by February 43.4% of the otoliths read had edge type 1, 0.2% had type 3, and 56.4% had type 4 (Figure 40). However, the second reader found that 38.1% of the otoliths collected during February had edge type 1, 0.2% had type 2 and 61.7% had type 4 (Figure 41). In March the primary reader observed that 72.1% of the otoliths had edge type 1, 0.3% had type 2, 0.7% had type 3, and 27.0% had type 4; where the second reader found that 62.6% had edge type 1, 0.4% had type 2, and 37.0% had type 4. In April the primary reader found that 79.6% of the otoliths had edge type 1, 3.6% had type 2, 1.1% had type 3, and 15.7% had type 4. Reader two indicated that by April 83.8% of the otoliths had edge type 1, 1.5% had type 2 and 0.4% had type 3, 14.3% had type 4. The biggest discrepancies in edge type were observed in July, where the primary reader observed that 4.8% of the otoliths read had edge type 2, 75.3% had type 3 and 19.9% had type 4, where reader two found that 60.2% had edge type 2, 33.5% had type 3, and 5.0% had type 4.

Although significant differences were observed among readers, the differences were minor. Greater than 80% of the otoliths read had the same age among the readers or reads. When the ages differed, it was typically a one year difference in age.

AGE DISTRIBUTION OF BLACK SEA BASS

Black sea bass growth rates were to be compared among different gears to determine if black sea bass caught with different gears had different growth rates. Growth rates based on typical growth function such as von Bertalanffy or logistic growth were not fit because few fish were collected under the minimum size limit which are needed to estimate growth during ages 0, 1, and 2 (Figure 42). These younger ages can account for a significant portion of an individual's growth. Instead age distributions were used to determine if the different gears caught different age black sea bass. The expanded age of black sea bass was significantly different for each gear (F=6.97, DF=3, P=0.0003). Black sea bass ranged in age from 1 to 10, with a median age of 4. A mean age of 3.81 was observed for fish caught on hook and line, 3.99 for fish caught by electromate rod and reel, and 3.85 for fish caught by bandit reels, and 3.69 for fish caught with pots. The majority of black sea bass landed were age 3 (24.7%), 4 (31.7%), and 5 (20.9%). Only ages 3 (33.3%), 4 (50.05%), and 5 (16.7%) were observed in the hook and line age distribution. Age 3 (26.6%), age 4 (32.6%), and age 5 (19.5%) black sea bass made up the majority of fish caught on electromate rod and reel. Black sea bass landed by bandit reels had a similar age distribution as sea bass landed on electromate rod and reel, with age 3 (24.4%), age 4 (32.0%), and age 5 (21.1%) making up the bulk of the catch. Older fish age 7 (3.7%), and age 8 (0.6%) made up only a small percentage of the fish landed on bandit reels. Black sea bass caught in pots were predominately age 3 (23.6%), age 4 (30.7), and age 5 (21.7%). Older fish age 7 (3.4%), age 8 (0.68%), age 9 (0.23%), and age 10 (0.23%) were less prevalent in fish pots. No significant interaction between depth and gear type was observed (F=0.98, DF=12, P=0.4778). However, mean age significantly increased from 3.24 (10 m) to 4.67 (65 m) as depth increased (F=4.67, DF=11, P<0.0001; Figure 43). Younger black sea bass were predominately caught in shallower waters, <40 m using electromate rod and reel, bandit reels, and manual hook and line (Figure 44) and <30 m using pots (Figure 45). A small percentage of age 3 and 4 fish were landed at deeper depths and older fish (age 6+) were observed across all depth ranges between both gear classes. A significant interaction between gear and month was observed (F=1.95, DF=15, P=0.0304); however, a significant interaction between depth and month was not observed (F=1.39, DF=35, P=0.1159). The interaction between gear and month in the ANOVA means that different gears fished in different months and the difference in mean age cannot be attributed to either gear or month independently. Mean age was significantly higher during the winter as compared to late summer and early fall (F=10.92, DF=11, P<0.0001; Figure 46). Mean age ranged from 3.57 (2009) to 3.97 (2006) (F=9.30, DF=4, P<0.0001; Figure 47). Significant interactions between year and gear (F=2.59, DF=7, P=0.0184), as well as depth and year (F=2.19, DF=23, P=0.0073) were also observed. These interactions among parameters (ie, year, gear, and depth) in the ANOVA prevented the model from detecting the effect each parameter had on mean age independently.

Black sea bass ages were significantly different for each size category (F=195.41, DF=4, P<0.0001; Figure 48). Ungraded or mixed bass ranged in age from 2 to 7 with a mean age of 4.13 and a median age of 4. Mixed bass were predominately age 3 (29.1%), age 4 (35.9%) and age 5 (21.2%). Small bass ranged in age from 2 to 8 with a mean age of 3.48 and median age of 3. Age 3 (45.6%) and age 4 (39.3%) made up the majority of small bass. Medium bass ranged in age from 2 to 8 with a mean age of 3.77 and a median age of 4. Medium bass were predominately age 3 (33.7%) and age 4 (42.3%). Large bass ranged in age from 1 to 8, with a mean age of 4.22 and a median age of 4. Age 4 (44.5%) and age 5 (26.2%) sea bass made up bulk of large bass. Jumbo bass ranged in age from 2 to 10, with a mean age of 4.80 and a median age of 5. Older sea bass, age 6 (18.3%), age 7 (4.7%), age 8+ (0.91%), were more prevalent in the jumbo category; however, a majority of the fish were age 4 (34.4%) and age 5

(33.7%). As the size category went from small to jumbo the proportion of age 3 sea bass gradually declined, while sea bass greater than age 6 gradually increased.

DISCUSSION

The snapper grouper fishery catches a diversity of species. Market categories generally included greater than 95% of the labeled category with the exception of black/gag grouper, amberjack, jolthead porgy, and strawberry grouper. Very few black grouper were observed in the catches of the snapper grouper fishery landed in North Carolina. Generally the catch of black and gag grouper can be classified as gag grouper. However, the size distribution of gag grouper was smaller than black grouper. The amberjack category was almost evenly split in terms of percent weight between almaco jack (49.9%) and greater amberjack (46.4%). The landings of the broad category of amberjacks are all counted toward the greater amberjack quota established by the SAFMC. Landings for other species of amberjack (*Seriola spp.)* are not counted toward the quota if they are listed on the trip ticket (Catie Bruger, NMFS, personal communication). Knowing the species composition and percent weight by species is important for effective management of a quota system. The jolthead porgy category is almost exclusively knobbed porgy. The category included 19 other species, but these species only accounted for 8.5 percent of the sampled weight during the study. The strawberry grouper category was made up of mostly four species: rock hind, red hind, graysby, and coney grouper. The maximum age for these species varies between 11 for coney grouper up to 22 years for red hind (NMFS 2005) and should be monitored to ensure the stock is sustainable.

Not only is species composition per market category crucial for accurate stock assessments but the number of fish per market category is essential. An accurate record of removals by weight for biomass models and number for age structured models is needed for each species. The count and weight of each species by market category can assist the SEDAR process, which needs to convert landings weight reported by commercial fishermen and dealers to numbers of fish. Typically this is done using length frequencies which are converted to weight using a length-weight relationship to get an average weight of fish as described in Vaughan et al. (1992). The total weight landed is then divided by the estimated average weight. This study observed the number of fish in each market category and determined the weight for each species. A total number per sample was derived from the observed trips and can be used to expand out to the total number of fish harvested. Although this type of expansion has not been used in the past for snapper grouper species in the South Atlantic in the SEDAR process, it provides a second technique to estimate numbers of fish and uncertainty estimates can be derived for the number of fish harvested by commercial fisheries.

One aspect of importance to stock assessments is gear selectivity. Past assessments for snapper grouper species in the South Atlantic have used different groupings of gear but no assessment has different selectivity estimates for electromate rod and reel and bandit reel gears. These two gears had different harvest selectivity patterns for vermilion snapper, gag grouper, red grouper, gray triggerfish, greater amberjack, almaco jack, red porgy, and snowy grouper. The electromate rod and reel fishery, which typically operates in shallower water, appears to target younger, smaller fish. Amendment 15B of the SAFMC Snapper Grouper Fishery Management Plan closed the bag limit sale of snapper grouper species for commercial fishermen not holding a federal snapper grouper license who typically made one day trips fishing with manual hook and line or electromate rod and reel gears. This closure will likely result in some protection of these smaller, younger fish.

The median size of some highly sought after fish had a latitudinal pattern of smaller fish captured further south. These species include red snapper, vermilion snapper, red grouper, snowy grouper, and red porgy. If fishing depth varies by fishing area, then the resulting size distribution would be biased by the dominant area fished and not represent the actual size distribution of the population. Length frequency data can be further biased by targeting different species with different gear. Fishermen using bandit reels typically fish for vermilion snapper, red porgy, and grouper off the coast of the Carolinas. Fishermen using electromate rod and reel typically target grouper. The electromate rod and reel is limited to fishing in shallower water due to the size of the line on the reel and current which cannot be overcome by the lighter weight on the terminal tackle. There was a consistent pattern of smaller fish harvested in this fishery because of targeting fish inshore. Given the differences in the length frequencies observed between electromate rod and reel and bandit gears, these two gears should be separated in the reporting of landings data.

Red snapper and red porgy both have been reported to migrate to deeper water as they grow and age (Vaughan et al. 1992; Burns et al. 2008). This ontogenetic shift to deeper water was observed in other species based on gear selectivity and length frequency plots. Gear fished can be used as a proxy for depth fished since different gears typically fished different depths. The cumulative abundance of red porgy less than 360 mm FL caught with electromate rod and reel was over 80% while only 50% of the bandit reel harvest was less than 360 mm. Length frequency was shifted toward smaller black sea bass collected in fish pots, which fish the shallowest water. Over 40% of black sea bass from sampled trips were within 40 mm of the minimum size limit while only 25% of the black sea bass were collected with electromate rod and reel and bandit gear were within 40 mm of the minimum size limit. The length frequency of snowy grouper caught with electromate rod and reel indicated that 84% were less than 600 mm. While bandit reels accounted for 74% of the sampled snowy grouper less than 600 mm and longlines only accounted for 8%. Length frequency plots indicated 50% and 24% of the gag grouper catches were less than 700 mm with electromate rod and reel and bandit gear, respectively. Gray triggerfish had the highest percentage of its length frequency less than 360 mm in fish pots (90%), followed by electromate rod and reel (52%), and bandit reels (33%). These shifts in length frequency provide evidence that some snapper grouper species migrate to deeper water. Assessment models and management need to account the emigration from the fishing area. Others species, such as white grunt, appear to be equally vulnerable among all gears.

BLACK SEA BASS AGING

Inaccuracies in the age determination of a population can severely impact demographic rates used to describe and manage a stock. Interpretation error can be biased or random and can affect both the accuracy and precision of the age distribution (Campana 2001). Accuracy can be described as the closeness of an age estimate to a true value, where precision is used to describe the reproducibility of a repeated age measurements (Beamish and Fournier 1981). Reader bias is affected by individual reader, true age of the fish being aged, and individual fish. Significant between-reader bias may indicate a lack of resolving power in the criteria, insufficient training, and peculiarities in the structure being aged (Kimura and Lyons 1990). Parametric paired t-tests and simple linear regressions conducted in our study detected slight systematic differences between reader ages. Paired t-tests indicated significant differences in age comparisons for 4 of 10 pairwise comparisons. Simple linear regressions testing slope also failed to indicate the extent of reader bias (Figures 31 to 39). However, the visual comparison of the age bias plots revealed that both readers typically overestimate ages 3 and 4 black sea bass compared to age estimates by the primary reader after the black sea bass aging workshop. Kimura and Lyons (1990) noted that the analysis of repeated age readings does not fall under the purview of classical statistical theory. Simple linear regressions can indicate presence or absence of aging bias but often cannot detect non-linear differences between readers when the differences are centered on the 1:1 line (Campana et al. 1995; Campana

2001). Age bias graphs are often better indicators of aging bias for describing the type and magnitude of the bias (Campana 2001).

At the SCDNR/MARMAP aging workshop, one of the major concerns was the interpretation of check marks between the 2nd and 3rd and/or 4th increment, which was thought to correspond with the timing of transition of black sea bass from females to males (McGovern et.al. 2002). Visual inspection of the age bias plots revealed that both readers commonly overestimated age of 3 to 5 year old fish. This discrepancy is an indication that the secondary reader potentially counted check marks as annuli. The primary reader's first read also had this discrepancy, indicating that check marks may have been counted as annuli prior to attending the aging workshop. Between-reader precision may be further compounded by the reader's inability to distinguish the first annulus. Thus, calendar age between readers could be potentially off by as much as two years as a result of these discrepancies.

The interpretation of edge type could also affect the precision and accuracy between readers. Comparing the percent composition of edge type by month for each reader (Figures 40 and 41), there appears to be a significant difference in the interpretation of edge type among readers. The SCDNR/MARMAP protocol indicates that if the specimen was collected between January 1 and April 30 (the month of increment formation) and have an edge type of 3 or 4, the increment counts are to be converted to calendar age by advancing the increment count by one. The primary reader assigned 43.4% of the otoliths an edge type 1 or 2 in February, 72.4% in March, and 83.3% in April; where the secondary reader observed 38.3% in February, 63.0% in March, and 85.3% in April. Reader differences of edge type 1 and 2 by month, ranged from 2.0% to 9.4%. Edge types of 3 and 4 were assigned 81.3% of the time by the primary reader in February, 56.6% in March, and 27.7% in April; and 61.7% in February, 37.0% in March, and 14.7% in April for reader two. Reader differences in edge types 3 and 4 by month, ranged from 13.0% to 19.6%. Increment counts could potentially account for 5.5% to 17.4% of the differences between readers.

Given the inherent limitations of using paired t-test and simple linear regressions to describe precision between readers, mean CV, percent agreement, and APE were assumed to be a more accurate measure of ageing precision (Table 10). In a literature review, Campana (2001) noted that most ageing studies can be carried out with a CV less than 7.6%, and the most frequently reported CV for otoliths was 5%. Under this guideline, 10 of 10 paired comparisons passed. Interestingly enough, removing otoliths with poor readabilities did not significantly affect the mean CV among readers. While the validity of using percent agreement has been questioned (Kimura and Lyons 1990), overall percent agreement was relatively high among reads and improved noticeably when otoliths with poor readabilities were excluded. Using an APE of 5% or less (as decided upon at the black sea bass aging workshop as an expectable APE), 10 out of 10 of our reader comparisons passed. Mean APE also improved significantly when otoliths with poor readabilities were excluded. However, otoliths with poor readabilities typically represent older fish and removal of these fish could severely impact estimates used to describe the harvested population. Detailed analysis of how readability and the interpretation of the first annulus should be further investigated to describe bias among readers. Interpretation errors and geographical variation in growth patterns as describe by Dery and Mayo (1988) may further complicate attempts to assign ages to individuals in a particular length class (Quinn and Deriso 1999). Thus, age estimates based on sample age frequency were used as opposed to an age-length key given that age estimates were very precise (>80% having the same age among reads) and growth differences have been observed.

Off the coast of North Carolina black sea bass are targeted by both commercial and recreational fishermen using a number of gears. Mercer (1978) speculated that size and age differences between black sea bass harvested in the South and Mid-Atlantic Bight could be attributed to gear selectivity. In our study, gear type was found to have a significant effect on the age of black sea bass captured, yet no interaction between gear and depths was observed. Our results indicated that fish pots selected younger fish; however, the mean age was only slightly lower for fish pots (3.69) than for manual hook and line (3.81), electromate rod and reel (3.99), and bandit reels (3.85). This difference in mean age is most likely a function of depth. Black sea bass landed using bandit and electromate reels were typically caught at deeper depths by fishermen targeting other species within the snapper grouper complex. Fishing depth and seasonality were found to influence mean age of black sea bass caught off the North Carolina Coast.

Our findings mirror those of Wenner et al. (1986) and McGovern et al. (2002), indicating that black sea bass live up to 10 years, with ages less than 5 commonly occurred at depths of 10 m to 65 m. Our results indicated that younger black sea bass were more frequently caught at shallow depths during the spring and early fall and at deeper depths in winter. Musick and Mercer (1977) indicated that larger and older black sea bass move offshore and winter in the deeper waters of the Mid-Atlantic Bight at depths of 73 m to 165 m. Black sea bass were also found to migrate inshore and northward over a wide bathymetric distribution in the spring, and by summer the highest numbers were found at depths less than 37 m. Low and Waltz (1991) concluded that the reduced representation of age 3 and 4 black sea bass off Charleston, SC during September reflected a combination of increased contribution of incompletely recruited age 1 fish, summer fishing mortality of larger fish, and a possible emigration of larger fish to deeper water. Age 3 and 4 black sea bass made up 79.4% of the fish pot catch by number and 82.1% of the hook and line catch at depth less than 40 m. This is contrary to Low and Waltz (1991) which found most of the black sea bass were ages 2 and 3.

A significant difference in mean age was observed from 2006 to 2010, dropping to a 4 year low of 3.57 in 2009. That same year, a large portion of the black sea bass landings were caught during the summer and fall of 2009 (Figure 40). Above average juvenile recruitment prior to 2009 may have contributed to the spike in landings and the subsequent drop in mean age. A long time black sea bass pot fisherman indicated that 2009 marked one of his best fishing years, citing that his fishing effort did not change and that he as well other commercial fishermen from his area fished year round prior to the SAFMC setting the total allowable catch (TAC) at 847,000 pounds. He also indicated that he caught more fish earlier in the season in both 2009 and 2010. Based on our results, younger black sea bass were predominantly caught at shallower depths throughout the summer and fall while older fish were typically found at deeper depths during the winter. The observed drop in mean age is most likely the result of more fish being landing earlier in the year at shallower depths, not a response to the TAC. Given the limited time series of this study, more time is needed to determine if fishing practices have changed in response to management practices by targeting black sea bass earlier in the fishing year or if the population is rebuilding due to the current management strategy.

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Table 1. SEDAR readability codes commonly used to age reef fish.

Code	Description	Analysis of consequence
A	Unreadable	Omit from analysis
B	Very difficult to read	Age estimate between readers are expected to > 2 years for young, and > 4 years for old fish (>10 years) Agreement on age may be difficult to reach, in which case otoliths should be classified as A and omitted from the analysis.
C	Fair Readability	Age estimates between readers should be within 2 years in young, and within 4 years in old fish (>10years). Agreement after second reading is expected after some discussion.
D	Good readability	Age estimates between readers should be within 1 year for young, to 2 years in old fish (>10 years). Agreement after second reading is expected without much discussion.
E	Excellent readability	Age estimates between readers should be the same.

Table 2a. Number of trips sampled targeting species in the snapper grouper complex.

Month	2006	2007	2008	2009	2010
January		19	25	20	17
February		28	28	38	26
March		46	13	17	35
April	12	31	21	43	7
May	14	24	41	36	29
June	14	31	25	26	22
July	12	15	38	32	20
August	17	17	29	23	29
September	16	19	19	14	33
October	29	30	29	5	
November	40	23	23	8	
December	26	32	20	16	
Total	180	315	311	278	218

Table 2b. Number of trips sampled targeting king mackerel.

Month	2006	2007	2008	2009	2010
January		3	1		7
February					3
March			6	8	3
April			7	12	
May				4	1
June				4	1
July				2	1
August	3				1
September	1				
October	4			2	
November		1		4	
December	1	1		5	
Total	9	5	14	41	17

Table 3. The percent of the market category weight from a sampled trip compared to the total weight landed reported on NC trip tickets for trips fishing for snapper grouper complex species south of Cape Hatteras (CH) and all trips landing in North Carolina and percent comparing landings south of Cape Hatteras to all landings in North Carolina.

Market Category	% Sampled South of CH	% Sampled NC	% Landings South of CH
Black Sea Bass	6.8%	4.3%	62.4%
Beeliner (Vermilion Snapper)	19.3%	19.3%	100.0%
Red Grouper	10.5%	10.5%	100.0%
Grey Tilefish	47.6%	5.2%	11.0%
Gag and Black Grouper	7.2%	7.2%	100.0%
Triggerfish	22.1%	21.9%	99.2%
Scup	3.2%	0.0%	0.2%
Amberjack	12.7%	12.6%	99.2%
Grunt	9.8%	9.8%	99.9%
Scamp Grouper	10.0%	10.0%	100.0%
Pink Snapper	12.0%	12.0%	100.0%
Snowy Grouper	14.7%	11.9%	80.8%
Almaco Jack	10.9%	10.8%	99.0%
Hinds**	12.3%	12.3%	100.0%
Sheepshead	0.0%	0.0%	49.3%
Porgy**	14.4%	14.0%	97.5%
Hogfish (Hog Snapper)	5.6%	5.6%	100.0%
Red Snapper	14.4%	14.4%	100.0%
Banded Rudderfish	17.8%	17.8%	100.0%
Gold Tilefish	0.0%	0.0%	88.5%
Yellowedge Grouper	6.7%	3.2%	47.7%
Yellowfin Grouper	17.6%	17.6%	100.0%
Mutton Snapper	15.9%	15.9%	99.9%
Spadefish	0.0%	0.0%	6.7%
Sand Tilefish	25.6%	25.6%	100.0%
Mixed Grouper	0.6%	0.4%	79.6%
Cubera Snapper	24.8%	24.8%	100.0%
Yelloweye (Silk) Snapper	37.5%	37.5%	100.0%
Mixed Snapper (Toro/Bigeye)	39.0%	39.0%	100.0%
Mangrove Snapper	5.5%	5.5%	100.0%
Blackfin Snapper	6.2%	6.2%	100.0%
Yellowtail Snapper	0.0%	0.0%	100.0%

**NCTTP for market categories were grouped due to very low landings in some categories.

Table 4. The number of trips sampled for each gear and area fished by year. Electromate=electromate rod and reel, Manual H&L=manual hook and line.

Gear	Area Fished	2006	2007	2008	2009	2010	Total
Bandit Reel	N of Cape Hatteras	7	2		3		12
	Raleigh Bay	14	13	34	10	7	78
	Onslow Bay	54	165	125	100	120	564
	S of Cape Fear	40	51	57	62	30	240
Spear	Onslow Bay					2	2
	S of Cape Fear					4	4
Electromate	Raleigh Bay	2	1		1	1	5
	Onslow Bay	43	40	36	41	22	182
	S of Cape Fear					2	2
Manual H&L	N of Cape Hatteras				1		1
	Raleigh Bay		1				1
	Onslow Bay				2	16	18
	S of Cape Fear				12		12
Longline	N of Cape Hatteras			8	10	1	19
	Raleigh Bay	5			1		6
	S of Cape Fear			1			1
Fish Pot	N of Cape Hatteras	2	1				3
	Raleigh Bay			1			1
	Onslow Bay	11	35	42	41	8	137
	S of Cape Fear	2	6	5	8	3	24
Trolling	N of Cape Hatteras				1		1
	Raleigh Bay	4		1			5
	Onslow Bay	5	5	14	24	19	67
	S of Cape Fear				2		2
Total		189	320	324	319	235	1,387

Table 5. The median, minimum, and maximum number of days fished by commercial fishermen by gear and area fished. Electromate = electromate rod and reel, Manual H&L = manual hook and line.

Area Fished	N of Cape Hatteras	Onslow Bay	Raleigh Bay	S of Cape Fear
		Median		
Bandit	1	3	3	4
Spear		4.5		5
Electromate		1	1	3.5
Manual H&L		1	1	1
Longline	2		2	3
Fish Pot	1	1	2	2
Trolling		2	1	2
		Minimum		
Bandit	1	1	1	1
Spear		3		4
Electromate		1	1	1
Manual H&L		1	1	1
Longline	1		1	3
Fish Pot	1	1	2	1
Trolling		1	1	2
		Maximum		
Bandit	2	10	5	12
Spear		6		6
Electromate		5	4	6
Manual H&L		3	1	1
Longline	4		3	3
Fish Pot	1	5	2	4
Trolling		5	1	2

Table 6. The median, minimum, and maximum depth (m) fished by commercial fishermen by gear and area fished. Electromate = electromate rod and reel, Manual H&L = manual hook and line.

Gear	N of Cape Hatteras	Onslow Bay	Raleigh Bay	S of Cape Fear
		Median		
Bandit	91	42	57	38
Spear		24		33.5
Electromate		32	36	35.5
Manaul H&L		45	168	27.5
Longline	95		99	201
Fish Pot	73	24	24	17.5
Trolling		24	27	18
		Minimum		
Bandit	27	18	18	18
Spear		24		24
Electromate		18	26	31
Manaul H&L		30	168	21
Longline	91		93	201
Fish Pot	37	9	24	9
Trolling		9	27	18
		Maximum		
Bandit	99	274	274	108
Spear		24		41
Electromate		59	46	40
Manaul H&L		50	168	34
Longline	101		110	201
Fish Pot	73	45	24	45
Trolling		53	27	18

Table 7. The number of lengths collected over the grant period by species and year in descending order of lengths collected.

Common Name	2006	2007	2008	2009	2010	Total
vermilion snapper	4,651	2,195	2,074	1,456	1,418	11,794
black sea bass	1,658	2,690	1,632	1,784	565	8,329
gray triggerfish	1,413	936	829	737	664	4,579
red grouper	1,176	1,167	1,091	552	287	4,273
king mackerel	173	343	1,616	1,472	103	3,707
almaco jack	414	974	1,005	378	493	3,264
snowy grouper	1,051	804	421	265	578	3,119
blueline tilefish	1,251	260	449	471	156	2,587
red porgy	930	416	493	337	275	2,451
gag	686	615	422	323	280	2,326
white grunt	902	467	248	336	149	2,102
dolphin	173	232	231	543	405	1,584
scamp grouper	279	404	299	238	191	1,411
squirrelfish	243	282	186	76	128	915
spottail pinfish	58	222	328	147	54	809
greater amberjack	84	137	260	92	193	766
rock hind	114	275	110	127	73	699
knobbed porgy	223	205	111	69	30	638
little tunny	6	46	127	432	18	629
sand tilefish	58	193	159	9	24	443
banded rudderfish	56	106	70	73	107	412
red snapper	29	59	153	149	1	391
red hind	80	106	102	70	30	388
creole grouper	44	128	120	43	49	384
silk snapper	26	159	61	52	62	360
lesser amberjack	28	45	124	36	65	298
graysby	34	93	51	45	27	250
bluefish	27	1	24	138	23	213
short bigeye	15	59	47	38	52	211
tomtate	13	13	82	17	72	197
coney grouper	20	80	45	34	16	195
bank sea bass	28	101	48	6	3	186
scup	62	6	30	29	33	160
conger eel	20	28	65	40		153
bigeye	19	28	24	5	41	117
hogfish	32	52	7	1	25	117
pigfish	2	25	5	77		109
cobia	18	22	19	6	28	93
yellowmouth grouper	18	41	5	8	12	84

Table 7 continued.

Common Name	2006	2007	2008	2009	2010	Total
queen triggerfish	19	23	11	8	14	75
spanish mackerel	8			54	12	74
blackfin snapper	1	31	5	12	21	70
yellowfin grouper	6	33	4	8	12	63
whitebone porgy	9	14	13	14	11	61
Atlantic bonito	29	7	8	6	7	57
spinycheek scorpionfish	15	11	14	4	13	57
yellowedge grouper	21	16	8	6	6	57
African pompano	5	10	31		10	56
red hake	1	17	15	5	2	40
great barracuda	6	12	8	12	4	42
goldface tilefish		8	14	5	8	35
blue runner	6	5	15	7		33
blackbar drum	6	9	3		13	31
speckled hind	8	14	8		1	31
mutton snapper	5	9	11	2	3	30
pinfish	1	3	3	2	15	24
wahoo		4	3	10	6	23
wreckfish	22					22
spotfin hogfish	7	7	6		1	21
yellowtail snapper		4		5	8	17
blackfin tuna	2	1	3	2	7	15
Gulf flounder	1	7	1		4	13
blackbelly rosefish	8			2		10
warsaw grouper	1	1	4	2	2	10
longspine porgy				9		9
oyster toadfish				9		9
southern hake			9			9
blue tang		1	1	4	2	8
gray snapper		1	2	1	4	8
black grouper		2	4	1		7
whitespotted soapfish	2	2		1	2	7
Atlantic bearded brotula	4				2	6
cubera snapper	2	1	2		1	6
blackline tilefish			2	2	1	5
greater soapfish	1		1		3	5
spotted moray				1	4	5
misty grouper	1	2			1	4
blackbar soldierfish					3	3

Table 7 continued.

Common Name	2006	2007	2008	2009	2010	Total
pearly razorfish					3	3
rainbow runner		2	1			3
sand perch		1	2			3
big roughy			2			2
horse-eye jack	2					2
jolthead porgy				2		2
lionfish					2	2
longtail bass				1	1	2
queen angelfish			1	1		2
yellowfin tuna					2	2
barrelfish	1					1
bermuda chub		1				1
blue angelfish	1					1
bluehead wrasse		1				1
bluespotted cornetfish	1					1
Carolina hake				1		1
deepbody boarfish		1				1
hunchback scorpionfish				1		1
northern puffer		1				1
ocean surgeonfish		1				1
painted wrasse				1		1
rock sea bass			1			1
sheepshead					1	1
spadefish					1	1
spanish flag				1		1
white trevally					1	1
yellow jack		1				1
Total	16,316	14,279	13,389	10,913	6,944	61,841

Table 8. The number of aging structures collected over the grant period by species and year. Otoliths were collected for all species except gray and queen triggerfishes which had dorsal spines collected.

Common Name	2006	2007	2008	2009	2010	Total
vermilion snapper	310	1,603	2,028	1,292	1,418	6,651
black sea bass	666	1,730	1,511	1,571	565	6,043
red grouper	248	1,026	1,051	537	287	3,149
gray triggerfish	166	707	822	653	663	3,011
snowy grouper		688	412	248	576	1,924
gag	234	563	412	315	280	1,804
red porgy	99	371	473	304	274	1,521
scamp grouper	66	379	287	204	191	1,127
white grunt	134	301	231	255	148	1,069
rock hind	16	91	108	117	73	405
king mackerel	14	10	187	81	80	372
red snapper	7	57	149	145	1	359
silk snapper	3	150	60	48	62	323
red hind	26	73	99	69	30	297
creole grouper		93	108	39	48	288
blueline tilefish		53	77	54	98	282
graysby	9	48	51	44	25	177
coney grouper	7	48	42	33	16	146
bank sea bass	5	44	22	4		75
blackfin snapper		26	5	10	21	62
yellowmouth grouper	2	40	5	8	6	61
queen triggerfish	9	18	9	8	14	58
yellowfin grouper	1	18	4	8	6	37
mutton snapper	3	9	11	2	3	28
yellowedge		11	5	3	6	25
speckled hind	1	13	8		1	23
tomtate			21	2		23
goldface tilefish		4	7	4	7	22
yellowtail snapper		4		5	4	13
squirrelfish			5		7	12
cobia					11	11
African pompano					10	10
longspine porgy				9		9
spanish mackerel	2			7		9
gray snapper		1	2	1	4	8
black grouper		2	4	1		7
bluefish				7		7
warsaw grouper		1	3	2	1	7
dolphin		6				6

Table 8 continued.

Common Name	2006	2007	2008	2009	2010	Total
hogfish			1		5	6
spotfin hogfish			5		1	6
blackline tilefish			2	2	1	5
wahoo					5	5
cubera snapper		1	2		1	4
misty grouper		2			1	3
triggerfish		3				3
bigeye			1	1		2
almaco jack		1				1
Atlantic bonito		1				1
great barracuda			2			2
greater amberjack		1				1
greater soapfish			1			1
lesser amberjack		1				1
longtail bass					1	1
rock sea bass			1			1
sand tilefish					1	1
sheepshead					1	1
short bigeye					1	1
spadefish					1	1
spanish flag				1		1
white trevally					1	1
Total	2,028	8,198	8,234	6,094	4,956	29,510

Table 9. The median size of select snapper grouper complex species caught by North Carolina fishermen by gear and area fished. Electro = electromate rod and reel, Manual = manual hook and line, Pots=fish pots, CH=Cape Hatteras, CF=Cape Fear.

Common Name	Area Fished	Bandit	Spear	Electro	Manual	Longline	Pot	Trolling
almaco jack	Raleigh Bay	588		738			613	
	Onslow Bay	638		763			888	838
	S of CF	488						
red snapper	Raleigh Bay	563		513				
	Onslow Bay	538		538			488	
	S of CF	513			513			
black grouper	Onslow Bay	913						
	S of CF	888						
black sea bass	N of CH	385					395	
	Raleigh Bay	355		375			335	
	Onslow Bay	305		325			295	335
	S of CF	325	345				295	
coney grouper	Raleigh Bay	310						
	Onslow Bay	305		340				325
	S of CF	325						
gag	Raleigh Bay	788		738				
	Onslow Bay	763		713	788		713	788
	S of CF	838	813	813	638			
gray triggerfish	Raleigh Bay	385		365			305	
	Onslow Bay	385		355	370		315	355
	S of CF	375						
graysby	Raleigh Bay	285						
	Onslow Bay	325		325				
	S of CF	325	295	335				
greater amberjack	Raleigh Bay	963		988			863	
	Onslow Bay	938		938			838	838
	S of CF	1063						
hogfish	Onslow Bay	613						
	S of CF	538	613					
knobbed porgy	Raleigh Bay	415						
	Onslow Bay	355		365				315
	S of CF	335						

Table 9. continued

Common Name	Area Fished	Bandit	Spear	Electro	Manual	Longline	Pot	Trolling
red grouper	Raleigh Bay	688		663			613	
	Onslow Bay	663		688	663		613	713
	S of CF	513	713					
red hind	Raleigh Bay	425						
	Onslow Bay	425		435	455			425
	S of CF	425						
red porgy	Raleigh Bay	375		345				
	Onslow Bay	355		335	320			355
	S of CF	315	355					
rock hind	Raleigh Bay	355						
	Onslow Bay	385		435			565	365
	S of CF	375						
scamp grouper	Raleigh Bay	588		600				
	Onslow Bay	563		563	563		638	588
	S of CF	488	538	638				
silk snapper	Raleigh Bay	455		295				
	Onslow Bay	385		455				
	S of CF	345						
snowy grouper	N of CH	563				963	813	
	Raleigh Bay	538		300	713	838		
	Onslow Bay	513		538				538
	S of CF	413				713		
speckled hind	Onslow Bay	288						
vermilion snapper	Raleigh Bay	385		335			335	
	Onslow Bay	365		325	305		335	365
	S of CF	320		285				
warsaw grouper	Onslow Bay	713						
white grunt	Raleigh Bay	305						
	Onslow Bay	325		315	295		315	375
	S of CF	315					315	

Table 10. Results of various tests of accuracy and precision used to determine reader error or bias. Primary is the primary reader which conducted a first (1st) and second (2nd) read. The secondary reader read the otoliths once. * Indicates significance. Readability codes are listed in Table 1.

Reader	Reader	Reader	Readability Code	N	Paired t-Test	Linear Regression	CV	% Agreement	APE
Primary (1st)	Primary (2nd)	Secondary	E,D,C,B,A	2,944	-	-	2.79%	80.74%	3.19%
Primary (1st)	Primary (2nd)		E,D,C,B,A	5,300	<0.01*	<0.01*	2.14%	87.19%	1.52%
Primary (1st)	Secondary		E,D,C,B,A	2,946	0.54	<0.01*	2.67%	85.06%	1.89%
Primary (2nd)	Secondary		E,D,C,B,A	3,784	0.07	<0.01*	2.70%	85.44%	1.91%
Primary (1st)	Primary (2nd)		E, D	5,076	<0.01*	<0.01*	1.94%	88.51%	1.37%
Primary (1st)	Secondary		E, D	2,834	0.48	<0.01*	2.36%	86.59%	1.67%
Primary (2nd)	Secondary		E, D	3,643	0.57	<0.01*	2.38%	87.13%	1.69%
Primary (1st)	Primary (2nd)		E	3,490	0.02*	<0.01*	1.02%	94.18%	0.72%
Primary (1st)	Secondary		E	2,269	0.01*	<0.01*	1.59%	91.32%	1.12%
Primary (2nd)	Secondary		E	2,677	0.25	<0.01*	1.56%	92.08%	1.10%

Figure 1. Commercial snapper grouper fishing vessel with bandit reels.

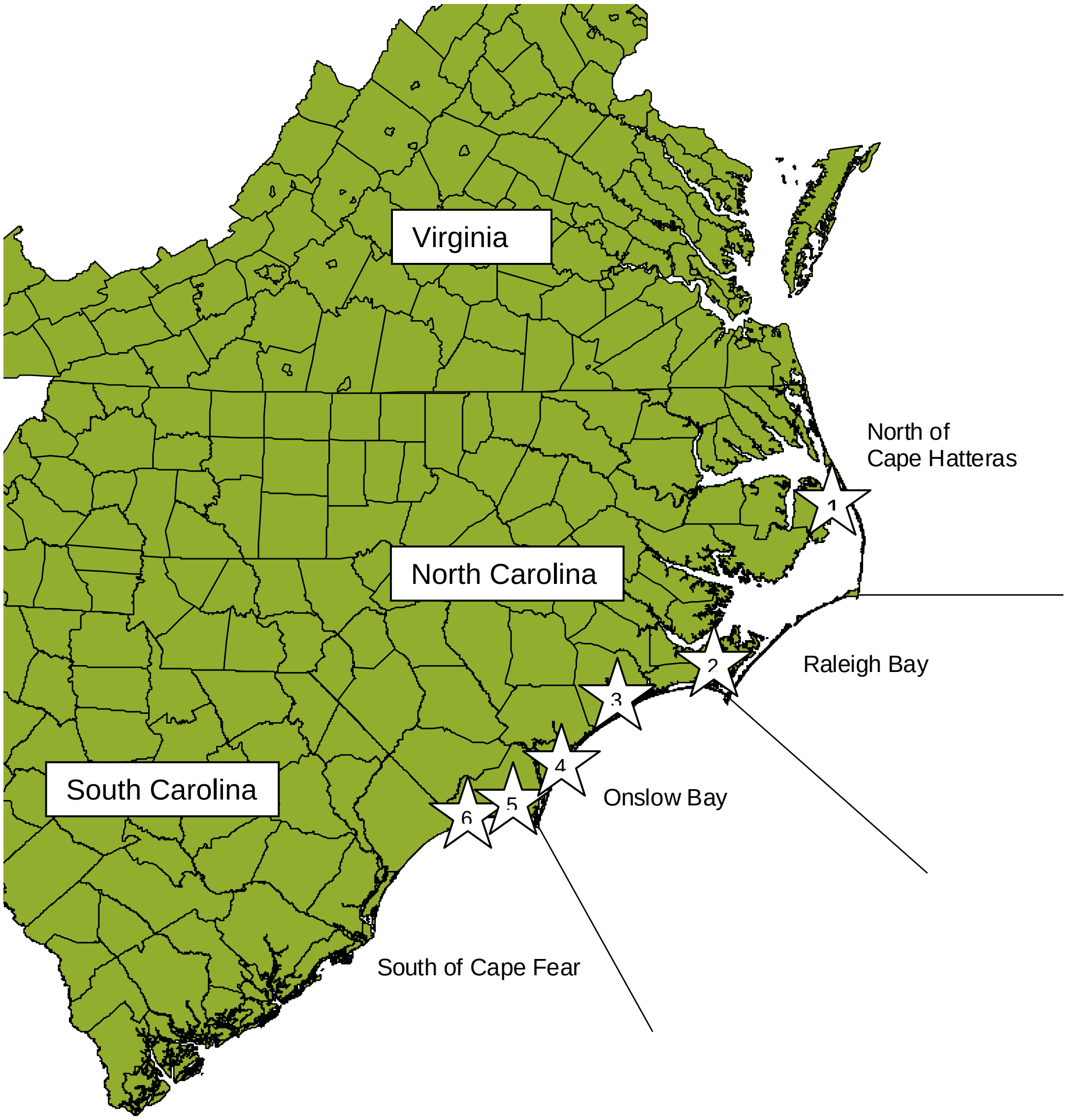

Figure 2. Map of harvest areas and major sampling ports. 1=Manteo, 2=Morehead City/ Beaufort, 3=Sneads Ferry, 4=Wilmington, 5=Southport, 6=Holden Beach.

Figure 3 Port sampler removing an otolith from a scamp. Picture courtesy of Bob Sadler.

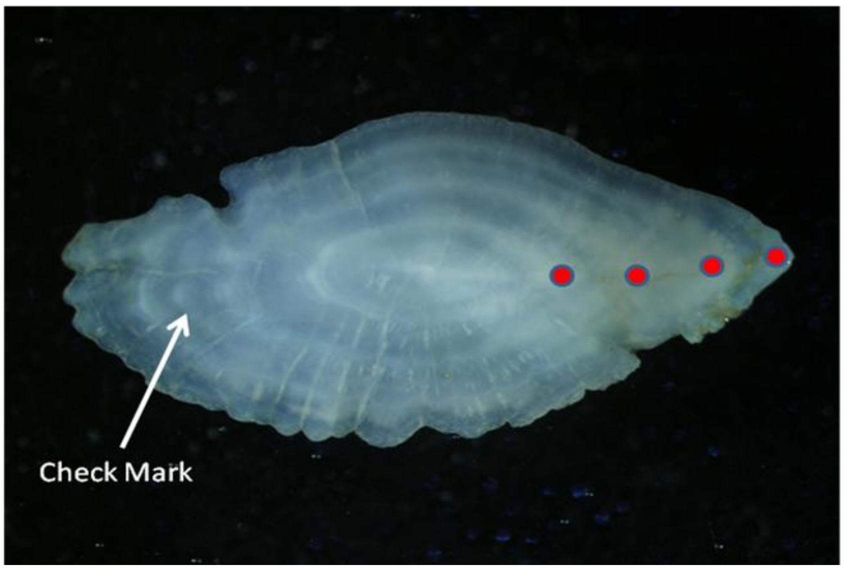

Figure 4. Sagittal otolith of an age 4 black sea bass with an edge type 1 (opaque zone on the edge) with a false annuli or "check" between the 2nd and 3rd annuli (edge type 1). Red dots indicate increment counts.

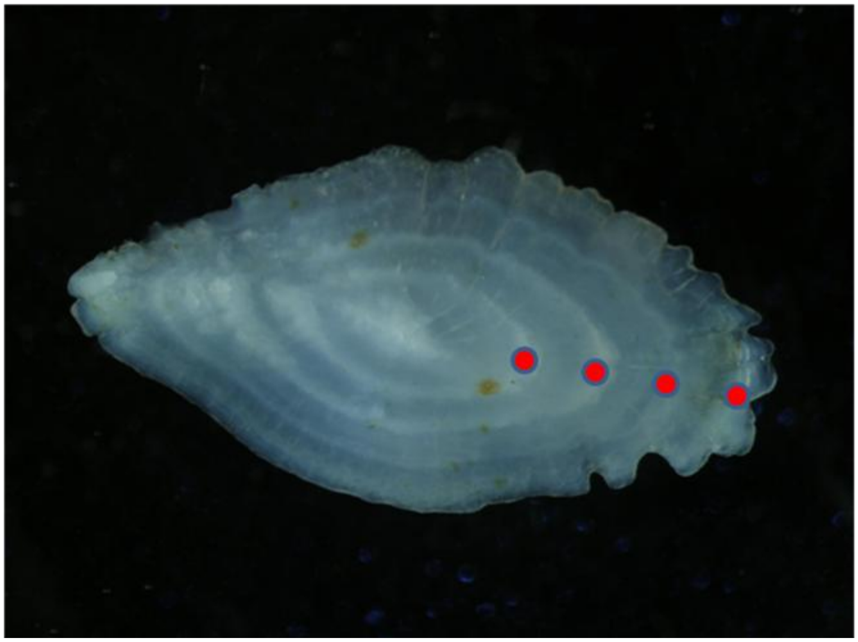

Figure 5. Sagittal otolith of an age 4 black sea bass with an edge type 2 (a narrow translucent zone on edge with a width less than 30% of previous increment). Red dots indicate increment counts.

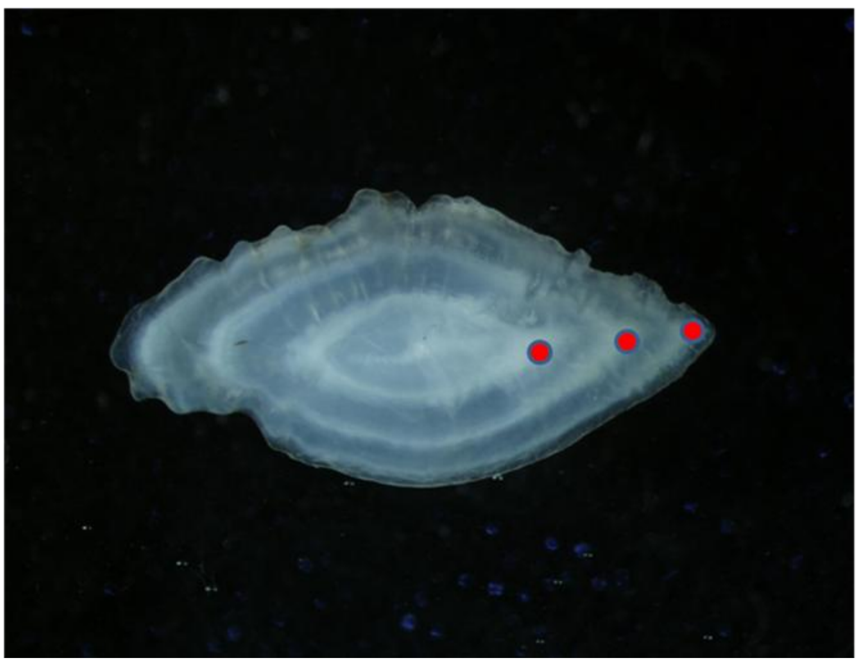

Figure 6. Sagittal otolith of an age 3 black sea bass collected in October 2006 with an edge type 3 (medium translucent zone on edge and a width about 30-60% of previous increment). Red dots indicate increment counts.

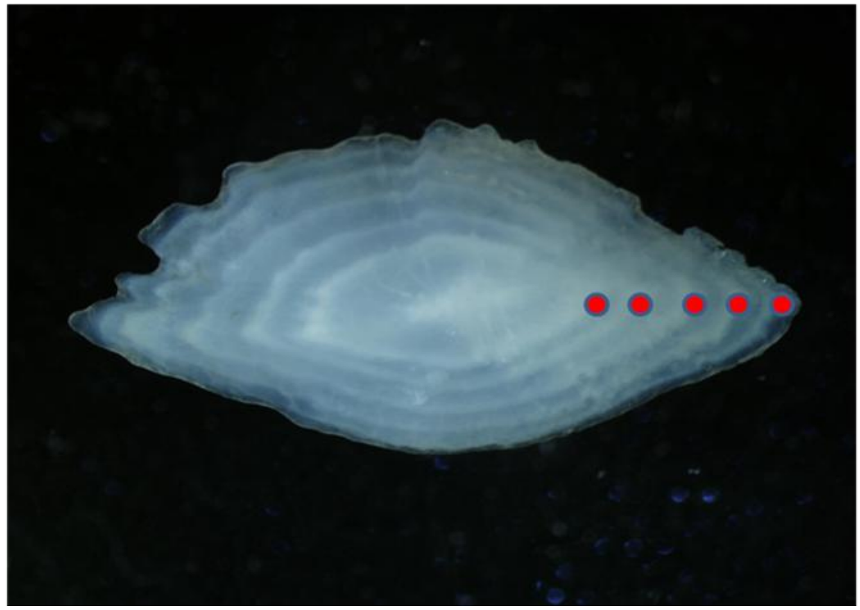

Figure 7. Sagittal otolith of an age 5 black sea bass collected in October 2006 with an edge type 4 (wide translucent zone on edge and a width more than 60% of previous increment). Red dots indicate increment counts.

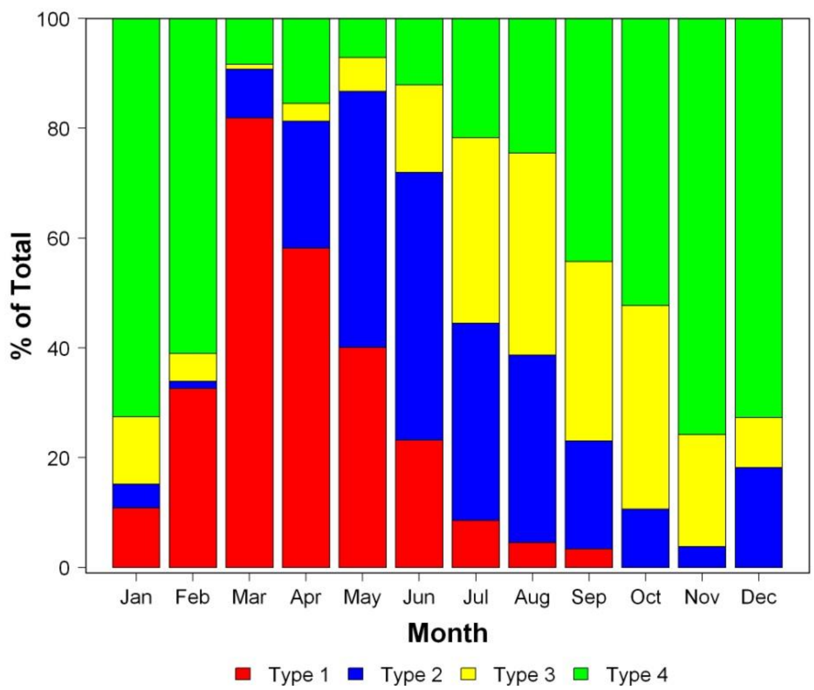

Figure 8. Black sea bass edge type distribution by month for individuals aged (n=21,005) by SCDNR/MARMAP. Figure used with permission from the 2009 black sea bass age workshop, Charleston SC.

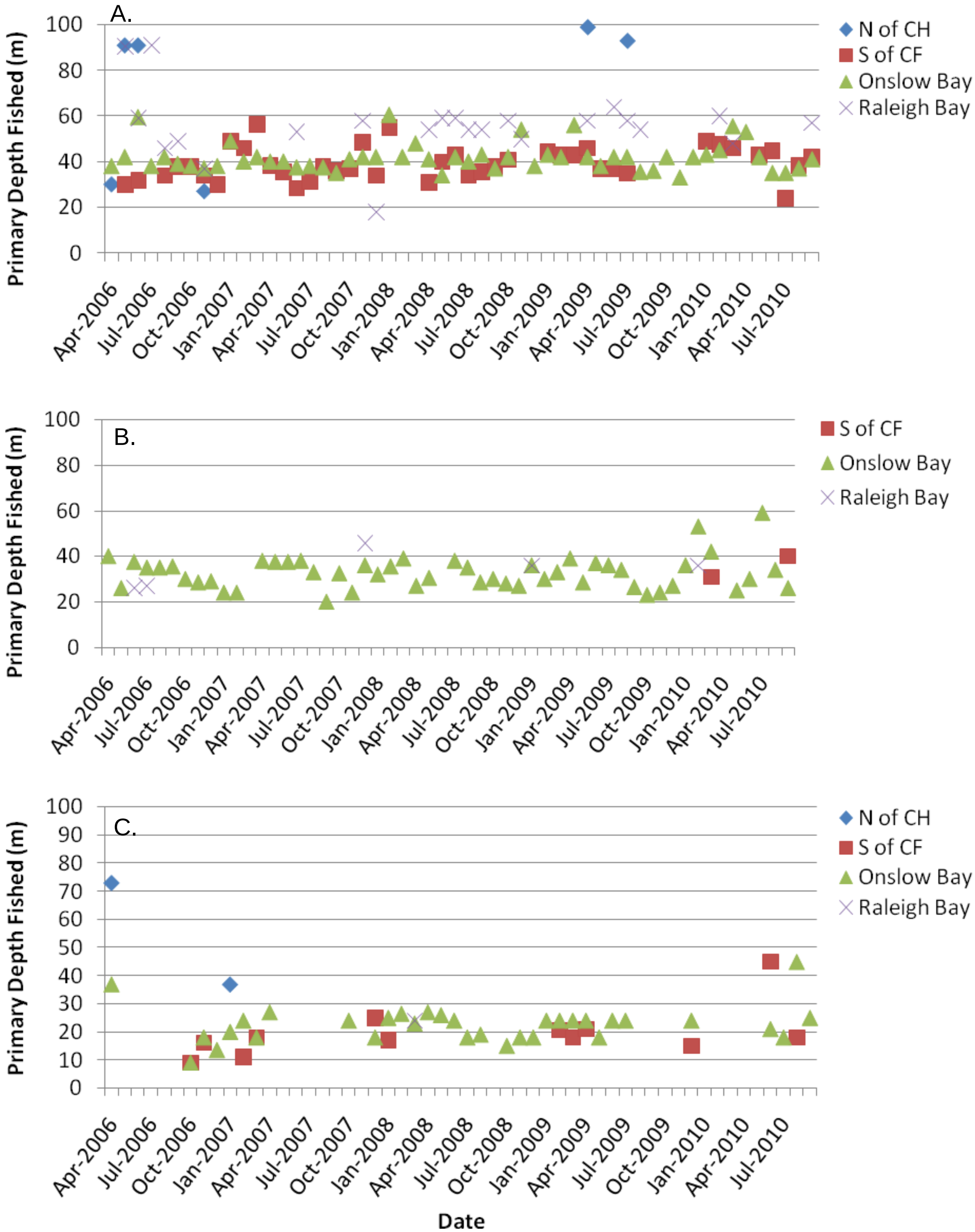

Figure 9. Median depth fished by commercial fishermen targeting snapper grouper species for bandit reels (A), electromate rod and reel (B), and fish pots (C). N of CH= north of Cape Hatteras, S of CF= south of Cape Fear.

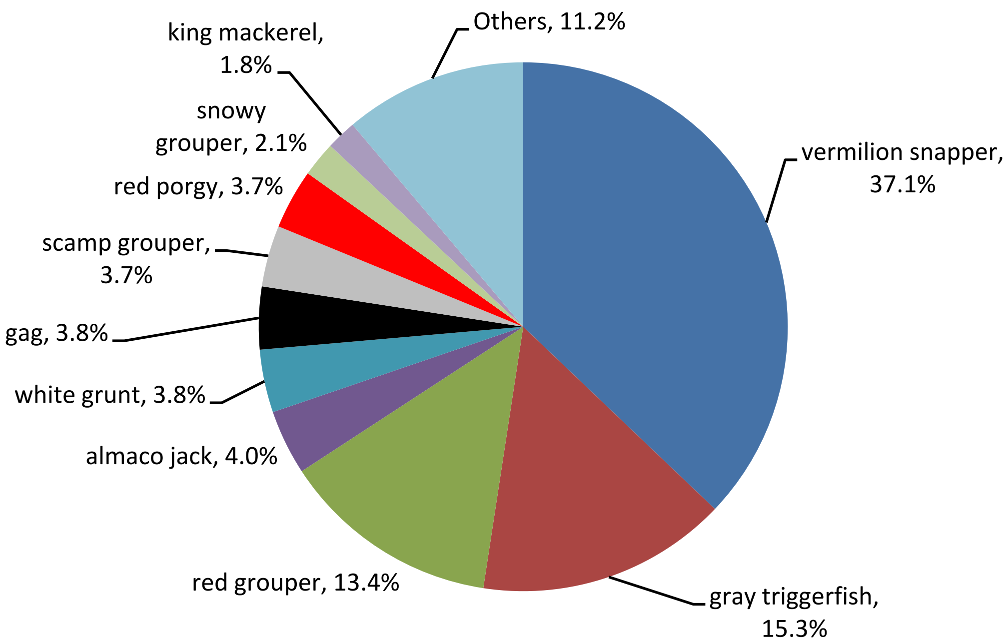

Figure 10. Species composition by weight for trips using bandit reel. Top ten species are graphed and the remaining species grouped (others).

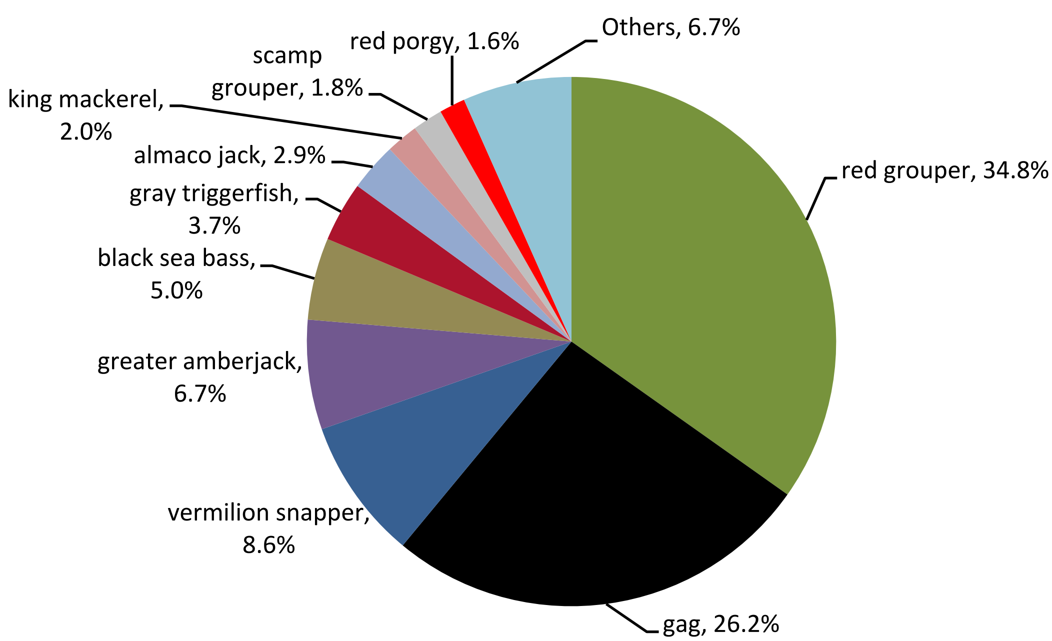

Figure 11. Species composition by weight for trips using electromate rod and reel. Top ten species are graphed and the remaining species grouped (others).

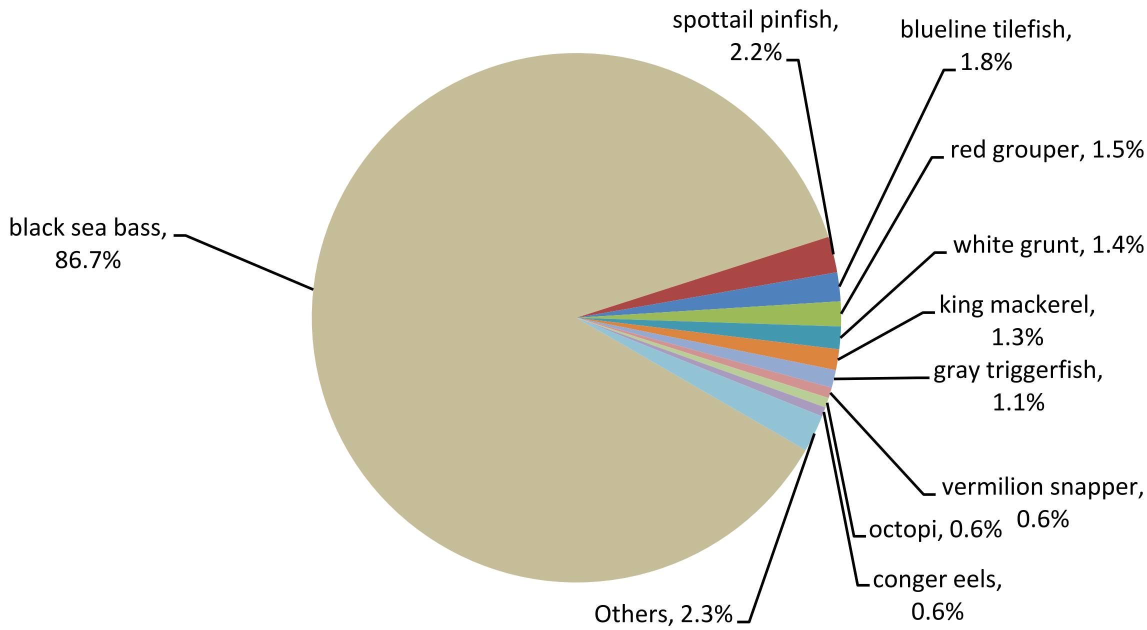

Figure 12. Species composition by weight for trips using fish pots. Top ten species are graphed and the remaining species grouped (others).

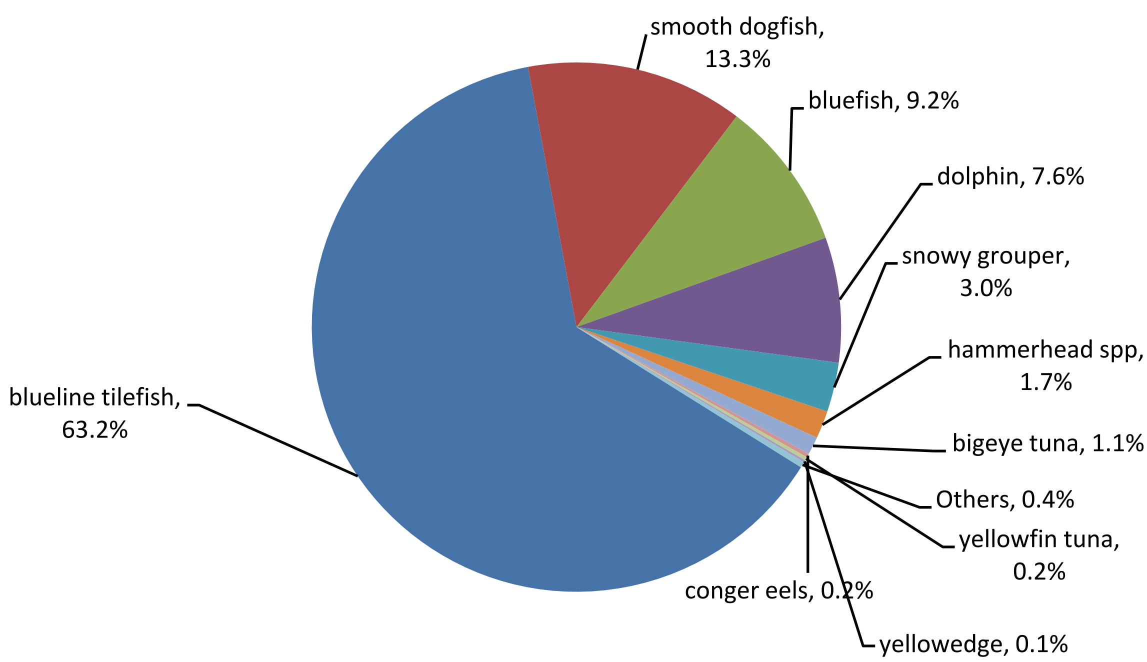

Figure 13. Species composition by weight for trips using longlines. Top ten species are graphed and the remaining species grouped (others).

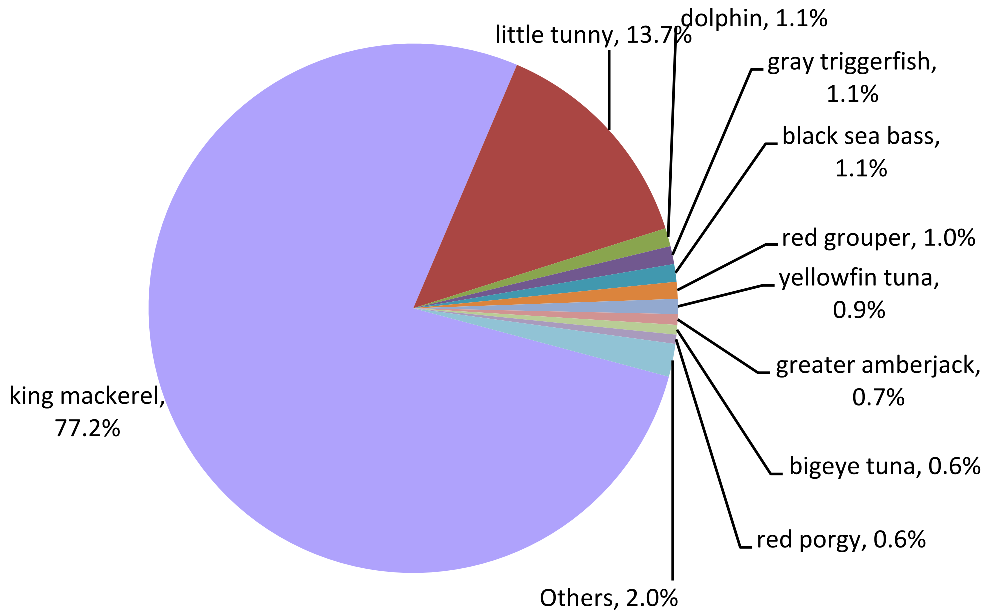

Figure 14. Species composition by weight for trips using trolling gear. Top ten species are graphed and the remaining species grouped (others).

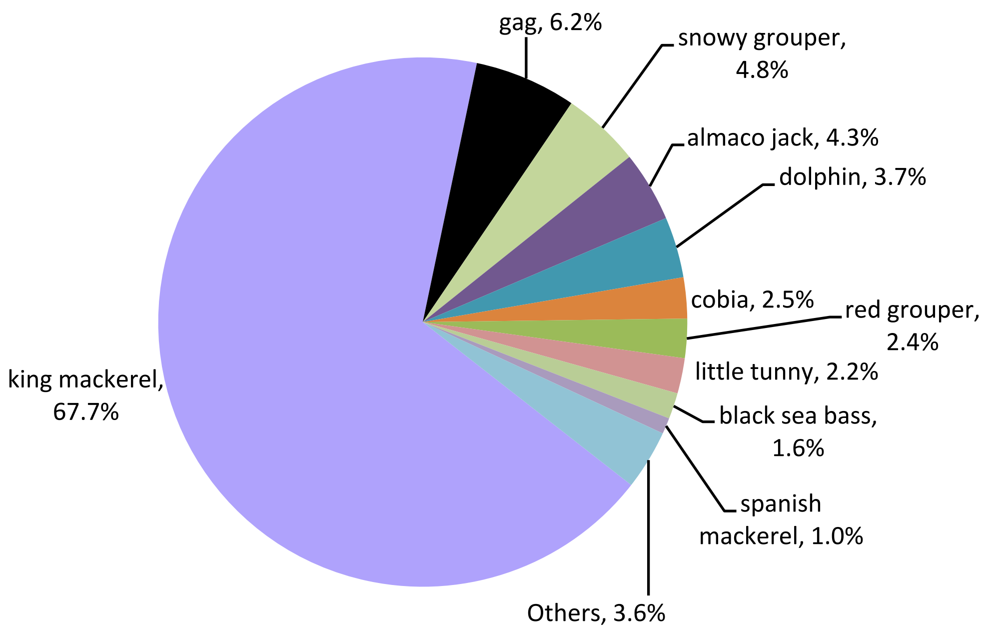

Figure 15. Species composition by weight for trips using manual hook and line. Top ten species are graphed and the remaining species grouped (others).

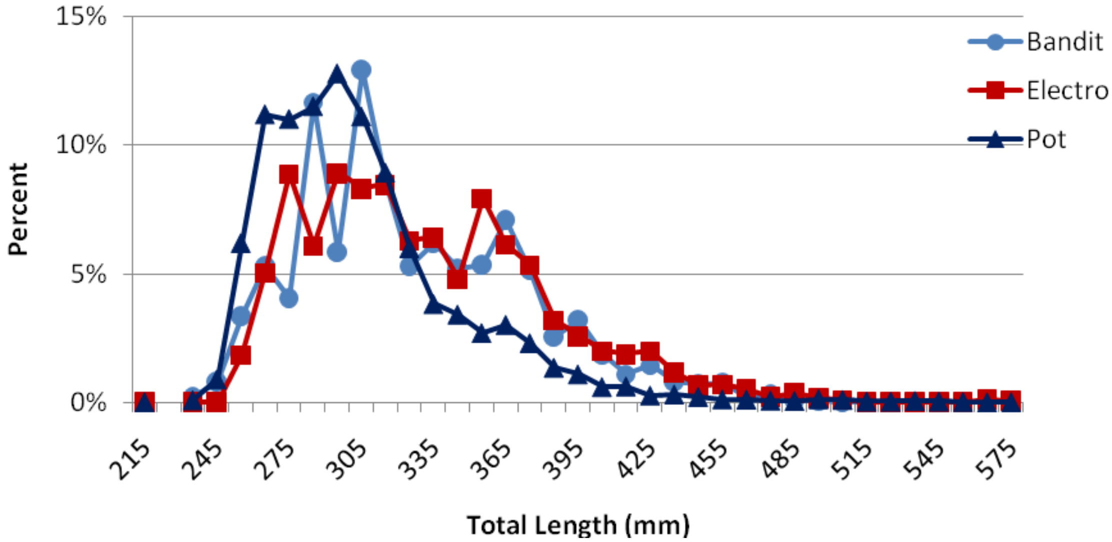

Figure 16. Length frequency plot of expanded lengths for black sea bass caught with bandit reels, electromate rod and reel (electro), and fish pots.

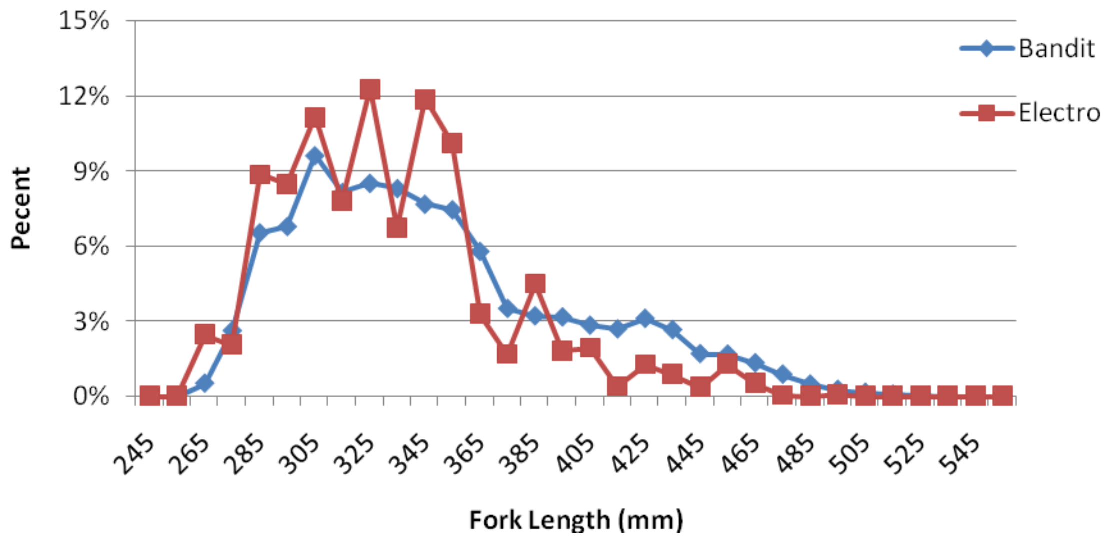

Figure 17. Length frequency plot of expanded lengths for vermilion snapper caught with bandit reels and electromate rod and reel (electro).

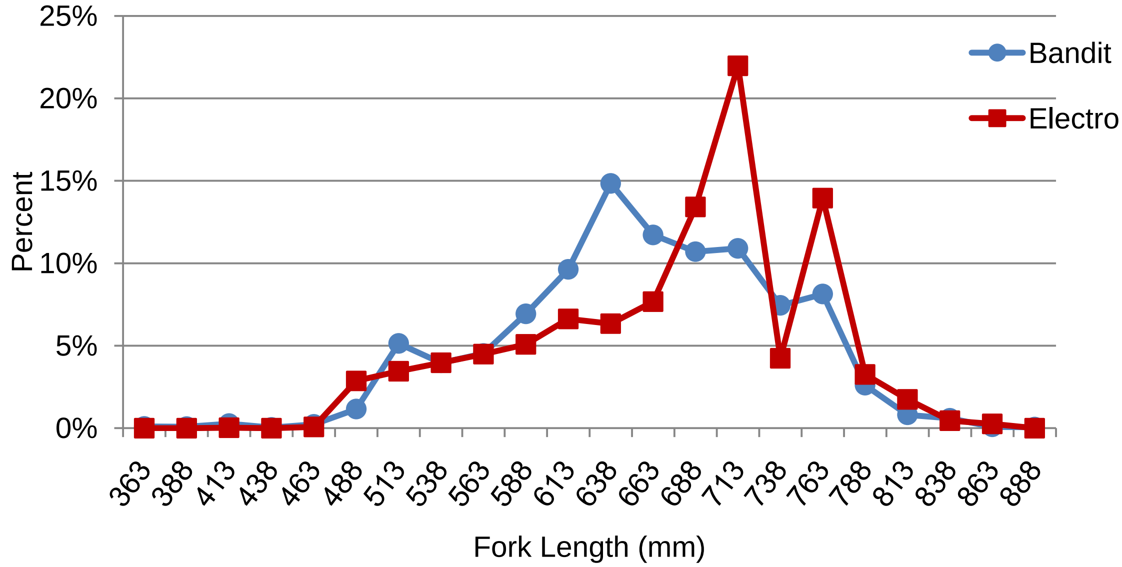

Figure 18. Length frequency plot of expanded lengths for red grouper caught with bandit reels and electromate rod and reel (electro).

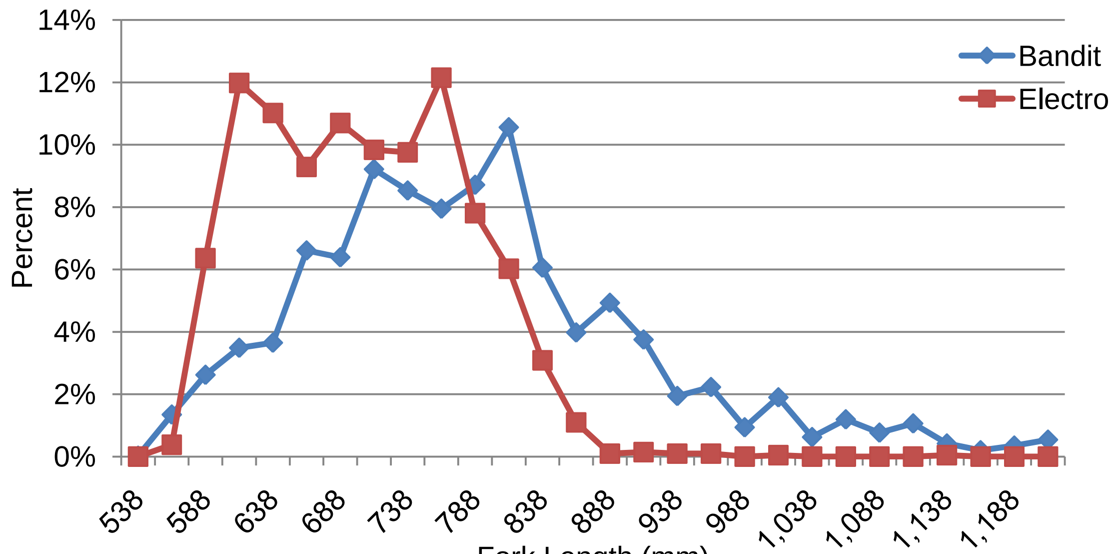

Figure 19. Length frequency plot of expanded lengths for gag grouper caught with bandit reels and electromate rod and reel (electro).

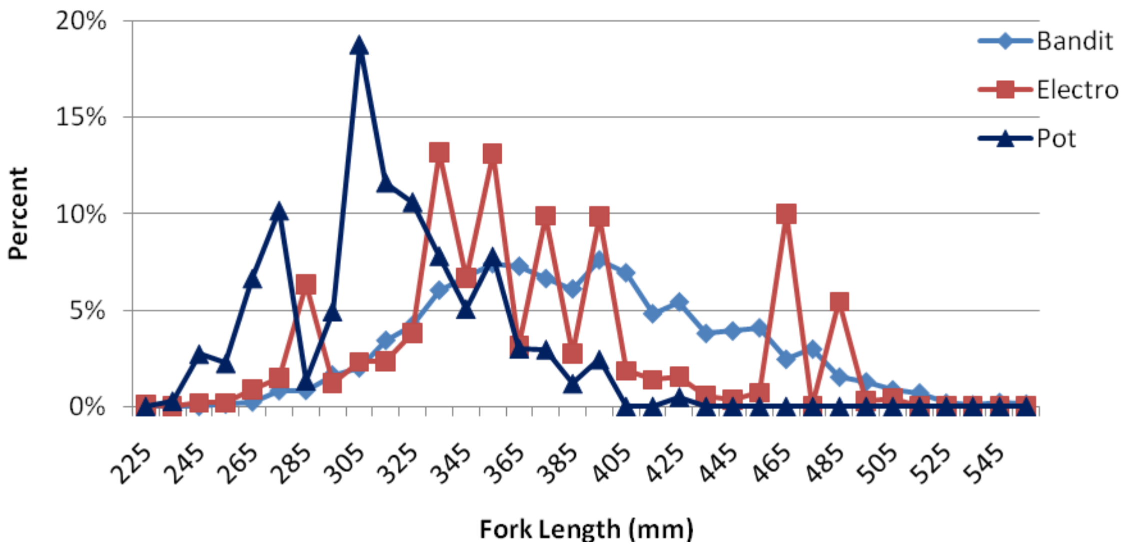

Figure 20. Length frequency plot of expanded lengths for gray triggerfish caught with bandit reels, electromate rod and reel (electro), and fish pots.

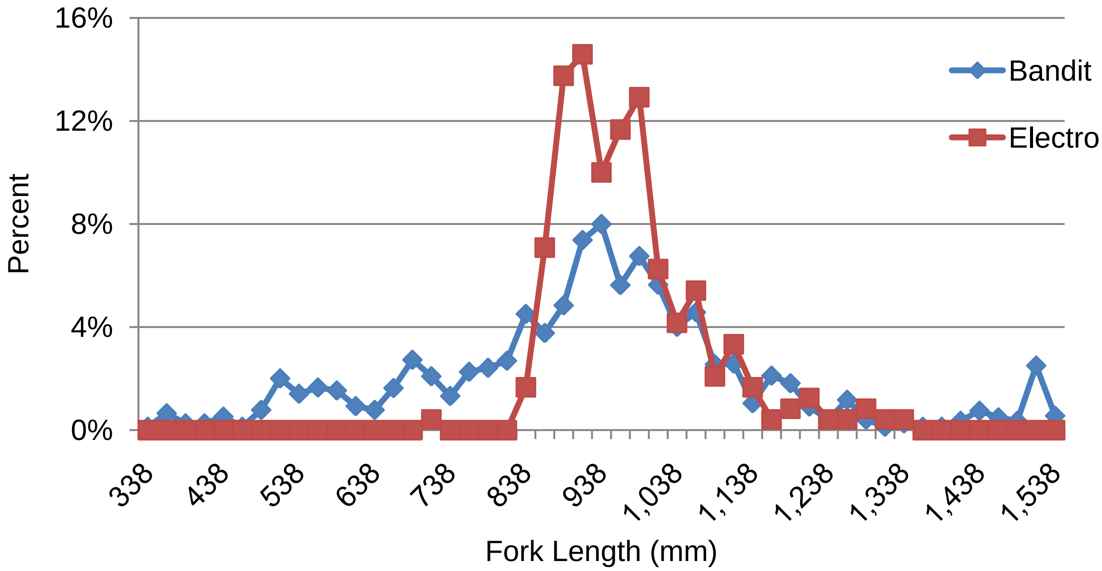

Figure 21. Length frequency plot of expanded lengths for greater amberjack caught with bandit reels and electromate rod and reel (electro).

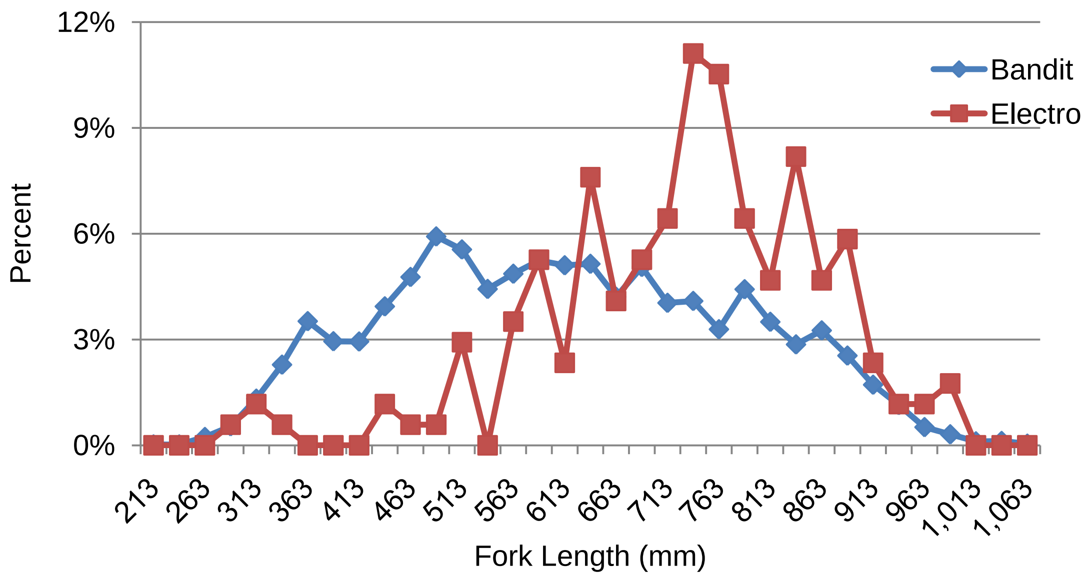

Figure 22. Length frequency plot of expanded lengths for almaco jack caught with bandit reels and electromate rod and reel (electro).

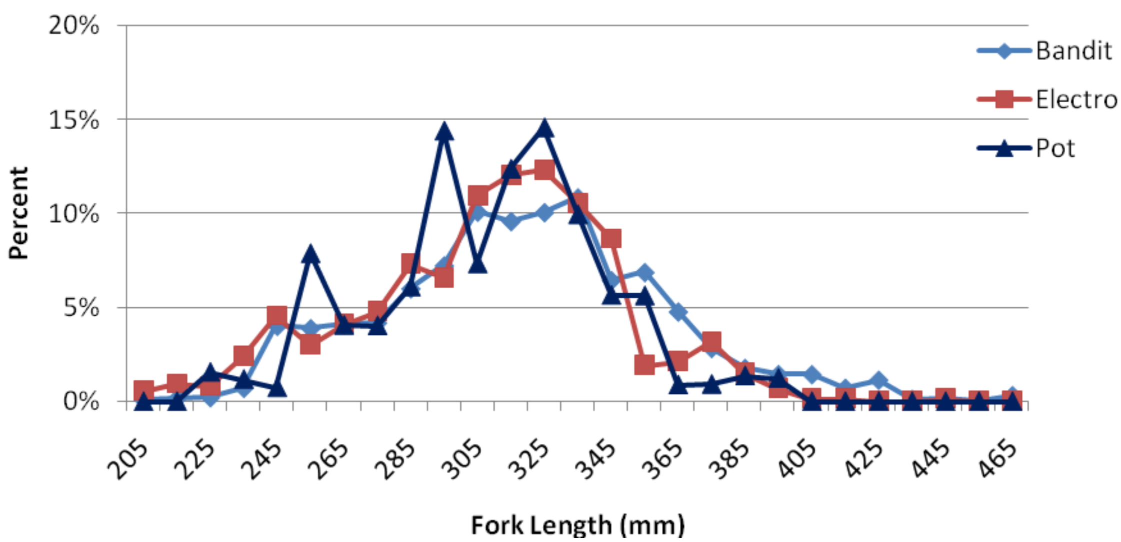

Figure 23. Length frequency plot of expanded lengths for white grunt caught with bandit reels, electromate rod and reel (electro), and fish pots.

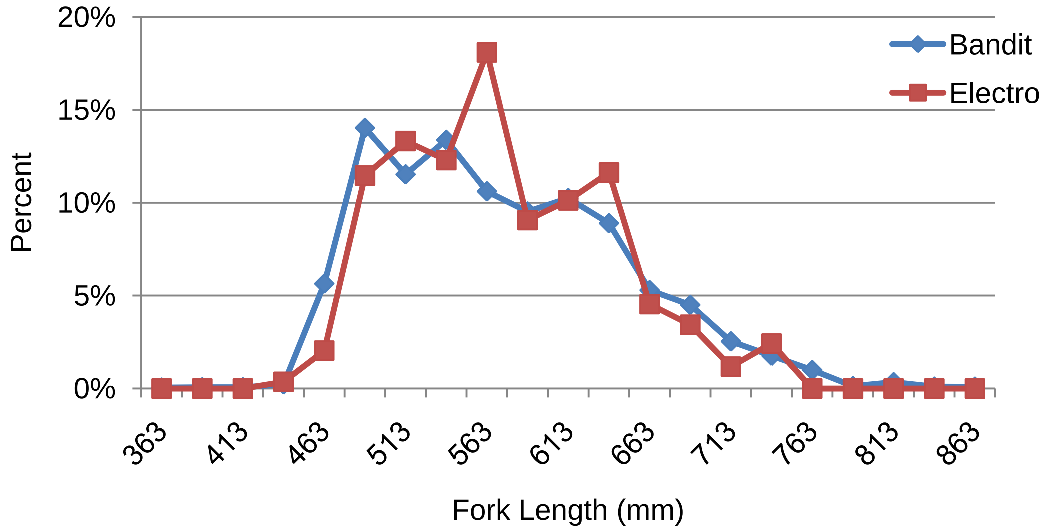

Figure 24. Length frequency plot of expanded lengths for scamp caught with bandit reels and electromate rod and reel (electro).

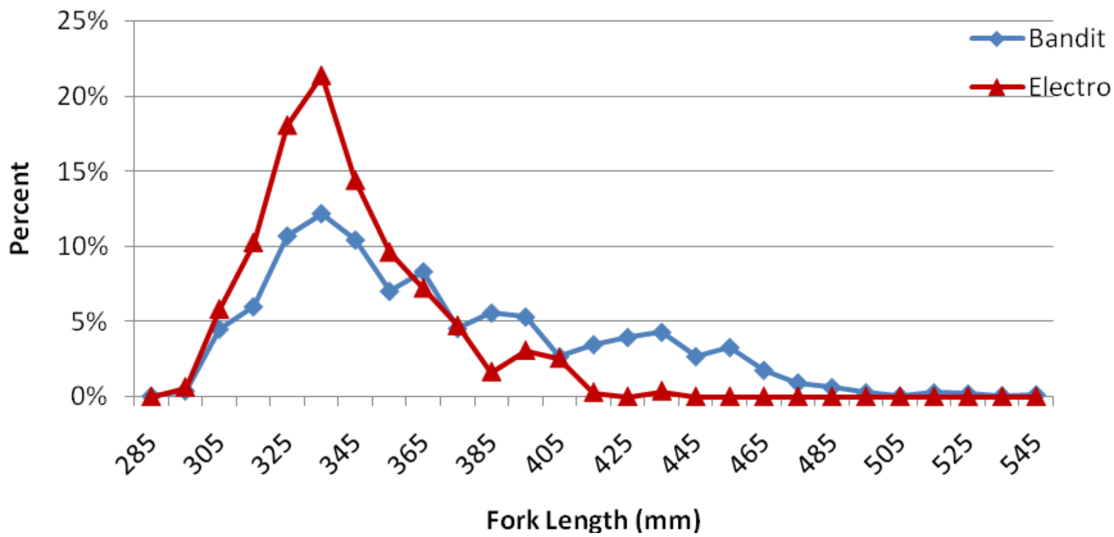

Figure 25. Length frequency plot of expanded lengths for red porgy caught with bandit reels and electromate rod and reel (electro).

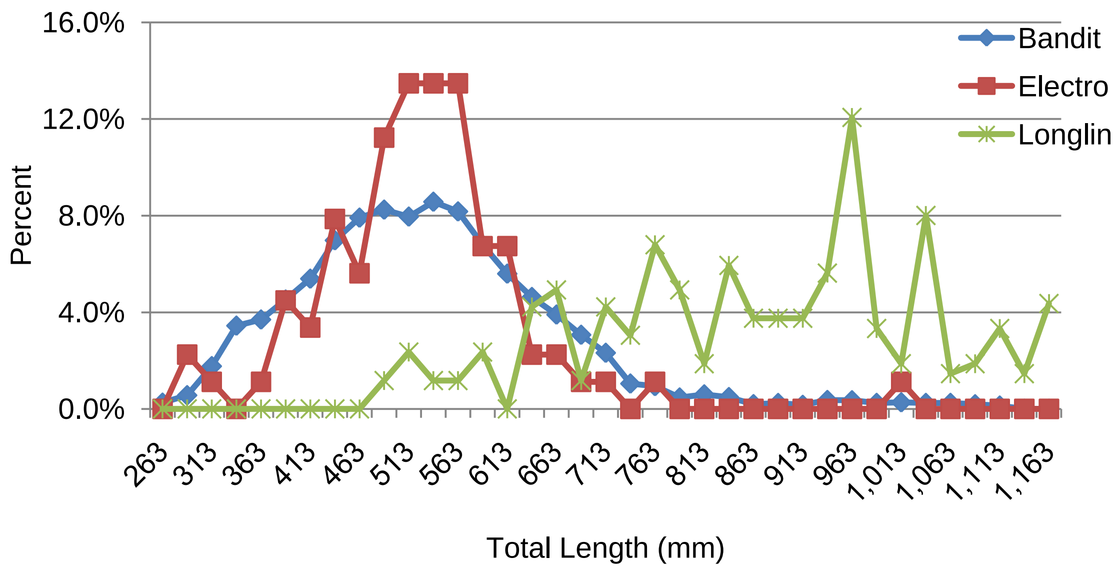

Figure 26. Length frequency plot of expanded lengths for snowy grouper caught with bandit reels, electromate rod and reel (electro), and longlines (longlin) gears.

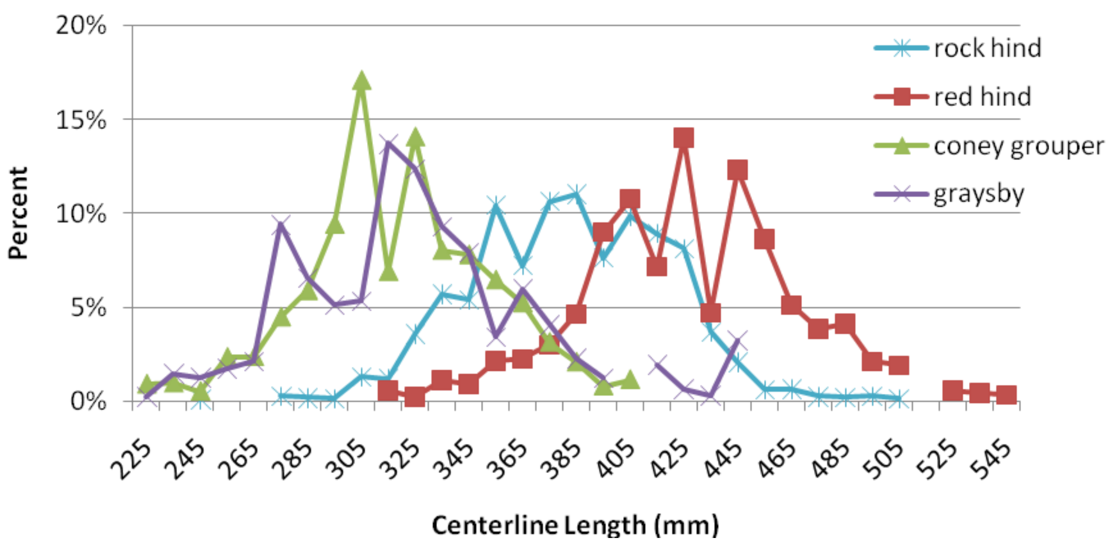

Figure 27. Length frequency plot of expanded lengths for hinds or strawberry grouper (rock hind, red hind, coney, and graysby) caught with bandit reels.

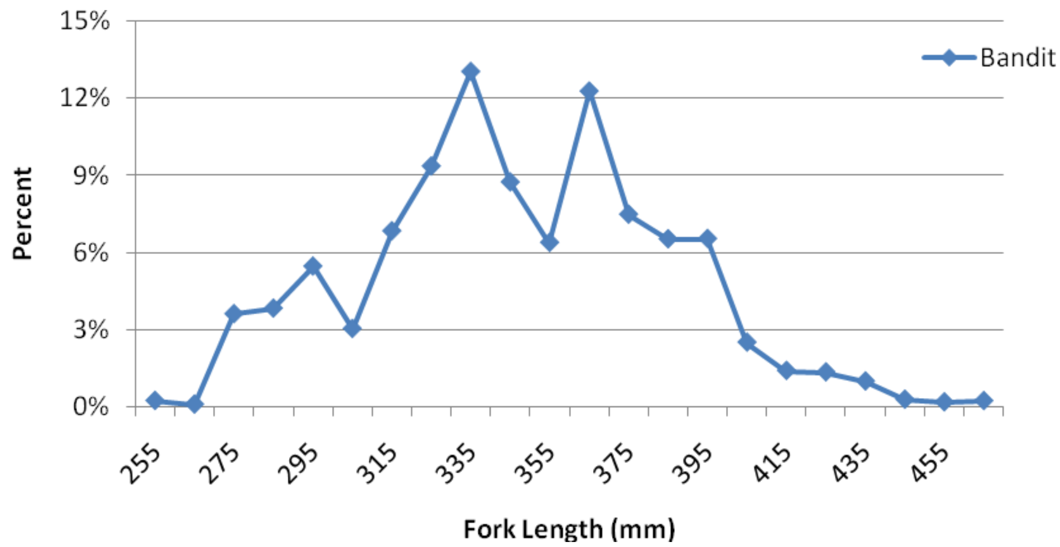

Figure 28. Length frequency plot of expanded lengths for knobbed porgy caught with bandit reel gear.

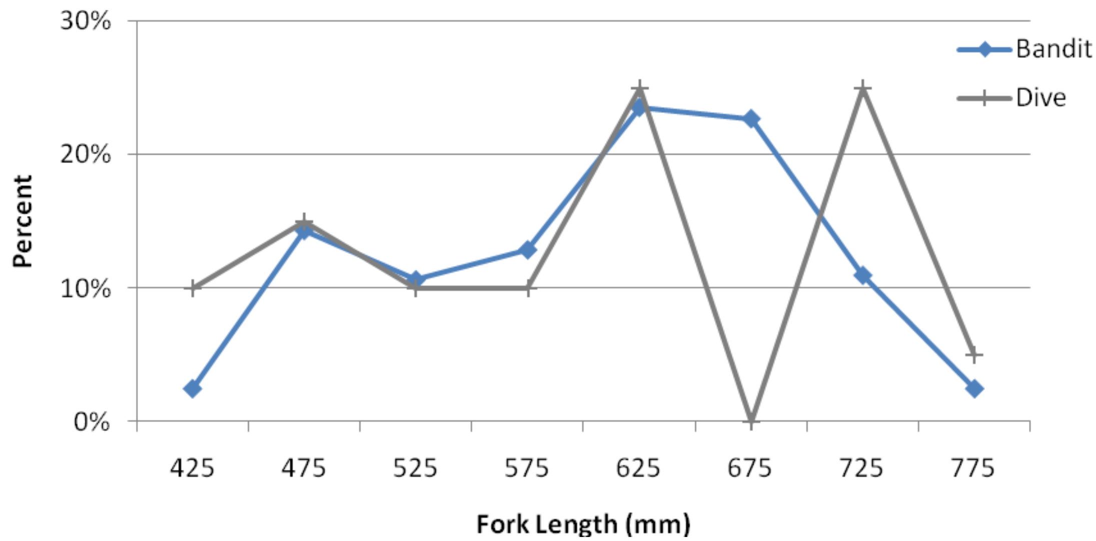

Figure 29. Length frequency plot of expanded lengths for hogfish caught with bandit reels and on dive trips. Size bins were increased to 50 mm size bins for better visualization.

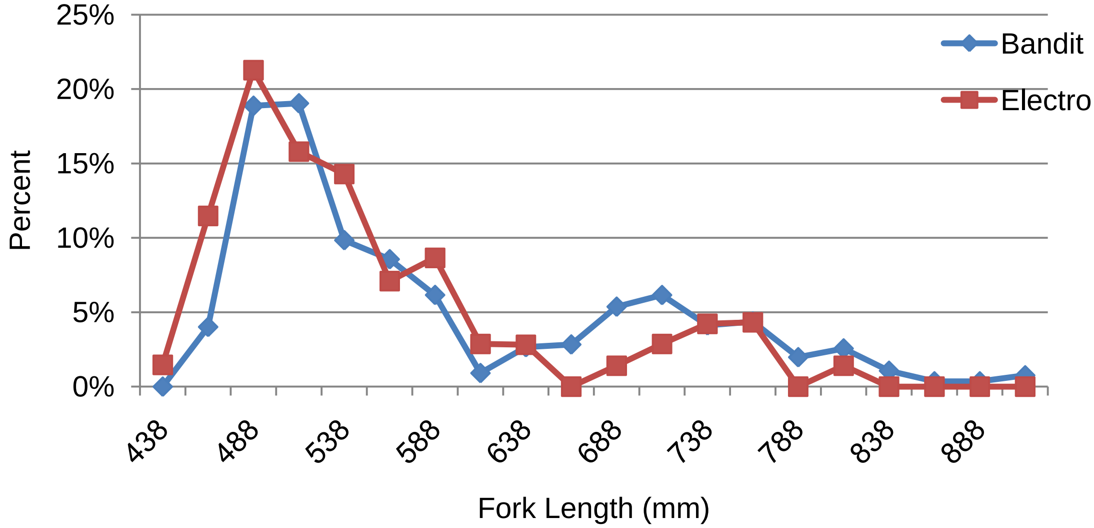

Figure 30. Length frequency plot of expanded lengths for red snapper caught with bandit reels and electromate rod and reel (electro).

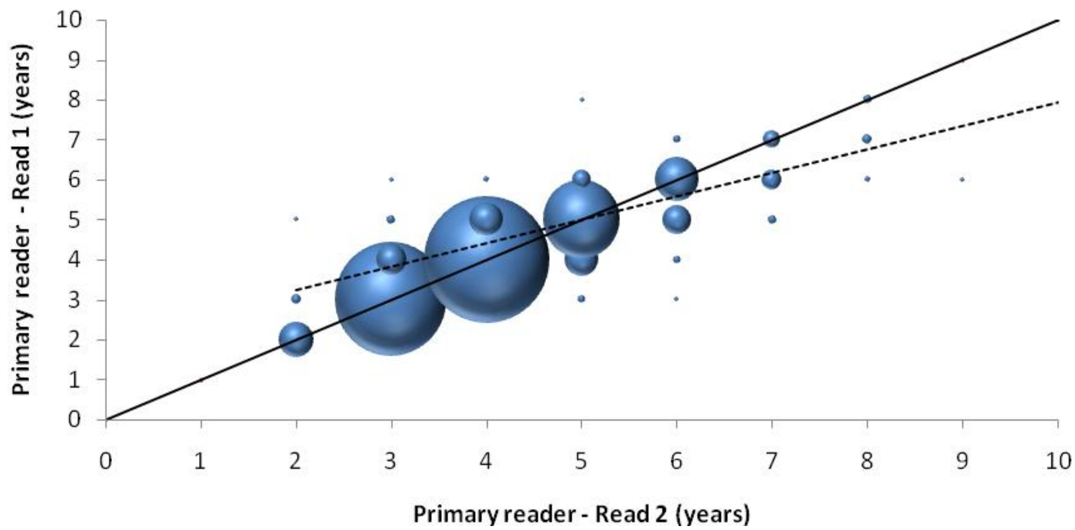

Figure 31. Age bias plot for the primary reader's first and second reads (all readabilities). The size of the bubble is proportional to the number of ages observed for each age class between readers. The solid line signifies perfect agreement (1:1) between reads, the dashed line indicates the calculated linear regression between age readings.

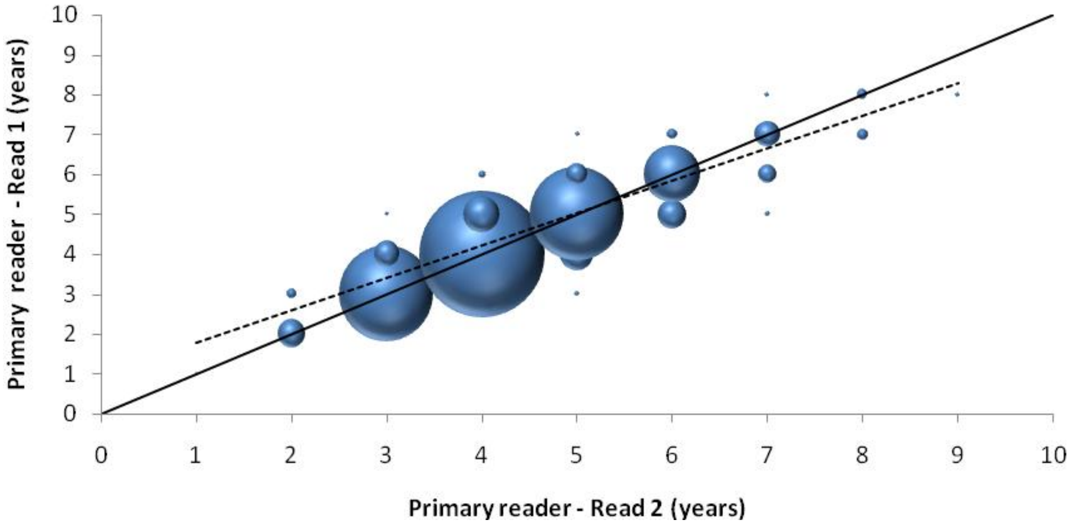

Figure 32. Age bias plot for the primary reader's first and second reads (readabilities E and D). The size of the bubble is proportional to the number of ages observed for each age class between readers. The solid line signifies perfect agreement (1:1) between reads, the dashed line indicates the calculated linear regression between age readings.

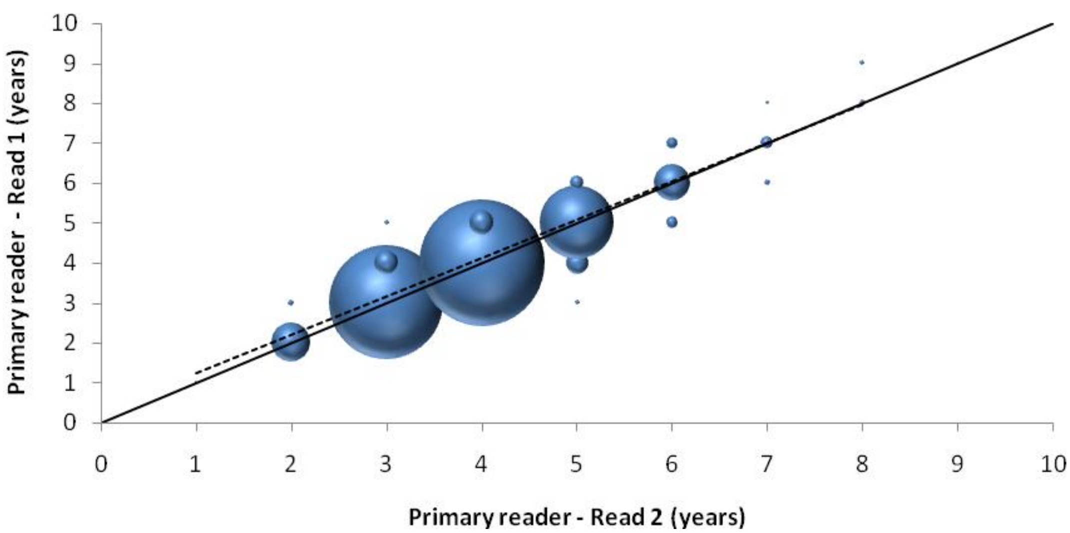

Figure 33. Age bias plot for the primary reader's first and second reads (readabilitiy E). The size of the bubble is proportional to the number of ages observed for each age class between readers. The solid line signifies perfect agreement (1:1) between reads, the dashed line indicates the calculated linear regression between age readings.

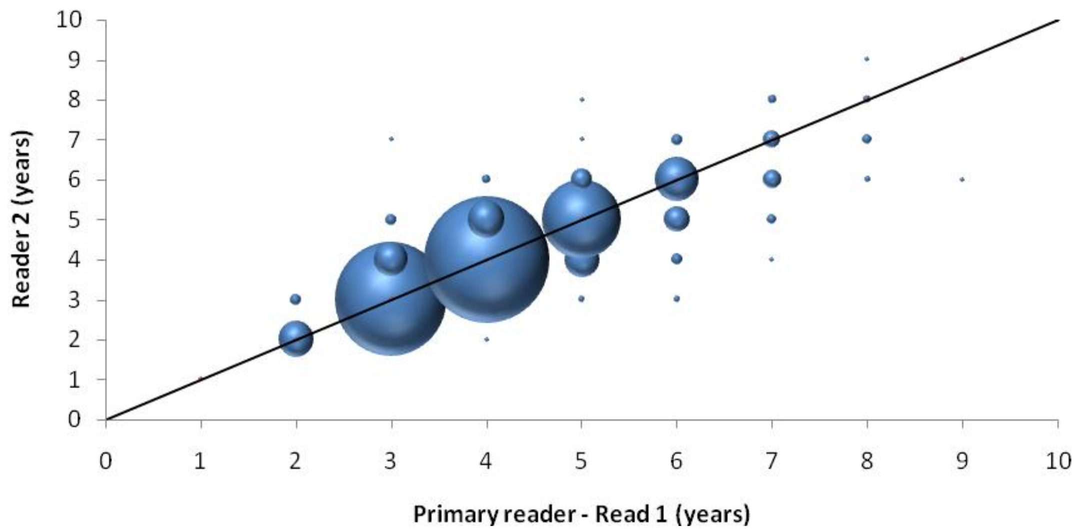

Figure 34. Age bias plot for the primary reader's first and secondary reader (all readabilities). The size of the bubble is proportional to the number of ages observed for each age class between readers. The solid line signifies perfect agreement (1:1) between reads, the dashed line indicates the calculated linear regression between age readings.

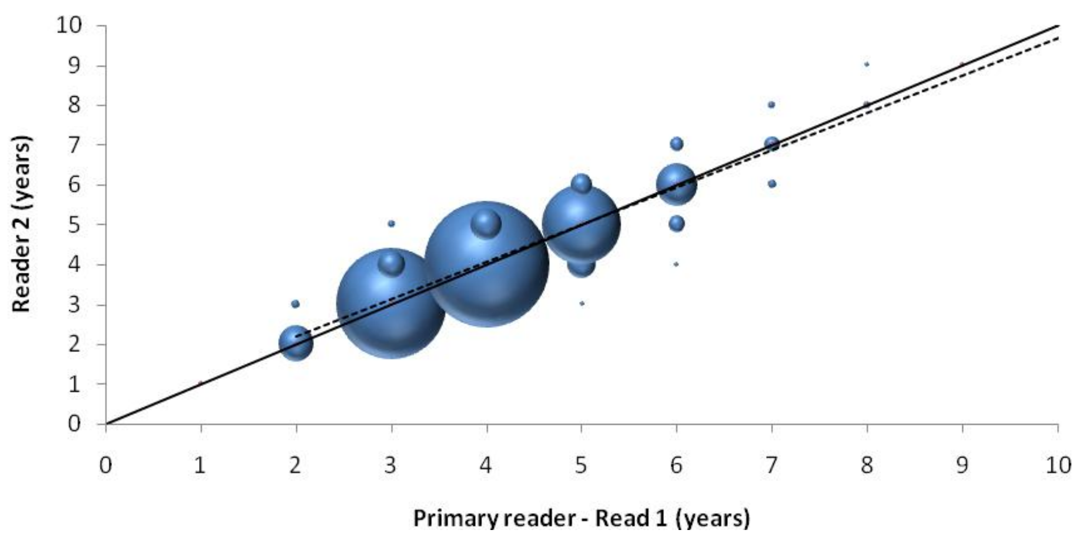

Figure 35. Age bias plot for the primary reader's first and secondary reader (readabilities E and D). The size of the bubble is proportional to the number of ages observed for each age class between readers. The solid line signifies perfect agreement (1:1) between reads, the dashed line indicates the calculated linear regression between age readings.

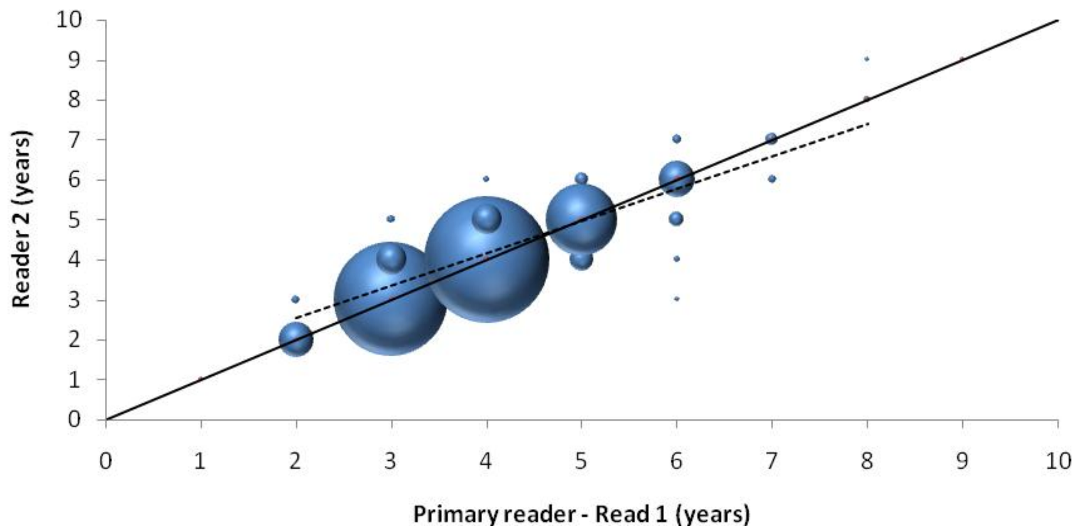

Figure 36. Age bias plot for the primary reader's first and secondary reader (readability E). The size of the bubble is proportional to the number of ages observed for each age class between readers. The solid line signifies perfect agreement (1:1) between reads, the dashed line indicates the calculated linear regression between age readings.

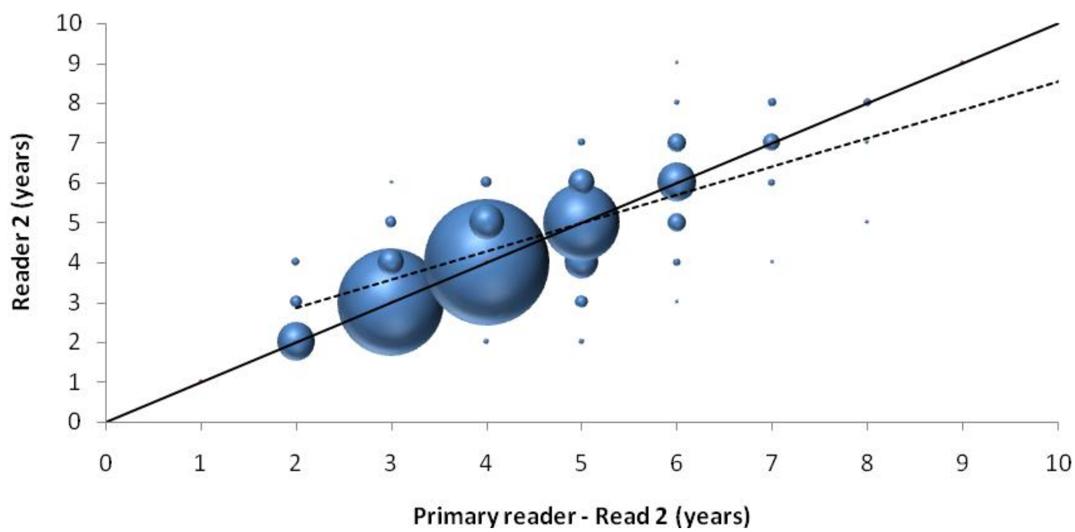

Figure 37. Age bias plot for the primary reader's second and secondary reader (all readabilities). The size of the bubble is proportional to the number of ages observed for each age class between readers between readers. The solid line signifies perfect agreement (1:1) between reads, the dashed line indicates the calculated linear regression between age readings.

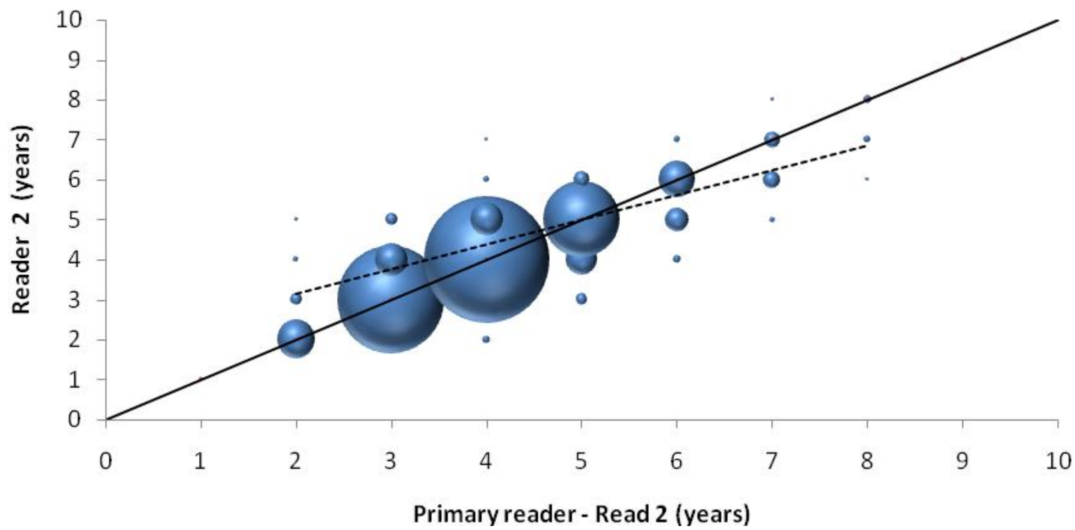

Figure 38. Age bias plot for the primary reader's second and secondary reader (readabilities E and D). The size of the bubble is proportional to the number of ages observed for each age class between readers. The solid line signifies perfect agreement (1:1) between reads, the dashed line indicates the calculated linear regression between age readings.

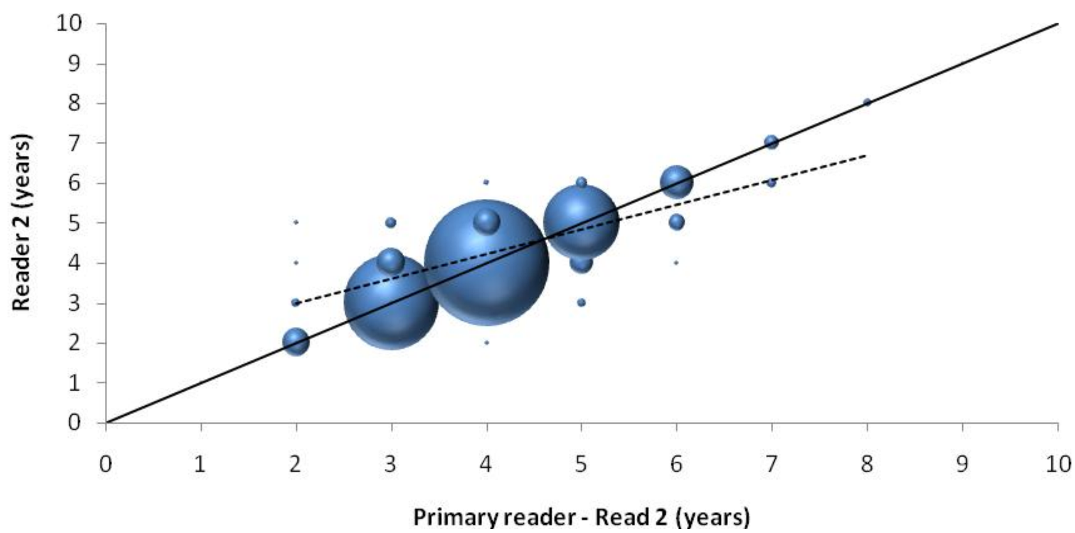

Figure 39. Age bias plot for the primary reader's second and secondary reader (readability E). The size of the bubble is proportional to the number of ages observed for each age class between readers. The solid line signifies perfect agreement (1:1) between reads, the dashed line indicates the calculated linear regression between age readings.

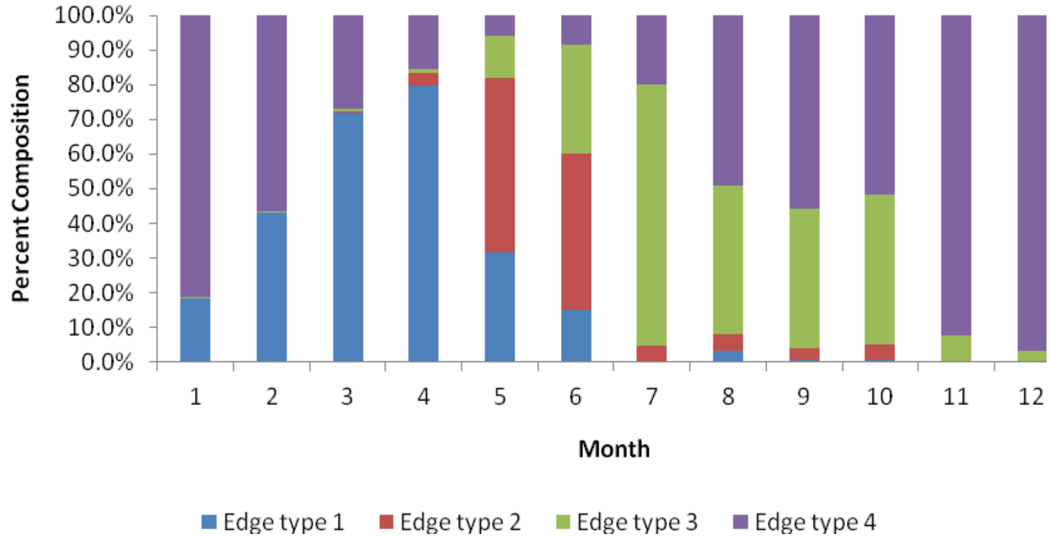

Figure 40. Black sea bass edge type by month observed by primary reader.

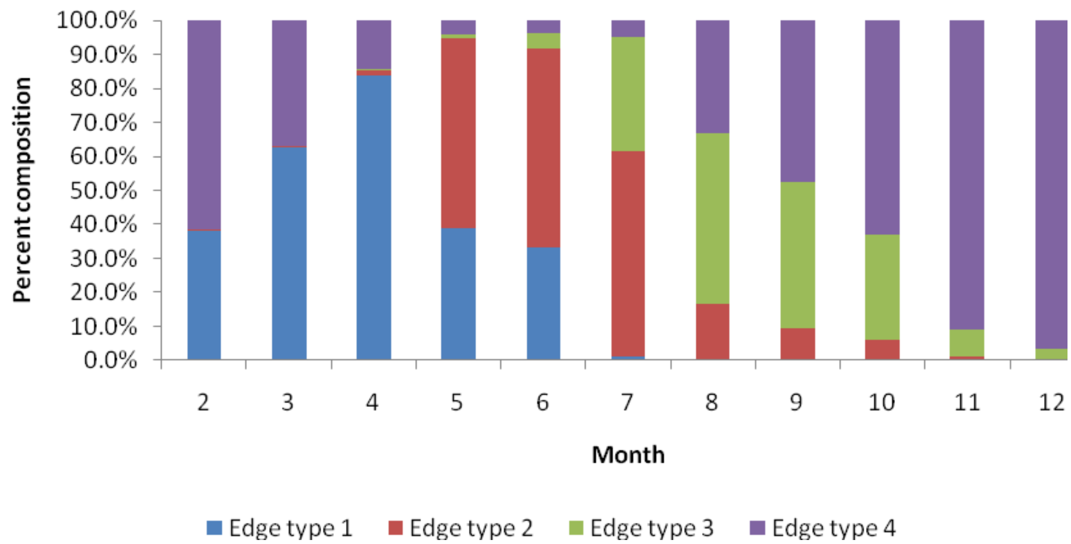

Figure 41. Black sea bass edge type by month observed by the secondary reader.

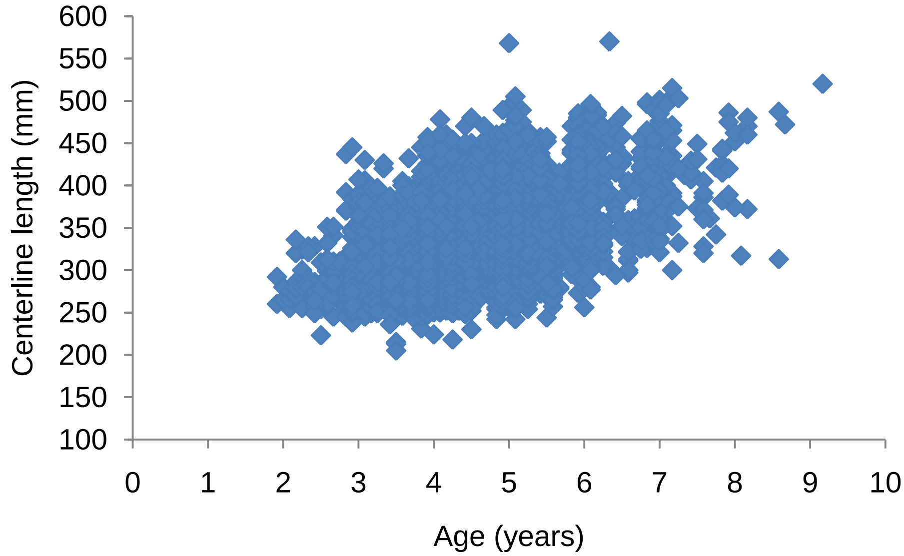

Figure 42. Length at age plot for commercially harvested black sea bass harvested off North Carolina from 2006 to 2010.

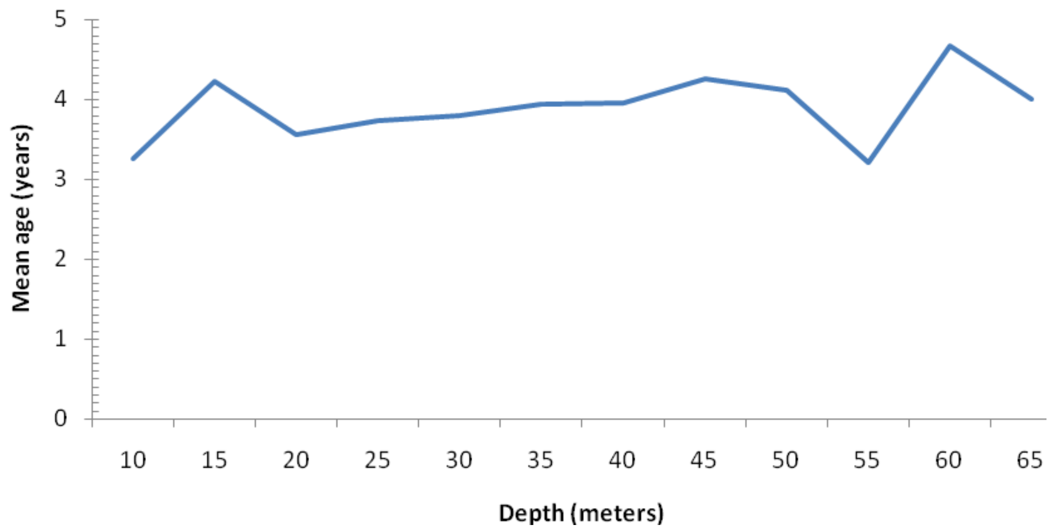

Figure 43. Mean black sea bass age at depth for all gears, 2006-2010.

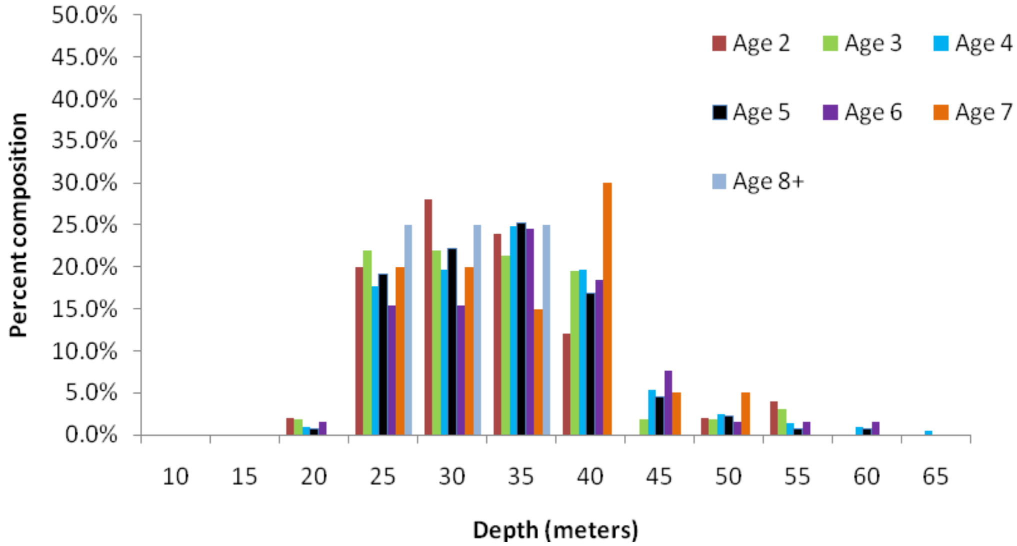

Figure 44. Black sea bass age distribution by depth for fish caught using vertical lines (manual hook and line, electromate rod and reel, and bandit reel).

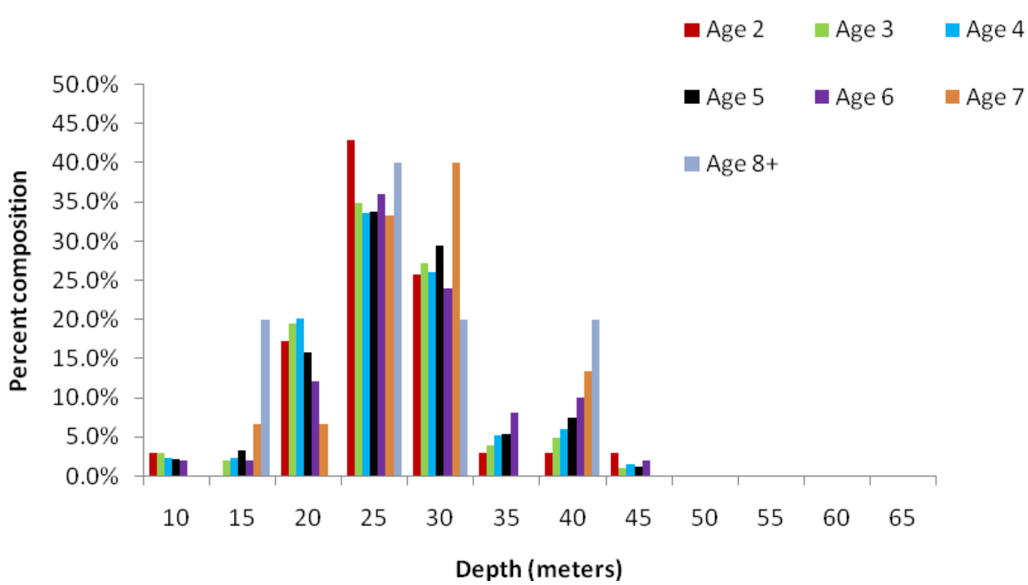

Figure 45. Black sea bass age distribution by depth for caught using fish pots.

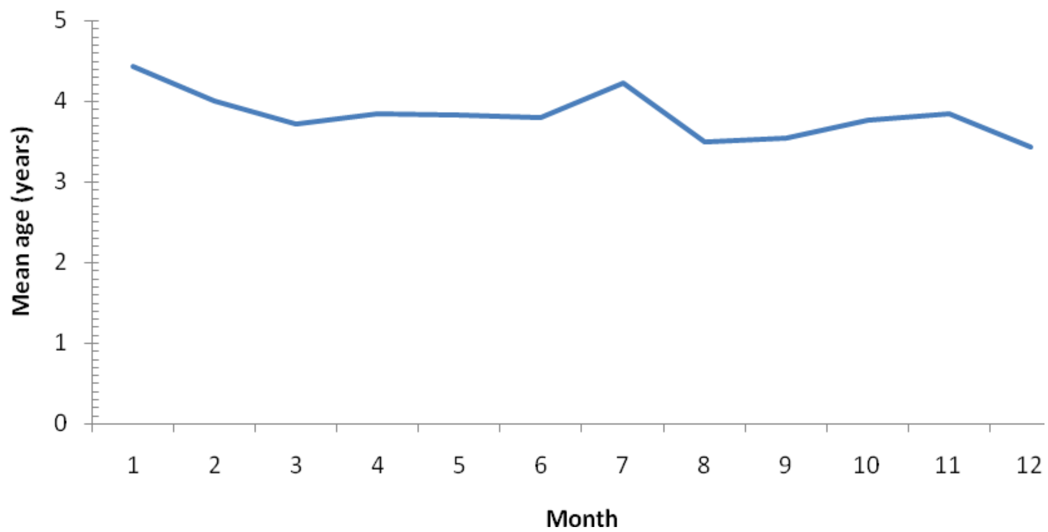

Figure 46. Monthly mean black sea bass age for all gears from 2006 to 2010.

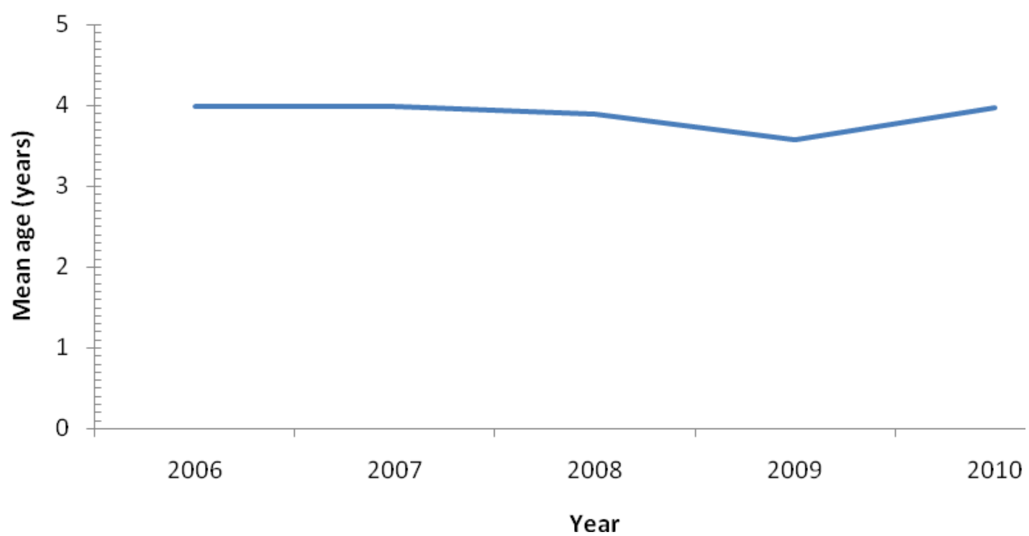

Figure 47. Mean black sea bass age for all gear observed from 2006-2010.

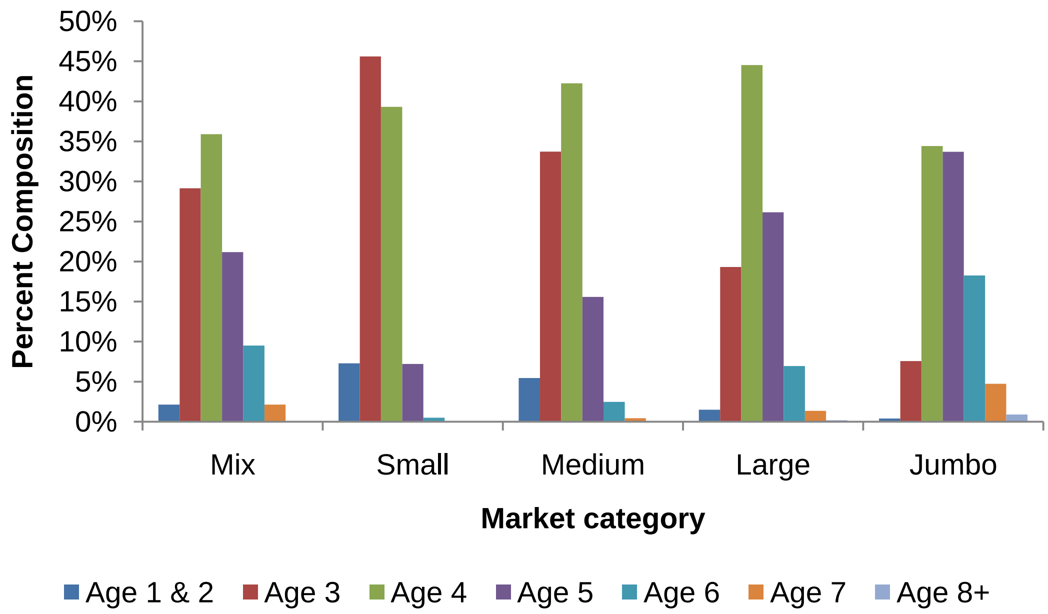

Figure 48. Percent composition of black sea bass by age for different market categories.

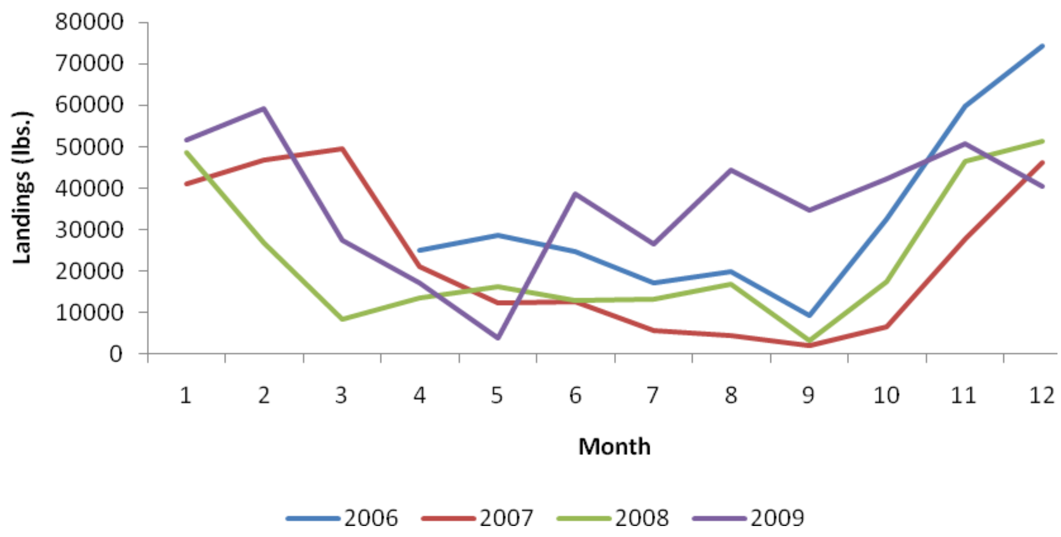

Figure 49. Monthly black sea bass landings (lbs.) from 2006 to 2010 in North Carolina.

APPENDIX

Collection of biological data is collected by the NMFS and NCDMF. To avoid double counting of effort and biological information, data collected by both agencies port agents were combined to form one sample (Table 1). This only occurred with the port agent out of the Wilmington Regional Office. All samples collected in Morehead City were collected by NCDMF.

Table 1. Number of trips and biological samples taken from 2006 to 2010 recorded in the NMFS TIP.

Year	# of TIP Interviews	Biological Samples Taken
2006	104	4,461
2007	165	6,632
2008	211	4,817
2009	242	3,118
2010	157	1,958