First direct assessment of the size-selectivity of hook and line gear, Chevron traps, and underwater cameras for Red Snapper and other reef fishes in the U.S. South Atlantic.

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ABSTRACT

The ongoing prohibition of commercial and recreational harvest of Red Snapper in the U.S. South Atlantic (aside from very limited seasons), has dramatically eroded the utility of fishery-dependent data for assessing Red Snapper stock status. To address this loss of information, there have been ongoing efforts to improve fishery-independent data streams. Most notably, the long-term federal Chevron trap survey was modified to add a video camera component and expand spatial coverage, while FWC has developed a standardized, fishery-independent hooked-gear survey. Despite these efforts, important questions remain as to the selectivity of these sampling gears. We conducted a one-year study to begin to assess size-selectivity of Chevron trap, fisheries-independent hooked-gear, and fisheries-dependent hooked-gear surveys by pairing capture gears with underwater stereoscopic cameras. In 2016, a total of 93 stations were sampled from Cape Canaveral to the Florida/Georgia border. Overall, forty distinct taxa (n = 2,473 individuals) were collected in the three capture gears, while concomitantly, 166 taxa (n = 27,685 individuals) were observed on video. Based on available data, we assessed the size-selectivity of capture gears for three managed reef fishes: Red Snapper (all gears), Black Sea Bass (all gears), and Vermilion Snapper (all gears except Chevron traps). For Red Snapper, size composition from all three capture gears differed significantly from that obtained from corresponding stereo-video surveys. Overall, average Red Snapper captured in Chevron traps had a smaller average length than did those observed on stereo-video; this is largely attributable to decreasing capture probability with increasing size, especially individuals over 600 mm FL. In contrast, both hooked-gears captured larger Red Snapper on average than were observed on stereo-video, due primarily to the fact that small Red Snapper (< 300 mm FL) were captured with reduced probability in both hooked-gear surveys. Interestingly, both fisheries-independent and fisheries-dependent hooked-gear surveys performed similarly with respect to relative abundance and size composition of Red Snapper. We also detected significant differences in selectivity for Black Sea Bass and Vermilion Snapper, although observed differences were much less pronounced than those observed for Red Snapper. Overall mean length of Black Sea Bass was lower for individuals captured in traps, and higher for individuals captured in hooked-gear surveys, than was observed on stereo-video. Insufficient numbers of Vermilion Snapper were captured in traps for selectivity analyses; however, hooked-gears captured larger Vermilion Snapper than were observed on stereo-video. Combined, these analyses provide new insight into the size-selectivity of various sampling approaches for managed reef fishes, although due to insufficient sample sizes, additional efforts are required to quantitatively assess selectivity for other managed reef fishes (e.g., Gray Triggerfish, Red Porgy, Scamp).

EXECUTIVE SUMMARY

Reef fish resources (specifically the grouper-snapper complex) along the U.S. South Atlantic coast have historically supported multi-million dollar commercial and recreational fisheries, with species such as Red Snapper, Vermilion Snapper, Gag, Red Porgy, Scamp, and Black Sea Bass among the most heavily targeted reef fishes over the past 50 years. In recent years, stock assessments for these and other species in the U.S. South Atlantic have shown varied degrees of overfishing, and as a result, numerous recreational and commercial fishing regulations (e.g., size limits, bag limits, trip limits, seasonal closures, annual quotas) have been implemented as mandated by the Magnuson-Stevens Act to alleviate overfishing. Traditional management practices such as restrictive size and bag limits and closures have proven to be problematic in managing reef fisheries, and when incorporated, complicate the assessment of managed stocks by altering the availability of fisheries-dependent data. While management decisions have traditionally relied on fishery-dependent data, the need for fishery-independent surveys has become evident. State (FWC) and federal (SERFS) fishery-independent monitoring programs in the South Atlantic are evaluating different gear-types in collecting data on a variety of reef fishes and are furthering the development of a multi-species, ecosystem-based approach to providing reef-fish data for stock assessments. Although both the SERFS and FWC surveys have proven effective at characterizing reef-fish populations in the U.S. South Atlantic, important questions remain as to the size-selectivity of each respective sampling gear. Accordingly, this study was designed to assess the size-selectivity of actively-fished hooked-gear and Chevron traps for Red Snapper and other reef fishes in the U.S. South Atlantic.

A total of 93 stations, proportionally allocated between NMFS statistical zones 722, 728, and 732, were sampled between April – August 2016. At each station, one of the three capture gears [fisheries-independent hooked-gear (RTD), fisheries-dependent hooked-gear (Captain's Choice), Chevron traps] were deployed resulting in a total of 279 sample sites. In addition, at each of the sampled sites a stereoscopic camera was deployed either concurrently (Chevron traps) or immediately preceding (RTD or Captain's Choice) active sampling. Forty distinct taxa (n=2,473) were collected in capture gears (all gears combined) during the project. A total of 27,685 individuals representing 166 distinct taxa were observed on 227 successful stereo-video camera deployments. Numerically, the four most abundant taxa observed on video were unidentified baitfish (n = 7,133), Tomtate (n = 4,377), Vermilion Snapper (n = 3,560), and members of the Scad complex (n = 3,452). Overall, a total of 3,258 individuals were measurable from video data, representing 48 distinct taxa. Demographic data (i.e., sex, age, growth, mercury analysis) was summarized for a randomized subset of Red Snapper and other federally-managed fishes collected during the survey.

The primary objective of this project was to assess the size-selectivity of various sampling approaches (Chevron traps, fishery-independent repetitive timed-drop hooked-gear surveys, and unstandardized hooked-gear surveys) for Red Snapper and, where possible, other managed reef fishes in the U.S. South Atlantic. To accomplish this goal, data from paired stereo-video surveys, which are typically less selective than capture gears, were used to estimate the size composition of the source population. Although all sampling approaches were effective at characterizing the relative abundance of Red Snapper, there were significant differences among sampling gear with respect to size selectivity for Red Snapper. The length frequency distribution of all three capture gears differed significantly from that obtained from corresponding stereo-video surveys. Overall,

average Red Snapper captured in Chevron traps had a smaller average length than did those observed on stereo-video; this is largely attributable to decreasing capture probability with increasing size, especially individuals over 600 mm FL. In contrast, both hooked-gears captured larger Red Snapper on average than were observed on stereo-video. Small Red Snapper less than 300 mm FL were captured with reduced probability in both hooked-gear surveys, although both hooked-gears along with stereo-video characterized a second distributional peak (600 – 800 mm) that was not detected with Chevron traps. Interestingly, both hooked-gear surveys performed similarly with respect to relative abundance and size composition of Red Snapper, indicating that standardized, fishery-independent RTD surveys are effective at sampling adult Red Snapper.

In addition to Red Snapper, we were able to assess selectivity for two additional reef fishes, Black Sea Bass and Vermilion Snapper. Although significant differences in selectivity were detected for both species, observed differences were much less pronounced than those observed for Red Snapper. For Black Sea Bass, the overall shape of length frequency distributions was similar among all gears, although similar to Red Snapper, the mean length of Black Sea Bass was lower for individuals captured in traps, and higher for individuals captured in hooked-gear surveys, than was observed on stereo-video. Insufficient numbers of Vermilion Snapper were captured in traps for selectivity analyses; however, hooked-gears captured larger Vermilion Snapper than were observed on stereo-video. Combined, these analyses provide new insight into the size-selectivity of various sampling approaches for managed reef fishes, although due to insufficient sample sizes, additional efforts are required to quantitatively assess selectivity for other managed reef fishes (e.g., Gray Triggerfish, Red Porgy, Scamp).

PURPOSE

A. PROBLEM DESCRIPTION

Reef fish resources (specifically the grouper-snapper complex; Ault et al. 2006) along the U.S. South Atlantic coast have historically supported multi-million dollar commercial and recreational fisheries, with species such as Red Snapper, Vermilion Snapper, Gag, Red Porgy, Scamp, and Black Sea Bass among the most heavily targeted reef fishes over the past 50 years. In recent years, stock assessments for these and other species in the U.S. South Atlantic have been variably assessed as overfished and/or undergoing overfishing, and as a result, numerous recreational and commercial fishing regulations (e.g., size limits, bag limits, trip limits, seasonal closures, annual quotas) have been implemented as mandated by the Magnuson-Stevens Act to alleviate overfishing and rebuild overfished stocks (SEDAR 15 2008). Although management regulations have been implemented for numerous reef fishes in the U.S. South Atlantic, none have been more restrictive, or more controversial, than those implemented for Red Snapper. Results from the 2008 stock assessment indicated that U.S. South Atlantic Red Snapper were experiencing overfishing and were overfished. In response to the assessment, the South Atlantic Fisheries Management Council (SAFMC) implemented an emergency closure in 2010 of the commercial and recreational Red Snapper fishery throughout federal waters (3 to 200 miles offshore). The benchmark assessment completed in 2010 confirmed that Red Snapper were still overfished and undergoing overfishing (SEDAR 24 2010). Accordingly, aside from very limited recreational and commercial season in 2012 – 2014, Red Snapper remain closed to all recreational and commercial harvest, although signs of stock recovery resulted in a recent limited season in the fall of 2017.

A new benchmark assessment for Red Snapper was recently completed, and the final Stock Assessment Report was released in April 2016 (SEDAR 41 2016). Assessment results indicate that the Red Snapper stock in the U.S. South Atlantic continues to be overfished and that overfishing is occurring. The report also concluded that, despite the estimated abundance at age and the total estimated abundance increasing in recent years, each showed a truncation of older age classes during the assessment period (SEDAR 41 2016). In particular, the overall abundance estimates for 2014 were relatively high and similar to those seen in the 1960s, but were comprised primarily of fish ages 1-4 years old (96% by number). Therefore, the stock was still considered overfished due to the paucity of older fish in the population. For Red Snapper populations, older, larger females generally have markedly higher batch fecundities, and produce more batches in a given year, than do smaller females (Collins et al. 1996; Lowerre-Barbieri et al. 2015), therefore age truncation may have profound impacts on overall stock productivity and the potential for stock recovery. Accordingly, it is critical to effectively monitor the potential recovery of older, larger Red Snapper through time.

The implementation of management measures to end overfishing and rebuild overfished stocks may restrict our ability to accurately assess stock recovery. In extreme cases, such as Red Snapper in the U.S. South Atlantic, management restrictions severely alter fishing behavior, such that fishery-dependent data are not directly comparable with that collected in prior years. Further, existing fishery-dependent surveys are not well-equipped to characterize fisheries of extremely short duration, as was the case with the limited Red Snapper fishing seasons in 2012 – 2014 (3 – 8 days per year). Even when management regulations do not directly impact a particular species being assessed, they can alter fishing behavior and species captured, thus reducing the effectiveness of traditional fishery-dependent data-filtering techniques (e.g., Stephens and MacCall 2004). Due to these issues, most fishery-dependent indices for Red Snapper in the U.S. South Atlantic terminate in 2009 (Sustainable Fisheries Branch–NMFS 2014; SEDAR 41 2016).

The recognized limitations of the available fishery-dependent data sources have resulted in significant effort during recent years to improve the availability of fishery-independent data in the U.S. South Atlantic. In 2010, the long-running Marine Resources Monitoring, Assessment, and Prediction program (MARMAP) and South Atlantic Southeast Area Monitoring and Assessment Program (SA-SEAMAP) were augmented by the initiation of the NMFS Southeast Fishery-Independent Survey (SEFIS). Collectively referred to as the Southeast Reef Fish Survey (SERFS), these new and expanded survey efforts have involved (1) a range extension south to St. Lucie Inlet, Florida and north to Cape Hatteras, North Carolina, (2) an increase in annual sampling effort throughout the survey area, and (3) the addition of video cameras to the Chevron traps long used by the MARMAP program (Bacheler et al. 2013). In the SEDAR 41 Data Workshop, the SERFS Chevron and video datasets were recommended as separate fisheries-independent indices of abundance in the assessment. At the SEDAR 41 Assessment Workshop it was concluded that these two indices should be combined since the data collected for each came from the same sampling platform and were thus not independent of each other (SEDAR 41 2016). The end result is that only one fisheries-independent index, covering 2010-2014, was used in the assessment model. Research recommendations at the SEDAR 41 Data, Assessment, and Review workshops all highlighted the increased need for additional fisheries-independent surveys to provide reliable indices of abundance and estimates of size and age composition for future stock assessments (SEDAR 41 2016). To complement ongoing SERFS trap and camera surveys, the Florida Fish and Wildlife Conservation Commission (FWC) has been working towards the development of fishery-independent hooked-gear surveys of hard bottom habitats since 2011. Of the various methods explored to date by FWC, the most successful method tested has been a repetitive timed-drop (RTD) approach that incorporates many of the techniques used by the Red Snapper fishery while greatly reducing angler bias (Guenther et al. 2013). This survey has shown great potential in the ability to detect differences in the relative abundance of federally managed reef fishes, including Red Snapper (Guenther et al. 2014).

Although both the SERFS and FWC surveys have proven effective at characterizing reef-fish populations in the U.S. South Atlantic, important questions remain as to the size-selectivity of each respective sampling gear. All sampling gear, whether fishery-independent or fishery-dependent, exhibits some degree of size-selection that must be accurately described to identify which proportion of the population collected data represent. With the exception of gears designed to target ichthyoplankton, all gears have a minimum size for which fishes are fully recruited. Individuals smaller than this are not effectively characterized because they either (1) are too small to be captured (e.g., trawls, traps, hooked-gear), (2) are too small to be identified accurately (e.g., visual or video surveys), or (3) are not present in the area or habitat sampled. It is also important to assess if sampling gear can effectively target larger individuals. Some sampling gears are capable of characterizing all individuals beyond a given size (flat-topped selectivity). Other sampling gears might not effectively characterize larger fishes (dome-shaped selectivity) because they (1) are too large or too fast to be captured (e.g., trawls, traps, hooked-gear), or (2) aren’t present in the area or habitat sampled. Indirect estimates of size-selectivity can be inferred from the size structure of the resultant catch; however, direct comparisons of size-selectivity, where the size structure of the catch is compared to the size structure of the population, can produce more reliable estimates of selectivity. The difficulty lies in accurately characterizing the size structure of the population. Our study used video survey data as the basis for comparison since visual or video surveys exhibit relatively low selectivity. Although the video cameras currently deployed in SERFS surveys are not capable of providing estimates of size, stereoscopic cameras currently used in Gulf of Mexico reef fish surveys, by both FWC and NMFS, have allowed for a direct measurement of fishes observed at each sampling site. Directly comparing the size structure of Red Snapper and other reef fishes as determined from multiple sampling gears deployed in the same locations would allow for an estimation of gear-specific selectivity functions that can be directly incorporated into future stock assessments (Hilborn and Walters 1992).

At the SEDAR 41 Data Workshop for Red Snapper and Gray Triggerfish, members of the recreational and commercial fishing sectors asserted that current fishery-independent monitoring efforts were not adequately characterizing demographics of Red Snapper populations. Industry representatives suggested that larger fish are more wary than smaller ones and are disproportionately under-sampled in the current sampling surveys. They also presented video examples that they claimed showed smaller fish being much more aggressive than larger fish when feeding, which would likely limit the larger fish from being collected during hooked-gear surveys. They further suggested that many of the larger fish are trap/camera wary and are, therefore, less likely to be documented by those gears. While the size range of fish susceptible to capture in traps will be partially dependent on trap dimensions (trap size, mesh size, mouth opening, etc.), stereoscopic video camera surveys can provide data on all size ranges of Red Snapper and other reef fish species that are in a particular habitat, including those individuals that may be somewhat wary.

We conducted a one-year study off the east coast of Florida designed to examine the selectivity of Red Snapper and other reef fishes to gear types currently used during ongoing fisheries-independent monitoring surveys. The study paired underwater stereoscopic camera units with FWC's standardized hooked-gear surveys, Chevron traps (identical to those used in current SERFS surveys), and fishery-dependent hook-and-line methods used in the commercial and for-hire fishing industry. Length data was collected by the use of stereoscopic camera surveys similar to what has been incorporated into the assessment of several Gulf of Mexico reef fishes (e.g., Hogfish, Gag, Greater Amberjack, and Red Snapper) as well as in other United States fisheries (Hannah and Blume 2014; Williams et al. 2010). The survey was conducted during April to July 2016 within NMFS statistical zones 722, 728, and 732 in water depths <150 m, which represents the core distribution of Red Snapper along the east coast of Florida and includes depths beyond which Red Snapper have been collected in prior surveys (Guenther et al. 2014; Mitchell et al. 2014). Sampling occurred at randomly-selected sites known to contain hard-bottom reef habitat. Overall sampling effort was stratified by NMFS statistical zone (722, 728, and 732) and depth (< 30 m and 30 – 150 m) and was allocated proportionally based on the total number of potential reef sites within each stratum. Within each stratum, sites were randomly assigned to three types of capture gear in equal allocation: FWC fishery-independent hooked-gears (RTD), industry defined fishery-dependent hooked-gears (Captain's Choice), and Chevron traps. All capture gears were paired with stereoscopic cameras that provided visual estimates of the relative abundance and size-structure of observed fishes at each site. Fishery-independent sampling methods were standardized throughout the study and followed methods used in similar ongoing surveys conducted by FWC and SERFS in the U.S. South Atlantic to assure comparability of collected data.

B. OBJECTIVES

The primary goal of the proposed project was to assess the size-selectivity of actively-fished hooked-gear and Chevron traps for Red Snapper and other reef fishes in the SA. To accomplish this, the project was developed to address the following specific objectives:

1. Evaluate the size-selectivity of hooked-gear (both fishery-dependent and fishery-independent) and Chevron traps by comparing the size structure of the catches with those determined by stereoscopic cameras for Red Snapper and other reef fishes.

2. Provide demographic data (i.e., age, sex, reproductive condition) for Red Snapper and other reef fish species for use in future stock assessments in the U.S. South Atlantic.

3. Evaluate the size, age structure, and abundance for each gear type to estimate the effectiveness of each gear for collecting Red Snapper and other reef fishes in the U.S. South Atlantic.

APPROACH

A. WORK PERFORMED

Objective 1: Evaluate the size-selectivity of hooked-gear (both fishery-dependent and fishery-independent) and Chevron traps by comparing the size structure of the catches with those determined by stereoscopic cameras for Red Snapper and other reef fishes.

A fisheries-independent survey of reef fishes was designed based on prior FWC hooked-gear and ongoing SERFS Chevron trap surveys conducted in the U.S. South Atlantic as well as ongoing stereoscopic camera surveys conducted by FWC and NMFS in the Gulf of Mexico. In addition, input from commercial, charter, and recreational fishers from the east coast of Florida was solicited and incorporated into the project design. A number of project-development meetings were held in conjunction with commercial, charter, and recreational fishers at the outset of the study, and all field sampling activities were conducted cooperatively with industry partners.

Sampling Period – All sampling was conducted during the months of April – August 2016 which corresponds to peak spawning and months of highest relative abundance of Red Snapper within the U.S. South Atlantic (White and Palmer 2004; Brown-Peterson et al. 2009; Guenther et al. 2013; Brodie and Switzer 2015; Lowerre-Barbieri et al. 2015). This sampling period also corresponds to that of prior FWC studies and of ongoing SERFS surveys.

Geographic Coverage and Survey Design – Red Snapper and other federally-managed reef fish species were quantified during a fisheries-independent survey using a stratified-random sampling design. The implementation of a stratified-random sampling design has the advantages that 1) effort is appropriately applied to strata of interest (i.e., reef surveys do not target unconsolidated sediment habitats), 2) stratification generally improves the precision of parameter estimates by subdividing a heterogeneous population into relatively homogeneous strata, and 3) stratification assures that specific sampling effort is assigned to strata of particular importance to the species of interest. For this project, sampling effort was also stratified based on latitude and depth. Surveys were conducted within three regions of the South Atlantic (Figure 1): NMFS statistical zones 722, 728, and 732. These regions occupy the portion of the South Atlantic Bight from roughly 28° 00' N (Melbourne, FL) to 30° 45' N latitude (Florida-Georgia border). Each zone was further subdivided into two depth strata – nearshore (≤ 30 m) and offshore (> 30 m).

Sample sites were proportionally allocated between zones and depth strata based on total available sampling area in each. Sampling was limited to depths less than 150 m as that is the effective depth limit for the stereoscopic cameras used during the project (unlighted); nevertheless, this depth extended well beyond the depths at which Red Snapper have been collected in prior surveys (Guenther et al. 2014; Mitchell et al. 2014). Only natural hard-bottom sites were sampled during this survey.

Our aim was to complete a total of 100 sampling stations during this study. Each capture gear tested during this study (Chevron traps, RTD, Captain's Choice; descriptions below) was to be deployed at each station for a total of 300 possible sampling sites. Each capture gear was paired with an underwater stereoscopic camera array to facilitate abundance and size selectivity comparisons.

Gear Description – Stereo Imaging System (SIS) Units – Stereo imaging systems (SIS) were deployed at all selected sampling sites. Each individual SIS unit (Figure 2A) consisted of an underwater housing that contained a digital camcorder to record video (used to assess relative abundance of reef fishes), a pair of stereoscopic cameras to capture still images at a rate of one per second (used to obtain length measurements of observed individuals), and an internal computer to control the camcorder/cameras and save recorded video/images. Each SIS unit also contained an internally-recording digital compass (OceanServer OS5000) to record cardinal direction. An external waterproof housing with a small battery powered each SIS unit (Figure 2B). For stations sampled via fishery-independent and fishery-dependent hooked-gears, baited (mackerel, *Scomber* spp.) SIS units were deployed on a stand-alone stationary underwater camera array (SUCA) developed by FWC (Figure 3) prior to conducting the hooked-gear sampling. Each SUCA was equipped with a pair of SIS units positioned at an angle of 180° from one another to maximize the total field of view. Two GoPro© HD digital video cameras were positioned at an angle of 90º from the SIS units to obtain additional video of the surrounding habitat. Each SUCA was deployed and allowed to soak for a minimum of thirty minutes. For Chevron traps, a single SIS unit was mounted onto the trap above the throat, similar to current SERFS camera-mounting protocols (Figure 4).

A qualitative characterization of benthic habitat that included the measure of bottom relief, habitat heterogeneity, substrate composition, dominant/subdominant benthic fauna, and relative visibility was completed for each sample site by examination of video files from the SIS units and GoPro© video cameras. Only one SIS unit from each deployment was selected to be analyzed for fish abundance (i.e. counts). The camera selected was determined following a pseudo-random approach. If both SIS units viewed reef habitat, the unit to be analyzed was randomly selected. If only one SIS unit viewed habitat, then that camera was read. If one of the units was unreadable (e.g., out-of-focus, severely obstructed view, faulty/short recording, did not record), the opposite camera was selected. Both units were analyzed for habitat characterization and habitat metrics were recorded (e.g., maximum relief by substrate, biota composition and coverage, substrate composition and coverage, general habitat characteristics). Only one SIS unit was deployed in conjunction with Chevron traps, therefore all readable trap videos were analyzed for fish abundance and habitat characterization.

All video analysis for fish abundance was completed using Luxriot® software. During analysis, viewers recorded the maximum number of individuals (MaxN) observed on a single video frame for each species identified during a continuous 20-minute analysis. Fish were visually identified to the lowest possible taxon. Certain taxa were only identified to the family or genus level since certain distinguishing characteristics/meristics were not observable on video. For example, *Diplectrum* taxa were left at the genus level and all flatfish were identified as *Pleuronectiformes* spp. Baitfish were characterized as either “unidentified baitfish” or a Scad complex identified as *Decapterus/Selar/Trachurus* complex. If a fish could not be identified to the family level it was not recorded and excluded from future analysis, though noted in the database. FWC has determined that accurate counts of large schools of fish can be made up to approximately 300 fish on any single video frame. Therefore, if a large school of fish occurred and the estimated count was over 299, then 999 was recorded to indicate that the school was >300 fish and an accurate count was not possible. Video from GoPro© cameras placed on the SUCA units were only read for habitat.

When video conditions allowed, observed individuals were measured to the nearest mm fork length (FL) using stereo still images and SeaGIS® software (Figure 5). As with MaxN, measurements were only taken of individuals observed on a single video frame to avoid duplicate measurements; measurements were typically taken at the time of MaxN, unless more measurements were possible at some other point during the twenty-minute read.

Gear Description – Chevron Traps – Chevron traps were constructed and deployed following established protocols developed and currently utilized during SERFS sampling (Collins 1990; MARMAP 2009; Mitchell et al. 2014). Chevron traps deployed during this survey were arrowhead shaped with a total interior volume of 0.91 m^3 (Figure 6; Ballenger et al. 2014). Each trap was constructed of 35 x 35 mm square mesh plastic-coated wire with a single entrance funnel and a release panel to remove the catch (Ballenger et al. 2014; Collins 1990; MARMAP 2009). Prior to deployment, each trap was baited with a combination of whole or cut clupeids (*Brevoortia* spp.). Four whole clupeids on each of four stringers were suspended within the trap and approximately 8 clupeids (abdomens cut open) were placed loose in the trap (Ballenger et al. 2014; Collins 1990; MARMAP 2009). All traps were equipped with a blow-out panel fastened with magnesium releases to minimize the potential of ghost fishing should traps be lost. Each Chevron trap was attached to an appropriate length of polypropylene line fastened to a surface polyball buoy. A 10-m line was attached to the surface buoy with an additional trailer buoy to aid in trap retrieval. Each Chevron trap was equipped with one SIS unit mounted onto the trap above the throat, similar to current SERFS camera-mounting protocols (Purcell et al. 2014), so that Chevron traps and SIS units fished simultaneously. Each Chevron trap soaked for a minimum of 90 minutes prior to retrieval. Traps were retrieved using an onboard commercial-style pot hauler or by other mechanical means depending on the equipment available to each of the contracted commercial/for-hire vessels.

Gear Description – Fishery-Independent Hooked-Gear (RTD) – Powered (12V DC) Elec-tra-mate© rigs (model 940XP) were used during this survey (Figure 7). The Elec-tra-mate© rig was outfitted with a Penn 115L 9/0 (Senator model) reel equipped with 45 kg (100 lb.) test monofilament. The entire rig was mounted onto a heavy-duty fiberglass fishing pole (~ 2.4 m). Terminal tackle for all Elec-tra-mate© rigs was standardized. A barrel swivel was attached to the mainline from the reel. Starting from the swivel a 1.8 m section of 45 kg (100 lb.) test monofilament leader was attached. Two short leads (~ 0.2 m long) were tied along the length of this leader (i.e., “dropper loops”); one located near the top of the rig and the other near the bottom. A specific hook size (either 8/0, 11/0, and 15/0 Mustad circle hooks (Ref 39960D)) was assigned to both the top and bottom leads for each rig. A lead egg sinker or bank sinker (size depending on prevailing current conditions, ranging from 0.17 kg to 0.40 kg, was inserted at the bottom of the leader followed by a barrel swivel (Figure 8).

Fishery-independent monitoring sampling employed a standardized system of active fishing that used a series of “team drops” with a set bottom soak time for each individual fisher at each site [referred to as repetitive timed-drop (RTD)] aimed to reduce individual fisher bias. A “team drop” consisted of all fishers simultaneously dropping their rigs to the bottom and allowing their rig to soak for no more than two minutes. Fishers soaked their rigs in contact with the bottom and reeled in their rig as soon as a fish was hooked. After the two-minute time period elapsed for each “team drop”, all remaining rigs were retrieved and rebaited. All fishers who retrieved their rig within the two-minute time period (i.e. caught fish, check bait, lost fish, etc.) were not permitted to re-drop their rig during that “team drop”. After all fishers had retrieved their rig, unhooked and processed any captured fish, and rebaited hooks, a subsequent “team drop” was performed by all anglers. An individual “team drop”, beginning with drop one, was numbered at each site and the number of the “team drop” in which any fish were captured was recorded.

At each RTD sampling site, three anglers were assigned to a particular rig with a specific hook combination. All hooks were baited with Atlantic mackerel (*Scomber scombrus*) cut proportional to hook size. A total of ten “team drops” were completed at each site. The rig fished by anglers was alternated at each sampling site throughout the day to remove any biases of angler experience with respect to hook size or fishing position on the boat.

Gear Description – Fishery-Dependent Hooked-Gear (Captain’s Choice) – At each selected Captain’s Choice sampling site, the specific fishery-dependent hooked-gear methods chosen were based on the knowledge and experience of our industry partners and meant to maximize our ability to catch Red Snapper. The specific gear, tackle, and bait to be fished was dictated by the captain of the vessel who was instructed to fish these sites using similar methods as to what they would employ during a commercial or charter fishing trip specifically targeting Red Snapper. Careful attention was made to document fishing tackle and methods used, which allowed for post-sampling catch analyses of various metrics and variables (i.e., compare catch rates, bait type, hook size, etc.). For each Captain’s Choice fishing site, three anglers actively fished for 30 minutes keeping accurate count of how many times that they retrieved and deployed their respective baits at each sampling site to provide some measure of effort. The start and end time of sampling was recorded and any breaks in individual fisher sampling (i.e. tying new rigs, working up fish, etc.) were recorded.

Collection and processing of field data – Geographic coordinates and water depths were recorded at each sampling site along with various other metrics (i.e., soak/fishing time, weather, time of day, etc.). A HOBO U22 temperature logger was deployed to record representative bottom temperatures at all sites sampled.

Sample processing for Chevron traps followed standard methods used in fishery-independent surveys currently in practice by FWC. All fish collected were identified, enumerated, and measured. Length measurements (mm) were recorded as standard length (SL), fork length (FL), and total length (TL) for fish or precaudal length for elasmobranchs. Any individuals that were not positively identified in the field were brought back to the laboratory for confirmation of identification.

For RTD and Captain’s Choice surveys, deployment and catch data were recorded at each sampling site. Angler specific parameters recorded at each sampling site included fishing mode, drop duration, team drops (total number of drops performed at each site), water depth, fisher/crew initials, rig number, leader (lb. test and type), reel type, start and end time, bait type, number of team drops completed per angler, and detailed hook information. Catch specific parameters were recorded that included fisher/crew initials (i.e., who caught the fish), rig number, drop number (number of team drop captured), species (identified to the lowest possible taxa), length measurements, sex, use, fish health code, bait type, rod attended, hooking information (i.e., location of hook in fish and tool used to remove hook), release information (i.e., condition of fish and venting information), tagging information (i.e., type and number), specimen number, and wetlab samples taken. All individuals collected were identified to the lowest taxonomic level possible and measured to the nearest mm (SL, FL, and TL) prior to either being released or culled for biological processing. Fish that exhibited barotrauma were vented prior to release if not being culled. On occasion, measurements were not recorded due to uncontrollable situations (i.e., fish partially preyed upon prior to landing). In these situations, plus counts towards overall catches (individual species) were recorded.

A random sub-sample (1st, 3rd, 5th, 10th, and 13th) of Red Snapper were sacrificed to provide valuable fisheries-independent demographic data (i.e., sex, age, mercury concentration). In addition, a random subsample (1st, 3rd, 5th, 10th, and 13th) of other federally managed species were also culled at each sampling site. Biological material was provided to the Fish and Wildlife Research Institute for processing.

Data Entry and Management – Data collection and management followed standard FWC methods which included the use of currently utilized data sheets and data entry programs. Data were entered into an existing relational SQL database that can capture physical, hydrological, habitat, abundance, length frequency, age and growth, reproductive, fish health, and contaminant data. Once entered, all data passed through an established system of QA/QC procedures developed by FWC to ensure the accuracy and reliability of the data captured by this database.

Community Analysis – Analysis of Variance (ANOVA) models were run to compare the catch-per-unit-effort (CPUE; individuals per site) among all three capture gears and between each capture gear and associated camera deployments for Red Snapper, Black Sea Bass, and Vermilion Snapper. In all comparisons, the tests for normality failed. Therefore, to test for significant differences, Kruskal-Wallis One Way Analysis of Variance on Ranks were performed. Results of all ANOVAs were explored visually with box plots.

The managed species assemblage (Appendix 1) was compared across all three capture gears as well as corresponding camera surveys using non-parametric analytical methods and PRIMER-E with PERMANOVA+ software (Clarke and Warwick, 2001; Clarke and Gorley, 2006; Anderson et al., 2008). Data were arranged into a matrix format where 1) each row represented the catch at a sampling station for a specific sampling method 2) each column represented a species collected during the survey, and 3) each cell represented the relative CPUE of a species expressed in terms of total number of individuals collected at that deployment. Data were pooled over all stations by trip for each sampling method.

Differences in the managed species assemblage were first tested using a series of permutational analysis of variance (PERMANOVA) tests including gear, camera, or gear-camera pairs applied to the Bray-Curtis similarity matrix (Bray and Curtis, 1957) using square-root transformed CPUE data to reduce the influence of overly-abundant taxa. Where significant differences were detected, pairwise, post-hoc comparisons were conducted using repeated PERMANOVA runs. Differences in managed species assemblage by gear and camera were also explored visually by constructing non-metric, multidimensional scaling plots and tested by running Analysis of Similarity (ANOSIM) tests. Managed species contributing to any observed differences in assemblage structure were then identified using the similarity percentages (SIMPER) routine, and relative abundances summarized for comparison.

Objective 2: Provide demographic data (i.e., sex, age, growth, mercury analysis) for Red Snapper and other reef fish species for use in future stock assessments in the U.S. South Atlantic.

A randomized subset of Red Snapper and other federally-managed fishes collected during the survey were sacrificed to provide valuable demographic data (i.e., sex, age, growth, mercury analysis).

Demographic Data Procedures

Sex – Sex of each culled fish collected during the survey was determined through macroscopic inspection of gonads by FWC staff either in the field or upon return to the laboratory. If the sex of a fish was unable to be determined through macroscopic determination (i.e. gonads were undeveloped), it was categorized as “unsexed”.

Annual Age – Otoliths for ageing were extracted by field staff from each culled fish collected during the survey and were further processed by the FWC Fish and Wildlife Research Institute’s Age-and-Growth Lab. Thin (~0.5 mm) transverse sections were cut at or adjacent to the core of the left sagitta with a Buhler Isomet low-speed saw equipped with a diamond blade; the right sagitta was sectioned when the left sagitta was missing or had been damaged. Otolith sections were mounted on microscope slides by using Histomount solution (Thermo Fisher Scientific, Waltham, MA). With a dissecting microscope (8 – 25× magnification), 2 or 3 readers independently counted the opaque rings on each otolith twice under reflected light. Readers counted rings without knowledge of sex, length, or capture date of specimens. Disagreements in annulus counts were resolved by at least 2 readers, without knowledge of previous counts. If an annulus count could not be agreed upon after re-examination, the otolith was rejected from the age and growth analysis.

A von Bertalanffy growth model for Red Snapper was estimated based on determined ages. The model was fitted using the re-parameterized von Bertalanffy growth equation of Francis (1988) using nonlinear least squares estimation. Conventional von Bertalanffy parameters were back calculated from the model output. Von Bertalanffy growth models and parameters were estimated using the R statistical package (R Project 2006).

Mercury Analysis – Tissue samples for mercury analysis were collected from all fish collected during HNL and trap surveys. For each fish, a clean stainless-steel knife was used to remove white axial muscle tissue samples from the left dorsal area in the region anterior to the origin of the dorsal fin and above the lateral line. White muscle tissue taken near this region is representative of the portion of fish muscle that is consumed by humans and other predators (Adams et al. 2003). Care was taken to assure that the sample made no contact with the external surface of the specimen, scales, blood, or any surrounding surfaces during the extraction process. All tissue samples were immediately placed in sterile polyethylene scintillation vials, sealed, and frozen at -20° C until analyzed.

Total mercury (THg) concentration, measured as milligrams per kilogram (mg/kg) wet weight, of each muscle sample was determined at FWC-FWRI by thermal decomposition, amalgamation, and atomic absorption spectrometry [EPA Method 7473] (EPA 2007). Total mercury serves as a reasonable proxy for methylmercury in Red Snapper because the majority of mercury in muscle tissue (>97%) is in the monomethyl form (CH3Hg) (Bank et al. 2007). Briefly, wet muscle subsamples of 0.05 to 0.10 g were cut from filet tissues, and the analysis was completed with a calibrated DMA-80 Direct Mercury Analyzer (Milestone Inc., Shelton, Connecticut). Quality control procedures included analysis of laboratory method blanks, duplicate or triplicate tissue samples, and certified reference material (CRM; TORT-3 or DORM-4 obtained from the National Research Council of Canada) for each group of 10 samples analyzed. In addition, we performed duplicate matrix spikes with the CRM BCR-463 for each group of 40 samples analyzed. All quality assurance measurements were within recommended EPA limits for the analytical method (EPA 2007).

Objective 3: Evaluate the size, age structure, and abundance for each gear type to estimate the effectiveness of each gear for collecting Red Snapper and other reef fishes in the U.S. South Atlantic

Evaluation of the size, age structure, and abundance for each gear type to estimate the effectiveness of each gear for collecting Red Snapper and other reef fishes (contingent on sufficient availability of size-composition data) was developed based on data and survey results collected in conjunction with Objective 1.

Statistical Analysis – Length-frequency distributions were compared using kernel density estimates (KDE). This method is sensitive to differences both in the shape and the location of length-frequency distributions. To examine differences due to shape data were standardized by median and variance (y = x - median/stdev) (Bowman an Azzalini 1997). Following Langlois et al. (2012), statistical differences were tested by comparing the area between KDEs for each method to that of random pairs resulting from permutations of the data (10,000 permutations) using the R package 'sm' (Bowman and Azzalini 2010, R Core Team 2017). If the data from both methods have the same distribution, the KDEs should only differ in minor ways due to within-population variance and sampling effects (Langlois et al. 2012). The 'sm.density.compare' function in the 'sm' package was used to plot the length-frequency distributions with a grey band centered on the mean KDE and extending one standard error above and below, therefore showing the null model of no difference between the pair of KDEs (Bowman and Azzalini 1997).

For relative and indirect selectivity analyses length-frequency data were pooled into 25 mm (Black Sea Bass and Vermilion Snapper) or 50 mm (Red Snapper) FL size classes for each gear type and species. Exploratory plots of the observed proportion of catch were calculated as the relative catch per length group in each sampling method to the relative catch in each length group from the sampling method plus the relative catch in each length group from SUCA (Millar 1995). The 90% confidence interval is calculated for the observed proportions by:

$$p \pm \frac{z_{\alpha/2}}{2\sqrt{n}}$$

Where p is the observed proportion, $z_{\alpha/2}$ is the quantile of the standard normal distribution, and n is the total number of fish in the length group from the gears that are compared.

Indirect selectivity curves were modeled for RTD collections of Red Snapper and Black Sea Bass, using methods outlined for gillnets (Millar and Fryer 1999, Campbell et al. 2014). Four selectivity models were fit using the SELECT (Share Each Length's Catch Total) method (outlined in Millar and Fryer (1999) and Millar and Holst (1997)) and the "gillnetfunctions" package in R

(Millar 2003, 2010). Three models accept Baranov's principle of geometrical similarity; this assumption implies that the location and spread of the selection curve are both proportional to the hook size (Baranov 1948). The fourth model was run with normal scale and constant spread, not according to Baranov's principle. Models were fit to the data twice; once assuming relative fishing intensity was equal for all hook sizes and once assuming relative fishing intensity was proportional to hook size. Relative fishing intensity is a combined measure of fishing effort and fishing power (Millar and Holst 1997). Each hook was fished with equal effort and hence fishing power is the same as fishing intensity in this study. Manufacturer's hook number does not represent the actual measurement of hook size; therefore, the measurement of hook gape was used to model the relative size proportions of the hooks (Campbell et al. 2014).

B. PROJECT MANAGEMENT

Dr. Richard Paperno (Research Administrator, Florida Fish and Wildlife Conservation Commission/ Fish and Wildlife Research Institute/ Fisheries-Independent Monitoring) was responsible for overall project management, overseeing field operations, as well as the preparation of interim and final reports. He also aided in overall survey design and final data analysis.

Mr. Russell Brodie (Research Administrator, Florida Fish and Wildlife Conservation Commission/ Fish and Wildlife Research Institute/ Fisheries-Independent Monitoring), was responsible for organizing and coordinating field operations, budgetary tracking, and preparation of interim and final progress reports.

Mr. Justin Solomon (Research Associate, Florida Fish and Wildlife Conservation Commission/ Fish and Wildlife Research Institute/ Fisheries-Independent Monitoring), was responsible for overseeing field operations and data processing with the assistance of the hired research technicians and current FWRI staff.

Dr. Theodore Switzer (Research Scientist, Florida Fish and Wildlife Conservation Commission/ Fish and Wildlife Research Institute/ Fisheries-Independent Monitoring) helped develop the study design and conduct statistical analyses.

Dr. Todd Kellison (NMFS – Beaufort, NC) served as the NMFS collaborative partner and provided insight into management needs and implications.

FINDINGS

A. ACTUAL ACCOMPLISHMENTS AND FINDINGS

Objective 1: Evaluate the size-selectivity of hooked-gear (both fishery-dependent and fishery-independent) and Chevron traps by comparing the size structure of the catches with those determined by stereoscopic cameras for Red Snapper and other reef fishes.

The project-development meetings held prior to the start of the survey served as a forum for discussing appropriate sampling sites, methods for comparative surveys of hooked-gears and Chevron traps, implementation of gear sampling techniques onboard commercial and charter vessels, and the overall goals and expected benefits of the proposed research. By adopting a cooperative approach for this project, we were able to combine the strengths of each respective group to improve the overall effectiveness of the study. Of particular benefit, the knowledge of our participating industry partners allowed us to eliminate artificial reef habitats from our sampling universe and select alternate sampling sites at the outset of the project as opposed to setting expensive trap/camera gear on unintended, potentially damaging artificial hard bottom locations.

Geographic Coverage and Survey Design – The selected sampling area (NMFS statistical zones 722, 728, and 732) covered an area from roughly 28° 00' N (Melbourne, FL) to 30° 45' N latitude (Florida-Georgia border; Figure 1). Each zone was subdivided into two depth strata – nearshore (≤ 30 m) and offshore (> 30 m). As stated earlier, the offshore strata was truncated at 150 m.

Sampling effort was allocated to only natural hard bottom habitats (HB) for this project. The full spatial extent of the sampling universe was gridded into a series of 0.1 nm W x 0.3 nm L sampling units, and HB habitats were identified. All 0.1 nm x 0.3 nm sampling units that intersected with areas of known or potential HB habitat were included in the sampling universe. An extensive HB sampling universe has been created in association with two recently completed CRP grants to FWC (award #'s NA11NMF4540116 and NA13NMF4540054; Figure 1). This sampling universe also includes hundreds of potential sampling sites provided by industry participants, publicly known fishing sites, habitat mapping data from current federally funded projects (i.e., MARMAP, SA-SEAMAP, and SEFIS), the SAFMC Habitat and Ecosystem Internet Map Server, as well as information from commercial and recreational fishers involved with previous FWC sampling efforts along Florida's east coast. This existing sampling universe was amended to meet the needs of the current project.

Site Selection – Sites within each spatial/depth stratum were randomly selected using ArcGIS software and the Hawth's Tools extension and were proportionally allocated based on available sample sites (transects) in each area. A total of 100 potential sampling stations were randomly selected from the survey area. For each of the 100 selected stations, all sampling units containing a hard bottom point within a 2-mile radius of the originally selected sites were identified and two additional sites were randomly selected. The resulting selections formed a three-site cluster to be sampled (one Chevron trap, RTD, and Captain's Choice at each station). All individual sampling sites within the three-site cluster were selected at least 200 m away from each other to preserve the independence of the samples. If two additional sites were not identified within a 2-mile radius of the originally selected station, then an alternate station was selected for sampling. For each three-site cluster, one of three sampling gears were randomly assigned to each of the sites.

Stereoscopic cameras were paired with each of the three capture gears and deployed at all selected sites.

Sampling Overview – Overall, 93 of the proposed 100 (93%) three-site station clusters were sampled between April – August 2016. Sampling was proportionally allocated between zones: zone 722 (n=18), zone 728 (n=49), and zone 732 (n=26) (Figure 9). At each station, each of the three capture gears were deployed resulting in a total of 279 sampled sites (Table 1). In addition, at each of the sampled sites a stereoscopic camera was deployed either concurrently (Chevron traps) or immediately preceding (RTD or Captain's Choice) active sampling. A total of 117 sites were completed in the inshore (<30 m) strata and 162 completed in the offshore (30 – 150 m) strata (Table 1). Forty distinct taxa were collected in capture gears (all gears combined) during the project; 30 taxa were collected from the inshore strata and 29 collected from the offshore strata (Table 2). A total of 2,473 individuals were collected in capture gears (all gears combined) during the study; 1,531 individuals collected from the inshore strata and 942 individuals collected from the offshore strata (Table 2).

Chevron Traps – A total of 93 Chevron trap sites were sampled during the project. A total of 1,281 individuals were collected by Chevron traps representing 18 distinct taxa (14 managed taxa; Table 3). Trap catches were dominated by Tomtate (*Haemulon aurolineatum*; n=638), Black Sea Bass (*Centropristis striata*; n=358), and Red Snapper (*Lutjanus campechanus*; n =208) which accounted for 94% of the overall Chevron trap catch. Red Snapper was the third most abundant species collected in all three NMFS statistical zones sampled (Table 3). Positive collections of Red Snapper in Chevron traps ranged from 1 to 41 individuals per site (Figure 10).

RTD Hooked-Gear – A total of 93 RTD sites were sampled during the project. A total of 659 individuals were collected during RTD surveys representing 26 distinct taxa (23 managed taxa; Table 4). RTD catches were dominated by Red Snapper (n =240) and Black Sea Bass (n=147) which accounted for 58.7% of the overall RTD catch. Red Snapper was the most abundant species collected in NMFS statistical zones 728 (n=128) and 732 (n=97), comprising 35.2% and 46.4% of the total RTD catch, respectively (Table 4). In NMFS statistical zone 722, Red Snapper (n=15) was the second most abundant species (behind Vermilion Snapper) accounting for 17.4% of the total catch in that zone. Positive collections of Red Snapper with RTD hooked-gear ranged from 1 to 20 individuals per site (Figure 11).

Captain's Choice Hooked-Gear – A total of 93 Captain's Choice sites were sampled during the project. A total of 533 individuals were collected during Captain's Choice surveys representing 30 distinct taxa (24 managed taxa; Table 5). Captain's Choice catches were dominated by Red Snapper (n =266) and Black Sea Bass (n=116) which accounted for 71.7% of the overall Captain's Choice catch. Red Snapper was the most abundant species collected in NMFS statistical zones 728 (n=184) and 732 (n=68), comprising 57.0% and 56.2% of the total Captain's Choice catch, respectively (Table 5). In NMFS statistical zone 722, Red Snapper (n=14) was the third most abundant species (behind Black Sea Bass and Vermilion Snapper) accounting for 15.7% of the total catch in that zone. Positive collections of Red Snapper with Captain's Choice hooked-gear ranged from 1 to 20 individuals per site (Figure 11).

Video Analysis – In total, 27,685 individuals representing 166 distinct taxa (68 managed taxa) were observed on 227 successful stereo-video camera deployments (Table 6). Numerically, the four most abundant taxa observed on video were unidentified baitfish (n = 7,133), Tomtate (n = 4,377), Vermilion Snapper (n = 3,560), and members of the Scad complex (n = 3,452). Additionally, several managed fishes were abundant on video (n > 200), including Red Snapper, Spadefish, Blue Runner, Gray Snapper, Gray Triggerfish, Almaco Jack, Black Sea Bass, and Greater Amberjack. In general, forage fishes (unidentified baitfish, Scad complex, and Tomtate) were more abundant in nearshore waters, whereas most managed fishes were similarly abundant in both nearshore and offshore waters. In zone 722, the most abundant managed fishes (excluding Tomtate) were Vermilion Snapper (n = 1,140), Almaco Jack (n = 129), Red Snapper (n = 72), Banded Rudderfish (n = 72), and Gray Snapper (n = 69). In zone 728, the most abundant managed fishes (excluding Tomtate) were Vermilion Snapper (n = 1,869), Atlantic Spadefish (n = 769), Red Snapper (n = 479), Blue Runner (n = 417), Gray Snapper (n = 307), and Gray Triggerfish (n = 301). In zone 732, the most abundant managed fishes (excluding Tomtate) were Vermilion Snapper (n = 551), Red Snapper (n = 378), Blue Runner (n = 159), Gray Snapper (n = 122), and Black Sea Bass (n = 93). MaxN numbers of Red Snapper observed on video ranged from 1 to 46 individuals per site (Figure 12).

Overall, a total of 3,258 individuals were measurable on video, representing 48 distinct taxa (44 managed species; Table 7). More than 100 individual fish measurements were obtained for eight taxa, including Vermilion Snapper (n = 818), Red Snapper (n = 457), Blue Runner (n = 313), Gray Snapper (n = 283), Gray Triggerfish (n = 274), Almaco Jack (n = 177), Greater Amberjack (n = 127), and Black Sea Bass (n = 122).

Community Analysis – Results from the PERMANOVA identified significant differences in the managed species assemblage between gear types (Pseudo-F 8.8494; $p< 0.001$; Figure 13). Pairwise comparisons of assemblage structure among capture gears indicated that the community observed with Chevron traps differed significantly from that of Captain's Choice ($p < 0.01$) and the RTD ($p < 0.001$), but that assemblage structure did not differ between Captain's Choice and RTD (Figure 13A). The were no significant differences among the cameras (Figure 13B). Significant differences ($p<0.001$) also existed when each gear type was compared with the associated camera (Figure 14). The observed differences between Captain's Choice and Captain's Choice-camera were primarily attributable to higher numbers of Red Snapper and Black Sea Bass caught at the Captain's Choice sites and higher numbers of Vermilion Snapper, Tomtate, and several other managed species observed by Captain's Choice-camera (Figure 15). The observed differences between RTD and RTD-camera were also attributable to higher numbers of Red Snapper and Black Sea Bass caught at the RTD sites and higher numbers of Vermilion Snapper, Tomtate, and several other managed species observed by RTD-camera (Figure 16). The observed differences between Chevron traps and Chevron trap-camera were also attributable to higher numbers of Black Sea Bass captured within Chevron traps and higher numbers of Vermilion Snapper, Gray Triggerfish, and Blue Runner observed by Chevron trap-cameras (Figure 17).

Examining the CPUE for specific managed species by gear type indicated that there were no significant differences in the numbers of Red Snapper captured per site between Captain's Choice, RTD, and Chevron traps (Figure 18). The numbers of Red Snapper recorded by cameras associated with these gear types were not significantly different from each other (Figure 19). Comparisons of CPUE of Black Sea Bass between gear types indicated there were no significant differences between capture gears (Figure 20). The numbers of Black Sea Bass recorded by cameras associated with these gear types were not significantly different from each other (Figure 21). Comparisons of CPUE of Vermilion Snapper between gear types indicated there were no significant differences between Captain's Choice and Chevron traps, but RTD had a significantly higher CPUE than the other two capture gears (p<0.05; Figure 22). The numbers of Vermilion Snapper recorded by cameras associated with these gear types were not significantly different from each other (Figure 23).

Comparisons of relative abundance between capture gears (Chevron traps, RTD, and Captain's Choice) and their respective camera sets indicated that relative abundance of Red Snapper and Black Sea Bass did not differ between capture gears and their associated cameras sets, with the notable exception of Red Snapper, which were statistically less abundant within Chevron traps than they were within corresponding trap-camera surveys (Figures 24 and 25). In contrast, Vermilion Snapper were statistically more abundant within camera surveys than with paired capture gears (Figure 26).

Objective 2: Provide demographic data (i.e., sex, age, mercury analysis) for Red Snapper and other reef fish species for use in future stock assessments in the U.S. South Atlantic.

A randomized subset of Red Snapper and other federally-managed species collected during the survey were sacrificed to provide valuable fisheries-independent demographic data (i.e., sex, age, growth, mercury analysis) (Table 8). As the focus of this project was on Red Snapper, information for that species will be summarized for all sections of this objective, though we have also included some summary information for Black Sea Bass and Vermilion Snapper in some sections. Data for other species will be available upon request from project Principal Investigators.

<u>Demographic Data Results</u>

Lengths – The mean size of Red Snapper collected during RTD (483.5 mm FL; SE = 8.7) and Captain's Choice (486.3 mm FL; SE = 8.5) surveys was larger than those collected during Chevron trap surveys (336.6 mm FL; SE = 7.1) and measured from video surveys (449.6 mm FL; SE = 8.4; Figure 27).

The mean size of Black Sea Bass collected during RTD (266.8 mm TL; SE = 5.4) and Captain's Choice (278.3 TL; SE = 4.7) surveys was larger than those collected during Chevron trap surveys (247.7 mm TL; SE = 2.5) and measured from video surveys (247.9 mm FL; SE = 2.5; Figure 28).

The mean size of Vermilion Snapper collected during RTD (297.4 mm FL; SE = 5.4) and Captain's Choice (304.6 FL; SE = 7.0) surveys was larger than those collected during Chevron trap surveys (261.1 mm FL; SE = 18.8) and measured from video surveys (225.4 mm FL; SE = 2.6; Figure 29).

Sex – Sex was determined for 308 Red Snapper culled throughout the project. Of the 308 fish sexed, 147 fish were classified as male and 161 were classified as female. Sizes of male Red Snapper ranged from 212 – 798 mm FL with a mean size of 457.3 mm FL (SE = 13.4). Sizes of female Red Snapper ranged from 233 – 831 mm FL with a mean size of 457.9 mm FL (SE = 12.5) (Figure 30).

Annual Age – A total of 309 Red Snapper were aged. The mean age for Red Snapper was 3.6 years (SE = 0.2). The youngest Red Snapper captured was age 1 (n=44) while the oldest was age

16 (n=1). The median age of Red Snapper collected was 3 and most frequent age was 2 years (n=97) (Figure 31).

The RTD and Captain's Choice hooked-gear surveys collected proportionally more older Red Snapper than did the Chevron traps (Figure 32). The mean Red Snapper ages for RTD and Captain's Choice hooked-gears was 4.2 years (SE = 0.3) and 4.4 years (SE = 0.3), respectively. The mean age for Chevron traps was lower at 2.1 years (SE = 0.2).

The age frequency between male and female Red Snapper collected (all gears combined) was similar (Figure 33). The mean age of male Red Snapper was 3.6 years (SE = 0.3) while the mean age of females was 3.6 years (SE = 0.22).

The age structure of Red Snapper collected between NMFS stastical zones was similar though older fish were generally collected in NMFS zone 722 (Figure 34). The mean Red Snapper ages for NMFS zone 722 was 5.1 years (SE = 0.9) which was older than NMFS zones 728 and 732 where the mean ages were 3.7 years (SE = 0.2) and 3.2 years (SE = 0.2), respectively.

The von Bertalanffy growth curve confirms that Red Snapper grow rapidly during the younger ages and growth slows after age 5 (Figure 35). The estimated parameters from the von Bertalanffy growth model are: L_{∞} = 839.71 mm, K = 0.226 and t0=-0.532.

Mercury Analysis – Total mercury (THg) concentrations were determined for 163 Red Snapper ranging in size from 212 – 831 mm FL (Table 9). At these sizes, THg concentrations ranged from 0.038 – 0.889 mg/kg with a mean THg concentration of 0.153 mg/kg. Approximately 82% of all samples collected had THg concentrations less than 0.200 mg/kg (Figure 36). Several individuals above 700 mm SL contained THg concentrations that were noticeably higher than the majority analyzed. Mercury concentrations in Red Snapper collected during this project (up to approximately 800 mm FL) increased directly with fish length (Figure 36), as described by the Equation: THg = –0.145 + (0.000669 * FL).

Total mercury (THg) concentrations were determined for 109 Black Sea Bass ranging in size from 151 – 412 mm FL (Table 10). At these sizes, THg concentrations ranged from 0.039 – 0.455 mg/kg with a mean THg concentration of 0.158 mg/kg. Approximately 84% of all samples collected had THg concentrations less than 0.200 mg/kg (Figure 37). Several individuals above 250 mm SL contained THg concentrations that were noticeably higher than the majority analyzed. Mercury concentrations in Black Sea Bass collected during this project (up to approximately 400 mm FL) increased directly with fish length (Figure 37), as described by the Equation: THg = 0.628 + (0.000357 * FL).

Total mercury (THg) concentrations were determined for 68 Vermilion Snapper ranging in size from 196 – 301 mm FL (Table 11). At these sizes, THg concentrations ranged from 0.028 – 0.116 mg/kg with a mean THg concentration of 0.058 mg/kg. All samples collected had THg concentrations less than 0.200 mg/kg (Figure 38). Mercury concentrations in Vermilion Snapper collected during this project (up to approximately 360 mm FL) increased directly with fish length (Figure 38), as described by the Equation: THg = 0.00707 + (0.000174 * FL).

Objective 3: Evaluate the size, age structure, and abundance for each gear type to estimate the effectiveness of each gear for collecting Red Snapper and other reef fishes in the U.S. South Atlantic

For three of the most commonly occurring species across all gears (*Lutjanus campechanus*, Red Snapper; *Centropristis striata*, Black Sea Bass; and *Rhomboplites aurorubens*, Vermilion Snapper) the following analyses were conducted for each individual sampling method (i.e., Chevron trap, RTD, or Captain's Choice) compared with video data from SIS units deployed with that gear. Data were pooled over all sites for each sampling method.

Lutjanus campechanus – Using the KDE method, the shape of the length-frequency distributions differed between Chevron traps and SIS video as well as between RTD and SIS video (Figure 39A, 39B). The location of length-frequency distributions was significantly different between all three gears and SIS video (Figure 39). SIS video had a second peak between 600-800 mm FL that was not evident for traps; likely driving the difference in both shape and location that was seen. RTD and Captain's Choice both had larger mean lengths than observed by SIS video, although there was a second slight peak for both hooked-gears and SIS video around 700-800 mm FL.

The plot of relative selectivity between Chevron traps and SIS video indicated that as individual size increased, capture in Chevron traps decreased (Figure 40). RTD and Captain's Choice had the opposite trend; whereas fish size increased, the proportion caught on hooked-gears also increased. However, the largest individual fish were observed by SIS video for both gears.

The normal model with proportional scale and spread under the assumption that fishing intensity was proportional to hook size was the best fit model for indirect selectivity of the three hook sizes used in RTD (Figure 41A). The indirect selectivity curves were broad for all hook sizes and the median size at full selectivity increased with increasing hook size. The deviance residuals were generally small with no obvious patterns in positive or negative residuals.

Centropristis striata – The KDE analysis found no significant difference between the shape of the length-frequency distributions for SIS video and any of the three sampling methods (Figure 42). However, significant differences in the location of distributions were evident for all sampling methods. The mean length observed by SIS video was higher than captured in Chevron traps. However, the number of Black Sea Bass observed by SIS video was low, so this result must be interpreted with caution. Both hooked-gear methods had higher mean lengths than observed by SIS video.

The plot of catch in Chevron traps compared to those observed by SIS video indicated that video observed both larger and smaller size classes of Black Sea Bass than Chevron traps (Figure 43A). The relative selectivity curves for both hooked-gears indicated as length increased, proportionally more Black Sea Bass were captured by the hooked-gears (Figure 43B, 43C).

The lognormal model provided the best fit for both assumptions (Figure 41B). The selection curves were broad with increasing median size at full selectivity with increasing hook size. Overall, the residuals were small for all hook sizes with no patterns in positive or negative residuals. Residuals for both models were similar and could not distinguish a better fit between the two assumptions.

Rhomboplites aurorubens – The sample size of Vermilion Snapper captured by Chevron traps was too low to conduct size selectivity analyses. Additionally, the sample size was too low to conduct an indirect selectivity analysis of either hooked-gear.

The KDE analysis indicated the shape of the distributions were not significantly different for either hooked-gear compared to SIS video, however the location of both distributions were significantly different (Figure 44). The mean length of fish captured by both hooked-gears was larger than observed by video.

The relative selectivity curves for both hooked-gears compared to SIS video indicated that video observed both the largest and smallest size classes (Figure 45) while hooked-gears had proportionally more occurrences of the medium size classes.

B. IF SIGNIFICANT PROBLEMS DEVELOPED WHICH RESULTED IN LESS THAN SATISFACTORY OR NEGATIVE RESULTS, THEY SHOULD BE DISCUSSSED

While no significant problems were encountered that impacted the current project, weather-related conditions did prevent us from completing all 100 proposed stations. Regardless, we were able to complete the majority of the targeted sampling for the project (93 sites) and feel that the survey was successful in meeting its stated goals.

At the outset of the project there was some initial collaborative talks between FWC and the SERFS Chevron trap survey to increase the number of trap sets with stereo-video cameras mounted to them. Above and beyond the stated goals of the original project, we developed a training protocol and provided stereo-video cameras and trap mounting brackets to SERFS. Initial plans were to have SERFS deploy a subset of their originally planned Chevron traps with identically mounted stereo-video cameras to the FWC survey. However, because the stereo-video camera was substantially larger than the video camera used by SERFS, there were concerns as to whether the larger camera may influence trap catches, particularly of wary species. Accordingly, stereo-video cameras were never deployed by SERFS, and so no data were provided for reef-fish populations off the coasts of Georgia, South Carolina, and North Carolina. To begin to address these concerns, we performed a cursory analysis of the length frequency of Red Snapper collected in Chevron traps by both SERFS and FWC surveys within the same spatial area. SERFS Chevron traps collected a greater proportion of larger Red Snapper (> 600 mm FL) than traps deployed by the FWC, while the FWC Chevron traps collected a greater proportion of smaller (<300 mm FL) Red Snapper; no such differences were evident with respect to Black Sea Bass. It is unclear whether these differences may be attributable to actual trap avoidance behaviors, or may result from marked differences in overall effort, timing, and spatial extent of sampling between the SERFS and FWC surveys. Regardless, these differences likely need to be explored further.

C. DESCRIPTION OF NEED, IF ANY, FOR ADDITIONAL WORK

Although the project was largely successful at meeting proposed objectives, additional efforts are required to fully assess size selectivity of Chevron trap surveys in the U.S. South Atlantic. Data from the SERFS Chevron trap and camera survey are critical for the assessment of many other reef fishes, most notably Gray Triggerfish and Red Porgy among others. For these and other fishes, too few individuals were captured in Chevron traps in the current study to appropriately conduct a quantitative evaluation of size selectivity; nevertheless, additional efforts to address these are warranted. We had originally intended to collaborate with ongoing SERFS surveys conducted by NMFS – Beaufort and the South Carolina DNR MARMAP program to (1) increase overall sample size, and (2) expand the spatial extent of these efforts by affixing stereo cameras to a subset of their traps. However, in early discussions with SERFS scientists, concerns were raised as to whether mounting a stereo camera much larger than cameras already in use by the SERFS survey might affect catchability through increased gear avoidance, so these efforts were not realized. Increasing both the sample size and spatial coverage of further efforts to assess selectivity would allow for similar analyses to be conducted on a suite of additional species beyond those assessed in the current study.

Overall, our results indicate that trap-mounted stereo-video surveys observe larger Red Snapper than are captured within Chevron traps, although what, if any, implications this discrepancy may have on the assessment of Red Snapper is not clear. Although beyond the scope of this study, additional efforts to explore what implications our results may have on Red Snapper assessment would be valuable. Ultimately, the SERFS video survey would greatly benefit from incorporating stereo-video cameras to, at a minimum, a subset of traps deployed each year. This is something that the SERFS group is actively exploring, although they require a much less expensive stereo camera than the ones utilized for the current study due to the number of traps lost each year during their survey.

Finally, although the standardized repetitive timed-drop hooked-gear survey has shown great promise as an alternative approach to characterizing the relative abundance and size composition of Red Snapper and other managed reef fishes, questions still remain as to whether this survey can further be improved upon. Notably, recent reviews of survey results question whether standardizing drop duration to a set time period (e.g., two minutes), regardless of whether or not an angler detects a potential bite, may further remove any angler bias from survey methods. One contraindication to this approach is the concern that failure to reel in immediately upon hooking may result in an increased number of fish pulling the gear into reef habitat, thus reducing catch rates dramatically. Nevertheless, implications of increased standardization to RTD methods should be further explored.

EVALUATION

A. EXTENT TO WHICH THE PROJECT GOALS AND OBJECTIVES WERE ATTAINED

Overall, the project successfully met proposed objectives. The primary objective was to assess the size-selectivity of various sampling approaches (Chevron traps, fishery-independent repetitive timed-drop hooked-gear surveys, and unstandardized hooked-gear surveys) for Red Snapper and, where possible, other managed reef fishes in the U.S. South Atlantic. To accomplish this goal, data from paired stereo-video surveys, which are typically less selective than capture gears, were used to estimate the size composition of the source population. Although all sampling approaches were effective at characterizing the relative abundance of Red Snapper, there were significant differences among sampling gear with respect to size selectivity for Red Snapper. The length frequency distribution of all three capture gears differed significantly from that obtained from corresponding stereo-video surveys. Overall, average Red Snapper captured in Chevron traps had a smaller average length than did those observed on stereo-video; this is largely attributable to decreasing capture probability with increasing size, especially individuals over 600 mm FL. In contrast, both hooked-gears captured larger Red Snapper on average than were observed on stereo-video. Small Red Snapper less than 300 mm FL were captured with reduced probability in both hooked-gear surveys, although both hooked-gears along with stereo-video characterized a second distributional peak (600 – 800 mm) that was not detected with Chevron traps. Interestingly, both hooked-gear surveys performed similarly with respect to relative abundance and size composition of Red Snapper, indicating that standardized, fishery-independent RTD surveys are effective at sampling adult Red Snapper.

In addition to Red Snapper, we were able to assess selectivity for two additional reef fishes, Black Sea Bass and Vermilion Snapper. Although significant differences in selectivity were detected for both species, observed differences were much less pronounced than those observed for Red Snapper. For Black Sea Bass, the overall shape of length frequency distributions was similar among all gears, although similar to Red Snapper, the mean length of Black Sea Bass was lower for individuals captured in traps, and higher for individuals captured in hooked-gear surveys, than was observed on stereo-video. Insufficient numbers of Vermilion Snapper were captured in traps for selectivity analyses; however, hooked-gears captured larger Vermilion Snapper than were observed on stereo-video. Combined, these analyses provide new insight into the size-selectivity of various sampling approaches for managed reef fishes.

In addition to addressing questions regarding selectivity of various sampling approaches, we were also able to obtain valuable life history data for fifteen managed fish species, although most data pertain to two managed reef fishes (Red Snapper and Black Sea Bass). Overall, life history data were obtained from nearly 700 individuals, approximately equally distributed among the three capture gears.

B. DISSEMINATION OF PROJECT RESULTS

We anticipate presenting project results at various regional meetings over the coming years and investigating the potential of manuscript development for a peer-reviewed scientific journal. Preliminary results of this project have already been presented by FWC Leadership (Dr. Luiz

Barbieri) at a South Atlantic Marine Fisheries Council meeting in 2017. Results from this study will also be available to any group involved with upcoming stock assessments for Red Snapper. Data collected during this study will also be available to the general public and other researchers, in a variety of formats, upon request.

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Table 1. The number of stations sampled (proposed) for each NMFS Statistical Zone and depth strata (nearshore and offshore) during FWC trap and hooked-gear surveys along the Atlantic coast of Florida (2016). All three capture gears [Chevron traps, fisheries-independent hooked-gear (RTD), and fisheries-dependent hooked-gear (Captain's Choice)] and associated video cameras were deployed at each station.

NMFS Statistical Zone	Nearshore (<30 m) Sampled (Proposed)	Offshore (30 - 150 m) Sampled (Proposed)	Total Sites Sampled (Proposed)
722	5 (5)	13 (16)	18 (21)
728	21 (21)	28 (32)	49 (53)
732	13 (13)	13 (13)	26 (26)
TOTALS	39 (39)	54 (61)	93 (100)

Table 2. Summary of taxa collected by gear type in the inshore (<30 m) and offshore strata (30-150 m) during FWC trap and hooked-gear surveys along the Atlantic coast of Florida (2016). Sampling gears are defined as Chevron traps (Chevron), fisheries-independent hooked-gear (RTD), and fisheries-dependent hooked-gear (CC). Taxa in **bold** are managed species. Taxa are arranged alphabetically.

Taxon	Inshore (<30 m) Number Collected			Offshore (30-150 m) Number Collected			Totals
	Chevron	RTD	CC	Chevron	RTD	CC	
Balistes capriscus	18	4	4	14	8	4	52
***Calamus* sp.**	-	-	-	-	1	-	1
Caranx crysos	-	2	1	-	-	-	3
Carcharhinus falciformis	-	-	-	-	2	1	3
Carcharhinus limbatus	-	1	-	-	-	-	1
Carcharhinus plumbeus	-	3	-	-	3	1	7
Centropristis ocyurus	8	6	1	8	5	1	29
Centropristis striata	247	105	88	111	42	28	621
Diplectrum formosum	1	3	-	3	-	1	8
Diplodus holbrookii	-	-	1	-	-	-	1
Echeneis spp.	-	3	5	1	2	1	12
Epinephelus drummondhayi	-	-	-	-	-	1	1
Equetus lanceolatus	2	-	-	1	-	-	3
Galeocerdo cuvier	-	1	-	-	-	-	1
Ginglymostoma cirratum	1	-	-	-	-	-	1
Gymnothorax vicinus	3	-	1	-	1	1	6
Haemulon aurolineatum	579	63	21	59	26	13	761
Holacanthus bermudensis	-	-	-	1	-	-	1
Holocentrus adscensionis	-	3	1	-	4	-	8
Holocentrus sp.	1	-	-	-	-	-	1
Lutjanus analis	-	-	2	-	-	1	3
Lutjanus campechanus	78	85	118	130	155	148	714
Lutjanus griseus	-	1	3	-	1	1	6
Lutjanus synagris	1	-	1	-	-	-	2
Mycteroperca microlepis	-	1	-	-	-	1	2
Mycteroperca phenax	-	-	-	-	-	1	1
Ocyurus chrysurus	-	2	-	-	-	-	2
Opsanus pardus	-	-	-	-	-	2	2
Pagrus pagrus	-	-	-	1	5	5	11
Pareques umbrosus	3	-	-	-	-	-	3
Rachycentron canadum	-	-	1	-	-	-	1
Rhizoprionodon terraenovae	-	11	10	-	8	7	36

Taxon	Inshore (<30 m) Number Collected			Offshore (30-150 m) Number Collected			Totals
	Chevron	RTD	CC	Chevron	RTD	CC	
Rhomboplites aurorubens	3	13	13	5	53	18	105
Scomberomorus cavalla	-	-	-	-	-	1	1
Seriola dumerili	-	2	2	-	2	8	14
Seriola rivoliana	-	-	1	1	10	11	23
Seriola zonata	-	-	-	-	17	1	18
Sphyraena barracuda	-	2	-	-	-	-	2
Stenotomus caprinus	1	-	-	-	-	-	1
Synodus foetens	-	-	-	-	-	1	1
Trachinocephalus myops	-	-	-	-	3	1	4
Totals	**946**	**311**	**274**	**335**	**348**	**259**	**2473**

Table 3. Summary of catch by NMFS statistical zone during FWC Chevron trap surveys (n=93) along the Atlantic coast of Florida (2016). Percent (%) Total Catch is the percentage each taxon represents out of all fish collected during Chevron trap surveys. Percent (%) Catch per Zone is the percentage each taxon represents out of all fish collected during Chevron trap surveys in each NMFS statistical zone. Taxa in **bold** are managed species. Taxa are arranged alphabetically.

Taxon	Number Collected			Total	% Total Catch	% Catch per Zone		
	722	728	732			722	728	732
Balistes capriscus	4	21	7	32	2.5	2.5	3.4	1.4
Centropristis ocyurus	4	7	5	16	1.2	2.5	1.1	1.0
Centropristis striata	33	206	119	358	27.9	20.6	33.4	23.6
Diplectrum formosum	3	-	1	4	0.3	1.9	-	0.2
Echeneis sp.	-	1	-	1	0.1	-	0.2	-
Equetus lanceolatus	-	2	1	3	0.2	-	0.3	0.2
Ginglymostoma cirratum	-	1	-	1	0.1	-	0.2	-
Gymnothorax vicinus	-	-	3	3	0.2	-	-	0.6
Haemulon aurolineatum	100	298	240	638	49.8	62.5	48.4	47.5
Holacanthus bermudensis	-	1	-	1	0.1	-	0.2	-
Holocentrus sp.	-	1	-	1	0.1	-	0.2	-
Lutjanus campechanus	16	69	123	208	16.2	10.0	11.2	24.4
Lutjanus synagris	-	-	1	1	0.1	-	-	0.2
Pagrus pagrus	-	-	1	1	0.1	-	-	0.2
Pareques umbrosus	-	2	1	3	0.2	-	0.3	0.2
Rhomboplites aurorubens	-	5	3	8	0.6	-	0.8	0.6
Seriola rivoliana	-	1	-	1	0.1	-	0.2	-
Stenotomus caprinus	-	1	-	1	0.1	-	0.2	-
Totals	**160**	**616**	**505**	**1,281**				

Table 4. Summary of catch by NMFS statistical zone during FWC fisheries-independent hooked-gear (RTD) surveys (n=93) along the Atlantic coast of Florida (2016). Percent (%) Total Catch is the percentage each taxon represents out of all fish collected during RTD surveys. Percent (%) Catch per Zone is the percentage each taxon represents out of all fish collected during RTD surveys in each NMFS statistical zone. Taxa in **bold** are managed species. Taxa are arranged alphabetically.

Taxon	Number Collected			Total	% Total Catch	% Catch per Zone		
	722	728	732			722	728	732
Balistes capriscus	1	7	4	12	1.8	1.2	1.9	1.9
***Calamus* sp.**	-	1	-	1	0.2	-	0.3	-
Caranx crysos	-	2	-	2	0.3	-	0.5	-
Carcharhinus falciformis	-	1	1	2	0.3	-	0.3	0.5
Carcharhinus limbatus	-	1	-	1	0.2	-	0.3	-
Carcharhinus plumbeus	-	3	3	6	0.9	-	0.8	1.4
Centropristis ocyurus	3	7	1	11	1.7	3.5	1.9	0.5
Centropristis striata	12	92	43	147	22.3	14.0	25.3	20.6
Diplectrum formosum	-	3	-	3	0.5	-	0.8	-
Echeneis spp.	1	3	1	5	0.8	1.2	0.8	0.5
Galeocerdo cuvier	-	1	-	1	0.2	-	0.3	-
Gymnothorax vicinus	1	-	-	1	0.2	1.2	-	-
Haemulon aurolineatum	15	46	28	89	13.5	17.4	12.6	13.4
Holocentrus adscensionis	2	2	3	7	1.1	2.3	0.5	1.4
Lutjanus campechanus	15	128	97	240	36.4	17.4	35.2	46.4
Lutjanus griseus	1	1	-	2	0.3	1.2	0.3	-
Mycteroperca microlepis	1	-	-	1	0.2	1.2	-	-
Ocyurus chrysurus	-	-	2	2	0.3	-	-	1.0
Pagrus pagrus	3	1	1	5	0.8	3.5	0.3	0.5
Rhizoprionodon terraenovae	-	15	4	19	2.9	-	4.1	1.9
Rhomboplites aurorubens	21	32	13	66	10.0	24.4	8.8	6.2
Seriola dumerili	1	3	-	4	0.6	1.2	0.8	-
Seriola rivoliana	-	10	-	10	1.5	-	2.7	-
Seriola zonata	8	1	8	17	2.6	9.3	0.3	3.8
Sphyraena barracuda	1	1	-	2	0.3	1.2	0.3	-
Trachinocephalus myops	-	3	-	3	0.5	-	0.8	-
Totals	**86**	**364**	**209**	**659**				

Table 5. Summary of catch by NMFS statistical zone during FWC fisheries-dependent hooked-gear (Captain's Choice) surveys (n=93) along the Atlantic coast of Florida (2016). Percent (%) Total Catch is the percentage each taxon represents out of all fish collected during Captain's Choice surveys. Percent (%) Catch per Zone is the percentage each taxon represents out of all fish collected during Captain's Choice surveys in each NMFS statistical zone. Taxa in **bold** are managed species. Taxa are arranged alphabetically.

Taxon	Number Collected			Total	% Total Catch	% Catch per Zone		
	722	728	732			722	728	732
Balistes capriscus	1	7	-	8	1.5	1.1	2.2	-
Caranx crysos	-	1	-	1	0.2	-	0.3	-
Carcharhinus falciformis	-	1	-	1	0.2	-	0.3	-
Carcharhinus plumbeus	1	-	-	1	0.2	1.1	-	-
Centropristis ocyurus	1	1	-	2	0.4	1.1	0.3	-
Centropristis striata	19	69	28	116	21.8	21.3	21.4	23.1
Diplectrum formosum	1	-	-	1	0.2	1.1	-	-
Diplodus holbrookii	1	1	-	1	0.2	1.1	0.3	-
Echeneis spp.	-	4	2	6	1.1	-	1.2	1.7
Epinephelus drummondhayi	-	1	-	1	0.2	-	0.3	-
Gymnothorax vicinus	-	-	1	2	0.4	-	-	0.8
Haemulon aurolineatum	14	11	9	34	6.4	15.7	3.4	7.4
Holocentrus adscensionis	-	1	-	1	0.2	-	0.3	-
Lutjanus analis	1	2	-	3	0.6	1.1	0.6	-
Lutjanus campechanus	14	184	68	266	49.9	15.7	57.0	56.2
Lutjanus griseus	1	2	1	4	0.8	1.1	0.6	0.8
Lutjanus synagris	-	-	1	1	0.2	-	-	0.8
Mycteroperca microlepis	-	1	-	1	0.2	-	-	-
Mycteroperca phenax	-	-	1	1	0.2	-	-	0.8
Opsanus pardus	-	2	-	2	0.4	-	0.6	-
Pagrus pagrus	3	2	-	5	0.9	3.4	0.6	-
Rachycentron canadum	-	1	-	1	0.2	-	-	-
Rhizoprionodon terraenovae	1	9	7	17	3.2	1.1	2.8	5.8
Rhomboplites aurorubens	18	12	1	31	5.8	20.2	3.7	0.8
Scomberomorus cavalla	-	-	1	1	0.2	-	-	0.8
Seriola dumerili	4	6	-	10	1.9	4.5	1.9	-
Seriola rivoliana	7	5	-	12	2.3	7.9	1.5	-
Seriola zonata	-	-	1	1	0.2	-	-	0.8
Synodus foetens	1	-	-	1	0.2	1.1	-	-
Trachinocephalus myops	1	-	-	1	0.2	1.1	-	-
Totals	**89**	**323**	**121**	**533**				

Table 6. Summary of taxa (sum of MaxN) observed on stereo-video surveys along the Atlantic coast of Florida (2016). Catch summaries are broken down by NMFS statistical zone (722, 728, and 732) for Nearshore (<30 m) and Offshore (30 – 150 m) depth strata, respectively. Taxa in **bold** represent managed species. Taxa are arranged alphabetically.

Taxon	**Inshore (<30 m) Number Collected**			**Offshore (30-150 m) Number Collected**			**Totals**
	722	**728**	**732**	**722**	**728**	**732**	
Acanthostracion sp.	-	-	-	-	1	-	1
Acanthuridae	-	-	3	-	-	-	3
Acanthurus chirurgus	-	2	4	-	2	1	9
Acanthurus coeruleus	-	-	1	1	-	1	3
Acanthurus spp.	-	11	9	4	-	-	24
Alectis ciliaris	-	-	-	9	-	-	9
Aluterus monoceros	1	68	10	17	52	-	148
Aluterus schoepfii	2	-	-	3	3	-	8
Aluterus spp.	-	1	27	7	9	-	44
Anisotremus surinamensis	-	-	8	-	-	-	8
Anisotremus virginicus	-	15	28	5	20	2	70
Archosargus probatocephalus	12	49	40	-	22	7	130
Aulostomus maculatus	-	-	-	-	1	-	1
Balistes capriscus	3	157	60	46	144	28	438
Balistes spp.	-	1	1	1	-	1	4
Balistes vetula	-	-	-	1	-	1	2
Blenniidae	-	-	-	-	2	-	2
Bodianus pulchellus	-	9	5	11	27	4	56
Bodianus rufus	-	5	7	4	2	-	18
Bodianus sp.	-	-	1	-	-	-	1
Calamus bajonado	-	1	-	-	1	-	2
Calamus proridens	2	3	-	-	-	-	5
***Calamus* spp.**	18	41	26	36	36	31	188
Canthigaster jamestyleri	-	-	-	-	1	-	1
Canthigaster rostrata	-	3	1	4	7	-	15
Canthigaster spp.	-	1	2	2	4	-	9
Carangidae	7	1	13	25	33	-	79
Caranx bartholomaei	-	9	6	10	13	-	38
Caranx crysos	4	236	147	57	181	12	637
Caranx hippos	-	1	4	-	2	-	7
Caranx ruber	1	10	1	2	-	-	14
Caranx spp.	-	4	7	47	15	-	73

Taxon	Inshore (<30 m) Number Collected			Offshore (30-150 m) Number Collected			Totals
	722	728	732	722	728	732	
Carcharhinidae	-	1	1	1	-	1	4
Carcharhiniformes	-	8	-	-	-	-	8
Carcharhinus acronotus	-	1	-	-	-	-	1
Carcharhinus falciformis	-	-	-	-	-	11	11
Carcharhinus plumbeus	-	1	2	1	4	1	9
Centropomus undecimalis	-	-	1	-	-	-	1
Centropristis ocyurus	1	1	-	4	1	8	15
Centropristis philadelphica	-	1	-	-	-	-	1
Centropristis spp.	2	1	-	-	-	2	5
Centropristis striata	16	104	49	3	22	44	238
Cephalopholis cruentata	-	3	-	1	6	-	10
Chaetodipterus faber	29	639	5	-	130	-	803
Chaetodon ocellatus	4	18	11	1	19	8	61
Chaetodon sedentarius	-	22	27	6	28	5	88
Chaetodon spp.	2	4	3	2	8	5	24
Cheloniidae	-	1	-	-	1	-	2
Chloroscombrus chrysurus	-	450	527	-	-	-	977
Chromis enchrysura	10	19	7	13	35	4	88
Chromis scotti	-	-	2	-	3	-	5
Chromis spp.	-	-	-	-	34	-	34
Dasyatis spp.	-	-	2	3	1	1	7
***Decapterus/Selar/Trachurus* spp.**	1,196	366	1,481	3	206	200	3,452
Diplectrum spp.	3	49	7	24	7	13	103
Diplodus holbrookii	-	-	2	-	-	-	2
Diplodus spp.	6	6	4	-	1	-	17
Echeneis spp.	-	5	3	3	5	-	16
Elagatis bipinnulata	-	-	1	12	5	-	18
Epinephelidae	-	-	1	1	-	-	2
Epinephelus itajara	-	-	1	1	2	1	5
Epinephelus morio	-	-	-	-	-	1	1
Equetus lanceolatus	18	32	-	10	17	9	86
Fistularia sp.	-	-	-	1	-	-	1
Ginglymostoma cirratum	1	1	2	1	2	-	7
Gonioplectrus hispanus	-	-	-	-	2	-	2
Gymnothorax moringa	-	-	2	1	1	-	4
Gymnothorax sp.	-	-	-	-	1	-	1
Haemulon aurolineatum	166	1,166	1,282	425	955	383	4,377

Taxon	Inshore (<30 m) Number Collected			Offshore (30-150 m) Number Collected			Totals
	722	728	732	722	728	732	
Haemulon plumierii	-	2	5	-	-	1	8
Haemulon spp.	307	179	87	46	21	-	640
Haemulon striatum	-	-	-	-	8	-	8
Halichoeres bathyphilus	1	-	-	-	2	1	4
Halichoeres bivittatus	9	6	3	1	2	-	21
Halichoeres caudalis	-	2	3	-	-	-	5
Halichoeres garnoti	-	1	-	1	2	-	4
Halichoeres spp.	22	93	27	43	53	26	264
Heteroconger spp.	-	-	-	7	-	-	7
Holacanthus bermudensis	5	30	17	23	51	10	136
Holacanthus ciliaris	-	13	2	5	14	3	37
Holacanthus spp.	14	24	25	9	22	9	103
Holacanthus tricolor	-	-	-	-	1	-	1
Holocentridae	-	4	-	-	-	-	4
Holocentrus adscensionis	-	-	-	2	-	-	2
Holocentrus spp.	-	9	2	3	8	-	22
Labridae (Unknown)	-	1	-	-	-	-	1
Labridae (parrotfishes)	-	1	1	-	-	-	2
Labridae (wrasses)	1	1	-	2	2	-	6
Lachnolaimus maximus	-	2	-	-	2	2	6
Lagocephalus sp.	-	-	-	-	1	-	1
Lagodon rhomboides	-	13	7	-	-	-	20
Leiostomus xanthurus	-	2	-	-	-	-	2
Liopropoma eukrines	-	-	-	-	2	-	2
Lutjanidae	8	-	1	-	1	-	10
Lutjanus analis	-	-	-	4	4	-	8
Lutjanus campechanus	23	272	105	49	207	273	929
Lutjanus griseus	10	163	91	59	144	31	498
***Lutjanus* spp.**	2	4	4	5	5	3	23
Lutjanus synagris	-	53	24	-	5	21	103
Monacanthidae	-	2	-	-	1	-	3
Mullidae	-	-	6	-	-	14	20
Muraena retifera	-	-	-	-	-	1	1
Muraenidae	-	2	1	-	1	-	4
Mycteroperca bonaci	-	1	-	-	-	-	1
Mycteroperca microlepis	-	3	-	3	1	5	12
Mycteroperca phenax	-	2	2	-	3	5	12

Taxon	Inshore (<30 m) Number Collected			Offshore (30-150 m) Number Collected			Totals
	722	728	732	722	728	732	
Mycteroperca sp.	1	-	-	-	-	-	1
Myripristis jacobus	-	1	-	-	8	-	9
Ocyurus chrysurus	-	-	2	-	2	4	8
Ogcocephalidae	-	-	1	-	-	-	1
Ophichthus puncticeps	-	-	-	-	1	-	1
Opistognathidae	-	-	-	-	-	1	1
Opistognathidae (light)	-	5	-	3	6	2	16
Opistognathus aurifrons	-	-	-	-	-	1	1
Opsanus sp.	-	-	1	-	-	-	1
Orthopristis chrysoptera	-	1	29	-	-	-	30
Ostraciidae	-	-	-	-	2	-	2
Pagrus pagrus	-	-	2	35	26	9	72
Panulirus spp.	-	-	1	-	1	-	2
Pareques spp.	1	28	8	-	60	11	108
Pareques umbrosus	-	-	-	-	1	-	1
Pleuronectiformes	-	1	1	5	1	-	8
Pomacanthidae	-	6	-	-	-	-	6
Pomacanthus arcuatus	1	2	2	-	-	-	5
Pomacanthus paru	-	-	2	6	-	-	8
Pomacanthus spp.	-	3	-	1	1	4	9
Pomacentridae	5	30	18	15	32	2	102
Pristigenys alta	-	-	-	1	-	-	1
Prognathodes aya	-	-	-	-	1	-	1
Pseudupeneus maculatus	-	5	3	7	-	1	16
Ptereleotris spp.	-	10	-	5	1	-	16
***Pterois* spp.**	6	25	6	7	63	5	112
Rachycentron canadum	1	-	1	-	1	4	7
Rhinobatos lentiginosus	-	2	-	1	-	-	3
Rhinoptera bonasus	-	-	60	-	-	-	60
Rhomboplites aurorubens	507	580	209	633	1,289	342	3,560
Rypticus maculatus	2	7	1	-	1	-	11
Rypticus spp.	-	3	-	-	1	2	6
Sciaenidae	-	-	1	-	-	-	1
Scomberomorus spp.	2	1	-	-	-	6	9
Scombridae (mackerels)	3	43	3	2	1	-	52
Scombridae (tunas)	-	6	-	-	-	-	6
Seriola dumerili	11	40	13	17	125	24	230

Taxon	Inshore (<30 m) Number Collected			Offshore (30-150 m) Number Collected			Totals
	722	728	732	722	728	732	
Seriola fasciata	-	-	-	-	-	2	2
Seriola rivoliana	38	27	1	91	85	13	255
Seriola spp.	2	6	7	9	22	11	57
Seriola zonata	-	2	-	72	37	2	113
Serranidae	-	1	-	-	-	-	1
Serranus annularis	-	-	-	-	1	-	1
Serranus baldwini	-	-	-	3	3	-	6
Serranus phoebe	-	-	2	2	8	16	28
Serranus subligarius	3	9	9	-	-	2	23
Sphoeroides spengleri	7	8	1	1	3	1	21
Sphoeroides sp.	-	-	1	-	-	-	1
Sphyraena barracuda	5	4	4	6	6	-	25
Sphyraena spp.	-	-	1	1	-	-	2
Sphyraenidae	1	-	-	-	-	-	1
Sphyrna mokarran	-	-	-	-	-	1	1
Stegastes partitus	-	-	-	-	2	-	2
Stegastes spp.	3	18	2	3	6	-	32
Stegastes variabilis	-	-	-	-	1	-	1
Stenotomus caprinus	-	6	2	-	-	-	8
Stenotomus spp.	-	12	-	-	-	-	12
Tetraodontidae	-	-	1	-	-	1	2
Thalassoma bifasciatum	1	2	7	-	2	-	12
Unidentified baitfish	478	2,258	1,907	598	1,258	634	7,133
Total Observed	**2,984**	**7,564**	**6,556**	**2,595**	**5,695**	**2,291**	**27,685**

Table 7. Summary of the total number of stereo-video measurements, by species, from FWC SIS video surveys associated with Chevron traps (Trap Cameras), repetitive timed-drop hooked-gear surveys (RTD Cameras), and Captain's Choice hooked-gear surveys (CC Cameras), respectively. Taxa in **bold** are managed species. Taxa are arranged alphabetically.

Taxon	Trap Cameras	RTD Cameras	CC Cameras	Total
Alectis ciliaris	0	0	2	2
Aluterus monoceros	17	26	39	82
Aluterus schoepfii	1	1	2	4
Anisotremus surinamensis	1	3	1	5
Anisotremus virginicus	14	20	24	58
Archosargus probatocephalus	21	32	33	86
Aulostomus maculatus	0	0	1	1
Balistes capriscus	114	74	86	274
Balistes vetula	1	0	1	2
Calamus bajonado	0	1	1	2
Calamus proridens	2	1	1	4
Caranx bartholomaei	5	9	14	28
Caranx crysos	108	128	77	313
Caranx hippos	0	0	2	2
Caranx ruber	7	0	6	13
Carcharhinus acronotus	0	1	0	1
Carcharhinus falciformis	2	0	0	2
Carcharhinus plumbeus	0	1	3	4
Centropomus undecimalis	0	1	0	1
Centropristis striata	24	45	53	122
Cephalopholis cruentata	0	1	7	8
Chaetodipterus faber	18	37	31	86
Elagatis bipinnulata	2	1	8	11
Epinephelus itajara	0	1	0	1
Epinephelus morio	1	0	0	1
Ginglymostoma cirratum	0	2	1	3
Gonioplectrus hispanus	1	0	0	1
Haemulon plumierii	0	4	2	6
Lachnolaimus maximus	4	0	1	5
Leiostomus xanthurus	0	2	0	2
Lutjanus analis	4	2	0	6
Lutjanus campechanus	157	138	162	457
Lutjanus griseus	94	90	99	283

Taxon	Trap Cameras	RTD Cameras	CC Cameras	Total
Lutjanus synagris	26	19	22	67
Mycteroperca bonaci	0	0	1	1
Mycteroperca microlepis	4	0	1	5
Mycteroperca phenax	4	2	4	10
Ocyurus chrysurus	3	1	3	7
Pagrus pagrus	24	9	16	49
***Pterois* spp.**	9	4	17	30
Rachycentron canadum	1	1	4	6
Rhinobatos lentiginosus	1	0	0	1
Rhomboplites aurorubens	273	196	349	818
Seriola dumerili	46	29	52	127
Seriola fasciata	0	1	0	1
Seriola rivoliana	44	43	90	177
Seriola zonata	15	4	44	63
Sphyraena barracuda	6	8	6	20
Total Measured Fish	**1054**	**938**	**1266**	**3258**

Table 8. Summary of biological specimens retained for demographic analysis by gear type during FWC Chevron trap and hooked-gear surveys along the Atlantic coast of Florida (2016). Data have been aggregated over all three NMFS statistical zones. Taxa are arranged alphabetically.

Species	**Gear Type**			**Totals**
	Chevron	**RTD**	**Captain's Choice**	
Balistes capriscus	32	8	9	49
Centropristis striata	112	52	67	231
Epinephelus drummondhayi	-	1	-	1
Lutjanus analis	-	2	-	2
Lutjanus campechanus	96	118	98	312
Lutjanus griseus	-	4	2	6
Lutjanus synagris	1	1	-	2
Mycteroperca microlepis	-	1	1	2
Mycteroperca phenax	-	1	-	1
Ocyurus chrysurus	-	-	1	1
Pagrus pagrus	1	4	4	9
Rachycentron canadum	-	1	-	1
Rhomboplites aurorubens	8	18	43	69
Scomberomorus cavalla	-	1	-	1
Seriola dumerili	-	6	4	10
Totals	**250**	**218**	**229**	**697**

Table 9. Summary of fish length (mm) and total mercury concentrations (mg/kg) for Red Snapper (n=163) collected during FWC Chevron trap and hooked-gear surveys along the Atlantic coast of Florida (2016).

Length Statistic	Fork Length (mm)	Total Mercury (mg/kg)
Mean	445	0.153
Median	399	0.104
Std. Dev.	169	0.152
Minimum	212	0.037
Maximum	831	0.889

Table 10. Summary of fish length (mm) and total mercury concentrations (mg/kg) for Black Sea Bass (n=109) collected during FWC Chevron trap and hooked-gear surveys along the Atlantic coast of Florida (2016).

Length Statistic	Fork Length (mm)	Total Mercury (mg/kg)
Mean	267	0.158
Median	259	0.144
Std. Dev.	60	0.068
Minimum	151	0.039
Maximum	412	0.455

Table 11. Summary of fish length (mm) and total mercury concentrations (mg/kg) for Vermilion Snapper (n=68) collected during FWC Chevron trap and hooked-gear surveys along the Atlantic coast of Florida (2016).

Length Statistic	Fork Length (mm)	Total Mercury (mg/kg)
Mean	292	0.058
Median	301	0.056
Std. Dev.	44	0.020
Minimum	196	0.028
Maximum	372	0.116

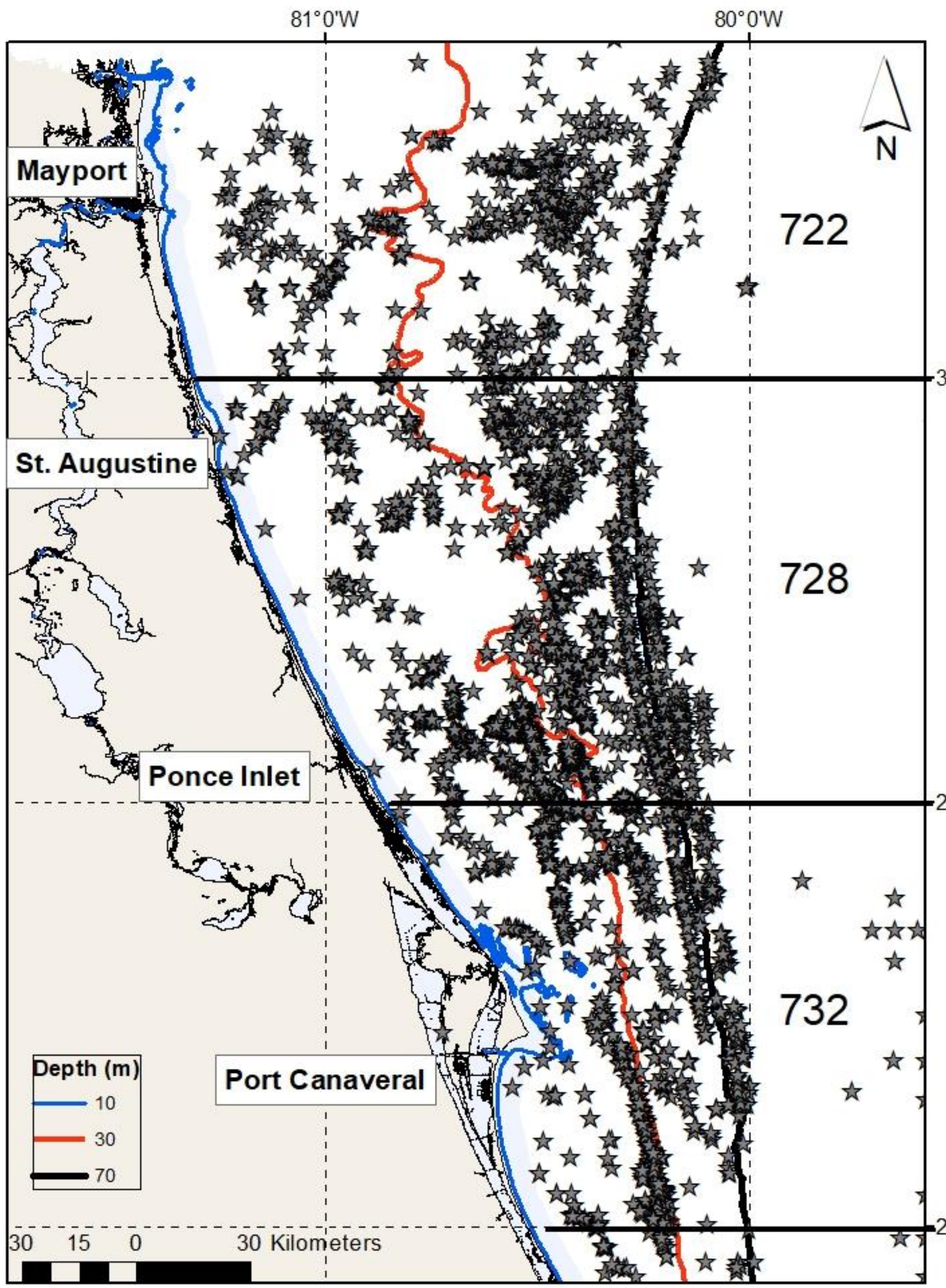

Figure 1. Study area (sampling bounded by 28° 00'N and 30° 45'N) for FWC Chevron trap and hooked-gear (RTD and Captain's Choice) surveys along the Atlantic coast of Florida (2016), including NMFS statistical zones 722, 728 and 732. The colored lines represent the 10 m (blue), 30 m (red), and 70 m (black) isobaths. Stars represent hardbottom sites in the FWC sampling universe.

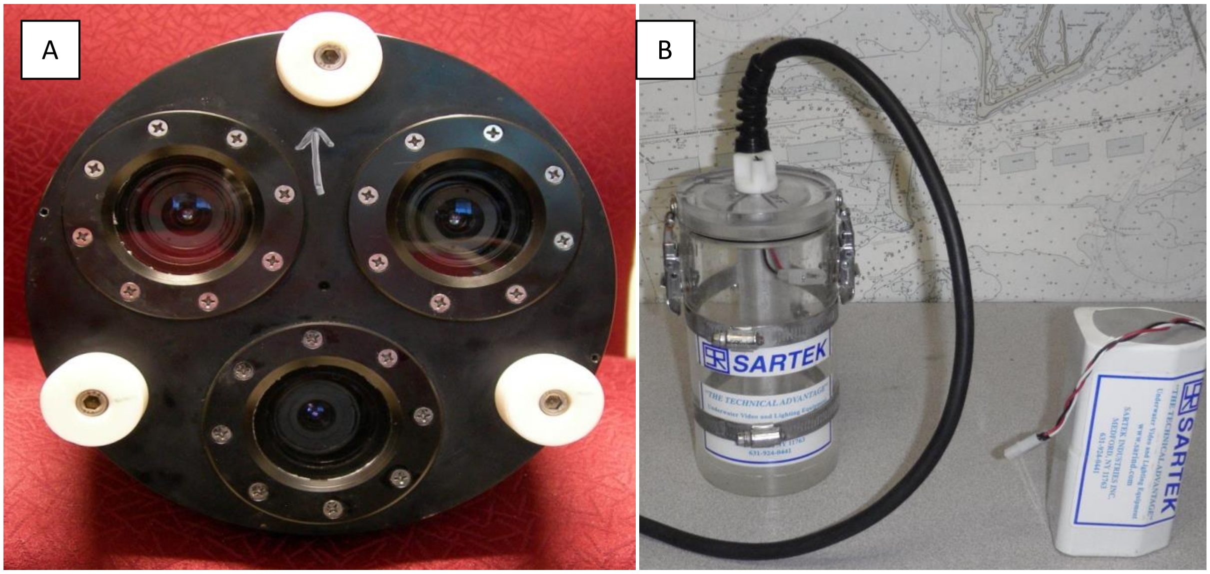

Figure 2. (A) Lens end of a stereo imaging system (SIS) unit and (B) battery housing and battery used during FWC video surveys along the Atlantic coast of Florida (2016).

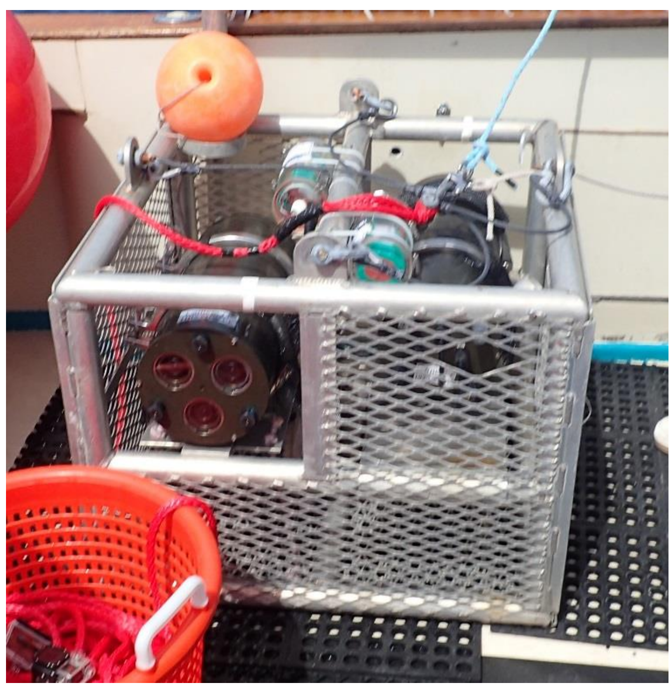

Figure 3. Stationary underwater camera array (SUCA) used to deploy stereo imaging system (SIS) units during FWC video surveys along the Atlantic coast of Florida (2016).

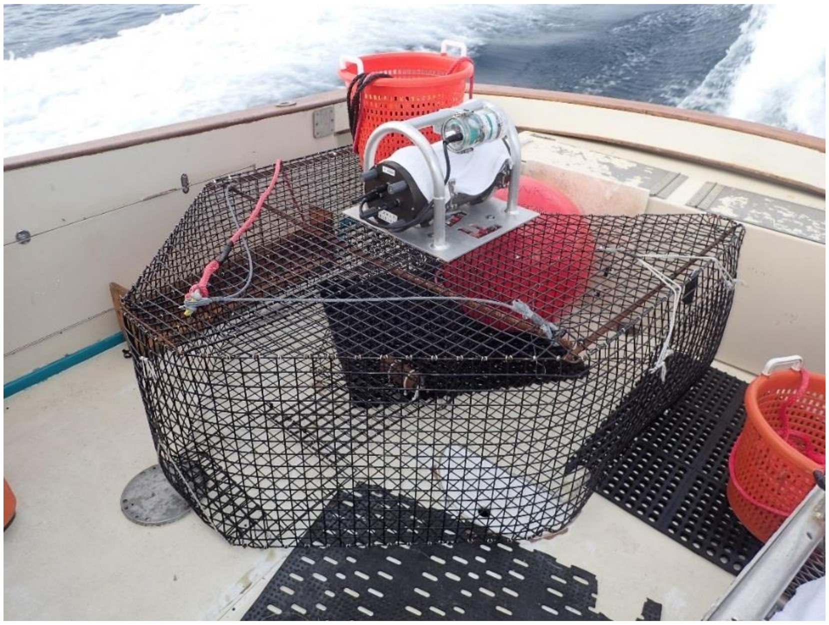

Figure 4. Photo of Chevron trap with attached stereo imaging system (SIS) unit used during FWC Chevron trap surveys along the Atlantic coast of Florida (2016).

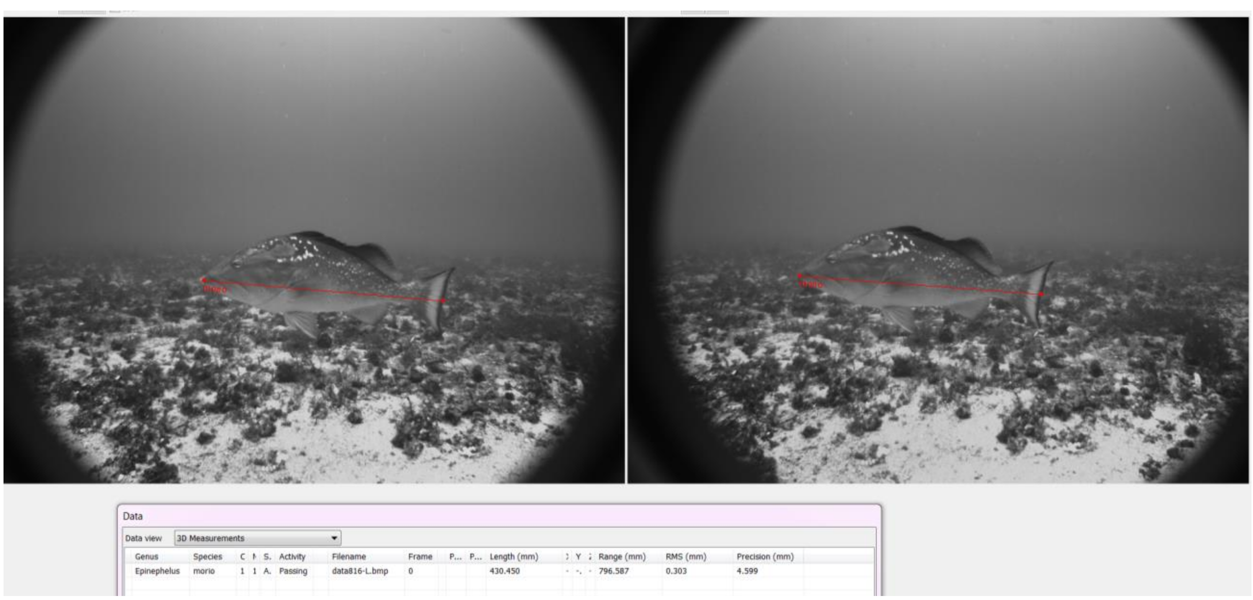

Figure 5. Screen shot example of individual fish observed on stereo imaging system (SIS) units used during FWC video surveys along the Atlantic coast of Florida (2016). Fish were measured to the nearest mm fork length (FL) using still images and SeaGIS® software.

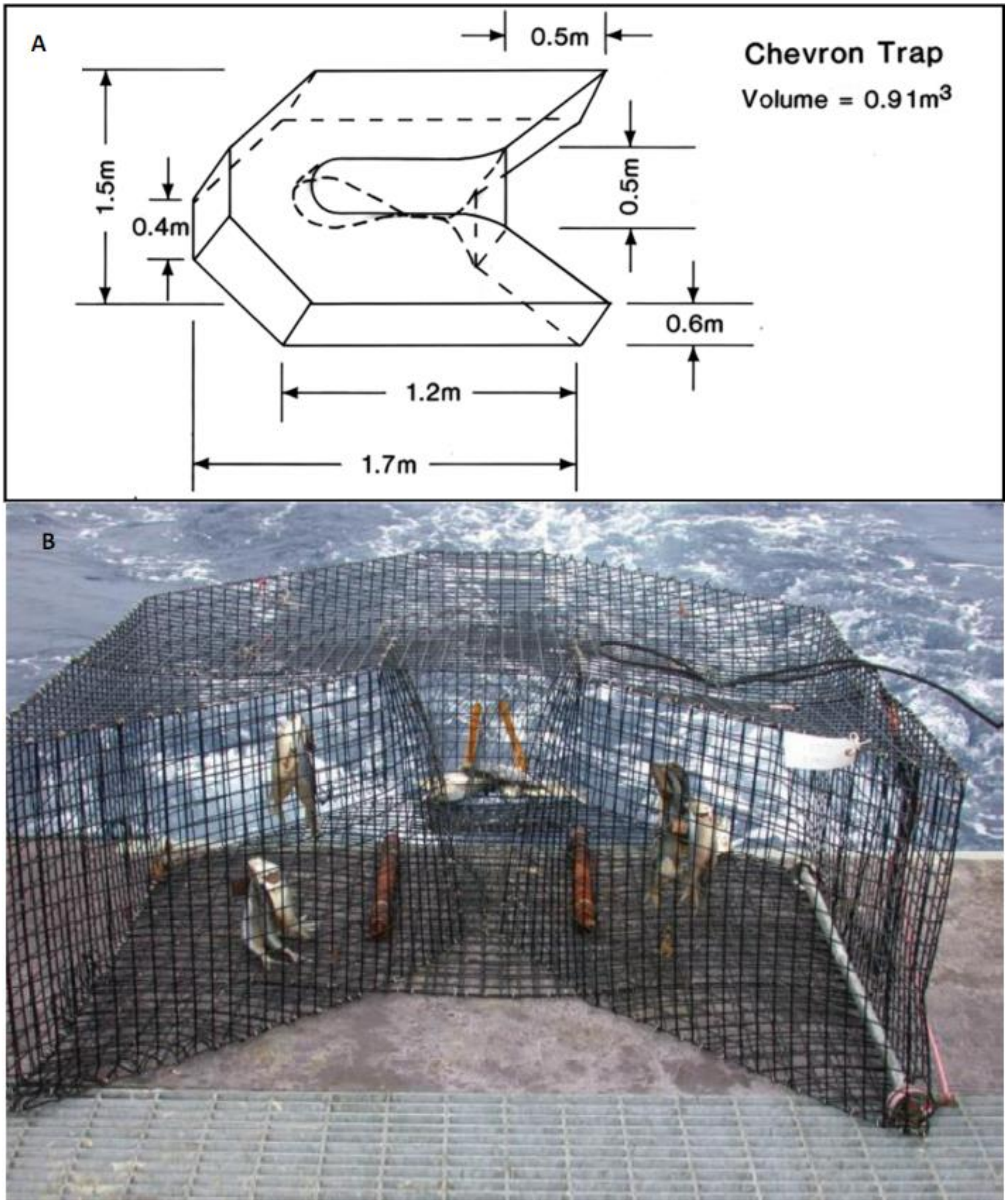

Figure 6. Chevron traps used in SERFS surveys for monitoring reef fish. (A) Diagram of Chevron trap with dimensions. (B) Chevron trap ready for deployment baited with clupeids. Iron sashes attached to the bottom weigh the trap down and help maintain the proper orientation of the trap on the bottom. Images and figure text taken from Ballenger et al. (2014).

Figure 7. Electric reel (Elec-tra-Mate© model 920xp) equipped with a Penn 9/0 Senator reel used during FWC fisheries-independent hooked-gear (RTD) surveys along the Atlantic coast of Florida (2016).

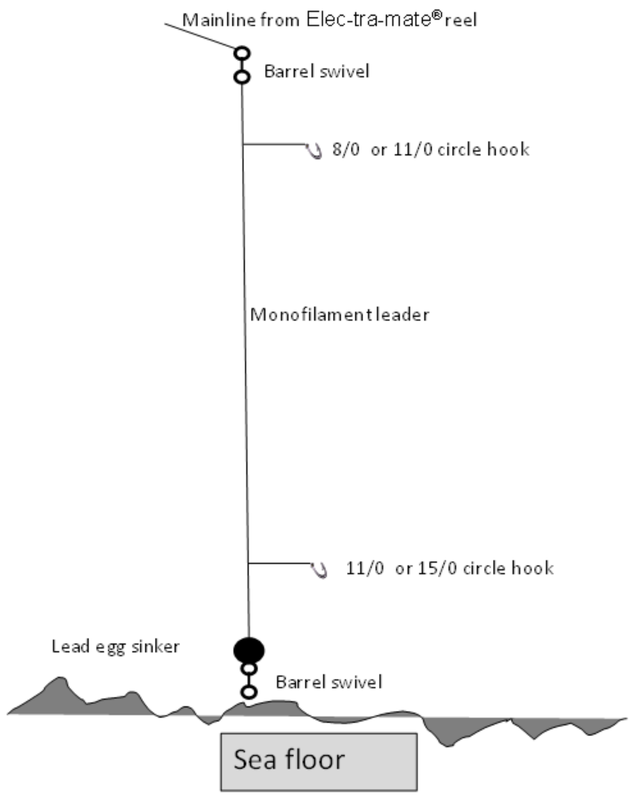

Figure 8. Diagram of terminal tackle, double-hook "chicken rig" used during FWC fisheries-independent hooked-gear (RTD) surveys along the Atlantic coast of Florida (2016).

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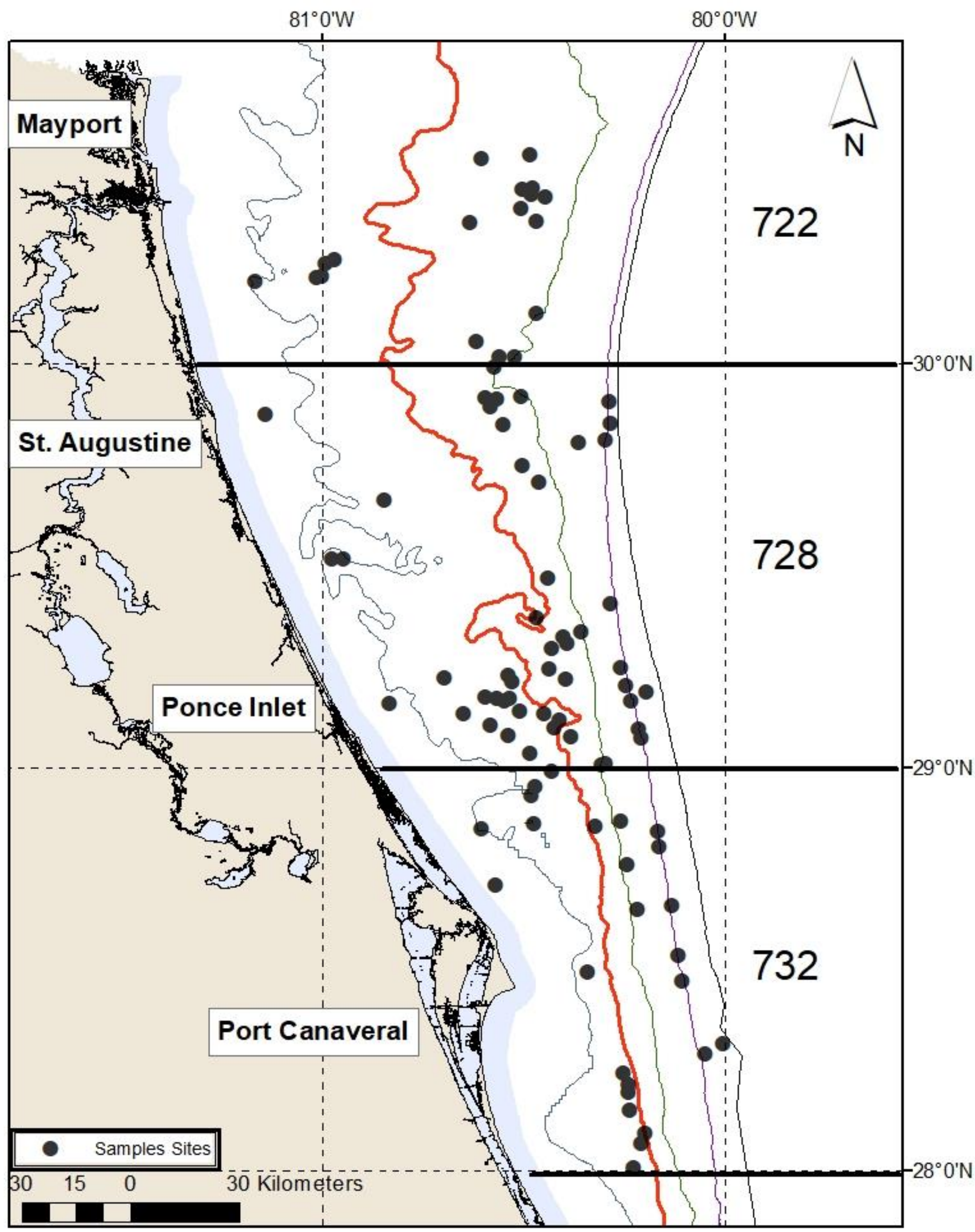


Figure 9. Study area (sampling bounded by 28º 00'N and 30º 45'N) for FWC Chevron trap and hooked-gear (RTD and Captain's Choice) surveys along the Atlantic coast of Florida (2016), including NMFS statistical zones 722, 728 and 732. Black circles represent the location of sampled stations (n=93). The colored lines represent the 10 m (blue), 30 m (red), and 70 m (black) isobaths.

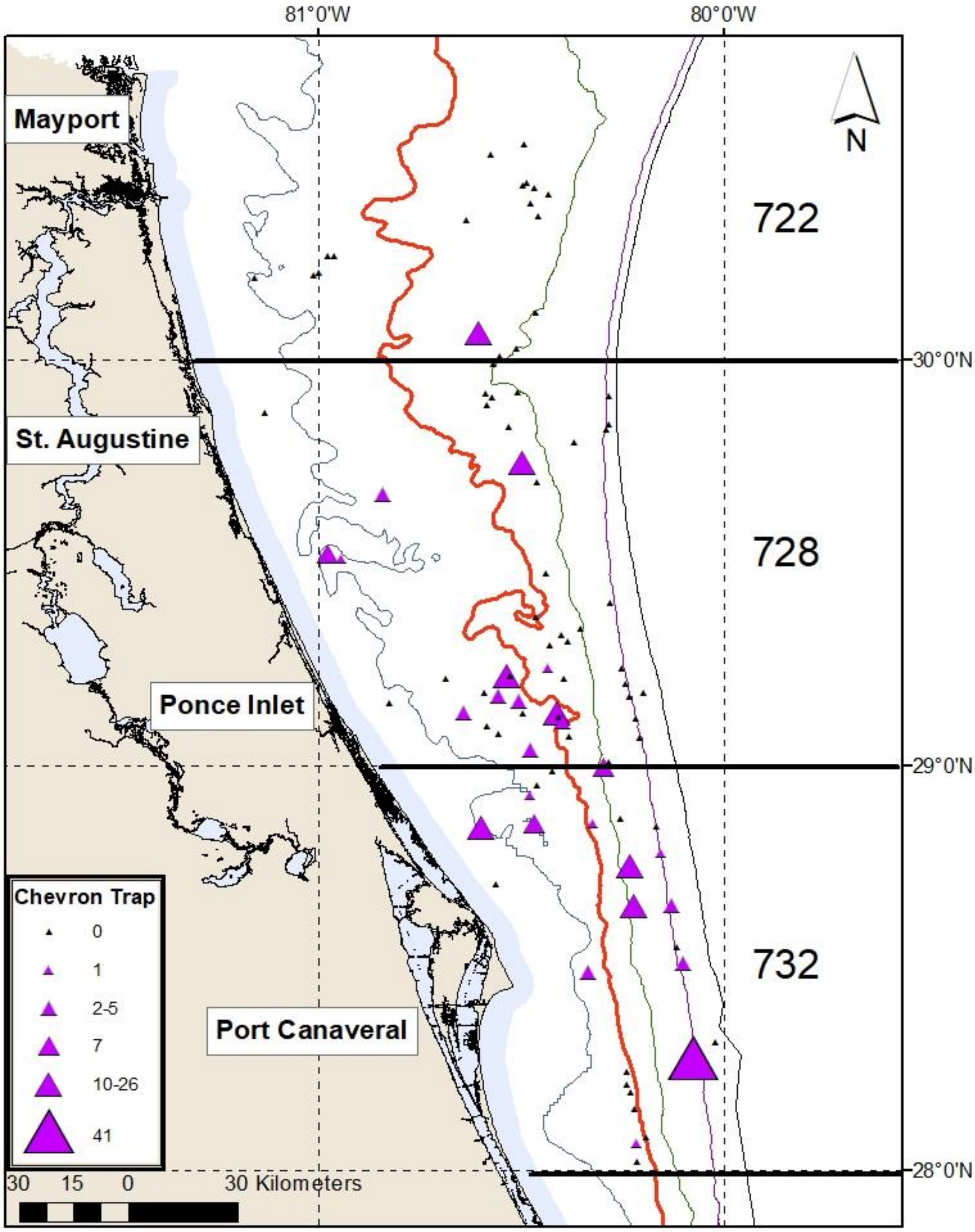


Figure 10. Bubble plot showing locations of Red Snapper collected during FWC Chevron trap surveys along the Atlantic coast of Florida (2016). Number of Red Snapper collected at each site correspond to the size of the triangle as given in the legend. Small black triangles represent sampled sites where no Red Snapper were collected.

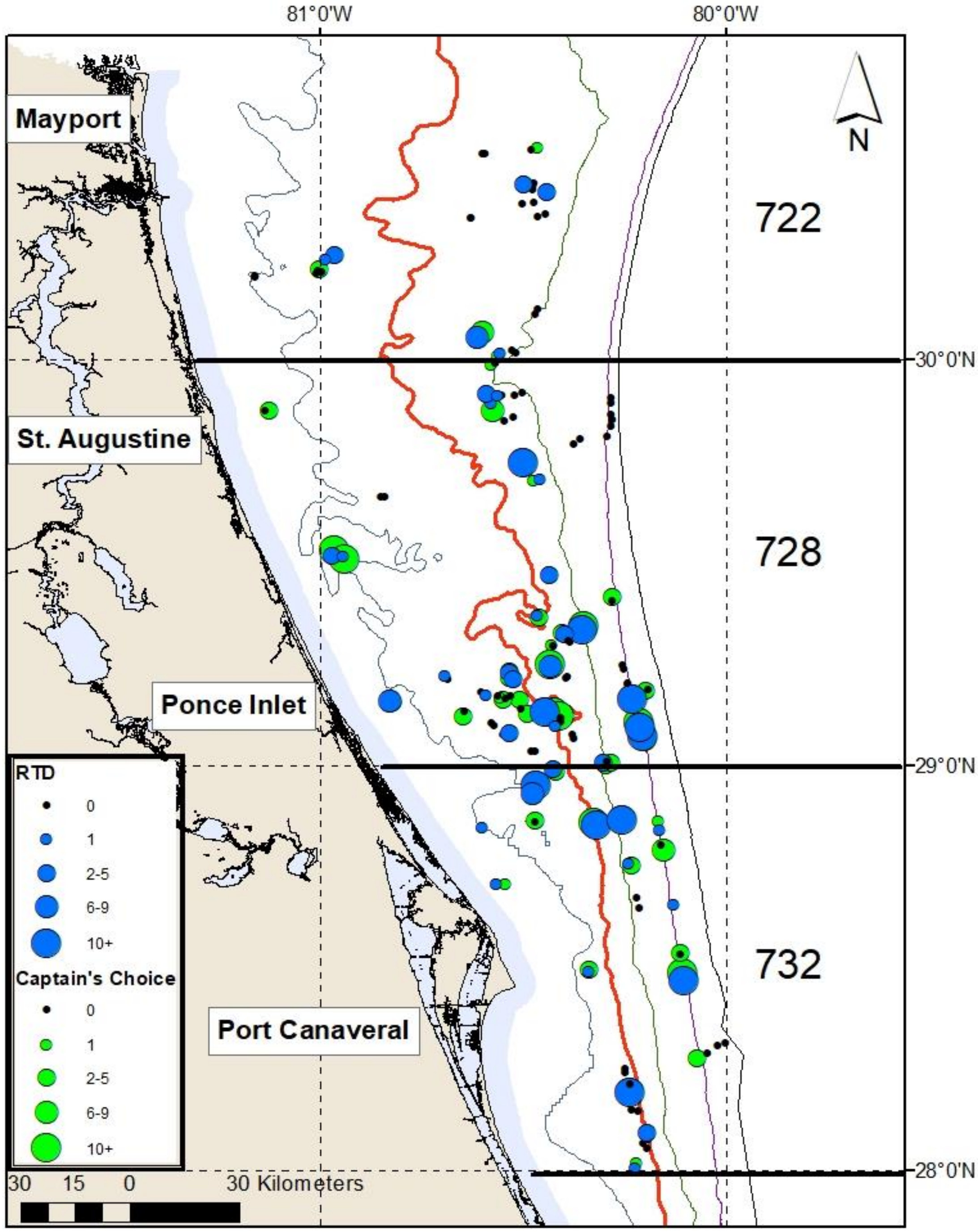


Figure 11. Bubble plot showing locations of Red Snapper collected during FWC hooked-gear surveys (RTD and Captain's Choice) along the Atlantic coast of Florida (2016). Number of Red Snapper collected at each site correspond to the size of the circle (RTD=blue, Captain's Choice=green) as given in the legend. Small black circles represent sampled sites where no Red Snapper were collected.

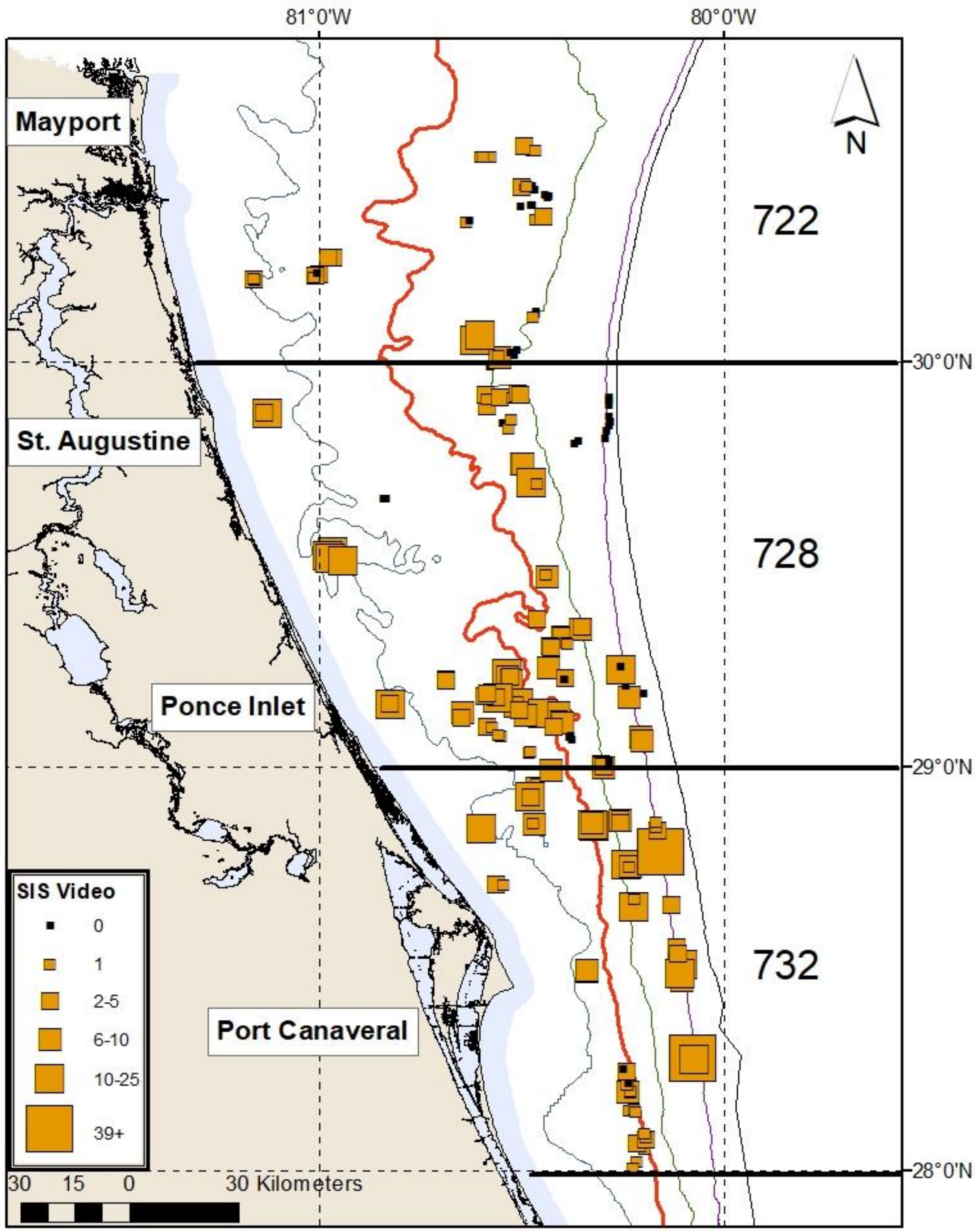


Figure 12. Bubble plot showing locations of Red Snapper observed during FWC video surveys along the Atlantic coast of Florida (2016). Number of Red Snapper observed at each site (MaxN) correspond to the size of the square as given in the legend. Small black squares represent sampled sites where no Red Snapper were observed.

Figure 13. Non-metric multidimensional scaling plot of community structure comparing data collected by A) Repetitive Timed-Drop (RTD), Captain's Choice (CC), and Chevron Trap (V) gear and B) cameras associated with each gear type. Each point represents averaged catch-per-unit-effort (CPUE) per trip (Sqrt Total fish count).

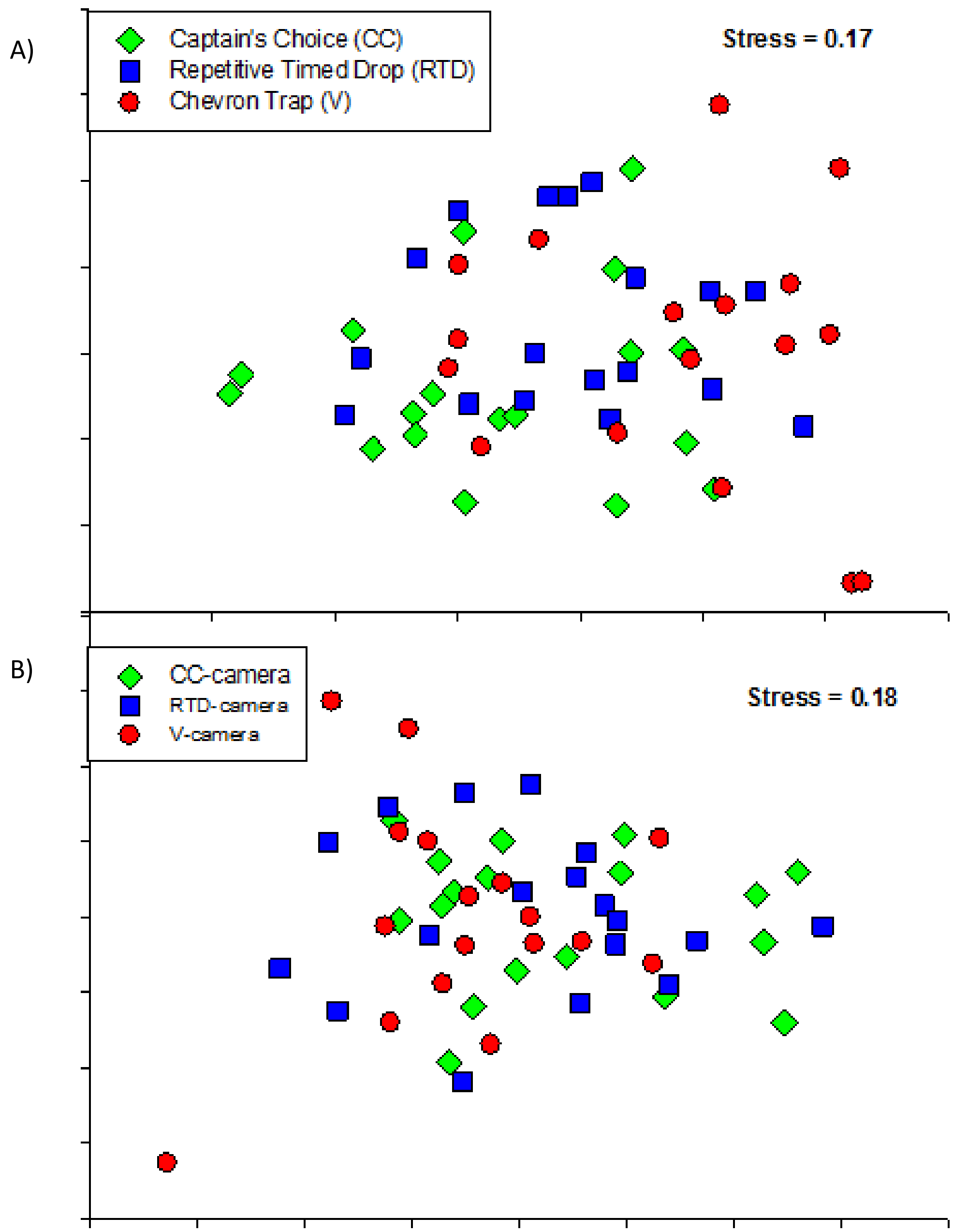


Figure 14. Non-metric multidimensional scaling plot of community structure for data comparing A) Repetitive Timed-Drop (RTD) v Repetitive Timed-Drop-camera (RTD-camera), B) Captain's Choice (CC) v Captain's Choice-camera (CC-camera), and C) Chevron Trap (V) v Chevron Trap-camera (V-camera). Each point represents averaged catch-per-unit-effort (CPUE) per trip (Sqrt Total fish count).

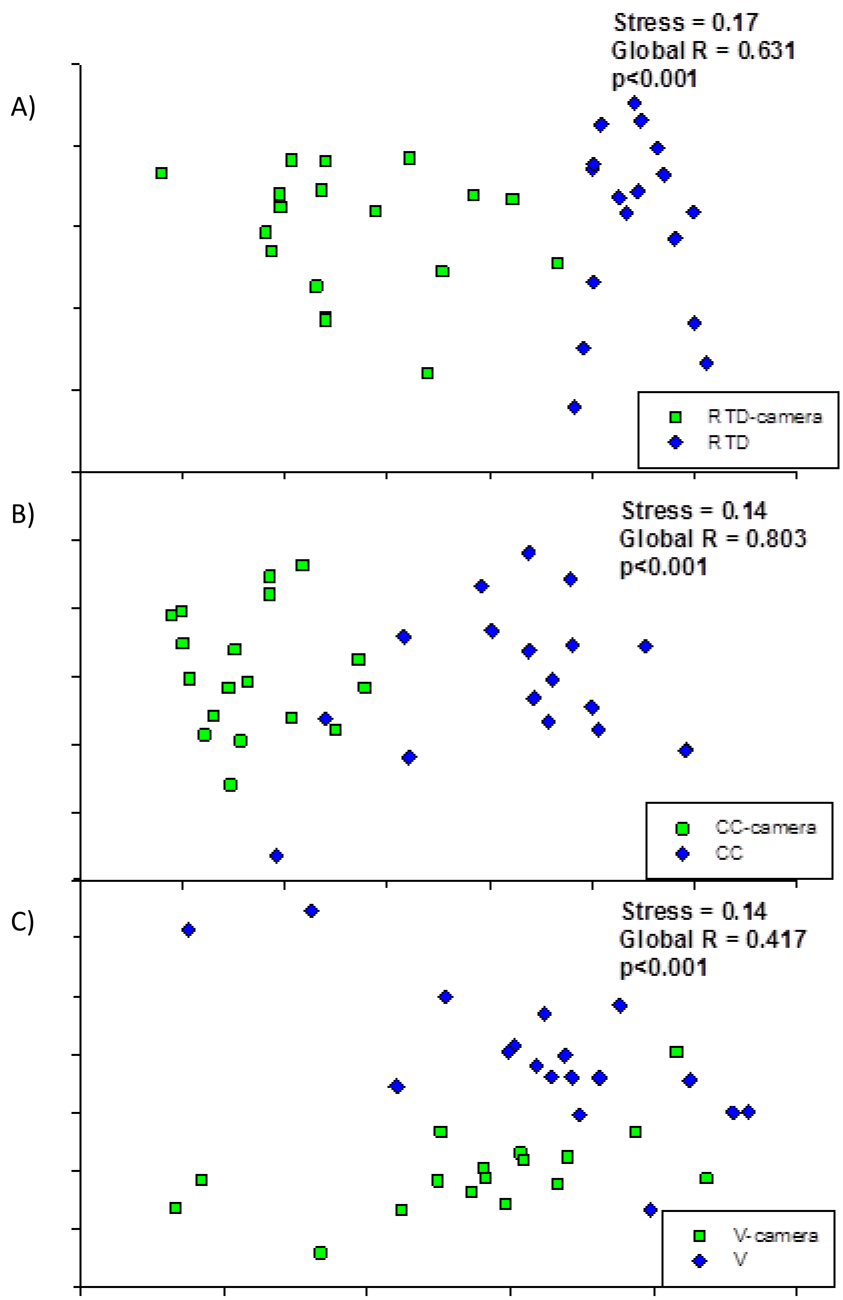


Figure 15. Summary of the square-root transformed catch-per-unit-effort (CPUE) of taxa identified by SIMPER as contributing to observed differences in assemblage structure between Captain's Choice (CC) and Captain's Choice-camera (CC-camera).

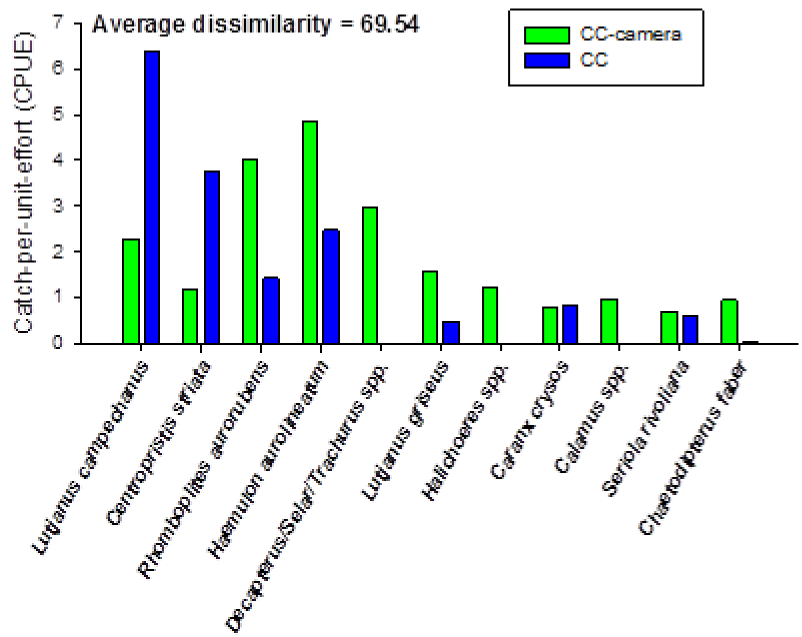


Figure 16. Summary of the square-root transformed catch-per-unit-effort (CPUE) of taxa identified by SIMPER as contributing to observed differences in assemblage structure between Repetitive Timed-Drop (RTD) and Repetitive Timed-Drop-camera (RTD-camera).

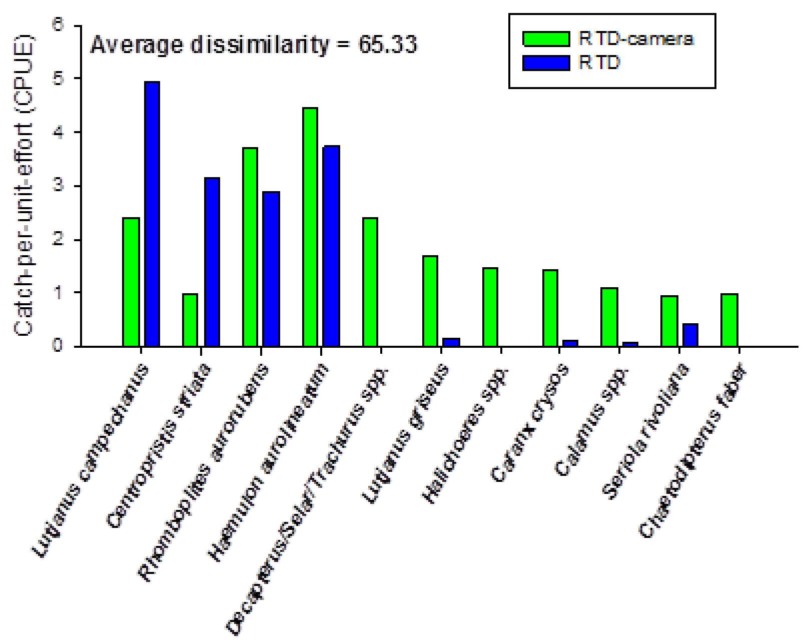


Figure 17. Summary of the square-root transformed catch-per-unit-effort (CPUE) of taxa identified by SIMPER as contributing to observed differences in assemblage structure between Chevron Trap (V) and Chevron Trap-camera (V-camera).

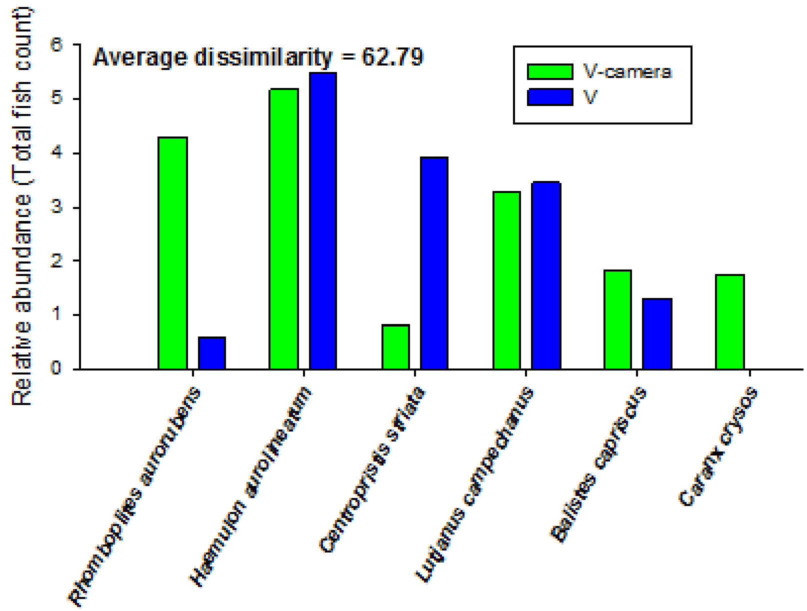


Figure 18. Comparison of catch-per-unit-effort (Sqrt Total Fish count) of Red Snapper, *Lutjanus campechanus* between Repetitive Timed-Drop (RTD), Captain's Choice (CC), and Chevron Trap (V) gear. Significant differences are indicated by differing letters.

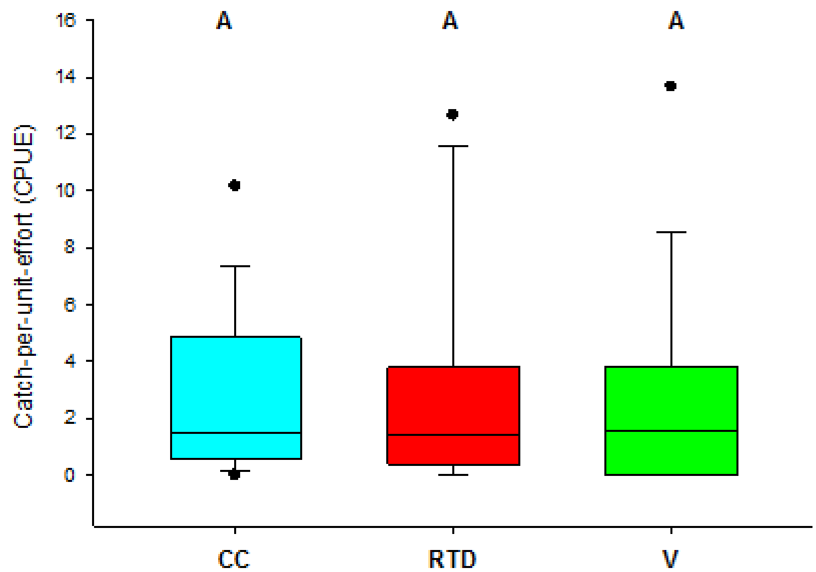


Figure 19. Comparison of catch-per-unit-effort (Sqrt Total Fish count) of Red Snapper, *Lutjanus campechanus* between Repetitive Timed-Drop-camera (RTD-camera), Captain's Choice-camera (CC-camera), and Chevron Trap-camera (V-camera). Significant differences are indicated by differing letters.

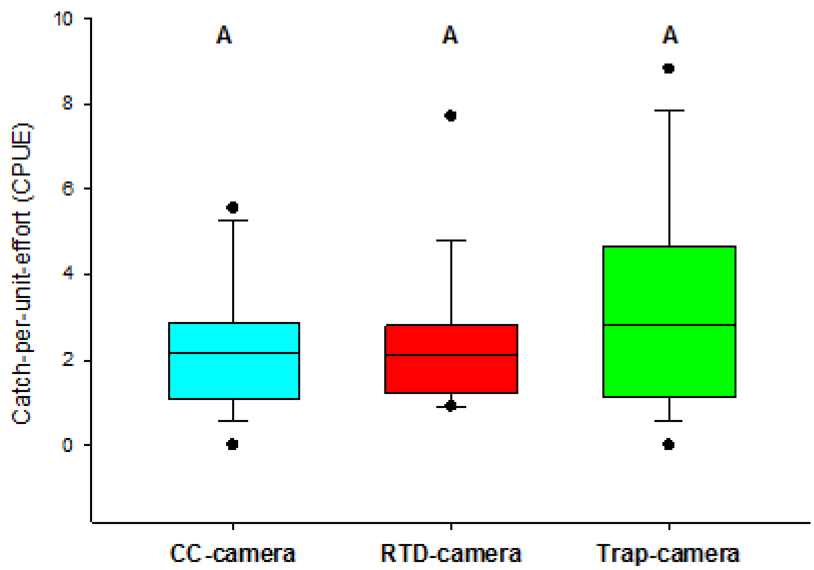


Figure 20. Comparison of catch-per-unit-effort (Sqrt Total Fish count) of Black Sea Bass, *Centropristis striata* between Repetitive Timed-Drop (RTD), Captain's Choice (CC), and Chevron Trap (V) gear. Significant differences are indicated by differing letters.

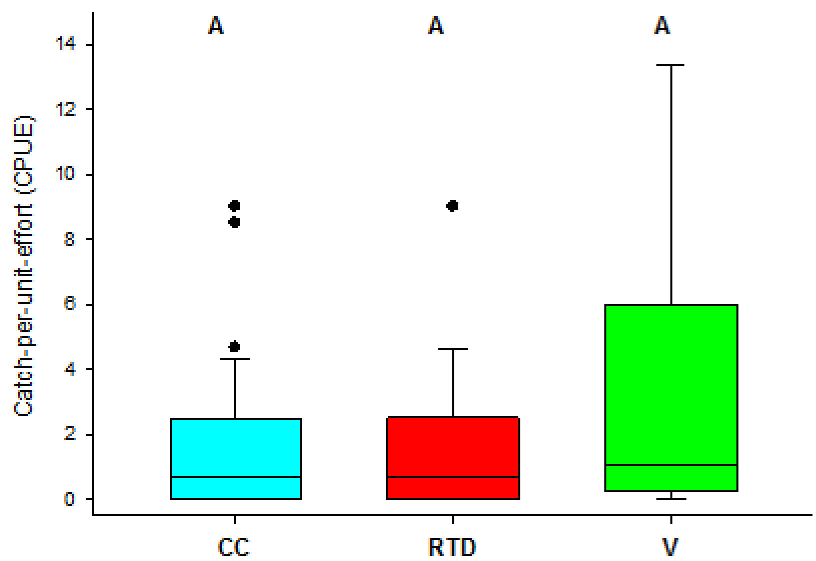


Figure 21. Comparison of catch-per-unit-effort (Sqrt Total Fish count) of Black Sea Bass, *Centropristis striata* between Repetitive Timed-Drop-camera (RTD-camera), Captain's Choice-camera (CC-camera), and Chevron Trap-camera (V-camera). Significant differences are indicated by differing letters.

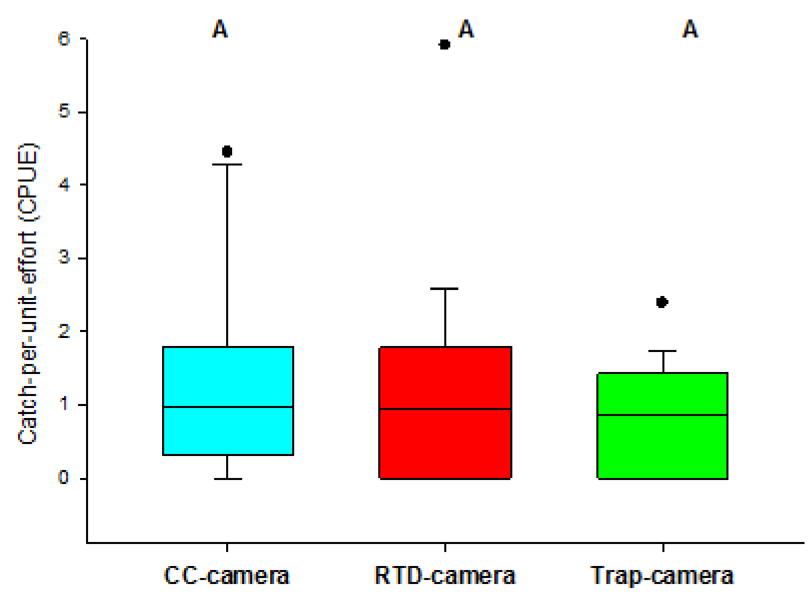


Figure 22. Comparison of catch-per-unit-effort (Sqrt Total Fish count) of Vermilion Snapper, *Rhomboplites aurorubens* between Repetitive Timed-Drop (RTD), Captain's Choice (CC), and Chevron Trap (V) gear. Significant differences are indicated by differing letters.

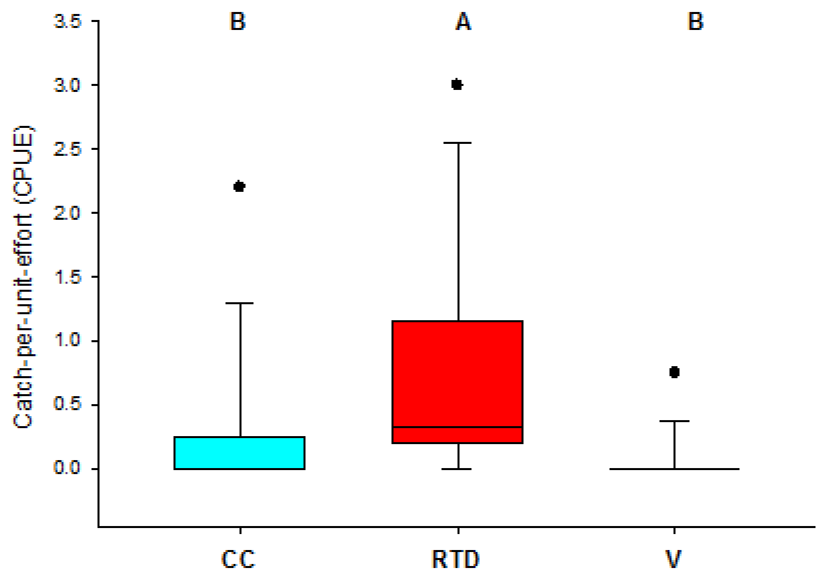


Figure 23. Comparison of catch-per-unit-effort (Sqrt Total Fish count) of Vermilion Snapper, *Rhomboplites aurorubens* between Repetitive Timed-Drop-camera (RTD-camera), Captain's Choice-camera (CC-camera), and Chevron Trap-camera (V-camera). Significant differences are indicated by differing letters.

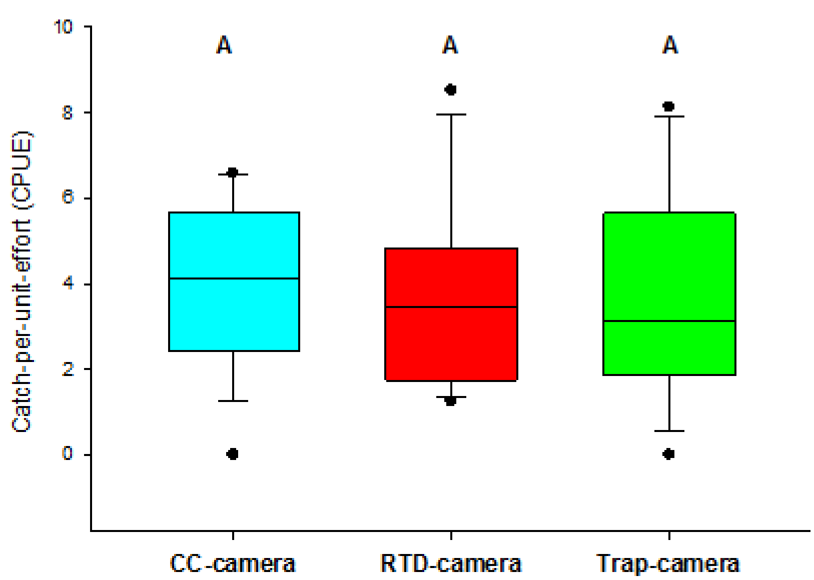


Figure 24. Comparison of catch-per-unit-effort of Red Snapper for Repetitive Timed-Drop (RTD) v RTD-camera, Captain's Choice (CC) v CC-camera, and Chevron Trap (V) v V-camera.

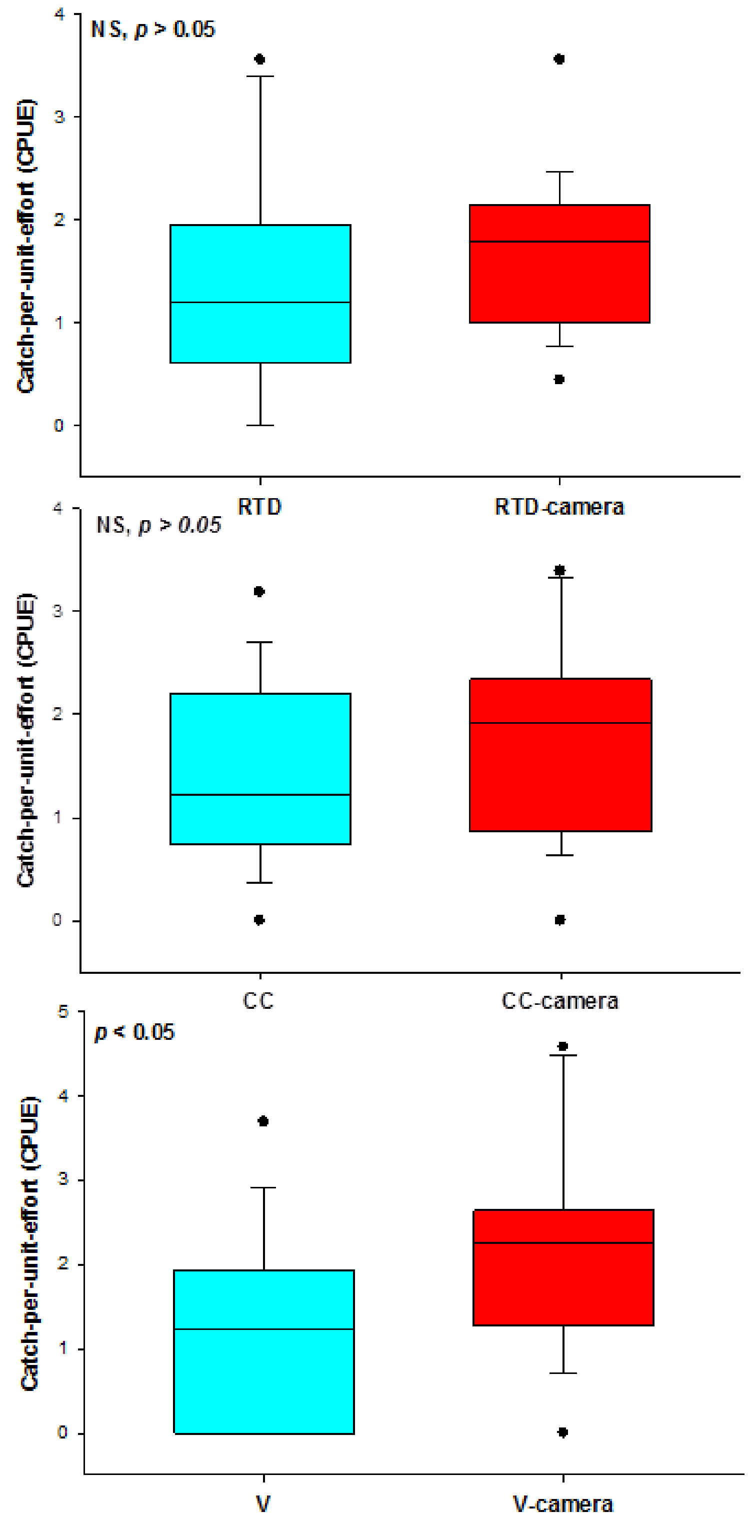


Figure 25. Comparison of catch-per-unit-effort of Black Sea Bass for Repetitive Timed-Drop (RTD) v RTD-camera, Captain's Choice (CC) v CC-camera, and Chevron Trap (V) v V-camera.

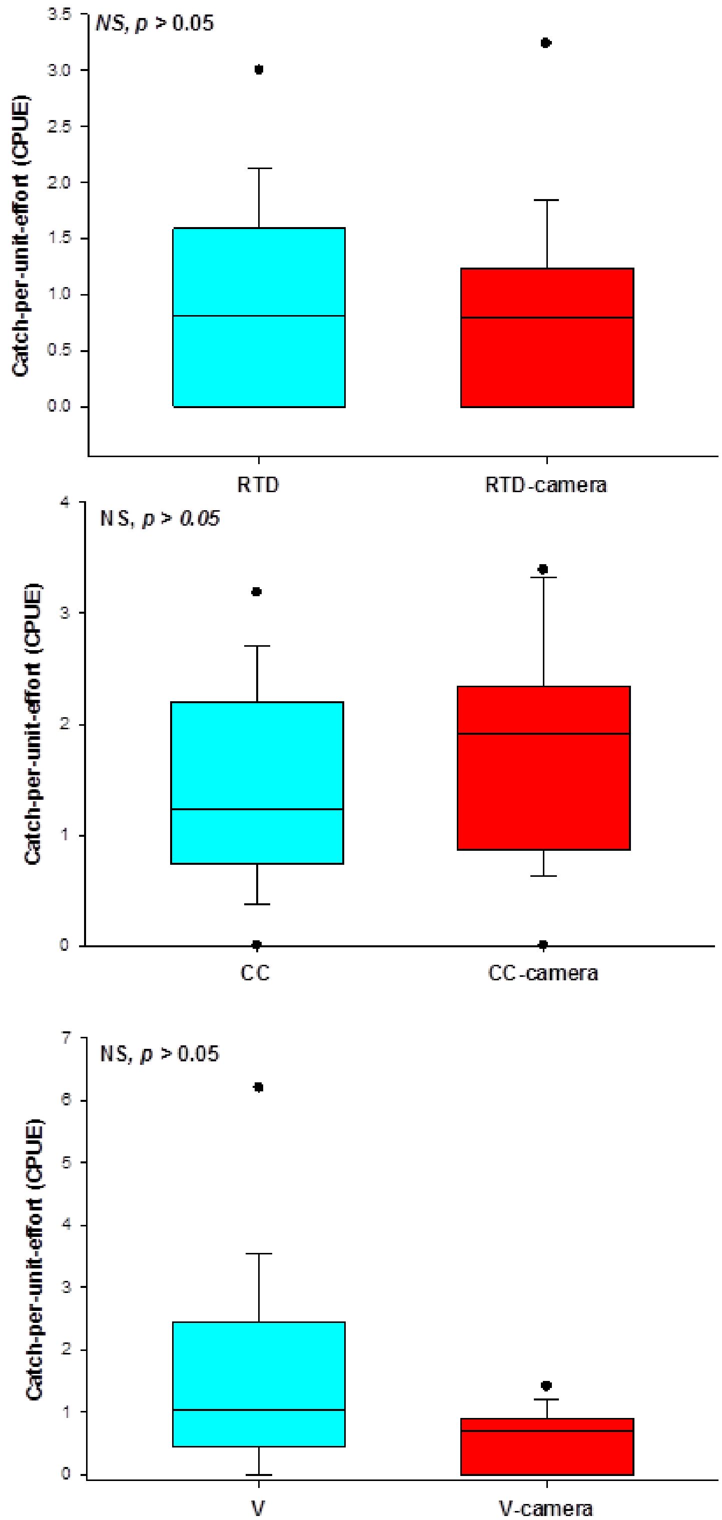
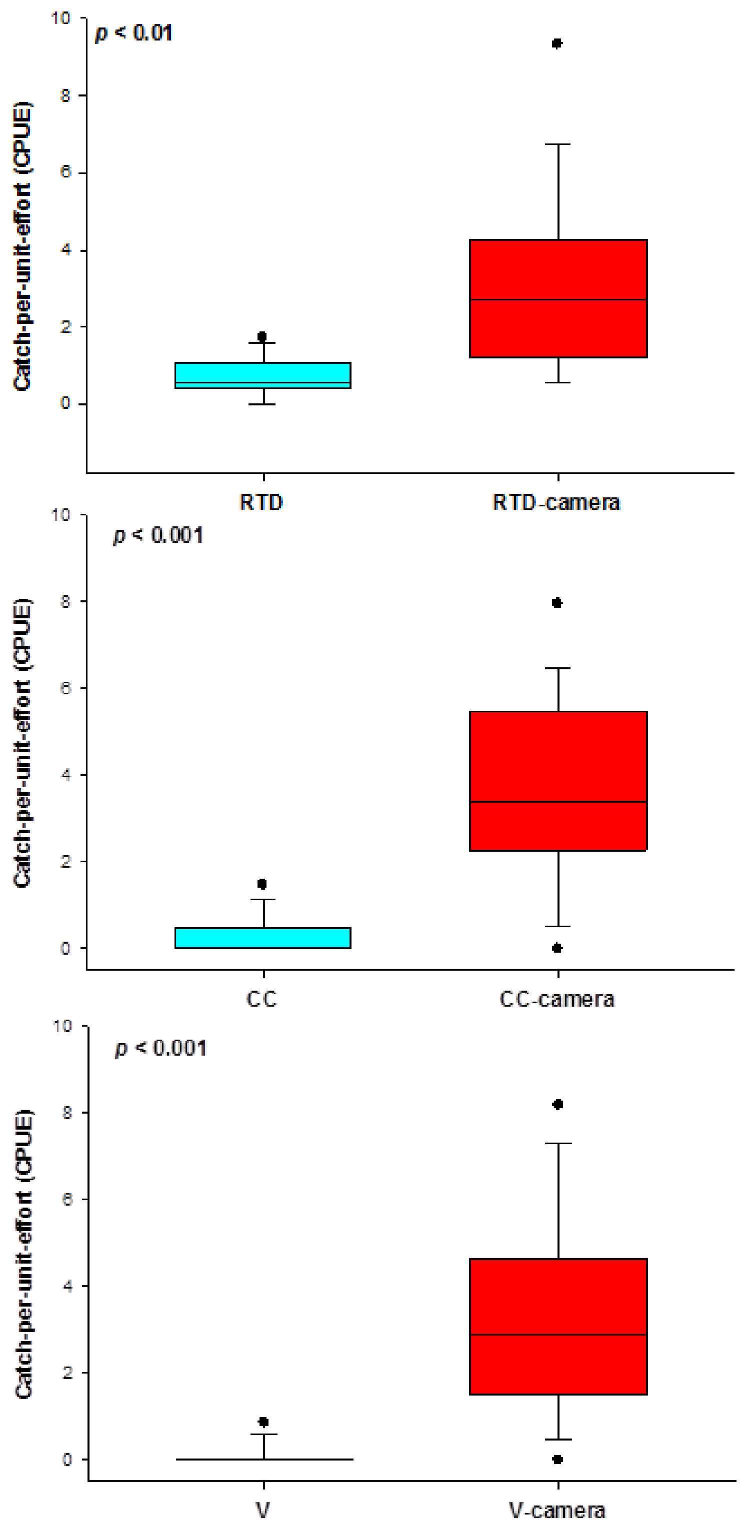


Figure 26. Comparison of catch-per-unit-effort of Vermilion Snapper for Repetitive Timed-Drop (RTD) v RTD-camera, Captain's Choice (CC) v CC-camera, and Chevron Trap (V) v V-camera.



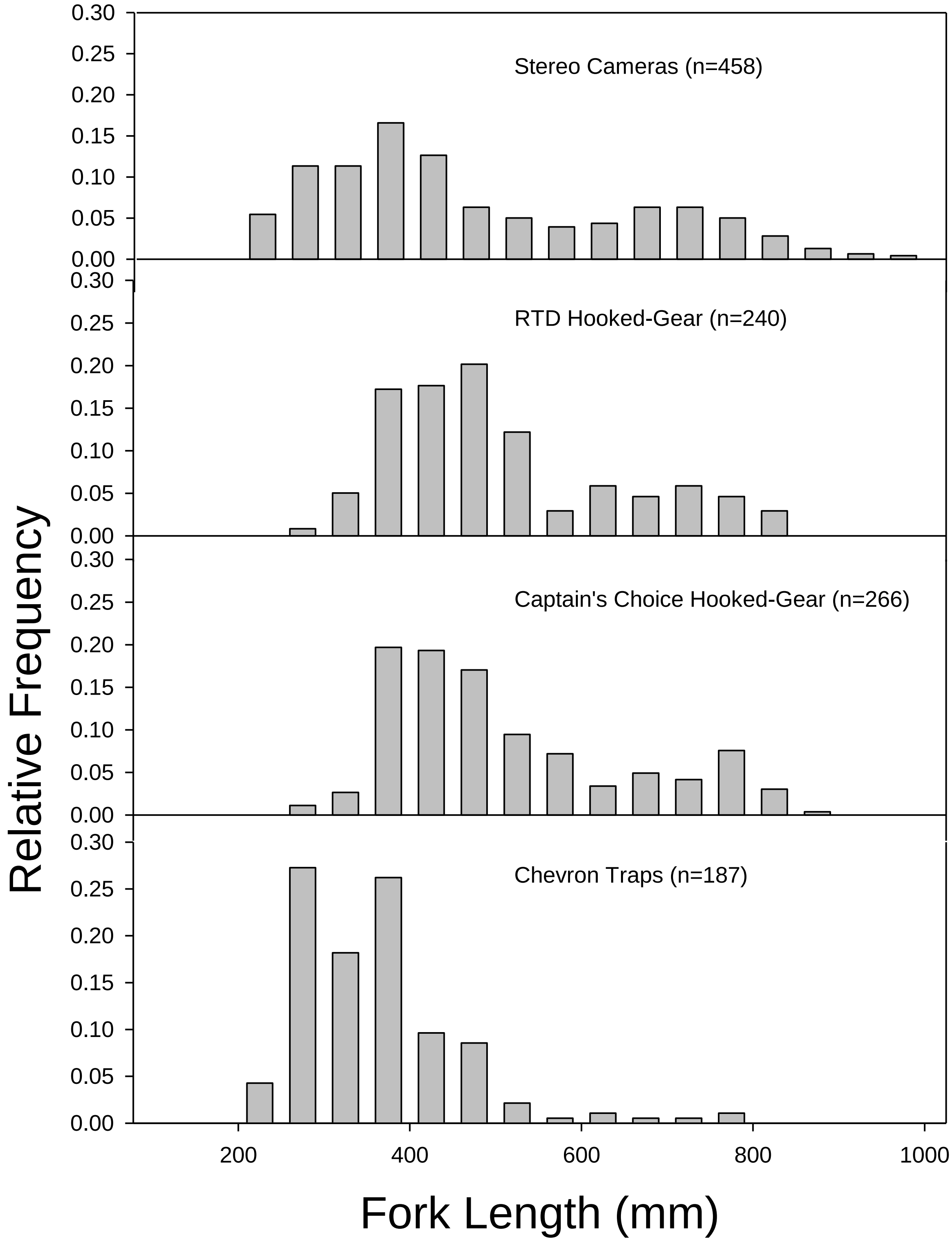


Figure 27. Red Snapper length frequency (mm FL) collected or observed during FWC Chevron trap and hooked-gear surveys (RTD and Captain's Choice) paired with stereo video camera surveys along the Atlantic coast of Florida (2016).

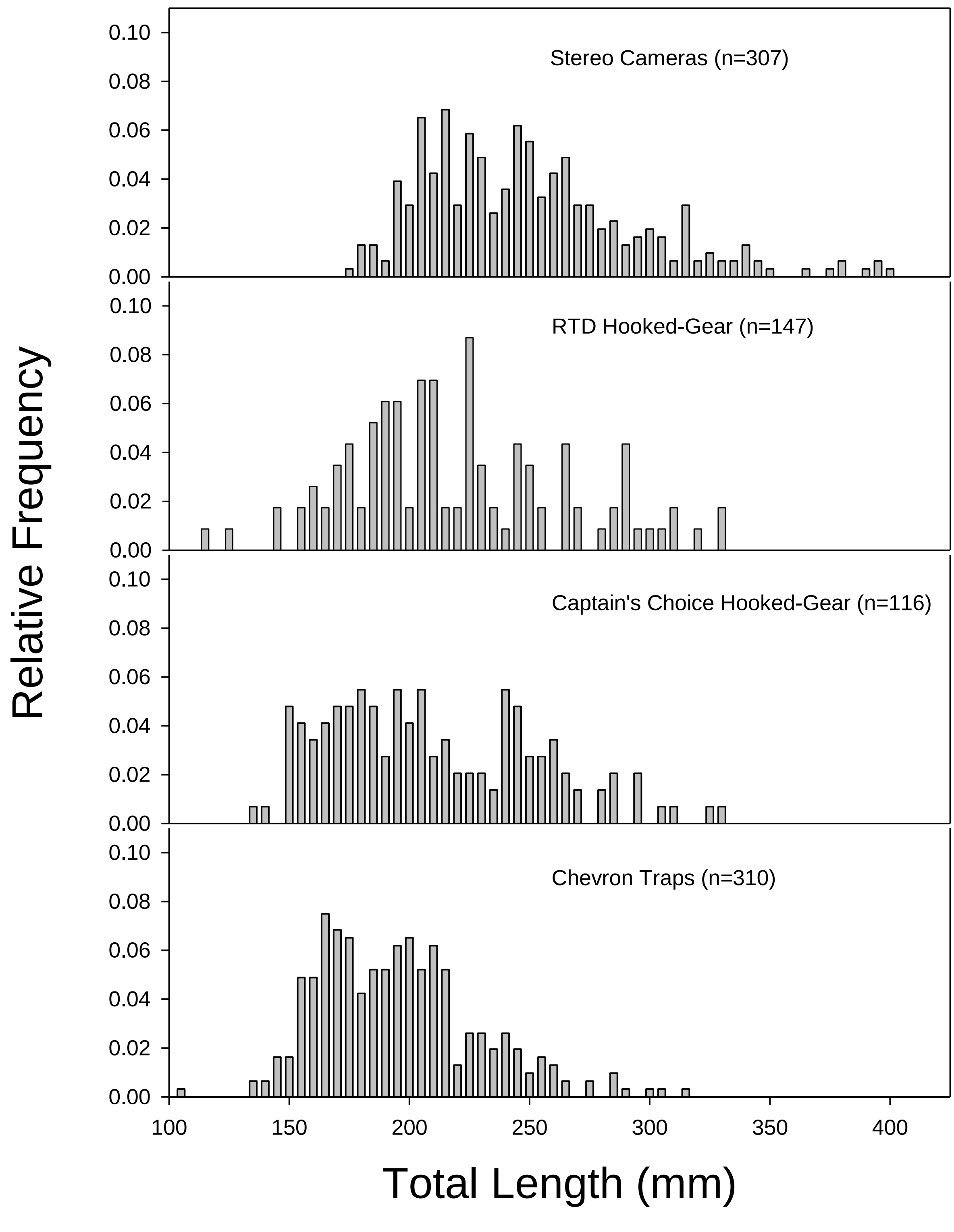


Figure 28. Black Sea Bass length frequency (mm TL) collected or observed during FWC Chevron trap and hooked-gear surveys (RTD and Captain's Choice) paired with stereo video camera surveys along the Atlantic coast of Florida (2016).

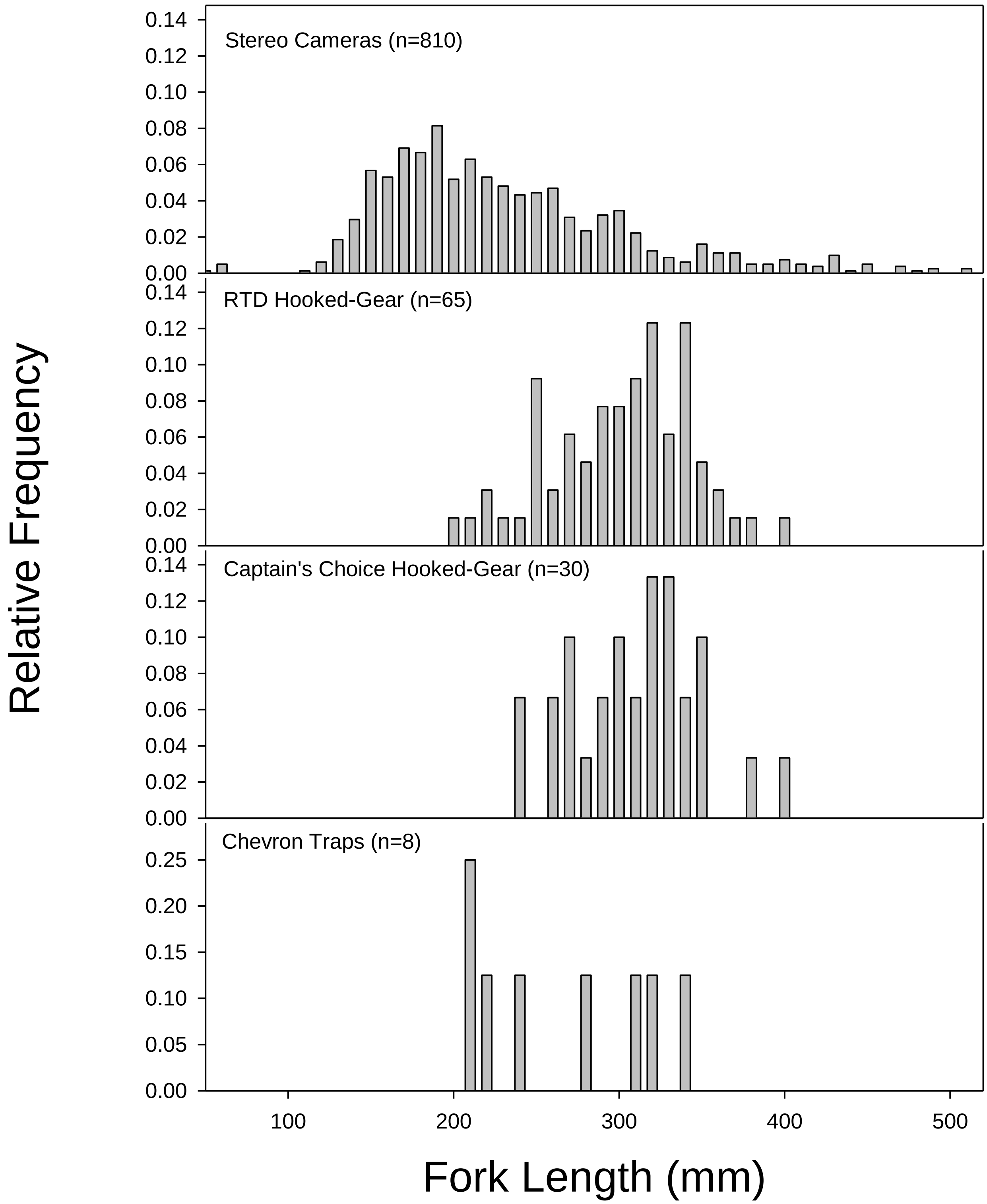


Figure 29. Vermilion Snapper length frequency (mm FL) collected or observed during FWC Chevron trap and hooked-gear surveys (RTD and Captain's Choice) paired with stereo video camera surveys along the Atlantic coast of Florida (2016).

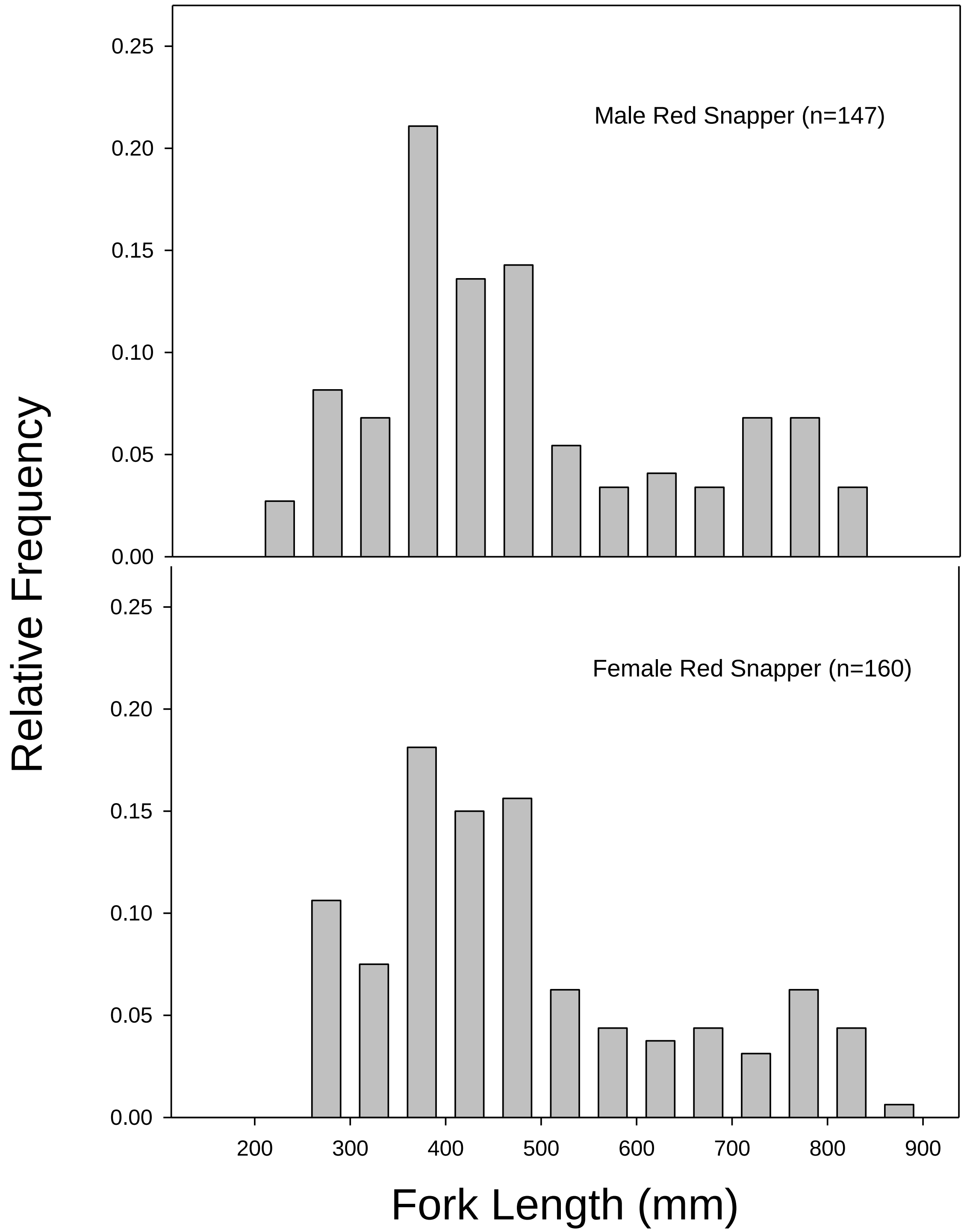


Figure 30. Length frequency of Red Snapper, by sex, collected during FWC Chevron trap and hooked-gear surveys (RTD and Captain's Choice) along the Atlantic coast of Florida (2016).

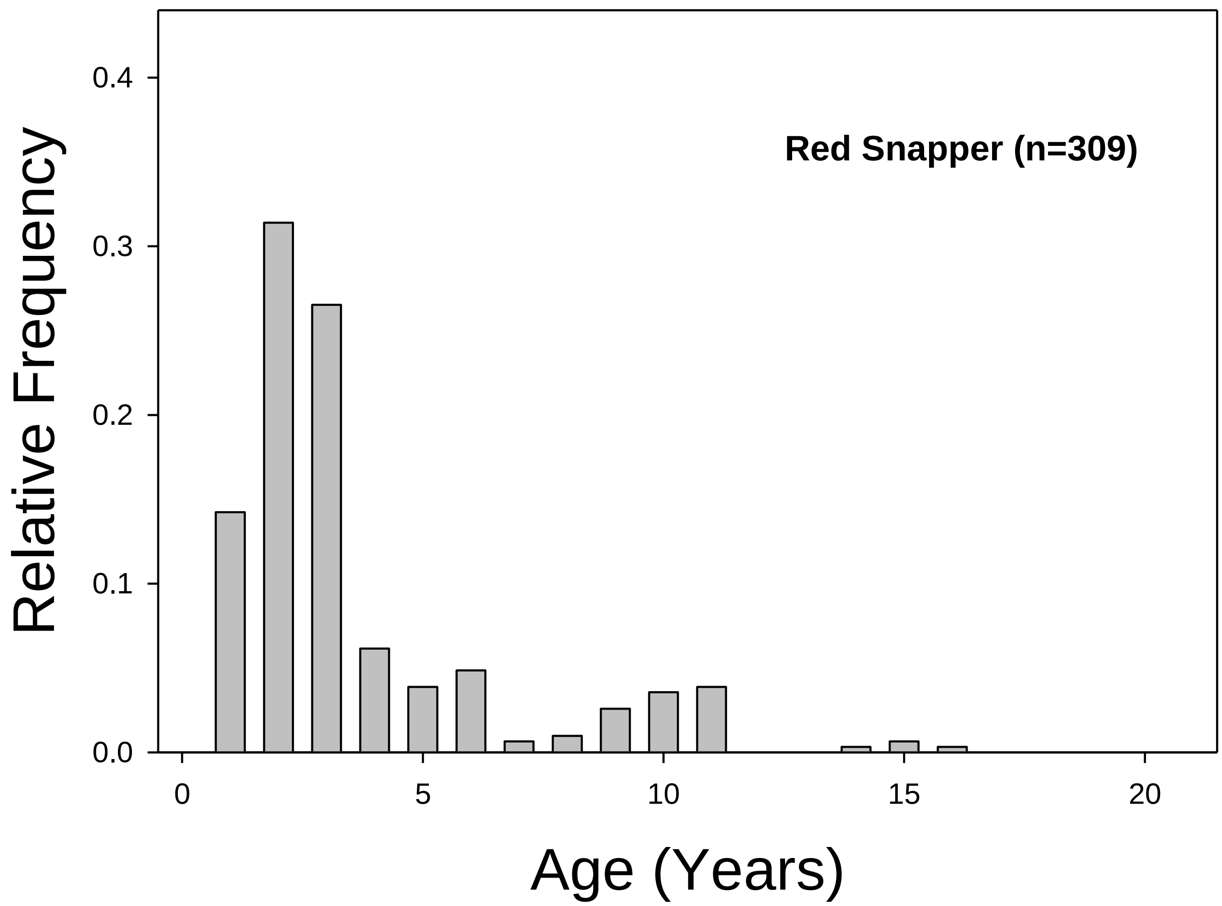


Figure 31. Age frequency of all Red Snapper collected during FWC Chevron trap and hooked-gear surveys (RTD and Captain’s Choice) along the Atlantic coast of Florida (2016).

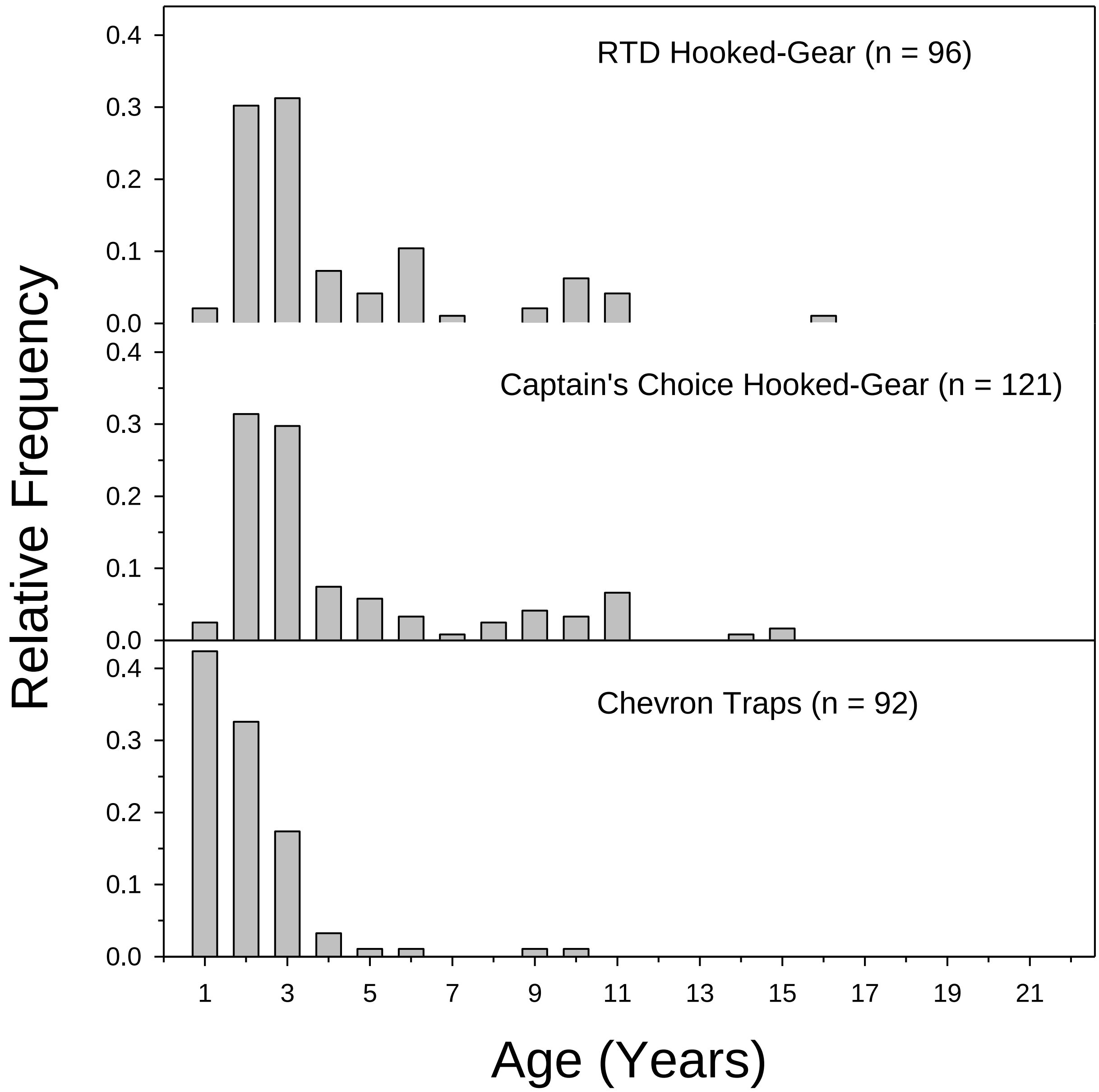


Figure 32. Age frequency of Red Snapper by sampling gear collected during FWC Chevron trap and hooked-gear surveys (RTD and Captain's Choice) along the Atlantic coast of Florida (2016).

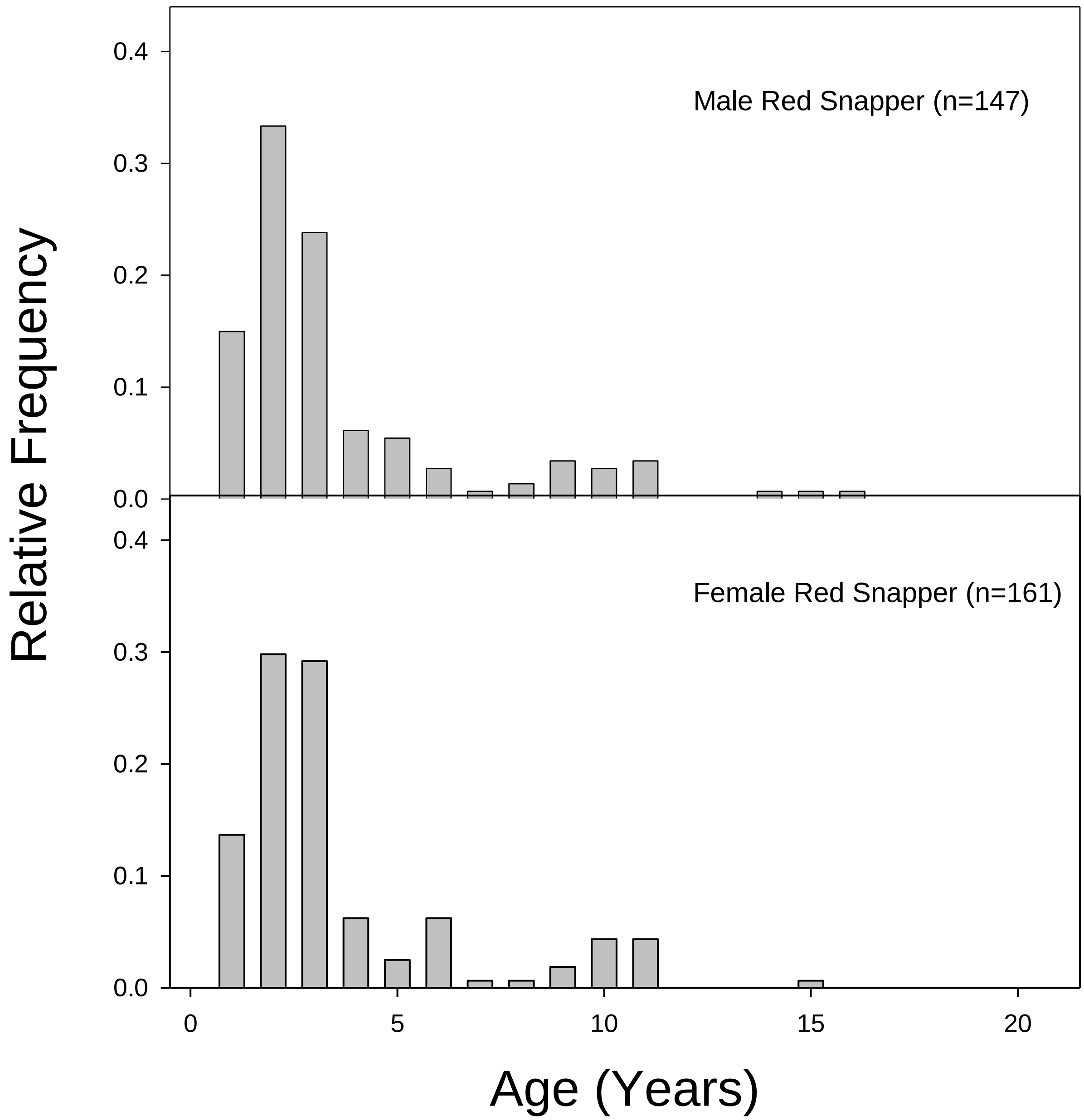


Figure 33. Age frequency of Red Snapper by sex (all sampling gears combined) collected during FWC Chevron trap and hooked-gear surveys (RTD and Captain's Choice) along the Atlantic coast of Florida (2016).

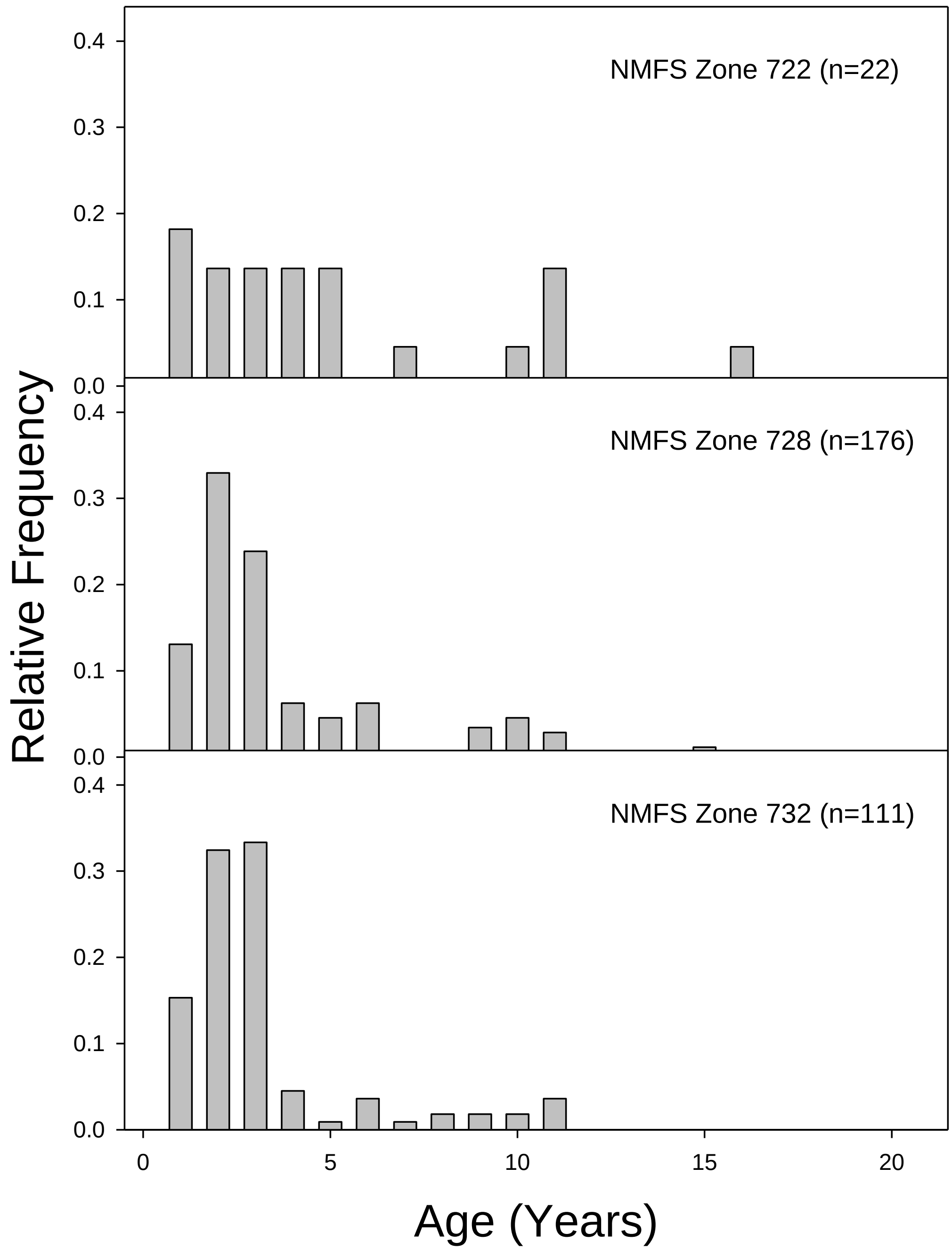


Figure 34. Age frequency of Red Snapper by NMFS statistical zone (all sampling gears combined) collected during FWC Chevron trap and hooked-gear surveys (RTD and Captain's Choice) along the Atlantic coast of Florida (2016).

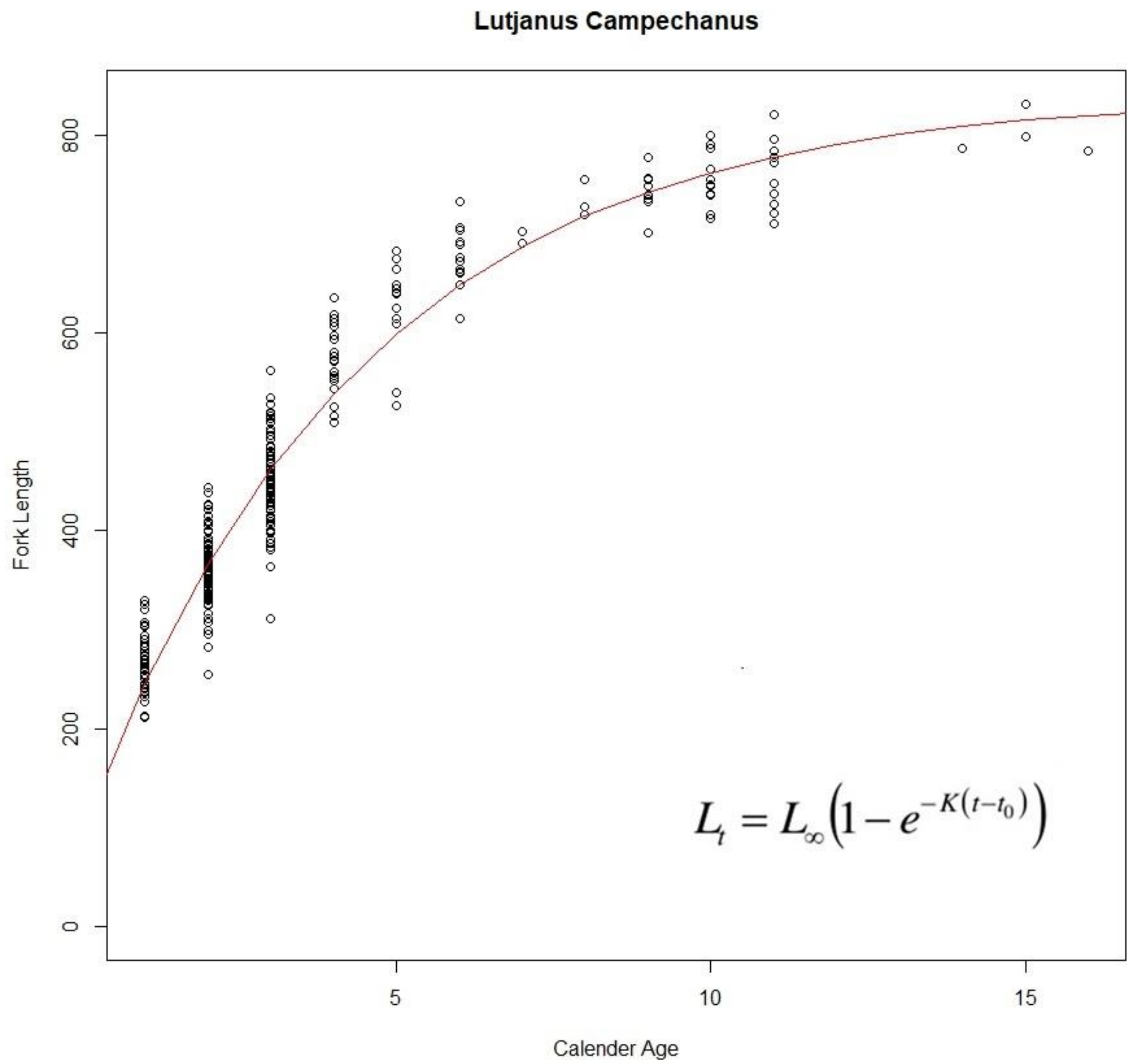


Figure 35. Observed length-at-age of Red Snapper (n=309) collected during FWC Chevron trap and hooked-gear surveys (RTD and Captain’s Choice) along the Atlantic coast of Florida (2016). The continuous line is the estimated von Bertalanffy function where $L\infty$ = 839.71 mm, K = 0.226 and t0=-0.532.

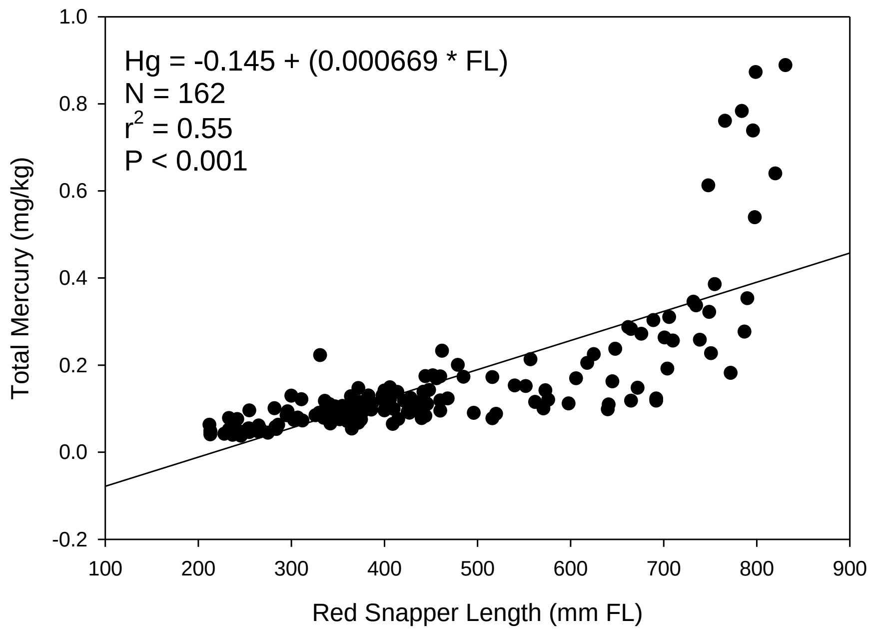


Figure 36. Total mercury concentrations (mg/kg) in Red Snapper (n=162), by Fork Length, collected during FWC Chevron trap and hooked-gear surveys (RTD and Captain's Choice) along the Atlantic coast of Florida (2016).

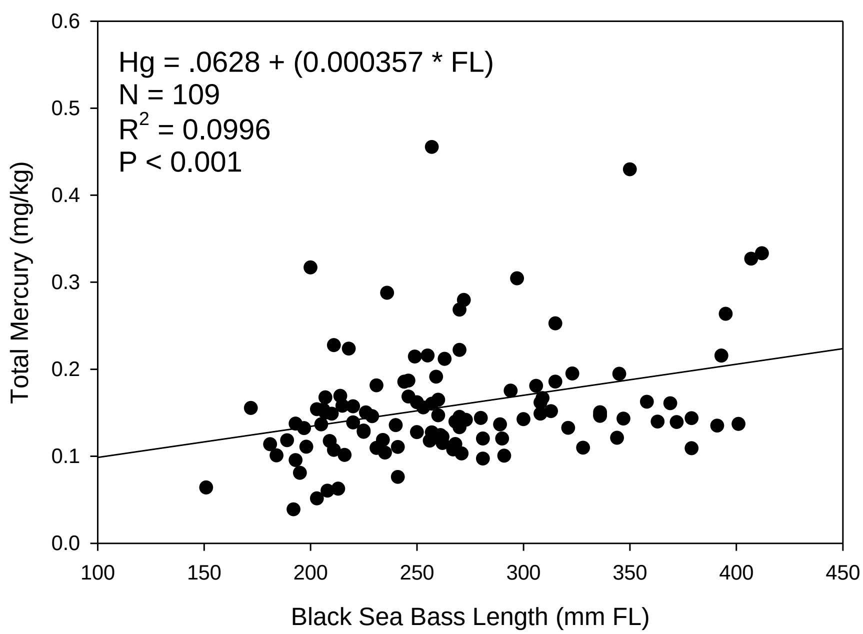


Figure 37. Total mercury concentrations (mg/kg) in Black Sea Bass (n=109), by Fork Length, collected during FWC Chevron trap and hooked-gear surveys (RTD and Captain's Choice) along the Atlantic coast of Florida (2016).

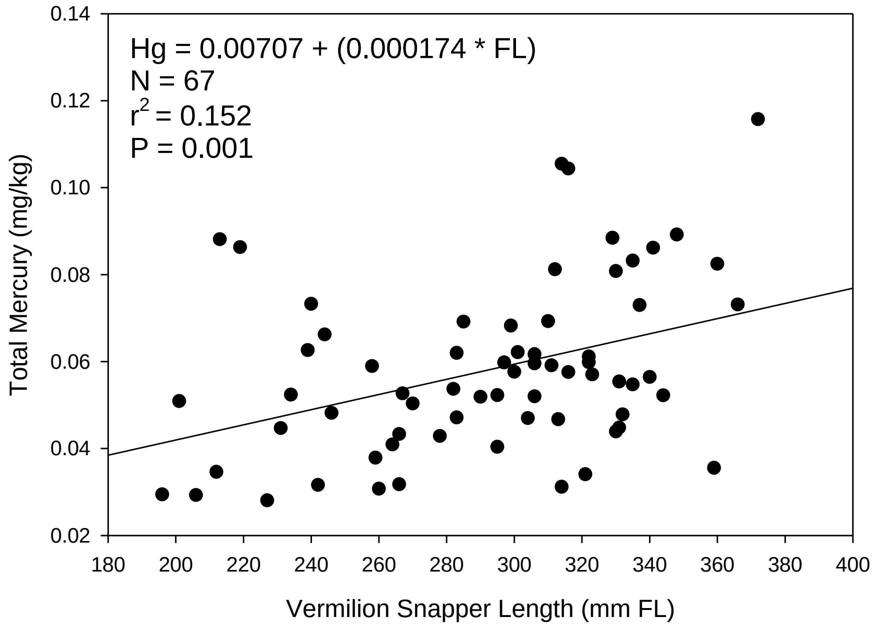


Figure 38. Total mercury concentrations (mg/kg) in Vermilion Snapper (n=67), by Fork Length, collected during FWC Chevron trap and hooked-gear surveys (RTD and Captain's Choice) along the Atlantic coast of Florida (2016).

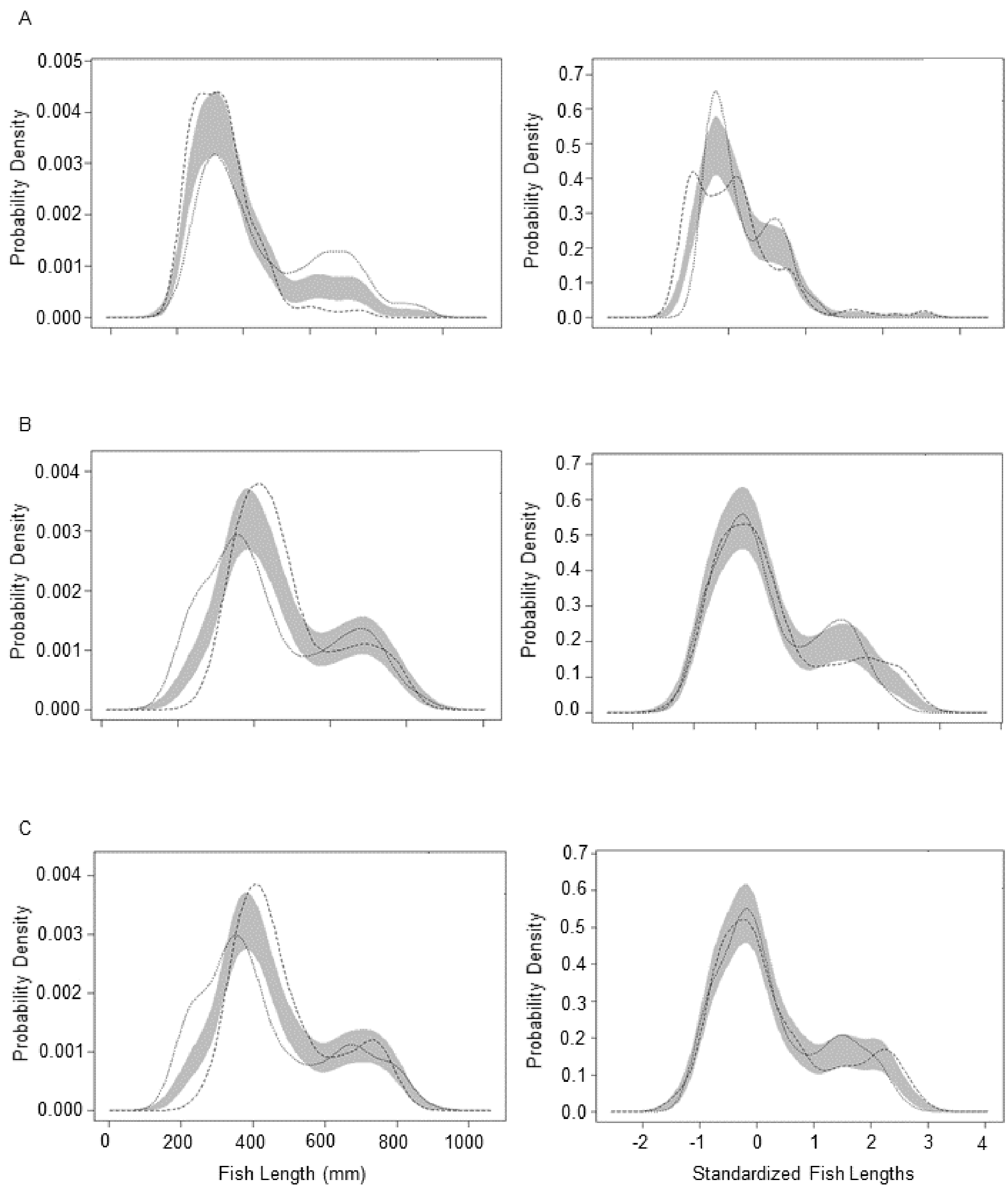


Figure 39. Comparison of kernel density estimate (KDE) probability density functions for Red Snapper (*Lutjanus campechanus*) sampled using A) Chevron Trap, B) Repetitive Time-Drop (RTD), or C) Captain's Choice. Dotted lines represent individual sampling method, while solid lines represent SIS video. Grey bands represent one standard error either side of the null model of no difference between the KDEs for each method. Significance tests on raw data (left column) provide a test of differences in both location and shape of the length-frequency distributions, whereas tests on standardized data (right column) provide a test of shape only.

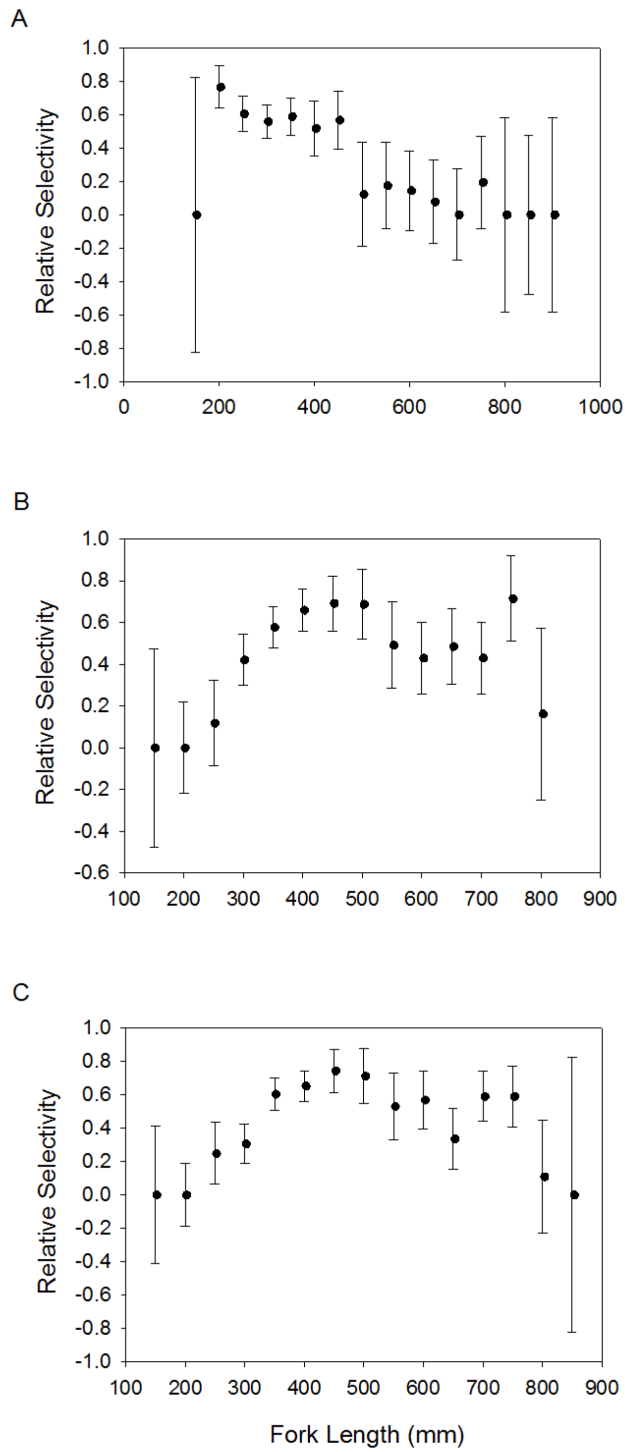


Figure 40. Relative selectivity of A) Chevron Traps relative to SIS video, B) Repetitive Time-Drop relative to SIS video, and C) Captain's Choice relative to SIS video for Red Snapper (*Lutjanus campechanus*). Error bars are 90% confidence intervals.

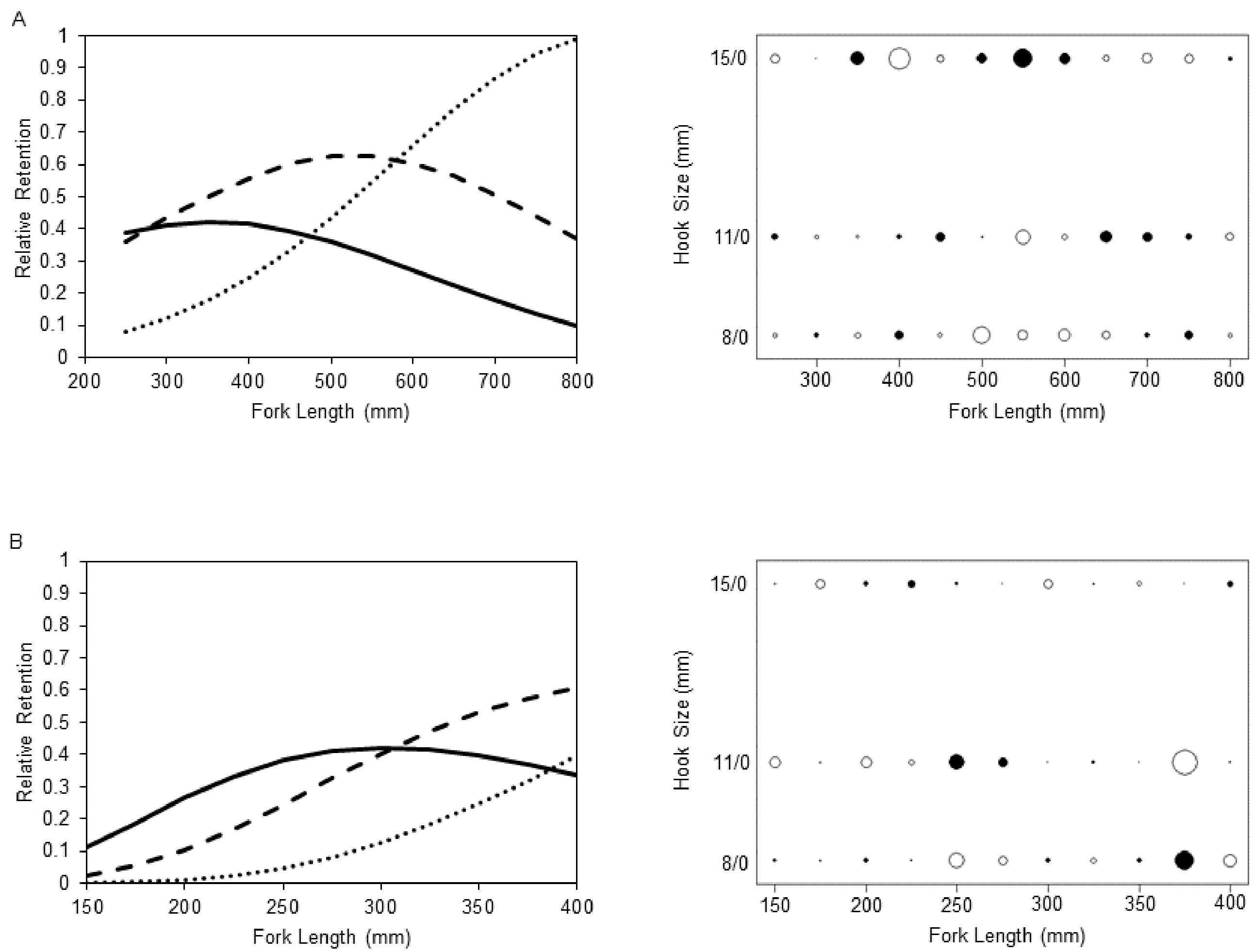


Figure 41. Hook selectivity curves for A) Red Snapper (*Lutjanus campechanus*) calculated from the normal distribution assuming proportional fishing intensity with increasing hook size and B) Black Sea Bass (*Centropristis striata*) calculated from the lognormal distribution assuming fishing intensity proportional to hook size. Solid lines represent 8/0 hooks, dashed lines represent 11/0 hooks, and dotted lines represent 15/0 hooks. Graphs on right side are the deviance residuals, closed circles represent positive residuals and open circles represent negative residuals. The area of the circle is proportional to the absolute value of the residual.

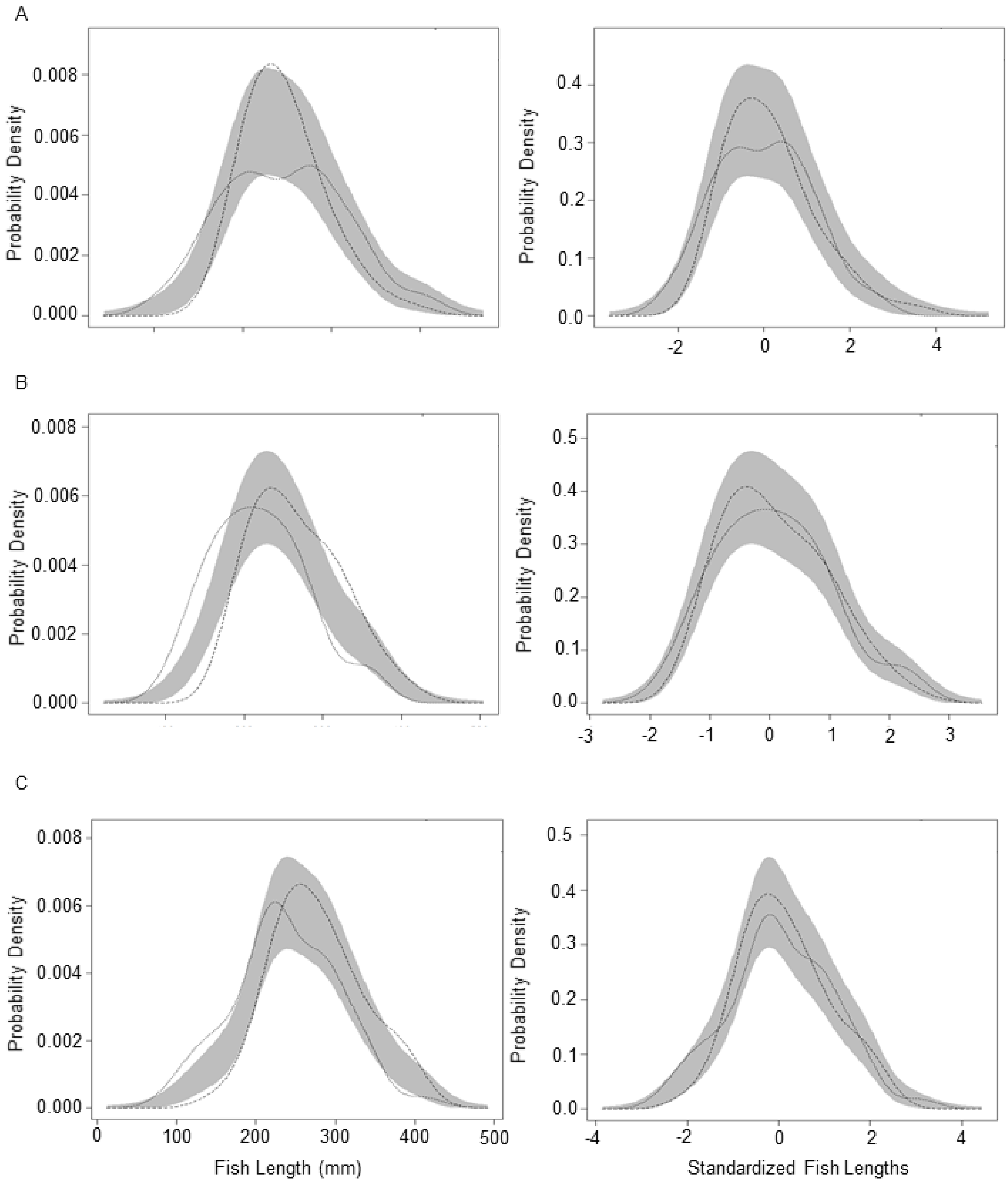


Figure 42. Comparison of kernel density estimate (KDE) probability density functions for Black Sea Bass (*Centropristis striata*) sampled using A) Chevron Trap, B) Repetitive Time-Drop (RTD), or C) Captain's Choice. Dotted lines represent individual sampling method, while solid lines represent SIS video. Grey bands represent one standard error either side of the null model of no difference between the KDEs for each method. Significance tests on raw data (left column) provide a test of differences in both location and shape of the length-frequency distributions, whereas tests on standardized data (right column) provide a test of shape only.

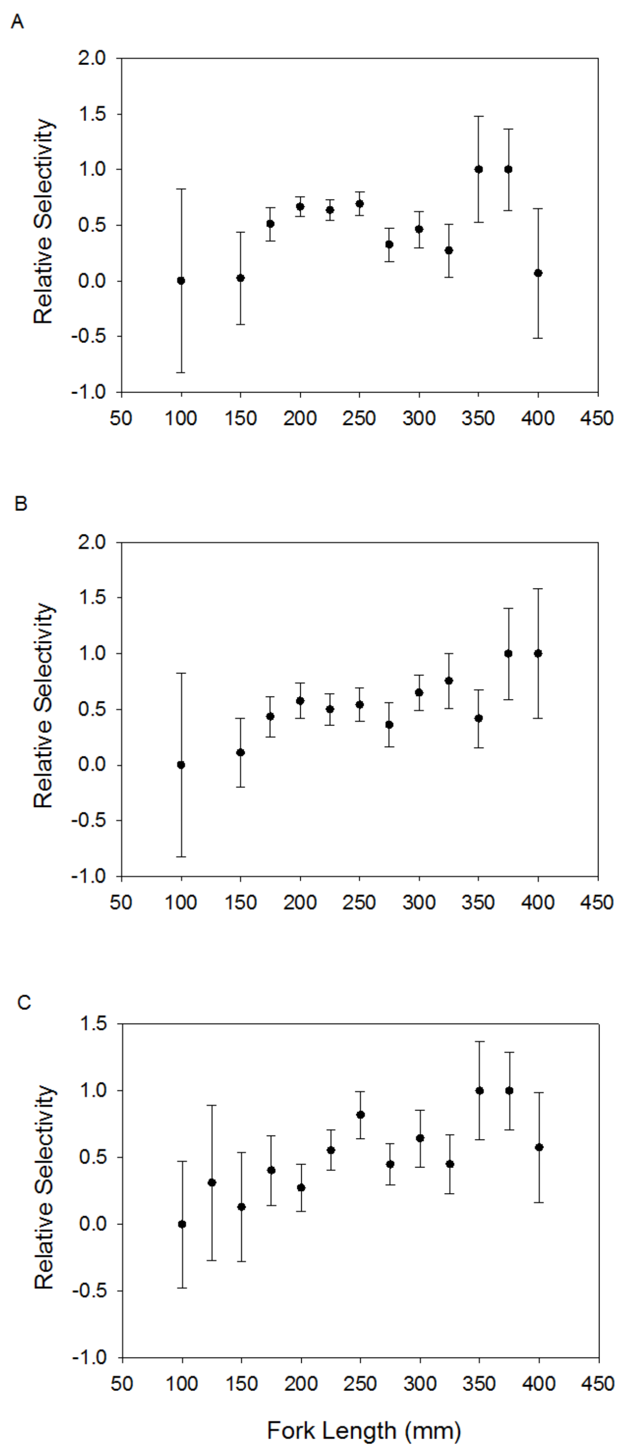


Figure 43. Relative selectivity of A) Chevron Trap relative to SIS video, B) Repetitive Time-Drop relative to SIS video, and C) Captain's Choice relative to SIS video for Black Sea Bass (*Centropristis striata*). Error bars are 90% confidence intervals.

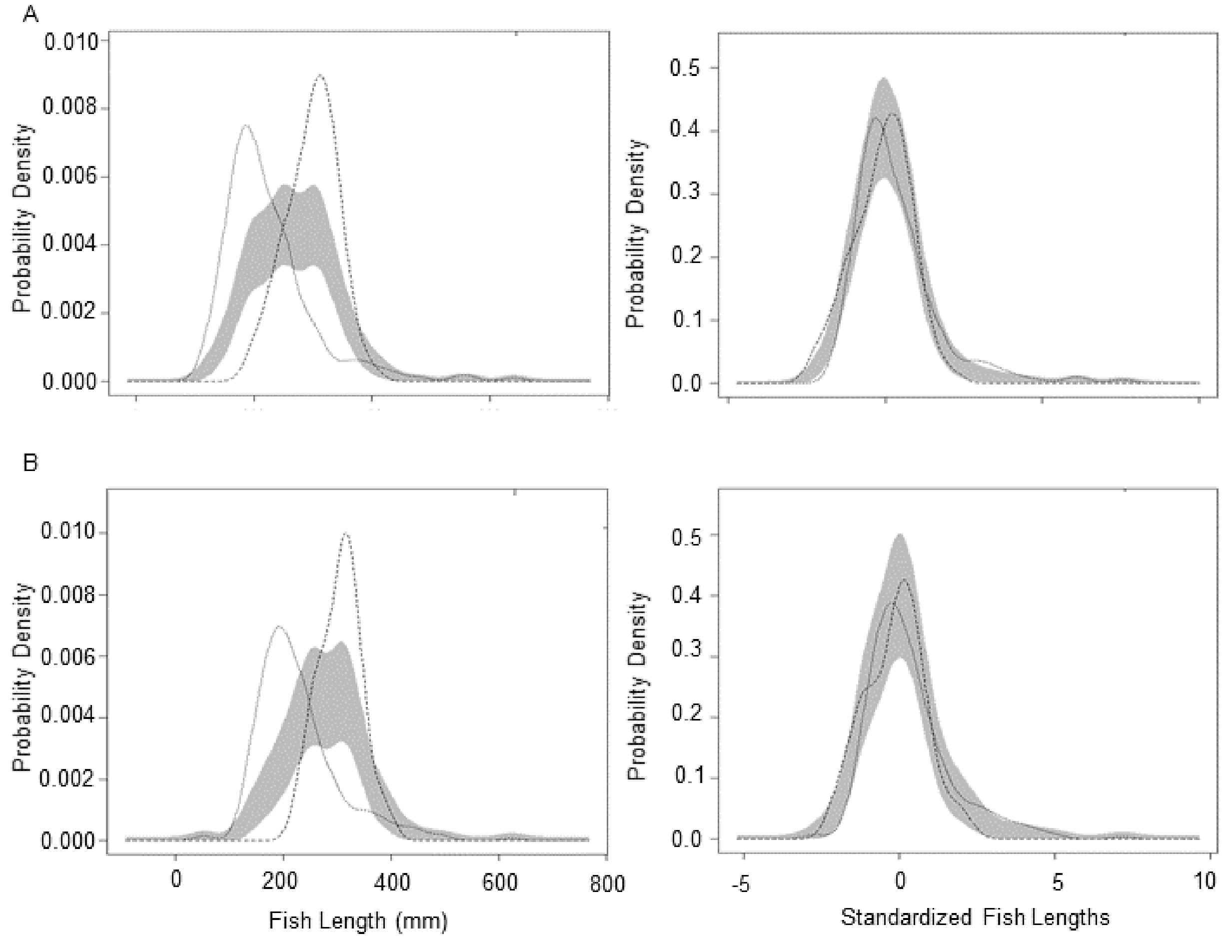
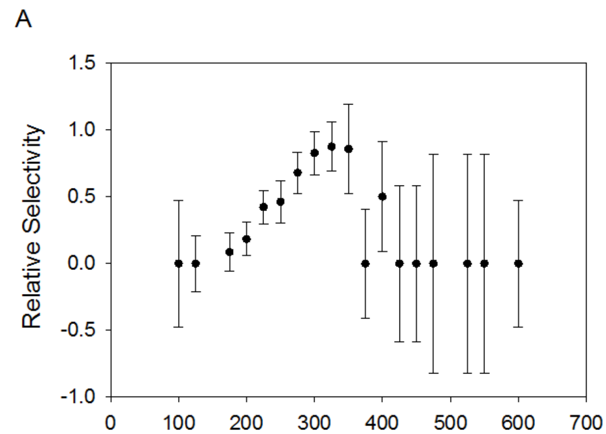


Figure 44. Comparison of kernel density estimate probability density functions for Vermilion Snapper (*Rhomboplites aurorubens*) sampled using A) Repetitive Time-Drop (RTD), or B) Captain's Choice. Dotted lines represent individual sampling method, while solid lines represent SIS video. Grey bands represent one standard error either side of the null model of no difference between the KDEs for each method. Significance tests on raw data (left column) provide a test of differences in both location and shape of the length-frequency distributions, whereas tests on standardized data (right column) provide a test of shape only.



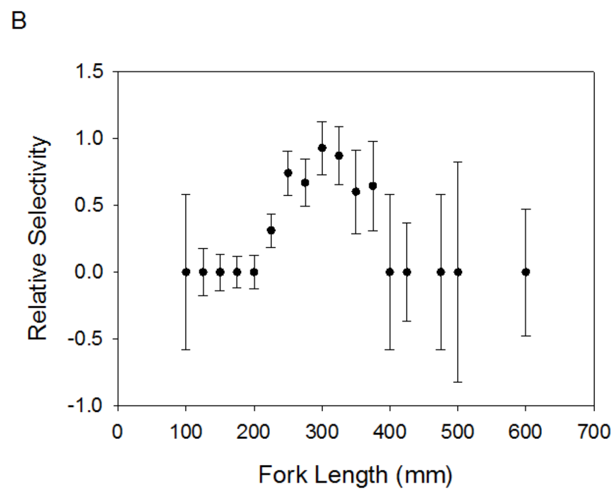


Figure 45. Relative selectivity of A) Repetitive Time Drop (RTD) relative to SIS video, and B) Captain's Choice relative to SIS video for Vermilion Snapper (*Rhomboplites aurorubens*). Error bars are 90% confidence intervals.

Appendix 1. List of taxa considered as managed species during FWC Chevron trap and hooked-gear surveys (RTD and Captain's Choice) paired with stereo video camera surveys along the Atlantic coast of Florida (2016).

Taxon	**Common Name**
Acanthurus chirurgus	Doctorfish
Acanthurus coeruleus	Blue Tang
Alectis ciliaris	African Pompano
Anisotremus surinamensis	Black Margate
Anisotremus virginicus	Porkfish
Archosargus probatocephalus	Sheepshead
Balistes capriscus	Gray Triggerfish
Balistes vetula	Queen Triggerfish
Calamus bajonado	Jolthead Porgy
Calamus proridens	Littlehead Porgy
Calamus spp.	Unidentified Porgies
Caranx bartholomaei	Yellow Jack
Caranx crysos	Blue Runner
Caranx hippos	Crevalle Jack
Caranx ruber	Bar Jack
Carcharhinus acronotus	Blacknose Shark
Carcharhinus falciformis	Silky Shark
Carcharhinus limbatus	Blacktip Shark
Carcharhinus plumbeus	Sandbar Shark
Centropomus undecimalis	Common Snook
Centropristis ocyurus	Bank Sea Bass
Centropristis philadelphica	Rock Sea Bass
Centropristis striata	Black Sea Bass
Cephalopholis cruentata	Graysby
Chaetodipterus faber	Atlantic Spadefish
Decapterus/Selar/Trachurus spp.	Unidentified Scads
Diplectrum formosum	Sand Perch
Elagatis bipinnulata	Rainbow Runner
Epinephelus drummondhayi	Speckled Hind
Epinephelus itajara	Goliath Grouper

Taxon	Common Name
Epinephelus morio	Red Grouper
Equetus lanceolatus	Jackknife-fish
Galeocerdo cuvier	Tiger Shark
Ginglymostoma cirratum	Nurse Shark
Haemulon aurolineatum	Tomtate
Haemulon plumierii	White Grunt
Haemulon striatum	Striped Grunt
Holacanthus bermudensis	Blue Angelfish
Holacanthus ciliaris	Queen Angelfish
Holacanthus tricolor	Rock Beauty
Holocentrus adscensionis	Squirrelfish
Lachnolaimus maximus	Hogfish
Leiostomus xanthurus	Spot
Lutjanus analis	Mutton Snapper
Lutjanus campechanus	Red Snapper
Lutjanus griseus	Gray Snapper
Lutjanus spp.	Unidentified Snappers
Lutjanus synagris	Lane Snapper
Mycteroperca bonaci	Black Grouper
Mycteroperca microlepis	Gag
Mycteroperca phenax	Scamp
Myripristis jacobus	Blackbar Soldierfish
Ocyurus chrysurus	Yellowtail Snapper
Orthopristis chrysoptera	Pigfish
Pagrus pagrus	Red Porgy
Pareques umbrosus	Cubbyu
Pomacanthus arcuatus	Gray Angelfish
Pomacanthus paru	French Angelfish
Pristigenys alta	Short Bigeye
Pseudupeneus maculatus	Spotted Goatfish
Pterois spp.	Lionfishes
Rachycentron canadum	Cobia
Rhinobatos lentiginosus	Atlantic Guitarfish

Taxon	Common Name
Rhinoptera bonasus	Cownose Ray
Rhizoprionodon terraenovae	Atlantic Sharpnose Shark
Rhomboplites aurorubens	Vermilion Snapper
Scomberomorus cavalla	King Mackerel
Seriola dumerili	Greater Amberjack
Seriola fasciata	Lesser Amberjack
Seriola rivoliana	Almaco Jack
Seriola zonata	Banded Rudderfish
Sphyraena barracuda	Great Barracuda
Sphyrna mokarran	Great Hammerhead
Stenotomus caprinus	Longspine Porgy