Size and age composition of Red Snapper, *Lutjanus campechanus*, collected in association with fishery-independent and fishery-dependent projects along Florida's Atlantic coast, 2012 to 2019.

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SEDAR73-WP13

Received: 11/13/2020

Please cite this document as:

Solomon, Justin J, Jessica Carroll, Dominique Lazarre, Russell B. Brodie, Heather Christiansen, Beverly Sauls, Richard Paperno, and Theodore S. Switzer. 2020. Size and age composition of Red Snapper, *Lutjanus campechanus*, collected in association with fishery-independent and fishery-dependent projects along Florida's Atlantic coast, 2012 to 2019. SEDAR73-WP13. SEDAR, North Charleston, SC. 44 pp.

Size and age composition of Red Snapper, *Lutjanus campechanus*, collected in association with fishery-independent and fishery-dependent projects along Florida's Atlantic coast, 2012 to 2019

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Introduction:

The U.S. South Atlantic Red Snapper *Lutjanus campechanus* fishery has been active since the 1950s, with a substantial proportion of landings recorded along the Atlantic coast of Florida. Following peak annual Red Snapper landings during the 1970s, landings markedly declined (White and Palmer 2004). Declines in landings from commercial, recreational, and headboat fisheries from 1986 to 1995 were also documented by Manooch et al. (1998) as part of the first formal assessment of the U.S. South Atlantic Red Snapper stock. Results from a 2008 South East Data Assessment and Review (SEDAR) stock assessment indicated that the stock was overfished and experiencing overfishing (SEDAR 15 2008). In response to this assessment, the South Atlantic Fishery Management Council implemented an emergency closure of the commercial and recreational Red Snapper fishery throughout federal waters (3 to 200 miles offshore) in the U.S. South Atlantic region in 2010. The SAFMC also approved Amendment 17A to the South Atlantic Snapper Grouper Fishery Management Plan to reduce overfishing and rebuild Red Snapper stocks as mandated by the Magnuson-Stevens Act (SAFMC 2010). Amendment 17A involved several provisions, including the continuation of the closure of the Red Snapper fishery (Gitschlag and Renaud 1994; Rummer and Bennett 2005; SAFMC 2010). Before Amendment 17A was enacted an updated assessment (SEDAR 24 2010) was completed. The assessment confirmed that Red Snapper were overfished and undergoing overfishing (SEDAR 24 2010), but it revealed that stocks were in better condition than what was initially indicated in SEDAR 15. Subsequently, aside from very limited recreational and commercial seasons in 2012 – 2014, 2017, 2018, and 2019 Red Snapper have been closed to recreational and commercial harvest.

When harvest of Red Snapper was prohibited in 2010, there was a relative paucity of life history data for Red Snapper. However, since 2012, the Florida Fish and Wildlife Conservation Commission's Fish and Wildlife Research Institute (FWRI) has initiated new fishery-independent research and monitoring activities along the Atlantic coast of Florida that have increase life history samples from Red Snapper. These data are in addition to the recently expanded Southeast Reef Fish Survey, which utilizes chevron traps and provides some life history data for Red Snapper. FWRI has also greatly enhanced fishery-dependent monitoring efforts since 2012, during years that harvest is permitted, to directly target biological sampling of Red Snapper landings along the Atlantic coast. Combined, these efforts have increased the amount of life history data available in recent years for assessing recovery of the Red Snapper stock.

Fishery-Independent Sources of Life History Data:

Life history samples for Red Snapper were collected along the Atlantic coast of Florida between 2012 – 2018 in association with various fishery-independent research and monitoring projects. The majority of life history samples were collected through research projects designed to test the efficacy of hooked-gears, specifically repetitive actively fished hook-and-line (RTD), for collecting Red Snapper abundance and life history data (SEDAR41-DW10; Brodie and Switzer

2015; Paperno et al. 2018; Switzer et al. 2019). In 2012 and 2013 Red Snapper were culled in association with a three-year tagging study to examine movement of Red Snapper (SEDAR41-DW10). Sampling sites for this project were opportunistically chosen by cooperative fishing partners to maximize the number of Red Snapper caught at each site (Figure 2). During a select few sampling trips, a random subset of Red Snapper collected were culled instead of tagged and released. In addition to the randomly culled Red Snapper, a few larger (> 700 mm TL) individuals that would have normally been tagged and released were non-randomly culled. Additional survey details can be found in SEDAR41-DW10. A one year pilot study initiated in 2012 explored the utility of various fishery-independent, hooked-gear methods (vertical longlines, short bottom longlines, and repetitive active fishing surveys (RTD hooked-gear) to provide data for Red Snapper and other managed reef fishes (SEDAR41-DW08). This survey implemented a stratified-random survey design in which monthly sampling sites (April – October) were randomly selected within three latitudinal strata (statistical reporting zones 722, 728, and 732) and two depth strata (0 – 30 m and 30 – 200 m; Figure 1). Most individuals were culled following randomization procedures (random culls); however, some larger individuals (> 700 mm TL) that would have otherwise been released were also culled (nonrandom culls) to better characterize the age composition of larger and, presumably, older Red Snapper. All three gear types were able to capture a wide size range of Red Snapper, although the RTD hooked-gear collected significantly more fish during the study. A federally funded FWC RTD hooked-gear study focused on spawning aggregations of Red Snapper, Scamp, and Gag was completed in 2014 - 2015 (Brodie and Switzer 2015). The site selection protocols differed from the 2012 FWC study, focusing primarily on deeper sites with a high likelihood of spawning-capable Red Snapper, Scamp, and Gag. Nevertheless, the age compositions from this study showed the utility of the RTD hooked-gear approach at tracking strong year-classes of Red Snapper over time. To address the selectivity of Red Snapper and other reef fishes to gear types currently used during ongoing fisheries-independent monitoring surveys in the U.S. South Atlantic off the east coast of Florida, the FWC completed a one year study (Paperno et al. 2018) in 2016 examining the relative size selectivity of three capture gears (Chevron Traps, fishery-independent RTD hooked-gear, and fishery-dependent hooked-gear) to that of stereo camera observations. This study was conducted within a similar sampling universe and time frame as the 2012 survey and a randomized subsample of Red Snapper were collected to provide life history information. Results of this study indicated that RTD hooked-gear collected larger/older fish than what was observed on the stereo-video cameras, while conversely, chevron traps collected proportionally smaller/younger Red Snapper than were observed. Utilizing a similar sampling universe and RTD methods as the 2016 selectivity study, a one year survey was conducted in 2017 to complement historically collected data, maintain ongoing survey timelines, and improve FWC's ability to assess the relative abundance of Red Snapper and other managed reef fishes along Florida's Atlantic Coast over time. For this project all Red Snapper collected were culled. In 2018 a one-year federally funded project was completed that partially replicated the 2012 pilot study to assess whether the size- and age-composition of Red Snapper in the U.S. South Atlantic had expanded following several years of a near-complete prohibition of harvest. The sampling universe and time-frame of sampling was similar to the 2012 pilot study and the first 2,000 Red Snapper collected were retained for life history analysis (Switzer et al. 2019).

In addition to the above surveys focusing on adult Red Snapper, a pilot study was conducted between 2014 - 2016 to evaluate the utility of trawls and small fish traps in providing fisheries-independent data for juvenile (age 0-1) Red Snapper and other managed fishes in the US South Atlantic (SA). Trawl surveys targeted low-relief, soft-bottom/shell habitat in depths ranging from 10-70 m, while trap surveys were deployed on low- to high-relief hard bottom habitats that were not accessible by trawl gear. All Red Snapper collected from both the trawl and trap surveys were culled for life-history analysis.

Fishery-Dependent Sources of Life History Data:

Life history samples for Red snapper were collected along the Atlantic coast of Florida in association with several fishery-dependent research and monitoring projects. Since fish must be returned quickly during fishery-dependent surveys, priority was given to collecting the left otolith if both otoliths could not be removed. Each fishery dependent research or monitoring project that contributed to the age and length data provided to the Life History Group is described below.

At-Sea Observer Sampling of the For-Hire Fisheries

Since 2005, cooperative headboat vessels have been randomly selected weekly throughout the year for observer coverage along the Atlantic coast of Florida, however, otoliths were not routinely collected as part of this survey until 2011. Headboat measurements and otoliths collected dockside or from observer coverage represent supplemental sampling separate of the dockside sampling conducted for the Southeast Regional Headboat Survey (SRHS). In addition to headboat coverage, FWRI received a three-year MARFIN grant to place fishery observers on charter fishing vessels from 2013-2015. Cooperative charter vessels were randomly selected weekly throughout the year, and all Red Snapper caught during sampled trips were measured (midline in mm). For charter trips sampled during the three-day recreational season in 2013, otoliths were extracted from harvested Red Snapper. Methods used to collect biological data through these two programs are summarized in a separate working paper for this SEDAR (SEDAR73-WP12).

Recreational Mini-Season Sampling

Since 2012, FWRI has enhanced fishery-dependent monitoring efforts to collect biological data, including lengths, weights and ages of Red Snapper landed in the private boat and charter fisheries (and to a lesser extent, the headboat fishery) during short recreational harvest seasons in the South Atlantic. Samples were collected through a variety of methods:

1. Randomized Catch and Effort Survey

   FWRI conducts a specialized fishery-dependent survey aimed at providing more precise catch estimates for private boat mode during Red Snapper recreational mini-seasons. This survey includes dockside sampling at randomly selected angler intercept sites adjacent to major inlets from Cumberland Sound to Port St. Lucie, which also provides an opportunity to collect biological data from harvested fish. These inlets serve as egress points to Red Snapper fishing grounds in the Atlantic Ocean, and very few Red Snapper are landed south of this region along the east coast of Florida. Private anglers returning from offshore recreational boat-based fishing trips were intercepted, and harvested Red Snapper were measured (at midline in mm), weighed (kg), and an otolith was extracted when permitted by the angler. Landings estimates may be used to apply sample weights to each fish sampled. The survey design and sample weighting methods are documented in four reference documents: SEDAR73-RD04, SEDAR73-RD05, SEDAR73-RD06 and SEDAR73-RD07.

   In 2018 and 2019, dockside sampling was expanded to allow interviews of charter vessels intercepted at access point sites, in addition to private boat-based fishing trips. Methods are described in two reference documents: SEDAR73-RD05 and SEDAR73-RD07.

2. Supplemental Biological Sampling

   During 2012-2014 mini-seasons, targeted biological sampling was conducted to supplement size-at-age data collected through the randomized catch and effort survey, described above. Red Snapper were targeted for biological sampling at private boat landings sites, including fish cleaning stations and boat ramps, and charter and headboat landing sites from Cumberland Sound to Port St. Lucie. Sampling sites were not randomly selected; instead, biologists went to sites where Red Snapper trips were known to occur because of the short window of opportunity to collect samples. Returning vessels were sampled in order that they arrived, and biologists did not target any particular size of fish.

   Additionally, during 2012 and 2013, Red Snapper carcasses were collected at select locations on the east coast of Florida from all three recreational fishing modes. It is impossible to determine whether biological samples collected from donated carcasses are biased or if they are representative of the harvested population. Nevertheless, data from targeted biological sampling and carcass donations may be able to provide additional size-at-age data for older fish and fish caught in deeper depths that are rare in other randomly selected, fishery dependent samples (SEDAR 41-RD15). Carcass collections were largely discontinued in 2014 in favor of more representative sampling.

From 2017-2019, a randomized sample design was employed for supplemental biological sampling as part of a three-year MARFIN grant awarded to FWRI. This dockside intercept sampling was aimed at collecting representative biological data to improve stock assessments in the data-poor region of the South Atlantic. A randomized draw was used to select angler intercept sites in close proximity to navigable egress points that allow boating access to the Atlantic Ocean. Unlike the randomized catch and effort survey, this supplemental biological survey was conducted year-round and coast-wide (including south of St. Lucie inlet to Key West). Additional assignments were scheduled during the South Atlantic Red snapper mini-seasons to enhance data collection during the short sampling windows. Private and charter anglers returning from offshore recreational boat-based fishing trips were intercepted (headboats were not sampled as part of this project, since NOAA Fisheries conducts extensive dockside sampling for this segment of the recreational fishery). Red snapper were among the priority species for which biological samples were taken, including lengths (at the midline in mm), weights (kg), and otoliths.

Commercial TIP Sampling:

During the limited commercial seasons (2012-2014 & 2017-2019), FWC biologists made a special effort to visit commercial fish houses where Red Snapper are known to be landed. Fish were sampled as they were offloaded from the vessels with no preference for size. Effort and trip information was also collected, including commercial zone fished, depth, and gear used. All effort and biological data were entered into the Trip Intercept Program (TIP) website.

Ageing Protocols:

Sagittal otoliths were removed from the head, cleaned, dried and stored in vials. The left otolith was processed for age determination unless it was broken through the core, in which case the right otolith was processed. The core of the otolith was marked with pencil and the whole otolith was mounted on card stock using hot glue. Otoliths were processed on a Buhler Isomet low speed saw that was equipped with four equally spaced diamond wafering blades. With this multi-blade technique, one transverse cut yields three ~400μm thick sections that encompass both the core and the entire region surrounding the core (Vanderkooy 2009). After processing, sections were mounted on glass slides with Flo-texx, a chemical mounting medium.

Sectioned otoliths were examined on a stereo microscope using either reflected or transmitted light, which was at the reader's discretion. Each otolith was examined with at least two blind reads. These reads were conducted either by two readers working independently, or by a single reader examining the otolith two separate times. When age estimates did not agree between reads, a third read was conducted to resolve the discrepancy. Ageing was conducted on the dorsal lobe of the otolith along an axis near the sulcal groove from the core to the edge.

Annual ages were calculated using annulus count (number of opaque zones), degree of marginal completion, average date of otolith increment deposition, and date of capture. This traditional method is based on a calendar year instead of time since spawning (Jerald 1983; VanderKooy 2009). Previous studies have found that Red Snapper off the Southeastern US complete annulus formation by late spring to early summer (Wilson and Nieland 2001; White and Palmer 2004, Allman, et al. 2005). Using these criteria, age was advanced by one year if a large translucent zone was visible on the margin and the capture date was between January 1 and June 30. For all fish collected after June 30, age was assigned to be annulus count, since opaque zone formation is typically complete (Allman, et al. 2005). Calendar ages were converted to fractional, or monthly biological, ages by adding or subtracting the fraction of a year calculated between the assumed July 1 birth date and month of capture.

Six readers aged the collection of otoliths from FWRI sampling on the East Coast of Florida (n=23,433). Prior to ageing these samples, each reader read through an in-house reference set of Red Snapper otoliths representing a range of age classes, seasons, sexes and collection locations (Campana 2001) to calibrate ageing technique, particularly identification and interpretation of the first annulus and margin type. Quality control subsets were read each sampling year by all active readers to estimate precision. Readers were assigned different portions of the collections for individual reading. The average percent error (APE) on all first and second reads was 1.22%, which is considered highly precise (Campana 2001); moreover, there was an 90% age agreement between all first and second reads, and a 99% agreement +/- 1 year. All age data provided for SEDAR73 included increment count, calendar age and fractional age; however, the summaries including ages in this report were based on adjusted calendar age.

Fishery-Independent Results:

All fishery-independent age data have been independently provided to the life history workgroup; what follows is a summary of aged Red Snapper. Age data collected between 2012 and 2018 are summarized for a total of 5,346 Red Snapper for which ages were obtained from a total of 5,303 fish. Red Snapper were collected along a broad geographic area from the Atlantic coast of Florida between 2012 – 2018 in association with various fishery-independent research and monitoring projects (Figures 1 – 7). Between 2012 – 2018 research projects designed to test the efficacy of hooked-gears, specifically repetitive actively fished hook-and-line (RTD), collected Red Snapper throughout the survey area in depths ranging from 15 – 87 meters (Figures 1- 6), which represent depths well within the depth limits of the various projects. The pilot study conducted between 2014 - 2016 to evaluate the utility of trawls and small fish traps in providing fisheries-independent data for juvenile (age 0-1) Red Snapper showed that most Red Snapper were captured in nearshore waters (<30 m deep), indicating that in the Atlantic, shallow, coastal waters likely function as nursery habitat for Red Snapper (Figure 7).

A total of 1,472 individuals (1,446 random and 26 nonrandom culls) were collected during the 2012 -2013 tagging study and the 2012 fishery-independent hooked-gear study (Figures 8 -12).

Ages from these two studies ranged from 1 to 21 years of age, although 90% of individuals were six years old or younger (Figures 8 -12). The age distribution was bimodal, with exceptionally high numbers of age-3 and age-5 Red Snapper, corresponding to the 2009 and 2007 year classes, respectively. Ages of Red Snapper collected during the 2014- 2015 RTD hooked-gear study that focused on spawning aggregations of Red Snapper, Scamp, and Gag showed a higher frequency of older (5 -10 years) Red Snapper than the previous RTD hooked-gear studies conducted in 2012 – 2013 (Figure 13). Ages of Red Snapper collected during the 2016 selectivity study (N = 324, Figure 16), the 2017 survey (N = 492, Figure 19), and the 2018 comparison study (N = 1,962, Figure 22) continued to exhibit strong recruitment with high numbers of Red Snapper < 5 years old. In addition, results of the 2018 comparison study indicated that Red Snapper in the U.S. South Atlantic were exhibiting continued recovery, as evidenced by both a dramatic increase in juvenile recruitment as well as an increase the overall abundance of older fish in the population.

A total of 443 Red Snapper were collected during the pilot study conducted between 2014 - 2016 to evaluate the utility of trawls and small fish traps in providing fisheries-independent data for juvenile (age 0-1) Red Snapper. A total of 223 Red Snapper were collected in trawl samples of which 82% of the overall catch were age 0 fish (Figure 25). Trap samples captured a total of 220 Red Snapper of which 66% were classified as age 1 fish (Figure 25).

Generally, no notable differences in age distribution were evident between males and females for the RTD hooked-gear studies conducted between 2012 – 2018. For the non-spawning aggregation RTD hooked-gear studies, the majority of the oldest fish aged were males (Figures 11, 17, 20, 23), however the opposite was observed in the RTD sampling conducted during the spawning aggregation study (Figure 14). An examination of age-specific depths of capture did not identify a significant increase in depth with age in the RTD hooked-gear fishery-independent studies (Figures 12, 15, 18, 21, 24).

Fishery-Dependent Results:

All fishery-dependent age data have been provided to the life history workgroup; what follows is a summary of aged Red Snapper. Age data are summarized for a total of 18,130 individuals for which ages were obtained. A total of 3,441 samples were collected from the commercial sector (3,441 samples); and the majority of age samples were obtained from surveys of the recreational sector, including 8,015 samples from private recreational boat trips, 4,609 from charter trips, and 3,441 from headboats. In addition, fishing tournaments accounted for 322 samples. Approximately 45% (8,165 samples) of Red Snapper were unsexed.

Overall, results largely mirrored those from the fishery-independent surveys. There were some notable differences in age-frequency distribution among the various fishing sectors surveyed. Notably, the commercial (Figure 27) and headboat fisheries (Figure 28) generally targeted younger Red Snapper than seen in the private boat or tournament fisheries. Over the full time series, the headboat fleet targeted the youngest fish with a mean age of 3.57 (SD±1.90); 60% of the fish sampled were age-3 or younger. Across all years (2012-2019), Red snapper sampled from the charter fishery (Figure 29), private recreational fishery (Figure 30), and in association with fishing tournaments (Figure 31) were all somewhat older, with mean ages of 5.60 (SD±2.97), 5.65 (SD±3.08), and 6.52 (SD±3.23) years of age, respectively. Unlike the headboat fleet, fish sampled from the private-boat, charter and tournaments, show a broader age distribution; more than 65% of the fish sampled were aged 4-9-year-old fish. The recreational and commercial fisheries were closed for two consecutive years in 2015-2016, and when fishing resumed in 2017, there was an increase in the proportion of fish landed from younger year-classes for all fishing modes, which is apparent signal of new recruitment to the fishery. In the charter and private boat fishery, there is also a higher proportion of fish in the 12-15-year age classes in the latter years (2017-2019) as compared to years prior to the closure (Figure 33). Very few older fish were sampled, although a maximum age of 32 was observed in two unsexed individuals in the commercial fishery and age 29 from an unsexed individual obtained from a tournament sample in the recreational fleet. Overall, maximum size at age levels off at just over 800 mm TL for all sectors, and there were no discernible differences in age structure or size at age by sex (Figures 27 – 31).

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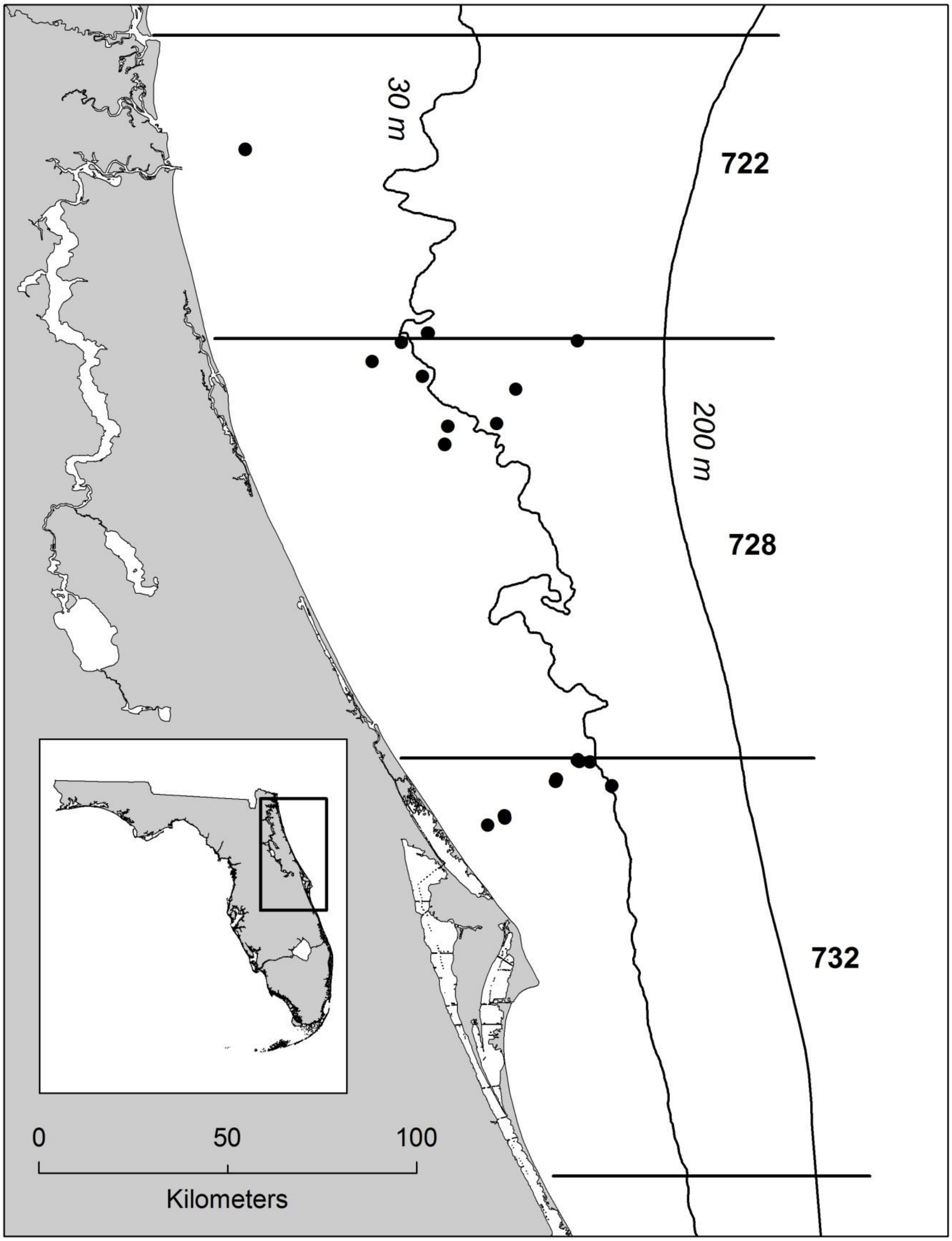


Figure 1. Locations of Red Snapper life history samples collected with actively fished hooked-gear as part of a three-year tagging study on the movement of Red Snapper. Sampling was conducted from 2011 – 2013, although life history samples were only collected in 2012 and 2013.

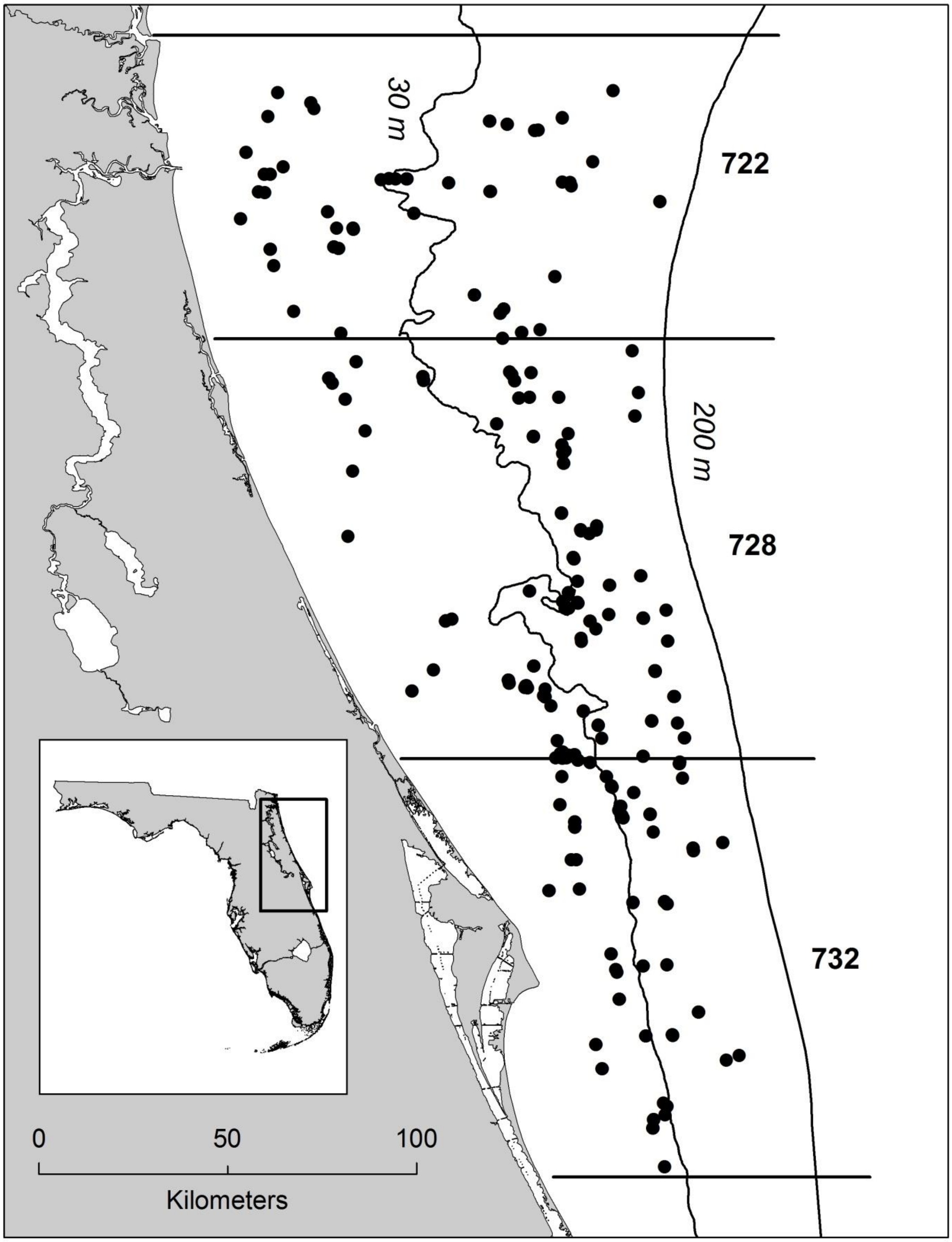


Figure 2. Locations of Red Snapper life history samples collected with vertical longlines, short bottom longlines, and RTD hooked-gear as part of a one-year pilot study on the utility of fishery-independent hooked-gears conducted in 2012.

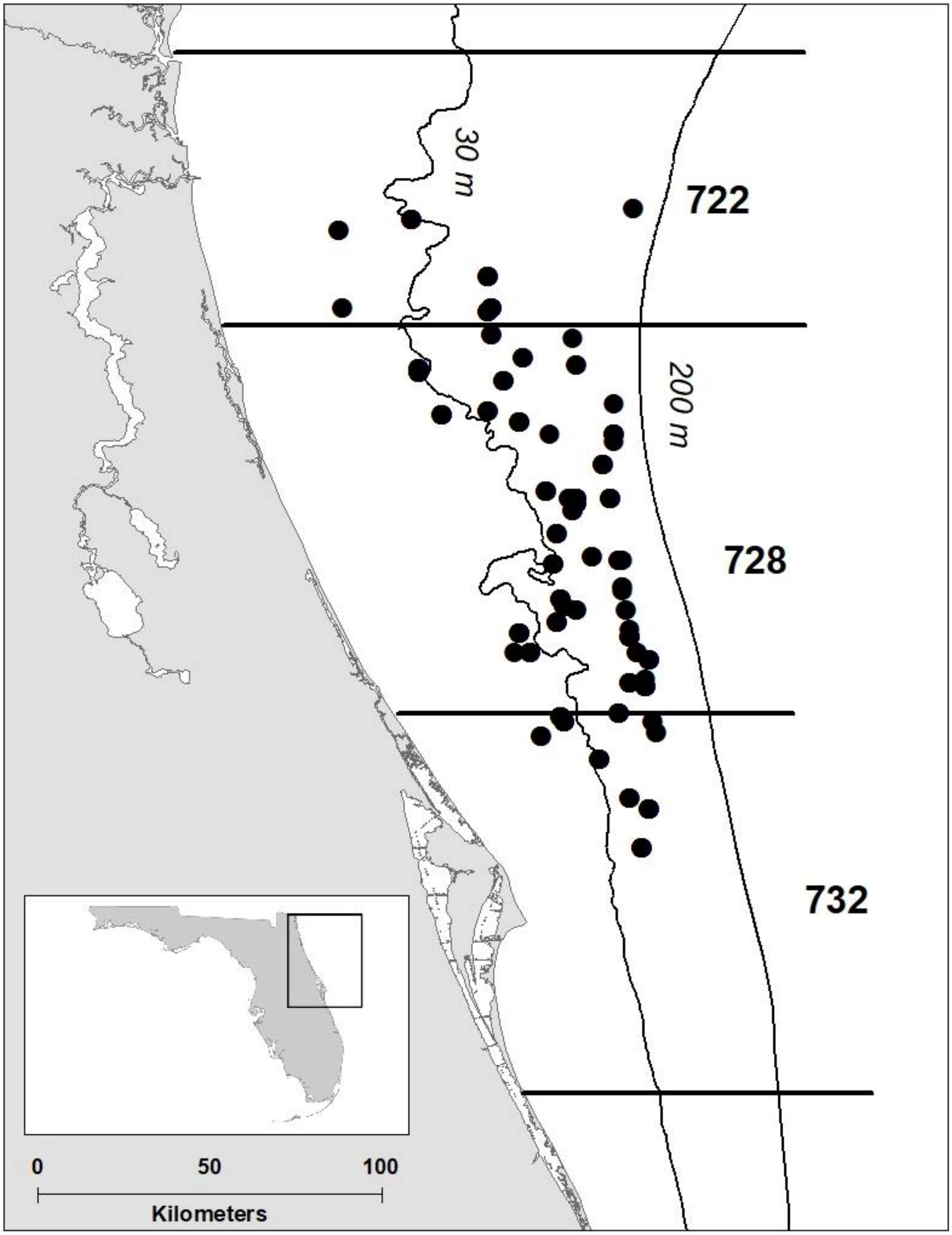


Figure 3. Locations of Red Snapper life history samples collected with RTD hooked-gear as part of a two-year study on spawning aggregations of Red Snapper and Gag and Scamp grouper conducted from 2014 – 2015.

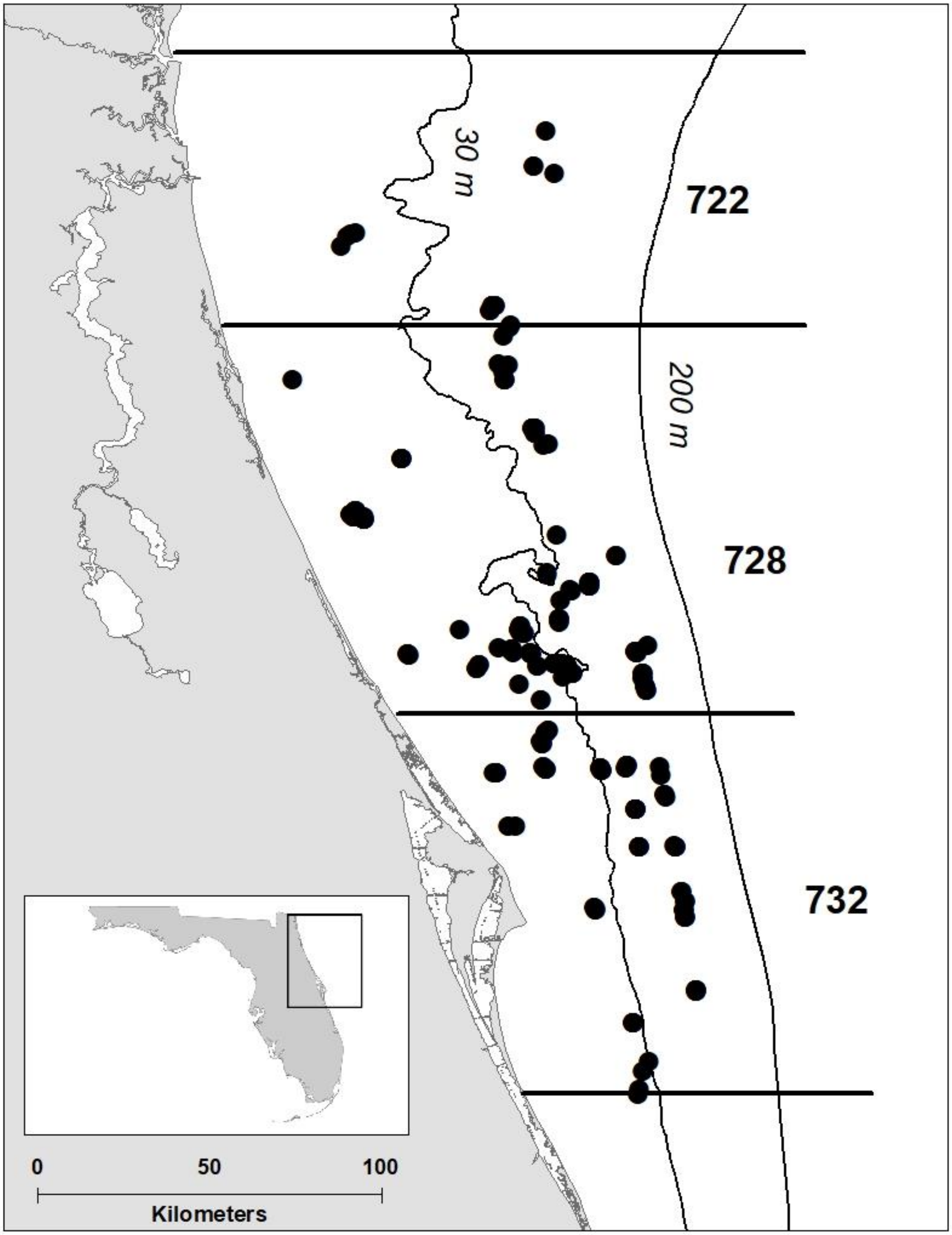


Figure 4. Locations of Red Snapper life history samples collected as part of a one-year study to the assess the size-selectivity of hook and line gear, chevron traps, and underwater cameras for Red Snapper conducted in 2016.

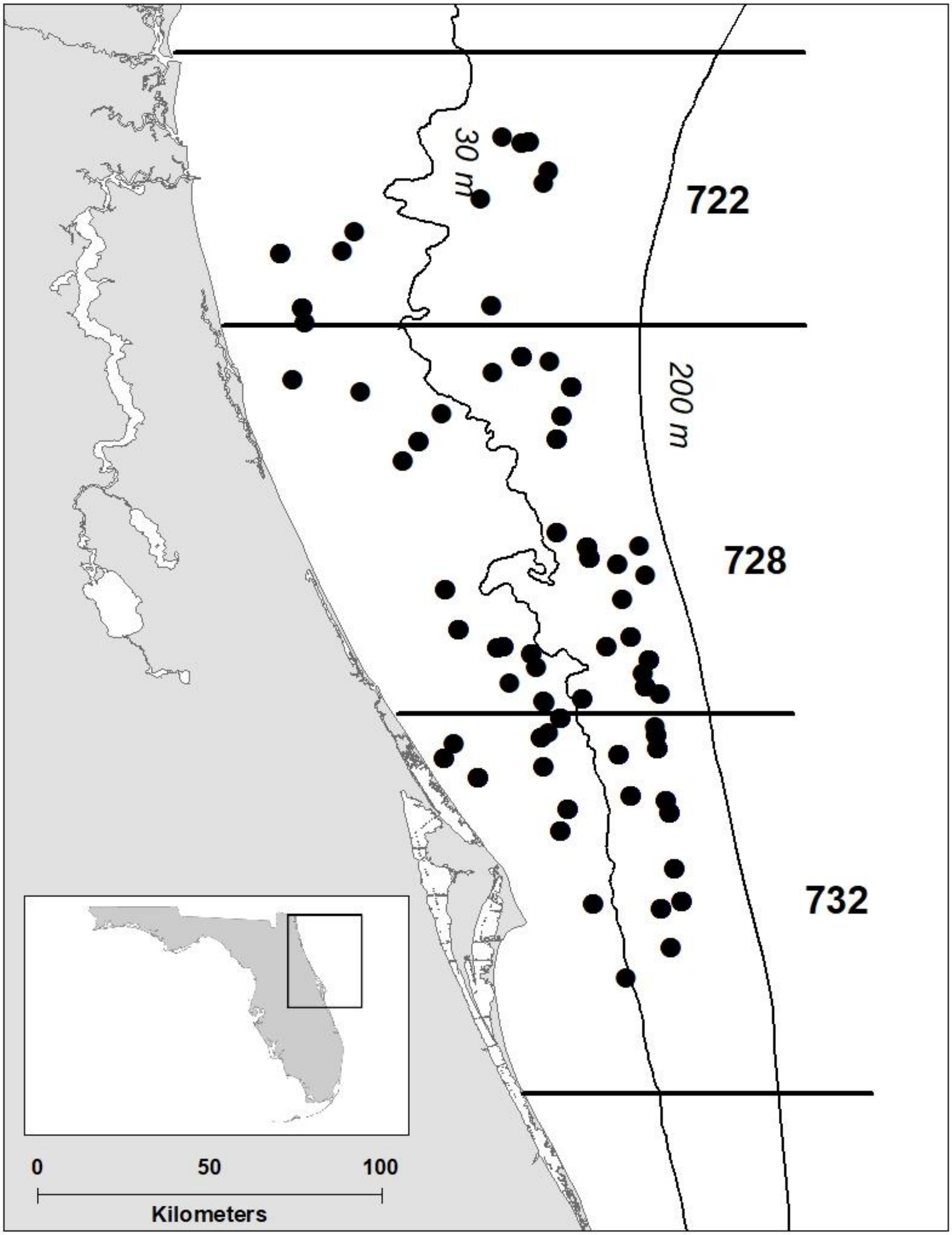


Figure 5. Locations of Red Snapper life history samples collected with RTD hooked-gear as part of a one-year fisheries-independent hooked-gear survey of reef fishes conducted in 2017.

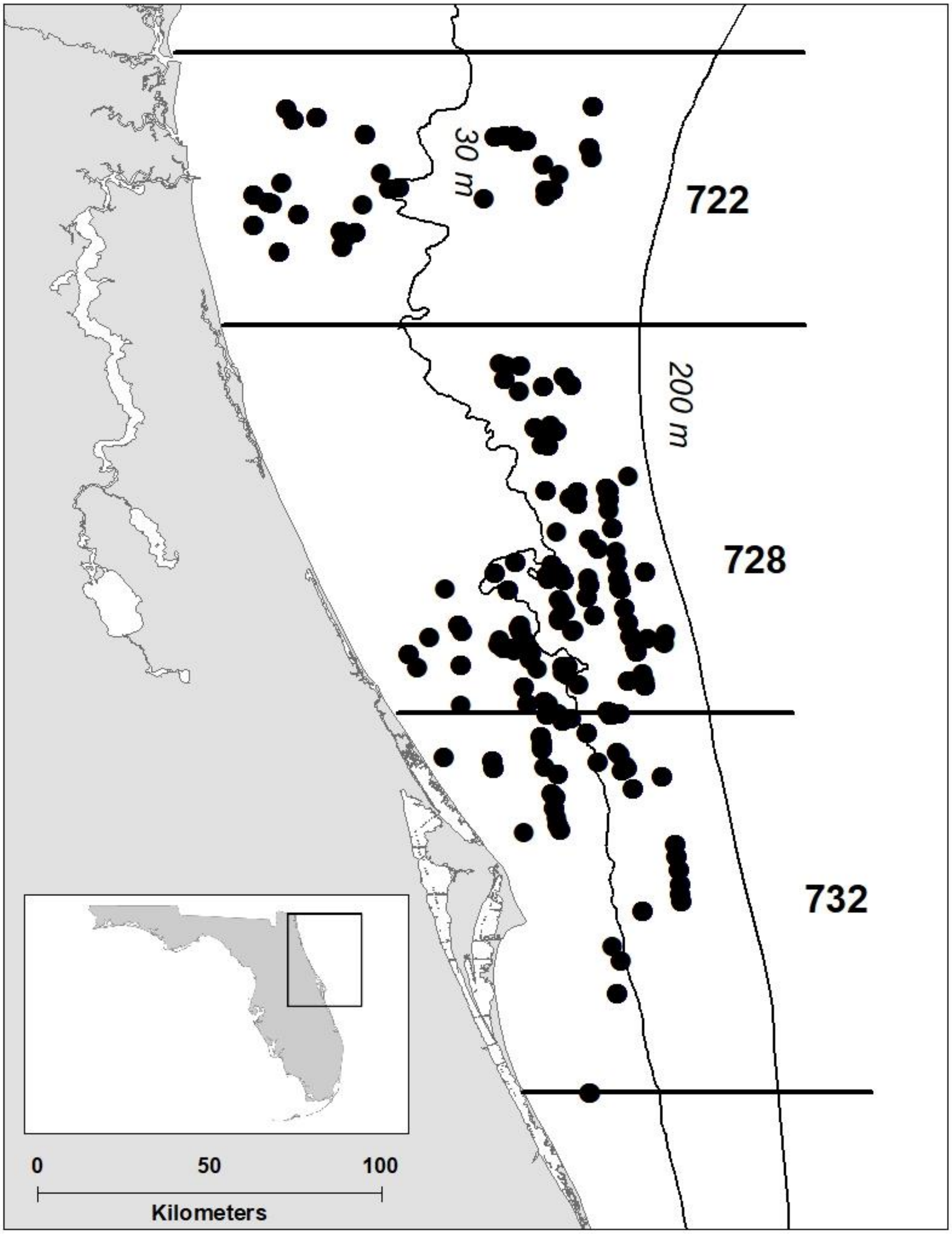


Figure 6. Locations of Red Snapper life history samples collected with RTD hooked-gear as part of a one-year hooked-gear study to the assess the expansion of Red Snapper size and age composition during an ongoing fishing moratorium between 2012 and 2018. Sampling was conducted in 2018.

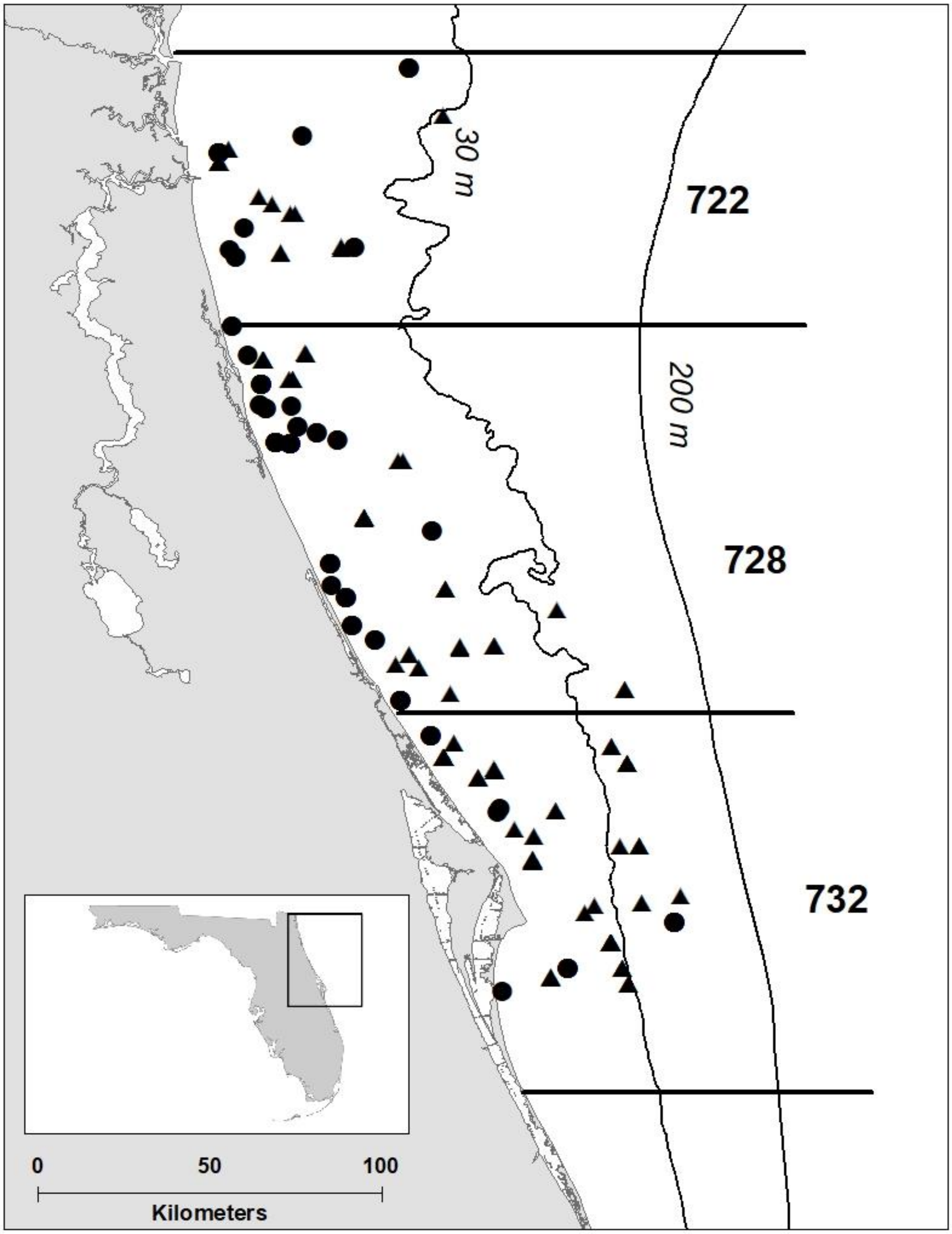


Figure 7. Locations of Red Snapper life history samples collected as part of a two-year pilot study on the utility of small mesh traps and trawls for developing indices of abundance for juvenile (age 0-1) Red Snapper conducted from 2015 – 2016. Triangles represent samples collected from small mesh z-traps, and circles represent samples collected from trawl samples.

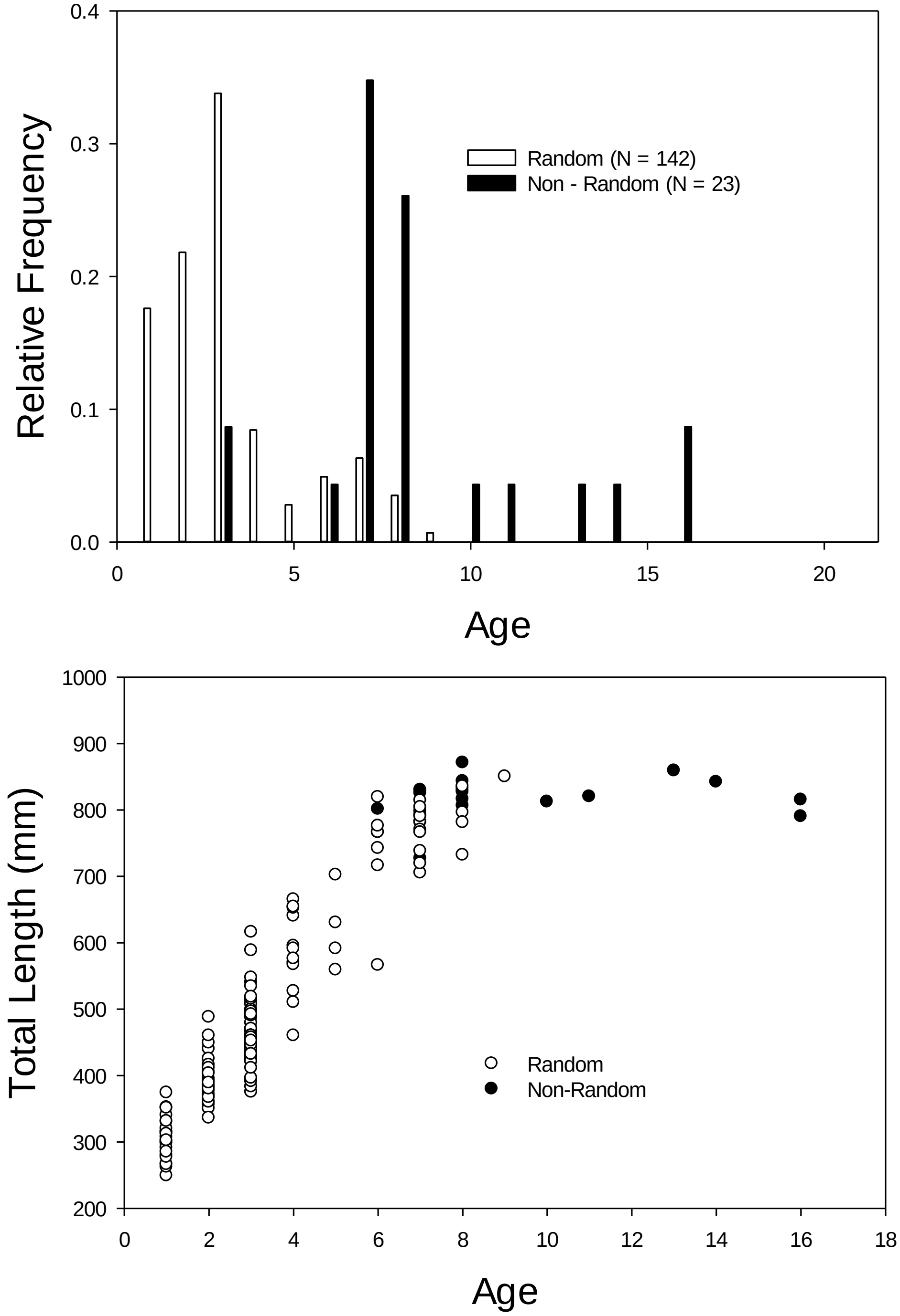


Figure 8. Summaries of age-frequency distributions (upper panel) and size at age (lower panel) for Red Snapper collected with actively fished hooked-gear in association with a tagging study conducted in 2012 and 2013. Note that these plots include both randomly and non-randomly culled Red Snapper.

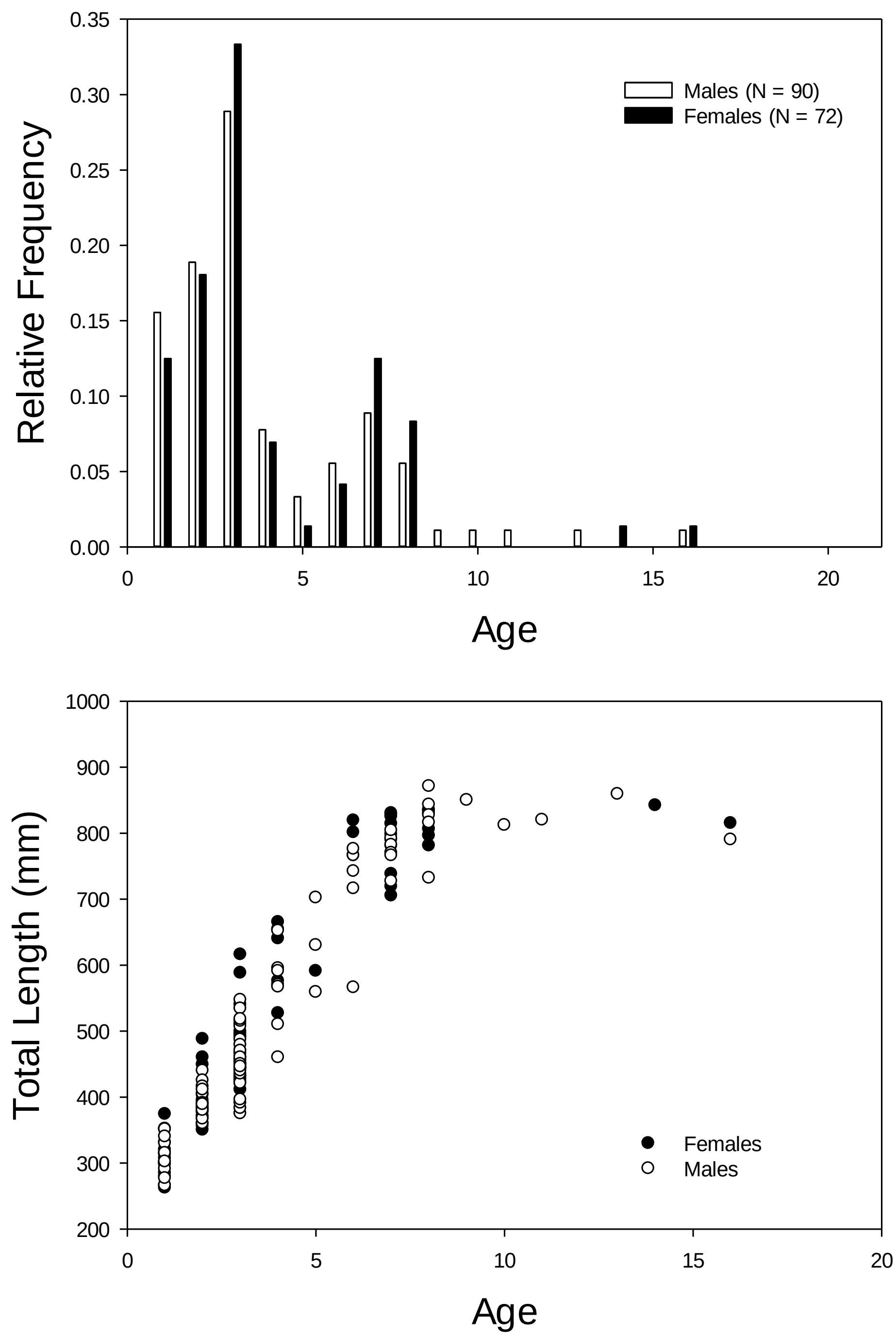


Figure 9. Summaries of age-frequency distributions (upper panel) and size at age (lower panel) by sex for Red Snapper collected with actively fished hooked-gear in association with a tagging study conducted in 2012 and 2013. Note that these plots include both randomly and non-randomly culled Red Snapper.

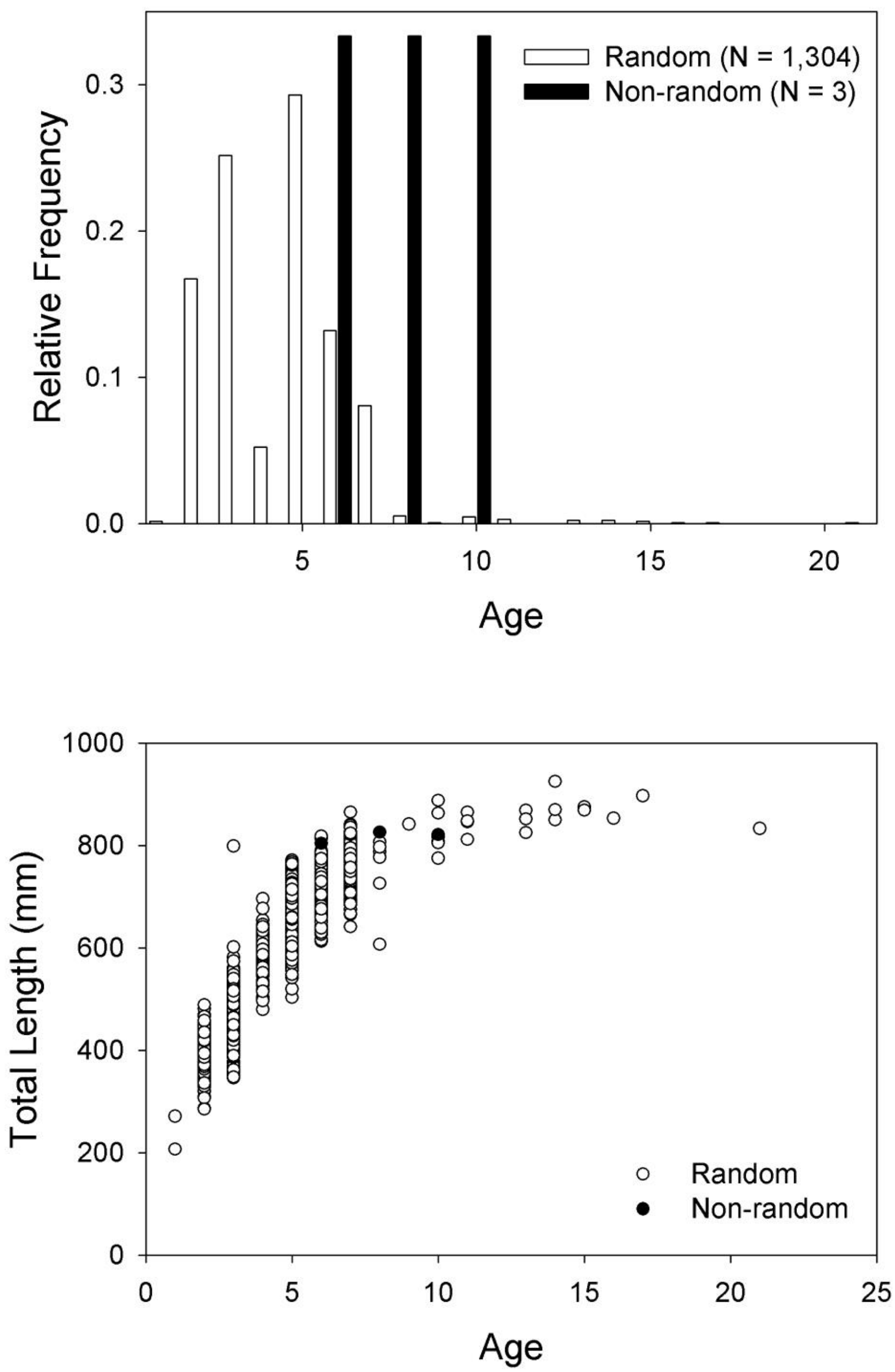


Figure 10. Summaries of age-frequency distributions (upper panel) and size at age (lower panel) for Red Snapper collected with vertical longlines, short bottom longlines, and RTD hooked-gear in association with fishery-independent hooked-gear surveys conducted in 2012. Note that these plots include both randomly and non-randomly culled Red Snapper.

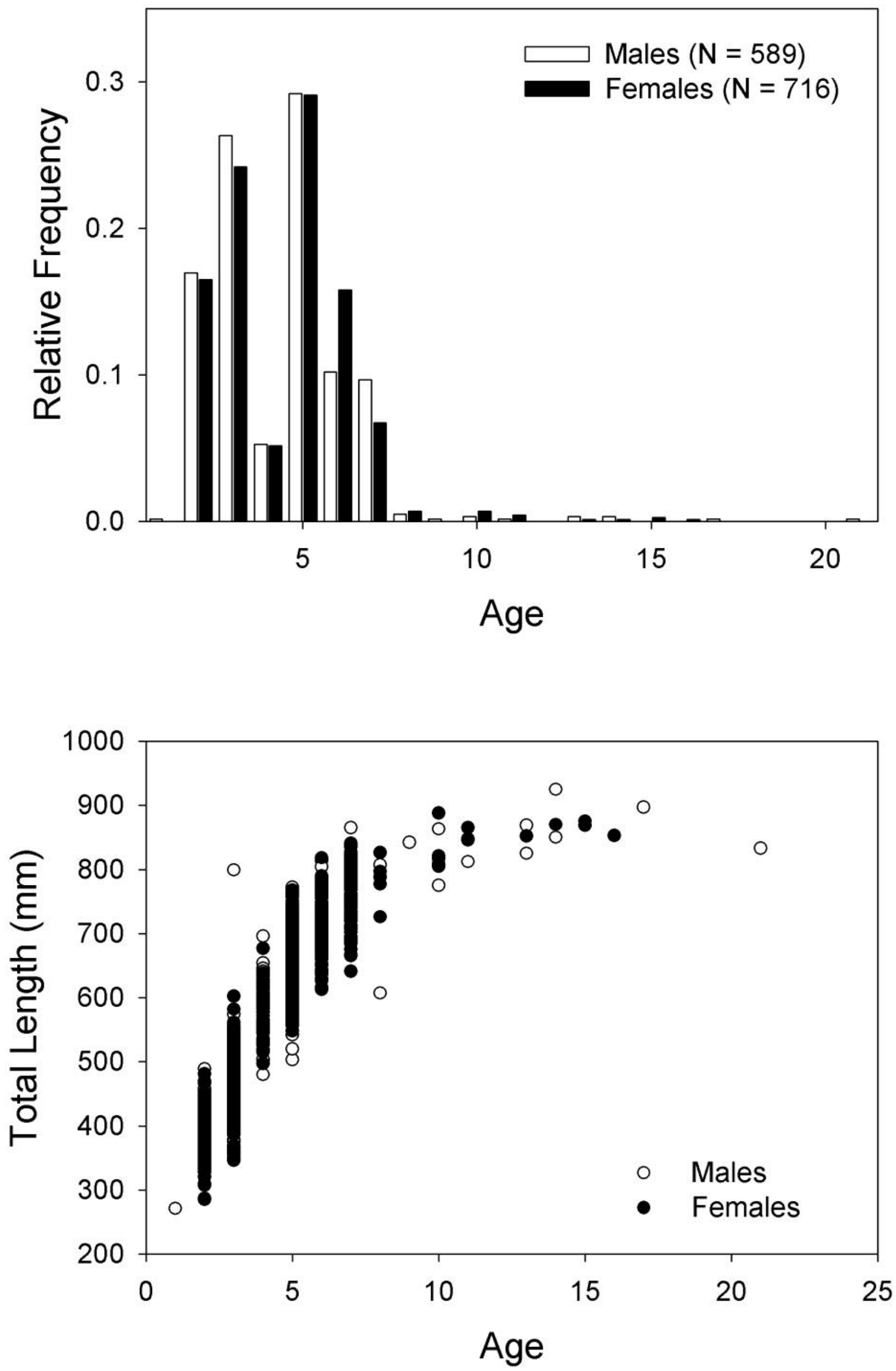


Figure 11. Summaries of age-frequency distributions (upper panel) and size at age (lower panel) by sex for Red Snapper collected with vertical longlines, short bottom longlines, and RTD hooked-gear in association with fishery-independent hooked-gear surveys conducted in 2012. Note that these plots include both randomly and non-randomly culled Red Snapper.

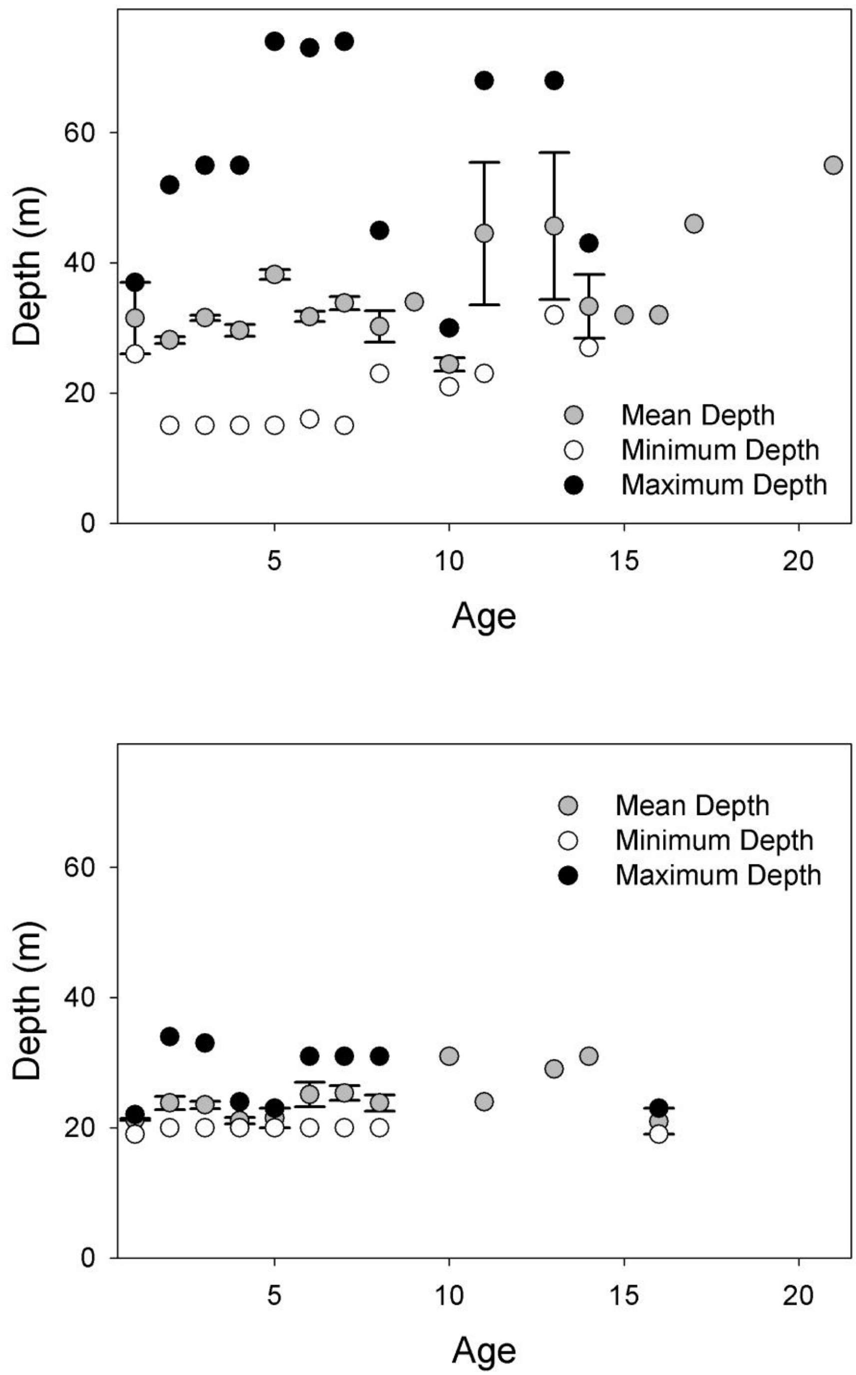


Figure 12. Summary of mean (± SE), minimum, and maximum depths (m) of capture by age for Red Snapper collected with vertical longlines, short bottom longlines, and RTD hooked-gear in association with fishery-independent hooked-gear surveys conducted in 2012 (upper panel) and a tagging study conducted in 2012 and 2013 (lower panel).

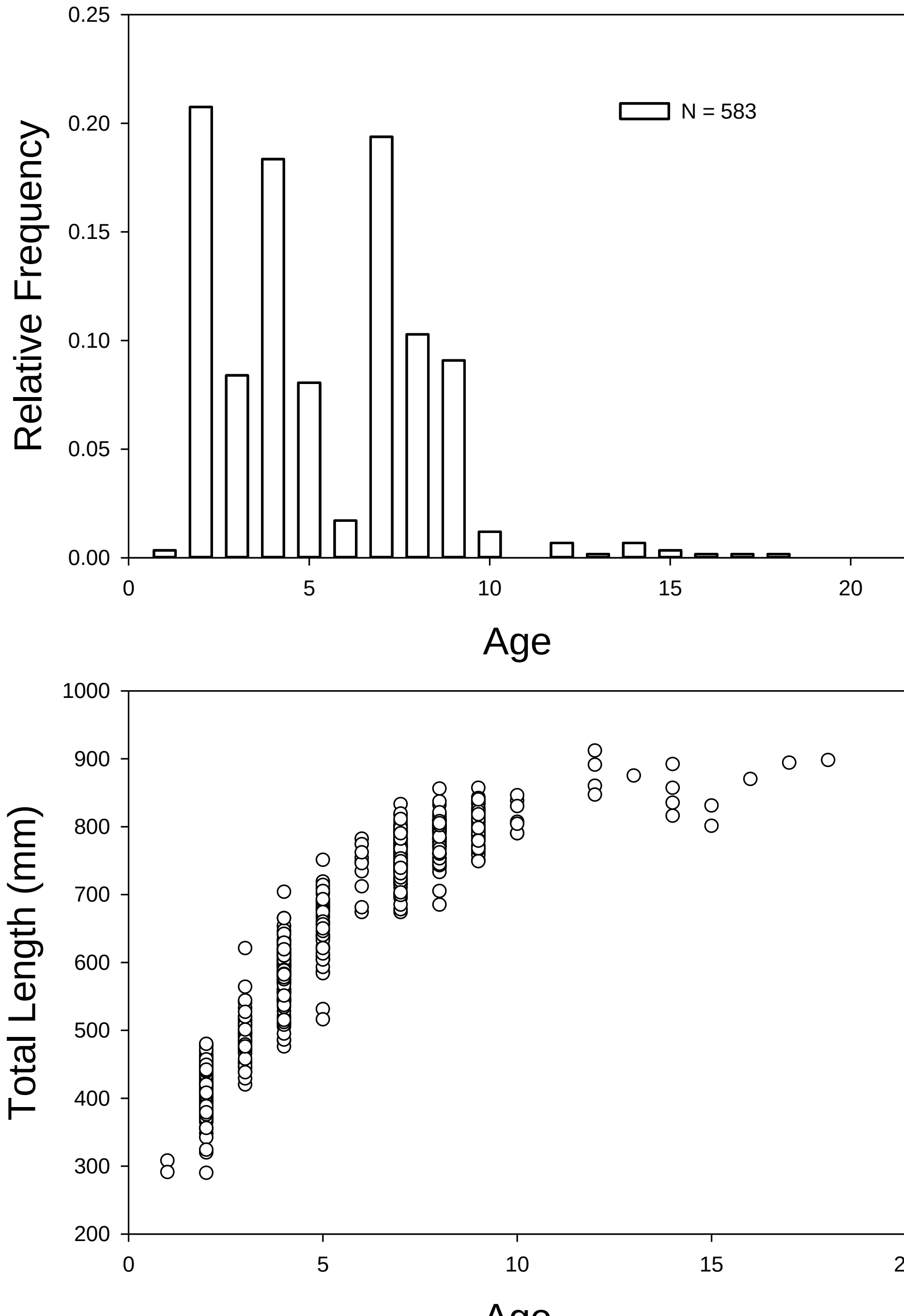


Figure 13. Summaries of age-frequency distributions (upper panel) and size at age (lower panel) for Red Snapper collected with RTD hooked-gear as part of a two-year study on spawning aggregations of Red Snapper, Gag, and Scamp conducted from 2014 – 2015.

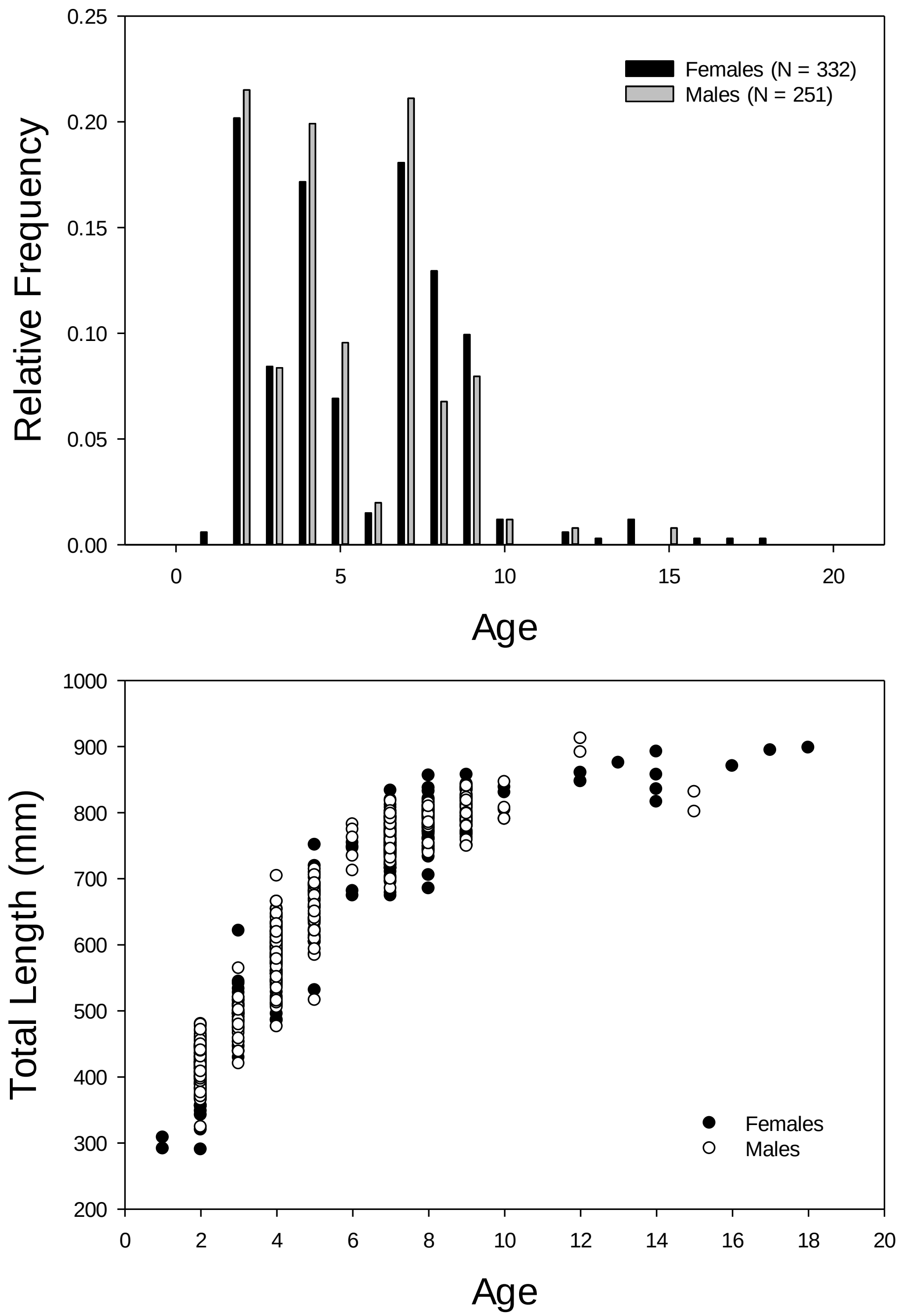


Figure 14. Summaries of age-frequency distributions (upper panel) and size at age (lower panel) by sex for Red Snapper collected with RTD hooked-gear as part of a two-year study on spawning aggregations of Red Snapper, Gag, and Scamp conducted from 2014 – 2015.

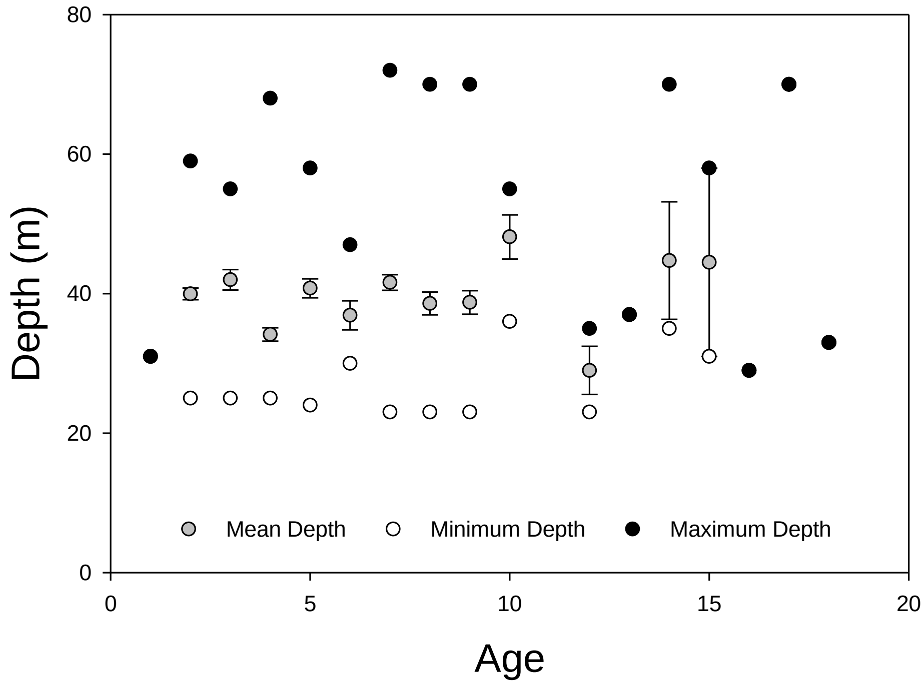


Figure 15. Summary of mean (± SE), minimum, and maximum depths (m) of capture by age for Red Snapper collected with RTD hooked-gear as part of a two-year study on spawning aggregations of Red Snapper, Gag, and Scamp conducted from 2014 – 2015.

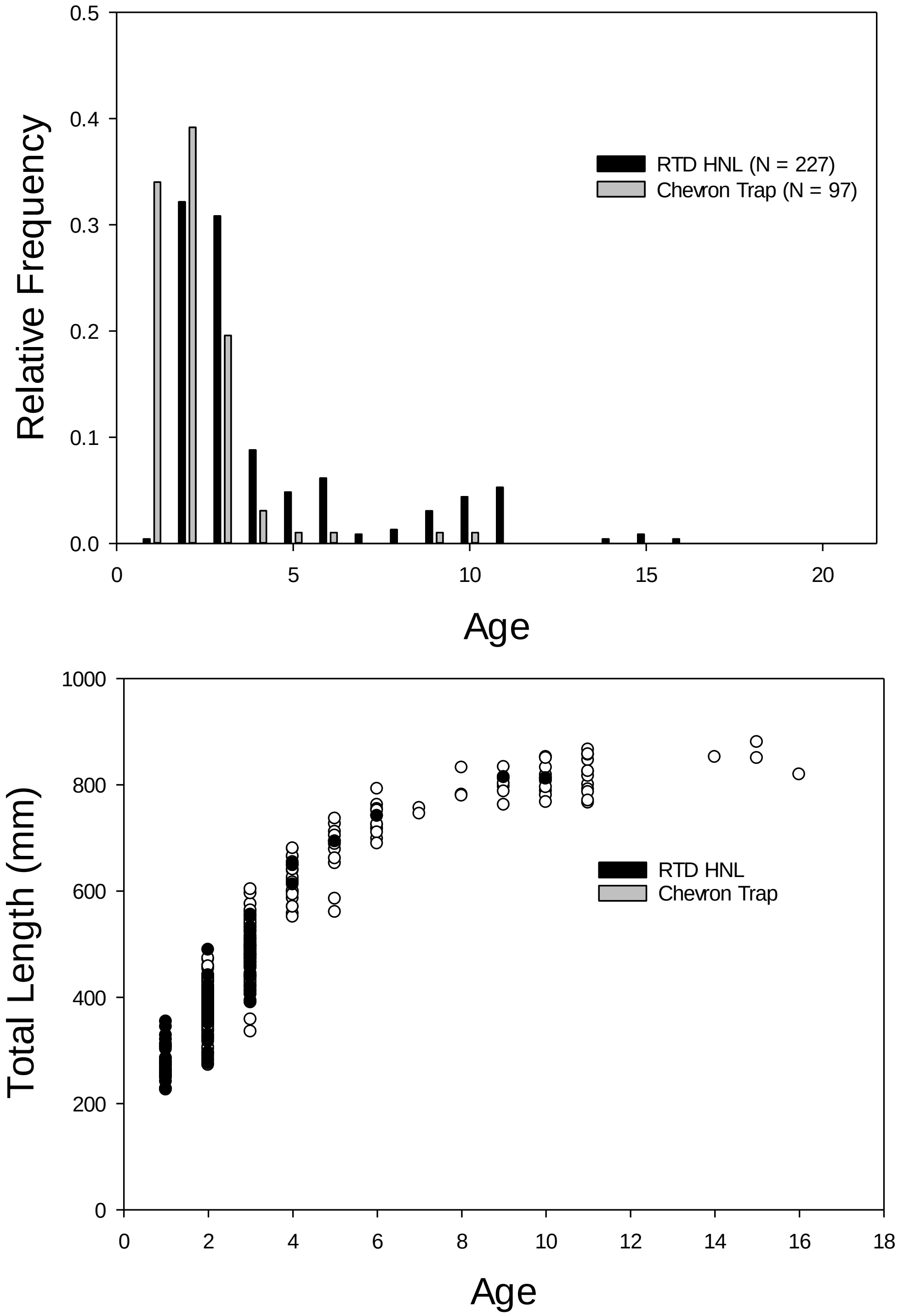


Figure 16. Summaries of age-frequency distributions (upper panel) and size at age (lower panel) by gear type for Red Snapper collected as part of a one-year study to the assess the size-selectivity of hook and line gear, chevron traps, and underwater cameras for Red Snapper conducted in 2016.

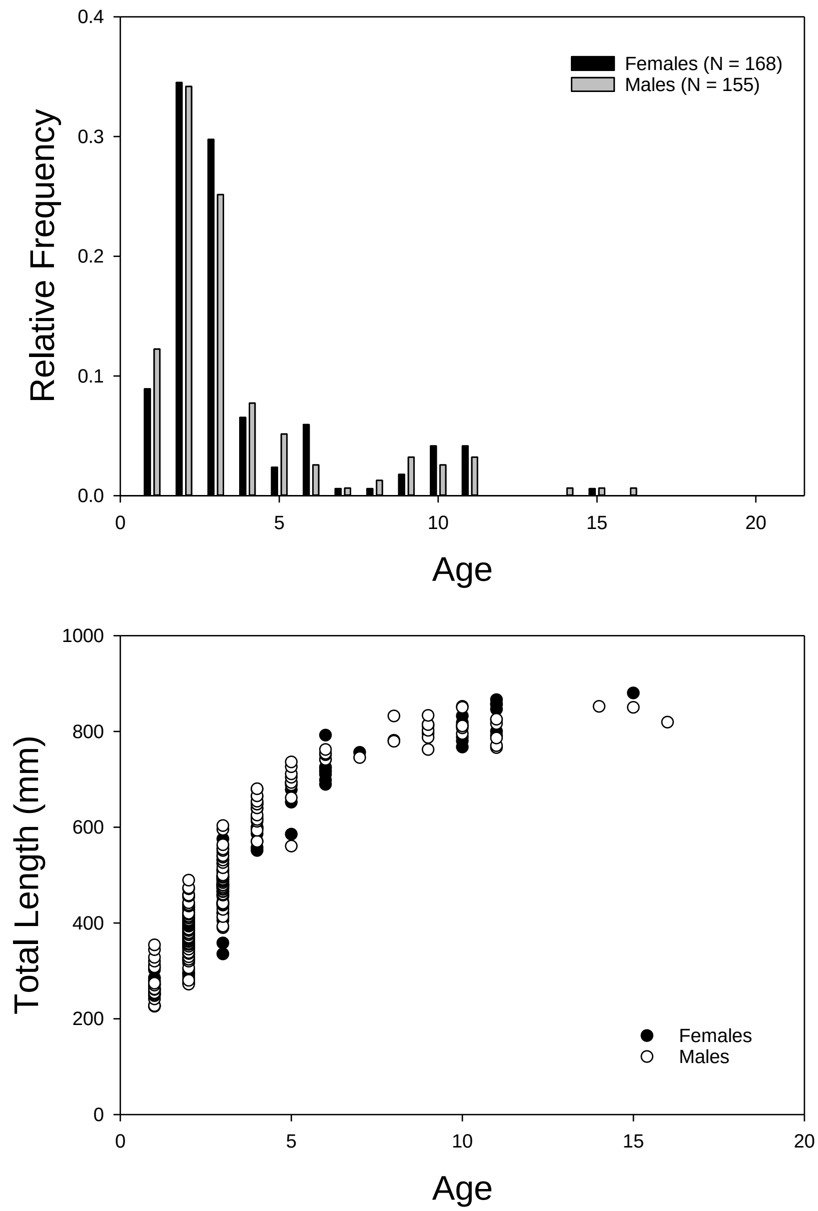


Figure 17. Summaries of age-frequency distributions (upper panel) and size at age (lower panel) by sex for Red Snapper collected as part of a one-year study to the assess the size-selectivity of hook and line gear, chevron traps, and underwater cameras for Red Snapper conducted in 2016.

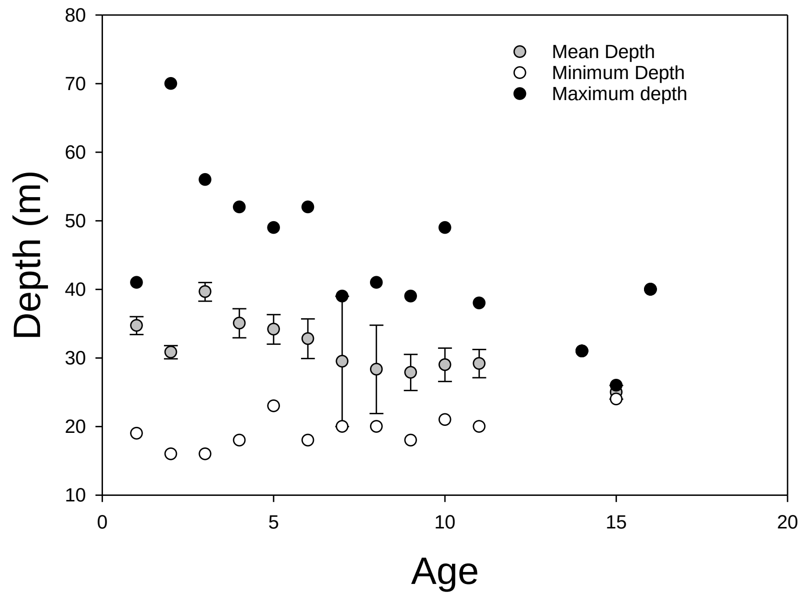


Figure 18. Summary of mean (± SE), minimum, and maximum depths (m) of capture by age for Red Snapper collected as part of a one-year study to the assess the size-selectivity of hook and line gear, chevron traps, and underwater cameras for Red Snapper conducted in 2016.

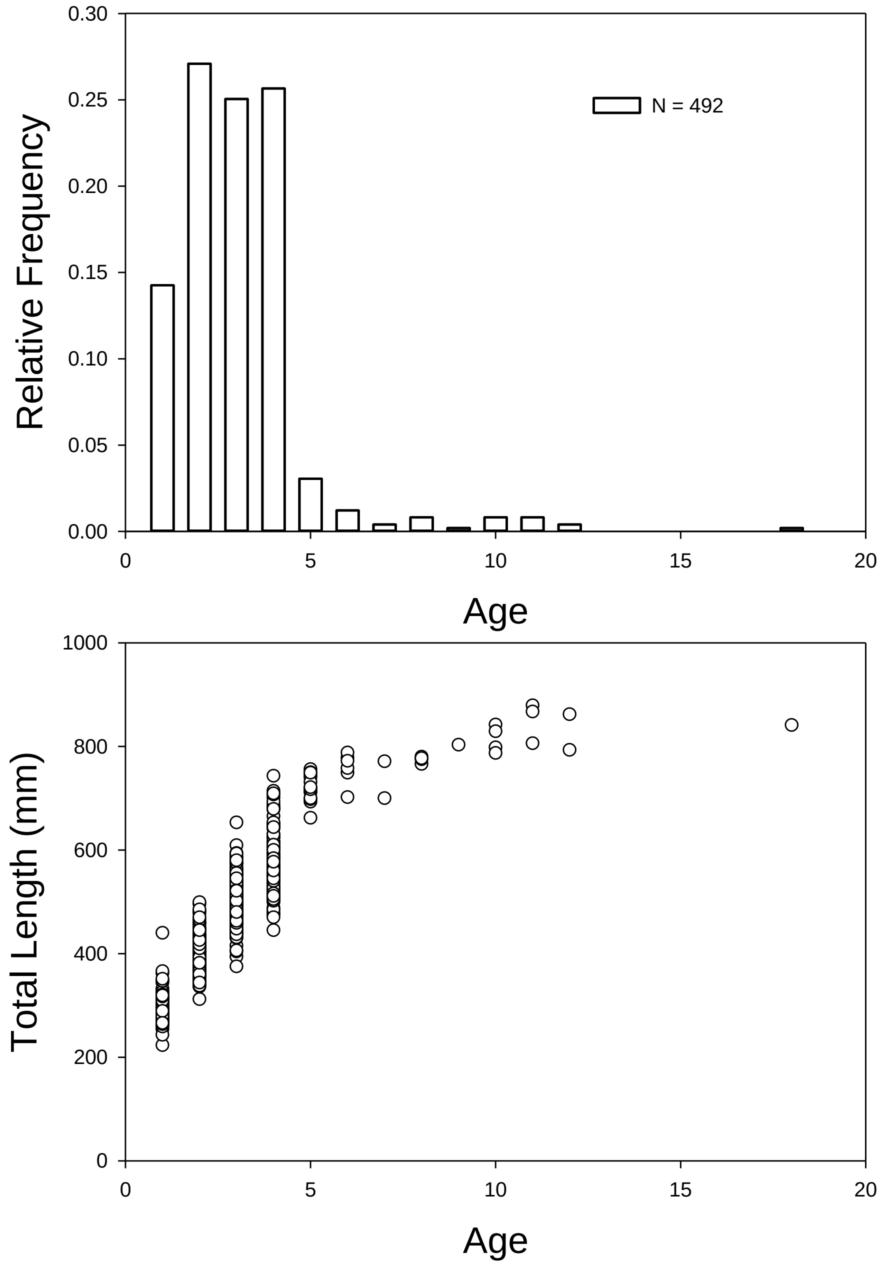


Figure 19. Summaries of age-frequency distributions (upper panel) and size at age (lower panel) for Red Snapper collected with RTD hooked-gear as part of a one-year fisheries-independent hooked-gear survey of reef fishes conducted in 2017.

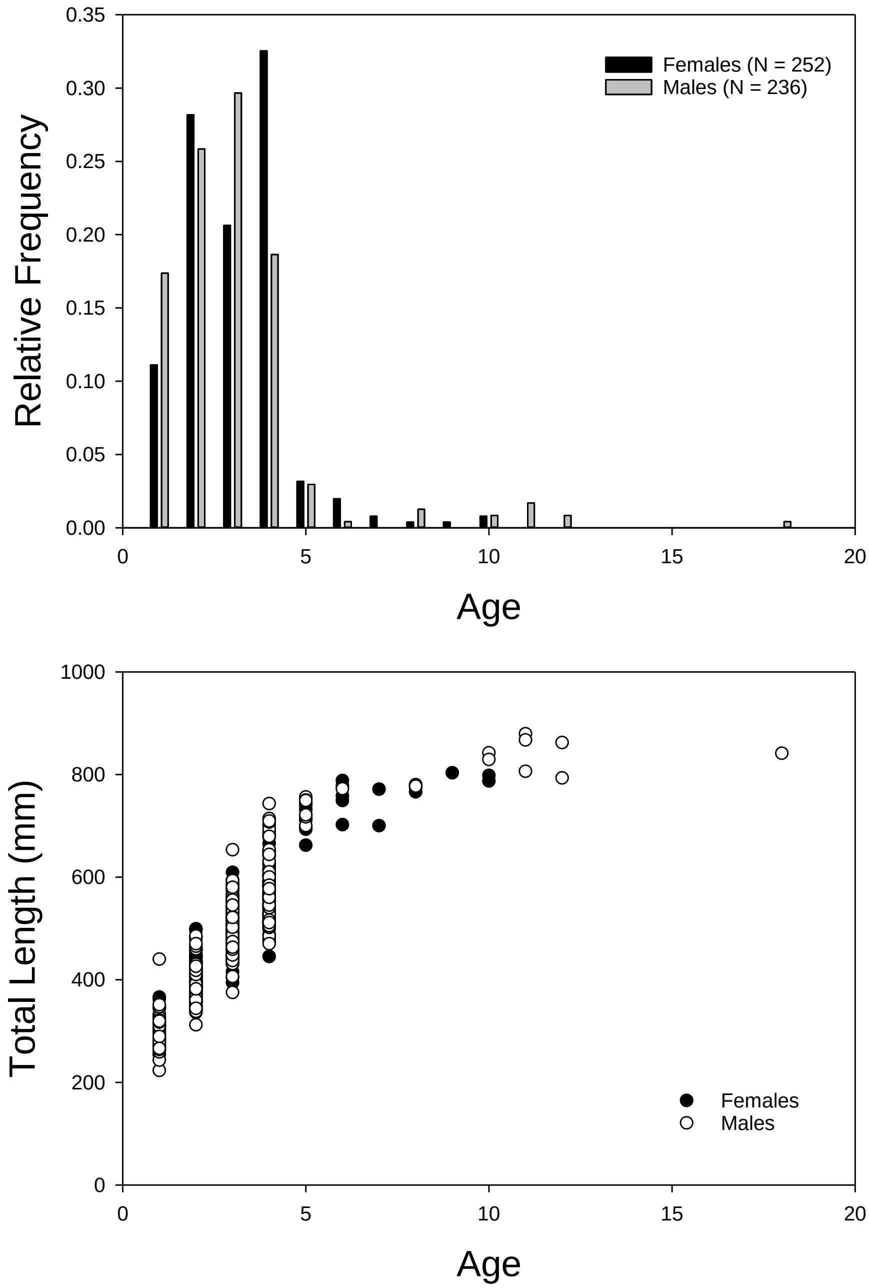


Figure 20. Summaries of age-frequency distributions (upper panel) and size at age (lower panel) by sex for Red Snapper collected with RTD hooked-gear as part of a one-year fisheries-independent hooked-gear survey of reef fishes conducted in 2017.

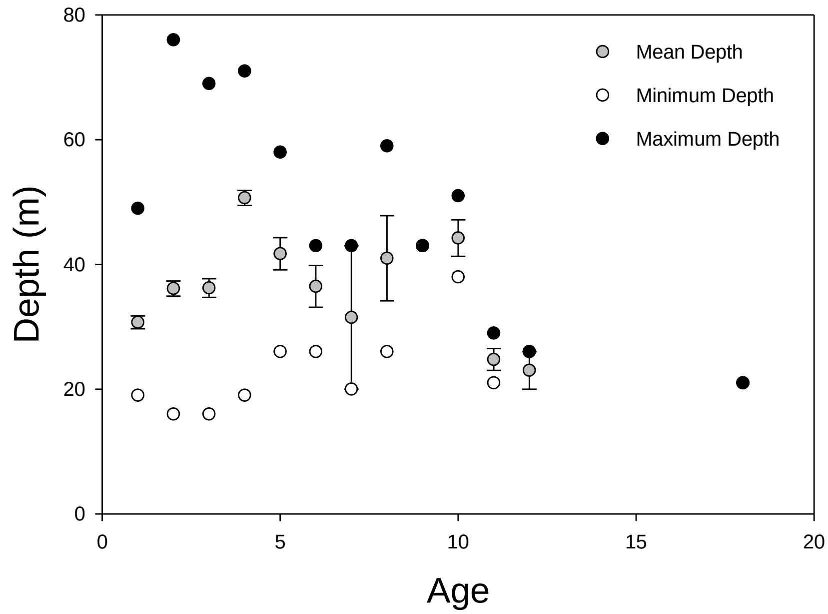


Figure 21. Summary of mean (± SE), minimum, and maximum depths (m) of capture by age for Red Snapper collected with RTD hooked-gear as part of a one-year fisheries-independent hooked-gear survey of reef fishes conducted in 2017.

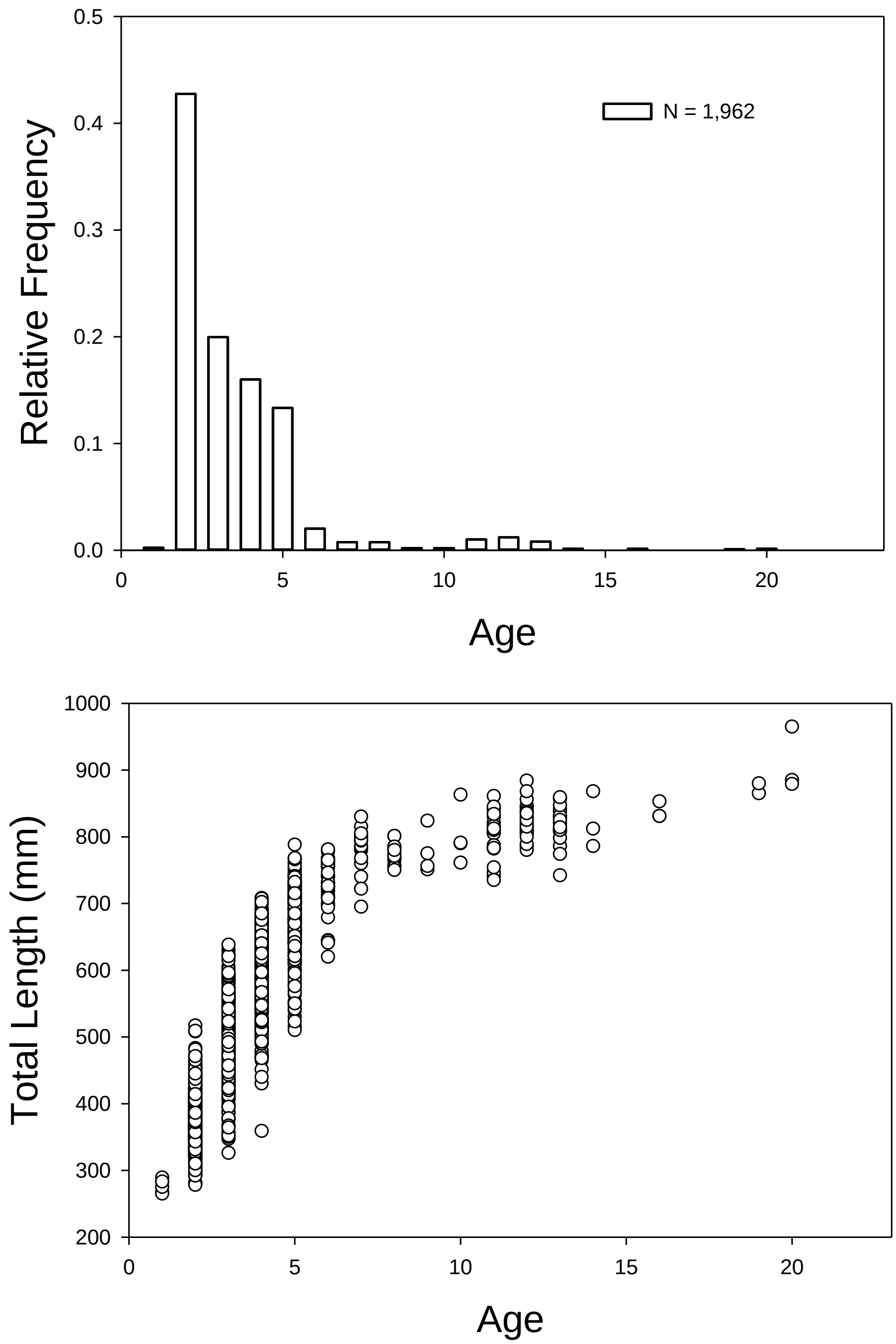


Figure 22. Summaries of age-frequency distributions (upper panel) and size at age (lower panel) for Red Snapper collected with RTD hooked-gear as part of a one-year hooked-gear study to the assess the expansion of Red Snapper size and age composition during an ongoing fishing moratorium between 2012 and 2018. Sampling was conducted in 2018.

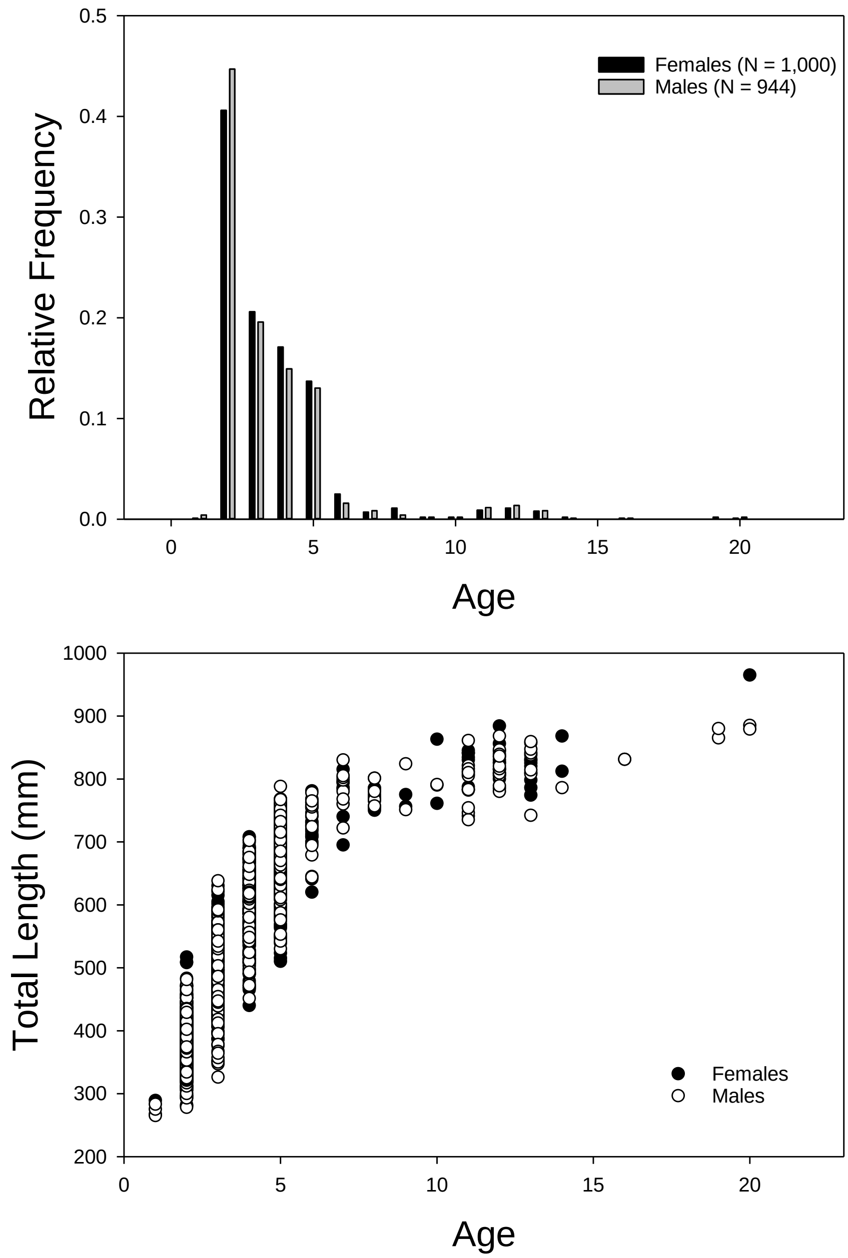


Figure 23. Summaries of age-frequency distributions (upper panel) and size at age (lower panel) by sex for Red Snapper collected with RTD hooked-gear as part of a one-year hooked-gear study to the assess the expansion of Red Snapper size and age composition during an ongoing fishing moratorium between 2012 and 2018. Sampling was conducted in 2018.

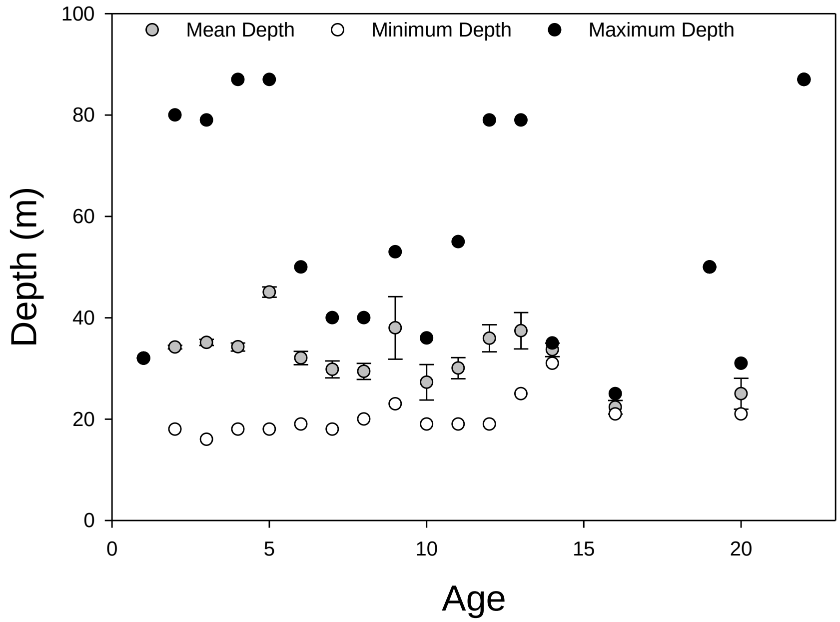


Figure 24. Summary of mean (± SE), minimum, and maximum depths (m) of capture by age for Red Snapper collected with RTD hooked-gear as part of a one-year hooked-gear study to the assess the expansion of Red Snapper size and age composition during an ongoing fishing moratorium between 2012 and 2018. Sampling was conducted in 2018.

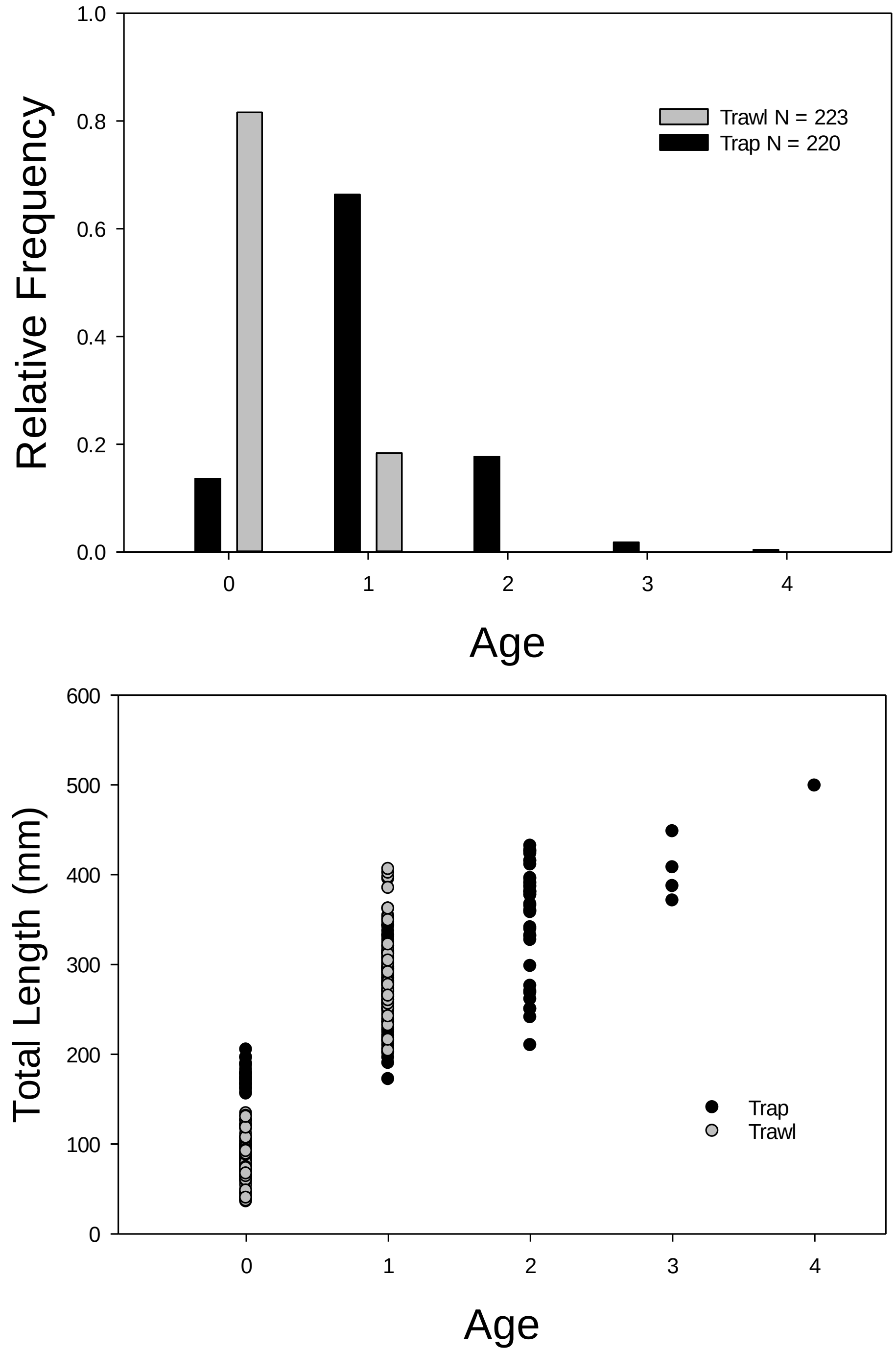


Figure 25. Summaries of age-frequency distributions (upper panel) and size at age (lower panel) for Red Snapper collected as part of a two-year pilot study on the utility of small mesh traps and trawls for developing indices of abundance for juvenile (age 0-1) Red Snapper conducted from 2015 – 2016.

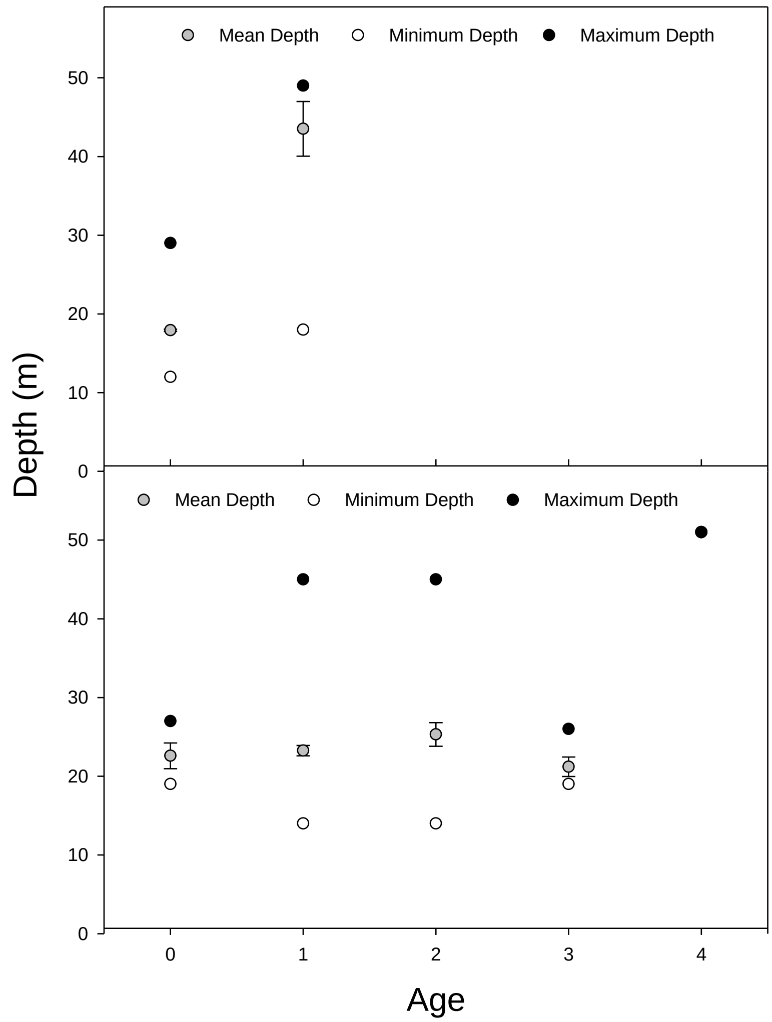


Figure 26. Summary of mean (± SE), minimum, and maximum depths (m) of capture by age for Red Snapper collected as part of a two-year pilot study on the utility of small mesh traps and trawls for developing indices of abundance for juvenile (age 0-1) Red Snapper conducted from 2015 – 2016.

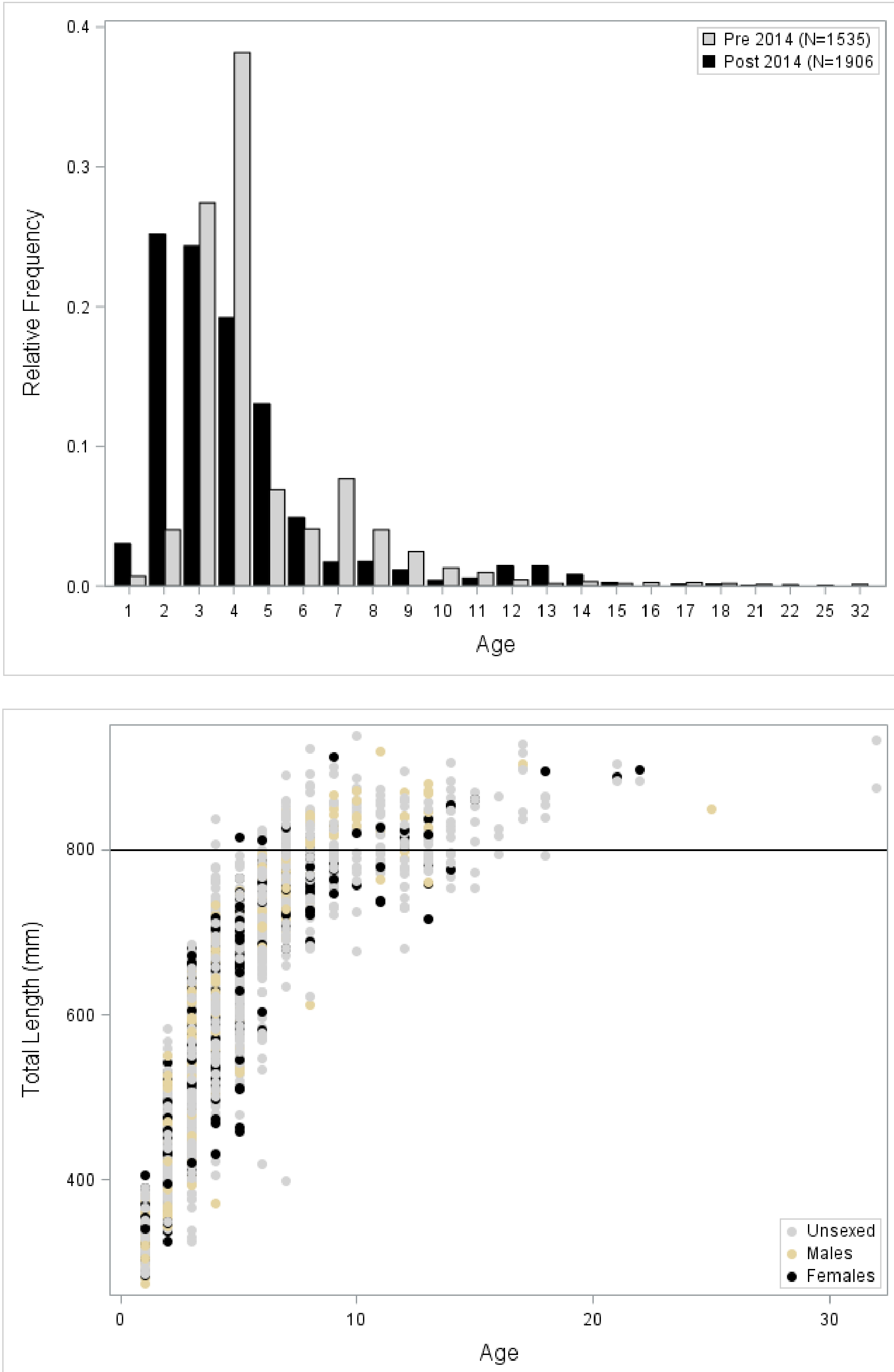


Figure 27. Summaries of age-frequency distributions (upper panel) and size at age (lower panel) by sex for Red Snapper collected in association with fishery-dependent surveys of the commercial fishery conducted in 2012-2014 and 2017-2019.

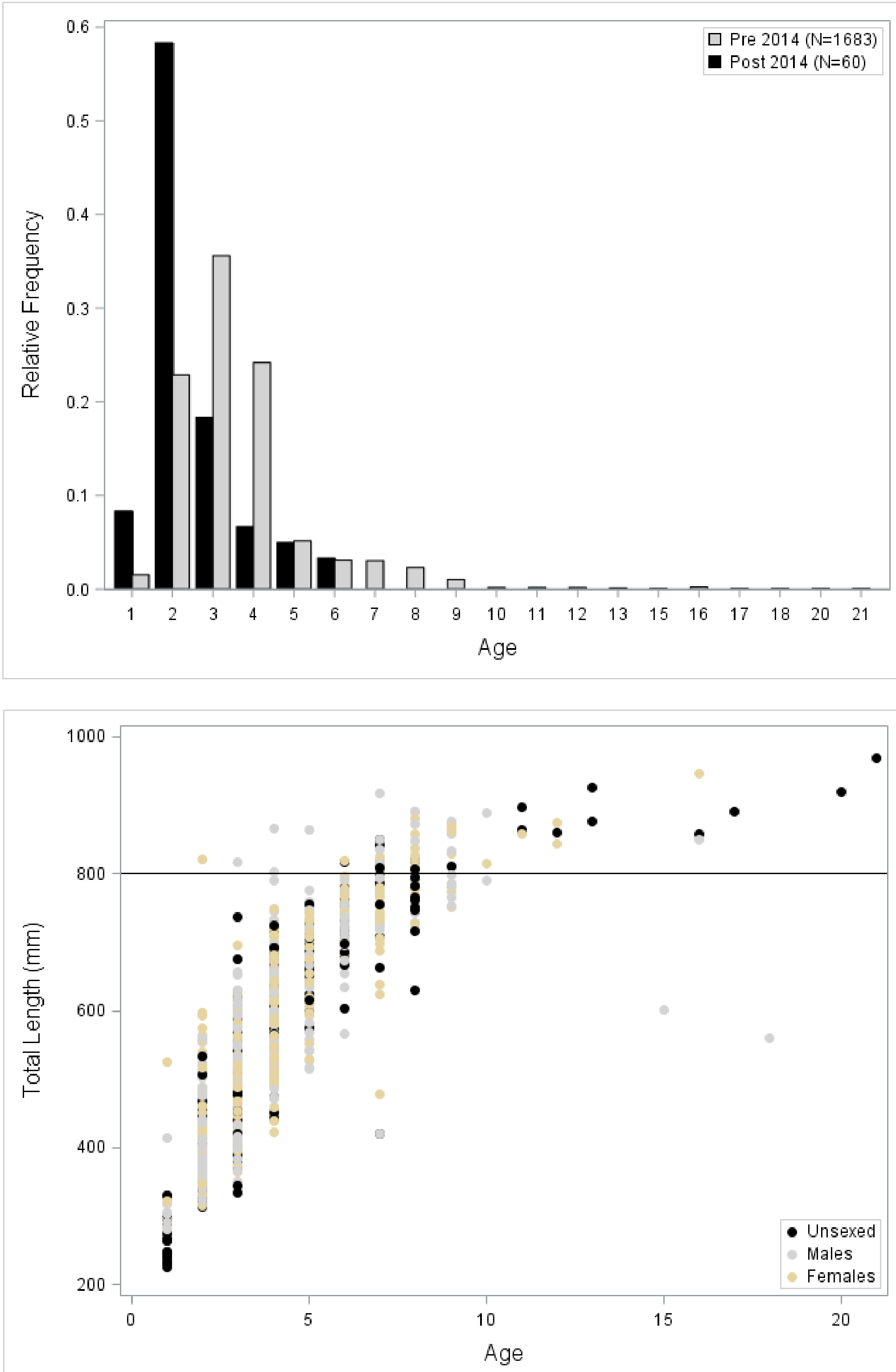


Figure 28. Summaries of age-frequency distributions (upper panel) and size at age (lower panel) by sex for Red Snapper collected in association with fishery-dependent at-sea headboat observer and supplemental dockside sampling conducted between 2004-2018.

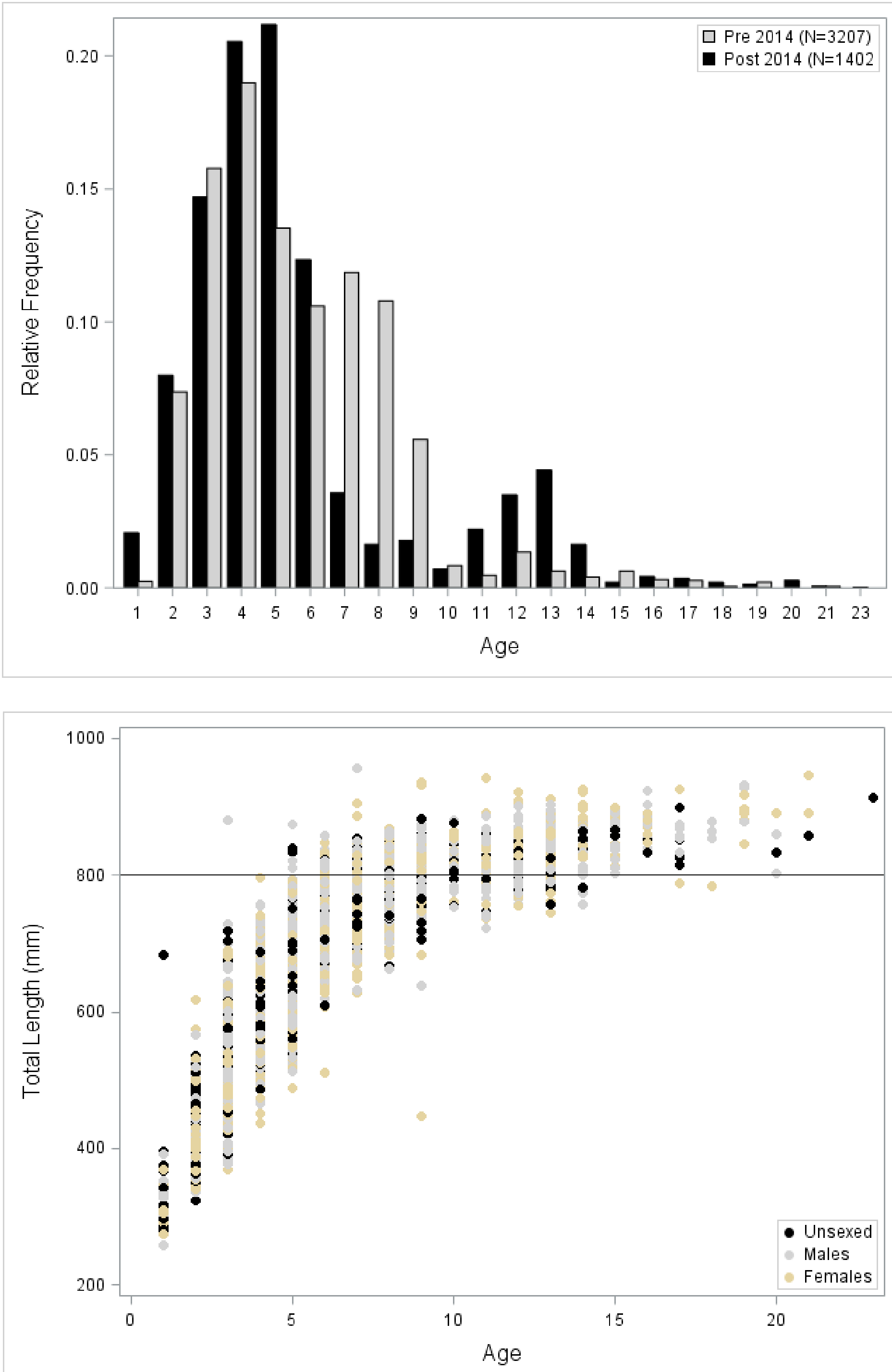


Figure 29. Summaries of age-frequency distributions (upper panel) and size at age (lower panel) by sex for Red Snapper collected in association with fishery-dependent surveys of the charter fishing industry conducted in 2012-2014 and 2017-2019. Note that these plots include samples obtained through random catch and effort surveys, supplemental biological sampling, and volunteer carcass donations.

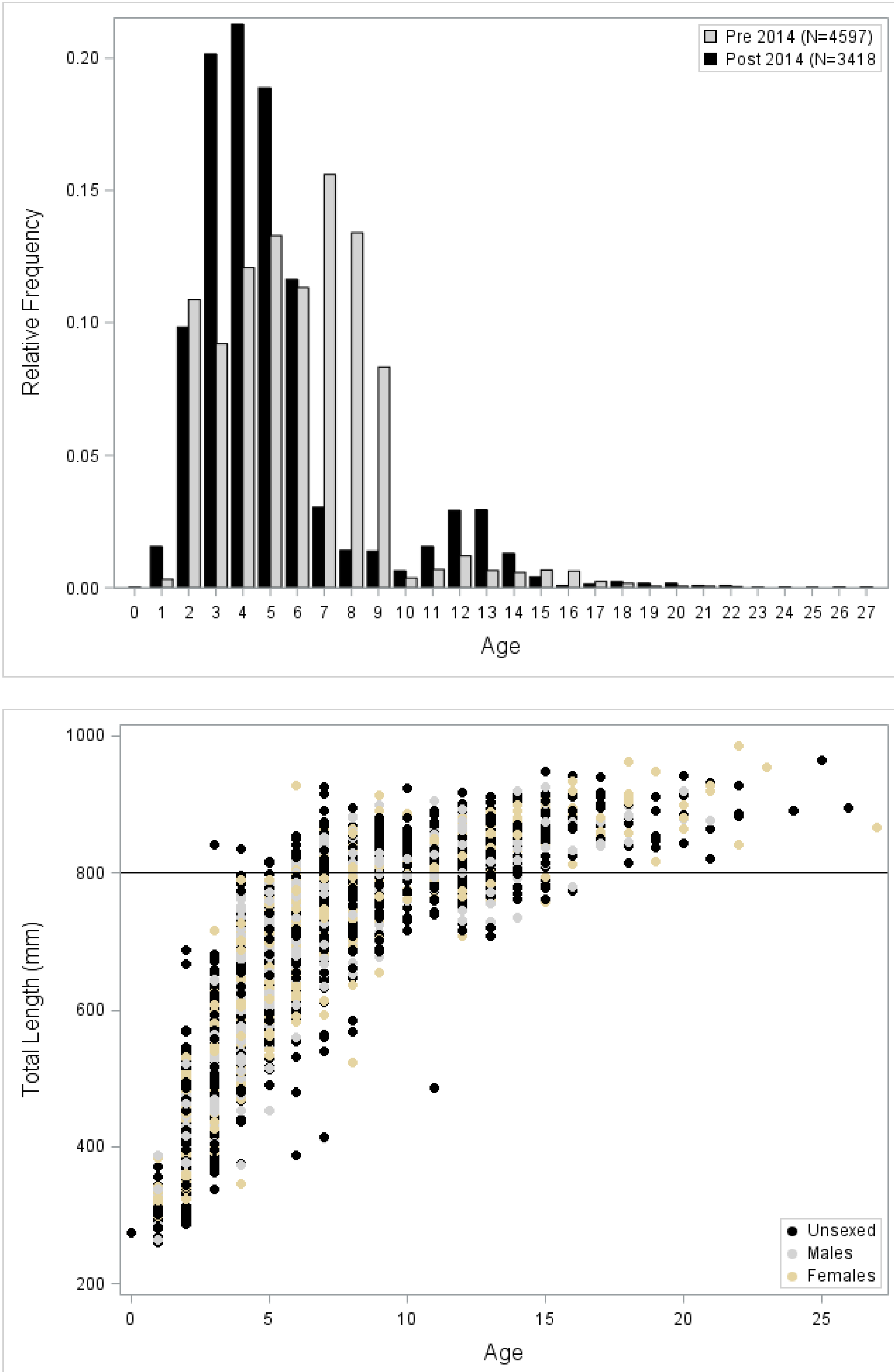
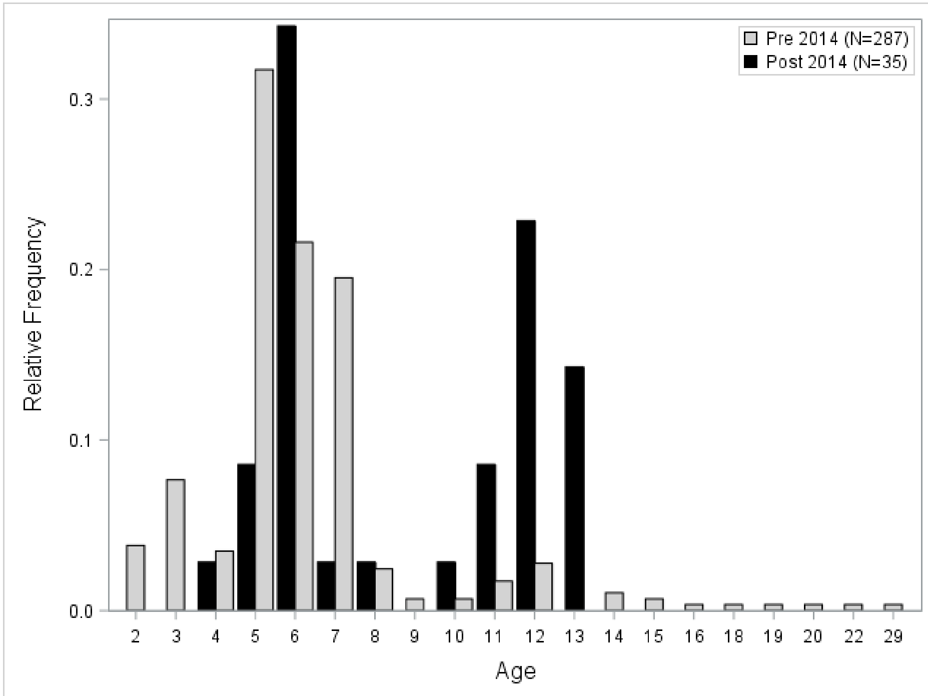


Figure 30. Summaries of age-frequency distributions (upper panel) and size at age (lower panel) by sex for Red Snapper collected in association with fishery-dependent surveys of the private recreational boat fishery conducted in 2012-2014 and 2017-2019. Note that these plots include samples obtained through random catch and effort surveys, supplemental biological sampling, and volunteer angler carcass donations.



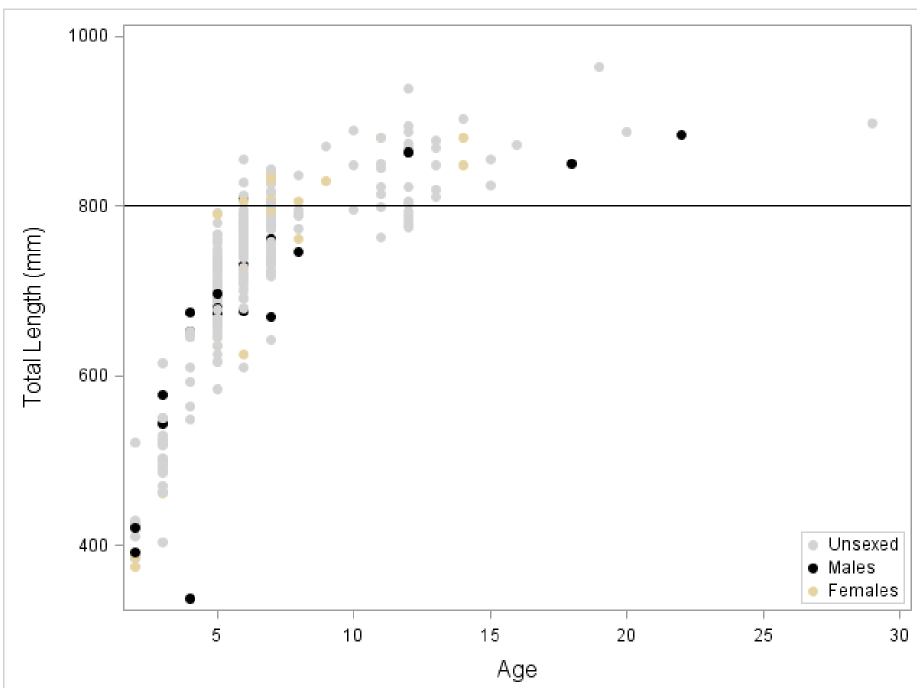


Figure 31. Summaries of age-frequency distributions (upper panel) and size at age (lower panel) by sex for Red Snapper collected in association with fishery-dependent surveys of fishing tournaments conducted in 2012, 2013 and 2019

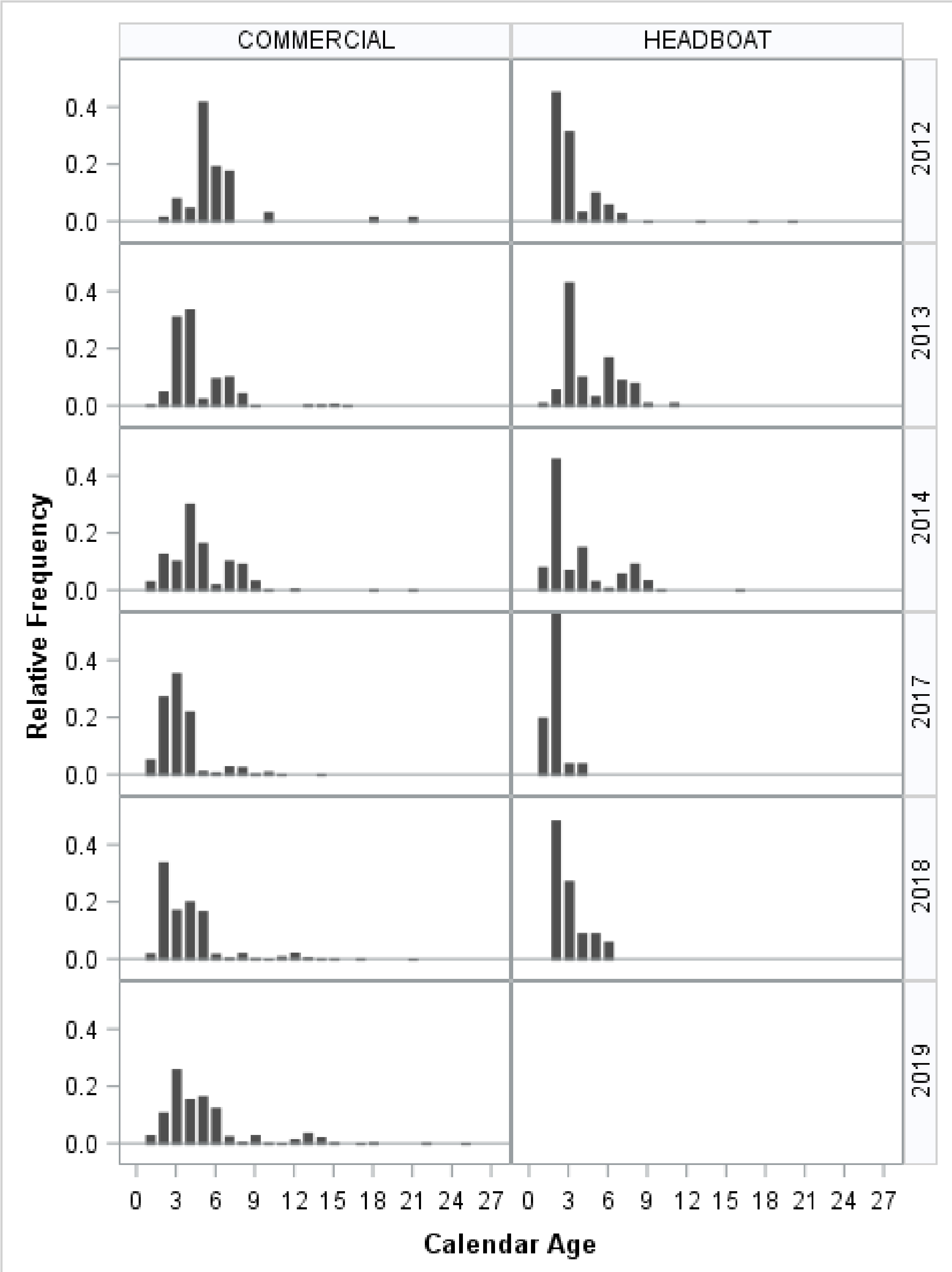


Figure 32. Relative frequency of age distributions by year for Red Snapper harvested by the commercial fishery and the headboat fishery from 2012-2019. This timeframe corresponds to the implementation of dedicated supplemental biological sampling and random catch and effort surveys.

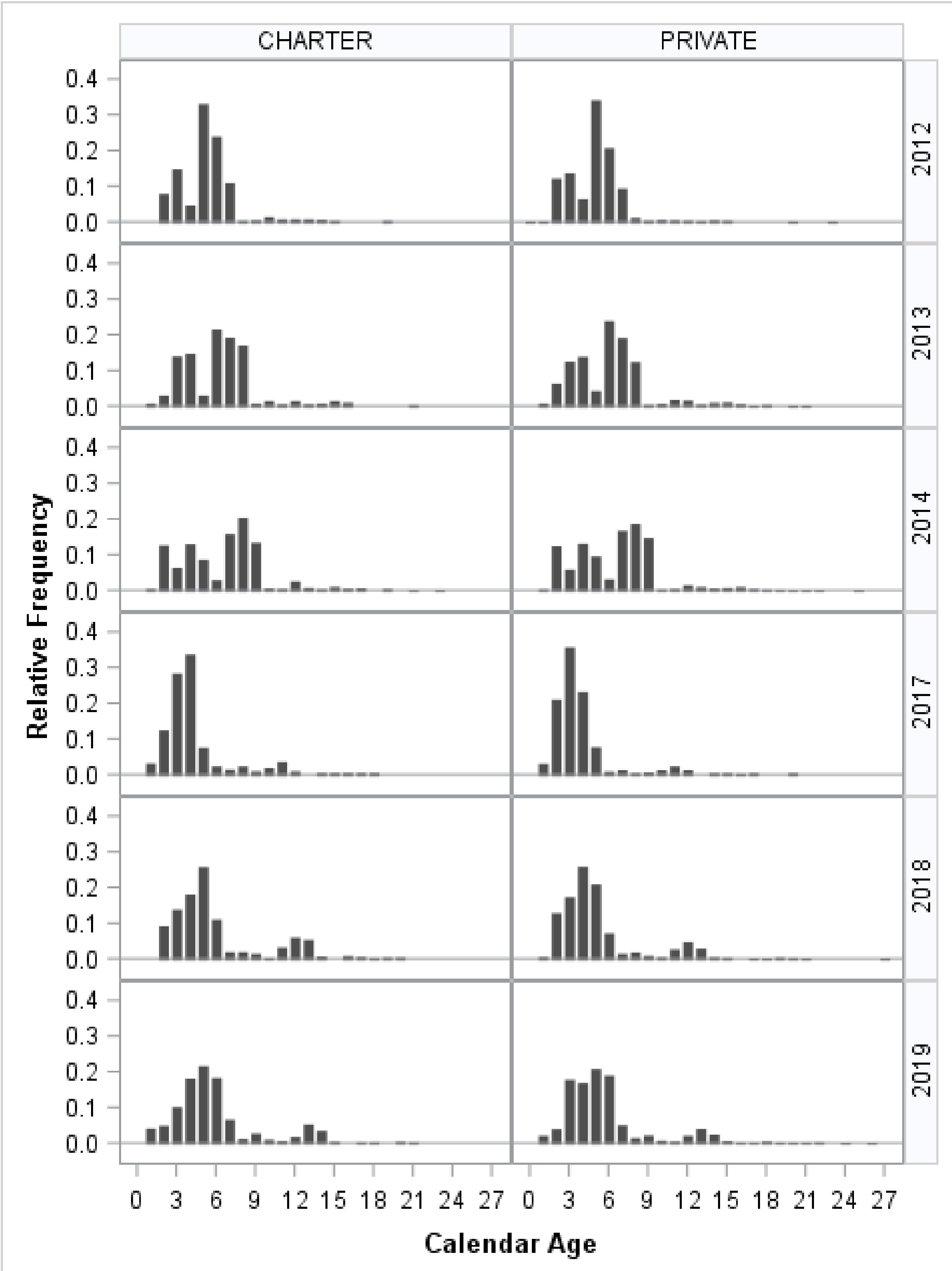


Figure 33. Relative frequency of age distributions by year for Red Snapper harvested by the charter fishing industry and private recreational boat fishery from 2012-2019. This timeframe corresponds to the implementation of dedicated supplemental biological sampling and random catch and effort surveys.