Comparing reef fish catch rates between single- and double-hook tackle off the Atlantic coast of Florida

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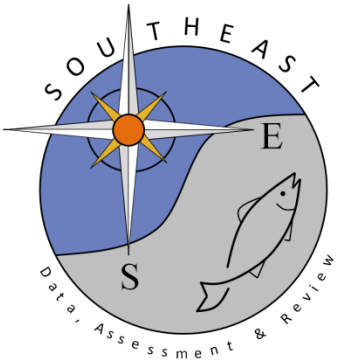

Comparing reef fish catch rates between single- and double-hook tackle off the Atlantic coast of Florida.

Purpose

A. Problem Description

Red Snapper in the U.S. South Atlantic (SA) have been assessed as overfished and undergoing overfishing for more than a decade (SEDAR 73). Despite a near-total prohibition on commercial and recreational harvest during this time, overfishing is still occurring, due primarily to a high number of estimated dead discards by the recreational fishing sector. Throughout the South Atlantic, discard mortality accounts for an estimated 85%+ of total Red Snapper mortality, with the highest number of estimated Red Snapper discards occurring off Florida in the private recreational fishery. Fishermen use a wide array of tackle to harvest fish; however, there is limited information on usage rates of different tackle, the relative rates of catch or discards with such tackle, and the condition of the discarded fish. To address this issue, the South Atlantic Fishery Management Council (SAFMC) is considering various potential measures to reduce the overall discard rates for the snapper-grouper species complex as an action in Regulatory Amendment 35. One consideration being investigated to reduce discards is implementing gear restrictions, in particular the requirement of using single-hook tackle (as opposed to double-hook) to reduce encounter rates and catch per unit effort (CPUE) of Red Snapper.

Some limited studies have been conducted comparing catch and discard rates among different gear types commonly employed in the SA Red Snapper recreational fishery. These include a research project conducted by SAFMC staff to understand the potential reduction of catch due to using single- or double-hook rigs, and a Marine Fisheries Initiative (MARFIN) project conducted by The Florida Fish and Wildlife Conservation Commission (FWC) – Fish and Wildlife Research Institute (FWRI) in the Gulf of America (GOA, formally known as the Gulf of Mexico) that estimated CPUE using double-hook and Carolina rigs. Although these studies provide some basic information, an expanded comparison of catch rates by gear and gear modifications under a more robust statistical design would provide data to better understand the potential impact of gear restrictions or gear modifications on overall discard rates of Red Snapper and other snapper-grouper species.

The FWC has been conducting a highly standardized actively fished hooked-gear survey (repetitive timed drop, or RTD) in the SA as an alternate source of fishery-independent abundance data for Red Snapper and other reef fishes since 2011. In 2024, the FWC was awarded funds by the SAFMC to conduct a field study, in conjunction with annual RTD sampling (which uses double-hook terminal tackle), to assess potential catch and discard rates between single- and double-hook terminal tackle off the Atlantic coast of Florida where much of the Red Snapper discards are thought to occur. In addition to the experimental gear study, the FWC analyzed data from historical hooked-gear sampling during prior standardized FWC hooked-gear surveys to provide additional insight into catch rates of single- vs. double-hook rigs.

B. Objectives

The overarching goal of this project was to provide data and analyses to fisheries managers on catch rates of Red Snapper and other reef fishes between single- and double-hook terminal tackle off the South Atlantic coast of Florida. In addressing the overarching goal, the project was designed to address four primary objectives:

1. Conduct an experimental hooked-gear study to assess reef fish catch rates between single- and double-hook tackle off the Atlantic coast of Florida.

2. Summarize experimental data and provide analyses comparing reef fish catch rates between single- and double-hook tackle off the Atlantic coast of Florida.

3. Supplement field sampling for the FWC repetitive timed-drop (RTD) hooked-gear survey off the east coast of Florida during April – August 2024 to provide data to assess the relative abundance and age composition of reef fishes (e.g., Red Snapper, Vermilion Snapper, Black Sea Bass) through time.

4. Determine whether data from historical single- and double-hook rigs collected during standardized FWC RTD hooked-gear surveys since 2012 can provide additional insight into catch rates.

Approach

A. Study Design

A standardized fisheries-independent survey of reef fishes was designed based on prior FWC surveys conducted in the U.S. South Atlantic between 2012 – 2023. The goals of this study were to (1) supplement a portion of the standard FWC RTD hooked-gear sampling sites for the year (RTD Sites), and (2) pair a portion of the standard sites with an experimental hooked-gear study to compare reef fish catch rates between single- and double-hook tackle (experimental sites).

Sampling Location – All sampling efforts for this project were focused on identified hard bottom habitats in water depths less than 150 m in National Marine Fisheries Service (NMFS) statistical zone 728 which extends from 30° 00’ N (St. Augustine, Florida) south to 29° 00’ N latitude (Ponce Inlet, Florida; **Figure 1**). The study area is part of the South Atlantic Bight off the east coast of Florida that has historically supported a multi-million dollar commercial and recreational reef fishery and represents the historical core of the U.S. South Atlantic Red Snapper population. Prior studies conducted by FWC have shown that hard bottom reef sites within this region are productive for many federally managed reef fish species, including Red Snapper, Black Sea Bass, Red Porgy, Vermilion Snapper, and Gag. The survey area also contains home ports for many industry vessels, which facilitated the cooperation of commercial and recreational fishers to complete sampling. Standard FWC RTD hooked-gear sampling was also conducted by the FWC in NMFS zones 722 and 732 during 2024 through alternate funding sources; however, only project efforts within NMFS zone 728 are summarized within this report (**Figure 2**).

Survey Design – Overall survey design and protocols for this project were identical to previous FWC RTD hooked-gear studies conducted since 2012. Sampling sites containing reef habitat were

randomly selected from an established FWC universe that includes sites from the federal Southeast Reef Fish Survey (SERFS) sampling universe, prior FWC work conducted in the region, data from USGS, and sites provided from participating commercial and recreational fishers. All sampling for this project was conducted during daylight hours (approximately 0600 - 2000 hours) from April – August 2024. Sampling effort was stratified by depth (inshore: <30 m and offshore 30–150 m) and proportionally allocated based on the percentage of the total number of possible reef sites contained within each depth strata **(Table 1).**

Site Selection – FWC RTD Hooked-Gear Survey – A total of 123 sites were selected for sampling to supplement the 2024 FWC RTD hooked-gear survey and maintain the time series to assess the relative abundance and age composition of Red Snapper and other reef fishes through time (**Table 1, Figure 2**). Sites selected for RTD hooked-gear sampling were selected from NMFS zone 728 and followed the standardized sampling site selection implemented by FWC for all RTD sampling conducted since 2021.

Site Selection – Experimental Hooked-Gear Survey – A total of 60 sites were selected for the experimental hooked-gear study to compare reef fish catch rates between single- and double-hook tackle (**Table 1, Figure 2**). First, a random subset (n=60) of RTD sites was selected, then a nearby paired site was selected for the experimental hooked-gear survey. Each experimental site was required to meet two criteria: (1) it was not part of the original RTD random draw, and (2) it was more than 200-m from the primary RTD site to maintain sample independence. At each of the experimental sites we first completed the scheduled FWC RTD hooked-gear survey. Experimentally selected sites were then sampled opportunistically, and sampling was not always completed on the same day as the RTD site.

Gear Deployment and Retrieval – A standardized fisheries-independent survey of reef fishes was designed based on prior FWC reef fish surveys conducted in the U.S. South Atlantic between 2012 – 2023. The current study utilized a repetitive timed-drop (RTD) hooked-gear survey similar to past FWC reef fish surveys conducted in the survey area. Several project-development meetings were held in conjunction with commercial, charter, and recreational fishers at the outset of the study to solicit their input regarding project design of the experimental hooked-gear survey and all field sampling activities were conducted cooperatively with industry partners.

Active hooked-gear fishing methods and effort were standardized at all sampling sites (experimental and supplemental RTD). At each sampling site, anglers were randomly assigned to a particular fishing rig and grouped into teams (three fishers for RTD sites; four fishers for experimental sites). A series of 10 “team drops” where then performed with all fishers simultaneously dropping their rigs to the bottom and allowing their rigs to soak for no more than two minutes starting when the first rig reached the bottom. All fishers soaked their rigs in contact with the bottom and retrieved their rig as soon as a fish was hooked or once the two-minute time period elapsed. All fishers then retrieved their rig and re-baited their hooks. Fishers who retrieved their rig during the two-minute time period (caught fish, checked bait, lost fish, etc.) were not permitted to re-drop their rig during that “team drop”. Subsequent drops began only when all fishers retrieved their rig, processed any captured fish, and re-baited hooks.

Gear Description – FWC RTD Hooked-Gear Survey –Three powered (12V DC) Electramate© rigs (model 940XP; **Figure 3**) were used for the FWC RTD hooked-gear survey. Each Electramate©

rig was outfitted with a Penn 115L 9/0 (Senator Model) reel equipped with Ande© 100 lb. test monofilament and mounted onto a heavy-duty fiberglass fishing pole (~ 8 ft.). Terminal tackle for all Electramate© rigs was standardized and fitted with a two-hook terminal fishing rig, consisting of a barrel swivel attached to the mainline from the reel (**Figure 4**). Starting from the swivel an ~ 6 ft. section of 100 lb. test monofilament leader was attached. Two short leads (~ 6 in. long) were tied along the length of this leader, one located near the top of the rig ending with either an 8/0, 11/0, or 15/0 Mustad circle hook (Ref 39960D) and the other near the bottom ending with the same size hook as the top lead. This resulted in a total of three fishing rigs – one with 8/0 hooks, one with 11/0 hooks, and one with 15/0 hooks. A lead bank sinker was attached at the bottom of each leader. All hooks were baited with cut Atlantic mackerel sized proportionately to the size of the hook.

Gear Description – Experimental Hooked-Gear Survey– Four powered (12V DC) Electramate© rigs (model 940XP; **Figure 3**) were used for the experimental hooked-gear survey. Each Electramate© rig was outfitted with a Penn 115L 9/0 (Senator Model) reel equipped with Ande© 100 lb. test monofilament and mounted onto a heavy-duty fiberglass fishing pole (~ 8 ft.). Terminal tackle for all Electramate© rigs was standardized. Four Electramate© rods were fitted with terminal fishing rigs: two with the double-hook terminal fishing rig, as described above, and two with a single-hook terminal fishing rig. The double-hook rigs had leaders ending in either 8/0 or 11/0 Mustad circle hooks (Ref 39960D). The single-hook terminal fish rigs were made in a similar manner to the FWC RTD double-hook rig, except for only the bottom lead was used (**Figure 5**). A barrel swivel was attached to the mainline from the reel. Starting from the swivel an ~ 6 ft. section of 100 lb. test monofilament leader was attached. Only the bottom short lead (~ 6 in. long) was tied along the length of this leader. One of the single hook rigs was fitted with an 8/0 Mustad circle hook, and the other with an 11/0 Mustad circle hook (Ref 39960D). A lead bank sinker was attached at the bottom of the leader. This resulted in four fishing rigs - one with a single 8/0 hook, one with two 8/0 hooks, one with a single 11/0 hook, and one with two 11/0 hooks. All hooks were baited with cut Atlantic mackerel sized proportionately to the size of the hook.

Video Cameras and Temperature Loggers – At the completion of sampling at each selected site (experimental and RTD), a Hobo© temperature logger and GoPro© video camera were deployed using standardized techniques for approximately 5 minutes to collect water temperature (ºC) data and capture images of the habitat being surveyed. The video data will be examined later to qualitatively characterize current direction, visibility, and a variety of habitat metrics, including bottom relief, habitat heterogeneity, substrate composition, and dominant benthic fauna.

Sample Processing – Geographic coordinates, depth, physiochemical conditions (e.g., temperature), gear-specific deployment information, and time of day was recorded at each specific sampling site. All individuals captured during the hooked-gear surveys were identified and measured (standard length for non-managed fishes; standard, fork, and total lengths for managed fishes). Ancillary information on evidence of barotrauma (e.g., bloated stomach, exophthalmia, everted intestines) were recorded for each fish captured and all individuals were assessed visually to identify potential health-related abnormalities (i.e., lesions, ulcers, skeletal malformations, parasite infestations).

Detailed data on fishing effort for individual fishers and fishing rigs were recorded at each sampling site that included the number of drops completed, water depth, fisher/crew initials, rig #,

and start and end time of fishing. We also recorded catch specific parameters including hooking location (lip, throat, gill, gut, foul, etc.), signs of barotrauma, whether the fish was vented, and release condition (good, fair, bad, preyed upon, or dead) that provided information on the composition/disposition of bycatch as well as the effects of various hooking methods on non-targeted species and sizes.

Data Entry and Management – Data were entered into an existing relational SQL Server database managed by FWC. The database has been fully documented as to its procedures and protocols, and extensive metadata exists to assist in defining and interpreting the data. Data used to assess reef fish catch rates between single- and double-hook tackle will be available to the SAMFC at the end of the project upon request.

Experimental FWC RTD Hooked-gear Data Summary and Statistical Analyses – Upon completion of field sampling, overall summaries of sampling effort (# sites) and catch were compiled by depth strata (nearshore [< 30 m] and offshore [30-150 m]) and fishing rig (single-hook and double-hook). Length frequency histograms were constructed for Red Snapper by fishing rig and hook type, drop group (early [drops 1-3], mid [drops 3-7], and late [drops 8-10]) and depth strata (shallow [<31 m], mid [31 – 49 m] and deep [>49 m]). Post-stratified depth strata were based on classifications from Mitchell et al. 2014 and were utilized to examine depth-related distribution of Red Snapper throughout the survey area, and to facilitate comparisons to that study. Post-stratification of drop number into "drop group" was utilized as a proxy to fishing effort to examine if a relationship existed between the size of Red Snapper collected and the fishing effort at each site (i.e., were larger Red Snapper more gear shy than smaller fish and thus more likely to be captured in later drops). Statistical models were developed to compare catch rates between fishing rigs and estimate fishing efficiency for Red Snapper and other reef fishes.

The mean, minimum, maximum, and standard error for length was calculated for Red Snapper collected for each hook size and fishing rig. Length and age frequency plots were calculated for Red Snapper for each of the hook sizes. A One-Way ANOVA test (α=0.05; SAS Institute 2017) was used to compare mean length distributions among hook sizes and fishing rig. The Shapiro-Wilk test was used to test Normality within the population. Pairwise Multiple Comparison procedures used Dunn's Method, and Post Hoc tests used an alpha value of α=0.05.

To examine the differences in catch rate between single- and double-hook rigs we calculated CPUE for both rig types as the total number of fish caught on each rig by total sites sampled (n=60). We calculated CPUE for both hook sizes as well as all hook sizes combined for Red Snapper as well as all species caught per site.

Historical FWC RTD Hooked-gear Statistical Analysis – To examine the changes in relative abundances of rigs that captured two fish on the same rig (both the top and bottom hooks of the rig on the same drop) between 2016 and 2023, indices of abundance (IOA) were calculated as the overall average abundance per sample site. The index was computed using a generalized linear model with a negative binomial distribution to adjust for the effects of spatial and temporal variability between samples. Depth strata (nearshore and offshore), month, NMFS statistical zone, and year were treated as classification variables. Covariates included the total number of each hook size dropped (8/0, 11/0, 15/0). The GLIMMIX procedure (SAS Institute Inc 2015), which fits

generalized linear models and allows for non-normal data, was used to complete all analyses. For the RTD hooked-gear IOA (all hook sizes and NMFS statistical zones combined), all variables that were not significant ($\alpha > 0.05$) were dropped, with the exception of year and total number of drops for each hook size, and the analysis repeated. Least-squares adjusted means and standard errors were calculated for each year. For the RTD hooked-gear IOA plot, the nominal per site and CPUE were calculated and plotted with the standardized index.

Standardization of Response Variable:

To calculate the RTD hooked-gear IOA, the response variable was modeled as the total drops that collected two fish from all hook sizes combined at each sampling site.

Explanatory Variables:

We considered 7 explanatory variables in the original model.

Year (*Y*) – Year was included since standardized catch rates by year are the objective of the analysis. We modeled data from 2012, 2014, 2016-2018, and 2021-2023.

Month (*M*) – A temporal parameter based on the month of sampling. Sampling occurred from April to August.

Depth (*DQ*) – Water depth may be an important component affecting the distribution of reef fish. All depths sampled (12-90 m) were included and treated as a quantile factor with four levels.

Latitude (*LatQ*) – The latitude of sampling location was included as a spatial parameter in the model and treated as a quantile factor with four levels.

8/0 hooks (Sm) – The total number of 8/0 hooks dropped on all rigs at each site was included as a continuous factor.

11/0 hooks (Md) – The total number of 11/0 hooks dropped on all rigs at each site was included as a continuous factor.

15/0 hooks (Lg) – The total number of 15/0 hooks dropped on all rigs at each site was included as a continuous factor.

The total number of drops where two fish were collected on both the top and bottom hooks during the same drop represents count data and therefore does not conform to assumptions of normality. Therefore, the data were modeled using a negative binomial distribution to fit the data. Backwards step-wise model selection and comparisons of AIC values were used to determine the optimal model. The final overall index model is given by the following equation:

$$Total = Y+M+DQ$$

Findings

A. Actual Accomplishments and Findings

Overall Project Accomplishments:

Project-development meetings were held with SAFMC scientists prior to the start of the survey that served as a forum for discussing appropriate sampling sites, methods for the experimental hooked-gear survey of hooked-gears, 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 address questions or concerns from our partners as well as combine the strengths of each representative group to improve the overall effectiveness of the study. The knowledge and experience of our participating partners ensured that the selected sample sites corresponded to the desired targeted strata.

Objective 1: Conduct an experimental hooked-gear study to assess reef fish catch rates between single- and double-hook tackle off the Atlantic coast of Florida.

Objective 2: Summarize collected experimental data and provide analyses comparing reef fish catch rates between single- and double-hook tackle off the Atlantic coast of Florida.

All proposed sampling sites (n=60) were sampled as planned for the experimental hooked-gear study. At each of the 60 sampled sites, we first completed the scheduled supplemental FWC RTD hooked-gear survey. An experimental hooked-gear site was then selected from available habitat within a 2-mile buffer and a minimum distance of 200 m from the original FWC RTD hooked-gear site to maintain sample independence. Sampling sites were opportunistically sampled and were not always sampled on the same research cruise. A total of 55 hardbottom (18 inshore and 37 offshore) and 5 artificial reef sites were sampled (**Table 1**). Twenty-three inshore sites (<30 m) and 37 offshore sites (>30 m) were sampled during the project period (**Table 1, Figure 6**). At each sampling site four anglers each completed 10 drops. At each of the ten drops four rigs with a total of six hooks were dropped, one with a single 8/0 hook, one with two 8/0 hooks, one with a single 11/0 hook, and one with two 11/0 hooks. The overall 60 completed sampling stations were comprised of 600 timed drops. There was a total of 600 hooks for each single-hook rig (8/0 and 11/0) and 1,200 hooks for each double-hook rig (8/0 and 11/0) for a total number of 3,600 hooks dropped for the entire experimental project (**Table 2**).

We collected 840 fish representing 27 species with Red Snapper, Tomtate, and Vermilion Snapper comprising 88.7% of the total catch. Red Snapper was the most abundant species overall (n=518), accounting for 61.7% of the total catch (**Table 3**). Single-hook rigs caught 322 fish representing 22 species with Red Snapper comprising 63.0% of the single rig catch. Double-hook rigs caught 518 fish representing 23 species with Red Snapper comprising 60.8% of the double-rig catch. Tomtate accounted for 15.6% of the overall catch, 16.2% for single-hook rigs, and 15.3% for double-hook rigs. Vermilion Snapper represented 11.4% of the overall catch, 8.3% for single-hook rigs, and 12.7% for double-hook rigs. (**Table 3**). Out of the 1,200 double rig drops, two fish were caught on 32 (2.6%) of the drops. Red Snapper made up 67% of the catch when two fish were caught.

Mean size of collected Red Snapper increased with increasing hook size for both single- and double- hook rigs (**Table 4, Figure 7**). The mean size of Red Snapper collected with the 8/0 single-hook rig was 387.8 mm FL (SE=12.4) and the 8/0 double-hook rig was 389.3 mm FL (SE=8.76). The mean size for the 11/0 single-hook rig was 465.8 mm FL (SE=12.89) and the 11/0 double-hook rig was 457.0 mm FL (SE=10.03). The mean size of Red Snapper collected throughout the study was similar for the single-hook and double-hook rigs. The smallest Red Snapper collected was with an 8/0 single hook rig and the largest collected with an 11/0 double-hook rig **(Table 4)**. Red Snapper abundance increased with increasing number of hooks for both hook sizes (**Figure 7**). The 8/0 single-hook rigs collected 91 Red Snapper, while the 8/0 double-hook rigs collected 142. The 11/0 single-hook rigs collected 110 Red Snapper, with the 11/0 double-hook rigs collecting 171 Red Snapper. Red Snapper length-frequency distributions were significantly different among hook comparisons between 8/0 and 11/0 hooks ($P<0.001$). No significant difference in Red Snapper length-frequency was observed when comparing 8/0 single- vs. 8/0 double-hook rigs, and 11/0 single- vs. 11/0 double-hook rigs ($P=1.000$).

Red Snapper length frequency was compared to depth of the site caught, where depth was post-stratified into 3 categories: <30 (shallow, n=28), 30-49 m (mid, n=24), and >49 m (deep, n=8), (**Figure 8**). Of the 518 Red Snapper caught, 169 were caught in shallow, 297 in mid, and 52 in the deep strata. The mean size of Red Snapper was 347.8 mm in shallow (SE=6.51), 462.7 mm in mid (SE=7.15), and 484.8 mm in deep (SE=20.78). Red Snapper length frequency was significantly different between shallow and deep ($P<0.001$) and shallow and mid ($P<0.001$). There was no significant difference in Red Snapper length-frequency between the mid and deep strata ($P=1.000$).

The mean size of Red Snapper collected was not significantly affected by the drop on which it was caught. Drop number was post-stratified into three categories, early drops (1-3), mid drops (4-7), and late drops (8-10). Red Snapper had a mean length of 438.4 mm (n=171, SE=10.16) caught on early drops, 428.6 mm (n=219, SE=8.51) on mid drops, and 412.3 mm (n=124, SE=11.07) on late drops (**Figure 9**). There was no significant difference in Red Snapper length-frequency between all drop category comparisons ($P=1.000$).

When examining the Red Snapper catch on a per-site basis, CPUE was calculated as the total number of Red Snapper collected per the total number of sites (n=60). The CPUE for Red Snapper was higher for the 11/0 hooks compared to the 8/0 hooks, for both rig types. For the 8/0 hook size, CPUE was 1.52 (single-hook rig) and 2.37 (double-hook rig). For the 11/0 hook size, CPUE was 1.87 (single rig) and 2.88 (double rig). When combining hook sizes, CPUE for single-hook rigs was 3.38, and double hook-rigs 5.25, for a difference of 1.45. (**Figure 10**). When examining CPUE for all species combined caught on a per-site basis, the trend was slightly different as the 8/0 had a higher CPUE than the 11/0 hooks (**Figure 11**). CPUE for the 8/0 hook size for all species was 3.02 (single-hook rig) and 4.95 (double-hook rig). CPUE for the 11/0 hook size for all species was 2.35 (single-hook rig) and 3.68 (double-hook rig). In addition, the 8/0 hook size caught more total fish (n=478) than the 11/0 hook size (n=362). This can be explained by commonly caught species such as Tomtate and Vermilion Snapper collected more abundantly with the smaller 8/0 hooks. However, like Red Snapper CPUE, CPUE of all species combined was higher for the double-hook rigs for both hook sizes. When combining hook sizes for both rig types, CPUE for all species using single-hook rigs was 5.37, and double-hook rigs 8.63, for a difference of 3.26.

Objective 3: Supplement field sampling for the FWC repetitive timed-drop (RTD) hooked-gear survey off the east coast of Florida during April – July 2024 to provide data to assess the relative abundance and age composition of reef fishes (e.g., Red Snapper, Vermilion Snapper, Black Sea Bass) through time.

A total of 116 of the proposed 123 FWC Supplemental RTD hooked-gear sites in NMFS statistical zone 728 during the 2024 sample season (April – August) within three strata – inshore hardbottom, inshore artificial reef, and offshore natural hardbottom were sampled.

We caught a total of 1,383 fish **(Table 5)**, of which we culled 1,231 for life history analysis (**Table 6**). A total of 25 species were caught with Red Snapper, Vermilion Snapper, Tomtate, and Black Seabass comprising 94.2% of total catch. Red Snapper was the most abundant species, representing 74.9% of total catch. All Red Snapper caught were culled for further life history analysis. A random subset of Vermilion Snapper (7.8% of total catch), Tomtate (7.1% of total catch), Black Seabass (4.4% of total catch), and other selected species of reef fish (5.8% of total catch) were also culled for further life history analysis (**Table 6**).

For the purpose of this report, only basic summary information has been provided above detailing the sampling for this objective of the study. RTD hooked-gear sampling funded by this study will be combined with RTD hooked-gear surveys conducted by the FWC in the SA off the coast of Florida between 2012 - 2024 with the overarching goal of assessing the utility of a fisheries-independent hooked-gear survey to track changes in Red Snapper age and abundance over time. Specifically, this data will aid in assessing the utility of the FWC's RTD hooked-gear at (1) providing an index of abundance for Red Snapper in the SA and (2) tracking changes in the size and age structure of Red Snapper under a fishing moratorium. Ultimately, through these combined studies, we aim to provide a recommendation for the use of FWC RTD hooked-gear surveys to be used as an additional source of data for the assessment of the SA Red Snapper population.

Objective 4: Determine whether data from historical single- and double-hook rigs collected during standardized FWC RTD hooked-gear surveys since 2012 can provide additional insight into catch rates.

For this portion of the study, we evaluated historical hooked-gear surveys conducted by the FWC in the SA off the coast of Florida between 2012 – 2023 with the overarching goal of providing additional catch rates of fish collected on single- and double-hook rigs.

Sampling Studies and Location: We analyzed data collected in association with fishery-independent hooked-gear studies conducted by the FWC between 2012 – 2023. During this time frame the FWC conducted several hooked-gear studies that have applied the standardized RTD hooked-gear methodology (Guenther et al. 2013; Brodie and Switzer 2015; Paperno et al. 2018; Switzer et al. 2019; Brodie et al. 2023) as well as an unstandardized "captains' choice" sampling methodology. Although individual studies addressed subtly different objectives, the data collected during each survey, including hook size, fishing effort, catch data, etc., followed standardized FWC hooked-gear data collection protocols allowing comparisons between surveys where applicable. Upon analyses of sampling protocols for each study, the most appropriate sites from each survey were selected to provide the most pertinent analyses of catch rates of single- vs. double-hooked rigs.

For the purpose of our analyses, only samples collected during the months of April – August of each sampling year were included in further analyses, despite the fact that some studies sampled into September and October. A cursory look at the total sites sampled between 2012 – 2023 showed that the FWC deployed a standardized single-hook rig on randomly selected sites on less than 3.5% of the total overall sites sampled. The majority of these single-hook sites were also sampled in conjunction with directed spawning aggregation surveys of Gag Grouper and Red Snapper and did not sample the full extent of our sampling universe or have direct comparisons to double-hook sampling. As a result of the paucity of single-hook samples in our historical HNL database, combined with the nature of these samples, it was determined that further analysis of catch rates would only be analyzed using data from historical double-hook rig samples. In addition, FWC RTD hooked-gear sampling prior to 2016 often employed double-hook rigs with different size hooks on the top and bottom leads of each rig. Although this data is useful in providing overall CPUE of collected fish, it does not apply as well when examining a single snapshot of fish collected on a single drop. Therefore, for this analysis, only data collected beginning in 2016 was used, as this is the time when the double-hook rigs were deployed with the same size hook on each of the top and bottom leads similar to the experimental hooked gear study conducted in conjunction with these historical analyses. Furthermore, FWC RTD hooked-gear studies beginning in 2017 have incorporated habitat type (natural hard-bottom vs. artificial reef) as a specific stratum in the nearshore depth stratum (<30 m). As artificial reefs were not sampled as a specific stratum prior to 2017, they were excluded from our analysis for all years. An annual summary of sampling effort for each survey by year, including final sample sizes, and total number of hooks dropped for our study is provided below.

A total of 1,170 double-hook rig sampling stations were analyzed from FWC RTD hooked-gear sampling between 2016 – 2023. A total of 35,360 total double-hook rig drops were analyzed from those stations with a high of 10,110 drops in 2018 and a low of 2,790 drops in 2016 (**Table 7**). During the survey period analyzed, 2.69% (9,500 out of the 35,360) of the total drops completed collected 2 fish on the same rig on the same drop. The percentage of drops that captured 2 fish on the same rig on the same drop increased on a yearly basis from 2016 through 2023, with a low of 1.36% in 2016 and a high of 4.03% in 2023.

There were nearly an equal number of 8/0 (20,358), 11/0 (20,361), and 15/0 (20,353) hooks dropped during the analyzed survey period (**Table 8**). Despite the nearly equal number of dops for each hook size, the 15/0 hook size had significantly less drops where two fish were caught on the same drop. 15/0 hooks caught two fish on the same drop at a roughly 1% rate while the 8/0 and 11/0 hooks caught two fish on the same drop at a similar rate around 4% of the time.

A total of 1,900 fish were captured on drops where two fish were collected on both the top and bottom hooks during the same drop. A total of 30 different species were collected on drops where two fish were captured. Red Snapper was the most abundant species accounting for 73.4% of the overall catch. The top 4 species collected represented 94.4% of the total catch (**Table 9**).

The calculated index of abundance indicates that since 2016 there has been a general increase in the number of drops where two fish were caught on both the top and bottom hooks during the

same drop (**Figure 12**). Annual standardized index values for stations where two fish were caught on both the top and bottom hooks during the same drop, including coefficients of variation, are presented in **Table 10.** In general, the standardized index values indicate an overall increasing trend in the incidence of two double-hook catches from 2016 – 2023 (**Table 10, Figure 12**).

EVALUATION

EXTENT TO WHICH THE PROJECT GOALS AND OBJECTIVES WERE ATTAINED

Overall, the project successfully met the proposed objectives. The primary objective was to complete a hooked-gear study to assess catch rates between single- and double-hook tackle off the Atlantic coast of Florida. To accomplish this goal, we designed and conducted a one-year fishery-independent repetitive timed-drop hooked-gear survey similar to other FWC standardized studies conducted between 2012 and 2023 but incorporated the comparison of single- vs double-hook tackle. Utilizing the FWC's RTD hooked-gear protocols we were able to standardize many of the variables (bait type, hook size, fishing time, angler skill, number of drops, etc.) that are commonly thought to introduce bias to active hooked-gear fishing analysis. Utilizing identical effort between single- and double-hook rigs, approximately 60% of the overall catch was made by the double hook rigs. Red Snapper accounted for 67% of the double-hook catch where two fish were caught on the same drop. In addition, Red Snapper dominated the overall catch during this experimental hooked-gear survey making up almost 62% of the overall catch of all species. Not only were we able to assess the CPUE of single- vs double-hook tackle between all species encountered, similar to the SAFMC study on which this study was modeled after, we were also able to assess the CPUE of Red Snapper separately. Both analyses examining CPUE of all species combined, as well as Red Snapper, separately showed higher per site catch rates when utilizing tackle with two hooks. As the genesis of this study was to investigate potential avenues to reduce encounter rates and CPUE of Red Snapper, the fact that Red Snapper was the most abundant species encountered overall, was the most common species collected on double-hook rigs, and was the most common species collected when two-fish were caught on the same double-hook rig drop, during the study aided in successfully meeting our stated objectives.

Further analysis of the Red Snapper catch from this study also indicated similar trends to other FWC RTD hooked-gear projects conducted in both the GOA and the SA. The mean size of Red Snapper in this study increased with increasing hook size. Although only 8/0 and 11/0 hooks were utilized in this study, this trend where significantly larger Red Snapper are collected with increasing hook size is consistent with other FWC studies that utilize an additional larger 15/0 hook. In addition to hook size, depth was also significantly related to the mean size of Red Snapper caught. Red Snapper caught were significantly larger in both water depths >49 m as well as depths between 30 and 49m when compared to those caught in depths <30 m.

In addition to completing an experimental hooked-gear study comparing single- and double-hook tackle, funding from this project provided the FWC the ability to continue a long-term RTD hooked-gear sampling program in the SA. Funding provided by this survey allowed the FWC to

leverage other funding sources to complete a full suite of RTD hooked-gear sampling sites in 2024 throughout the historical sampling range off the Florida SA Coast. Supplemental RTD hooked-gear sites sampled in NMFS Zone 728 during this study will be combined with data collected from the other leveraged funding sources to provide a full one-year suite of RTD-hooked gear samples from 2024. In turn, the complete 2024 RTD hooked-gear sampling partially funded by this study will be combined with RTD hooked-gear surveys conducted by the FWC in the SA off the coast of Florida between 2012 – 2024 to track changes in Red Snapper age and abundance over time. Ultimately, through these combined studies, we aim to provide a recommendation for the use of FWC RTD hooked-gear surveys to be used as an additional source of data for the assessment of Red Snapper populations. Furthermore, life history data for Red Snapper and 19 other selected species were collected as part of this study. Life history data collected on Red Snapper along with data collected from other species, will be available for use in future stock assessments in the U.S. South Atlantic.

The final objective of this study was to examine the historical double-hook rig drops made by the FWC during standard RTD hooked-gear surveys. Historical FWC RTD hooked-gear studies showed that Red Snapper were by far the most abundant species collected using double-hook rigs in the SA making up almost 73% of the total catch. In addition, annual trends in the number of double-hook rig drops that caught two-fish increased every year from 2016 – 2023. This trend tracks with other FWC RTD hooked-gear studies that demonstrate an increase in the relative abundance of Red Snapper over that same time period. As Red Snapper were the most abundant species when two fish were caught on the same double-hook rig, it is not surprising that as overall abundance of Red Snapper has increased throughout the SA so has the occurrence of two Red Snapper caught on the same double-hook rig.

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Table 1. Proposed number of Supplemental FWC RTD hooked-gear (n=123) and experimental hooked-gear sample sites (n=60) to be sampled by strata (inshore natural hardbottom, inshore artificial reef, and offshore natural hardbottom) within NMFS statistical zone 728 along the Atlantic coast of Florida (April – July 2024).

	Inshore Natural Hardbottom	Inshore Artificial Reef	Offshore Natural Hardbottom	Total
Selectable RTD Transects in Zone 728	461	116	937	1,514
% of total selectable sites in Zone 728	31%	8%	61%	100%
Proposed # Supplemental FWC RTD sites in Zone 728	38	10	75	123
Proposed # Experimental Hooked-gear sites in Zone 728	18	5	37	60

Table 2. Summary of the number of total Drops Completed and total Hooks Dropped for 8/0 and 11/0 single- and double-hooked rigs in Inshore (<30 m) and Offshore (30 – 150 m) depth strata during FWC RTD experimental hooked-gear study (n=60) within NMFS statistical zone 728 along the Atlantic coast of Florida (April – August 2024).

	Sites Sampled	Drops Completed		Total Drops	Hooks Dropped		Total Hooks
		Single	Double		8/0	11/0	
Inshore	23	460	460	920	690	690	1,380
Offshore	37	740	740	1,480	1,110	1,110	2,220
Total	60	1,200	1,200	2,400	1,800	1,800	3,600

Table 3. Summary of species caught by rig type (Single and Double) during the FWC RTD experimental hooked-gear study (n=60) within NMFS statistical zone 728 along the Atlantic coast of Florida (April – August 2024). Percent Catch per Rig Type is the percentage composition of each species out of all fish collected calculated for each rig type (Single and Double) and for both rig types combined (Percent Total). Taxa are arranged alphabetically by common name.

	Number Collected				Percent Catch per Rig type	
Species	Single	Double	Total	Percent Total	Single	Double
Almaco Jack	1	1	2	0.2	0.3	0.2
Atlantic Sharpnose Shark	4	5	9	1.1	1.2	1.0
Bank Sea Bass	1	6	7	0.8	0.3	1.2
Black Grouper	-	1	1	0.1	-	0.2
Black Sea Bass	2	8	10	1.2	0.6	1.5
Blue Runner	2	2	4	0.5	0.6	0.4
Gag	1	1	2	0.2	0.3	0.2
Grasby	2	5	7	0.8	0.6	1.0
Gray Snapper	-	1	1	0.1	-	0.2
Gray Triggerfish	2	5	7	0.8	0.6	1.0
Greater Amberjack	2	-	2	0.2	0.6	-
Lane Snapper	1	4	5	0.6	0.3	0.8
Pigfish	1	1	2	0.2	0.3	0.2
Leopard Toadfish	1	-	1	0.1	0.3	-
Rainbow Runner	-	2	2	0.2	-	0.4
Red Grouper	1	2	3	0.4	0.3	0.4
Red Porgy	4	2	6	0.7	1.2	0.4
Red Snapper	203	315	518	61.7	63.0	60.8
Round Scad	-	1	1	0.1	-	0.2
Sand Perch	4	2	6	0.7	1.2	0.4
Unidentified Sharksuckers	5	5	10	1.2	1.6	1.0
Silky Runner	1	3	4	0.5	0.3	0.6
Snakefish	-	1	1	0.1	-	0.2
Unidentified Squirrelfish	1	-	1	0.1	0.3	-
Tomtate	52	79	131	15.6	16.2	15.3
Vermilion Snapper	30	66	96	11.4	9.3	12.7
Whitespotted Soapfish	1	-	1	0.1	0.3	-
Total	322	518	840			

Table 4. Mean, minimum, and maximum fork-length (mm) of Red Snapper by rig type and hook size caught during the FWC RTD experimental hooked-gear study (n=60) within NMFS statistical zone 728 along the Atlantic coast of Florida (April – August 2024).

Hook size/rig type	Mean FL (mm)	Minimum FL (mm)	Maximum FL (mm)	Std. Error
8/0 Single	387.8	170	720	12.4
11/0 Single	465.8	261	786	12.9
8/0 Double	389.3	236	708	8.8
11/0 Double	457.0	182	816	10.0

Table 5. Summary of species caught during the FWC RTD supplemental hooked-gear study (n=116) within NMFS statistical zone 728 along the Atlantic coast of Florida (April – August 2024). Percentage of Catch is the percent composition of each species out of all fish collected (all rigs and hooks combined). Taxa are arranged alphabetically by common name.

Species	Total Caught	Percentage of Catch
Almaco Jack	4	0.3
Atlantic Sharpnose Shark	2	0.1
Banded Rudderfish	4	0.3
Black Sea Bass	61	4.4
Blue Runner	2	0.1
Cubbyu	1	0.1
Gag	7	0.5
Grasby	8	0.6
Gray Snapper	4	0.3
Gray Triggerfish	4	0.3
Greater Amberjack	3	0.2
Lane Snapper	5	0.4
Red Grouper	6	0.4
Red Porgy	4	0.3
Red Snapper	1,036	74.9
Round Scad	1	0.1
Sandbar Shark	8	0.6
Scamp	4	0.3
Unidentified Sharksuckers	4	0.3
Silk Shark	3	0.2
Unidentified Squirrelfish	2	0.1
Tomtate	98	7.1
Vermilion Snapper	108	7.8
White Grunt	1	0.1
Whitespotted Soapfish	3	0.2
Total Fish Collected	1,383	

Table 6. Summary of species culled during the FWC RTD supplemental hooked-gear study (n=116) within NMFS statistical zone 728 along the Atlantic coast of Florida (April – August 2024). Percentage of Total Cull is the percent composition of each species out of all fish culled. Taxa are arranged alphabetically by common name.

Species	Total Culled	Percentage of Total Cull
Almaco Jack	2	0.2
Banded Rudderfish	2	0.2
Black Sea Bass	18	1.5
Blue Runner	1	0.1
Cubbyu	1	0.1
Gag	7	0.6
Grasby	7	0.6
Gray Snapper	4	0.3
Gray Triggerfish	4	0.3
Greater Amberjack	2	0.2
Lane Snapper	5	0.4
Red Grouper	6	0.5
Red Porgy	4	0.3
Red Snapper	1,036	84.2
Scamp	4	0.3
Unidentified Sharksuckers	3	0.2
Tomtate	60	4.9
Vermilion Snapper	62	5
White Grunt	1	0.1
Whitespotted Soapfish	2	0.2
Total Fish Culled	1,231	

Table 7. Total number of sampled sites (Total # Sites), the total number of two-hook drops (Total # Drops), total number of drops that captured two fish on the same drop (Total # 2 Fish Drops), and the percentage of total drops that captured two fish on the same drop (% Drops 2 Fish) for FWC RTD surveys conducted along the Atlantic coast of Florida, 2016 – 2023.

Year	Total # Sites	Total # Drops	Total # 2 Fish Drops	% Drops 2 Fish
2016	93	2,790	38	1.4
2017	107	3,220	60	1.9
2018	337	10,110	212	2.1
2021	216	6,720	177	2.6
2022	200	6,000	200	3.3
2023	217	6,520	263	4.0
TOTAL	1170	35,360	950	2.7

Table 8. The total number of hooks dropped (Total # Hooks Dropped), the total number of fish caught (all species combined) when two fish were caught on the same rig on the same drop (Total # Fish Caught), and the percentage of the total # of hooks dropped that captured two fish on the same rig on the same drop (% Total), for each hook size deployed for FWC RTD surveys conducted along the Atlantic coast of Florida, 2016 – 2023.

Hook Size	Total # Hooks Dropped	Total # Fish Caught	% Total
8/0	23,580	836	3.5
11/0	23,610	860	3.6
15/0	23,530	204	0.9
Total	70,720	1,900	2.7

Table 9. Species collected when two fish were caught on the same rig during the same drop for FWC RTD hook-gear surveys conducted along the Atlantic coast of Florida, 2016 – 2023. Taxa are arranged alphabetically by common name.

Common Name	2016	2017	2018	2021	2022	2023	Total
Almaco Jack	-	-	-	1	1	2	4
Atlantic Sharpnose Shark	2	1	1	-	-	-	4
Banded Rudderfish	3	-	4	3	3	4	17
Bank Sea Bass	2	7	2	-	2	-	13
Black Sea Bass	31	20	46	27	43	17	184
Blue Runner	1	-	-	-	-	1	2
Bluefish	-	-	2	-	-	-	2
Goliath Grouper	-	-	-	-	-	1	1
Gray Snapper	-	-	-	3	-	-	3
Gray Triggerfish	-	2	3	3	4	1	13
Greater Amberjack	-	-	-	-	-	2	2
Inshore Lizardfish	-	-	-	-	-	1	1
Lane Snapper	-	-	1	1	2	3	7
Largespot Lizardfish	-	-	-	-	-	1	1
Little Tunny	-	-	-	1	-	-	1
Pigfish	-	-	-	-	-	1	1
Red Grouper	-	-	-	-	-	1	1
Red Porgy	-	2	1	7	1	1	12
Red Snapper	25	64	312	267	303	424	1,395
Sand Perch	-	-	1	-	3	2	6
Sandbar Shark	-	-	-	-	-	2	2
Scamp	-	-	-	1	1	1	3
Unidentified Sharksuckers	-	-	-	-	2	1	3
Silk Snapper	-	-	-	1	-	-	1
Silky Shark	1	-	3	-	-	-	4
Spanish Mackerel	-	-	-	-	1	-	1
Unidentified Squirrelfish	1	-	-	-	-	-	1
Tomtate	8	5	19	15	20	20	87
Vermilion Snapper	2	19	28	24	14	40	127
Whitebone Porgy	-	-	1	-	-	-	1
Total	76	120	424	354	400	526	1,900

Table 10. Relative nominal CPUE (total number of drops that collected two fish on the same rig per total sites sampled), number of sites sampled (N), proportion of positive sets, standardized index, and coefficient of variation (CV) for historical FWC RTD two fish caught on the same rig index (RTD hooked-gear IOA) of U.S. South Atlantic, 2016 – 2023.

Year	Nominal CPUE	N	Proportion Positive	Standardized Index	CV
2016	0.41	93	0.25	0.3721	0.22009
2017	0.56	107	0.27	0.5102	0.19029
2018	0.63	337	0.34	0.5617	0.10699
2021	0.82	216	0.39	0.7128	0.12237
2022	1.00	200	0.42	0.9083	0.12333
2023	1.21	217	0.51	1.0176	0.12273

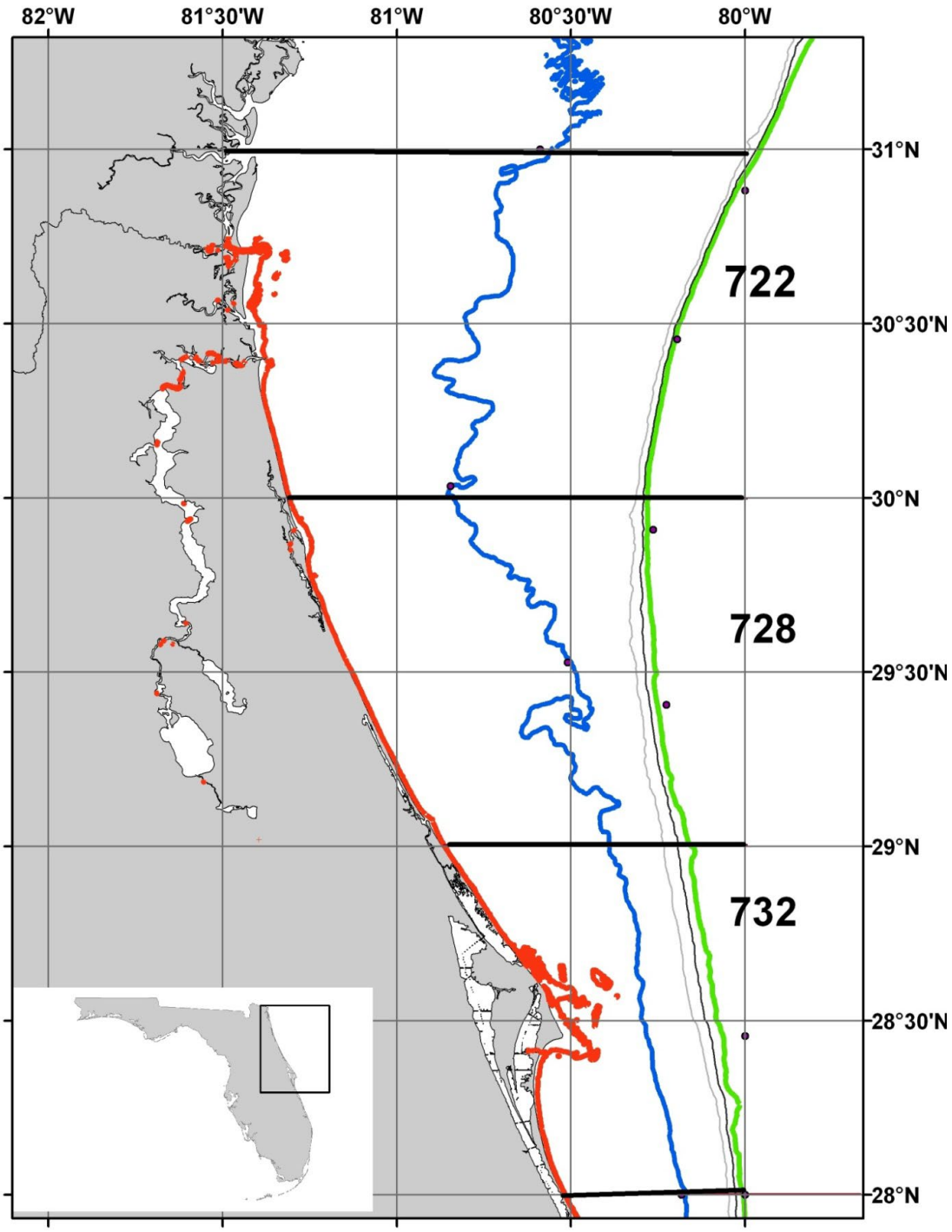

Figure 1. Overall study area for FWC RTD surveys along the Atlantic coast of Florida (2012 – 2024), including NMFS statistical zones 722, 728, and 732. Sampling for the 2024 experimental hooked-gear survey and 2024 supplemental FWC RTD hooked-gear sampling was concentrated in NMFS statistical zone 728. The colored lines represent the 10-m (red), 30-m (blue), and 150-m (green) isobaths, respectively.

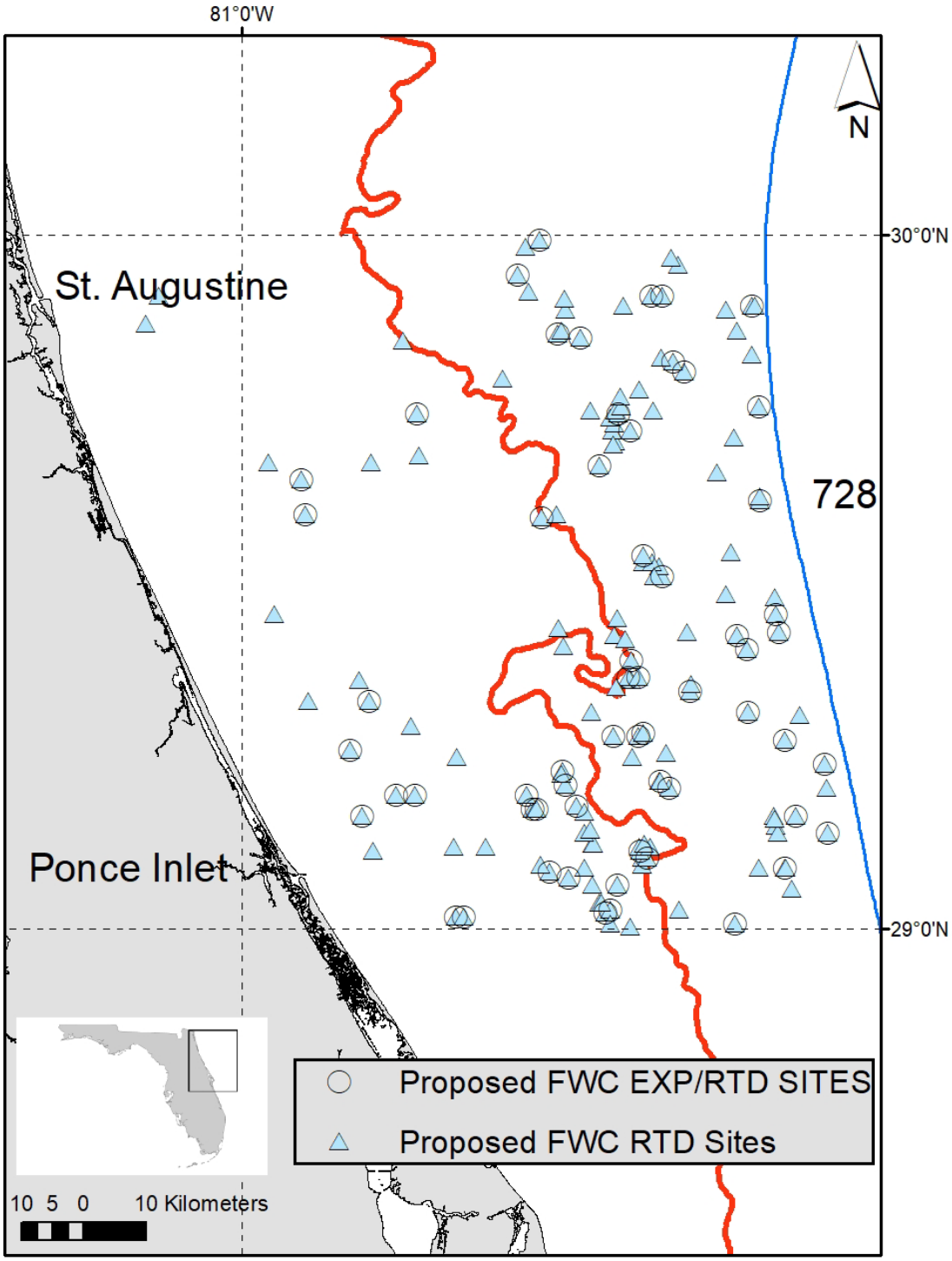

Figure 2. Proposed sampling sites for the experimental surveys (n=60; circled blue triangles) and supplemental FWC RTD hooked-gear surveys (n=123; blue triangles) to be sampled April – July 2024 within NMFS statistical zone 728 along the Atlantic coast of Florida. The red and blue lines represent the 30-m and 150-m isobaths, respectively.

Figure 3. Electric reel (Electramate© model 920-XP) equipped with a Penn 9/0 Senator reel used during FWC RTD and experimental hooked-gear surveys along the Atlantic coast of Florida (2024).

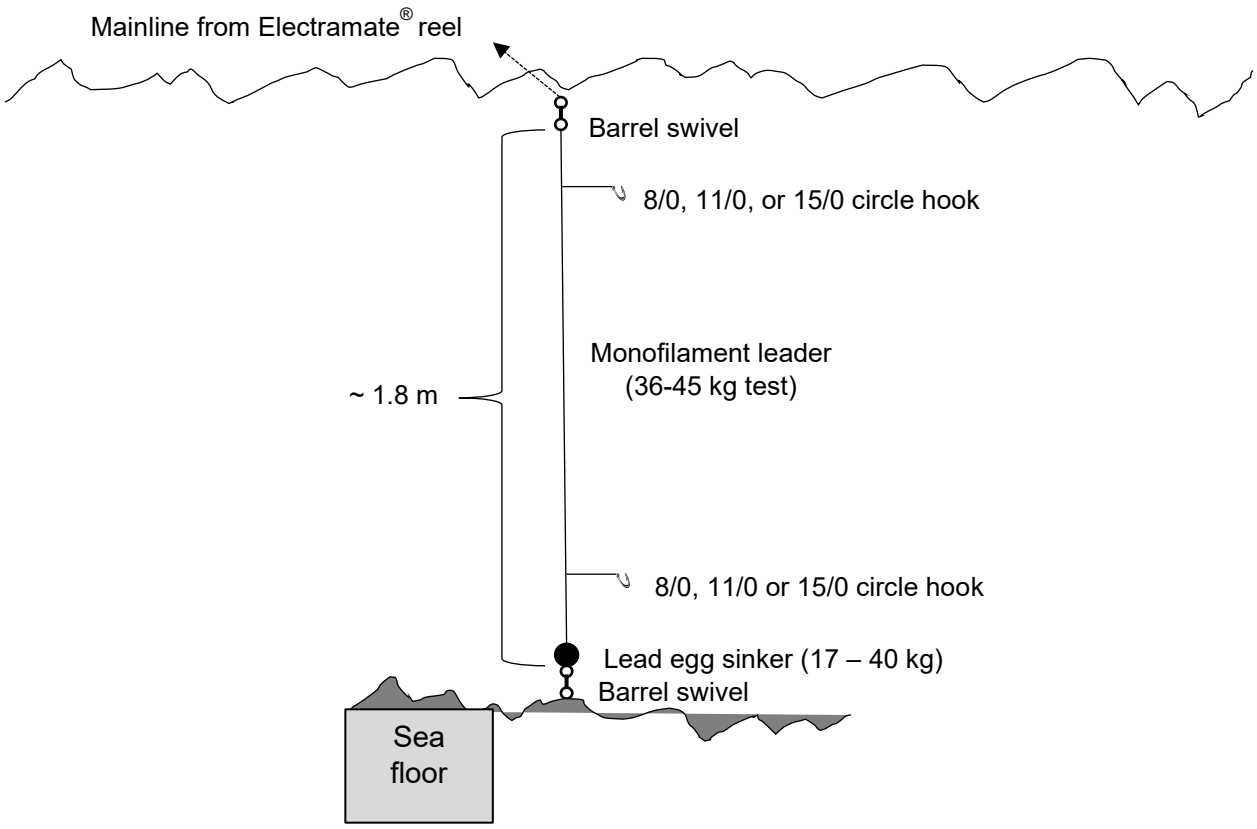

Figure 4. Diagram of standardized terminal tackle, double-hook "chicken rig", used during FWC RTD hooked-gear surveys along the Atlantic coast of Florida (2016 – 2024).

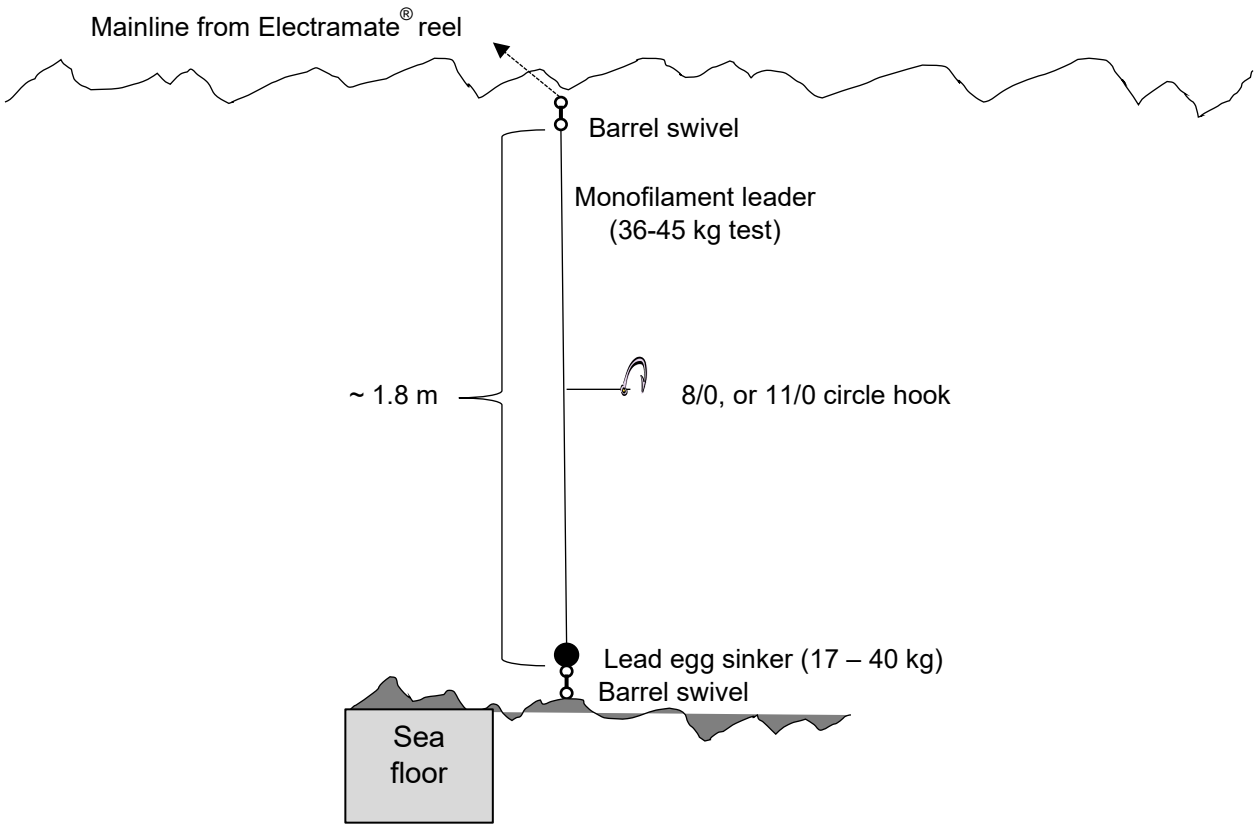

Figure 5. Diagram of terminal tackle, single-hook rig, used during FWC experimental hooked-gear surveys along the Atlantic coast of Florida (2024).

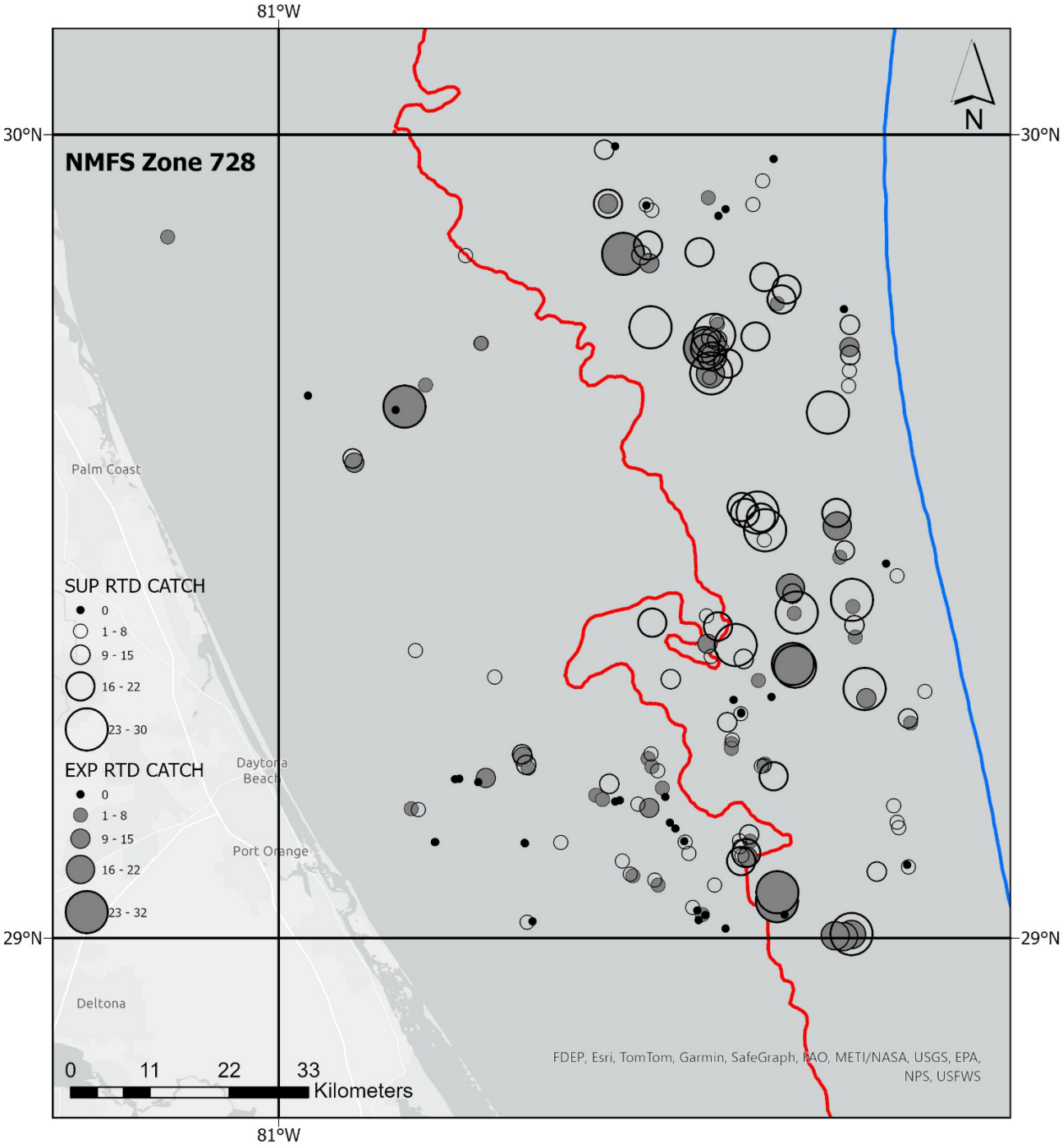

Figure 6. Map of the study area, with symbols representing the locations of sites sampled during the 2024 comparative study. The number of Red Snapper collected at each site corresponds to the size of the circle as given in the legend for Supplemental FWC RTD hooked-gear (SUP RTD, black circles) and Experimental RTD hooked-gear (EXP RTD, grey circles), respectively. The red and blue lines represent the 30-m and 150-m isobaths, respectively.

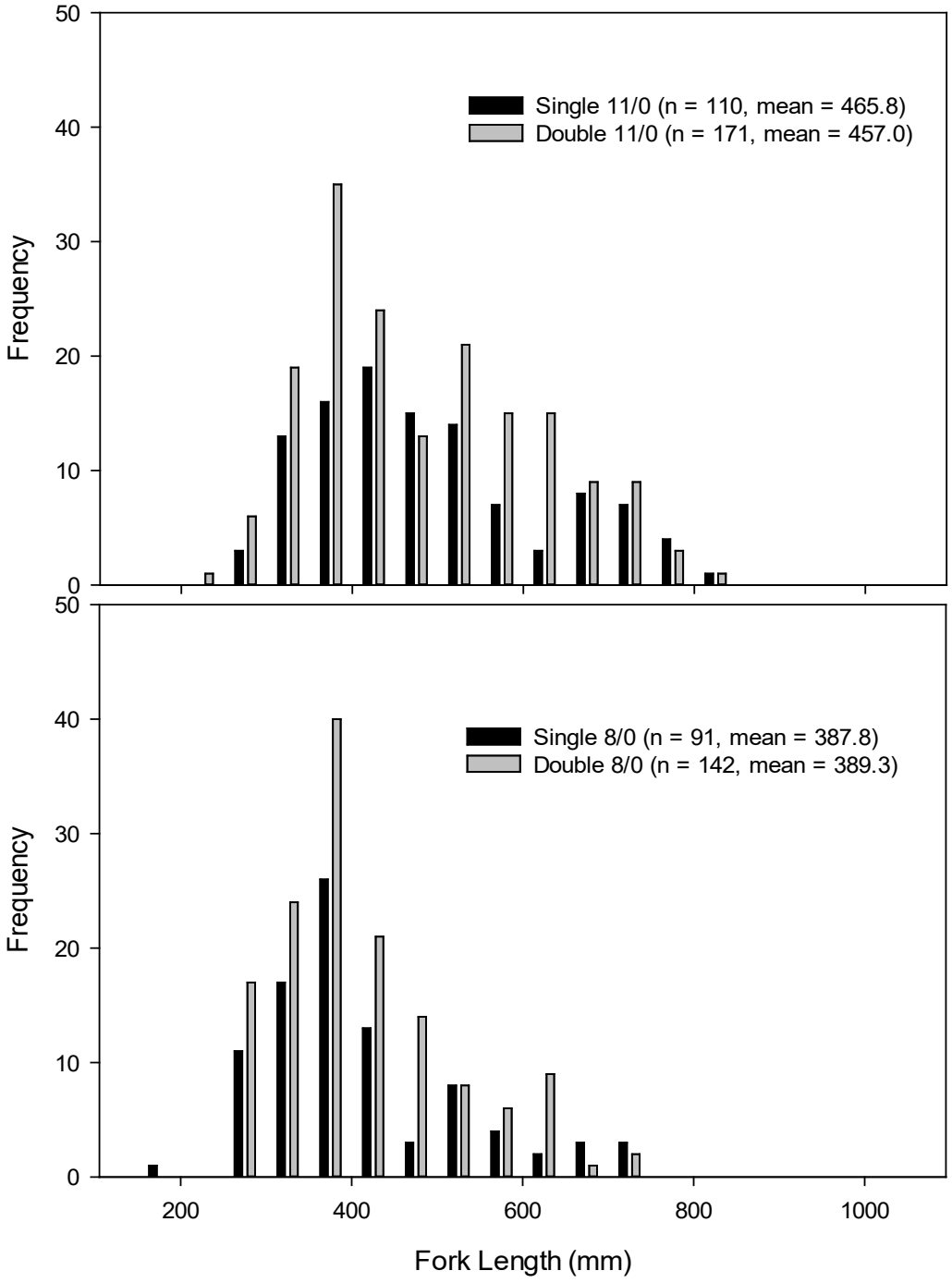

Figure 7. Length frequency (mm FL) of Red Snapper collected during FWC experimental RTD hooked-gear survey within NMFS statistical zone 728 along the Atlantic coast of Florida (April – August 2024) by rig type (single and double) and hook size (8/0 and 11/0). The total number of Red Snapper collected (n) and associated mean fork length (mm) for each rig type and hook size combination is shown in parentheses.

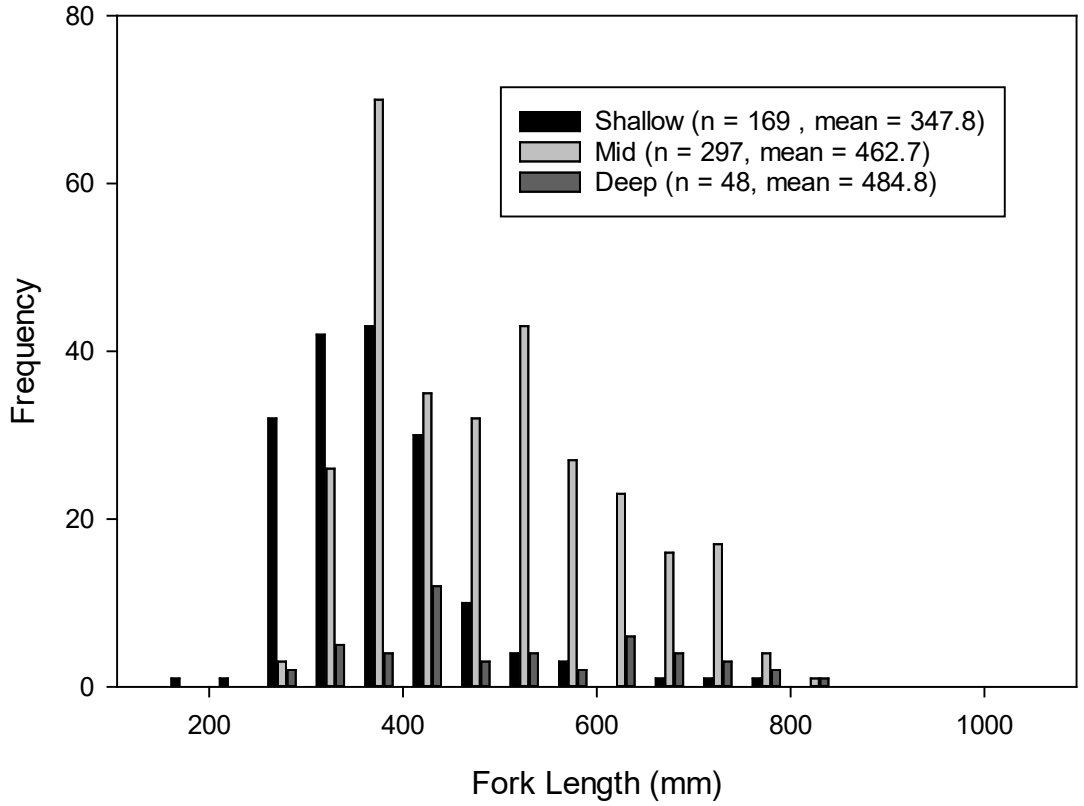

Figure 8. Length frequency (mm FL) of Red Snapper collected during FWC experimental RTD hooked-gear survey within NMFS statistical zone 728 along the Atlantic coast of Florida (April – August 2024) by depth strata: Shallow (< 31 m), Mid (31-49 m) and Deep (>49 m). The total number of Red Snapper collected (n) and associated mean fork length (mm) for each depth strata is shown in parentheses.

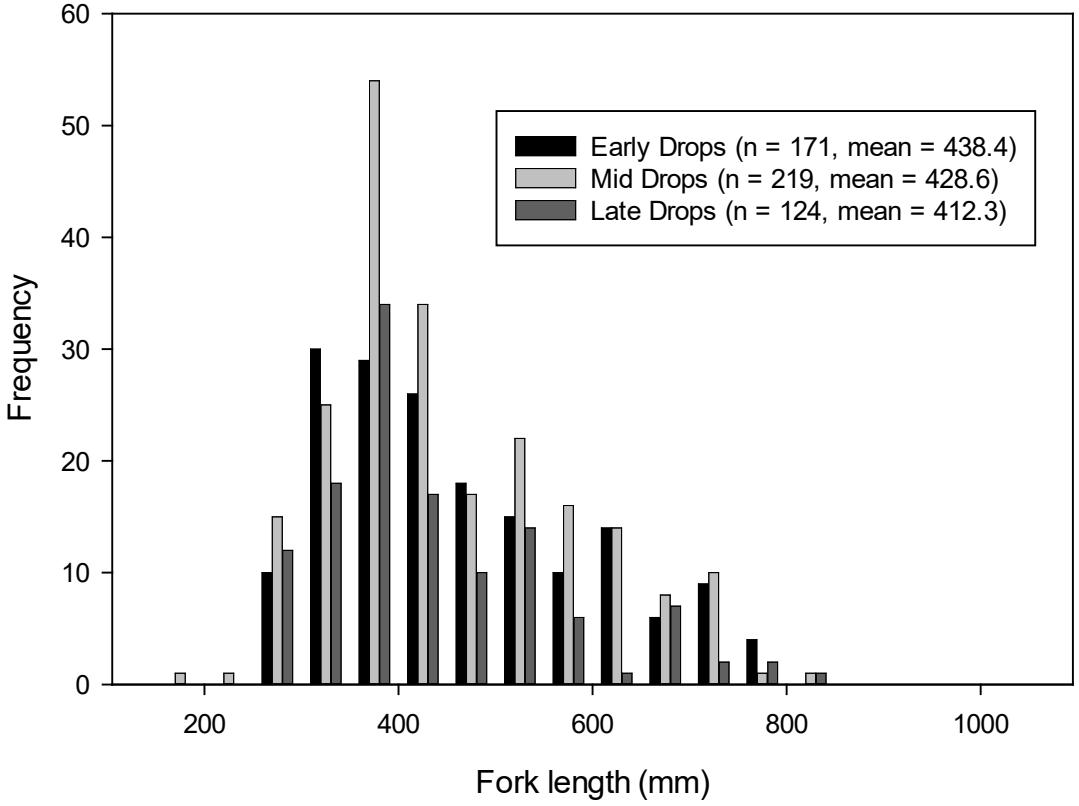

Figure 9. Length frequency (mm FL) of Red Snapper collected during FWC experimental RTD hooked-gear survey within NMFS statistical zone 728 along the Atlantic coast of Florida (April – August 2024) by drop group: Early (drops 1-3), Mid (drops 4-7), and Late (drops 8-10). The total number of Red Snapper collected (n) and associated mean fork length (mm) for each drop group is shown in parentheses.

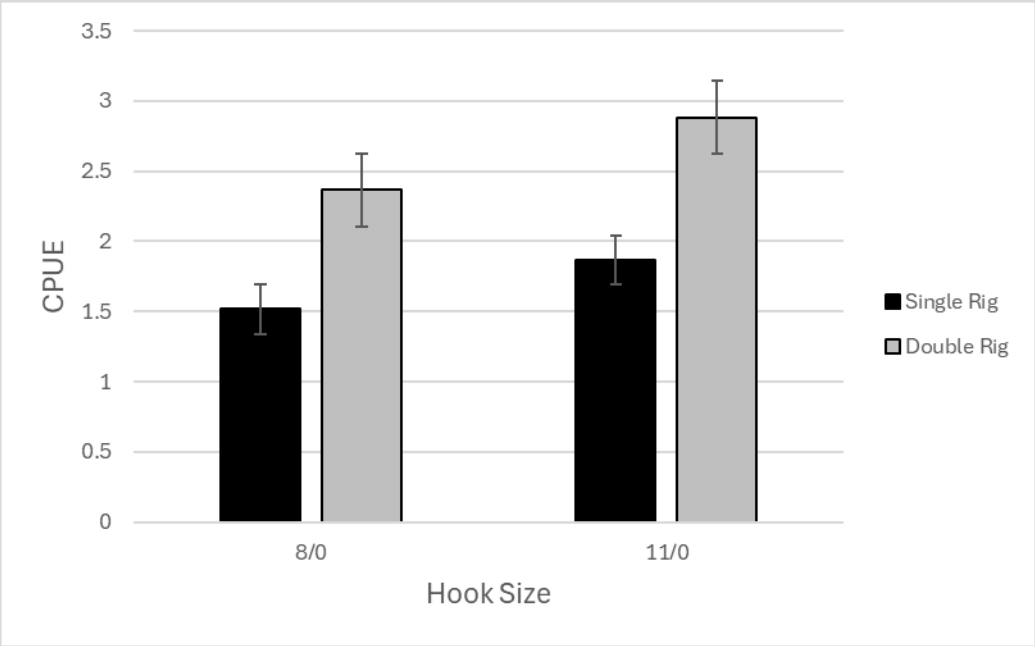

Figure 10. Bar chart displaying CPUE (Total number collected per total number of sites sampled) values for Red Snapper caught using each rig type (single or double) with each hook size (8/0 or 11/0 hooks) based on the number of sites sampled in the experimental RTD survey (n=60 sites) conducted by FWC along the Atlantic coast of Florida (2024).

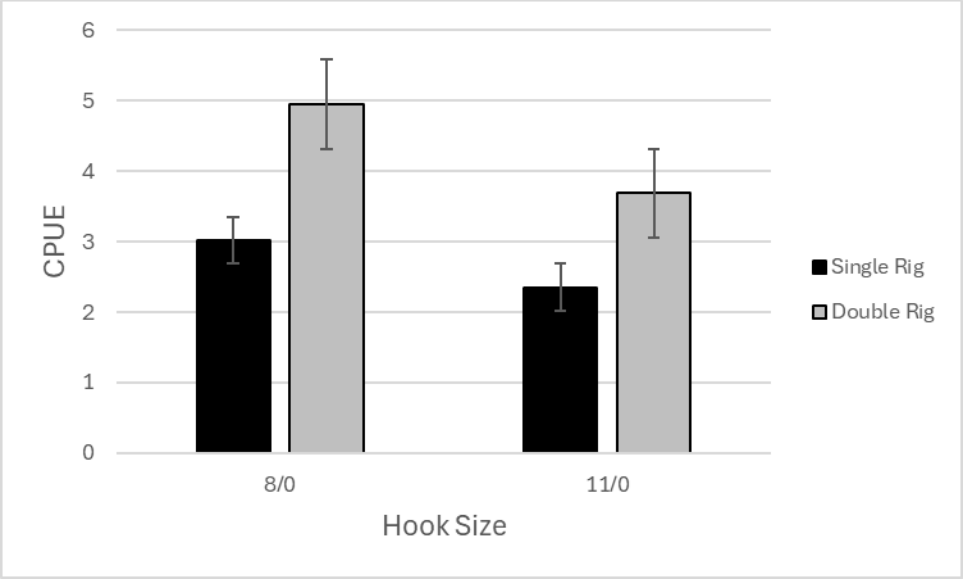

Figure 11. Bar chart displaying CPUE (Total number collected per total number of sites sampled) values for all species caught using each rig type (single or double) with each hook size (8/0 or 11/0) based on the number of sites sampled in the experimental RTD survey (n=60 sites) conducted by FWC along the Atlantic coast of Florida (2024).

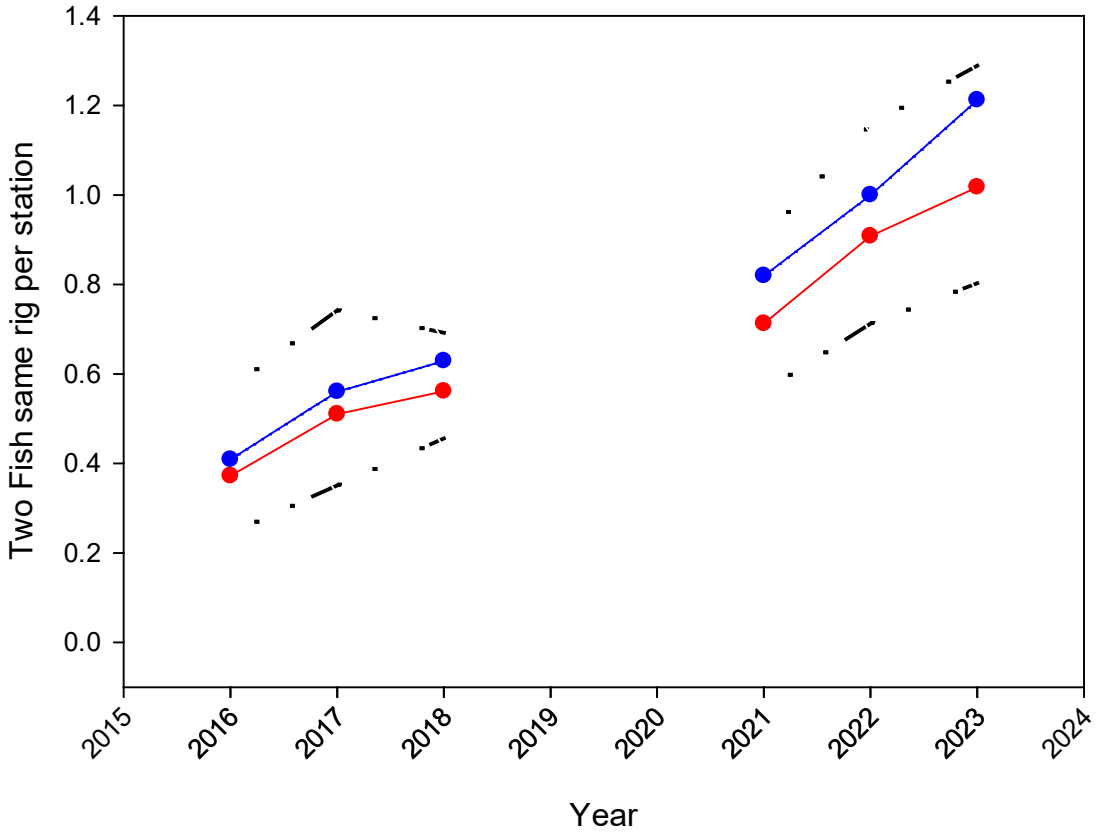

Figure 12. Relative standardized index (red line) with 95% confidence intervals (dashed lines), and the nominal per site CPUE (blue line) for two fish (all fish species) collected on the same rig during FWC RTD surveys conducted along the Atlantic coast of Florida, 2016 – 2023.