**Project Goals and Objectives**:

- Provide spatially-explicit, fisheries-independent data for reef-fish stock assessments, especially for higher-priority fishes (e.g., gag, red grouper, red snapper).
- Address acknowledged data gaps which are currently hindering efforts to develop an ecosystem-based approach to fisheries management in the West Florida Shelf.
- **SAFMC Add-on: Investigate catch rates of single hook Carolina rig and double hook chicken rigs**

## Methods:

The project was developed to create a fisheries-independent reef fish monitoring program for the West Florida Shelf (WFS). The project was a component of an overall sampling strategy that used multiple sampling methods to target important life-history stages that range from post-settlement juveniles in estuarine habitats to fully-recruited adults in neritic waters. This report contains only aspects of the project related to hook and line sampling, because the project used single and double hook rigs fished at the same time. New analyses were conducted to determine if the number of fish per station varied among the gear types used in the study.

### Surveys Design

An exploratory survey of reef fishes was conducted using experimental hooked gears in 2010 only. Sampling was conducted within NMFS statistical zones 5 (Tampa Bay), 6 (Crystal River), and 8 (Panama City), and sampling effort was stratified by depth (Nearshore: 10 – 37m and Offshore: 38 – 110m, Figure 1). Within each sampling region, locations (GPS coordinates) of suitable hard-bottom habitats were obtained from either participating fishers (i.e., commercial or recreational), federal agency partners (i.e., NMFS, USGS), or existing historical data collected by FWC. All habitat data were combined into a sampling universe and subdivided into sampling units or stations (0.3 nm latitude x 0.1 nm longitude). Sampling stations were randomly selected from the sampling universe by region and depth strata: 64 stations per region, 32 within each of the two depth zones (Figure 1).

Hooked-gear surveys were conducted using actively fished hooked gears. A powered (12V DC) Elec-tra-mate© rig (model 620D) was used to conduct active hook and line sampling. Elec-tra-mates© were outfitted with a Diawa 600H 6/0 (Sealine model) reel equipped with Ande© 100 lb. test monofilament. The entire rig was mounted onto a heavy-duty fiberglass fishing pole (~ 8 ft.). Two styles of terminal tackle were used for active hooked-gear sampling, a "chicken" rig and a "Carolina" rig (Figure 2). The "chicken" rig consisted of a pair of Mustad circle hooks, one located near the top of the rig (8/0 or 11/0 circle hook) and the other near the bottom (11/0 or 13/0 circle hook, Figure 2). The "Carolina" rig consisted of a single 11/0 or 13/0 Mustad circle hook.

Prior to beginning sampling within a station the captain of the research vessel would search for and select a suitable fishing site within that station (0.3 nm latitude x 0.1 nm longitude area). If suitable hard-bottom habitat was not available within the station then the captain was allowed to

spiral search an area of 4.8km from the original station to select a site with adequate reef habitat. Active hook and line fishing involved simultaneous bottom fishing of reef habitat for 30 minutes by four anglers. Two anglers fished with "chicken" rigs (one with 8/0 circle hook on top and 11/0 circle hook on bottom; one with 11/0 circle hook on top and 13/0 circle hook on bottom) and the other two anglers fished with "Carolina" rigs (one with a single 11/0 circle hook and the other with a single 13/0 circle hook). All hooks were baited with cut Atlantic mackerel. At each sampling station, anglers were assigned to a particular rig with a specific hook combination. The rig combinations fished by anglers were alternated between sampling stations to remove any angler bias with respect to rig or terminal tackle.

Overall sampling effort (# stations fished) was summarized separately by each region (NMFS statistical zones 5, 6, and 8) and depth stratum (nearshore: 10 – 37m, offshore: 38 – 110m). Reef fish catch was summarized by rig type (single hook 11/0, single hook 13/0, double hook 8/0 over 11/0, and double hook 11/0 over 13/0) and angler type (commercial or scientist). Catch per unit effort statistics (CPUE; # fish/station) were calculated by rig type for key managed species. Length frequency plots were generated for Red Snapper, Red Grouper, and Gag by rig type.

Statistical Analysis:

The goal of this analysis was to investigate if there was a statistical difference in the count of catch between single hook Carolina rigs vs double hook chicken rigs for Red Snapper, Red Grouper, and Gag (top 3 species and had over 100 fish each). A generalized mixed model was attempted using station as a fixed effect with angler nested within station. The suite of models was unstable due to limited sample size. Therefore a generalized negative binomial model (glm.nb) was explored to determine best model for the available data with variables for Rig Type (Carolina Rig vs Double Hook), Hook Category (Small - 11/0 single and 8/0 and 11/0 for double rigs vs Large – 13/0 single and 11/0 and 13/0 double), Hooks Used (8/0 and 11/0, 11/0, 11/0 and 13/0, and 13/0), depth fished, and angler type (commercial vs scientific). Hooks used and rig type were not combined in the models due to potential duplication in the parameter since hooks used identified both single and double hooks rigs along with hook category. AIC was used to select the best fitting model (aictab). All models were fit using packages in R Software v4.1.2.

Reasoning for including interaction variables in the model testing
Experience can result in different anglers being more successful with certain gear configurations or at different depths. Also gear efficiency may vary with depth. Therefore interactions terms were included in the model testing to deduce if interactions occurred among the variables.

## Results:

D) General Results:

Hooked gear sampling was conducted from August through October 2010 at 211 stations (Table 1). A total of 2,067 fish, representing 40 species were collected during active hooked-gear sampling (Table 2). A total of 933 fish (29 species) were collected using Carolina rigs, whereas a total of 1,134 fish (35 species) were collected using Chicken rigs. The top five species collected with Carolina rigs comprised 91% of the catch and included Red Grouper (n = 412),

Red Snapper (n = 313), gag (n = 68), scamp (n = 27), and Red Porgy (n = 25). The top five species collected with Chicken rigs comprised 88% of the catch and included Red Snapper (n = 464), Red Grouper (n = 373), Red Porgy (n = 60), Vermilion Snapper (n = 59), and Gag (n = 47).

The mean catch per unit effort (CPUE) is provided for the top six species by gear configuration (rig type) (Table 3). The mean catch per unit effort was generally low with most having less than one fish caught per station. Red Grouper and Red Snapper both had highest mean CPUE around 1 fish per station. Some stops had substantial catches of Red Snapper and Red Grouper by a gear type with maximum catches of 14 and 16 for Red Grouper and Red Snapper, respectively. Catch rates of Red Grouper, Red Snapper, Gag, and Scamp were relatively similar across rig types. However, CPUE of smaller reef fish species (Red Porgy and Vermilion Snapper) were higher using Chicken rigs and smaller hook sizes.

The catch by angler was higher for scientists compared to commercial fishers; however overall CPUE was similar (Commercial CPUE = 2.7 fish/station; Scientist CPUE = 2.3 fish/station) (Table 4). Despite having lower effort commercial anglers caught more Red Grouper (1.5 fish/station) than scientists (0.6 fish/station). Scientists had a higher CPUE of Red Snapper (1.1 fish/station) compared to commercial fishers (0.5 fish/station). Scientists caught more fish for most other species including Gag, Red Porgy, Red Snapper, and Vermilion Snapper. Scientists also caught a higher number of species (34) compared to commercial anglers (28).

Red Snapper

Most Red Snapper were caught on double hook rigs (Table 5) and were caught at 89 stations (42% of stations fished). Of the variables tested for inclusion, depth was included in all of the top 10 models (Table 6). A hook related factor was also included in all models with rig type being in eight of the models, hook category (small vs large) being in two, and hooks used in two.

In three of the four best models, there was interaction between angler type and depth. The interaction between depth and angler limits the inferences that can be drawn about the two variables independently, which was potentially due to the higher number of samples collected by scientists over a wider range of depths. In the top four models (delta AIC was less than 4), more Red Snapper were caught in shallower depths compared to deeper depths, in general (model 3) and by scientists (models 1, 2, and 4). Commercial fishermen tended to catch more Red Snapper at deeper depths (models 1, 2, and 4). Larger hooks tended to catch more Red Snapper than smaller hooks (models 2 and 4).

The top four models indicated that Red Snapper catches were higher for double hook rigs compared to single hook rigs (Figure 3). The estimate of the difference in catch number per station for single hook vs double hook ranged from -0.37 (model 2) to -0.41 (model 4). Comparing the median Red Snapper catches by depth bins, rig type, and angler type confirms Red Snapper catches with double hook rigs are higher compared to catches on single hook rigs (Figure 4). Median of Red Snapper caught on double hook rigs was higher for six out of the nine depth bins (50 m was excluded due to missing percentile), two had equal median values among the rig types, and only one depth had higher median catches with single hook rigs for samples collected by scientists. Commercial fishermen median catches with double hook rigs were

higher for five out of the seven depth bins, one had equal median values, and one had a lower median catch of Red Snapper with double hook rigs.

The length distribution for Red Snapper single hook rigs caught a wider distribution than double hook rigs (Figure 5). The modal size range on single hook 11/0 rigs was smaller (325 mm SL) compared to single hook 13/0 rigs (375 and 400 mm SL). Modal size for the double hook rigs was in the range of single hook rigs.

Red Grouper

Most Red Grouper were caught on single hook rigs (Table 7) and were caught at 124 stations (58.8% of stations fished). No models fit the data particularly well with the AIC weight being less than 0.4 for all models (Table 8). Therefore, no model was selected as a best fit model. Differences in Red Grouper catches could not be detected based on the variables in the model: rig type, hook category, hooks used, angler type, and depth.

Interestingly, catches were similar among single hook 11/0, single hook 13/0, and double hook 11/0 and 13/0 (202 to 210 fish). The catches with double hooks 8/0 and 11/0 were lower (168). Red Grouper catches tended to decrease with depth based on median catches by 10 m depth bins (Figure 6). In depths deeper than 30 m, the median catch varied between zero and one fish.

Red Grouper length distribution was similar among rig configurations (Figure 7). Lengths ranged from 200 to 650 mm SL. The largest modal size was caught with larger hook sizes for both rig configurations.

Gag

Due to the lower number of Gag caught, the model was run using a binomial distribution. Most gag were caught on single hook rigs (Table 9) and were caught at 55 stations (26% of stations fished). No models fit the data well with the AIC weight being less than 0.4 for all models (Table 10). Therefore, no model was selected as a best fit model. Differences in Gag observations could not be detected based on the variables in the model: rig type, hook category, hooks used, angler type, and depth.

Catches of Gag tended to be higher on single hook rigs (29 and 39 fish) compared to double hook rigs (20 to 27 fish). Due to the low number of Gag caught, median values for Gag tended to be zero and differences between rig types were not observed (Figure 8).

The length range for Gag was approximately 300 to 850 mm SL for both rig types (Figure 9). The highest percent were caught on 13/0 hooks for single rigs and with 8/0 over 11/0 hooks for double rigs.

## Conclusions:

The data collected here are from the Gulf of Mexico from 2010 and should not be assumed to have the same relative impact of changing gears in the South Atlantic region. Catch rates can vary due to abundance of an individual species, presence of other species in the area, and physical parameters in the area (i.e., current and temperature). However, the relative catches among rig types may give some indication on the directionality of changes that could occur.

For Red Snapper,

- Single hook rigs caught fewer Red Snapper than double hook rigs,
- Larger hook sizes tended to catch more fish,
- Depth typically had an interactive effect with angler type, and
- Hook size did not appear to have a significant impact on size of fish caught.

For Red Grouper,

- No model detected differences in catch rates with AICc weight greater than 0.25 (meaning there was no model among the models tested with greater than 25% probability of being the best model),
- Single hook rigs caught more than double hook rigs,
- Few Red Grouper were caught in depths 40 meters and deeper, and
- Larger hook sizes caught a larger modal size of Red Grouper.

For Gag,

- No model detected differences in catch rates with AICc weight greater than 0.1 (meaning there was no model among the models tested with greater than 10% probability of being the best model),
- Single hook rigs caught more than double hook rigs,
- The few number of fish caught resulted in a zero median catch rate by depth for most depth bins, and
- Limited inferences can be made on size distribution for hook size or gear configuration due to limited catches.

Additional research is needed in the South Atlantic region to determine if hook size, gear configuration, or depth has an impact on the catch rates for Red Snapper and other species. The research could be expanded to include season or temperature as potential factors if sufficient sampling is possible. This type of information would be valuable for understanding the impacts of different gear, season, or spatial closures for Red Snapper and other species in the Snapper Grouper Complex.

Table 1. Summary of the number of stations sampled in each region and depth startum in 2010 ( nearshore: 10 – 37m, offshore: 38 – 110m).

| | Depth Stratum | |
|---|---|---|
| Sampling Region/ NMFS statistical zone | Nearshore | Offshore |
| | | |
| Stat Zone 5 – Tampa Bay | 39 | 49 |
| | | |
| Stat Zone 6 – Crystal River | 30 | 29 |
| | | |
| Stat Zone 8 – Panama City | 32 | 32 |
| | | |
| **Totals** | **101** | **110** |

Table 2. Catch by Rig type. FIM COOP hooked gear sampling 2010. Rig type 0811 is double hook rig with 8/0 hook on top and 11/0 on bottom, rig11 is single 11/0 hook, rig1113 is double hook rig with 11/0 on top and 13/0 on bottom, and rig13 is single 13/0 hook.

| | | rigtyp | | | | Total |
|---|---|---|---|---|---|---|
| | | rig0811 | rig11 | rig1113 | rig13 | |
| | | N | N | N | N | N |
| Species | Common Name | | | | | |
| Balistes capriscus | Gray triggerfish | 2 | 3 | . | 1 | 6 |
| Calamus nodosus | Knobbed porgy | . | 2 | 1 | . | 3 |
| Carcharhinus acronotus | Blacknose shark | 1 | . | 2 | 1 | 4 |
| Carcharhinus falciformis | Silky shark | 2 | . | 1 | . | 3 |
| Carcharhinus spp. | Requiem Sharks | . | . | . | 1 | 1 |
| Centropristis ocyurus | bank sea bass | . | . | 1 | . | 1 |
| Centropristis striata | Black sea bass | 3 | 2 | 4 | 1 | 10 |
| Cephalopholis cruentata | Graysby | 2 | . | . | . | 2 |
| Diplectrum formosum | Sand perch | . | 3 | 1 | . | 4 |
| Echeneis spp. | Sharksuckers | 2 | 1 | 1 | 1 | 5 |
| Epinephelus adscensionis | Rock hind | . | . | . | 1 | 1 |
| Epinephelus drummondhayi | Speckled hind | 4 | 1 | 2 | . | 7 |
| Epinephelus morio | Red grouper | 168 | 210 | 205 | 202 | 785 |
| Euthynnus alletteratus | Little tunny | . | . | 1 | . | 1 |
| Galeocerdo cuvier | Tiger shark | 1 | . | . | . | 1 |
| Ginglymostoma cirratum | Nurse shark | 1 | . | . | 1 | 2 |
| Gymnothorax moringa | Spotted moray | . | 1 | 1 | 1 | 3 |
| Haemulon aurolineatum | Tomtate | 3 | 1 | 2 | 1 | 7 |
| Haemulon plumierii | White grunt | 8 | 6 | 7 | 2 | 23 |
| Lutjanus campechanus | Red snapper | 218 | 152 | 246 | 161 | 777 |
| Lutjanus griseus | Gray snapper | 7 | 10 | 9 | 7 | 33 |
| Lutjanus synagris | Lane snapper | 2 | 1 | 1 | 1 | 5 |
| Malacanthus plumieri | Sand tilefish | 1 | . | . | . | 1 |
| Mycteroperca microlepis | Gag | 20 | 29 | 27 | 39 | 115 |
| Mycteroperca phenax | Scamp | 21 | 15 | 15 | 12 | 63 |
| Opsanus pardus | Leopard toadfish | . | . | . | 3 | 3 |
| Orthopristis chrysoptera | Pigfish | . | 1 | . | . | 1 |
| Pagrus pagrus | Red porgy | 31 | 18 | 29 | 7 | 85 |
| Rachycentron canadum | Cobia | . | 1 | . | . | 1 |
| Rhizoprionodon terraenovae | Atlantic sharpnose shark | . | . | 1 | . | 1 |
| Rhomboplites aurorubens | Vermilion snapper | 36 | 11 | 23 | 5 | 75 |
| Scomber colias | Chub mackerel | 2 | . | . | . | 2 |
| Scomberomorus cavalla | King mackerel | . | . | 1 | 1 | 2 |
| Seriola dumerili | Greater amberjack | 2 | . | . | 2 | 4 |
| Seriola rivoliana | Almaco jack | 6 | 7 | 1 | 5 | 19 |
| Seriola spp. | Amberjacks | 1 | . | . | . | 1 |
| Seriola zonata | Banded rudderfish | 4 | 1 | 1 | . | 6 |
| Syacium papillosum | Dusky flounder | . | . | 1 | . | 1 |
| Synodus spp. | Lizardfish | . | 1 | 1 | . | 2 |
| Trachinocephalus myops | Snakefish | 1 | . | . | . | 1 |
| Total | | 549 | 477 | 585 | 456 | 2067 |

Table 3. Mean catch per unit effort (catch per station) by Species by Rig type. FIM COOP hooked gear sampling 2010.

| | Rig Type | Sites fished | Mean | StdErr | CV | Max catch | Total Catch |
|---|---|---|---|---|---|---|---|
| *Epinephelus morio* | Single Hook -11/0 | 211 | 1.00 | 0.12 | 180.14 | 12 | 210 |
| | Single Hook - 13/0 | 211 | 0.96 | 0.11 | 173.99 | 9 | 202 |
| | Dbl Hook - 8/0 over 11/0 | 211 | 0.80 | 0.12 | 215.15 | 13 | 168 |
| | Dbl Hook - 11/0 over 13/0 | 211 | 0.97 | 0.14 | 208.27 | 14 | 205 |
| | | | | | | | |
| *Lutjanus campechanus* | Single Hook -11/0 | 211 | 0.72 | 0.10 | 209.98 | 7 | 152 |
| | Single Hook - 13/0 | 211 | 0.76 | 0.12 | 219.33 | 10 | 161 |
| | Dbl Hook - 8/0 over 11/0 | 211 | 1.03 | 0.14 | 200.01 | 11 | 218 |
| | Dbl Hook - 11/0 over 13/0 | 211 | 1.17 | 0.16 | 199.77 | 16 | 246 |
| | | | | | | | |
| *Mycteroperca microlepis* | Single Hook -11/0 | 211 | 0.14 | 0.03 | 365.57 | 4 | 29 |
| | Single Hook - 13/0 | 211 | 0.18 | 0.03 | 258.10 | 3 | 39 |
| | Dbl Hook - 8/0 over 11/0 | 211 | 0.09 | 0.02 | 371.96 | 2 | 20 |
| | Dbl Hook - 11/0 over 13/0 | 211 | 0.13 | 0.03 | 339.12 | 3 | 27 |
| | | | | | | | |
| *Mycteroperca phenax* | Single Hook -11/0 | 211 | 0.07 | 0.02 | 433.39 | 2 | 15 |
| | Single Hook - 13/0 | 211 | 0.06 | 0.02 | 442.80 | 2 | 12 |
| | Dbl Hook - 8/0 over 11/0 | 211 | 0.10 | 0.03 | 372.80 | 2 | 21 |
| | Dbl Hook - 11/0 over 13/0 | 211 | 0.07 | 0.02 | 362.34 | 1 | 15 |
| | | | | | | | |
| *Pagrus pagrus* | Single Hook -11/0 | 211 | 0.09 | 0.03 | 474.88 | 3 | 18 |
| | Single Hook - 13/0 | 211 | 0.03 | 0.01 | 541.13 | 1 | 7 |
| | Dbl Hook - 8/0 over 11/0 | 211 | 0.15 | 0.04 | 346.57 | 4 | 31 |
| | Dbl Hook - 11/0 over 13/0 | 211 | 0.14 | 0.04 | 379.11 | 4 | 29 |
| | | | | | | | |
| *Rhomboplites aurorubens* | Single Hook -11/0 | 211 | 0.05 | 0.02 | 502.76 | 2 | 11 |
| | Single Hook - 13/0 | 211 | 0.02 | 0.01 | 643.40 | 1 | 5 |
| | Dbl Hook - 8/0 over 11/0 | 211 | 0.17 | 0.04 | 312.92 | 4 | 36 |
| | Dbl Hook - 11/0 over 13/0 | 211 | 0.11 | 0.03 | 360.86 | 3 | 23 |

Table 4. Catch by Angler type. FIM COOP hooked gear sampling 2010. Com= commercial fisher and sci=scientists.

| | # Sites Fished | 298 | 546 | |
|---|---|---|---|---|
| | | angler_type | | Total |
| | | com | sci | |
| | | N | N | N |
| Species | Common Name | | | |
| Balistes capriscus | Gray triggerfish | 1 | 5 | 6 |
| Calamus nodosus | Knobbed porgy | 2 | 1 | 3 |
| Carcharhinus acronotus | Blacknose shark | 1 | 3 | 4 |
| Carcharhinus falciformis | Silky shark | 1 | 2 | 3 |
| Carcharhinus spp. | Requiem Sharks | 1 | . | 1 |
| Centropristis ocyurus | bank sea bass | . | 1 | 1 |
| Centropristis striata | Black sea bass | 6 | 4 | 10 |
| Cephalopholis cruentata | Graysby | 2 | . | 2 |
| Diplectrum formosum | Sand perch | 3 | 1 | 4 |
| Echeneis spp. | Sharksuckers | 2 | 3 | 5 |
| Epinephelus adscensionis | Rock hind | . | 1 | 1 |
| Epinephelus drummondhayi | Speckled hind | . | 7 | 7 |
| Epinephelus morio | Red grouper | 449 | 336 | 785 |
| Euthynnus alletteratus | Little tunny | . | 1 | 1 |
| Galeocerdo cuvier | Tiger shark | . | 1 | 1 |
| Ginglymostoma cirratum | Nurse shark | . | 2 | 2 |
| Gymnothorax moringa | Spotted moray | 2 | 1 | 3 |
| Haemulon aurolineatum | Tomtate | 1 | 6 | 7 |
| Haemulon plumierii | White grunt | 14 | 9 | 23 |
| Lutjanus campechanus | Red snapper | 155 | 622 | 777 |
| Lutjanus griseus | Gray snapper | 16 | 17 | 33 |
| Lutjanus synagris | Lane snapper | 1 | 4 | 5 |
| Malacanthus plumieri | Sand tilefish | 1 | . | 1 |
| Mycteroperca microlepis | Gag | 44 | 71 | 115 |
| Mycteroperca phenax | Scamp | 26 | 37 | 63 |
| Opsanus pardus | Leopard toadfish | 2 | 1 | 3 |
| Orthopristis chrysoptera | Pigfish | 1 | . | 1 |
| Pagrus pagrus | Red porgy | 28 | 57 | 85 |
| Rachycentron canadum | Cobia | 1 | . | 1 |
| Rhizoprionodon terraenovae | Atlantic sharpnose shark | 1 | . | 1 |
| Rhomboplites aurorubens | Vermilion snapper | 28 | 47 | 75 |
| Scomber colias | Chub mackerel | . | 2 | 2 |
| Scomberomorus cavalla | King mackerel | . | 2 | 2 |
| Seriola dumerili | Greater amberjack | . | 4 | 4 |
| Seriola rivoliana | Almaco jack | . | 19 | 19 |
| Seriola spp. | Amberjacks | . | 1 | 1 |
| Seriola zonata | Banded rudderfish | . | 6 | 6 |
| Syacium papillosum | Dusky flounder | . | 1 | 1 |
| Synodus spp. | Lizardfish | 1 | 1 | 2 |
| Trachinocephalus myops | Snakefish | 1 | . | 1 |
| Total | | 791 | 1276 | 2067 |

Table 5. Red Snapper number of samples with positive catches by gear and hook configurations

| Rig type | Hook category | Hook size | Number of stations with a Red Snapper | Total number of Red Snapper |
|---|---|---|---|---|
| Double | Small | 8/0 and 11/0 | 72 | 218 |
| Single | Small | 11/0 | 54 | 152 |
| Double | Large | 11/0 and 13/0 | 66 | 246 |
| Single | Large | 13/0 | 61 | 161 |

Table 6. Top 10 models to describe Red Snapper catch rates based on depth fished, type of fisherfolk, hook type, and hook size. Criteria includes K (parameters), Akaike Information Criteria (AICc, corrected for small sample sizes), difference from best model (Delta AICc), model likelihood (LL), and proportion of predictive power of each model compared to the full set of models (AICc Wt). * indicates interaction between variables. Bold indicates possible model.

| Model Variables | K | AICc | Delta AICc | LL | AICc Wt |
|---|---|---|---|---|---|
| **Rig Type + Angler Type * Depth** | **6** | **1384.28** | **0.00** | **-686.02** | **0.42** |
| **Rig Type + Angler Type * Depth + Hook Category** | **7** | **1386.16** | **1.88** | **-685.92** | **0.17** |
| **Rig Type + Depth** | **4** | **1387.73** | **3.45** | **-689.81** | **0.08** |
| **Depth * Angler Type + Hooks Used** | **8** | **1388.03** | **3.75** | **-685.81** | **0.06** |
| Rig Type + Angler Type + Depth | 5 | 1388.78 | 4.51 | -689.31 | 0.04 |
| Rig Type * Depth | 5 | 1388.88 | 4.61 | -689.36 | 0.04 |
| Rig Type * Angler Type * Depth | 9 | 1389.40 | 5.12 | -685.44 | 0.03 |
| Rig Type * Depth + Angler Type | 6 | 1389.98 | 5.71 | -688.87 | 0.02 |
| Rig Type + Angler Type + Depth + Hook Category | 6 | 1390.71 | 6.43 | -689.23 | 0.02 |
| Rig Type * Angler Type + Depth | 6 | 1390.81 | 6.53 | -689.28 | 0.02 |

Table 7. Red Grouper number of samples with positive catches by gear and hook configurations

| Rig type | Hook category | Hook size | Number of stations with a Red Grouper | Total number of Red Grouper |
|---|---|---|---|---|
| Double | Small | 8/0 and 11/0 | 66 | 168 |
| Single | Small | 11/0 | 85 | 210 |
| Double | Large | 11/0 and 13/0 | 71 | 205 |
| Single | Large | 13/0 | 81 | 202 |

Table 8. Top 10 models to describe Red Grouper catch rates based on depth fished, type of fisherfolk, hook type, and hook size. Criteria includes K (parameters), Akaike Information Criteria (AIC corrected for small sample sizes), difference from best model (Delta AICc), model likelihood (LL), and proportion of predictive power of each model compared to the full set of models (AICc Wt). * indicates interaction between variables.

| Model Variables | K | AICc | Delta AICc | LL | AICc Wt |
|---|---|---|---|---|---|
| Angler Type + Depth | 4 | 1595.81 | 0.00 | -793.87 | 0.24 |
| Depth + Angler Type + Hook Category | 5 | 1597.39 | 1.58 | -793.63 | 0.11 |
| Rig Type + Angler Type + Depth | 5 | 1597.49 | 1.68 | -793.68 | 0.10 |
| Angler Type * Depth | 5 | 1597.73 | 1.92 | -793.80 | 0.09 |
| Depth * Hook Category + Angler Type | 6 | 1598.76 | 2.94 | -793.29 | 0.05 |
| Rig Type * Angler Type + Depth | 6 | 1598.90 | 3.09 | -793.37 | 0.05 |
| Rig Type * Depth + Angler Type | 6 | 1599.08 | 3.27 | -793.46 | 0.05 |
| Depth * Angler Type + Hook Category | 6 | 1599.34 | 3.53 | -793.59 | 0.04 |
| Rig Type + Angler Type + Depth + Hook Category | 6 | 1599.37 | 3.56 | -793.60 | 0.04 |
| Depth + Angler Type * Hook Category | 6 | 1599.43 | 3.61 | -793.63 | 0.04 |

Table 9. Gag number of samples with positive catches by gear and hook configurations

| Rig type | Hook category | Hook size | Number of stations with a Gag | Total number of Gag |
|---|---|---|---|---|
| Double | Small | 8/0 and 11/0 | 16 | 20 |
| Single | Small | 11/0 | 20 | 29 |
| Double | Large | 11/0 and 13/0 | 20 | 27 |
| Single | Large | 13/0 | 32 | 39 |

Table 10. Top 10 models to describe presence of Gag based on depth fished, type of fisherfolk, hook type, and hook size. Criteria includes K (parameters), Akaike Information Criteria (AIC corrected for small sample sizes), difference from best model (Delta AICc), model likelihood (LL), and proportion of predictive power of each model compared to the full set of models (AICc Wt). * indicates interaction between variables.

| Model Variables | K | AICc | Delta AICc | LL | AICc Wt |
|---|---|---|---|---|---|
| Rig Type | 2 | 564.96 | 0.00 | -280.47 | 0.08 |
| Rig Type + Angler Type * Depth + Hook Category | 6 | 565.10 | 0.14 | -276.50 | 0.07 |
| Hooks Used | 4 | 565.35 | 0.38 | -278.65 | 0.06 |
| Rig Type + Depth | 3 | 565.66 | 0.70 | -279.82 | 0.05 |
| Rig Type + Angler Type + Hook Category | 4 | 565.78 | 0.82 | -278.87 | 0.05 |
| Rig Type * Hook Category + Angler Type | 4 | 565.78 | 0.82 | -278.87 | 0.05 |
| Rig Type * Angler Type + Hook Category | 5 | 565.90 | 0.94 | -277.92 | 0.05 |
| Hooks Used + Depth | 5 | 566.05 | 1.08 | -277.99 | 0.04 |
| Rig Type + Angler Type * Depth | 5 | 566.38 | 1.42 | -278.16 | 0.04 |
| Rig Type * Depth | 4 | 566.46 | 1.50 | -279.21 | 0.04 |

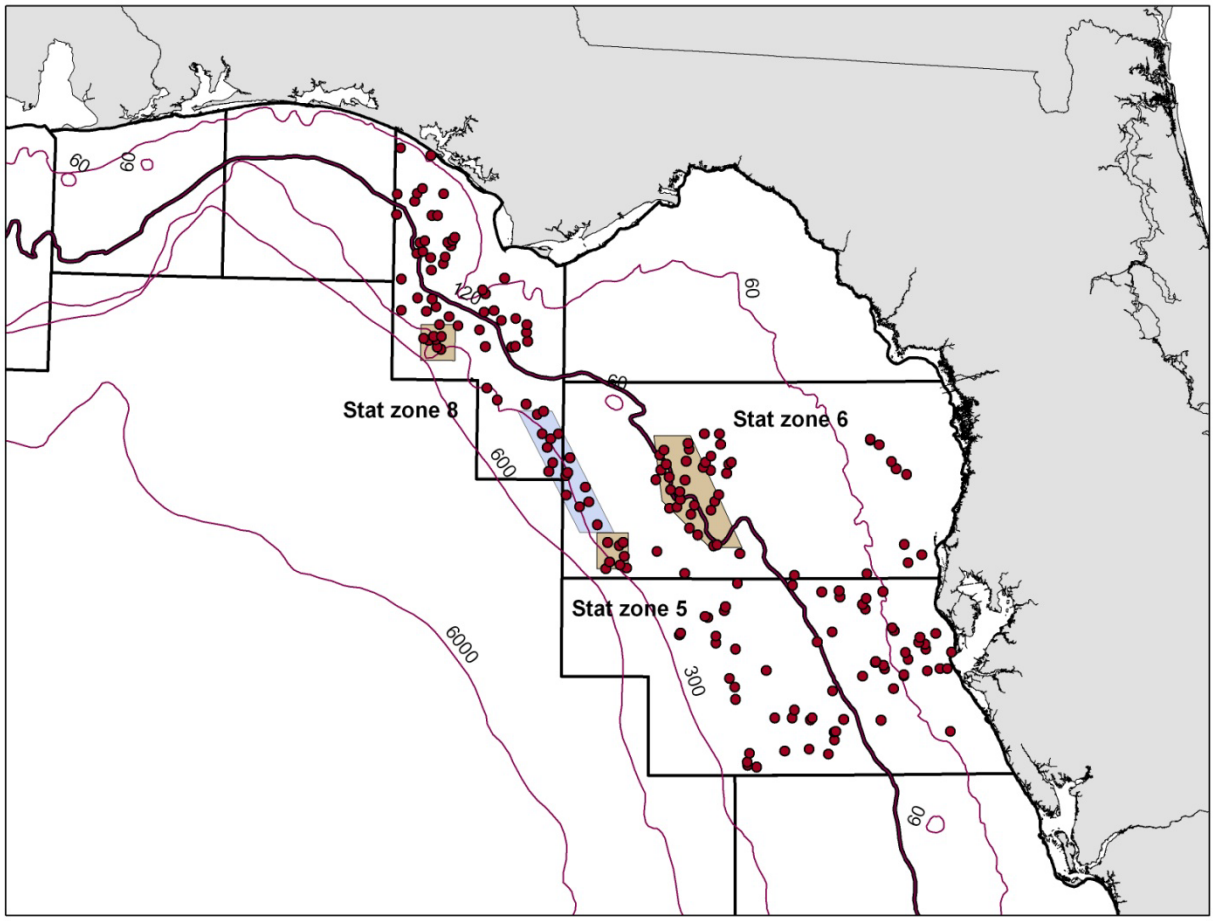
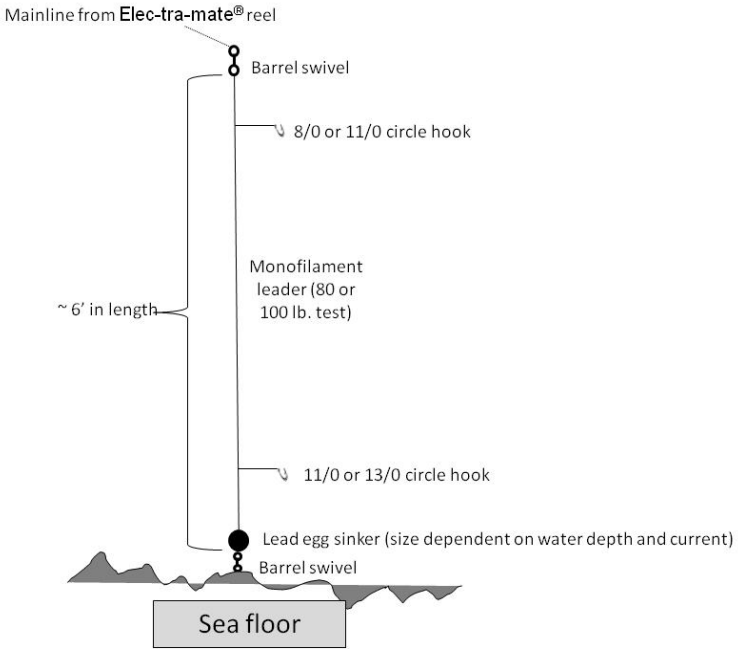
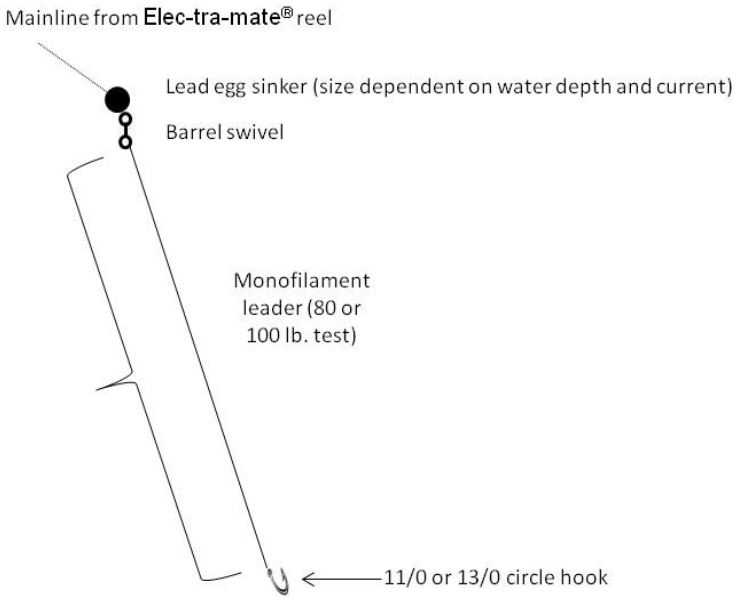



Figure 1. Sampling regions of the west Florida shelf; NMFS statistical zones 5, 6, and 8. Sampling was conducted within two depth strata, from 10 – 37m fathoms and from 37 – 110m. Randomly selected sampling stations (dots) are indicated within each of the three sampling regions. Shaded areas (polygons) designate closed or managed fisheries areas of special interest (i.e., Madison Swanson, The Edges, Steamboat Lumps, and Florida Middle Grounds).




A)




B)

Figure 2. Terminal tackle configurations (A. Chicken rig, B. Carolina rig) used in conjunction with active hook-and-line sampling.

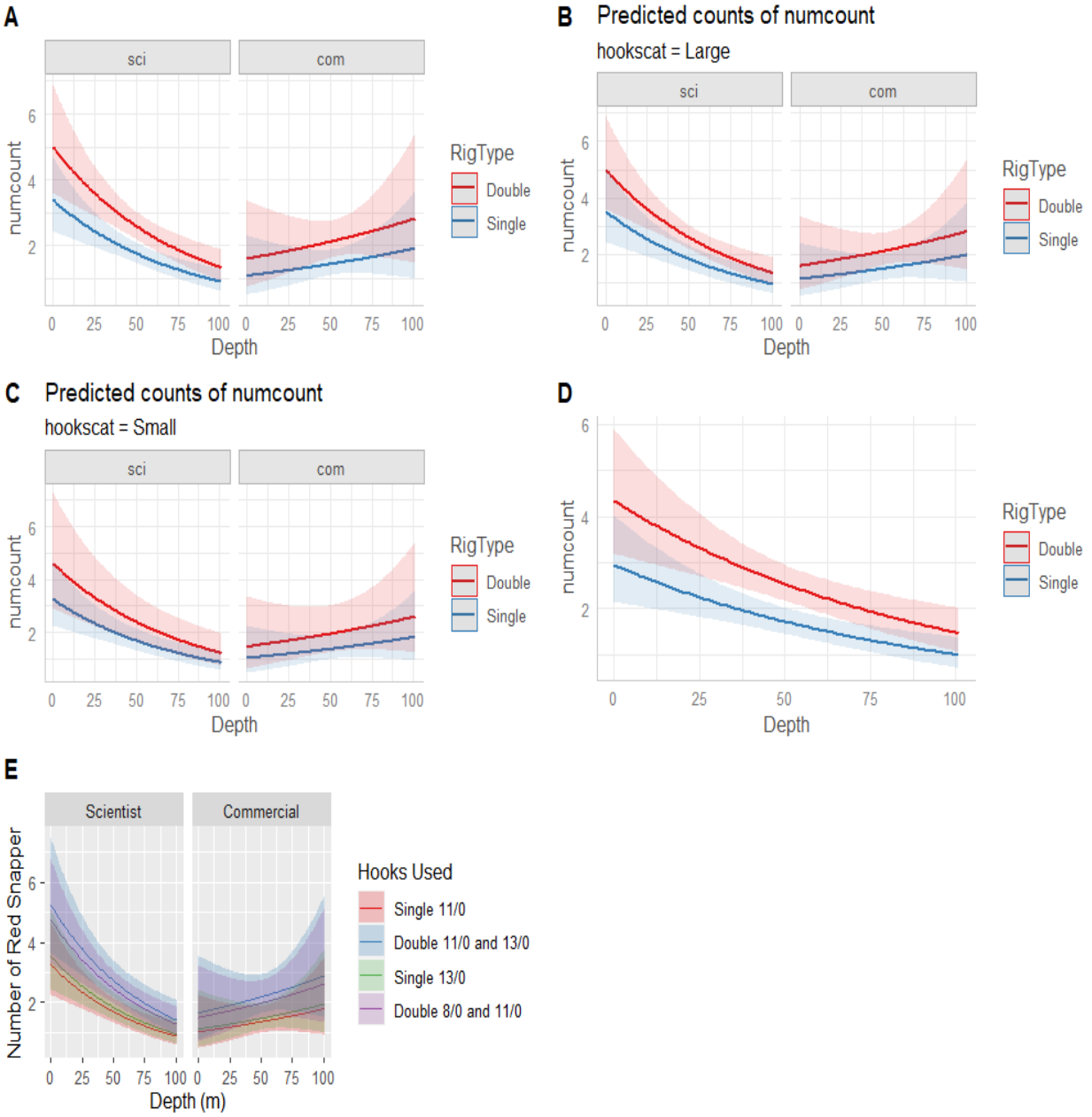



Figure 3. Predicted number of Red Snapper caught based on the top four models based on AICc (Table 6). A) Rig Type + Angler Type * Depth B) Rig Type + Angler Type * Depth + Hook Category (Large Hooks – Single =13/0; Double = 11/0 top and 13/0 bottom C) Rig Type + Angler Type * Depth + Hook Category (Small hooks – Single =11/0; Double = 8/0 top and 11/0 bottom D) Rig Type + Depth E) Depth * Angler Type + Hooks Used

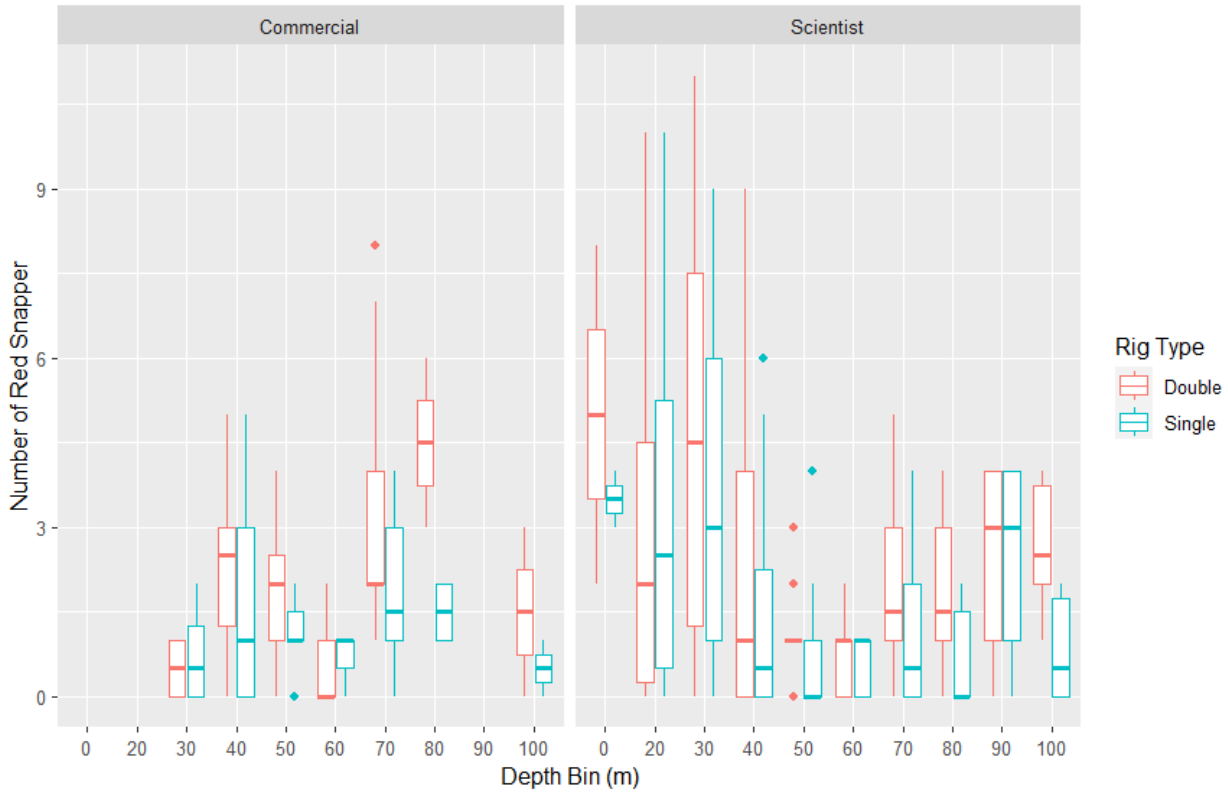



Figure 4. Box and whiskers plot of Red Snapper catch by depth, rig type, and angler type. The bolded bar (typically in near the middle of the box) is the median. The box represents the range for the 25$^{th}$ and 75$^{th}$ percentile. The whiskers extend to 1.5*interquartile range.

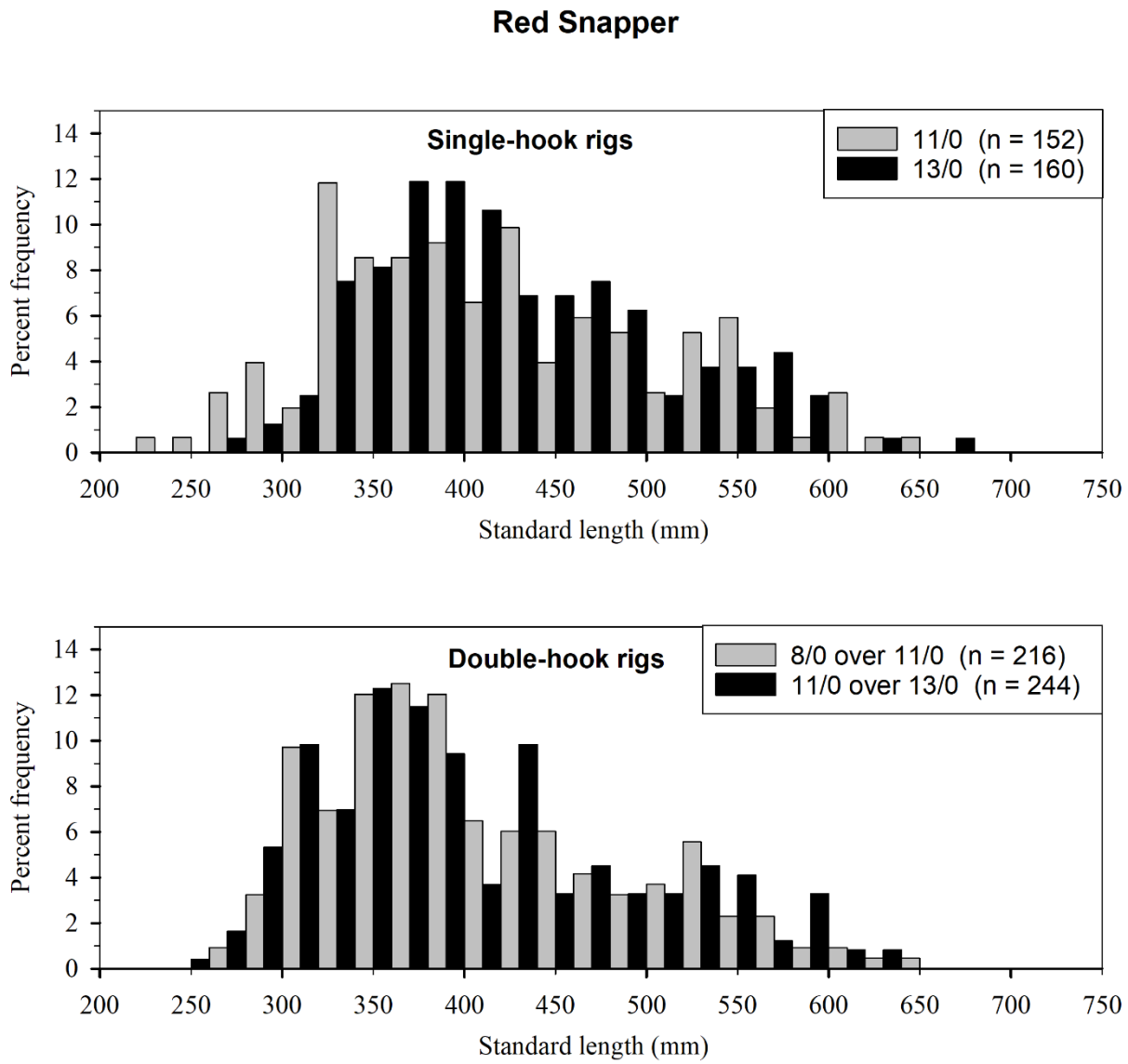



Figure 5. Percent frequency of Red Snapper standard length (mm) caught by rig type (single vs double) and hook sizes.

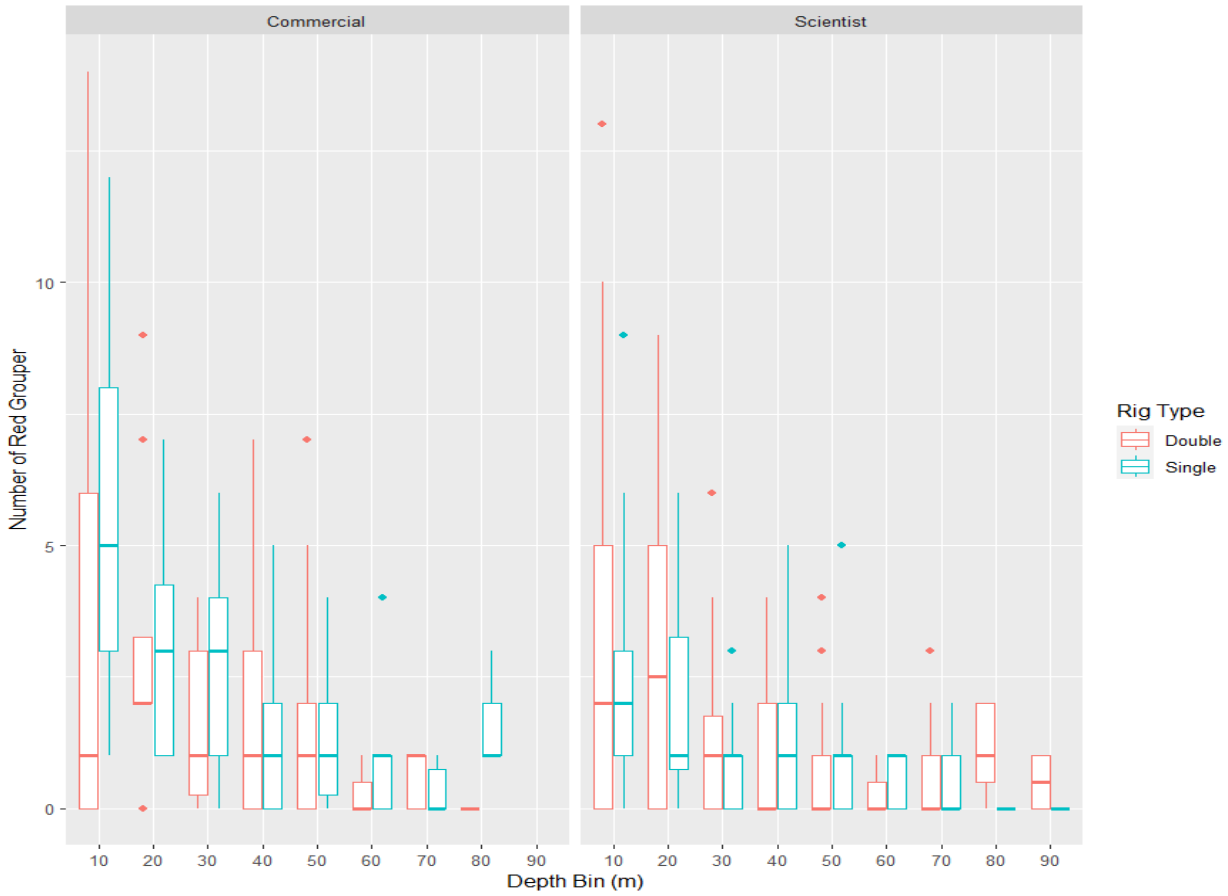



Figure 6. Box and whiskers plot of Red Grouper catch by depth, rig type, and angler type. The bolded bar (typically in near the middle of the box) is the median. The box represents the range for the 25$^{th}$ and 75$^{th}$ percentile. The whiskers extend to 1.5*interquartile range.

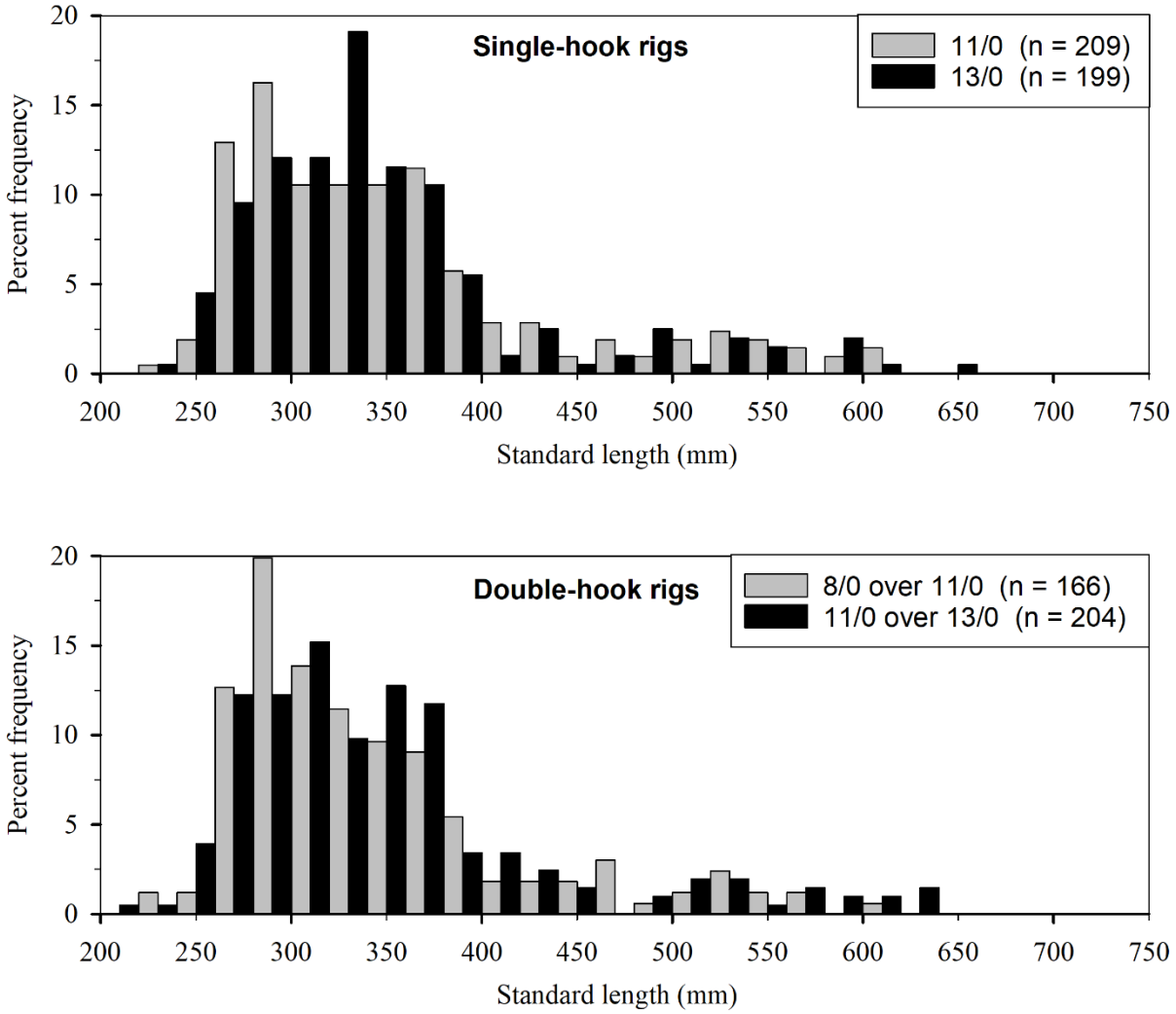



Figure 7. Percent frequency of Red Grouper standard length (mm) caught by rig type (single vs double) and hook sizes.

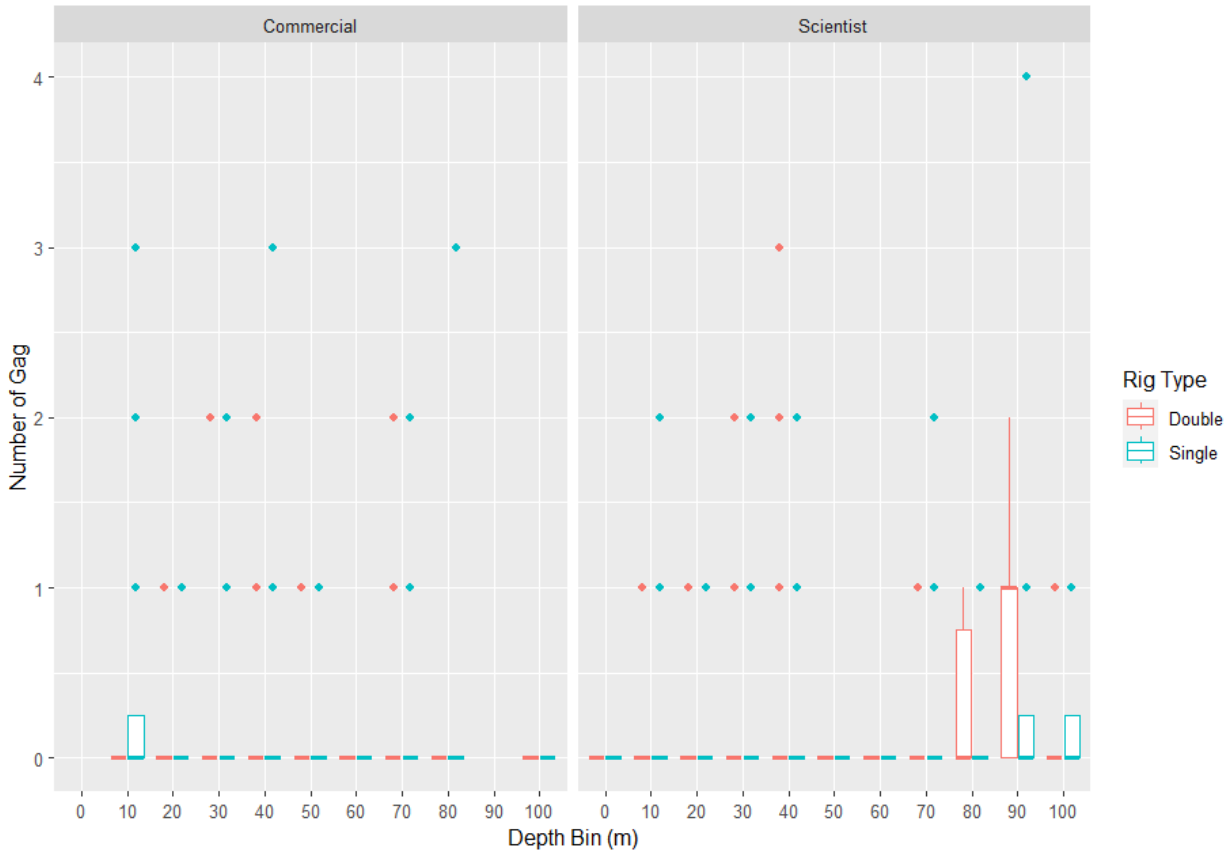



Figure 8. Box and whiskers plot of Gag catch by depth, rig type, and angler type. The bolded bar (typically in near the middle of the box) is the median. The box represents the range for the 25th and 75th percentile. The whiskers extend to 1.5*interquartile range.

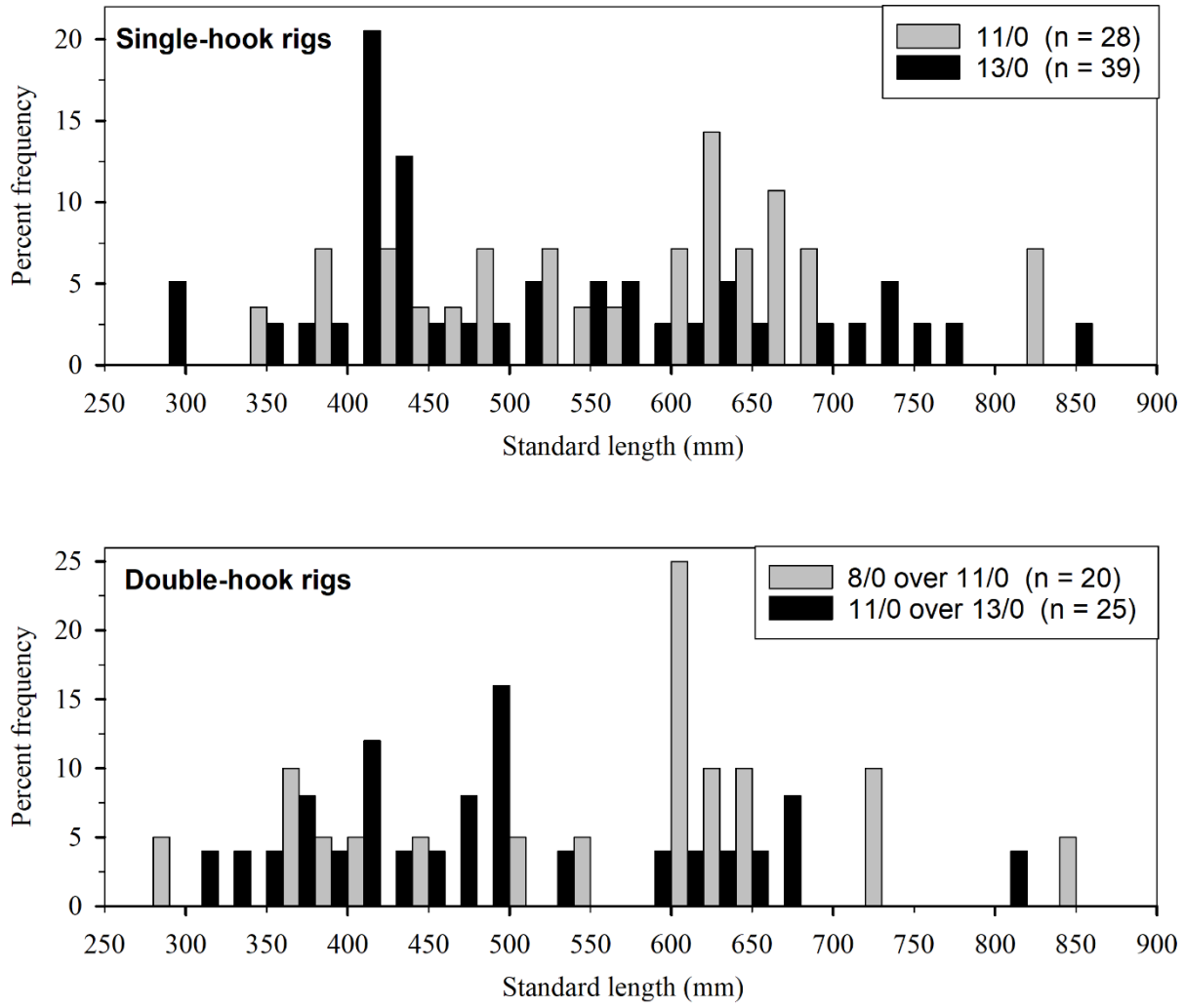



Figure 9. Percent frequency of Gag standard length (mm) caught by rig type (single vs double) and hook sizes.

Appendix. Extra graphs.

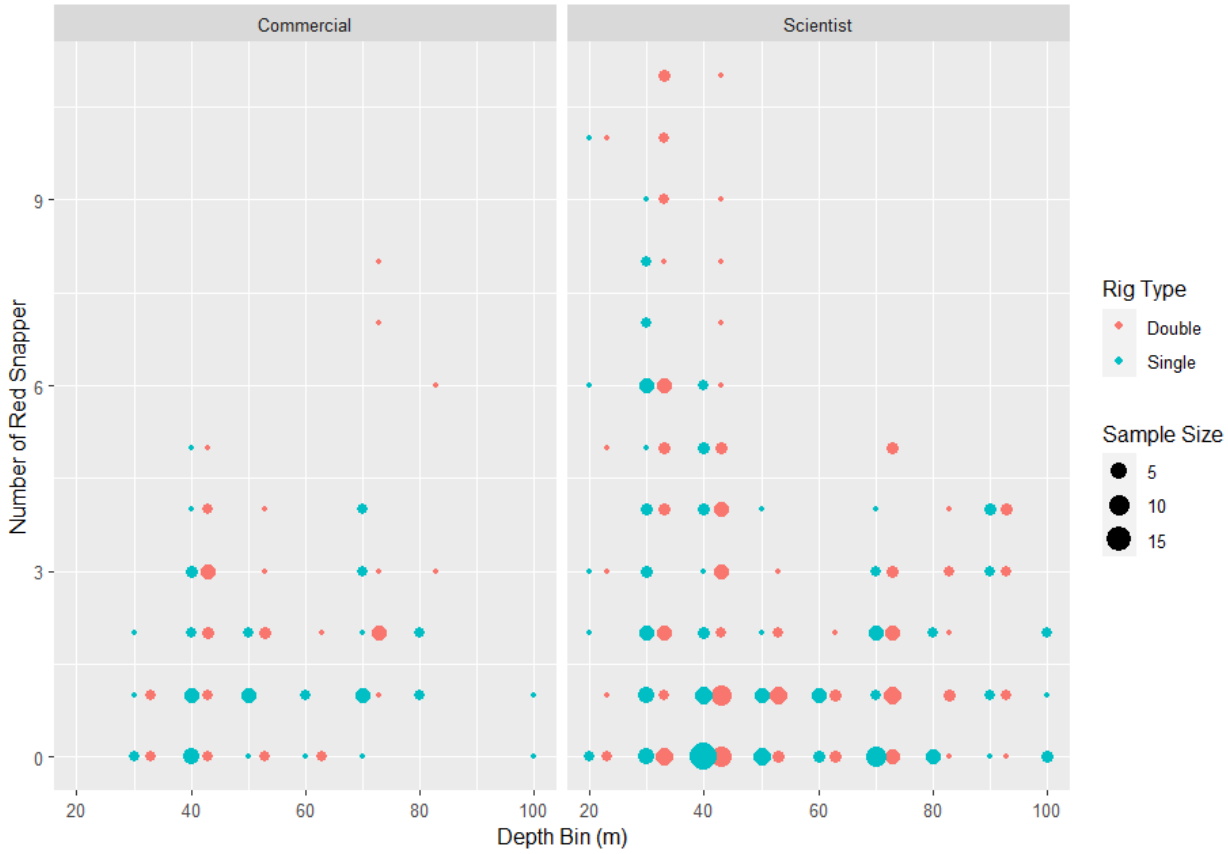



Figure A1. Number of stations catching Red Snapper by depth, rig type, number of Red Snapper, and angler type grouped by depth bins. Color of the circle represents the rig type and size of circle represents number of stations with that number of Red Snapper caught.