Summary report of the red snapper (Lutjanus campechanus) catch during the 2011 expanded annual stock assessment (EASA)

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Abstract

The expanded annual stock assessment program was started in 2011 with the intent to provide additional information on key fisheries in the Gulf of Mexico (GOM), create a truly synoptic survey, increase precision of relative abundance estimates, and to evaluate selectivity issues between gears and hook sizes. Four longline and two vertical line vessels simultaneously fished randomly selected sites in the northern GOM from April 7 – October 25, 2011. Longline and vertical line catch showed evidence of size selectivity in red snapper catch despite using identical hook size (15/0 circle hooks), and which suggests differential habitat use by size. Red snapper catch was highest from the region west of the Mississippi river delta for both gears. Red snapper from the eastern GOM are smaller on average and the population generally lacks older fish in the age structure being composed largely of fish from ages 4-7. Red snapper from the western Gulf of Mexico were larger in mean size, were older in age, and age structure is balanced with good representation of fish older than age 10. While in general red snapper from the west are larger, that pattern is largely driven by catch from longlines, while red snapper in the vertical line catch were larger from the eastern GOM. Low catch rates and large length-at-age from the eastern GOM catch suggests a density dependent effect where fish from this region experience less competition for resources and better growth rates.

Introduction

Length and age data collected from trawl, longline, directed fisheries, and pilot studies show fairly discrete age and size ranges suggesting that red snapper (*Lutjanus campechanus*) exhibit several shifts in habitat use throughout their lifespan (Walters and Ingram 2009, Cowan et al. 2011, Moser et al. 2012). For instance it is well documented that age 6+ red snapper are frequently captured in the National Marine Fisheries Service – Mississippi Laboratories (NMFS-ML) bottom longline survey in low-relief soft-bottom habitat (Mitchell et al. 2004), whereas those age groups are not captured during other annual surveys (e.g. reef fish video, and vertical line), suggesting that older/larger fish move off of reef habitat at around age 6. However in the past there has been no overlapping deployment of gears (i.e. equivalent effort in equivalent habitat) and hook size has not necessarily been consistent across or within surveys. All of these issues make it difficult to separate true habitat use shifts from gear selectivity effects. In response NMFS-ML conducted a survey in 2011 using bottom longline and vertical line gear with the intent to evaluate gear selectivity and habitat use for these age groups of red snapper.

The NMFS-ML bottom longline survey was initiated in 1995, settled on the current survey design in 2001 and since then has sampled the northern Gulf of Mexico (GOM) annually with the exception of a few years (e.g. Katrina in 2005). The annual bottom longline survey is traditionally conducted in late summer and early fall, targets low-relief soft-bottom habitat, and operates on a single vessel that slowly works its way around the GOM. Bottom longline gear primarily targets shark species but is also an effective gear used to target larger, older, red snapper (TL ~ 650 mm +, Age ~ 6+) that are not picked up by any of the other annual surveys conducted at NMFS-ML. The survey traditionally has sampled 200-300 sites, and in spite of that effort the estimates of relative abundance often show high levels of variation (i.e. coefficient of

variation, CV). High variation in indices of abundance could be indicative of low population size, inefficient targeting, ineffective gear, or ineffective effort and in turn affects the precision and confidence of models making use of the data.

Unlike for the bottom longline, NMFS–ML has not conducted an annual vertical line survey in the GOM, and until this extended annual stock assessment (EASA) effort, had only used the gear sporadically in various surveys. The gear employed during these surveys has variously been referred to as 'bandit reel' or 'bandit gear' but in this document will be referred to as vertical line. Vertical line gear is used to target high-relief hard-bottom habitat that is inaccessible to longline or trawls. Vertical line gear is primarily used to capture reef fish and is efficient at targeting red snapper that have recruited into the commercial and recreational fishery of the GOM (TL ~ 350 – 700 mm, Ages ~ 2-8). This age and size range of red snapper are typically sampled in the reef fish video surveys but that survey cannot sample for hard parts or reproductive organs, and is conducted almost exclusively on the shelf edge break. In 2005 and 2007 NMFS-ML conducted a pilot study on oil and gas platforms of the north central GOM and showed a more truncated age and length frequency as what is normally reported for the gear (Moser et al. 2012).

In August 2010, congress appropriated funds to expand fishery-independent surveys in the GOM. Funds were provided to the Gulf States Marine Fisheries Commission (GSMFC) to contract commercial fishing vessels to conduct expanded surveys in the Gulf of Mexico. Expansion of the bottom longline and vertical line surveys is intended to provide additional information on key fisheries in the GOM, increase precision of relative abundance estimates, and to evaluate selectivity issues within (i.e. hook size) or among gear (i.e. vertical and longline).

Methods

General methods

The survey was conducted on the continental shelf of the northern Gulf of Mexico from Brownsville, Texas to the southwest coast of Florida from April 7 – October 25, 2011. Contract vessels provided captains and deck-crew, while the Southeast Fisheries Science Center (SEFSC) provided scientific crew. Two longline and one vertical line vessel sampled east GOM sites while two longline and one vertical line vessel simultaneously sampled west GOM sites. Vessels were deployed as close in time as possible to ensure temporal overlap and to provide as synoptic a GOM-wide data set as possible. Randomly selected stations are restricted from being chosen within the boundaries of the Flower Garden Banks National Marine Sanctuary (Stetson Bank, West Flower Garden Bank and East Flower Garden Bank), the Madison-Swanson and Steamboat Lumps marine protected areas, the Florida Middle Grounds, within 1 nautical mile (nm) of oil and gas platform structures, and within 1 nm of any other station in the stratum.

All gear deployments were monitored using a shipboard SCS/FSCS computer system operated with weatherproof laptop computers with touch screen options. SCS/FSCS software will allow the acquisition of data to describe set and haulback events (GMT time/date stamp, position and any other connected ship sensors). Environmental data was collected using a Seabird CTD profiler during fishing gear soaks to obtain temperature, salinity and dissolved oxygen profiles.

Bottom Longline Survey

Sampling took place during daylight hours (12 hrs) and used the same gear and sample methodology as the NMFS bottom longline survey (Henwood et al. 2004). Site selection used a stratified random design based on the proportional allocation of stations among 52 strata as

defined by 18 longitude and/or latitude spatial zones and 3 depths zones (Figure 1). Allocation of stations is determined by the proportion of the surface area for each stratum with respect to the surface area of all strata (i.e. weighted by area). Each stratum was required to have a minimum of 2 stations with a target of 160 stations per cruise for all strata combined, which was then replicated over 7 total cruises. Once the number of stations was determined for each stratum a GIS model was used to randomly assign stations to latitude/longitude coordinates within each stratum.

Vertical line survey

Two different site selection methods were used over the course of the EASA survey. The first method coupled vertical line vessels with longline vessels (paired sampling) with the intent to evaluate gear selectivity, and was utilized over the first 3 legs of the survey (April 7 – June 29, 2011). During paired sampling cruises the vertical line vessels tracked the bottom longline vessels and fished longline selected sites simultaneously, therefore the site selection design is essentially identical to the longline sampling design. Vertical line sites however sampled a total of 5 sites at each selected longline stations in the 9 to 55 m and >55 to 183 m depth zones, and the initial bottom longline station position was always selected for vertical line sampling. The remaining four randomly selected locations were separated by at least 0.1 nm and were located within 1 nm radius of the original longline position (Figure 2). Because the longline vessels worked sites much slower, the vertical line vessel also opportunistically sampled reef sites within these randomly selected blocks during this time, but those data are excluded from broader analyses because they do not represent truly random sites.

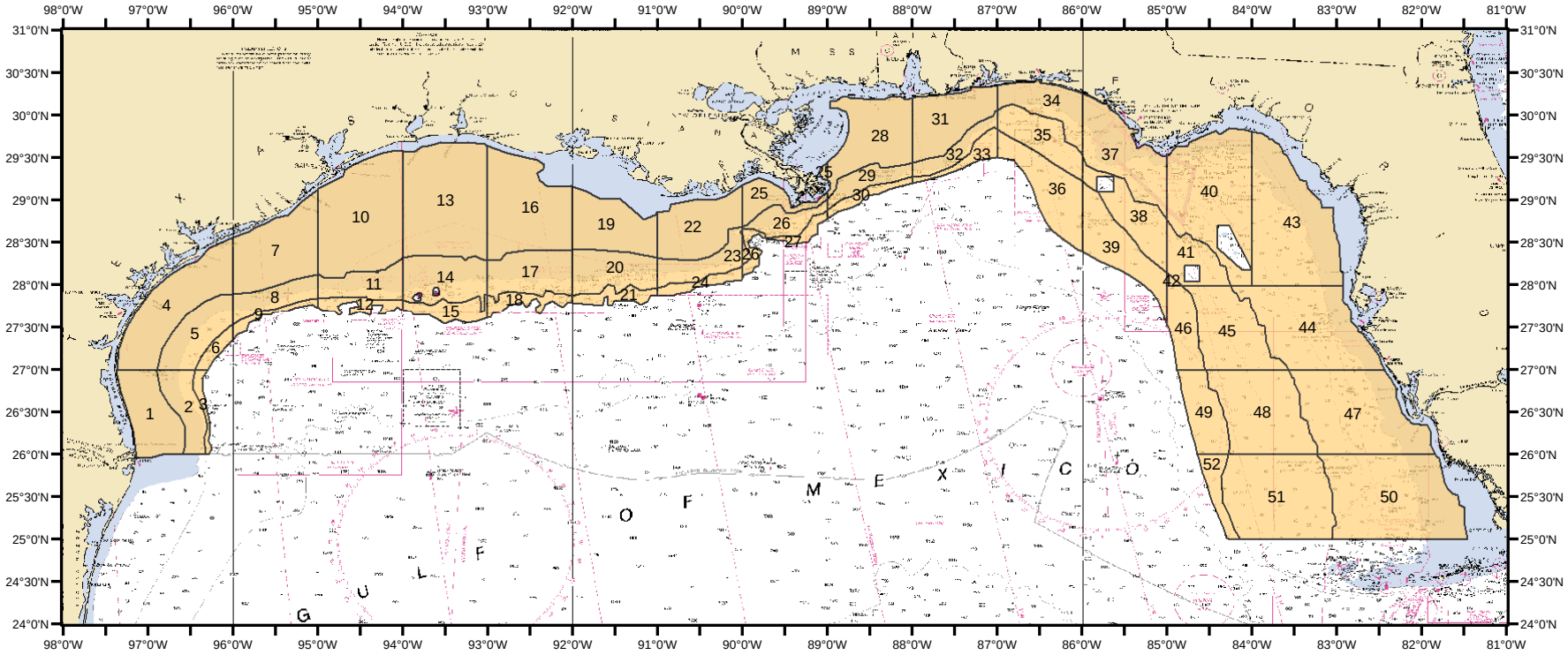

Figure 1. Expanding Annual Stock Assessment longline sampling strata. Stratified by lat/lon and depth zone, and weighted by area.

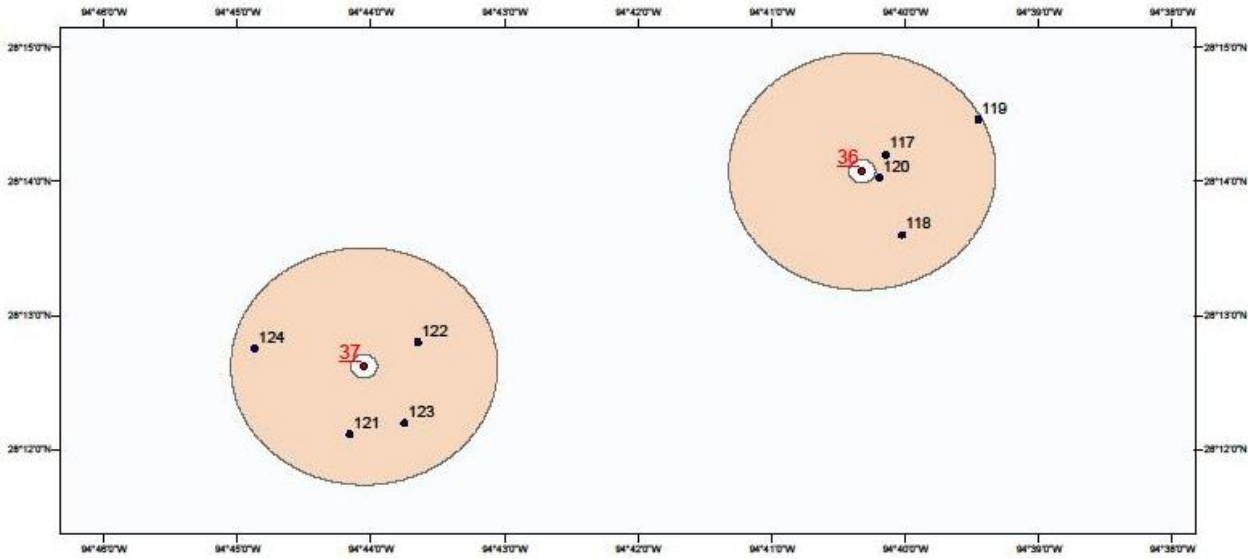

Figure 2. Paired vertical line (black) and bottom longline stations (red) used during cruises 1-3 (April 7 – June 29, 2011).

The second method (independent sampling) was used for the remainder of the legs (July31 – October 16, 2011) and made use of the existing reef fish video survey design (Campbell et al. 2012). Stratified random sampling was used to select 10 min. latitude by 10 min. longitude blocks that contain known reef habitat (Figure 3). Within a selected block 4-6 random transects were chosen to collect side-scan sonar data and identify potential natural reef bottom to sample. Ten sites were randomly selected from the side-scan transects. Those selected sites were located a minimum of 0.10 nautical miles apart, and any sites that appeared to be 'man made' were not selected (i.e. natural bottom only). Bandit gear was then fished at 8 randomly selected reef sites and 2 randomly selected non-reef sites (flat bottom).

The vertical line is composed of 300 m of 2 mm light blue 181 kg test monofilament mainline, with a 6.71 meter 181 kg test detachable backbone which is attached to the terminal end of the main line. Ten gangions constructed of 45.36 kg test twisted monofilament line were attached at intervals of 61 cm on the backbone. Each reel, or backbone, exclusively used 1 size of circle hook (8/0, 11/0 or 15/0). Hook size to be fished on a reel was determined randomly at the start of each fishing day and then rotated clockwise at each subsequent station. A 5-10 kg weight was placed at the terminal end of the backbone to insure stability and fishing throughout the water column. Hooks were baited with Atlantic mackerel (*Scomber scomberus*) cut to match the size of each hook (heads and tails excluded) and were fished on the bottom for 5 minutes.

Biological Sampling and Processing

Catch was identified to the lowest taxonomic group possible, weighed, and measured (except sharks greater than 1.5 m TL), and otoliths and gonads were removed from a randomly selected subset of fish ensuring spatio-temporal coverage. Otoliths and gonads were initially

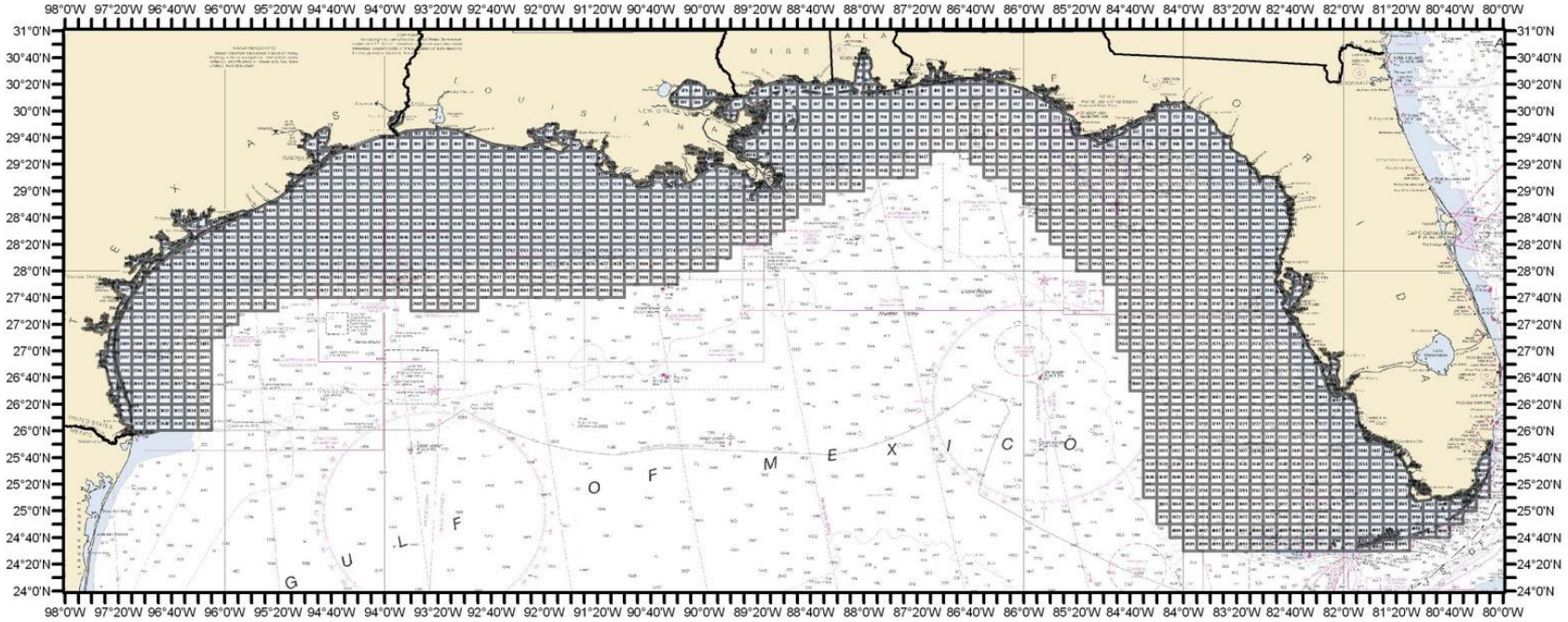

Figure 3. Map of the northern Gulf of Mexico divided into 10' x 10' grids from which grids containing reef were identified, and from which vertical line sampling sites were randomly selected.

stored at NMFS-ML but were analyzed at NMFS Panama City Laboratory.

Sex and macroscopic classification of gonads were identified for all target species captured (species with federal management plans). Sub-sampling of all target species samples was conducted for quality control of macroscopic identification. A small subsample (approximately 1 cubic cm) of gonads was preserved from 5% of the fish collected for quality control and histological processing and estimation of red snapper spawning fraction. Red snapper hydrated ovaries were subsampled for batch fecundity estimates.

Results

Over the course of the survey a total of 1,172 longline sites over 7 cruises, and 1,938 vertical line sites over 6 cruises were sampled (Table 1). Longline cruises and vessels sampled roughly similar numbers of sites and nearly synoptic coverage in space and time, while vertical line coverage was a bit more constrained having deployed only two vessels (Figure 4).

Longline sampling captured 149 unique species of which 25 species composed 93.2% of the total abundance (Table 2). The most frequently caught species was Atlantic sharpnose shark (*Rhizoprionodon terraenovae*), followed by red groupers (*Epinephelus morio*), red snapper (*Lutjanus campechanus*), blacktip shark (*Carcharhinus limbatus*), and golden tilefish (*Lopholatilus chamaeleonticeps*). Regional differences in catch composition were evident. West GOM catch was dominated by Atlantic sharpnose shark, followed by blacktip shark, red snapper, golden tilefish, and gafftopsail catfish (*Bagre marinus*). East GOM catch was dominated by Atlantic sharpnose shark, followed by red grouper, blacknose shark (*Carcharhinus acronotus*), red snapper, and sandbar shark (*Carcharhinus plumbeus*).

Table 1. Number of longline and vertical line stations sampled by cruise (7 longline, 6 vertical line), by vessel (4 longline, 2 vertical line), and in total.

				Longline			
By cruise	157	174	176	183	177	166	139
By vessel	299	263	325	285			
Total	1172						
				Vertical line			
By cruise	428	415	366	194	149	386	
By vessel	967	971					
Total	1938						

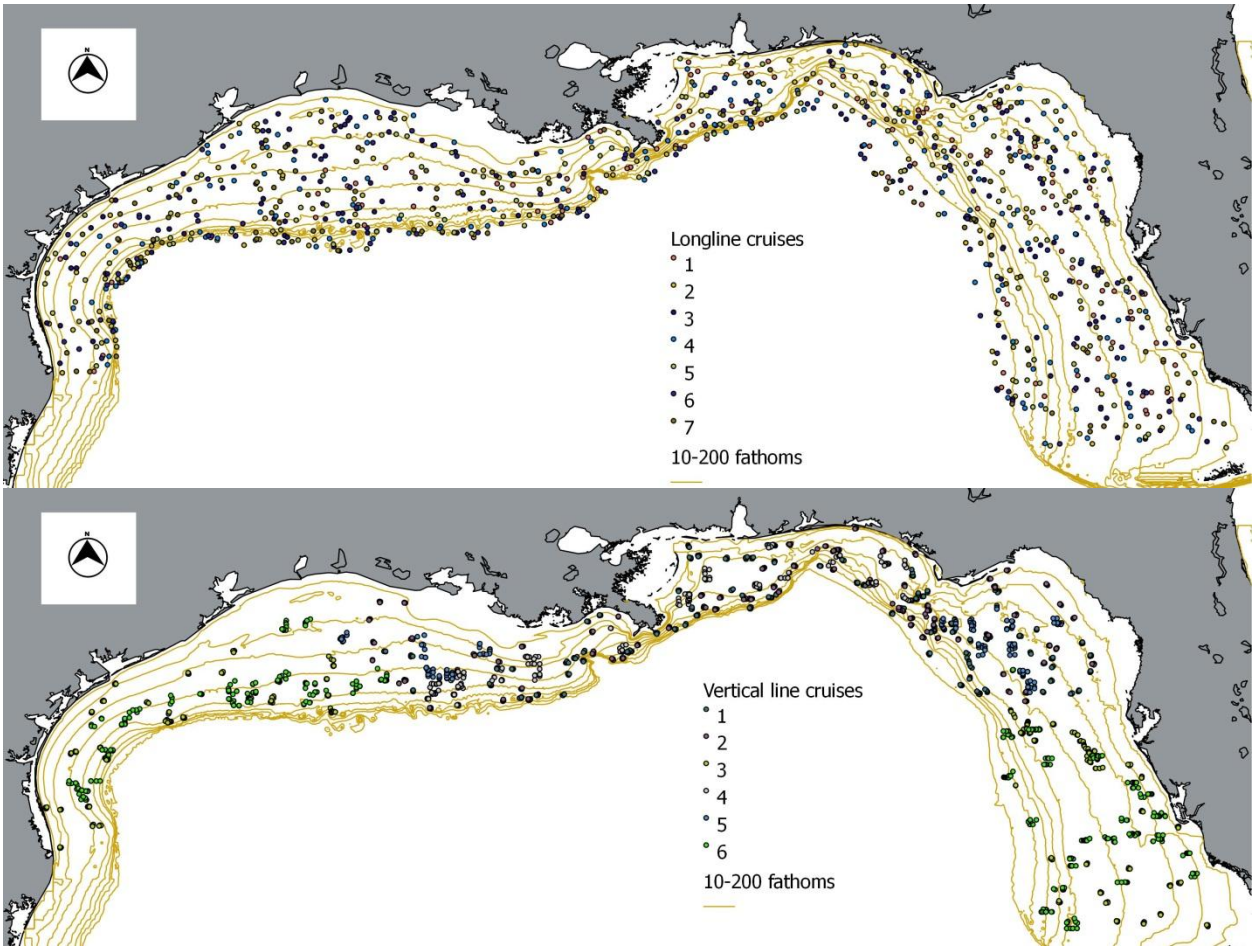

Figure 4. Map of the longline and vertical line stations by cruise number.

Table 2. Top 25 species of the longline catch by region and as a percent of the total catch for each species.

Species	**East**	**% East**	**West**	**% West**	**Total**	**% Total**
Rhizoprionodon terraenovae	1300	28.57	2781	40.18	4081	35.57
Epinephelus morio	994	21.84	0	0.00	994	8.66
Lutjanus campechanus	181	3.98	595	8.60	776	6.76
Carcharhinus limbatus	58	1.27	628	9.07	686	5.98
Lopholatilus chamaeleonticeps	132	2.90	457	6.60	589	5.13
Carcharhinus acronotus	228	5.01	298	4.31	526	4.58
Mustelus sinusmexicanus	146	3.21	286	4.13	432	3.77
Bagre marinus	25	0.55	335	4.84	360	3.14
Ophichthus rex	104	2.29	231	3.34	335	2.92
Carcharhinus brevipinna	64	1.41	213	3.08	277	2.41
Epinephelus flavolimbatus	95	2.09	126	1.82	221	1.93
Carcharhinus plumbeus	161	3.54	44	0.64	205	1.79
Sciaenops ocellatus	15	0.33	159	2.30	174	1.52
Mustelus canus	111	2.44	42	0.61	153	1.33
Galeocerdo cuvieri	109	2.40	36	0.52	145	1.26
Sphyrna lewini	63	1.38	77	1.11	140	1.22
Urophycis cirrata	30	0.66	77	1.11	107	0.93
Ginglymostoma cirratum	87	1.91	0	0.00	87	0.76
Carcharhinus leucas	26	0.57	57	0.82	83	0.72
Urophycis floridana	45	0.99	34	0.49	79	0.69
Centrophorus	32	0.70	41	0.59	73	0.64
Carcharhinus falciformis	29	0.64	25	0.36	54	0.47
Squalus cubensis	31	0.68	15	0.22	46	0.40
Trichiurus lepturus	17	0.37	23	0.33	40	0.35
Mustelus	10	0.22	24	0.35	34	0.30
Total	4551	89.94	6922	95.41	11473	93.24

Vertical line sampling captured 67 unique species of which 25 species composed between 92.87% (east GOM) and 96.48% (west GOM) of the abundance (Table 3). Similar to the bottom longline gear regional differences in catch composition were evident. East GOM catch was a bit more evenly distributed amongst species and was dominated by red snapper, followed by vermillion snapper (*Rhomboplites aurorubens*), red porgy (*Pagrus pagrus*), red grouper, and sand perch (*Diplectrum formosum*). West GOM was strongly dominated by 3 species with the top 5 including red snapper, Atlantic sharpnose shark, vermillion snapper, almaco jack (*Seriola rivoliana*), and shark sucker (*Echeneis naucrates*).

Longline and vertical line gears show clear differences in length composition, and mean length of red snapper regardless of region (Figures 5 and 6). Size selectivity is present when evaluated using catch data from equivalent hook sizes (15/0 hooks only) and is particularly apparent when including catch from the smaller hook sizes used in the vertical line (Figures 5 and 6). Inclusion of all hook sizes used during vertical line sampling resulted in shorter mean length of red snapper from vertical line catch. The largest red snapper sampled in the EASA survey were captured on longlines in the west GOM, while the smallest were sampled from the west-GOM using vertical lines. Longline sets from the west-GOM captured larger red snapper than did east-GOM longline sets. Vertical line sets from the east-GOM captured larger red snapper than did west-GOM vertical line sets.

Longline and vertical line gears show clear differences in age composition, and mean age of red snapper sampled in the east-GOM, west-GOM, and GOM-wide (Figures 7 and 8). West-GOM data shows a broader range of ages represented in the catch (1-34) with a much higher frequency of catch of age 10+ red snapper than east-GOM data. Most of the east-GOM catch is

Table 3. Top 25 species of the vertical line catch by region (calculated using all hooks combined), by hook type (8/0, 11/0, 15/0), and as a percent of the total catch for each species.

	East					West				
Species	**8/O**	**11/O**	**15/O**	**Total**	**% of total**	**8/O**	**11/O**	**15/O**	**Total**	**% of total**
Balistes capriscus	7	0	0	7	0.53	4	2	0	6	0.32
Carcharhinus brevipinna	0	1	2	3	0.23	0	1	2	3	0.16
Centropristis philadelphica	1	0	0	1	0.08	10	6	0	16	0.84
Centropristis striata	13	5	6	24	1.82	0	0	0	0	0.00
Cynoscion nothus	0	0	0	0	0.00	5	2	0	7	0.37
Diplectrum formosum	40	17	2	59	4.47	0	0	0	0	0.00
Echeneis naucrates	3	6	6	15	1.14	9	9	1	19	1.00
Epinephelus flavolimbatus	1	0	0	1	0.08	2	0	1	3	0.16
Epinephelus morio	22	23	18	63	4.78	0	0	1	1	0.05
Epinephelus nigritus	0	0	1	1	0.08	2	0	2	4	0.21
Haemulon aurolineatum	1	0	0	1	0.08	4	1	0	5	0.26
Haemulon plumierii	7	2	0	9	0.68	0	0	0	0	0.00
Lutjanus campechanus	120	192	146	458	34.72	427	509	321	1257	66.05
Lutjanus synagris	0	1	0	1	0.08	4	7	1	12	0.63
Micropogonias undulatus	2	1	0	3	0.23	2	1	0	3	0.16
Mycteroperca microlepis	0	2	2	4	0.30	0	0	1	1	0.05
Mycteroperca phenax	6	2	4	12	0.91	3	2	1	6	0.32
Pagrus pagrus	52	37	1	90	6.82	2	3	0	5	0.26
Pristipomoides aquilonaris	4	0	1	5	0.38	16	10	1	27	1.42
Rhizoprionodon terraenovae	15	15	21	51	3.87	75	117	98	290	15.24
Rhomboplites aurorubens	278	118	8	404	30.63	65	68	7	140	7.36
Seriola dumerili	2	3	3	8	0.61	5	5	2	12	0.63
Seriola rivoliana	1	0	4	5	0.38	11	7	1	19	1.00
Totals	632	456	231	1319	92.87	682	772	449	1903	96.48

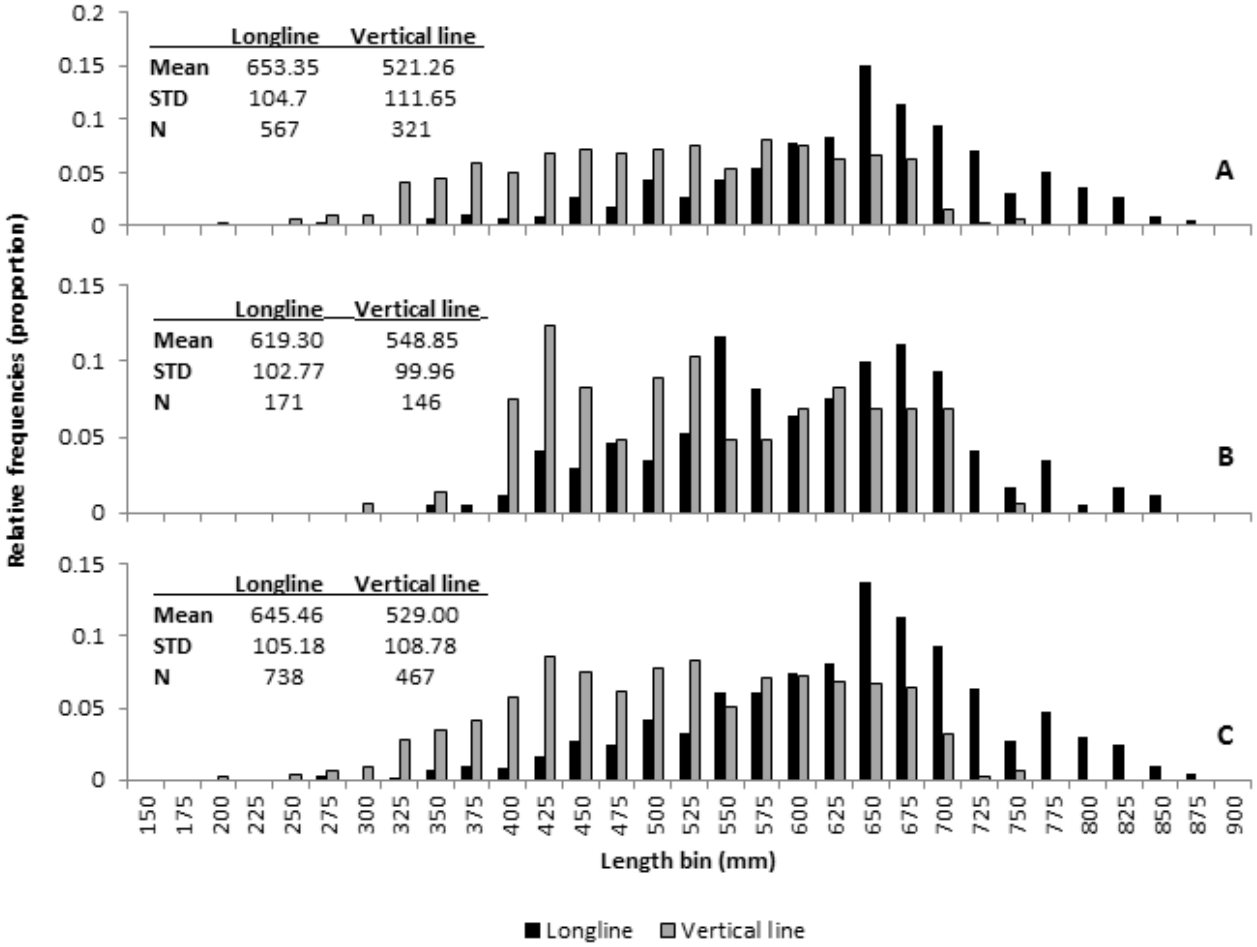

Figure 5. Length frequency distributions and descriptive statistics of red snapper caught on EASA vertical line versus longline sets in the west GOM (A), east GOM (B), and GOM-wide (C) during the 2011 EASA survey (using only 15/0 hooks from vertical line data).

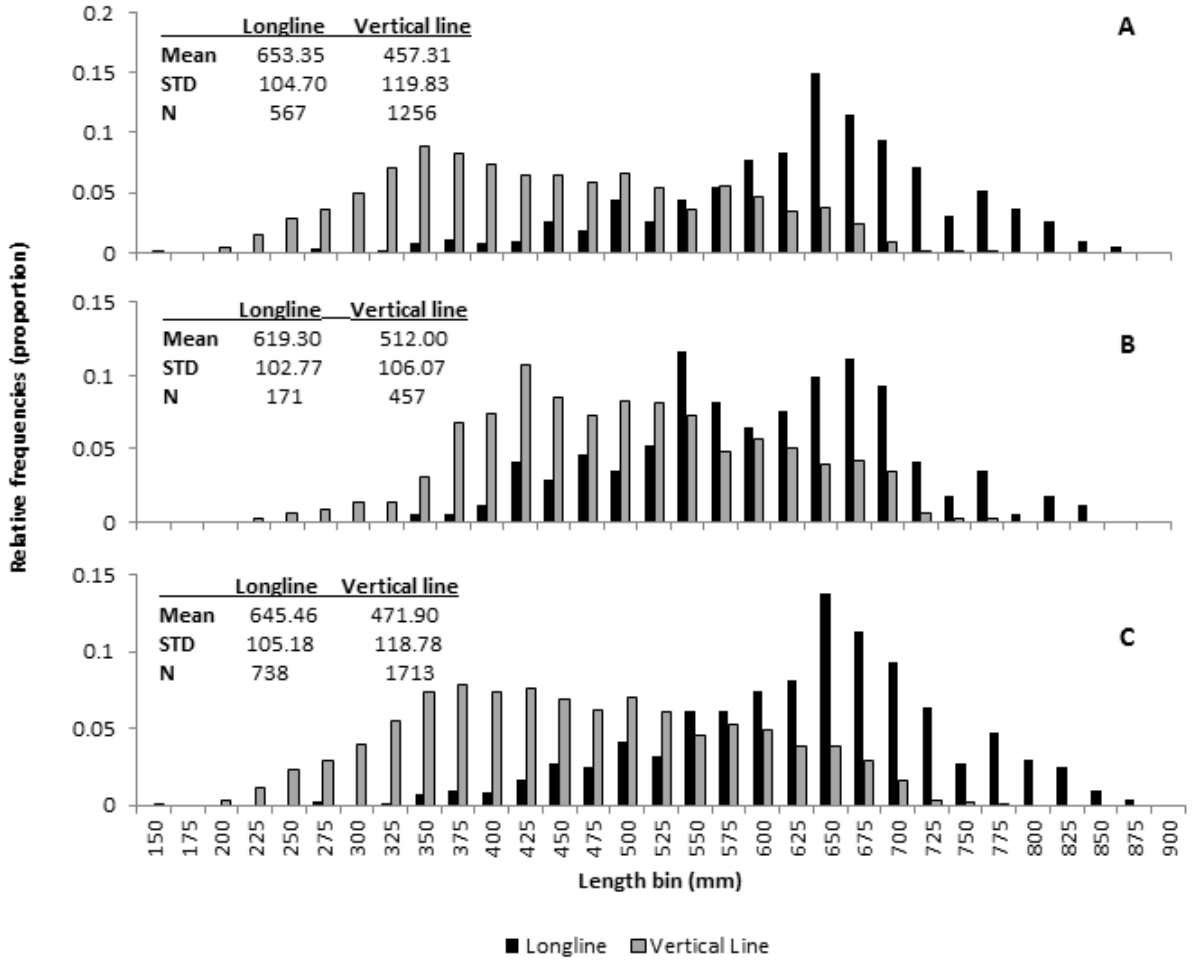

Figure 7. Length frequency distributions and descriptive statistics of red snapper caught on EASA vertical line versus longline sets in the west GOM (A), east GOM (B), and GOM-wide (C) during the 2011 EASA survey (using all hook sizes from vertical line data).

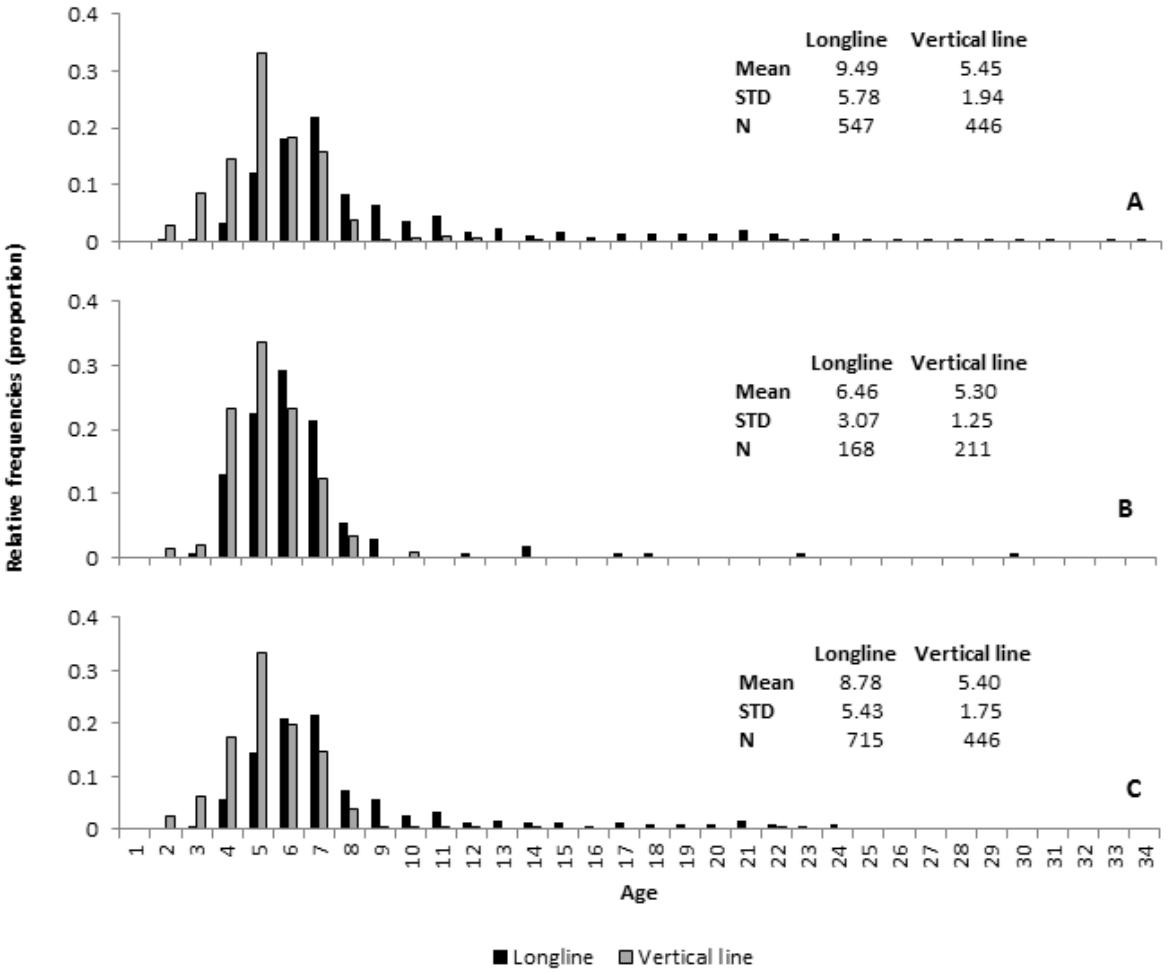

Figure 6. Age frequency distributions and descriptive statistics of red snapper caught on EASA vertical line versus longline sets in the west GOM (A), east GOM (B), and GOM-wide (C) during the 2011 EASA survey (using only 15/0 hook data from vertical line survey).

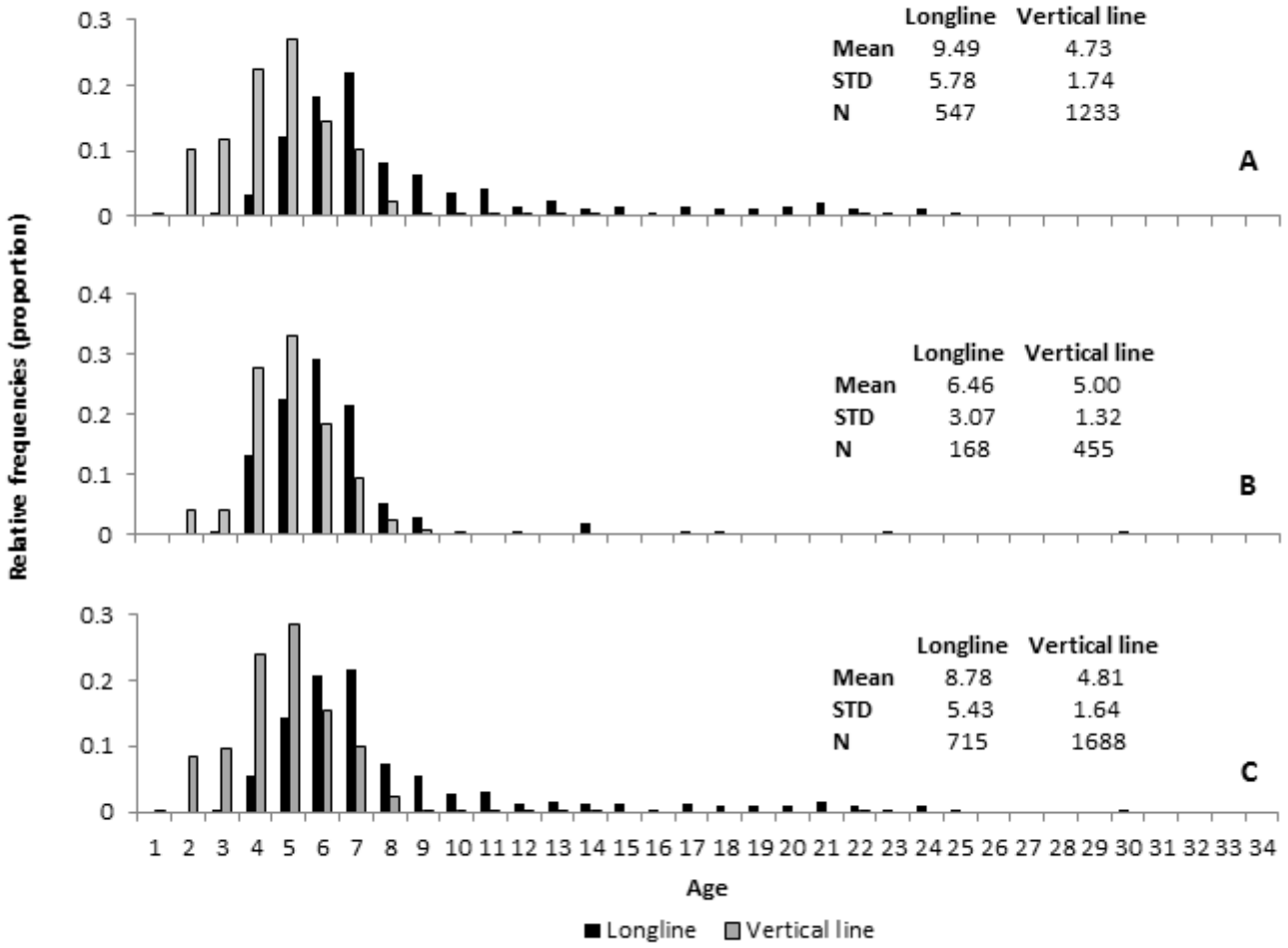

Figure 8. Age frequency distributions and descriptive statistics of red snapper caught on EASA vertical line versus longline sets in the west GOM (A), east GOM (B), and GOM-wide (C) during the 2011 EASA survey (using all hook sizes from vertical line survey).

dominated by red snapper ages 4-7 (year classes 2004 – 2007). The oldest red snapper were sampled in the EASA survey were captured on longlines in the west GOM (mean = 9.49, std = 5.78, max 34) while the youngest fish were sampled from the west GOM using vertical lines (mean = 4.73, std = 1.74). Longline catch is dominated by fish older than age 6, with west GOM fish being older red snapper than east GOM fish on average. Vertical line catch is dominated by fish from ages 2-7, with sets from the east GOM capturing older red snapper than did west GOM vertical line sets when all hooks sizes were considered. When only 15/0 hooks were considered red snapper catch from the west GOM were older than those from east-GOM catches.

Size distributions by hook size of red snapper catch from vertical line show some overlap but there is clear evidence of size selectivity (Figure 9). Red snapper mean length was longest for the 15/0 hook (mean = 518.04, std = 109.57), intermediate for the 11/0 hook (mean = 444.75, std = 114.21), and shortest for the 8/0 hook (mean = 429.76, std = 116.54). Age distributions also showed more overlap than did length distributions with 8/0 and 11/0 hooks being similar with 15/0 hooks sampling older fish on average (Figure 10).

Plots of spatial distributions show that the highest catch rates for the longline gear occur west of the Mississippi River delta for all ages of red snapper (Figure 11 and 12). Spatial plots also corroborate what is demonstrated from mean age data of fish from the east and west. East-GOM catch is dominated by low catches of fish from age groups 1-5 and 6-10, and most of that catch is composed of ages 4 – 7 (Figure 11 and 12). West-GOM catch show highest red snapper catches in ages 6-10, but were also high for age groups 1-5, and 11-15. Old red snapper (ages 15+) are caught less frequently than younger fish, and less one station, all of that biomass is west of the Mississippi River. Age structure in general is lacking from eastern catch.

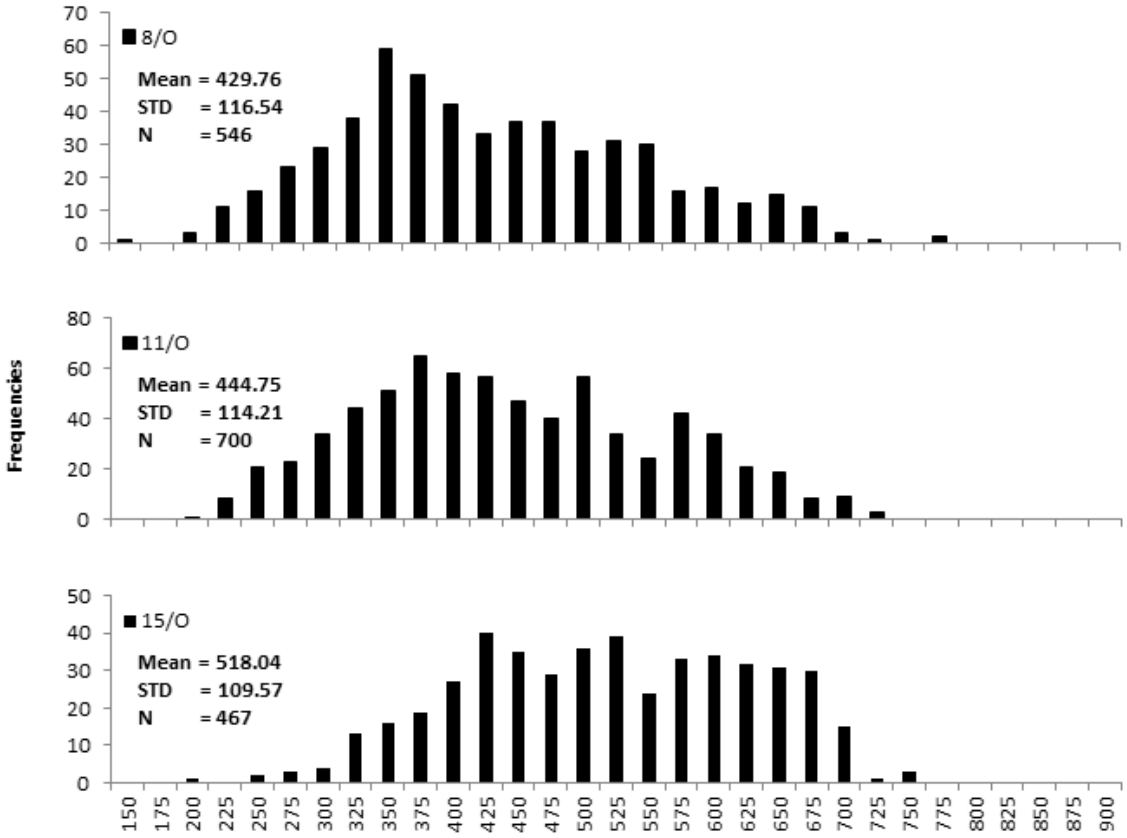

Figure 9. Length frequency histograms and descriptive statistics of GOM red snapper by circle hook size (8/0, 11/0, and 15/0) from EASA vertical line catch.

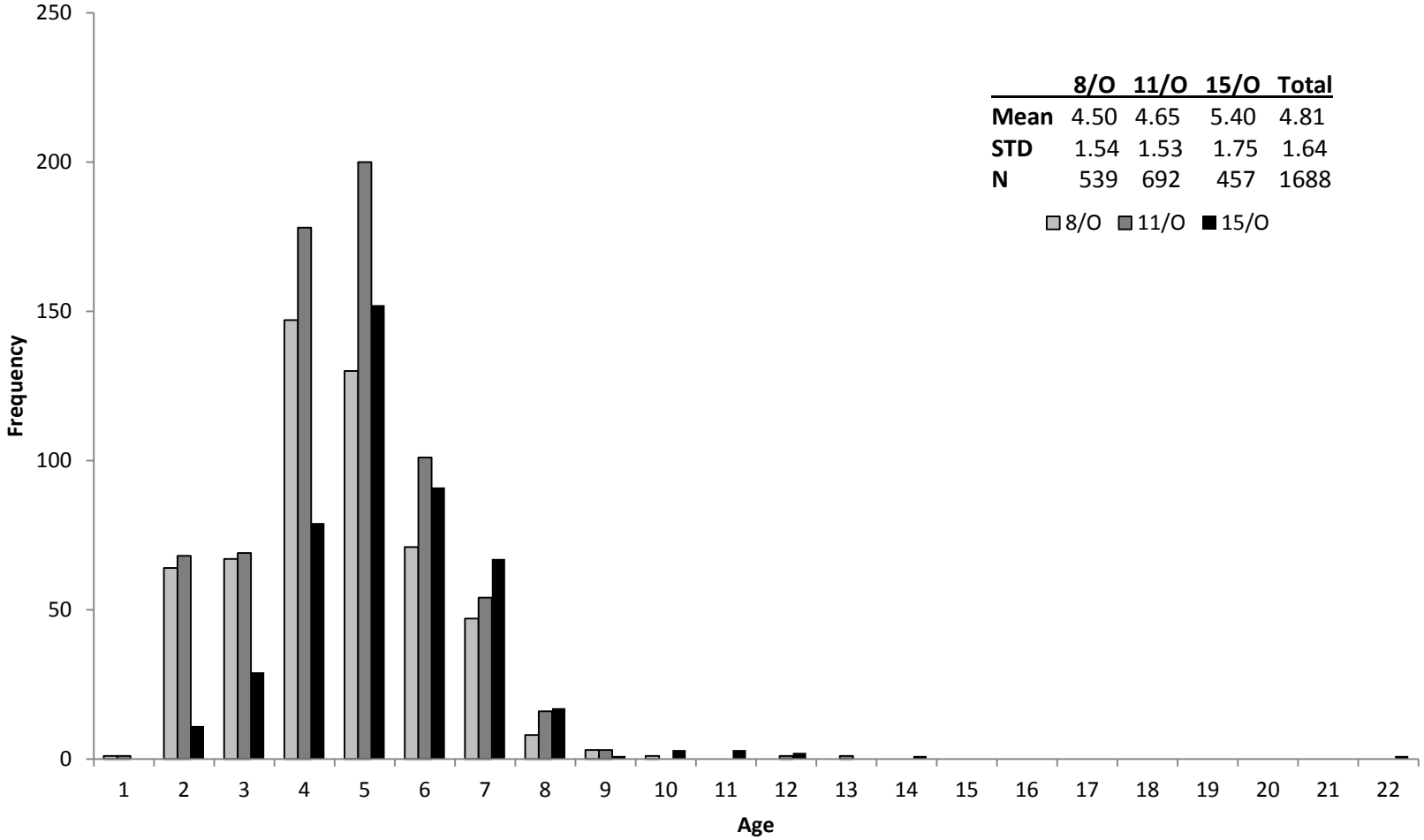

Figure 10. Age frequency histograms and descriptive statistics of GOM red snapper by circle hook size (8/0, 11/0, and 15/0) from EASA vertical line catch.

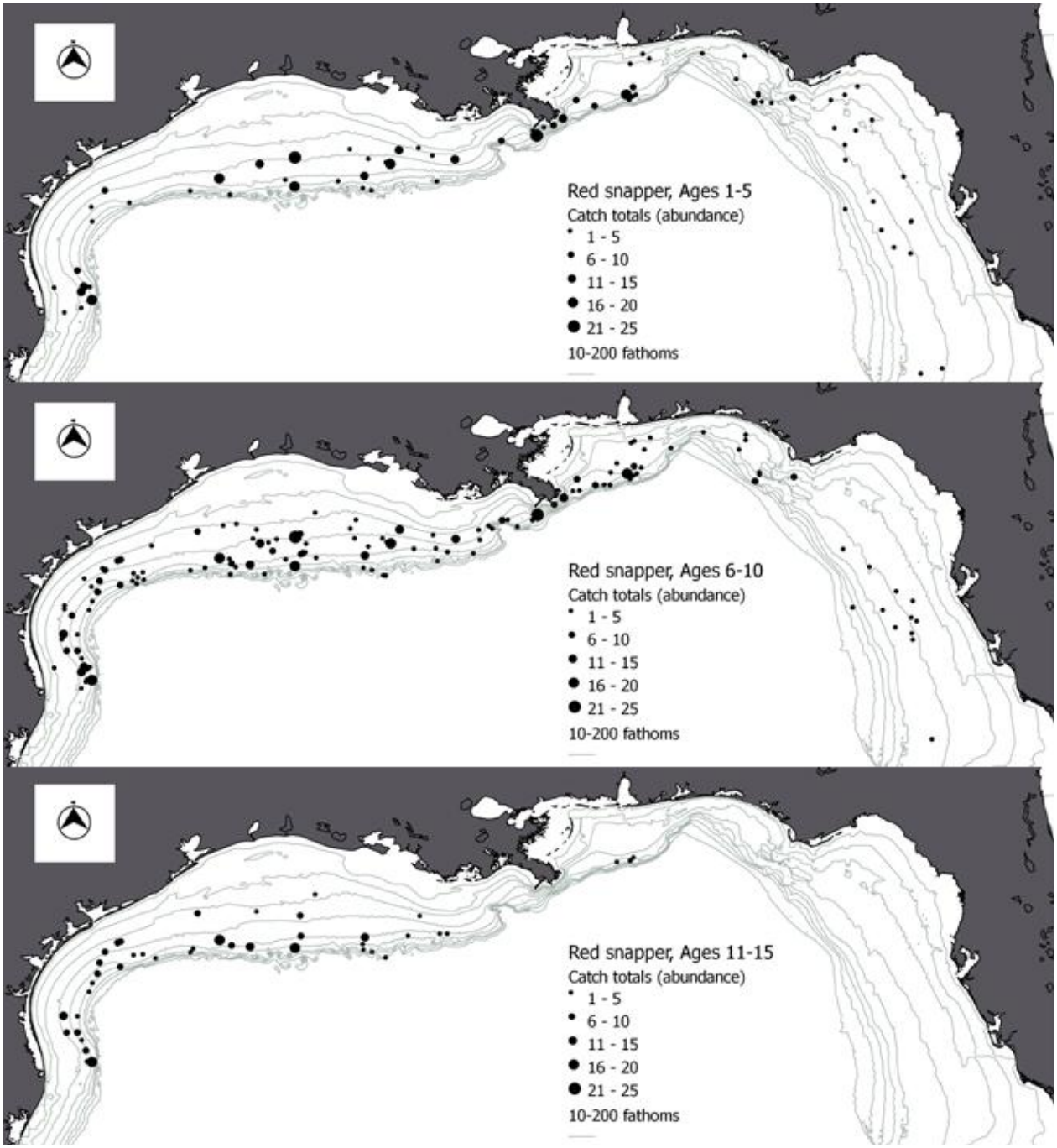

Figure 11. Spatial distribution of red snapper EASA longline catch for ages 1-5 (top), 6-10 (center), and 11-15 with bubble size indicating the total number of fish caught at the station (e.g. low catch = small bubble).

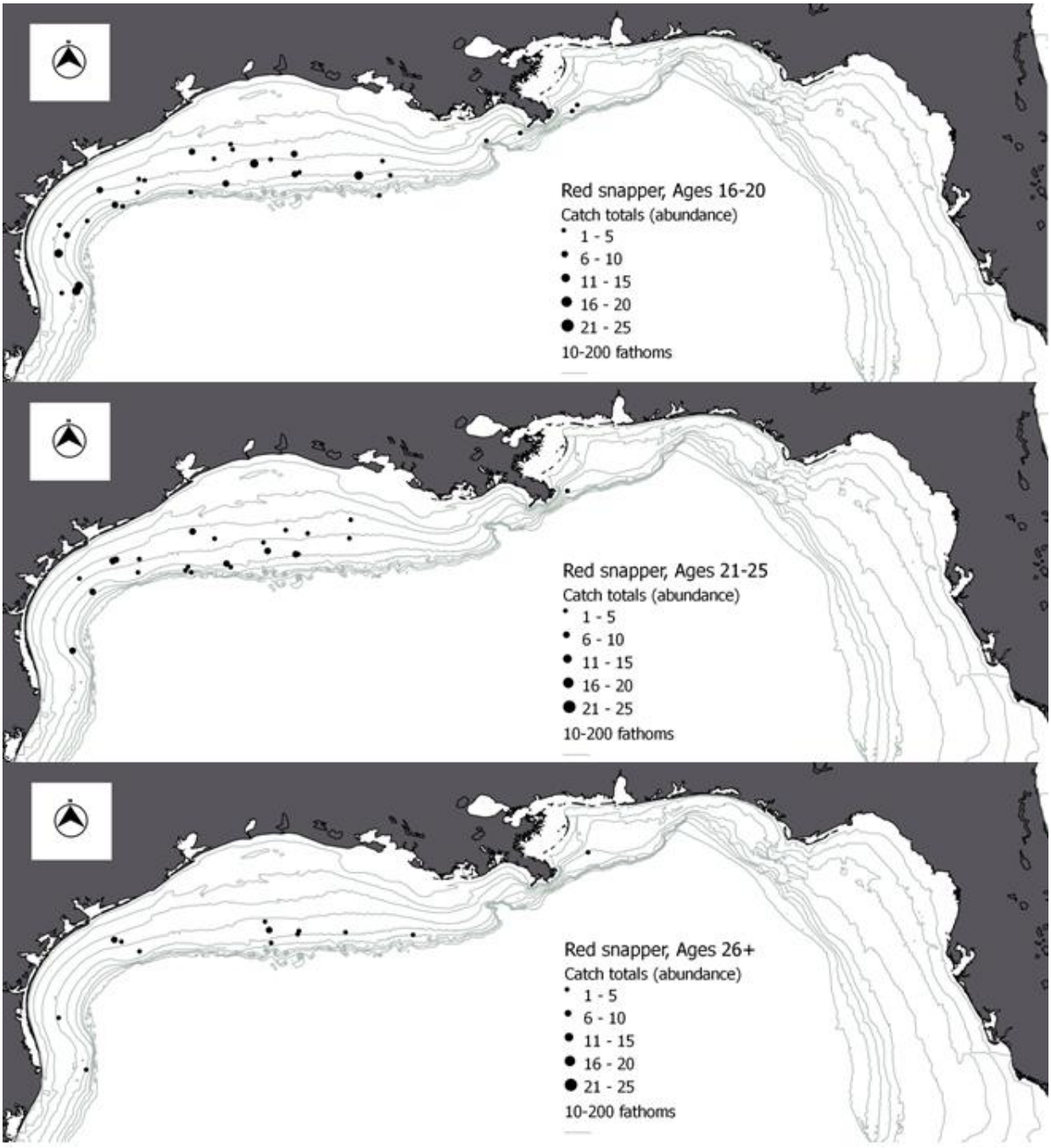

Figure 12. Spatial distribution of red snapper EASA longline catch for ages 16-20 (top), 21-25 (center), and 26+ with bubble size indicating the total number of fish caught at the station (e.g. low catch = small bubble).

Discussion

Spatial plots show that most of the red snapper catch from the Gulf of Mexico is located in sites west of Mobile Bay and evaluation by age group shows that most of the older fish in the population (Age 10+) are located west of the Mississippi River. In general larger and older red snapper are associated with western GOM catches, and size selectivity is clearly evident between gears with longline catching the older/larger fish. Red snapper from the eastern GOM tend to be smaller and younger and show less size selectivity between longline and vertical line gears. Given that the design is a randomly stratified design with good spatial balance in site selection (i.e. the east is sampled the same as the west) the data imply that the eastern GOM lacks age structure and is largely dependent on a few age classes to support the fishery in this region. Low catch rates and larger length-at-age from the eastern GOM vertical line catch suggests there is a density dependent effect where recruitment age red snapper (2-6) from this region experience less competition for resources and therefore may experience better growth rates. Whereas high catch rates and smaller length-at-age from the western GOM vertical line catch suggests an opposite effect on growth for recruitment age red snapper (2-6) from that region.

Data from the EASA survey will be used in the NMFS annual bottom longline index of relative abundance, and by the age and growth SEDAR working group (NMFS Panama City). In depth results from the EASA survey for those particular applications and analysis can be found in those SEDAR contributions. In depth analysis of gear selectivity and hook selectivity is planned for future analyses, and age and length composition data is available in its current format.

Literature cited

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