Gray Triggerfish *Balistes capriscus* Findings from the NMFS Panama City Laboratory Camera & Trap Fishery-Independent Survey 2004-2017

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Gray Triggerfish *Balistes capriscus* Findings from the NMFS Panama City Laboratory Camera & Trap Fishery-Independent Survey 2004-2017

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Survey history and overview

In 2002, the Panama City NMFS lab began development of a fishery-independent trap survey (PC survey) of natural reefs on the inner shelf in the northeast Gulf of Mexico, off Panama City, FL. The primary objective of the PC survey was establishing an age-based annual index of abundance for young (age 0-3), pre-recruit gag, scamp, and red grouper. Secondary objectives included examining regional catch, recruitment, demographic, and distribution patterns of other exploited reef fish species. Initially, the PC survey used the same chevron trap configuration and soak time that has been used by the South Atlantic MARMAP program for over 30 years (McGovern et. al. 1998), as traps are efficient at capturing a broad size range of several species of reef fish (Nelson et. al.1982, Collins 1990). However, an in-house study in 2003 indicated that traps with a throat entrance area 50% smaller than that in the MARMAP traps were much more effective at meeting our objective of capturing sufficient numbers of all three species of grouper. Video data from our study and consultations with fishermen suggested that the presence of larger red grouper in a trap tend to deter other species from entering. Beginning in 2004, the 50% trap throat size became the standard. That same year the survey was expanded east of Panama City to Apalachee Bay off the Big Bend region of Florida (Fig. 1), an area separated from the shelf off Panama City by Cape San Blas - an established hydrographic and likely zoogeographic boundary (Zieman and Zieman 1989).

Beginning in 2005, the collection of visual (stationary video) data was added to the survey to provide insight on trap selectivity, more complete information on community structure, relative abundance estimates on species rarely or never caught in the trap, and additional, independent estimates of abundance on species typically caught in the traps. Video sampling was only completed in Apalachee Bay in 2005, but was expanded to the entire survey in 2006. Additionally, the target species list was expanded to include the other exploited reef fishes common in the survey area, i.e., red, vermilion, gray, and lane snapper; gray triggerfish, red porgy, white grunt, black seabass, and hogfish in 2005. From 2005 through 2008 each site was sampled with the camera array, directly followed by a single trap. Beginning in 2009, trap effort was reduced ~50%, with one deployed at every other video site. This was done to increase the number of video samples, and thereby the accuracy and precision of the video abundance estimates. Camera arrays are much less selective and provide abundance estimates for many more species than traps, and those estimates are usually much less biased (DeVries et al. 2009). At each site, a CTD cast was made to collect temperature, salinity, oxygen, and turbidity profiles.

Through 2009, sampling was systematic because of a very limited sampling universe. In 2010, the design was changed to 2-stage unequal probability sampling design after side scan sonar surveys that year yielded an order of magnitude increase in the sampling universe (Fig. 1). Five by five minute blocks known to contain hard bottom reef sites, and proportionally allocated by region, sub-region, and depth (10-20, 20-30, 30+ m) to ensure uniform geographic and bathymetric coverage, are randomly selected first. Then, two known reef sites, a minimum of 250 m apart within each selected block are randomly selected (Fig. 2). Alternates are also selected for use and are utilized when another boat is found to be fishing the selected site or no hard bottom can be found with sonar at the designated location.

Depth coverage was ~8-30 m during 2004-07 and steadily expanded to ~8-52 m in 2008 (Fig. 3). The coverage was expanded again in 2017 and now ranges from ~7-58 m. Sampling effort has also increased since 2004 with a minimum of 59 and maximum of 186 video samples per year. Sample sizes per year, not including censored sites, are displayed in Tables 1 and 2. Nine sites in 2004 and 23 in 2005 were sampled twice; thereafter each site was only sampled once in a given year. All sampling has occurred between May and November, but primarily during June through August (Fig. 4).

Methods

Sampling was conducted during the daytime from one hr after sunrise until one hr before sunset. Chevron traps were baited each new drop, with three previously frozen Atlantic mackerel *Scomber scombrus*, and soaked for 1 to 1.5 hr. Traps were dropped as close as possible to the exact location sampled by the camera array. All trap-caught fish were identified, counted, and measured to maximum total (TL) and fork length (FL) (FL only for gray triggerfish and TL only for black seabass). Both sagittal otoliths were collected from a max of five randomly subsampled specimens of snappers (gray, lane, red, and vermilion), groupers (gag, red, and scamp), black seabass, red porgy, hogfish, white grunt, and gray triggerfish (first dorsal spine for the latter).

Visual data were collected using a stationary camera array composed of four Hi 8 video cameras (2005 only) or four high definition (HD) digital video cameras (2006-2008) mounted orthogonally 30 cm above the bottom of an aluminum frame. From 2007 until 2009, parallel lasers (100 mm spacing) mounted above and below each camera were used to estimate the sizes of fish which crossed the field of view perpendicular to the camera. In 2009 and 2010, one of the HD cameras was replaced with a stereo imaging system (SIS) consisting of two high resolution black and white still cameras mounted 8 cm apart, one digital video (MPEG) color camera, and a computer to automatically control these cameras as well as store the data. The SIS provides images from which fish measurements can be obtained with the Vision Measurement System (VMS) software (2009-2014) and SeaGIS software (2015-2017). Beginning in 2011, a second SIS facing 180º from the other was added, reducing the number of HDs to two; and both SIS's were also upgraded with HD, color MPEG cameras. In 2012 the two digital video cameras were replaced with HD GoPro cameras. The camera array was unbaited in 2005 through 2008, but since 2009 has been freshly baited each drop with one previously frozen Atlantic mackerel placed in a mesh bag near the center.

Before stereo camera systems were used (prior to 2009), soak time for the array was 30 min to allow sediment stirred up during camera deployment to dissipate and ensure tapes with an unoccluded view of at least 20 min duration (Gledhill and David 2003). With the addition of stereo cameras in 2009, soak time was increased to 45 min to allow sufficient time for the SIS to be settled on the bottom before starting its hard drive, and to insure the hard drive had time to shut down before retrieval. In mid-2013, stereo cameras were upgraded with solid state hard drives, enabling soak time to be reduced back to 30 min. Prior to 2009, tapes of the four HD cameras were scanned, and the one with the best view of the habitat was analyzed in detail. If none was obviously better, one was randomly chosen. In 2009 only the three HD video cameras were scanned and the one with the best view of the reef was analyzed. Starting in 2010, all four cameras – the HDs and the SIS MPEGs, which have virtually the same fields of view (64 vs 65º), were scanned, and again, the one with the best view of the habitat was analyzed. Beginning in 2012, when a video from a GoPro camera was selected to be read, predetermined, equal portions of each edge of the video were digitally cropped so that only the central 65° of the field of view was visible due to the GoPro's much larger field of view (122 vs 65º). The videos were viewed, beginning twenty minutes prior to pick up of the camera array, to ensure the cloud of sediment disturbed by the landing of the array had dissipated. All fish captured on videotape and identifiable to at least genus were counted. Data on habitat type and reef morphometrics were also recorded. If the quality of the MPEG video derived from the SIS was less than desirable, fish identifications were confirmed on the higher quality and concurrent stereo still frames. The estimator of abundance was the maximum number of a given species in the field of view at any time during the 20 min analyzed (= min count; Gledhill and Ingram 2004, or MaxN; Ellis and DeMartini 1995). Stereo measurements were taken from a still frame showing the min count of a given species (but not necessarily the same frame the actual min count came from) to eliminate the possibility of measuring the same fish more than once. Even for deployments where the SIS did not provide a good view of the reef habitat, the stereo files were examined to obtain fish measurements using VMS or SeaGIS, and again, those measurements were only taken from a still frame showing the min count of a given species. In contrast, when scaling lasers were used to obtain length data, there was no way to eliminate the possibility of double measuring a given fish, although this was probably not a serious problem, as usable laser hits were typically rare for any one sample.

Because of the significant differences we observed in both species composition and abundance of many reef fishes east and west of Cape San Blas, and because of the Cape's known status as a hydrographic and likely zoogeographic boundary (Zieman and Zieman 1989), many of the results presented herein are shown separately for the two areas.

Censored data sets were used in deriving the indices of relative abundance from video data. All video samples were screened, and those with no visible hard or live bottom and no visible species of fish strongly associated with hard bottom habitat, as well as samples where the view was obscured because of poor visibility, video out of focus, etc., were excluded from calculations of relative abundance. In 2014, ten video samples from an area with an ongoing red tide bloom which reduced visibility past a readable threshold were also censored.

The CPUE and proportion positive findings for the trap survey were based on all samples except those from sites which had already been sampled in a given year and ten sites in 2014 located in an ongoing red tide bloom that greatly reduced visibility.

Results

Since the Panama City lab reef fish survey began in 2004/2005, gray triggerfish have consistently been observed with stationary video gear and captured in chevron traps across the inner and mid-West Florida shelf, both east and west of Cape San Blas (Tables 1, Table 2, Fig. 5A) (DeVries et al. 2008, 2009, 2012). Gray triggerfish were encountered by both gears across virtually the entire depth range sampled (5-60 m), encounter rates did increase with depth from 9-39 m, leveling off at depths of 40-60 m. However, decreased sample size at deeper depths made it difficult to interpret results from > 40 m. (Table 3, Fig. 7, Fig. 8A, Fig. 8B). The video survey targeted both pre-recruit gray triggerfish (<381 mm fork length, the legal size limit in 2019) and those that had recruited to the fishery.

Encounter rates

From 2005-2017, the overall gray triggerfish annual proportion of positive video samples ranged from 0.14 to 0.95 ($\bar{x}$ =0.42). Throughout those years, the annual proportion of positive video samples ranged from 0.15 to 0.47 east of the Cape (2005-2017), and 0.48 to 0.95 west of the Cape (2006-2017) ($\bar{x}$ =0.63) (Table 1, Fig. 9). Gray triggerfish were noticeably more abundant west of the Cape than east with mean proportion of positive video samples equal to 0.63 and 0.30, respectively. Annual proportions positive were consistently higher every year west of the Cape than east, with the exception of 2005 when sampling was only completed in the east (Table 1, Fig. 9).

The annual proportion of positive gray triggerfish trap catches from 2004-2017 ranged from 0.06 to 0.55 east of the Cape ($\bar{x}$ =0.25) and 0.30 to 0.74 west of the Cape ($\bar{x}$ = 0.46) (Table 2, Fig. 16). Similarly to the video survey, proportion positive occurrences were typically higher in the west than the east with the exception of 2004 and 2007. Mean nominal video catch per trap hour west of the Cape were 1.59±0.15 and 0.42±0.04 east of the Cape. Gray triggerfish had consistently higher mean trap catch rates in the west versus the east with the exception of 2007 where $\bar{x}$ =0.75 east of the Cape and $\bar{x}$ =0.56 west of the Cape. This geographical difference in abundance is clearly visible in the overall relative density plot of pooled min count data from all years, with higher densities of gray triggerfish seen between 85° 45'N and 86° 30'W than any in the area east of the Cape (Fig. 5B, Fig. 18). The sampling region west of the Cape did not have any sites shallower than 17 m and east of the Cape did not have any sites deeper than 50 m. This difference in sites sampled between regions is attributed to a shallower slope of the West Florida Shelf east of the Cape and a steeper slope west of the Cape. Gray triggerfish were most commonly found between 21-41 m with proportion of positive occurrences ranging from 0.49-0.75 ($\bar{x}$ =.53) (Table 3, Fig. 8A). In the east, the proportion positive generally increased with depth, but remained fairly stable once deeper than 21 m until 41 m. The highest proportion positive in the east was from 33 – 37 m (0.53, 0.47, and 0.50 respectively) (Table 3, Fig. 7A). In the west, proportion positive were relatively stable from the starting depth of 17 m until 59 m with $\bar{x}$ =0.63. The peak proportion positive of 0.71 was between 21-29 m (Table 3, Fig. 7B). Areas both east and west of the Cape had high proportion positives at >43 m, but this could be due to small sample size.

Abundance trends

Estimates of relative abundance for gray triggerfish displayed overall similar patterns to those seen in proportion positives. Mean nominal video counts west of the Cape were 2.01±.15, and .52±.03 east of the Cape. Not surprisingly, video counts were higher every year in the west than east (2005-2017). Annual GIS plots of video min counts and trap catch of gray triggerfish showed very similar geographic patterns in relative abundance trends between 2005 and 2017 (Fig. 12, Fig. 19). Similar to the proportion positive findings, relative abundance trends were significantly higher west of the cape ($p<0.001$) than in the east (62-294% higher, $\bar{x}$=147%) with the exception of 2007 (Fig. 10). MaxN west of the Cape appeared to steadily rise starting in 2007 with a peak in 2009, followed by a decline until 2013, before rising again in 2014 (Figure 10). MaxN continued increasing through 2016 where it leveled off and remained stable through 2017. These data were not significant due to the high variance in some samples. While differences in year to year trends were seldom significant, patterns displayed over longer time scales showed a significant increase including a significant decrease in mean video counts from 2009 through 2011 ($\bar{x}$ =3.76 and 1.36, $p<0.04$) and a significant increase in mean video count from 2013 through 2016 ($\bar{x}$ =1.14 and 2.56, $p<0.02$). Trends in MaxN east of the Cape followed the west with only minor fluctuations in abundance. Mean video counts showed a significant increase from 2005 to 2006 ($\bar{x}$ =0.17 and 0.97, $p<0.001$), and a significant decrease from 2010 to 2011($\bar{x}$ =0.51 and 0.25, $p<0.01$). MaxN east of the cape gradually recovered with a significant increase in MaxN from 2014-2015 ($\bar{x}$ =0.34 and 0.73, $p<0.01$), but again dropped from 2016 through 2017 ($p<0.0001$) (Fig. 10). Overall trends show variable MaxN throughout the years of the survey, highlighted by a significant decrease from 2009 to 2010 ($p<0.009$) followed by a significant recovery period from 2012 to 2016 ($\bar{x}$ =0.88 and 0.30, $p<0.0002$) (Fig. 11).

Trends in mean trap cpue were much more variable, and only very roughly followed those in the video survey (Fig. 20). Like the video trends west of the Cape, mean trap cpue in the west gradually decline from 2004 to 2007 followed by a rise from 2007 to 2008 ($\bar{x}$=0.56 to 1.82, $p<0.05$), and a rise from 2013 to 2017 ($\bar{x}$=0.56 to 4.76, $p<0.05$) (Fig. 17). Unlike the video data, there was not a significant increase in mean trap catch in 2009, although there was a significant decline from 2011 to 2012 ($\bar{x}$ =2.11 to 0.55, $p<0.01$) (Fig. 17). East of the Cape trap cpue declined variably from its peak in 2004 to almost zero in 2011 ($\bar{x}$ = 1.04 to 0.07) where it remained through 2014 (Fig. 17). There was a significant increase from 2014 to 2015 ($\bar{x}$ =0.06 to 0.80, $p<0.05$) with the mean trap cpue declining steadily from 2015 to 2017 ($\bar{x}$ =0.80 to 0.14, $p<0.05$). When abundance trends are viewed by region there are noticeably different trends east and west of the Cape which may be evidence of sub-populations. Mean trap catch cpue was significantly higher west of the Cape than east from 2011 to 2014 ($p<0.05$) and again from 2016 to 2017 ($p<0.01$).

When habitat data from videos were analyzed, gray triggerfish show a significant correlation with the geoform category assigned to each video. Geoform is derived from a CMECS and FWRI habitat classification scheme and defines habitat for various types of observed substrates and attached biota. Both ledge features (linear change in elevation of the seafloor that is associated with an underwater ridge. generally greater than 0.5 m of relief) and fragmented live/hard bottom (exposed rock protruding at least 0.2 m but not more than 0.5 m) showed significant correlation with gray triggerfish presence on a given site in both east and west of the Cape ($p<0.001$ and 0.027, respectively). This data suggests gray triggerfish may be more abundant around higher relief and more rugose habitats, which fits with high abundance areas displayed in Fig. 5B depicting well known hard bottom features such as ledges.

Size and age

The trap catch strongly targeted pre-recruit gray triggerfish (94.7% of fish caught were below the legal size limit of 381 mm FL) from 2004-2017, with 93.5% of trap-caught fish west of the Cape below the legal size and 95% east of the Cape. The measurements derived from stereo images (2009-2017) showed a somewhat similar pattern of pre-recruit triggerfish, with 74.3% of measured fish below the legal size limit of 381 mm FL with 75% west of Cape San Blas and 73.7% east of Cape San Blas. This pattern can also be clearly seen in the annual length composition data from 2009-2017 and 2004-2017 (Fig. 15, Fig. 23)

Gray triggerfish caught in chevron traps during 2004-2017 ranged from 120 to 501 mm FL, with a modal size of 300 mm FL, and a mean of 304 mm FL. Fish caught in the west averaged significantly larger than those in the east from 2004-2017 ($\bar{x}$=308 and 294 respectively, $p<0.00001$) (Fig. 21). Those observed with stereo cameras, 2009-2017, ranged from 104 to 775 mm FL, with a modal size of 283 mm FL, and a mean of 332 mm (Table 4). A comparison of size data from trap catches with that from stereo images from the same years (2009-2017) indicated that the traps select for smaller gray triggerfish (<500 mm FL), whereas the video survey samples some of the larger gray triggerfish, although fish that large are much less common in the survey area based on the few stereo measurements obtained (Fig. 22). The modal size and mean are similar for both gears.

Gray triggerfish lengths calculated from stereo cameras during 2009-2017 displayed normal distributions both east and west of Cape San Blas (Fig. 13, Fig.14). Mean lengths were greater on the west side of the Cape, but not significantly so ($\bar{x} \pm$ 95% CL: 340 ± 8.8 vs 324 ± 9.1 mm FL, $p<0.1$) (Table 4). The correlation of depth on fork length from the video and trap data was significant for both regions combined ($p<0.0001$) as well as individual regions ($p<0.0001$) (Fig. 24). However, video data showed a wide range of sizes across depth ranges and the regression accounted for ~9% of the variation (Fig. 24). Gray triggerfish age was relatively uniform for all depth ranges with a median of 3 yr for every depth bin with the exception of 35 m which had a median age of 4 yr. With the exception of seven outliers throughout the dataset, the general range of years is fairly uniform throughout the depth ranges (Fig. 26).

Gray triggerfish caught and sampled in the trap survey ranged from 1-8 years of age with a mean age of 3.4±0.04 years and a strong mode of 3 years (Fig. 25). Fish sampled west of Cape San Blas averaged slightly older than fish sampled east (3.5±0.05 vs 3.1±0.06), although the range in ages was similar (1-7 vs 1-8 years), and the modal age was 3 in both regions (Fig. 25). The annual age structure data of gray triggerfish from the trap catches showed no evidence of the periodic strong year classes that characterize other reef fish species (i.e. red snapper, red grouper, etc.) on the West Florida Shelf (Fig. 27). Fish ages 1 and >6 years have been rare since the survey's inception in 2004 (n=113).

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Tables

Table 1: Annual video survey sample sizes, proportion positive occurrences, mean nominal video min counts, and standard errors of gray triggerfish east and west of Cape San Blas, 2005-2017. Estimates calculated using censored data sets (see Methods).

	Total sites sampled			Proportion positive occurrences			Mean nominal min count			Standard error		
Year	**East**	**West**	**Total**	**East**	**West**	**Total**	**East**	**West**	**Total**	**East**	**West**	**Total**
2005	41		41	0.15		0.15	0.17		0.17	0.07		0.07
2006	72	22	94	0.47	0.95	0.59	0.97	1.91	1.19	0.23	0.28	0.19
2007	34	24	58	0.44	0.63	0.52	0.91	1.54	1.17	0.23	0.34	0.20
2008	56	29	85	0.34	0.79	0.49	0.46	2.17	1.05	0.10	0.42	0.18
2009	64	42	106	0.47	0.81	0.60	0.81	3.76	1.98	0.17	1.14	0.48
2010	92	51	143	0.32	0.59	0.41	0.51	2.43	1.20	0.10	0.53	0.21
2011	100	58	158	0.21	0.48	0.31	0.25	1.36	0.66	0.05	0.31	0.13
2012	101	49	150	0.13	0.61	0.29	0.16	1.24	0.51	0.04	0.20	0.08
2013	38	64	102	0.24	0.53	0.42	0.34	1.14	0.84	0.11	0.19	0.13
2014	89	68	157	0.24	0.63	0.41	0.34	1.53	0.85	0.07	0.34	0.16
2015	99	58	157	0.35	0.53	0.42	0.73	2.33	1.32	0.14	0.58	0.24
2016	102	68	170	0.45	0.59	0.51	0.88	2.56	1.55	0.13	0.60	0.26
2017	94	49	143	0.20	0.71	0.38	0.30	2.43	1.03	0.07	0.36	0.16
Total	**982**	**582**	**1564**	**0.30**	**0.63**	**0.42**	**0.52**	**2.01**	**1.07**	**0.03**	**0.15**	**0.06**

Table 2: Annual chevron trap sample sizes, proportion positive occurrences, mean nominal catch/trap hr, and standard errors of gray triggerfish east and west of Cape San Blas, 2004-2017.

	Total sites sampled			Proportion positive occurrences			Mean nominal catch/trap hr			Standard error		
Year	**East**	**West**	**Total**	**East**	**West**	**Total**	**East**	**West**	**Total**	**East**	**West**	**Total**
2004	22	30	52	0.55	0.37	0.44	1.04	1.70	1.42	0.30	0.60	0.37
2005	70	21	91	0.20	0.62	0.30	0.38	1.62	0.66	0.10	0.62	0.17
2006	68	23	91	0.40	0.70	0.47	0.77	1.33	0.91	0.17	0.26	0.15
2007	44	20	64	0.41	0.30	0.38	0.75	0.56	0.69	0.20	0.25	0.16
2008	50	31	81	0.18	0.52	0.31	0.28	1.82	0.87	0.10	0.47	0.21
2009	51	28	79	0.47	0.57	0.51	0.63	1.76	1.03	0.14	0.45	0.19
2010	46	14	60	0.22	0.36	0.25	0.46	1.02	0.59	0.17	0.70	0.21
2011	48	31	79	0.06	0.65	0.29	0.07	2.11	0.87	0.04	0.54	0.24
2012	52	29	81	0.13	0.31	0.20	0.12	0.55	0.27	0.05	0.18	0.08
2013	14	37	51	0.14	0.30	0.25	0.10	0.56	0.43	0.06	0.20	0.15
2014	55	33	88	0.07	0.36	0.18	0.06	1.15	0.47	0.03	0.38	0.15
2015	30	29	59	0.37	0.38	0.37	0.80	1.87	1.32	0.34	0.64	0.36
2016	54	30	84	0.33	0.47	0.38	0.51	2.19	1.11	0.12	0.62	0.25
2017	41	19	60	0.10	0.74	0.30	0.14	4.76	1.60	0.07	1.36	0.51
Total	**645**	**375**	**1020**	**0.25**	**0.46**	**0.33**	**0.42**	**1.59**	**0.85**	**0.04**	**0.15**	**0.06**

Table 3: Video survey sample sizes and proportion positive occurrences gray triggerfish by depth zone east and west of Cape San Blas, 2005-2017 all years combined.

	Total sites sampled			**Proportion positive occurrences**		
Depth (m)	**East**	**West**	**Total**	**East**	**West**	**Total**
5-7	2		2	0.00		0.00
7-9	15		15	0.13		0.13
9-11	56		56	0.13		0.13
11-13	76		76	0.13		0.13
13-15	95		95	0.36		0.36
15-17	102		102	0.17		0.17
17-19	88	5	93	0.26	0.60	0.28
19-21	98	10	108	0.28	0.50	0.30
21-23	64	50	114	0.34	0.70	0.50
23-25	51	44	95	0.22	0.70	0.44
25-27	38	57	95	0.39	0.72	0.59
27-29	54	49	103	0.46	0.71	0.58
29-31	44	69	113	0.36	0.64	0.53
31-33	36	81	117	0.39	0.62	0.55
33-35	34	53	87	0.53	0.49	0.51
35-37	47	46	93	0.47	0.52	0.49
37-39	30	35	65	0.50	0.69	0.60
39-41	20	31	51	0.35	0.58	0.49
41-43	10	6	16	0.00	0.67	0.25
43-45	1	5	6	1.00	0.60	0.67
45-47	6	13	19	0.67	0.31	0.42
47-49	10	17	27	0.30	0.53	0.44
49-51	5	3	8	0.80	1.00	0.88
51-53		4	4		0.75	0.75
53-55						
55-57		1	1		1.00	1.00
57-59		3	3		0.33	0.33
Total	**982**	**582**	**1564**	**0.30**	**0.63**	**0.42**

Table 4A: Descriptive statistics of gray triggerfish sizes (fork length mm) obtained from chevron traps (2004-2017) and stereo camera measurements (2009-2017).

	Trap Caught Fish			Stereo Camera		
	East	**West**	**Total**	**East**	**West**	**Total**
Min.	157	120	120	104	143	104
1st Qu.	268	279	275	250	279	263
Median	295	304	429	313.5	331	328
Mode	300	290	300	302	283	283
Mean	294	308	300	324	340	332
Confidence Level on Mean (95%	4.2	3.2	2.6	18.0	17.4	12.5
3rd Qu.	315	340	330	388	377	382
Max.	434	501	501	645	775	775
Count	381	846	1227	118	124	242

Table 4B: Descriptive statistics of gray triggerfish sizes (fork length mm) obtained from chevron traps and stereo camera measurements for overlapping years (2009-2017).

	Trap Caught Fish			Stereo Camera		
	East	**West**	**Total**	**East**	**West**	**Total**
Min.	196	120	120	104	143	104
1st Qu.	273	292	287	250	279	263
Median	297	317	310	314	331	328
Mode	300	305	300	302	283	283
Mean	297	320	315	324	340	332
Confidence Level on Mean (95%)	6.7	4.0	3.5	18.0	17.4	12.5
3rd Qu.	313	348	344	388	377	382
Max.	434	501	501	645	775	775
Count	166	566	732	118	124	242

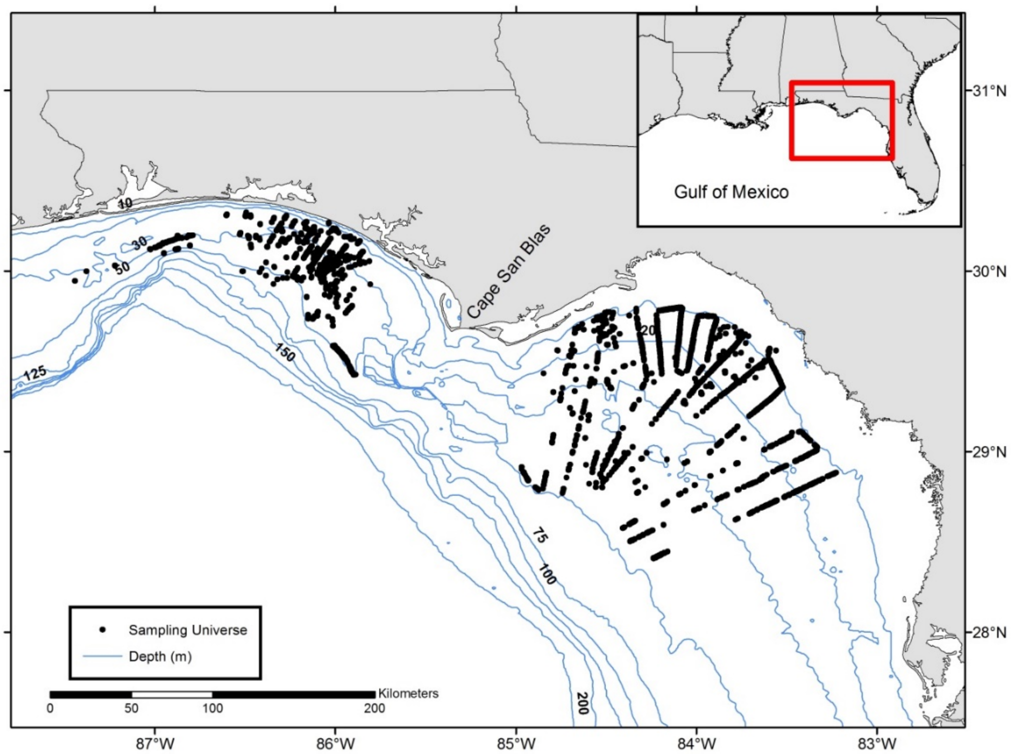


Figure 1. Locations of all natural reefs in the sampling universe of the Panama City NMFS reef fish video survey as of November 2017. Total sites: 4026 – 1360 west, and 2666 east, of Cape San Blas. Isobaths are in meters.

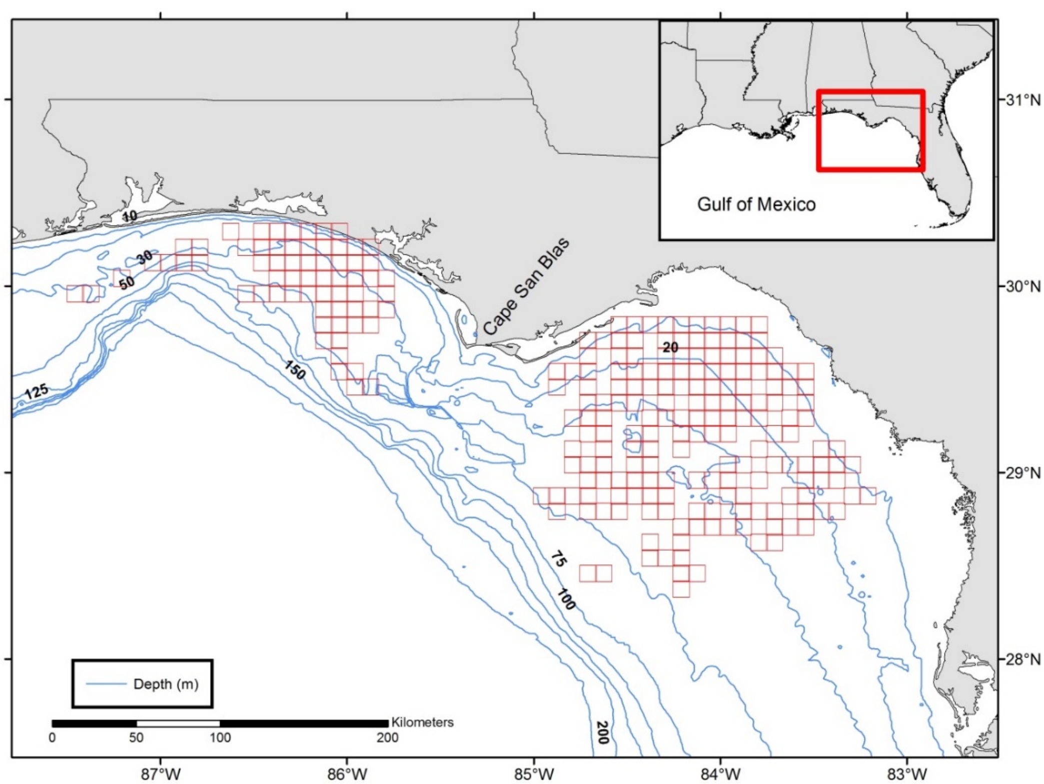


Figure 2. Sampling blocks (5 min lat. x 5 min. long.) of the Panama City reef fish survey. Blocks in red contain known hard bottom reefs and are subject to being selected for sampling. Isobaths are in meters.

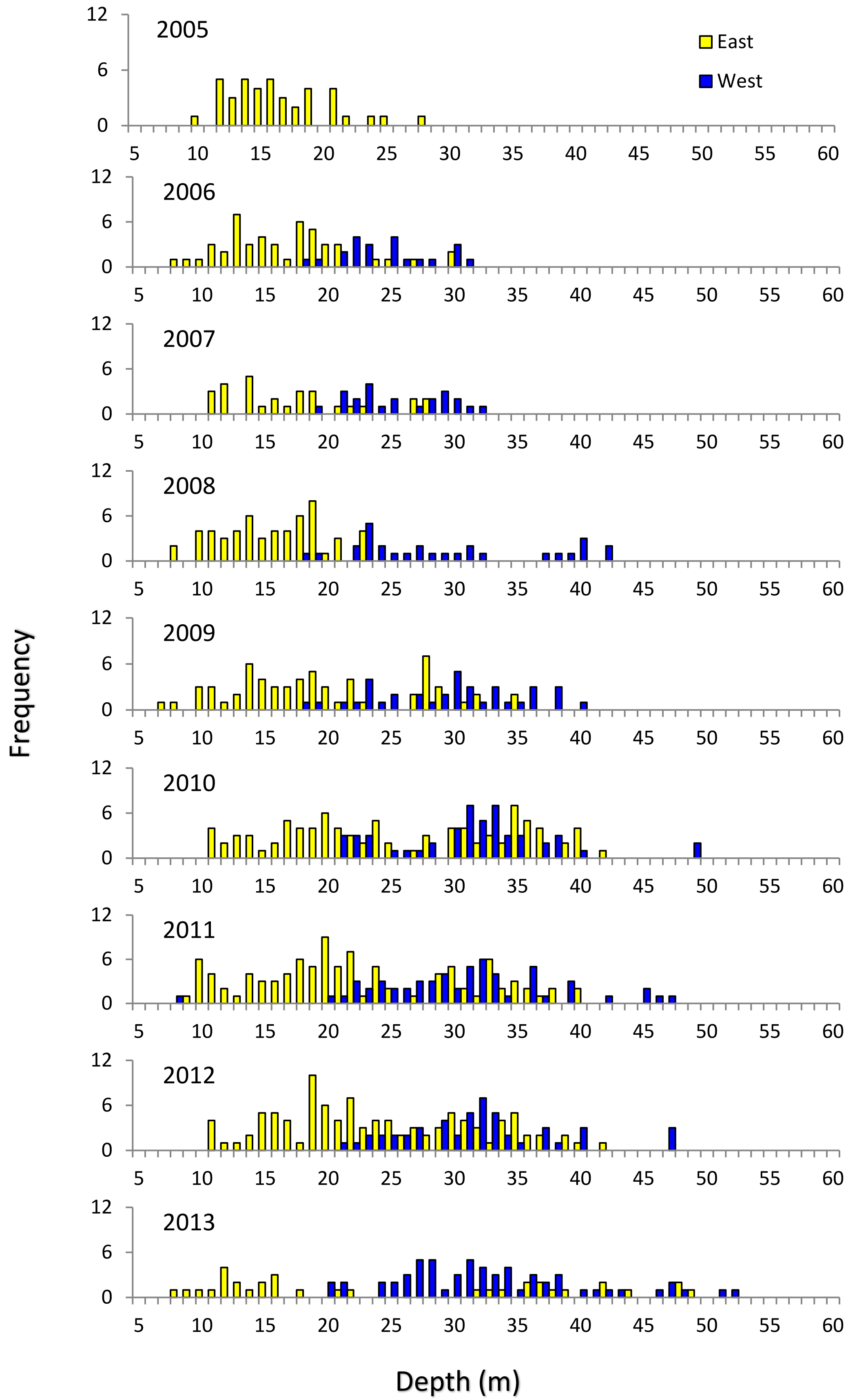


Figure 3. Annual depth distribution of Panama City reef fish survey video sample sites east and west of Cape San Blas, 2005-2017.

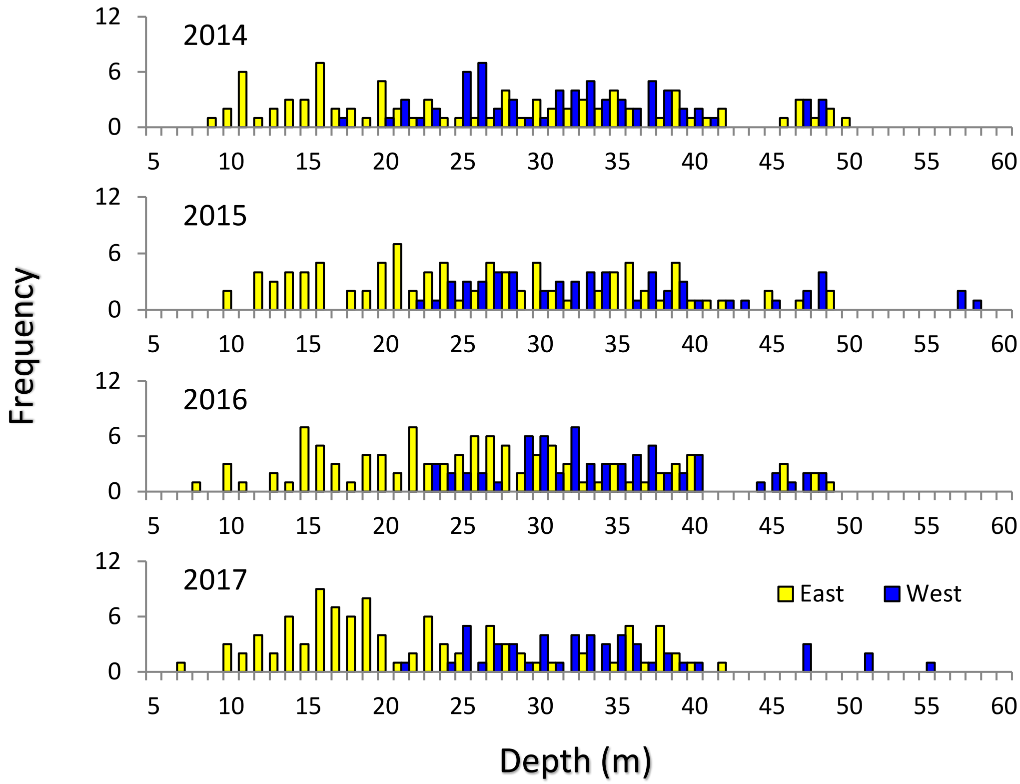


Figure 3 cont. Annual depth distribution of Panama City reef fish survey video sample sites east and west of Cape San Blas, 2005-2017.

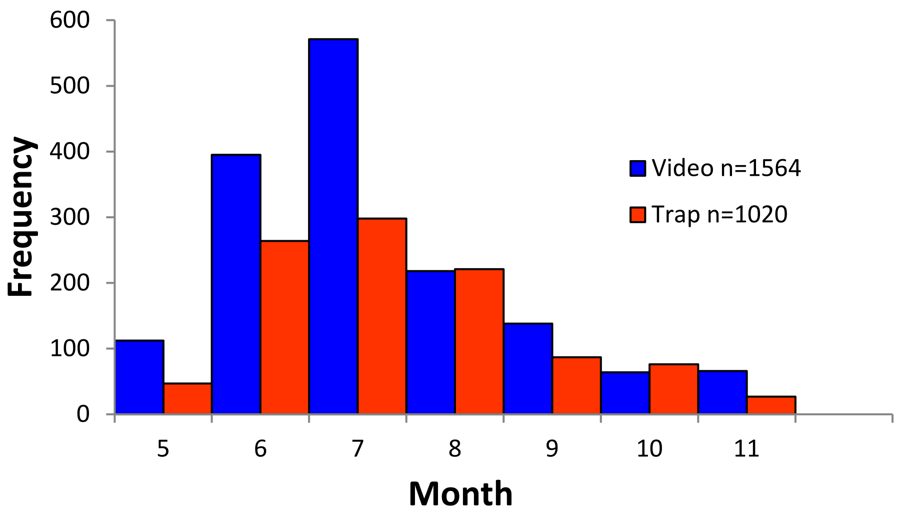


Figure 4. Overall monthly distribution of Panama City reef fish survey video and trap samples (censored data sets only), 2005-2017 (video) and 2004-2017 (trap).

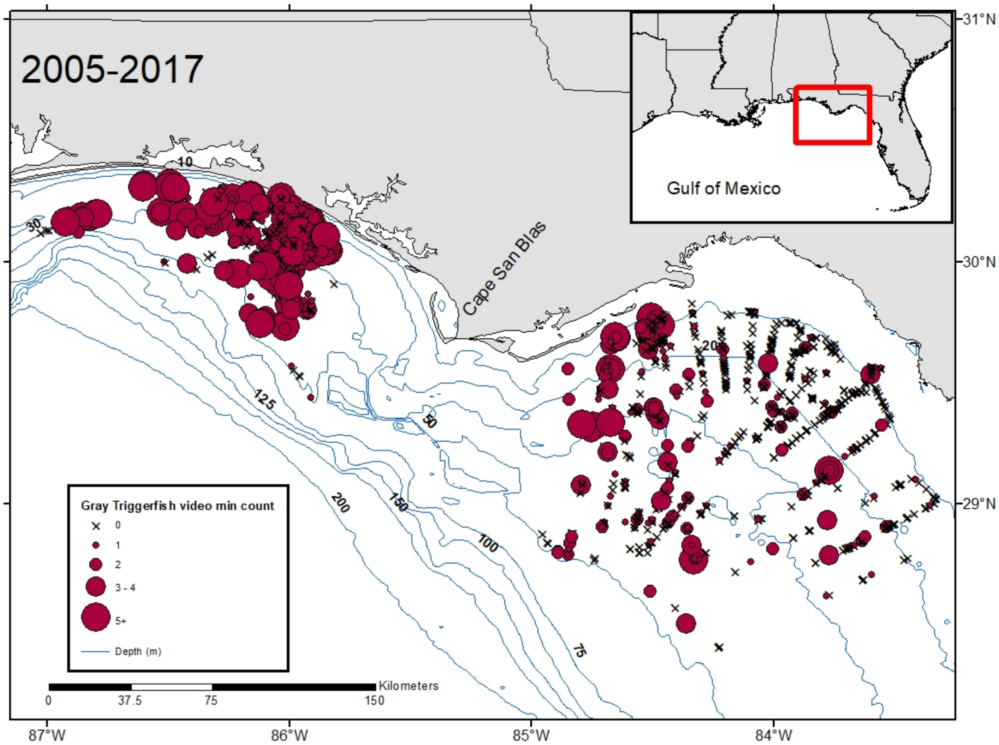


Figure 5A. Distribution and relative abundance of gray triggerfish observed with stationary, high definition video or MPEG cameras (min counts) in the Panama City NMFS reef fish survey, 2006-2017. X's are sites sampled, but where no gray triggerfish were observed.

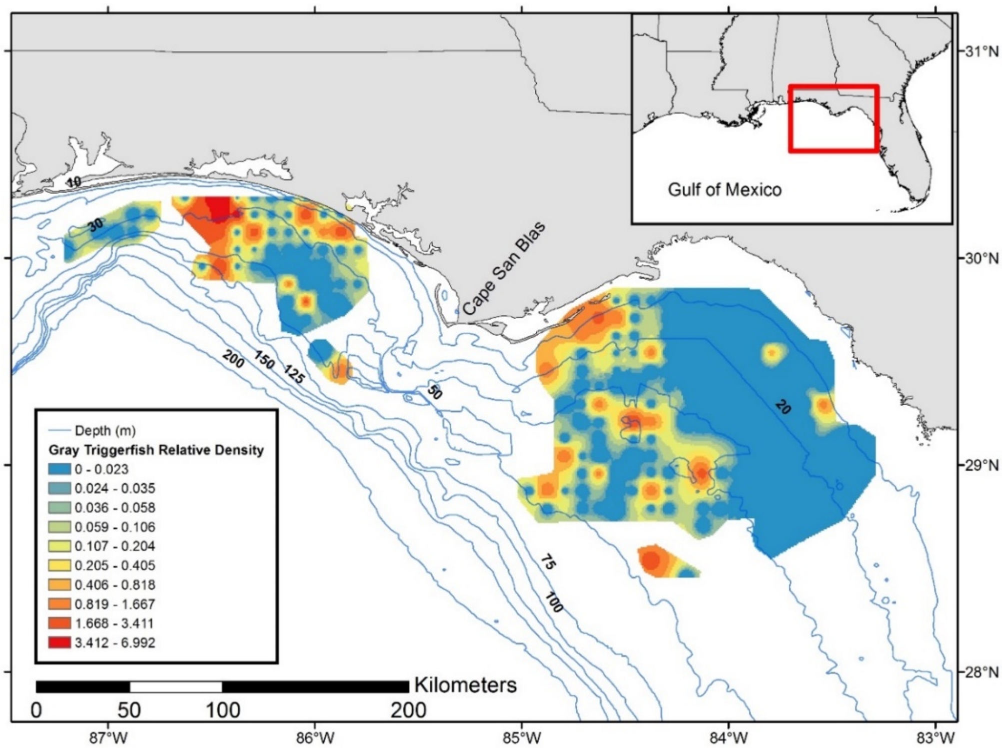


Figure 5B. Overall relative density plot of gray triggerfish based on count data (min-counts, also called MaxN) from video collected with stationary camera arrays in annual surveys, 2005-2017. Mean min counts per were standardized by 5 min latitude x 5 min longitude sampling block, then inverse distance weighting estimates were calculated each block and weighted by effort (See Fig. 2).

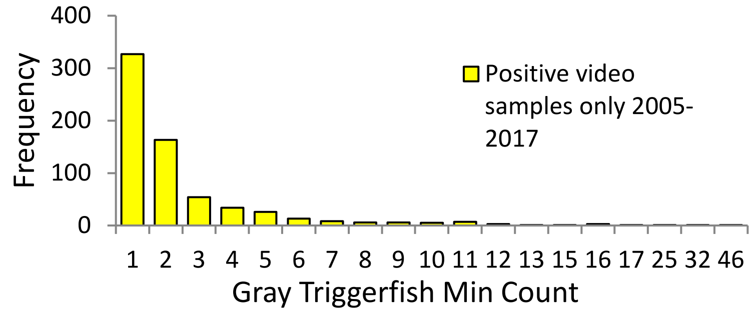


Figure 6. Frequency distribution of non-zero min counts of gray triggerfish from Panama City reef fish video samples, 2005-2017.

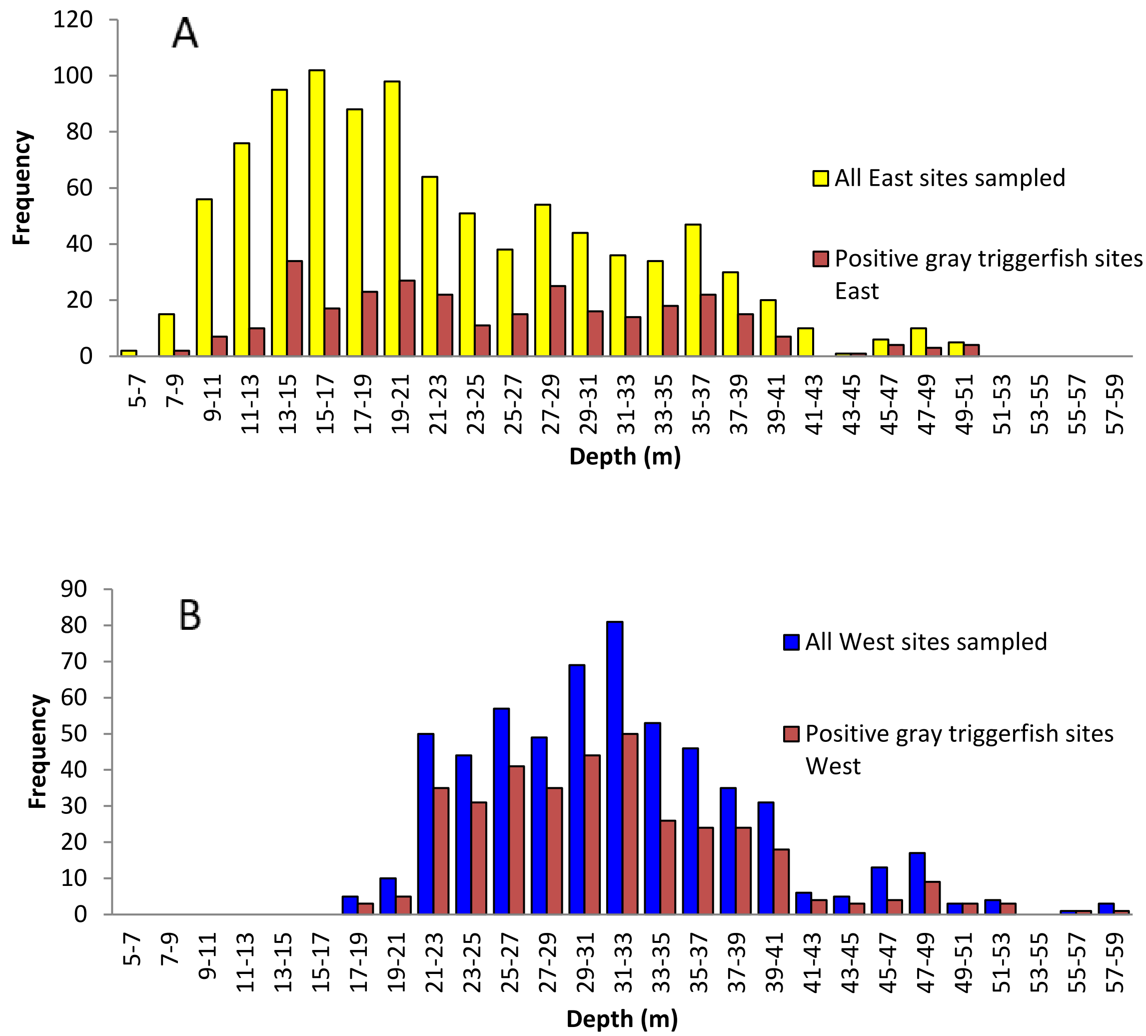
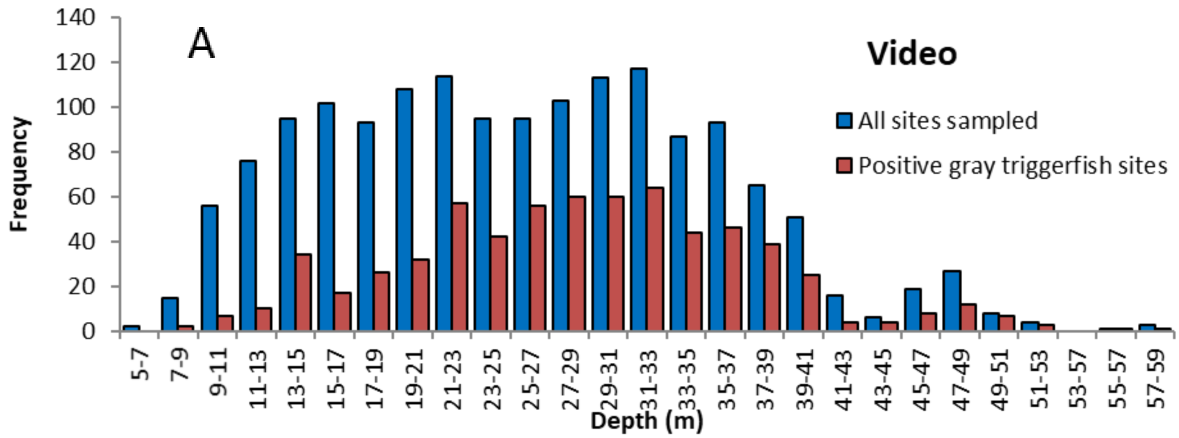


Figure 7. Depth distributions of all video sample sites vs only sites positive for gray triggerfish for east of Cape San Blas (A) and west of Cape San Blas (B).



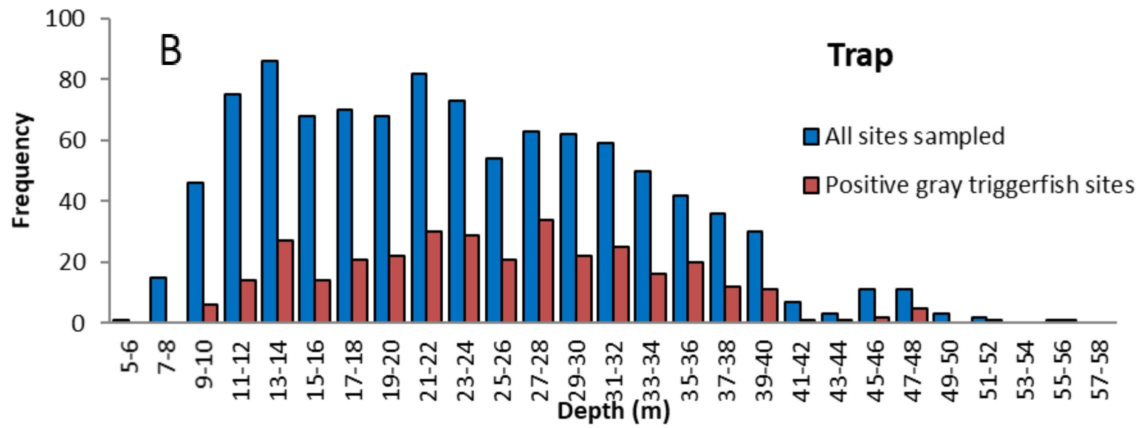


Figure 8. Depth distributions of all video (A) and trap (B) sample sites vs only sites positive for gray triggerfish (2005-2017, video; 2004-2017, trap).

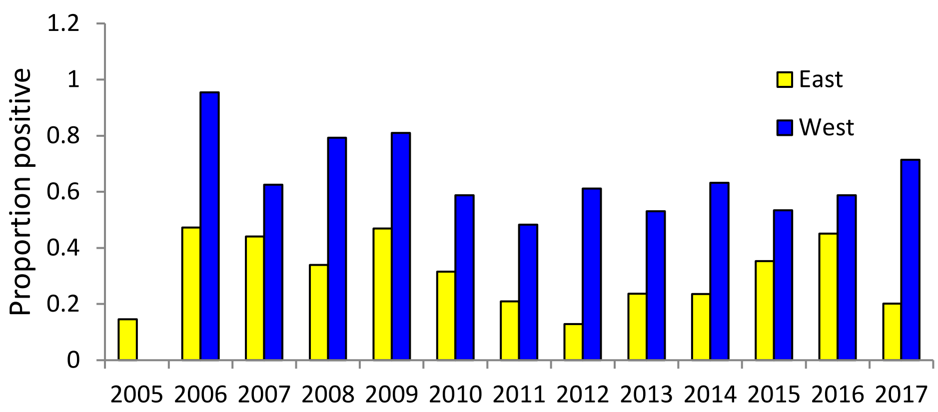


Figure 9. Annual proportions of positive gray triggerfish video samples, 2005-17 east and west of Cape San Blas.

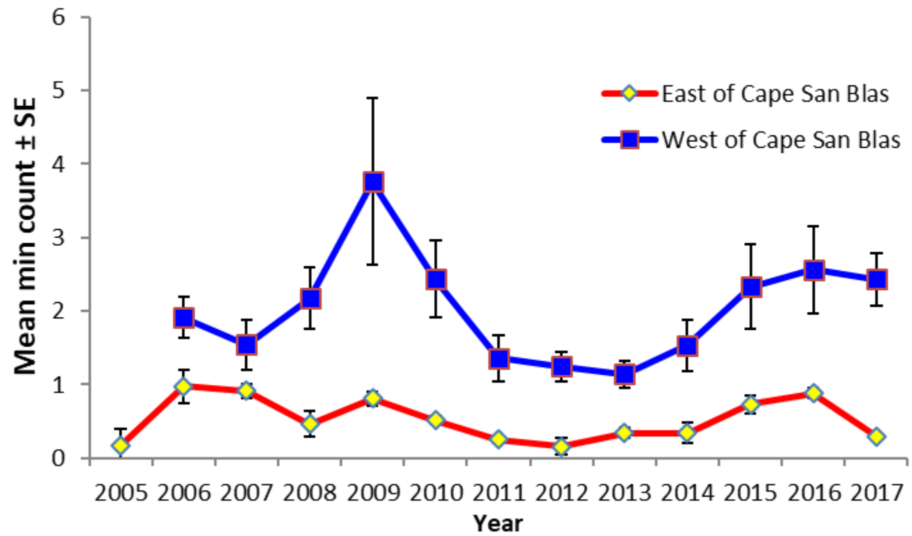


Figure 10. Mean annual nominal video min counts (MaxN) and standard errors of gray triggerfish east and west of Cape San Blas, 2005-2017.

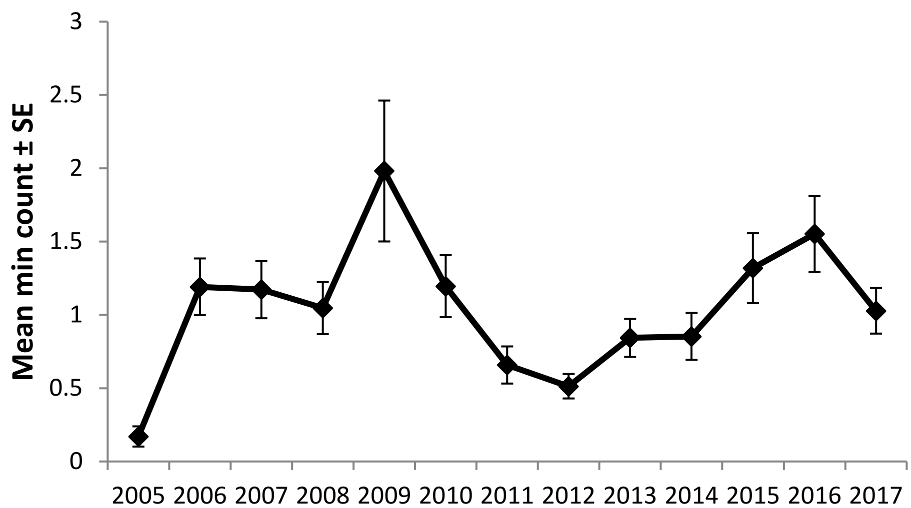


Figure 11. Overall (east + west of Cape San Blas) mean annual nominal video min counts (MaxN) and standard errors of gray triggerfish, 2005-2017.

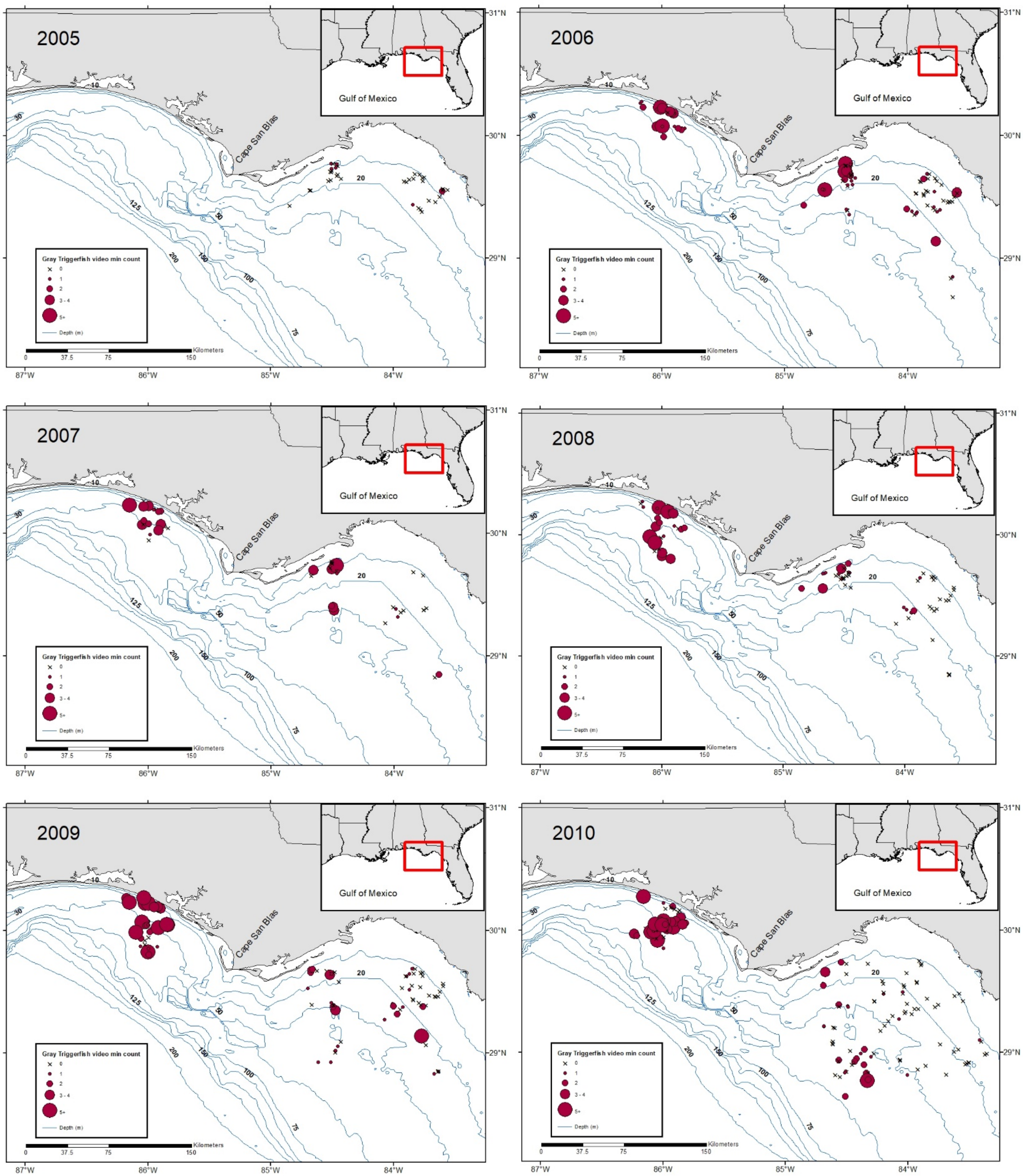


Figure 12. Annual distribution and relative abundance of gray triggerfish observed with stationary, high definition video or MPEG cameras (min counts) in the Panama City NMFS reef fish survey, 2005-2017. Sites sampled, but where no gray triggerfish were observed, are indicated with an X.

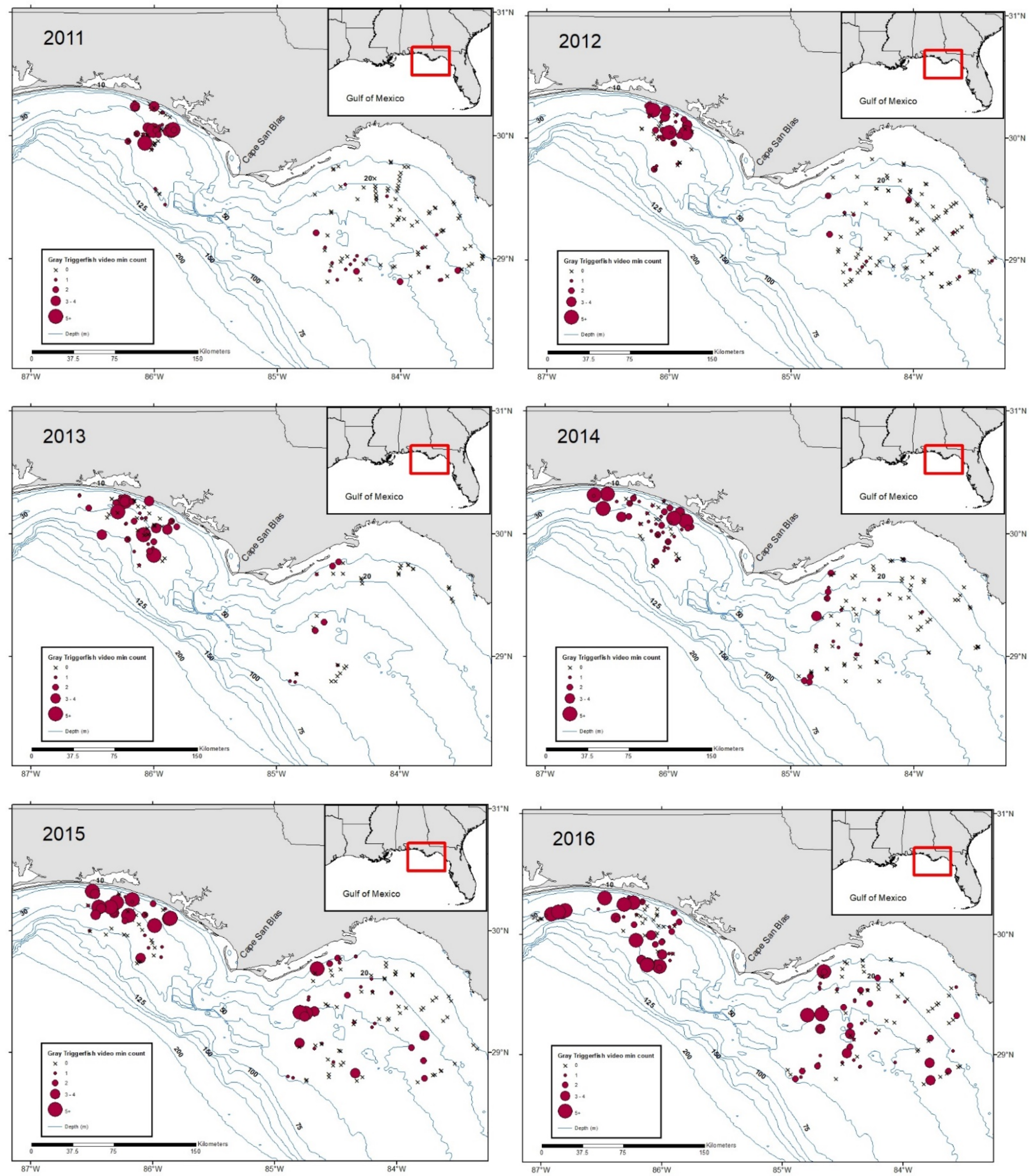


Figure 12 cont. Annual distribution and relative abundance of gray triggerfish observed with stationary, high definition video or MPEG cameras (min counts) in the Panama City NMFS reef fish survey, 2005-2017. Sites sampled, but where no gray triggerfish were observed, are indicated with an X.

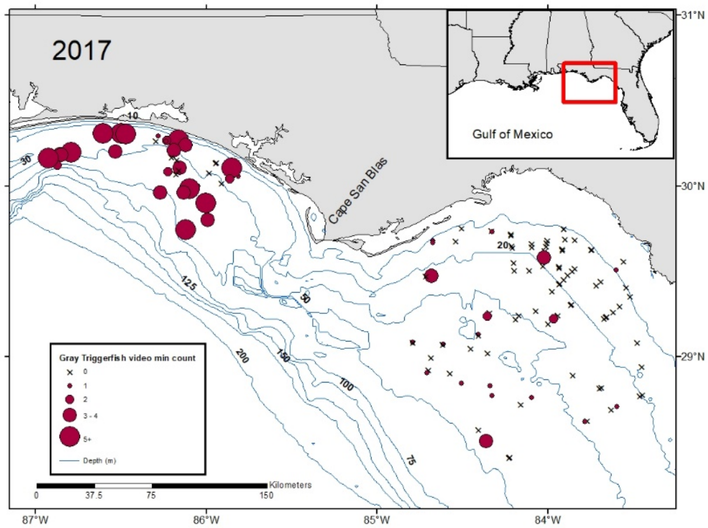


Figure 12 cont. Annual distribution and relative abundance of gray triggerfish observed with stationary, high definition video or MPEG cameras (min counts) in the Panama City NMFS reef fish survey, 2005-2017. Sites sampled, but where no gray triggerfish were observed, are indicated with an X.

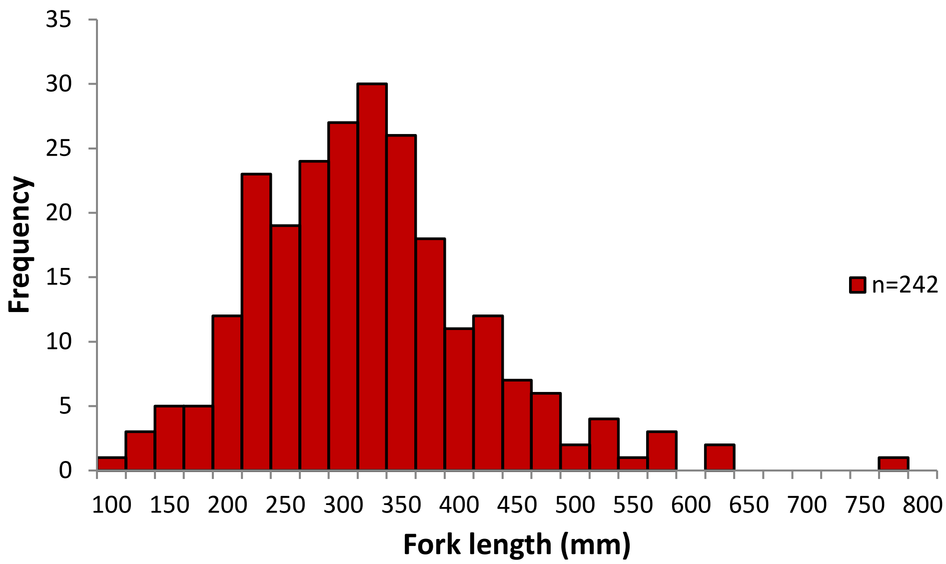


Figure 13. Overall size distributions of all gray triggerfish measured from stereo images, 2009-2017.

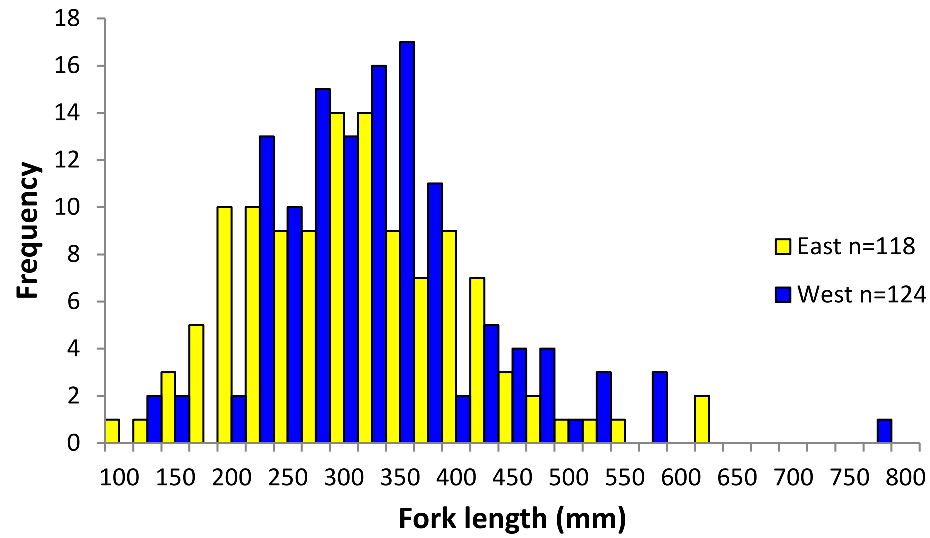


Figure 14. Overall size distributions of gray triggerfish east and west of Cape San Blas observed with stereo cameras, 2009-2017.

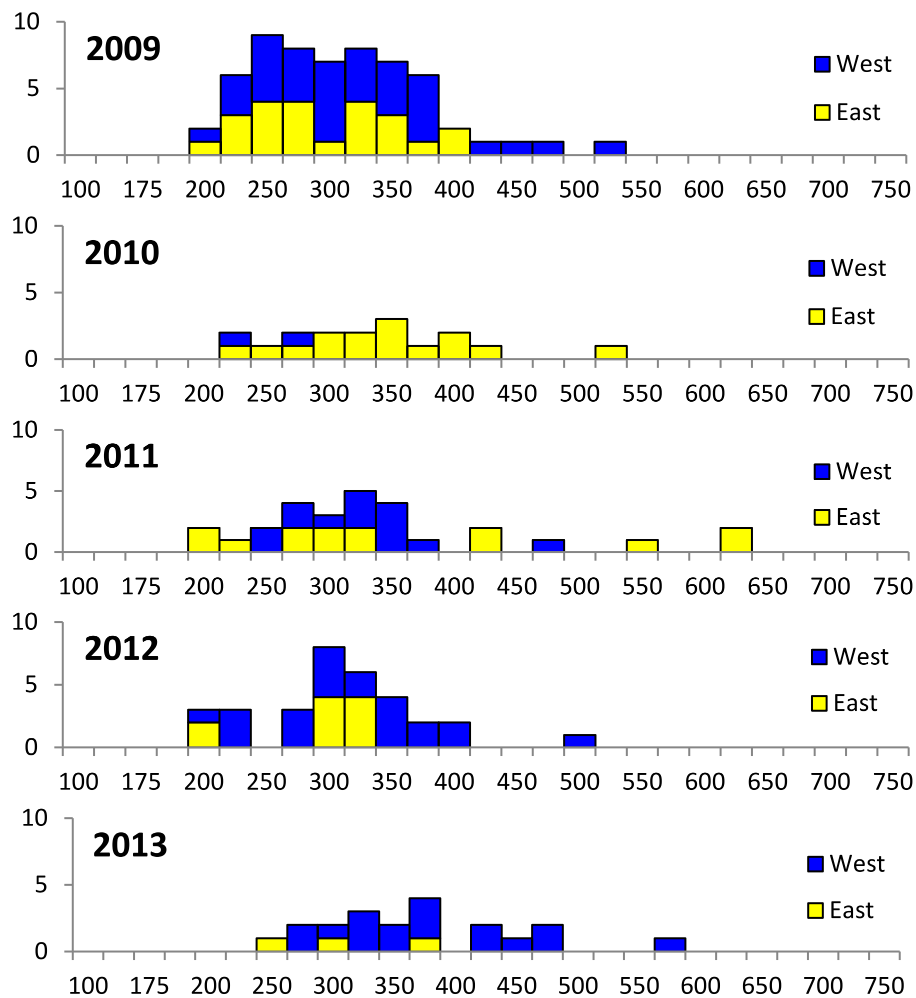


Figure 15. Annual size distributions of gray triggerfish observed with stereo cameras, 2009-2017 east and west of Cape San Blas.

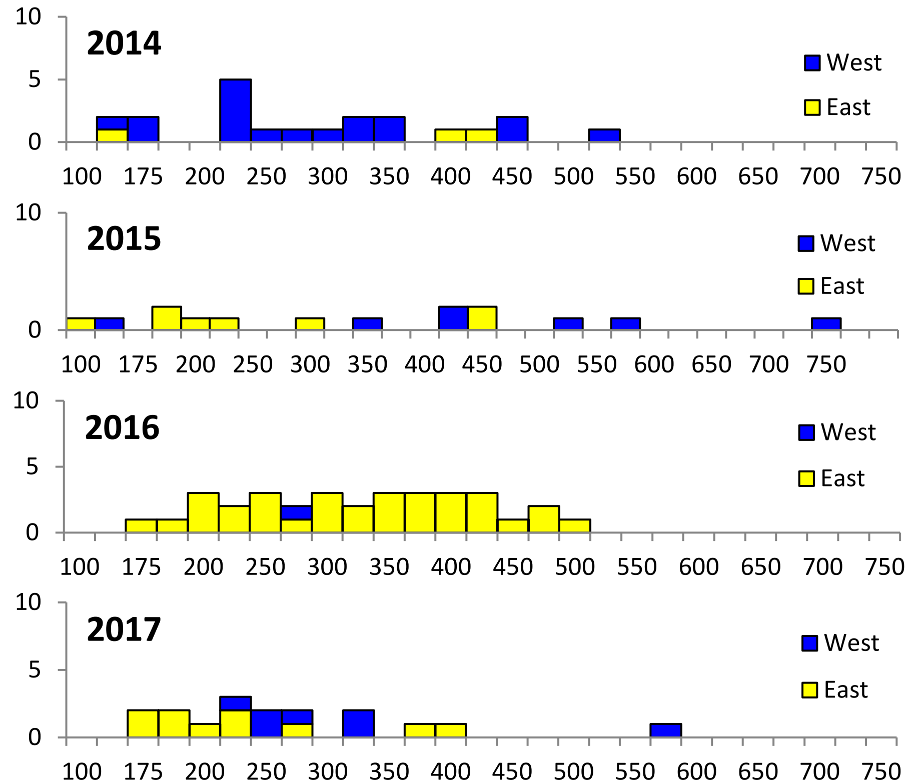


Figure 15 cont. Annual size distributions of gray triggerfish observed with stereo cameras, 2009-2017 east and west of Cape San Blas.

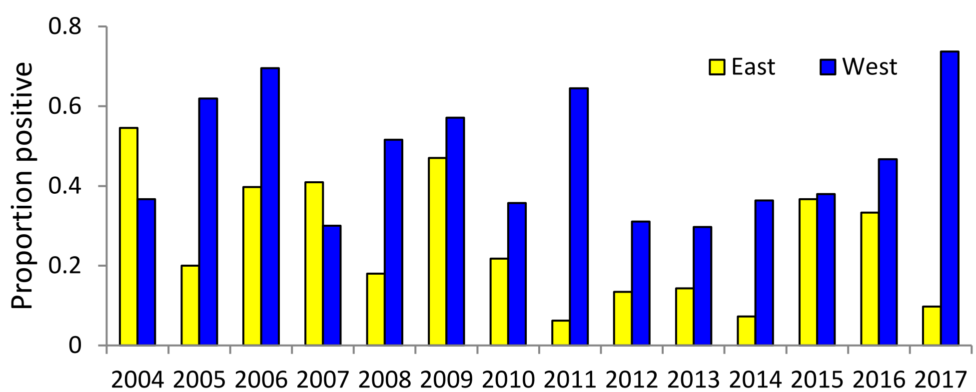


Figure 16. Annual proportions of positive gray triggerfish trap catches, 2004-2017 east and west of Cape San Blas.

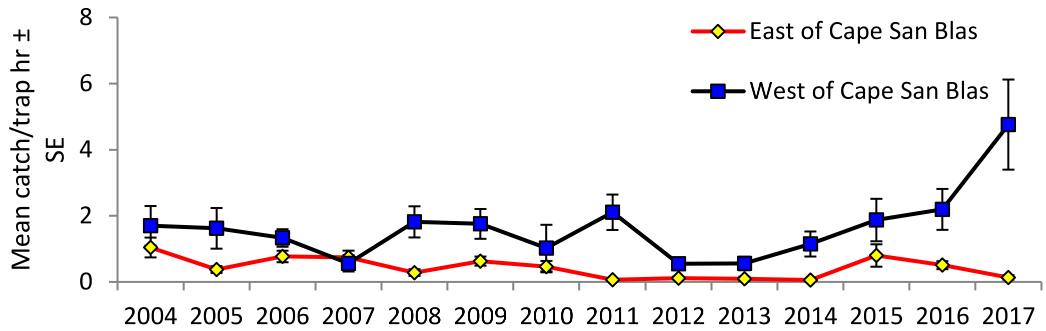


Figure 17. Mean catch per trap hr and standard errors of gray triggerfish east and west of Cape San Blas, 2004-2017.

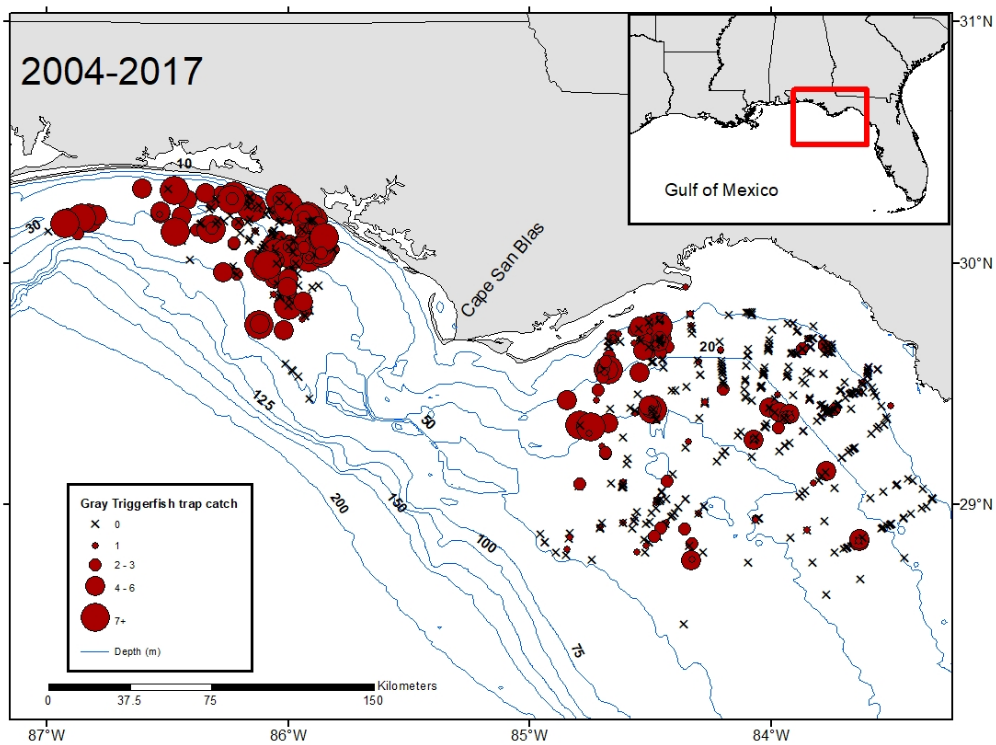


Figure 18. Distribution and relative abundance of gray triggerfish caught in chevron traps in the Panama City NMFS reef fish survey, 2004-2017. X's are sites sampled, but where no gray triggerfish were caught.

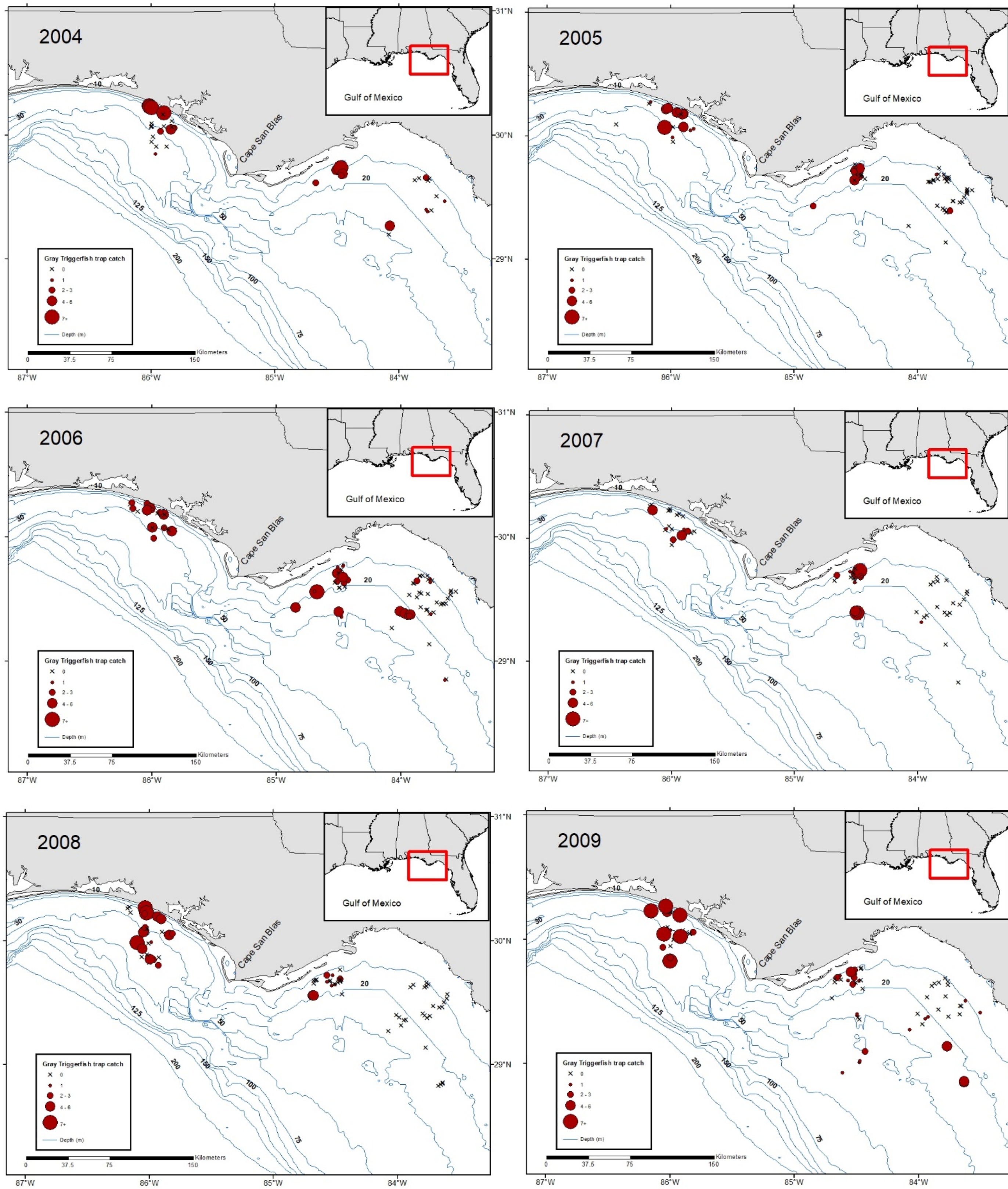


Figure 19. Annual distribution and relative abundance of gray triggerfish caught in chevron traps in the Panama City NMFS reef fish survey, 2004-2017. X's are sites sampled, but where no gray triggerfish were caught.

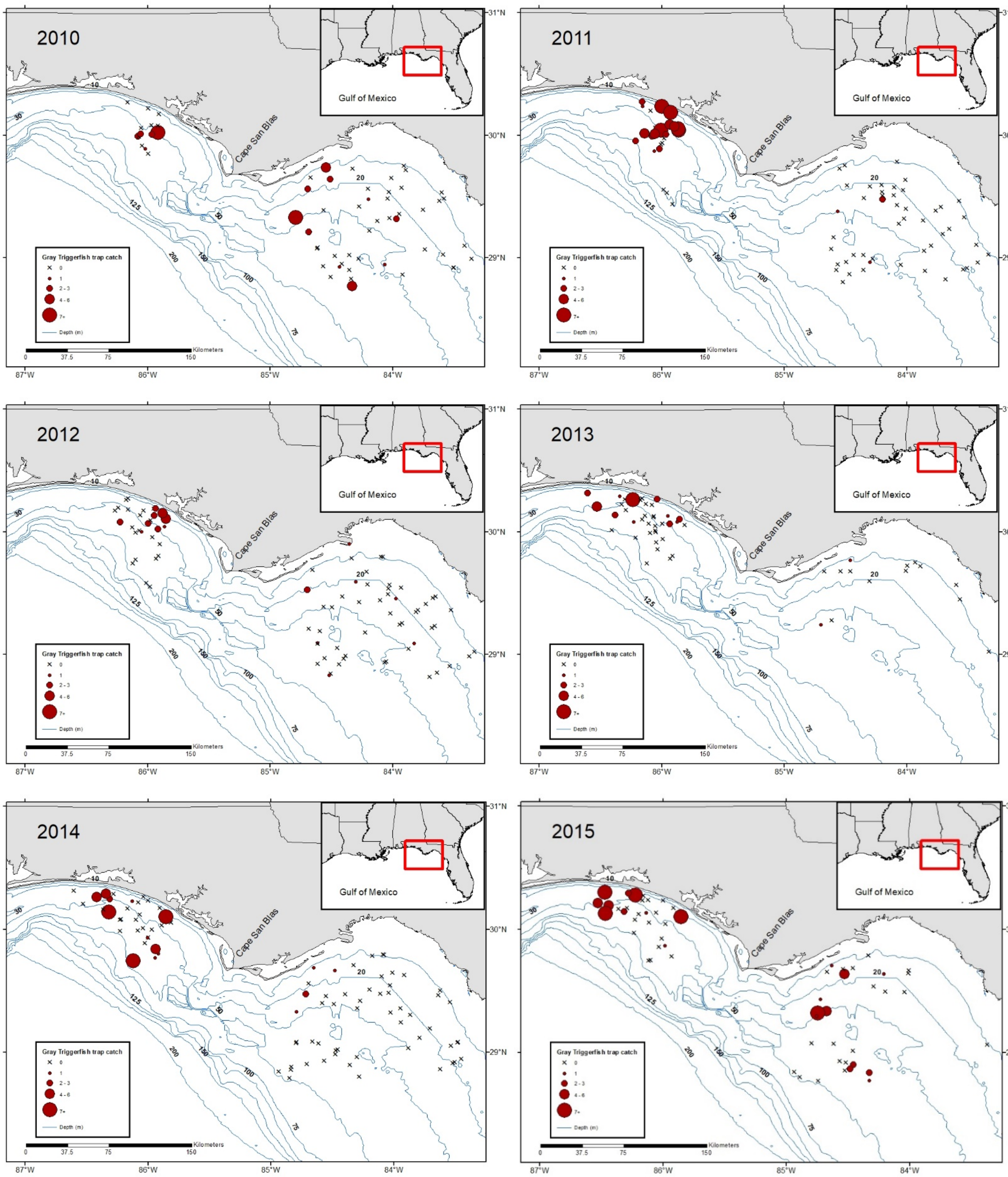


Figure 19 cont. Annual distribution and relative abundance of gray triggerfish caught in chevron traps in the Panama City NMFS reef fish survey, 2004-2017. X's are sites sampled, but where no gray triggerfish were caught.

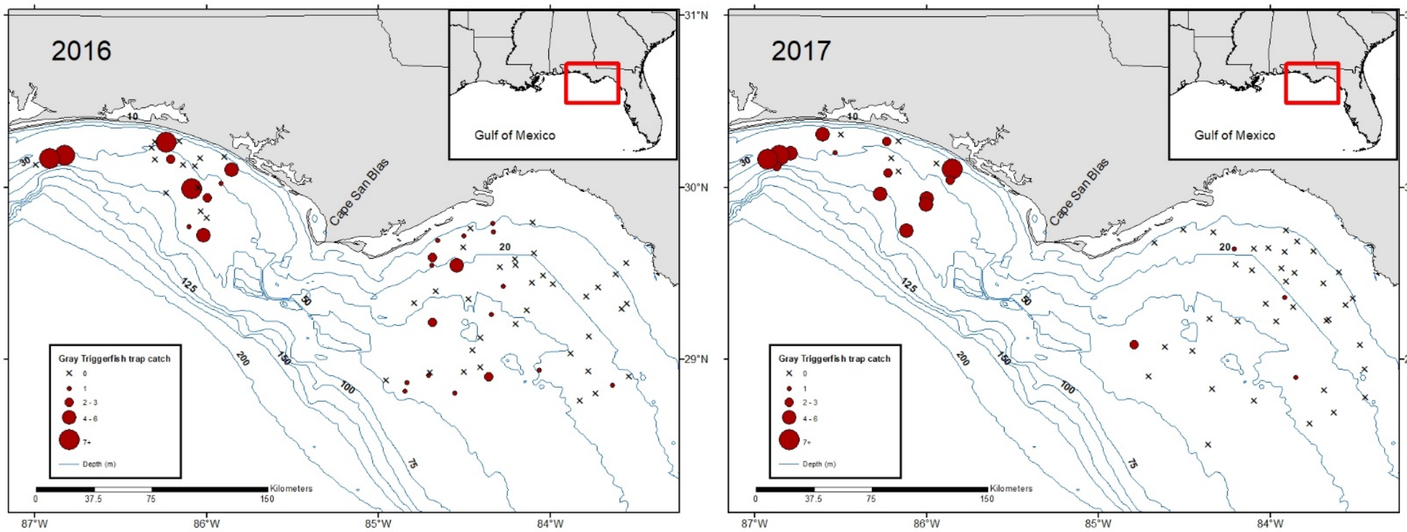


Figure 19 cont. Annual distribution and relative abundance of gray triggerfish caught in chevron traps in the Panama City NMFS reef fish survey, 2004-2017. X's are sites sampled, but where no gray triggerfish were caught.

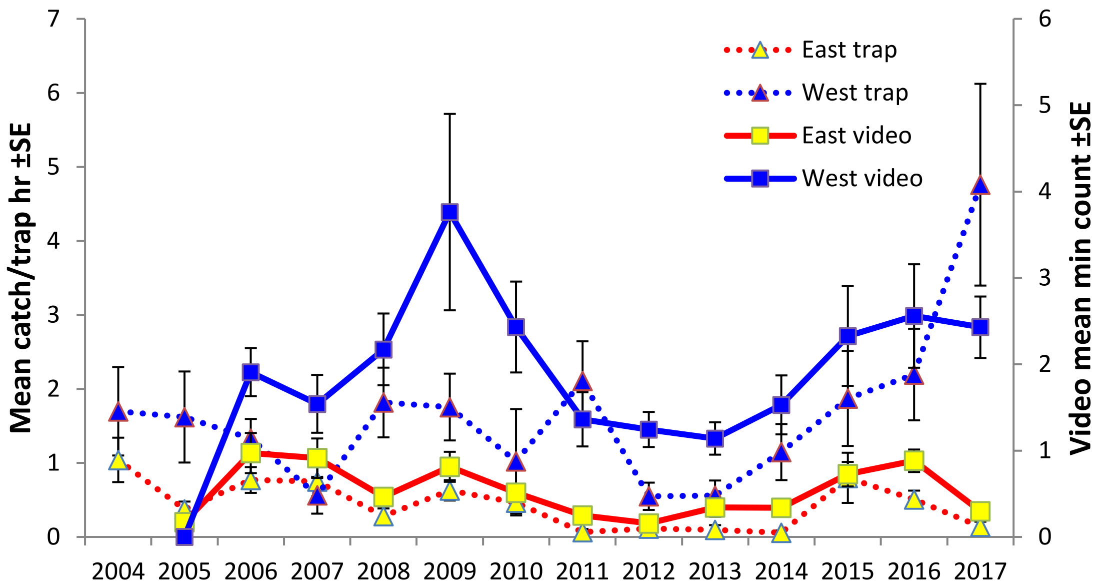


Figure 20. Annual trap (2004-2017) CPUE ± SE and video (2005-2017) mean min count ± SE of gray triggerfish east and west of Cape San Blas.

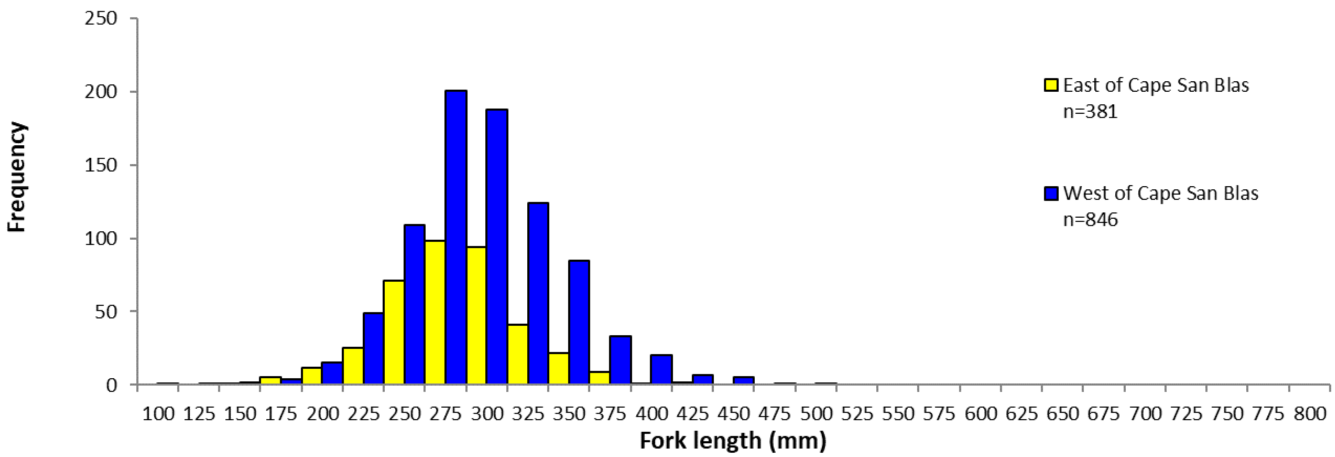


Figure 21. Overall size distributions of gray triggerfish east and west of Cape San Blas caught in chevron traps, 2004-2017.

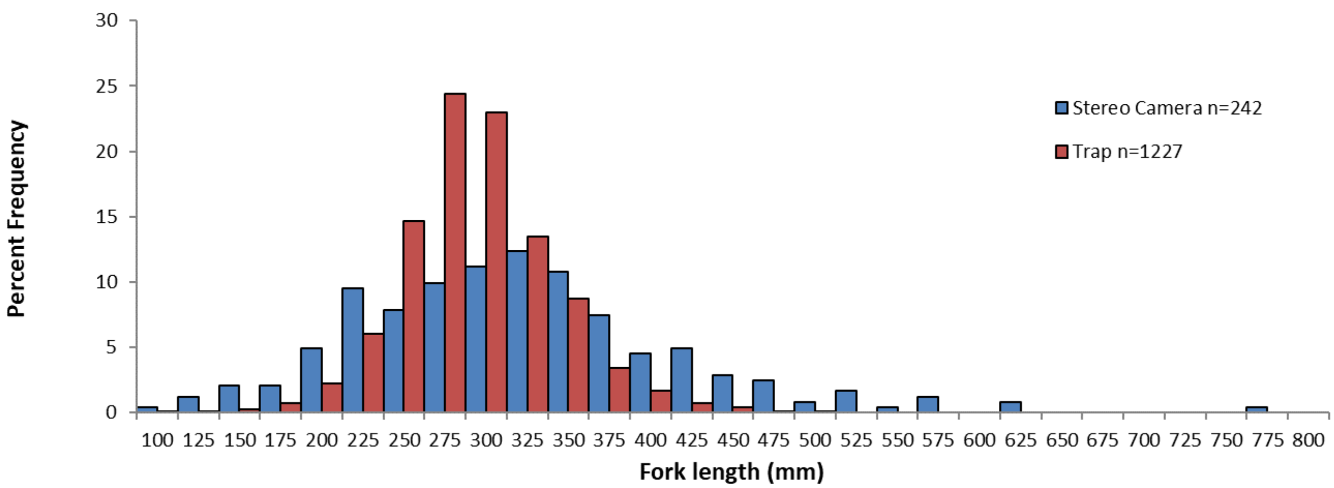


Figure 22. Overall size distributions of all gray triggerfish collected in chevron traps, 2004-2017, and measured in stereo images, 2009-2017.

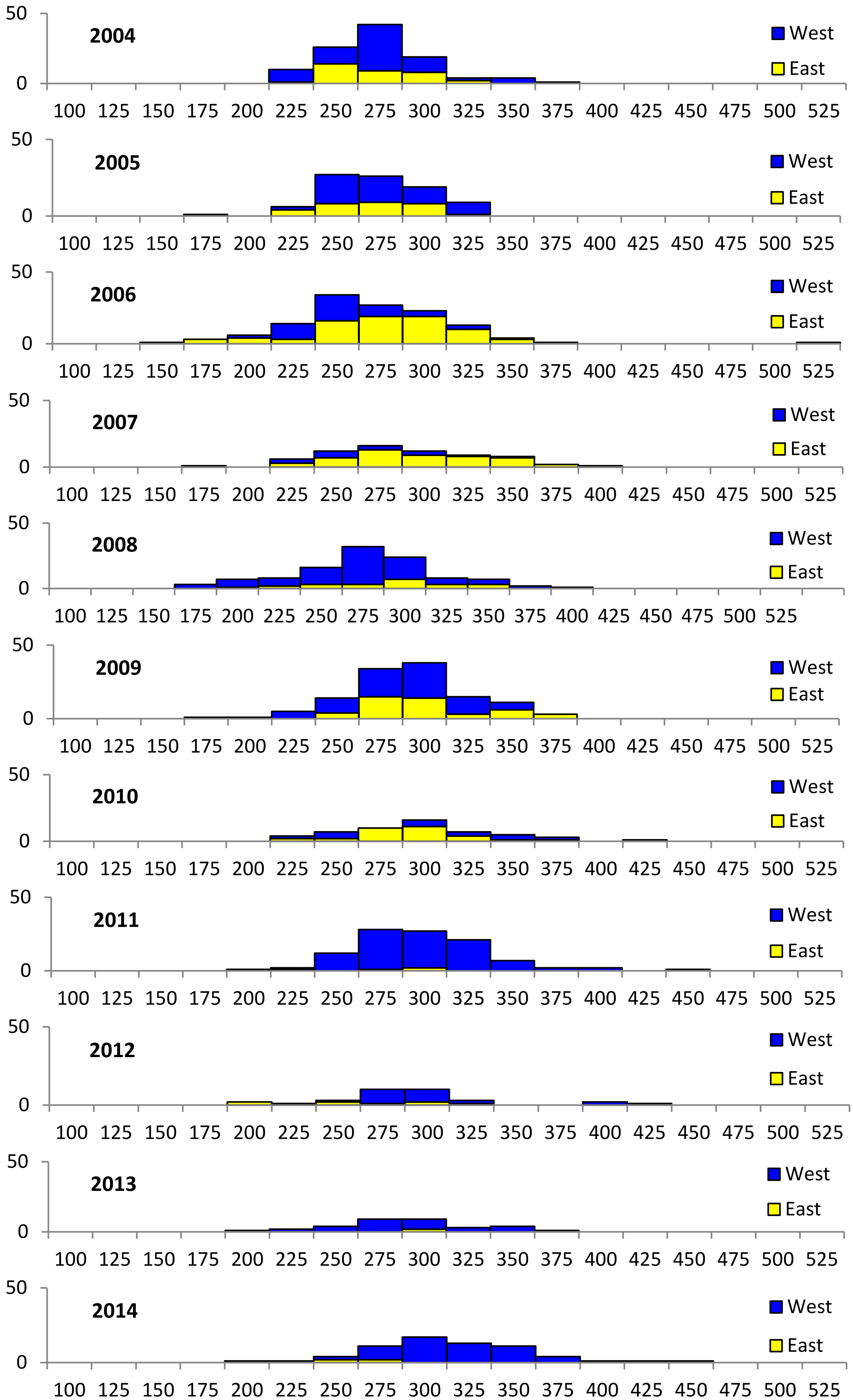


Figure 23. Annual size distributions of gray triggerfish collected in chevron traps, 2004-2017, east and west of Cape San Blas.

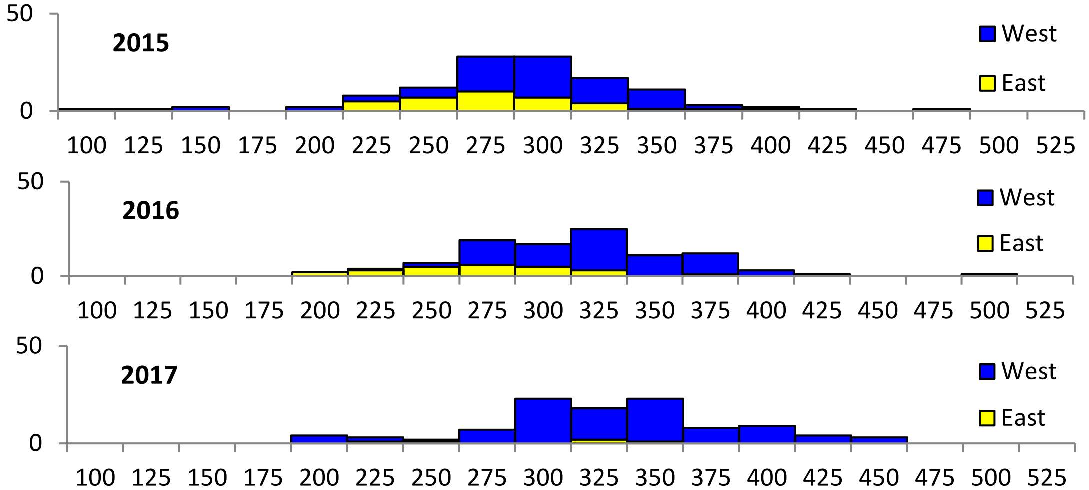


Figure 23 cont. Annual size distributions of gray triggerfish collected in chevron traps, 2004-2017, east and west of Cape San Blas.

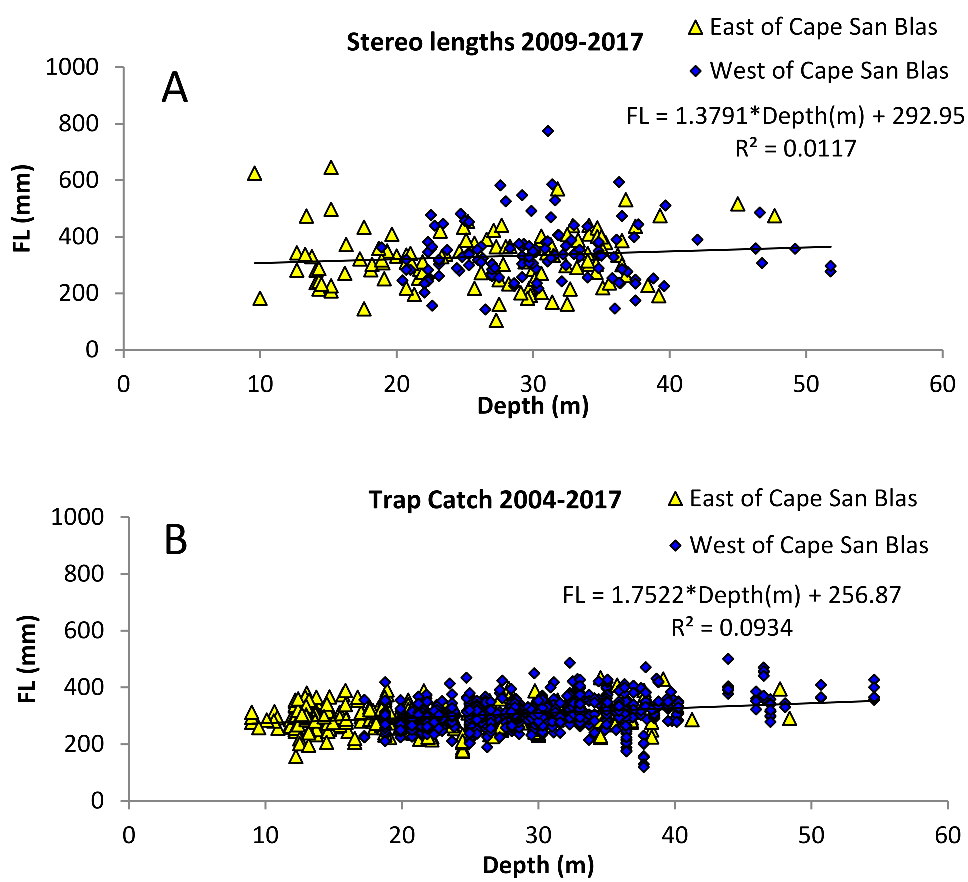


Figure 24. Fork length vs. depth relationship of gray triggerfish observed with: (A) stereo cameras east and west of Cape San Blas, 2009-2017, and (B) collected east and west of Cape San Blas with chevron traps, 2004-2017.

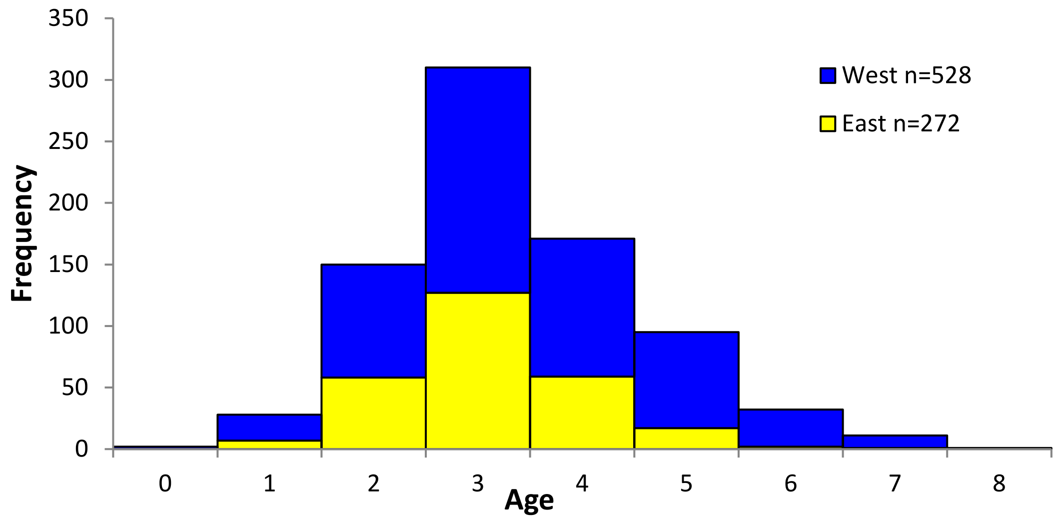


Figure 25. Overall age structure of trap-caught gray triggerfish, east and west of Cape San Blas, 2004-2017.

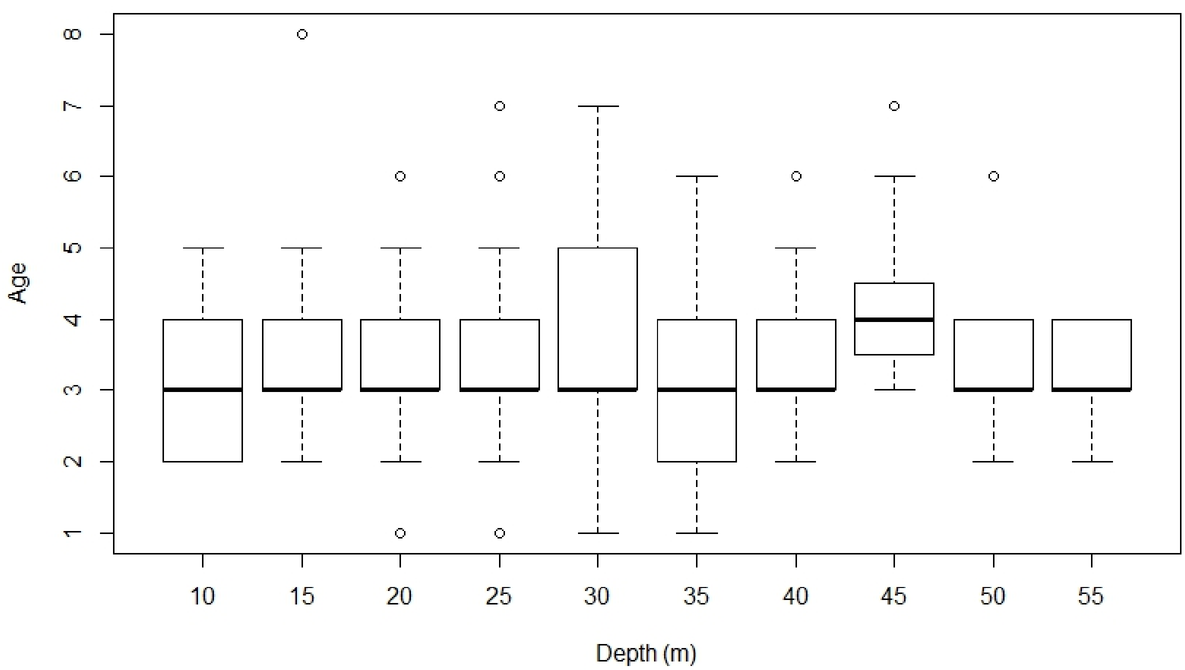


Figure 26. Age vs depth relationship of gray triggerfish caught in chevron traps, 2004-2017, in the Panama City reef fish survey.

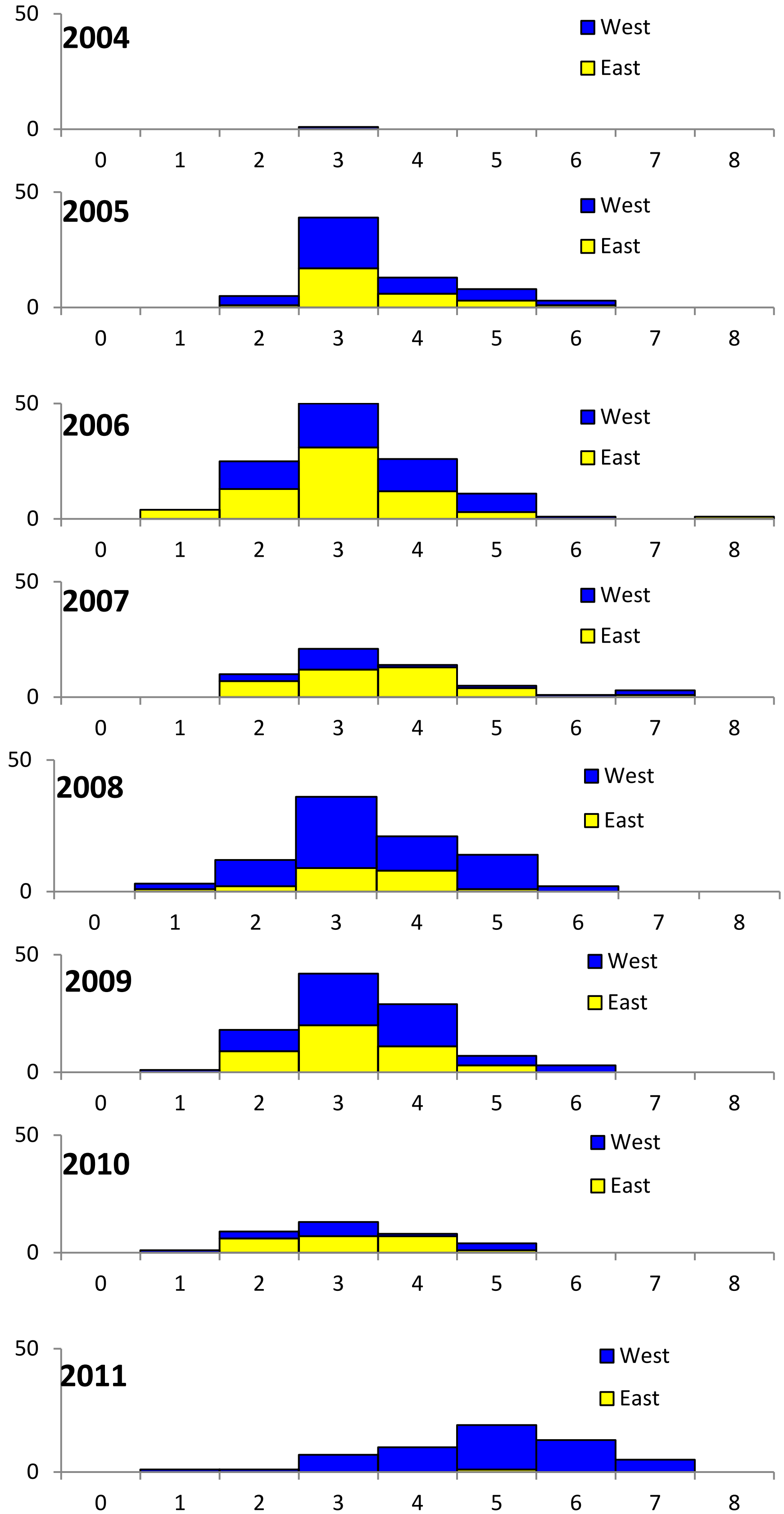


Figure 27. Annual age structure of gray triggerfish caught in chevron traps in the NOAA Panama City lab reef fish survey, 2004-2017, by region.

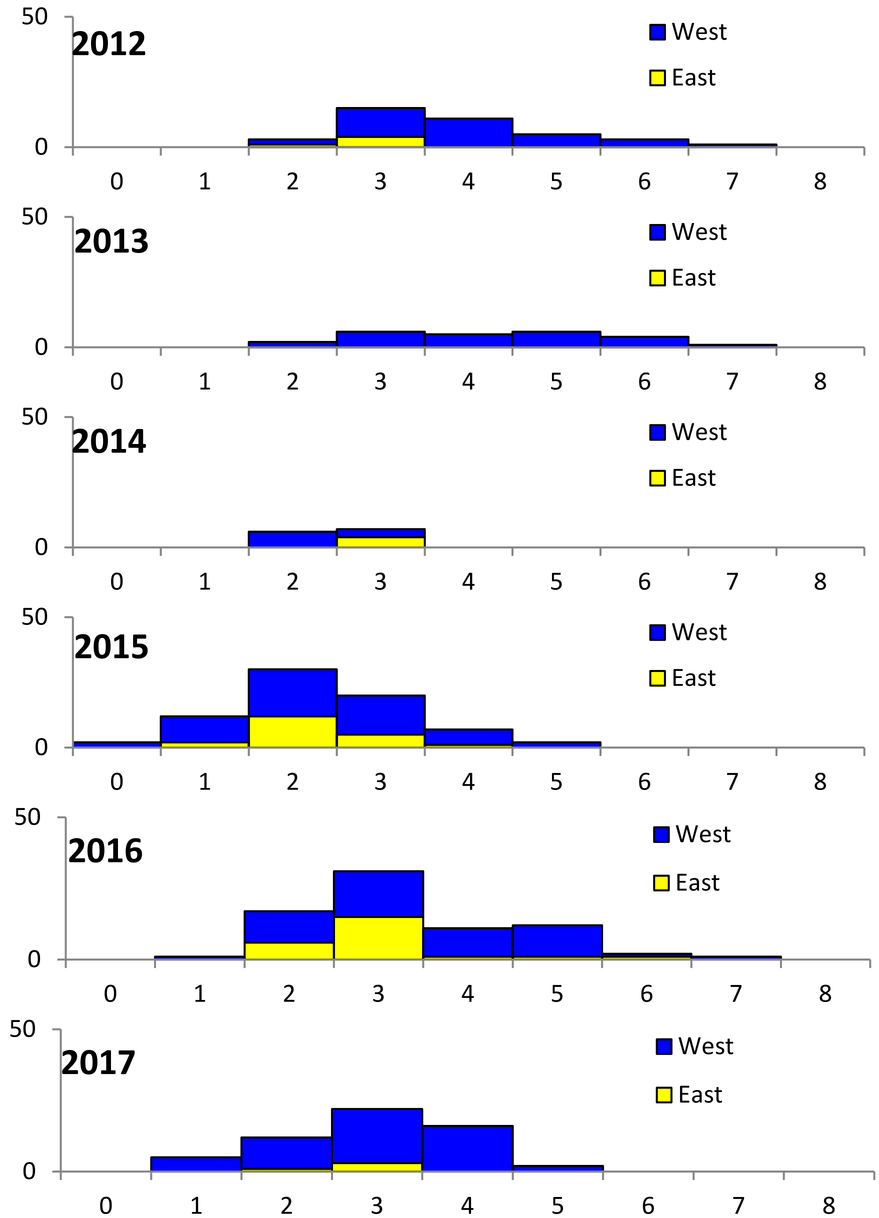


Figure 27 cont. Annual age structure of gray triggerfish caught in chevron traps in the NOAA Panama City lab reef fish survey, 2004-2017, by region.