Vermilion Snapper *Rhomboplites aurorubens* Findings from the NMFS Panama City Laboratory Camera & Trap Fishery-Independent Survey 2004-2017

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SEDAR67-WP-10

8 November 2019

Please cite this document as:

Overly, K.E., and C.L. Gardner. 2019. Vermilion Snapper *Rhomboplites aurorubens* Findings from the NMFS Panama City Laboratory Camera & Trap Fishery-Independent Survey 2004-2017. SEDAR67-WP-10. SEDAR, North Charleston, SC. 35 pp.

Vermilion Snapper *Rhomboplites aurorubens* Findings from the NMFS Panama City Laboratory Camera & Trap Fishery-Independent Survey 2004-2017

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November 2019

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Contribution
SEDAR67-WP-10

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. 1A, Fig. 1B). 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. 2A, Fig. 2B). 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 un-occluded 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, vermilion snapper 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). The schooling nature of this species was apparent in the overall frequency distribution of min counts (Fig. 6), with counts over 11 fish not uncommon. Vermilion snapper were never encountered in either video or trap samples from depths shallower than 18 m. They were observed in only 7 out of 582 video samples from depths < 21 m; in traps they were caught only once in 458 sets in depths shallower than 21 m (Fig. 8). East of Cape San Blas vermilion snapper were observed in 20 of 344 samples (5.8%) between 18 and 26 m. Encounter rates did increase noticeably with depth from 20 to ~40 m, but beyond those depths results were difficult to interpret because of small sample sizes (Fig. 7). Because of this pattern, data summaries are presented both for collections from all depths and for collections only from depths 18 m or greater. The video survey targeted both pre-recruit (<254 mm fork length, the legal size limit in 2019) and those that had recruited to the fishery.

Encounter rates

From 2005-2017, the overall vermilion snapper annual proportion of positive video samples ranged from 0.00 to 0.38 ($\bar{x}$ =0.26) for all depths (Fig. 1A). In 2005 the survey had a limited sampling range and only completed 41 stations in the east, the majority of which were shallow sites. For depths >18 m, the annual proportion of positive video samples ranges from 0.00 to 0.50 ($\bar{x}$ =0.34) (Fig. 1B). The annual proportion of positive video samples ranged from 0.00 to 0.29 ($\bar{x}$ =0.18) east of the Cape (2005-2017), and 0.12 to 0.73 ($\bar{x}$ =0.39) west of the Cape (2006-2017) when using all depths (Table 1A, Fig. 9). The annual proportion of positive video samples ranged from 0.00 to 0.40 ($\bar{x}$ =0.29) east of the Cape (2004-2017) and 0.12 to 0.73 ($\bar{x}$ =0.39) west of the Cape (2006-2007) when observing depths >18m (Table 1B, Fig. 9). Vermilion snapper were noticeably more abundant west of the Cape than east with mean proportion of positive video samples equal to 0.39 and 0.18, in all depths 0.39 and 0.29 in depths >18m respectively. Much of the difference in mean annual proportion positives was directly related to the much larger proportion of shallow (<20m) sites east of the Cape (Fig. 3). When all the sites <18m were excluded, the differences between east and west were much smaller. As more deep sites were added in the east in 2009 and 2010, the differences between east and west were minimized and actually reversed in 2011, and 2014-2015 (Table 1B, Fig. 3, Fig. 9). 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 when including all depths (Table 1, Fig. 9).

The annual proportion of positive vermilion snapper trap catches from 2004-2017 ranged from 0.00 to 0.30 east of the Cape ($\bar{x}$ =0.11) and 0.03 to 0.50 west of the Cape ($\bar{x}$ = 0.23) when looking at all depths (Table 2A, Fig. 16A). When observing only depths >18m annual proportion positive of vermilion snapper increases greatly to almost equal that of the west ($\bar{x}$ =0.22 versus $\bar{x}$ =0.23, respectively) (Table 2A, Table 2B). Overall annual proportion of positive vermilion snapper trap catches from 2004-2017 ranged from 0.02 to 0.27 ($\bar{x}$ =0.15) when looking at all depths, with annual proportion positive noticeably increasing when reducing the total sites sample to include only sites >18 m (0.03 to 0.36, $\bar{x}$ =0.22). Similarly to the video survey, proportion positive occurrences were typically higher in the west than the east with the exception of 2010, 2012, and 2015. Looking at all depths, mean nominal catch per trap hour west of the Cape were 1.28±0.26 and 0.60±0.13 east of the Cape (Fig. 2A). For depths >18m, nominal catch per trap hour west of the Cape were 1.29±0.26 and 1.22±0.27 east of the Cape (Fig. 2B). Vermilion snapper trap catch varied east and west of the Cape throughout the years, with the west, on average, having a higher nominal min count (Fig. 17). 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 vermilion snapper seen between 85° 40' and 87° W than any in the area east of the Cape (Fig. 5B, Fig. 18). Outside of the 40 m contour line east of the Cape, vermilion snapper abundance appears to be at its highest for the region (Fig. 5B). 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. Vermilion snapper were most commonly found between 27-41 m with proportion of positive occurrences ranging from 0.41-0.60 ($\bar{x}$ =.52) (Table 3, Fig. 8A). In the east, the proportion positive generally increased with depth, but remained fairly stable once deeper than 27 m until 41 m. The highest proportion positive in the east was from 33 – 37 m (0.64, and 0.69 respectively) (Table 3, Fig. 7A). In the west, proportion positive appear to vary from the starting depth of 17 m until 59 m with $\bar{x}$ =0.39. From 27-40 m proportion positive in the west appears the most stable, ranging from 0.37 to 0.62 ($\bar{x}$ =0.53) (Table 3, Fig. 7B). Areas west of the Cape had the highest proportion positives from >49 m, but this could be due to small sample size.

Abundance trends

Along with higher encounter rates, estimates of relative abundance for vermilion snapper were also noticeably higher west of the Cape. Respective mean min counts in the west and east from depths ≥18 m were 11.32±1.49 versus 2.99±0.58 (Fig. 20). This geographical difference in abundance is clearly visible in a kernel density plot of pooled min count data from all years (Fig. 5B), which shows a fairly large area between 85° 40' and 87° W with higher densities than any seen in the entire area east of Cape San Blas. Not surprisingly, video counts were higher every year in the west than east (2005-2017) when looking across the entire depth range (Fig. 20). Annual GIS plots of video min counts and trap catch of vermilion snapper showed very similar geographic patterns in relative abundance trends between 2005 and 2017 (Fig. 12, Fig. 19).

For depths >18m, overall MaxN depicts a generally stable trend, with significant peaks in mean MaxN in both 2008 and 2016. Mean MaxN rose from 0.195 in 2006 to 7.269 in 2007 ($p<0.01$), remaining relatively stable with no significant changes until 2016 (Fig. 11). In 2015, mean MaxN increased significantly from 4.871 to 15.513 in 2016 ($p<0.01$). Mean MaxN dropped after 2016 to a $\bar{x}$ =12.92, but not significantly so (Fig. 11B).

For depths >18m MaxN west of the Cape appeared to decline significantly from a $\bar{x}$ =4.14 in 2006 to $\bar{x}$ =0.16 in 2007 ($p<0.05$), followed by fairly stable trends until 2015 (Fig. 10B). MaxN increased significantly from an $\bar{x}$ =8.08 in 2015 to $\bar{x}$ =29.63 in 2016 ($p<0.01$). MaxN decreased following 2016, but not significantly so. These data were not significant due to the high variance in some samples. Trends in MaxN east of the Cape followed the west with only minor fluctuations in abundance from 2006 until 2011. Mean video counts showed a significant decrease from 2005 to 2006 ($\bar{x}$ =2.99 and 1.27, $p<0.05$), followed by a significant increase from 2012 to 2013($\bar{x}$ =1.269 and 6.371, $p<0.01$). MaxN east of the cape remained stable from 2013 to 2017 with only minor fluctuations in values (Fig. 11B). While the mean MaxN values west of the Cape do not differ significantly from the east of the Cape, values are generally higher when compared to the east. Mean MaxN values west of the Cape do not differ significantly from east of the Cape until 2015 ($\bar{x}$ =2.53 vs $\bar{x}$ = 8.08, $p<0.03$) and the trend continues through 2016 ($\bar{x}$ =2.51 vs $\bar{x}$ = 29.63, $p<0.001$) and 2017 ($\bar{x}$ =6.13 vs $\bar{x}$ =21.24, $p<0.02$) (Fig. 10B). The overall similar trends in relative abundance on both sides of Cape San Blas suggest one population, not sub populations with different dynamics.

Size and age

The trap catch targeted pre-recruit vermilion snapper (30.3% of fish caught were below the legal size limit of 232 mm FL) from 2004-2017, with 32.9% of trap-caught fish west of the Cape below the legal size and 27.4% east of the Cape. The measurements derived from stereo images (2009-2017) showed a somewhat similar pattern of pre-recruit vermilion snapper, with 39.6% of measured fish below the legal size limit of 254 mm FL with 44.1% west of Cape San Blas and 34.8% 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)

Vermilion snapper caught in chevron traps during 2004-2017 ranged from 178 to 432 mm FL, with a modal size of 232 mm FL, and a mean of 249 mm FL. Fish caught in the west averaged roughly the same size when compared to fish caught in the east from 2004-2017 ($\bar{x}$=251 and 247 respectively) (Fig. 21). Those observed with stereo cameras, 2009-2017, ranged from 126 to 663 mm FL, with a modal size of 209 mm FL, and a mean of 246 mm (Table 4). A comparison of size data from trap catches with stereo images from the same years (2009-2017) indicated that the traps select for smaller vermilion snapper (<402 mm FL), whereas the video survey samples some of the larger vermilion snapper, 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.

Vermilion snapper lengths calculated from stereo cameras during 2009-2017 displayed normal distributions both east and west of Cape San Blas (Fig. 13, Fig.14). There was very little relationship between size of vermilion snapper and depth for lengths calculated from stereo cameras. Although the regression from the trap survey data was significant, primarily because of large sample sizes, respectively, only 2.8% of the variance in size was explained by changes in depth (Fig. 24). Vermilion snapper age at depth was highly variable across all ranges with a median age range from 2-6 with an overall median age of 4 (Fig. 26).

Vermilion snapper caught and sampled in the trap survey from 2004-2017 ranged from 1-14 years of age with a mean age of 4.4±0.11 years and a strong mode of 3 years (Fig. 25). Fish sampled east of the Cape averaged slightly older than fish sampled west (5.5±0.18 versus 3.6±0.11). The range in ages was slightly smaller in the west than east (1-12 vs 1-14 years), and the modal age was 3 in both regions (Fig. 25). Vermilion snapper ages 1 and >9 yr have been rare in the survey since it began in 2005 (Fig. 25, Fig. 27). The annual age structure data of vermilion snapper from the trap catches showed some evidence of a strong 2006 year class, as it dominated the age structure each year 2009-2012 (Fig. 27). Strong year classes also appear to exist in both 2012, 2013 and 2014. Such periodic strong year classes characterize populations of co-occurring reef fish such as gag, red grouper, and red snapper on the northern West Florida Shelf.

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Tables

Table 1A: Annual video survey sample sizes, proportion positive occurrences, mean nominal video min counts, and standard errors of vermilion snapper east and west of Cape San Blas, in all water depths, 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		0	0		0	0		0
2006	72	23	95	0.04	0.22	0.08	1.42	3.96	2.03	1.39	1.79	1.14
2007	38	25	63	0.03	0.12	0.06	0.11	0.16	0.13	0.11	0.09	0.07
2008	57	34	91	0.04	0.44	0.19	1.09	9.29	4.15	1.05	3.84	1.62
2009	64	44	108	0.11	0.41	0.23	0.61	6.61	3.06	0.36	1.89	0.84
2010	93	52	145	0.15	0.35	0.22	1.61	7.35	3.67	0.68	3.08	1.20
2011	99	59	158	0.24	0.34	0.28	2.02	8.85	4.57	0.52	5.15	1.96
2012	101	49	150	0.19	0.33	0.23	0.98	11.35	4.37	0.32	6.24	2.08
2013	35	62	97	0.20	0.48	0.38	3.80	6.37	5.44	2.28	2.00	1.52
2014	94	70	164	0.28	0.29	0.28	2.84	8.04	5.06	0.75	4.45	1.95
2015	109	59	168	0.29	0.31	0.30	1.88	8.08	4.06	0.42	2.51	0.95
2016	101	70	171	0.26	0.49	0.35	1.89	29.63	13.25	0.55	8.22	3.53
2017	101	49	150	0.18	0.73	0.36	3.64	21.24	9.39	2.96	4.51	2.56
Total	**1005**	**596**	**1601**	**0.18**	**0.39**	**0.26**	**1.81**	**11.26**	**5.33**	**0.36**	**1.48**	**0.61**

Table 1B: Annual video survey sample sizes, proportion positive occurrences, mean nominal video min counts, and standard errors of vermilion snapper east and west of Cape San Blas, in water depths >18m, 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	5		5	0		0	0		0	0		0
2006	21	22	43	0.14	0.23	0.19	4.86	4.14	4.49	4.76	1.87	2.48
2007	16	25	41	0.06	0.12	0.10	0.25	0.16	0.20	0.25	0.09	0.11
2008	19	33	52	0.11	0.45	0.33	3.26	9.58	7.27	3.15	3.95	2.77
2009	30	43	73	0.23	0.42	0.34	1.30	6.77	4.52	0.76	1.93	1.22
2010	72	52	124	0.19	0.35	0.26	2.08	7.35	4.29	0.88	3.08	1.40
2011	67	59	126	0.36	0.34	0.35	2.99	8.85	5.73	0.74	5.15	2.45
2012	78	49	127	0.24	0.33	0.28	1.27	11.35	5.16	0.41	6.24	2.45
2013	18	62	80	0.39	0.48	0.46	7.39	6.37	6.60	4.32	2.00	1.82
2014	65	70	135	0.40	0.29	0.34	4.11	8.04	6.15	1.05	4.45	2.36
2015	81	59	140	0.40	0.31	0.36	2.53	8.08	4.87	0.55	2.51	1.12
2016	76	70	146	0.34	0.49	0.41	2.51	29.63	15.51	0.72	8.22	4.10
2017	60	49	109	0.30	0.73	0.50	6.13	21.24	12.93	4.98	4.51	3.47
Total	**608**	**593**	**1201**	**0.29**	**0.39**	**0.34**	**2.99**	**11.32**	**7.10**	**0.58**	**1.49**	**0.80**

Table 2A: Annual chevron trap sample sizes, proportion positive occurrences, mean nominal catch/trap hr, and standard errors of vermilion snapper east and west of Cape San Blas, in all water depths, 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	31	53	0.00	0.03	0.02	0.00	0.06	0.04	0.00	0.06	0.04
2005	68	23	91	0.00	0.35	0.09	0.00	1.15	0.29	0.00	0.47	0.13
2006	68	23	91	0.01	0.09	0.03	0.23	0.17	0.21	0.23	0.15	0.17
2007	44	20	64	0.07	0.10	0.08	0.14	0.19	0.15	0.09	0.14	0.07
2008	50	31	81	0.02	0.29	0.12	0.05	1.27	0.52	0.05	0.59	0.24
2009	51	29	80	0.08	0.28	0.15	0.39	0.88	0.57	0.24	0.36	0.20
2010	46	14	60	0.15	0.07	0.13	0.17	0.24	0.19	0.07	0.24	0.07
2011	48	31	79	0.19	0.32	0.24	1.18	1.29	1.22	0.51	0.80	0.44
2012	53	29	82	0.25	0.03	0.17	0.95	0.02	0.62	0.41	0.02	0.27
2013	14	29	43	0.00	0.28	0.19	0.00	1.43	0.96	0.00	0.84	0.57
2014	43	29	72	0.14	0.14	0.14	0.76	0.14	0.51	0.47	0.07	0.28
2015	30	28	58	0.30	0.14	0.22	1.01	0.85	0.94	0.44	0.55	0.35
2016	56	32	88	0.14	0.50	0.27	2.24	6.75	3.88	1.24	2.43	1.20
2017	45	19	64	0.16	0.47	0.25	0.79	2.06	1.17	0.33	0.73	0.32
Total	**638**	**368**	**1006**	**0.11**	**0.23**	**0.15**	**0.60**	**1.28**	**0.85**	**0.13**	**0.26**	**0.13**

Table 2B: Annual chevron trap sample sizes, proportion positive occurrences, mean nominal catch/trap hr, and standard errors of vermilion snapper east and west of Cape San Blas, in water depths >18m, 2004-2017.

	Sites sampled >18 m depth			Proportion positive occurrences			Mean nominal catch/trap hr			Standard error		
Year	East	West	Total	East	West	Total	East	West	Total	East	West	Total
2004	3	30	33	0.00	0.03	0.03	0.00	0.07	0.06	0.00	0.07	0.06
2005	5	23	28	0.00	0.35	0.29	0.00	1.15	0.94	0.00	0.47	0.39
2006	22	22	44	0.05	0.09	0.07	0.70	0.18	0.44	0.70	0.15	0.35
2007	13	20	33	0.23	0.10	0.15	0.46	0.19	0.30	0.27	0.14	0.14
2008	18	30	48	0.06	0.30	0.21	0.15	1.31	0.88	0.15	0.61	0.39
2009	22	29	51	0.18	0.28	0.24	0.90	0.88	0.89	0.54	0.36	0.31
2010	33	14	47	0.21	0.07	0.17	0.24	0.24	0.24	0.09	0.24	0.09
2011	36	31	67	0.25	0.32	0.28	1.58	1.29	1.44	0.66	0.80	0.51
2012	40	29	69	0.33	0.03	0.20	1.25	0.02	0.74	0.53	0.02	0.31
2013	3	29	32	0.00	0.28	0.25	0.00	1.43	1.29	0.00	0.84	0.76
2014	29	29	58	0.21	0.14	0.17	1.13	0.14	0.63	0.69	0.07	0.35
2015	22	28	50	0.41	0.14	0.26	1.38	0.85	1.09	0.59	0.55	0.40
2016	42	32	74	0.19	0.50	0.32	2.98	6.75	4.61	1.64	2.43	1.41
2017	25	19	44	0.28	0.47	0.36	1.43	2.06	1.70	0.56	0.73	0.44
Total	**313**	**365**	**678**	**0.22**	**0.23**	**0.22**	**1.22**	**1.29**	**1.26**	**0.27**	**0.26**	**0.19**

Table 3: Video survey sample sizes and proportion positive occurrences vermilion snapper 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
7-9	13		13	0.00		0.00
9-11	77		77	0.00		0.00
11-13	84		84	0.00		0.00
13-15	103		103	0.00		0.00
15-17	83		83	0.00		0.00
17-19	107	8	115	0.01	0.00	0.01
19-21	93	14	107	0.05	0.07	0.06
21-23	61	62	123	0.05	0.16	0.11
23-25	52	45	97	0.12	0.31	0.21
25-27	31	54	85	0.16	0.35	0.28
27-29	56	50	106	0.46	0.50	0.48
29-31	50	81	131	0.54	0.41	0.46
31-33	34	76	110	0.50	0.37	0.41
33-35	42	45	87	0.64	0.47	0.55
35-37	42	58	100	0.69	0.38	0.51
37-39	31	28	59	0.48	0.61	0.54
39-41	14	26	40	0.57	0.62	0.60
41-43	9	3	12	0.33	0.33	0.33
43-45	3	5	8	0.00	0.80	0.50
45-47	5	20	25	0.00	0.40	0.32
47-49	13	13	26	0.46	0.54	0.50
49-51	2	3	5	0.50	1.00	0.80
51-53		1	1		1.00	1.00
53-55		1	1		1.00	1.00
55-57		2	2		0.50	0.50
57-59		1	1		1.00	1.00
Total	**1005**	**596**	**1601**	**0.18**	**0.39**	**0.26**

Table 4A: Descriptive statistics of vermilion snapper 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.	178	178	178	126	123	123
1st Qu.	230	225	227	206	203	204
Median	247	244	246	246	241	244
Mode	246	232	232	144	255	209
Mean	247	251	249	244	249	246
Confidence Level on Mean (95%)	2.20	2.92	1.86	7.86	9.19	6.02
3rd Qu.	264	270	267	274	288	280
Max.	371	432	432	584	663	663
Count	532	596	1128	236	231	467

Table 4B: Descriptive statistics of vermilion snapper 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.	178	178	178	126	123	123
1st Qu.	230	224	227	206	203	204
Median	246	251	245	246	241	244
Mode	230	244	230	144	255	209
Mean	246	232	249	244	249	246
Confidence Level on Mean (95%)	2.27	3.34	2.01	7.86	9.19	6.02
3rd Qu.	263	270	267	274	288	280
Max.	371	402	402	584	663	663
Count	496	482	978	236	231	467

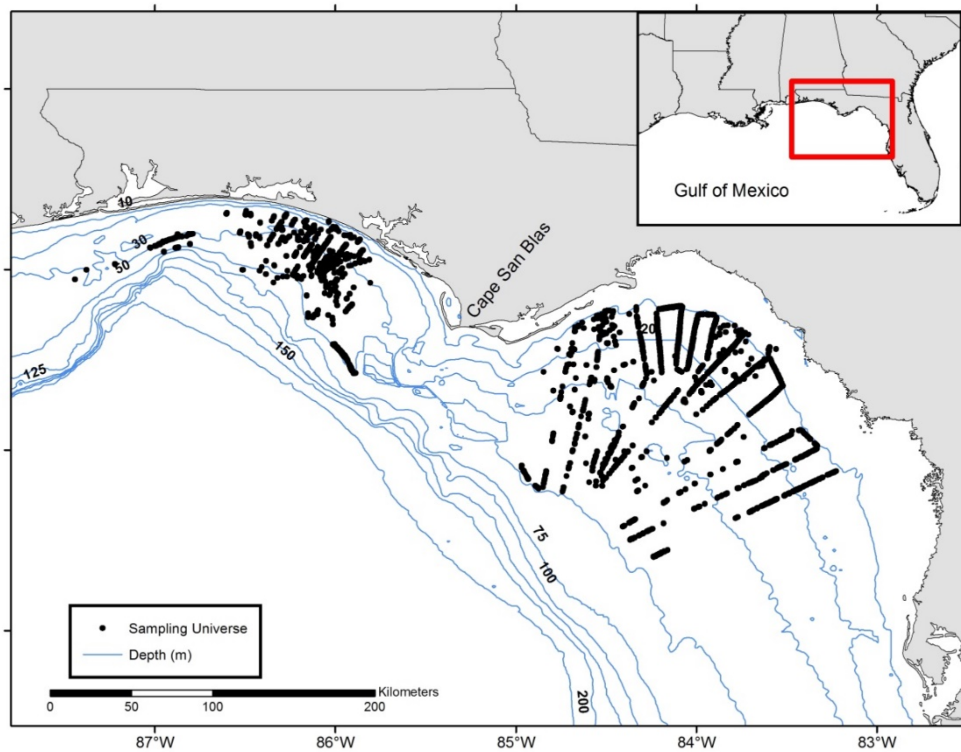


Figure 1. Locations of all natural reefs in the sampling universe of the Panama City NMFS reef fish video survey as of November 2017. Total sites: 4026 – 1360 west, and 2666 east, of Cape San Blas. Isobaths are in meters.

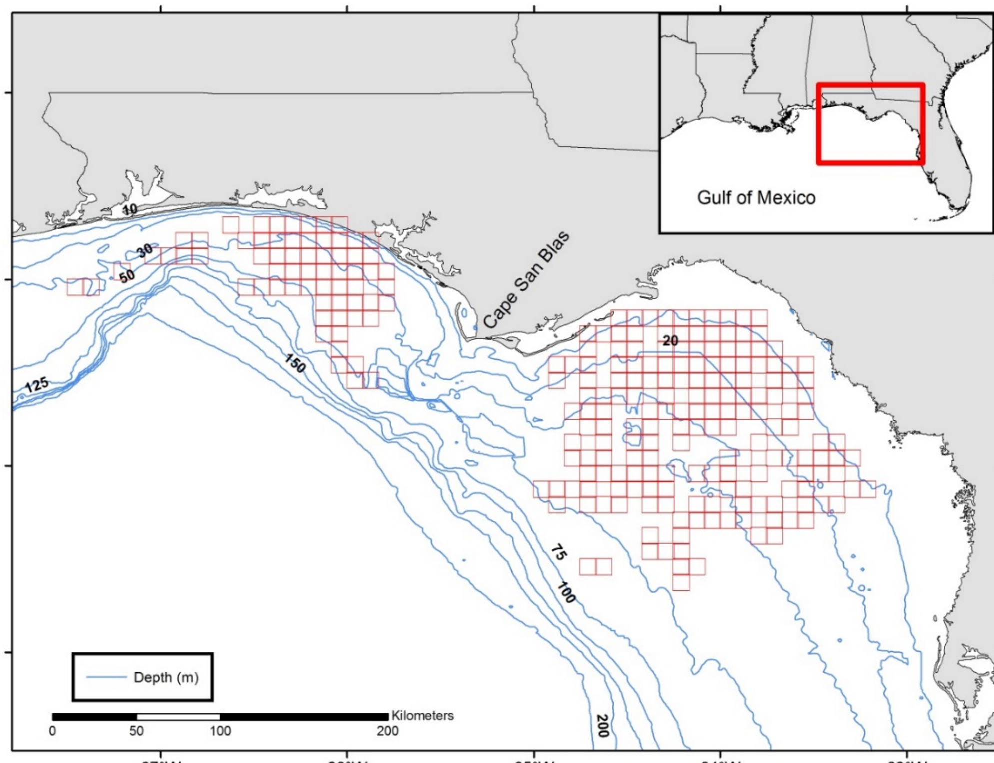


Figure 2. Sampling blocks (5 min lat. x 5 min. long.) of the Panama City reef fish survey. Blocks in red contain known hard bottom reefs and are subject to being selected for sampling. Isobaths are in meters.

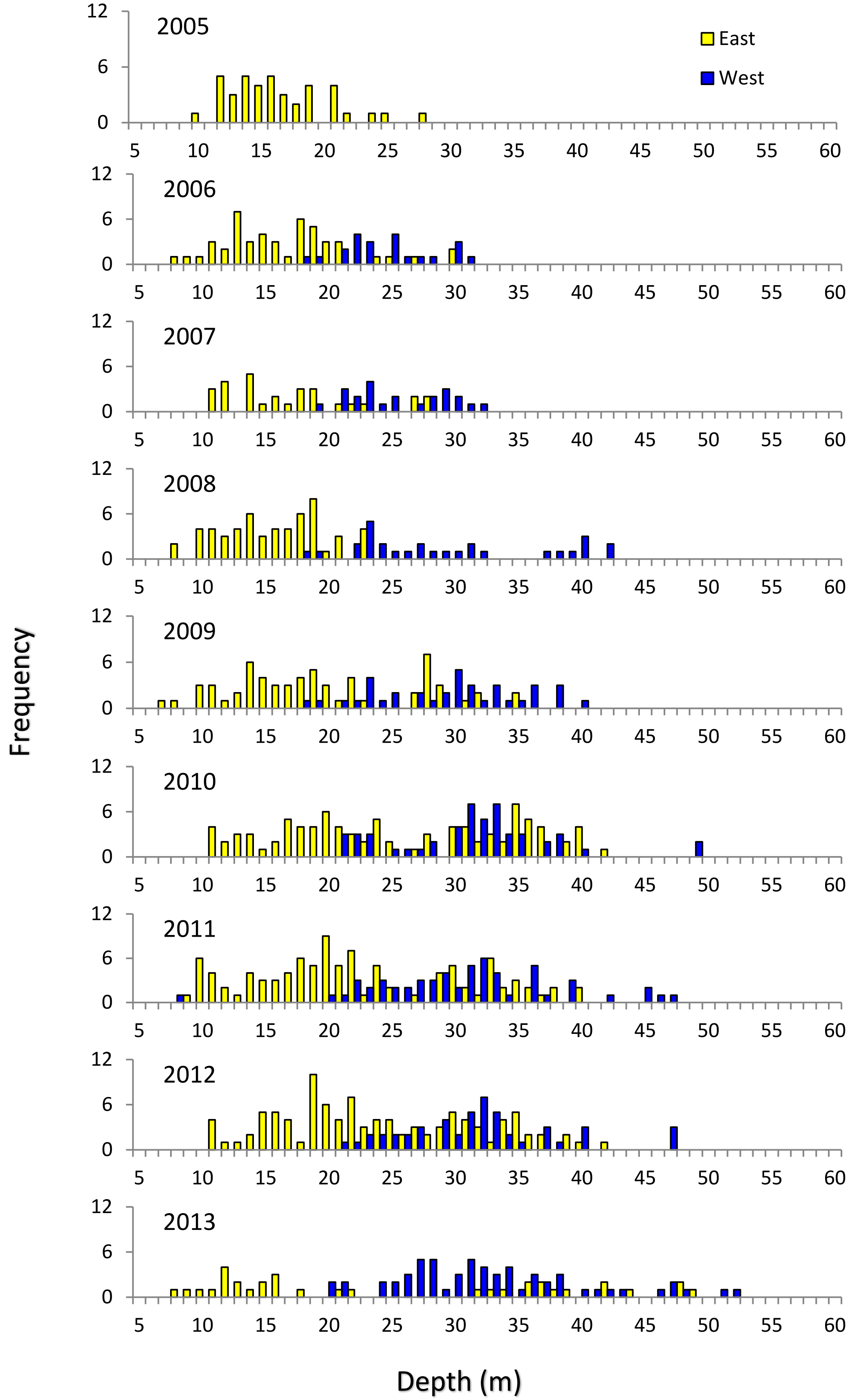


Figure 3. Annual depth distribution of Panama City reef fish survey video sample sites east and west of Cape San Blas, 2005-2017.

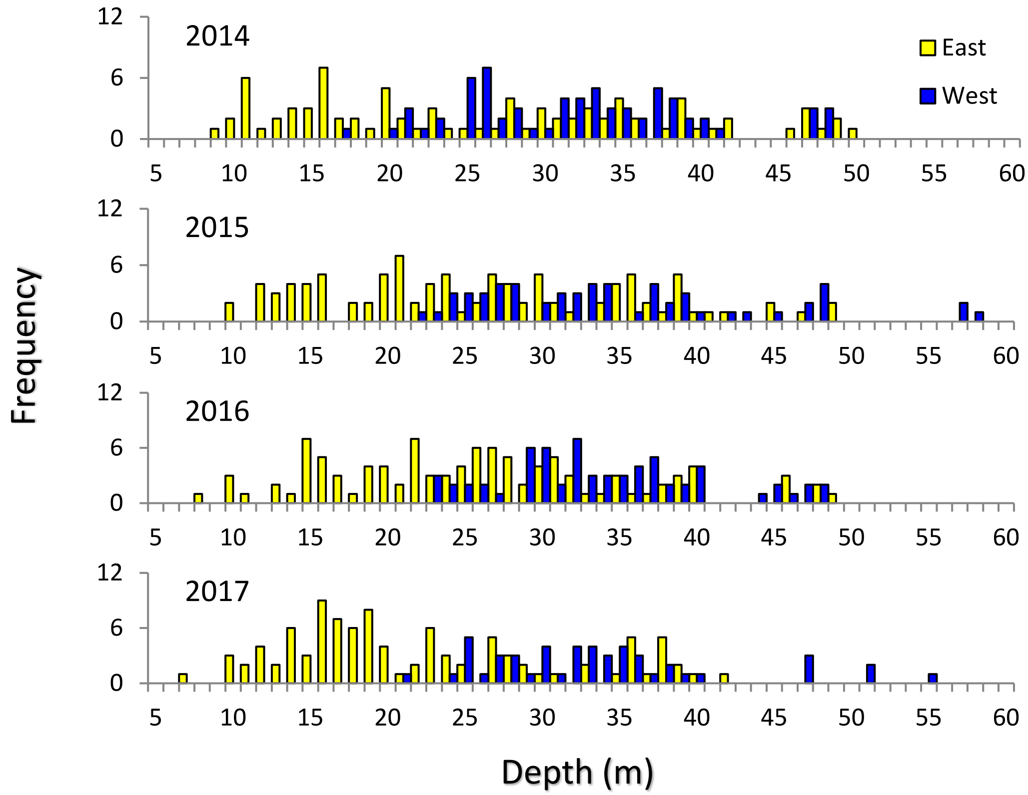


Figure 3 cont. Annual depth distribution of Panama City reef fish survey video sample sites east and west of Cape San Blas, 2005-2017.

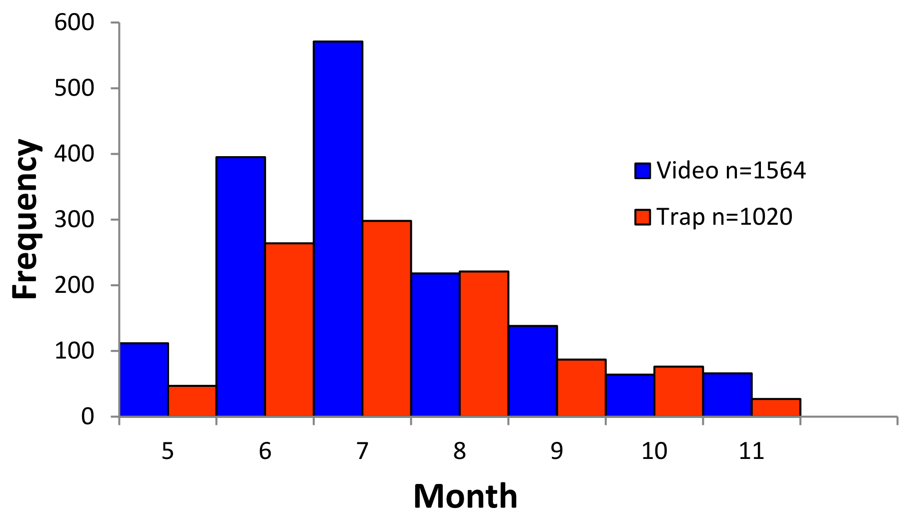


Figure 4. Overall monthly distribution of Panama City reef fish survey video and trap samples (censored data sets only), 2005-2017 (video) and 2004-2017 (trap).

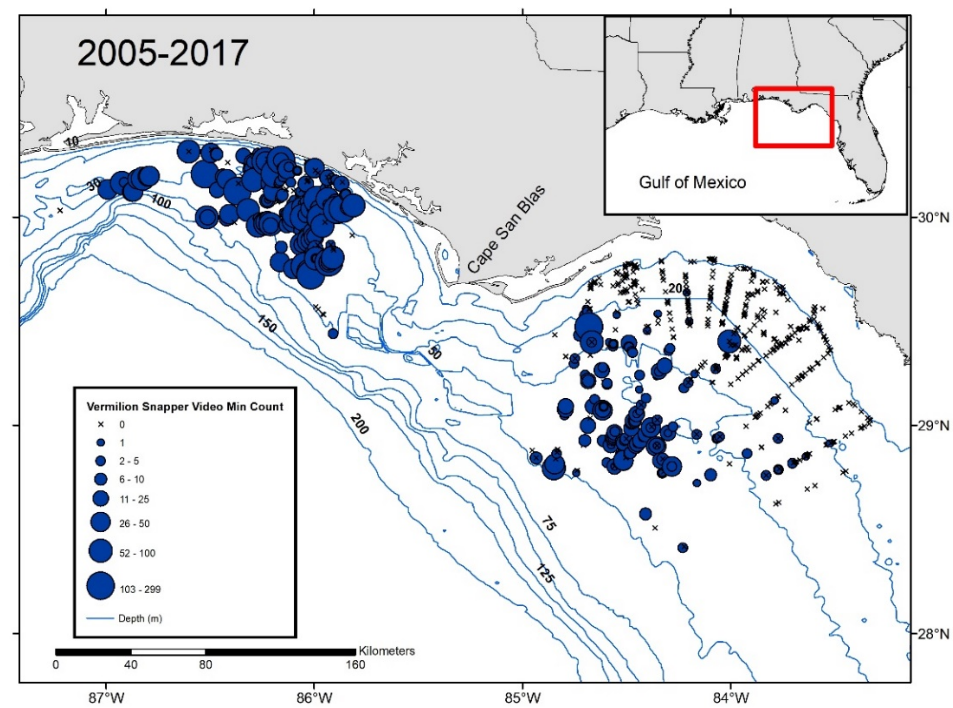


Figure 5A. Distribution and relative abundance of vermilion snapper observed with stationary, high definition video or MPEG cameras (min counts) in the Panama City NMFS reef fish survey, 2006-2017. X's are sites sampled, but where no vermilion snapper were observed.

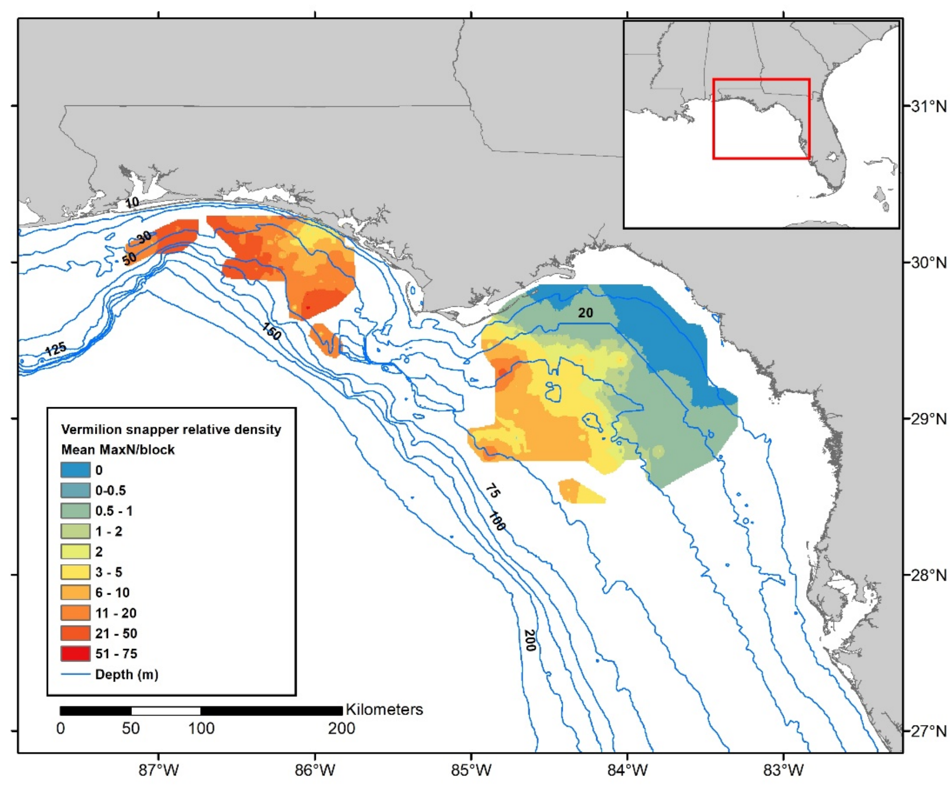


Figure 5B. Overall relative density plot of vermilion snapper based on count data (min-counts, also called MaxN) from video collected with stationary camera arrays in annual surveys, 2005-2017. Mean min counts per were standardized by 5 min latitude x 5 min longitude sampling block, then inverse distance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

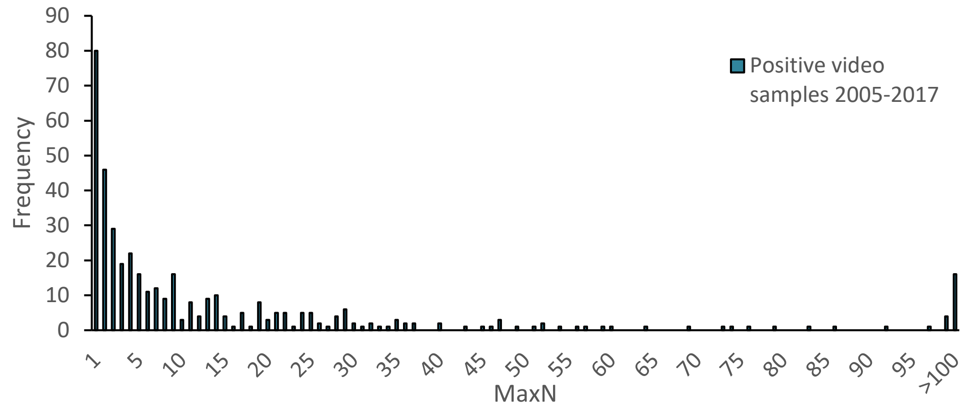
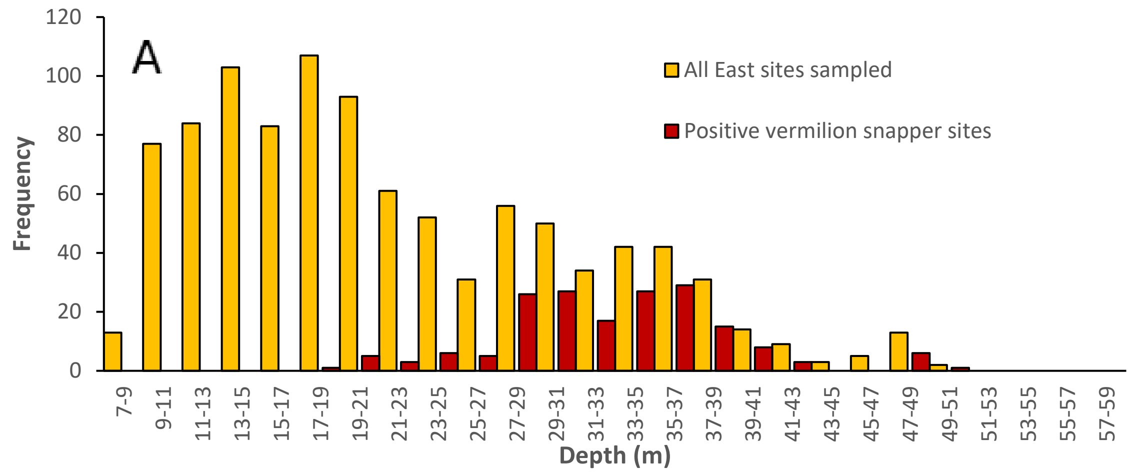


Figure 6. Frequency distribution of non-zero min counts of vermilion snapper from Panama City reef fish video samples, 2005-2017



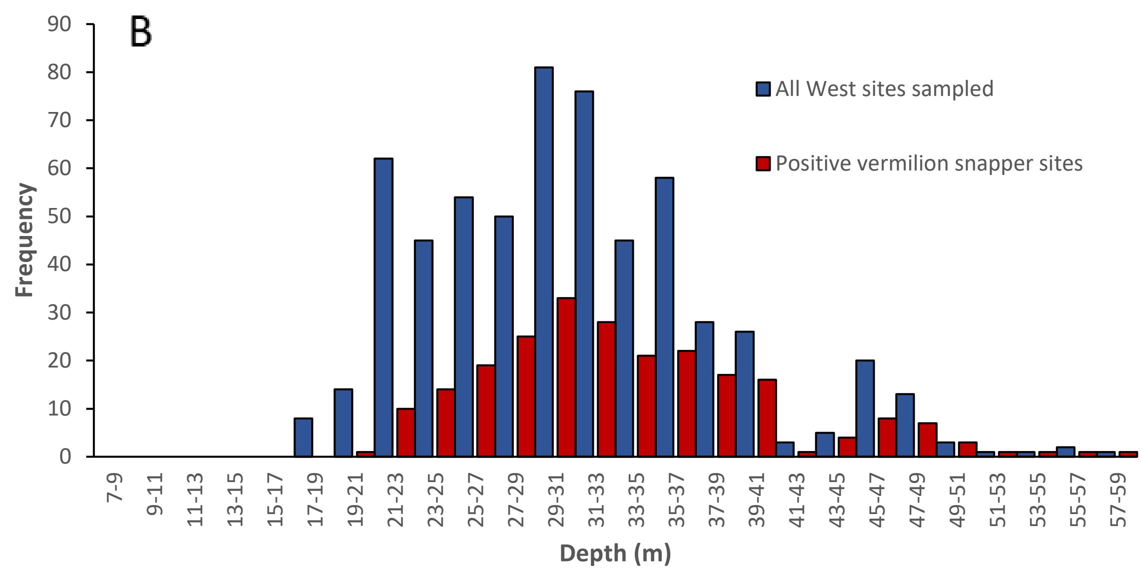


Figure 7. Depth distributions of all video sample sites vs only sites positive for vermilion snapper for east of Cape San Blas (A) and west of Cape San Blas (B).

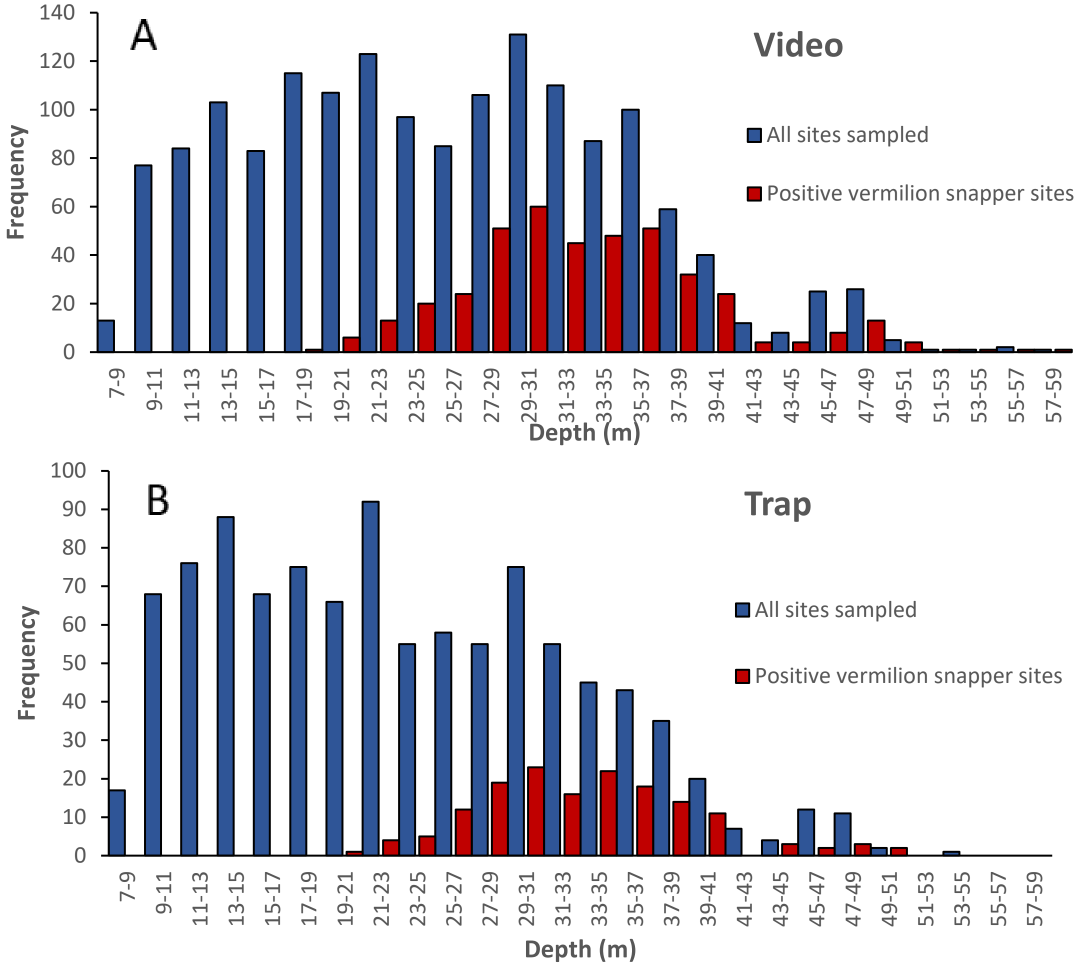


Figure 8. Depth distributions of all video (A) and trap (B) sample sites vs only sites positive for vermilion snapper (2005-2017, video; 2004-2017, trap).

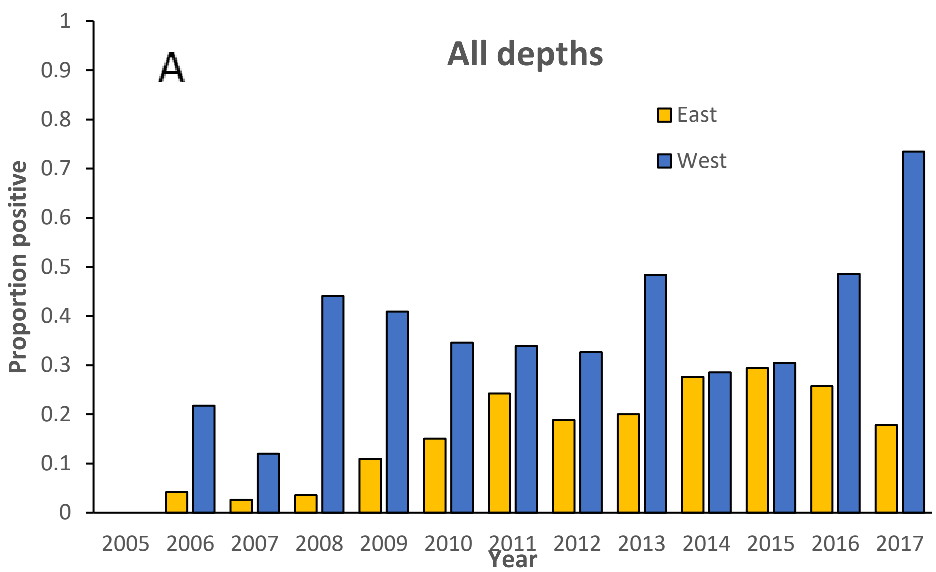


Figure 9. Annual proportions of positive vermilion snapper video samples, all depths (A) and depths >18m (B) from 2005-17 east and west of Cape San Blas.

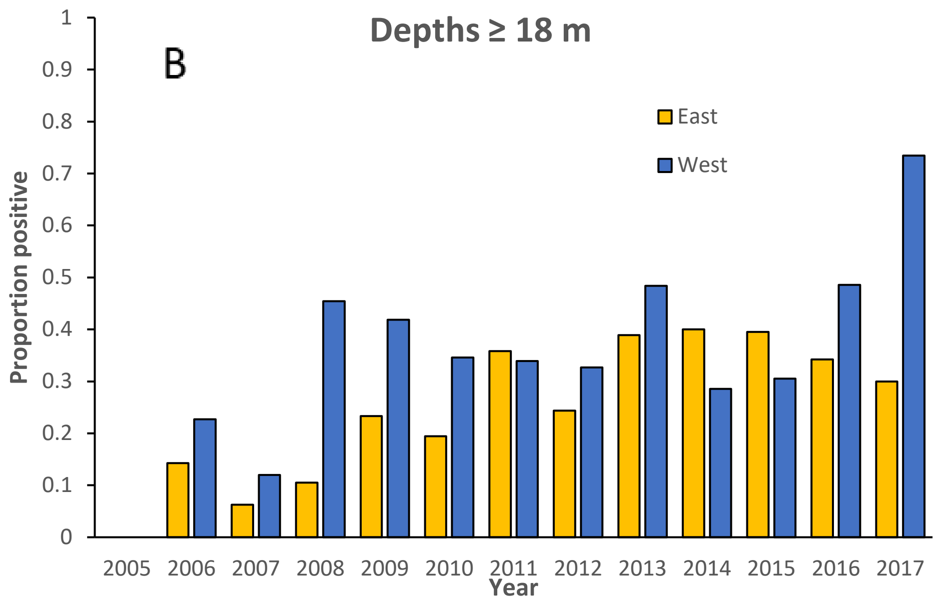


Figure 9 cont. Annual proportions of positive vermilion snapper video samples, all depths (A) and depths >18m (B) from 2005-17 east and west of Cape San Blas.

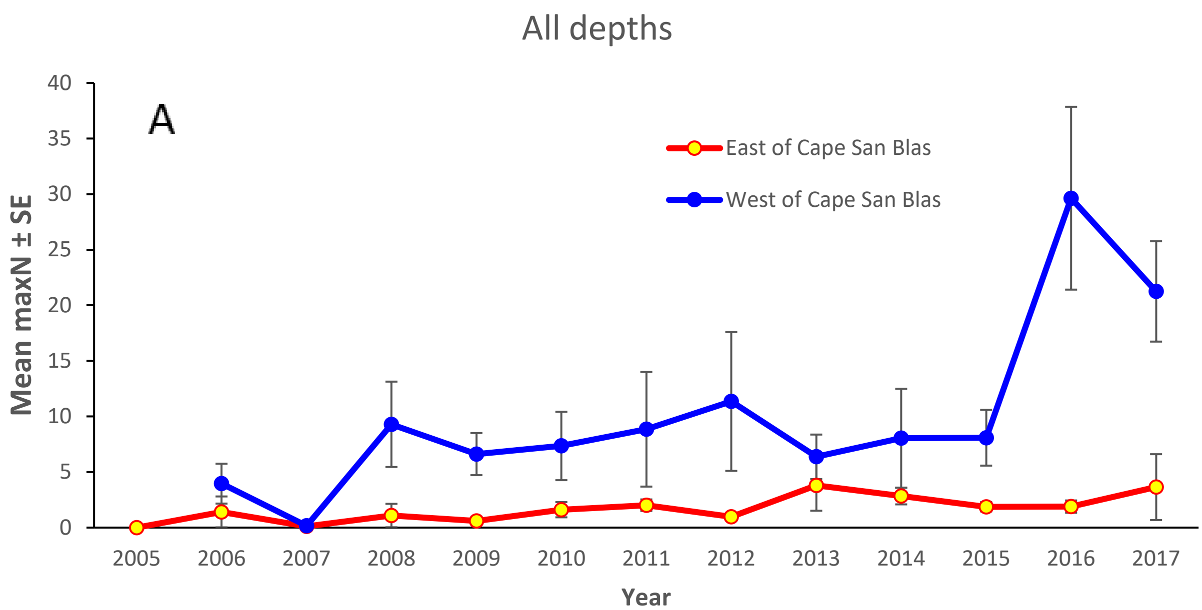


Figure 10. Mean annual nominal video min counts (MaxN) and standard errors of vermilion snapper east and west of Cape San Blas, all depths (A) and depths >18m (B), 2005-2017.

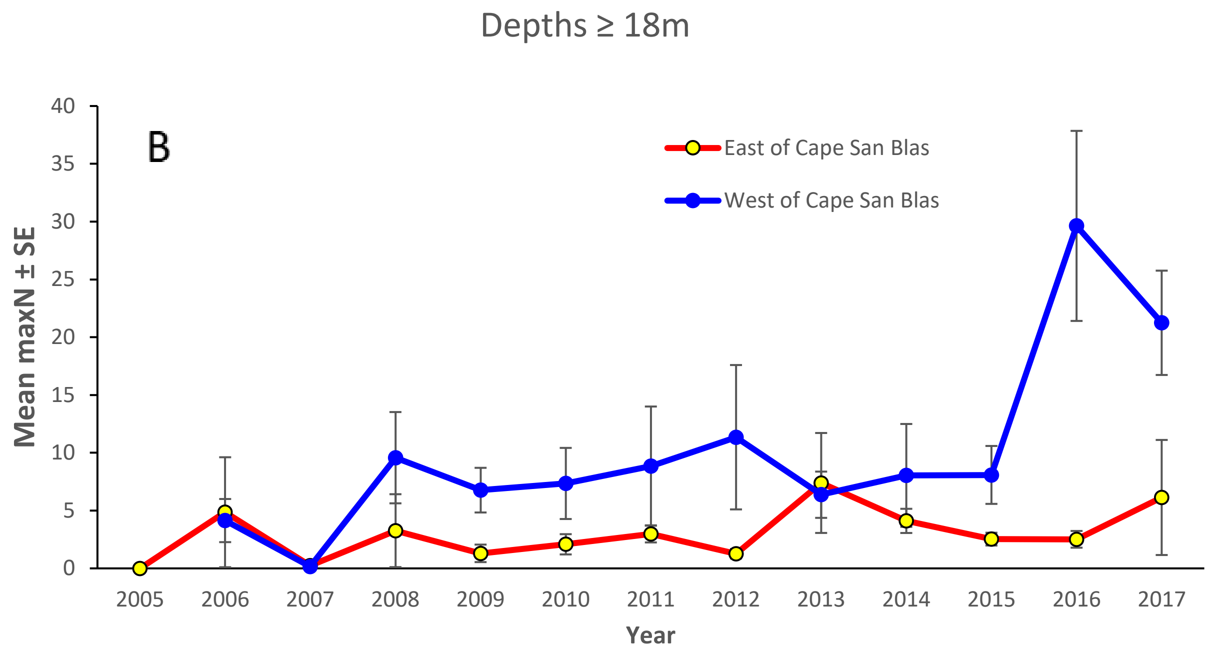


Figure 10 cont. Mean annual nominal video min counts (MaxN) and standard errors of vermilion snapper east and west of Cape San Blas, all depths (A) and depths >18m (B), 2005-2017.

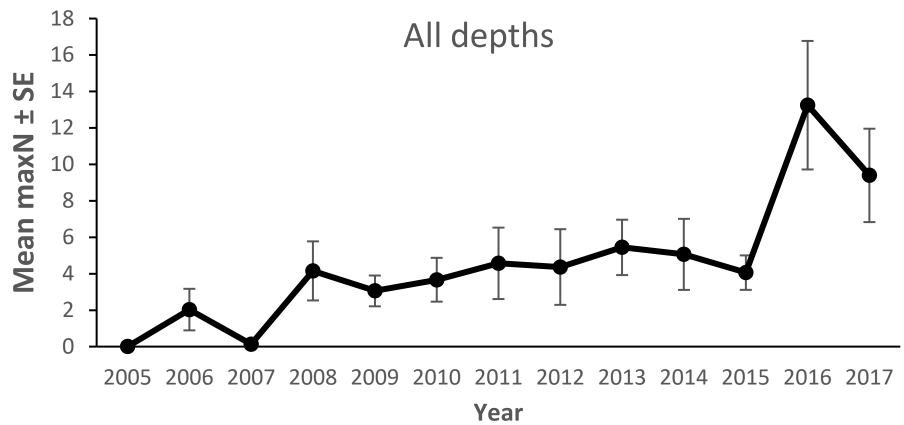


Figure 11. Overall (east + west of Cape San Blas) mean annual nominal video min counts (MaxN) and standard errors of gray vermilion snapper, all depths (A) and depths >18m (B), 2005-2017.

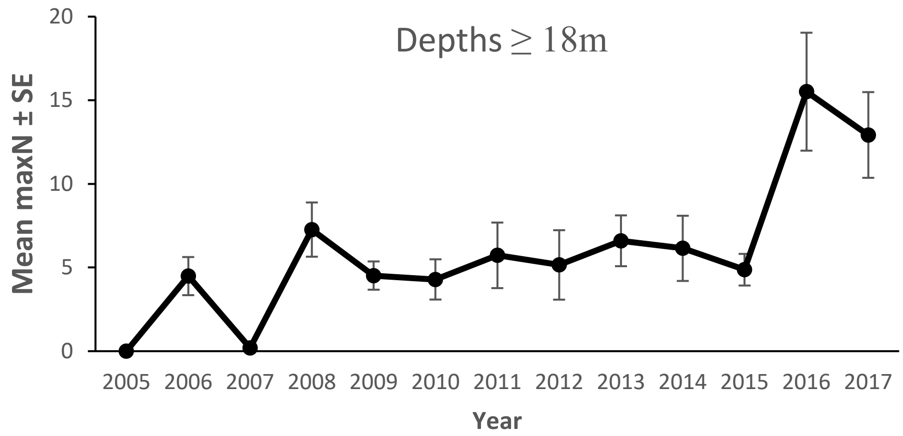


Figure 11 cont. Overall (east + west of Cape San Blas) mean annual nominal video min counts (MaxN) and standard errors of vermilion snapper, all depths (A) and depths >18m (B), 2005-2017.

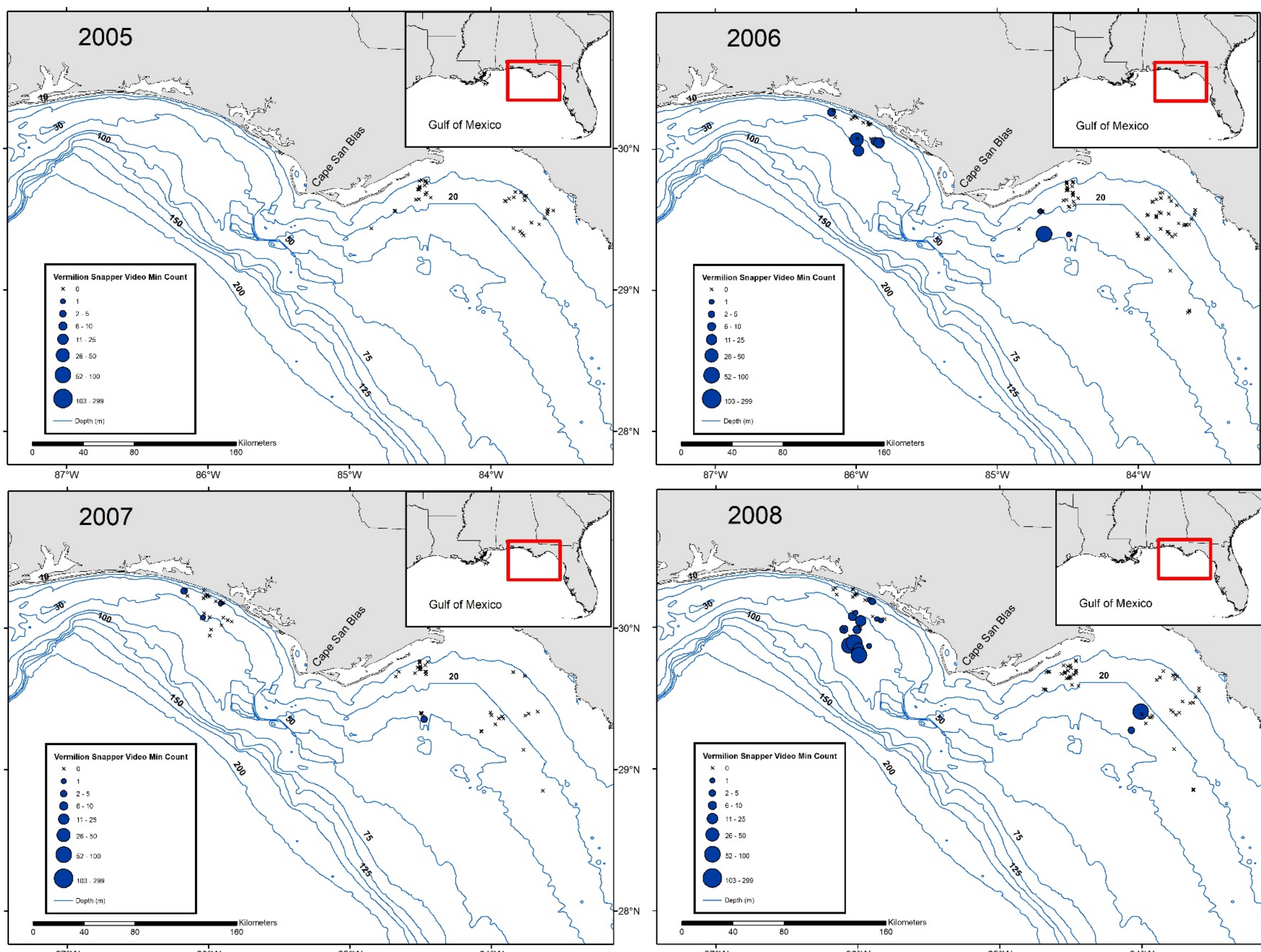


Figure 12. Annual distribution and relative abundance of vermilion snapper observed with stationary, high definition video or MPEG cameras (min counts) in the Panama City NMFS reef fish survey, 2005-2017. Sites sampled, but where no vermilion snapper were observed, are indicated with an X.

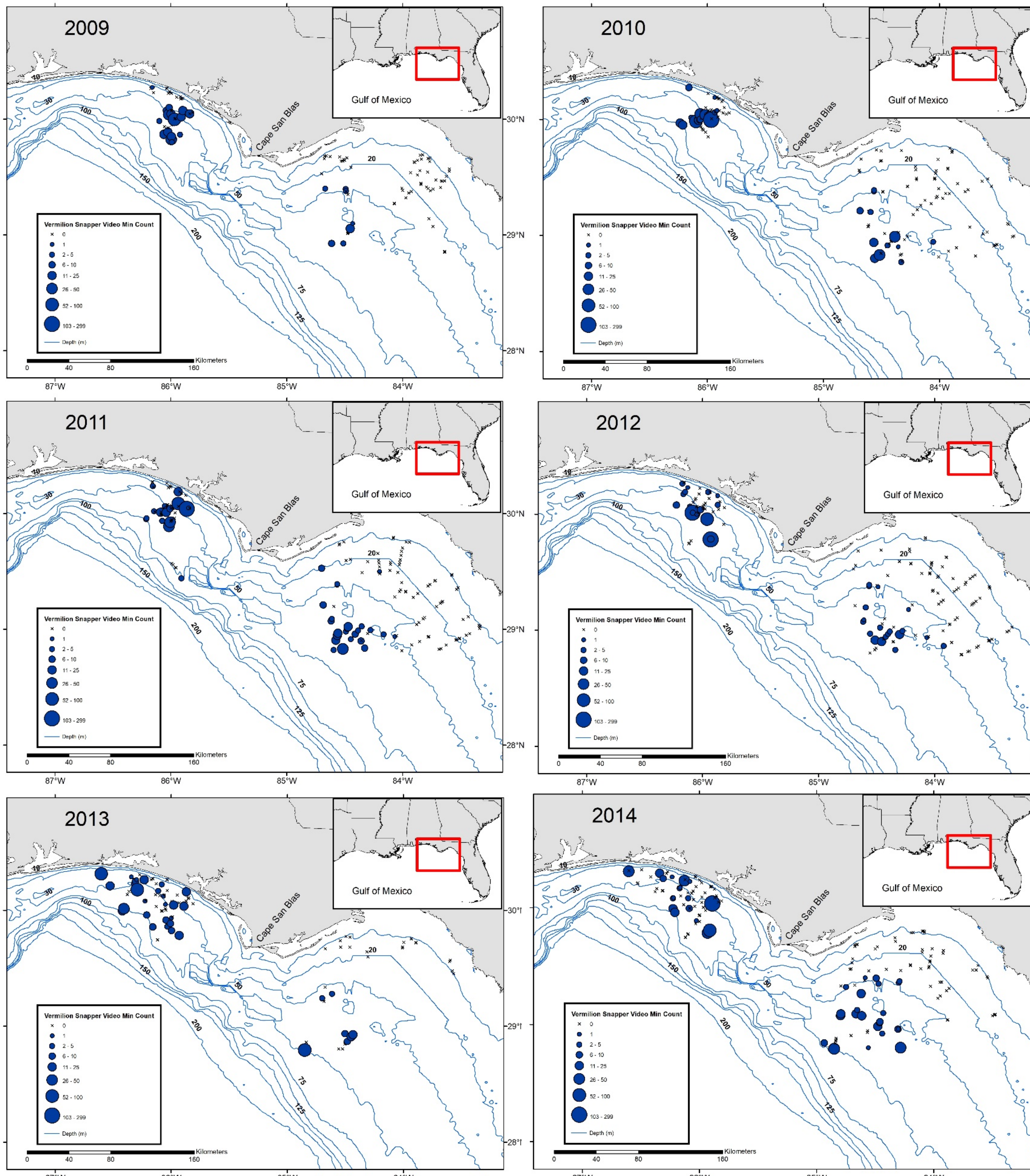


Figure 12 cont. Annual distribution and relative abundance of vermilion snapper observed with stationary, high definition video or MPEG cameras (min counts) in the Panama City NMFS reef fish survey, 2005-2017. Sites sampled, but where no vermilion snapper were observed, are indicated with an X.

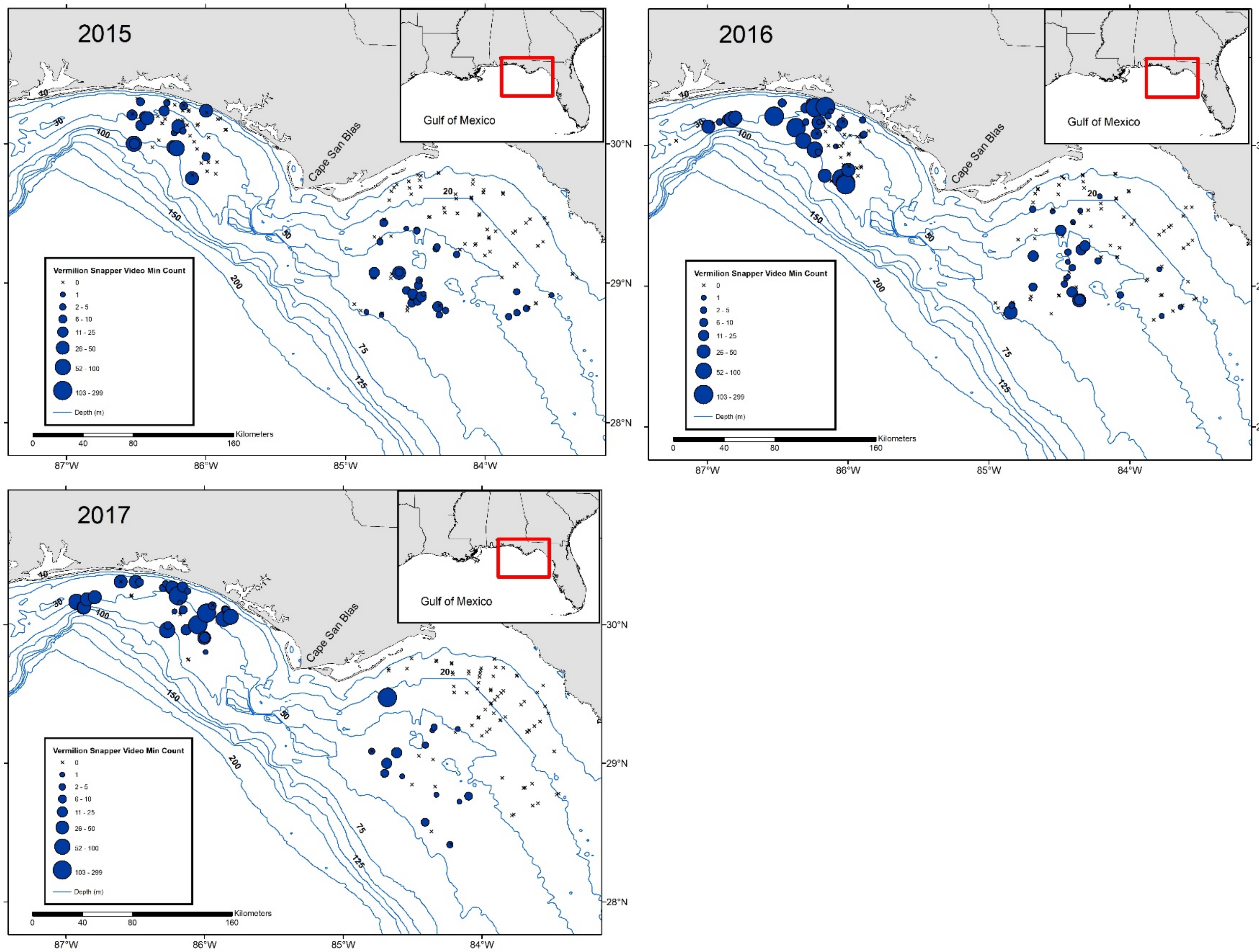


Figure 12 cont. Annual distribution and relative abundance of vermilion snapper observed with stationary, high definition video or MPEG cameras (min counts) in the Panama City NMFS reef fish survey, 2005-2017. Sites sampled, but where no vermilion snapper were observed, are indicated with an X.

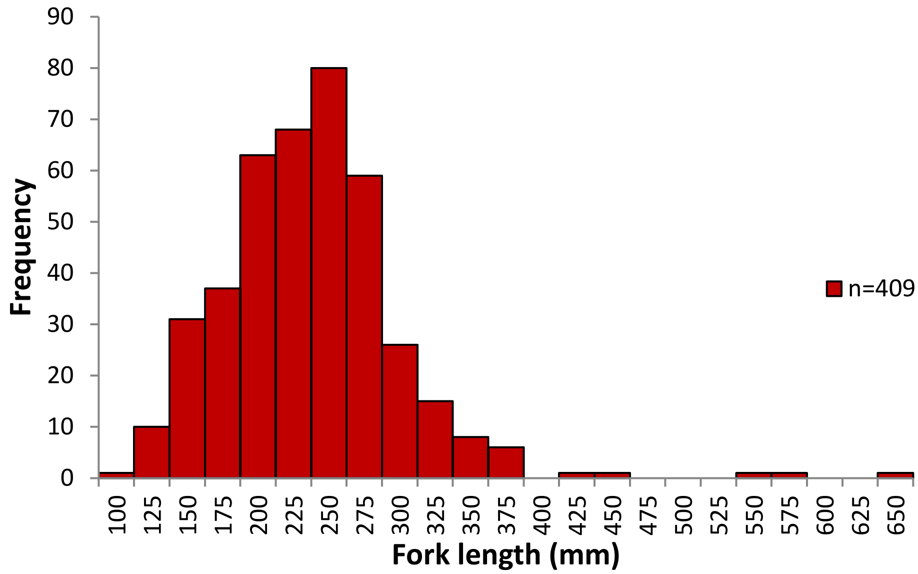


Figure 13. Overall size distributions of all vermilion snapper measured from stereo images, 2009-2017.

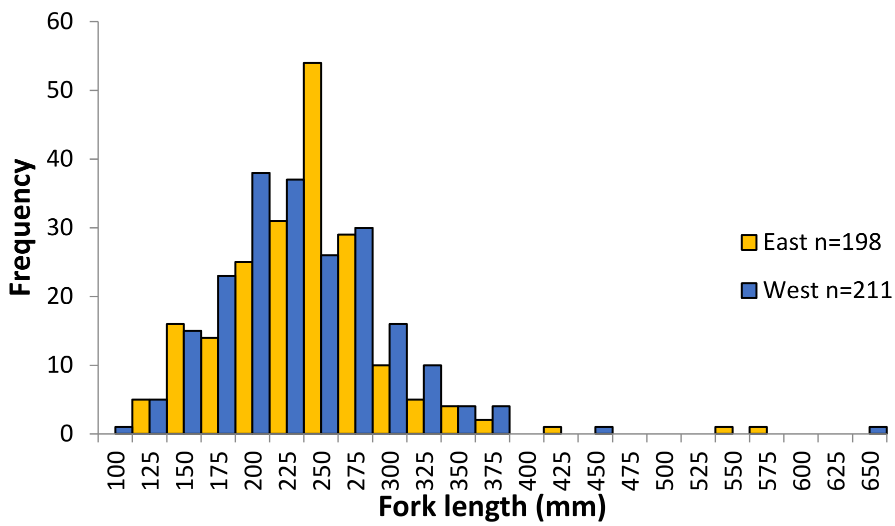


Figure 14. Overall size distributions of vermilion snapper east and west of Cape San Blas observed with stereo cameras, 2009-2017.

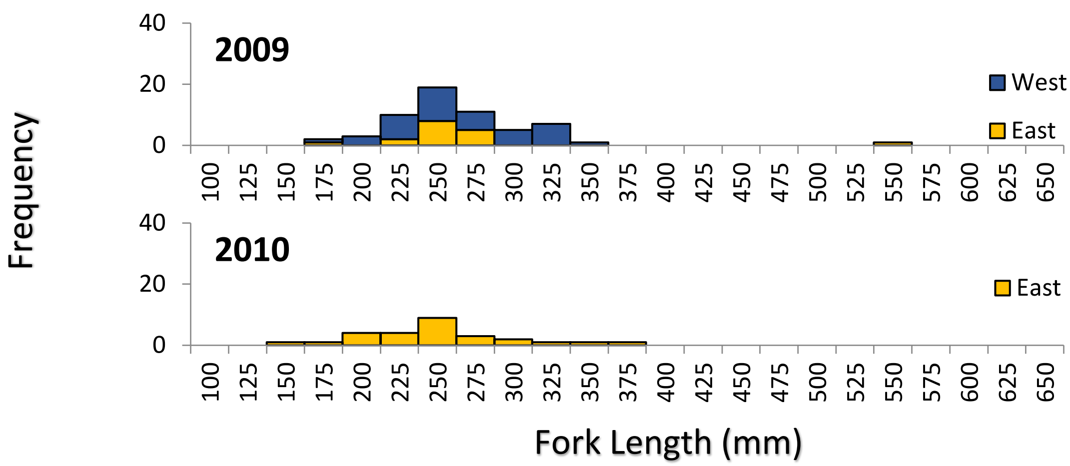


Figure 15. Annual size distributions of vermilion snapper observed with stereo cameras, 2009-2017 east and west of Cape San Blas.

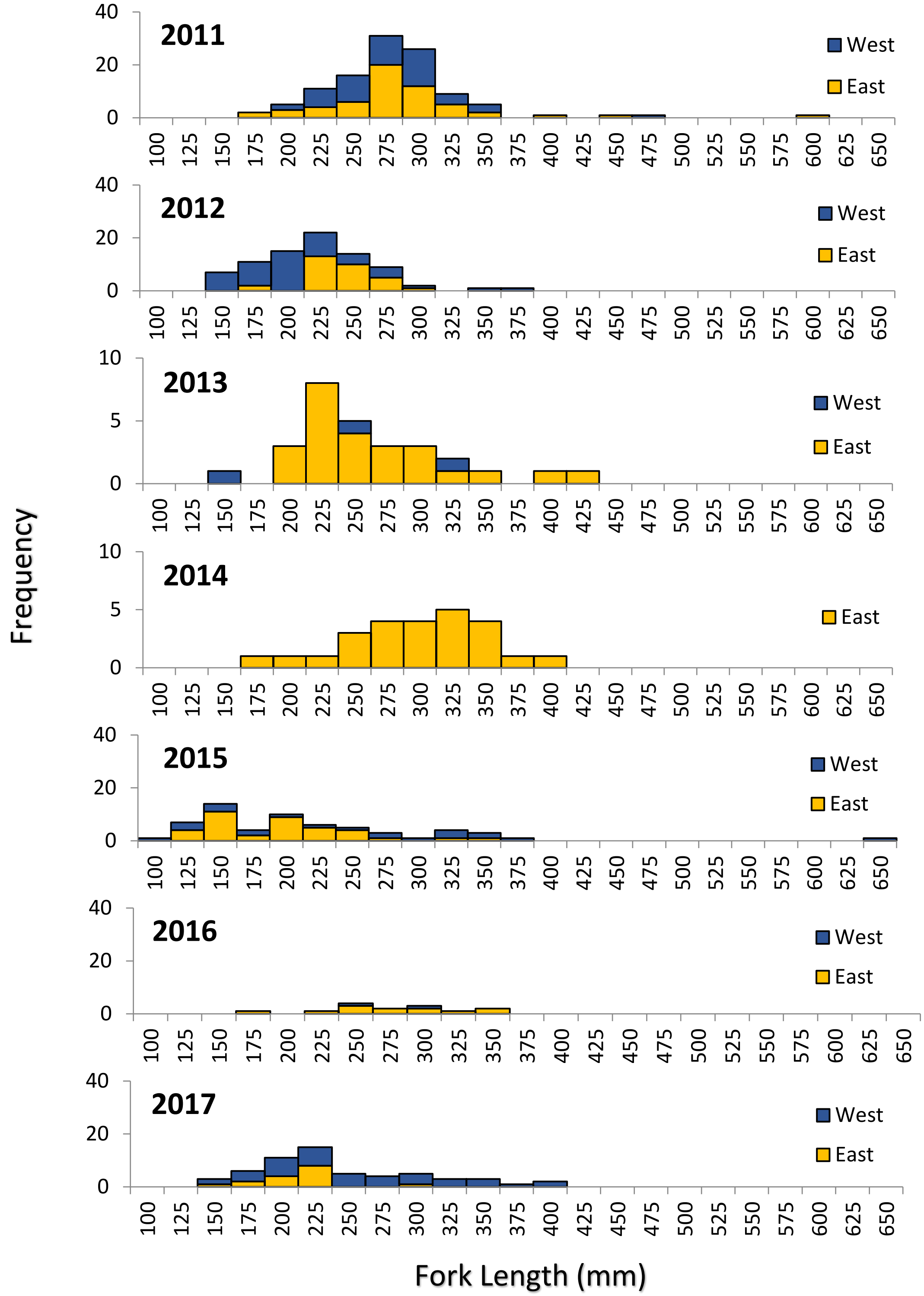


Figure 15 cont. Annual size distributions of vermilion snapper observed with stereo cameras, 2009-2017 east and west of Cape San Blas.

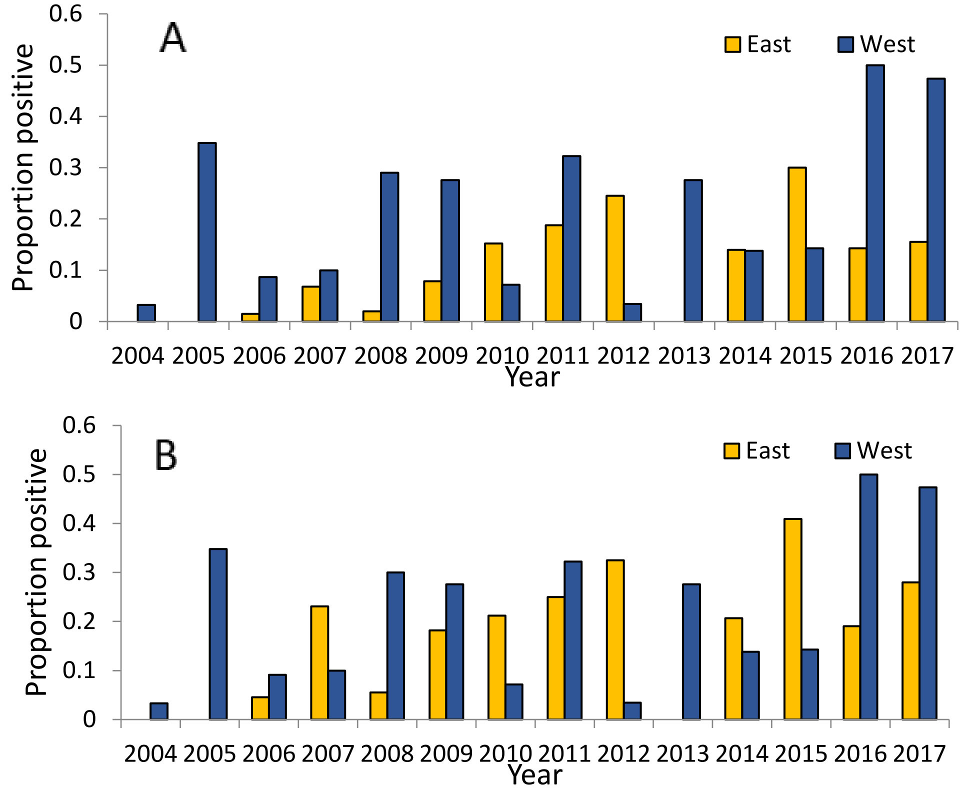


Figure 16. Annual proportions of positive vermilion snapper trap catches, all depths (A) and depths >18m (B), from 2004-2017 east and west of Cape San Blas.

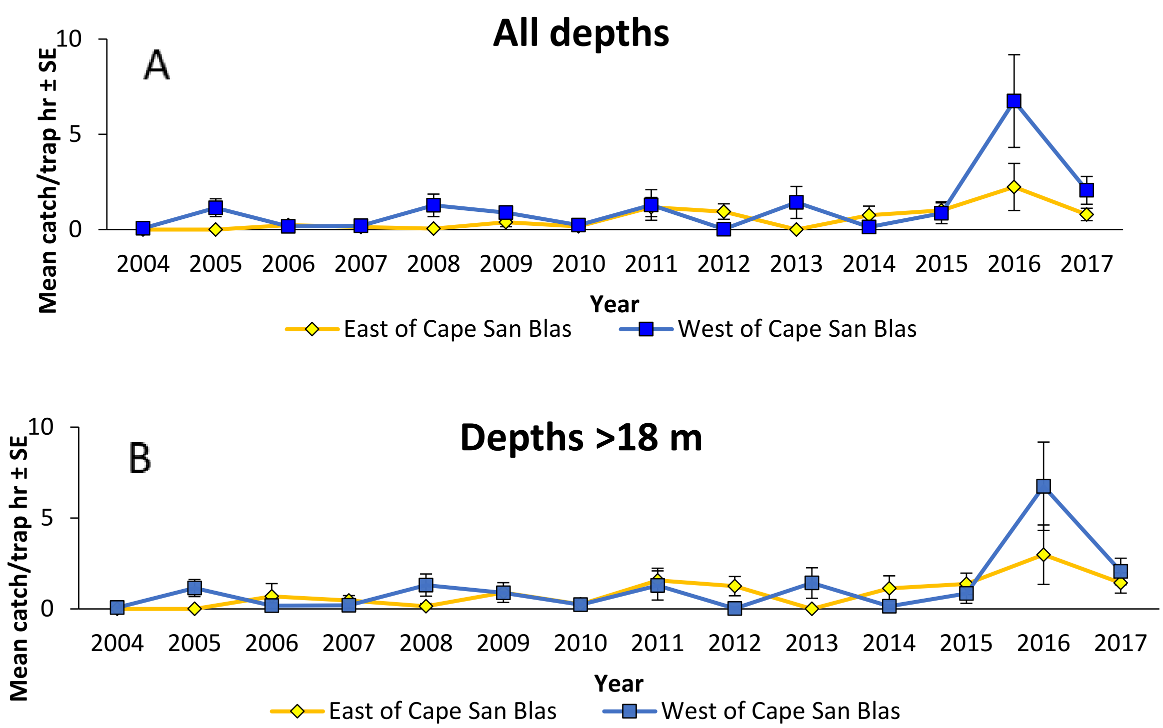


Figure 17. Mean catch per trap hr and standard errors of vermilion snapper east and west of Cape San Blas, all depths (A) and depths >18 m (B), 2004-2017.

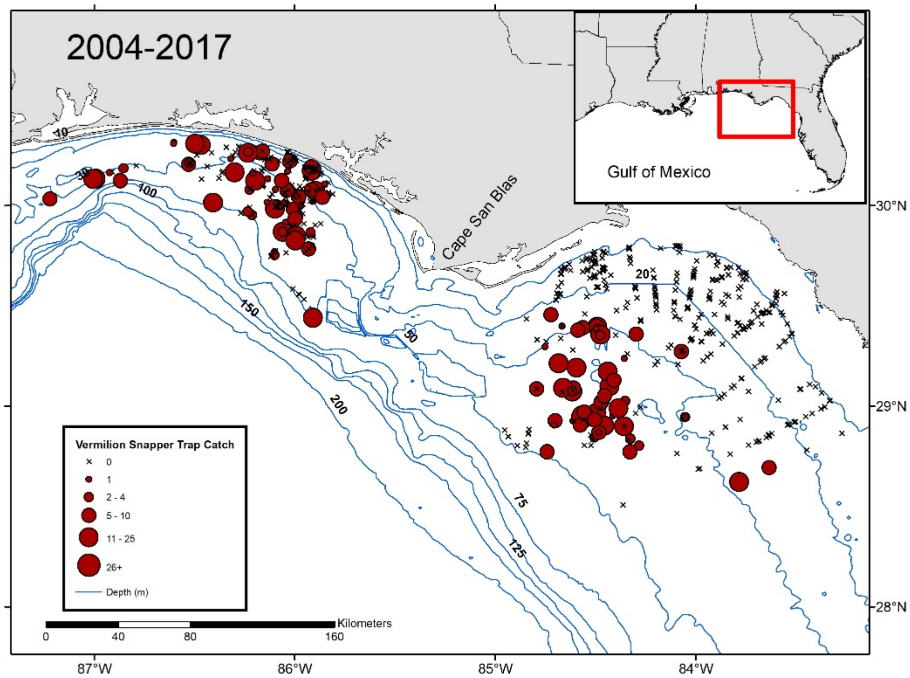


Figure 18. Distribution and relative abundance of vermilion snapper caught in chevron traps in the Panama City NMFS reef fish survey, 2004-2017. X's are sites sampled, but where no vermilion snapper were caught.

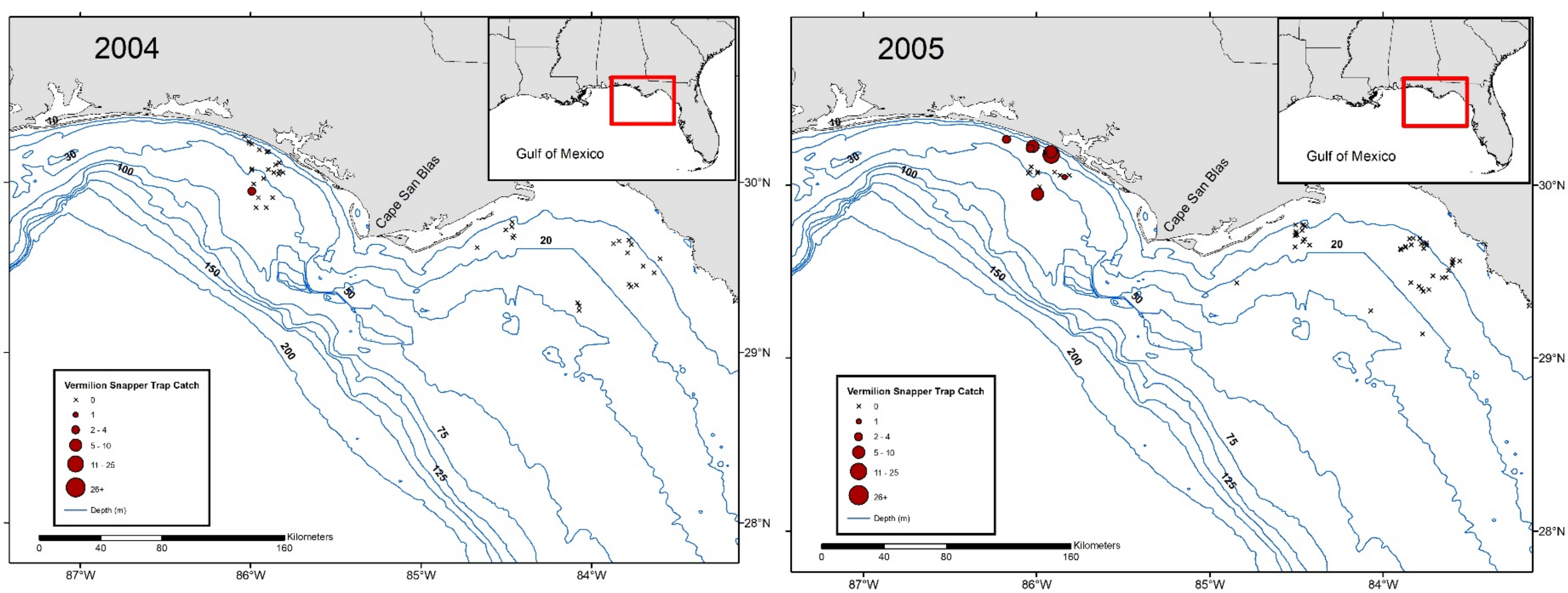
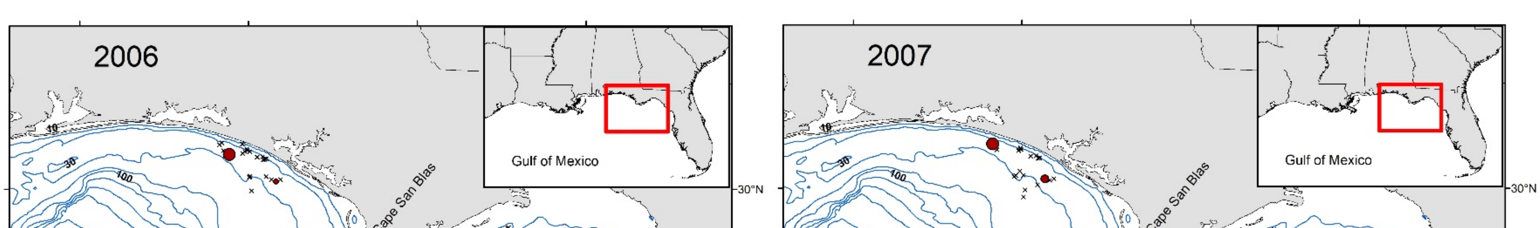


Figure 19. Annual distribution and relative abundance of vermilion snapper caught in chevron traps in the Panama City NMFS reef fish survey, 2004-2017. X's are sites sampled, but where no vermilion snapper were caught.



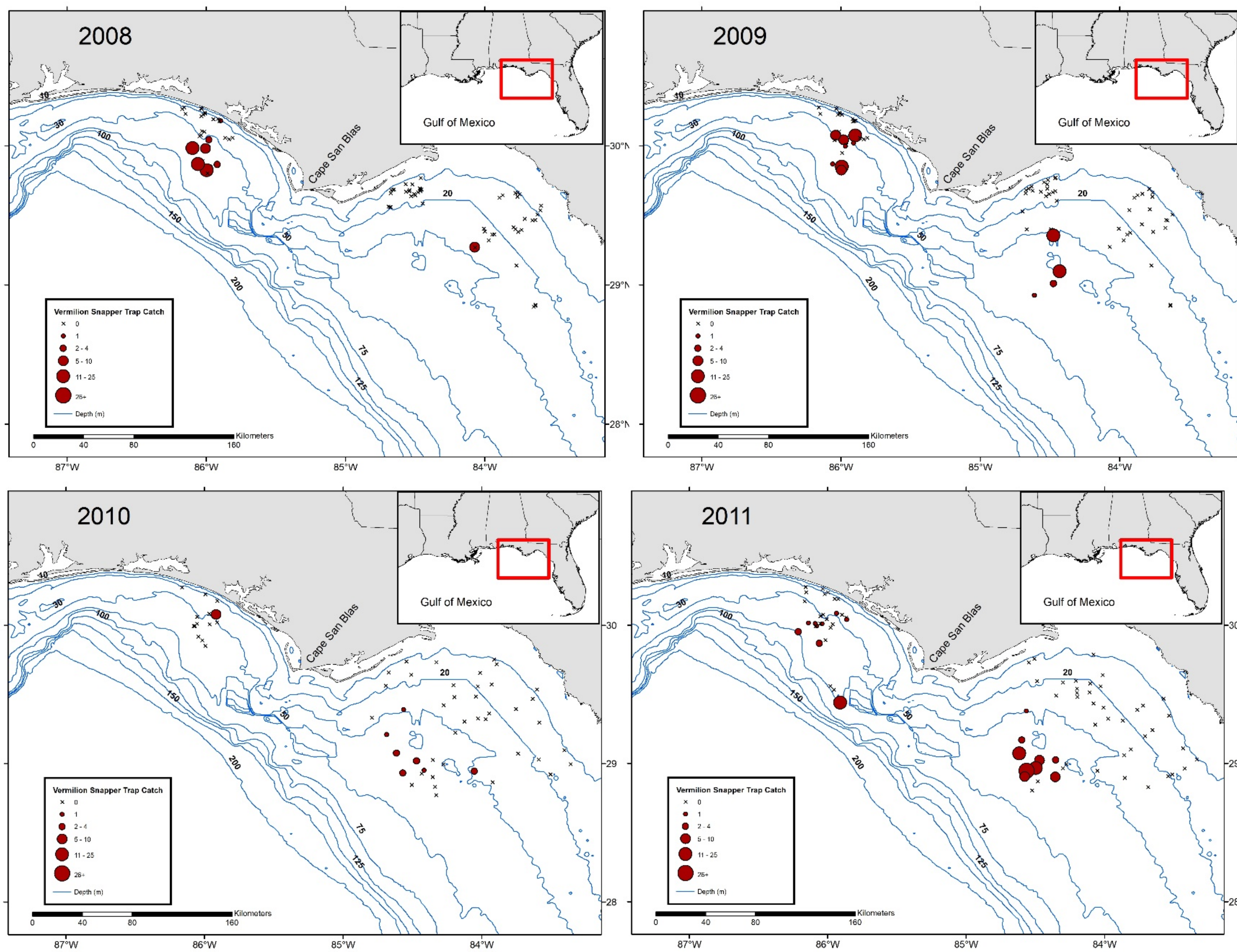
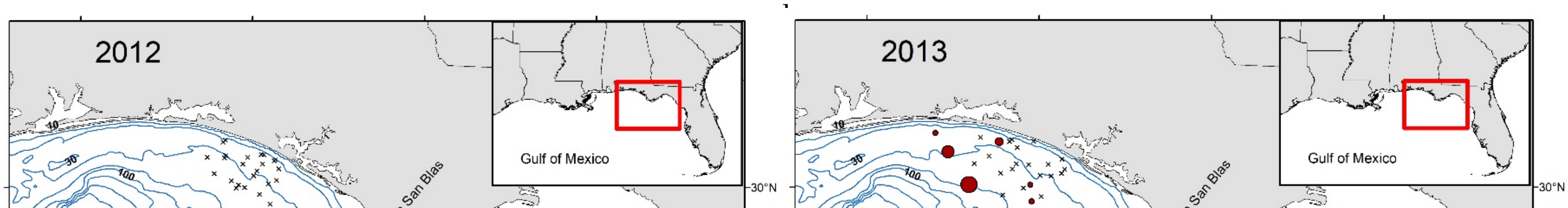


Figure 19 cont. Annual distribution and relative abundance of vermilion snapper caught in chevron traps in the Panama City NMFS reef fish survey, 2004-2017. X's are sites sampled, but where no vermilion snapper were



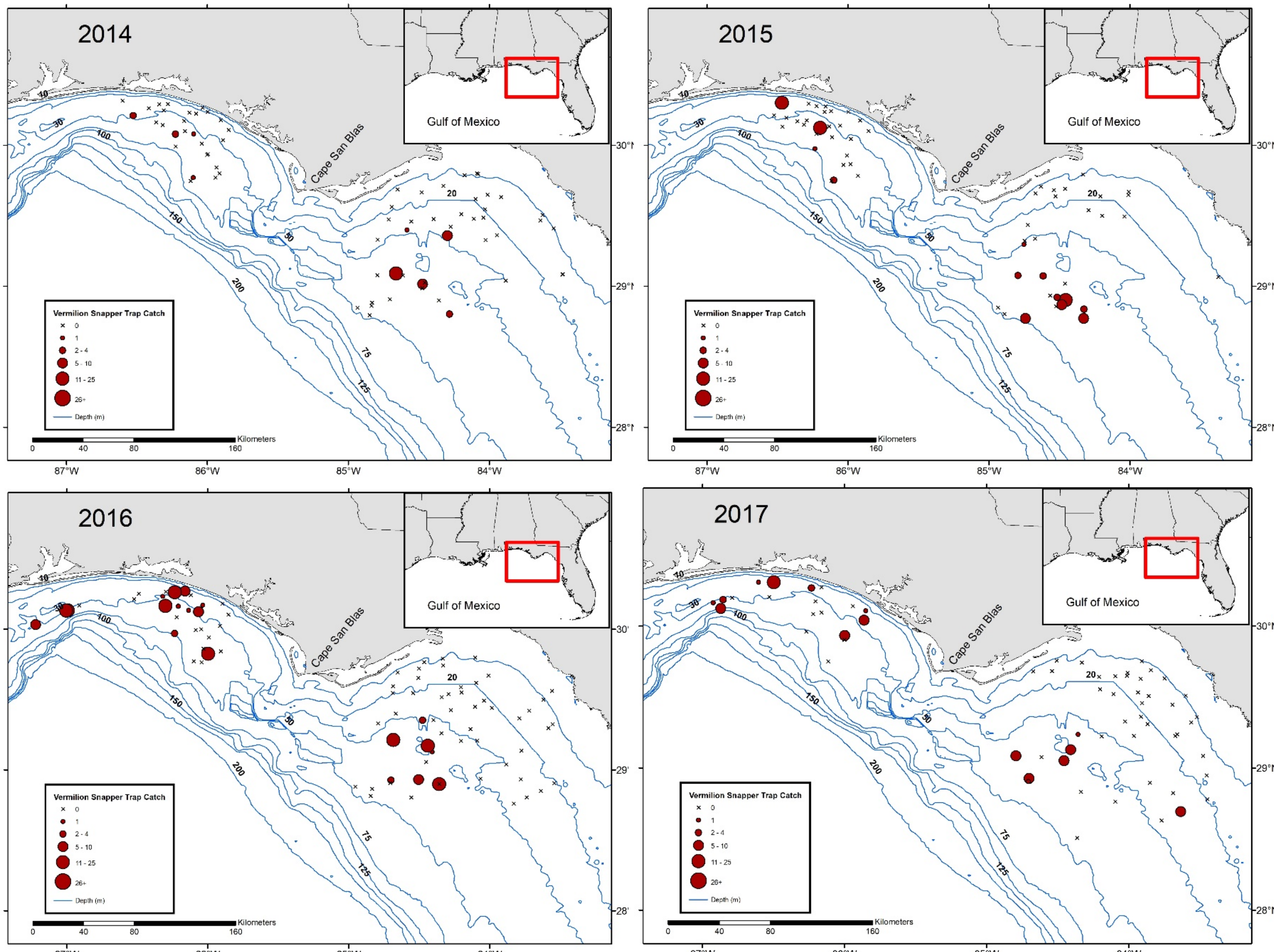


Figure 19 cont. Annual distribution and relative abundance of vermilion snapper caught in chevron traps in the Panama City NMFS reef fish survey, 2004-2017. X's are sites sampled, but where no vermilion snapper were caught.

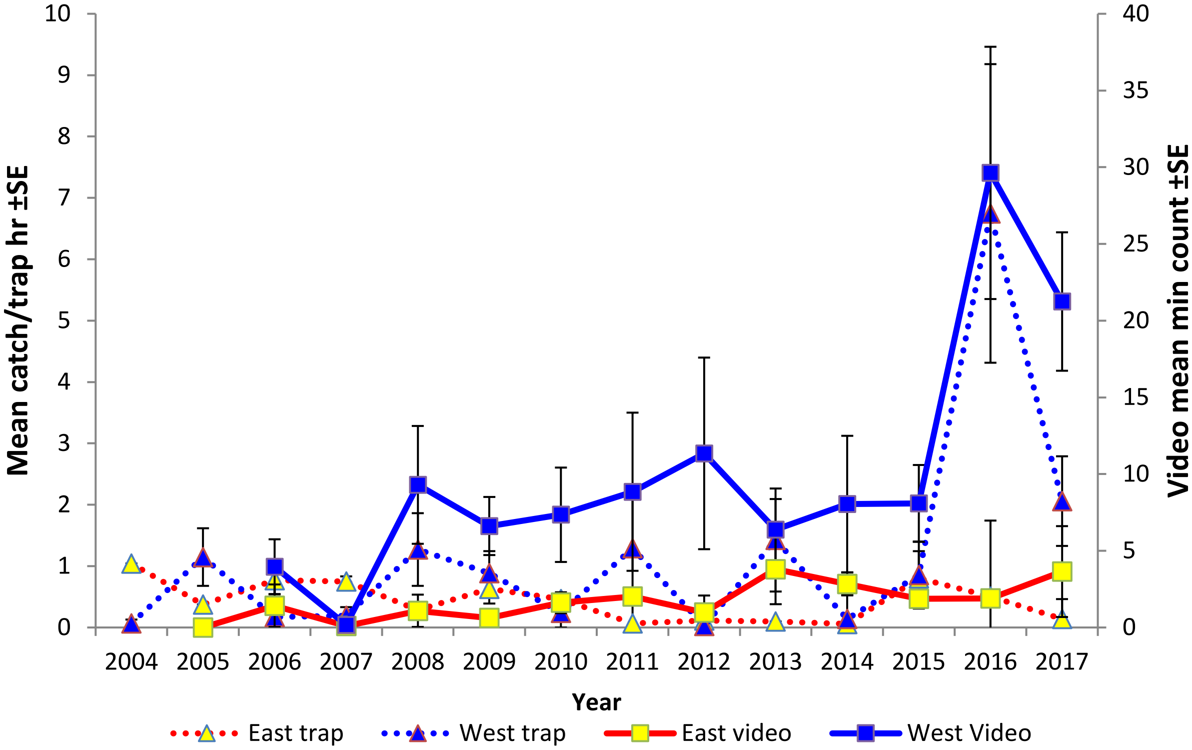


Figure 20. Annual trap (2004-2017) CPUE ± SE and video (2005-2017) mean min count ± SE of vermilion snapper east and west of Cape San Blas.

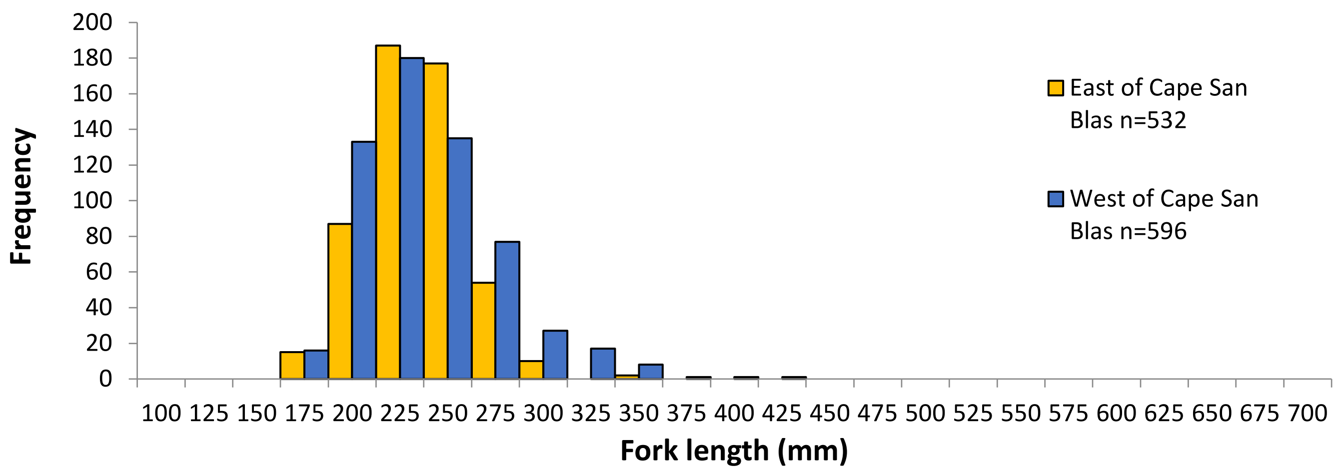


Figure 21. Overall size distributions vermilion snapper east and west of Cape San Blas caught in chevron traps, 2004-2017.

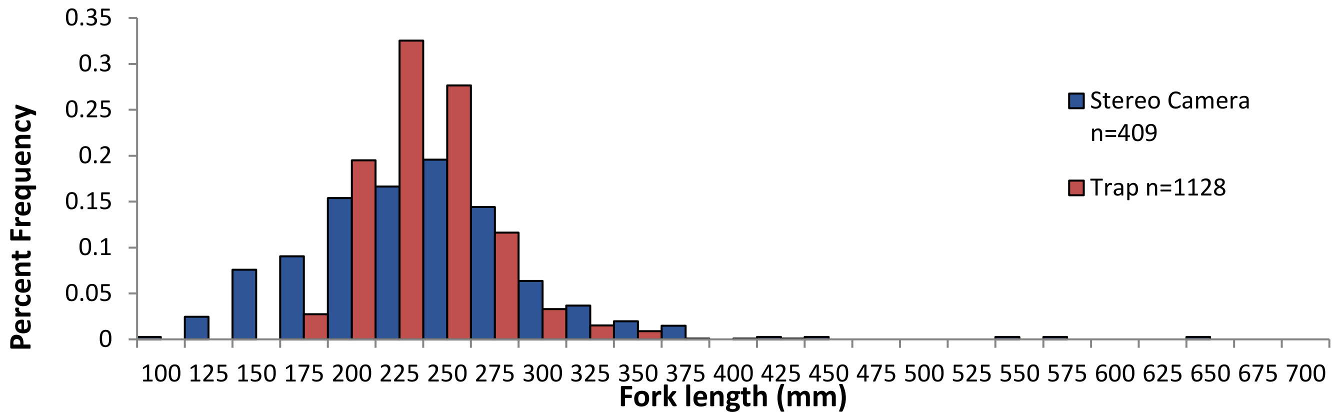


Figure 22. Overall size distributions of all vermilion snapper collected in chevron traps, 2004-2017, and measured in stereo images, 2009-2017.

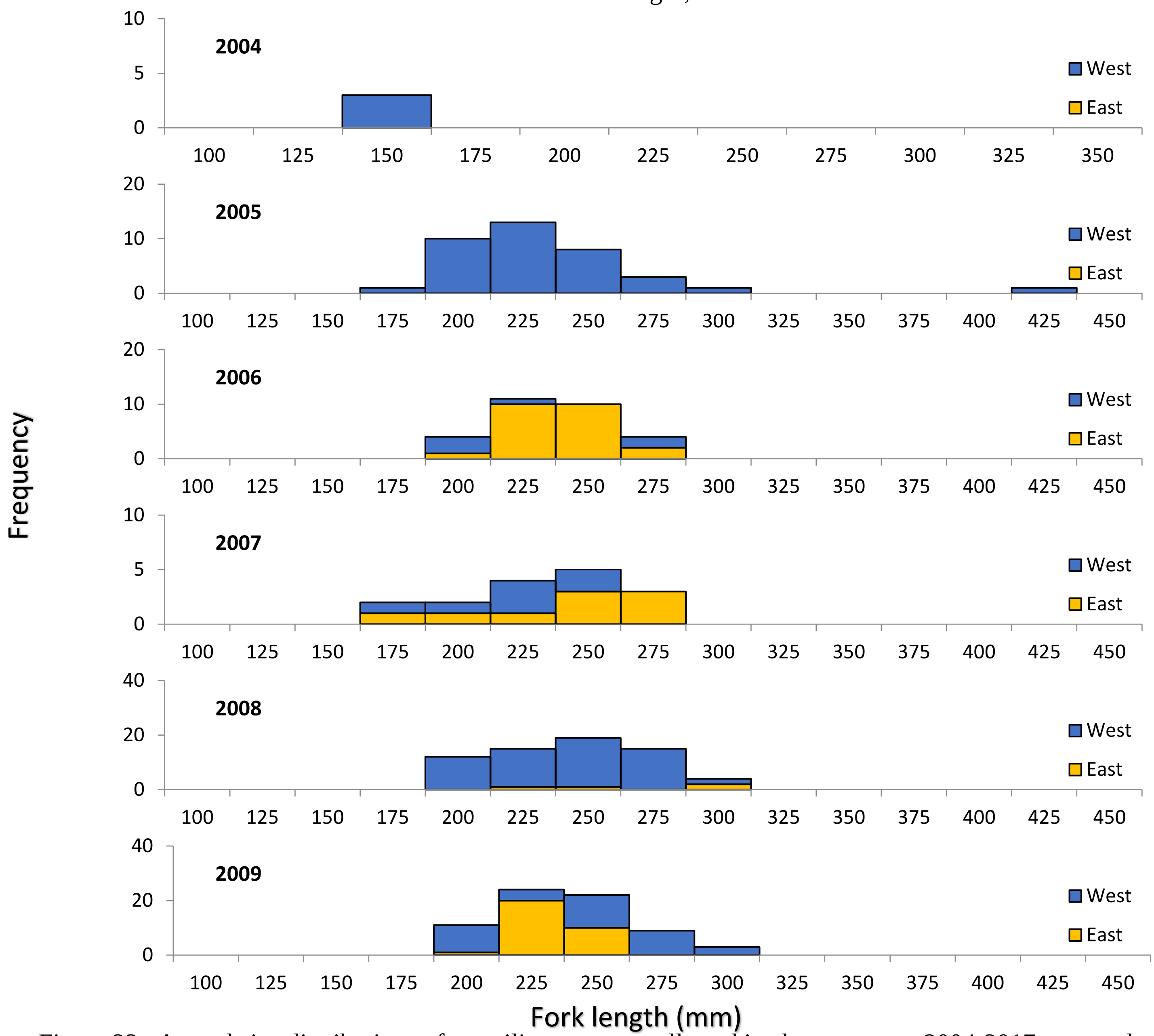


Figure 23. Annual size distributions of vermilion snapper collected in chevron traps, 2004-2017, east and west of Cape San Blas.

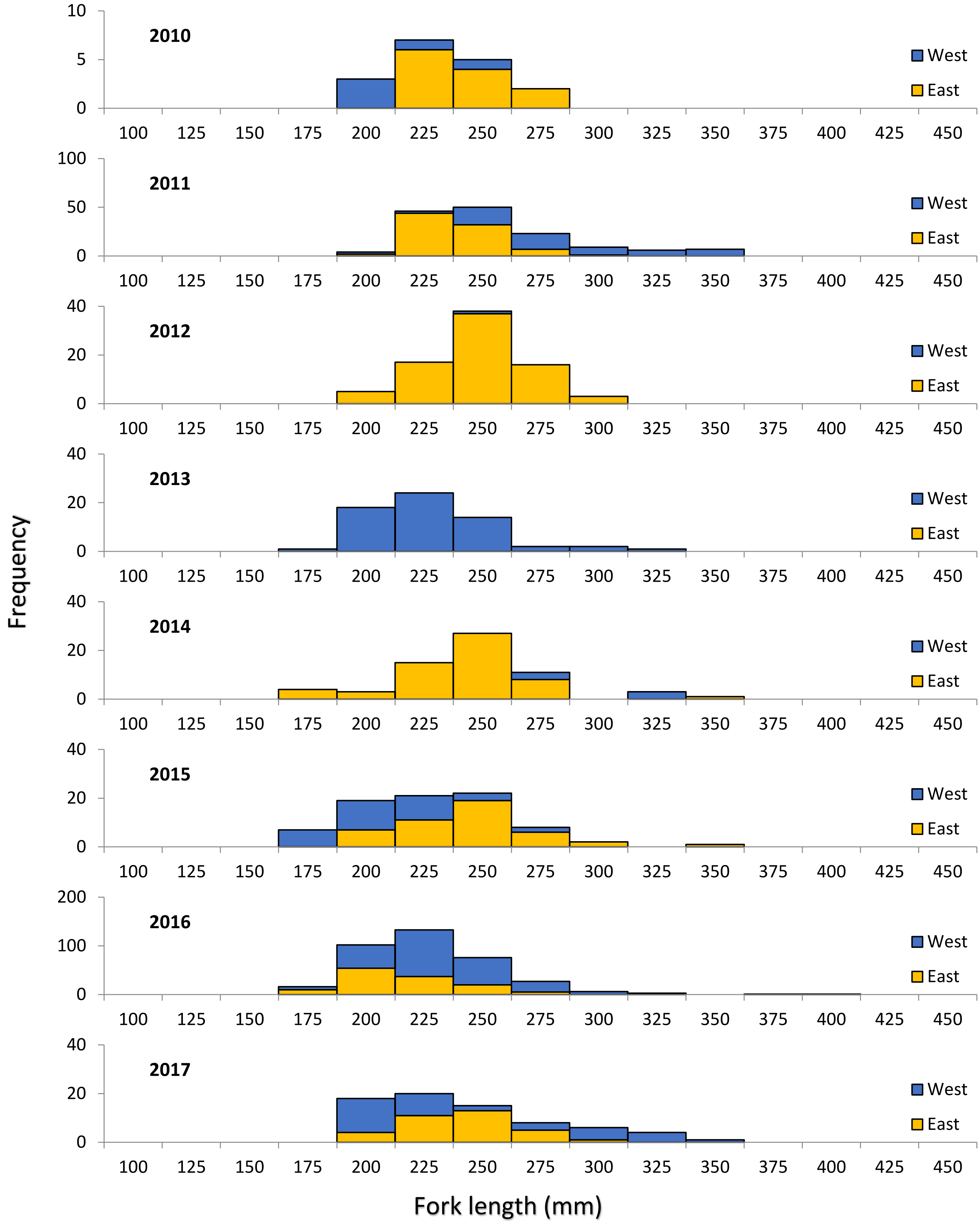


Figure 23 cont. Annual size distributions of vermilion snapper collected in chevron traps, 2004-2017, east and west of Cape San Blas.

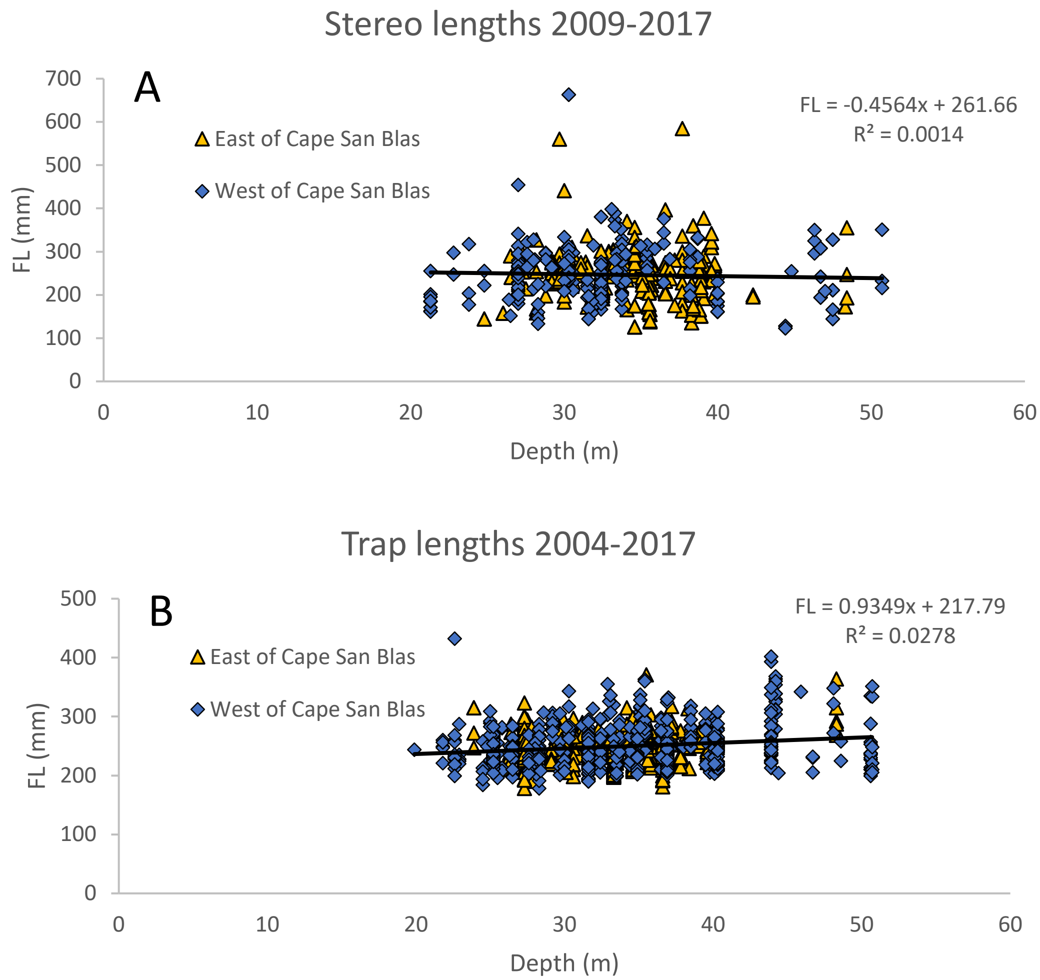


Figure 24. Fork length vs. depth relationship of vermilion snapper observed with: (A) stereo cameras east and west of Cape San Blas, 2009-2017, and (B) collected east and west of Cape San Blas with chevron traps, 2004-2017.

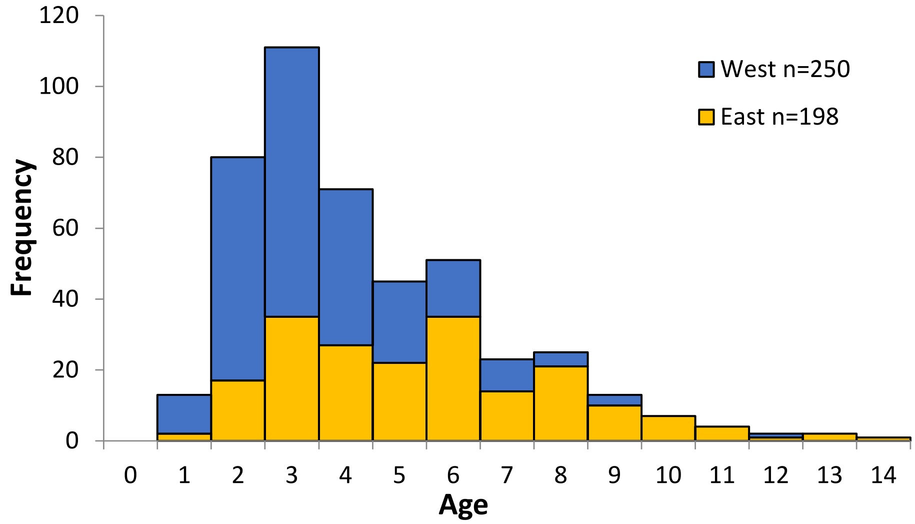


Figure 25. Overall age structure of trap-caught vermilion snapper, east and west of Cape San Blas, 2004-2017.

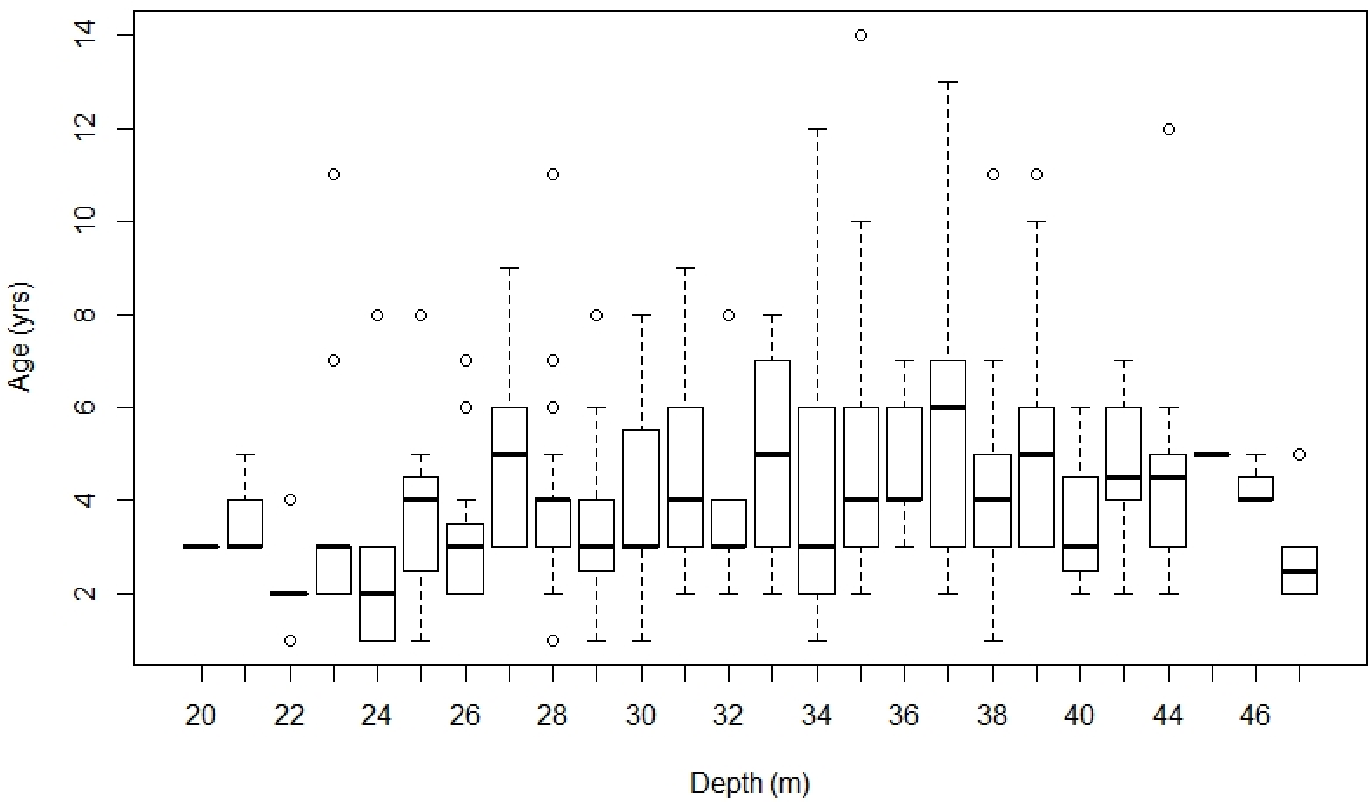


Figure 26. Age vs depth relationship of vermilion snapper caught in chevron traps, 2004-2017, in the Panama City reef fish survey.

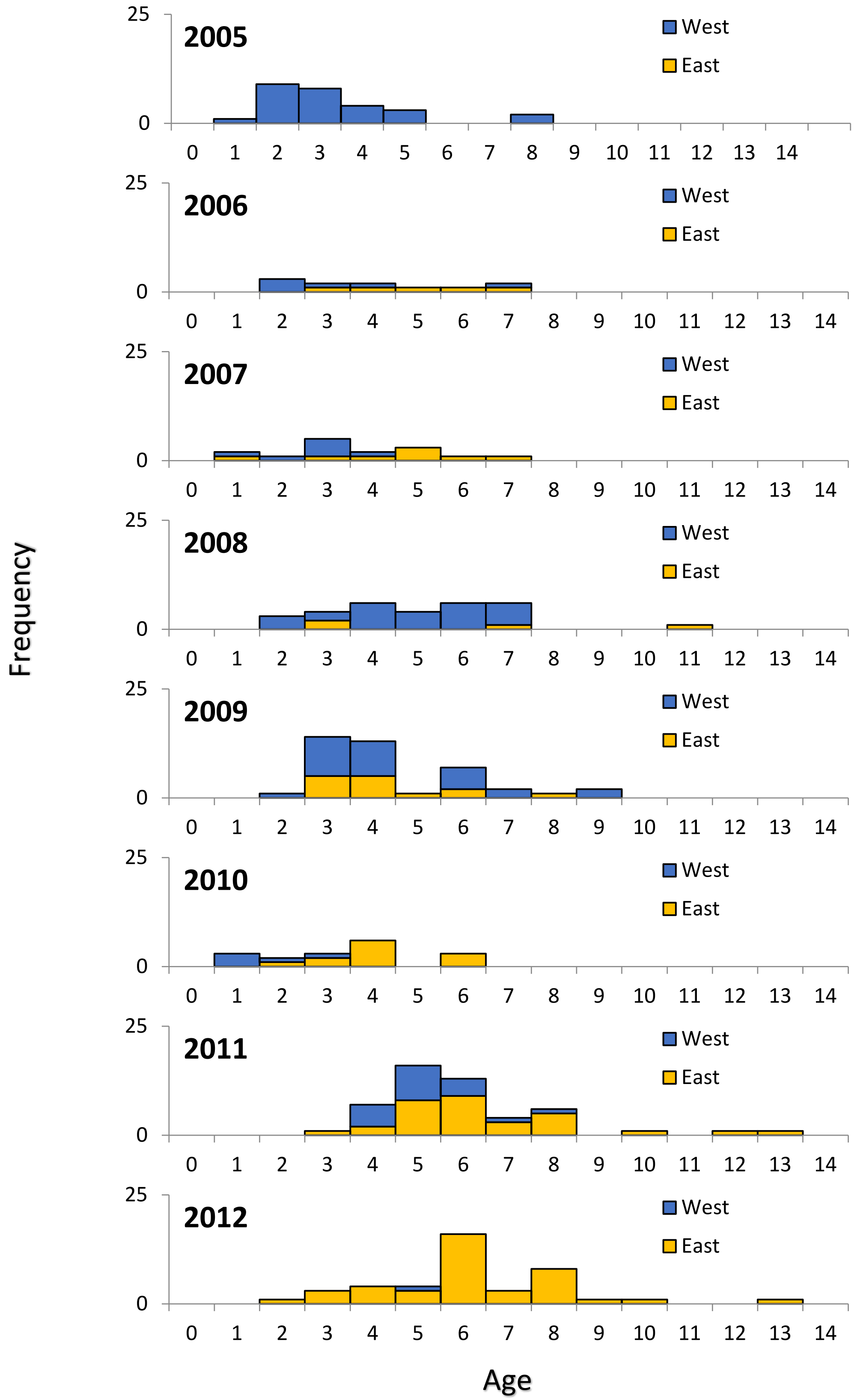


Figure 27. Annual age structure of vermilion snapper caught in chevron traps in the NOAA Panama City lab reef fish survey, 2004-2017, by region.

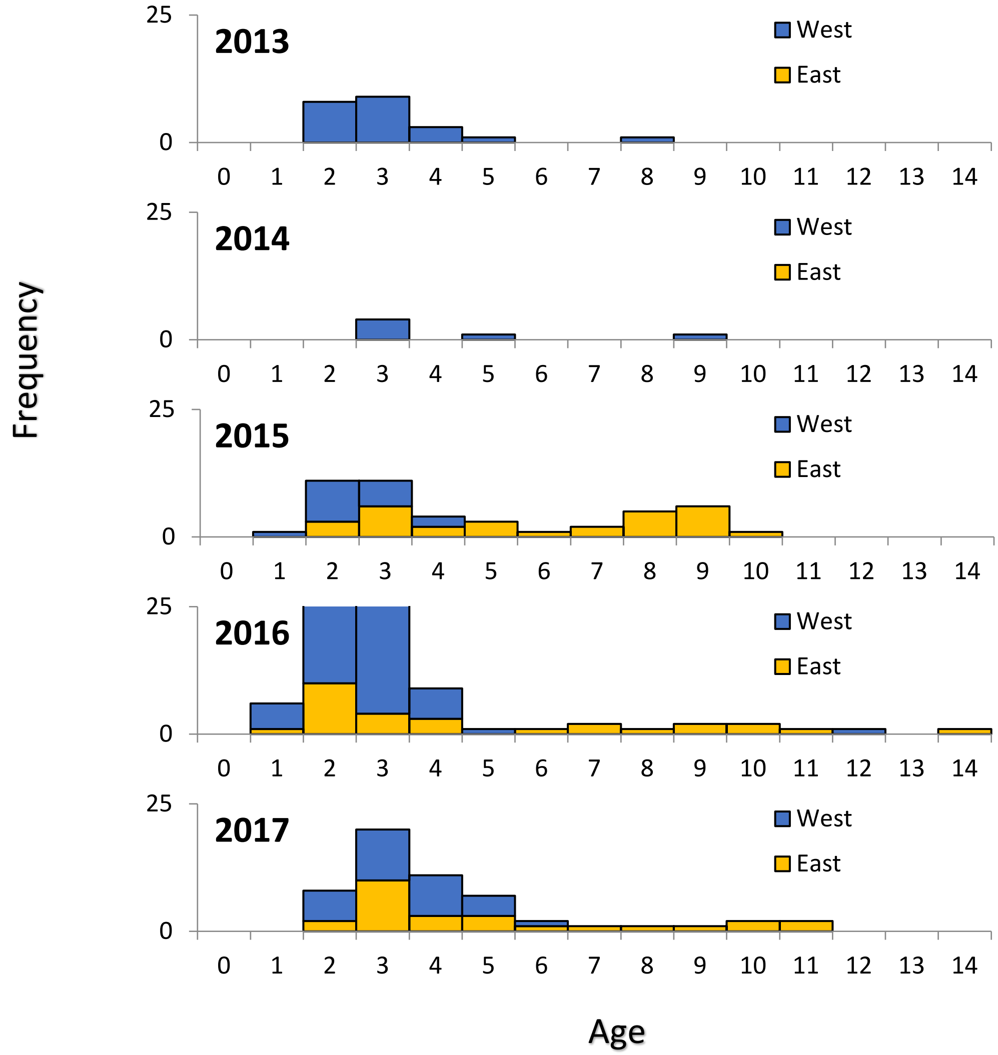


Figure 27 cont. Annual age structure of vermilion snapper caught in chevron traps in the NOAA Panama City lab reef fish survey, 2004-2017, by region.