Gag *Mycteroperca microlepis* Findings from the NMFS Panama City Laboratory Trap & Camera Fishery-Independent Survey – 2004-2012

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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 of the eastern Gulf of Mexico off Panama City, FL, with the primary objective of 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. The chevron trap is efficient at capturing a broad size range of several species of reef fish (Nelson et. al.1982, Collins 1990), and has been used by the South Atlantic MARMAP program for over 20 yr (McGovern et. al. 1998). Initially the PC survey used the same trap configuration and soak time used by MARMAP (McGovern et. al. 1998), but 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 tended 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 (Figure 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 done in Apalachee Bay that first year, but was expanded to the entire survey in 2006. Also in 2005 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. From 2005 through 2008 each site was sampled with the camera array followed immediately by a single trap. Beginning in 2009 trap effort was reduced ~50%, with one deployed at about every other video site, starting with the first site of the day. This was done so the number of video samples, and thereby the accuracy and precision of the video abundance estimates, could be increased. 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). All sampling has occurred between May and early October, but primarily during June through September. At each site, a CTD cast was made to collect temperature, salinity, oxygen, and turbidity profiles.

The survey sampling design was systematic through 2009 because of a very limited sample site universe. In 2010 the design was changed to 2 stage random after side scan sonar surveys that year yielded an order of magnitude increase in that universe. Five by five minute blocks known to contain 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 chosen first. Then 2 known reef sites a minimum of 300 m apart within each selected block are randomly selected (Figure 2). Alternates are also selected (if another boat was fishing the site or no hard bottom could be seen with sonar).

Depth coverage was ~8-30 m during 2004-07, and since then was steadily expanded to ~8 – 47 m (Fig. 3). Sampling effort has also increased since 2004. Sample sizes were 59 in 2004 (33 W: 26

E), 101 in '05 (24 W: 77 E), 113 in '06 (25 W: 89 E), 86 in '07 (29 W: 57 E), 98 in '08 (31 W: 66 E), 143 in '09 (48 W: 97 E), 162 in '10 (53 W: 109 E), 180 in '11 (65 W: 115 E), and 178 in '12 (61 W: 117 E). In 2004 and 2005 some sites were sampled twice: 9 in 04 and 23 in 05; thereafter each site was only sampled once in a given year.

Methods

Sampling is conducted only during daytime from 1 hr after sunrise until 1 hr before sunset. Chevron traps, identical to that used in the MARMAP program (McGovern et al. 1998) except for a 50% smaller throat opening, are baited each set with 3 previously frozen Atlantic mackerel *Scomber scombrus,* and soaked for 1.5 hr. Traps are fished as close as possible to the exact location sampled by the camera array that day. All trap-caught fish are identified, counted and measured to maximum total and fork length (FL only for gray triggerfish and TL only for black seabass). Both sagittal otoliths are collected from 4-5 randomly subsampled specimens of all 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 4 High 8 video cameras (2005 only) or 4 high definition (HDEF), digital video cameras (2006-08) mounted orthogonally 30 cm above the bottom of an aluminum frame. From 2007 to 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 HDEF 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. Beginning in 2011, a second SIS facing 180º from the other SIS was added, reducing the number of HDEFs to two; and both SIS's were also upgraded with HDEF, color mpeg cameras. The camera array was unbaited 2005-2008. Since 2009 the array 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. Prior to 2009, tapes of the 4 HDEF cameras were scanned, with the one with the best view of the habitat analyzed in detail. If none was obviously better, one was randomly chosen. In 2009 only the 3 HDEF video cameras were scanned and the one with the best view of the reef was analyzed. Starting in 2010, all 4 cameras – the HDEFs 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. Twenty min of the tape were viewed, beginning when the cloud of sediment disturbed by the landing of the array has dissipated. All fish captured on videotape were identified to the lowest discernable taxon. 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 (a common problem), fish identifications were confirmed on the much 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), and VMS measurements were only taken from a still frame showing the min count of a given species 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 files were examined to obtain fish measurements using VMS, and again, those measurements were only taken from a still frame showing the min count of a given species. In contrast, when using the scaling lasers on the array 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 in both species composition and abundance for many reef fishes east and west of Cape San Blas, especially in the inner and mid-shelf depths sampled by the Panama City survey, 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. Prior to 2010, the year we began using side scan sonar to locate reefs, lack of knowledge of reef habitat locations east of the Cape necessitated making a much higher proportion of "exploratory" camera and trap drops there versus west of the Cape. To compensate, more overall effort was expended in the east. Some of these "exploratory" sample sites turned out to be sand, mostly sand, or very marginal reef habitat at best, yielding little or no reef fish data. In addition, the gear occasionally missed the intended reef site. Inclusion of data from those sites would have reduced the precision of the abundance estimates and confounded any analyses. For that reason, video data – both habitat classification and fish counts – from all sites were screened, and those with no evidence that hard or live bottom was in close proximity, as well as sites where the view was obscured for some reason (poor visibility, bad camera angle), were censored (excluded) from calculations of relative abundance. As a result of this screening, of video samples east of the Cape, only 31 of 41 in 2005, 47 of 89 in 2006, 23 of 57 in 2007, 56 of 66 in 2008, 62 of 97 in 2009, 95 of 109 in 2010, 99 of 115, in 2011, and 100 of 115 in 2012 met the reef and visibility criteria and were retained. In contrast, west of the Cape, 24 of 25 sites in 2006, 29 of 29 in 2007, 29 of 31 in 2008, 42 of 47 in 2009, 52 of 53 in 2010, 57 of 64 in 2011, and 49 of 59 in 2012 were retained for analyses.

Results

Since the Panama City lab reef fish survey began in 2004/5, gag have consistently and commonly been observed with stationary video gear across the inner and mid- West Florida shelf both east and west of Cape San Blas (Tables 1, Fig. 4 and 5)(DeVries et al. 2008, 2009, 2012). Annual frequency of occurrence in video samples ranged from 21 to 57 % east of Cape San Blas during 2005-2011, and from 28 to 43 % west of the Cape during 2006-2011 (Table 1). In 2012 gag were much less frequently observed than in the previous 6 or 7 years – 10 % in the east and 12 % in the west (Table 1, Fig. 6). Gag were fairly uniformly distributed across all but the deepest depths sampled in the survey, with frequencies of occurrence in 2 m depth bins ranging from 21 to 50 % in 8 - 34 m depths with a peak at 22-24 m (Fig. 7). Low numbers of gag deeper than 34 m could be related to low sample size, lack of high relief sites in our sampling universe in those depths, and/or ontogenetic shifts in habitat preference.

The modal size of gag taken in chevron traps in the Panama City lab survey, 2004-2012, was 400-450 mm FL, and ranged from 250 to 700 mm (Fig. 8a). The survey strongly targets pre-recruit gags - about 93% were below the recreational minimum legal size limit of ~540 mm FL. Not surprisingly, a comparison of size data from trap catches with that from stereo images from the same years (09-12) indicated that the traps do select against most gag >600 mm FL, although fish that large are much less common in the survey area (and are more wary of the camera array) based on the few stereo measurements obtained and behavioral observations (Fig. 8b). Gag from east of Cape San Blas tended to be smaller than those west of the Cape; modes were 320 mm FL vs. 425 mm, means were 393 mm FL vs. 459 mm, and ranges were 235-637 mm FL vs. 315-675 mm (Fig. 9). This size difference likely reflects the differences in depths sampled between areas, i.e., much shallower in the east (Fig. 3) and the apparent positive relationship between size and depth in gags (Fig. 10).

Although sample sizes were quite small most years, annual size structure did appear to shift to increasingly larger sizes from 2005 through 2007, and then dropped considerably in 2008 followed by another steady increase through 2011 (Fig. 11). These patterns suggest different, strong cohorts were moving through the population during those periods. Size data from the video survey stereo images showed the same shift in size structure from 2009 through 2011, but the pattern did not continue in 2012, showing little change from 2011 (Fig. 12).

As expected, given the regional differences observed in size structure, gag were also younger east of the Cape. East of Cape San Blas, 2004-2012, they were 1 - 4 yr old with a mode of 2 (Fig. 13). West of the Cape they ranged between ages 1 and 5 yr, with a mode at age 3. Age structure in trap catches in 2004 and 2005 was dominated by 2 and 3 yr olds, respectively (2002 year class), but fish from that cohort were scarce in 2006, possibly due to the serious red tide event in 2005. There was no strong mode in 2006 or 2007, but from 2008 through 2011, the 2007 year class seemed to dominate. Only one gag was caught in 2012, suggesting that no new strong cohort was entering the population in the NE Gulf.

Nominal mean min count indices and frequency of occurrence data from the video survey, 2005-2012, revealed considerable annual fluctuations in the abundance of younger (ages 1-4 yr) gag on the northern portion of the west Florida shelf, at least on the inner and mid-shelf. Nominal mean min count declined 55% from 2006 to 2007, and 33% the following year; frequency of occurrence declined from a high of 52% in 2006 to 31% by 2008 (Fig. 15). Both metrics rebounded in 2009 but then declined steadily since. Nominal mean min count dropped 25% from 2009 to 2010, 27% the following year, and 73% from 2011 to 2012 – an overall decrease of 85% over the 3 years. During that same period, frequency of occurrence fell from 47 to 11 % - a 77% decrease. Nominal mean min counts were fairly similar east and west of Cape San Blas, and followed similar trends except in 2006 and 2011 (Fig. 6 and 16). In 2006 mean min count in the east was 190% higher than in the west – 2.90 vs. 1.0. This very large difference may reflect the presence of a strong 2004 cohort east of the Cape but not in the west that for some reason suffered abnormally high mortality (red tide?) prior to the 2007 sampling, although this is pure speculation. In 2011 mean min count was 102% higher in the west than the east – 0.93 vs. 0.46; but overall, between 2009 and 2012, min counts dropped in both regions - from 1.19 to 0.12 in the east (90% decline) and 1.10 to 0.29 in the west (74% decline).

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Tables

Table 1. Annual video survey sample sizes, % frequencies of occurrence, mean nominal video min counts, and standard errors of gag east and west of Cape San Blas, 2005-2012. Estimates calculated using censored data sets (see Methods).

	Total sites sampled		% Freq of occurrence		Mean nominal min count		Standard error	
Year	East	West	East	West	East	West	East	West
2005	31		25.8		0.548		0.296	
2006	49	24	57.1	41.7	2.898	1.000	0.722	0.295
2007	29	23	44.8	39.1	1.172	0.826	0.355	0.272
2008	56	29	32.1	27.6	0.679	0.690	0.169	0.268
2009	62	42	50.0	42.9	1.194	1.095	0.263	0.281

2010	95	52	34.7	38.5	0.895	0.808	0.174	0.188
2011	100	58	21.0	36.2	0.460	0.931	0.134	0.207
2012	101	49	9.9	12.2	0.119	0.286	0.038	0.157

Figures

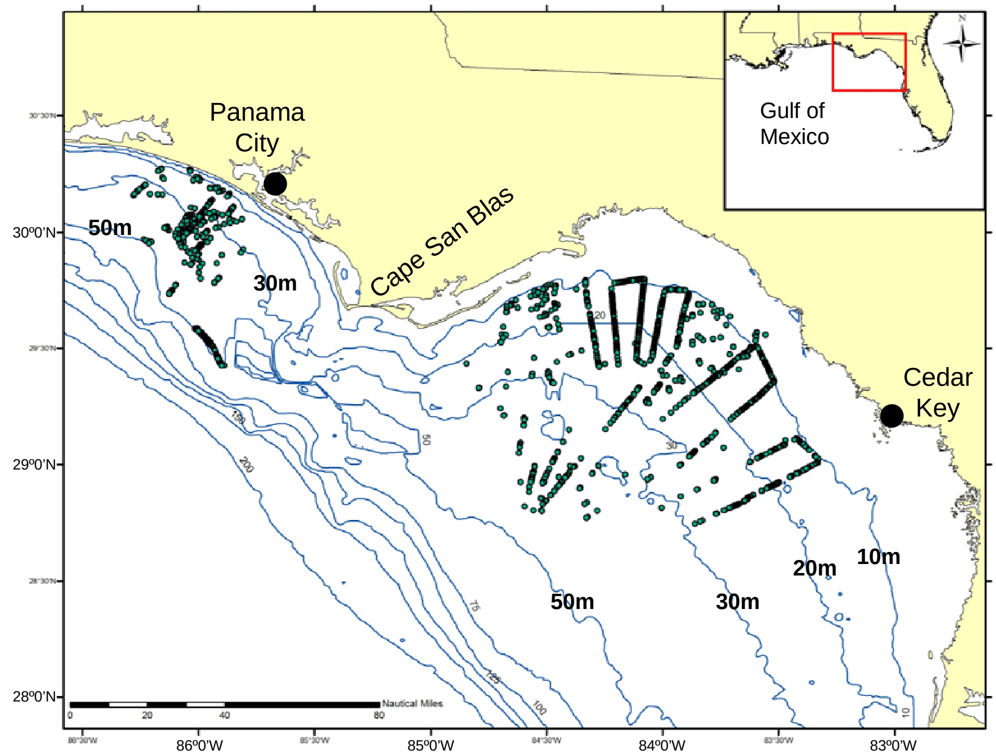

Figure 1**.** Locations of all natural reefs in the sampling universe of the Panama City NMFS reef fish video survey as of March 2012. Total sites: 2359, 722 west of and 1637 east of Cape San Blas.

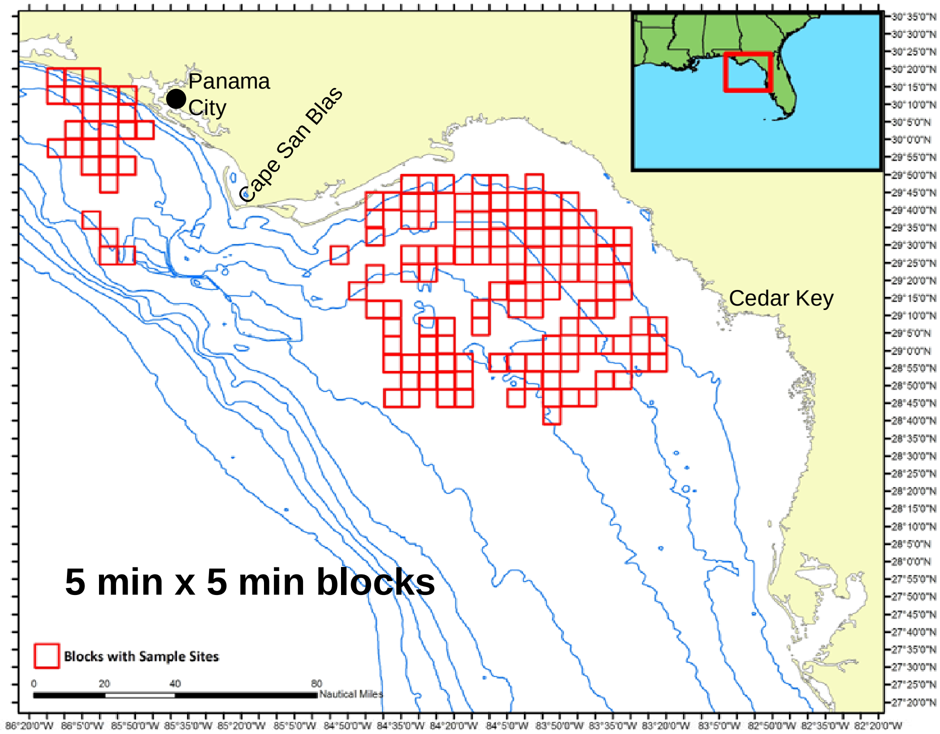

Figure 2. Sampling blocks, as of 2012, of the Panama City reef fish survey.

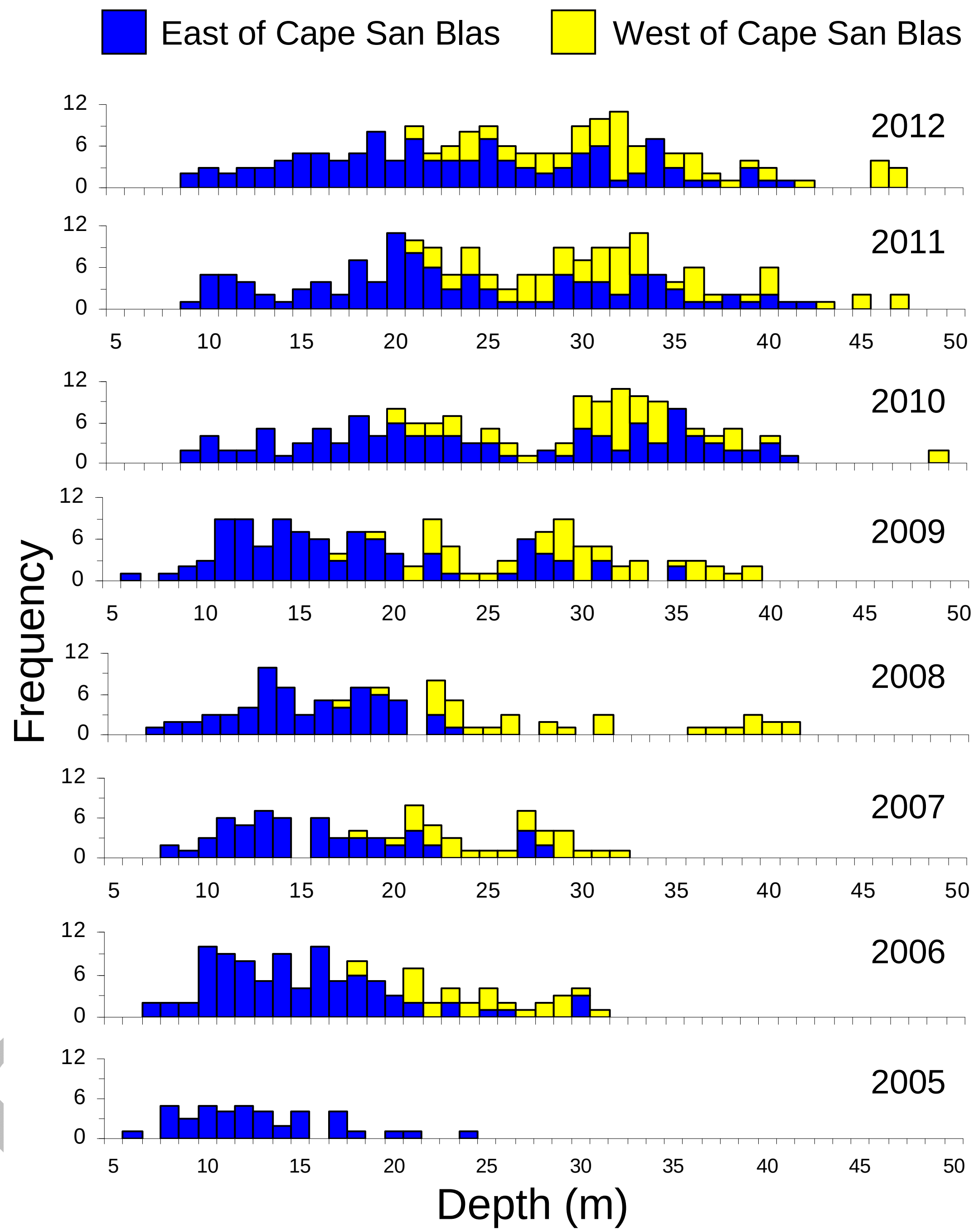

Figure 3. Annual depth distribution of Panama City reef fish survey video sample sites east and west of Cape San Blas, 2005-2012.

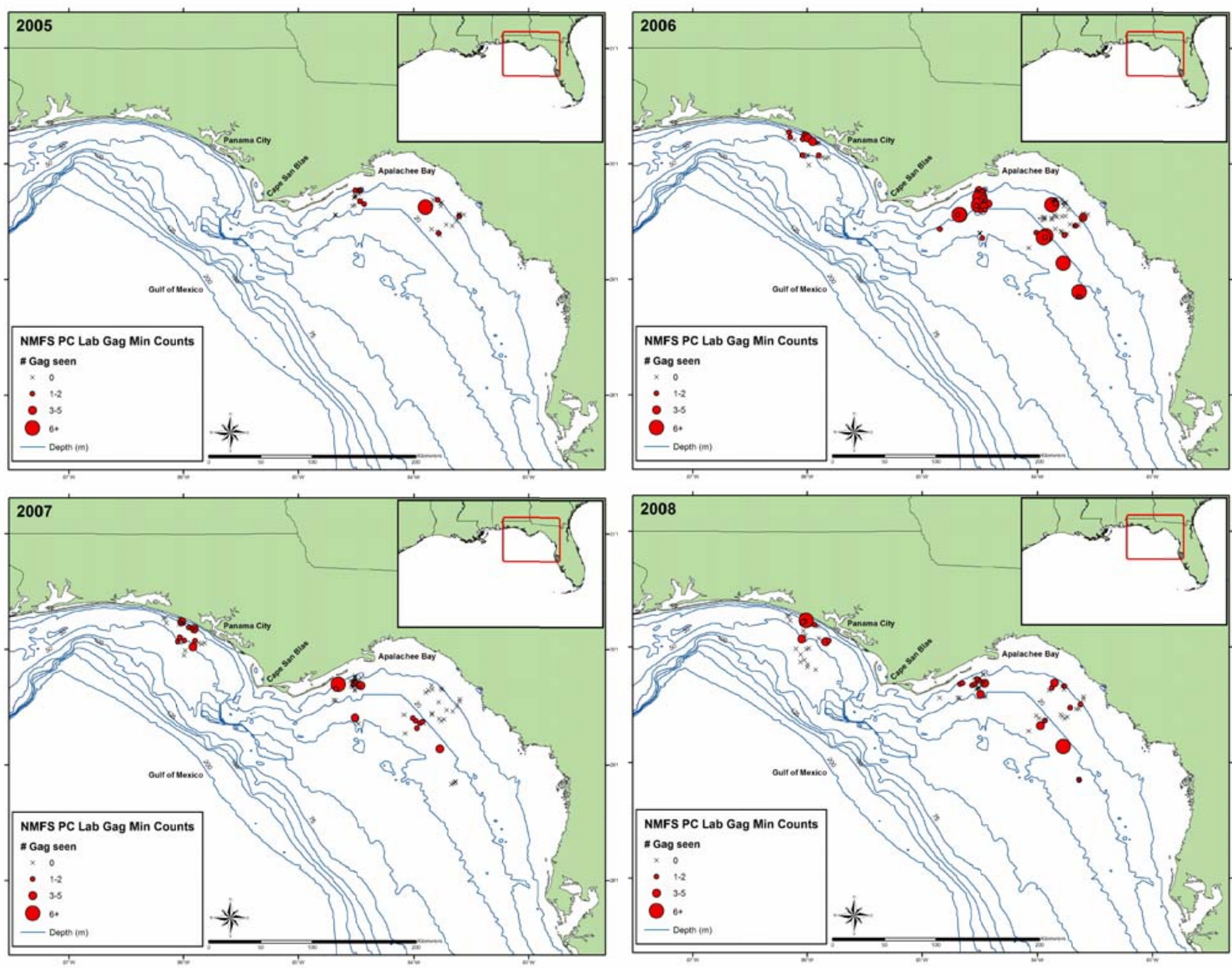

Figure 4. Annual distribution and relative abundance (min counts) of gag observed in the Panama City NMFS reef fish survey, 2005-2008, with stationary, high definition video or mpeg cameras. Sites sampled with video gear, but where no gag were observed, are indicated with an X.

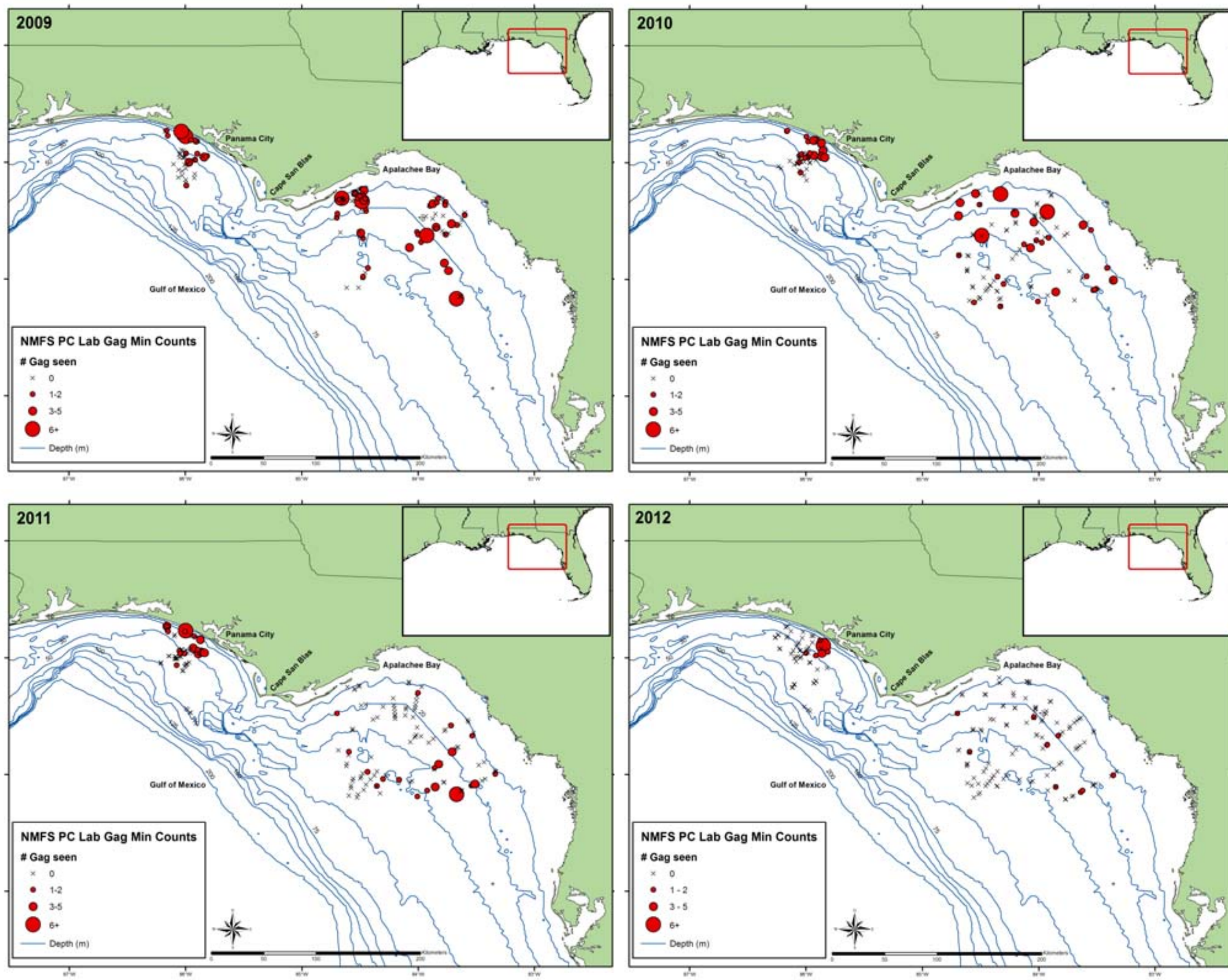

Figure 5. Annual distribution and relative abundance (min counts) of gag observed in the Panama City NMFS reef fish survey with stationary, high definition video or mpeg cameras, 2009-2012. Sites sampled with video gear, but where no gag were observed, are indicated with an X.

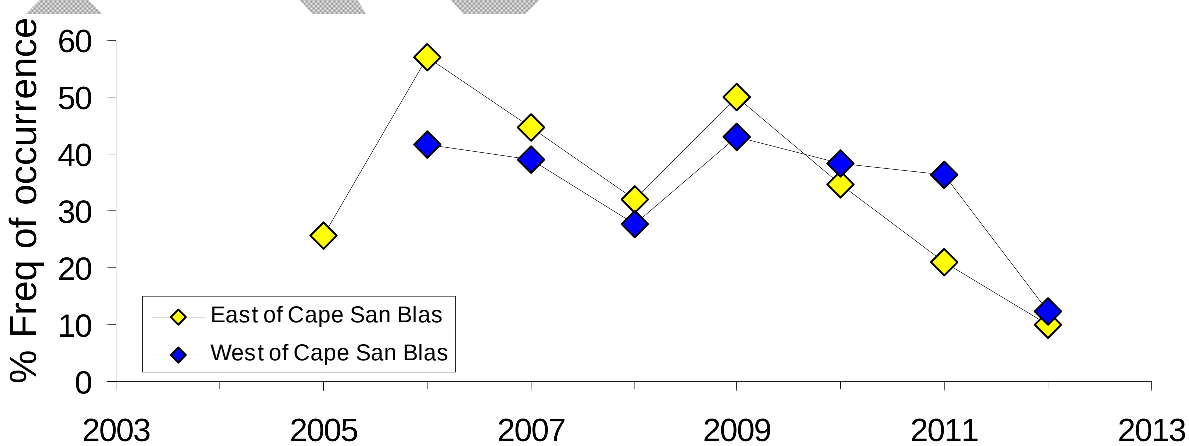

Figure 6. Annual percent frequency of occurrence of gag in video samples east and west of Cape San Blas, 2005-2012, using censored data sets.

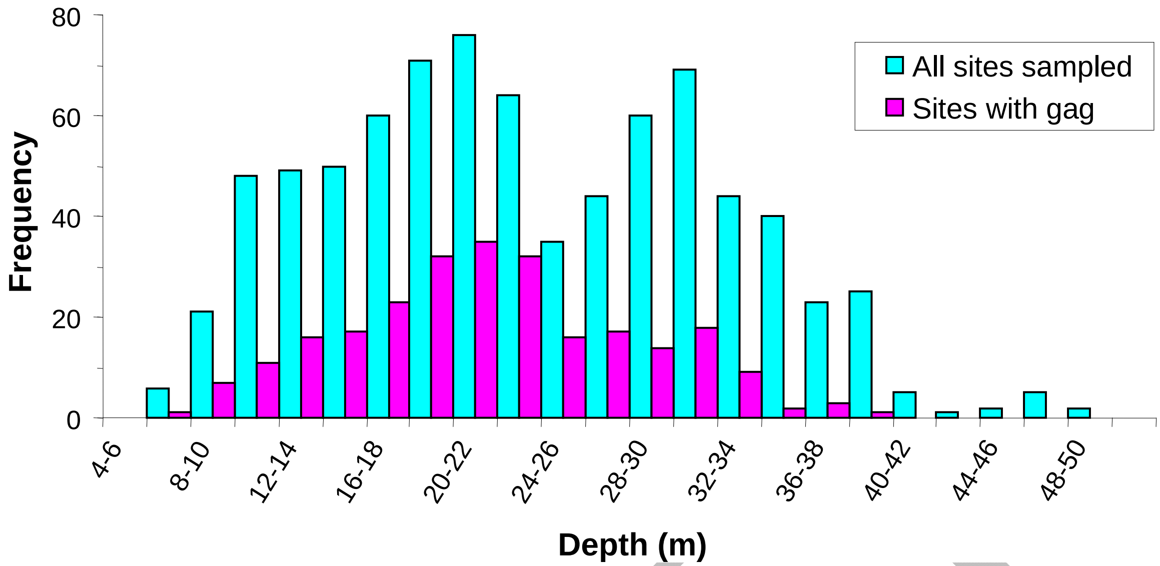

Figure 7. Depth distribution of all video sample sites and all sites with gag, 2005-2012.

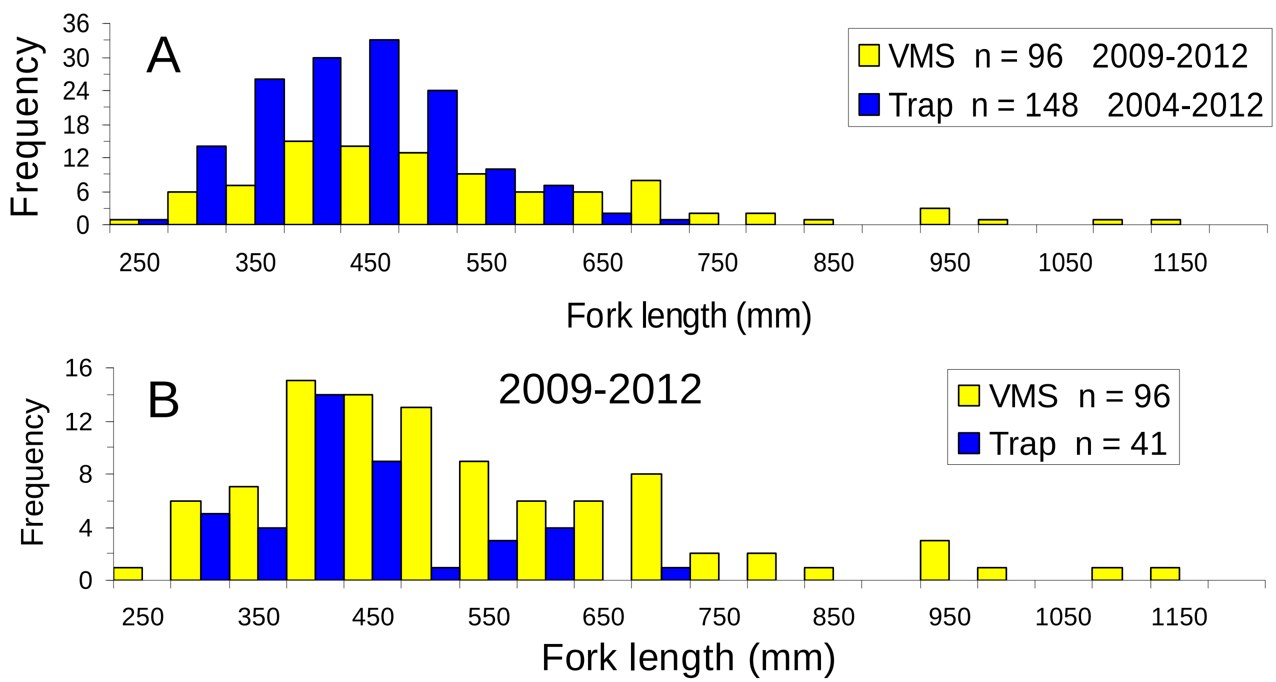

Figure 8. Overall size distributions of (A) all gag collected in chevron traps, 2004-2012, and measured in stereo still images using VMS, 2009-2012, and (B) all gag collected in chevron traps and measured in stereo still images using VMS, 2009-2012.

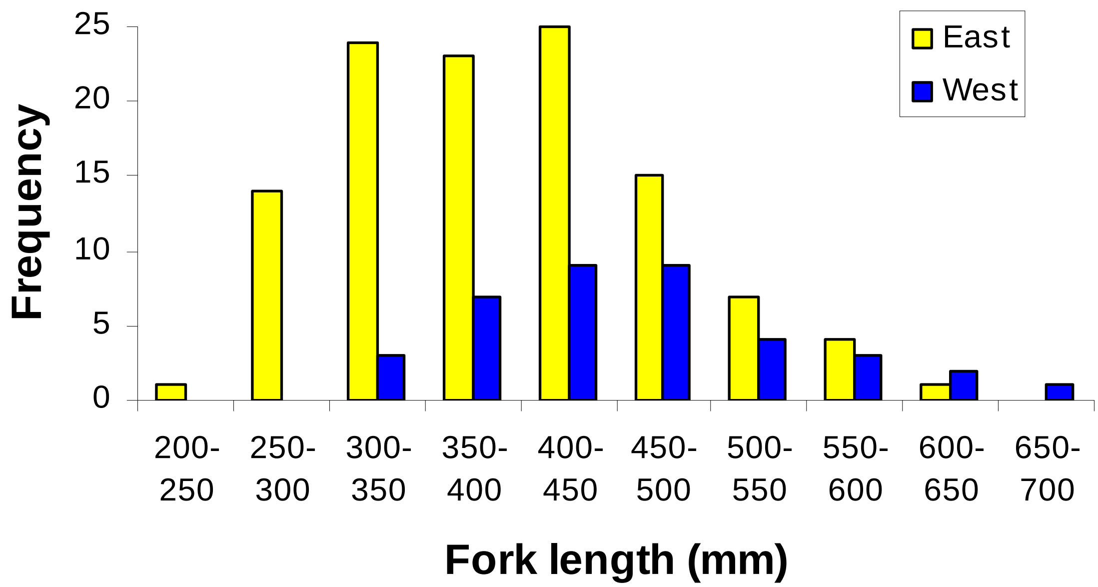

Figure 9. Overall size distributions of trap-caught gag by region, 2004-2012.

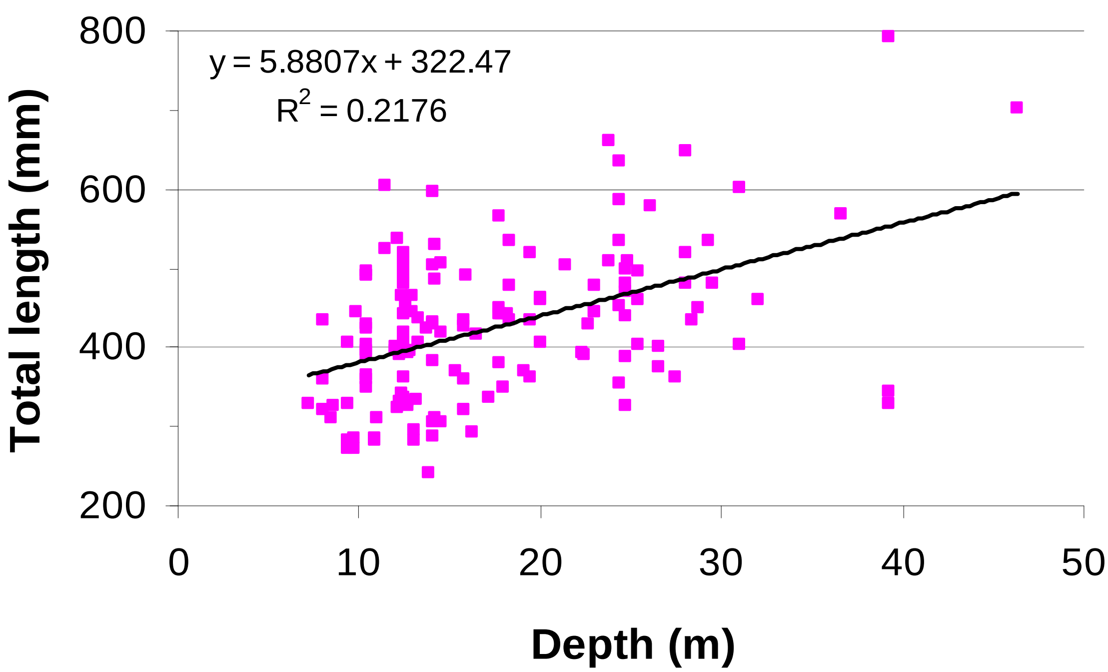

Figure 10. Total length vs. depth relationship of trap-caught gag, 2004-2012.

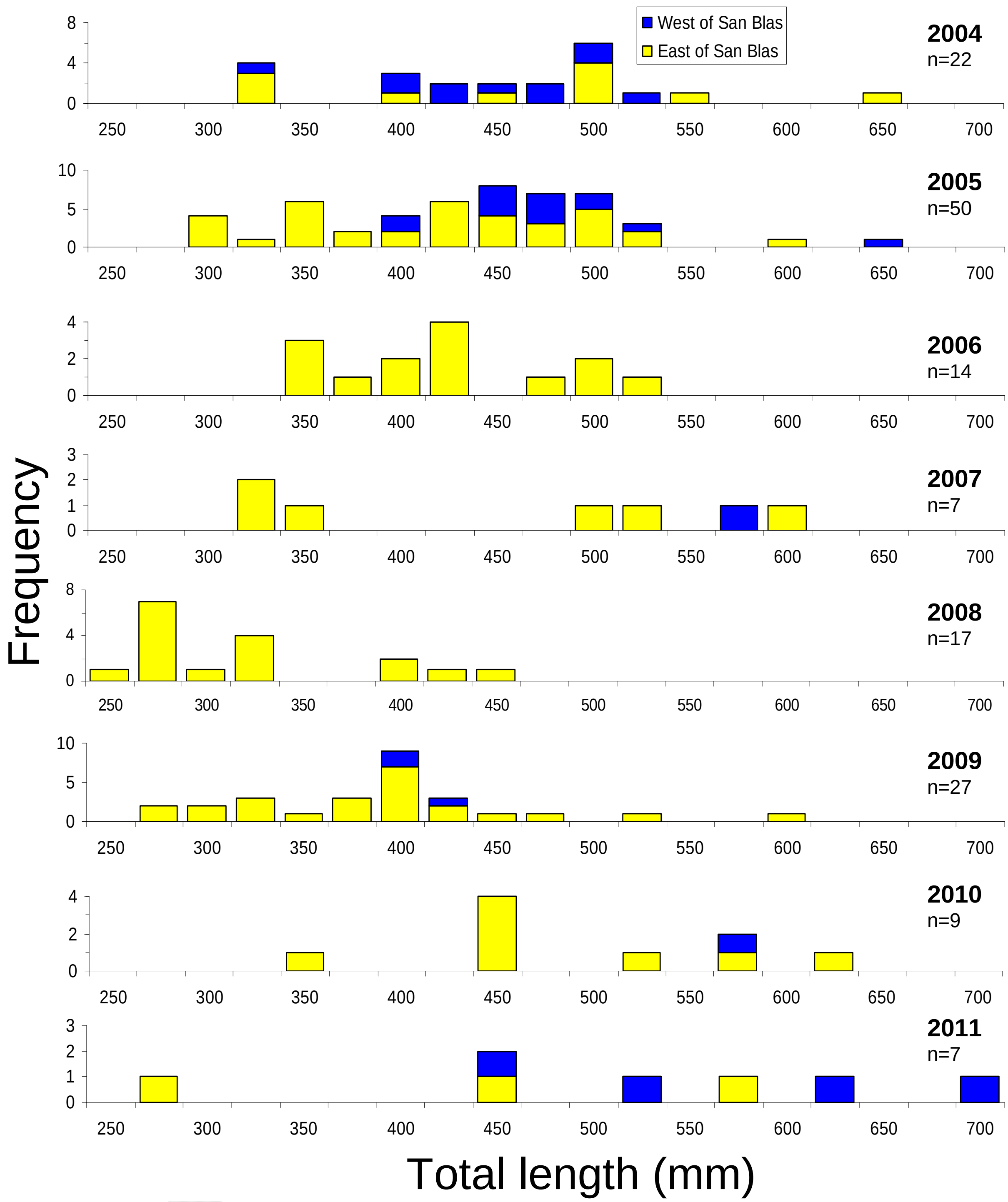

Figure 11. Annual size distributions of gag collected in chevron traps, 2004-2012, east and west of Cape San Blas.

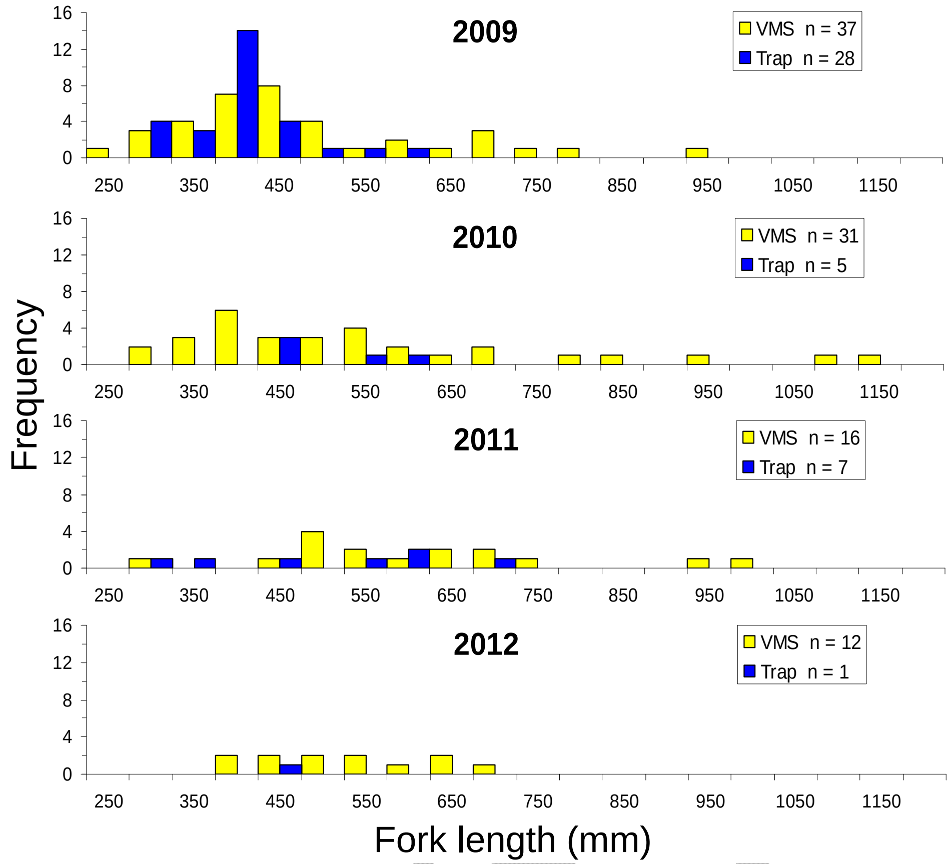

Figure 12. Comparison of overall (east + west) annual size distributions of gag collected in chevron traps and observed with stereo cameras (VMS) 2009-2012.

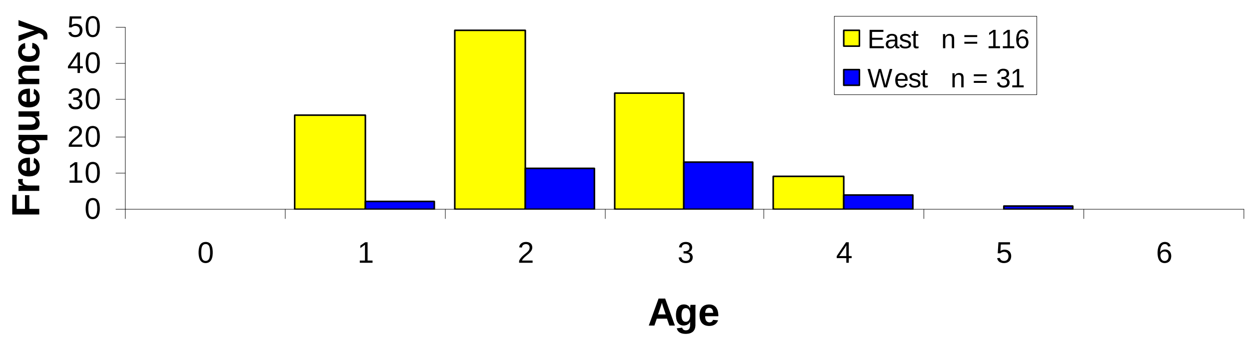

Figure 13. Overall age structure of trap-caught gag, 2004-2012, east and west of Cape San Blas.

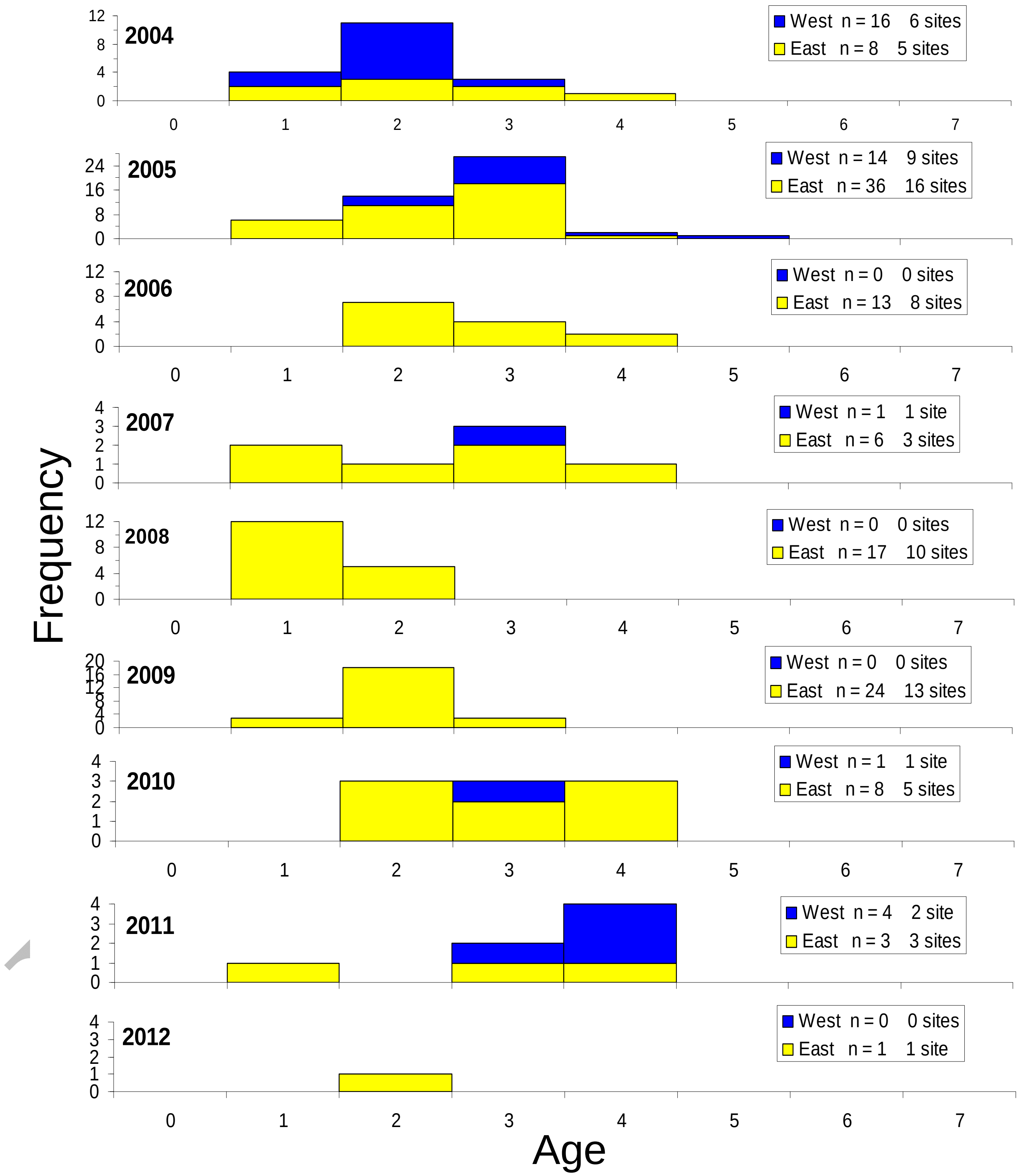

Figure 14. Annual age structure of trap-caught gag, 2004-2012, east and west of Cape San Blas.

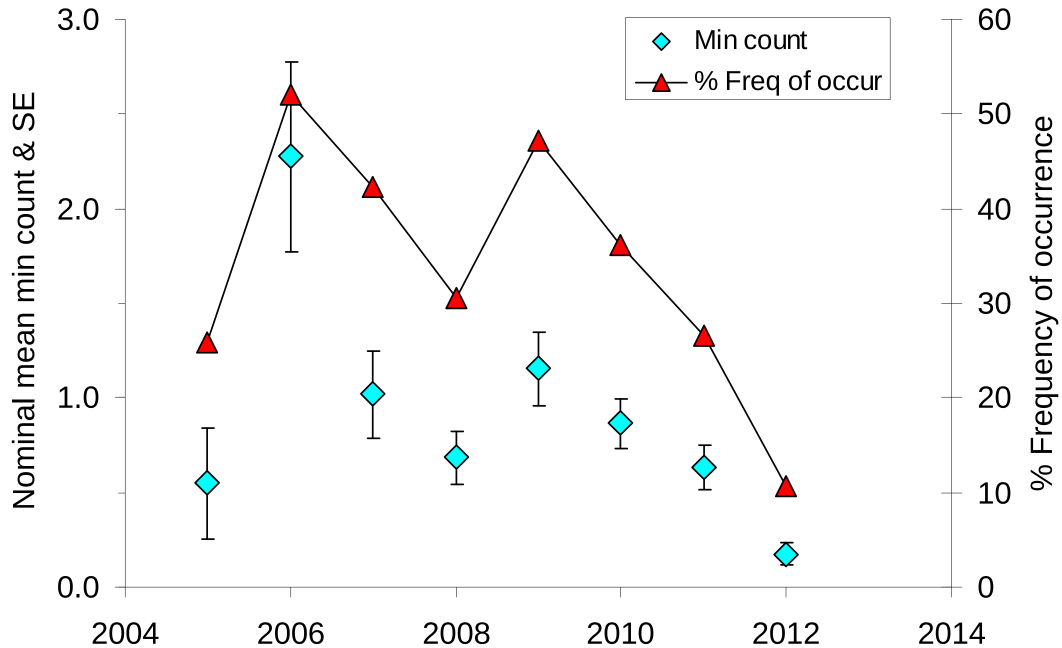

Figure 15. Overall (east + west of Cape San Blas) annual nominal mean video min counts ± SE and % frequencies of occurrence of gag, 2005-2012. Only 41 sites east of Cape San Blas were sampled in 2005, and 37 of those were shallower than 18 m.

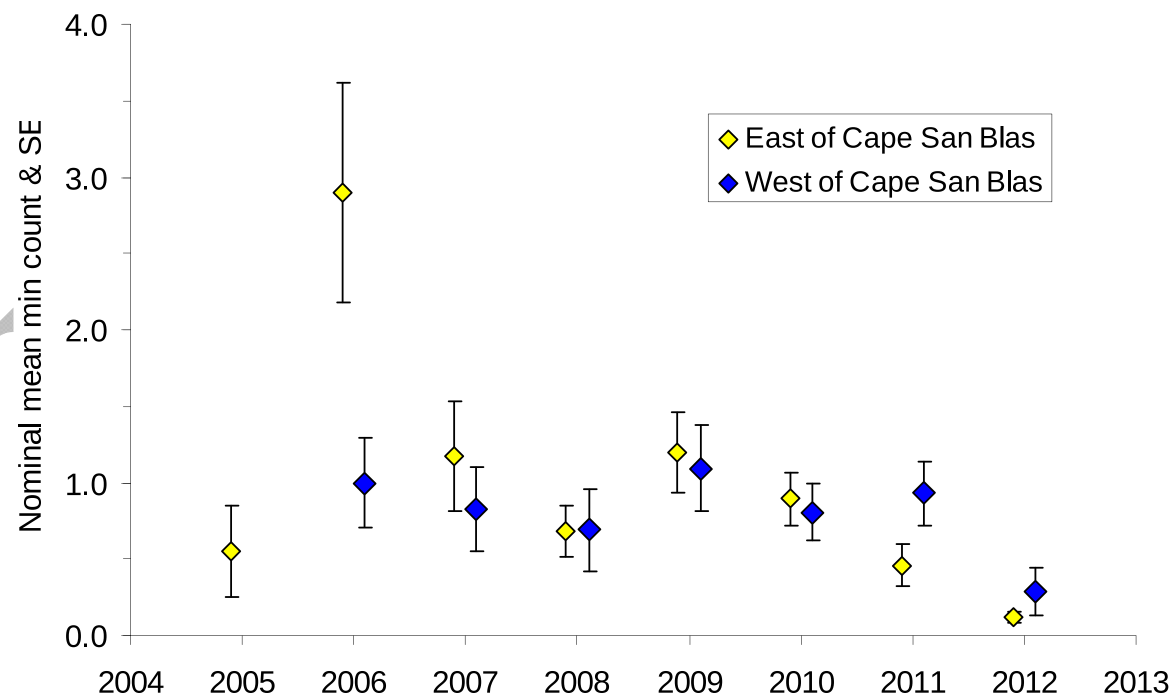

Figure 16. Nominal mean video min counts and standard errors of gag east and west of Cape San Blas, 2005-2012.