

SEAMAP Reef Fish Video Survey: Relative Indices of Abundance of Gag

Matthew D. Campbell, Kevin R. Rademacher, Paul Felts, Brandi Noble,
Joseph Salisbury, and John Moser

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Matthew D. Campbell, Kevin R. Rademacher, Paul Felts,
Brandi Noble, Joseph Salisbury, and John Moser
Southeast Fisheries Science Center
Mississippi Laboratories, Pascagoula, MS

Introduction

The primary objective of the annual Southeast Area Monitoring and Assessment Program (SEAMAP) reef fish video survey is to provide an index of the relative abundances of fish species associated with topographic features (e.g. reefs, banks, and ledges) located on the continental shelf of the Gulf of Mexico (GOM) from Brownsville, TX to the Dry Tortugas, FL (Figures 1, and 5-26). Secondary objectives include quantification of habitat types sampled (video, multi-beam and side-scan), and collection of environmental data throughout the survey. Because the survey is conducted on topographic features the species assemblages targeted are typically classified as reef fish (e.g. gag: *Mycteroperca microlepis*, red snapper: *Lutjanus campechanus*), but occasionally fish more commonly associated with pelagic environments are observed (e.g. Amberjack, *Seriola dumerili*). The survey has been executed from 1992-1997, 2001-2002, and 2004-present and historically takes place from April - May, however in limited years the survey was conducted through the end of August. The 2001 survey was abbreviated due to ship scheduling, during which, the only sites that were completed were located in the western Gulf of Mexico. Types of data collected on the survey include diversity, abundance (MinCount, i.e. MaxN), fish length, habitat type, habitat coverage, bottom topography and water quality. The size of fish sampled with the video gear is species specific however gag sampled over the history of the survey had fork lengths ranging from 238 – 1399 mm, and mean annual fork lengths ranging from 429 – 1352 mm (Table 3, Figure 27). Age and reproductive data cannot be collected with the camera gear but beginning with the 2012 survey, a vertical line component was coupled with the video drops to collect hard parts, fin clips, and gonads and was included in the life history information provided by the NMFS Panama City Laboratory.

Methods

Sampling design

Reef area available to select survey sites from is approximately 1771 km², of which 1244 km² is located in the eastern GOM and 527 km² in the western GOM. The large size of the survey area necessitates a two-stage sampling design to minimize travel time. The first-stage uses stratified random sampling to select blocks that are 10 minutes of latitude by 10 minutes of longitude in dimension (Figure 1). Block strata were defined by geographic region (4 regions: South Florida, Northeast Gulf, Louisiana-Texas Shelf, and South Texas), and by total reef habitat area contained in the block (blocks ≤ 20 km² reef, block > 20 km² reef). There are a total of 7 strata. A 0.1 by 0.1 mile grid is then overlaid onto the reef area contained within a given block and the ultimate sampling sites (second stage units) are randomly selected from that grid.

Gear and deployment

The SEAMAP reef fish survey has employed several camcorders in underwater housings since 1992. Sony VX2000 DCR digital camcorders mounted in Gates PD150M underwater housings were used from 2002 to 2005 and Sony PD170 camcorders during the years 2006 and 2007. In 2008 a stereo video camera system was developed and assembled at the NMFS Mississippi Laboratories - Stennis Space Center Facility and has been used in all subsequent surveys. The stereo video unit consists of a digital stereo still camera head, digital video camera, CPU, and hard drive mounted housed in an aluminum casing. All of the camcorder housings are rated to a maximum depth of 150 meters while the stereo camera housings are rated to 600 meters. Stereo cameras are mounted orthogonally at a height of 50 cm above the bottom of the pod and the array is baited with squid during deployment.

At each sampling site the stereo video unit is deployed for 40 minutes total, however the cameras and CPU delay filming for 5 minutes to allow for descent to the bottom, and settling of suspended sediment following impact. Once turned on, the cameras film for approximately 30 minutes before shutting off and retrieval of the array. During camera deployment the vessel drifts away from the site and a CTD cast is executed, collecting water depth, temperature, conductivity, and transmissivity from the surface to the maximum depth. Seabird units are the standard onboard NOAA vessels however the model employed was vessel/cruise dependent.

Video tape viewing

One video tape from each station is randomly selected for viewing out of all viewable videos. Videos that have issues with visibility, obstructions or camera malfunction cannot be randomly selected and are not viewed. Selected videos are viewed for twenty minutes starting from the time when the view clears from suspended sediment. Viewers identify, and enumerate all species to the lowest taxonomic level during the 20 minute viewable segment. From 1993-2007 the time when each fish entered and left the field of view was recorded a procedure referred to as time in - time out (TITO) and from these data a minimum count was calculated. The minimum count is the maximum number of individuals of a selected taxon in the field of view at one instance. Each 20 minute video is evaluated to determine the highest minimum count observed during a 20 minute recording. From 2008-present the digital video allows the viewer to record a frame number or time stamp of the image when the maximum number of individuals of a species occurred, along with the number of taxon identified in the image, but does not use the TITO method. Both the TITO and current viewing procedure result in the minimum count estimation of abundance (i.e. - mincount). Minimum count methodology is preferred because it prevents counting the same fish multiple times (e.g. if a fish were swimming in circles around the camera).

Fish length measurement

Beginning in 1995 fish lengths were measured from video using lasers attached on the camera system with known geometry. However, the frequency of hitting targets with the laser is low and to increase sample size any measureable fish during the video read was measured (i.e. not just at the mincount), and fish could have potentially been measured twice. The stereo cameras used in 2008-present allow size estimation from fish images. From 2008-2013 Vision Measurement System (VMS, Geometrics Inc.) was used to estimate size of fish and in 2014 we began use of SeaGIS software (SeaGIS Pty. Ltd.). Fish measurement is only performed at the point in the video corresponding to the mincount therefore fish are not measured twice.

Data reduction

Various limitations either in design, implementation, or performance of gear causes limitations in calculating mincount and are therefore dropped from the design-based indices development and analysis as follows. In 1992, each fish was counted every time it came into view over the entire record time and the total of all these counts was the maximum count. Maximum count methodologies are not preferred and the 1992 video tapes were destroyed during Hurricane Katrina and cannot be re-viewed, so 1992 data is excluded from analyses (unknown number of stations). From 1998 – 2000 and in 2003 the survey was not conducted. In 2001 the survey was spatially restricted to the west and was an abbreviated survey and therefore we removed that year as well. Occasionally tapes are unable to be read (i.e. organisms cannot be identified to species) for the following reasons including: 1) camera views are more than 50% obstructed, 2) sub-optimal lighting conditions, 3) increased backlighting, 4) increased turbidity, 5) cameras out of focus, 6) cameras failed to film. In all of these cases the station is flagged as 'XX' in the data set and dropped (190 total sites). Sites that did not receive a stratum assignment are also dropped (62) and all of those occurred early in the survey (1994-1995).

Explanatory variables and definitions

Year (Y) = The survey is conducted on an annual basis during the spring and the objective is to calculate standardized observation rates by year. Years included 1993-1997, 2001-2002, and 2004-2018.

Region (R) = The survey is conducted throughout the northern Gulf of Mexico, however historically the SEDAR data workshop has requested separate indices for the western and eastern Gulf which is divided at 89° west longitude. This variable is not included in the model itself.

Block (B) = The first stage of the random site selection process is selected from 10' latitude x 10' longitude blocks. Only blocks containing known reef are eligible for selection. Ten sites are randomly selected from within the blocks. Initial models always include a random block factor to test for autocorrelation among sites within a block.

Strata (ST) = Strata are defined by geographic region (4 regions: South Florida, Northeast Gulf, Louisiana-Texas Shelf, and South Texas), and by total reef habitat area contained in the block (blocks ≤ 20 km² reef, block > 20 km² reef). There are a total of 7 strata.

Depth (D) = Water depth at the lat-lon where the camera was deployed via TDR placed on the array.

Temperature (T) = Water temperature on the bottom (C°) taken during camera deployment via TDR placed on the camera array.

Dissolved oxygen (DO) = Dissolved oxygen (mg/l) taken via CTD cast slightly away from where the camera is deployed.

Salinity (S) = Salinity (ppt) taken via CTD cast slightly away from where the camera is deployed.

Silt sand clay (SSC) = Percent bottom cover of silt, sand, or clay substrates.

Shell gravel (SG) = Percent bottom cover of shell or gravel substrates.

Rock (RK) = Percent bottom cover of rock substrates.

Attached epifauna (AE) = Percent bottom cover of attached epifauna on top of substrate.

Grass (G) = Percent bottom covered by grass.

Sponge (SP) = Percent bottom covered by sponge.

Unknown sessiles (US) = Percent bottom covered by unknown sessile organisms.

Algae (AL) = Percent bottom covered by algae.

Hardcoral (HC) = Percent bottom covered by hard coral.

Softcoral (SC) = Percent bottom covered by soft coral.

Seawhips (SW) = Percent bottom covered by seawhips.

Relief Maximum (RM) = Maximum relief measured from substrate to highest point.

Relief Average (RA) = Average relief measured from substrate to all measurable points.

Reef (RF) = Boolean variable indicating whether or not a station landed on reef or missed reef.
It is a composite variable where positive reef stations are identified as having one of the following: > 5% hard coral or >5% rock or >5% soft coral

Index Construction

Video surveys produce count data that often do not conform to assumptions of normality and are frequently modeled using Poisson or negative-binomial error distributions (Guenther et al. 2014). Video data frequently has high numbers of ‘zero-counts’ commonly referred to as ‘zero-inflated’ data distributions, they are common in ecological count data and are a special case of over dispersion that cannot be easily addressed using traditional transformation procedures (Hall 2000). Delta lognormal models have been frequently used to model video count data (Campbell et al. 2012) but recent exploration of models using negative-binomial, poisson (SEDAR 2015), zero-inflated negative-binomial, and zero-inflated poisson models (Guenther et al. 2014) have been accepted for use in assessments in the southeast U.S. Additionally for certain species like Gulf of Mexico red grouper (SEDAR 2015) it has been determined that a combined video index was useful and included data from NMFS-Mississippi Labs, NMFS-

Panama City, and FWRI index (Thompson et al. 2019). We explored model fit using three different error distribution models to construct relative abundance indices including delta-lognormal, poisson and negative binomial.

As the assessment only required up dated model runs from previously accepted indices we only ran an east gulf model and used identical independent variables including year, reef, and maximum relief as fixed effects in the model ($\text{mincount} = \text{year} + \text{reef} + \text{maximum_relief}$). We used the composite variable ‘reef’ rather than the percent coverage of individual habitat variables because of the strong relationship that gag have with reef habitat and as a simplifying/aggregating variable to indicate if a camera observed reef habitat. Traditionally the individual coarse habitat metrics by themselves have not explained much variability. Additionally, in data webinars leading up to the workshop it was decided that a combination of video indices submitted by NMFS-Mississippi Labs, NMFS-Panama City and FWRI was also desired. Despite the good coordination between groups the percent habitat cover variables are fairly subjective and may be interpreted different among groups, however groups are consistent in determining if the camera landed on reef habitat (i.e. the ‘reef’ variable). Thus we have been consistently using the binomial reef variable to indicate whether or not the camera landed on what is considered to be reef. The GLIMMIX and MIXED procedure in SAS (v. 9.4) were used to develop the binomial and lognormal sub-models in the delta lognormal model (Lo et al. 1992), and GLIMMIX used to develop the poisson and negative binomial models. Best fitting models were determined by evaluating the conditional likelihood, over-dispersion parameter (Pearson chi-square/DF), and visual interpretation of the Q/Q plots.

Results

Gag were observed in low abundance at banks in both the western and eastern GOM (Figures 5-26), and the spatial distributions observed are highly reflective of the reef sampling universe used to select sampling sites (Figures 1). While gag are observed in the west GOM there were many years for which there were no observations (8/22 years with no positive observations, 33%) and generally they are observed in low abundance at 1-2 total reefs. Gag were consistently observed in the Madison-Swanson Marine Protected Area and nearby shelf edge break habitats in all years of the survey. Gaps in habitat level information existed in central Florida, Mississippi river delta region, and portions of the Texas coast however those gaps have slowly closed because 50% of the survey time since 2012 has been dedicated to habitat mapping with a multi-beam sonar (Figure 1). Thus the main sampling gap remaining in the survey around the shelf break is in close proximity to the Mississippi River Delta where water quality prevents collection of clear video. Inshore areas in the east Gulf are sampled by allied surveys run by NMFS Panama City and Florida Wildlife Research Institute. A separate combined index was submitted for the three video surveys that combines all three data sets into a single index of abundance. In most years the SEAMAP Reef Fish Video survey shows good coverage in the defined sampling universe, and coverage improved through time as the sampling universe expanded and more sites were added to the survey. Reef blocks from coastal Texas are often not selected for sampling due to small spatial coverage of reef, and frequent high winds and rough sea states during the spring/early summer sampling season.

For all models we determined that the negative binomial model fit the data best and returns a linear relationship as observed in the QQ plots (Figure 4), and reasonably low over

dispersion parameters (east Gulf = 1.06, good values approach 1.0). The over dispersion parameters and QQ plots were far better than either the Poisson or delta log-normal models. For previous gag assessments we attempted to create both west Gulf and Gulf wide indices however because of the inconsistent observation of the species in the west neither of these models converges to produce interpretable results. Models either did not converge or had very high CV. In addition, as this is an update to previous assessments, and that the east GOM model was previously used, we only present results for the east GOM.

In the east Gulf analysis variables retained included year, reef, and maxrelief (Table 1). The maximum relief variable was highly significant and the reef variable was only marginally significant but was retained in the model. East GOM gag proportion positives ranged from 0.016 (1994) to 0.23 (2004) with a reported value of 0.064 in 2019 (Table 2, Figure 2). East GOM gag standardized index of abundance (Table 2, Figure 3, predM) ranged from a low of 0.017 (1994) to 0.39 (2005), and reported a value of 0.125 in 2019 (Table 2, Figure 3). Coefficient of variation ranged from 17% (2011) to 98% (2019). Proportion positives and standardized index values indicate a consistent increase since a recent low point observed in 2016, having tripled standardized index mincount over those years. Despite the recent increases estimated mincounts are still significantly lower than peaks observed in the early 2000's and 2010's. Because there is insufficient data to create west and GOM wide population models, it is safe to say that gag population trends are primarily driven by eastern populations. Despite this eastern trend in the spatial data western population do exist in low abundance and frequency and are commonly but inconsistently observed on the high-relief Louisiana banks.

Length frequency histograms show that most of the measurements were captured from east populations with few coming from the west GOM. Regional size trends should be treated carefully due to the lack of sample in the west. East gulf Gag were 100 mm shorter than the west Gulf wide average however sample sizes in the west are small. In most years this trend holds true. Both regions showed a general trend of increasing total length of gag over the course of the survey with some inter-annual variability.

Literature cited

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Thompson, Kevin A. Theodore S. Switzer, Mary C. Christman, Sean F. Keenan, Christopher Gardner, Katherine E. Overly, Matt Campbell. 2019. Indices of abundance for Vermilion Snapper (*Rhomboplites aurorubens*) using combined data from three independent video surveys. SEDAR67-WP-03. SEDAR, North Charleston, SC. 17 pp.

Figure 1. Spatial distribution of known reef from which stations are randomly selected for sampling for the reef fish video survey. Over the history of the survey (1992-2019) new reef tract has been discovered and mapped and therefore this map represents what was available through 2019, and not necessarily what has been available over the entire time series.

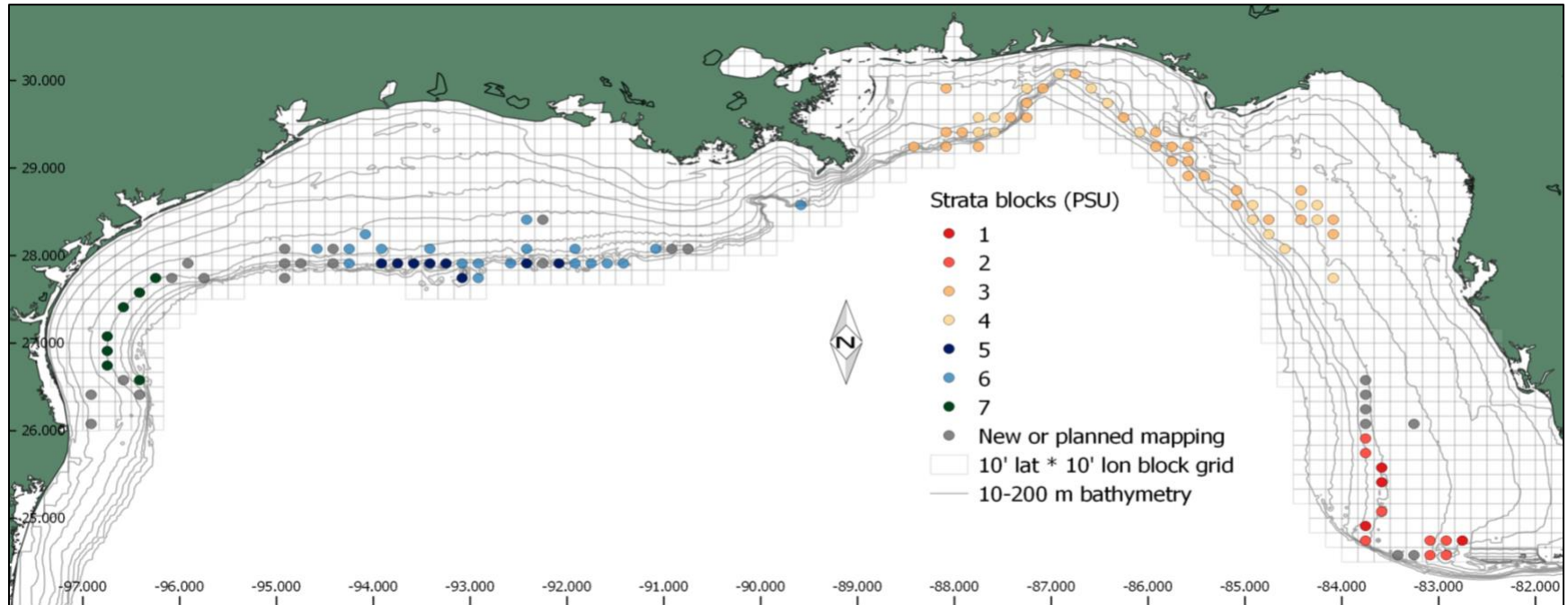


Table 1. Type III fixed effects output from the negative binomial model for east Gulf Gag.

Type III Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr>F
year	23	2487	3.46	<.0001
REEF	1	2487	3.22	0.0728
MREL	1	2487	11.96	0.0006

Table 2. Output for the negative binomial index of relative abundance of Gag by year, east Gulf negative binomial model run.

Year	N	PA	mincount	predM	CV	Lower 95% CI	Upper 95% CI	Run
1993	99	0.061	0.071	0.069	39.925	0.064	0.075	eGOM
1994	61	0.016	0.016	0.017	46.143	0.015	0.019	eGOM
1995	45	0.022	0.044	0.046	35.338	0.041	0.051	eGOM
1996	100	0.100	0.120	0.125	37.930	0.116	0.134	eGOM
1997	131	0.069	0.069	0.070	29.855	0.066	0.074	eGOM
2002	118	0.212	0.331	0.310	48.030	0.283	0.337	eGOM
2004	103	0.223	0.320	0.322	26.354	0.306	0.339	eGOM
2005	140	0.193	0.379	0.390	43.987	0.362	0.419	eGOM
2006	149	0.121	0.181	0.192	34.781	0.181	0.202	eGOM
2007	153	0.176	0.261	0.263	42.890	0.245	0.281	eGOM
2008	97	0.041	0.041	0.042	35.972	0.039	0.045	eGOM
2009	134	0.082	0.127	0.125	26.282	0.119	0.130	eGOM
2010	127	0.142	0.173	0.169	19.822	0.163	0.175	eGOM
2011	182	0.159	0.225	0.229	17.618	0.223	0.235	eGOM
2012	131	0.160	0.260	0.262	26.335	0.250	0.274	eGOM
2013	79	0.152	0.253	0.232	39.231	0.212	0.253	eGOM
2014	112	0.080	0.116	0.112	25.952	0.106	0.117	eGOM
2015	57	0.140	0.175	0.178	41.656	0.158	0.198	eGOM
2016	97	0.041	0.041	0.040	21.149	0.039	0.042	eGOM
2017	118	0.059	0.059	0.060	24.122	0.058	0.063	eGOM
2018	88	0.045	0.068	0.068	21.301	0.065	0.071	eGOM
2019	140	0.064	0.107	0.125	98.952	0.104	0.146	eGOM

Figure 2. Plot of the proportion positives for Gag, for the east Gulf negative binomial model run.

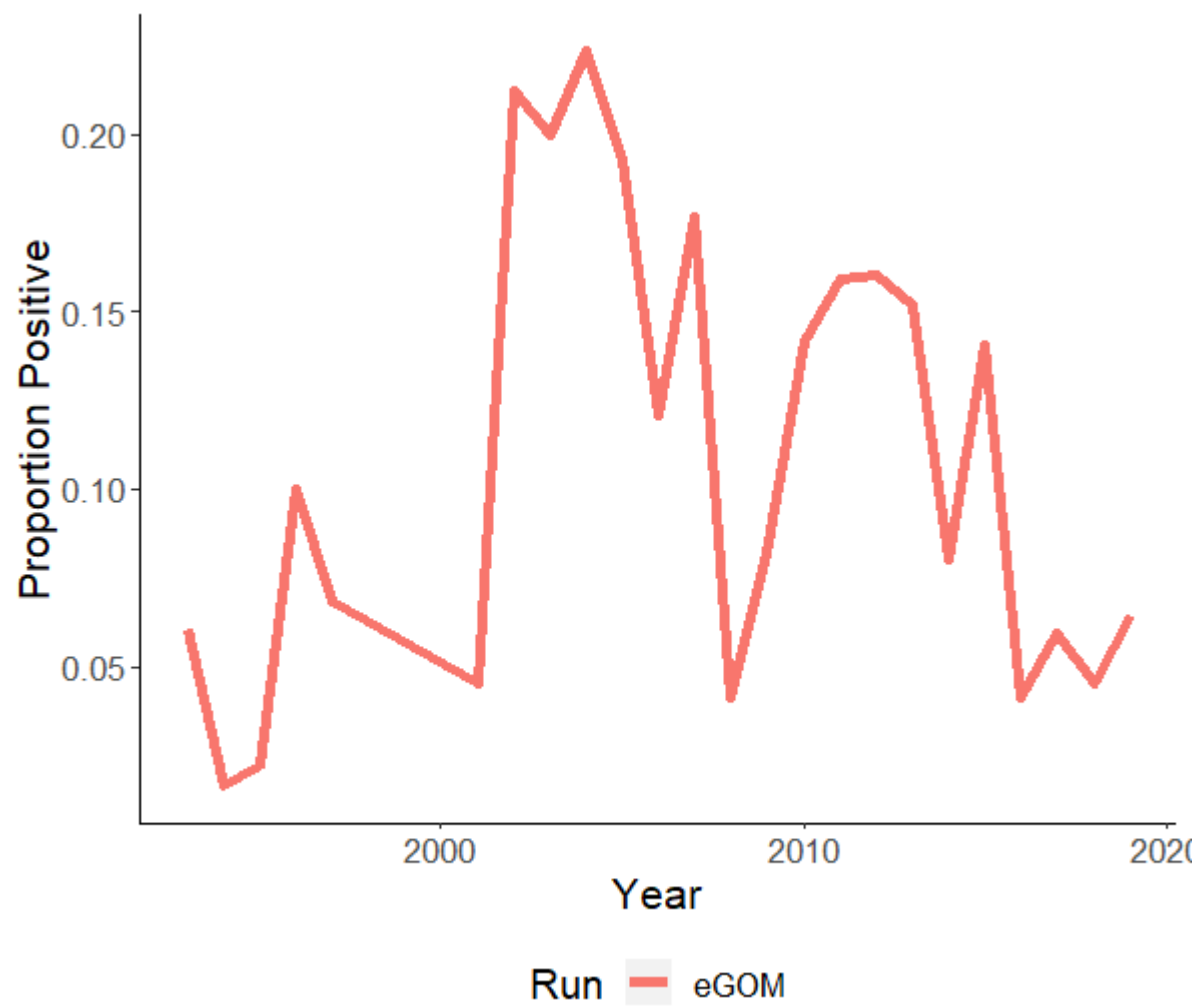


Figure 3. Plot of the standardized indices for Gag, for the east Gulf wide negative binomial model run.

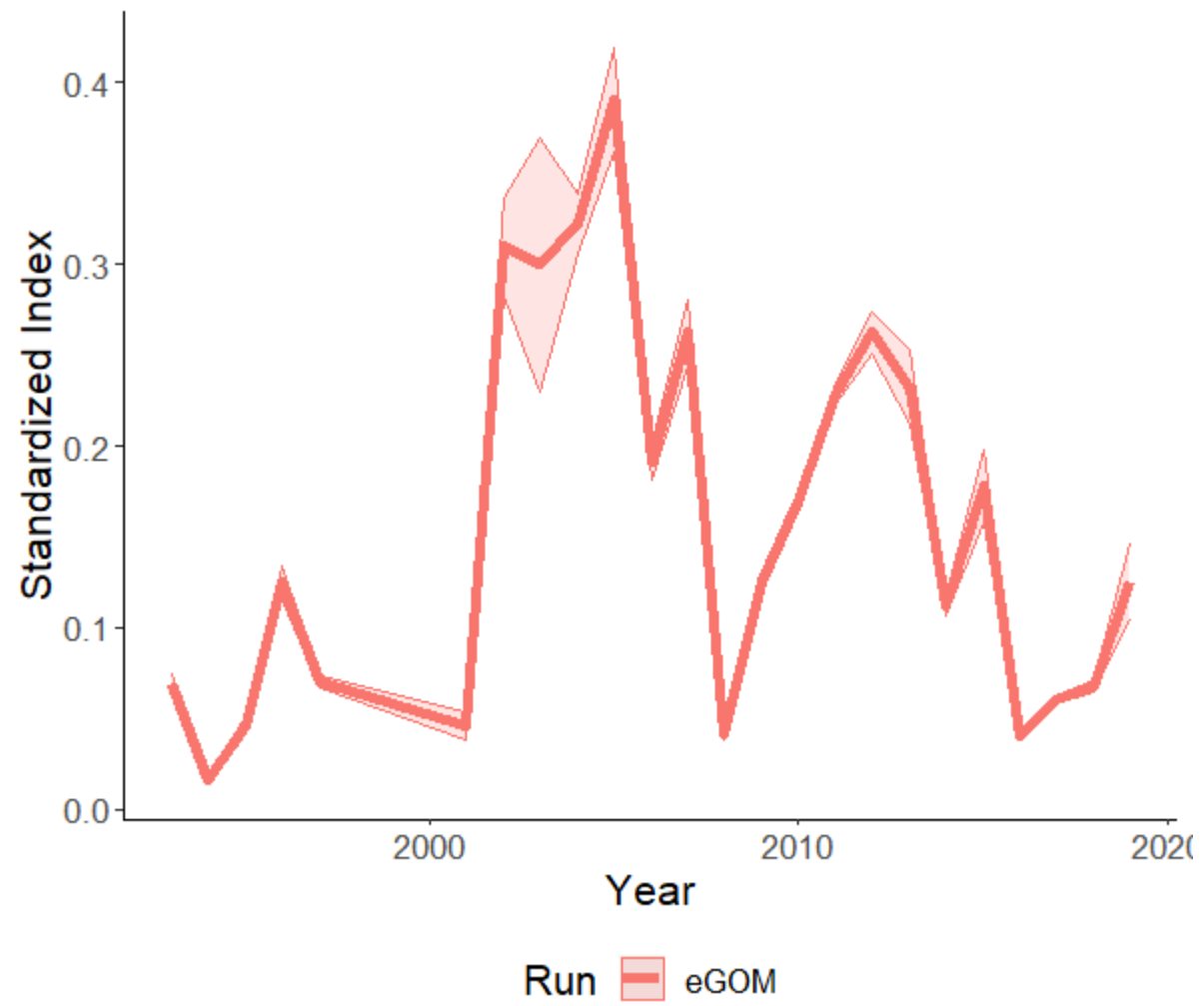


Figure 4. QQ plot of conditional residuals for the east Gulf negative binomial model run.

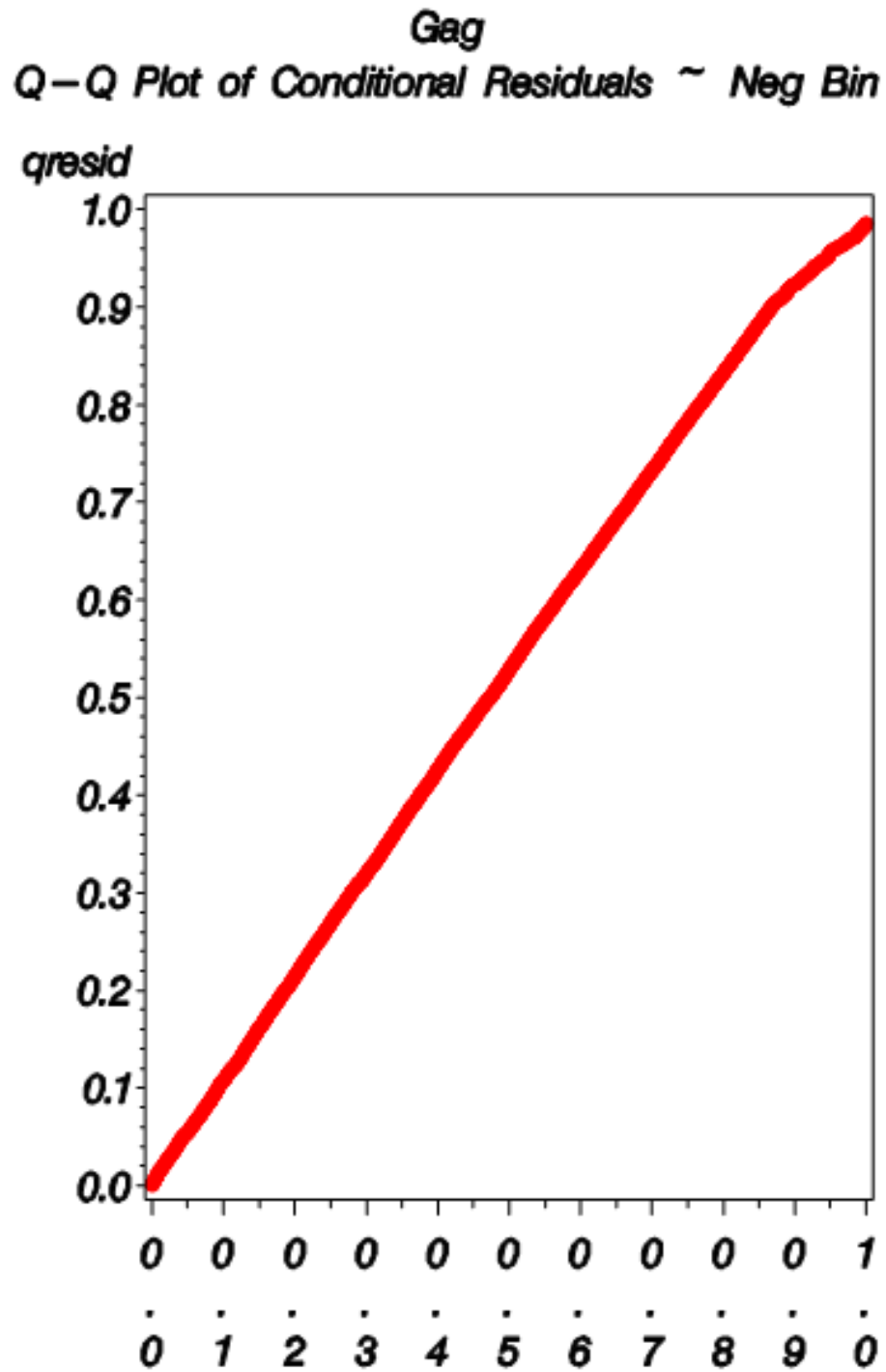


Figure 5. Map of Gag mincounts during the SEAMAP reef fish video cruise in 1993.

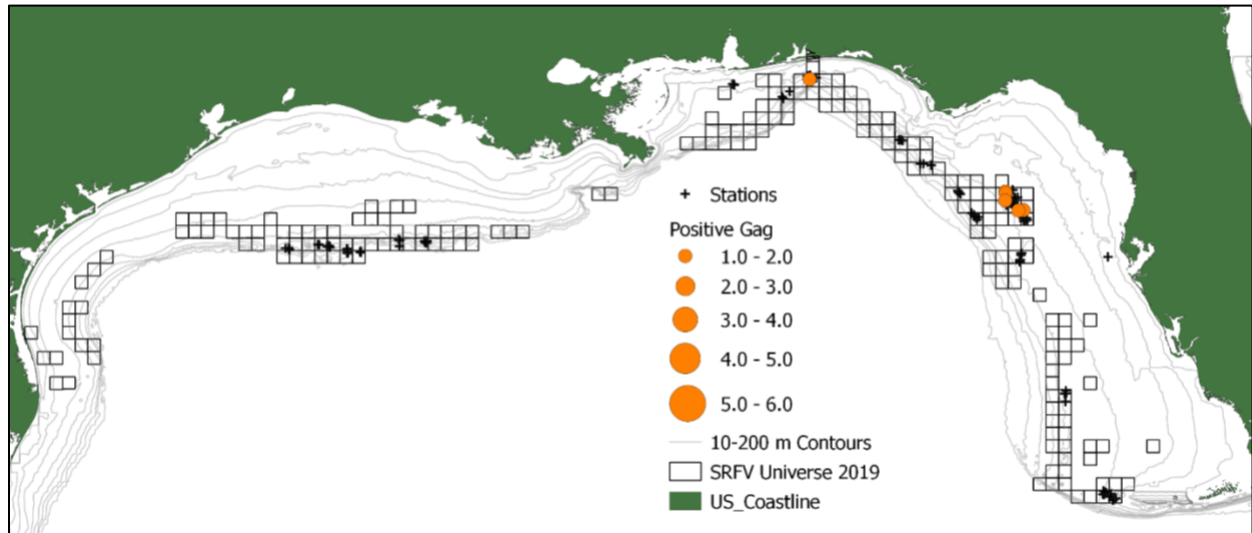


Figure 6. Map of Gag mincounts during the SEAMAP reef fish video cruise in 1994.

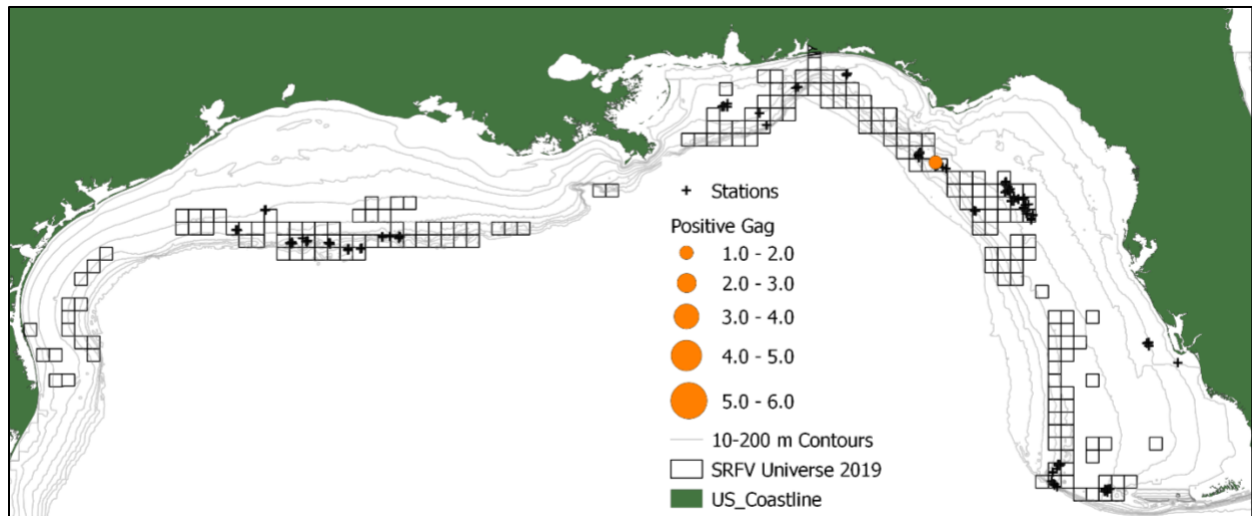


Figure 7. Map of Gag mincounts during the SEAMAP reef fish video cruise in 1995.

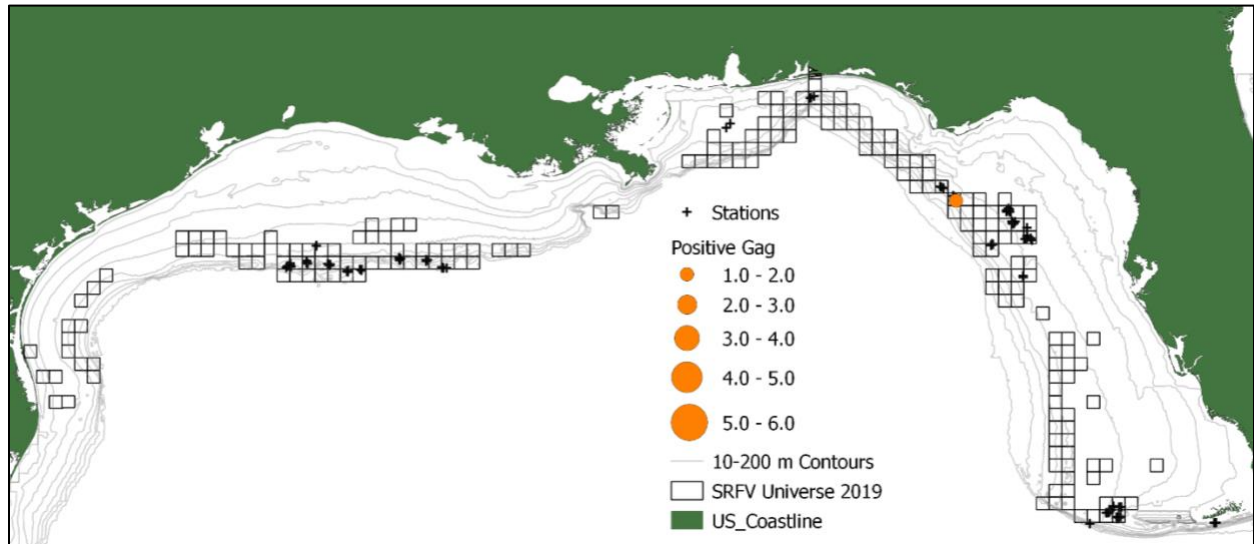


Figure 8. Map of Gag mincounts during the SEAMAP reef fish video cruise in 1996.

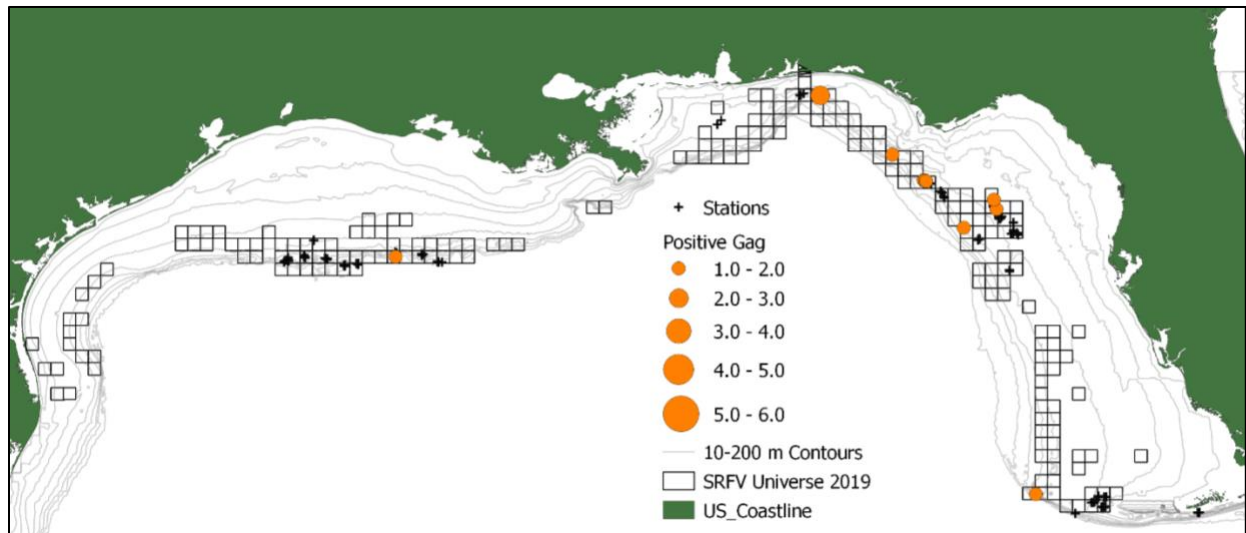


Figure 9. Map of Gag mincounts during the SEAMAP reef fish video cruise in 1997.

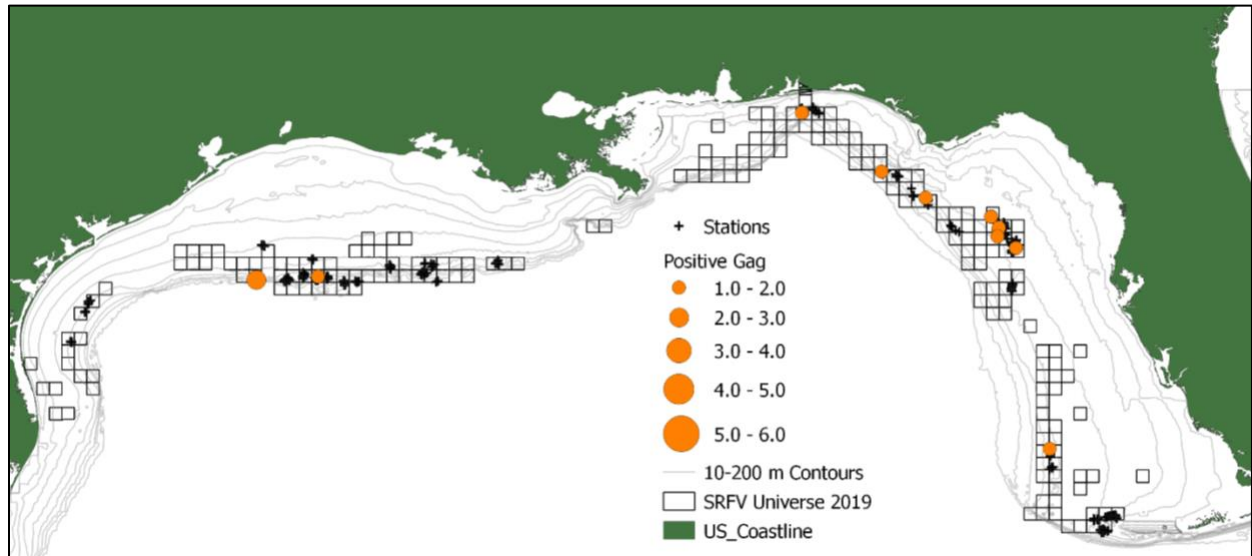


Figure 10. Map of Gag mincounts during the SEAMAP reef fish video cruise in 2002.

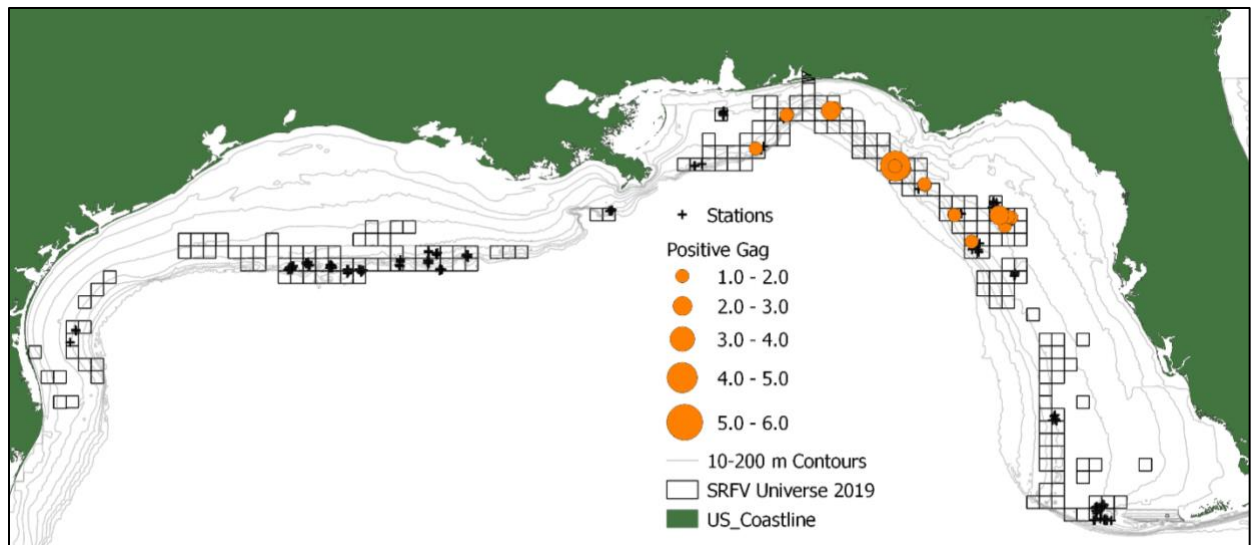


Figure 11. Map of Gag mincounts during the SEAMAP reef fish video cruise in 2004.

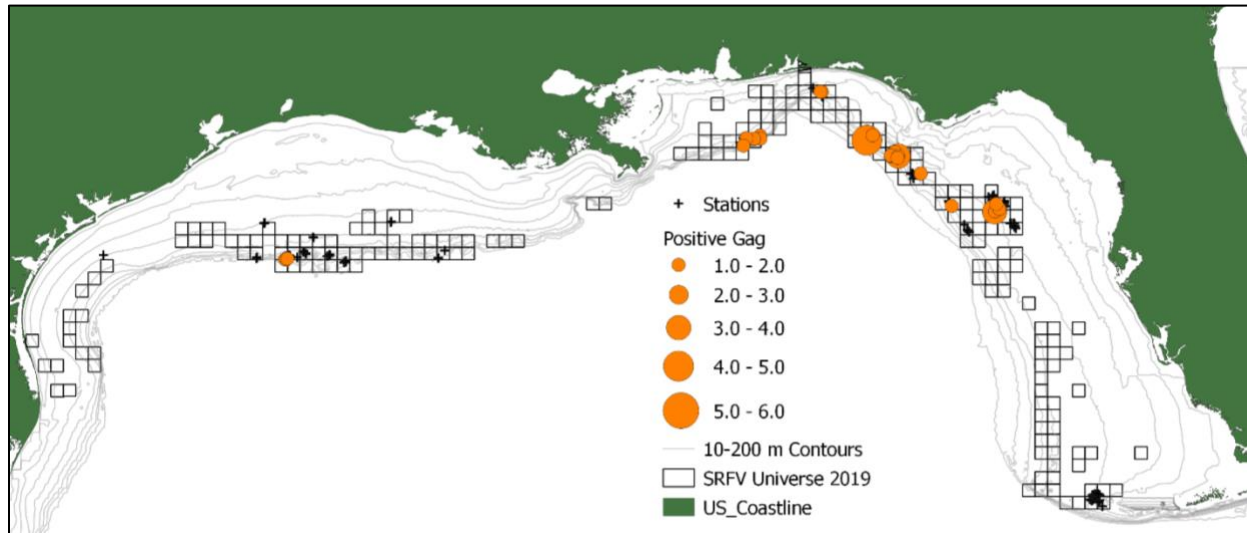


Figure 12. Map of Gag mincounts during the SEAMAP reef fish video cruise in 2005.

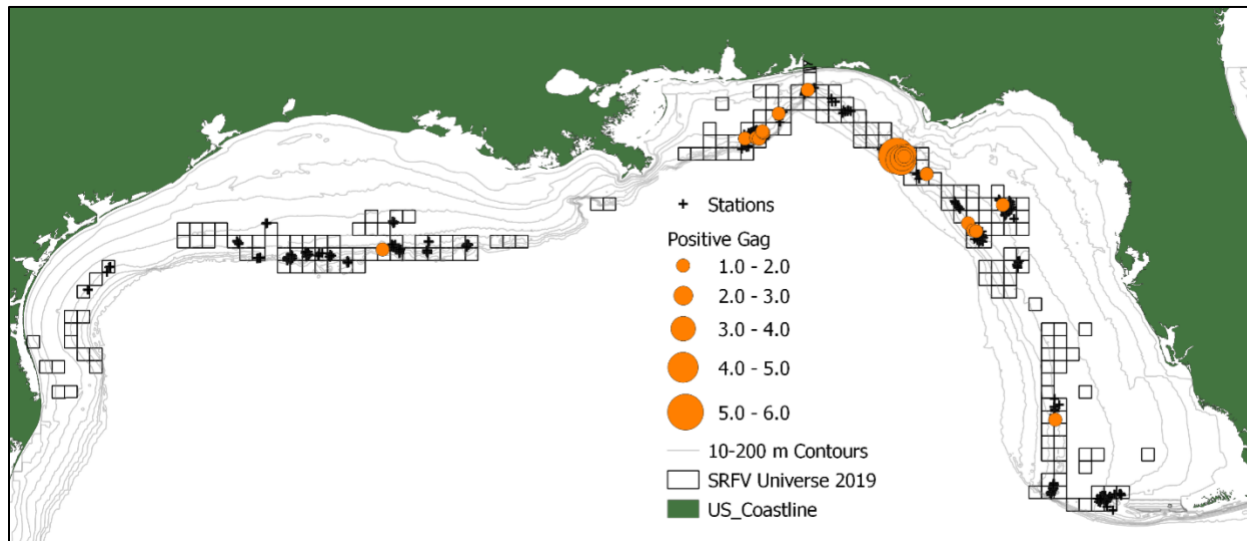


Figure 13. Map of Gag mincounts during the SEAMAP reef fish video cruise in 2006.

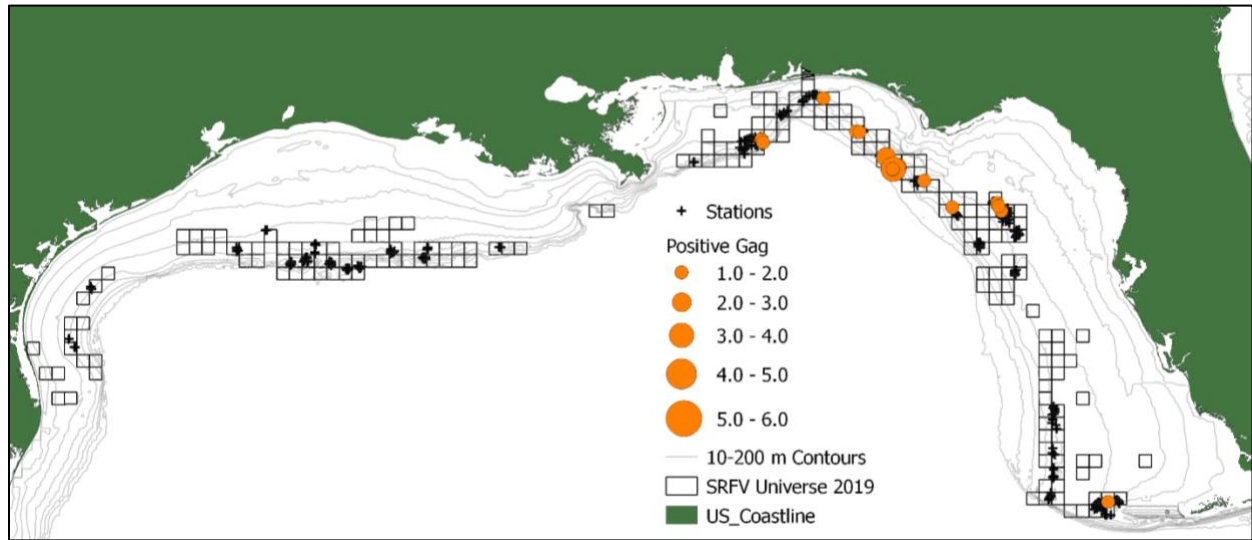


Figure 14. Map of Gag mincounts during the SEAMAP reef fish video cruise in 2007.

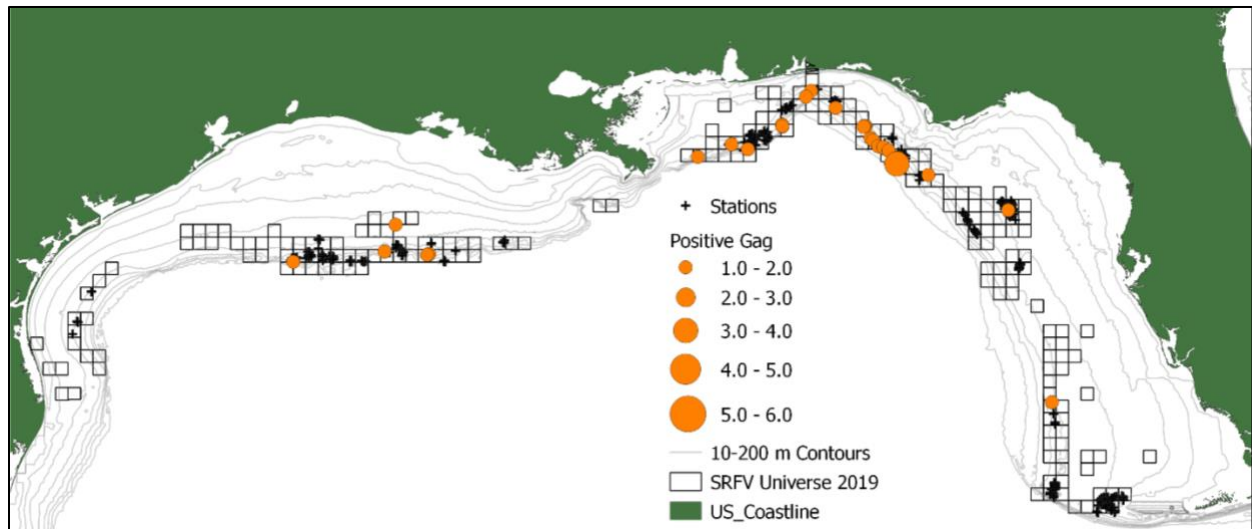


Figure 15. Map of Gag mincounts during the SEAMAP reef fish video cruise in 2008.

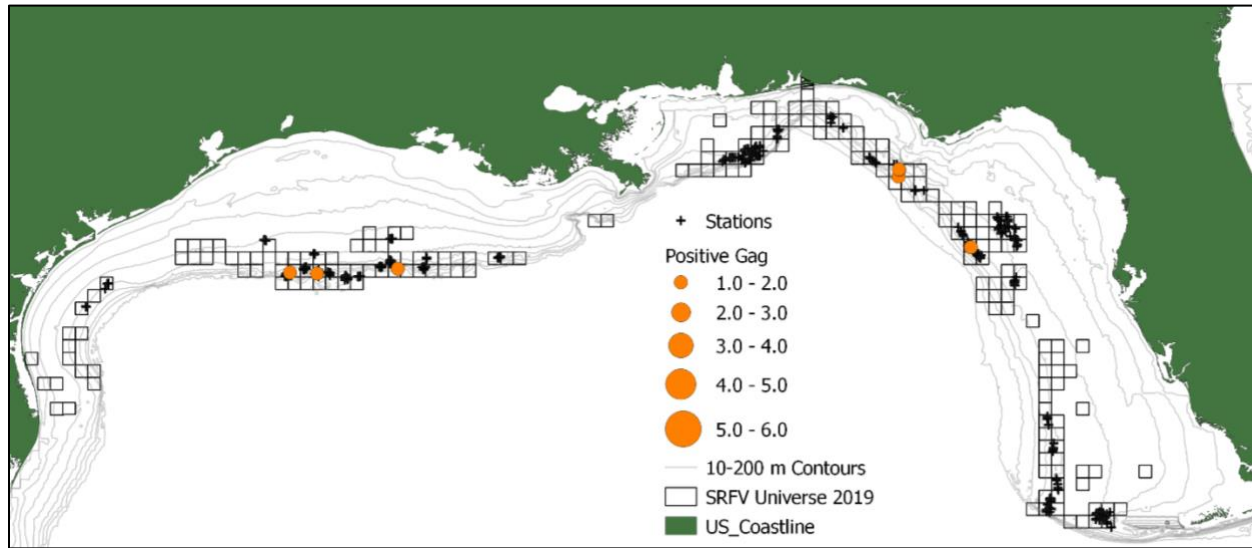


Figure 16. Map of Gag mincounts during the SEAMAP reef fish video cruise in 2009.

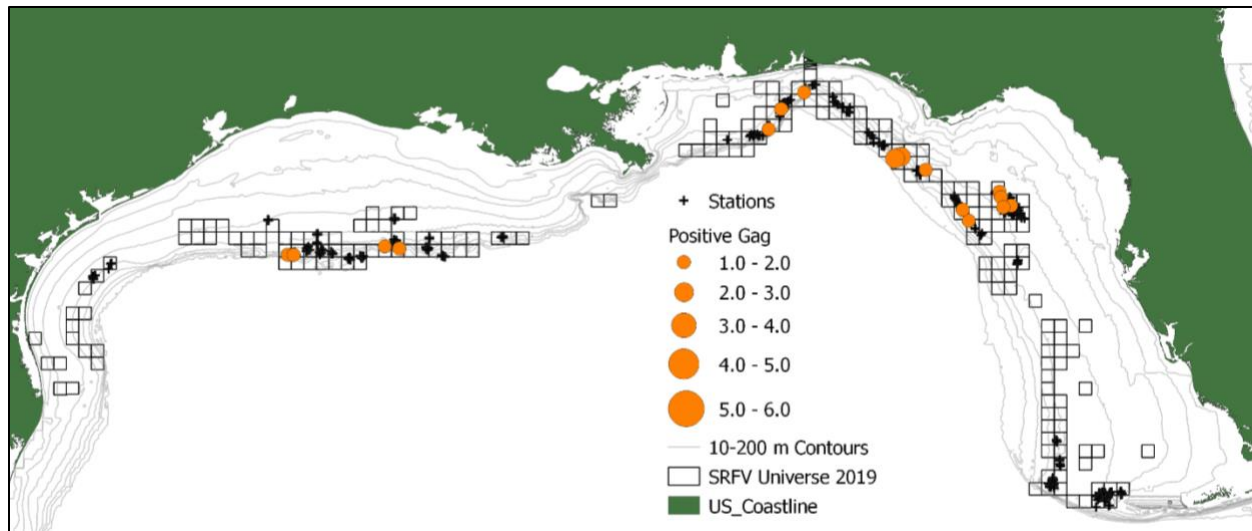


Figure 17. Map of Gag mincounts during the SEAMAP reef fish video cruise in 2010.

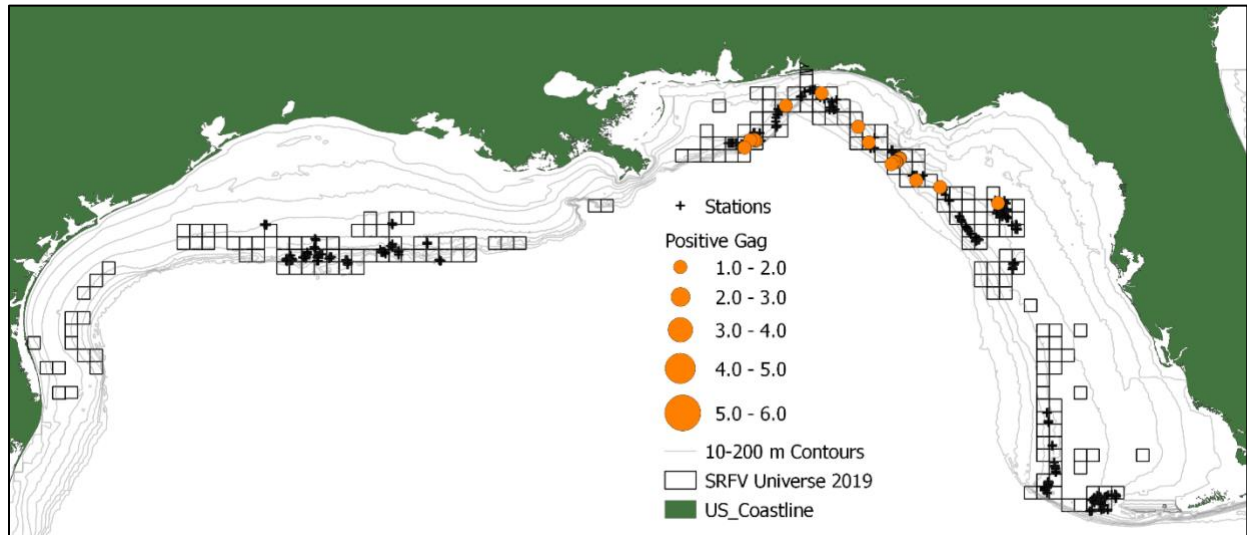


Figure 18. Map of Gag mincounts during the SEAMAP reef fish video cruise in 2011.

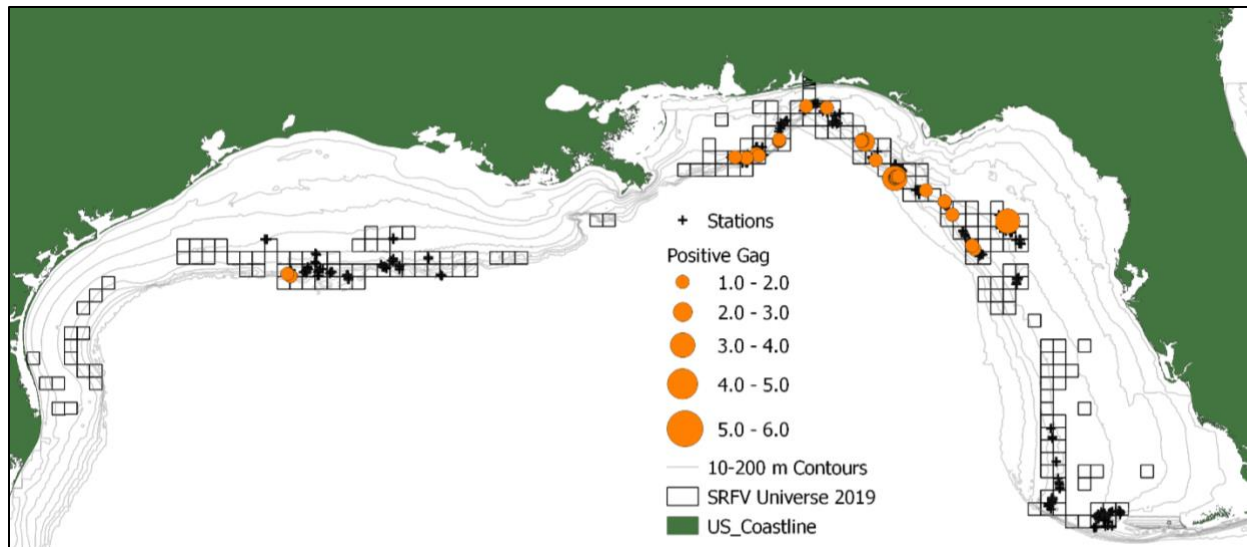


Figure 19. Map of Gag mincounts during the SEAMAP reef fish video cruise in 2012.

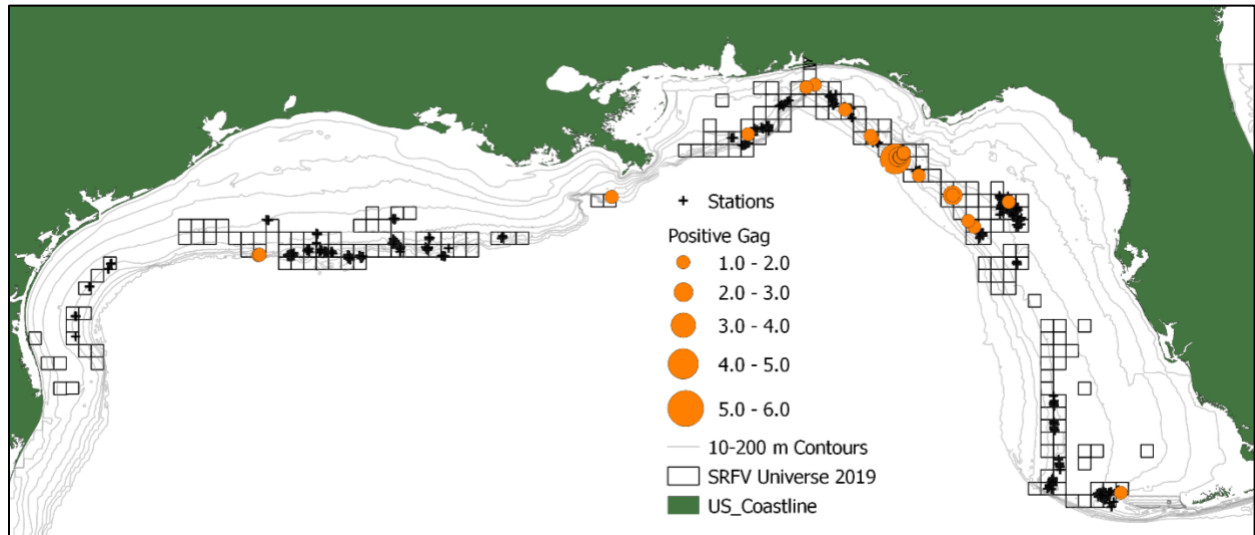


Figure 20. Map of Gag mincounts during the SEAMAP reef fish video cruise in 2013.

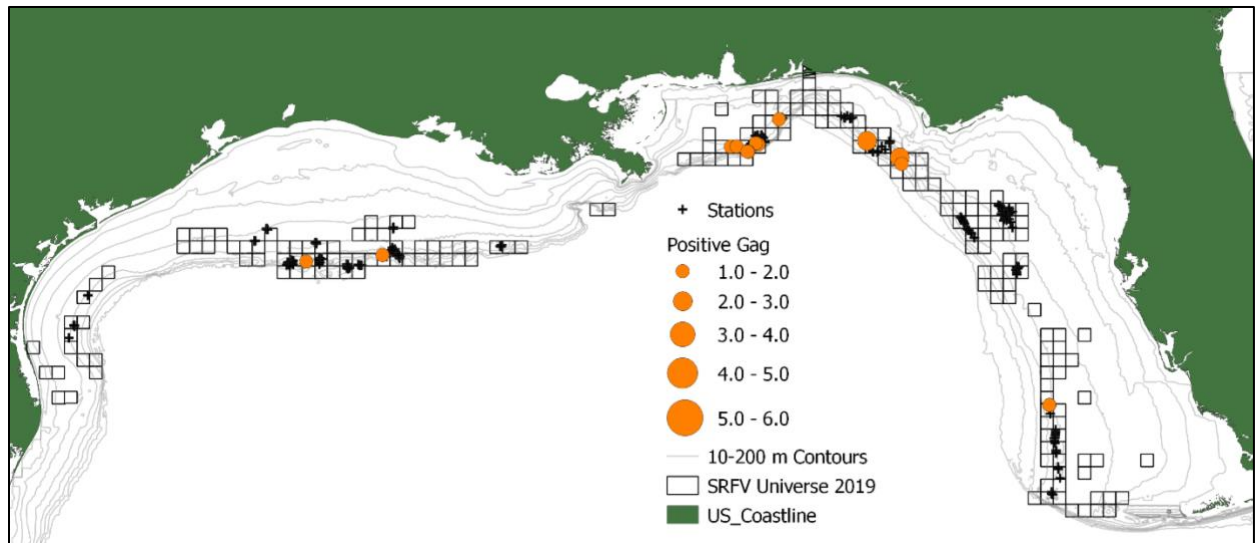


Figure 21. Map of Gag mincounts during the SEAMAP reef fish video cruise in 2014.

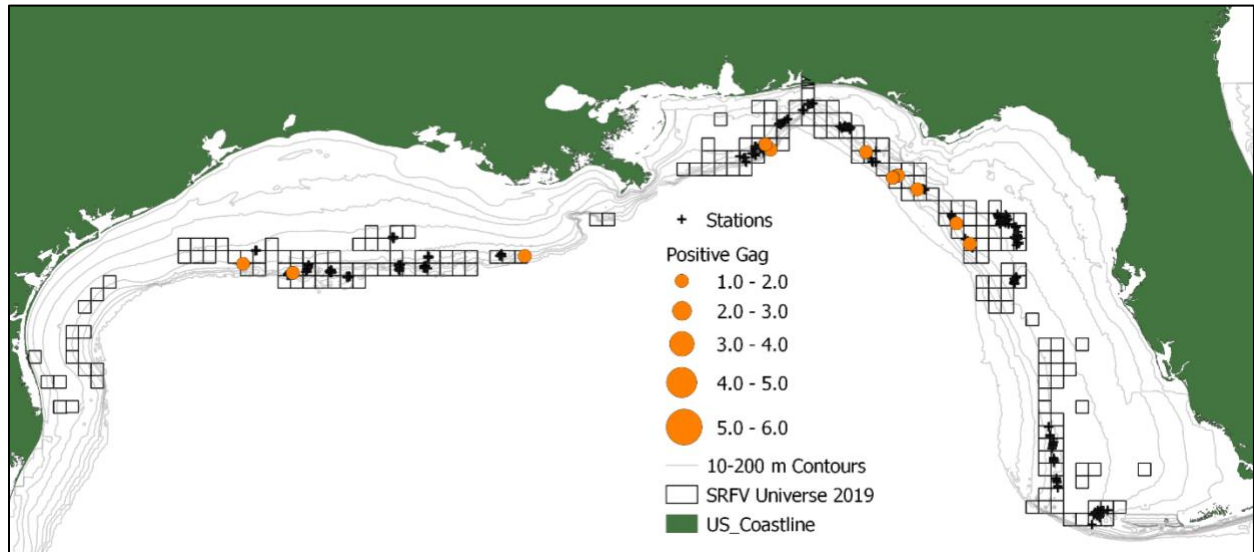


Figure 22. Map of Gag mincounts during the SEAMAP reef fish video cruise in 2015.

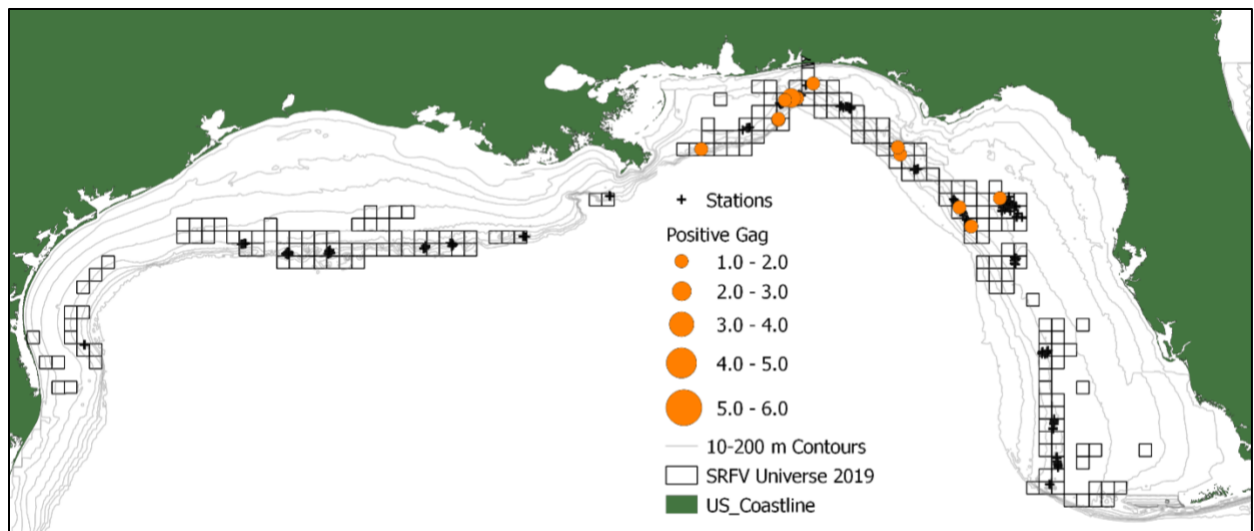


Figure 23. Map of Gag mincounts during the SEAMAP reef fish video cruise in 2016.

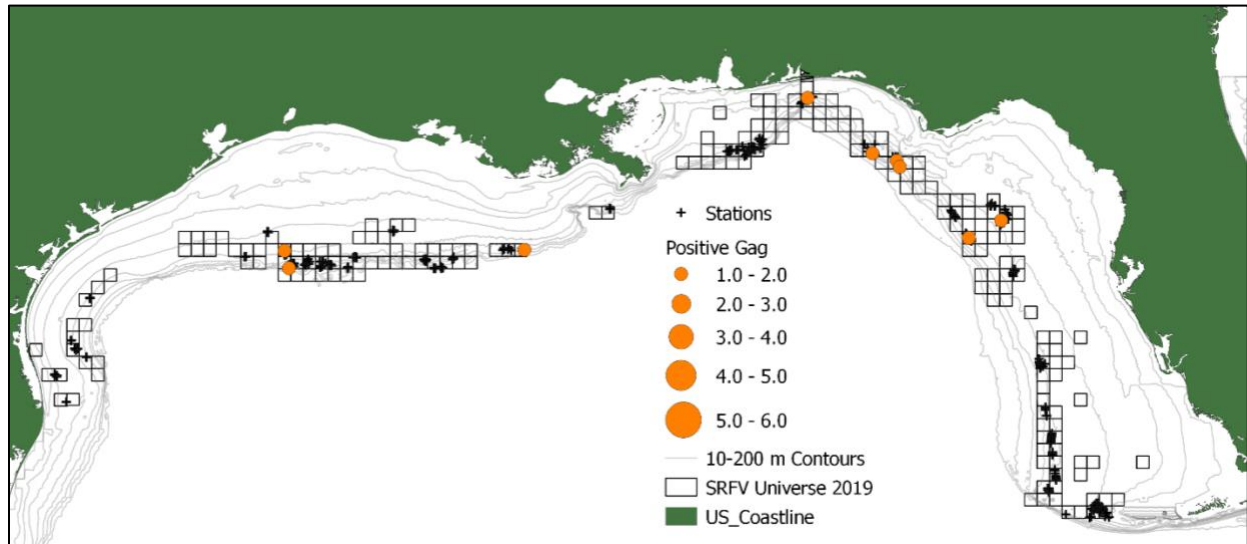


Figure 24. Map of Gag mincounts during the SEAMAP reef fish video cruise in 2017.

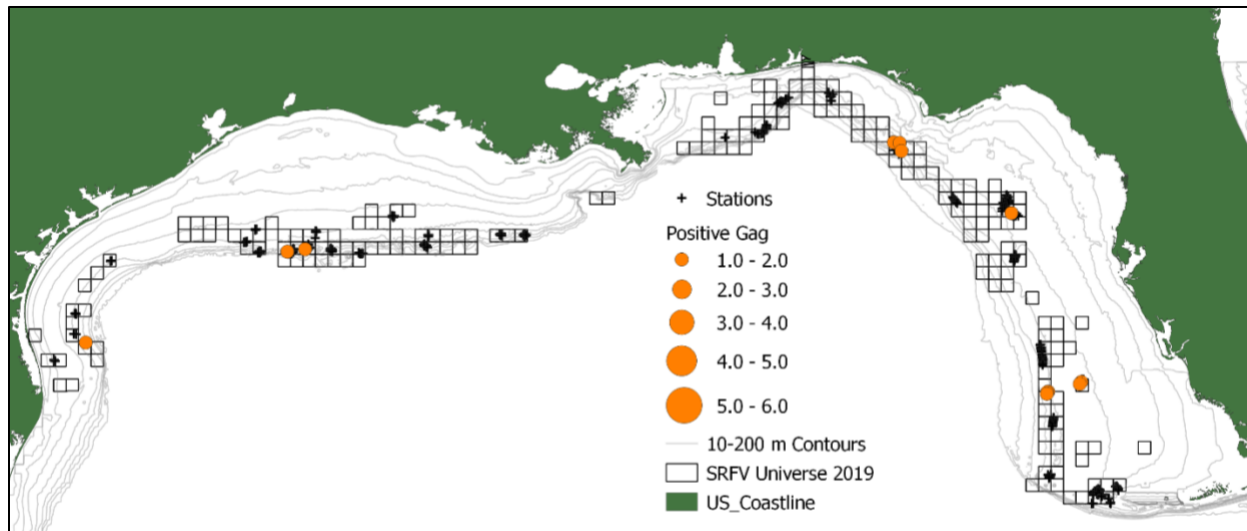


Figure 25. Map of Gag mincounts during the SEAMAP reef fish video cruise in 2018.

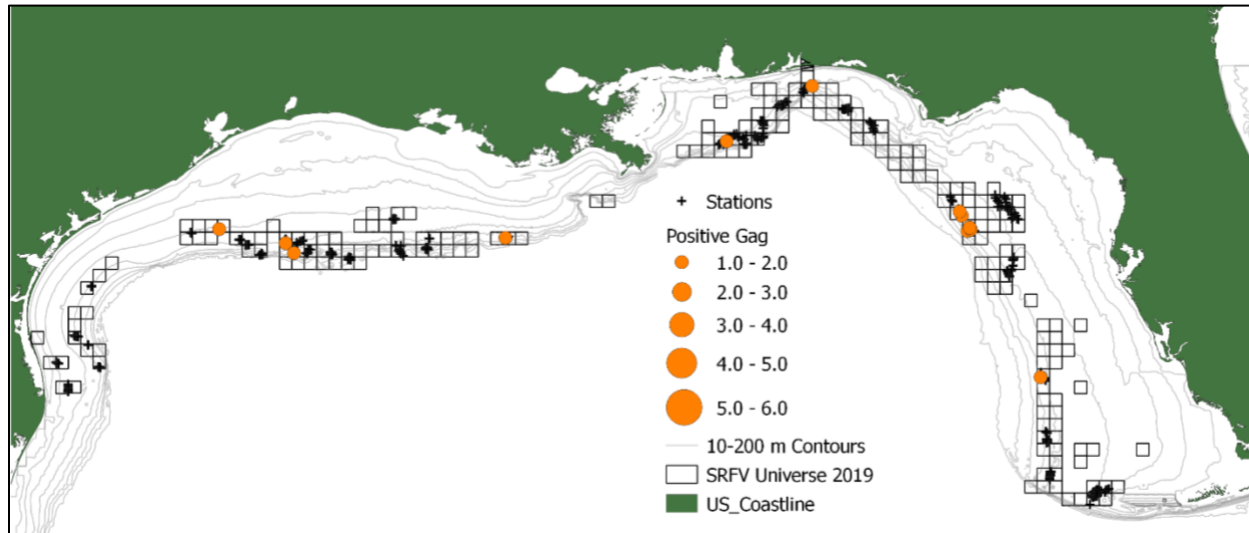


Figure 26. Map of Gag mincounts during the SEAMAP reef fish video cruise in 2019.

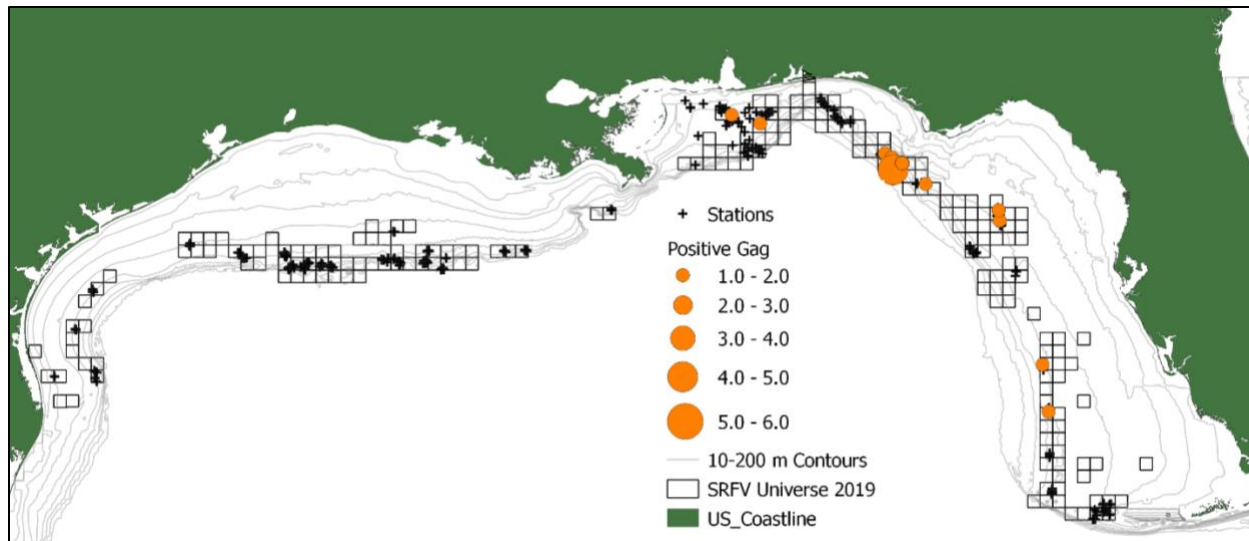


Table 3. Gag lengths (TL) from the SEAMAP reef fish video cruise from 1993 – 2019 for the east and west Gulf of Mexico.

East				West		
<i>year</i>	<i>n</i>	<i>Mean</i>	<i>SD</i>	<i>n</i>	<i>Mean</i>	<i>SD</i>
1996	1	429.00	-	-	-	-
2002	11	721.35	79.27	-	-	-
2003	43	662.06	142.33	-	-	-
2004	47	709.85	81.89	-	-	-
2005	68	728.70	109.34	-	-	-
2006	42	643.81	103.38	-	-	-
2007	20	740.82	84.18	-	-	-
2008	3	743.68	129.42	2	698.73	74.22
2009	13	678.67	85.59	1	1352.94	-
2010	15	799.12	124.52	-	-	-
2011	21	801.51	153.08	1	794.92	-
2012	32	767.67	122.87	2	941.56	242.00
2013	33	758.32	188.87	-	-	-
2014	10	795.48	196.98	1	977.20	-
2015	5	903.46	157.49	1	868.79	-
2016	2	726.45	99.16	1	1001.11	-
2017	1	675.32	-	-	-	-
2018	6	970.48	265.10	3	839.47	84.37
2019	4	844.49	281.24	-	-	-
Pooled	377	729.09	141.84	12	899.50	192.38

Figure 27. Length frequency histogram (TL, 25 mm bins) of Gag observed during the SEAMAP reef fish video cruise from 1993 – 2019 for East (grey) and West (Orange) Gulf observations.

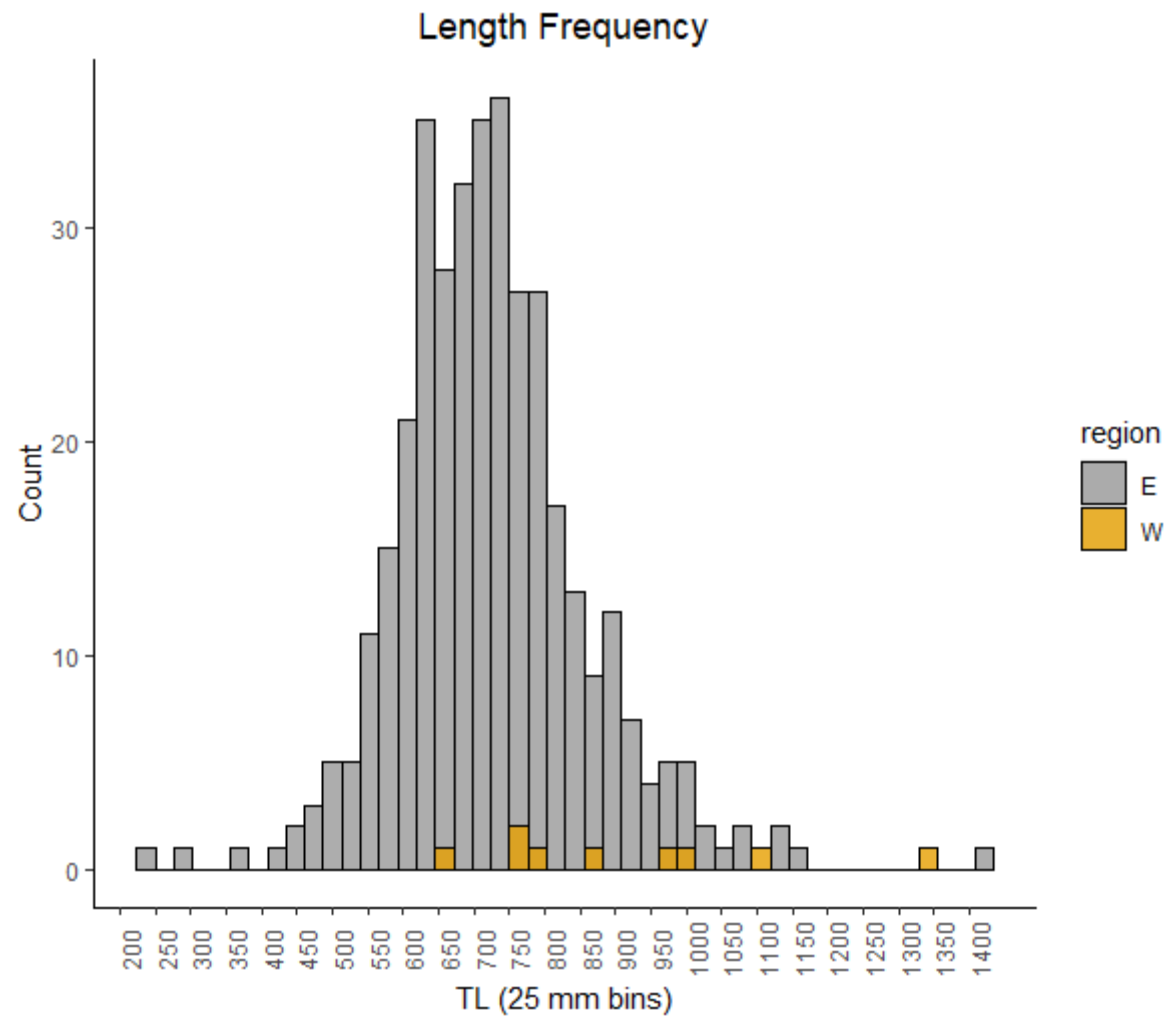


Figure 28. Mean annual total length (TL, mm) of Gag observed during the SEAMAP reef fish video cruise from 1993 – 2019 for East (orange) and West (cyan) Gulf observations. Both east and west Gulf gag show increasing trends with some variability.

