Vermilion Snapper Abundance Indices from SEAMAP Groundfish Surveys in the Northern Gulf of Mexico

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SEAMAP Reef Fish Video Survey:
Relative Indices of Abundance of Vermilion Snapper

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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 13-29). Secondary objectives include quantification of habitat types sampled (optical and acoustic data), 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. 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 (GOM). Types of data collected on the survey include diversity, abundance (min-count), fish length, habitat type, habitat coverage, bottom topography and water quality. The size of fish sampled with the video gear is species specific however vermilion snapper sampled over the history of the survey had fork lengths ranging from 84 – 685 mm, and mean annual fork lengths ranging from 243 – 307 mm (Table 7, Figures 30-31). 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 with the life history information provided by NMFS Panama City Laboratory.

Methods

Sampling design

Total 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 times between stations. 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). The 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 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 in parallel. However, the frequency of hitting targets with the lasers was low and to increase sample size all measureable fish during the video read were measured (i.e. not just at the mincount), and fish could have potentially been measured twice. The stereo-cameras used since 2008 allow size estimation from fish images and allows for increased sample sizes and allowed for measurements to be taken at the point in the video corresponding to the mincount therefore there is no potential to measure any fish twice. 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.).

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. Unfortunately the 1992 video tapes were destroyed during Hurricane Katrina and cannot be re-viewed to obtain mincounts, 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. No vermilion snapper were observed in depths less than 20 m and therefore sites in shallower depths than 20 m were excluded. 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 2004-2014.

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 area 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 United States. Additionally for certain species like Gulf of Mexico red grouper it has been determined that a combined video index was useful and included data from NMFS-Mississippi Labs, NMFS-Panama City, and FWRI index (SEDAR 2015). We explored model fit using three different error distributions to construct relative abundance indices including delta-lognormal, poisson and negative binomial.

East-, west- and GOM-wide models were run and independent variables tested in the model included year and reef as fixed effects and depth as a continuous variable (mincount = year + reef + depth). We used the composite variable 'reef' rather than the percent coverage of individual habitat variables because of the strong relationship vermilion snapper have with reef habitat and as a simplifying or aggregating variable to indicate if a camera observed reef habitat. Additionally, in past SEDAR data workshops (SEDAR 2015) it was decided that a combination of video indices submitted by NMFS-Mississippi Labs, NMFS-Panama City and FWRI was desired. Despite the good coordination between groups the percent habitat cover variables are fairly subjective and may be interpreted differently among the coordinating laboratories, however each group is consistent in determining if the camera landed on reef habitat (i.e. the 'reef' variable). 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

Initial runs of the poisson and negative-binomial models produced poor fits to the data that were non-linear (e.g. 'S shaped' QQ plots), whereas the delta lognormal model showed a mostly linear fit with some tailing (Figures 4, 7 and 10). Additional evaluation of error distributions showed improved fit statistics for the delta lognormal model in which only year was retained as a variable (Table 1). Delta lognormal models consistently showed lower AIC and conditional likelihood values. Pearson chi-square /DF measures of fit were not used to compare model runs as that information is not produced for the delta lognormal models, however both the poisson and negative binomial models had values exceeding 1 indicating poor fit for those distributions. Finally all of the delta lognormal models produced nearly linear QQ plots indicating good fitting models (Figures 4, 7 and 10). Therefore the delta lognormal models were selected as the best fitting model and we chose to only present model output and graphs from those runs for the east, west and GOM wide vermilion snapper indices.

Vermilion snapper were observed throughout the eastern and western Gulf of Mexico in most years and the spatial distributions observed are highly reflective of the reef sampling universe used to select sampling sites (Figures 1 and 13-29). The Dry Tortugas are the shallowest reefs available for sampling and in that region vermilion snapper were never observed, and thus those shallow sites were dropped from use in index estimation. Anecdotally sites shallower than 20 m in the Panama City video index also do not observe vermilion snapper (Doug DeVries, personal communication). Gaps in mapping and habitat information exist on the central portion of the west Florida shelf, Mississippi river delta region, and portions of the Texas coast and those are slowly being investigated and filled. In most years the 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. The most recent mapping and sampling efforts in south Texas and in the central portion of the west Florida shelf were accomplished in 2012-14 and beginning in 2014 are starting to be incorporated into the sampling frame.

In all three spatial runs (east, west, and GOM wide) year, reef and depth were significant variables for both the binomial and lognormal submodels (Tables 2 - 3). Through time it appears that the GOM wide index shows a peak in the index in 1994 followed by a decrease and generally stable values through 2007. From 2007 through 2011 index values trended up followed by a two year dip with a final increase back to 2011 levels in 2014. Highest mincounts were observed in 1994, 2011, and 2014, and the lowest was observed in 2007 (Table 4, Figures 3 and 11). Since 2002 mincount indices of vermilion snapper appear to be to be on the rise in GOM wide model with the exception of two low years in 2012 and 2013 (Figures 3 and 11). Proportion positives are largely reflective of the abundance trends (Table 4, Figures 2 and 12).

The east GOM trends were quite similar to the GOM wide trends (Figures 6 and 11). Highest index values were observed in 1994, 2011 and 2014 as was the case in the GOM wide model. Similar to the GOM wide model the population appears to stabilize around 2002 and increases in abundance through 2011. The west GOM model shows generally similar trends to both the east and GOM wide models with a few exceptions (Table 6, Figures 9-12). The west GOM model showed higher CVs likely due to less consistent sampling in that region. The differences in trends are likely due the decreasing detection probability with sampling less frequently. The highest mincounts were observed in 1993, 1997, 2012, and 2013. Similar to the other models, since 2002 the population appears to be stable with a general increasing trend in abundance although with high variability than the other two models (Figures 11 and 12).

Annual mean fork lengths are showing a decreasing trend GOM wide (Figure 30). East GOM vermilion ranged from 207 – 359 mm mean annual fork length (Table 7, Figure 31). West GOM vermilion snapper ranged from 209 – 320 mm mean annual fork length (Table 7, Figure 31). Mean length was larger in the west than the east GOM but generally showed overlapping length frequency histograms (Table 7, Figure 31).

Literature cited

Campbell, M.D., K.R. Rademacher, P. Felts, B. Noble, M. Felts, and J. Salisbury. 2012. SEAMAP Reef Fish Video Survey: Relative Indices of Abundance of Red Snapper, July 2012. SEDAR31-DW08. SEDAR, North Charleston, SC. 61 pp.

Guenther, C.B., T.S. Switzer, S.F. Keenan, and R.H. McMichael, Jr. 2014. Indices of abundance for Red Grouper (*Epinephelus morio*) from the Florida Fish and Wildlife Research Institute (FWRI) video survey on the West Florida Shelf. SEDAR42-DW-08. SEDAR, North Charleston, SC. 21 pp.

Lo, N. C. H., L.D. Jacobson, and J.L. Squire. 1992. Indices of relative abundance from fish spotter data based on delta-lognormal models. Can. J. Fish. Aquat. Sci. 49: 2515-1526.

SEDAR, 2015. Southeast Data, Assessment, and Review, Gulf of Mexico Red Grouper - Data Workshop Report. SEDAR-42-DW-report. SEDAR, North Charleston, SC. 286 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 (1992-2014) new reef tract has been discovered and mapped and therefore this map represents what was available in 2014, and not necessarily what has been available over the entire time series.

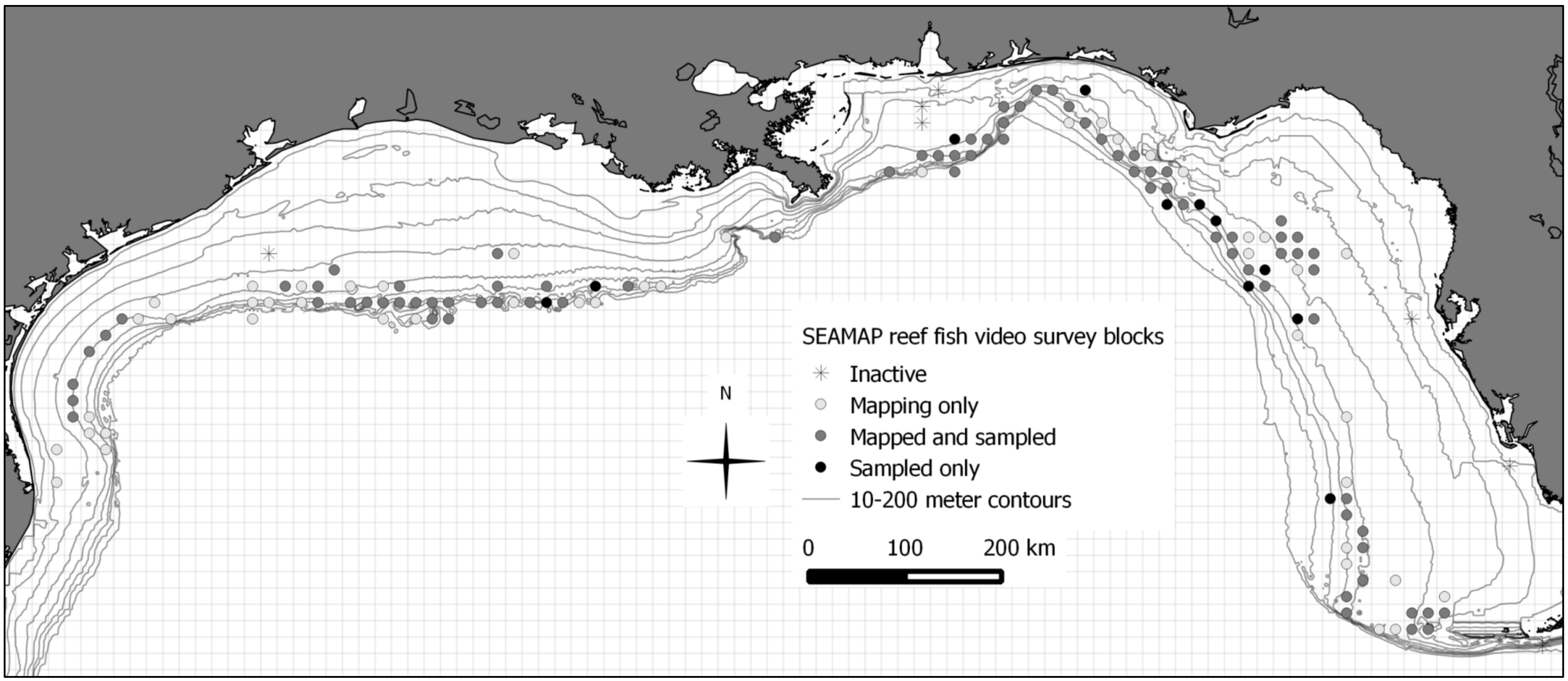

Table 1. Fit statistics (AIC and log likelihood) for model runs that only include year as a variable but used the negative binomial, poisson and lognormal error distributions.

AIC			**Log likelihood**		
Neg-Bin	**Poisson**	**Delta lognormal**	**Neg-Bin**	**Poisson**	**Delta lognormal**
11431	59776	3629	11395	59742	3627

Table 2. Test of type III fixed effects for the binomial portion of the delta lognormal model.

Model	**Effect**	**Num DF**	**Den DF**	**Chi-Square**	**F Value**	**Pr>ChiSq**	**Pr>F**
GOM Wide	*year*	16	1359	154.93	9.61	<.0001	<.0001
	REEF	1	4159	88.39	88.39	<.0001	<.0001
	DPTH	1	4177	71.9	71.9	<.0001	<.0001
East GOM	*year*	16	771	141.85	8.75	<.0001	<.0001
	REEF	1	2401	47.41	47.41	<.0001	<.0001
	DPTH	1	2486	70.08	70.08	<.0001	<.0001
West GOM	*year*	16	520	76.74	4.71	<.0001	<.0001
	REEF	1	1632	72.89	72.89	<.0001	<.0001
	DPTH	1	1610	6.71	6.71	0.0096	0.0097

Table 3. Test of type III fixed effects for the lognormal portion of the delta lognormal model.

Model	**Effect**	**Num DF**	**Den DF**	**F Value**	**Pr>F**
GOM Wide	*year*	16	969	4.96	<.0001
	REEF	1	969	38.6	<.0001
	DPTH	1	969	4.55	0.0332
East GOM	*year*	16	509	2.55	0.0009
	REEF	1	509	17	<.0001
	DPTH	1	509	8.05	0.0047
West GOM	*year*	16	446	6.78	<.0001
	REEF	1	446	18.4	<.0001
	DPTH	1	446	4.89	0.0275

Table 4. Output for the delta lognormal index of relative abundance of vermilion snapper by year, GOM wide delta lognormal model run.

Year	Prop-Pos	N	Lo Ind	Std Ind	CV	LCL	UCL
1993	0.11348	141	1.20247	0.82455	0.39537	0.38476	1.76700
1994	0.25714	105	3.22408	2.21078	0.27477	1.28888	3.79210
1995	0.25000	80	2.41861	1.65847	0.35036	0.83975	3.27538
1996	0.11871	278	0.40536	0.27796	0.28424	0.15917	0.48538
1997	0.29134	254	1.73717	1.19120	0.20275	0.79735	1.77959
2002	0.11864	236	0.57971	0.39751	0.30677	0.21820	0.72417
2004	0.15301	183	1.12577	0.77195	0.28192	0.44400	1.34212
2005	0.22812	377	0.91013	0.62408	0.16321	0.45125	0.86312
2006	0.13764	356	0.38391	0.26325	0.22910	0.16746	0.41383
2007	0.13927	438	0.31072	0.21306	0.21777	0.13853	0.32770
2008	0.24490	294	1.12698	0.77278	0.19392	0.52622	1.13485
2009	0.26893	383	1.77783	1.21908	0.14906	0.90629	1.63982
2010	0.29259	270	2.03686	1.39669	0.18361	0.97037	2.01032
2011	0.32973	370	2.32417	1.59370	0.12569	1.24070	2.04715
2012	0.20882	431	1.63981	1.12444	0.17771	0.79026	1.59992
2013	0.22426	272	1.15850	0.79439	0.24334	0.49171	1.28341
2014	0.23973	292	2.42975	1.66610	0.17445	1.17846	2.35554

Figure 2. Plot of the observed vs predicted proportion positives for vermilion snapper, GOM wide delta lognormal model run.

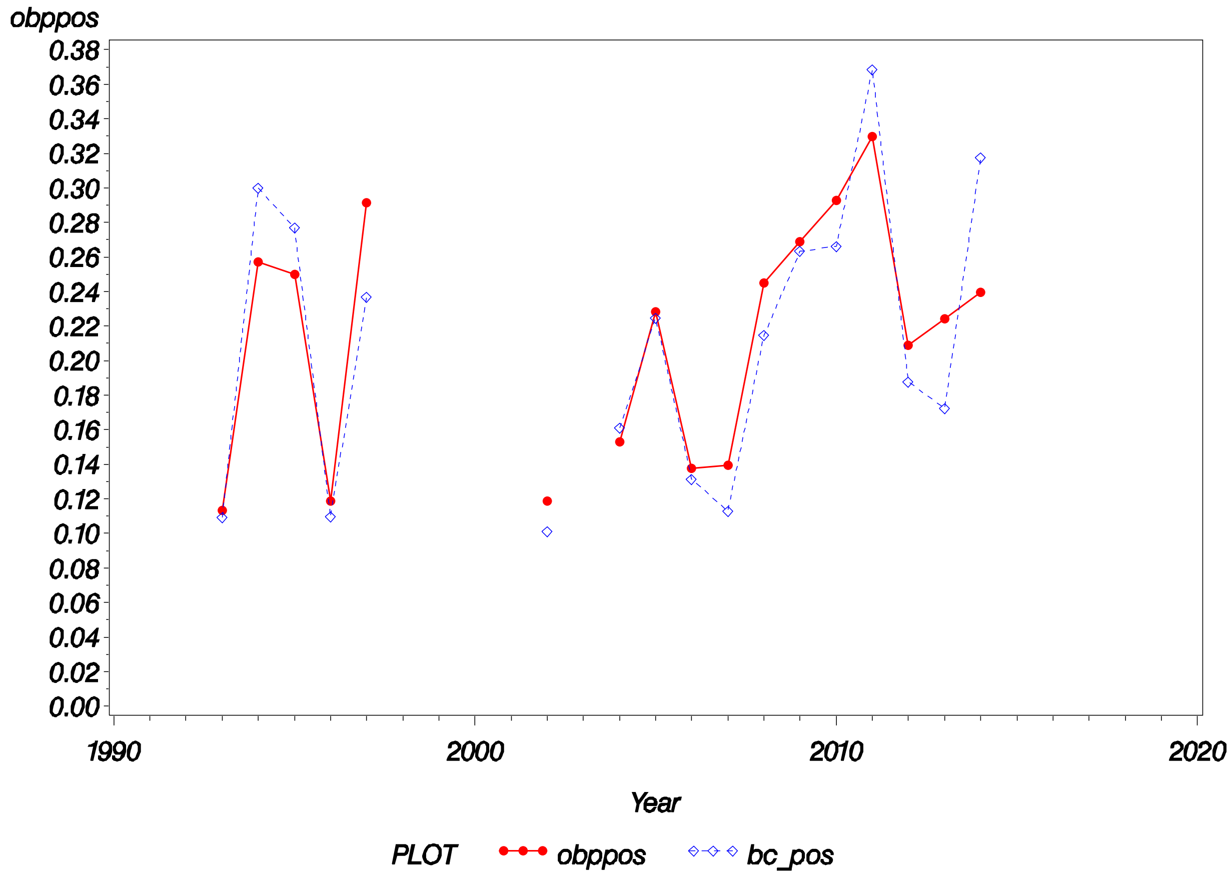

Figure 3. Observed and standardized mincounts of vermilion snapper from the GOM wide delta lognormal model run.

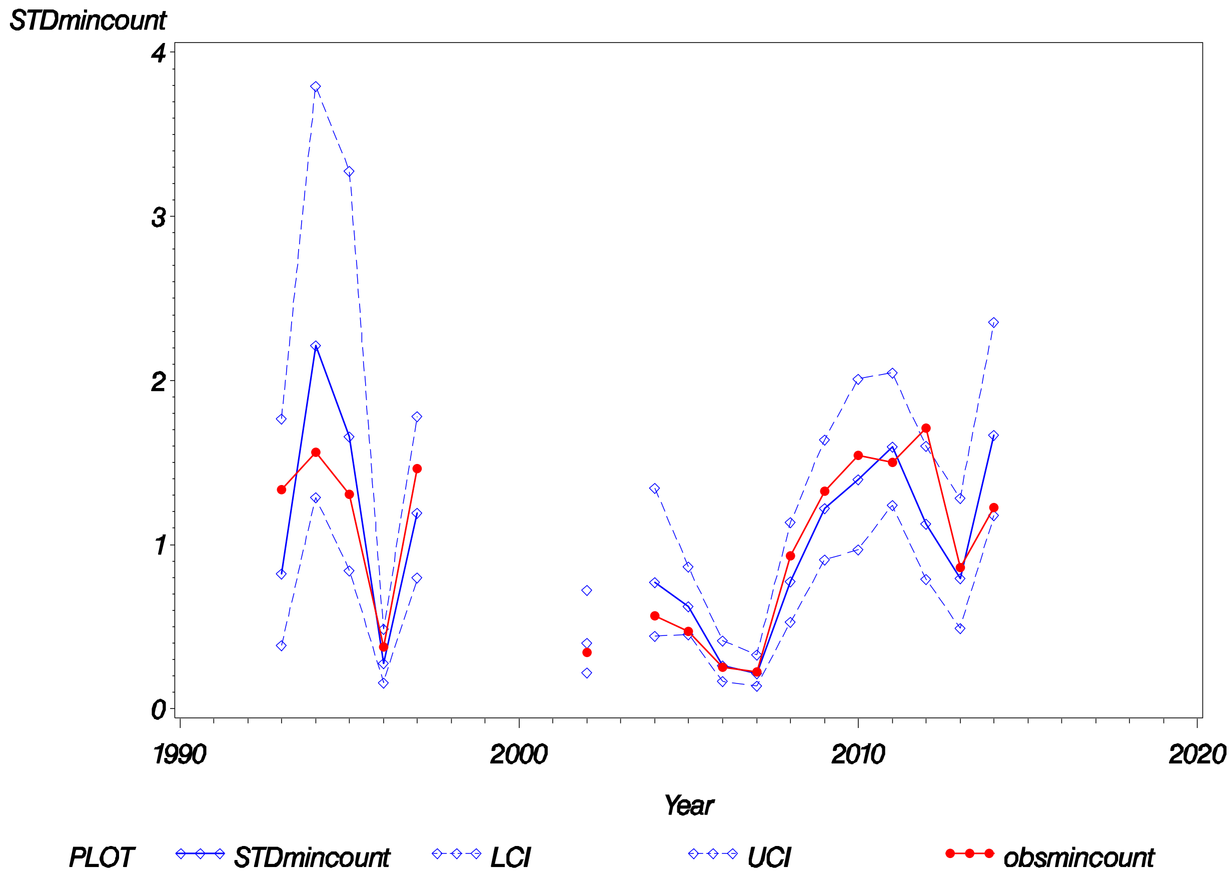

Figure 4. QQ plot of conditional residuals for the GOM wide delta lognormal model run.

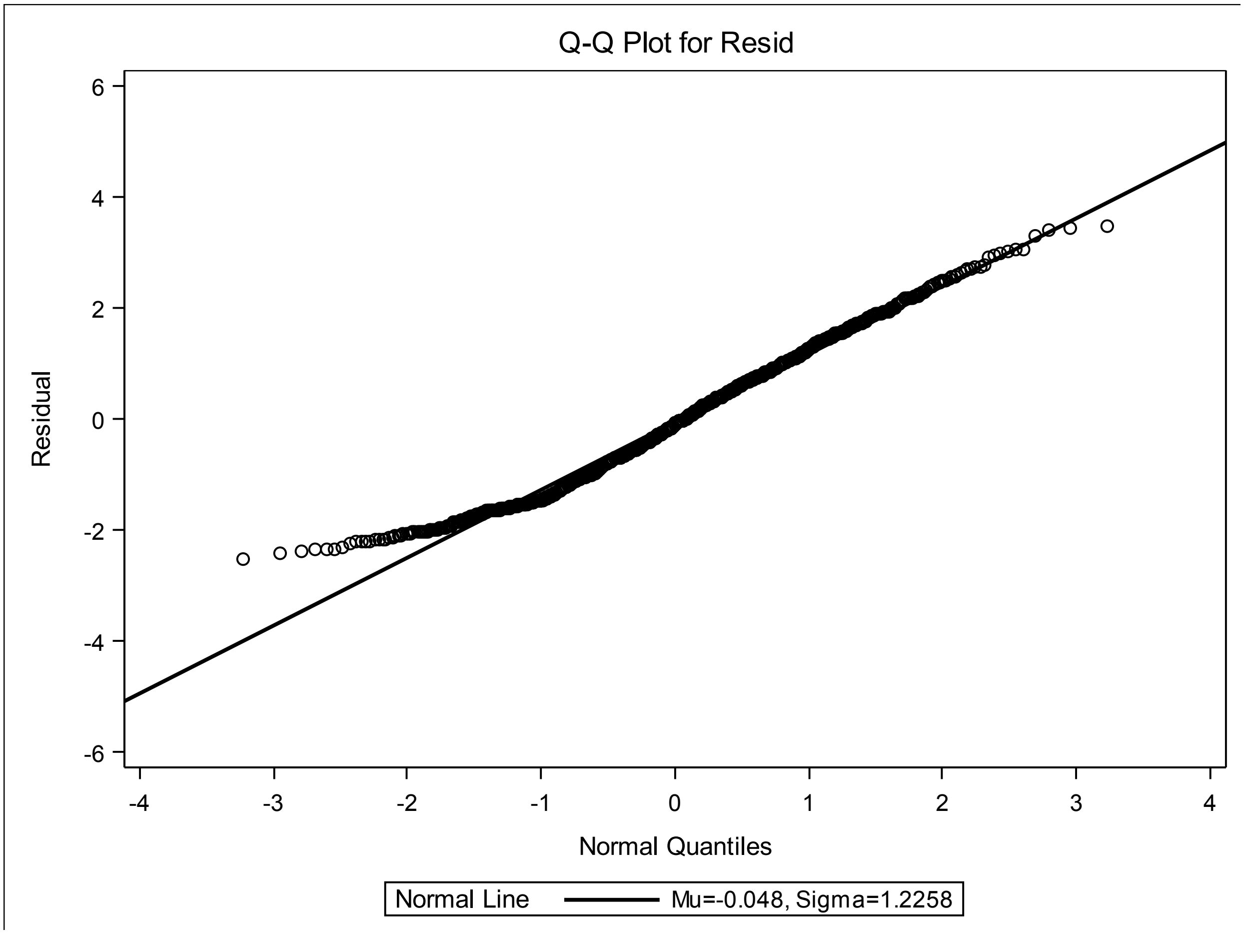

Table 5. Output for the delta lognormal index of relative abundance of vermilion snapper by year, east GOM model run.

Year	Prop Pos	N	Lo Ind	Std Ind	CV	LCL	UCL
1993	0.12371	97	0.82282	0.52588	0.50537	0.20260	1.36502
1994	0.28333	60	4.96032	3.17022	0.35318	1.59694	6.29348
1995	0.21053	38	2.69930	1.72517	0.54692	0.62016	4.79910
1996	0.09322	118	0.30787	0.19676	0.44642	0.08388	0.46155
1997	0.13077	130	0.99152	0.63369	0.35949	0.31555	1.27261
2002	0.08276	145	0.70572	0.45104	0.42293	0.20038	1.01523
2004	0.12030	133	1.05937	0.67706	0.36731	0.33237	1.37921
2005	0.21224	245	1.06717	0.68205	0.20764	0.45223	1.02866
2006	0.12393	234	0.43633	0.27886	0.27684	0.16194	0.48021
2007	0.09489	274	0.41845	0.26744	0.29142	0.15109	0.47338
2008	0.23529	170	1.35727	0.86745	0.23864	0.54179	1.38887
2009	0.24017	229	1.89231	1.20941	0.19523	0.82146	1.78057
2010	0.23429	175	2.46022	1.57237	0.23427	0.99033	2.49648
2011	0.36029	272	2.93140	1.87351	0.14965	1.39121	2.52300
2012	0.12134	239	1.11160	0.71044	0.27696	0.41247	1.22366
2013	0.11594	138	0.63526	0.40600	0.41033	0.18445	0.89365
2014	0.26486	185	2.74229	1.75264	0.20761	1.16215	2.64315

Figure 5. Plot of the observed vs predicted proportion positives for vermilion snapper, east GOM delta log normal model run.

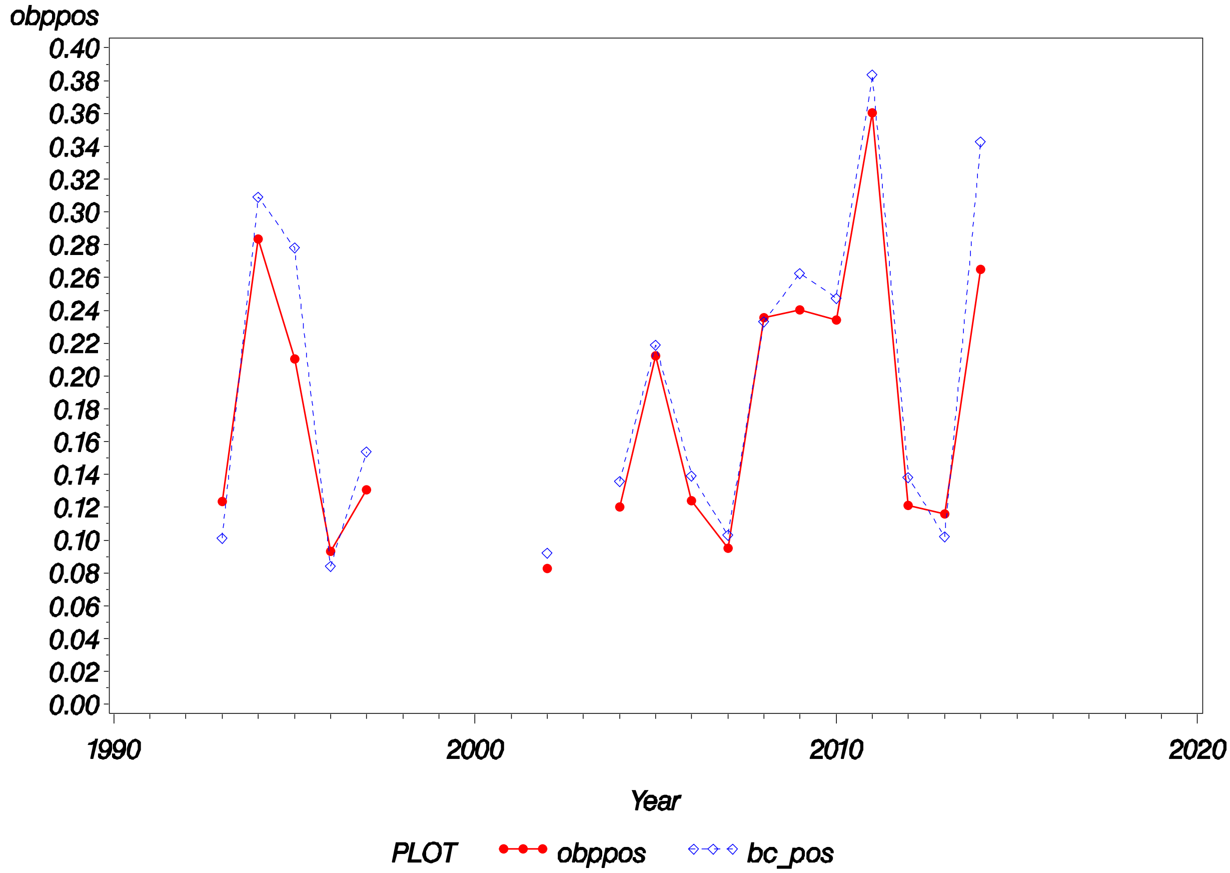

Figure 6. Observed and standardized mincounts of vermilion snapper from the east GOM delta lognormal model run.

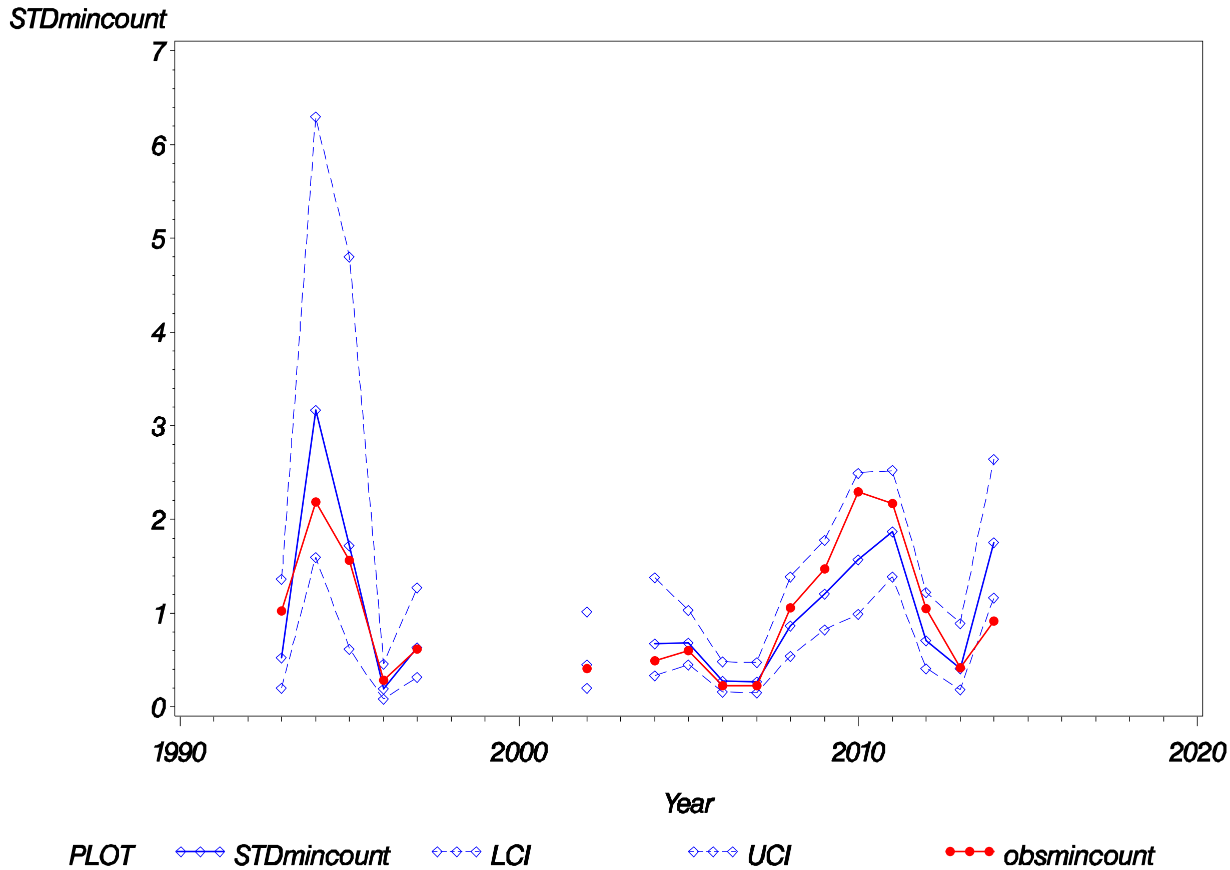

Figure 7. QQ plot of conditional residuals for the east GOM delta lognormal model run.

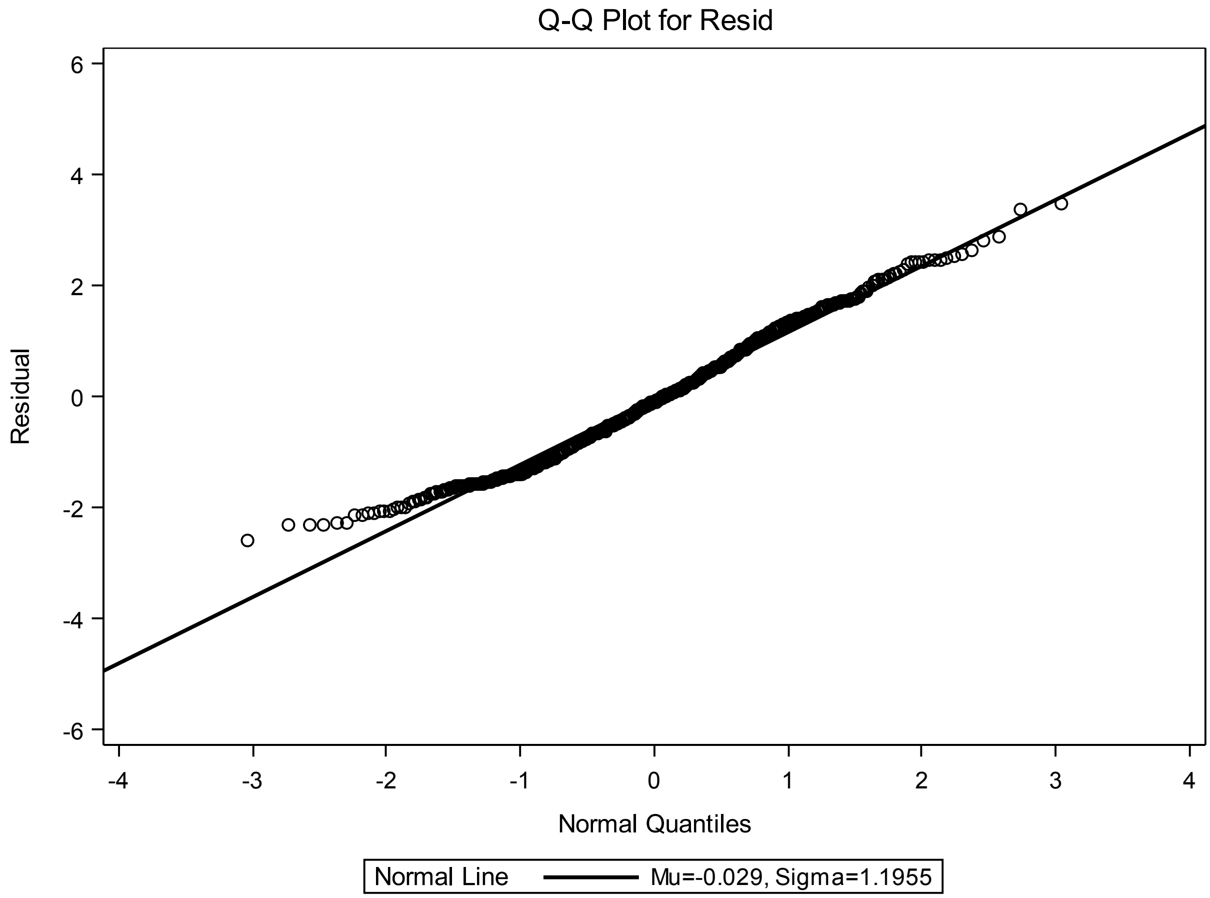

Table 6. Output for the delta lognormal index of relative abundance of vermilion snapper by year, west GOM model run.

Year	Prop Pos	N	Lo Ind	Std Ind	CV	LCL	UCL
1993	0.09091	44	5.66723	2.99482	0.65473	0.90693	9.88929
1994	0.22222	45	1.07265	0.56684	0.49775	0.22121	1.45247
1995	0.28571	42	2.44174	1.29033	0.41687	0.57945	2.87330
1996	0.13750	160	0.82520	0.43607	0.33677	0.22639	0.83995
1997	0.45968	124	4.09683	2.16495	0.20652	1.43858	3.25808
2002	0.17582	91	0.44080	0.23294	0.40824	0.10622	0.51081
2004	0.24000	50	1.88448	0.99585	0.42088	0.44403	2.23341
2005	0.25758	132	0.60481	0.31961	0.28241	0.18366	0.55619
2006	0.16393	122	0.38012	0.20087	0.44417	0.08597	0.46934
2007	0.21341	164	0.18298	0.09669	0.31245	0.05252	0.17803
2008	0.25806	124	1.00975	0.53360	0.32865	0.28122	1.01248
2009	0.31169	154	1.93119	1.02053	0.24188	0.63345	1.64415
2010	0.40000	95	1.28256	0.67776	0.32035	0.36274	1.26637
2011	0.24490	98	0.95827	0.50639	0.31847	0.27197	0.94288
2012	0.31771	192	3.82070	2.01903	0.20138	1.35507	3.00831
2013	0.33582	134	3.13492	1.65663	0.24899	1.01439	2.70551
2014	0.19626	107	2.43563	1.28709	0.39967	0.59599	2.77957

Figure 8. Plot of the observed vs predicted proportion positives for vermilion snapper, west GOM delta log normal model run.

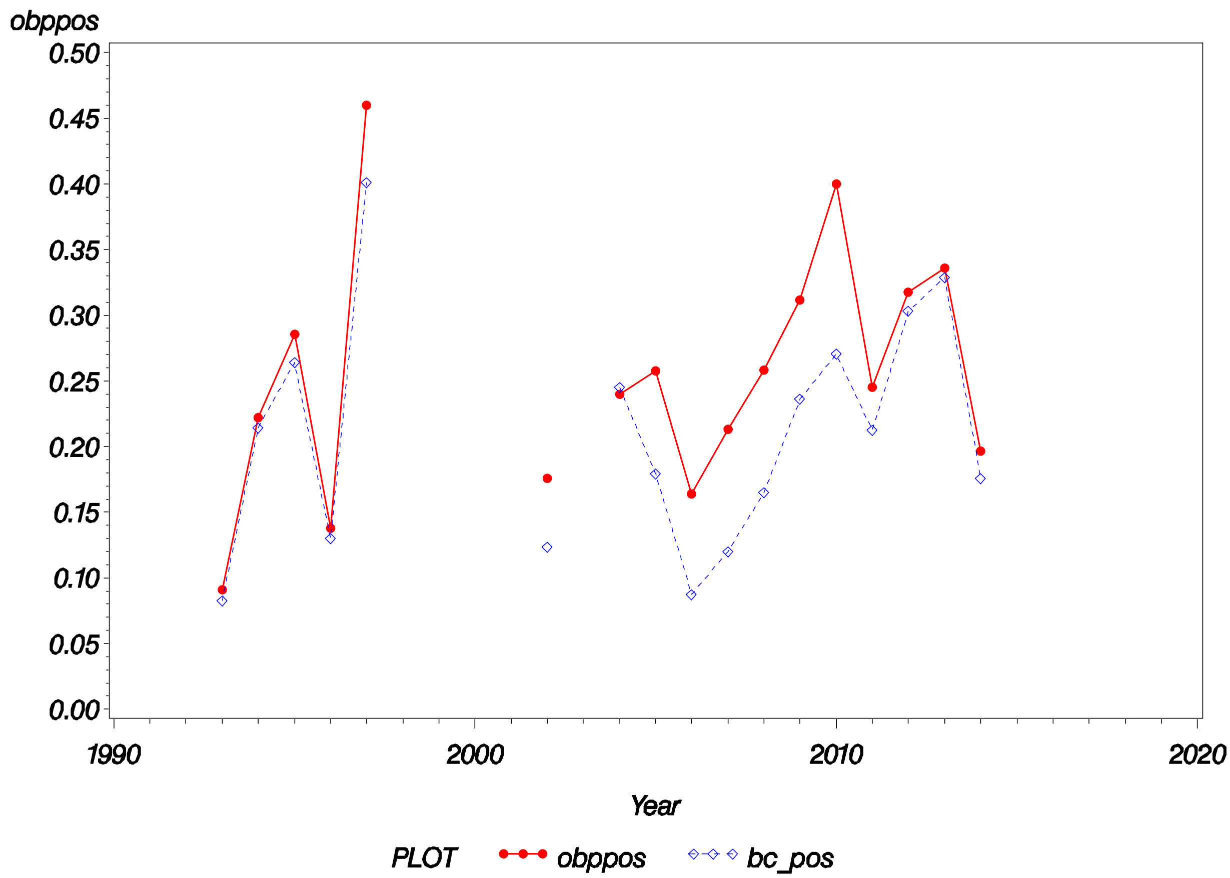

Figure 9. Observed and standardized mincounts of vermilion snapper from the east GOM delta lognormal model run.

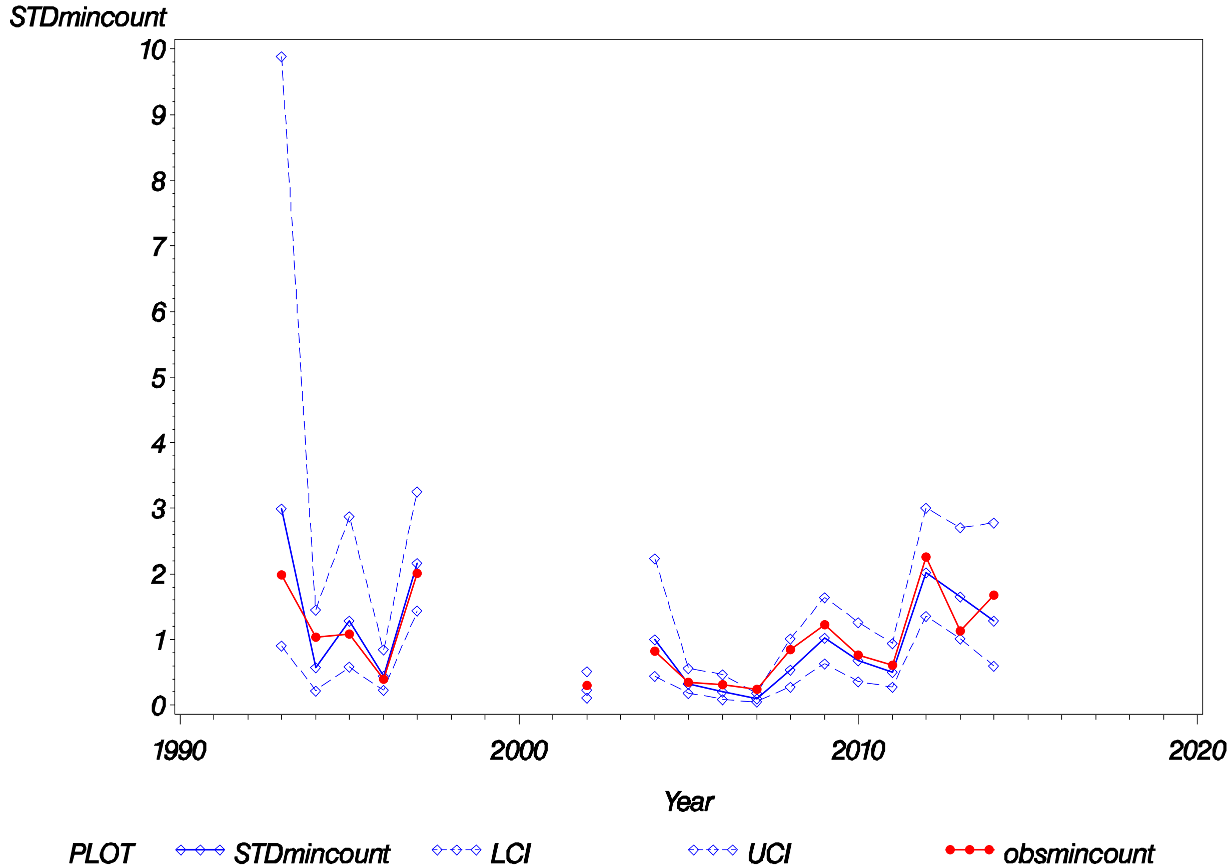

Figure 10. QQ plot of conditional residuals for the west GOM delta lognormal model run.

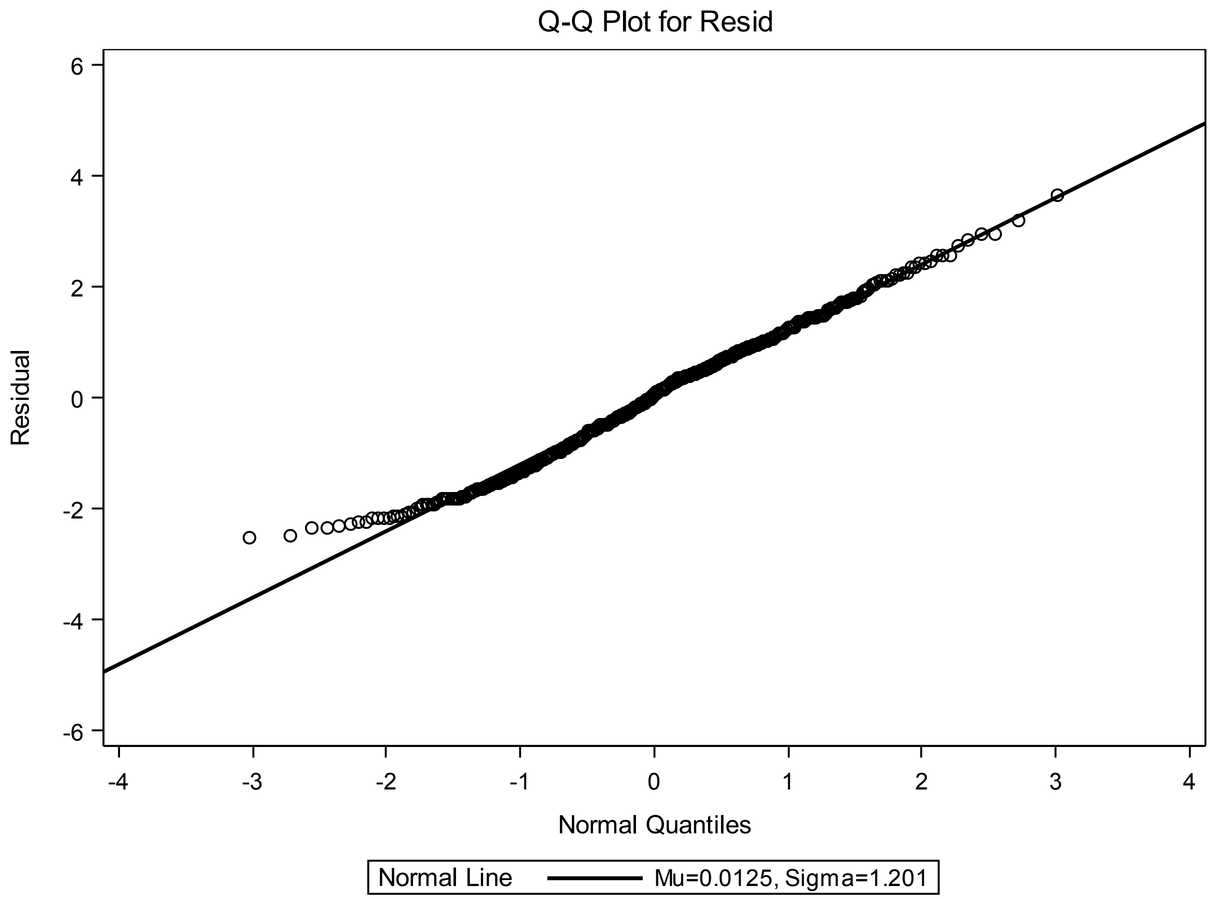

Figure 11. Regional and GOM wide comparison of the standardized mincounts of vermilion snapper from delta lognormal model runs.

Figure 12. Regional and GOM wide comparison of the proportion positives of vermilion snapper from delta lognormal model runs.

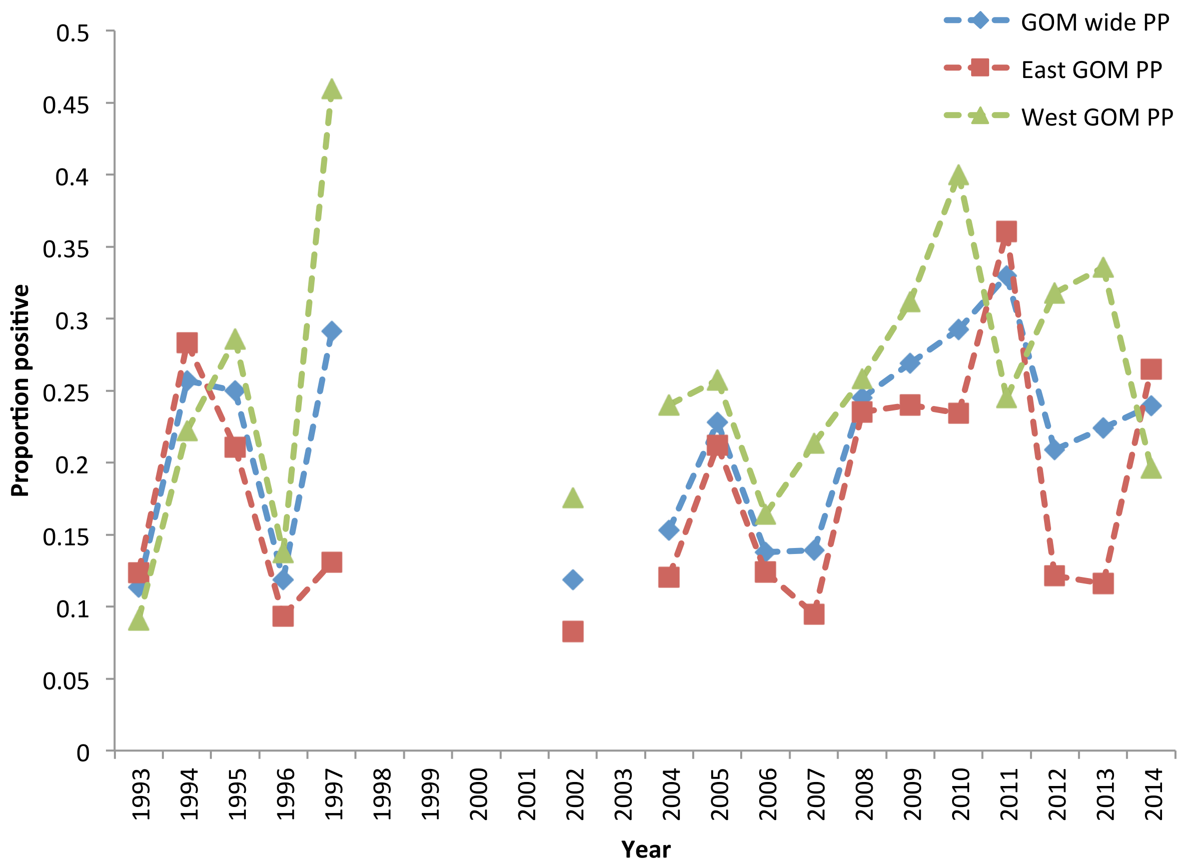

Figure 13. Map of vermilion snapper mincounts during the SEAMAP reef fish video cruise in 1993.

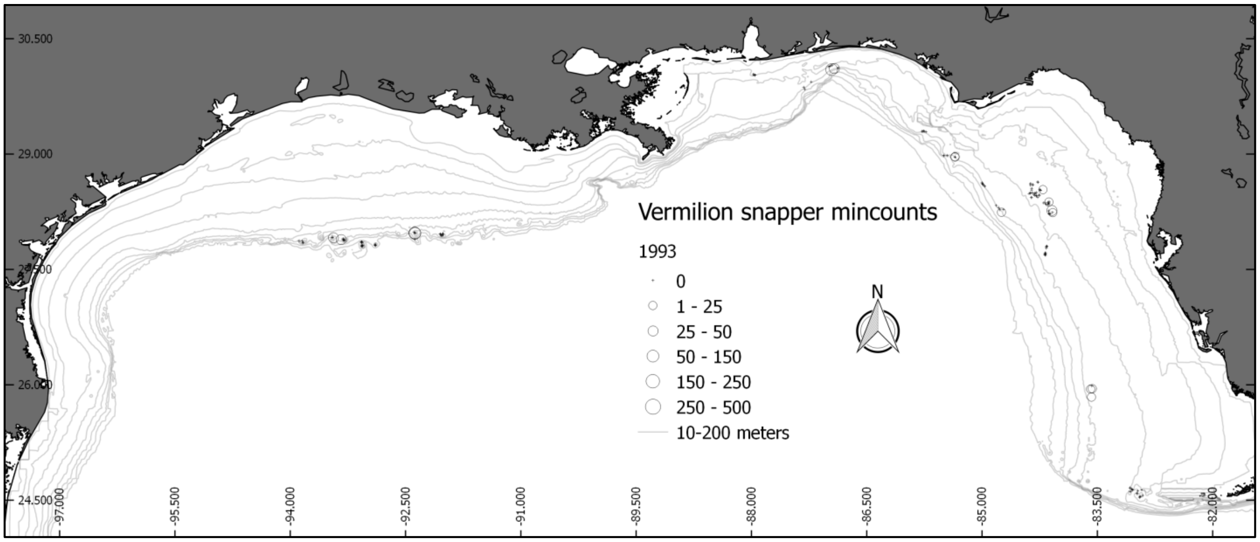

Figure 14. Map of vermilion snapper mincounts during the SEAMAP reef fish video cruise in 1994.

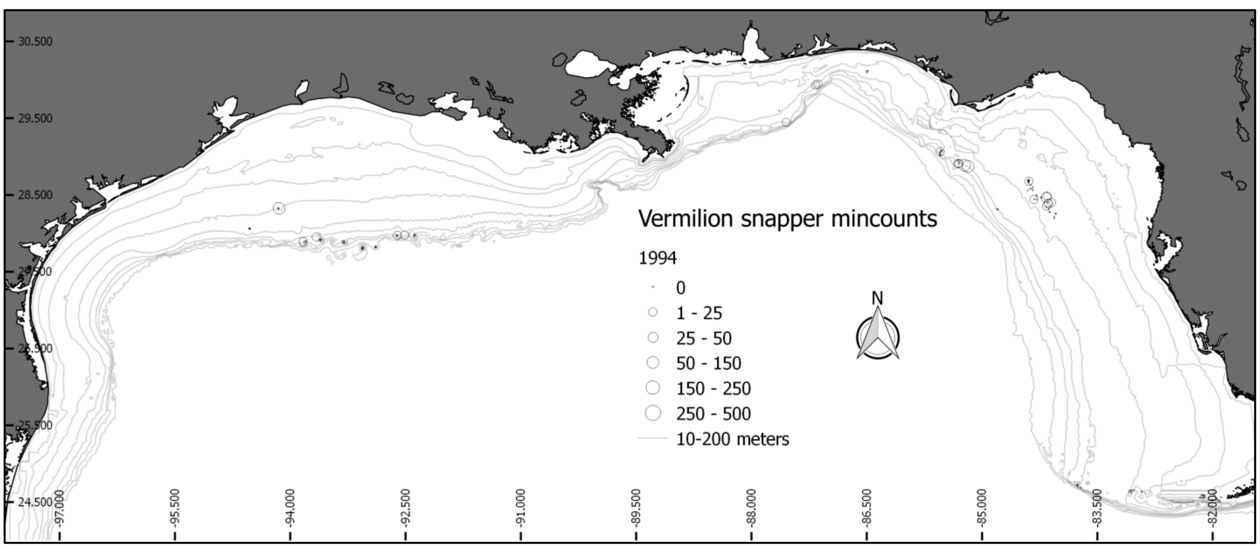

Figure 15. Map of vermilion snapper mincounts during the SEAMAP reef fish video cruise in 1995.

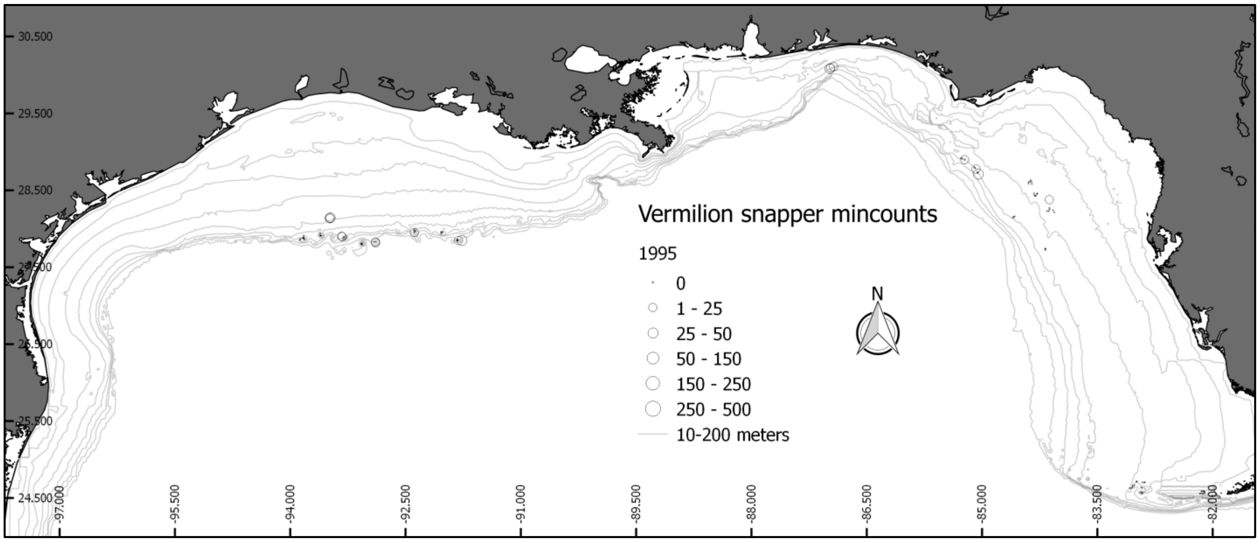

Figure 16. Map of vermilion snapper mincounts during the SEAMAP reef fish video cruise in 1996.

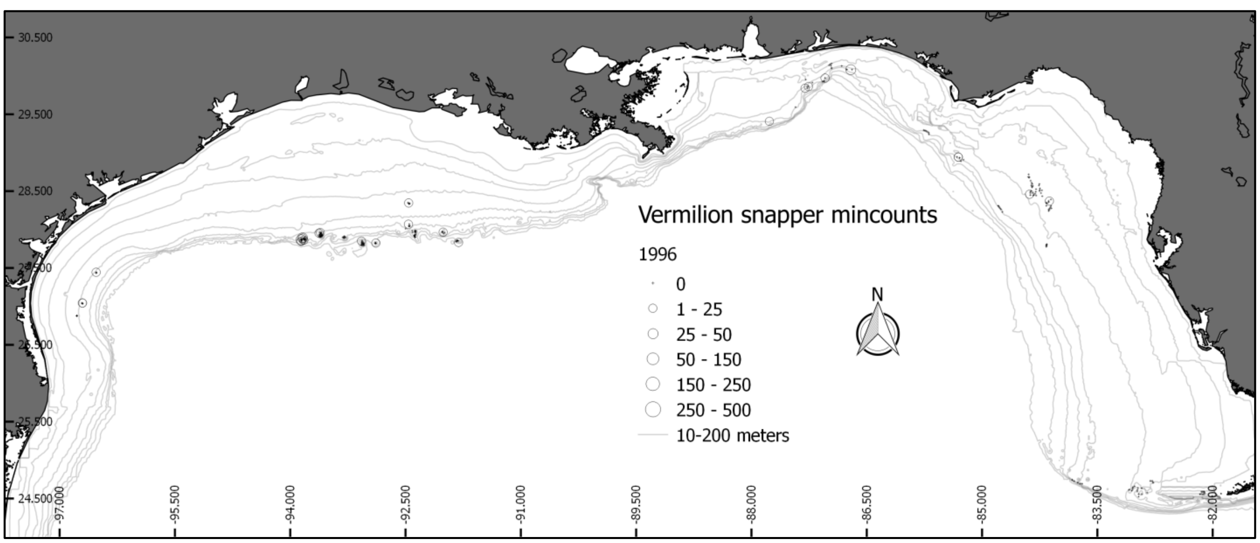

Figure 17. Map of vermilion snapper mincounts during the SEAMAP reef fish video cruise in 1997.

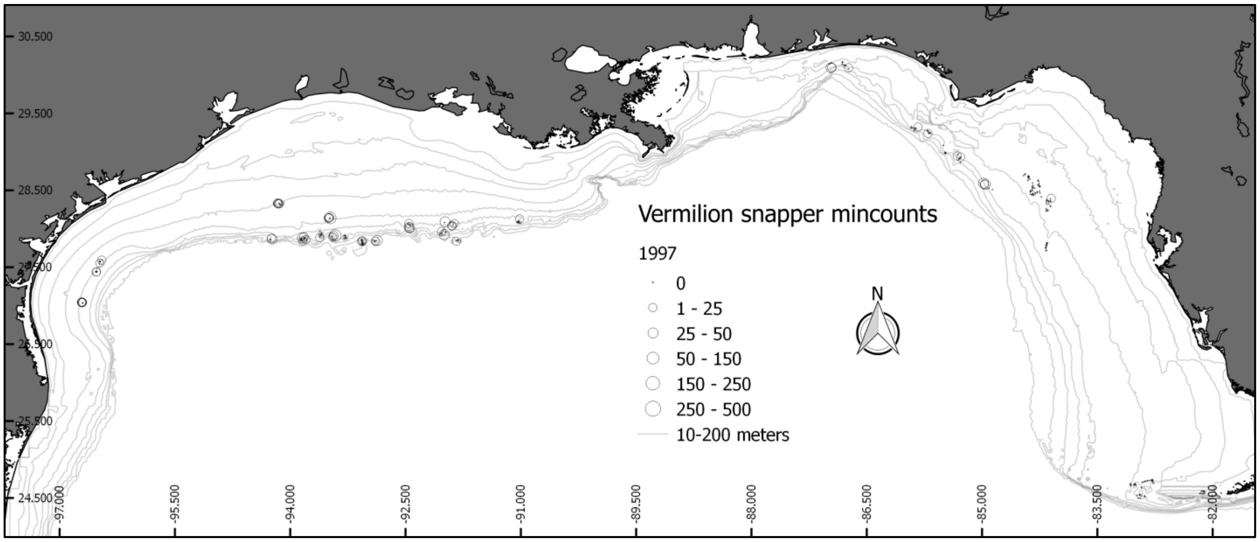

Figure 18. Map of vermilion snapper mincounts during the SEAMAP reef fish video cruise in 2002.

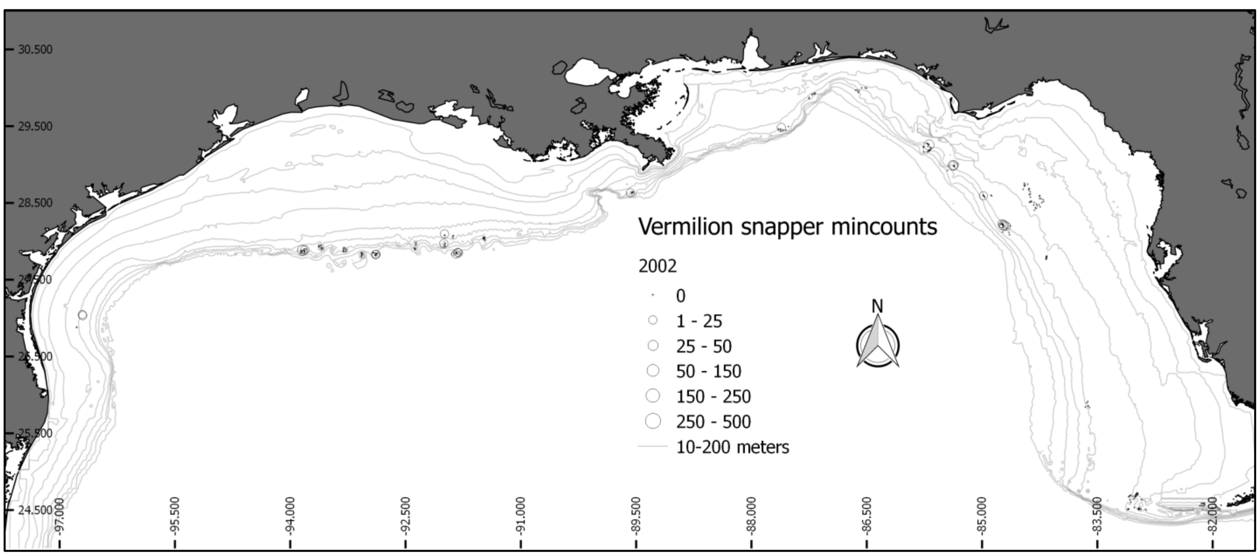

Figure 19. Map of vermilion snapper mincounts during the SEAMAP reef fish video cruise in 2004.

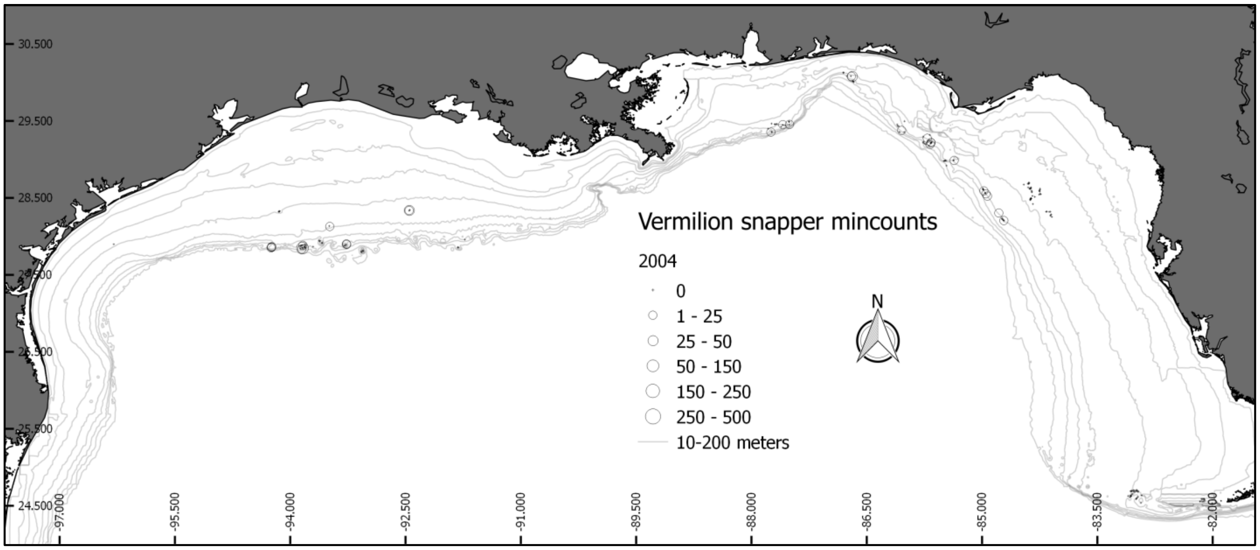

Figure 20. Map of vermilion snapper mincounts during the SEAMAP reef fish video cruise in 2005.

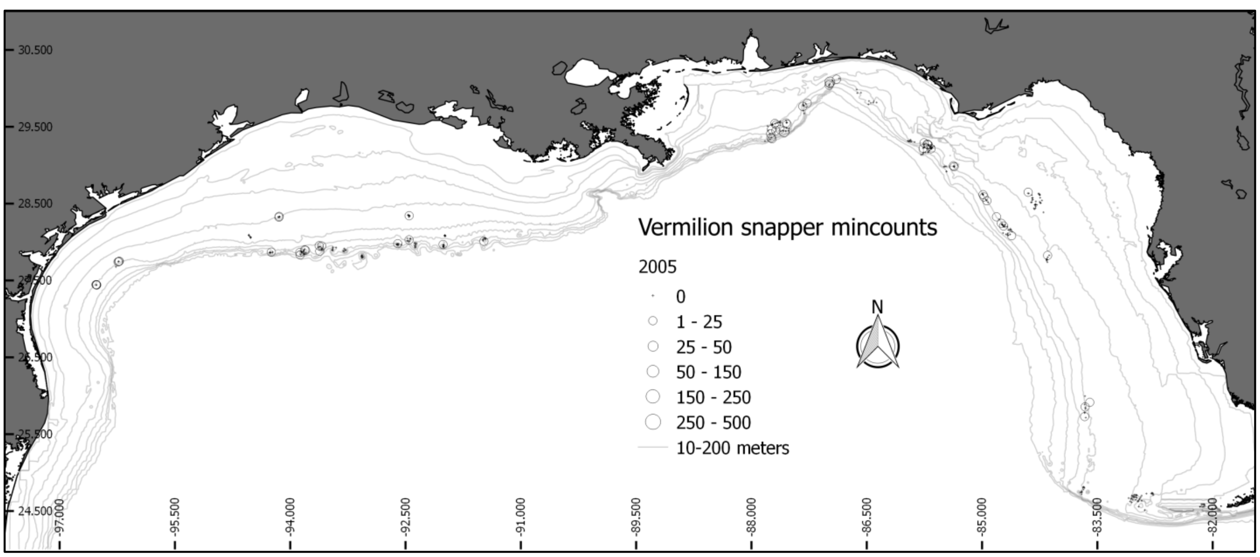

Figure 21. Map of vermilion snapper mincounts during the SEAMAP reef fish video cruise in 2006.

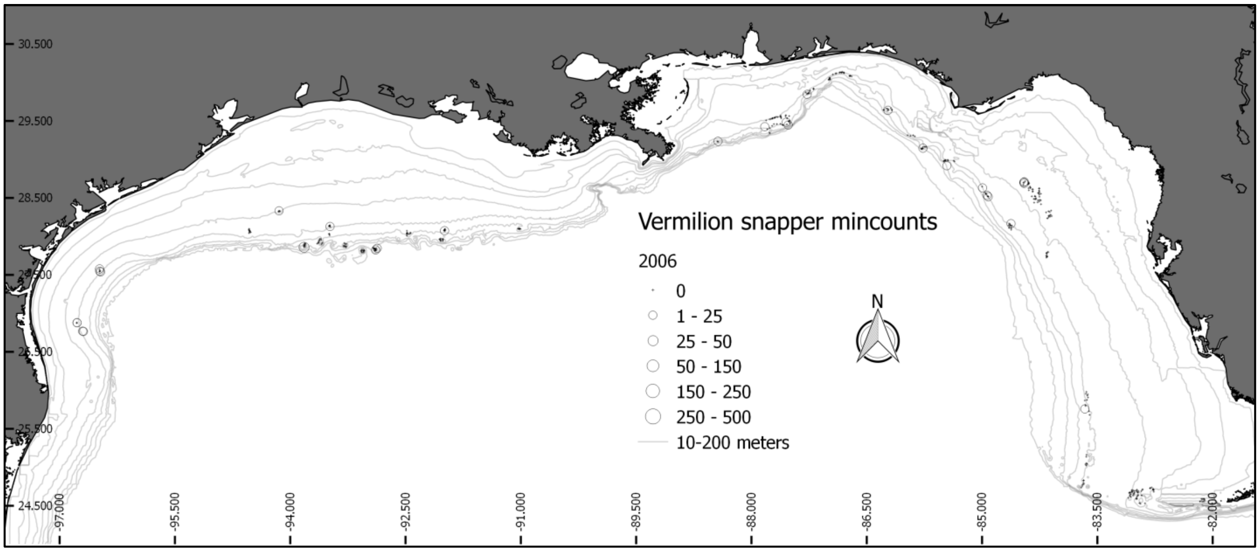

Figure 22. Map of vermilion snapper mincounts during the SEAMAP reef fish video cruise in 2007.

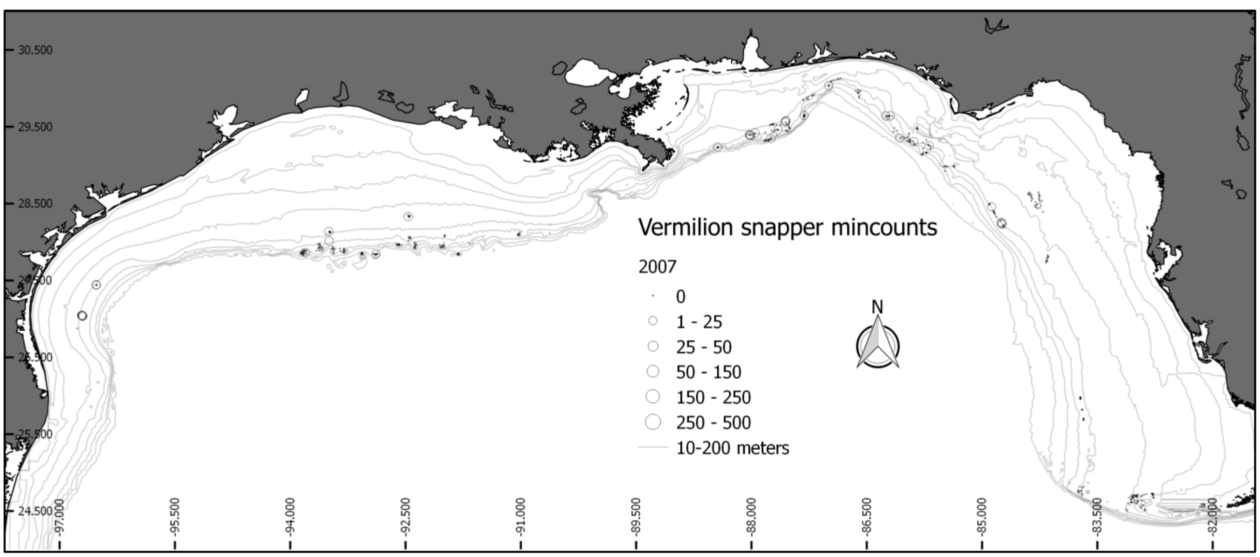

Figure 23. Map of vermilion snapper mincounts during the SEAMAP reef fish video cruise in 2008.

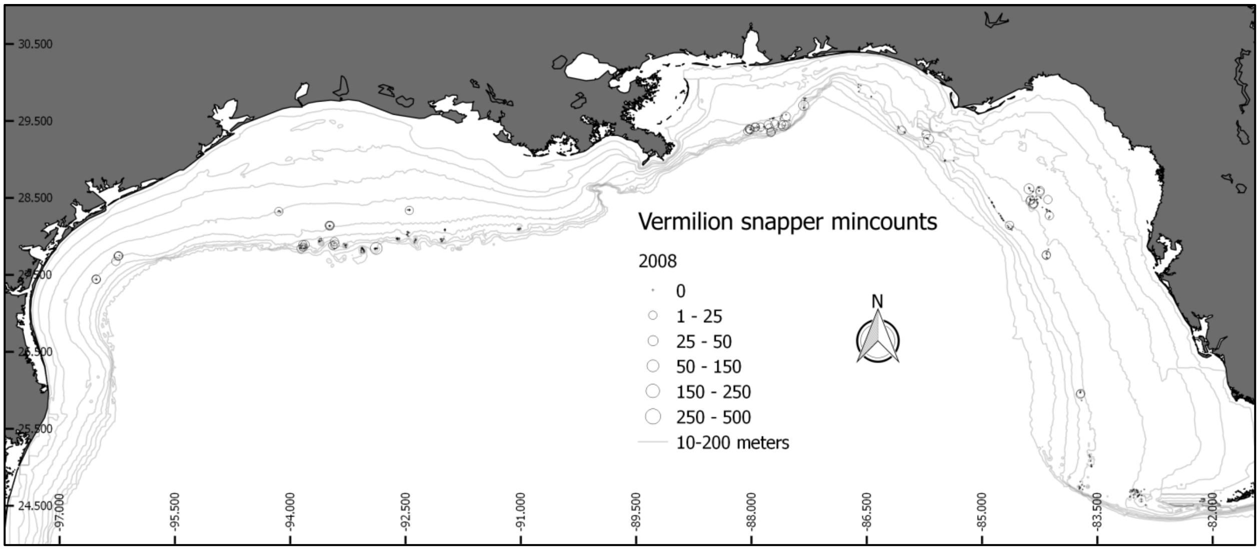

Figure 24. Map of vermilion snapper mincounts during the SEAMAP reef fish video cruise in 2009.

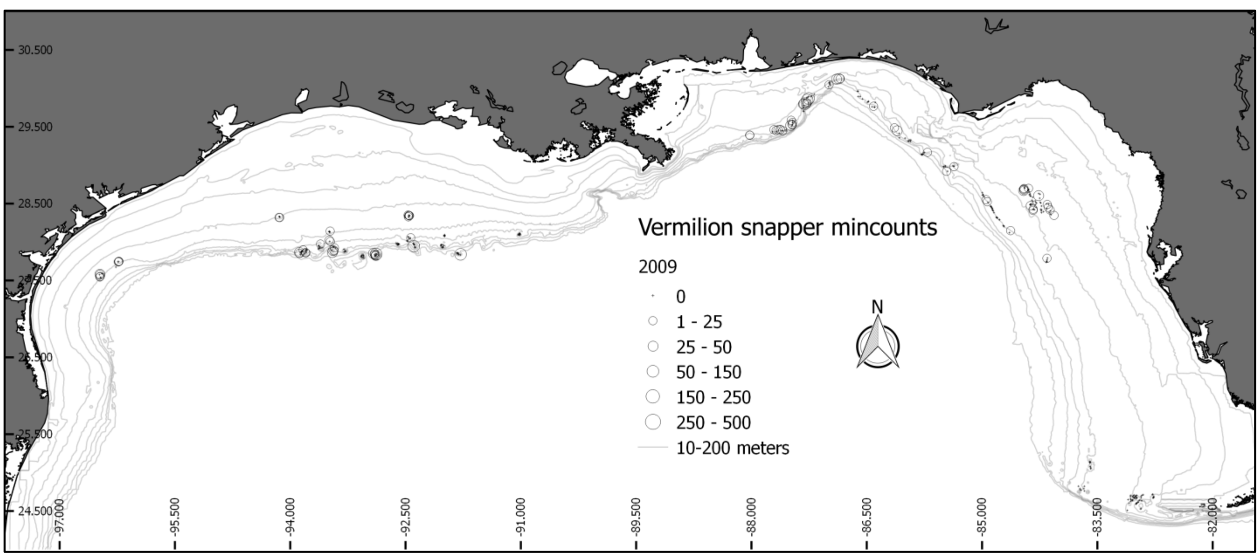

Figure 25. Map of vermilion snapper mincounts during the SEAMAP reef fish video cruise in 2010.

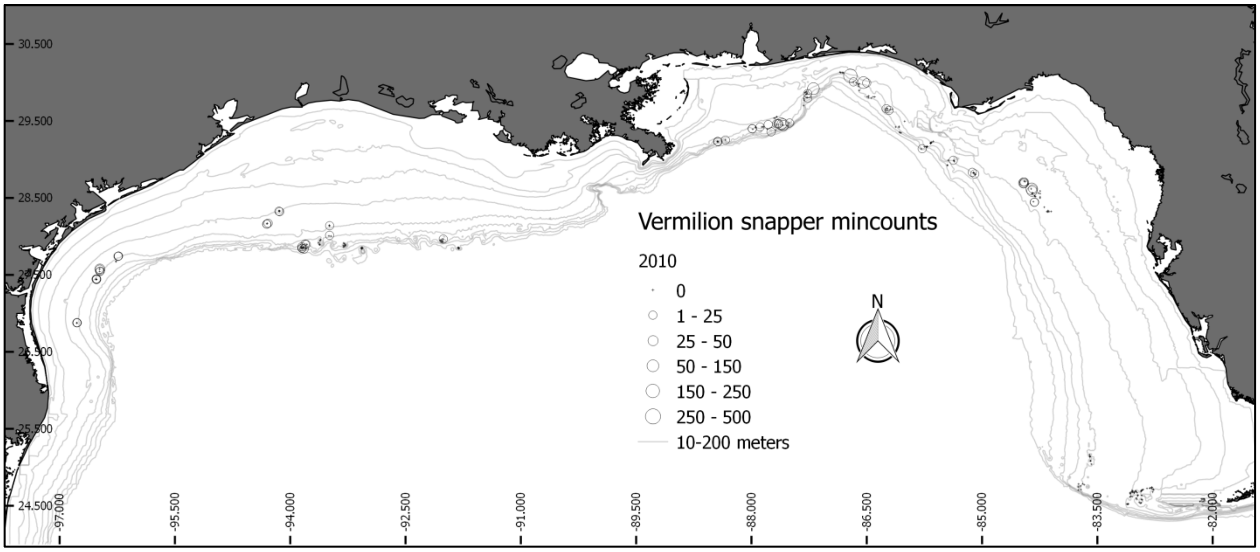

Figure 26. Map of vermilion snapper mincounts during the SEAMAP reef fish video cruise in 2011.

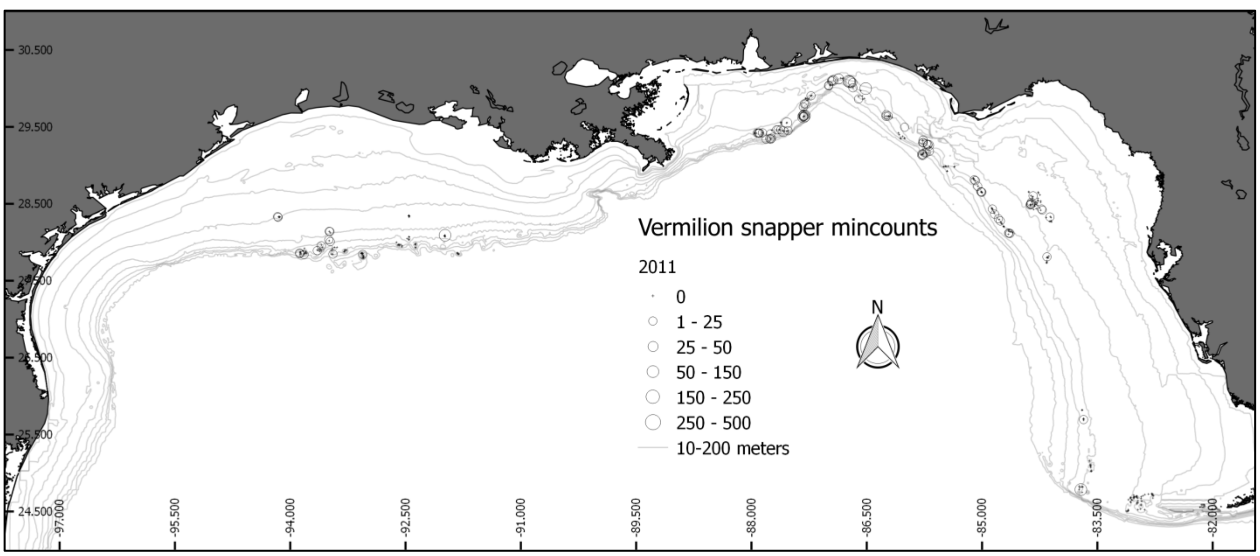

Figure 27. Map of vermilion snapper mincounts during the SEAMAP reef fish video cruise in 2012.

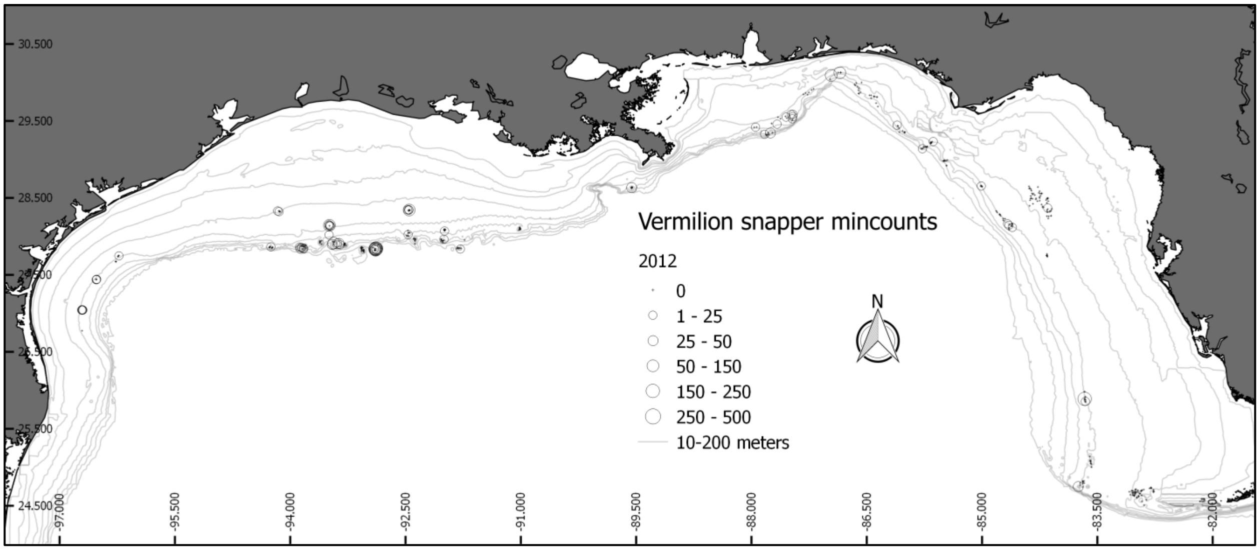

Figure 28. Map of vermilion snapper mincounts during the SEAMAP reef fish video cruise in 2013.

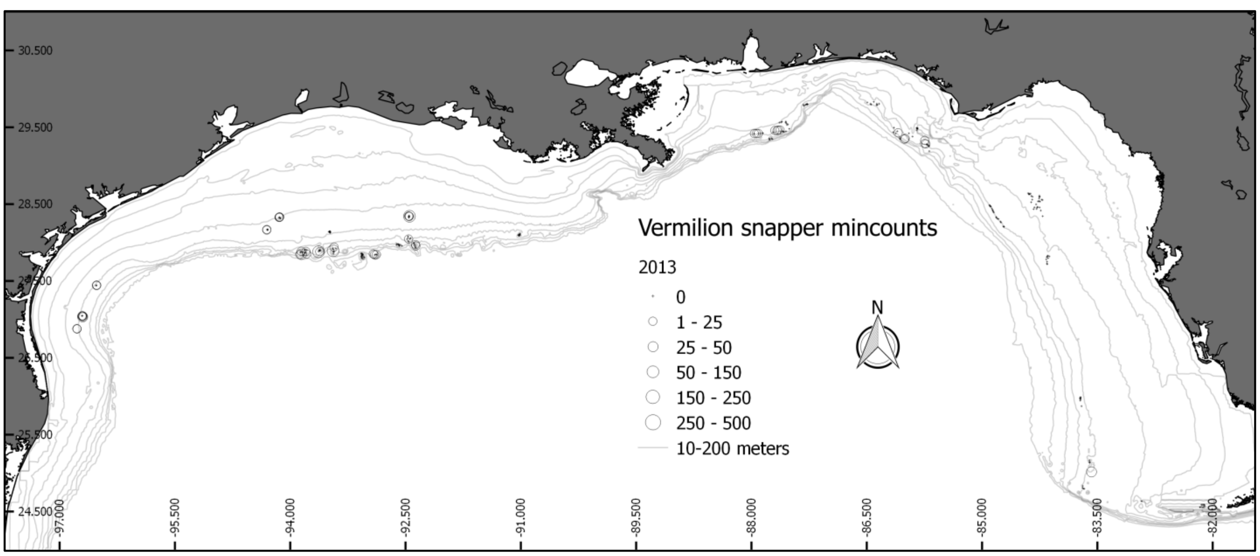

Figure 29. Map of vermilion snapper mincounts during the SEAMAP reef fish video cruise in 2014.

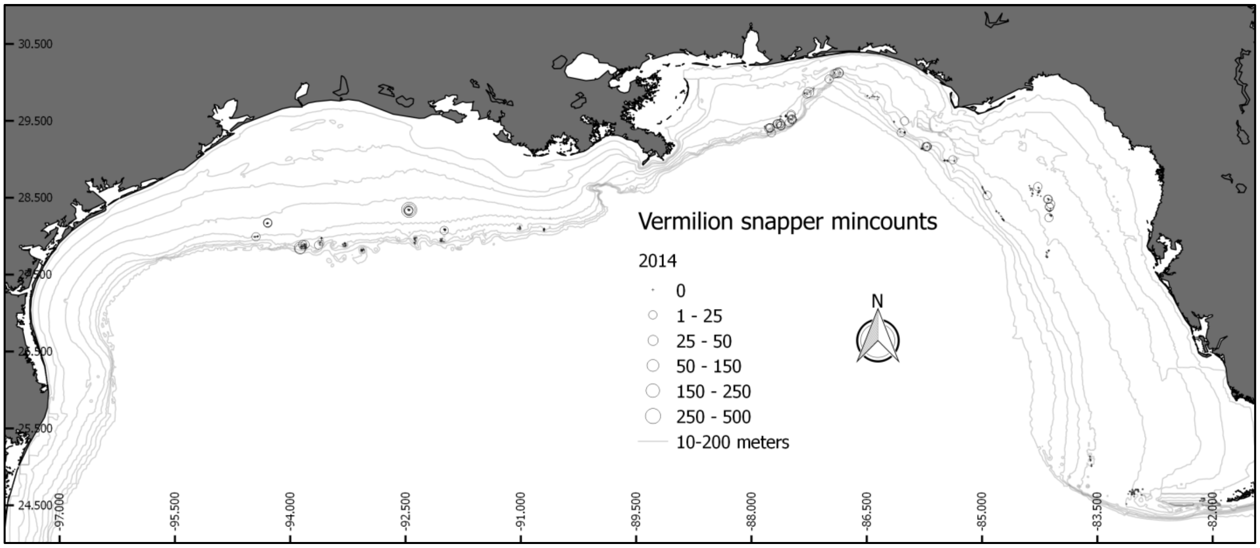

Table 7. Mean and standard deviation of vermilion snapper lengths (FL) from the SEAMAP reef fish video cruise from 1995 – 2013. Includes estimates by region and Gulf wide.

	East		**West**		**Gulf wide**	
	Mean	***SD***	***Mean***	***SD***	***Mean***	***SD***
1995	237.67	17.11	299.45	38.49	287.62	42.97
1996	252.00	58.84	300.08	53.53	289.94	57.93
1997	212.00	20.08	272.97	69.46	266.26	68.54
2001	na	na	301.00	53.43	301.00	53.43
2002	246.85	50.06	287.75	69.90	265.12	63.08
2003	307.21	79.31	na	na	307.21	79.31
2004	278.50	56.57	209.92	72.79	267.81	64.16
2005	285.59	79.68	285.46	52.69	285.56	74.05
2006	228.48	48.72	297.72	61.98	250.15	62.13
2007	277.03	59.45	288.49	58.64	283.75	59.21
2008	275.46	53.00	283.61	57.71	278.84	54.74
2009	272.22	52.49	215.65	46.23	258.29	56.43
2010	359.14	48.14	240.87	76.76	268.97	87.01
2011	258.08	117.77	320.75	60.33	263.39	115.31
2012	223.87	61.15	265.84	73.07	243.46	69.97
2013	207.04	76.01	283.77	75.15	254.84	83.92
Combined	264.74	76.02	284.22	65.01	272.30	72.56

Figure 30. Mean lengths and standard deviation of vermilion snapper observed during the SEAMAP reef fish video cruise from 1995 – 2013 showing decreasing mean fork length th time.

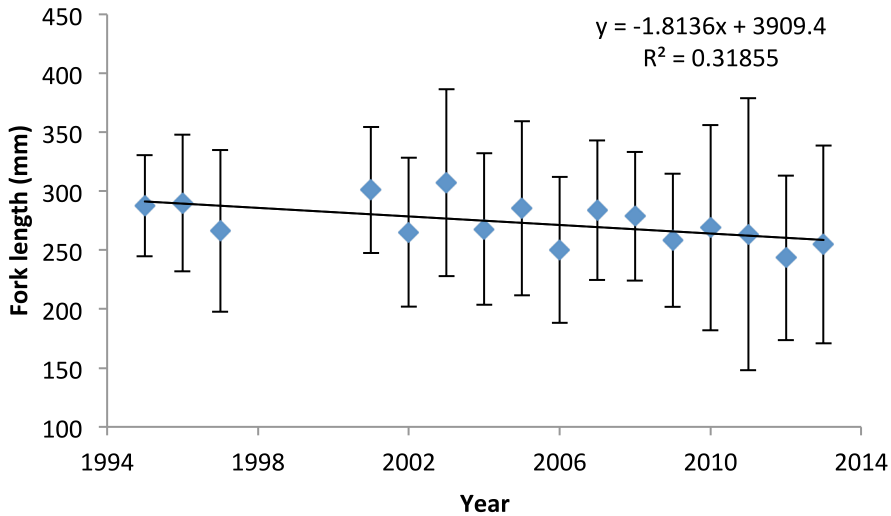

Figure 31. Length frequency histograms of vermilion snapper observed during the SEAMAP reef fish video cruise from 1995 - 2013.