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Red Snapper Abundance Indices from Bottom Longline Surveys in the Northern Gulf of Mexico

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Abstract: *Bottom longline data from three sampling programs were analyzed to calculate relative abundance indices for Red Snapper (Lutjanus campechanus) in the western, central, and eastern Gulf of Mexico (GOM). The data sources included a long-term (19-year) time series from the NOAA Fisheries Southeast Fisheries Science Center (SEFSC) Population and Ecosystem Monitoring Division (PEM), a single year of sampling from the Congressional Supplemental Sampling Program (CSSP) and a ten-year time series from the Dauphin Island Sea Lab (DISL). While the survey gear was similar between the sampling programs the survey design and spatial coverage was slightly different (allocation of stations) between the SEFSC survey and CSSP survey, while vastly different spatially when compared to the DISL survey. Relative abundance indices are presented for the eastern and western GOM from the SEFSC and CSSP data, while three indices are presented for the central GOM: SEFSC and CSSP data, SEFSC, CSSP and DISL data and DISL data.*

Introduction

The NOAA Fisheries Southeast Fisheries Science Center (SEFSC) Population and Ecosystem Monitoring (PEM) Division has conducted standardized bottom longline (SEFSC BLL) surveys in the Gulf of Mexico (GOM), Caribbean, and Western North Atlantic Ocean (Atlantic) since 1995. The objective of these surveys is to provide fisheries independent data for stock assessment purposes for as many species as possible. These surveys are conducted annually in U.S. waters of the GOM and/or the Atlantic, and provide an important source of fisheries independent information on sharks, snappers and groupers. The evolution of these surveys has been the subject of many documents (e.g., Ingram *et al*. 2005) and will not be described again in this document.

In 2011, the Congressional Supplemental Sampling Program (CSSP) focused on completing monthly gulfwide bottom longline surveys in the U.S. northern GOM from April through October (for a full review of the CSSP see Campbell et al. 2012). Sampling during the CSSP program was conducted using the same gear as the SEFSC BLL survey, and a similar survey design. The primary differences between the SEFSC BLL and CSSP surveys were in the depth range of coverage and the proportion of samples allocated to each depth strata. The SEFSC BLL survey samples in depths ranging from 9 to 366 m with 50% of samples in depths of 9 to 55 m, 40% of samples in depths of 55 to 183 m and 10% of samples in depths of 183 to 366 m, with samples allocated to defined longitude/latitude divisions within each depth strata by the proportional of spatial area in each division. In contrast, the CSSP survey sampled depths from 9 to 400m with samples allocated proportionally by the spatial area of 38 strata based on longitude/latitude divisions and 3 depth strata (9 to 55 m, 55 to 183 m and 183 to 400 m).

In addition to the SEFSC BLL and CSSP surveys, the Dauphin Island Sea Lab (DISL) has conducted fishery-independent bottom longline surveys in the north-central GOM off Alabama. The survey utilizes a gear configuration similar to the SEFSC BLL and CSSP surveys, but is conducted under a different sampling design. Details concerning the DISL surveys can be obtained from Dr. Sean Powers[1], DISL.

Red Snapper (*Lutjanus campechanus*) captured during fishery-independent bottom longline surveys were first used to reflect trends in stock size for the western and eastern GOM during the Southeast Data Assessment and Review (SEDAR7) Update Assessment process in 2009 (SEDAR Red Snapper Update, 2009), and have since been incorporated into the SEDAR31 (2013), SEDAR31 Update (2014) assessments, SEDAR52 (2018) and SEDAR52 update assessments. The SEDAR7 (2004) and SEDAR7 Update indices (2009) incorporated data only from the SEFSC BLL survey. Initial indices submitted for the SEDAR31 Data Workshop incorporated data from the SEFSC BLL and CSSP surveys, but the eastern GOM index was updated to include DISL survey data for the Assessment Workshop. Detailed information concerning iterations of the indices is documented in Henwood *et al.* (2005), Ingram and Pollack (2012), Ingram (2013) and Pollack *et al.* (2017). Based on the recommendations of the SEDAR 74 Stock Id Workshop, the current assessment will be transitioning from a two-area model to a three-area model (SEDAR 74 Stock ID 2021). This document outlines the development of abundance indices for the western GOM, central GOM, and eastern GOM. (Figure 1).

Currently, the time series of data from the SEFSC BLL survey available for analysis extends from 19995 to 2019, and the DISL survey from 2010 to 2019. The CSSP was a single year of sampling that extends from April to October in 2011. This document outlines the development of Red Snapper indices for the western GOM, central GOM, and eastern GOM continental shelf using the same statistical approach that has been used in previous assessments.

Methodology

Survey Design

Details concerning methodologies and evolution of the SEFSC BLL have been covered in previous documents (most recently LCS05/06-DW-27) and will not be repeated in this document. For reviews of the CSSP survey design see Campbell *et al.* (2012) and for the DISL survey contact Dr. Sean Powers[1]. When the SEFSC BLL survey began in 1995, J-hooks were the standard gear. Over time a change was made to 15/0 circle hooks. Henwood *et al.* (2005) examined the difference in catch rates between the two hooks types and found significant difference in catch rates for Red Snapper.

Data

Data for the annual SEFSC BLL survey and CSSP survey was obtained from an ORACLE database maintained at SEFSC MSLABS. Data from the CSSP was used to fill in gaps in the annual SEFSC BLL survey due to vessel breakdowns and weather delays in 2011. The

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combined data from the SEFSC BLL and CSSP surveys will be referred to as SEFSC BLL from this point forward. Data for the DISL survey was obtained from Dr. Sean Powers[1].

Indices

Indices of abundance were developed for the western GOM, central GOM and eastern GOM based solely on the SEFSC BLL survey. In addition, central GOM indices based on a combination of SEFSC BLL and DISL survey data and solely on the DISL survey data were also developed.

Data Exclusions

Based on the spatial distribution of sampling (mostly less than 55m) and the use of J hooks instead of circle hooks, the years 1995 – 2000 were excluded from the analysis, mirroring the recommendations of Henwood *et al.* (2005). For the western GOM SEFSC BLL index, data from the years 2005 and 2008 were excluded due to extremely low sampling effort and limited spatial coverage (see Appendix Figure 1). For the SEFSC BLL and combined SEFSC BLL/DISL central GOM indices, the years 2007 and 2008 were excluded because of the lack of positive captures. For the SEFSC BLL eastern GOM, no samples were taken in the area for 2002, and 2008 and 2015 were excluded from the model because of the lack of positive captures.

Depth was used to limit the data, with all sampling deeper than 183 m excluded. Since there were no records of Red Snapper being caught any deeper, (183 m was chosen because it is the inner extent of the deepest depth zone in the survey design). Sampling effort during the 2011 SEFSC BLL survey was limited in spatial coverage. Therefore, we utilized data from the CSSP survey to supplement sampling effort from the SEFSC BLL in 2011. This survey consisted of monthly sampling that covered the entire GOM. As to not over represent the 2011 sampling year, only data from July and August CSSP survey were used in the index.

The central GOM index based on combined SEFSC BLL and DISL data only utilizes DISL sampling conducted during July, August and September in order to maintain temporal consistency. In addition, any DISL sampling effort conducted outside of the SEFSC BLL sampling universe was also excluded.

Index Construction

Delta-lognormal modeling methods were used to estimate relative abundance indices for Red Snapper (Bradu and Mundlak 1970, Pennington 1983). The main advantage of using this method is allowance for the probability of zero catch (Ortiz *et al.* 2000). The index computed by this method is a mathematical combination of yearly abundance estimates from two distinct generalized linear models: a binomial (logistic) model which describes proportion of positive abundance values (i.e. presence/absence) and a lognormal model which describes variability in only the nonzero abundance data (*cf.* Lo *et al*. 1992).

The delta-lognormal index of relative abundance (I_y) was estimated as:

(1) $I_y = c_y p_y$,

where c_y is the estimate of mean CPUE for positive catches only for year y, and p_y is the estimate of mean probability of occurrence during year y. Both c_y and p_y were estimated using generalized linear models. Data used to estimate abundance for positive catches (c) and probability of occurrence (p) were assumed to have a lognormal distribution and a binomial distribution, respectively, and modeled using the following equations:

(2) $\ln(c) = X\beta + \varepsilon$

and

(3) $p = \dfrac{e^{\mathbf{X\beta+\varepsilon}}}{1+e^{\mathbf{X\beta+\varepsilon}}}$,

respectively, where c is a vector of the positive catch data, p is a vector of the presence/absence data, X is the design matrix for main effects, β is the parameter vector for main effects, and ε is a vector of independent normally distributed errors with expectation zero and variance σ^2. Therefore, c_y and p_y were estimated as least-squares means for each year along with their corresponding standard errors, SE (c_y) and SE (p_y), respectively. From these estimates, I_y was calculated, as in equation (1), and its variance calculated using the delta method approximation

(4) $V(I_y) \approx V(c_y)p_y^2 + c_y^2 V(p_y)$.

A covariance term is not included in the variance estimator since there is no correlation between the estimator of the proportion positive and the mean CPUE given presence. The two estimators are derived independently and have been shown to not covary for a given year (Christman, unpublished).

The submodels of the delta-lognormal model were built using a backward selection procedure based on type 3 analyses with an inclusion level of significance of $\alpha = 0.05$. Binomial submodel performance was evaluated using AIC, while the performance of the lognormal submodel was evaluated based on analyses of residual scatter and QQ plots in addition to AIC. Variables that could be included in the submodels were:

Submodel Variables (Western Gulf of Mexico – SEFSC BLL)

Year: 2001 – 2004, 2006 – 2007, 2009 – 2019
Area: 1 – 9 (Figure 1)
Depth: Continuous (9 – 183 m)
Time of Day: Day, Night

Submodel Variables (Central Gulf of Mexico – SEFSC BLL)

Year: 2001 – 2006, 2009 – 2019
Area: 10 – 14/15 (Figure 1)
Depth: Continuous (9 – 183 m)
Time of Day: Day, Night

Submodel Variables (Eastern Gulf of Mexico – SEFSC BLL)

Year: 2001, 2003 – 2007, 2009 – 2019
Area: 14 – 18 (Figure 1)
Depth: Continuous (9 – 183 m)
Time of Day: Day, Night

Submodel Variables (Central Gulf of Mexico – SEFSC BLL/DISL)

Year: 2001 – 2006, 2009 – 2019
Area: 10 – 14/15 (Figure 1)
Depth: Continuous (9 – 183 m)
Time of Day: Day, Night

Submodel Variables (Central Gulf of Mexico - DISL)

Year: 2010 – 2019
Depth: Continuous (3 – 125 m)

Results and Discussion

Spatial Distribution, Size and Age

The spatial distribution of Red Snapper is presented in Figure 2 for the SEFSC BLL survey and Figure 3 for the DISL Survey, with annual abundance and distribution presented in Appendix Figures 1 and 2. Annual catch and length summaries for the western GOM, central GOM, eastern GOM, and DISL data are presented in Tables 2a, 2b, 2c, and 3, respectively. Length and age distribution for the SEFSC BLL indices are presented in Figures 4 and 5 and Figures 6 and 7 for the central GOM indices based on combined SEFSC and DISL and DISL only data.

Abundance Index – Western Gulf of Mexico – SEFSC BLL

For the SEFSC BLL western GOM abundance index of Red Snapper, year, zone, and depth were retained in the binomial submodel, while year was retained in the lognormal submodel. A summary of the factors used in the analysis is presented in Appendix Table 1. Table 4 summarizes backward selection procedure used to select the final set of variables used in the submodels and their significance. The AIC for the binomial and lognormal submodels were 6,048.9 and 1023.2, respectively. The diagnostic plots for the binomial and lognormal submodels are shown in Figure 8, and indicated the distribution of the residuals was approximately normal. Annual abundance indices are presented in Table 5 and Figure 9.

Abundance Index – Central Gulf of Mexico – SEFSC BLL

For the SEFSC BLL central GOM abundance index of Red Snapper, year and zone were retained in the binomial submodel, while year was retained in the lognormal submodel. A summary of the factors used in the analysis is presented in Appendix Table 2. Table 6 summarizes backward selection procedure used to select the final set of variables used in the submodels and their significance. The AIC for the binomial and lognormal submodels were 3,554.4 and 178.9, respectively. There was an increase in the AIC when depth was removed from the binomial submodel (3,548.6 to 3,554.49), however since depth was not significant the final model run was deemed acceptable. There was an increase in the AIC when zone was removed from the lognormal submodel (174.3 to 178.9), however since zone was not significant the final model run was deemed acceptable. The diagnostic plots for the binomial and lognormal submodels are shown in Figure 10, and indicated the distribution of the residuals was approximately normal. Annual abundance indices are presented in Table 7 and Figure 11.

Abundance Index – Eastern Gulf of Mexico – SEFSC BLL

For the SEFSC BLL eastern GOM abundance index of Red Snapper, year, area and depth were retained in the binomial submodel, while only year was retained in the lognormal submodel. A summary of the factors used in the analysis is presented in Appendix Table 3. Table 8 summarizes backward selection procedure used to select the final set of variables used in the submodels and their significance. The AIC for the binomial and lognormal submodels were 5,441.1 and 60.8, respectively. There was an increase in the AIC when time of day and depth were removed from the binomial submodel (5,420.1 to 5,441.1), however since time of day and depth were not significant the final model run was deemed acceptable. The diagnostic plots for the binomial and lognormal submodels are shown in Figure 12, and indicated the distribution of the residuals was approximately normal. Annual abundance indices are presented in Table 9 and Figure 13.

Abundance Index – Central Gulf of Mexico – SEFSC BLL/DISL

For the SEFSC/DISL BLL abundance index of Red Snapper, year and zone were retained in both the binomial and lognormal submodels. A summary of the factors used in the analysis is presented in Appendix Table 4. Table 10 summarizes backward selection procedure used to select the final set of variables used in the submodels and their significance. The AIC for the binomial and lognormal submodels were 4,448.9 and 474.3, respectively. There was an increase in the AIC when time of day and depth were removed from the binomial submodel (4,422.2 to 4,448.9), however since area was not significant the final model run was deemed acceptable. The diagnostic plots for the binomial and lognormal submodels are shown in Figure 14, and indicated the distribution of the residuals was approximately normal. Annual abundance indices are presented in Table 11 and Figure 10.

Abundance Index – Central Gulf of Mexico - DISL

For the DISL BLL abundance index of Red Snapper, year was retained in the both the binomial and lognormal submodels. A summary of the factors used in the analysis is presented in Appendix Table 5. Table 12 summarizes backward selection procedure used to select the final set of variables used in the submodels and their significance. The AIC for the binomial and lognormal submodels were 1,928.3 and 675.4, respectively. There was an increase in the AIC when depth was removed from the lognormal submodel (1,926.8 to 1,928.3), however since depth was not significant the final model run was deemed acceptable. The diagnostic plots for the binomial and lognormal submodels are shown in Figure 16, and indicated the distribution of the residuals was approximately normal. Annual abundance indices are presented in Table 13 and Figure 17.

Concerns over the Incorporation of the DISL Data

During the SEDAR31 Data Workshop, it was recommended that the DISL survey data be incorporated into the SEFSC BLL time series. While this did not seem to be problematic at the time, the inclusion of the DISL data appears to be driving the overall index in the later years and may not be fully representative of the dynamics of the Red Snapper population across the entire central GOM. Of particular concern are the seemingly diverging trends in the individual indices, which are showing a marked increase in the SEFSC BLL index, particularly over the last few years and a decreasing trend in the DISL index (Figure 18). In addition, the frequency of occurrence between the surveys differs significantly (18% compared to 56% between 2010 and 2019 for the SEFSC BLL and DISL, respectively). Finally, the length composition (Figure 2) of the two surveys also appears to differ (mean fork length 673 mm compared to 771 mm, SEFSC BLL and DISL, respectively), which may be due to the areas sampled by each survey (MS to FL vs. area off AL).

Based on these concerns, it is our recommendation that the SEFSC BLL index (without the DISL data) be used in this assessment for the central GOM. This is not to say that the DISL BLL index should be not be considered for use in the assessment, but should be looked at independently from the SEFSC BLL index. Further research on combining the time series from SEFSC and DISL is needed. A research recommendation would be to examine a method to weight the respective indices before combining them in order to account for the differences in spatial coverage of the surveys.

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Table 1. Summary of the total number of stations sampled by bottom longline zone per year used in the analysis. Note that based regional boundaries, zones 14 and 15 are split between the central and eastern regions.

	Western									Central						Eastern					
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	14	15	16	17	18	Total
2001	10	13	14	17	23	18	14	9	6	9	9	11	16	5	5	14	6	20	21	6	246
2002	14	17	18	20	24	19	17	14	7	10	10	12	11	5							198
2003	8	12	12	13	15	13	12	10	5	10	7	12	15	8	3	10	8	21	26	31	251
2004		2	13	16	19	17	12	9	7	10	7	12	8	6	2	8	6	20	23	30	227
2005								4	3	5	6	4	10	2	1	6	1	5	10	21	78
2006	5	8	7	9	14	8	8	6	6	4	3	4	3			5	1	8	12	17	128
2007	5	8	6	11	12	12	9	5	2	4	4	6	8	2	1	2	3	6	9	17	132
2008	5	5	5	6						3	4	7	8	4	1	5	5	6	11	13	88
2009	6	8	8	9	15	10	9	8	3	8	5	6	8	3	2	7	4	7	17	19	162
2010	5	6	1	6	7	8	5	6	2	5	4	7	9	4	3	3	6	7	11	21	126
2011	11	13	15	23	26	17	14	10	10	19	14	15	32	14	3	19	20	26	33	42	376
2012	3	6	5	5	9	10	8	5	2	5	3	4	5	5		5	5	11	11	13	120
2013	3	6	6	11	13	11	5	5	3	14	7	8	5	2	2	4	3	10	9	11	138
2014		5	2	11	8	7	7	4	3	5	4	3	7	4	1	3	3	4	9	12	102
2015	4	7	6	8	10	7	6	7	1	7	7	10	9	3	2	5	4	11	10	11	135
2016	4	7	7	6	10	7	5	5	3	6	14	10	8	2	2	4	4	9	8	12	133
2017	7	10	7	11	11	7	7	4	3	7	4	5	5	3		3	5	7	9	14	129
2018	3	7	6	8	10	11	7	4	3	7	6	6	9	3	2	8	3	8	7	10	128
2019	3	7	6	8	7	6	4	5	2	4	3	5	5	3		4	4	6	8	12	102

Table 2a. Summary of the Red Snapper length data collected from SEFSC Bottom Longline surveys conducted between 2001 and 2019 in the western Gulf of Mexico.

Survey Year	Number of Stations	Number Collected	Number Measured	Minimum Fork Length (mm)	Maximum Fork Length (mm)	Mean Fork Length (mm)	Standard Deviation
2001	124	87	69	386	861	708	95
2002	150	76	75	380	890	746	95
2003	100	62	57	356	904	695	121
2004	95	63	57	442	865	670	117
2005	7	0					
2006	71	35	32	497	841	745	83
2007	70	41	40	355	920	704	99
2008	21	11	10	412	845	666	121
2009	76	75	32	420	880	677	117
2010	46	36	35	490	840	659	94
2011	139	222	216	290	850	648	105
2012	53	136	127	488	840	697	71
2013	63	139	131	542	829	692	61
2014	47	61	58	524	831	695	61
2015	56	231	220	418	866	686	76
2016	54	191	178	305	829	684	60
2017	67	320	304	435	841	690	62
2018	59	188	182	534	851	692	53
2019	48	197	173	365	855	674	71
Total Number of Years	Total Number of Stations	Total Number Collected	Total Number Measured			Overall Mean Fork Length (mm)	
19	1346	2171	1996			687	

Table 2b. Summary of the Red Snapper length data collected from SEFSC Bottom Longline surveys conducted between 2001 and 2019 in the central Gulf of Mexico.

Survey Year	Number of Stations	Number Collected	Number Measured	Minimum Fork Length (mm)	Maximum Fork Length (mm)	Mean Fork Length (mm)	Standard Deviation
2001	55	3	1	880	880	880	.
2002	48	2	2	618	746	682	91
2003	55	5	5	514	765	609	112
2004	45	2	2	526	680	603	109
2005	28	1	1	506	506	506	.
2006	14	1	1	825	825	825	.
2007	25	0					
2008	27	0					
2009	32	4	1	564	564	564	.
2010	32	11	11	460	810	612	115
2011	97	53	43	412	891	590	115
2012	22	15	12	483	857	725	104
2013	38	11	7	490	721	587	88
2014	24	13	9	534	845	737	89
2015	38	28	24	561	890	712	87
2016	42	50	50	463	825	688	75
2017	24	6	5	685	952	793	97
2018	33	14	13	686	850	759	53
2019	20	15	15	480	810	712	80
Total Number of Years	Total Number of Stations	Total Number Collected	Total Number Measured			Overall Mean Fork Length (mm)	
19	699	234	202			673	

Table 2c. Summary of the Red Snapper length data collected from SEFSC Bottom Longline surveys conducted between 2001 and 2019 in the eastern Gulf of Mexico.

Survey Year	Number of Stations	Number Collected	Number Measured	Minimum Fork Length (mm)	Maximum Fork Length (mm)	Mean Fork Length (mm)	Standard Deviation
2001	67	1	1	620	620	620	.
2002							
2003	96	4	4	483	587	528	52
2004	87	5	5	496	570	536	31
2005	43	2	2	629	644	637	11
2006	43	1	1	740	740	740	.
2007	37	7	6	534	670	629	51
2008	40	0					
2009	54	6	6	480	682	597	88
2010	48	7	7	460	670	582	85
2011	140	26	22	449	703	568	71
2012	45	2	2	514	694	604	127
2013	37	10	10	655	697	673	16
2014	31	1	1	670	670	670	.
2015	41	0					
2016	37	6	5	426	791	627	141
2017	38	2	1	451	451	451	.
2018	36	2	2	430	513	472	59
2019	34	3	3	565	705	641	71
Total Number of Years 18	Total Number of Stations 954	Total Number Collected 85	Total Number Measured 78			Overall Mean Fork Length (mm) 595	

Table 3. Summary of the Red Snapper length data collected from DISL Bottom Longline surveys conducted between 2010 and 2019 in the central Gulf of Mexico.

Survey Year	Number of Stations	Number Collected	Number Measured	Minimum Fork Length (mm)	Maximum Fork Length (mm)	Mean Fork Length (mm)	Standard Deviation
2010	26	18	18	400	875	670	136
2011	24	48	46	348	890	627	105
2012	28	175	168	342	875	672	109
2013	34	79	66	421	895	701	99
2014	59	309	284	383	921	710	76
2015	54	156	144	360	883	723	72
2016	54	209	195	385	887	721	80
2017	54	95	92	600	870	747	53
2018	53	110	100	480	903	738	66
2019	54	99	94	510	885	736	84
Total Number of Years	Total Number of Stations	Total Number Collected	Total Number Measured			Overall Mean Fork Length (mm)	
10	440	1298	1207			771	

Table 4. Summary of backward selection procedure for building delta-lognormal submodels for Red Snapper index of relative abundance for the western Gulf of Mexico from 2001 to 2019.

Model Run #1	*Binomial Submodel Type 3 Tests (AIC 6051.4)*						*Lognormal Submodel Type 3 Tests (AIC 1035.4)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	16	1290	103.97	6.50	<.0001	<.0001	16	374	5.63	<.0001
Depth	1	1290	73.74	73.74	<.0001	<.0001	1	374	0.19	0.6653
Zone	8	1290	30.18	3.77	0.0002	0.0002	8	374	1.66	0.1069
Time of Day	1	1290	0.02	0.02	0.8994	0.8995	1	374	2.78	0.0963
Model Run #2	*Binomial Submodel Type 3 Tests (AIC 6048.9)*						*Lognormal Submodel Type 3 Tests (AIC 1024.9)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	16	1291	104.10	6.51	<.0001	<.0001	16	375	5.69	<.0001
Depth	1	1291	73.81	73.81	<.0001	<.0001	Dropped			
Zone	8	1291	30.37	3.80	0.0002	0.0002	8	375	1.65	0.1089
Time of Day	Dropped						1	375	2.77	0.0969
Model Run #3	*Binomial Submodel Type 3 Tests (AIC 6048.9)*						*Lognormal Submodel Type 3 Tests (AIC 1023.0)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	16	1291	104.10	6.51	<.0001	<.0001	16	383	5.70	<.0001
Depth	1	1291	73.81	73.81	<.0001	<.0001	Dropped			
Zone	8	1291	30.37	3.80	0.0002	0.0002	Dropped			
Time of Day	Dropped						1	383	3.24	0.0725
Model Run #4	*Binomial Submodel Type 3 Tests (AIC 6048.9)*						*Lognormal Submodel Type 3 Tests (AIC 1023.2)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	16	1291	104.10	6.51	<.0001	<.0001	16	384	5.80	<.0001
Depth	1	1291	73.81	73.81	<.0001	<.0001	Dropped			
Zone	8	1291	30.37	3.80	0.0002	0.0002	Dropped			
Time of Day	Dropped						Dropped			

Table 5. Indices of Red Snapper abundance developed using the delta-lognormal model for 2001-2019 for the western Gulf of Mexico. The nominal frequency of occurrence, the number of samples (*N*), the DL Index (number per trawl-hour), the DL indices scaled to a mean of one for the time series, the coefficient of variation on the mean (CV), and lower and upper confidence limits (LCL and UCL) for the scaled index are listed.

Survey Year	Frequency	*N*	DL Index	Scaled Index	CV	LCL	UCL
2001	0.20161	124	0.60772	0.32272	0.25898	0.19387	0.53719
2002	0.23333	150	0.46586	0.24739	0.22340	0.15911	0.38465
2003	0.20000	100	0.54394	0.28885	0.28409	0.16546	0.50426
2004	0.21053	95	0.64913	0.34471	0.28458	0.19727	0.60233
2005							
2006	0.18310	71	0.52067	0.27649	0.35084	0.13988	0.54654
2007	0.18571	70	0.56252	0.29871	0.34949	0.15149	0.58900
2008							
2009	0.30263	76	0.96847	0.51429	0.26035	0.30815	0.85832
2010	0.17391	46	0.47423	0.25183	0.46088	0.10469	0.60577
2011	0.30935	139	1.32792	0.70517	0.19059	0.48330	1.02888
2012	0.35849	53	2.33553	1.24024	0.27629	0.72098	2.13346
2013	0.34921	63	2.15217	1.14287	0.25134	0.69666	1.87487
2014	0.31915	47	1.62789	0.86446	0.30549	0.47565	1.57107
2015	0.44643	56	4.00131	2.12482	0.22997	1.34939	3.34583
2016	0.50000	54	3.31684	1.76134	0.22033	1.13954	2.72245
2017	0.62687	67	5.07980	2.69753	0.16413	1.94695	3.73747
2018	0.45763	59	2.93994	1.56120	0.22425	1.00245	2.43138
2019	0.50000	48	4.43929	2.35740	0.22530	1.51062	3.67883

Table 6. Summary of backward selection procedure for building delta-lognormal submodels for Red Snapper index of relative abundance for the central Gulf of Mexico from 2001 to 2019.

Model Run #1	*Binomial Submodel Type 3 Tests (AIC 3559.0)*						*Lognormal Submodel Type 3 Tests (AIC 180.6)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	16	622	33.73	2.11	0.0059	0.0069	16	58	0.94	0.5303
Depth	1	622	0.64	0.64	0.4219	0.4222	1	58	0.09	0.7663
Zone	4	622	34.13	8.53	<.0001	<.0001	4	58	1.57	0.1936
Time of Day	1	622	0.46	0.46	0.4966	0.4969	1	58	0.46	0.5000
Model Run #2	*Binomial Submodel Type 3 Tests (AIC 3548.6)*						*Lognormal Submodel Type 3 Tests (AIC 175.5)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	16	623	34.00	2.13	0.0054	0.0064	16	60	0.93	0.5369
Depth	1	623	0.66	0.66	0.4171	0.4174	Dropped			
Zone	4	623	34.52	8.63	<.0001	<.0001	4	60	1.49	0.2155
Time of Day	Dropped						1	60	0.21	0.6504
Model Run #3	*Binomial Submodel Type 3 Tests (AIC 3554.4)*						*Lognormal Submodel Type 3 Tests (AIC 174.3)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	16	626	34.03	2.13	0.0054	0.0063	16	61	0.95	0.5226
Depth	Dropped						Dropped			
Zone	4	626	35.17	8.79	<.0001	<.0001	4	61	1.78	0.1455
Time of Day	Dropped						Dropped			
Model Run #4	*Binomial Submodel Type 3 Tests (AIC 3554.4)*						*Lognormal Submodel Type 3 Tests (AIC 178.9)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	16	626	34.03	2.13	0.0054	0.0063	16	65	0.88	0.5885
Depth	Dropped						Dropped			
Zone	4	626	35.17	8.79	<.0001	<.0001	Dropped			
Time of Day	Dropped						Dropped			

Table 7. Indices of Red Snapper abundance developed using the delta-lognormal model for 2001-2019 for the central Gulf of Mexico. The nominal frequency of occurrence, the number of samples (*N*), the DL Index (number per trawl-hour), the DL indices scaled to a mean of one for the time series, the coefficient of variation on the mean (CV), and lower and upper confidence limits (LCL and UCL) for the scaled index are listed.

Survey Year	Frequency	*N*	DL Index	Scaled Index	CV	LCL	UCL
2001	0.03636	55	0.04972	0.15237	0.88290	0.03338	0.69552
2002	0.04167	48	0.03422	0.10488	0.88624	0.02288	0.48083
2003	0.05455	55	0.07831	0.24000	0.72815	0.06512	0.88455
2004	0.02222	45	.	.	.	.	.
2005	0.03571	28	.	.	.	.	.
2006	0.07143	14	0.04818	0.14765	1.22517	0.02176	1.00196
2007							
2008							
2009	0.09375	32	0.10743	0.32922	0.73190	0.08884	1.22004
2010	0.18750	32	0.36830	1.12868	0.50307	0.43652	2.91831
2011	0.19588	97	0.49295	1.51067	0.29569	0.84665	2.69550
2012	0.13636	22	0.33739	1.03395	0.72472	0.28194	3.79174
2013	0.07895	38	0.16111	0.49373	0.74039	0.13160	1.85240
2014	0.29167	24	0.60620	1.85775	0.46027	0.77312	4.46405
2015	0.23684	38	0.69641	2.13419	0.41541	0.96089	4.74017
2016	0.19048	42	0.74602	2.28623	0.45247	0.96441	5.41973
2017	0.20833	24	0.25831	0.79160	0.56928	0.27435	2.28409
2018	0.15152	33	0.34990	1.07228	0.56710	0.37294	3.08302
2019	0.20000	20	0.56021	1.71680	0.61978	0.54890	5.36961

Table 8. Summary of backward selection procedure for building delta-lognormal submodels for Red Snapper index of relative abundance for the eastern Gulf of Mexico from 2001 to 2019.

Model Run #1	*Binomial Submodel Type 3 Tests (AIC 5420.1)*						*Lognormal Submodel Type 3 Tests (AIC 68.9)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	15	849	12.92	0.86	0.6082	0.6082	15	23	1.30	0.2767
Depth	1	849	0.45	0.45	0.5025	0.5027	1	23	0.76	0.3922
Zone	4	849	19.66	4.92	0.0006	0.0006	4	23	0.80	0.5396
Time of Day	1	849	0.00	0.00	0.9758	0.9758	1	23	0.23	0.6363
Model Run #2	*Binomial Submodel Type 3 Tests (AIC 5420.5)*						*Lognormal Submodel Type 3 Tests (AIC 67.7)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	15	850	12.95	0.86	0.6063	0.6063	15	24	1.35	0.2503
Depth	1	850	0.45	0.45	0.5028	0.5030	1	24	0.79	0.3841
Zone	4	850	19.67	4.92	0.0006	0.0006	4	24	0.89	0.4832
Time of Day	Dropped						Dropped			
Model Run #3	*Binomial Submodel Type 3 Tests (AIC 5441.1)*						*Lognormal Submodel Type 3 Tests (AIC 69.5)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	15	853	12.64	0.84	0.6303	0.6301	15	28	1.31	0.2625
Depth	Dropped						1	28	0.27	0.6076
Zone	4	853	19.04	4.76	0.0008	0.0008	Dropped			
Time of Day	Dropped						Dropped			
Model Run #4	*Binomial Submodel Type 3 Tests (AIC 5441.1)*						*Lognormal Submodel Type 3 Tests (AIC 60.8)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	15	853	12.64	0.84	0.6303	0.6301	15	29	1.38	0.2241
Depth	Dropped						Dropped			
Zone	4	853	19.04	4.76	0.0008	0.0008	Dropped			
Time of Day	Dropped						Dropped			

Table 9. Indices of Red Snapper abundance developed using the delta-lognormal model for 2001-2019 for the eastern Gulf of Mexico. The nominal frequency of occurrence, the number of samples (*N*), the DL Index (number per trawl-hour), the DL indices scaled to a mean of one for the time series, the coefficient of variation on the mean (CV), and lower and upper confidence limits (LCL and UCL) for the scaled index are listed.

Survey Year	Frequency	*N*	DL Index	Scaled Index	CV	LCL	UCL
2001	0.01493	67	0.01230	0.12015	1.15202	0.01912	0.7551
2002							
2003	0.02083	96	0.04361	0.42597	0.81321	0.10246	1.7710
2004	0.03448	87	0.07034	0.68704	0.66200	0.20576	2.2940
2005	0.02326	43	0.05378	0.52529	1.14653	0.08408	3.2817
2006	0.02326	43	0.02629	0.25678	1.14319	0.04125	1.5984
2007	0.05405	37	0.17769	1.73555	0.79655	0.42717	7.0514
2008							
2009	0.07407	54	0.11885	1.16084	0.57105	0.40116	3.3591
2010	0.10417	48	0.18950	1.85093	0.49667	0.72366	4.7342
2011	0.09286	140	0.18134	1.77124	0.31908	0.95020	3.3017
2012	0.04444	45	0.04944	0.48289	0.80844	0.11691	1.9945
2013	0.02703	37	0.29202	2.85228	1.14085	0.45937	17.7100
2014	0.03226	31	0.03682	0.35960	1.13798	0.05810	2.2259
2015							
2016	0.08108	37	0.17208	1.68080	0.65289	0.51044	5.5346
2017	0.05263	38	0.06619	0.64649	.	.	.
2018	0.05556	36	0.05217	0.50953	.	.	.
2019	0.05882	34	0.09569	0.93462	0.80558	0.22717	3.8451

Table 10. Summary of backward selection procedure for building delta-lognormal submodels for Red Snapper index of relative abundance for the central Gulf of Mexico (with DISL) from 2001 to 2019.

Model Run #1	*Binomial Submodel Type 3 Tests (AIC 4422.2)*						*Lognormal Submodel Type 3 Tests (AIC 479.3)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	15	849	12.92	0.86	0.6082	0.6082	15	23	1.30	0.2767
Depth	1	849	0.45	0.45	0.5025	0.5027	1	23	0.76	0.3922
Zone	4	849	19.66	4.92	0.0006	0.0006	4	23	0.80	0.5396
Time of Day	1	849	0.00	0.00	0.9758	0.9758	1	23	0.23	0.6363
Model Run #2	*Binomial Submodel Type 3 Tests (AIC 4440.0)*						*Lognormal Submodel Type 3 Tests (AIC 477.5)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	16	817	51.26	3.20	<.0001	<.0001	16	174	2.30	0.0044
Depth	Dropped						1	174	0.34	0.5612
Zone	4	817	62.85	15.71	<.0001	<.0001	4	174	3.06	0.0181
Time of Day	1	817	3.68	3.68	0.0550	0.0554	Dropped			
Model Run #3	*Binomial Submodel Type 3 Tests (AIC 4448.9)*						*Lognormal Submodel Type 3 Tests (AIC 474.3)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	16	818	55.61	3.48	<.0001	<.0001	16	178	2.48	0.0020
Depth	Dropped						Dropped			
Zone	4	818	69.24	17.31	<.0001	<.0001	4	178	3.01	0.0194
Time of Day	Dropped						Dropped			

Table 11. Indices of Red Snapper abundance developed using the delta-lognormal model for 2001-2019 for the central Gulf of Mexico (with DISL). The nominal frequency of occurrence, the number of samples (*N*), the DL Index (number per trawl-hour), the DL indices scaled to a mean of one for the time series, the coefficient of variation on the mean (CV), and lower and upper confidence limits (LCL and UCL) for the scaled index are listed.

Survey Year	Frequency	*N*	DL Index	Scaled Index	CV	LCL	UCL
2001	0.03636	55	0.05220	0.10184	0.92931	0.02102	0.49346
2002	0.04167	48	0.03220	0.06282	0.92294	0.01307	0.30192
2003	0.05455	55	0.06918	0.13498	0.75795	0.03508	0.51936
2004	0.02222	45	0.02265	0.04419	1.26049	0.00628	0.31080
2005	0.03571	28	0.01817	0.03545	1.26269	0.00503	0.24984
2006	0.07143	14	0.04393	0.08572	1.27227	0.01205	0.60997
2007							
2008							
2009	0.09375	32	0.08486	0.16556	0.76744	0.04245	0.64572
2010	0.22222	45	0.47434	0.92551	0.43331	0.40372	2.12169
2011	0.22642	106	0.54048	1.05457	0.28562	0.60233	1.84634
2012	0.39394	33	1.86824	3.64521	0.37481	1.76523	7.52738
2013	0.22917	48	0.63664	1.24218	0.42824	0.54672	2.82231
2014	0.49091	55	1.37505	2.68292	0.27588	1.56086	4.61162
2015	0.43077	65	0.96259	1.87816	0.26471	1.11606	3.16066
2016	0.39130	69	1.18136	2.30502	0.27718	1.33771	3.97179
2017	0.37255	51	0.40563	0.79144	0.33085	0.41541	1.50786
2018	0.25532	47	0.41024	0.80043	0.40709	0.36576	1.75169
2019	0.34884	43	0.53507	1.04399	0.36742	0.51240	2.12709

Table 12. Summary of backward selection procedure for building delta-lognormal submodels for Red Snapper index of relative abundance for the central Gulf of Mexico (DISL only) from 2010 to 2019.

Model Run #1	*Binomial Submodel Type 3 Tests (AIC 1926.8)*						*Lognormal Submodel Type 3 Tests (AIC 681.3)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	9	431	23.20	2.58	0.0058	0.0067	9	246	3.92	0.0001
Depth	1	431	3.33	3.33	0.0680	0.0687	1	246	0.01	0.9154
Model Run #2	*Binomial Submodel Type 3 Tests (AIC 1928.3)*						*Lognormal Submodel Type 3 Tests (AIC 675.4)*			
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*	*Num DF*	*Den DF*	*F Value*	*Pr > F*
Year	9	435	24.52	2.72	0.0036	0.0042	9	249	3.97	<.0001
Depth	Dropped						Dropped			

Table 13. Indices of Red Snapper abundance developed using the delta-lognormal model for 2010-2019 for the central Gulf of Mexico (DISL only). The nominal frequency of occurrence, the number of samples (*N*), the DL Index (number per trawl-hour), the DL indices scaled to a mean of one for the time series, the coefficient of variation on the mean (CV), and lower and upper confidence limits (LCL and UCL) for the scaled index are listed.

Survey Year	Frequency	*N*	DL Index	Scaled Index	CV	LCL	UCL
2010	0.25000	28	0.72570	0.25004	0.46292	0.10358	0.60359
2011	0.41667	24	1.58067	0.54462	0.36668	0.26766	1.10815
2012	0.73333	30	6.52162	2.24701	0.21843	1.45911	3.46037
2013	0.52941	34	2.82773	0.97429	0.26360	0.58018	1.63612
2014	0.66102	59	4.67988	1.61244	0.17165	1.14676	2.26723
2015	0.66667	54	2.94648	1.01520	0.17789	0.71326	1.44498
2016	0.72222	54	4.02515	1.38686	0.16691	0.99553	1.93201
2017	0.57407	54	1.72752	0.59521	0.19893	0.40138	0.88265
2018	0.51852	54	1.97577	0.68075	0.21374	0.44607	1.03888
2019	0.53704	54	2.01302	0.69358	0.20858	0.45904	1.04796

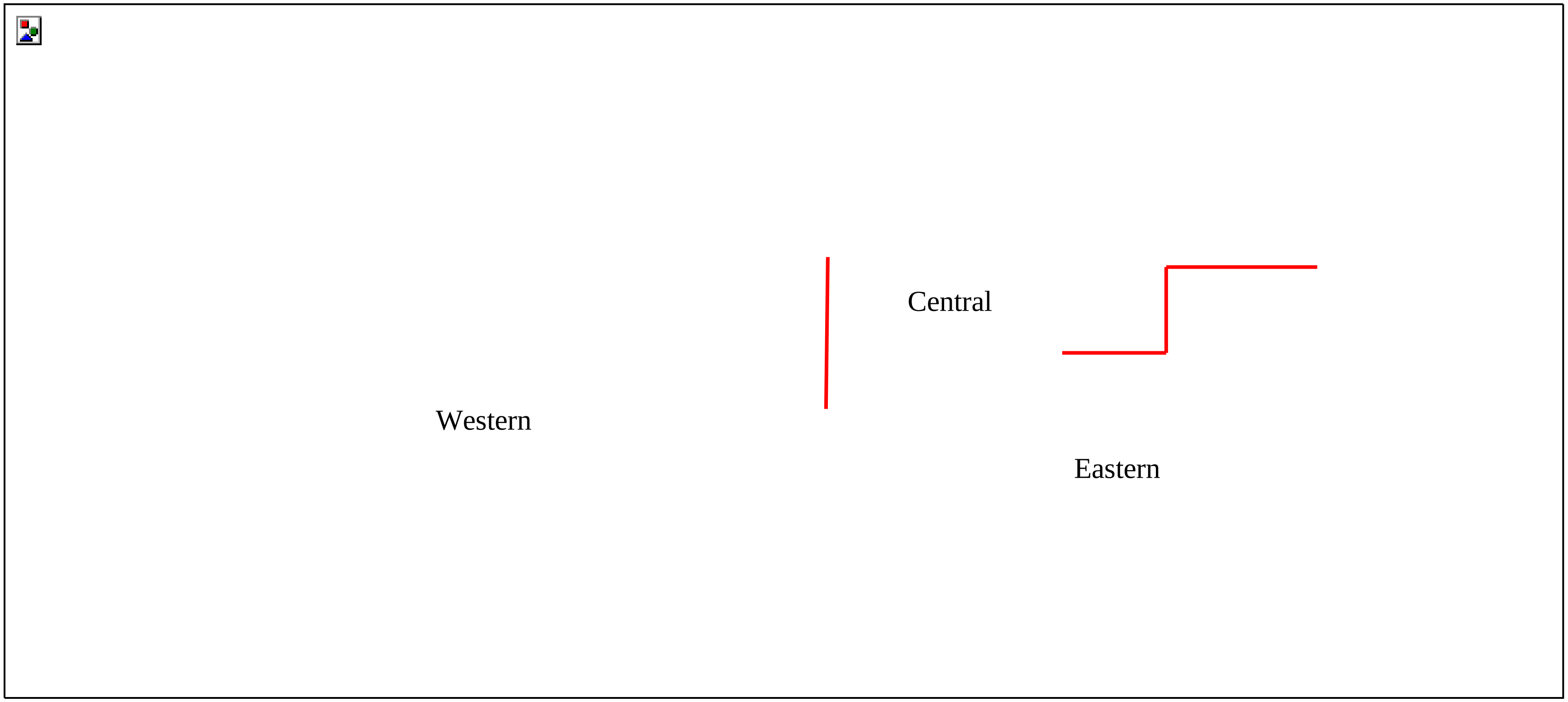

Figure 1. Breakdown of Gulf of Mexico for the SEFSC Bottom Longline Survey. Red lines represent the boundaries for the three areas for which indices were produced according to the SEDAR 74 Stock ID Workshop (SEDAR 74 Stock ID 2021).

Figure 2. Stations sampled from 2001 to 2019 during the SEFSC Bottom Longline Survey with the CPUE for Red Snapper.

Figure 3. Stations sampled from 2010 to 2019 during the DISL Bottom Longline Survey with the CPUE for Red Snapper.

Figure 4. Length frequency histogram for Red Snapper captured in SEFSC Bottom Longline for the **A.** Western Gulf, **B.** Central Gulf, and **C.** Eastern Gulf.

Figure 5. Breakdown of Red Snapper ages for fish caught in the: **A.** and **B.** Western Gulf, **C.** and **D.** Central Gulf, and **E.** and **F.** Eastern Gulf.

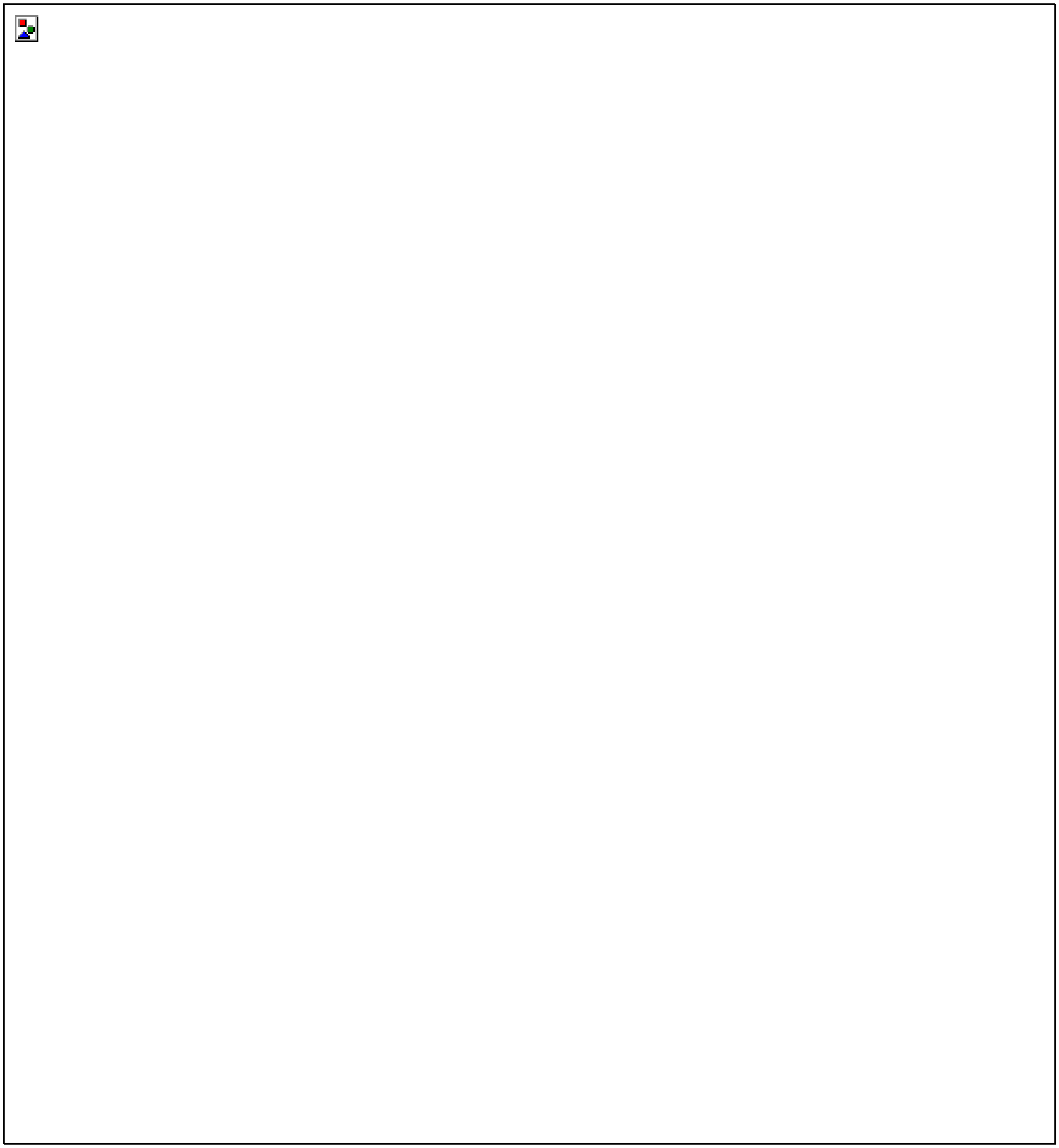

Figure 6. Length frequency histogram for Red Snapper captured in Central Gulf: **A.** SEFSC Bottom Longline Survey, **B.** Combined SEFSC and DISL Bottom Longline Surveys, and **C.** DISL Bottom Longline Survey.

Figure 7. Breakdown of Red Snapper ages for fish caught in the central GOM from: **A.** and **B.** SEFSC Bottom Longline Survey, **C.** and **D.** Combined SEFSC and DISL Bottom Longline Surveys, and **E.** and **F.** DISL Bottom Longline Survey.

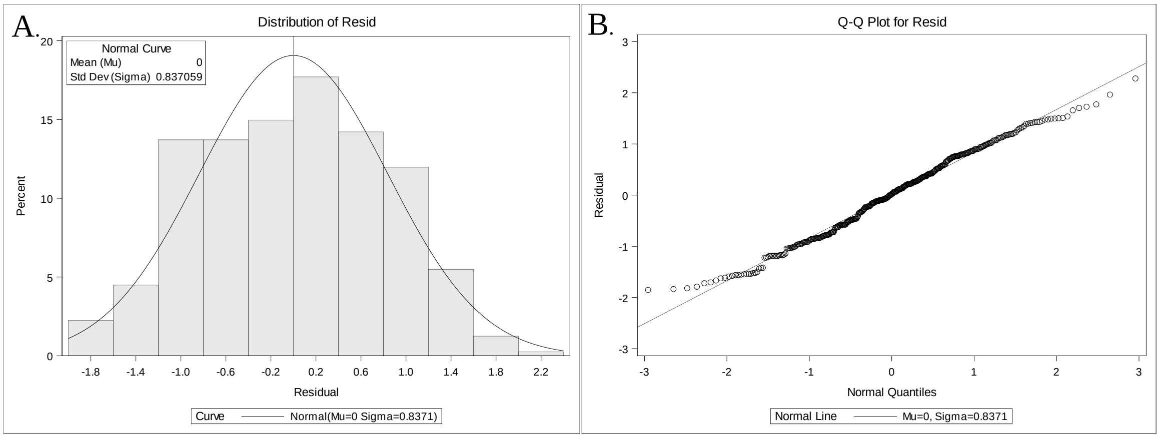

Figure 8. Diagnostic plots for lognormal component of the Red Snapper western Gulf of Mexico SEFSC Bottom Longline Surveys model: **A.** the frequency distribution of log (CPUE) on positive stations and **B.** the cumulative normalized residuals (QQ plot).

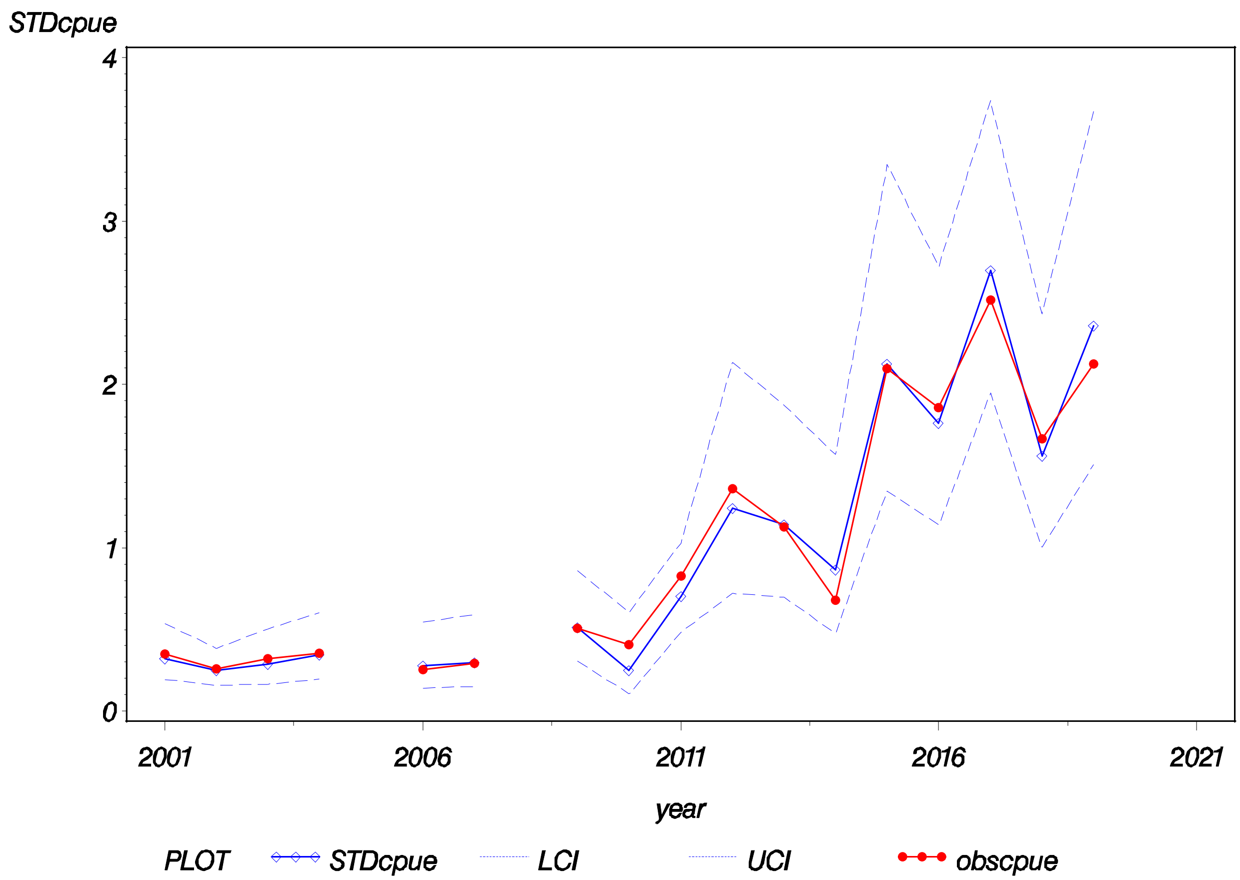

Figure 9. Annual index of abundance for the western Gulf of Mexico for Red Snapper from the SEFSC Bottom Longline Surveys from 2001 – 2019.

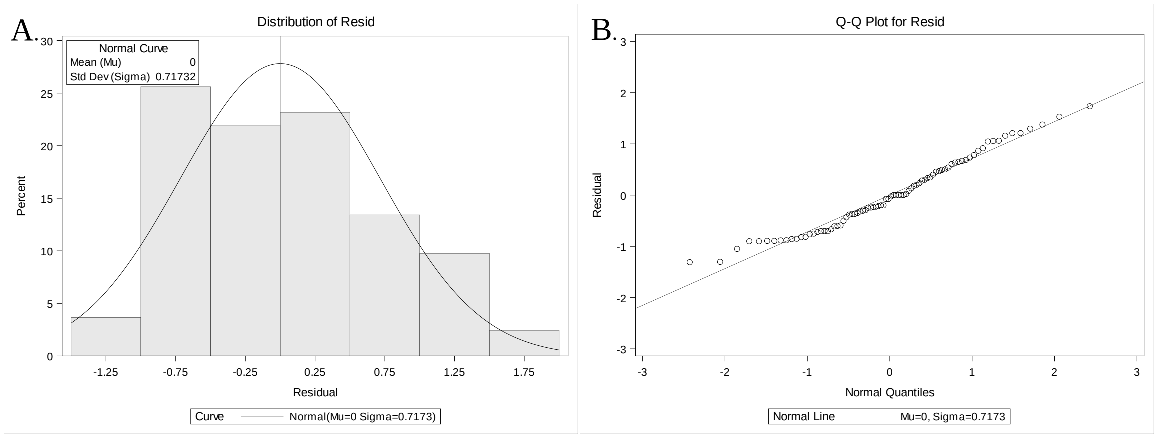

Figure 10. Diagnostic plots for lognormal component of the Red Snapper central Gulf of Mexico SEFSC Bottom Longline Surveys model: **A.** the frequency distribution of log (CPUE) on positive stations and **B.** the cumulative normalized residuals (QQ plot).

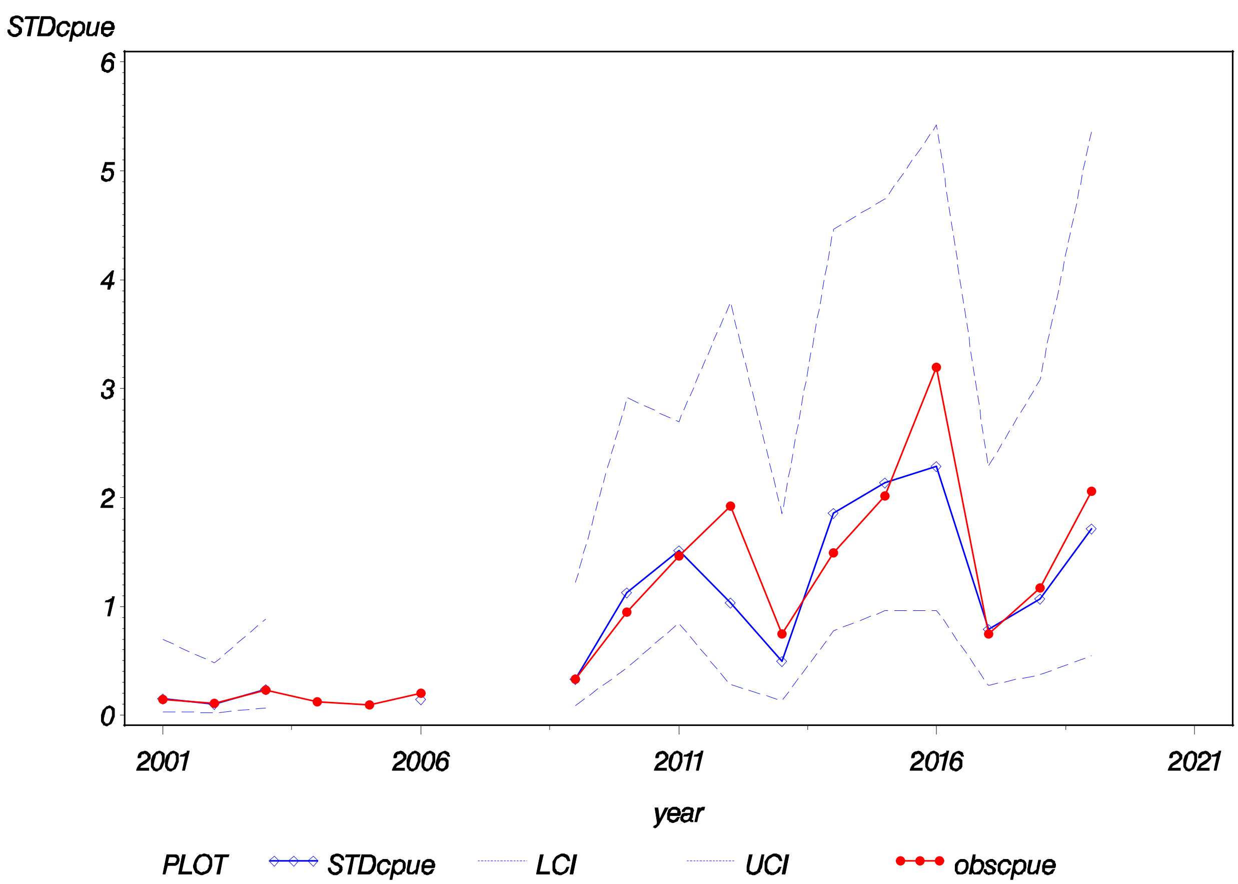

Figure 11. Annual index of abundance for the central Gulf of Mexico for Red Snapper from the SEFSC Bottom Longline Surveys from 2001 – 2019.

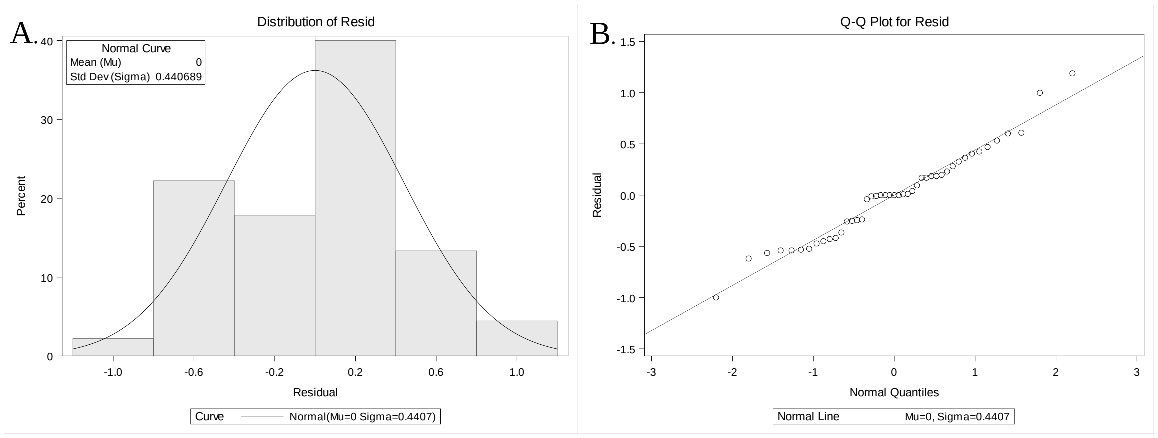

Figure 12. Diagnostic plots for lognormal component of the Red Snapper eastern Gulf of Mexico SEFSC Bottom Longline Surveys model: **A.** the frequency distribution of log (CPUE) on positive stations and **B.** the cumulative normalized residuals (QQ plot).

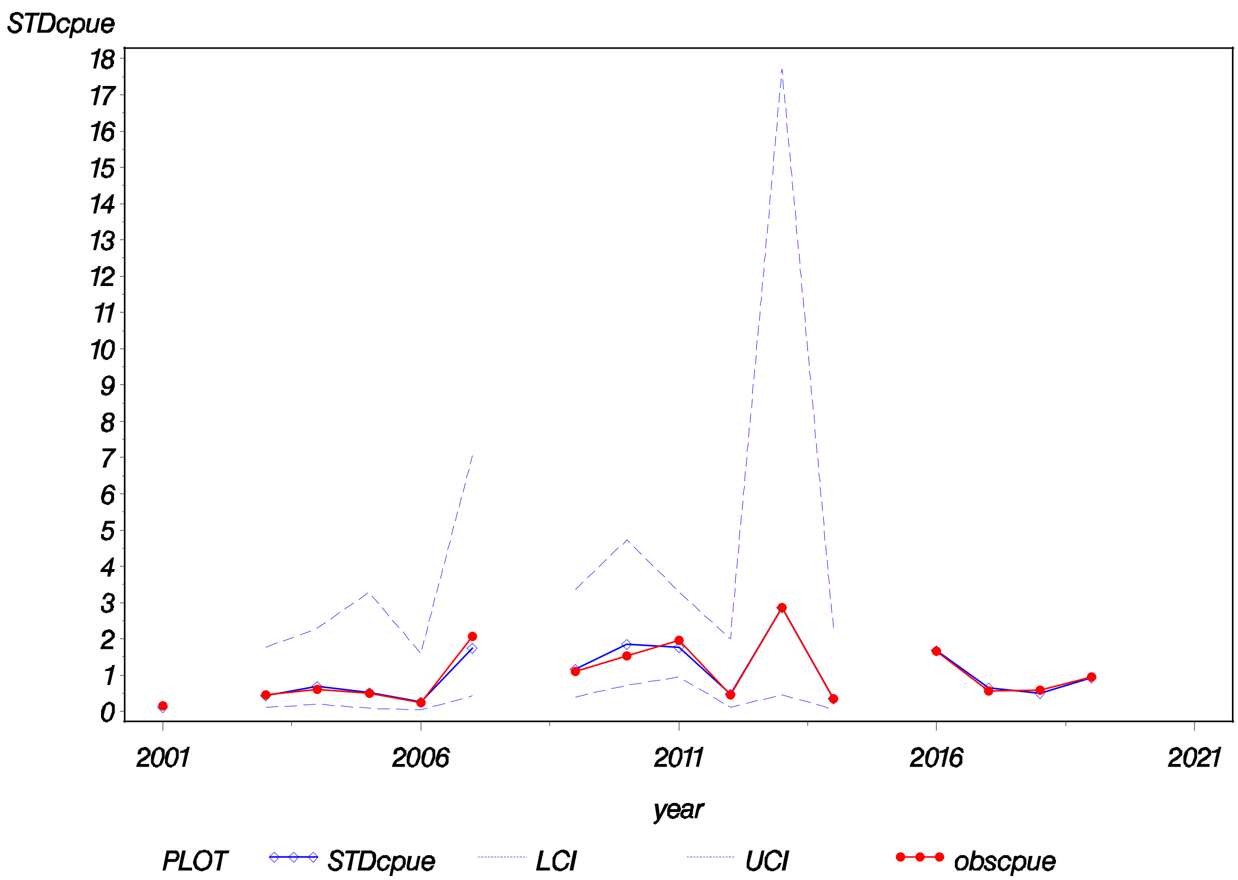

Figure 13. Annual index of abundance for the eastern Gulf of Mexico for Red Snapper from the eastern SEFSC Bottom Longline Surveys from 2001 – 2019.

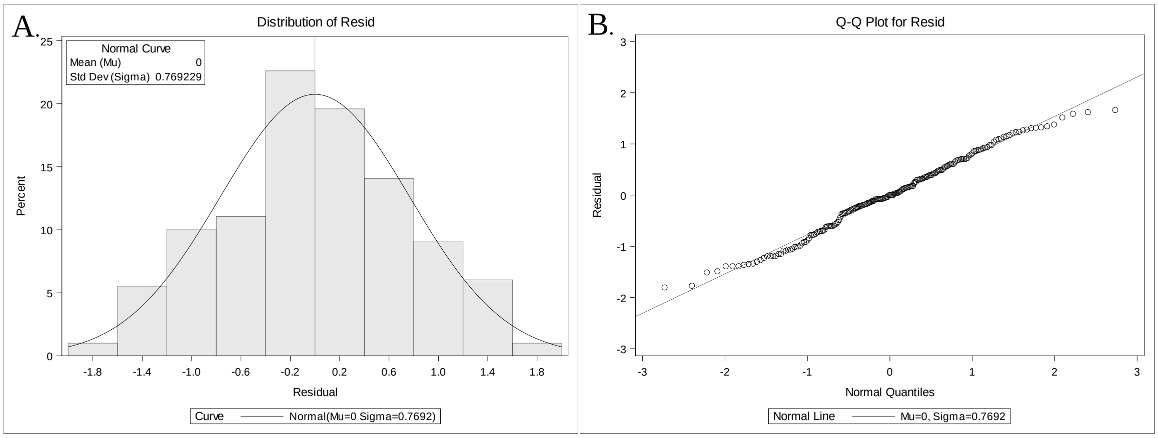

Figure 14. Diagnostic plots for lognormal component of the Red Snapper central Gulf of Mexico SEFSC Bottom Longline Surveys (with DISL) model: **A.** the frequency distribution of log (CPUE) on positive stations and **B.** the cumulative normalized residuals (QQ plot).

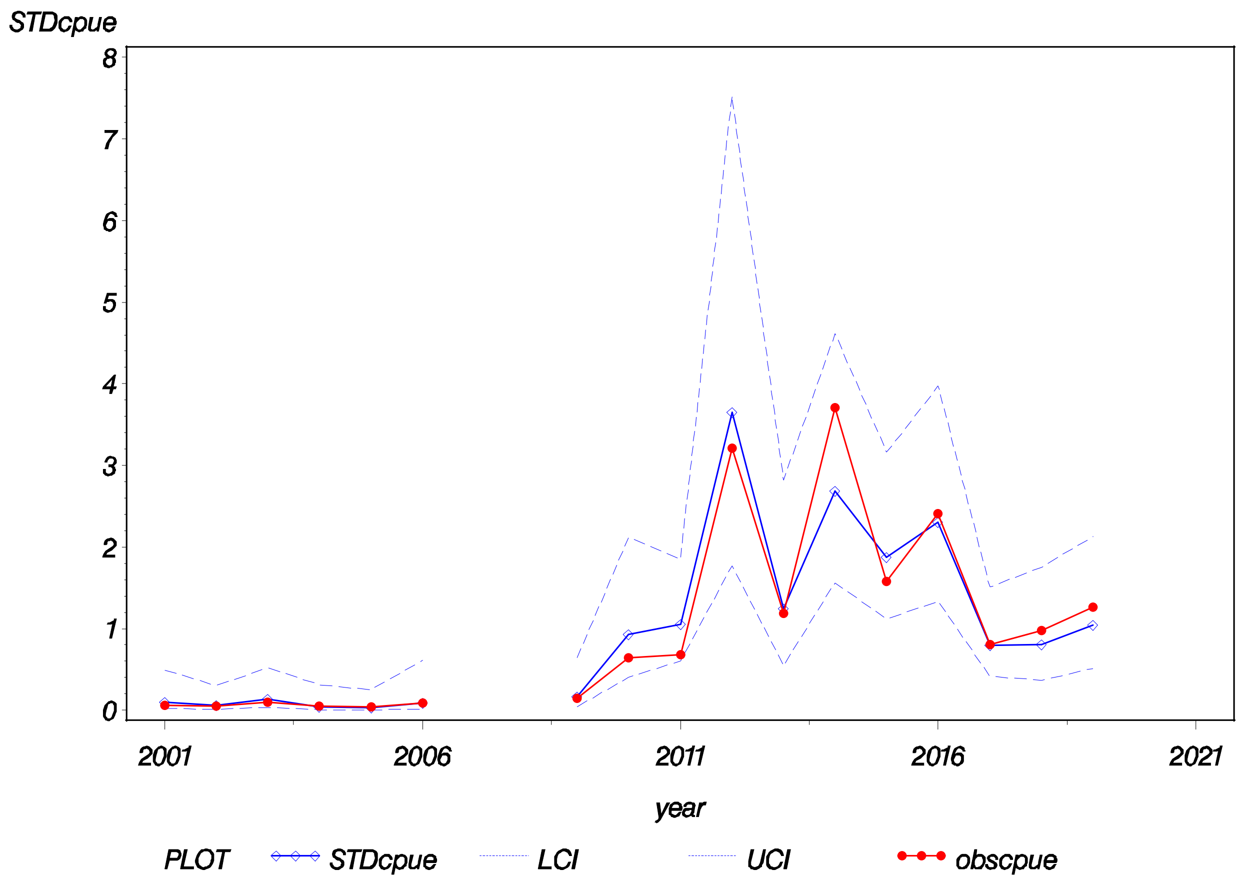

Figure 15. Annual index of abundance for the central Gulf of Mexico for Red Snapper from the SEFSC Bottom Longline Surveys (with DISL) from 2001 – 2019.

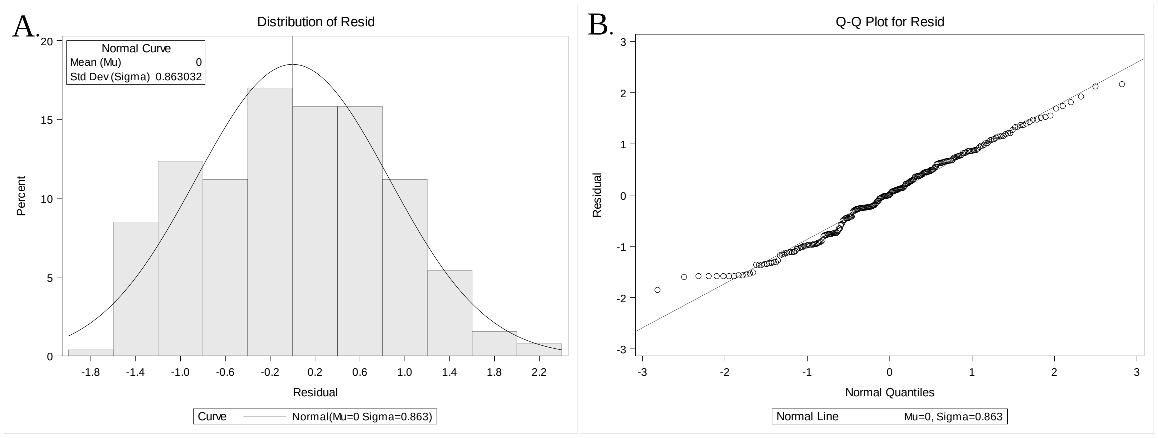

Figure 16. Diagnostic plots for lognormal component of the Red Snapper central Gulf of Mexico DISL Bottom Longline Surveys model: **A.** the frequency distribution of log (CPUE) on positive stations and **B.** the cumulative normalized residuals (QQ plot).

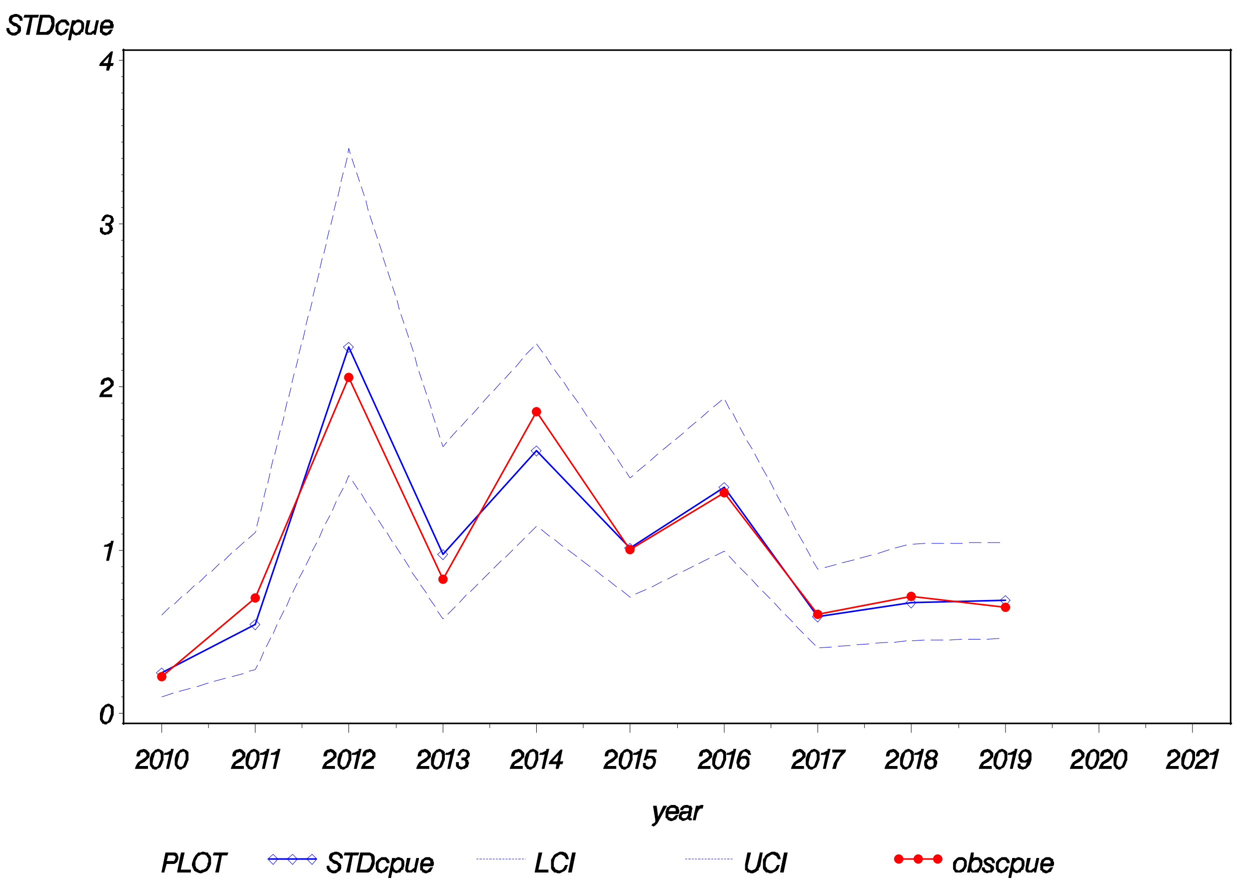

Figure 17. Annual index of abundance for the central Gulf of Mexico for Red Snapper from the DISL Bottom Longline Surveys from 2010 – 2019.

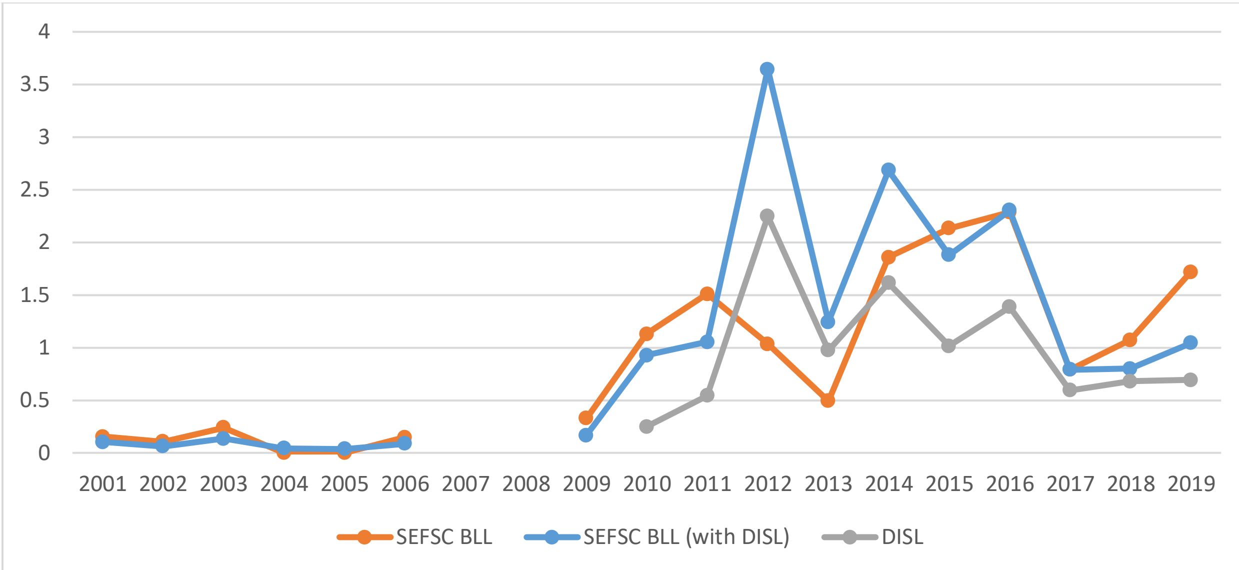

Figure 18. Comparison of indices for the central Gulf of Mexico.

Appendix

Appendix Table 1. Summary of the factors used in constructing the Red Snapper abundance index from the SEFSC bottom longline survey data for the western Gulf of Mexico. Note that the years 2005 and 2008 were excluded from the index.

Factor	Level	Number of Observations	Number of Positive Observations	Proportion Positive	Mean CPUE
Year	2001	124	25	0.20161	0.66572
Year	2002	150	35	0.23333	0.49703
Year	2003	100	20	0.20000	0.61757
Year	2004	95	20	0.21053	0.67673
Year	2005	7	0		
Year	2006	71	13	0.18310	0.48715
Year	2007	70	13	0.18571	0.56404
Year	2008	21	6	0.28571	0.51146
Year	2009	76	23	0.30263	0.97119
Year	2010	46	8	0.17391	0.77463
Year	2011	139	43	0.30935	1.58209
Year	2012	53	19	0.35849	2.60952
Year	2013	63	22	0.34921	2.15795
Year	2014	47	15	0.31915	1.29886
Year	2015	56	25	0.44643	4.01264
Year	2016	54	27	0.50000	3.55434
Year	2017	67	42	0.62687	4.81354
Year	2018	59	27	0.45763	3.18762
Year	2019	48	24	0.50000	4.06618
BLL Zone	9	68	14	0.20588	0.91693
BLL Zone	8	116	34	0.29310	1.67078
BLL Zone	7	149	43	0.28859	1.47384
BLL Zone	6	188	51	0.27128	1.23731
BLL Zone	5	233	79	0.33906	1.47665
BLL Zone	4	192	39	0.20313	1.06950
BLL Zone	3	139	48	0.34532	2.33223
BLL Zone	2	142	56	0.39437	2.54725
BLL Zone	1	91	37	0.40659	2.20441
Time of Day	Day	726	221	0.30441	1.47573
Time of Day	Night	592	180	0.30405	1.81232

Appendix Table 2. Summary of the factors used in constructing the Red Snapper abundance index from the SEFSC bottom longline survey data for the central Gulf of Mexico. Note that the years 2007 and 2008 were excluded from the index.

Factor	Level	Number of Observations	Number of Positive Observations	Proportion Positive	Mean CPUE
Year	2001	55	2	0.03636	0.05365
Year	2002	48	2	0.04167	0.04002
Year	2003	55	3	0.05455	0.08378
Year	2004	45	1	0.02222	0.04444
Year	2005	28	1	0.03571	0.03571
Year	2006	14	1	0.07142	0.07489
Year	2007	25	0		
Year	2008	27	0		
Year	2009	32	3	0.09375	0.12246
Year	2010	32	6	0.18750	0.34812
Year	2011	97	19	0.19588	0.53506
Year	2012	22	3	0.13636	0.70412
Year	2013	38	3	0.07895	0.27330
Year	2014	24	7	0.29167	0.54666
Year	2015	38	9	0.23684	0.73864
Year	2016	42	8	0.19048	1.17191
Year	2017	24	5	0.20833	0.27403
Year	2018	33	5	0.15152	0.42701
Year	2019	20	4	0.20000	0.75339
BLL Zone	14/15	100	5	0.05000	0.05912
BLL Zone	13	165	13	0.07879	0.18112
BLL Zone	12	134	9	0.06716	0.09750
BLL Zone	11	113	21	0.18584	0.46938
BLL Zone	10	135	34	0.25185	0.96744
Time of Day	Day	326	38	0.11656	0.29941
Time of Day	Night	321	44	0.13707	0.42025

Appendix Table 3. Summary of the factors used in constructing the Red Snapper abundance index from the SEFSC bottom longline survey data for the eastern Gulf of Mexico. Note that the years 2002 and 2008 were excluded from the index.

Factor	Level	Number of Observations	Number of Positive Observations	Proportion Positive	Mean CPUE
Year	2001	67	1	0.01493	0.01468
Year	2002	0			
Year	2003	96	2	0.02083	0.04203
Year	2004	87	3	0.03448	0.05713
Year	2005	43	1	0.02326	0.04730
Year	2006	43	1	0.02326	0.02251
Year	2007	37	2	0.05405	0.19386
Year	2008	40	0		
Year	2009	54	4	0.07407	0.10324
Year	2010	48	5	0.10417	0.14307
Year	2011	140	13	0.09286	0.18451
Year	2012	45	2	0.04444	0.04343
Year	2013	37	1	0.02703	0.26852
Year	2014	31	1	0.03226	0.03226
Year	2016	37	3	0.08108	0.15535
Year	2017	38	2	0.05263	0.05380
Year	2018	36	2	0.05556	0.05510
Year	2019	34	2	0.05882	0.08895
BLL Zone	18	288	8	0.02778	0.05490
BLL Zone	17	223	8	0.03587	0.08884
BLL Zone	16	175	7	0.04000	0.08199
BLL Zone	15	82	8	0.09756	0.15990
BLL Zone	14	105	14	0.13333	0.20042
Time of Day	Day	472	25	0.05297	0.09838
Time of Day	Night	401	20	0.04988	0.09399

Appendix Table 4. Summary of the factors used in constructing the Red Snapper abundance index from the SEFSC bottom longline survey data (with DISL) for the central Gulf of Mexico. Note that the years 2007 and 2008 were excluded from the index.

Factor	Level	Number of Observations	Number of Positive Observations	Proportion Positive	Mean CPUE
Year	2001	55	2	0.03636	0.05365
Year	2002	48	2	0.04167	0.04002
Year	2003	55	3	0.05455	0.08378
Year	2004	45	1	0.02222	0.04444
Year	2005	28	1	0.03571	0.03571
Year	2006	14	1	0.07143	0.07489
Year	2007	25	0		
Year	2008	27	0		
Year	2009	32	3	0.09375	0.12246
Year	2010	45	10	0.22222	0.53353
Year	2011	106	24	0.22642	0.56528
Year	2012	33	13	0.39394	2.67218
Year	2013	48	11	0.22917	0.98749
Year	2014	55	27	0.49091	3.08776
Year	2015	65	28	0.43077	1.31081
Year	2016	69	27	0.39130	2.00191
Year	2017	51	19	0.37255	0.67158
Year	2018	47	12	0.25532	0.81492
BLL Zone	14/15	100	5	0.05000	0.05912
BLL Zone	13	165	13	0.07879	0.18112
BLL Zone	12	134	9	0.06716	0.09750
BLL Zone	11	230	87	0.37826	1.30145
BLL Zone	10	210	85	0.40476	1.90285
Time of Day	Day	518	155	0.29923	1.18320
Time of Day	Night	321	44	0.13707	0.42025

Appendix Table 5. Summary of the factors used in constructing the Red Snapper abundance index from the DISL bottom longline survey data for the eastern Gulf of Mexico.

Factor	Level	Number of Observations	Number of Positive Observations	Proportion Positive	Mean CPUE
Year	2010	28	7	0.25000	0.64154
Year	2011	24	10	0.41667	2.01433
Year	2012	30	22	0.73333	5.84211
Year	2013	34	18	0.52941	2.34054
Year	2014	59	39	0.66102	5.25044
Year	2015	54	36	0.66667	2.84753
Year	2016	54	39	0.72222	3.84426
Year	2017	54	31	0.57407	1.73159
Year	2018	54	28	0.51852	2.03593
Year	2019	54	29	0.53704	1.85370

Appendix Figure 1. Annual survey effort and catch of Red Snapper from the SEFSC bottom longline survey (2001-2019).

Appendix Figure 2. Annual survey effort and catch of Red Snapper from the DISL bottom longline survey (2010-2019).