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Spanish Mackerel and Cobia Abundance Indices from SEAMAP Groundfish Surveys in the Northern Gulf of Mexico

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Abstract: Beginning in 1987, standardized groundfish surveys have been conducted in the northern Gulf of Mexico during the summer and fall under the Southeast Area Monitoring and Assessment Program (SEAMAP). This fisheries independent data was used to develop abundance indices for Spanish mackerel (Scomberomorus maculatus) and cobia (Rachycentron canadum). Due to low occurrences of cobia in the data, only a nominal annual CPUE was produced. For Spanish mackerel, a delta-lognormal index of relative abundance was used to produce annual abundance indices. Based upon the recommendations of the Data Working Group, three models were produced for Spanish mackerel, a full model run incorporating the summer and fall datasets and individual models for the summer and fall, respectively.

Introduction

The Southeast Fisheries Science Center (SEFSC) Mississippi Laboratories has conducted standardized groundfish surveys under the Southeast Area Monitoring and Assessment Program (SEAMAP) in the Gulf of Mexico (GOM) since 1987. SEAMAP is a collaborative effort between federal, state and university programs, designed to collect, manage and distribute fishery independent data throughout the region. The primary objective of this trawl survey is to collect data about the abundance and distribution of demersal organisms in the northern Gulf of Mexico. This survey, which is conducted semi-annually (summer and fall), provides an important source of fisheries independent information on many commercially and recreationally important species throughout the GOM. The purpose of this document is to provide abundance indices for Spanish mackerel (*Scomberomorus maculatus*) and cobia (*Rachycentron canadum*).

Methodology

Survey Design

The survey methodologies and descriptions of the datasets used herein have been previously presented in detail by Nichols (2004) and Pollack and Ingram (2010). It is important to note that a change to the survey design was implemented between the summer and fall surveys of 2008. Prior to the fall survey of 2008, the basic structure of the groundfish surveys (i.e. 1987- summer of 2008) follows a stratified random station location assignment with strata derived from depth zones (5-6, 6-7, 7-8, 8-9, 9-10, 10-11, 11-12, 12-13, 13-14, 14-15, 15-16, 16-17, 17-18, 18-19, 19-20, 20-22, 22-25, 25-30, 30-35, 35-40, 40-45, 45-50 and 50-60 fathoms), shrimp statistical zones (between 88° and 97° W longitude, statistical zones from west to east: 21-20, 19-18, 17-16, 15-13 and 12-10), and time of day (i.e. day or night). Starting in the fall of 2008 and continuing until the present, station allocation is randomized design within each shrimp statistical zone with a weighting by area. Other notable changes included a standardized 30 minute tow and dropping the day/night stratification. The main purpose of these changes was to increase the sample size of each survey and expand the survey into the waters off of

Florida. Data collected in the fall of 2008 through the present were post stratified into the aforementioned strata used in the 1987 – summer of 2008 survey.

Data

Based upon the data available at this time for analysis, 2011 SEAMAP data will not be included in the analysis, because the fall survey just recently has been completed and all data have not undergone complete QA/QC procedures. A total of 11,433 stations were sampled from 1987- 2010 (Table 1). Based upon the limited recent sampling that has taken place in shrimp statistical zones 3-9, it was decided to limit the data for this analysis to only zones 10-21 (note that zone 12 is completely outside of the depth range of this survey (5 to 60 fathoms), therefore it is not sampled). Of the 495 stations sampled, only 3 occurrences of Spanish mackerel and 2 occurrences of cobia were reported from these statistical zones. Based upon the low occurrences of cobia (2%), even with limiting the data, it was decided that only a nominal CPUE would be produced. Cobia catch by depth zone is presented in Table 2.

Upon examining the depth zone distribution of occurrences of Spanish mackerel (Table 3), the data were also limited by depth zone, in addition to the aforementioned shrimp statistical zones. For the full model run, all depth zones greater than 35 fathoms were excluded from the analysis. These depth zones accounted for less than 1% of all Spanish mackerel occurrence overall, in addition to not having occurrences greater than 1 % individually. Based upon the recommendations of the Data Working Group, in addition to the indices from the combined summer and fall surveys, individual indices were prepared from summer and fall surveys. For the fall survey, the same depth zones and statistical zones as the full model run were excluded. However, during the summer months, Spanish mackerel were found in shallower depths overall, with only 6 stations outside of 20 fathoms having a positive occurrence, therefore it was necessary to exclude all depth zones greater than 20 fathoms from the analysis.

Index Construction

Delta-lognormal modeling methods were used to estimate relative abundance indices for Spanish mackerel (Lo *et al.* 1992). 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 (Lo *et al.* 1992).

The delta-lognormal index of relative abundance (I_y) as described by Lo *et al.* (1992) 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)
$$p = \frac{e^{X\beta+\varepsilon}}{1+e^{X\beta+\varepsilon}},$$

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 as:

(4)
$$V(I_y) \approx V(c_y)p_y^2 + c_y^2V(p_y) + 2c_yp_y\operatorname{Cov}(c, p),$$

where:

(5)
$$\operatorname{Cov}(c, p) \approx \rho_{c,p} [\operatorname{SE}(c_y) \operatorname{SE}(p_y)],$$

and $\rho_{c,p}$ denotes correlation of *c* and *p* among years.

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: Year (1987-2010), Area (defined as Texas (statistical zones 18-21), West Delta (statistical zones 13-17), East Delta (statistical zones 10-11)), Depth Zone (5-6, 6-7, 7-8, 8-9, 9-10, 10-11, 11-12, 12-13, 13-14, 14-15, 15-16, 16-17, 17-18, 18-19, 19-20, 20-22, 22-25, 25-30, 30-35), Time of Day (Day, Night), Season (Summer, Fall) and Survey (Old, New). The survey variable refers to the change in design that occurred in the middle of the 2008 sampling year.

Results and Discussion

Cobia

The distribution of cobia is presented in Figure 1. The total number of cobia captured ranged from 0 to 31 (Table 4). Of the 330 cobia captured, a total of 296 were measured from 1987 – 2010 with an average total length of 405 mm. From the length frequency histogram (Figure 2), the majority of cobia captured ranged from 160 to 500 mm, with some larger fish being captured. Due to low occurrences, only a nominal CPUE was produced, along with the proportion of stations with a positive catch (Table 5). Nominal CPUE was relatively consistent through the years, with 2 spikes in the mid-1990s and proportion of positive catches that remain low (Figure 3).

Spanish Mackerel

The distribution of Spanish mackerel is presented in Figure 4. The total number of Spanish mackerel captured ranged from 32 to 487 (Table 6). Of the 3,223 Spanish mackerel captured, a total of 2,127 were measured from 1987 – 2010 with an average total length of 230 mm. From the length frequency histogram (Figure 5), the majority of Spanish mackerel captured probably age 0 and age 1 fish, with no individual fish greater than 520 mm being measured. The nominal CPUE and number of stations with a positive catch are presented in Figures 6-8, which indicated annual variation in nominal CPUE, with varying proportion of positive catches over the years.

The variables that were retained differed slightly among models. For the full model (summer and fall surveys), year, area, depth zone, time of day and season were retained in the binomial submodel. The variables retained in the lognormal submodel were year, area, depth zone and time of day. Table 7 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 56,581.5 and 1999.9, respectively. The AIC for the binomial submodel increased slightly when the survey variable was removed from the submodel, however, based upon the p-value (0.2844), it was determined that the slight increase was acceptable. However, the AIC for the lognormal submodels are shown in Figures 9-11, and indicated the distribution of the residuals is approximately normal. Annual abundance indices are presented in Table 8.

For the summer model, year, area, depth zone and time of day were retained in the binomial submodel. The variable retained in the lognormal submodel was year. Table 9 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 23,424.2 and 627.0, respectively. Since all the variables were significant in the binomial submodel the AIC remained unchanged. However, the AIC value increased slightly when variables were removed from the lognormal submodel. Based upon the p-values for area, depth zone and time of day (0.9707, 0.2587 and 0.0691, respectively), it was determined that the slight increase was acceptable. The diagnostic plots for the binomial and lognormal submodels are shown in Figures 12-14, and indicated the distribution of the residuals is approximately normal. Annual abundance indices are presented in Table 10.

For the fall model, year, area, depth zone and time of day were retained in both the binomial and lognormal submodels. Table 11 summarizes the final set of variables used in the submodels and their significance. The AIC for the binomial and lognormal submodels were 27,218.7 and 1300.5, respectively. Since all variables were significant in the both submodels the AIC remained unchanged. The diagnostic plots for the binomial and lognormal submodels are shown in Figures 15-17, and indicated the distribution of the residuals is approximately normal. Annual abundance indices are presented in Table 12.

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								Sł	nrimp Sta	atistical	Zone								
Year	3	4	5	6	7	8	9	10	11	13	14	15	16	17	18	19	20	21	Total
1987								30	66	6	20	19	25	20	16	25	28	19	274
1988								19	49	5	4	3	19	24	14	25	28	23	213
1989								23	30		3	18	25	7	15	20	29	24	194
1990									68	11	20	15	23	16	20	23	24	20	240
1991								1	46	12	24	13	23	22	12	18	23	26	231
1992								1	45	10	20	24 17	20	10	12	20	20	20	220
1995									43 61	6	19	22	24	19	20	29	24	22	223
1994									44	10	16	18	23	23	13	27	20	21	230
1996									46	14	12	19	22	18	17	21	26	25	220
1997									44		12	16	22	23	10	28	26	26	207
1998									35	2	14	21	25	18	14	22	36	17	204
1999									44	7	20	19	20	23	13	25	32	20	223
2000									45	2	19	15	19	27	8	29	31	21	216
2001									36	7	18	18	13	3	10	9	17	21	152
2002									44	11	14	21	27	19	15	25	29	22	227
2003									44	9	10	8	2	17	20	22	26	23	181
2004									39	11	18	17	20	25	21	19	25	21	216
2005									32	10	9	11	16	21	5	28	22	27	181
2006									45	11	21	12	20	23	17	23	31	18	221
2007									41		6	15	22	23	7	29	32	21	196
2008		1	8	11	6	11	8	11	43	24	19	27	23	22	17	24	21	29	305
2009		25	17	29	15	16	18	25	68	25	21	38	39	47	55	34	30	24	526
2010 Tatal	31	24	17	24	10	12	14	15	22	5	20	16	21	33	34	27	27	19	371
Total	31	30	42	04	31	39	40	124	1082	200	370	422	517	515	411	383	043	551	5705
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Year 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006	3	4	5	6	7	8	9	SI 10 16 8 1 1	rrimp Sta 11 28 28 43 52 47 33 72 50 40 45 44 44 42 43 21 51 76 43 44 44 42 32	atistical 13 15 7 12 14 6 7 10 9 10 9 10 10 10 10 10 10 10 10 10 10	Zone 14 14 22 19 12 24 23 19 16 17 18 17 18 17 18 17 14 17 13 16 11 20 22 20	15 16 17 23 14 17 21 18 19 20 14 17 21 18 19 22 21 18 16 14 17	16 17 18 22 20 25 26 25 24 17 26 29 20 26 22 24 17 33 18	17 15 26 20 19 25 18 18 20 19 28 19 28 19 28 19 11 18 26 20 23 22 27 18 28 28	18 15 19 17 18 24 17 16 21 14 13 18 15 12 14 14 14 14 14 14 13 17	19 15 21 22 21 22 19 27 25 23 26 25 23 24 23 24 23 24 23 20	20 18 31 25 30 28 24 30 29 29 29 29 29 29 29 29 25 28 30 25 30 24 30 25 30 28 24 30 29 29 29 29 29 29 29 29 29 29	21 3 20 26 27 22 18 18 20 19 24 24 22 21 23 21 23 21 23 21 27 19 26 27 27 22 18 18 20 26 27 27 22 18 20 26 27 27 22 22 22 22 22 22 22 22	Total 172 217 223 228 226 212 249 229 217 227 223 225 223 205 233 260 205 230 205 230 205 230 205 230 205 230 205 230 205 230 205 230 205 230 205 230 205 230 205 230 205 230 205 230 205 230 205 230 205 230 205 230 205 230 205 205 205 205 205 205 205 20
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Year 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008	3	4	5	6	7	8	9	SI 10 16 8 1 1 1 1 1 1 4	rrimp Sta 11 28 28 43 52 47 33 72 50 40 45 44 44 42 43 21 51 76 43 44 47 32 6 43 44 47 32 43 43 44 45 45 45 45 45 45 45 45 45	atistical 13 15 7 12 14 6 7 10 9 10 9 10 10 10 10 10 10 10 10 10 10	Zone 14 14 22 19 12 24 23 19 16 17 18 17 18 17 22 17 14 17 13 16 11 20 22 20 28 23	15 16 17 23 14 17 21 18 19 20 14 18 22 21 18 19 22 21 18 16 14 17 34 23	16 17 18 22 20 25 26 25 24 17 26 29 20 26 22 24 17 34 29 20 26 22 24 17 33 18 42 31	17 15 26 20 19 25 18 18 20 19 28 19 28 19 28 19 28 19 28 19 28 20 23 22 27 18 28 22 27 18 28 28 46 49	$\begin{array}{c} 18\\ 15\\ 19\\ 17\\ 18\\ 24\\ 17\\ 16\\ 21\\ 14\\ 13\\ 18\\ 15\\ 12\\ 12\\ 14\\ 14\\ 20\\ 14\\ 14\\ 13\\ 17\\ 44\\ 48\end{array}$	19 15 21 22 19 27 25 23 26 25 23 24 23 24 23 24 23 24 23 24 23 24 23 24 23 24 23 24 23 24 23 23 24 23 23 24 23 23 24 25 26 27 28 29 20 19 31	20 18 31 25 30 28 24 30 29 29 29 29 29 29 25 28 30 25 30 24 30 25 30 24 30 25 30 28 24 30 29 29 25 28 29 29 29 25 28 29 29 29 25 28 29 29 29 25 28 29 29 29 25 28 29 29 25 28 29 29 25 28 29 29 25 28 29 29 25 28 29 29 25 28 29 29 25 28 30 29 29 25 28 29 29 25 28 30 29 29 25 28 30 29 29 25 28 30 29 29 25 28 30 29 29 25 28 30 29 29 25 28 30 29 25 28 30 29 25 28 30 29 25 28 30 25 30 26 30 26 27 29 25 28 30 25 30 24 30 25 30 25 30 24 30 25 30 24 30 25 30 24 30 25 30 24 30 25 30 24 30 25 30 24 30 25 30 24 30 25 30 24 32 30 24 32 30 24 36 36 36 36 36 36 36 36 36 36	21 3 20 26 27 22 18 18 20 19 24 24 22 21 23 21 23 21 23 21 23 21 27 19 26 20 24 22 21 23 21 23 21 23 21 23 21 23 24 24 24 24 24 24 24 24 24 24	Total 172 217 223 228 226 212 249 229 217 227 223 225 223 205 233 260 205 230 224 205 230 205 230 244 205 230 205 230 244 205 230 245 235 205 235 235 205 236 246 245 245 245 245 245 245 245 245
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Table 1. Number of stations sampled by shrimp statistical zone during the Summer (top) and Fall (bottom) SEAMAP groundfish survey from 1987-2010.

											De	pui ze	me											
Year	0506	0607	0708	0809	0910	1011	1112	1213	1314	1415	1516	1617	1718	1819	1920	2022	2225	2530	3035	3540	4045	4550	5060	Total
1987	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
1994	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
1995	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	3
1996	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1997	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	2
1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
2001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2003	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
2004	0	2	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	2
2005	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
2000	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
2007	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	3
2000	Ő	0	0	1	1	0	0	0	Ő	Ő	1	Ő	0	0	0	0	0	Ő	0	Ő	õ	Ő	0	3
2010	Ő	0	Ő	0	0	Ő	0	0	Ő	Ő	0	Ő	0	0	Ő	Ő	Ő	Ő	0	Ő	Ő	Ő	0	0
Total	3	3	3	2	4	0	0	1	0	1	3	0	1	0	1	0	1	1	0	0	0	0	0	24
											De	pth Zo	one											
Year	0506	0607	0708	0809	0100	1011	1112	1213	1314	1415	1516 De	pth Zo 191	one 1118	1819	1920	2022	2225	2530	3035	3540	4045	4550	5060	Total
Year	0506	0607	0708	0809	0010	0 1011	0 1112	0 1213	0 1314	0 1415	0 1516 0	pth Zo 1911 0	one 1218 0	0 1819	0 1920	1 2022	0 2225	1 2530	0 3035	0 3540	0 4045	0 4550	09060	Total
Year 1987 1988	0 0 0506	0 0 0607	0 0 0708	0 0809	0 0 0910	0 0 1011	0 0 1112	0 0 1213	0 0 1314	0 0 1415	0 0 0 0	pth Zo 191 0 0	one 81218 0 0	0 0 1819	0 0 1920	0 1 2022	0 0 2225	0 1 2530	0 0 3035	0 0 3540	0 0 4045	0 0 4550	0 0 5060	Total
Year 1987 1988 1989	0 0 0506	0 0 0 000	8020 0 1	0 0809	0 0 0 0910	0 0 1011	0 0 1112	0 0 0 1213	1 0 1314	1 0 1415	0 0 0 0 0	pth Zo 1911 0 0 0	one 8121 0 0 0	0 0 0 1819	0 0 0 1920	1 0 1	0 0 0 2225	0 0 1 2530	0 0 0 3035	0 0 0 3540	0 0 0 4045	1 0 0 4550	0 0 0 5060	Total
Year 1987 1988 1989 1990	0 0000	0 0 0007	000 00 1 1	6080 0 0 1	0010 0 00 1	0 0 0 0 0 0	1112 0 0 1	0 0 0 1213	1 1 1 1 3 1 4 1 8 1 8 1 8	1 1 1 1 1 1 1 1 1 5	0 0 0 0 0 0 0	1913 1913 0 0 0	one 1218 0 0 0 0	0 0 1819	0 0 0 0 1920	0 1 0 1 0	0 0 0 2225	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 3035	0 0 0 3540	0 0 0 4045	0 1 0 4550	0 0 0 0 0 0 0	Total 2 0 5 7
Year 1987 1988 1989 1990 1991	0206 0 0 0 0 0 1	000000000000000000000000000000000000000	8020 0 1 1 0	6080 0 0 0 1 0	0160 0 0 0 1 0	0 0 0 0 0 0 0 0	1112 0 0 1 1 1	0 0 0 1213	0 0 1314	1 1 1 1 1 1 1 1 1 1 1 5	90 1216 0 0 0 1 1	pth Zc [19] 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	6181 0 0 0 1 0	0 0 0 0 0 1920	0 0 1 2022	0 0 0 2225	1 5530 1 0 0 1	0 0 0 3035	0 0 0 0 3540	0 0 0 0 4045	0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	Total 2 0 5 7 5
Year 1987 1988 1989 1990 1991 1992	0200 0000 000 00 00 00 0	0000 0000 0000	80L0 0 1 1 0 0	6080 0 0 0 1 0 0	0160 0 0 0 1 0 0	101 0 0 0 0 0 1	0 0 0 1 1 1	E121 0 0 0 0 0 0 2	0 0 1314 1314	0 1415 0	De 9151 0 0 0 0 0 1 0	pth Zc [19] 0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0	6181 0 0 0 1 0 0	1920 1920	1 0 1 0 1 1 0 1	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	1 0 0 0 0 0 0 0 0 0 0	0 0 0 0 3035 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 0 0 3540	0 0 0 0 0 4045	0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0	Total 2 0 5 7 5 6
Year 1987 1988 1989 1990 1991 1992 1993	0206 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	L090 0 0 0 0 0 0 1	8020 0 1 1 0 0 1	6080 0 0 0 1 0 0 0	0160 0 0 0 1 0 0 2	0 0 0 0 0 0 1 2	0 0 0 1 1 1 0	0 0 0 0 2 1	1 0 0 1 3 1 4 1 8 1 8	0 1 1 5 1 4 1 5	De 9151 0 0 0 0 0 1 0 2	pth Zc [9] 0 0 0 0 0 0 0 1	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	6181 0 0 0 1 0 0 1	0 0 0 0 0 0 0 1 2	0 1 0 0 1 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	1 0 0 0 0 0 0 1 0 2 2	0 0 0 0 0 0 0 0 1	0 0 0 0 0 3540	0 0 0 0 0 0 0 4045	0 0 4550 0 0 0 0	0 0 0 0 0 0 0 0 0 0 0 0	Total 2 0 5 7 5 6 19
Year 1987 1988 1989 1990 1991 1992 1993 1994	9050 0 0 0 0 1 0 0 0	L090 0 0 0 0 0 0 0 0 0 0 0 0 0	8020 0 1 1 0 1 0	6080 0 0 0 1 0 0 0 1	0160 0 0 0 0 0 1 0 0 2 1	100 0 0 0 0 0 1 2 1	CIII 0 0 0 1 1 1 0 0	E121 0 0 0 0 0 2 1 0	1311 1311 1311 1311 1311 1311 1311 131	0 0 1 1 1 1 5 1 4 1 5	De 9151 0 0 0 0 0 0 1 0 2 0	pth Zc 51 0 0 0 0 0 0 0 0 0 1 2	0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0	61881 0 0 0 1 0 0 1 2	0 0 0 0 0 0 0 0 0 0 1 2 0	1 0 1 0 1 0 2022 2022	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	02230 1 0 0 1 0 2 1	3035 0 0 0 0 0 0 1 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 4045	0 0 0 4550 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	Total 2 0 5 7 5 6 19 14
Year 1987 1988 1989 1990 1991 1992 1993 1994 1995	9050 0 0 0 0 0 0 0 0 0 0	L090 0 0 0 0 0 0 0 0 0 0 0 0 0	80L0 0 1 1 0 0 1 0 1	6080 0 0 0 1 0 0 0 1 0 0	$\begin{array}{c} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 1 \\ 0 \\ 2 \\ 1 \\ 0 \\ 0 \\ \end{array}$	1001 0 0 0 0 0 0 1 2 1 1	CIII 0 0 0 1 1 1 0 0 1	E121 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	131 10 0 1 1 1 0 0 1 1 2 1	0 0 1 1 1 1 0 2 0 0 0 1	De 9[5] 0 0 0 0 0 1 0 2 0 1	ppth Zo [19] 0 0 0 0 0 0 1 2 0 0	one 0 0 0 0 0 0 0 0 0 0 0 0 0 1	6181 0 0 0 1 0 0 1 2 0	0700 0000 0000 0000 00000 00000 00000000	5002 1 0 1 0 1 0 2 0 0 0 1 0 2 0 0	55552 0 0 0 0 0 0 1 2 2 2	00000000000000000000000000000000000000	3035 0 0 0 0 0 0 1 0 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0000 0000 0000 00000 00000	Total 2 0 5 7 5 6 19 14 9
Year 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996	9000 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	L090 0000 0000 0000 0000 0000 0000 0000	80L0 0 1 1 0 1 0 1 0	6080 0 0 0 1 0 0 0 1 0 0	0160 0 0 0 0 1 0 0 2 1 0 1	1001 0 0 0 0 0 0 1 2 1 1 1	0 0 0 1 1 1 0 0 1 0 0 0	E121 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	1314 0 0 1 1 1 0 0 1 1 1 1 0 0 1 1 1 1 1 1 1	0 0 1 1 1 1 2 0 0 0 1 1 1 1 2 0 0 0 1	De 9[5] 0 0 0 0 0 1 0 2 0 1 2	ppth Zo [9] 0 0 0 0 0 0 1 2 0 1 2	one 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0	6181 0 0 0 1 0 0 1 2 0 1	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	1 0 1 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 1 2 2 5 2 5 2 5 2 5 2 1 2 5 5 2 5 2 5 2	05230 1 0 0 0 1 0 2 1 0 1 1 0 1	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	Total 2 0 5 7 5 6 19 14 9 11
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Table 2. Number of stations with a positive occurrence of cobia by depth zone during the Summer (top) and Fall (bottom) SEAMAP groundfish survey from 1987-2010.

14 10 14 11 11 11 9 14 12 11 10 10 11

4 0

Total

											DC	րուշվ	me											
Year	0506	0607	0708	0809	0910	1011	1112	1213	1314	1415	1516	1617	1718	1819	1920	2022	2225	2530	3035	3540	4045	4550	5060	Total
1987	1	1	1	2	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	7
1988	2	1	0	1	0	1	0	õ	0	1	0	1	0	õ	Ő	Ő	õ	õ	0	1	0	0	Ő	8
1989	3	1	1	0	2	1	1	1	Ő	0	0	0	0	Ő	1	Ő	Ő	Ő	0	0	0	0	0	11
1990	2	3	1	2	1	2	1	3	1	1	ő	Ő	Ő	1	0	ő	ő	ő	ő	ő	õ	Ő	ő	18
1001	3	1	2	0	1	0	1	2	2	0	0	1	0	1	Ő	1	ő	Ő	0	Ő	Ő	0	ő	15
1992	1	0	1	ő	0	ő	1	õ	õ	ő	ő	0	Ő	0	ő	0	ő	ő	ő	ő	õ	Ő	ő	3
1993	1	Ő	1	0	0	0	0	Ő	1	1	0	0	0	Ő	Ő	Ő	1	Ő	0	0	0	0	0	5
1994	2	0	0	0	0	0	1	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	8
1995	3	2	1	0	1	0	0	Ő	1	0	0	0	1	0	Ő	Ő	Ő	Ő	0	0	0	0	0	9
1996	1	1	2	0	0	2	1	õ	1	ő	0	0	0	õ	Ő	Ő	õ	õ	0	0	0	0	Ő	8
1997	1	1	1	Ő	1	0	0	Ő	1	Ő	Ő	Ő	Ő	Ő	Ő	Ő	Ő	Ő	Ő	0	Ő	Ő	Ő	5
1998	2	2	0	°2	2	ő	Ő	õ	1	ŏ	ő	Ő	Ő	õ	õ	õ	õ	õ	ŏ	ő	Ő	Ő	ŏ	9
1999	1	õ	Ő	1	0	Ő	ŏ	Ő	0	õ	Ő	1	Ő	õ	Ő	Ő	Ő	õ	Ő	Ő	Ő	Ő	Ő	3
2000	1	1	1	3	1	2	ő	Ő	Ő	õ	Ő	0	Ő	Ő	Ő	1	1	Ő	Ő	0	Ő	Ő	Ő	11
2000	0	1	0	1	2	0	1	Ő	1	õ	Ő	Ő	Ő	õ	Ő	0	0	õ	Ő	Ő	Ő	Ő	Ő	6
2002	õ	0	2	0	0	0	0	Ő	0	õ	1	Ő	Ő	1	Ő	Ő	Ő	Ő	Ő	0	Ő	Ő	Ő	4
2002	ĩ	1	1	Ő	1	Ő	1	Ő	Ő	õ	0	Ő	Ő	0	Ő	Ő	Ő	õ	Ő	Ő	Ő	Ő	Ő	5
2004	2	1	0	Ő	0	1	2	Ő	2	1	Ő	Ő	Ő	Ő	Ő	Ő	Ő	Ő	Ő	Ő	Ő	Ő	Ő	9
2005	4	2	Ő	Ő	ı 1	2	1	Ő	0	1	Ő	Ő	Ő	Ő	Ő	Ő	Ő	Ő	Ő	Ő	Ő	Ő	Ő	í1
2006	1	3	3	2	1	0	0	1	0	0	Ő	1	Õ	0	0	0	0	0	1	Õ	Õ	Õ	Ő	13
2007	2	3	0	1	1	Ő	ŏ	2	1	ĩ	ĩ	1	2	Ő	2	Ő	Ő	Ő	0	Ő	Ő	Ő	Ő	17
2008	2	3	2	1	1	Õ	Õ	0	0	0	0	0	0	0	1	0	0	0	Õ	Õ	Õ	Õ	Ő	10
2009	0	0	1	0	1	1	5	1	Ő	ĩ	Ő	Ő	Ő	Ő	0	Ŏ	Ő	Ő	Ő	Ő	Ő	Ő	Ő	10
2010	Õ	0	3	1	0	0	1	0	Ő	1	2	Õ	Õ	0	0	0	0	0	Õ	Õ	Õ	Õ	Ő	8
Total	36	28	24	17	17	12	17	10	13	9	5	6	5	4	4	2	2	0	1	1	0	0	0	213
											De	pth Zo	one											
V	90	17	8	60	0	1	5	n	4	5	De	epth Zo	one ∞	6	03	5	5	03	5	0	5	09	09	T-4-1
Year	0506	0607	0708	0809	0910	1011	1112	1213	1314	1415	1516 PG	epth Zo	one 1218	1819	1920	2022	2225	2530	3035	3540	4045	4550	5060	Total
Year 1987	0506	0607	0 0708	6080	0160	0 1011	0 1112	0 1213	0 1314	0 1415	0 1516 0	epth Zo 191 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 1819	0 1920	0 2022	2225	0 2530	1 3035	0 3540	0 4045	0 4550	0 5060	Total
Year 1987 1988	0 2 0	L090 0 2	0 0 2	6080 1 1	0010	1011 1011	0 2	c 0 1213	1 0 1314	0 0 1415	91516 1516	epth Zo L191 0 1	one %121 0 2	0 1819	0 0 1920	0 0 2022	2225	0 0 2530	0 1 3035	0 0 3540	0 0 4045	0 0 4550	0 0 5060	Total 5 23
Year 1987 1988 1989	9050 0 2 1	L090 0 2 2	80L0 0 2 3	6080 1 1 2	0160 1 3 2	1011 1 1	21 11 2 1	0 2 0 1213	5 1314 1314	0 0 0 1415	De 1516 1 0	pth Zo [19] 0 1 1	0 2 0	0 1 0 1 0	0 0 0 1920	0 0 0 2022	2225 0	1 0 0 2530	1 0 1	0 0 0 3540	0 0 0 4045	0 0 0 4550	0 0 0 2060	Total 5 23 17
Year 1987 1988 1989 1990	0200 0 2 1 3	L090 0 2 0	8020 0 2 3 4	6080 1 1 2 1	0160 1 3 2 0	1011 0 1 1 1	CIII 0 2 1 1	0 2 3 3	5 0 1314 1314	1 0 0 1415	9 0 1 0 0 0 0	epth Zc [9] 0 1 1 2	one <u> \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ </u>	0 1819 0 1819	1 1920 1	0 0 0 0 2022	52252 2 0 0 0	0 0 0 0 0	3035 1 0 1 0	0 0 0 3540	0 0 0 4045	0 0 0 4550	2060 0 0 0	Total 5 23 17 19
Year 1987 1988 1989 1990 1991	90 <u>90</u> 0 2 1 3 2	L090 0 2 2 0 1	8020 0 2 3 4 2	6080 1 1 2 1 1	0160 1 3 2 0 2	0 1 1 2	CIII 0 2 1 1 1 1	1213 0 1213 1213	1315 0 1 2 0	0 0 0 1415	90 1516 0 0 0 0 0	ppth Zc [19] 0 1 2 0	one ⁸⁰ ¹² ¹² ⁰ ² ⁰ ⁰ ⁰ ⁰ ⁰ ⁰ ⁰ ⁰	1 1819 0 1 1819	0 0 1920	0 0 0 0 0 2022	22255 0 0 0	0 0 0 0 0 0 0 0	3035 1 0 1 0 1	0 0 0 0 3540	0 0 0 0 0 4045	0 0 0 4550	0 0 0 0 0 0 0 0 0	Total 5 23 17 19 14
Year 1987 1988 1989 1990 1991 1992	9050 0 2 1 3 2 2	L090 0 2 2 0 1 1	8020 0 2 3 4 2 2	6080 1 1 2 1 1 2	0100 1 3 2 0 2 0	1 0 1 1 2 1	CIII 0 2 1 1 1 4	1213 0 1 1 1	1314 0 0 0 0	1 0 0 1415	9 0 1 1 2 1 9 0 0 0 0 0 1 2 1 6	CI91 0 1 2 0 3	one [®] 121 0 2 0 0 0 0 0 0	0 1 0 181 0 1 81 0	0 0 0 1920 0	1 0 0 0 0 1 2022	2 2 2 2 0 0 0 1	$\begin{array}{ccc} 2530 \\ 0 \\ 1 \\ 0 \\ 1 \end{array}$	1 0 1 0 1 0	$\begin{array}{cccc} 1 \\ 0 \\ 0 \\ 0 \\ 0 \\ 3540 \\ \end{array}$	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 0 0 4550 4550	0 0 0 0 0 0 0 0 0 0	Total 5 23 17 19 14 22
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Year 1987 1988 1989 1990 1991 1992 1993 1994 1995	90 <u>90</u> 0 2 1 3 2 2 4 2 3	L090 0 2 2 0 1 1 2 3 2	8020 0 2 3 4 2 2 3 1 0	6080 1 1 2 1 1 2 5 0 1	0160 1 3 2 0 2 0 1 0 1 0 1	0 1 1 2 1 3 1 1	CIII 0 2 1 1 1 4 1 0 0	EI2I 0 2 0 3 1 1 1 1 2	1 2 0 0 0 0 0 2 1	S111 0 0 1 1 1 0 2	De 9151 0 1 0 0 0 1 1 2 0	epth Zc [19] 0 1 2 0 3 3 0 0	0 0 2 0 0 0 0 0 0 0 0 0 0 1 0 2 0 0 0 0 0 0 0 0 0 0 0 0 0	6181 0 1 0 1 0 1 0 1 0 2	0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 1 2 0 3 0 1	2 2 2 2 0 0 0 1 1 2	0 0 0 0 0 0 1 1 0 2 2	3035 1 0 1 0 1 0 1 0 1 0 1	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0000 0 0 0 0 0 0 0 0 0 1 0 0	Total 5 23 17 19 14 22 36 13 23
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Table 3. Number of stations with a positive occurrence of Spanish mackerel by depth zone during the Summer (top) and Fall (bottom) SEAMAP groundfish survey from 1987-2010.

10 11

34 48

Total

				Minimum	Maximum	Mean	
	Number	Number	Number	Total	Total	Total	Standard
Survey Year	of Stations	Collected	Measured	Length (mm)	Length (mm)	Length (mm)	Deviation
1987	446	3	0				
1988	430	0	0				
1989	417	5	5	335	515	417	66
1990	468	12	10	108	495	370	109
1991	457	5	5	329	440	395	43
1992	438	9	9	277	935	445	234
1993	472	31	28	179	705	380	87
1994	467	17	17	244	508	408	61
1995	437	15	13	180	933	515	243
1996	447	17	16	224	486	344	63
1997	430	29	28	245	655	373	73
1998	429	9	8	321	823	648	188
1999	448	15	15	175	461	388	74
2000	439	2	2	383	435	409	37
2001	357	16	16	242	470	353	56
2002	460	7	6	322	695	490	157
2003	441	17	9	192	1080	407	265
2004	421	18	17	36	512	356	105
2005	411	23	22	164	1175	383	275
2006	445	19	13	237	795	436	133
2007	401	9	9	215	456	316	87
2008	672	23	19	299	1260	558	280
2009	974	12	12	162	550	414	121
2010	626	17	17	182	425	305	78
Total Number	Total Number	Total Number	Total Number			Overall Mean Total	
of Years	of Stations	Collected	Measured			Length (mm)	
24	11,433	330	296			405	

Table 4. Summary of the cobia data used in these analyses collected by NOAA Fisheries during Summer and Fall SEAMAP groundfish surveys conducted between 1987 and 2010.

Year	Ν	Nominal CPUE	Proportion Positive
1987	446	0.00862	0.004484
1988	430	0	0
1989	417	0.02056	0.01199
1990	468	0.09092	0.014957
1991	457	0.03155	0.010941
1992	438	0.0484	0.013699
1993	472	0.17458	0.042373
1994	467	0.06091	0.03212
1995	437	0.07223	0.02746
1996	447	0.06796	0.024609
1997	430	0.16853	0.037209
1998	429	0.02865	0.009324
1999	448	0.0578	0.033482
2000	439	0.00628	0.004556
2001	357	0.08463	0.039216
2002	460	0.03476	0.013043
2003	441	0.076	0.020408
2004	421	0.05383	0.030879
2005	411	0.08424	0.03163
2006	445	0.06032	0.024719
2007	401	0.04735	0.017456
2008	587	0.08275	0.015332
2009	744	0.03204	0.008065
2010	446	0.07559	0.022422

Table 5. Nominal CPUE and proportion of positive catch stations for cobia captured during Summer and Fall SEAMAP Groundfish Surveys from 1987 to 2010.

				Minimum	Maximum	Mean	
	Number	Number	Number	Total	Total	Total	Standard
Survey Year	of Stations	Collected	Measured	Length (mm)	Length (mm)	Length (mm)	Deviation
1987	385	32	14	120	380	237	94
1988	360	104	82	108	406	255	80
1989	358	129	93	116	370	199	53
1990	405	231	137	100	415	196	76
1991	382	147	107	90	422	311	67
1992	363	123	98	130	530	252	84
1993	403	199	138	92	409	234	72
1994	387	78	61	94	389	197	88
1995	371	99	89	51	518	268	95
1996	372	140	78	154	498	267	74
1997	359	34	34	56	378	246	81
1998	357	67	61	55	432	227	74
1999	374	85	68	80	430	234	85
2000	369	156	97	102	371	204	64
2001	302	90	68	73	435	165	60
2002	384	35	28	149	454	264	96
2003	379	193	129	137	369	213	48
2004	356	61	54	98	362	238	75
2005	363	487	166	105	380	205	58
2006	382	82	75	137	407	271	65
2007	347	203	124	51	441	218	68
2008	489	132	100	75	436	225	83
2009	645	204	161	137	405	216	59
2010	389	112	64	70	382	253	80
Total Number of Years 24	Total Number of Stations 9281	Total Number Collected 3223	Total Number Measured 2127			Overall Mean Total Length (mm) 230	

Table 6. Summary of the Spanish mackerel data used in these analyses collected by NOAA Fisheries during Summer and Fall SEAMAP groundfish surveys conducted between 1987 and 2010.

Model Run #1		Binomia	l Submodel	Type 3 Tes	ts (AIC 56564.0	5)	Lognormal Subm	odel Type 3	Tests (AIC	7 2000.2)
Effect	Num DF	Den DF	Chi- Square	F Value	Pr > ChiSq	Pr > F	Num DF	Den DF	F Value	Pr > F
Year	23	3254	55.72	2.41	0.0002	0.0002	23	634	1.39	0.1083
Area	2	7546	57.36	28.68	<.0001	<.0001	2	634	3.04	0.0487
Depth Zone	18	7717	260.30	14.46	<.0001	<.0001	18	634	6.84	<.0001
Time of Day	1	7773	107.24	107.24	<.0001	<.0001	1	634	29.30	<.0001
Season	1	7349	143.09	143.09	<.0001	<.0001	1	634	2.53	0.1125
Survey	1	525	1.15	1.15	0.2839	0.2844	1	634	0.02	0.8992
Model Run #2		Binomia	l Submodel	Type 3 Tes	ts (AIC 56581.:	5)	Lognormal Subm	odel Type 3	Tests (AIC	7 2000.7)
Effect	Num DF	Den DF	Chi- Square	F Value	Pr > ChiSq	Pr > F	Num DF	Den DF	F Value	Pr > F
Year	23	3253	57.74	2.50	<.0001	<.0001	23	635	1.39	0.1082
Area	2	7530	56.88	28.44	<.0001	<.0001	2	635	3.06	0.0478
Depth Zone	18	7707	260.96	14.50	<.0001	<.0001	18	635	6.85	<.0001
Time of Day	1	7758	107.12	107.12	<.0001	<.0001	1	635	29.45	<.0001
Season	1	7692	143.76	143.76	<.0001	<.0001	1	635	2.51	0.1136
Survey				dropped				dropped		
Model Run #3		Binomia	l Submodel	Type 3 Tes	ts (AIC 56581.:	5)	Lognormal Subm	odel Type 3	Tests (AIC	C 1999.9)
Effect	Num DF	Den DF	Chi- Square	F Value	Pr > ChiSq	Pr > F	Num DF	Den DF	F Value	Pr > F
Year	23	3253	57.74	2.50	<.0001	<.0001	23	636	1.37	0.1147
Area	2	7530	56.88	28.44	<.0001	<.0001	2	636	3.08	0.0465
Depth Zone	18	7707	260.96	14.50	<.0001	<.0001	18	636	7.68	<.0001
Time of Day	1	7758	107.12	107.12	<.0001	<.0001	1	636	28.84	<.0001
Season	1	7692	143.76	143.76	<.0001	<.0001		dropped		
Survey				dropped				dropped		

Table 7. Summary of backward selection procedure for building delta-lognormal submodels for Spanish mackerel full index of relative abundance from 1987 to 2010.

Table 8. Indices of Spanish mackerel (full model) developed using the delta-lognormal model for 1987-2010. 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	Ν	DL Index	Scaled Index	CV	LCL	UCL	
1987	0.03117	385	0.10039	0.31226	0.67432	0.09178	1.06238	
1988	0.08333	360	0.33883	1.05392	0.28133	0.60686	1.83033	
1989	0.07821	358	0.45726	1.42231	0.29306	0.80108	2.52530	
1990	0.09136	405	0.53600	1.66725	0.28593	0.95171	2.92076	
1991	0.07592	382	0.28553	0.88814	0.33637	0.46143	1.70944	
1992	0.06612	363	0.18879	0.58722	0.31427	0.31786	1.08487	
1993	0.09181	403	0.51389	1.59848	0.25684	0.96421	2.64997	
1994	0.05426	387	0.23166	0.72057	0.43390	0.31400	1.65358	
1995	0.08625	371	0.35457	1.10289	0.28118	0.63524	1.91482	
1996	0.06183	372	0.31361	0.97551	0.37302	0.47394	2.00786	
1997	0.04735	359	0.09861	0.30674	0.49132	0.12102	0.77745	
1998	0.06723	357	0.17563	0.54631	0.34927	0.27717	1.07678	
1999	0.06150	374	0.24460	0.76083	0.33175	0.39868	1.45194	
2000	0.08130	369	0.36328	1.12998	0.34691	0.57580	2.21755	
2001	0.05960	302	0.25269	0.78600	0.38920	0.37086	1.66583	
2002	0.02865	384	0.10442	0.32480	0.60282	0.10667	0.98902	
2003	0.07916	379	0.45133	1.40387	0.26920	0.82715	2.38271	
2004	0.06742	356	0.14970	0.46564	0.29732	0.26016	0.83339	
2005	0.12948	363	0.74764	2.32555	0.25517	1.40725	3.84308	
2006	0.08639	382	0.28682	0.89216	0.29229	0.50321	1.58175	
2007	0.11239	347	0.56336	1.75234	0.28765	0.99706	3.07977	
2008	0.04499	489	0.24844	0.77279	0.38643	0.36645	1.62970	
2009	0.09457	645	0.33117	1.03011	0.18099	0.71935	1.47512	
2010	0.07455	389	0.37753	1.17432	0.26837	0.69299	1.98997	

Model Run #1	Binomial Submodel Type 3 Tests (AIC 23424.2)					2)	Lognormal Subm	odel Type .	3 Tests (Ale	C 608.4)	
Effect	Num DF	Den DF	Chi- Square	F Value	Pr > ChiSq	Pr > F	Num DF	Den DF	F Value	Pr > F	
Year	23	1246	36.45	1.57	0.0371	0.0431	23	163	1.38	0.1290	
Area	2	2715	17.03	8.52	0.0002	0.0002	2	163	0.03	0.9707	
Depth Zone	14	2721	97.92	6.99	<.0001	<.0001	14	163	1.20	0.2769	
Time of Day	1	2760	4.83	4.83	0.0280	0.0280	1	163	4.20	0.0420	
Model Run #2		Binomia	l Submodel	Type 3 Tes	ts (AIC 23424.2	2)	Lognormal Subm	nodel Type 3 Tests (AIC 606			
Effect	Num DF	Den DF	Chi- Square	F Value	Pr > ChiSq	Pr > F	Num DF	Den DF	F Value	Pr > F	
Year	23	1246	36.45	1.57	0.0371	0.0431	23	165	1.46	0.0924	
Area	2	2715	17.03	8.52	0.0002	0.0002		dropped			
Depth Zone	14	2721	97.92	6.99	<.0001	<.0001	14	165	1.23	0.2587	
Time of Day	1	2760	4.83	4.83	0.0280	0.0280	1	165	4.23	0.0414	
Model Run #3		Binomia	l Submodel	Type 3 Tes	ts (AIC 23424.2	2)	Lognormal Subm	odel Type .	3 Tests (AI	C 625.3)	
Model Run #3 Effect	Num DF	Binomia Den DF	l Submodel Chi- Square	Type 3 Tes F Value	Pr > ChiSq	$\frac{2}{Pr > F}$	Lognormal Subm Num DF	odel Type . Den DF	3 Tests (Ale F Value	C 625.3) Pr > F	
Model Run #3 Effect Year	Num DF 23	Binomia Den DF 1246	l Submodel Chi- Square 36.45	Type 3 Tes F Value 1.57	$\frac{Fr > ChiSq}{0.0371}$	$\frac{Pr > F}{0.0431}$	Lognormal Subm Num DF 23	Den DF 179	3 Tests (Ale F Value 1.48	$\frac{Pr > F}{0.0831}$	
Model Run #3 Effect Year Area	Num DF 23 2	Binomia Den DF 1246 2715	l Submodel Chi- Square 36.45 17.03	<i>Type 3 Tes</i> <i>F Value</i> 1.57 8.52	$\frac{Fr > ChiSq}{0.0371}$	$\frac{Pr > F}{0.0431}$ 0.0002	Lognormal Subm Num DF 23	Den DF 179 dropped	3 Tests (AI F Value	C 625.3) Pr > F 0.0831	
Model Run #3 Effect Year Area Depth Zone	Num DF 23 2 14	Binomia Den DF 1246 2715 2721	l Submodel Chi- Square 36.45 17.03 97.92	Type 3 Tes F Value 1.57 8.52 6.99	$\frac{Pr > ChiSq}{0.0371}$ 0.0002 <.0001	$\frac{Pr > F}{0.0431}$ 0.0002 <.0001	Lognormal Subm Num DF 23	Den DF Den DF 179 dropped dropped	3 Tests (All F Value	C 625.3) Pr > F 0.0831	
Model Run #3 Effect Year Area Depth Zone Time of Day	Num DF 23 2 14 1	Binomia Den DF 1246 2715 2721 2760	l Submodel Chi- Square 36.45 17.03 97.92 4.83	Type 3 Tes F Value 1.57 8.52 6.99 4.83	$\frac{Pr > ChiSq}{0.0371}$ 0.0002 <.0001 0.0280	Pr > F 0.0431 0.0002 <.0001 0.0280	Lognormal Subm Num DF 23 1	Den DF Den DF 179 dropped dropped 179	3 Tests (Alo F Value 1.48 3.34	C 625.3) Pr > F 0.0831 0.0691	
Model Run #3 Effect Year Area Depth Zone Time of Day Model Run #4	Num DF 23 2 14 1	Binomia Den DF 1246 2715 2721 2760 Binomia	l Submodel Chi- Square 36.45 17.03 97.92 4.83 l Submodel	Type 3 Tes F Value 1.57 8.52 6.99 4.83 Type 3 Tes	$\frac{Pr > ChiSq}{0.0371}$ 0.0002 <.0001 0.0280 ts (AIC 23424	Pr > F 0.0431 0.0002 <.0001 0.0280 2)	Lognormal Subm Num DF 23 1 Lognormal Subm	Den DF Den DF 179 dropped dropped 179	3 Tests (Ald F Value 1.48 3.34 3 Tests (Ald	$\frac{C \ 625.3)}{Pr > F}$ 0.0831 0.0691 C \ 627.0)	
Model Run #3 Effect Year Area Depth Zone Time of Day Model Run #4 Effect	Num DF 23 2 14 1 1 Num DF	Binomia Den DF 1246 2715 2721 2760 Binomia Den DF	l Submodel Chi- Square 36.45 17.03 97.92 4.83 l Submodel Chi- Square	Type 3 Tes F Value 1.57 8.52 6.99 4.83 Type 3 Tes F Value	$\frac{Pr > ChiSq}{0.0371}$ 0.0002 <.0001 0.0280 ts (AIC 23424.) $Pr > ChiSq$	Pr > F 0.0431 0.0002 <.0001 0.0280 2) $Pr > F$	Lognormal Subm Num DF 23 1 Lognormal Subm Num DF	Den DF 179 dropped dropped 179 nodel Type	3 Tests (Alo F Value 1.48 3.34 3 Tests (Alo F Value	$\frac{C \ 625.3)}{Pr > F}$ 0.0831 0.0691 $C \ 627.0)$ $Pr > F$	
Model Run #3 Effect Year Area Depth Zone Time of Day Model Run #4 Effect Year	Num DF 23 2 14 1 1 Num DF 23	Binomia Den DF 1246 2715 2721 2760 Binomia Den DF 1246	l Submodel Chi- Square 36.45 17.03 97.92 4.83 I Submodel Chi- Square 36.45	Type 3 Tes F Value 1.57 8.52 6.99 4.83 Type 3 Tes F Value 1.57	$\frac{Fr > ChiSq}{0.0371}$ $\frac{0.0002}{0.0280}$ $\frac{0.0280}{0.0280}$ $\frac{0.0280}{0.0284}$ $\frac{Fr > ChiSq}{0.0371}$	Pr > F 0.0431 0.0002 <.0001 0.0280 2) $Pr > F$ 0.0431	Lognormal Subm Num DF 23 1 Lognormal Subm Num DF 23	Den DF 179 dropped dropped 179 nodel Type Den DF 180	3 Tests (Alo F Value 1.48 3.34 3 Tests (Alo F Value 1.58	$\frac{C \ 625.3)}{Pr > F}$ 0.0831 0.0691 $\frac{C \ 627.0)}{Pr > F}$ 0.0526	
Model Run #3 Effect Year Area Depth Zone Time of Day Model Run #4 Effect Year Area	Num DF 23 2 14 1 1 Num DF 23 2	Binomia Den DF 1246 2715 2721 2760 Binomia Den DF 1246 2715	l Submodel Chi- Square 36.45 17.03 97.92 4.83 I Submodel Chi- Square 36.45 17.03	Type 3 Tes F Value 1.57 8.52 6.99 4.83 Type 3 Tes F Value 1.57 8.52	$\frac{Pr > ChiSq}{0.0371}$ $\frac{0.0002}{0.0280}$ $\frac{Vr > ChiSq}{0.0280}$ $\frac{Vr > ChiSq}{0.0371}$ $\frac{Vr > ChiSq}{0.0371}$ $\frac{0.0371}{0.0002}$	Pr > F 0.0431 0.0002 <.0001 0.0280 2) $Pr > F$ 0.0431 0.0002	Lognormal Subm Num DF 23 1 Lognormal Subm Num DF 23	Den DF 179 dropped dropped 179 nodel Type Den DF 180 dropped	3 Tests (Alo F Value 1.48 3.34 3 Tests (Alo F Value 1.58	$\frac{Pr > F}{0.0831}$ $\frac{0.0691}{C \ 627.0}$ $\frac{Pr > F}{0.0526}$	
Model Run #3 Effect Year Area Depth Zone Time of Day Model Run #4 Effect Year Area Depth Zone	Num DF 23 2 14 1 1 Num DF 23 2 14	Binomia Den DF 1246 2715 2721 2760 Binomia Den DF 1246 2715 2760	l Submodel Chi- Square 36.45 17.03 97.92 4.83 I Submodel Chi- Square 36.45 17.03 97.92	Type 3 Tes F Value 1.57 8.52 6.99 4.83 Type 3 Tes F Value 1.57 8.52 6.99	Pr > ChiSq 0.0371 0.0002 <.0001 0.0280 ts (AIC 23424.) $Pr > ChiSq$ 0.0371 0.0028 <.001 ts (AIC 23424.)	Pr > F 0.0431 0.0002 <.0001 0.0280 2) $Pr > F$ 0.0431 0.0002 <.0001 <.0001	Lognormal Subm Num DF 23 1 Lognormal Subm Num DF 23	Den DF 179 dropped dropped 179 nodel Type Den DF 180 dropped dropped	3 Tests (Alu F Value 1.48 3.34 3 Tests (Alu F Value 1.58	$\frac{C \ 625.3)}{Pr > F}$ 0.0831 0.0691 $\frac{C \ 627.0)}{Pr > F}$ 0.0526	

Table 9. Summary of backward selection procedure for building delta-lognormal submodels for Spanish mackerel summer index of relative abundance from 1987 to 2010.

Table 10. Indices of Spanish mackerel (summer model) developed using the delta-lognormal model for 1987-2010. 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	Ν	DL Index	Scaled Index	CV	LCL	UCL
1987	0.03784	185	0.18625	0.46182	0.89668	0.09938	2.14620
1988	0.04930	142	0.23456	0.58162	0.73493	0.15626	2.16494
1989	0.07857	140	1.34106	3.32531	0.46395	1.37506	8.04159
1990	0.10465	172	1.40658	3.48777	0.41285	1.57749	7.71131
1991	0.09150	153	0.60189	1.49245	0.52590	0.55551	4.00965
1992	0.02013	149	0.09337	0.23153	1.20364	0.03488	1.53671
1993	0.02685	149	0.19434	0.48189	0.86371	0.10827	2.14481
1994	0.05229	153	0.36121	0.89565	0.86398	0.20116	3.98779
1995	0.06122	147	0.38049	0.94347	0.59443	0.31401	2.83476
1996	0.05479	146	0.39826	0.98753	0.60307	0.32418	3.00825
1997	0.03650	137	0.03294	0.08167	1.29947	0.01117	0.59685
1998	0.06618	136	0.28571	0.70846	0.58943	0.23768	2.11170
1999	0.02041	147	0.04729	0.11726	1.70488	0.01136	1.21085
2000	0.06338	142	0.27592	0.68418	0.57334	0.23557	1.98716
2001	0.05660	106	0.65155	1.61558	0.60729	0.52682	4.95446
2002	0.02703	148	0.10513	0.26067	1.63964	0.02653	2.56104
2003	0.04000	125	0.19127	0.47428	0.79479	0.11702	1.92227
2004	0.06164	146	0.26634	0.66042	0.57553	0.22658	1.92497
2005	0.07746	142	0.48427	1.20081	0.49449	0.47123	3.05996
2006	0.08000	150	0.29427	0.72967	0.52206	0.27334	1.94782
2007	0.12687	134	1.24088	3.07690	0.47541	1.24746	7.58927
2008	0.04372	183	0.29391	0.72879	0.63276	0.22833	2.32618
2009	0.03831	261	0.12175	0.30190	0.69478	0.08605	1.05923
2010	0.04930	142	0.18968	0.47034	0.97410	0.09181	2.40950

Model Run #1		Binomia	l Submodel	Type 3 Tes	ets (AIC 27218.	7)	Lognormal Subm	odel Type 3	Tests (AIC	C 1300.5)
Effect	Num DF	Den DF	Chi- Square	F Value	Pr > ChiSq	Pr > F	Num DF	Den DF	F Value	Pr > F
Year	23	1620	68.42	2.95	<.0001	<.0001	23	427	1.50	0.0643
Area	2	3464	47.12	23.56	<.0001	<.0001	2	427	4.40	0.0128
Depth Zone	18	3624	171.99	9.55	<.0001	<.0001	18	427	8.52	<.0001
Time of Day	1	3613	110.67	110.67	<.0001	<.0001	1	427	21.59	<.0001

Table 11. Summary of backward selection procedure for building delta-lognormal submodels for Spanish mackerel fall index of relative abundance from 1987 to 2010.

Table 12. Indices of Spanish mackerel (fall model) developed using the delta-lognormal model for 1987-2010. 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	Ν	DL Index	Scaled Index	CV	LCL	UCL
1987	0.03268	153	0.04749	0.12163	0.97095	0.02383	0.62068
1988	0.12778	180	0.56827	1.45531	0.34682	0.74169	2.85555
1989	0.09140	186	0.26759	0.68529	0.37082	0.33427	1.40490
1990	0.09794	194	0.21522	0.55116	0.39663	0.25661	1.18381
1991	0.07407	189	0.19748	0.50574	0.41327	0.22857	1.11901
1992	0.12000	175	0.33683	0.86261	0.34460	0.44142	1.68569
1993	0.14884	215	0.86505	2.21538	0.27656	1.28719	3.81290
1994	0.06806	191	0.14301	0.36624	0.50194	0.14191	0.94514
1995	0.12500	184	0.53668	1.37442	0.34304	0.70536	2.67811
1996	0.07979	188	0.26482	0.67819	0.43130	0.29689	1.54921
1997	0.06417	187	0.17352	0.44438	0.54814	0.15942	1.23867
1998	0.07979	188	0.22838	0.58487	0.49573	0.22903	1.49355
1999	0.10638	188	0.49804	1.27546	0.37277	0.61995	2.62408
2000	0.10053	189	0.32053	0.82088	0.36157	0.40721	1.65478
2001	0.07186	167	0.21556	0.55205	0.51677	0.20864	1.46068
2002	0.03571	196	0.13674	0.35020	0.78728	0.08731	1.40453
2003	0.11312	221	0.74927	1.91886	0.28751	1.09209	3.37152
2004	0.08721	172	0.21528	0.55133	0.42316	0.24485	1.24147
2005	0.18462	195	1.09266	2.79826	0.29318	1.57568	4.96947
2006	0.10309	194	0.36455	0.93360	0.39451	0.43632	1.99764
2007	0.12155	181	0.32770	0.83924	0.32478	0.44548	1.58106
2008	0.05224	268	0.25678	0.65760	0.46635	0.27081	1.59688
2009	0.17057	299	0.65631	1.68079	0.19864	1.13408	2.49107
2010	0.12291	179	0.69368	1.77651	0.30726	0.97427	3.23934



Figure 1. Stations sampled from 1987 to 2010 during the Summer and Fall SEAMAP Groundfish Survey with the CPUE for cobia.



Figure 2. Length frequency distribution for cobia captured during the Summer and Fall SEAMAP Groundfish Survey from 1987 to 2010.



Figure 3. Annual trends for cobia captured during Summer and Fall SEAMAP Groundfish Surveys from 1987 to 2010 in **A.** nominal CPUE and **B.** proportion of positive stations.



Figure 4. Stations sampled from 1987 to 2010 during the Summer and Fall SEAMAP Groundfish Survey with the CPUE for Spanish mackerel. Top figure has stations from all depth zones, bottom figure has only stations used for the analysis.



Figure 5. Length frequency distribution for Spanish mackerel caught during the Summer (top) and Fall (bottom) SEAMAP Groundfish Survey from 1987 to 2010.



Figure 6. Annual trends for Spanish mackerel captured during Summer and Fall SEAMAP Groundfish Surveys from 1987 to 2010 in **A.** nominal CPUE and **B.** proportion of positive stations.



Figure 7. Annual trends for Spanish mackerel captured during the Summer SEAMAP Groundfish Surveys from 1987 to 2010 in **A.** nominal CPUE and **B.** proportion of positive stations.



Figure 8. Annual trends for Spanish mackerel captured during the Fall SEAMAP Groundfish Surveys from 1987 to 2010 in **A.** nominal CPUE and **B.** proportion of positive stations.



Figure 9. Diagnostic plots for binomial component of the Spanish mackerel SEAMAP Groundfish Survey (full model, summer and fall) model: **A.** the Chi-Square residuals by year, **B.** the Chi-Square residuals by area, **C.** the Chi-Square residuals by depth zone, **D.** the Chi-Square residuals by time of day and **E.** the Chi-Square residuals by season.



Figure 10. Diagnostic plots for lognormal component of the Spanish mackerel SEAMAP Groundfish Survey (full model, summer and fall) model: **A.** the frequency distribution of log(CPUE) on positive stations and **B.** the cumulative normalized residuals (QQ plot).



Figure 11. Diagnostic plots for lognormal component of the Spanish mackerel SEAMAP Groundfish Survey (full model, summer and fall) model: **A.** the Chi-Square residuals by year, **B.** the Chi-Square residuals by area, **C.** the Chi-Square residuals by depth zone and **D**. the Chi-Square residuals by time of day



Figure 12. Diagnostic plots for binomial component of the Spanish mackerel SEAMAP Groundfish Survey (summer survey) model: **A.** the Chi-Square residuals by year, **B.** the Chi-Square residuals by area, **C.** the Chi-Square residuals by depth zone and **D.** the Chi-Square residuals by time of day.



Figure 13. Diagnostic plots for lognormal component of the Spanish mackerel SEAMAP Groundfish Survey (summer survey) model: **A.** the frequency distribution of log(CPUE) on positive stations and **B.** the cumulative normalized residuals (QQ plot).



Figure 14. Diagnostic plot for binomial component of the Spanish mackerel SEAMAP Groundfish Survey (summer survey) model: the Chi-Square residuals by year.



Figure 15. Diagnostic plots for binomial component of the Spanish mackerel SEAMAP Groundfish Survey (fall survey) model: **A.** the Chi-Square residuals by year, **B.** the Chi-Square residuals by area, **C.** the Chi-Square residuals by depth zone and **D.** the Chi-Square residuals by time of day.



Figure 16. Diagnostic plots for lognormal component of the Spanish mackerel SEAMAP Groundfish Survey (fall survey) model: **A.** the frequency distribution of log(CPUE) on positive stations and **B.** the cumulative normalized residuals (QQ plot).



Figure 17. Diagnostic plots for binomial component of the Spanish mackerel SEAMAP Groundfish Survey (fall survey) model: **A.** the Chi-Square residuals by year, **B.** the Chi-Square residuals by area, **C.** the Chi-Square residuals by depth zone and **D.** the Chi-Square residuals by time of day.

Appendix:

Annual Effort and Catch

Appendix Figure 1. Annual survey effort and catch of Spanish mackerel from the SEAMAP groundfish survey during the summer and fall of 1987-2010.







SEDAR28-DW03

Addendum to SEDAR28-DW03

SEDAR28-DW03

Spanish Mackerel

During the Data Workshop, concerns were raised the lack of the index for Gulf of Mexico Spanish mackerel from the SEAMAP survey through the terminal year of 2011. As stated in the main body of this document, not all data was ready for distribution at the time of the meeting. Since all the federal data was present through 2011 and the majority of the early surveys were completed on the federal vessels, we were asked to produce an index using only the federal data. Some caution may be required when examining the resulting index because during the 2008 survey year, the states took on additional sampling responsibilities in order to expand the sampling universe to include the waters off of Florida. Station distribution maps illustrate what the survey looks like under the new design if you leave out the state data (Addendum Figure 1).

The nominal CPUE and number of stations with a positive catch are presented in Addendum Figures 2, which indicated annual variation in nominal CPUE, with varying proportion of positive catches over the years. For the federal data only model, year, area, depth zone, time of day and season were retained in the binomial submodel. The variables retained in the lognormal submodel were year, depth zone, time of day and season. Addendum Table 1 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 48957.6 and 1826.3, respectively. The AIC for the both submodels increased slightly as variables were removed, however, due to the p-values, it was determined that the slight increase was acceptable. The diagnostic plots for the binomial and lognormal submodels are shown in Addendum Figures 3-5, and indicated the distribution of the residuals is approximately normal. Annual abundance indices are presented in Addendum Table 2.

Based upon the stations sampled in 2011, the dip in the index (Addendum Figure 6) might not necessarily be indicative of a population drop, or just for lack of stations from the complete survey design. We caution using this index, especially under the new survey design since the states make up a larger portion of the survey (2009: 645 vs. 506 total stations; 2010: 389 vs. 286 total stations). A significant about of data is lost east of the Mississippi River, since MS and AL sample about 60 stations a year. It is also important to note that the majority of the state stations are the shallower stations that get included in the analysis due to the depth distribution of Spanish mackerel.

<u>Cobia</u>

The indices group requested an attempt at the development of abundance indices of cobia using the zeroinflated delta-lognormal method of Ingram et al. (2010). Results of that model run are present in Addendum Table 3 and Addendum Figures 7 and 8. Ultimately, the index was deemed unusable due to the low number of cobia collected each year during groundfish surveys.

Literature Cited

Ingram, G.W., Jr., W.J. Richards, J.T. Lamkin and B. Muhling. 2010. Annual indices of Atlantic bluefin tuna (Thunnus thynnus) larvae in the Gulf of Mexico developed using delta-lognormal and multivariate models. *Aquatic Living Resources*. 23(1):35-47.

Model Run #1	Binomial Submodel Type 3 Tests (AIC 48953.5)					Lognormal Submodel Type 3 Tests (AIC 1825.5)				
Effect	Num DF	Den DF	Chi- Square	F Value	Pr > ChiSq	Pr > F	Num DF	Den DF	F Value	Pr > F
Year	24	2810	62.16	2.58	<.0001	<.0001	24	583	2.77	<.0001
Area	2	4752	13.89	6.95	0.0010	0.0010	2	583	2.76	0.0638
Depth Zone	18	6312	247.03	13.72	<.0001	<.0001	18	583	7.21	<.0001
Time of Day	1	6395	125.59	125.59	<.0001	<.0001	1	583	36.58	<.0001
Season	1	5898	151.86	151.86	<.0001	<.0001	1	583	7.11	0.0079
Survey	1	432	3.07	3.07	0.0798	0.0805	1	583	0.05	0.8316
Model Run #2	Binomial Submodel Type 3 Tests (AIC 48957.6)					Lognormal Submodel Type 3 Tests (AIC 1826.2)				
Effect	Num DF	Den DF	Chi- Square	F Value	Pr > ChiSq	Pr > F	Num DF	Den DF	F Value	Pr > F
Year	24	2794	64.73	2.68	<.0001	<.0001	24	584	3.19	<.0001
Area	2	4744	13.46	6.73	0.0012	0.0012	2	584	2.77	0.0633
Depth Zone	18	6299	247.55	13.75	<.0001	<.0001	18	584	7.22	<.0001
Time of Day	1	6375	124.97	124.97	<.0001	<.0001	1	584	36.74	<.0001
Season	1	6192	150.85	150.85	<.0001	<.0001	1	584	7.07	0.0080
Survey	dropped					dropped				
Model Run #3	Binomial Submodel Type 3 Tests (AIC 48957.6)					Lognormal Submodel Type 3 Tests (1826.3)				
Effect	Num DF	Den DF	Chi- Square	F Value	Pr > ChiSq	Pr > F	Num DF	Den DF	F Value	Pr > F
Year	24	2794	64.73	2.68	<.0001	<.0001	24	586	3.02	<.0001
Area	2	4744	13.46	6.73	0.0012	0.0012		dropped		
Depth Zone	18	6299	247.55	13.75	<.0001	<.0001	18	586	7.40	<.0001
Time of Day	1	6375	124.97	124.97	<.0001	<.0001	1	586	35.53	<.0001
Season	1	6192	150.85	150.85	<.0001	<.0001	1	586	7.24	0.0073
Survey	dropped					dropped				

Addendum Table 1. Summary of backward selection procedure for building delta-lognormal submodels for Spanish mackerel federal data only index of relative abundance from 1987 to 2010.

Addendum Table 2. Indices of Spanish mackerel developed using the delta-lognormal model for 1987-2011. 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.

SurveyYear	Nominal Frequency	Ν	LoIndex	ScaledLoIndex	CV	LCL	UCL
1987	0.02632	304	0.11394	0.33644	0.80738	0.08158	1.38761
1988	0.09153	295	0.41440	1.22368	0.31215	0.66499	2.25173
1989	0.09333	300	0.54253	1.60204	0.29993	0.89073	2.88138
1990	0.09118	340	0.41034	1.21170	0.28382	0.69443	2.11426
1991	0.07407	324	0.24360	0.71933	0.35316	0.36237	1.42794
1992	0.07419	310	0.20560	0.60713	0.31848	0.32607	1.13045
1993	0.09855	345	0.46782	1.38144	0.26542	0.81979	2.32787
1994	0.05780	346	0.23494	0.69375	0.44503	0.29647	1.62341
1995	0.09006	322	0.38846	1.14710	0.30000	0.63771	2.06340
1996	0.06646	316	0.24417	0.72102	0.37025	0.35207	1.47663
1997	0.05034	298	0.09165	0.27063	0.54715	0.09725	0.75313
1998	0.06040	298	0.17914	0.52898	0.38035	0.25361	1.10333
1999	0.06329	316	0.26530	0.78341	0.37615	0.37845	1.62168
2000	0.09585	313	0.46291	1.36694	0.37098	0.66658	2.80314
2001	0.06923	260	0.29871	0.88206	0.41513	0.39733	1.95814
2002	0.03416	322	0.12694	0.37485	0.61055	0.12160	1.15549
2003	0.08777	319	0.53389	1.57653	0.28052	0.90917	2.73377
2004	0.07797	295	0.16363	0.48318	0.31052	0.26337	0.88641
2005	0.13947	337	0.83409	2.46301	0.26108	1.47375	4.11630
2006	0.09259	324	0.28550	0.84306	0.32510	0.44724	1.58920
2007	0.12587	286	0.55241	1.63122	0.31521	0.88141	3.01887
2008	0.05316	395	0.32744	0.96689	0.39637	0.45037	2.07576
2009	0.10870	506	0.44728	1.32079	0.18544	0.91437	1.90785
2010	0.09091	286	0.58607	1.73062	0.28306	0.99326	3.01536
2011	0.03252	246	0.04545	0.13422	0.51406	0.05096	0.35353

Addendum Table 3. Indices of cobia developed using the zero-inflated delta-lognormal model for 1987-2011. The nominal frequency of occurrence, the number of samples (*N*), the ZIDL Index (number per trawl-hour), the ZIDL 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	Nominal Frequency	Ν	Index	Scaled_Index	Scaled_Nominal	CV	LCL	UCL
1987	0.01724	116	0.04507	0.38953	0.24074	0.87708	0.08599	1.76453
1988	0		0	0	0			
1989	0.02158	139	0.03627	0.31352	0.27179	0.71563	0.08664	1.13452
1990	0.03378	148	0.10494	0.90708	1.62447	0.56133	0.31846	2.58364
1991	0.02857	140	0.05787	0.50024	0.43699	0.62916	0.15761	1.58776
1992	0.04380	137	0.10986	0.94959	1.12444	0.51284	0.36126	2.49602
1993	0.09697	165	0.26910	2.32595	2.63955	0.31458	1.25830	4.29951
1994	0.08966	145	0.14044	1.21389	1.13015	0.35055	0.61444	2.39817
1995	0.05036	139	0.09468	0.81836	0.56318	0.47622	0.33133	2.02131
1996	0.07857	140	0.23139	2.00003	1.57674	0.37939	0.96055	4.16442
1997	0.10072	139	0.35074	3.03168	3.66417	0.33497	1.57917	5.82022
1998	0.01370	146	0.02346	0.20279	0.19078	0.87946	0.04463	0.92152
1999	0.08392	143	0.14889	1.28698	1.03974	0.36422	0.63535	2.60692
2000	0.00699	143	0.00508	0.04387	0.05543	1.20879	0.00657	0.29274
2001	0.10156	128	0.23665	2.04554	1.69754	0.34639	1.04332	4.01049
2002	0.04196	143	0.10369	0.89624	0.81252	0.51212	0.34138	2.35294
2003	0.03681	163	0.09970	0.86176	1.08391	0.51213	0.32824	2.26247
2004	0.07031	128	0.10428	0.90131	0.91148	0.41752	0.40428	2.00939
2005	0.05594	143	0.08650	0.74766	0.84892	0.44696	0.31843	1.75546
2006	0.06207	145	0.14883	1.28644	1.06249	0.42076	0.57373	2.88450
2007	0.02963	135	0.06583	0.56898	0.54014	0.62426	0.18064	1.79214
2008	0.01843	217	0.04907	0.42410	0.40003	0.62668	0.13414	1.34087
2009	0.01339	224	0.03502	0.30266	0.25858	0.72172	0.08289	1.10508
2010	0.04286	140	0.11359	0.98180	0.82621	0.31029	0.53540	1.80041



Addendum Figure 1. Comparison between annual survey effort and catch of Spanish mackerel from the SEAMAP groundfish survey (all vessels and federal vessel (US) only) during the summer and fall of 2009-2011. Note that not all state data was available for 2011, thus only the federal survey effort is presented.



Addendum Figure 2. Annual trends for Spanish mackerel captured during Summer and Fall SEAMAP Groundfish Surveys (federal vessels only) from 1987 to 2011 in **A.** nominal CPUE and **B.** proportion of positive stations.



Addendum Figure 3. Diagnostic plots for binomial component of the Spanish mackerel SEAMAP Groundfish Survey (full model, summer and fall) model: **A.** the Chi-Square residuals by year, **B.** the Chi-Square residuals by area, **C.** the Chi-Square residuals by depth zone, **D.** the Chi-Square residuals by time of day and **E.** the Chi-Square residuals by season.



Addendum Figure 4. Diagnostic plots for lognormal component of the Spanish mackerel SEAMAP Groundfish Survey (full model, summer and fall) model: **A.** the frequency distribution of log(CPUE) on positive stations and **B.** the cumulative normalized residuals (QQ plot).



Addendum Figure 5. Diagnostic plots for lognormal component of the Spanish mackerel SEAMAP Groundfish Survey (full model, summer and fall) model: **A.** the Chi-Square residuals by year, **B.** the Chi-Square residuals by area, **C.** the Chi-Square residuals by depth zone and **D**. the Chi-Square residuals by time of day



Spanish Mackerel Gulf of Mexico SEAMAP 1987 to 2011 Observed and Standardized CPUE (95% Cl)

Addendum Figure 6. Annual index of abundance for Spanish mackerel from SEAMAP groundfish survey (federal vessels only) from 1987 – 2011.



Addendum Figure 7. Cumulative normalized residuals (QQ plot) plot for zero-inflated delta lognormal index of cobia captured during SEAMAP Groundfish Survey.



Zero-inflated delta-lognormal for U.S. Gulf Groundfish Cobia 1987 to 2010 Run 1 020 Observed and Standardized CPUE (95% CI)

Addendum Figure 8. Annual index of abundance for cobia from SEAMAP groundfish survey from 1987 -2010.