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

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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, $\beta$ is the parameter vector for main effects, and ε is a vector of independent normally distributed errors with expectation zero and variance $\sigma^2$. 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) $$V(I_y) \approx V(c_y)p_y^2 + c_y^2 V(p_y) + 2c_y p_y \mathrm{Cov}(c, p),$$

where:

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

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 submodel was the lowest of all the model runs. The diagnostic plots for the binomial and 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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Table 1. Number of stations sampled by shrimp statistical zone during the Summer (top) and Fall (bottom) SEAMAP groundfish survey from 1987-2010.

| | Shrimp Statistical 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 | | | | | | | | | 46 | 12 | 24 | 13 | 23 | 22 | 24 | 18 | 23 | 26 | *231* |
| 1992 | | | | | | | | 1 | 45 | 2 | 20 | 24 | 20 | 25 | 12 | 31 | 26 | 20 | *226* |
| 1993 | | | | | | | | | 45 | 10 | 19 | 17 | 24 | 19 | 14 | 29 | 24 | 22 | *223* |
| 1994 | | | | | | | | | 61 | 6 | 17 | 22 | 25 | 17 | 20 | 22 | 26 | 22 | *238* |
| 1995 | | | | | | | | | 44 | 10 | 16 | 18 | 22 | 23 | 13 | 27 | 26 | 21 | *220* |
| 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 | 31 | 24 | 17 | 24 | 10 | 12 | 14 | 15 | 22 | 5 | 20 | 16 | 21 | 33 | 34 | 27 | 27 | 19 | *371* |
| Total | *31* | *50* | *42* | *64* | *31* | *39* | *40* | *124* | *1082* | *200* | *376* | *422* | *517* | *515* | *411* | *585* | *645* | *531* | *5705* |

| | Shrimp Statistical Zone | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | Total |
| 1987 | | | | | | | | 16 | 28 | 15 | 14 | 16 | 17 | 15 | 15 | 15 | 18 | 3 | *172* |
| 1988 | | | | | | | | 8 | 28 | 7 | 22 | 17 | 18 | 26 | 19 | 21 | 31 | 20 | *217* |
| 1989 | | | | | | | | | 43 | 12 | 19 | 17 | 22 | 20 | 17 | 22 | 25 | 26 | *223* |
| 1990 | | | | | | | | | 52 | 14 | 12 | 23 | 22 | 19 | 18 | 22 | 19 | 27 | *228* |
| 1991 | | | | | | | | | 47 | 6 | 24 | 14 | 20 | 25 | 24 | 19 | 25 | 22 | *226* |
| 1992 | | | | | | | | | 33 | 7 | 23 | 14 | 25 | 18 | 17 | 27 | 30 | 18 | *212* |
| 1993 | | | | | | | | | 72 | 10 | 19 | 17 | 26 | 18 | 16 | 25 | 28 | 18 | *249* |
| 1994 | | | | | | | | | 50 | 9 | 16 | 21 | 25 | 20 | 21 | 23 | 24 | 20 | *229* |
| 1995 | | | | | | | | | 40 | 10 | 17 | 18 | 24 | 19 | 14 | 26 | 30 | 19 | *217* |
| 1996 | | | | | | | | | 45 | 9 | 18 | 19 | 17 | 28 | 13 | 25 | 29 | 24 | *227* |
| 1997 | | | | | | | | | 44 | 10 | 17 | 20 | 26 | 19 | 18 | 23 | 22 | 24 | *223* |
| 1998 | | | | | | | | | 44 | 10 | 22 | 14 | 34 | 11 | 15 | 24 | 29 | 22 | *225* |
| 1999 | | | | | | | | | 42 | 10 | 17 | 18 | 29 | 18 | 12 | 28 | 29 | 22 | *225* |
| 2000 | | | | | | | | | 43 | 10 | 14 | 22 | 20 | 26 | 12 | 30 | 25 | 21 | *223* |
| 2001 | | | | | | | | | 21 | 10 | 17 | 19 | 26 | 20 | 14 | 27 | 28 | 23 | *205* |
| 2002 | | | | | | | | 1 | 51 | 10 | 13 | 22 | 22 | 23 | 14 | 26 | 30 | 21 | *233* |
| 2003 | | | | | | | | 1 | 76 | 9 | 16 | 21 | 24 | 22 | 20 | 23 | 25 | 23 | *260* |
| 2004 | | | | | | | | | 43 | | 11 | 18 | 17 | 27 | 14 | 24 | 30 | 21 | *205* |
| 2005 | | | | | | | | | 44 | 11 | 20 | 16 | 33 | 18 | 14 | 23 | 24 | 27 | *230* |
| 2006 | | | | | | | | 1 | 47 | 7 | 22 | 14 | 18 | 28 | 13 | 23 | 32 | 19 | *224* |
| 2007 | | | | | | | | | 32 | 9 | 20 | 17 | 18 | 28 | 17 | 20 | 18 | 26 | *205* |
| 2008 | | | 15 | 14 | 4 | 4 | 3 | 4 | 36 | 18 | 28 | 34 | 42 | 46 | 44 | 19 | 36 | 20 | *367* |
| 2009 | | 20 | 21 | 25 | 10 | 21 | 13 | 12 | 49 | 12 | 23 | 23 | 31 | 49 | 48 | 31 | 36 | 24 | *448* |
| 2010 | | 9 | 10 | 11 | 18 | | | 14 | 16 | 7 | 15 | 18 | 26 | 31 | 29 | 18 | 19 | 14 | *255* |
| Total | | *29* | *46* | *50* | *32* | *25* | *16* | *57* | *1026* | *232* | *439* | *452* | *582* | *574* | *458* | *564* | *642* | *504* | *5728* |

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.

| Year | Depth Zone | | | | | | | | | | | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0506 | 0607 | 0708 | 0809 | 0910 | 1011 | 1112 | 1213 | 1314 | 1415 | 1516 | 1617 | 1718 | 1819 | 1920 | 2022 | 2225 | 2530 | 3035 | 3540 | 4045 | 4550 | 5060 | |
| 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 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | *2* |
| 2005 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | *3* |
| 2006 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | *2* |
| 2007 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | *2* |
| 2008 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | *3* |
| 2009 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | *3* |
| 2010 | 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 | *3* | *3* | *3* | *2* | *4* | *0* | *0* | *1* | *0* | *1* | *3* | *0* | *1* | *0* | *1* | *0* | *1* | *1* | *0* | *0* | *0* | *0* | *0* | *24* |

| Year | Depth Zone | | | | | | | | | | | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0506 | 0607 | 0708 | 0809 | 0910 | 1011 | 1112 | 1213 | 1314 | 1415 | 1516 | 1617 | 1718 | 1819 | 1920 | 2022 | 2225 | 2530 | 3035 | 3540 | 4045 | 4550 | 5060 | |
| 1987 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | *2* |
| 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 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | *5* |
| 1990 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | *7* |
| 1991 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | *5* |
| 1992 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | *6* |
| 1993 | 0 | 1 | 1 | 0 | 2 | 2 | 0 | 1 | 1 | 2 | 2 | 1 | 0 | 1 | 2 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | *19* |
| 1994 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 2 | 0 | 0 | 2 | 1 | 2 | 0 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | *14* |
| 1995 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | *9* |
| 1996 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 2 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | *11* |
| 1997 | 0 | 0 | 0 | 0 | 4 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | *14* |
| 1998 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | *4* |
| 1999 | 0 | 1 | 0 | 1 | 2 | 0 | 0 | 3 | 1 | 0 | 1 | 1 | 1 | 2 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | *15* |
| 2000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | *1* |
| 2001 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 3 | 0 | 1 | 2 | 1 | 0 | 0 | 0 | 0 | *14* |
| 2002 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | *6* |
| 2003 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | *8* |
| 2004 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 2 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | *11* |
| 2005 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | *10* |
| 2006 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 1 | 0 | 0 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | *9* |
| 2007 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | *5* |
| 2008 | 0 | 0 | 0 | 2 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | *8* |
| 2009 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | *3* |
| 2010 | | 1 | 0 | 3 | 1 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | *10* |
| Total | *2* | *6* | *6* | *9* | *17* | *14* | *10* | *14* | *11* | *11* | *11* | *9* | *14* | *12* | *11* | *10* | *10* | *11* | *4* | *0* | *1* | *3* | *0* | *196* |

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.

| Year | Depth Zone | | | | | | | | | | | | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0506 | 0607 | 0708 | 0809 | 0910 | 1011 | 1112 | 1213 | 1314 | 1415 | 1516 | 1617 | 1718 | 1819 | 1920 | 2022 | 2225 | 2530 | 3035 | 3540 | 4045 | 4550 | 5060 | |
| 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 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | *8* |
| 1989 | 3 | 1 | 1 | 0 | 2 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | *11* |
| 1990 | 2 | 3 | 1 | 2 | 1 | 2 | 1 | 3 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | *18* |
| 1991 | 3 | 1 | 2 | 0 | 1 | 0 | 1 | 2 | 2 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | *15* |
| 1992 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | *3* |
| 1993 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 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 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | *9* |
| 1996 | 1 | 1 | 2 | 0 | 0 | 2 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | *8* |
| 1997 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | *5* |
| 1998 | 2 | 2 | 0 | 2 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | *9* |
| 1999 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | *3* |
| 2000 | 1 | 1 | 1 | 3 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | *11* |
| 2001 | 0 | 1 | 0 | 1 | 2 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | *6* |
| 2002 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | *4* |
| 2003 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | *5* |
| 2004 | 2 | 1 | 0 | 0 | 0 | 1 | 2 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | *9* |
| 2005 | 4 | 2 | 0 | 0 | 1 | 2 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | *11* |
| 2006 | 1 | 3 | 3 | 2 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | *13* |
| 2007 | 2 | 3 | 0 | 1 | 1 | 0 | 0 | 2 | 1 | 1 | 1 | 1 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | *17* |
| 2008 | 2 | 3 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | *10* |
| 2009 | 0 | 0 | 1 | 0 | 1 | 1 | 5 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | *10* |
| 2010 | 0 | 0 | 3 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | *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* |

| Year | Depth Zone | | | | | | | | | | | | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0506 | 0607 | 0708 | 0809 | 0910 | 1011 | 1112 | 1213 | 1314 | 1415 | 1516 | 1617 | 1718 | 1819 | 1920 | 2022 | 2225 | 2530 | 3035 | 3540 | 4045 | 4550 | 5060 | |
| 1987 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | *5* |
| 1988 | 2 | 2 | 2 | 1 | 3 | 1 | 2 | 2 | 1 | 0 | 1 | 1 | 2 | 1 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | *23* |
| 1989 | 1 | 2 | 3 | 2 | 2 | 1 | 1 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | *17* |
| 1990 | 3 | 0 | 4 | 1 | 0 | 1 | 1 | 3 | 2 | 1 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | *19* |
| 1991 | 2 | 1 | 2 | 1 | 2 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | *14* |
| 1992 | 2 | 1 | 2 | 2 | 0 | 1 | 4 | 1 | 0 | 1 | 1 | 3 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | *22* |
| 1993 | 4 | 2 | 3 | 5 | 1 | 3 | 1 | 1 | 0 | 1 | 1 | 3 | 1 | 1 | 1 | 2 | 0 | 1 | 1 | 2 | 1 | 0 | 1 | *36* |
| 1994 | 2 | 3 | 1 | 0 | 0 | 1 | 0 | 1 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | *13* |
| 1995 | 3 | 2 | 0 | 1 | 1 | 1 | 0 | 2 | 1 | 2 | 0 | 0 | 2 | 2 | 0 | 1 | 2 | 2 | 1 | 0 | 0 | 0 | 0 | *23* |
| 1996 | 0 | 3 | 3 | 2 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | *15* |
| 1997 | 0 | 0 | 1 | 1 | 2 | 0 | 0 | 3 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | *14* |
| 1998 | 1 | 1 | 0 | 0 | 1 | 2 | 0 | 1 | 0 | 1 | 1 | 4 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | *16* |
| 1999 | 3 | 4 | 3 | 1 | 2 | 2 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | *20* |
| 2000 | 3 | 1 | 2 | 4 | 2 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | *19* |
| 2001 | 0 | 2 | 2 | 0 | 2 | 2 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | *12* |
| 2002 | 0 | 2 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | *7* |
| 2003 | 0 | 0 | 6 | 6 | 5 | 4 | 3 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | *25* |
| 2004 | 0 | 0 | 0 | 0 | 1 | 2 | 2 | 1 | 1 | 1 | 0 | 1 | 2 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | *15* |
| 2005 | 2 | 1 | 4 | 2 | 3 | 1 | 5 | 2 | 2 | 2 | 1 | 0 | 2 | 1 | 2 | 1 | 1 | 3 | 1 | 0 | 0 | 0 | 1 | *37* |
| 2006 | 2 | 2 | 1 | 2 | 1 | 3 | 1 | 2 | 0 | 2 | 1 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | *20* |
| 2007 | 0 | 2 | 2 | 1 | 2 | 4 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | *22* |
| 2008 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 3 | 0 | 0 | 2 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | *14* |
| 2009 | 0 | 2 | 4 | 1 | 7 | 9 | 5 | 5 | 3 | 3 | 4 | 1 | 3 | 1 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | *51* |
| 2010 | | 1 | 2 | 5 | 3 | 4 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | *22* |
| Total | *30* | *34* | *48* | *40* | *45* | *49* | *35* | *32* | *16* | *17* | *18* | *20* | *15* | *15* | *10* | *10* | *11* | *15* | *12* | *4* | *1* | *1* | *3* | *481* |

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.

| Survey Year | Number of Stations | Number Collected | Number Measured | Minimum Total Length (mm) | Maximum Total Length (mm) | Mean Total Length (mm) | Standard 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 of Years | Total Number of Stations | Total Number Collected | Total Number Measured | | | Overall Mean Total Length (mm) | |
| 24 | 11,433 | 330 | 296 | | | 405 | |

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

| Year | N | 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 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.

| Survey Year | Number of Stations | Number Collected | Number Measured | Minimum Total Length (mm) | Maximum Total Length (mm) | Mean Total Length (mm) | Standard 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 | Total Number of Stations | Total Number Collected | Total Number Measured | | | Overall Mean Total Length (mm) | |
| 24 | 9281 | 3223 | 2127 | | | 230 | |

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

| ***Model Run #1*** | *Binomial Submodel Type 3 Tests (AIC 56564.6)* | | | | | | *Lognormal Submodel Type 3 Tests (AIC 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*** | *Binomial Submodel Type 3 Tests (AIC 56581.5)* | | | | | | *Lognormal Submodel Type 3 Tests (AIC 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*** | *Binomial Submodel Type 3 Tests (AIC 56581.5)* | | | | | | *Lognormal Submodel Type 3 Tests (AIC 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 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 | *N* | 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 |

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

| ***Model Run #1*** | *Binomial Submodel Type 3 Tests (AIC 23424.2)* | | | | | | *Lognormal Submodel Type 3 Tests (AIC 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*** | *Binomial Submodel Type 3 Tests (AIC 23424.2)* | | | | | | *Lognormal Submodel Type 3 Tests (AIC 606.4)* | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| *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 | 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*** | *Binomial Submodel Type 3 Tests (AIC 23424.2)* | | | | | | *Lognormal Submodel Type 3 Tests (AIC 625.3)* | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| *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 | 179 | 1.48 | 0.0831 |
| *Area* | 2 | 2715 | 17.03 | 8.52 | 0.0002 | 0.0002 | | dropped | | |
| *Depth Zone* | 14 | 2721 | 97.92 | 6.99 | <.0001 | <.0001 | | dropped | | |
| *Time of Day* | 1 | 2760 | 4.83 | 4.83 | 0.0280 | 0.0280 | 1 | 179 | 3.34 | 0.0691 |

| ***Model Run #4*** | *Binomial Submodel Type 3 Tests (AIC 23424.2)* | | | | | | *Lognormal Submodel Type 3 Tests (AIC 627.0)* | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| *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 | 180 | 1.58 | 0.0526 |
| *Area* | 2 | 2715 | 17.03 | 8.52 | 0.0002 | 0.0002 | | dropped | | |
| *Depth Zone* | 14 | 2721 | 97.92 | 6.99 | <.0001 | <.0001 | | dropped | | |
| *Time of Day* | 1 | 2760 | 4.83 | 4.83 | 0.0280 | 0.0280 | | dropped | | |

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 | *N* | 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 |

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

| ***Model Run #1*** | *Binomial Submodel Type 3 Tests (AIC 27218.7)* | | | | | | *Lognormal Submodel Type 3 Tests (AIC 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 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 | *N* | 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 |

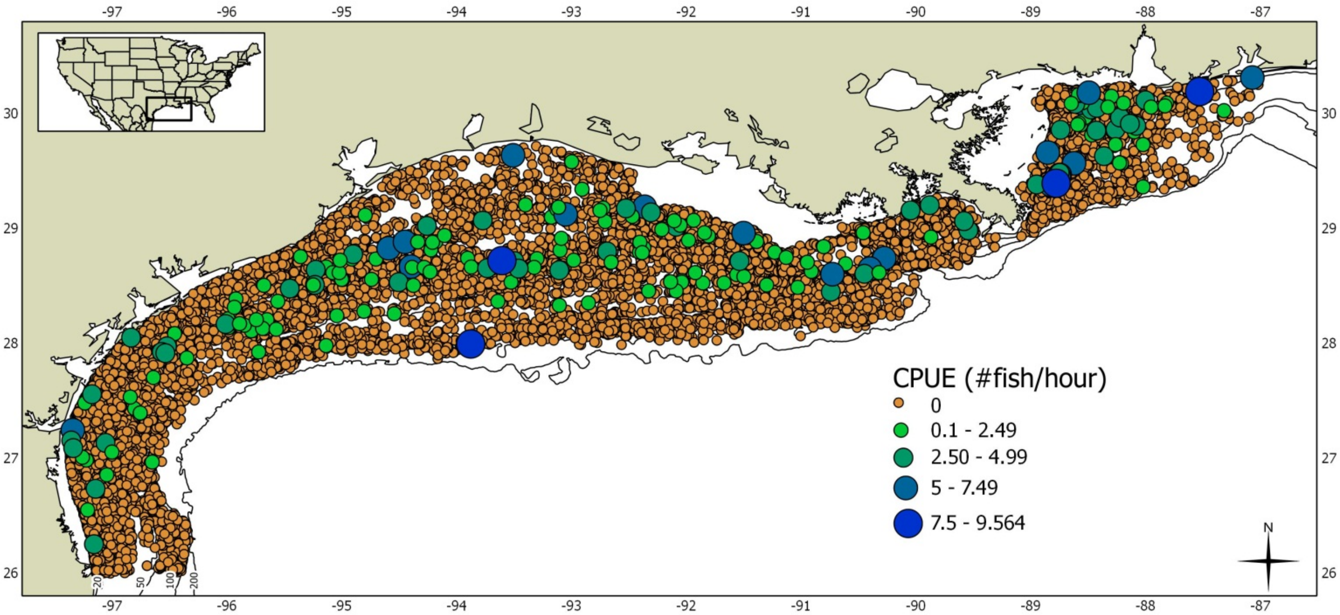



Figure 1. Stations sampled from 1987 to 2010 during the Summer and Fall SEAMAP Groundfish Survey with the CPUE for cobia.

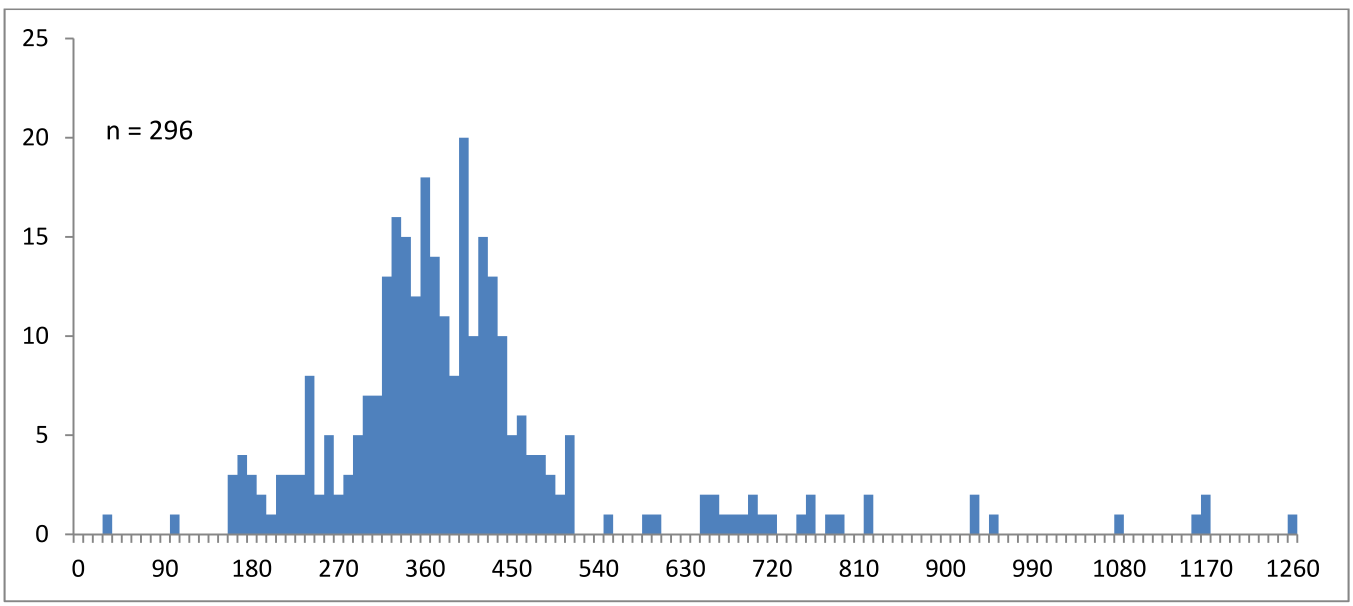



Figure 2. Length frequency distribution for cobia captured during the Summer and Fall SEAMAP Groundfish Survey from 1987 to 2010.

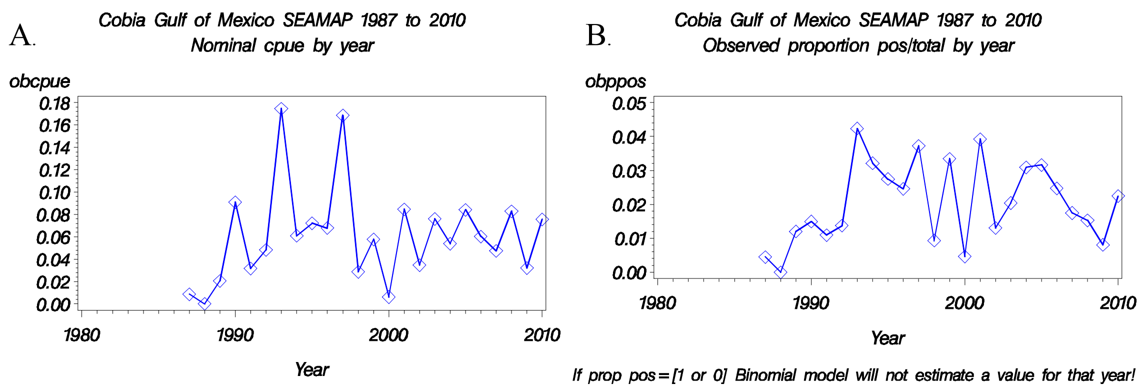



Figure 3. Annual trends for cobia captured during Summer and Fall SEAMAP Groundfish Surveys from 1987 to 2010 in **A.** nominal CPUE and **B.** proportion of positive stations.

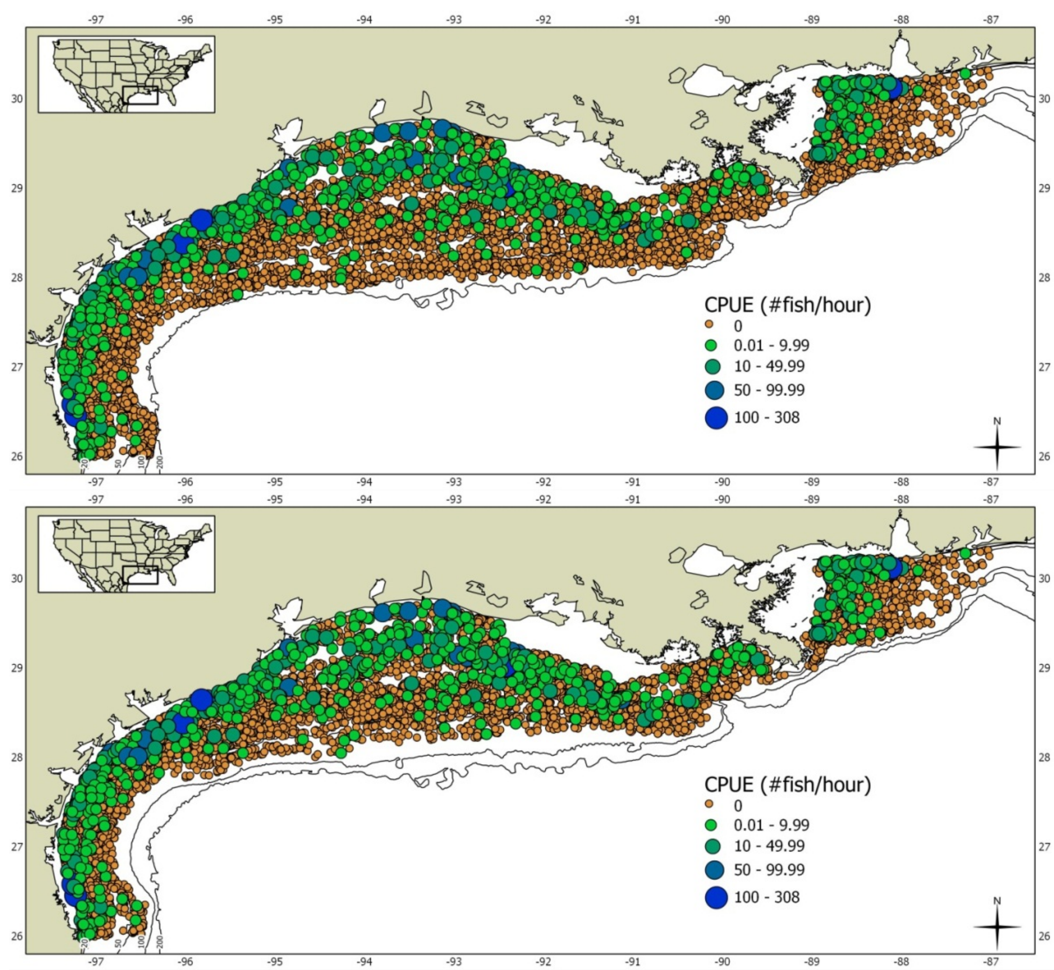
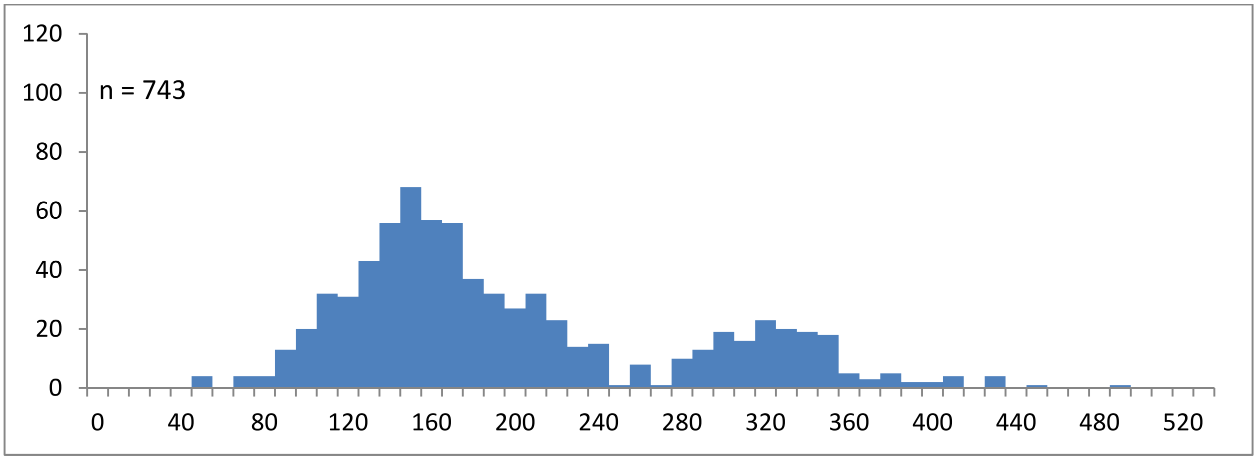



Figure 4. Stations sampled from 1987 to 2010 during the Summer and Fall SEAMAP Groundfish Survey with the CPUE for Spanish mackerel. Top figure has stations from all depth zones, bottom figure has only stations used for the analysis.



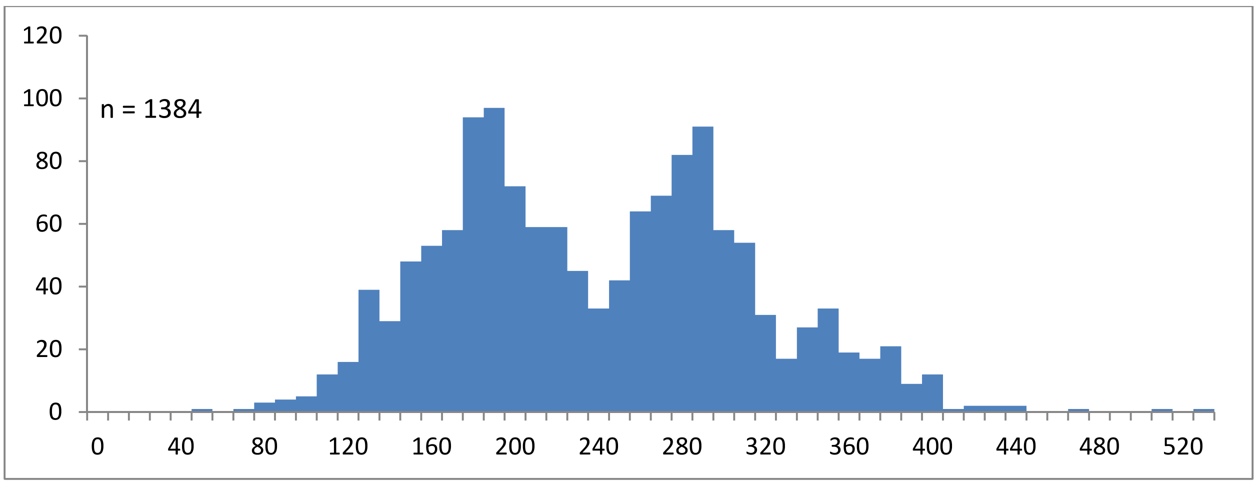




Figure 5. Length frequency distribution for Spanish mackerel caught during the Summer (top) and Fall (bottom) SEAMAP Groundfish Survey from 1987 to 2010.

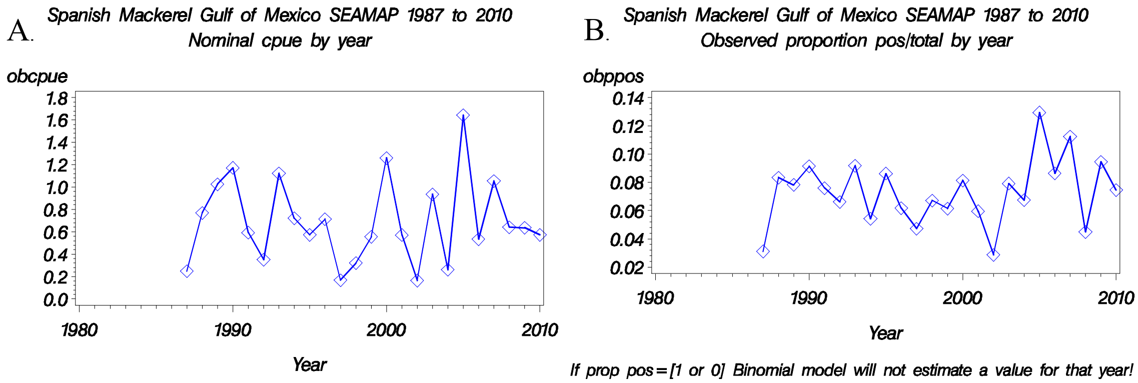



Figure 6. Annual trends for Spanish mackerel captured during Summer and Fall SEAMAP Groundfish Surveys from 1987 to 2010 in **A.** nominal CPUE and **B.** proportion of positive stations.

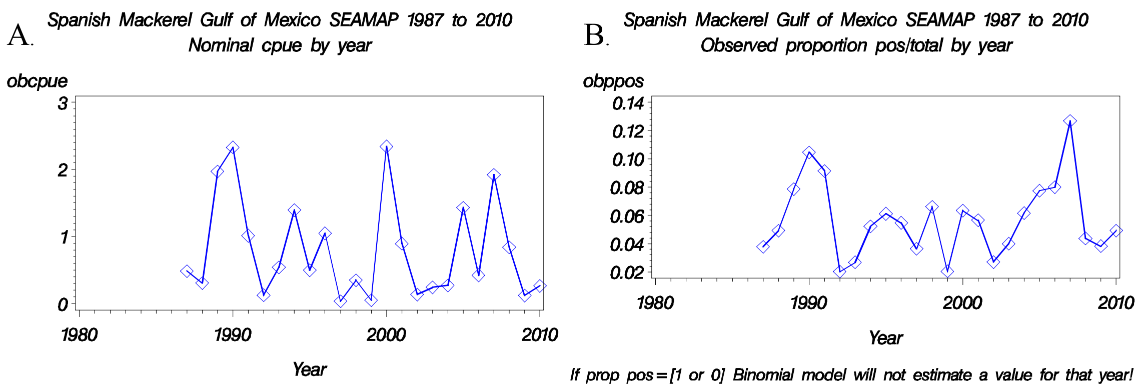



Figure 7. Annual trends for Spanish mackerel captured during the Summer SEAMAP Groundfish Surveys from 1987 to 2010 in **A.** nominal CPUE and **B.** proportion of positive stations.

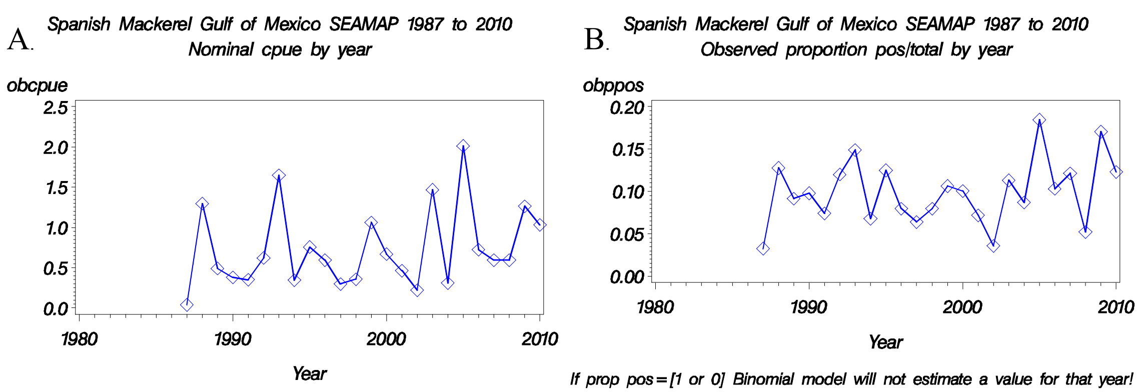



Figure 8. Annual trends for Spanish mackerel captured during the Fall SEAMAP Groundfish Surveys from 1987 to 2010 in **A.** nominal CPUE and **B.** proportion of positive stations.

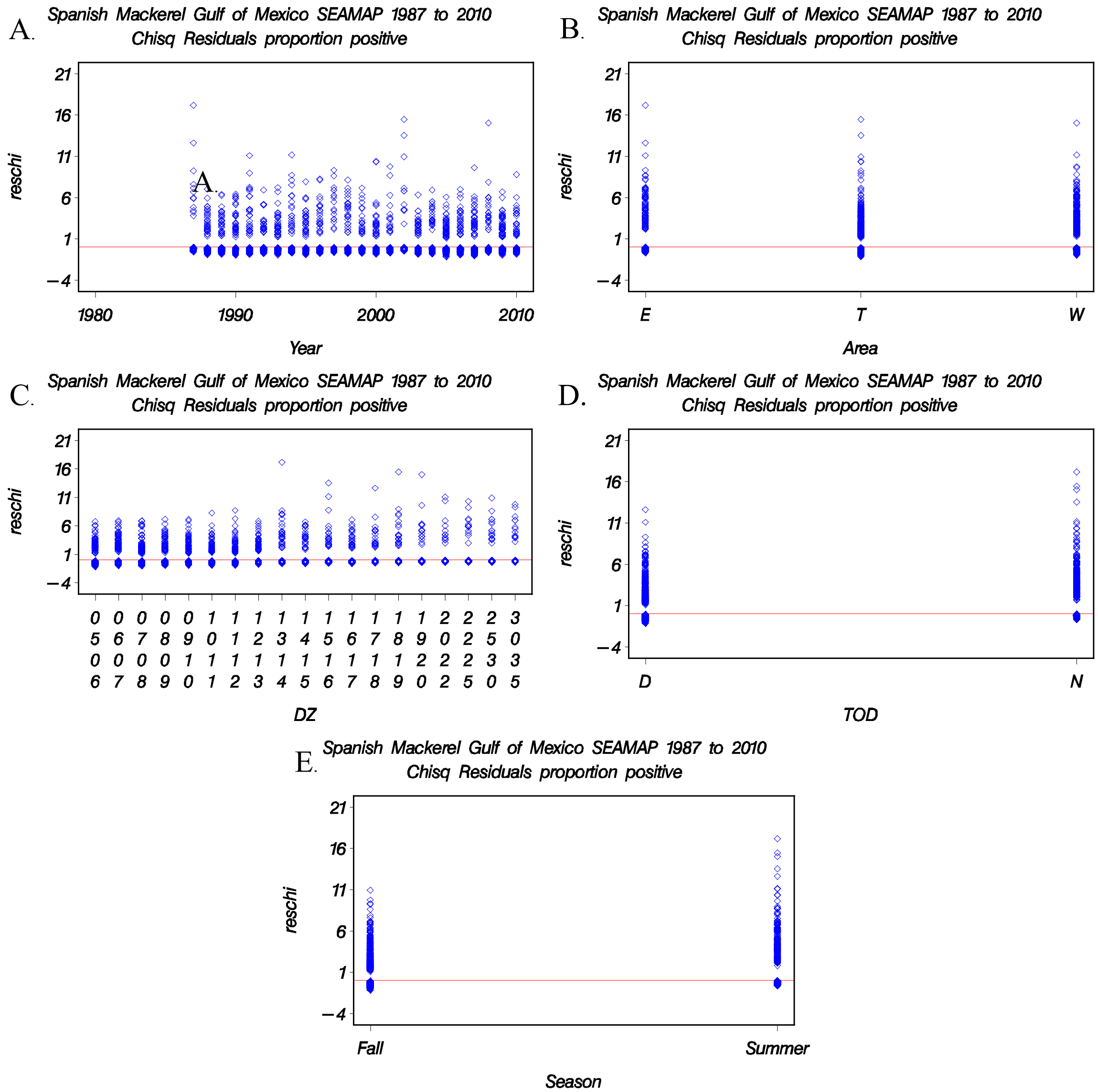



Figure 9. Diagnostic plots for binomial component of the Spanish mackerel SEAMAP Groundfish Survey (full model, summer and fall) model: **A.** the Chi-Square residuals by year, **B.** the Chi-Square residuals by area, **C.** the Chi-Square residuals by depth zone, **D.** the Chi-Square residuals by time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

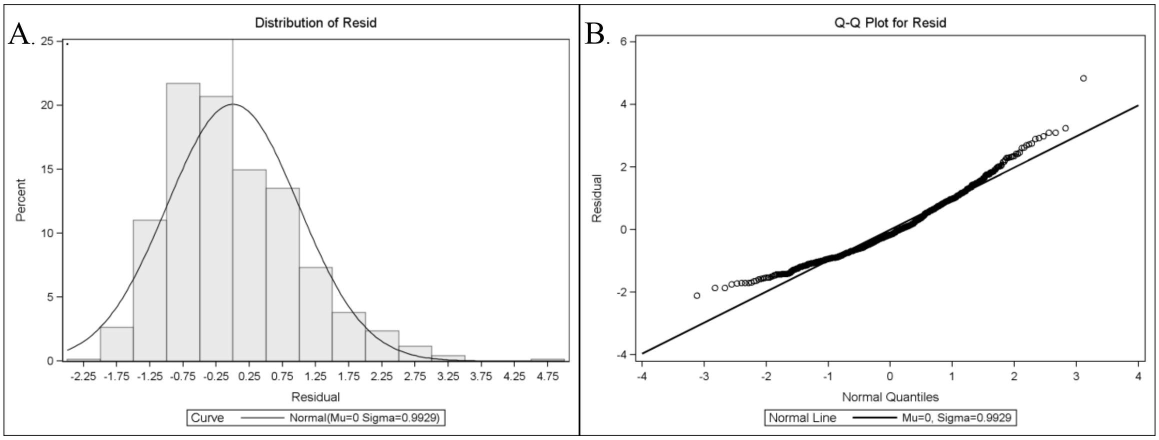



Figure 10. Diagnostic plots for lognormal component of the Spanish mackerel SEAMAP Groundfish Survey (full model, summer and fall) model: **A.** the frequency distribution of log(CPUE) on positive stations and **B.** the cumulative normalized residuals (QQ plot).

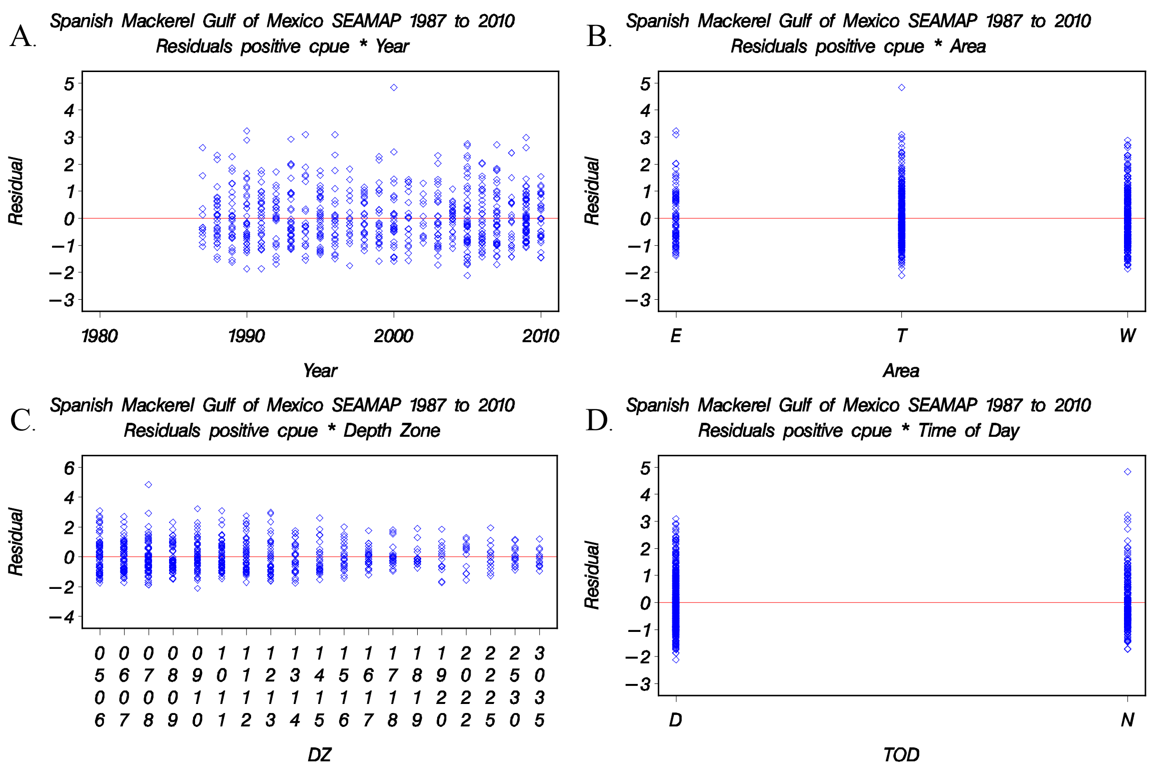



Figure 11. Diagnostic plots for lognormal component of the Spanish mackerel SEAMAP Groundfish Survey (full model, summer and fall) model: **A.** the Chi-Square residuals by year, **B.** the Chi-Square residuals by area, **C.** the Chi-Square residuals by depth zone and **D**. the Chi-Square residuals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

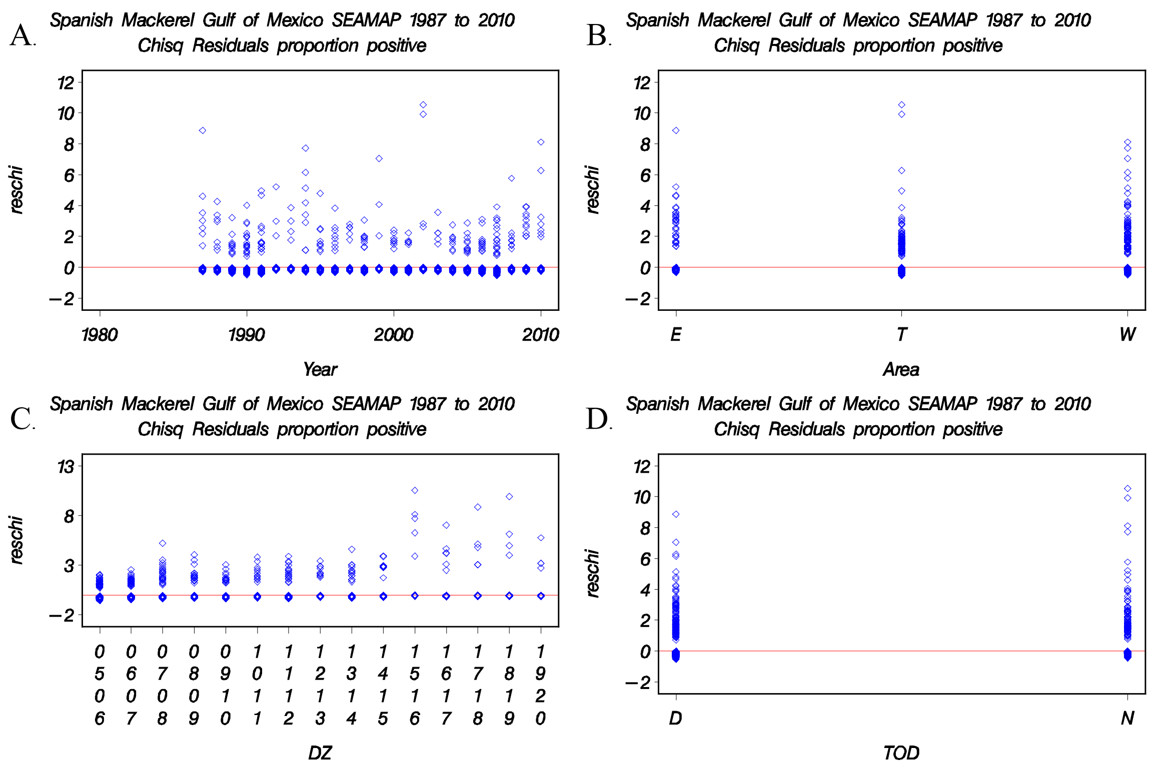



Figure 12. Diagnostic plots for binomial component of the Spanish mackerel SEAMAP Groundfish Survey (summer survey) model: **A.** the Chi-Square residuals by year, **B.** the Chi-Square residuals by area, **C.** the Chi-Square residuals by depth zone and **D.** the Chi-Square residuals by time of day.

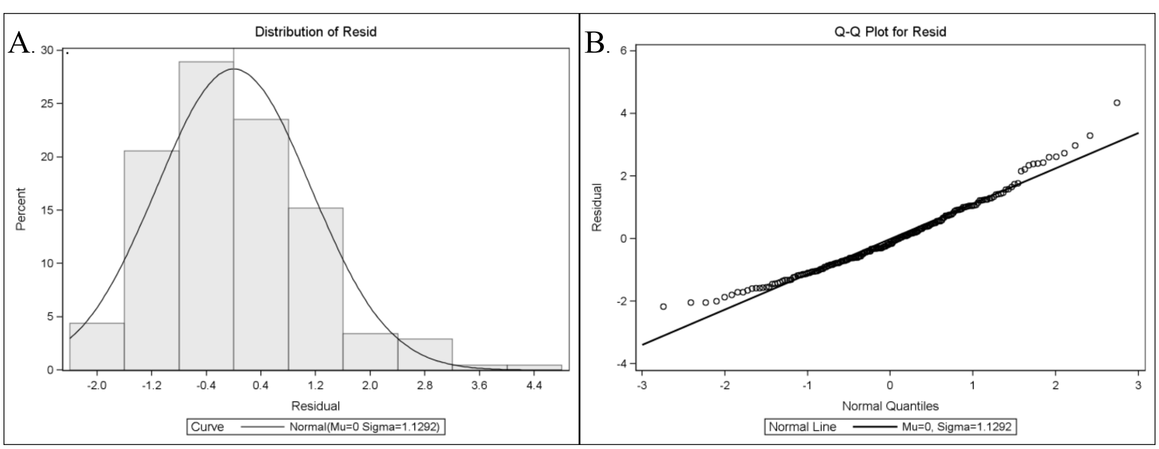



Figure 13. Diagnostic plots for lognormal component of the Spanish mackerel SEAMAP Groundfish Survey (summer survey) model: **A.** the frequency distribution of log(CPUE) on positive stations and **B.** the cumulative normalized residuals (QQ plot).

A.

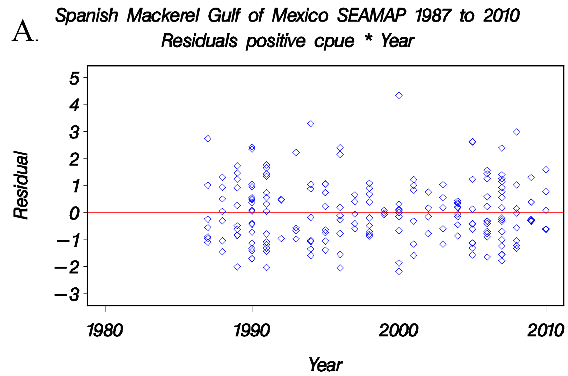



Figure 14. Diagnostic plot for binomial component of the Spanish mackerel SEAMAP Groundfish Survey (summer survey) model: the Chi-Square residuals by year.

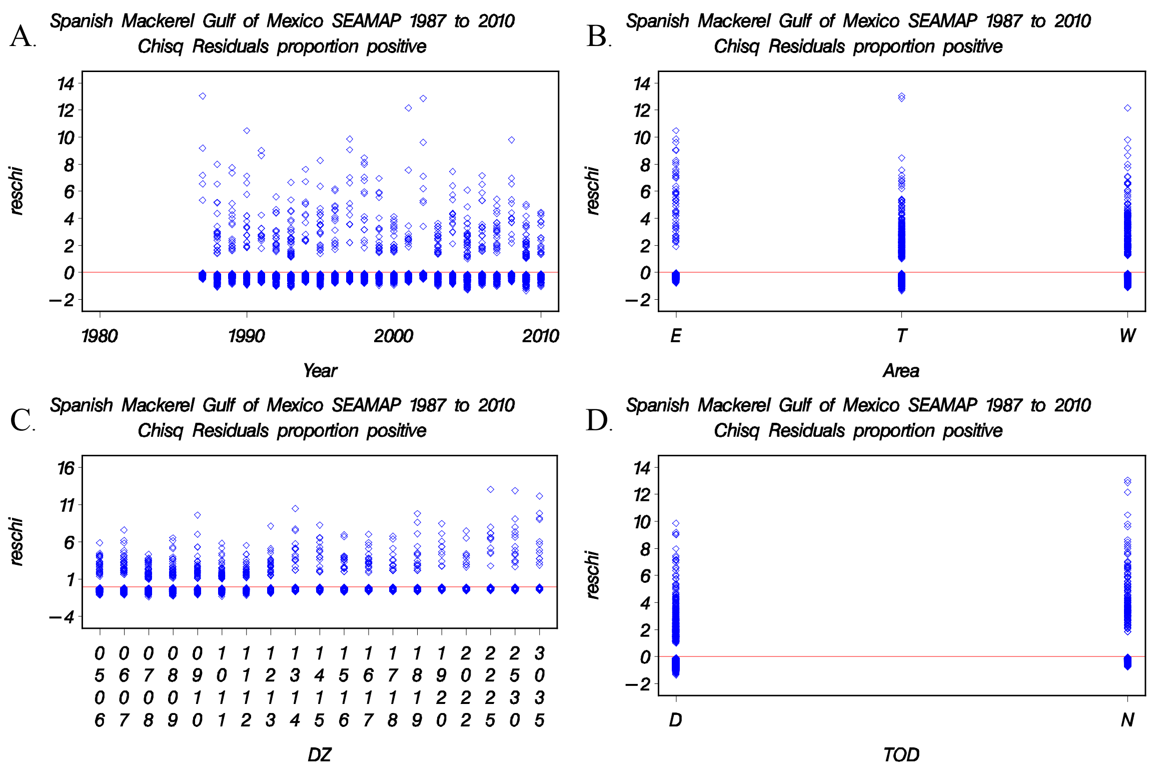



Figure 15. Diagnostic plots for binomial component of the Spanish mackerel SEAMAP Groundfish Survey (fall survey) model: **A.** the Chi-Square residuals by year, **B.** the Chi-Square residuals by area, **C.** the Chi-Square residuals by depth zone and **D.** the Chi-Square residuals by time of day.

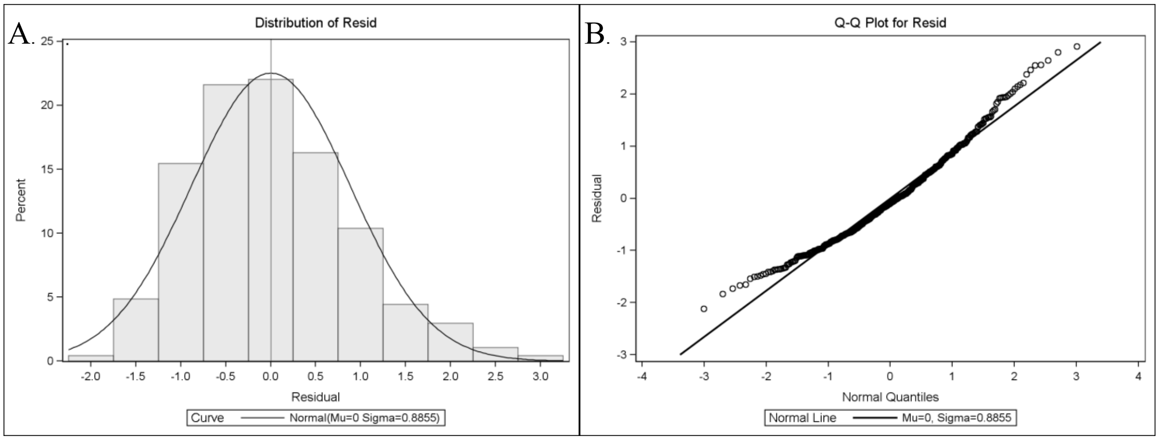



Figure 16. Diagnostic plots for lognormal component of the Spanish mackerel SEAMAP Groundfish Survey (fall survey) model: **A.** the frequency distribution of log(CPUE) on positive stations and **B.** the cumulative normalized residuals (QQ plot).

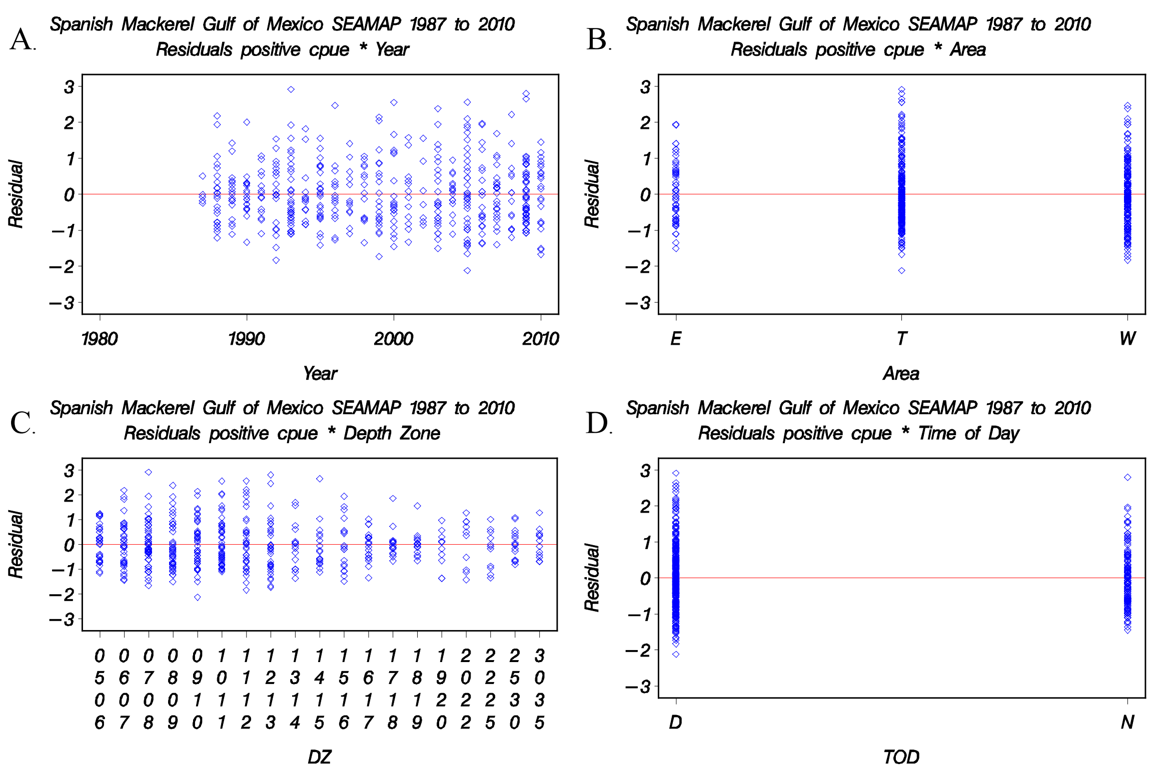
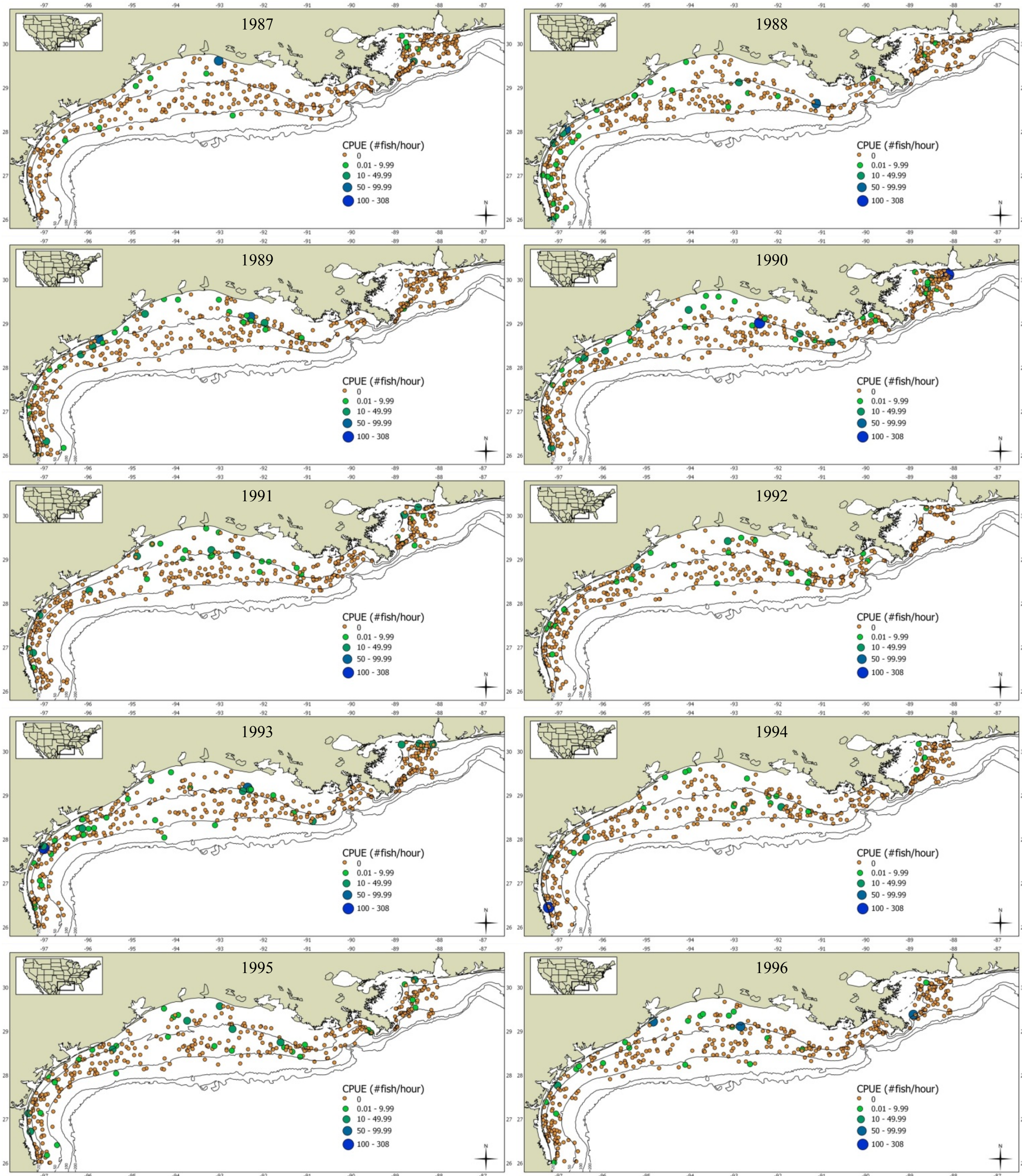


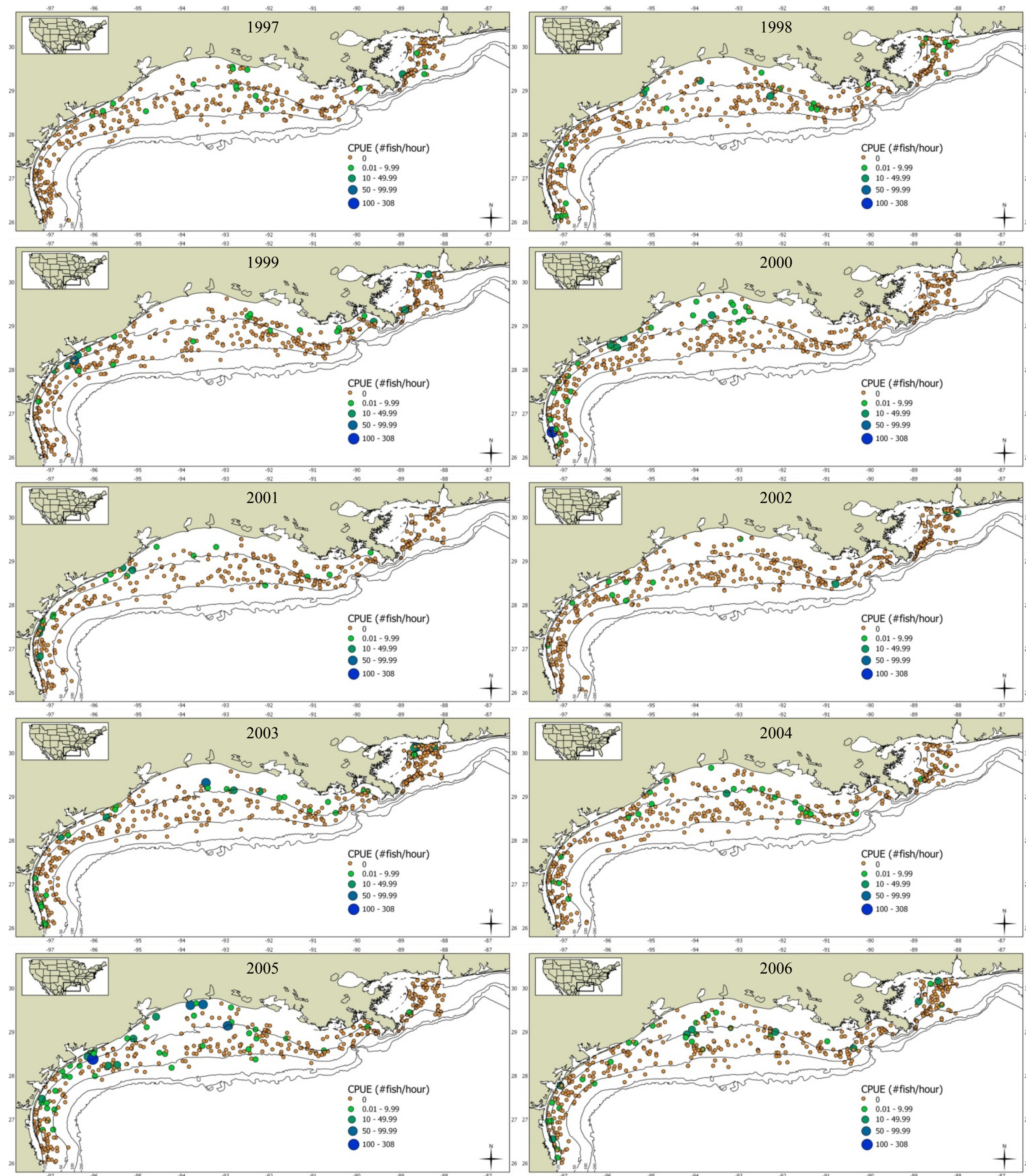

Figure 17. Diagnostic plots for binomial component of the Spanish mackerel SEAMAP Groundfish Survey (fall survey) model: **A.** the Chi-Square residuals by year, **B.** the Chi-Square residuals by area, **C.** the Chi-Square residuals by depth zone and **D.** the Chi-Square residuals by time of day.

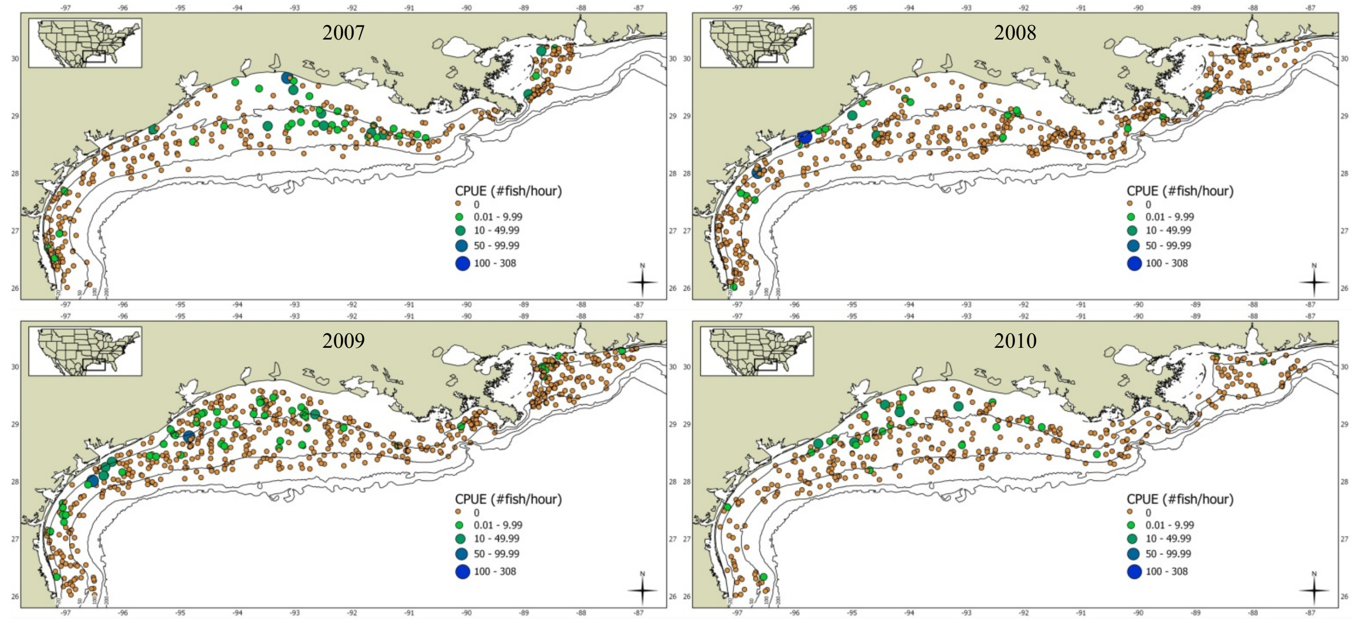
# Appendix:

# 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.




1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
CPUE (#fish/hour)
0
0.01 - 9.99
10 - 49.99
50 - 99.99
100 - 308


2007
2008
2009
2010
CPUE (#fish/hour)
0
0.01 - 9.99
10 - 49.99
50 - 99.99
100 - 308

# Addendum to 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.

## Cobia

The indices group requested an attempt at the development of abundance indices of cobia using the zero-inflated 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.

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.

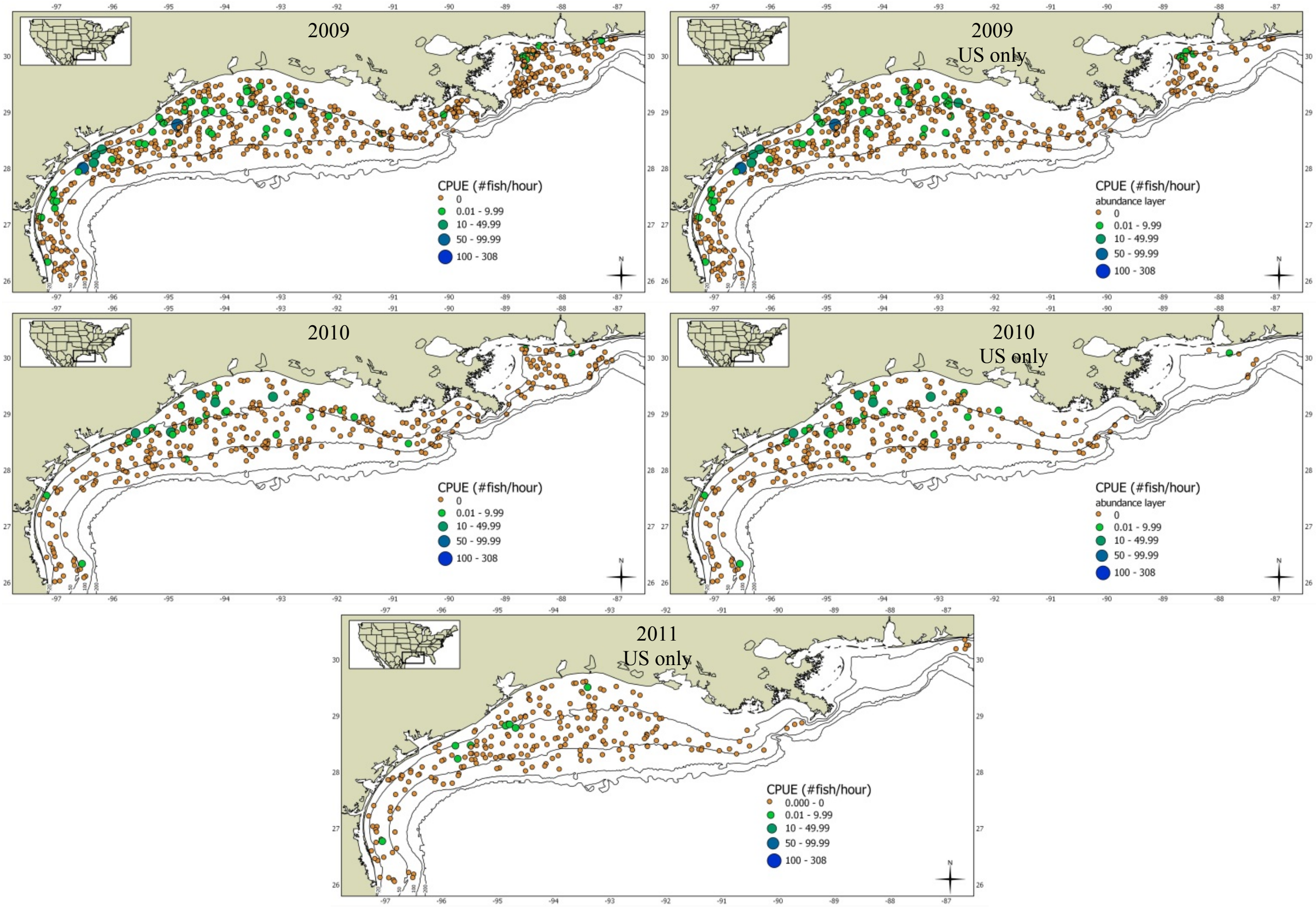
| ***Model Run #1*** | *Binomial Submodel Type 3 Tests (AIC 48953.5)* | | | | | | *Lognormal Submodel Type 3 Tests (AIC 1825.5)* | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| *Effect* | *Num DF* | *Den DF* | *Chi-Square* | *F Value* | *Pr > ChiSq* | *Pr > F* | *Num DF* | *Den DF* | *F Value* | *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 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.

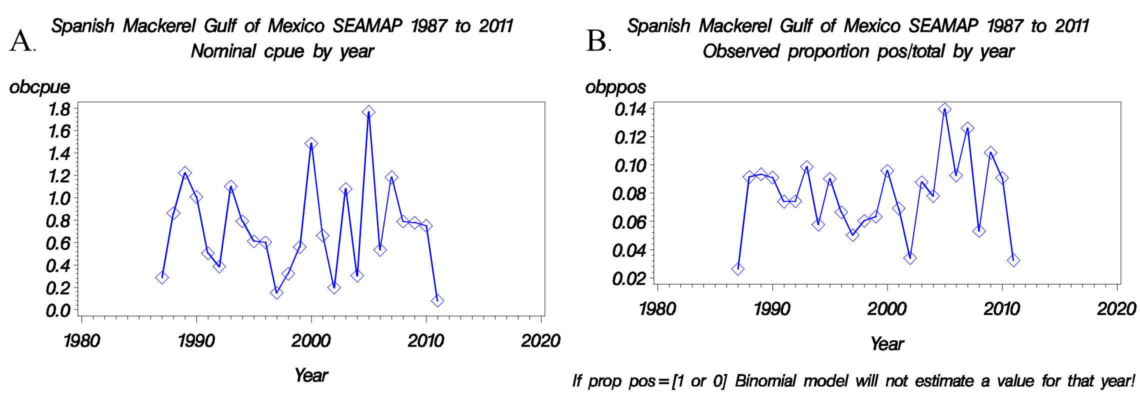
| *SurveyYear* | *NominalFrequency* | *N* | *LoIndex* | *ScaledLoIndex* | *CV* | *LCL* | *UCL* |
|---|---|---|---|---|---|---|---|
| 1987 | 0.02632 | 304 | 0.11394 | 0.33644 | 0.80738 | 0.08158 | 1.38761 |
| 1988 | 0.09153 | 295 | 0.41440 | 1.22368 | 0.31215 | 0.66499 | 2.25173 |
| 1989 | 0.09333 | 300 | 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.

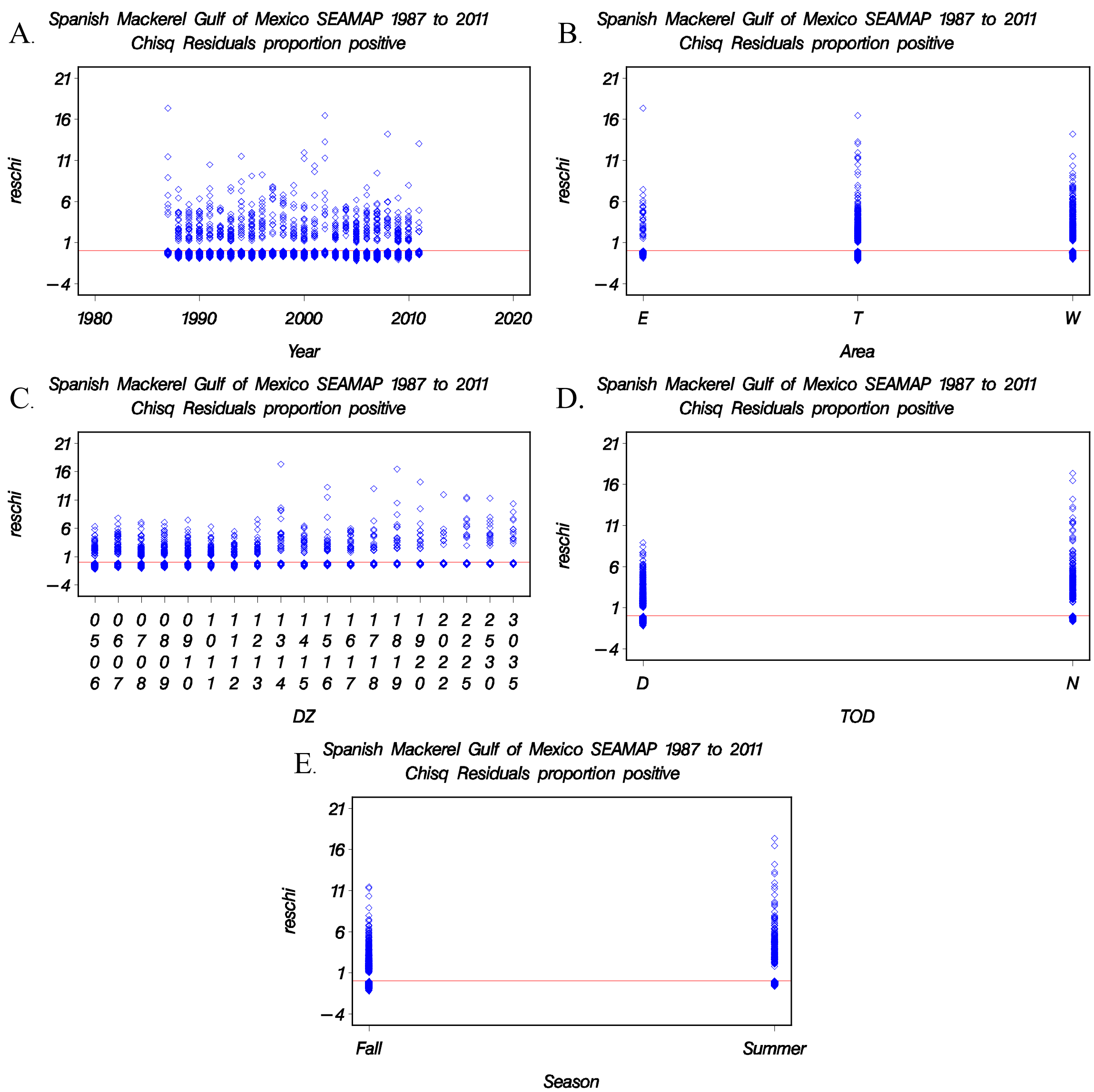
| *Survey Year* | *Nominal Frequency* | *N* | *Index* | *Scaled_Index* | *Scaled_Nominal* | *CV* | *LCL* | *UCL* |
|---|---|---|---|---|---|---|---|---|
| 1987 | 0.01724 | 116 | 0.04507 | 0.38953 | 0.24074 | 0.87708 | 0.08599 | 1.76453 |
| 1988 | 0 | . | 0 | 0 | 0 | . | . | . |
| 1989 | 0.02158 | 139 | 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 |



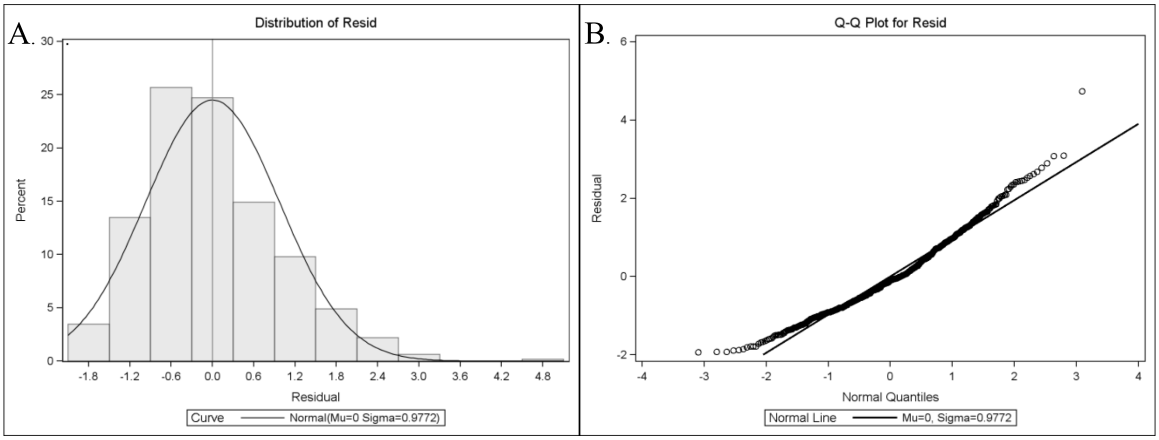

Addendum Figure 1. Comparison between annual survey effort and catch of Spanish mackerel from the SEAMAP groundfish survey (all vessels and federal vessel (US) only) during the summer and fall of 2009-2011. Note that not all state data was available for 2011, thus only the federal survey effort is presented.



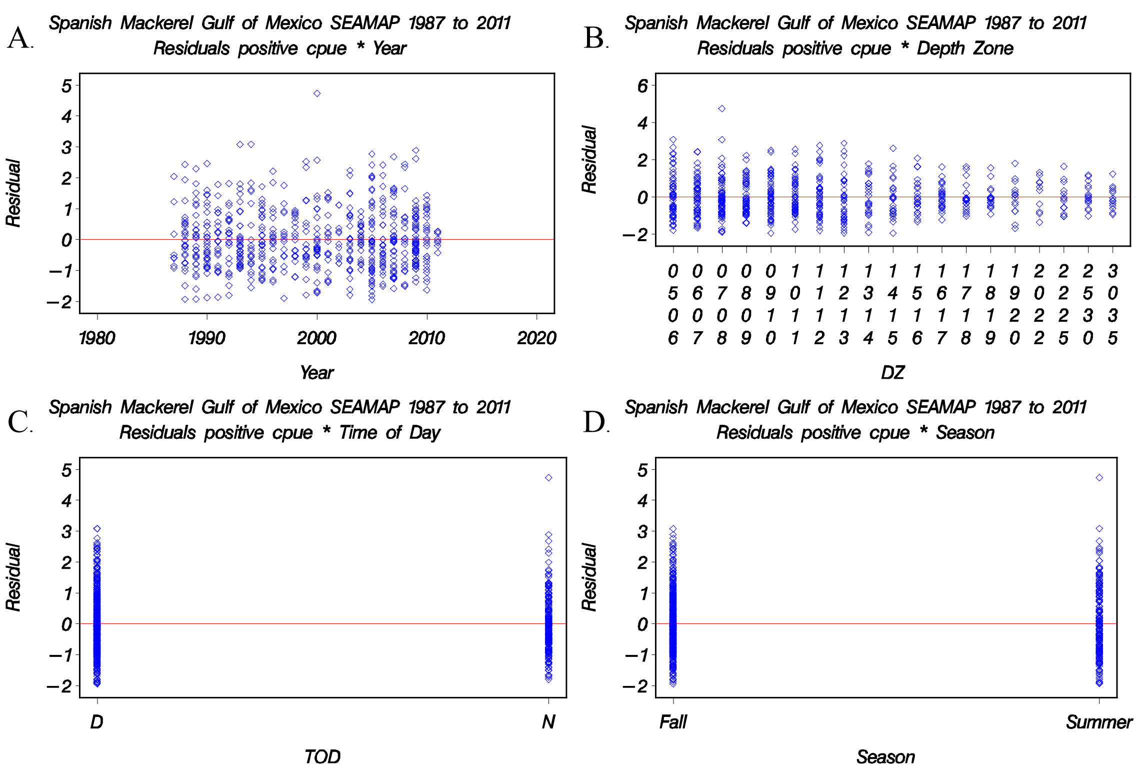

Addendum Figure 2. Annual trends for Spanish mackerel captured during Summer and Fall SEAMAP Groundfish Surveys (federal vessels only) from 1987 to 2011 in **A.** nominal CPUE and **B.** proportion of positive stations.



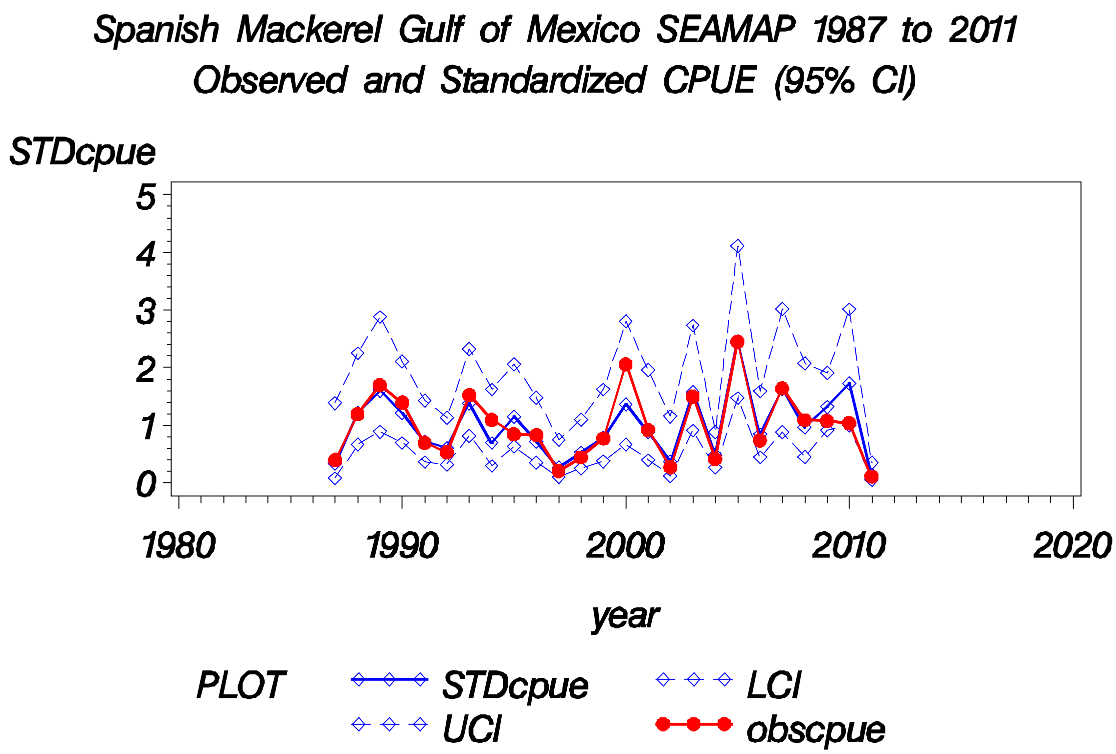

Addendum Figure 3. Diagnostic plots for binomial component of the Spanish mackerel SEAMAP Groundfish Survey (full model, summer and fall) model: **A.** the Chi-Square residuals by year, **B.** the Chi-Square residuals by area, **C.** the Chi-Square residuals by depth zone, **D.** the Chi-Square residuals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



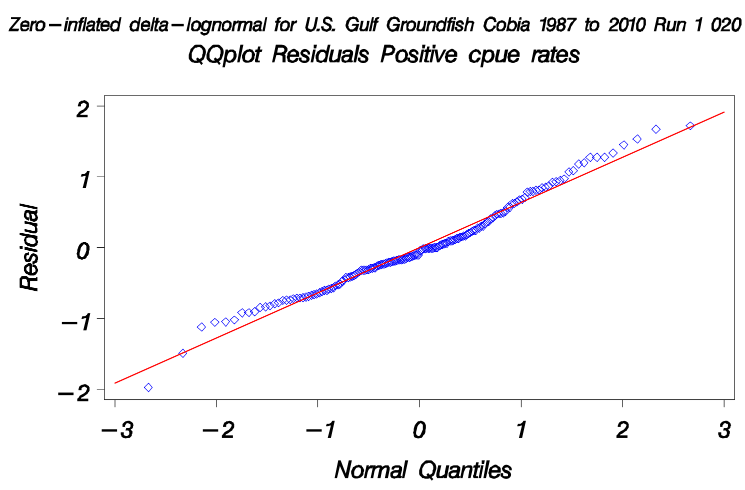

Addendum Figure 4. Diagnostic plots for lognormal component of the Spanish mackerel SEAMAP Groundfish Survey (full model, summer and fall) model: **A.** the frequency distribution of log(CPUE) on positive stations and **B.** the cumulative normalized residuals (QQ plot).



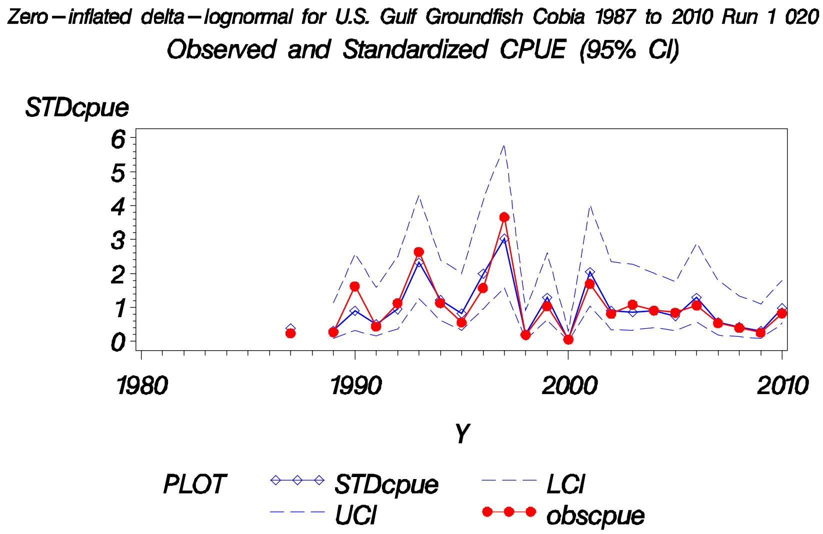

Addendum Figure 5. Diagnostic plots for lognormal component of the Spanish mackerel SEAMAP Groundfish Survey (full model, summer and fall) model: **A.** the Chi-Square residuals by year, **B.** the Chi-Square residuals by area, **C.** the Chi-Square residuals by depth zone and **D**. the Chi-Square residuals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




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.




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