STANDARDIZED CATCH RATES OF KING MACKEREL (*SCOMBEROMORUS CAVALLA*) FROM THE HEADBOAT FISHERY IN THE U.S. GULF OF MEXICO AND U.S. SOUTH ATLANTIC

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SUMMARY

Indices of abundance of king mackerel from the United States headboat fishery in the Gulf of Mexico and the U.S. South Atlantic are presented for the period 1979-2006. All were standardized using Generalized Linear Mixed Models, and a delta-lognormal approach. Two indices were constructed using the 2003 methods and area definitions. These are intended to be used during continuity case models. Additional indices were constructed using updated methods and the area definitions recommended by the previous assessment panel (SEDAR5). Updated indices were constructed for the U.S. Gulf of Mexico, the U.S. South Atlantic and a "Mixing Area". Two different indices were constructed for each area. The first eliminated vessels that did not fish in 10 or more years. The second index did not restrict vessels, but used species composition on each trip to restrict the dataset to trips that fished in the habitat of king mackerel. All updated indices also used the "repeated measures" procedure to account for the variance in catch rates between vessels.

KEY WORDS

Catch/effort, abundance, headboat, multivariate analyses

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1. INTRODUCTION

Rod and reel catch and effort from party (head) boats have been monitored by the NMFS Southeast Zone Headboat Survey (conducted by the NMFS Beaufort Laboratory) since 1973 in the U.S. South Atlantic and 1986 in the U.S Gulf of Mexico. The Headboat Survey collects data on the catch and effort for a vessel trip. Reported information includes landing date and location, vessel identification, the number of anglers, fishing location, trip duration and/or type (half/three-quarter/full/multi-day, day/night, morning/afternoon), and catch by species in number and weight. These data were used to construct standardized catch rate indices for king mackerel in the U.S. South Atlantic, Gulf of Mexico and the "Mixing Zone" as defined by the SEDAR 5 assessment panel.

2. MATERIALS AND METHODS

2.1 "Continuity Cases"

Two indices, one each for the Gulf of Mexico and Atlantic migratory groups, were constructed using the methods employed during the previous assessment (Ortiz, 2003). The following factors were examined as possible influences on the proportion positive trips, and the catch rates on positive trips:

FACTOR	LEVELS	DESCRIPTION
YEAR (FISHING YEAR)	26	1981 - 2006
SEASON	4	Jan – Mar Apr – Jun, Jul –Oct Nov-Dec
AREA	21	1 = Cape Hatteras Offshore
		2 = Cape Fear Inshore
		3 = Cape Fear Offshore
		4 = South Carolina Inshore
		5 = South Carolina Offshore
		6 = Georgia
		7 = NE Florida
		8 = East Central Florida
		9 = Cape Lookout Inshore
		10 = Cape Lookout Offshore
		11 = SE Florida
		12 = FL Keys Atlantic Vessels
		17 = Dry Tortugas Atlantic Vessels
		18 =Dry Tortugas Gulf Vessels
		21 = Naples/Crystal River
		22 = FL Middle Grounds
		23 = NW Florida and Alabama
		24 = Louisiana
		25 = NE Texas - Sabine/Freeport
		26 = Central Texas - Port Aransas
		27 = South Texas - Port Isabel

Catch rate (CPUE) on positive trips was calculated in number of fish per 1000 anglers.

CPUE = 1000 *{number of fish / anglers}

The migratory groups (Atlantic, Gulf) were defined according to area and month as follows:

Area Code	Area Description	November - March	April - October
1	Cape Hatteras Offshore	Atlantic	Atlantic
2	Cape Fear Inshore	Atlantic	Atlantic
3	Cape Fear Offshore	Atlantic	Atlantic
4	South Carolina Inshore	Atlantic	Atlantic
5	South Carolina Offshore	Atlantic	Atlantic
6	Georgia	Atlantic	Atlantic
7	NE Florida	Atlantic	Atlantic
8	East Central Florida	Gulf	Atlantic
9	Cape Lookout Inshore	Atlantic	Atlantic
10	Cape Lookout Offshore	Atlantic	Atlantic
11	SE Florida	Gulf	Atlantic
12	FL Keys Atlantic Vessels	Gulf	Atlantic
17	Dry Tortugas Atlantic Vessels	Gulf	Atlantic
18	Dry Tortugas Gulf Vessels	Gulf	Atlantic
21	Naples/Crystal River	Gulf	Atlantic
22	FL Middle Grounds	Gulf	Gulf
23	NW Florida and Alabama	Gulf	Gulf
24	Louisiana	Gulf	Gulf
25	NE Texas - Sabine/Freeport	Gulf	Gulf
26	Central Texas - Port Aransas	Gulf	Gulf
27	South Texas - Port Isabel	Gulf	Gulf

Areas 14,15 and 16 are defined, but are not used by the Headboat Program, and are not included in this analysis. Area 13 (Bahamas) was also excluded from the analysis since it falls outside U.S. jurisdiction. As in the previous analysis (Ortiz, 2003), trips prior to 1981 and longer than 24 hours were excluded.

For the "continuity case" indices, "YEAR" was defined using fishing years rather than calendar years. For the Atlantic migratory group, trips that took place in January – March were assigned a fishing year equal to calendar year minus one while trips that took place April – December were assigned a fishing year equal to the calendar year. For the Gulf migratory group, trips that took place in January – June were assigned a fishing year equal to calendar year minus one and trips that took place July – December were assigned a fishing year equal to the calendar year.

The dataset was also restricted to those vessels that fished during 10 or more years. Out of 261 vessels present in the Atlantic Migratory dataset, 103 fished in 10 or more years, and these landed 78% of all king mackerel. Of 239 vessels present in the Gulf Migratory dataset, 109 fished in 10 or more years, and these landed 87% of all king mackerel.

A forward stepwise regression procedure was used to determine the set of fixed factors and interaction terms that explained a significant portion of the observed variability. Factors and interaction terms were selected for final analysis if: 1) the percent reduction in deviance per degree of freedom explained by adding the factor exceeded one percent , 2) the χ^2 test was significant and 3) the Type-III test was significant for the specified model.

Once a set of fixed factors was identified, the influence of the YEAR*FACTOR interactions were examined. YEAR*FACTOR interaction terms were included in the model as random effects. Selection of the final mixed model was based on the Akaike's Information Criterion (AIC), Schwarz's Bayesian Criterion (BIC), and a chi-square test of the difference between the –2 log likelihood statistics between successive model formulations (Littell

et al. 1996). The final delta-lognormal model was fit using the SAS macro GLIMMIX and the SAS procedure PROC MIXED (SAS Institute Inc. 1997) following the procedures described by Lo et al. (1992).

2.2 Updated Indices with Modeling of Vessel Effects

The previous king mackerel assessment panel (SEDAR 5) recommended that future assessments consider three regions: 1) the Atlantic, 2) the "Mixing Area" and 3) the Gulf of Mexico. Therefore, three indices were constructed using updated methods and the recommended regional definitions. The following factors were examined as possible influences on the proportion positive trips, and the catch rates on positive trips:

1) ATLANTIC INDEX		
FACTOR	**LEVELS**	**DESCRIPTION**
YEAR	28	1979 – 2006
SEASON	4	Jan – Mar Apr – Jun, Jul –Oct Nov-Dec
AREA	10	1 = Cape Hatteras Offshore
		2 = Cape Fear Inshore
		3 = Cape Fear Offshore
		4 = South Carolina Inshore
		5 = South Carolina Offshore
		6 = Georgia
		7 = NE Florida ***IF LATITUDE ≥ 29°N or Unreported***
		8 = East Central Florida ***IF LATITUDE ≥ 29°N***
		9 = Cape Lookout Inshore
		10 = Cape Lookout Offshore
VESSEL		Analyzed using "Repeated Measures" approach

1) MIXING INDEX		
FACTOR	**LEVELS**	**DESCRIPTION**
YEAR	28	1979 – 2006
SEASON	4	Jan – Mar Apr – Jun, Jul –Oct Nov-Dec
AREA	7	7 = NE Florida ***IF LATITUDE < 29°N***
		8 = East Central Florida ***IF LATITUDE < 29°N or Unreported***
		11 = SE Florida
		12 = FL Keys Atlantic Vessels
		17 = Dry Tortugas Atlantic Vessels
		18 =Dry Tortugas Gulf Vessels
		21 = Naples/Crystal River ***IF LATITUDE < 26°N***
VESSEL		Analyzed using "Repeated Measures" approach

2) GULF INDEX		
FACTOR	**LEVELS**	**DESCRIPTION**
YEAR	21	1986 – 2006
SEASON	4	Jan – Mar Apr – Jun, Jul –Oct Nov-Dec
AREA	7	21 = Naples/Crystal River ***IF LATITUDE ≥ 26°N or Unreported***
		22 = FL Middle Grounds
		23 = NW Florida and Alabama
		24 = Louisiana
		25 = NE Texas - Sabine/Freeport
		26 = Central Texas - Port Aransas
		27 = South Texas - Port Isabel
VESSEL		Analyzed using "Repeated Measures" approach

The variable "Hours Fished" does not exist in the dataset. To estimate the number of hours fished, the following assumptions were necessary (Ortiz, 2003).

TRIP CODE	DEFINITION	HOURS FISHED
21,29	½ day, in PM	6
23	¾ day (2nd trip)	9
1,9	½ day, in AM or at night	3
3	¾ day	4.5
2,4	Full day or Overnight	6
25	1½ days	9
5	Two days	12
6	Three days	18
7	Four days	24
8	Five days	30
10	Six days	36
11	Seven days	42

.Catch rate (CPUE) on positive trips was calculated in number of fish per 1000 angler hours.

CPUE = 1000 *{number of fish / (anglers * hours fished)}

The indices described in this section were constructed using the calendar year. No adjustment was made to accommodate the "fishing year" definitions. Areas 13, 14, 15 and 16 were excluded from these analyses, either because they are not used (14,15,16) or because they are outside U.S. jurisdiction (13). Trips prior to 1979 were excluded since they almost never report landing king mackerel. Trips longer than 24 hours ***were not*** excluded from these analyses.

Like the "continuity case" indices, datasets were restricted to those vessels that fished during 10 or more years. Out of 115 vessels that fished in the Atlantic region, 49 fished in 10 or more years, and these were responsible for 77% of the total landings of king mackerel. 129 vessels fished in the "mixing region". Of these, 59 fished in 10 or more years, and they were responsible for 88% of the total landings of king mackerel. Lastly, 139 vessels fished in the Gulf region. Of these, 64 fished during 10 or more years, and these landed 92% of the king mackerel.

The regression procedures used to determine fixed factors and interaction terms was identical to that described in Section 2.1 expect that the variation in catch rates by VESSEL was examined using a "repeated measures" approach

(Little et al., 1998). The term "repeated measures" refers to multiple measurements taken over time on the same experimental unit (i.e. vessel). Specifying the repeated measure "VESSEL" and the subject "VESSEL(YEAR)" allows PROC MIXED to model the covariance structure of the data. This is particularly important because catch rates may vary by vessel *and because* catch rates on trips by a given vessel close in time can be more highly correlated that those far apart in time (Littell et al., 1998).

2.3 Updated Indices with Selection of Trips Using Species Composition and Modeling of Vessel Effects

A second set of updated indices were constructed using a filtering technique intended to restrict the dataset to trips that fished in the habitat of king mackerel. In the absence of direct information useful to infer targeting (e.g. depth of fishing, fine-scale fishing location, bottom type, gear configuration), an objective approach developed by Stephens and McCall (2004) was used to subset trip records using species composition. A brief summary of the methodology follows (***adapted from Stephens and McCall, 2004):***

First, the species composition from catch records was used to estimate the parameters of a logistic regression. For example, let Y_j be a categorical variable describing the presence/absence of the non-target species for trip j. Similarly, let x_{ij} describe the presence/absence of king mackerel.

$$Y_j = \begin{cases} 1 & \text{if the target species is caught} \\ 0 & \text{if the target species is not caught} \end{cases}$$

Then a logistic regression was applied to estimate the probability that king mackerel would have been encountered on a trip. Using the regression results, a score (S_j) was assigned to each trip j as a function of the species encountered on that trip:

$$S_j = \exp \sum_{i=0}^{k} x_{ij}\beta_i$$

where the coefficients $\beta_1,\beta_2,\ldots\beta_k$ quantify the predictive effect of each species and β_0 is the intercept of the logistic regression.

This score was then converted into the probability of observing king mackerel given the vector of presence/absence of the other species observed on the trip (j).

$$\pi_j = \Pr\{Y_j = 1\} = \frac{S_j}{1 + S_j}$$

Given the coefficients β_0, β_1, . . ., β_k and the presence/absence indicators $x_{1j},\ldots, x_{kj}$, the log-likelihood (excluding constants independent of the parameters) is the sum:

$$\boldsymbol{L}\{Y|\beta_0, \ldots, \beta_k, x_{1j}, \ldots, x_{kj}\} = \sum_{j \in j+} \log(\pi_j) + \sum_{j \in j-} \log(1 - \pi_j)$$

where j+ indicates trips that observed king mackerel, and j- indicates trips that did not observe king mackerel. The log-likelihood was maximized using the statistical package R (Ihaka and Gentleman, 1996). The estimated β coefficients reflect the association (positive or negative) between the non-target species and king mackerel, π_j is intended to estimate the probability that the trip *j* fished in the habitat of king mackerel.

Trip records were selected for CPUE analysis using a critical value. The critical value was determined by examining the relationship between the critical value and the number of incorrect predictions. Both false positives (king mackerel predicted to occur when absent) and false negatives (king mackerel not expected to occur when present)

were considered. The critical value that minimized the number of incorrect predictions was selected. Trip records were included in the CPUE analysis if π (as calculated above) was above the critical value.

All other methods were identical to those described in Section 2.2 except that vessels were not excluded from the analysis on the basis of their number of years of fishing.

3. RESULTS AND DISCUSSION

3.1 "Continuity Cases"

3.1.1 Atlantic Migratory Group

The stepwise construction of the binomial model on the proportion of positive trips and the lognormal model on catch rates is described in **Table 1**. The significance of the YEAR*FACTOR interaction terms were tested using Likelihood ratio tests. These are summarized in **Table 2**. The final models were:

- PPT = AREA + YEAR + YEAR*AREA
- LN(CPUE) = AREA + YEAR + YEAR*AREA + YEAR*SEASON

From 1981 to 2006, the annual proportion of positive trips (PPT: trips that caught king mackerel) declined substantially, from 39% to 21% (**Figure 1A; Table 3**). Nominal CPUE also shows a general decrease, from 110 fish/1000 anglers in 1984 to 65 fish/1000 anglers in 2006 (**Figure 1B; Table 3**).

Diagnostic plots were constructed to examine the fit of the components of the delta-lognormal model. The frequency distribution of the proportion of positive trips, by factor, and the Chi-square residuals, by year, indicate that the fit of the binomial model is adequate (**Figure 2**). The distribution of the nominal catch rates is similar to the expected normal distribution (**Figure 3A**) and the residuals from the lognormal model on catch rates are evenly distributed above and below zero (**Figure 3B**), indicating an acceptable fit to the model. The cumulative normalized residuals (QQ-Plot) from the lognormal model are shown in **Figure 3C**. The QQ-Plot indicates small departures from the assumption of a normal distribution, particularly at the extremes. However, the fit appears to be adequate.

The delta-lognormal catch rate index, with 95% confidence intervals, is shown in **Figure 4** and summarized in **Table 3**. The standardized abundance index is flatter than the nominal CPUE series (**Figure 4**), but is quite similar to the index developed for the previous assessment (**Figure 5**). The index suggests that standardized catch rates were fairly constant from 1981-2006.

3.1.2 Gulf Migratory Group

The stepwise construction of the binomial model on the proportion of positive trips and the lognormal model on catch rates is described in **Table 4**. The significance of the YEAR*FACTOR interaction terms were tested using Likelihood ratio tests. These are summarized in **Table 5**. The final models were:

- PPT = AREA + SEASON + YEAR + YEAR*SEASON + YEAR*AREA
- LN(CPUE) = AREA + YEAR + AREA*SEASON + YEAR*AREA + YEAR*SEASON

From 1981 to 1987, the annual proportion of positive trips (PPT: trips that caught king mackerel) declined substantially, from 44% to 19%. Since 1987, PPT has generally increased. In 2006, PPT was roughly 43%, the highest recorded since 1983 (**Figure 6A; Table 6**). Nominal CPUE shows the same general trend, ranging from 232 fish/1000 anglers in 1983 to 51 fish/1000 anglers in 1988. The nominal CPUE in 2006 was the highest on record, 234 fish/1000 anglers (**Figure 6B; Table 6**).

Diagnostic plots were constructed to examine the fit of the components of the delta-lognormal model. The frequency distribution of the proportion of positive trips, by factor, and the Chi-square residuals, by year, indicate that the fit of the binomial model is adequate (**Figure 7**). The distribution of the nominal catch rates is similar to the expected

normal distribution (**Figure 8A**) and the residuals of the lognormal model on catch rates are evenly distributed above and below zero (**Figure 8B**), indicating an acceptable fit to the model. The cumulative normalized residuals (QQ-Plot) of the lognormal model are shown in **Figure 8C**. The QQ-Plot indicates very little departure from the assumption of a normal distribution.

The delta-lognormal catch rate index, with 95% confidence intervals, is shown in **Figure 9** and summarized in **Table 6**. The standardized abundance index is roughly similar to the nominal CPUE series (**Figure 9**) and to the index developed for the previous assessment (**Figure 10**). The index suggests that standardized catch rates declined from 1981 to 1988, then slowly increased.

3.2 Updated Indices with Vessel Effects

3.2.1 Atlantic Region

The stepwise construction of the binomial model on the proportion of positive trips and the lognormal model on catch rates is described in **Table 7**. The significance of the YEAR*FACTOR interaction terms were tested using Likelihood ratio tests. These are summarized in **Table 8**. The final models were:

- PPT = AREA + SEASON + YEAR + YEAR*AREA + YEAR*SEASON
- LN(CPUE) = AREA + YEAR + YEAR*SEASON + VESSEL(YEAR)

From 1979 to 2006, the annual proportion of positive trips (PPT: trips that caught king mackerel) varied with a slight increasing trend (**Figure 11A; Table 9**). Nominal CPUE shows a more substantial increase, ranging from roughly 2 fish/1000 angler hours in the early 1980s to 6 to 25 fish/1000 angler hours since 1997 (**Figure 11B; Table 9**).

Diagnostic plots were constructed to examine the fit of the components of the delta-lognormal model. The frequency distribution of the proportion of positive trips, by factor, and the Chi-square residuals, by year, indicate that the fit of the binomial model is adequate (**Figure 12**). The distribution of the nominal catch rates is similar to the expected normal distribution (**Figure 13A**) and the residuals from the lognormal model on catch rates are evenly distributed above and below zero (**Figure 13B**), indicating an acceptable fit to the model. The cumulative normalized residuals (QQ-Plot) from the lognormal model are shown in **Figure 13C**. The QQ-Plot indicates some departure from the assumption of a normal distribution, particularly at the extremes. However, the fit appears to be adequate.

The delta-lognormal catch rate index, with 95% confidence intervals, is shown in **Figure 14** and summarized in **Table 9**. The standardized abundance index is flatter than the nominal CPUE series (**Figure 14**), and suggests that standardized catch rates were increasing only slightly from 1979-2006.

3.2.2 Mixing Region

The stepwise construction of the binomial model on the proportion of positive trips and the lognormal model on catch rates is described in **Table 10**. The significance of the YEAR*FACTOR interaction terms were tested using Likelihood ratio tests. These are summarized in **Table 11**. The final models were:

- PPT = AREA + SEASON + YEAR
- LN(CPUE) = AREA + YEAR + AREA*SEASON + VESSEL(YEAR)

From 1979 to 2006, the annual proportion of positive trips (PPT: trips that caught king mackerel) decreased steeply, from 58% in 1981 to 29% in 2006 (**Figure 15A; Table 12**). Nominal CPUE shows a similar decrease, ranging from roughly 62 fish/1000 angler hours in the early 1980s to 26 fish/1000 angler hours in 2006 (**Figure 15B; Table 12**).

Diagnostic plots were constructed to examine the fit of the components of the delta-lognormal model. The frequency distribution of the proportion of positive trips, by factor, and the Chi-square residuals, by year, indicate that the fit of the binomial model is adequate (**Figure 16**). The distribution of the nominal catch rates is similar to the expected

normal distribution (**Figure 17A**) and the residuals from the lognormal model on catch rates are evenly distributed above and below zero (**Figure 17B**), indicating an acceptable fit to the model. The cumulative normalized residuals (QQ-Plot) from the lognormal model are shown in **Figure 17C**. The QQ-Plot indicates a minor departure from the assumption of a normal distribution, particularly at the extremes. However, the fit appears to be adequate.

The delta-lognormal catch rate index, with 95% confidence intervals, is shown in **Figure 18** and summarized in **Table 12**. The standardized abundance index is similar to, but flatter than the nominal CPUE series (**Figure 18**). It indicates that standardized catch rates were generally declining, albeit gradually, during 1979-2006.

3.2.2 Gulf Region

The stepwise construction of the binomial model on the proportion of positive trips and the lognormal model on catch rates is described in **Table 13**. The significance of the YEAR*FACTOR interaction terms were tested using Likelihood ratio tests. These are summarized in **Table 14**. The final models were:

- PPT = AREA + SEASON + YEAR + AREA*SEASON + YEAR*AREA
- LN(CPUE) = AREA + YEAR + AREA*SEASON + VESSEL(YEAR)

From 1986 to 1990, the annual proportion of positive trips (PPT: trips that caught king mackerel) declined from 19% to 10%. Since that time PPT has generally increased to 32% in 2006 (**Figure 19A; Table 15**). Nominal CPUE shows a similar trend, ranging from roughly 6 fish/1000 angler hours in 1990 to 36 fish/1000 angler hours in 2006 (**Figure 19B; Table 15**).

Diagnostic plots were constructed to examine the fit of the components of the delta-lognormal model. The frequency distribution of the proportion of positive trips, by factor, and the Chi-square residuals, by year, indicate that the fit of the binomial model is adequate (**Figure 20**). The distribution of the nominal catch rates is similar to the expected normal distribution (**Figure 21A**) and the residuals from the lognormal model on catch rates are evenly distributed above and below zero (**Figure 21B**), indicating an acceptable fit to the model. The cumulative normalized residuals (QQ-Plot) from the lognormal model are shown in **Figure 21C**. The QQ-Plot indicates very little departure from the assumption of a normal distribution. Therefore, the fit appears to be adequate.

The delta-lognormal catch rate index, with 95% confidence intervals, is shown in **Figure 22** and summarized in **Table 15**. The standardized abundance index is similar to the nominal CPUE series (**Figure 22**), and suggests that standardized catch rates were increasing from 1986-2006.

3.3 Updated Indices using Species Composition and Vessel Effects

The results of the Stephens and McCall (1994) species composition procedure, including percent occurrence, percent catch and the logistic regression coefficients, are summarized in **Tables 16 – 18**. Species were selected for the analysis if they were present on at least 2% of all trips. For the Atlantic, Mixing, and Gulf regions, 39, 47, and 38 species were included in the analysis, respectively. In each case, the included species represented about 98% of all fish landed in the region. The logistic regression coefficients quantify the predictive importance of each species. Values greater than zero indicate positive association with king mackerel while values less than zero indicate species that are seldom observed in association with king mackerel. Species that are important predictors of king mackerel habitat include common pelagic species such as Spanish mackerel, dolphin, little tunny, Atlantic bonito, bluefish, cobia, blackfin tuna and sharpnose shark (**Tables 16-18**).

3.3.1 Atlantic Region

The stepwise construction of the binomial model on the proportion of positive trips and the lognormal model on catch rates is described in **Table 19**. The significance of the YEAR*FACTOR interaction terms were tested using Likelihood ratio tests. These are summarized in **Table 20**. The final models were:

- PPT = AREA + YEAR + SEASON
- LN(CPUE) = AREA + YEAR + SEASON + AREA*SEASON + YEAR*SEASON + VESSEL(YEAR)

From 1979 to 2006, the annual proportion of positive trips (PPT: trips that caught king mackerel) varied without obvious trend (**Figure 23A; Table 21**). Nominal CPUE shows a more substantial increase, ranging from roughly 10 fish/1000 angler hours in the early 1980s to 30-40 fish/1000 angler hours in recent years (**Figure 23B; Table 21**).

Diagnostic plots were constructed to examine the fit of the components of the delta-lognormal model. The frequency distribution of the proportion of positive trips, by factor, and the Chi-square residuals, by year, indicate that the fit of the binomial model is adequate (**Figure 24**). The distribution of the nominal catch rates is similar to the expected normal distribution (**Figure 25A**) and the residuals from the lognormal model on catch rates are evenly distributed above and below zero (**Figure 25B**) with some increase in the magnitude of the residuals during the time series. The cumulative normalized residuals (QQ-Plot) from the lognormal model are shown in **Figure 25C**. The QQ-Plot indicates some departure from the assumption of a normal distribution, particularly at the extremes. However, the fit to the lognormal model appears adequate.

The delta-lognormal catch rate index, with 95% confidence intervals, is shown in **Figure 26** and summarized in **Table 21**. The standardized abundance index is flatter than the nominal CPUE series (**Figure 26**), and suggests that standardized catch rates varied without obvious trend during 1979-2006.

3.3.2 Mixing Region

The stepwise construction of the binomial model on the proportion of positive trips and the lognormal model on catch rates is described in **Table 22**. The significance of the YEAR*FACTOR interaction terms were tested using Likelihood ratio tests. These are summarized in **Table 23**. The final models were:

- PPT = AREA + SEASON + YEAR
- LN(CPUE) = AREA + YEAR + YEAR*SEASON + VESSEL(YEAR)

From 1979 to 2006, the annual proportion of positive trips (PPT: trips that caught king mackerel) varied without obvious trend (**Figure 27A; Table 24**). Nominal CPUE also varied without trend, although the 2006 CPUE is one of the highest on record, 119 fish/1000 angler hours (**Figure 27B; Table 24**).

Diagnostic plots were constructed to examine the fit of the components of the delta-lognormal model. The frequency distribution of the proportion of positive trips, by factor, and the Chi-square residuals, by year, indicate that the fit of the binomial model is adequate (**Figure 28**). The distribution of the nominal catch rates is similar to the expected normal distribution (**Figure 29A**) and the residuals from the lognormal model on catch rates are evenly distributed above and below zero (**Figure 29B**). The cumulative normalized residuals (QQ-Plot) from the lognormal model are shown in **Figure 29C**. The QQ-Plot indicates very little departure from the assumption of a normal distribution. Therefore, the fit to the lognormal model appears adequate.

The delta-lognormal catch rate index, with 95% confidence intervals, is shown in **Figure 30** and summarized in **Table 24**. The standardized index is very similar to the nominal CPUE series (**Figure 30**), and suggests that standardized catch rates varied without obvious trend during 1979-2006.

3.3.2 Gulf Region

The stepwise construction of the binomial model on the proportion of positive trips and the lognormal model on catch rates is described in **Table 25**. The significance of the YEAR*FACTOR interaction terms were tested using Likelihood ratio tests. These are summarized in **Table 26**. The final models were:

- PPT = SEASON + AREA + YEAR
- LN(CPUE) = AREA + SEASON + YEAR + YEAR*SEASON + VESSEL(YEAR)

From 1986 to 1990, the annual proportion of positive trips (PPT: trips that caught king mackerel) decreased from 55% to 43%. Since that time, PPT has generally increased. The PPT in 2006 was the highest reported, 67% (**Figure 31A; Table 27**). Nominal CPUE has also generally increased, and in 2006 was the highest reported, 79 fish/1000 anglers hours (**Figure 31B; Table 27**).

Diagnostic plots were constructed to examine the fit of the components of the delta-lognormal model. The frequency distribution of the proportion of positive trips, by factor, and the Chi-square residuals, by year, indicate that the fit of the binomial model is adequate (**Figure 32**). The distribution of the nominal catch rates is similar to the expected normal distribution (**Figure 33A**) and the residuals from the lognormal model on catch rates are evenly distributed above and below zero (**Figure 33B**). The cumulative normalized residuals (QQ-Plot) from the lognormal model are shown in **Figure 33C**. The QQ-Plot indicates some departure from the assumption of a normal distribution. However, the fit to the lognormal model appears adequate.

The delta-lognormal catch rate index, with 95% confidence intervals, is shown in **Figure 34** and summarized in **Table 27**. The standardized index is very similar to the nominal CPUE series (**Figure 34**), and suggests that standardized catch rates have increased somewhat since historical lows in the late 1980s. The 2006 index value is the highest reported.

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Table 1. GENMOD regression statistics for the fixed factors and interactions terms for A) the proportion positive trips and B) catch rates on positive trips for the ***Continuity Case-Atlantic Migratory Group.***

A)

LR Statistics For Type 3 Analysis

Source	DF	Chi-Square	Pr > ChiSq
area	12	49787.6	<.0001
year	25	848.26	<.0001

B)

LR Statistics For Type 3 Analysis

Source	DF	Chi-Square	Pr > ChiSq
area	12	12951.8	<.0001
year	25	557.21	<.0001

Table 2. Analysis of the mixed model formulations of the ***Continuity Case-Atlantic Migratory Group***. The likelihood ratio was used to test the difference of –2 REM log likelihood between two nested models. The final models are indicated with gray shading.

ANALYSIS OF MIXED MODEL FORMULATIONS

Proportion Positive	-2 REM Log likelihood	Akaike's Information Criterion	Schwartz's Bayesian Criterion	Likelihood Ratio Test	P
Area + Year	14575.9	14577.9	14584.1	-	-
Area + Year + Year*Area	**14365.7**	**14369.7**	**14377.1**	**210.2**	**<0.0001**
Area + Year + Year*Area + Year*Season	14365.8	14371.8	14382.8	-0.1	1.0000

Catch Rates on Positive Trips	-2 REM Log likelihood	Akaike's Information Criterion	Schwartz's Bayesian Criterion	Likelihood Ratio Test	P
Area + Year	150317.1	150319.1	150327.9	-	-
Area + Year + Year*Area	149311.6	149315.6	149322.9	1005.5	<0.0001
Area + Year + Year*Area + Year*Season	**148967.9**	**148973.9**	**148984.8**	**343.7**	**<0.0001**

Table 3. Nominal CPUE, number of trips, number of positive trips, proportion positive trips (PPT) and abundance index statistics for the ***Continuity Case - Atlantic Migratory Group***.

Year	Nominal CPUE	Trips	Proportion Positive Trips	Positive Trips	Rel. Index	LCI	UCI	CV
1981	105.346	5884	0.394	2317	0.912	0.499	1.665	0.308
1982	87.226	6521	0.388	2530	0.788	0.440	1.410	0.297
1983	107.485	7261	0.409	2968	0.845	0.489	1.459	0.278
1984	110.395	6735	0.410	2763	0.969	0.575	1.633	0.265
1985	83.399	7374	0.364	2684	0.564	0.322	0.988	0.286
1986	83.429	9554	0.359	3434	0.761	0.445	1.301	0.273
1987	90.347	9213	0.361	3327	1.287	0.773	2.142	0.259
1988	67.321	8330	0.291	2428	0.869	0.501	1.509	0.281
1989	76.473	7578	0.287	2176	0.624	0.352	1.105	0.292
1990	66.099	9717	0.286	2780	0.744	0.432	1.283	0.277
1991	107.995	9352	0.317	2963	1.545	0.944	2.529	0.250
1992	70.726	11596	0.303	3515	1.407	0.868	2.281	0.245
1993	63.833	10519	0.256	2689	0.844	0.505	1.410	0.261
1994	63.558	9615	0.244	2342	1.041	0.628	1.727	0.257
1995	56.144	8343	0.239	1997	0.935	0.564	1.551	0.257
1996	52.747	7084	0.157	1115	0.626	0.365	1.074	0.275
1997	77.892	7670	0.229	1754	1.129	0.675	1.887	0.261
1998	64.810	6877	0.193	1325	0.911	0.538	1.545	0.269
1999	38.078	5757	0.174	1002	1.163	0.694	1.947	0.262
2000	92.914	5847	0.233	1365	1.852	1.131	3.031	0.250
2001	59.066	5362	0.201	1079	1.215	0.719	2.053	0.267
2002	43.370	4547	0.181	821	0.979	0.573	1.672	0.273
2003	40.512	5019	0.134	672	0.838	0.484	1.451	0.280
2004	29.842	5168	0.124	639	0.715	0.414	1.237	0.279
2005	43.469	4633	0.165	763	1.200	0.705	2.043	0.271
2006	64.633	4599	0.210	964	1.238	0.730	2.100	0.269

Table 4. GENMOD regression statistics for the fixed factors and interactions terms for A) the proportion positive trips and B) catch rates on positive trips for the ***Continuity Case-Gulf Migratory Group.***

A)

LR Statistics For Type 3 Analysis

Source	DF	Chi-Square	Pr > ChiSq
area	10	32398.9	<.0001
SEASON	3	9250.03	<.0001
year	25	2891.97	<.0001

B)

LR Statistics For Type 3 Analysis

Source	DF	Chi-Square	Pr > ChiSq
area	10	2962.41	<.0001
year	25	1097.48	<.0001
area*SEASON	23	781.24	<.0001

Table 5. Analysis of the mixed model formulations of the ***Continuity Case-Gulf Migratory Group***. The likelihood ratio was used to test the difference of –2 REM log likelihood between two nested models. The final models are indicated with gray shading.

ANALYSIS OF MIXED MODEL FORMULATIONS

Proportion Positive	-2 REM Log likelihood	Akaike's Information Criterion	Schwartz's Bayesian Criterion	Likelihood Ratio Test	P
Area+ Season + Year	16476.1	16478.1	16484.4	-	-
Area+ Season + Year + Year*Season	16458.9	16462.9	16468.0	17.2	<0.0001
Area+ Season + Year + Year*Season + Year*Area	**16436.5**	**16442.5**	**16450.1**	**22.4**	**<0.0001**

Catch Rates on Positive Trips	-2 REM Log likelihood	Akaike's Information Criterion	Schwartz's Bayesian Criterion	Likelihood Ratio Test	P
Area + Year + Area*Season	156493.7	156495.7	156504.6	-	-
Area + Year + Area*Season + Year*Area	155576.8	155580.8	155587.7	916.9	<0.0001
Area + Year + Area*Season + Year*Area + Year*Season	**155045.7**	**155051.7**	**155062.1**	**531.1**	**<0.0001**

Table 6. Nominal CPUE, number of trips, number of positive trips, proportion positive trips (PPT) and abundance index statistics for the ***Continuity Case - Gulf Migratory Group***.

Year	Nominal CPUE	Trips	Proportion Positive Trips	Positive Trips	Rel. Index	LCI	UCI	CV
1981	179.255	2955	0.436	1289	1.462	0.771	2.773	0.328
1982	89.845	2769	0.395	1095	0.865	0.446	1.678	0.340
1983	232.580	2971	0.543	1614	1.942	1.071	3.520	0.304
1984	58.718	3133	0.313	981	0.620	0.314	1.225	0.351
1985	71.045	3839	0.304	1167	0.445	0.248	0.799	0.299
1986	109.239	6694	0.354	2367	0.489	0.298	0.802	0.252
1987	58.491	6660	0.191	1269	0.324	0.185	0.568	0.286
1988	50.818	6917	0.212	1467	0.379	0.220	0.653	0.277
1989	87.760	8316	0.279	2317	0.612	0.371	1.010	0.254
1990	79.048	8946	0.237	2118	0.504	0.300	0.848	0.264
1991	107.213	8738	0.280	2446	0.797	0.494	1.284	0.242
1992	119.690	9689	0.303	2939	1.028	0.648	1.632	0.234
1993	116.868	9989	0.316	3152	1.230	0.781	1.937	0.230
1994	117.415	10103	0.328	3314	1.117	0.713	1.750	0.227
1995	127.137	8373	0.308	2575	1.078	0.676	1.720	0.237
1996	126.709	8154	0.291	2376	1.673	1.075	2.603	0.224
1997	158.688	8304	0.332	2761	1.317	0.843	2.057	0.226
1998	104.027	7085	0.283	2008	1.083	0.686	1.708	0.231
1999	114.080	6132	0.293	1795	1.127	0.717	1.773	0.229
2000	106.039	5659	0.306	1730	0.967	0.608	1.538	0.235
2001	128.439	5625	0.305	1713	1.152	0.726	1.827	0.234
2002	164.005	5396	0.326	1760	1.164	0.738	1.835	0.231
2003	104.395	5190	0.255	1323	0.961	0.594	1.555	0.244
2004	186.324	4459	0.325	1451	1.096	0.684	1.758	0.240
2005	229.098	4323	0.338	1459	1.378	0.872	2.179	0.232
2006	234.405	1919	0.434	833	1.191	0.662	2.142	0.300

Table 7. GENMOD regression statistics for the fixed factors and interactions terms for A) the proportion positive trips and B) catch rates on positive trips for the ***Updated Indices –Atlantic Region.***

A)

LR Statistics For Type 3 Analysis

Source	DF	Chi-Square	Pr > ChiSq
area	8	6833.02	<.0001
SEASON	3	919.78	<.0001
year	27	851.32	<.0001

B)

LR Statistics For Type 3 Analysis

Source	DF	Chi-Square	Pr > ChiSq
area	8	2737.90	<.0001
year	27	691.94	<.0001

Table 8. Analysis of the mixed model formulations of the ***Updated Indices –Atlantic Region***. The likelihood ratio was used to test the difference of –2 REM log likelihood between two nested models. The final models are indicated with gray shading.

Proportion Positive	-2 REM Log likelihood	Akaike's Information Criterion	Schwartz's Bayesian Criterion	Likelihood Ratio Test	P
Area+ Season + Year	9968.8	9970.8	9976.6	-	-
Area+ Season + Year + Year*Area	9809.1	9813.1	9819.8	159.7	<0.0001
Area+ Season + Year + Year*Area+ Year*Season	**9785.8**	**9791.8**	**9801.9**	**23.3**	**<0.0001**

Catch Rates on Positive Trips	-2 REM Log likelihood	Akaike's Information Criterion	Schwartz's Bayesian Criterion	Likelihood Ratio Test	P
Area + Year	42433.0	42435.0	42442.5	-	-
Area + Year + Year*Area	41983.6	41987.6	41994.2	449.4	<0.0001
Area + Year + Year*Area + Year*Season	41875.3	41881.3	41891.2	108.3	<0.0001
Area + Year + VESSEL(Year)	36051.3	36055.3	36055.3	6381.7	<0.0001
Area + Year + VESSEL(Year) + Year*Area			Does not converge		
Area + Year + VESSEL(Year) + Year*Season	**35897.6**	**35903.6**	**35911.8**	**153.7**	**<0.0001**

Table 9. Nominal CPUE, number of trips, number of positive trips, proportion positive trips (PPT) and abundance index statistics for the ***Updated Index- Atlantic Region***.

Year	Nominal CPUE	Trips	Proportion Positive Trips	Positive Trips	Rel. Index	LCI	UCI	CV
1979	2.091	2654	0.076	202	0.240	0.081	0.709	0.585
1980	3.237	3234	0.135	438	1.039	0.439	2.462	0.452
1981	2.767	2393	0.128	306	1.185	0.475	2.958	0.482
1982	3.040	2659	0.151	402	0.576	0.239	1.389	0.462
1983	2.611	2708	0.149	404	0.831	0.365	1.892	0.429
1984	2.715	2701	0.160	433	1.056	0.503	2.219	0.384
1985	1.217	2963	0.129	382	0.638	0.295	1.383	0.401
1986	2.324	3597	0.152	545	0.815	0.381	1.743	0.394
1987	4.483	3659	0.169	619	1.104	0.526	2.317	0.384
1988	2.932	3395	0.154	523	0.801	0.366	1.750	0.406
1989	1.441	2386	0.084	201	0.644	0.270	1.541	0.457
1990	1.469	2346	0.118	277	0.742	0.321	1.714	0.438
1991	12.348	2481	0.212	526	1.909	0.916	3.978	0.380
1992	9.109	3811	0.261	996	1.991	0.994	3.988	0.358
1993	5.894	3832	0.173	662	0.942	0.439	2.024	0.397
1994	5.131	3445	0.161	556	0.956	0.455	2.009	0.384
1995	4.213	3326	0.180	599	1.096	0.534	2.251	0.372
1996	3.282	3221	0.123	395	0.559	0.258	1.213	0.402
1997	16.485	3500	0.190	664	1.186	0.567	2.481	0.382
1998	19.461	3313	0.192	635	1.141	0.541	2.408	0.387
1999	7.035	2972	0.178	528	1.168	0.553	2.468	0.388
2000	25.684	3112	0.242	752	1.961	0.969	3.970	0.364
2001	14.001	2799	0.186	520	0.983	0.446	2.165	0.411
2002	9.078	2730	0.174	475	0.847	0.379	1.891	0.419
2003	10.573	2916	0.141	410	0.772	0.349	1.705	0.412
2004	6.160	2918	0.117	341	0.612	0.273	1.372	0.421
2005	7.826	2270	0.155	351	1.033	0.468	2.282	0.412
2006	14.690	2787	0.192	535	1.173	0.547	2.513	0.395

Table 10. GENMOD regression statistics for the fixed factors and interactions terms for A) the proportion positive trips and B) catch rates on positive trips for the ***Updated Indices –Mixing Region.***

A)

LR Statistics For Type 3 Analysis

Source	DF	Chi-Square	Pr > ChiSq
area	5	25023.8	<.0001
SEASON	3	2201.47	<.0001
year	27	1770.13	<.0001

B)

LR Statistics For Type 3 Analysis

Source	DF	Chi-Square	Pr > ChiSq
area	4	7789.02	<.0001
year	27	1170.21	<.0001
area*SEASON	13	733.54	<.0001

Table 11. Analysis of the mixed model formulations of the ***Updated Indices –Mixing Region***. The likelihood ratio was used to test the difference of –2 REM log likelihood between two nested models. The final models are indicated with gray shading.

ANALYSIS OF MIXED MODEL FORMULATIONS

Proportion Positive	-2 REM Log likelihood	Akaike's Information Criterion	Schwartz's Bayesian Criterion	Likelihood Ratio Test	P
Area + Season + Year	**8612.4**	**8614.4**	**8620.2**	**-**	**-**
Area + Season + Year + Year*Season			Not Convergent		
Area + Season + Year + Year*Area			Not Convergent		

Catch Rates on Positive Trips	-2 REM Log likelihood	Akaike's Information Criterion	Schwartz's Bayesian Criterion	Likelihood Ratio Test	P
Area + Year + Area*Season	198897.0	198899.0	198909.0	-	-
Area + Year + Area*Season + Year*Season	197629.5	197633.5	197638.9	1267.5	<0.0001
Area + Year + Area*Season + Year*Season + Year*Area	197241.3	197247.3	197255.5	388.2	<0.0001
Area + Year + Area*Season + VESSEL(Year)	**195573.9**	**195577.9**	**195587.0**	**3323.1**	**<0.0001**
Area + Year + Area*Season + Year*Season + VESSEL(Year)			Not Convergent		
Area + Year + Area*Season + Year*Area + VESSEL(Year)	195573.4	195579.4	195587.5	**0.5**	**0.4795**
Area + Year + Area*Season + Year*Area + Year*Season + VESSEL(Year)			Not Convergent		

Table 12. Nominal CPUE, number of trips, number of positive trips, proportion positive trips (PPT) and abundance index statistics for the ***Updated Index- Mixing Region***.

Year	Nominal CPUE	Trips	Proportion Positive Trips	Positive Trips	Rel. Index	LCI	UCI	CV
1979	57.009	2965	0.577	1712	1.250	0.651	2.398	0.335
1980	67.672	4563	0.572	2608	1.387	0.742	2.591	0.320
1981	65.530	6168	0.537	3315	1.403	0.740	2.659	0.328
1982	35.569	6856	0.507	3476	0.922	0.479	1.776	0.337
1983	41.687	7255	0.520	3769	1.043	0.541	2.013	0.338
1984	47.621	6909	0.530	3662	1.230	0.660	2.295	0.319
1985	29.693	7523	0.445	3351	0.705	0.343	1.447	0.372
1986	31.569	8650	0.469	4061	0.725	0.359	1.468	0.364
1987	41.995	8343	0.522	4357	1.026	0.542	1.942	0.327
1988	21.116	7260	0.317	2299	0.494	0.218	1.122	0.427
1989	33.023	7068	0.446	3153	0.812	0.395	1.669	0.372
1990	36.285	8721	0.470	4103	0.957	0.485	1.889	0.350
1991	44.023	8258	0.445	3678	0.976	0.484	1.969	0.362
1992	28.241	9268	0.400	3709	0.765	0.370	1.578	0.375
1993	36.949	8235	0.427	3514	1.025	0.519	2.025	0.350
1994	31.802	7261	0.414	3003	0.927	0.462	1.861	0.359
1995	30.146	6996	0.361	2528	0.807	0.390	1.673	0.377
1996	35.861	4557	0.314	1431	1.232	0.611	2.485	0.362
1997	39.801	5410	0.376	2032	1.391	0.721	2.684	0.338
1998	29.259	4484	0.318	1424	1.376	0.685	2.762	0.359
1999	20.040	3194	0.269	858	1.003	0.484	2.079	0.377
2000	17.963	3248	0.281	914	0.931	0.452	1.915	0.373
2001	17.721	2832	0.316	894	1.034	0.514	2.083	0.361
2002	11.816	1977	0.266	525	0.883	0.419	1.860	0.386
2003	16.011	2069	0.227	470	0.951	0.433	2.086	0.409
2004	11.406	2147	0.209	448	0.583	0.254	1.336	0.433
2005	27.762	2216	0.291	645	1.024	0.495	2.118	0.376
2006	26.377	2195	0.287	630	1.137	0.549	2.351	0.376

Table 13. GENMOD regression statistics for the fixed factors and interactions terms for A) the proportion positive trips and B) catch rates on positive trips for the ***Updated Indices –Gulf Region.***

A)

LR Statistics For Type 3 Analysis

Source	DF	Chi Square	Pr > ChiSq
area	6	9999.73	<.0001
SEASON	3	2008.59	<.0001
year	20	1968.38	<.0001
area*SEASON	18	1251.66	<.0001

B)

LR Statistics For Type 3 Analysis

Source	DF	Chi-Square	Pr > ChiSq
area	6	2178.50	<.0001
year	20	341.42	<.0001
area*SEASON	21	579.06	<.0001

Table 14. Analysis of the mixed model formulations of the ***Updated Indices –Gulf Region***. The likelihood ratio was used to test the difference of –2 REM log likelihood between two nested models. The final models are indicated with gray shading.

ANALYSIS OF MIXED MODEL FORMULATIONS

Proportion Positive	-2 REM Log likelihood	Akaike's Information Criterion	Schwartz's Bayesian Criterion	Likelihood Ratio Test	P
Area+ Season + Year + Area*Season	15022.6	15024.6	15030.7	-	-
Area+ Season + Year + Area*Season + Year*Area	**14999.3**	**15003.3**	**15009.2**	**23.3**	**<0.0001**
Area+ Season + Year + Area*Season + Year*Area + Year*Season	15338.0	15344.0	15352.7	-338.7	1.0000

Catch Rates on Positive Trips	-2 REM Log likelihood	Akaike's Information Criterion	Schwartz's Bayesian Criterion	Likelihood Ratio Test	P
Area + Year + Area*Season	86914.4	86916.4	86924.6	-	-
Area + Year + Area*Season + Year*Season	86700.6	86704.6	86709.4	213.8	<0.0001
Area + Year + Area*Season + Year*Season + Year*Area	86344.8	86350.8	86359.6	355.8	<0.0001
Area + Year + Area*Season + VESSEL(Year)	**82448.0**	**82452.0**	**82461.5**	**4466.4**	**<0.0001**
Area + Year + Area*Season + Year*Season + VESSEL(Year)			Not Convergent		
Area + Year + Area*Season + Year*Area + VESSEL(Year)			Not Convergent		
Area + Year + Area*Season + Year*Area + Year*Season + VESSEL(Year)			Not Convergent		

Table 15. Nominal CPUE, number of trips, number of positive trips, proportion positive trips (PPT) and abundance index statistics for the ***Updated Index- Gulf Region***.

Year	Nominal CPUE	Trips	Proportion Positive Trips	Positive Trips	Rel. Index	LCI	UCI	CV
1986	13.592	3023	0.192	579	0.420	0.264	0.669	0.235
1987	12.149	3682	0.194	715	0.466	0.302	0.719	0.219
1988	11.011	4806	0.147	706	0.373	0.240	0.578	0.222
1989	9.770	5496	0.128	702	0.360	0.234	0.556	0.219
1990	6.594	7479	0.106	789	0.431	0.288	0.646	0.204
1991	9.047	6953	0.147	1021	0.775	0.534	1.123	0.187
1992	16.416	8175	0.179	1462	0.931	0.654	1.325	0.178
1993	10.611	8379	0.174	1457	0.790	0.556	1.122	0.177
1994	15.620	8753	0.222	1944	1.171	0.848	1.616	0.162
1995	20.861	7659	0.259	1987	1.281	0.922	1.781	0.166
1996	18.274	7248	0.229	1659	1.173	0.835	1.648	0.171
1997	20.054	7073	0.249	1759	1.302	0.933	1.816	0.168
1998	15.783	6769	0.226	1533	1.049	0.744	1.478	0.173
1999	19.385	6160	0.229	1413	1.307	0.930	1.837	0.171
2000	19.780	5769	0.282	1625	1.334	0.946	1.882	0.173
2001	20.425	5227	0.252	1317	0.998	0.694	1.435	0.183
2002	21.684	5445	0.275	1499	1.103	0.778	1.563	0.176
2003	26.244	5146	0.277	1424	1.337	0.946	1.889	0.174
2004	21.530	4986	0.231	1154	0.966	0.669	1.394	0.185
2005	30.052	4462	0.256	1142	1.472	1.030	2.103	0.180
2006	35.680	4210	0.322	1357	1.960	1.381	2.783	0.177

Table 16. Logistic regression coefficients and species composition information for the ***Atlantic Region***. Regression coefficients quantify the predictive importance of each species.

ATLANTIC REGION							
Species	**Common Name**	**Scientific Name**	**Positive Trips**	**% Occurrence**	**Number**	**% Catch (numbers)**	**Regression Coefficient**
74	KING MACKEREL	SCOMBEROMORUS CAVALLA	17216	14.60	60157	0.20	NA
56	SPANISH MACKEREL	SCOMBEROMORUS MACULATUS	2767	2.35	34060	0.11	1.23
117	DOLPHIN	CORYPHAENA HIPPURUS	8022	6.80	39660	0.13	0.99
116	LITTLE TUNNY	EUTHYNNUS ALLETTERATUS	7776	6.59	26056	0.09	0.90
121	GREAT BARRACUDA	SPHYRAENA BARRACUDA	6388	5.42	11636	0.04	0.72
5	JOLTHEAD PORGY	CALAMUS BAJONADO	2778	2.36	18776	0.06	0.56
60	GREATER AMBERJACK	SERIOLA DUMMERILI	24411	20.70	144068	0.47	0.55
10	VERMILION SNAPPER	RHOMBOPLITES AURORUBENS	55832	47.33	7786062	25.66	0.53
50	WHITE GRUNT	HAEMULON PLUMIERI	28912	24.51	1668970	5.50	0.38
55	COBIA	RACHYCENTRON CANADUM	8354	7.08	15101	0.05	0.31
98	BIGEYE	PRIACANTHUS ARENATUS	4608	3.91	22123	0.07	0.21
18	GRAY SNAPPER	LUTJANUS GRISEUS	12845	10.89	101198	0.33	0.21
1	RED PORGY	PAGRUS PAGRUS	36504	30.95	2760233	9.10	0.19
82	QUEEN TRIGGERFISH	BALISTES VETULA	4313	3.66	14810	0.05	0.19
77	GRAY TRIGGERFISH	BALISTES CAPRISCUS	45461	38.54	955119	3.15	0.16
22	RED GROUPER	EPINEPHELUS MORIO	9320	7.90	27730	0.09	0.15
3	KNOBBED PORGY	CALAMUS NODOSUS	13295	11.27	167772	0.55	0.14
29	GAG	MYCTEROPERCA MICROLEPIS	36060	30.57	176121	0.58	0.14
30	SCAMP	MYCTEROPERCA PHENAX	25301	21.45	259625	0.86	0.09
26	ROCK HIND	EPINEPHELUS ADSCENSIONIS	6104	5.18	31700	0.10	0.08
2	WHITEBONE PORGY	CALAMUS LEUCOSTEUS	29206	24.76	186940	0.62	0.08
123	BANDED RUDDERFISH	SERIOLA ZONATA	4381	3.71	131965	0.43	0.07
11	RED SNAPPER	LUTJANUS CAMPECHANUS	32661	27.69	288651	0.95	0.05
34	BANK SEA BASS	CENTROPRISTIS OCYURUS	14369	12.18	405533	1.34	0.04
88	GRAYSBY	EPINEPHELUS CRUENTATUS	5427	4.60	42451	0.14	0.03
51	TOMTATE	HAEMULON AUROLINEATUM	51024	43.26	3302250	10.88	0.00
62	ALMACO JACK	SERIOLA RIVOLIANA	6478	5.49	44561	0.15	-0.02
15	YELLOWTAIL SNAPPER	OCYURUS CHRYSURUS	2597	2.20	9199	0.03	-0.04
78	SQUIRRELFISH	HOLOCENTRUS ASCENSIONIS	2632	2.23	17182	0.06	-0.06
230	SHARPNOSE SHARK	RHIZOPRIONODON TERRAENOVAE	15552	13.19	117218	0.39	-0.08
38	SAND PERCH	DIPLECTRUM FORMOSUM	7145	6.06	122125	0.40	-0.10
9	LONGSPINE PORGY	STENOTOMUS CARPRINUS	3898	3.30	105175	0.35	-0.16
79	BLUEFISH	POMATOMUS SALTATRIX	2723	2.31	31788	0.10	-0.17
16	LANE SNAPPER	LUTJANUS SYNAGRIS	8451	7.16	34982	0.12	-0.26
83	PINFISH	LAGODON RHOMBOIDES	6627	5.62	92311	0.30	-0.29
33	BLACK SEA BASS	CENTROPRISTIS STRIATUS	89651	76.01	9996595	32.94	-0.33
4	SPOTTAIL PINFISH	DIPLODUS HOLBROOKI	17301	14.67	614005	2.02	-0.42
81	PIGFISH	ORTHOPRISTIS CHRYSOPTERA	7968	6.76	109992	0.36	-0.43
20	SPECKLED HIND	EPINEPHELUS DRUMMONDHAYI	6849	5.81	32790	0.11	-0.43

Table 17. Logistic regression coefficients and species composition information for the ***Mixing Region***. Regression coefficients quantify the predictive importance of each species.

MIXING REGION							
Species	**Common Name**	**Scientific Name**	**Positive Trips**	**% Occurrence**	**Number**	**% Catch (numbers)**	**Regression Coefficient**
74	KING MACKEREL	SCOMBEROMORUS CAVALLA	75877	40.79	400185	3.68	NA
120	ATLANTIC BONITO	SARDA SARDA	7675	4.13	45382	0.42	1.06
116	LITTLE TUNNY	EUTHYNNUS ALLETTERATUS	40569	21.81	212372	1.95	0.70
56	SPANISH MACKEREL	SCOMBEROMORUS MACULATUS	4088	2.20	14644	0.13	0.51
78	SQUIRRELFISH	HOLOCENTRUS ASCENSIONIS	8405	4.52	34434	0.32	0.44
79	BLUEFISH	POMATOMUS SALTATRIX	4173	2.24	50121	0.46	0.38
55	COBIA	RACHYCENTRON CANADUM	9968	5.36	15099	0.14	0.31
30	SCAMP	MYCTEROPERCA PHENAX	6775	3.64	14892	0.14	0.30
19	MUTTON SNAPPER	LUTJANUS ANALIS	64371	34.60	234645	2.16	0.28
97	BLUE RUNNER	CARANX CRYSOS	48027	25.82	405330	3.73	0.23
121	GREAT BARRACUDA	SPHYRAENA BARRACUDA	18166	9.77	31693	0.29	0.17
41	CERO	SCOMBEROMORUS REGALIS	6985	3.75	15652	0.14	0.12
44	SAND TILEFISH	MALACANTHUS PLUMIERI	8563	4.60	33401	0.31	0.10
88	GRAYSBY	EPINEPHELUS CRUENTATUS	4295	2.31	9888	0.09	0.09
60	GREATER AMBERJACK	SERIOLA DUMMERILI	10516	5.65	44415	0.41	0.09
98	BIGEYE	PRIACANTHUS ARENATUS	17400	9.35	90101	0.83	0.05
82	QUEEN TRIGGERFISH	BALISTES VETULA	5647	3.04	9308	0.09	0.04
26	ROCK HIND	EPINEPHELUS ADSCENSIONIS	8913	4.79	31301	0.29	0.03
77	GRAY TRIGGERFISH	BALISTES CAPRISCUS	44360	23.85	187122	1.72	0.03
117	DOLPHIN	CORYPHAENA HIPPURUS	12852	6.91	93788	0.86	0.02
57	RAINBOW RUNNER	ELAGATIS BIPINNULATUS	4894	2.63	22027	0.20	-0.04
76	OCEAN TRIGGERFISH	CANTHIDERMIS SUFFLAMEN	5788	3.11	13816	0.13	-0.07
7	SHEEPSHEAD PORGY	CALAMUS PENNA	4597	2.47	16183	0.15	-0.09
22	RED GROUPER	EPINEPHELUS MORIO	27616	14.84	71289	0.66	-0.09
145	FRENCH GRUNT	HAEMULON FLAVOLINEATUM	4895	2.63	31943	0.29	-0.10
62	ALMACO JACK	SERIOLA RIVOLIANA	3870	2.08	10008	0.09	-0.10
16	LANE SNAPPER	LUTJANUS SYNAGRIS	42794	23.00	529666	4.87	-0.12
10	VERMILION SNAPPER	RHOMBOPLITES AURORUBENS	34137	18.35	1012321	9.31	-0.13
2	WHITEBONE PORGY	CALAMUS LEUCOSTEUS	7238	3.89	29085	0.27	-0.14
29	GAG	MYCTEROPERCA MICROLEPIS	21896	11.77	52786	0.49	-0.14
53	MARGATE	HAEMULON ALBUM	6375	3.43	20176	0.19	-0.14
11	RED SNAPPER	LUTJANUS CAMPECHANUS	12936	6.95	132548	1.22	-0.16
1	RED PORGY	PAGRUS PAGRUS	8020	4.31	61992	0.57	-0.24
12	SILK SNAPPER	LUTJANUS VIVANUS	5272	2.83	59000	0.54	-0.24
6	LITTLEHEAD PORGY	CALAMUS PRORIDENS	5872	3.16	27269	0.25	-0.27
230	SHARPNOSE SHARK	RHIZOPRIONODON TERRAENOVAE	5213	2.80	32698	0.30	-0.30
3	KNOBBED PORGY	CALAMUS NODOSUS	18587	9.99	117002	1.08	-0.35
32	BLACK GROUPER	MYCTEROPERCA BONACI	8670	4.66	16369	0.15	-0.37
129	SAUCEREYE PORGY	CALAMUS CALAMUS	4281	2.30	21930	0.20	-0.40
15	YELLOWTAIL SNAPPER	OCYURUS CHRYSURUS	92857	49.91	2299022	21.14	-0.41
18	GRAY SNAPPER	LUTJANUS GRISEUS	56346	30.29	582037	5.35	-0.45
99	SCHOOLMASTER	LUTJANUS APODUS	4065	2.19	13646	0.13	-0.48
5	JOLTHEAD PORGY	CALAMUS BAJONADO	16722	8.99	72777	0.67	-0.54
54	BLUESTRIPED GRUNT	HAEMULON SCIURUS	14785	7.95	159044	1.46	-0.55
51	TOMTATE	HAEMULON AUROLINEATUM	22673	12.19	715732	6.58	-0.60
33	BLACK SEA BASS	CENTROPRISTIS STRIATUS	21085	11.33	788206	7.25	-0.74
50	WHITE GRUNT	HAEMULON PLUMIERI	39897	21.45	1790486	16.47	-0.97

Table 18. Logistic regression coefficients and species composition information for the ***Gulf Region***. Regression coefficients quantify predictive importance of each species.

GULF OF MEXICO REGION							
Species	**Common Name**	**Scientific Name**	**Positive Trips**	**% Occurrence**	**Number**	**% Catch (numbers)**	**Regression Coefficient**
74	KING MACKEREL	SCOMBEROMORUS CAVALLA	31440	19.91	281901	1.00	NA
117	DOLPHIN	CORYPHAENA HIPPURUS	8361	5.30	66444	0.24	0.99
56	SPANISH MACKEREL	SCOMBEROMORUS MACULATUS	3667	2.32	9914	0.04	0.94
116	LITTLE TUNNY	EUTHYNNUS ALLETTERATUS	15519	9.83	67125	0.24	0.80
230	SHARPNOSE SHARK	RHIZOPRIONODON TERRAENOVAE	15665	9.92	195365	0.69	0.76
55	COBIA	RACHYCENTRON CANADUM	10671	6.76	23716	0.08	0.75
126	BLACKFIN TUNA	THUNNUS ATLANTICUS	4319	2.74	75556	0.27	0.47
123	BANDED RUDDERFISH	SERIOLA ZONATA	4056	2.57	102401	0.36	0.34
18	GRAY SNAPPER	LUTJANUS GRISEUS	29285	18.55	420868	1.49	0.26
231	BLACKTIP SHARK	CARCHARHINUS LIMBATUS	3554	2.25	11745	0.04	0.26
26	ROCK HIND	EPINEPHELUS ADSCENSIONIS	4357	2.76	14658	0.05	0.21
30	SCAMP	MYCTEROPERCA PHENAX	12596	7.98	40128	0.14	0.18
62	ALMACO JACK	SERIOLA RIVOLIANA	5406	3.42	25502	0.09	0.14
16	LANE SNAPPER	LUTJANUS SYNAGRIS	43477	27.54	634224	2.25	0.13
60	GREATER AMBERJACK	SERIOLA DUMMERILI	18441	11.68	218686	0.78	0.09
97	BLUE RUNNER	CARANX CRYSOS	6493	4.11	64766	0.23	0.03
1	RED PORGY	PAGRUS PAGRUS	34188	21.65	1735404	6.15	0.01
47	ATLANTIC SPADEFISH	CHAETODIPTERUS FABER	4063	2.57	169955	0.60	-0.01
79	BLUEFISH	POMATOMUS SALTATRIX	3885	2.46	53984	0.19	-0.06
10	VERMILION SNAPPER	RHOMBOPLITES AURORUBENS	60065	38.05	6324714	22.43	-0.11
3	KNOBBED PORGY	CALAMUS NODOSUS	7812	4.95	38626	0.14	-0.12
81	PIGFISH	ORTHOPRISTIS CHRYSOPTERA	6394	4.05	94494	0.34	-0.13
2	WHITEBONE PORGY	CALAMUS LEUCOSTEUS	11017	6.98	43588	0.15	-0.17
11	RED SNAPPER	LUTJANUS CAMPECHANUS	65113	41.24	5266793	18.68	-0.18
83	PINFISH	LAGODON RHOMBOIDES	4256	2.70	34303	0.12	-0.28
23	WARSAW GROUPER	EPINEPHELUS NIGRITUS	4870	3.08	7139	0.03	-0.30
77	GRAY TRIGGERFISH	BALISTES CAPRISCUS	72817	46.12	1161030	4.12	-0.31
34	BANK SEA BASS	CENTROPRISTIS OCYURUS	15613	9.89	710331	2.52	-0.32
29	GAG	MYCTEROPERCA MICROLEPIS	47331	29.98	258250	0.92	-0.33
38	SAND PERCH	DIPLECTRUM FORMOSUM	17685	11.20	416125	1.48	-0.33
22	RED GROUPER	EPINEPHELUS MORIO	31251	19.79	173208	0.61	-0.39
32	BLACK GROUPER	MYCTEROPERCA BONACI	3244	2.05	21935	0.08	-0.57
139	GRASS PORGY	CALAMUS ARCTIFRONS	5583	3.54	29171	0.10	-0.57
15	YELLOWTAIL SNAPPER	OCYURUS CHRYSURUS	4141	2.62	44323	0.16	-0.62
51	TOMTATE	HAEMULON AUROLINEATUM	29868	18.92	2129848	7.55	-0.67
6	LITTLEHEAD PORGY	CALAMUS PRORIDENS	10600	6.71	75534	0.27	-0.73
33	BLACK SEA BASS	CENTROPRISTIS STRIATUS	23114	14.64	399859	1.42	-0.76
50	WHITE GRUNT	HAEMULON PLUMIERI	57980	36.72	6200503	21.99	-2.63

Table 19. GENMOD regression statistics for the fixed factors and interactions terms for A) the proportion positive trips and B) catch rates on positive trips for the ***Updated Indices with Species Composition –Atlantic Region.***

A)

LR Statistics For Type 3 Analysis

Source	DF	Chi-Square	Pr > ChiSq
area	8	632.95	<.0001
year	26	374.61	<.0001
SEASON	3	287.70	<.0001

B)

LR Statistics For Type 3 Analysis

Source	DF	Chi-Square	Pr > ChiSq
area	8	124.79	<.0001
year	26	339.67	<.0001
SEASON	3	12.28	0.0065
area*SEASON	20	186.63	<.0001

Table 20. Analysis of the mixed model formulations of the ***Updated Indices with Species Composition –Atlantic Region***. The likelihood ratio was used to test the difference of –2 REM log likelihood between two nested models. The final models are indicated with gray shading.

ANALYSIS OF MIXED MODEL FORMULATIONS

Proportion Positive	-2 REM Log likelihood	Akaike's Information Criterion	Schwartz's Bayesian Criterion	Likelihood Ratio Test	P
Area+ Year + Season	**67957.8**	**67959.8**	**67967.5**	**-**	**-**
Area+ Year + Season + Year*Area			Did not converge		
Area+ Year + Season + Year*Season			Did not converge		

Catch Rates on Positive Trips	-2 REM Log likelihood	Akaike's Information Criterion	Schwartz's Bayesian Criterion	Likelihood Ratio Test	P
Area + Year + Season + Area*Season	22453.8	22455.8	22462.7	-	-
Area + Year + Season + Area*Season + Year*Area	22282.6	22286.6	22292.9	171.2	<0.0001
Area + Year + Season + Area*Season + Year*Area + Year*Season	22262.5	22268.5	22277.9	20.1	<0.0001
Area + Year + Season + Area*Season + Vessel(Year)	19212.9	19216.9	19225.6	3240.9	<0.0001
Area + Year + Season + Area*Season + Vessel(Year) + Year*Area			Did not converge		
Area + Year + Season + Area*Season + Vessel(Year) + Year*Season	**19174.4**	**19180.4**	**19188.2**	**38.5**	**<0.0001**

Table 21. Nominal CPUE, number of trips, number of positive trips, proportion positive trips (PPT) and abundance index statistics for the ***Updated Index with Species Composition- Atlantic Region***.

Year	Nominal CPUE	Trips	Proportion Positive Trips	Positive Trips	Rel. Index	LCI	UCI	CV
1979	2.976	150	0.187	28	0.513	0.194	1.361	0.518
1980	11.112	311	0.396	123	0.997	0.531	1.872	0.323
1981	11.666	208	0.433	90	1.624	0.809	3.261	0.360
1982	10.263	281	0.520	146	1.497	0.753	2.975	0.354
1983	6.721	395	0.494	195	1.470	0.800	2.700	0.311
1984	10.112	455	0.451	205	0.886	0.523	1.502	0.268
1985	5.285	426	0.413	176	0.598	0.336	1.067	0.295
1986	9.087	530	0.451	239	0.817	0.501	1.333	0.249
1987	12.186	609	0.437	266	0.925	0.572	1.495	0.243
1988	8.521	487	0.462	225	0.842	0.509	1.394	0.256
1989	18.061	4	1.000	4	NA	NA	NA	NA
1990	NA	0	0.000	0	NA	NA	NA	NA
1991	29.248	601	0.571	343	1.114	0.680	1.827	0.251
1992	22.681	671	0.590	396	1.571	1.000	2.470	0.229
1993	17.046	705	0.414	292	0.785	0.474	1.300	0.256
1994	9.581	716	0.387	277	0.562	0.336	0.937	0.260
1995	8.734	775	0.414	321	0.612	0.375	0.999	0.249
1996	8.165	778	0.338	263	0.386	0.230	0.648	0.263
1997	40.647	943	0.466	439	0.979	0.626	1.531	0.227
1998	42.127	865	0.510	441	1.106	0.707	1.730	0.226
1999	14.968	841	0.460	387	0.987	0.624	1.560	0.232
2000	52.282	876	0.604	529	1.692	1.093	2.620	0.221
2001	28.626	750	0.487	365	1.076	0.679	1.705	0.233
2002	22.960	709	0.453	321	0.873	0.532	1.432	0.251
2003	36.122	550	0.473	260	0.825	0.507	1.343	0.247
2004	37.643	736	0.361	266	0.863	0.527	1.413	0.250
2005	30.365	568	0.467	265	1.353	0.810	2.260	0.261
2006	37.966	725	0.476	345	1.045	0.655	1.667	0.237

Table 22. GENMOD regression statistics for the fixed factors and interactions terms for A) the proportion positive trips and B) catch rates on positive trips for the ***Updated Indices with Species Composition –Mixing Region.***

A)

LR Statistics For Type 3 Analysis

Source	DF	Chi-Square	Pr > ChiSq
area	6	7568.26	<.0001
SEASON	3	1250.74	<.0001
year	27	920.78	<.0001

B)

LR Statistics For Type 3 Analysis

Source	DF	Chi-Square	Pr > ChiSq
area	5	1582.53	<.0001
year	27	1225.62	<.0001

Table 23 . Analysis of the mixed model formulations of the ***Updated Indices with Species Composition –Mixing Region***. The likelihood ratio was used to test the difference of –2 REM log likelihood between two nested models. The final models are indicated with gray shading.

ANALYSIS OF MIXED MODEL FORMULATIONS

Proportion Positive	-2 REM Log likelihood	Akaike's Information Criterion	Schwartz's Bayesian Criterion	Likelihood Ratio Test	P
Area + Season + Year	**9084.1**	**9086.1**	**9091.9**	**-**	**-**
Area + Season + Year + Year*Area			Not Convergent		
Area + Season + Year + Year*Season			Not Convergent		

Catch Rates on Positive Trips	-2 REM Log likelihood	Akaike's Information Criterion	Schwartz's Bayesian Criterion	Likelihood Ratio Test	P
Area + Year	165131.0	165133.0	165142.0	-	-
Area + Year + Year*Area	164913.9	164917.9	164923.2	217.1	<0.0001
Area + Year + Year*Area + Year*Season	162970.2	162976.2	162984.1	1943.7	<0.0001
Area + Year + Vessel(Year)	161888.8	161892.8	161902.1	3242.2	<0.0001
Area + Year + Vessel(Year) + Year*Area			Not Convergent		
Area + Year + Vessel(Year) + Year*Season	**160319.8**	**160325.8**	**160334.0**	**1569.0**	**<0.0001**

Table 24. Nominal CPUE, number of trips, number of positive trips, proportion positive trips (PPT) and abundance index statistics for the ***Updated Index with Species Composition - Mixing Region***.

Year	Nominal CPUE	Trips	Proportion Positive Trips	Positive Trips	Rel. Index	LCI	UCI	CV
1979	80.559	2571	0.698	1795	0.969	0.490	1.915	0.351
1980	96.089	4037	0.703	2840	1.103	0.589	2.065	0.321
1981	119.902	4754	0.655	3115	1.257	0.656	2.412	0.334
1982	54.547	5319	0.639	3399	0.752	0.382	1.481	0.349
1983	56.060	5311	0.626	3324	0.772	0.388	1.539	0.355
1984	74.149	4084	0.687	2804	0.952	0.506	1.793	0.324
1985	50.142	3783	0.644	2438	0.699	0.346	1.413	0.363
1986	52.422	4738	0.671	3177	0.593	0.298	1.181	0.355
1987	63.185	4877	0.682	3324	0.886	0.458	1.714	0.339
1988	40.681	3614	0.525	1897	0.386	0.171	0.869	0.424
1989	58.396	4341	0.668	2899	0.761	0.379	1.529	0.360
1990	66.560	4386	0.691	3031	0.916	0.463	1.812	0.352
1991	89.755	4435	0.686	3041	1.100	0.563	2.147	0.344
1992	54.898	4435	0.648	2876	0.818	0.416	1.607	0.348
1993	69.828	4167	0.667	2781	0.965	0.502	1.854	0.335
1994	62.672	3502	0.655	2293	0.835	0.430	1.622	0.342
1995	66.419	3312	0.616	2041	0.825	0.411	1.658	0.360
1996	84.583	1761	0.601	1058	1.232	0.633	2.399	0.343
1997	93.081	2110	0.690	1455	1.537	0.857	2.759	0.299
1998	72.887	1615	0.633	1022	1.047	0.561	1.953	0.320
1999	52.802	1162	0.529	615	0.947	0.470	1.906	0.361
2000	56.135	1122	0.635	713	1.089	0.564	2.103	0.338
2001	51.359	837	0.654	547	1.008	0.526	1.934	0.335
2002	42.840	494	0.536	265	0.927	0.440	1.952	0.386
2003	62.479	442	0.602	266	1.295	0.645	2.600	0.360
2004	45.219	481	0.568	273	0.860	0.405	1.822	0.389
2005	104.990	574	0.777	446	1.763	0.967	3.213	0.307
2006	118.595	524	0.782	410	1.707	0.924	3.152	0.314

Table 25. GENMOD regression statistics for the fixed factors and interactions terms for A) the proportion positive trips and B) catch rates on positive trips for the ***Updated Indices with Species Composition –Gulf Region.***

A)

LR Statistics For Type 3 Analysis

Source	DF	Chi-Square	Pr > ChiSq
SEASON	3	3142.36	<.0001
area	6	2364.47	<.0001
year	20	648.65	<.0001

B)

LR Statistics For Type 3 Analysis

Source	DF	Chi-Square	Pr > ChiSq
area	6	423.52	<.0001
SEASON	3	0.54	0.9097
year	20	149.69	<.0001
area*SEASON	18	209.37	<.0001

Table 26 . Analysis of the mixed model formulations of the ***Updated Indices with Species Composition – Gulf Region***. The likelihood ratio was used to test the difference of –2 REM log likelihood between two nested models. The final models are indicated with gray shading.

ANALYSIS OF MIXED MODEL FORMULATIONS

Proportion Positive	-2 REM Log likelihood	Akaike's Information Criterion	Schwartz's Bayesian Criterion	Likelihood Ratio Test	P
Season + Area + Year	**9127.5**	**9129.5**	**9135.2**	**-**	**-**
Season + Area + Year + Year*Season	9351.5	9355.5	9360.4	-224.0	1.0000
Season + Area + Year + Year*Area	9128.3	9132.3	9138.1	-0.8	1.0000
Catch Rates on Positive Trips	-2 REM Log likelihood	Akaike's Information Criterion	Schwartz's Bayesian Criterion	Likelihood Ratio Test	P
Area + Season + Year	63142.0	63144.0	63151.8	-	-
Area + Season + Year + Year*Area	62562.2	62566.2	62571.8	579.8	<0.0001
Area + Season + Year + Year*Area + Year*Season	62434.6	62440.6	62449.1	127.6	<0.0001
Area + Season + Year + Vessel(Year)	59569.7	59573.7	59582.9	3572.3	<0.0001
Area + Season + Year + Vessel(Year) + Year*Area			Not Convergent		
Area + Season + Year + Vessel(Year) + Year*Season	**59374.2**	**59380.2**	**59387.3**	**3060.4**	**<0.0001**

Table 27. Nominal CPUE, number of trips, number of positive trips, proportion positive trips (PPT) and abundance index statistics for the ***Updated Index with Species Composition - Gulf Region***.

Year	Nominal CPUE	Trips	Proportion Positive Trips	Positive Trips	Rel. Index	LCI	UCI	CV
1986	46.563	958	0.550	527	0.745	0.442	1.253	0.265
1987	40.099	1160	0.506	587	0.649	0.394	1.067	0.253
1988	43.822	1273	0.493	627	0.730	0.439	1.215	0.259
1989	48.839	1337	0.461	616	0.545	0.328	0.906	0.258
1990	37.585	1532	0.428	655	0.535	0.328	0.872	0.248
1991	39.379	1519	0.460	699	0.737	0.453	1.199	0.247
1992	65.771	1834	0.523	959	1.009	0.626	1.627	0.242
1993	46.016	1623	0.503	817	0.783	0.492	1.247	0.236
1994	50.206	2101	0.599	1258	1.136	0.731	1.766	0.223
1995	63.156	2123	0.629	1335	1.160	0.754	1.784	0.218
1996	68.161	1611	0.636	1025	1.461	0.940	2.272	0.223
1997	64.423	1908	0.631	1203	1.395	0.901	2.160	0.221
1998	50.681	1823	0.581	1060	1.196	0.769	1.859	0.223
1999	63.380	1685	0.564	951	1.106	0.704	1.739	0.229
2000	52.064	1724	0.557	961	1.141	0.729	1.787	0.227
2001	54.179	1578	0.528	833	0.816	0.514	1.297	0.235
2002	48.896	1888	0.525	992	0.849	0.541	1.331	0.228
2003	73.492	1591	0.620	987	1.354	0.864	2.121	0.227
2004	62.361	1547	0.560	867	0.642	0.402	1.025	0.237
2005	79.031	1450	0.597	865	1.183	0.745	1.877	0.234
2006	79.151	1812	0.671	1216	1.829	1.176	2.844	0.224

A) B)

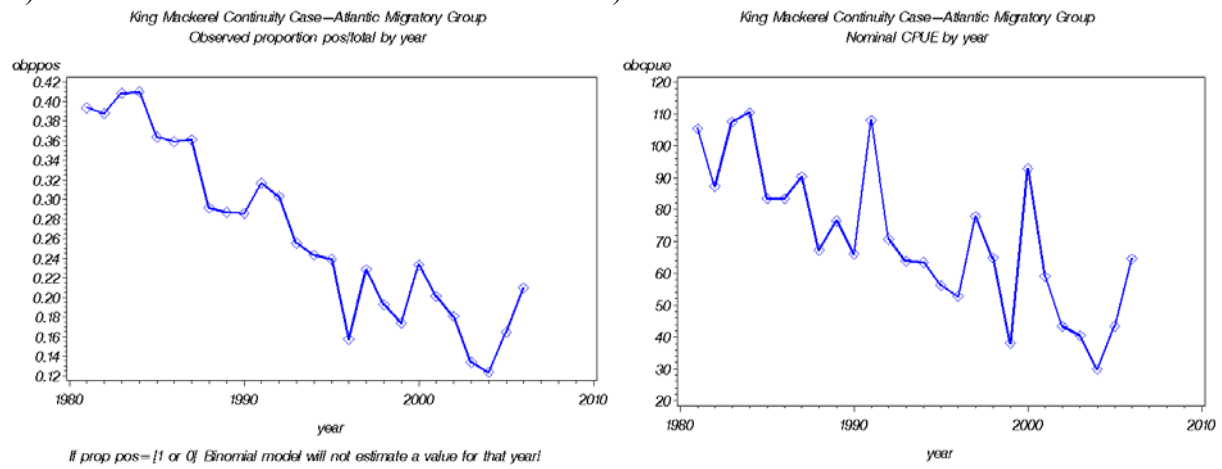


Figure 1. Annual trend in the proportion of positive trips (A) and nominal CPUE (B) for the ***Continuity Case - Atlantic Migratory Group***.

A) B)

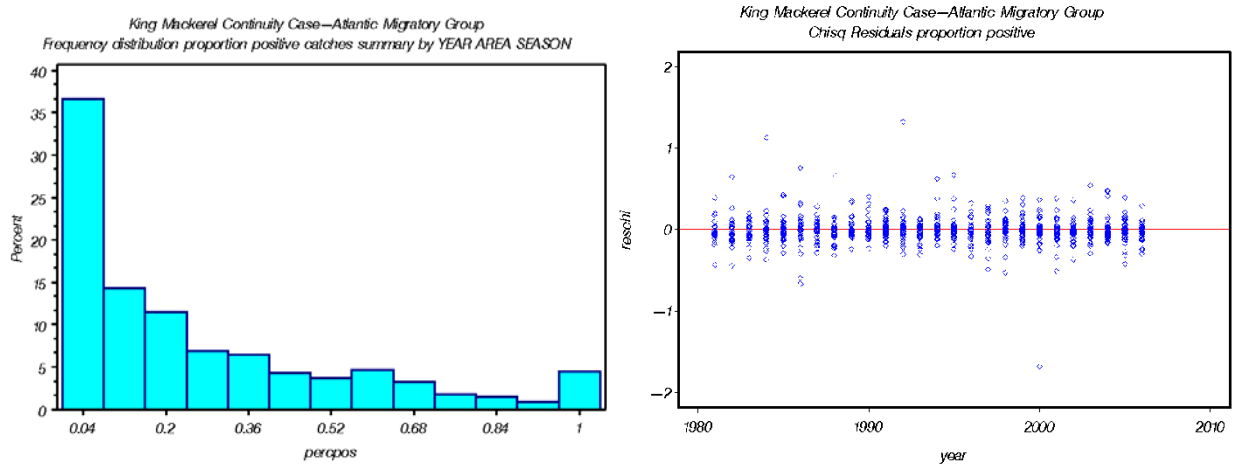
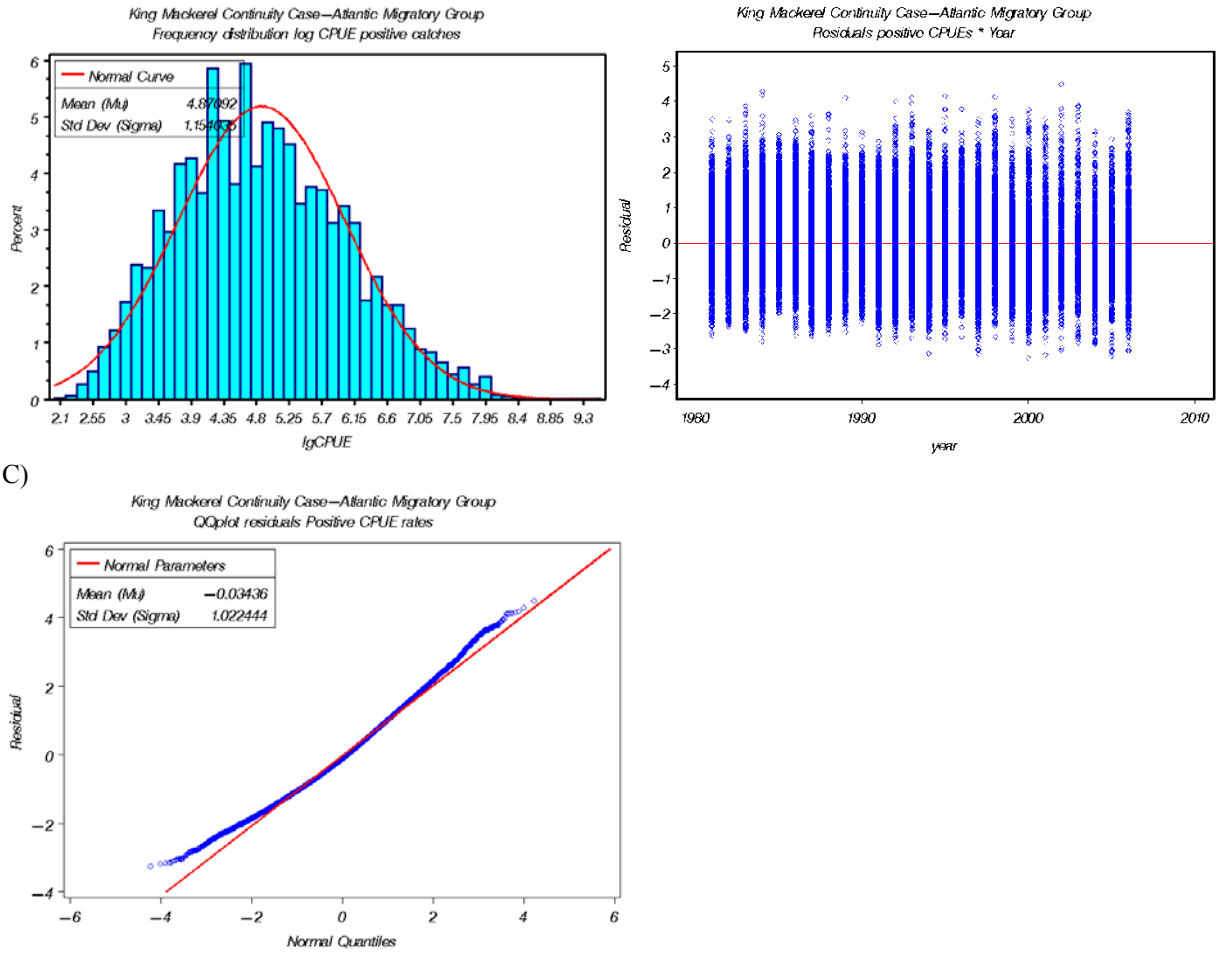


Figure 2. Diagnostic plots for the binomial component of the ***Continuity Case - Atlantic Migratory Group***: A) the frequency distribution of the proportion positive trips and B) the Chi-Square residuals by year.

A) B)



C)

Figure 3. Diagnostic plots for the lognormal component of the ***Continuity Case - Atlantic Migratory Group***: A) the frequency distribution of log(CPUE)on positive trips, B) the residuals by year and C) the cumulative normalized residuals (QQ-Plot) from the lognormal model on the catch rates of positive trips. The red line is the expected normal distribution.

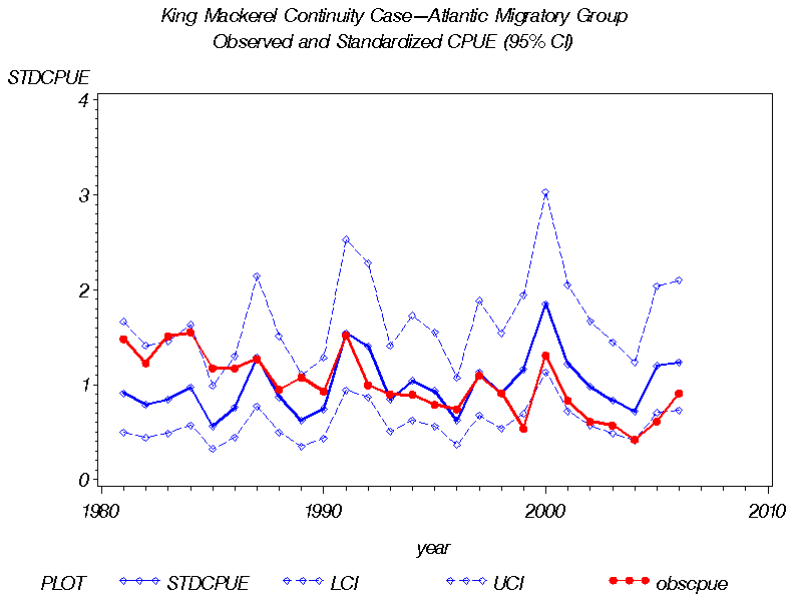


Figure 4. The standardized index (solid blue line open symbols) and nominal CPUE (solid red line filled symbols) with 95% confidence intervals (dashed lines) for the ***Continuity Case for the Atlantic Migratory Group***.

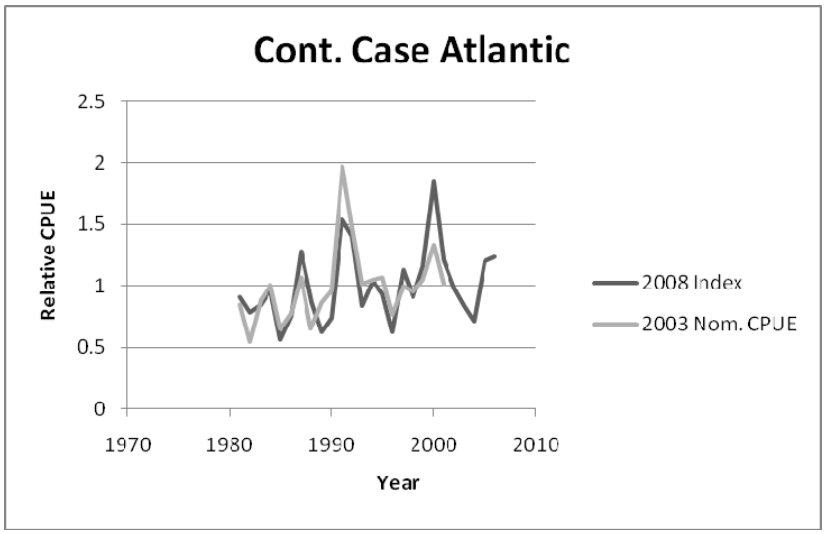


Figure 5. The previous standardized index (2003) compared to the 2008 ***Continuity Case for the Atlantic Migratory Group***.

A) B)

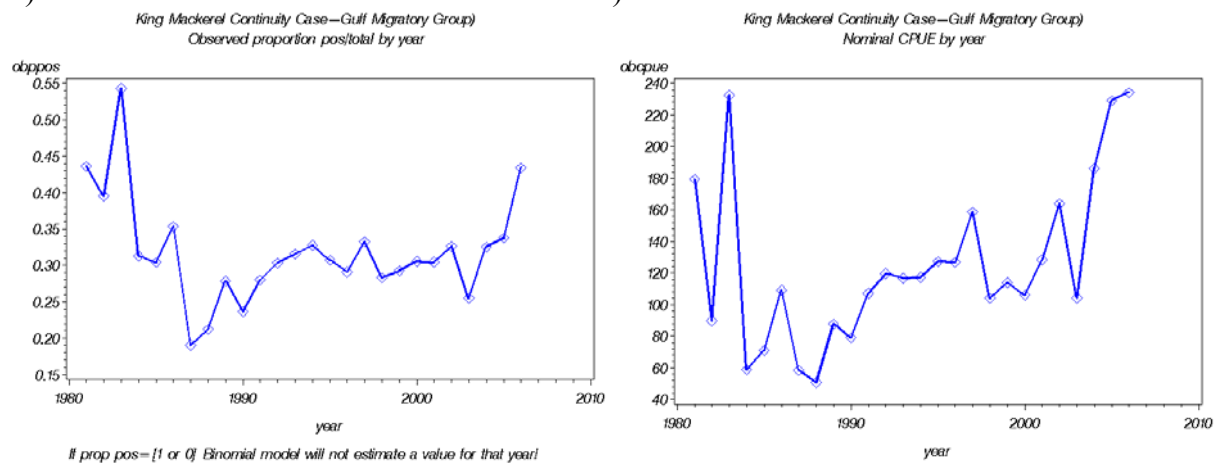


Figure 6. Annual trend in the proportion of positive trips (A) and nominal CPUE (B) for the ***Continuity Case - Gulf Migratory Group***.

A) B)

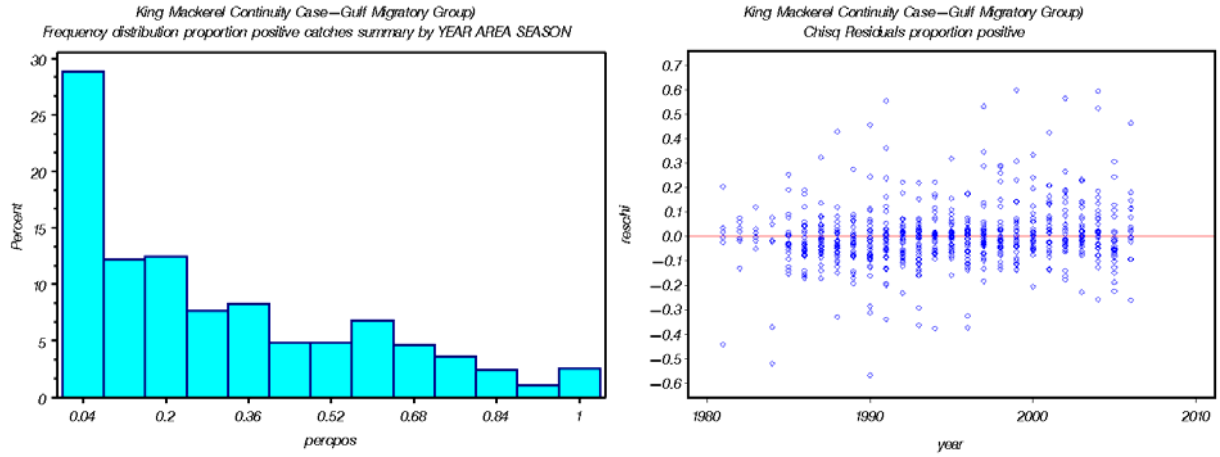
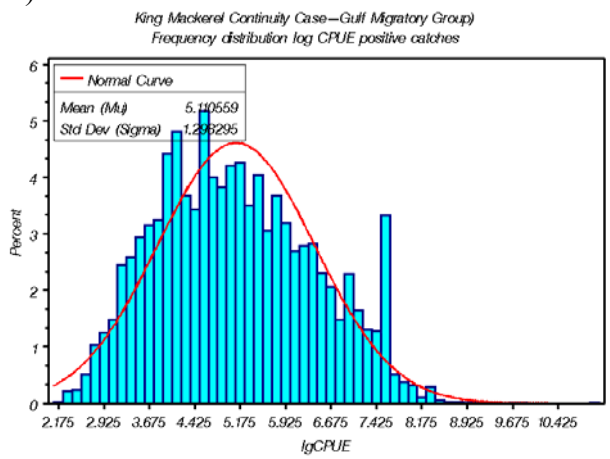
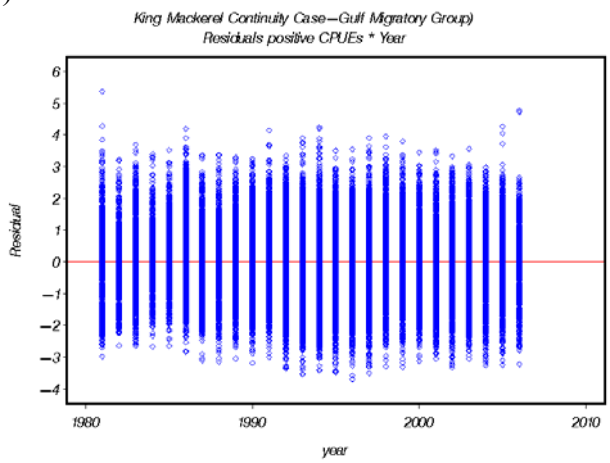


Figure 7. Diagnostic plots for the binomial component of the ***Continuity Case - Gulf Migratory Group***: A) the frequency distribution of the proportion positive trips and B) the Chi-Square residuals by year.

A)



B)



C)

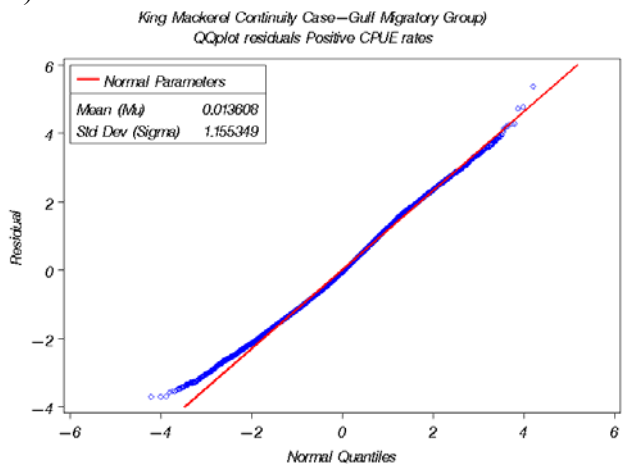


Figure 8. Diagnostic plots for the lognormal component of the ***Continuity Case - Gulf Migratory Group***: A) the frequency distribution of log(CPUE)on positive trips, B) the residuals by year and C) the cumulative normalized residuals (QQ-Plot) from the lognormal model on the catch rates of positive trips. The red line is the expected normal distribution.

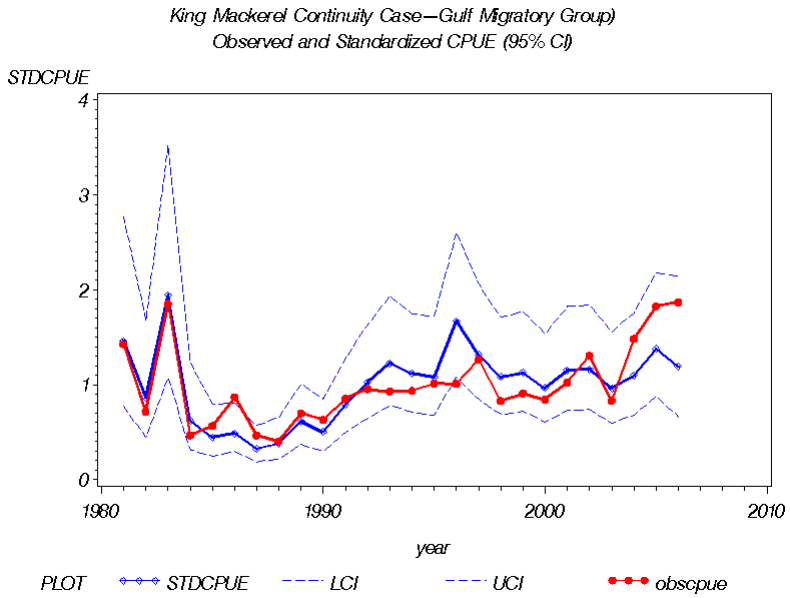


Figure 9. The standardized index (solid blue line open symbols) and nominal CPUE (solid red line filled symbols) with 95% confidence intervals (dashed lines) for the ***Continuity Case - Gulf Migratory Group***.

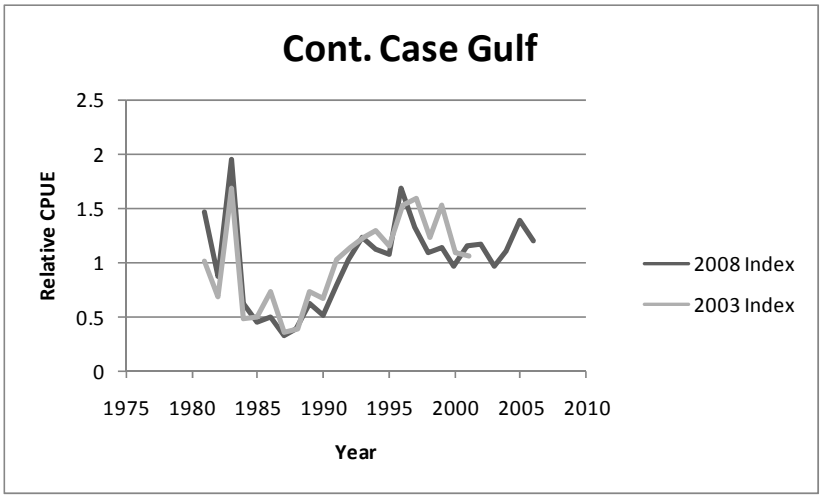


Figure 10. The previous standardized index (2003) compared to the 2008 ***Continuity Case - Gulf Migratory Group***.

A) B)

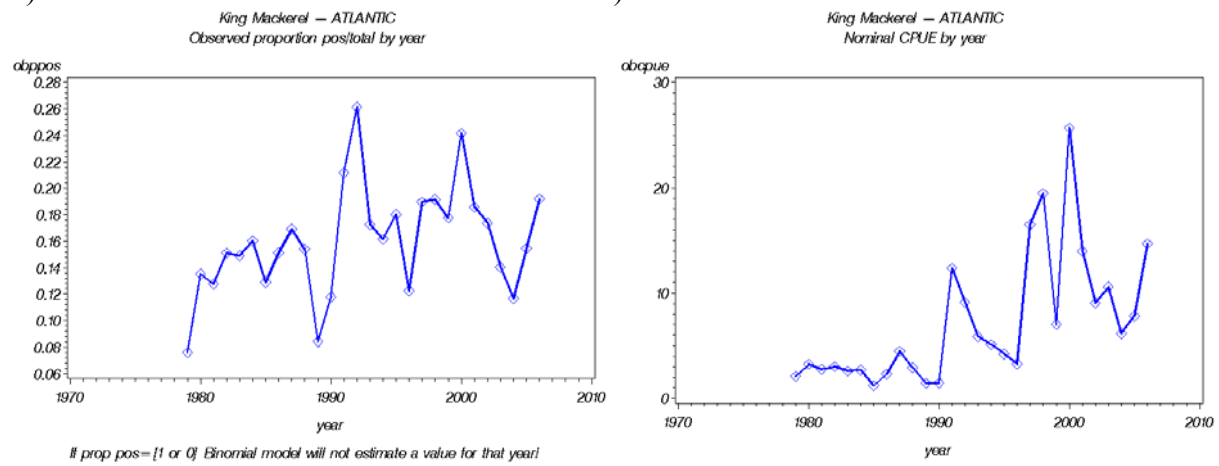


Figure 11. Annual trend in the proportion of positive trips (A) and nominal CPUE (B) for the ***Updated Model – Atlantic Region***.

A) B)

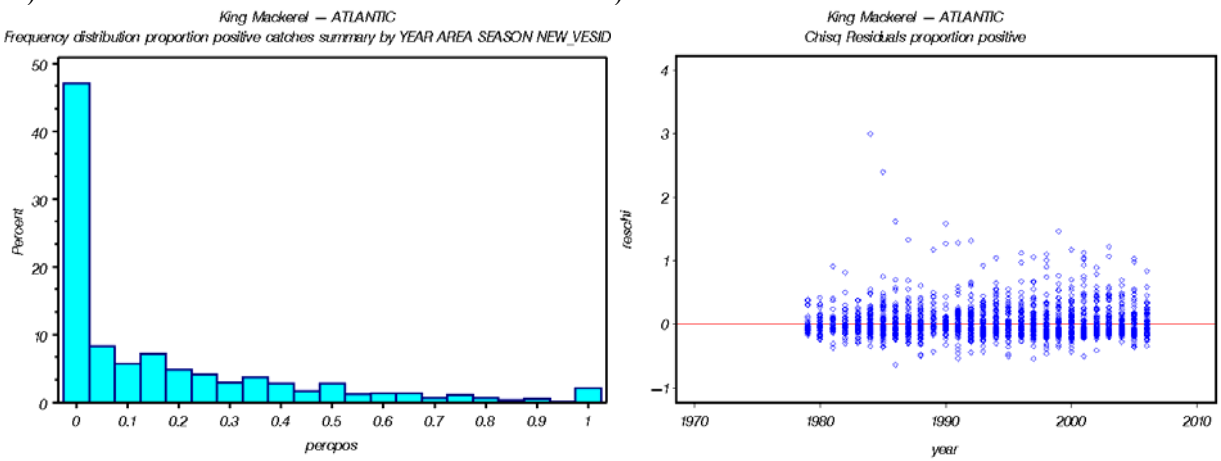
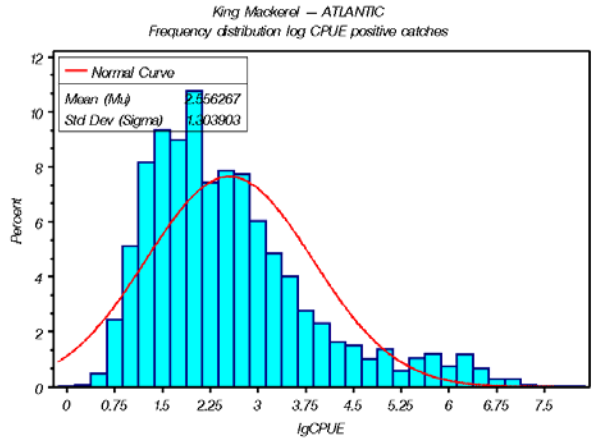
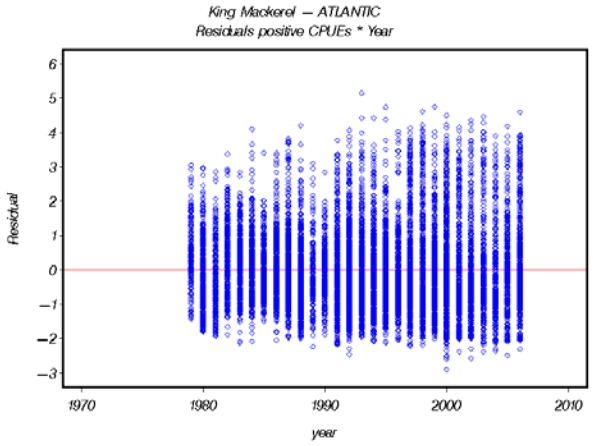


Figure 12. Diagnostic plots for the binomial component of the ***Continuity Updated Model – Atlantic Region***: A) the frequency distribution of the proportion positive trips and B) the Chi-Square residuals by year.

A)



B)



C)

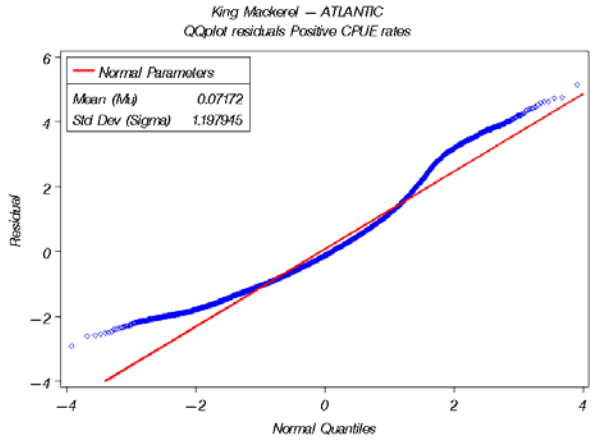


Figure 13. Diagnostic plots for the lognormal component of the ***Updated Model – Atlantic Region***: A) the frequency distribution of log(CPUE)on positive trips, B) the residuals by year and C) the cumulative normalized residuals (QQ-Plot) from the lognormal model. The red line is the expected normal distribution.

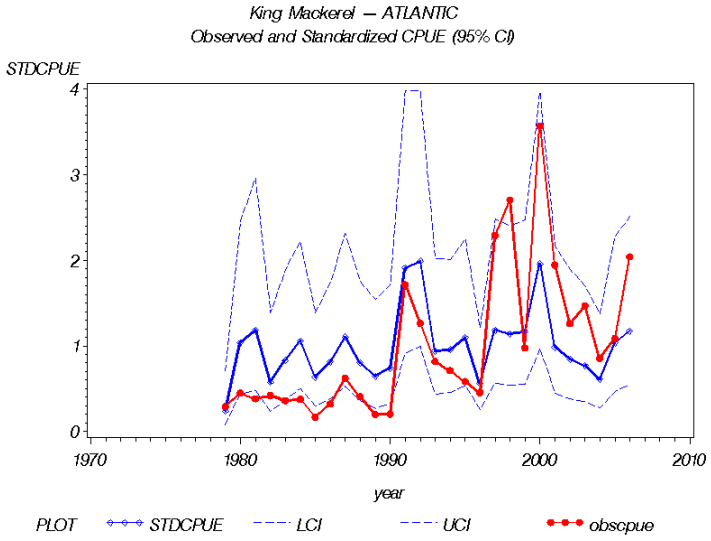


Figure 14. The standardized index (solid blue line open symbols) and nominal CPUE (solid red line filled symbols) with 95% confidence intervals (dashed lines) for the ***Updated Model – Atlantic Region***.

A) B)

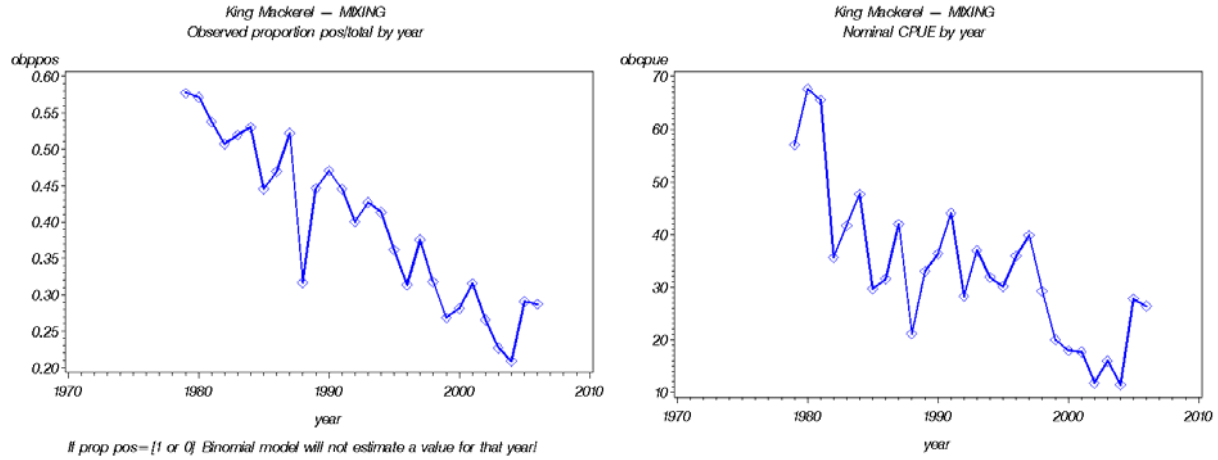


Figure 15. Annual trend in the proportion of positive trips (A) and nominal CPUE (B) for the ***Updated Model – Mixing Region***.

A) B)

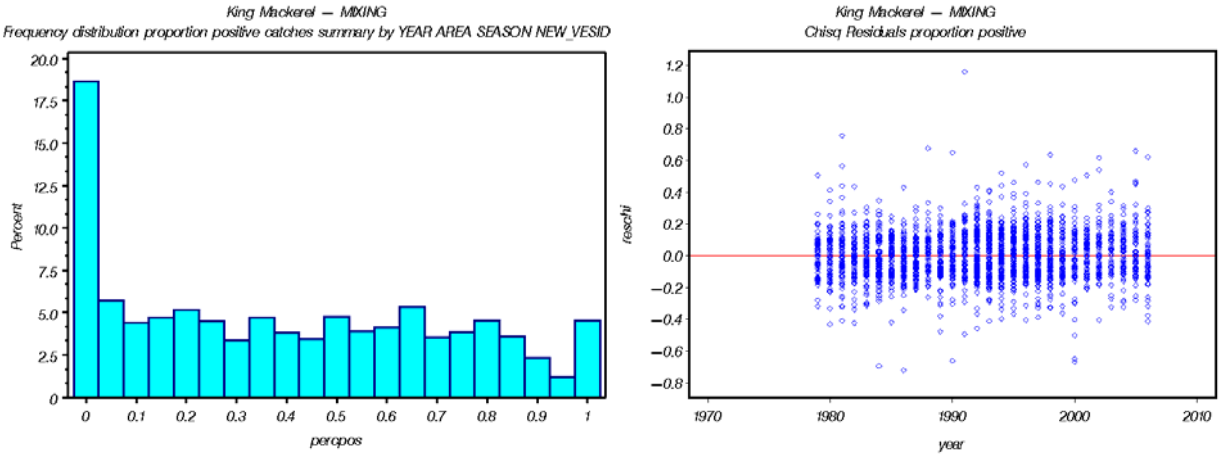
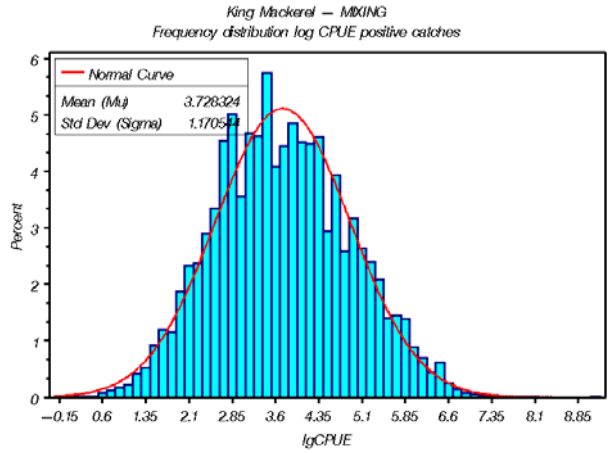
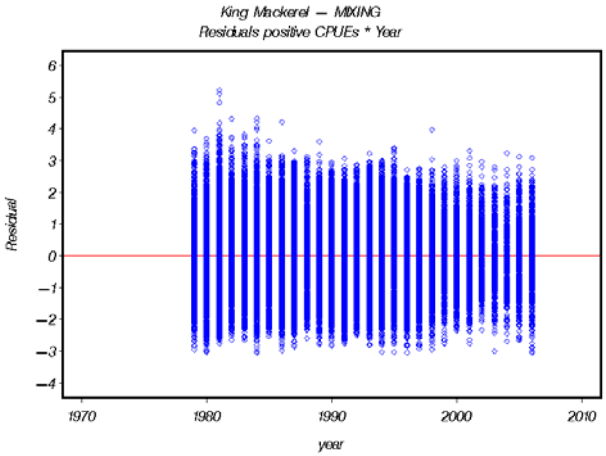


Figure 16. Diagnostic plots for the binomial component of the ***Updated Model – Mixing Region***: A) the frequency distribution of the proportion positive trips and B) the Chi-Square residuals by year.

A)



B)



C)

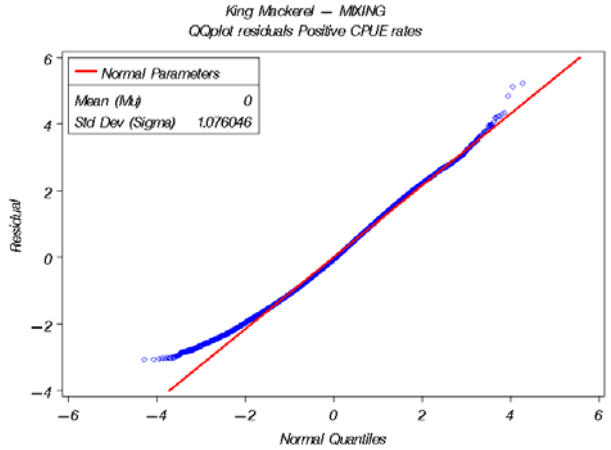


Figure 17. Diagnostic plots for the lognormal component of the ***Updated Model – Mixing Region***: A) the frequency distribution of log(CPUE)on positive trips, B) the residuals by year and C) the cumulative normalized residuals (QQ-Plot) from the lognormal model. The red line is the expected normal distribution.

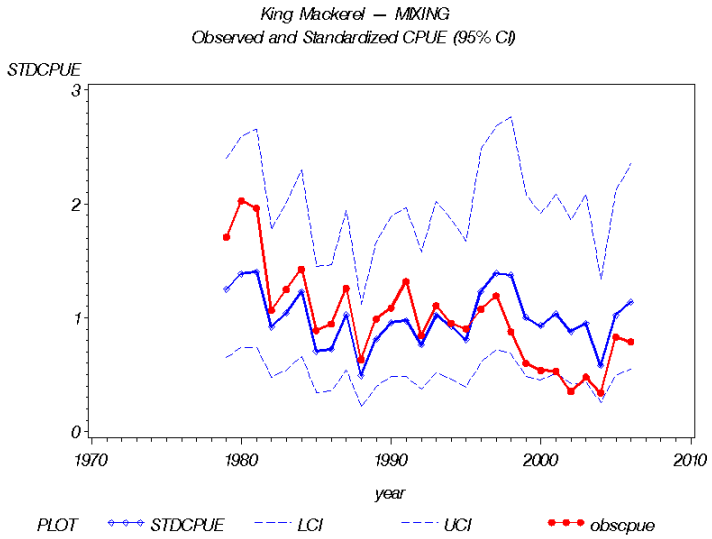


Figure 18. The standardized index (solid blue line open symbols) and nominal CPUE (solid red line filled symbols) with 95% confidence intervals (dashed lines) for the ***Updated Model – Mixing Region***.

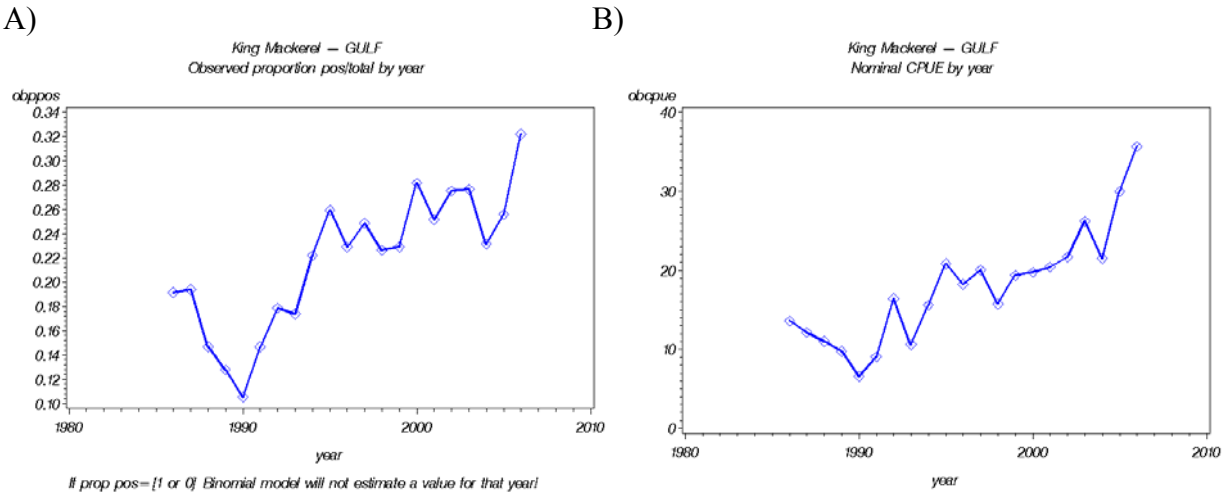


Figure 19. Annual trend in the proportion of positive trips (A) and nominal CPUE (B) for the ***Updated Model – Gulf Region***.

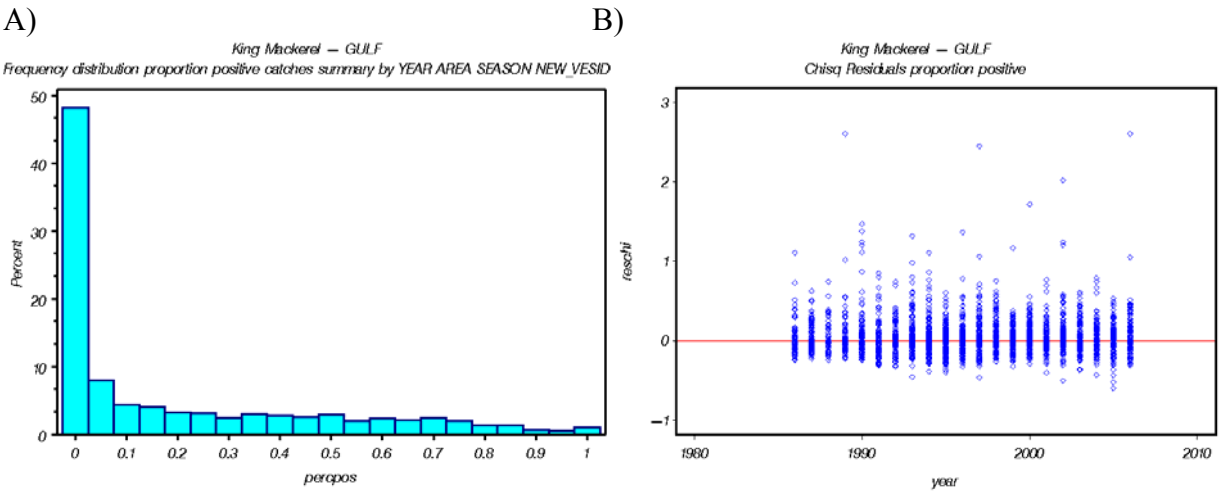
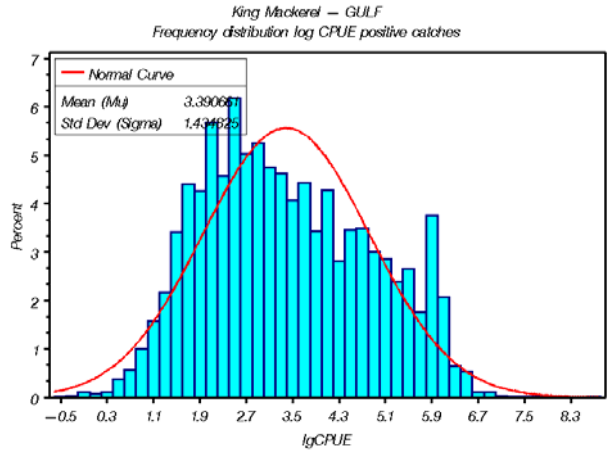
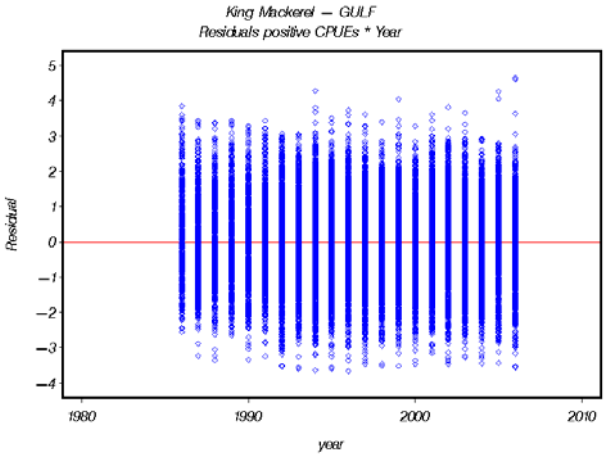


Figure 20. Diagnostic plots for the binomial component of the ***Updated Model – Gulf Region***: A) the frequency distribution of the proportion positive trips and B) the Chi-Square residuals by year.

A)



B)



C)

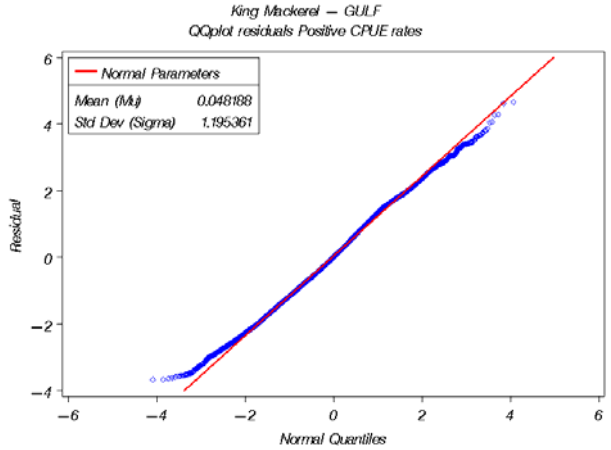


Figure 21. Diagnostic plots for the lognormal component of the ***Updated Model – Gulf Region***: A) the frequency distribution of log(CPUE)on positive trips, B) the residuals by year and C) the cumulative normalized residuals (QQ-Plot) from the lognormal model. The red line is the expected normal distribution.

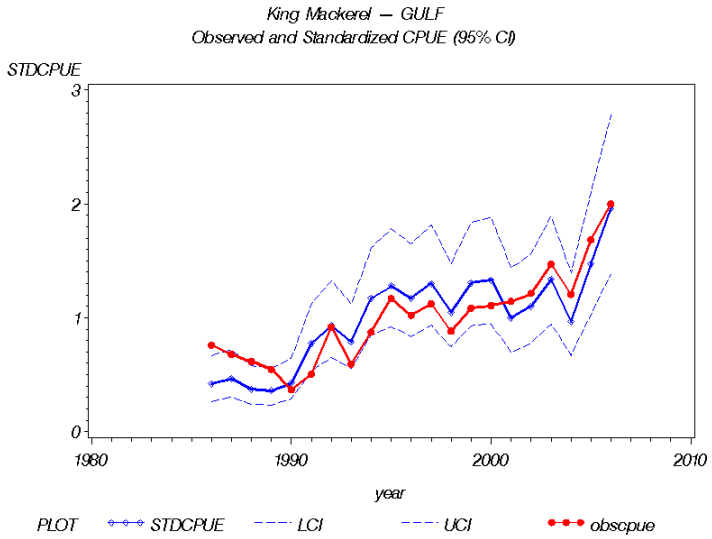


Figure 22. The standardized index (solid blue line open symbols) and nominal CPUE (solid red line filled symbols) with 95% confidence intervals (dashed lines) for the ***Updated Model – Gulf Region***.

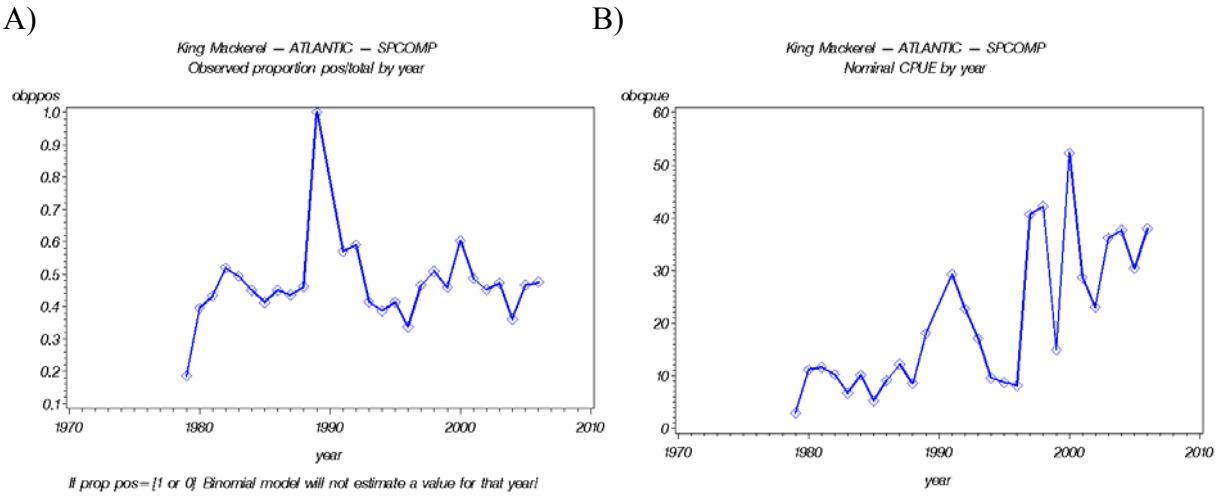


Figure 23. Annual trend in the proportion of positive trips (A) and nominal CPUE (B) for the ***Updated Model with Species Composition – Atlantic Region***.

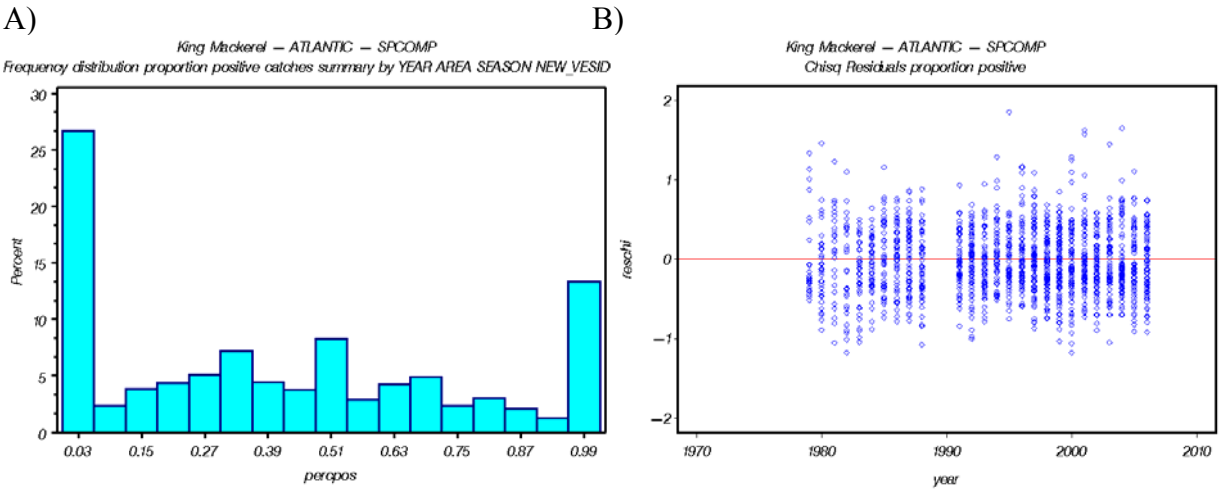
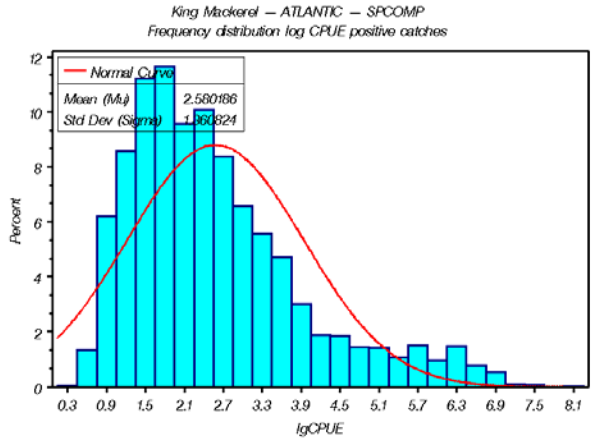
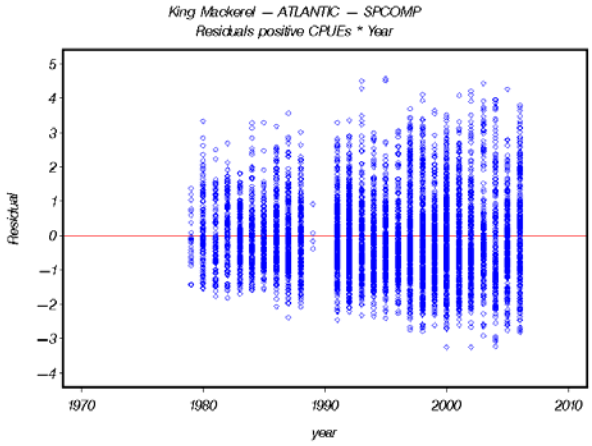


Figure 24. Diagnostic plots for the binomial component of the ***Updated Model with Species Composition – Atlantic Region***: A) the frequency distribution of the proportion positive trips and B) the Chi-Square residuals by year.

A)



B)



C)

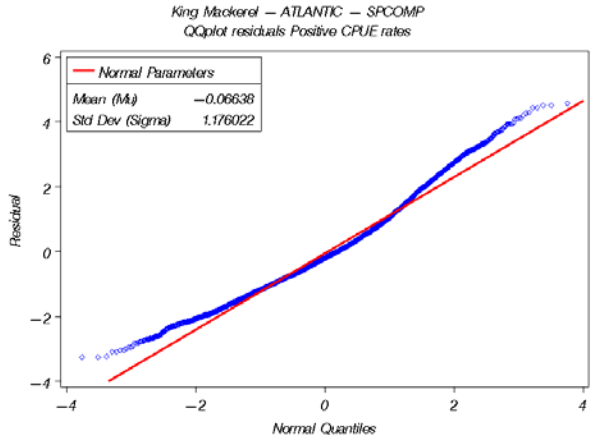


Figure 25. Diagnostic plots for the lognormal component of the ***Updated Model with Species Comp – Atlantic Region***: A) the frequency distribution of log(CPUE)on positive trips, B) the residuals by year and C) the cumulative normalized residuals (QQ-Plot) from the lognormal model. The red line is the expected normal distribution.

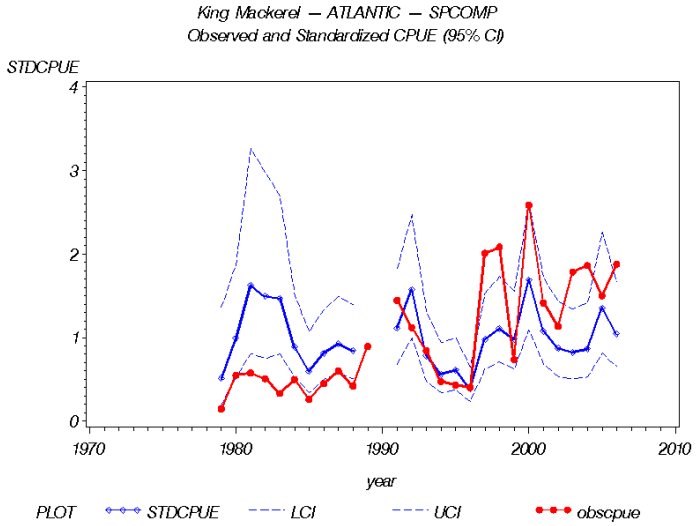


Figure 26. The standardized index (solid blue line open symbols) and nominal CPUE (solid red line filled symbols) with 95% confidence intervals (dashed lines) for the ***Updated Model with Species Comp – Atlantic Region***.

A) B)

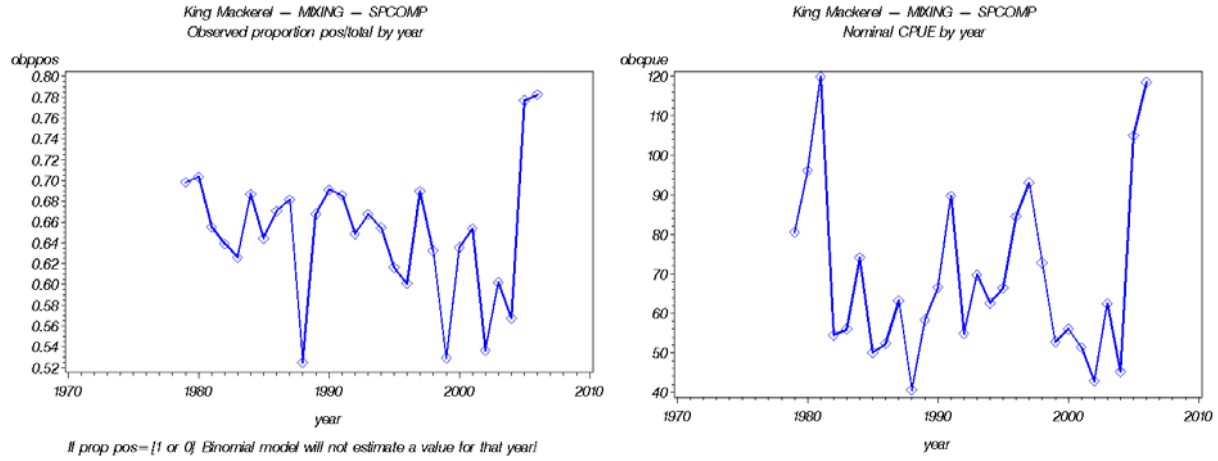


Figure 27. Annual trend in the proportion of positive trips (A) and nominal CPUE (B) for the ***Updated Model with Species Composition – Mixing Region***.

A) B)

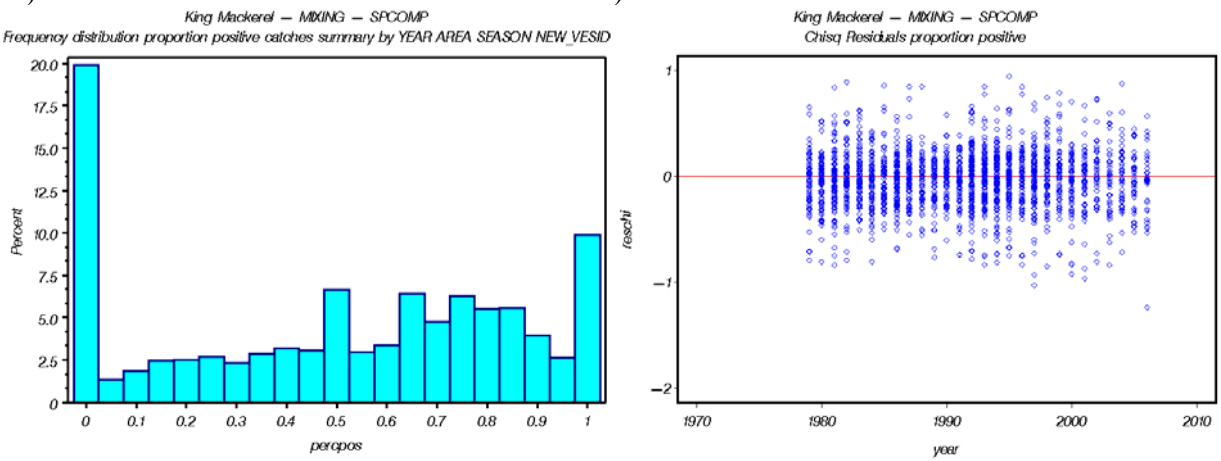
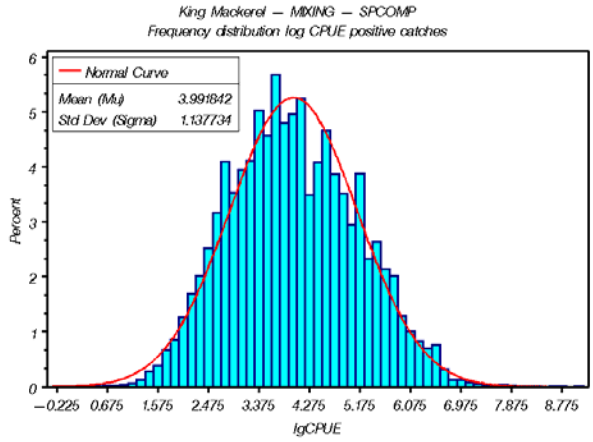
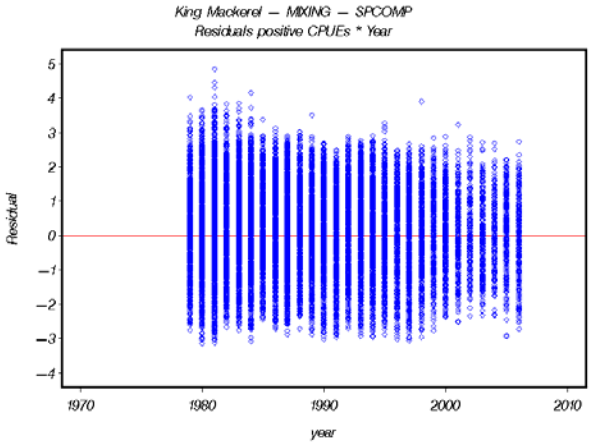


Figure 28. Diagnostic plots for the binomial component of the ***Updated Model with Species Composition – Mixing Region***: A) the frequency distribution of the proportion positive trips and B) the Chi-Square residuals by year.

A)



B)



C)

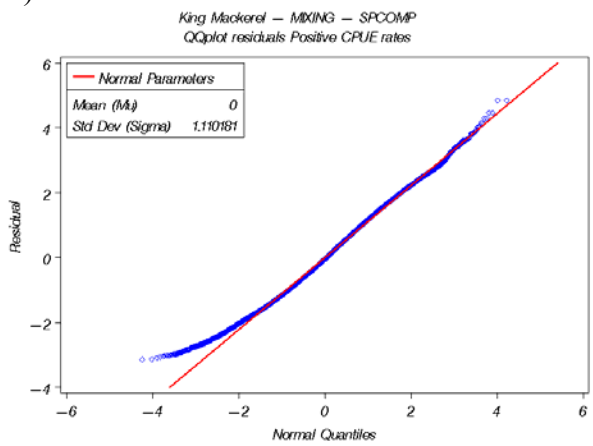


Figure 29. Diagnostic plots for the lognormal component of the ***Updated Model with Species Comp – Mixing Region***: A) the frequency distribution of log(CPUE)on positive trips, B) the residuals by year and C) the cumulative normalized residuals (QQ-Plot) from the lognormal model. The red line is the expected normal distribution.

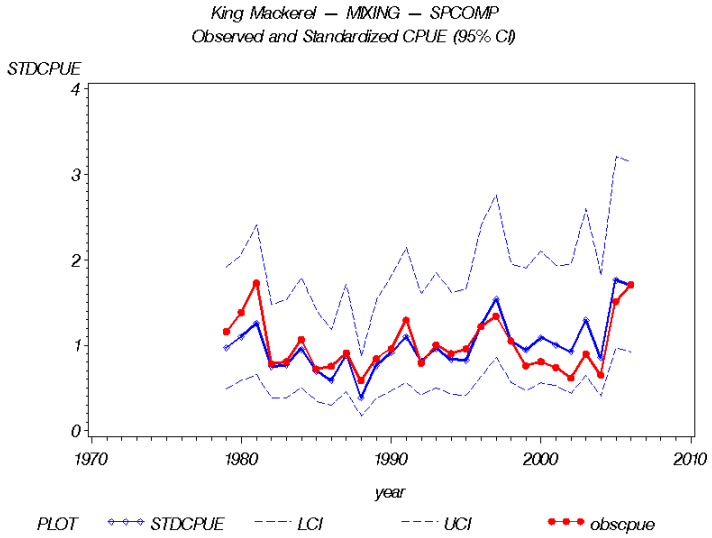


Figure 30. The standardized index (solid blue line open symbols) and nominal CPUE (solid red line filled symbols) with 95% confidence intervals (dashed lines) for the ***Updated Model with Species Comp – Mixing Region***.

A) B)

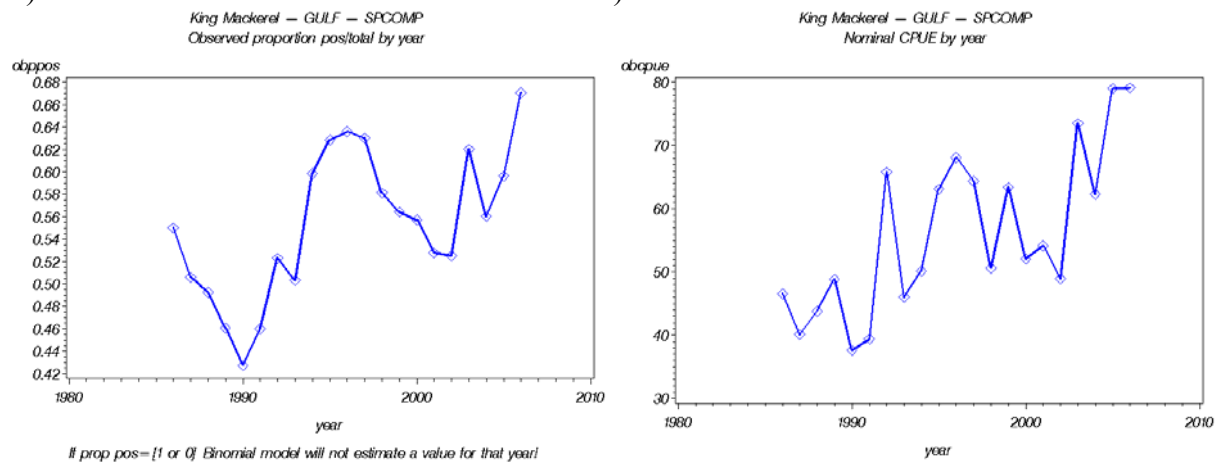


Figure 31. Annual trend in the proportion of positive trips (A) and nominal CPUE (B) for the ***Updated Model with Species Composition – Gulf Region***.

A) B)

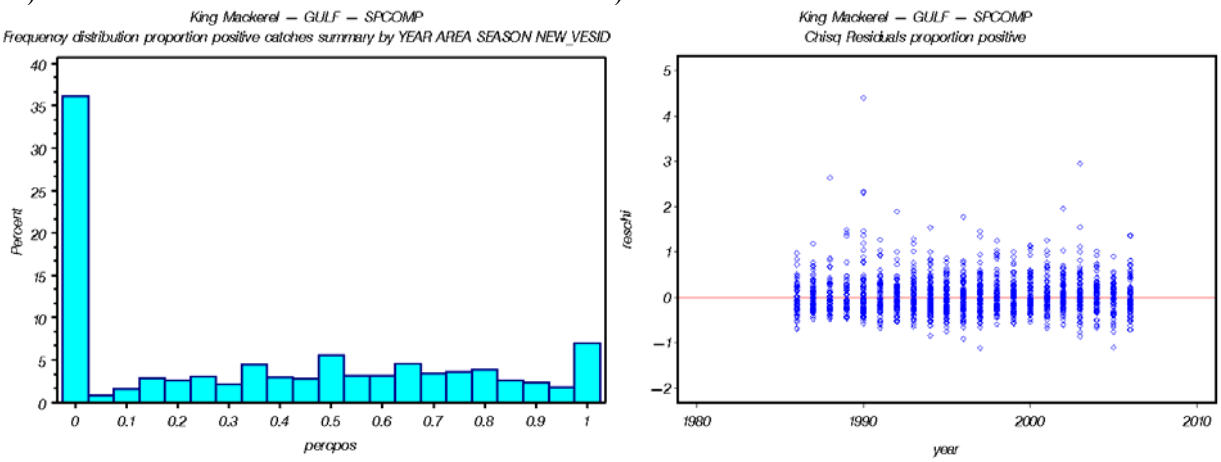


Figure 32. Diagnostic plots for the binomial component of the ***Updated Model with Species Composition – Gulf Region***: A) the frequency distribution of the proportion positive trips and B) the Chi-Square residuals by year.

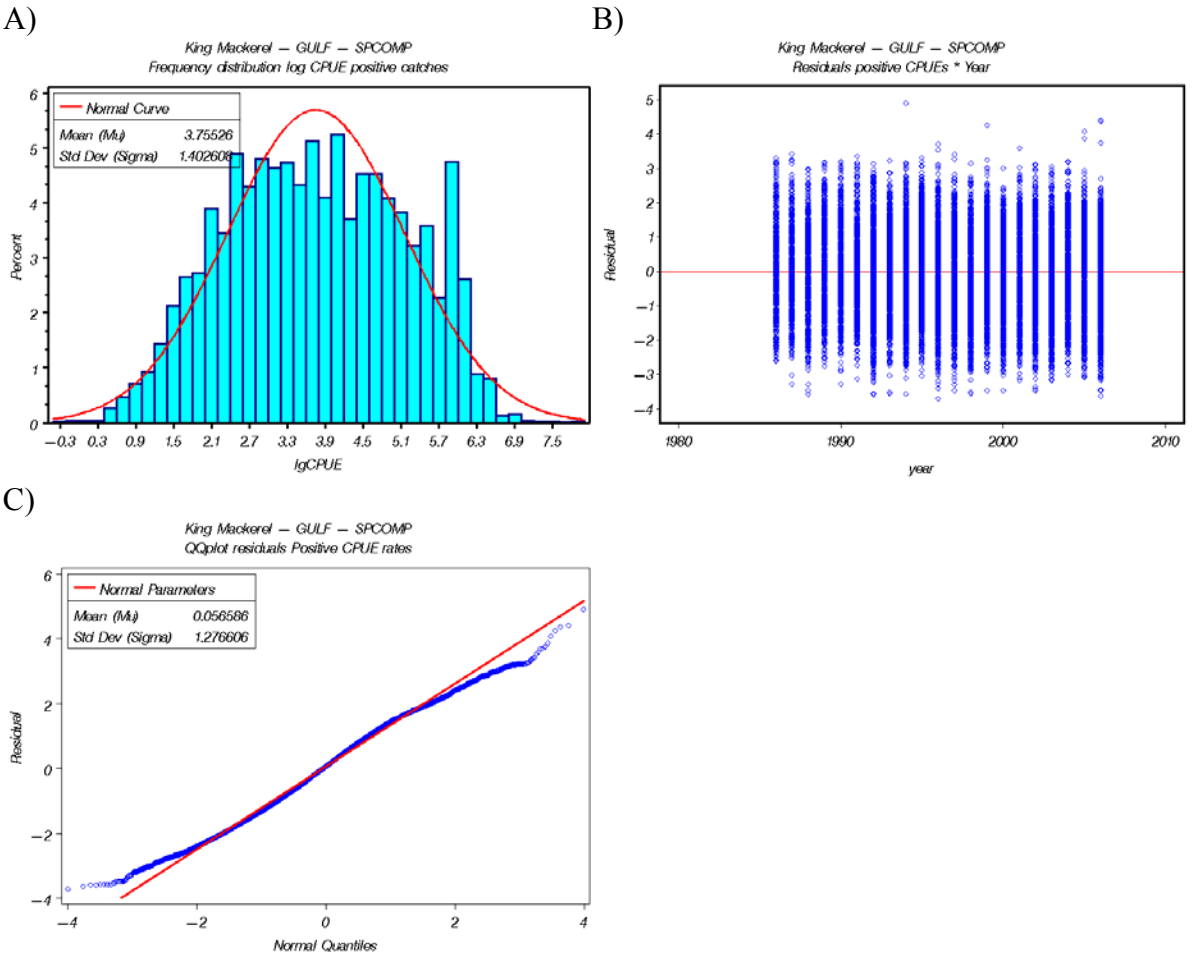


Figure 33. Diagnostic plots for the lognormal component of the ***Updated Model with Species Comp – Gulf Region***: A) the frequency distribution of log(CPUE)on positive trips, B) the residuals by year and C) the cumulative normalized residuals (QQ-Plot) from the lognormal model. The red line is the expected normal distribution.

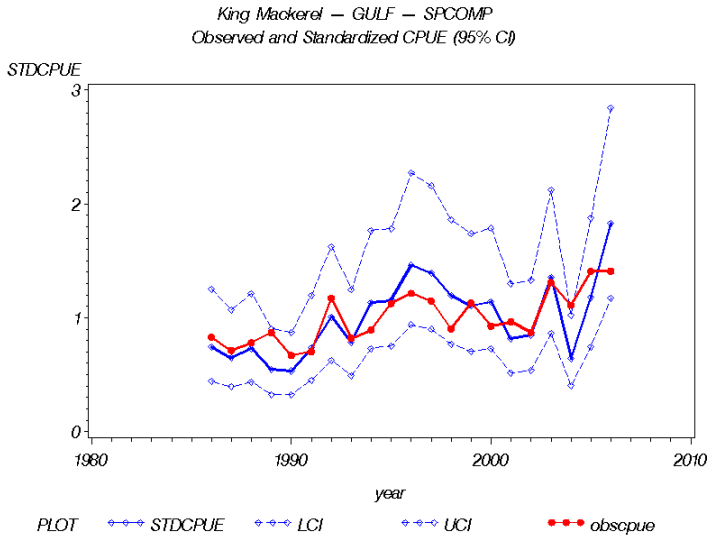


Figure 34. The standardized index (solid blue line open symbols) and nominal CPUE (solid red line filled symbols) with 95% confidence intervals (dashed lines) for the ***Updated Model with Species Comp – Gulf Region***.