Standardized catch indices of king mackerel from the U.S. Marine Recreational Fisheries Statistics Survey, 1981 to 2012

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SEDAR38-DW-04

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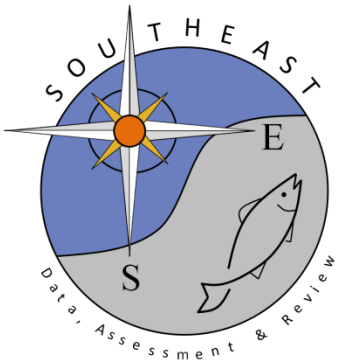

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Updated standardized catch rates of king mackerel, *Scomberomorus cavalla* from the Marine Recreational Fisheries Statistical Survey MRFSS.

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SUMMARY

Catch and effort data from the US Marine Recreational Fisheries Statistical Survey of the Atlantic coast and Gulf of Mexico (excluding Texas) were used to update the indices of abundance for king mackerel Gulf of Mexico and Atlantic stocks. Standardized catch rates were updated using a Generalized Linear Mixed modeling approach that maintained the same model structure as SEDAR 16, assuming a delta-lognormal error distribution. The explanatory variables used for standardization continuity included: geographical area, seasonal trimesters, fishing target species, and mode (a factor that classifies recreational fishing in shore, charter or private/rental boat).

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Introduction

Indices of abundance from recreational fisheries have been used to tune stock assessment models (Quinn and Deriso 1999). Data collected and estimated by the Marine Recreational Fisheries Statistical Survey (MRFSS) were used to develop standardized catch per unit effort (CPUE) indices for the king mackerel stocks of the Gulf of Mexico and Atlantic. The recreational fisheries survey started in 1979, and its purpose is to establish a reliable database for estimating the impact of marine recreational fishing on marine resources. More detailed information on the methods and protocols of the survey can be found at http://www.st.nmfs.gov/st1/recreational/overview/ overview.html. This Report updates the methods applied to the available US recreational data through 2012, and presents the king mackerel standardized indices for Gulf or Mexico (GOM) and Atlantic (ATL) stocks. Standardized catch rates were estimated using the Generalized Linear Mixed Model (GLMM) approach that represents a strict continuity of SEDAR 16 methods.

Materials and methods:

The MRFSS estimates of catch and effort were based on intercept (i.e. interview at dock) and telephone surveys. Each record report included: the catch in numbers of all caught species; whether it was retained, or released alive or death; number of participating anglers; number of fishing hours; information on gear used; target species; mode (shore, headboat, charter, or private/rental); area (inshore, ocean < 3 miles, 3 < ocean < 10 miles, ocean > 10 miles); county/state; and date. Headboat mode trip/interviews were not included in any of the present analyses. The frequency and sampling design of the interview and telephone surveys were based on demographic and seasonal (wave) considerations by county from Maine through Louisiana on the Atlantic and US Gulf of Mexico coast. This Report does not include MRFSS estimates from the US Caribbean region.

The MRFSS data included the estimates of catch and effort from 1981 through 2012 from Louisiana through Maine. Because of the reduced number of records for some states, regional areas were defined and used as a spatial factor: Central Gulf (LA, AL, MS), Western Gulf (FLW), Florida east coast (FLE), NC-GE (GE, SC, NC), Mid Atlantic (VA, MD, DE, NJ, NY), and New England (CT, RI, MA, NH, ME). Trimesters were used to account for seasonal fishery distribution through the year (Jan-Mar, Apr-Jun, Jul-Sep, and Oct-Dec). Interviews also collected information on the intended target species for each trip; based on the ecological and habitat groups, target species were classified into “guilds” in the MRFSS data base: inshore species, reef species, non-reef species, pelagic species, and sharks. When no primary or secondary target was specified, the record was assigned as an unclassified guild. Fishing effort (angler hours) was estimated as the number of anglers times the number of hours fishing; nominal catch rates were defined as the total catch kept and released (AB1B2, number of fish) per thousand angler hours.

One potential problem with indices derived from the recreational MRFSS database is the selection of trips/interviews that have relevance to the species in the analysis, in this case king mackerel. MRFSS covers all recreational fisheries from shore anglers or small bays up to large charter vessels fishing offshore. The task is then to identify the trips that potentially had a positive probability of catching king. In the interview, anglers are asked for targeted species of each trip, and in general the catch composition reflects the species found in the habitat associated with the intended/target species. As mentioned before, the MRFSS database classified the trips into “guilds” based on habitat related species: sharks, pelagic species, inshore species, reef species, and non-reef species. However, about 50% of the trip-interviews did not have a target species definition. Looking in more detail at the trips that caught king mackerel and the other species reported in the same trip, it is possible to create a matrix of co-occurring species, and possibly use this composition matrix as a subsetting condition. From 1981 to 2012, 16,766 trip/interviews reported catches of king in the Gulf of Mexico, and 8,606 trip/interviews reported catches of king in the Atlantic. In the Gulf, the most common co-occurring species was red snapper (21%), followed by little tunny and Spanish mackerel (Figure 1). In general, the reef-associated and pelagic species were the main co-occurring species (98%). In the Atlantic, the most common co-ocurring species was little tunny (19%), followed by dolphin fish, Spanish mackerel and great barracuda (Figure 1). Standardization analyses were done with trips/records of guild pelagic species, reef species and unclassified guild species.

Standardized indices of abundance were estimated for the king mackerel Gulf of Mexico and Atlantic current stock unit definition (the Gulf stock boundary extends into the Florida east coast up to Volusia-Flagler County line during the Nov-Mar months, while during the Apr-Oct months the Collier-Monroe county line is the boundary), as well as by regions, where the Atlantic no mix region is north of Flagler county, the Gulf no mix region is north and west of Collier county, and the mix region is the Florida east coast between Monroe and Volusia counties. King relative indices of abundance were estimated by the Generalized Linear Modeling approach assuming a delta lognormal model distribution. The standardization protocols assumed a delta model with a binomial error distribution for modeling the proportion of positive sets, and a lognormal error distribution for modeling the mean catch rate of successful (i.e. positive king catch) trip/interviews. Parameterization of the models used the GLM structure; the proportion of successful observations per stratum was assumed to follow a binomial distribution where the estimated probability was a linear function of fixed factors and interactions. The logit function was used as a link between the linear factor component and the binomial error. For successful trip/interviews, estimated CPUE rates assumed a lognormal distribution of a linear function of fixed and random effect interactions when the *year* term was within the interaction.

The same set of systematic factors and interactions from the previous assessment were used in the updated generalized linear mixed model for both the Gulf of Mexico and Atlantic non-mixing zones. Deviance tables were presented for each analysis by Ortiz (2008, SEDAR 16-DW-14). Final selection of the explanatory factors was conditional on: a) the relative percent of deviance explained by adding the factor in consideration (normally factors that explained more than 5% were included in the final model), b) the χ^2 test significance, and c) a type III test significance within the final specified model. Once a set of fixed factors was specified, possible first level interactions were evaluated and in particular interactions between the *year* effect and other factors which were assumed to be random. The significance of random interactions was evaluated between nested models by using the likelihood ratio test (Pinheiro and Bates 2000), the Akaike information criteria (AIC), and the Bayesian information criteria (BIC) (Littell et al 1996), where lower values indicated better model fitting. Analyses were done using GLIMMIX and MIXED procedures from the SAS® statistical computer software (SAS Institute Inc. 1997).

Relative indices were calculated as the product of the year effect least square means (LSmeans) from the binomial and the lognormal components. LSmeans estimates were weighted proportional to observed marginal sums in the positive observations data; for the lognormal estimates, a log-back transformed bias correction was applied (Lo et al. 1992). Final model for the region scenarios selected by Ortiz (2008) were used to estimate yearly indices requested for assessment models that track annual changes of abundance.

Results

The results of the standardization continuity model are presented in Tables 1 and 2. The proportion of trips that caught King mackerel was low for both regions (ranged from less than 1 to 3.5% in the Gulf of Mexico, and ranged from less than 1 to 4.5% in the Atlantic). In general, the proportion of recreational charter and private trips that captured King mackerel has decreased over the last decade in the Gulf of Mexico, but is higher than the early period of the time series (Figure 2). Standardized catch indices for the Gulf of Mexico (non-mixing region) show a general increase during the late 1980s and a relatively flat trend between 1990 and 2012 (Figure 3). In the Atlantic non-mixing region, the proportion of recreational charter and private trips has declined steadily since an observed peak in 1987, with 2011 and 2012 data indicating the lowest proportions across the time series (Figure 4). Catch indices for the Atlantic indicated relatively high catch rates during 1986 to 1988, and a decline since that time (Table 2, Figure 5). The standardized indices for 2011 and 2012 indicate the lowest catch rates since the early part of the time series, with 2011 demonstrating the lowest index on record. Model fit diagnostics (Figure 6) indicated a relatively good fit of the normal distribution the $\log_e$-transformed catch rates. Kolmogorov-Smirnov goodness-of-fit tests (KS test) on data quantiles (2.5% to 97.5% by 0.5%) indicated non-significant difference between the positive CPUE of King mackerel and a normal probability distribution for both the Gulf (KS test p-value=0.68) and Atlantic (KS test p-value=0.68) datasets. Model residuals demonstrated approximately normally distributed model error across the data range (Figure 6), indicating good model fit of the normal regression GLMM to the transformed data.

Acknowledgements

This analysis represents an update of the generalized linear mixed model developed by Ortiz (2008, SEDAR 16-DW-14), updated for the SEDAR 38 continuity to include the period 2007 to 2012. The SAS scripts and text written and developed by Ortiz (2008) were adapted for this analysis, and the results represent a strict update of the standardization model.

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Table 1. Standardized Catch Indices of Gulf of Mexico King Mackerel (Mixing Zone Excluded) from MRFSS recreational surveys during 1981-2012.

Year	n	Prop_Postive	Observed_CPUE	Standardized_CPUE	Lower_CI	Upper_CI	CV
1981	4295	0.012	5.20	0.71	0.33	1.53	0.40
1982	7687	0.008	2.99	0.45	0.22	0.94	0.38
1983	5105	0.009	6.36	0.90	0.41	1.94	0.40
1984	6098	0.011	3.50	0.49	0.24	0.99	0.36
1985	6847	0.007	2.34	0.54	0.25	1.14	0.39
1986	13859	0.011	3.42	0.46	0.25	0.83	0.31
1987	13229	0.033	11.79	1.09	0.64	1.87	0.27
1988	14603	0.016	5.00	0.72	0.41	1.28	0.29
1989	10648	0.014	6.83	0.92	0.51	1.67	0.30
1990	9019	0.021	8.79	1.27	0.72	2.24	0.29
1991	10922	0.025	9.55	1.26	0.74	2.16	0.27
1992	23462	0.016	5.92	1.00	0.59	1.68	0.26
1993	20405	0.014	4.21	0.97	0.57	1.66	0.27
1994	23211	0.017	6.31	1.20	0.72	2.02	0.26
1995	21106	0.012	4.55	1.07	0.62	1.85	0.28
1996	21823	0.014	5.55	1.28	0.75	2.19	0.27
1997	22912	0.023	8.28	1.49	0.90	2.47	0.26
1998	28885	0.023	7.39	1.08	0.65	1.79	0.26
1999	39921	0.024	8.41	0.92	0.56	1.51	0.25
2000	37369	0.035	11.38	1.23	0.76	2.01	0.25
2001	37195	0.027	9.95	1.12	0.68	1.83	0.25
2002	38679	0.031	9.98	1.25	0.77	2.03	0.25
2003	39263	0.025	8.15	0.98	0.60	1.61	0.25
2004	40727	0.024	7.14	1.01	0.61	1.65	0.25
2005	36216	0.020	6.61	0.85	0.51	1.41	0.26
2006	34679	0.028	10.59	1.56	0.96	2.55	0.25
2007	35994	0.021	6.34	0.92	0.56	1.51	0.25
2008	36234	0.019	5.65	0.84	0.51	1.40	0.26
2009	36137	0.022	7.86	1.39	0.85	2.27	0.25
2010	34576	0.017	5.16	1.01	0.61	1.69	0.26
2011	37260	0.015	4.07	0.80	0.48	1.33	0.26
2012	37209	0.022	7.27	1.21	0.74	1.98	0.25

Table 2. Standardized Catch Indices of Atlantic King Mackerel (Mixing Zone Excluded) from MRFSS recreational surveys during 1981-2012.

Year	n	Prop_Positive	Observed_CPUE	Standardized_CPUE	Lower_CI	Upper_CI	CV
1981	4665	0.005	1.76	1.36	0.36	5.16	0.75
1982	4863	0.013	4.03	1.57	0.46	5.37	0.68
1983	6539	0.006	1.79	1.56	0.44	5.51	0.70
1984	3379	0.019	4.58	1.70	0.50	5.77	0.67
1985	7876	0.013	4.40	1.57	0.49	5.04	0.64
1986	11935	0.028	10.05	5.18	1.86	14.41	0.55
1987	12534	0.045	18.46	1.90	0.63	5.77	0.60
1988	11896	0.040	12.47	1.36	0.45	4.16	0.60
1989	17718	0.023	5.65	1.10	0.37	3.31	0.60
1990	20320	0.021	6.78	1.00	0.32	3.15	0.62
1991	21795	0.022	6.79	1.38	0.46	4.15	0.59
1992	20974	0.022	7.17	1.09	0.36	3.33	0.61
1993	17971	0.013	4.34	0.63	0.18	2.18	0.69
1994	21112	0.015	3.87	0.40	0.11	1.49	0.74
1995	17132	0.017	6.03	0.44	0.12	1.66	0.74
1996	21871	0.014	4.12	0.39	0.10	1.45	0.73
1997	23970	0.022	8.55	1.32	0.44	3.96	0.59
1998	21634	0.015	4.95	0.64	0.19	2.12	0.65
1999	17927	0.017	5.12	1.09	0.35	3.40	0.62
2000	18038	0.023	8.18	0.94	0.29	3.00	0.64
2001	24892	0.013	3.86	0.46	0.13	1.66	0.71
2002	20896	0.008	1.71	0.21	0.05	0.95	0.87
2003	20758	0.009	2.69	0.30	0.07	1.20	0.79
2004	19871	0.012	3.79	0.51	0.15	1.82	0.70
2005	18299	0.015	4.77	0.96	0.31	2.95	0.61
2006	18369	0.014	4.43	0.69	0.21	2.30	0.66
2007	19774	0.014	4.58	0.69	0.21	2.26	0.65
2008	20368	0.010	3.04	0.66	0.20	2.23	0.67
2009	17701	0.012	3.49	0.46	0.12	1.69	0.73
2010	20349	0.007	1.84	0.20	0.04	0.94	0.89
2011	18142	0.003	0.67	0.08	0.01	0.58	1.32
2012	18451	0.006	1.43	0.15	0.03	0.79	0.98

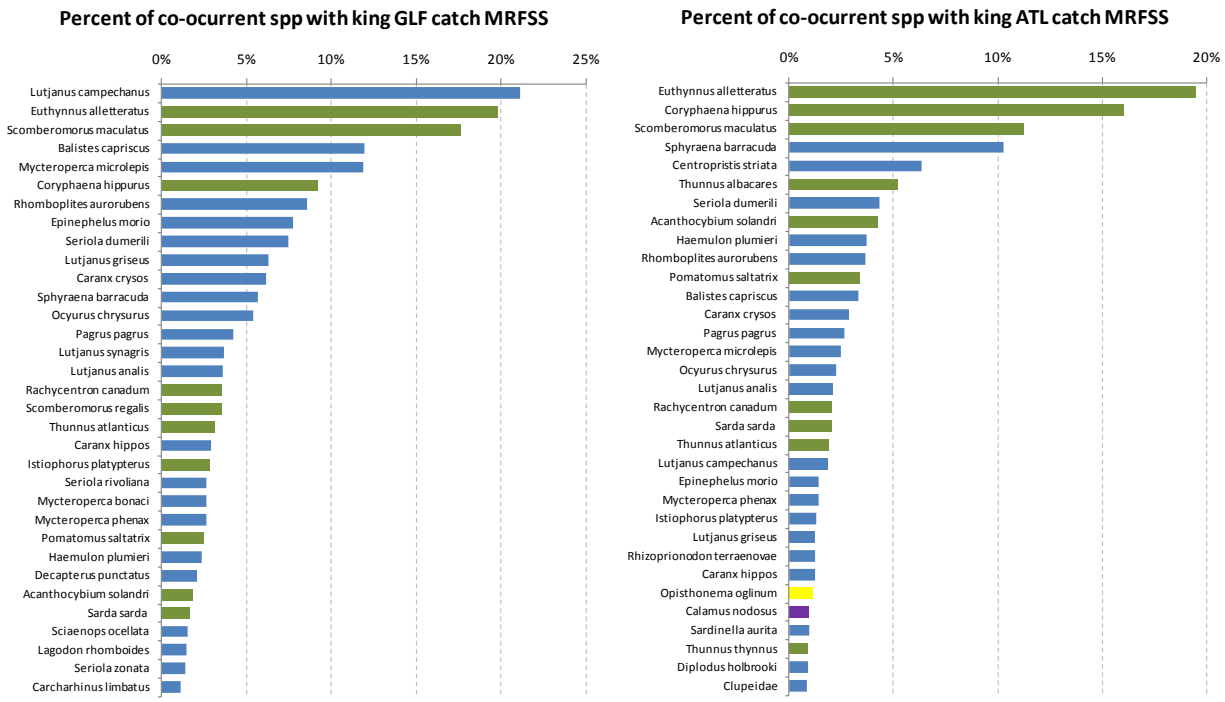

Figure 1. Percent of concurrent species caught with king mackerel by recreational fishers in the Gulf of Mexico (left) and Atlantic waters. Bar colors associated with pelagic guild species (green), reef species (blue), inshore species (yellow), and non-reef species (purple). Figure reprinted from SEDAR 16-DW-14.

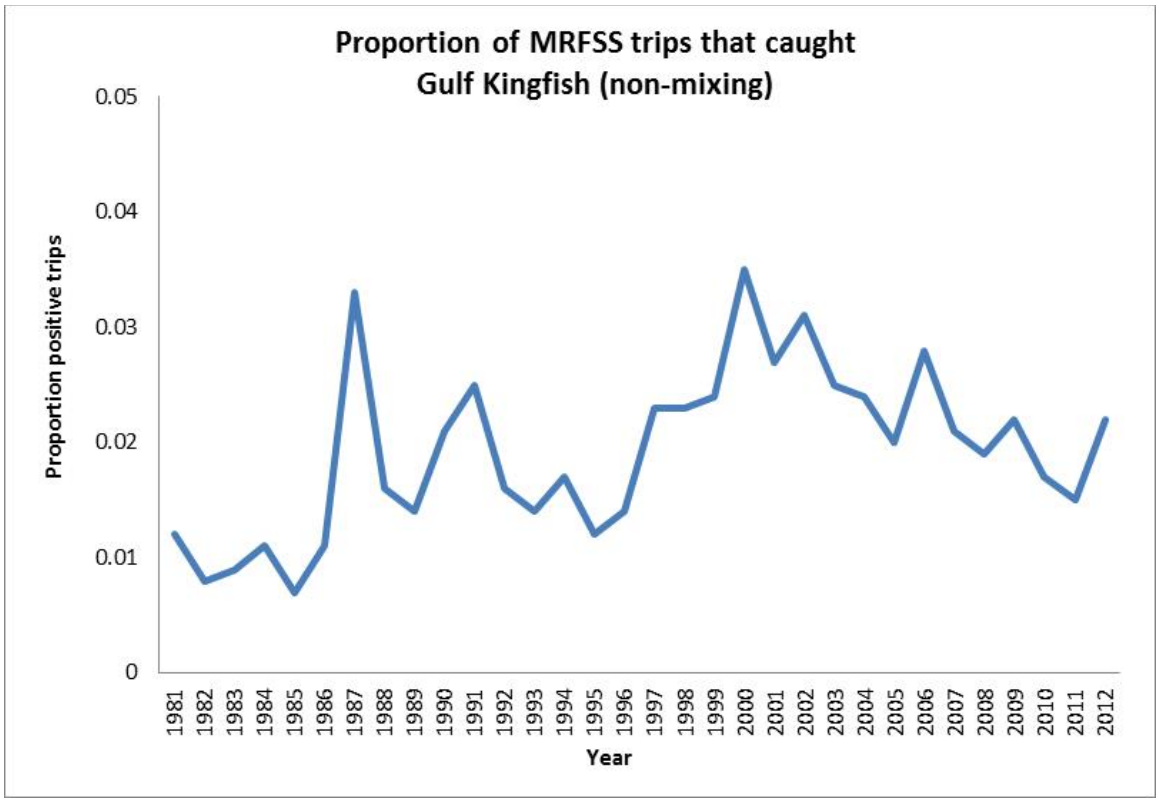

Figure 2. Observed proportion of surveyed recreational trips that caught Gulf of Mexico King mackerel.

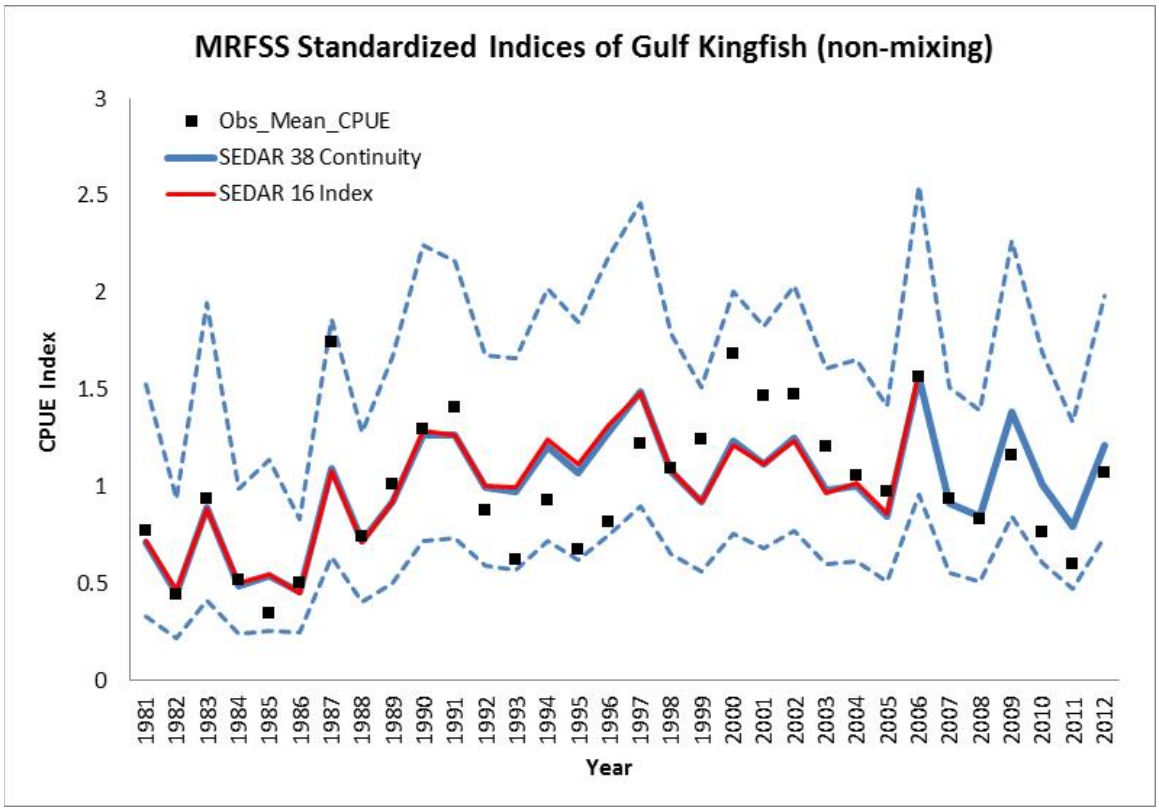

Figure 3. Updated MRFSS indices of abundance for SEDAR 38 continuity assessment model of Gulf King mackerel.

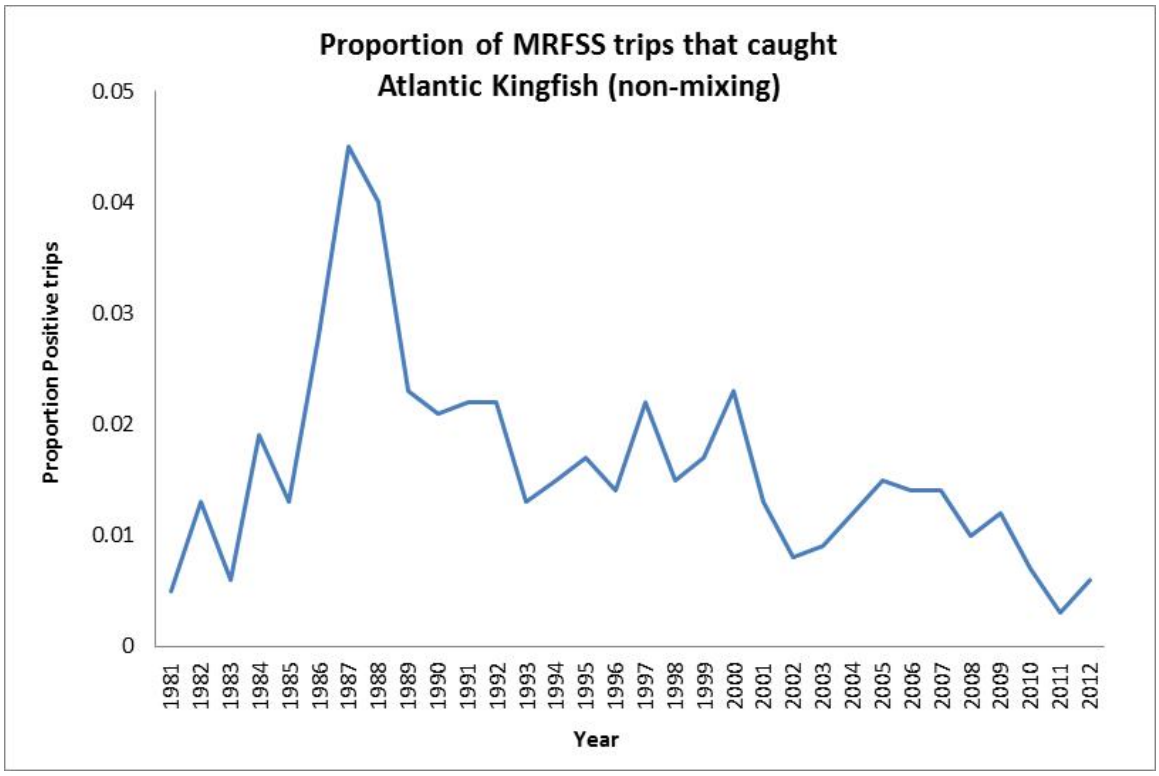

Figure 4. Observed proportion of surveyed recreational trips that caught Atlantic King mackerel.

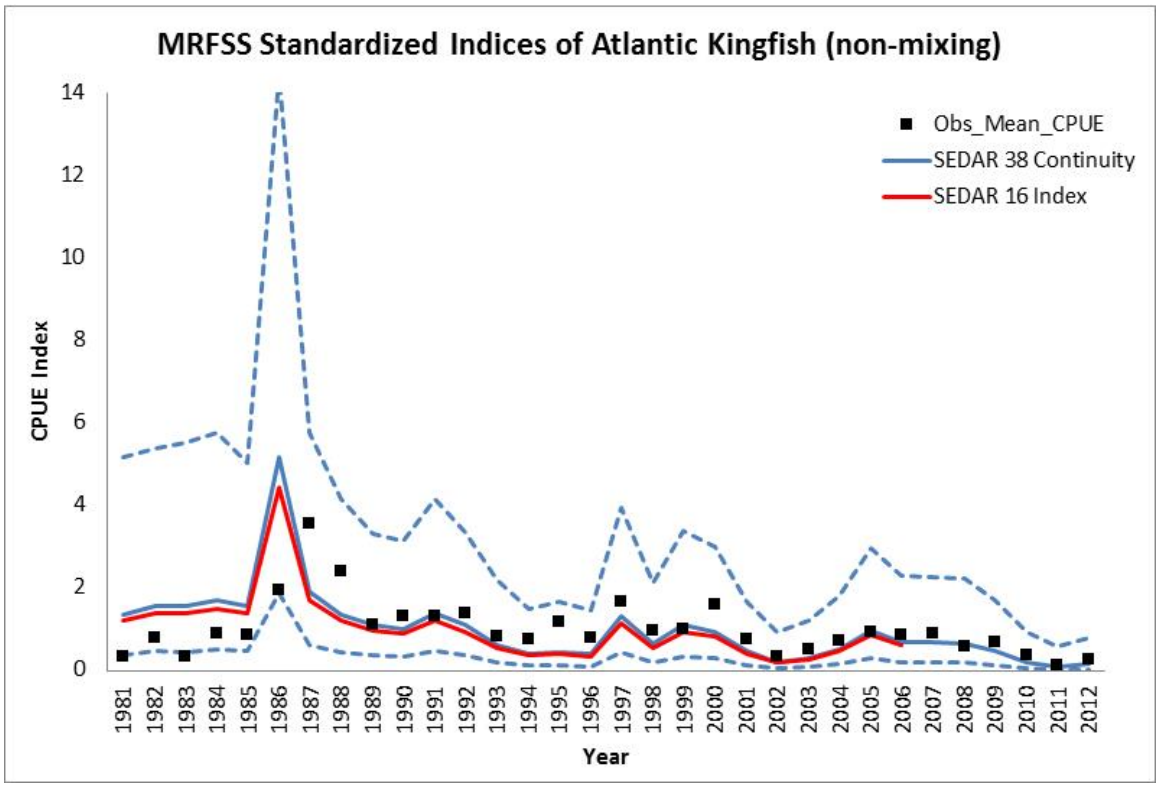

Figure 5. Updated MRFSS indices of abundance for SEDAR 38 continuity assessment model of Atlantic King mackerel.

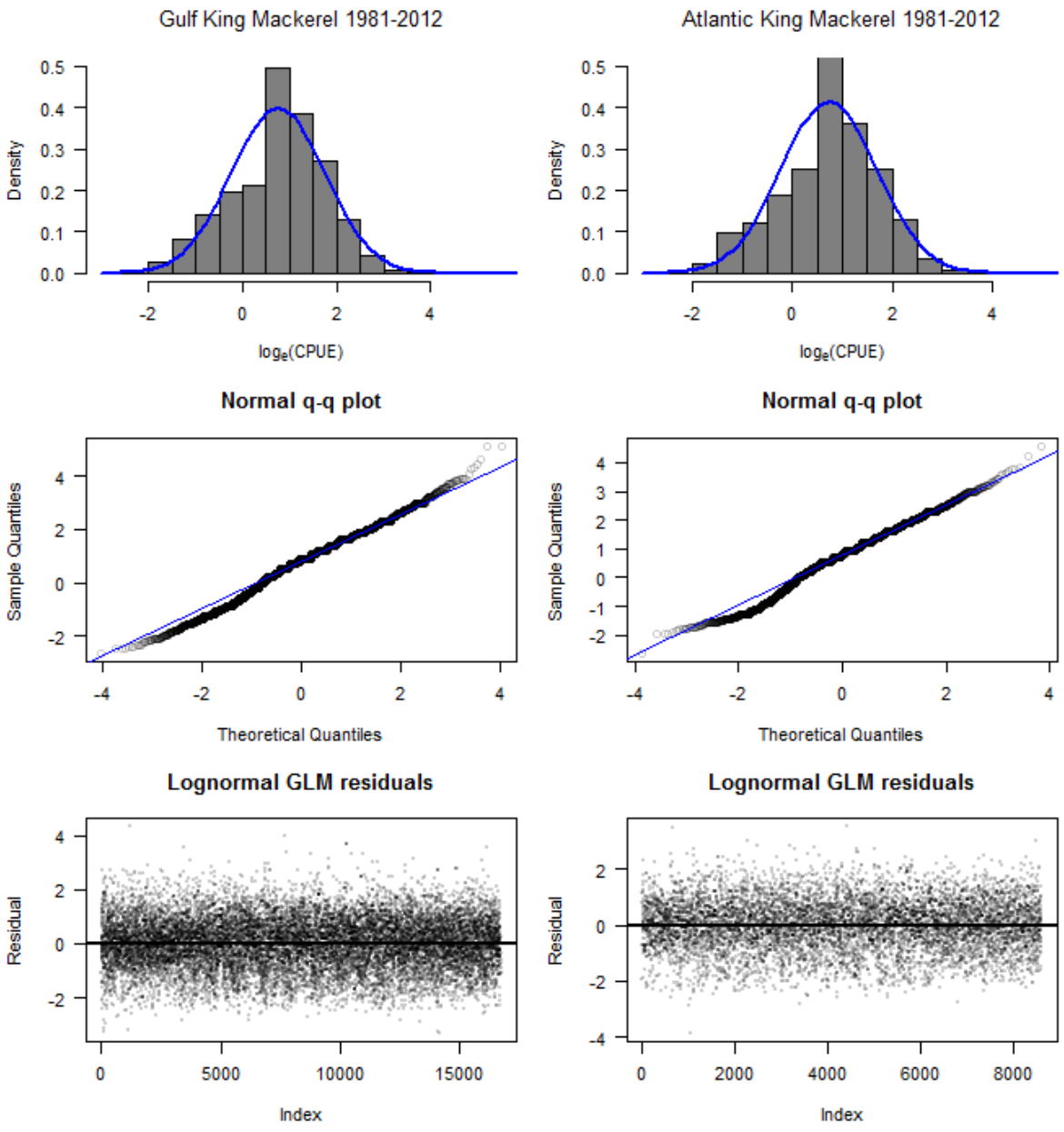

Figure 6. Lognormal regression GLMM model fit to MRFSS survey log-transformed cacth per unit effort (measured as fish per 10 angler hrs) of King mackerel (measured as number of fish per 10 angler hrs) in the Gulf of Mexico and Atlantic non-mixing zones.