STANDARDIZED CATCH RATES OF SANDBAR SHARKS (*Carcharhinus plumbeus*) AND DUSKY SHARKS (*Carcharhinus obscurus)* FROM THE LARGE PELAGICS ROD AND REEL SURVEY 1986-2009

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SUMMARY

This paper presents an update to two abundance indices for sandbar (Carcharhinus plumbeus) sharks off the coast of the United States from Virginia through Massachusetts were developed using data obtained during interviews of rod and reel anglers in 1986-2009. Subsets of the data were analyzed to assess effects of factors such as month, area fished, boat type (private or charter), interview type (dockside or phone) and fishing method on catch per unit effort. Standardized catch rates were estimated through generalized linear models by applying delta-Poisson error distribution assumptions. A stepwise approach was used to quantify the relative importance of the main factors explaining the variance in catch rates. The same models used in the indices constructed in 2004 were used in this paper for the binomial and Poisson submodels for both shark species. The indices both show a pattern of declines from the 1980s into the 1990s and a recent pattern of slight increases.

KEYWORDS

Catch/effort, Abundance, Sport fishing, Fishery surveys, Multivariate analyses, Stock assessments, Catch rate standardization, Generalized linear model, Shark fisheries, Pelagic fisheries

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1. INTRODUCTION

Data from the United States National Marine Fisheries Service's Large Pelagic Survey have typically been used to develop abundance indices for a variety of species, including bluefin tuna (Brown 2002), sharks (Brown 2000), bigeye and yellowfin tuna (Brown 1999, Brown 2004), and sharks (Brown 2000, Brown 2004) . This paper describes the development of indices of abundance for sandbar sharks (*Carcharhinus plumbeus*) for the period 1986-2004.

2. MATERIAL AND METHODS

The Large Pelagic Survey (LPS) collects data on the catch and effort of individual fishing trips through interviews with fishermen at the dock and in some years has collected such information over the telephone. Information collected usually includes date, landing area, boat type (charter or private), fishing area, number of anglers fishing, number of lines in the water, hours fished, type of fishing (primarily trolling or chumming), fishing target, sea surface temperature (SST) and catch.

Fishing areas were defined for this analysis at two levels of detail based upon landing location, STATE and REGION. The states included (from south to north along the mid-Atlantic coast of the United States) Virginia, Maryland, Delaware, New Jersey, New York, Connecticut, Rhode Island, and Massachusetts. Considering that fishing trips in this fishery are generally of short duration (less than one day, some of two-three days), the landing state can be expected to provide a reasonable proxy for fishing area. The REGIONs were defined based upon state; they were the southern area (SOUTH) from Virginia through New Jersey and the northern area (NORTH) from New York through Massachusetts. These definitions are consistent with definitions for previous shark catch per unit effort (CPUE) standardization analyses for this fishery (Brown 2000, Brown 2004). There is some severe imbalance in the state representation which could warrant condensing the strata to regions.

Observations were limited to those on which anglers indicated that they were targeting sharks and were employing the chumming fishing method exclusively. These restrictions are consistent with restrictions imposed for previous shark catch per unit effort (CPUE) standardization analyses for this fishery (Brown 2000, Brown 2004). Trips targeting other species categories (such as tunas) were not included because they were thought to be adding noise rather than information.

Species composition was assumed to have been reported correctly, however, given the close similarity of dusky and sandbar sharks, and prohibitions on retention of large coastal sharks, the species identifications may have become less reliable over time.

Factors which were considered as possible influences on catch rates included YEAR, MONTH, REGION, BOATTYPE, sea surface temperature (TEMP), STATE, MILES offshore, tournament participation (TOURNAMENT, Y=yes and N=no) and interview type (dockside/telephone recall or DOCKRECL). Preliminary analysis indicated that sandbar shark CPUE defined as fish per line*hour (number of lines X number of hours fished) was more independent of effort level than was CPUE defined as fish per hour. Therefore, line*hours was considered to be the preferred measure of fishing effort, in contrast to previous analyses of LPS catch rate data for sharks (Brown 2000, Brown 2004) where fishing effort had been defined as hours fished. The logarithm of the lines*hour was used as an offset term for the positive observation (Poisson) submodel.

The Lo method (Lo *et al.* 1992) was used to develop standardized indices; with that method separate analyses are conducted of the positive catch rates and the proportions of the observed trips which were successful. The error distribution for the proportion positive analysis was assumed to be binomial; for the positive catch rate analyses a Poisson error distribution was assumed, fitting the number of yellowfin tuna per trip with the natural log of the fishing hours as the offset term.

For this analysis, the same models used in the Brown (2004c) paper and a subsequent index developed for dusky sharks were used with updated information. Brown (2004c) used a stepwise approach to quantify the relative importance of the main factors explaining the variance in catch rates. That is, first the Null model was run, in which no factors were entered in the model. These results reflect the distribution of the nominal data. Each potential factor was then tested one at a time. The results were then ranked from greatest to least reduction in deviance per degree of freedom when compared to the Null model. The factor which resulted in the greatest reduction in deviance per degree of freedom was then incorporated into the model, provided two conditions were met: 1) the effect of the factor was determined to be significant at at least the 5% level based upon a Chi-Square test, and 2) the deviance per degree of freedom was reduced by at least 1% from the less complex model. This process was repeated, adding factors one at a time at each step, until no factor met the criteria for incorporation into the final model. After development of the main effects model, two-way interactions between factors were tested for inclusion for in the model.

The indices of relative abundance by year are determined based upon the standardized year effects. The product of the standardized proportion positives and the standardized positive catch rates was used to calculate overall standardized catch rates.

A revision to the formula used to estimate the variance of the product of two random variables was incorporated into the variance estimation. The proposed change is based upon the following three recommendations:
1) Use the Pearson correlation coefficient to test the correlation between the binomial and the poisson model component lsmeans.

2) If significant and either positive or negative, use the Taylor series approximation for the variance of two correlated random variables, as follows:

$$\hat{V}(\hat{I}) \approx \hat{P}^2\hat{V}(\hat{C}) + \hat{C}^2\hat{V}(\hat{P}) + 2\hat{C}\hat{P}\rho_{\hat{C},\hat{P}}[\sigma(\hat{C})\sigma(\hat{P})].$$

Where $\hat{V}(\hat{I})$) is the variance of the product of the estimated proportion positive, $\hat{P}$, and the positive catch rate, $\hat{C}$ is the estimated positive catch rate term, σ is the within year standard deviations of C and P and $\rho_{\hat{C},\hat{P}}$, is the Pearson correlation between the C and P.

3) if non-significant, use the Goodman (1960) exact estimator of the variance of the product of two independent variables:

$$\hat{V}(\hat{I}) = \hat{P}^2\hat{V}(\hat{C}) + \hat{C}^2\hat{V}(\hat{P}) - \hat{V}(\hat{P})\hat{V}(\hat{C}).$$

Testing of the significance of the correlation and changes to the variance formula were incorporated into the SAS code used to obtain the indices.

3. RESULTS

General results
Maps of sample observations of dusky and sandbar sharks by year are shown in **Figure 1**. Nominal catch rate and effort trends for both species are shown in **Tables 1 and 2** and included in **Figures 11 and 12**.

Histograms of the number of kept and released dusky and sandbar sharks for the all trips (top row) and just positive trips (bottom row) are shown in **figure 3**, while nominal catch rates versus miles fished and temperature are shown in **figure 4**. Some noteworthy (Table 3) patterns are evident when looking at the mean catch rates per positive trip, proportion of positive trips and the total number of sandbar and dusky sharks reported by year and region. First, dusky sharks are more numerous and more frequently encountered. Second, the percentage of positive trips declined substantially in the mid to late 1990s but it looks to have increased in recent years. Third the mean number of fish kept and released has been relatively constant over time, so the abundance signal is almost entirely in the proportion positive.

Model results: sandbar shark

Stepwise construction of the standardization model from Brown 2004c are shown in **tables 4** and **5**. The final models are:

Model: **prop positive = YEAR+TEMP** (for proportion positive)
Model**: cpue = YEAR+ MONTH +STATE** (for positive catches)

No two-way interactions, including year interactions, were found to be significant in either proportion positive or positive catch rates in the previous modeling and no interactions were incorporated into these indices. Type 3 sums of squares, factor effects and fitting criteria are shown in **tables 6** and **7** for the binomial and Poisson submodels respectively. A non-significant correlation was found between the proportion positive and the catch rates of the positive observations (**table 8)**. For this reason, the Goodman exact formula for the variance of the product of the two variables was used, under the assumption that they were independent.

Chi-square residuals for the proportion positive observations (binomial component) by factor and for the positive observations (poisson component) by factor are shown in **Figures 7** and **8**. The residual do show an expected departure from normality for the poisson component. Index results are shown in **Table 12** and **Figure 12** and a comparison with the previous index is shown in **Figure 13**.

Model results: dusky shark

Stepwise construction of the standardization models for Dusky are not shown, however, the final models used by Brown (2004c) are:

Model: **prop positive ~ YEAR+ STATE**
Model: **CPUE ~ YEAR + MONTH +STATE + DOCKRECL**

No two-way interactions, including year interactions, were found to be significant in either proportion positive or positive analyses in the previous modeling and no interactions were incorporated into these indices. Type 3 sums of squares, factor effects and fitting criteria are shown in **tables 9** and **10** for the binomial and Poisson submodels respectively. A non-significant correlation between the two model components was obtained and accordingly the Goodman (1960) exact estimator was used to obtain the index variance (**Table 11**).

Chi-square residuals for the proportion positive observations (binomial component) by factor and for the positive observations (poisson component) by factor are shown in **Figures 9** and **10**. The residual do show an expected departure from normality for the poisson component. Index results are shown in **Table 13** and **Figure 12**.

4. Discussion

- Particularly problematic is the temperature records from 1993. Preliminary exploration of modeling a year*temp interaction created wildly divergent index values, largely due to the recorded temperatures in 1993 which had a mean of 40 degrees, which appears quite cold positive catches of both sandbar and dusky sharks.
- Including an offset parameter in the binomial component had no effect on the sandbar index, and so was not done in the models presented here, though it would be recommended.
- Large numbers of missing temperature, miles fished and missing year and state or region combinations appear to create spurious interactions. Filling in these missing cells or condensing over cells could be useful to model interaction effects. The imbalance in the sample distribution makes modeling some of the factors problematic as there are substantial observations with no temperature or miles fished information, resulting in a potentially non-ignorable bias in the sample datasets that could be used to model temperature or miles fished as a factor in the catch rates.
- The Goodman exact formula reduced the variance estimates and confidence intervals, largely because of correcting the variance formula, rather than any difference in the data.
- There was a very high extra-deviance term for the dusky shark index indicating a relatively poor fit to the model.
- The most worrisome problem in the data is the combined decline in the indices and the decline in the proportion of positive trips in the Northern states (Table 1 and 2).
- This pattern could be indicative of a declining angling preference for sharks in the recreational fishery since the percentage of shark-targeted trips have declined (Table 3). There have also been regulations in effect prohibiting retention of the both dusky and sandbar sharks in federal waters but not always in state waters which could have led to a decrease in targeting of either species. However it could also be indicative of a decline in the population abundance manifested as a range contraction as the frequency of positive trips for these species in the north region (New York, Connecticut and Rhode Island, Massachusetts) have also declined substantially into the 1990s. Though in recent years the proportion positive has been increasing slightly in these areas.
- Despite the limited knowledge this analyst has of the fisheries and population status of both species, the higher total catch and higher absolute catch rates for dusky sharks appears incongruous as I would have expected sandbar sharks to be more abundant in the recreational catch. This may be indicative of a bias in what is called dusky or sandbar within the recreational community. It could be possible to explore whether these patterns are the same for the dockside interviews of versus the recalled reports within the same year.
- In conclusion both indices show similar patterns of declines into the 1990s and then increases in recent years. In this case species mis-identification (above) may be less of a problem. The indices cover a fairly wide spatial coverage of the population, however they do not incorporate the inshore habitat which is commonly used by sandbar sharks. No size composition information was available to the analyst so it is not known what ages or sizes this index corresponds to however it can likely be linked to larger fish.

4. REFERENCES

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Table 1. SANDBAR SHARK: Table of total large pelagic survey trips, selected trips and nominal catch rates of sandbar sharks. Selected trips met the criteria of being 'shark directed' and chumming trips.

year	total offshore trips	Shark Directed	identified as 'shark directed'	total directed, selected trips	Total sandbar kept and released	Total sandbar kept	Prop. positive	Avg per trip	Avg per positive trip
1986	11006	2076	18.86%	971	209	57	12.05%	0.2152	1.79
1987	10060	2206	21.93%	1043	117	58	6.42%	0.1122	1.75
1988	7841	1638	20.89%	458	100	18	12.88%	0.2183	1.71
1989	9689	1712	17.67%	807	267	69	21.07%	0.3309	1.58
1990	11457	2154	18.80%	972	116	21	8.95%	0.1193	1.35
1991	10729	1910	17.80%	882	142	10	7.48%	0.161	2.15
1992	11774	1854	15.75%	799	100	11	8.14%	0.1252	1.55
1993	11398	1156	10.14%	433	10	3	1.62%	0.0231	1
1994	9541	1012	10.61%	354	13	2	3.11%	0.0367	1.33
1995	14314	1252	8.75%	410	19	5	1.71%	0.0463	1.5
1996	4190	474	11.31%	189	11	0	3.17%	0.0582	1.83
1997	8413	816	9.70%	301	15	3	3.32%	0.0498	1.33
1998	8982	392	4.36%	139	3	1	2.16%	0.0216	1
1999	4341	316	7.28%	116	5	0	1.72%	0.0431	2.5
2000	7646	690	9.02%	218	4	0	0.92%	0.0183	2
2001	6414	428	6.67%	147	16	2	2.72%	0.1088	4
2002	7062	564	7.99%	162	5	0	1.85%	0.0309	1.67
2003	10555	1302	12.34%	566	11	0	0.88%	0.0194	2.2
2004	9875	1336	13.53%	579	8	1	1.04%	0.0138	1.33
2005	9371	1056	11.27%	456	24	0	2.19%	0.0526	2.4
2006	7836	1254	16.00%	473	9	0	0.85%	0.019	2.25
2007	11826	1604	13.56%	649	26	2	1.85%	0.0401	2.17
2008	12286	1406	11.44%	508	19	1	1.97%	0.0374	1.9

Table 2. Dusky SHARK: Table of total large pelagic survey trips, selected trips and nominal catch rates of dusky sharks. Selected trips met the criteria of being 'shark directed' and chumming trips.

year	total offshore trips	Shark Directed	identified as 'shark directed'	total directed, selected trips	Total sandbar kept and released	Total sandbar kept	Prop. positive	Avg per trip	Avg per positive trip
1986	11006	2076	18.86%	971	309	140	0.165	0.3182	1.93
1987	10060	2206	21.93%	1043	289	123	0.149	0.2771	1.8
1988	7841	1638	20.89%	458	42	14	0.057	0.0917	1.62
1989	9689	1712	17.67%	807	137	45	0.112	0.1698	1.51
1990	11457	2154	18.80%	972	162	42	0.108	0.1667	1.56
1991	10729	1910	17.80%	882	155	31	0.095	0.1757	1.86
1992	11774	1854	15.75%	799	45	10	0.035	0.0563	1.63
1993	11398	1156	10.14%	433	72	19	0.086	0.1663	1.25
1994	9541	1012	10.61%	354	32	2	0.057	0.0904	1.79
1995	14314	1252	8.75%	410	37	14	0.056	0.0902	1.5
1996	4190	474	11.31%	189	23	4	0.069	0.1217	1.83
1997	8413	816	9.70%	301	32	8	0.043	0.1063	2.6
1998	8982	392	4.36%	139	15	0	0.072	0.1079	1.5
1999	4341	316	7.28%	116	8	0	0.035	0.069	2
2000	7646	690	9.02%	218	13	0	0.037	0.0596	1.62
2001	6414	428	6.67%	147	7	0	0.041	0.0476	1.17
2002	7062	564	7.99%	162	9	1	0.037	0.0556	1.5
2003	10555	1302	12.34%	566	27	0	0.027	0.0477	1.8
2004	9875	1336	13.53%	579	34	0	0.036	0.0587	1.62
2005	9371	1056	11.27%	456	36	0	0.042	0.0789	1.89
2006	7836	1254	16.00%	473	18	0	0.021	0.0381	1.8
2007	11826	1604	13.56%	649	71	1	0.056	0.1094	1.97
2008	12286	1406	11.44%	508	95	1	0.104	0.187	1.79
2009	13140	1526	11.61%	622	66	0	0.051	0.1061	2.06

Table 3. Table of average caught per positive trip, percent of positive trips and total caught by region and species and total directed trips by region.

	Dusky						Sandbar							
	Average per trip caught and released		Percent of positive trips		total caught and released		Average per trip caught and released		Percent of positive trips		total caught and released		Total directed trips	
	North	South	N	S	N	S	N	S	N	S	N	S	N	S
1986	1.7	2.0	7	22.7	45	246	2.0	1.6	14.8	10.3	114	94	386	585
1987	2.3	1.7	5.9	20.3	54	187	1.6	2.0	9.7	4.5	60	45	393	650
1988	1.7	1.4	4.4	25.9	32	10	1.7	1.7	13	11.1	94	5	431	27
1989	1.6	1.4	9.6	12.8	64	63	1.7	1.5	17.2	25.4	124	134	425	382
1990	1.4	1.6	7	13.6	38	120	1.1	1.4	4.9	12	22	91	412	560
1991	1.3	2.0	3.5	15.2	20	134	1.5	2.8	7.9	7	51	91	428	454
1992	1.5	1.7	2.7	4.3	17	27	1.5	1.6	8.6	7.6	52	47	405	394
1993	1.5	1.0	4.2	17.2	6	4	NA	1.0	1	2.8	NA	1	288	145
1994	1.0	1.8	2	10.5	1	24	1.0	2.0	4.5	1.3	4	4	202	152
1995	NA	1.5	1.2	12.3	NA	9	NA	1.5	0.4	3.7	NA	3	248	162
1996	NA	1.8	0.9	15.2	NA	22	1.0	2.0	0.9	6.3	1	10	110	79
1997	NA	2.6	0	12.5	NA	26	NA	1.3	0.5	8.7	NA	8	197	104
1998	1.0	1.6	1.2	17	1	14	NA	1.0	0	5.7	NA	3	86	53
1999	2.0	2.0	3.4	3.4	6	2	NA	2.5	0	6.9	NA	5	87	29
2000	1.0	1.7	0.9	6.5	1	12	NA	2.0	0	1.9	NA	4	111	107
2001	1.0	1.2	1.3	7.4	1	6	NA	4.0	0	5.9	NA	16	79	68
2002	1.0	1.6	0.8	14.3	1	8	1.7	NA	2.4	0	5	NA	127	35
2003	6.0	1.5	0.3	6.2	6	21	2.0	2.3	0.3	1.8	2	9	340	226
2004	1.0	1.7	0.8	8.4	3	31	NA	1.3	0	2.8	NA	8	364	215
2005	2.0	1.9	0.3	11	2	34	NA	2.4	0	6.1	NA	24	292	164
2006	1.8	1.8	1.1	5.3	7	11	NA	2.3	0	3.5	NA	9	360	113
2007	1.5	2.0	0.5	14.5	3	68	3.0	2.1	0.2	4.7	3	23	414	235
2008	1.0	1.8	0.7	22.4	2	93	NA	1.9	0	4.4	NA	19	280	228
2009	1.0	2.2	0.7	13.4	3	63	NA	2.8	0	6	NA	37	406	216
average	1.6	1.7	2.5	13.0	14.9	51.5	1.6	2.0	3.6	6.3	44.3	30.0	286.3	224.3

Table 4. Results of the stepwise procedure to develop the proportion positive catch rate model for sandbar sharks (*Carcharhinus plumbeus*).

There are no explanatory factors in the base model.

FACTOR	DEGF	DEVIANCE	DEV/DF	%REDUCTION	LOGLIKE	CHISQ	PROBCHISQ
BASE	7887	3864.7	0.4900		-1932.4		
YEAR	7869	3468.9	0.4408	10.04	-1734.5	395.80	0.00000
TEMP	7886	3755.1	0.4762	2.82	-1877.6	109.57	0.00000
TEMP*TEMP	7886	3757.2	0.4764	2.77	-1878.6	107.49	0.00000
STATE	7880	3812.0	0.4838	1.28	-1906.0	52.70	0.00000
MONTH	7884	3832.9	0.4862	0.78	-1916.5	31.79	0.00000
DOCKRECL	7886	3850.6	0.4883	0.35	-1925.3	14.11	0.00017
REGION	7886	3858.8	0.4893	0.14	-1929.4	5.91	0.01508
BOATTYPE	7886	3862.3	0.4898	0.05	-1931.1	2.46	0.11701
TOURNAMENT	7886	3862.9	0.4898	0.04	-1931.4	1.86	0.17276

The explanatory factors in the base model are: YEAR

FACTOR	DEGF	DEVIANCE	DEV/DF	%REDUCTION	LOGLIKE	CHISQ	PROBCHISQ
BASE	7869	3468.9	0.4408		-1734.5		
TEMP	7868	3405.0	0.4328	1.83	-1702.5	63.89	0.00000
TEMP*TEMP	7868	3405.2	0.4328	1.82	-1702.6	63.67	0.00000
STATE	7862	3431.4	0.4365	0.99	-1715.7	37.53	0.00000
MONTH	7866	3444.6	0.4379	0.66	-1722.3	24.27	0.00002
TOURNAMENT	7868	3463.1	0.4401	0.16	-1731.5	5.85	0.01557
REGION	7868	3464.7	0.4404	0.11	-1732.3	4.22	0.03992
BOATTYPE	7868	3465.7	0.4405	0.08	-1732.8	3.25	0.07146
DOCKRECL	7868	3468.1	0.4408	0.01	-1734.1	0.80	0.37052

The explanatory factors in the base model are: YEAR TEMP

FACTOR	DEGF	DEVIANCE	DEV/DF	%REDUCTION	LOGLIKE	CHISQ	PROBCHISQ
BASE	7868	3405.0	0.4328		-1702.5		
STATE	7861	3375.4	0.4294	0.78	-1687.7	29.66	0.00011
MONTH	7865	3397.5	0.4320	0.18	-1698.8	7.49	0.05774
BOATTYPE	7867	3403.3	0.4326	0.04	-1701.6	1.76	0.18479
TOURNAMENT	7867	3403.5	0.4326	0.03	-1701.7	1.57	0.20993
DOCKRECL	7867	3404.6	0.4328	-0.00	-1702.3	0.42	0.51661
REGION	7867	3404.7	0.4328	-0.00	-1702.3	0.34	0.56052
TEMP*TEMP	7867	3405.0	0.4328	-0.01	-1702.5	0.00	0.99272

FINAL MODEL: SUCCESS=YEAR+TEMP (sea surface temperature)
%REDUCTION: percent difference in deviance/df between the newly included factor and the previous factor entered into the model; LOGLIKE: log likelihood; CHISQ: Pearson Chi-square statistic; PROBCHISQ: significance level of the Chi-square statistic.

Table 5. Results of the stepwise procedure to develop the positive catch rate model for sandbar sharks (*Carcharhinus plumbeus*). Note that this is the same as in Brown (2004c).

There are no explanatory factors in the base model.

FACTOR	DEGF	DEVIANCE	DEV/DF	%REDUCTION	LOGLIKE	CHISQ	PROBCHISQ
BASE		677	742.8	1.0972		-642.0	
YEAR	659	688.0	1.0440	4.85	-614.6	54.82	0.00001
MONTH	674	717.0	1.0638	3.05	-629.1	25.83	0.00001
DOCKRECL	676	731.4	1.0820	1.38	-636.4	11.36	0.00075
TOURNAMENT	676	731.5	1.0820	1.38	-636.4	11.34	0.00076
STATE	671	728.5	1.0857	1.05	-634.9	14.29	0.02660
REGION	676	739.2	1.0935	0.34	-640.2	3.60	0.05780
BOATTYPE	676	742.6	1.0985	-0.12	-641.9	0.24	0.62404

The explanatory factors in the base model are: YEAR

FACTOR	DEGF	DEVIANCE	DEV/DF	%REDUCTION	LOGLIKE	CHISQ	PROBCHISQ
BASE	659	688.0	1.0440		-614.6		
MONTH	656	667.0	1.0168	2.60	-604.2	20.93	0.00011
STATE	653	673.4	1.0313	1.21	-607.3	14.54	0.02414
DOCKRECL	658	680.1	1.0335	1.00	-610.7	7.93	0.00486
TOURNAMENT	658	680.1	1.0336	1.00	-610.7	7.88	0.00499
BOATTYPE	658	686.8	1.0438	0.02	-614.0	1.17	0.27953
REGION	658	686.9	1.0440	0.00	-614.1	1.04	0.30672

The explanatory factors in the base model are: YEAR MONTH

FACTOR	DEGF	DEVIANCE	DEV/DF	%REDUCTION	LOGLIKE	CHISQ	PROBCHISQ
BASE	656	667.0	1.0168		-604.2		
STATE	650	650.9	1.0014	1.52	-596.1	16.12	0.01315
DOCKRECL	655	661.8	1.0103	0.64	-601.5	5.29	0.02145
TOURNAMENT	655	663.9	1.0136	0.32	-602.6	3.14	0.07627
BOATTYPE	655	664.6	1.0147	0.21	-602.9	2.45	0.11770
REGION	655	666.9	1.0181	-0.13	-604.1	0.18	0.67440

The explanatory factors in the base model are: YEAR MONTH STATE

FACTOR	DEGF	DEVIANCE	DEV/DF	%REDUCTION	LOGLIKE	CHISQ	PROBCHISQ
BASE	650	650.9	1.0014		-596.1		
TOURNAMENT	649	645.2	0.9941	0.73	-593.2	5.76	0.01644
DOCKRECL	649	646.7	0.9965	0.49	-594.0	4.19	0.04065
REGION	650	650.9	1.0014	0.00	-596.1	0.00	.
BOATTYPE	649	650.6	1.0024	-0.10	-595.9	0.35	0.55237

FINAL MODEL: Sandbar Sharks (Kept+Released) =YEAR+MONTH+STATE

%REDUCTION: percent difference in deviance/df between the newly included factor and the previous factor entered into the model; LOGLIKE: log likelihood; CHISQ: Pearson Chi-square statistic; PROBCHISQ: significance level of the Chi-square statistic.

Table 6. SANDBAR SHARK: Binomial sub-model results for proportion of positive CPUE

Class Level Information

Class	Levels	Values
YEAR	24	1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009

Description	Value
Deviance	3786.6029
Scaled Deviance	3649.5436
Pearson Chi-Square	10820.6629
Scaled Pearson Chi-Square	10429.0000
Extra-Dispersion Scale	1.0376

Effect	YEAR	Estimate	Error	DF	t Value	Pr > |t|	Alpha	Lower	Upper
Intercept		-8.8575	0.6938	1.00E+04	-12.77	<.0001	0.05	-10.2175	-7.4974
YEAR	1986	2.1654	0.3505	1.00E+04	6.18	<.0001	0.05	1.4784	2.8524
YEAR	1987	0.9923	0.3704	1.00E+04	2.68	0.0074	0.05	0.2663	1.7183
YEAR	1988	2.0821	0.359	1.00E+04	5.8	<.0001	0.05	1.3783	2.7858
YEAR	1989	2.4367	0.3432	1.00E+04	7.1	<.0001	0.05	1.764	3.1095
YEAR	1990	1.4543	0.3511	1.00E+04	4.14	<.0001	0.05	0.7661	2.1424
YEAR	1991	1.3908	0.3537	1.00E+04	3.93	<.0001	0.05	0.6975	2.0842
YEAR	1992	1.6899	0.3527	1.00E+04	4.79	<.0001	0.05	0.9984	2.3813
YEAR	1993	0.7732	0.5142	1.00E+04	1.5	0.1327	0.05	-0.2348	1.7813
YEAR	1994	0.5144	0.4525	1.00E+04	1.14	0.2556	0.05	-0.3725	1.4013
YEAR	1995	-0.4484	0.607	1.00E+04	-0.74	0.4601	0.05	-1.6382	0.7414
YEAR	1996	0.359	0.5666	1.00E+04	0.63	0.5263	0.05	-0.7515	1.4696
YEAR	1997	0.5275	0.4751	1.00E+04	1.11	0.2669	0.05	-0.4037	1.4587
YEAR	1998	-0.2908	0.7973	1.00E+04	-0.36	0.7154	0.05	-1.8536	1.2721
YEAR	1999	-0.05327	0.7971	1.00E+04	-0.07	0.9467	0.05	-1.6157	1.5092
YEAR	2000	-0.6003	0.7939	1.00E+04	-0.76	0.4496	0.05	-2.1565	0.9559
YEAR	2001	0.002573	0.6793	1.00E+04	0	0.997	0.05	-1.329	1.3342
YEAR	2002	-0.06829	0.6779	1.00E+04	-0.1	0.9198	0.05	-1.3971	1.2605
YEAR	2003	-0.7435	0.562	1.00E+04	-1.32	0.1859	0.05	-1.8451	0.3581
YEAR	2004	-0.9455	0.606	1.00E+04	-1.56	0.1187	0.05	-2.1333	0.2423
YEAR	2005	-0.1358	0.507	1.00E+04	-0.27	0.7888	0.05	-1.1297	0.858
YEAR	2006	-1.4192	0.792	1.00E+04	-1.79	0.0732	0.05	-2.9717	0.1332
YEAR	2007	-0.3397	0.4872	1.00E+04	-0.7	0.4857	0.05	-1.2948	0.6153
YEAR	2008	-0.05378	0.4612	1.00E+04	-0.12	0.9072	0.05	-0.9579	0.8503
YEAR	2009	0	.	.	.	.	.	.	.
TEMP		0.07268	0.009205	1.00E+04	7.9	<.0001	0.05	0.05464	0.09073

Table 7. SANDBAR SHARK: Poisson sub-model results for positive observations.

Class Level Information

Class	Levels	Values
YEAR	24	1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009
MONTH	4	6 7 8 9
STATE	7	CT DE MD NJ NY RI VA

Criteria for Assessing Goodness Of Fit

Description	Value
Deviance	727.0856
Scaled Deviance	405.5296
Pearson Chi-Square	1244.2924
Scaled Pearson Chi-Square	694.0000
Extra-Dispersion Scale	1.7929

Effect	factor	Estimate	SE	DF	t Value	Pr > |t|	alpha	95% LCL	95% UCL
Intercept		-2.0558	0.4994	694	-4.12	<.0001	0.05	-3.0364	-1.0753
YEAR	1986	-0.3414	0.2552	694	-1.34	0.1814	0.05	-0.8424	0.1597
YEAR	1987	-0.4887	0.2777	694	-1.76	0.0789	0.05	-1.0339	0.0565
YEAR	1988	-0.3543	0.2901	694	-1.22	0.2224	0.05	-0.9238	0.2153
YEAR	1989	-0.4886	0.2509	694	-1.95	0.0519	0.05	-0.9812	0.00399
YEAR	1990	-0.7312	0.2737	694	-2.67	0.0077	0.05	-1.2686	-0.1939
YEAR	1991	-0.1577	0.2677	694	-0.59	0.5561	0.05	-0.6832	0.3679
YEAR	1992	-0.6801	0.2783	694	-2.44	0.0148	0.05	-1.2266	-0.1337
YEAR	1993	-0.4893	0.4794	694	-1.02	0.3078	0.05	-1.4306	0.4519
YEAR	1994	-0.7276	0.4471	694	-1.63	0.1042	0.05	-1.6054	0.1503
YEAR	1995	0.07198	0.3793	694	0.19	0.8495	0	-0.6727	0.816
YEAR	1996	-0.5122	0.4621	694	-1.11	0.268	0.05	-1.4194	0.395
YEAR	1997	-0.5373	0.4115	694	-1.31	0.1921	0.05	-1.3452	0.2707
YEAR	1998	-1.042	0.9737	694	-1.07	0.2849	0.05	-2.9538	0.8697
YEAR	1999	-0.9036	0.6501	694	-1.39	0.165	0.05	-2.1801	0.3729
YEAR	2000	-0.1809	0.7078	694	-0.26	0.7984	0.05	-1.5706	1.2088
YEAR	2001	0.6469	0.406	694	1.59	0.1116	0.05	-0.1504	1.4441
YEAR	2002	-0.3528	0.6502	694	-0.54	0.5875	0.05	-1.6293	0.9237
YEAR	2003	-0.454	0.4649	694	-0.98	0.3291	0.05	-1.3667	0.4587
YEAR	2004	-0.8238	0.5451	694	-1.51	0.1311	0.05	-1.894	0.2463
YEAR	2005	-0.1646	0.3517	694	-0.47	0.64	0.05	-0.8551	0.526
YEAR	2006	-0.0354	0.501	694	-0.07	0.9437	0.05	-1.0191	0.9483
YEAR	2007	-0.3099	0.3436	694	-0.9	0.3674	0.05	-0.9846	0.3647
YEAR	2008	-0.4272	0.3827	694	-1.12	0.2647	0.05	-1.1785	0.3242
YEAR	2009	0	.	.	.	.	.	.	.
month	6	-0.6228	0.2044	694	-3.05	0.0024	0.05	-1.0241	-0.2214
month	7	-0.5547	0.2052	694	-2.7	0.0071	0.05	-0.9576	-0.1517
month	8	-0.1594	0.2153	694	-0.74	0.4594	0.05	-0.582	0.2633

month	9	0	.	.	.	.	.	.	.
state	CT	0.4703	0.4864	694	0.97	0.3339	0.05	-0.4846	1.4252
state	DE	0.1688	0.4219	694	0.4	0.6893	0.05	-0.6596	0.9972
state	MD	0.1853	0.4172	694	0.44	0.657	0.05	-0.6337	1.0044
state	NJ	0.4508	0.3985	694	1.13	0.2582	0.05	-0.3315	1.2332
state	NY	0.3618	0.3973	694	0.91	0.3627	0.05	-0.4182	1.1418
state	RI	0.472	0.4219	694	1.12	0.2636	0.05	-0.3563	1.3002
state	VA	0	.	.	.	.	.	.	.

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	Chi-Square	F Value	Pr > ChiSq	Pr > F
YEAR	23	694	34.38	1.49	0.0598	0.0642
MONTH	3	694	22.51	7.50	<.0001	<.0001
STATE	6	694	5.68	0.95	0.4602	0.4610

Table 8. SANDBAR SHARK: Correlation between binomial and poisson components is not significant

Pearson Correlation Statistics (Fisher's z Transformation)

Variable	With Variable	95% Confidence Limits		p Value for H0:Rho=0
ppos	cpue	-0.526633	0.263554	0.4599

Table 9. DUSKY SHARK: Binomial sub-model results for proportion of positive CPUE.

Class Level Information

Class Level Information

Class	Levels	Values
YEAR	24	1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009
STATE	8	CT DE MA MD NJ NY RI VA

GLIMMIX Model Statistics

Description	Value
Deviance	5677.5983
Scaled Deviance	5934.3476
Pearson Chi-Square	11397.5845
Scaled Pearson Chi-Square	11913.0000
Extra-Dispersion Scale	0.9567

Type 3 Tests of Fixed Effects

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	Chi-Square	F Value	Pr > ChiSq	Pr > F
YEAR	23	12E3	233.99	10.17	<.0001	<.0001
STATE	7	12E3	505.50	72.21	<.0001	<.0001

<table>
<tr><th>Effect</th><th>YEAR</th><th>Estimate</th><th>Error</th><th>DF</th><th>t Value</th><th>Pr > |t|</th><th>Alpha</th><th>Lower</th><th>Upper</th></tr>
<tr><td>Intercept</td><td></td><td>-1.8218</td><td>0.3392</td><td>1.20E+04</td><td>-5.37</td><td><.0001</td><td>0.05</td><td>-2.4867</td><td>-1.1568</td></tr>
<tr><td>YEAR</td><td>1986</td><td>1.0168</td><td>0.2067</td><td>1.20E+04</td><td>4.92</td><td><.0001</td><td>0.05</td><td>0.6116</td><td>1.422</td></tr>
<tr><td>YEAR</td><td>1987</td><td>1.1025</td><td>0.2076</td><td>1.20E+04</td><td>5.31</td><td><.0001</td><td>0.05</td><td>0.6955</td><td>1.5094</td></tr>
<tr><td>YEAR</td><td>1988</td><td>0.9023</td><td>0.2803</td><td>1.20E+04</td><td>3.22</td><td>0.0013</td><td>0.05</td><td>0.3528</td><td>1.4518</td></tr>
<tr><td>YEAR</td><td>1989</td><td>0.9079</td><td>0.2192</td><td>1.20E+04</td><td>4.14</td><td><.0001</td><td>0.05</td><td>0.4782</td><td>1.3375</td></tr>
<tr><td>YEAR</td><td>1990</td><td>0.8181</td><td>0.2149</td><td>1.20E+04</td><td>3.81</td><td>0.0001</td><td>0.05</td><td>0.3968</td><td>1.2394</td></tr>
<tr><td>YEAR</td><td>1991</td><td>0.7508</td><td>0.2196</td><td>1.20E+04</td><td>3.42</td><td>0.0006</td><td>0.05</td><td>0.3204</td><td>1.1811</td></tr>
<tr><td>YEAR</td><td>1992</td><td>-0.3389</td><td>0.2689</td><td>1.20E+04</td><td>-1.26</td><td>0.2075</td><td>0.05</td><td>-0.8659</td><td>0.1881</td></tr>
<tr><td>YEAR</td><td>1993</td><td>0.5866</td><td>0.2587</td><td>1.20E+04</td><td>2.27</td><td>0.0234</td><td>0.05</td><td>0.07943</td><td>1.0938</td></tr>
<tr><td>YEAR</td><td>1994</td><td>-0.2026</td><td>0.3109</td><td>1.20E+04</td><td>-0.65</td><td>0.5146</td><td>0.05</td><td>-0.8119</td><td>0.4067</td></tr>
<tr><td>YEAR</td><td>1995</td><td>0.01374</td><td>0.2856</td><td>1.20E+04</td><td>0.05</td><td>0.9616</td><td>0.05</td><td>-0.5461</td><td>0.5736</td></tr>
<tr><td>YEAR</td><td>1996</td><td>-0.0768</td><td>0.346</td><td>1.20E+04</td><td>-0.22</td><td>0.8243</td><td>0.05</td><td>-0.7551</td><td>0.6014</td></tr>
<tr><td>YEAR</td><td>1997</td><td>-0.3776</td><td>0.3394</td><td>1.20E+04</td><td>-1.11</td><td>0.266</td><td>0.05</td><td>-1.0429</td><td>0.2877</td></tr>
<tr><td>YEAR</td><td>1998</td><td>0.1236</td><td>0.382</td><td>1.20E+04</td><td>0.32</td><td>0.7462</td><td>0.05</td><td>-0.6252</td><td>0.8724</td></tr>
<tr><td>YEAR</td><td>1999</td><td>-0.3966</td><td>0.5415</td><td>1.20E+04</td><td>-0.73</td><td>0.4639</td><td>0.05</td><td>-1.4579</td><td>0.6648</td></tr>
<tr><td>YEAR</td><td>2000</td><td>-0.7288</td><td>0.4042</td><td>1.20E+04</td><td>-1.8</td><td>0.0714</td><td>0.05</td><td>-1.5211</td><td>0.06347</td></tr>
<tr><td>YEAR</td><td>2001</td><td>-0.5471</td><td>0.4546</td><td>1.20E+04</td><td>-1.2</td><td>0.2288</td><td>0.05</td><td>-1.4382</td><td>0.344</td></tr>
<tr><td>YEAR</td><td>2002</td><td>-0.2353</td><td>0.4558</td><td>1.20E+04</td><td>-0.52</td><td>0.6057</td><td>0.05</td><td>-1.1289</td><td>0.6582</td></tr>
<tr><td>YEAR</td><td>2003</td><td>-0.7616</td><td>0.3183</td><td>1.20E+04</td><td>-2.39</td><td>0.0167</td><td>0.05</td><td>-1.3855</td><td>-0.1377</td></tr>
<tr><td>YEAR</td><td>2004</td><td>-0.3344</td><td>0.289</td><td>1.20E+04</td><td>-1.16</td><td>0.2473</td><td>0.05</td><td>-0.9009</td><td>0.2321</td></tr>
<tr><td>YEAR</td><td>2005</td><td>-0.2498</td><td>0.2981</td><td>1.20E+04</td><td>-0.84</td><td>0.402</td><td>0.05</td><td>-0.8341</td><td>0.3345</td></tr>
<tr><td>YEAR</td><td>2006</td><td>-0.7576</td><td>0.3663</td><td>1.20E+04</td><td>-2.07</td><td>0.0386</td><td>0.05</td><td>-1.4756</td><td>-0.0396</td></tr>
<tr><td>YEAR</td><td>2007</td><td>0.228</td><td>0.2524</td><td>1.20E+04</td><td>0.9</td><td>0.3663</td><td>0.05</td><td>-0.2667</td><td>0.7228</td></tr>
<tr><td>YEAR</td><td>2008</td><td>0.6821</td><td>0.2364</td><td>1.20E+04</td><td>2.89</td><td>0.0039</td><td>0.05</td><td>0.2187</td><td>1.1455</td></tr>
<tr><td>YEAR</td><td>2009</td><td>0</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td></tr>
</table>

STATE	CT	-3.1932	0.7528	1.20E+04	-4.24	<.0001	0.05	-4.6689	-1.7176
STATE	DE	0.03313	0.3168	1.20E+04	0.1	0.9167	0.05	-0.5879	0.6541
STATE	MA	-4.1716	1.0217	1.20E+04	-4.08	<.0001	0.05	-6.1742	-2.169
STATE	MD	0.2041	0.2951	1.20E+04	0.69	0.4892	0.05	-0.3744	0.7826
STATE	NJ	-0.8358	0.294	1.20E+04	-2.84	0.0045	0.05	-1.412	-0.2596
STATE	NY	-1.8465	0.2971	1.20E+04	-6.21	<.0001	0.05	-2.4289	-1.264
STATE	RI	-2.9454	0.3869	1.20E+04	-7.61	<.0001	0.05	-3.7038	-2.1871
STATE	VA	0	.	.	.	.	.	.	.

Table 10. DUSKY SHARK: Poisson sub-model results for positive observations. Note the extremely high extra-dispersion scale.

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Class Level Information
Class          Levels    Values
YEAR               24    1986 1987 1988 1989 1990 1991
1992 1993 1994 1995 1996 1997V
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Class        Levels    Values
YEAR             24    1986 1987 1988 1989 1990 1991
1992 1993 1994 1995 1996 1997
1998 1999 2000 2001 2002 2003
2004 2005 2006 2007 2008 2009
MONTH             4    6 7 8 9
STATE             8    CT DE MA MD NJ NY RI VA
dockrecl          2    1 2
```

GLIMMIX Model Statistics

Description	Value
Deviance	1117.9829
Scaled Deviance	498.0700
Pearson Chi-Square	2022.4117
Scaled Pearson Chi-Square	901.0000
Extra-Dispersion Scale	2.2446

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	Chi-Square	F Value	Pr > ChiSq	Pr > F
YEAR	23	901	16.23	0.71	0.8453	0.8434
MONTH	3	901	22.88	7.63	<.0001	<.0001
STATE	7	901	10.20	1.46	0.1774	0.1790
dockrecl	1	901	6.11	6.11	0.0134	0.0136

Effect	factor	Estimate	SE	DF	t Value	Pr > |t|	alpha	95% LCL	95% UCL
Intercept		-1.642	0.392	901	-4.19	<.0001	0.05	-2.4117	-0.873
YEAR	1986	-0.113	0.2209	901	-0.51	0.6088	0.05	-0.5466	0.3205
YEAR	1987	-0.182	0.2191	901	-0.83	0.4053	0.05	-0.6123	0.2475
YEAR	1988	-0.181	0.3138	901	-0.58	0.5638	0.05	-0.7971	0.4347
YEAR	1989	-0.16	0.2402	901	-0.66	0.5067	0.05	-0.631	0.3118
YEAR	1990	-0.365	0.2361	901	-1.55	0.1227	0.05	-0.828	0.0986
YEAR	1991	-0.307	0.2359	901	-1.3	0.1933	0.05	-0.7702	0.1559
YEAR	1992	-0.454	0.3054	901	-1.49	0.1377	0.05	-1.0529	0.1456
YEAR	1993	-0.288	0.2704	901	-1.07	0.2865	0.05	-0.819	0.2423
YEAR	1994	-0.407	0.3569	901	-1.14	0.2543	0.05	-1.1076	0.2933
YEAR	1995	-0.503	0.3224	901	-1.56	0.1192	0.05	-1.1357	0.1299
YEAR	1996	0.0753	0.3656	901	0.21	0.8368	0.05	-0.6422	0.7928
YEAR	1997	0.3133	0.3261	901	0.96	0.337	0.05	-0.3268	0.9533
YEAR	1998	-0.764	0.4414	901	-1.73	0.084	0.05	-1.6297	0.1028
YEAR	1999	-0.226	0.5718	901	-0.4	0.6928	0.05	-1.3481	0.8962

YEAR	2000	0.0288	0.458	901	0.06	0.9499	0.05	-0.87	0.9276
YEAR	2001	-0.647	0.5999	901	-1.08	0.2814	0.05	-1.8239	0.5308
YEAR	2002	-0.201	0.5402	901	-0.37	0.7105	0.05	-1.2607	0.8596
YEAR	2003	-0.131	0.3461	901	-0.38	0.7052	0.05	-0.8103	0.5483
YEAR	2004	-0.155	0.3225	901	-0.48	0.6301	0.05	-0.7883	0.4775
YEAR	2005	-0.057	0.3135	901	-0.18	0.8564	0.05	-0.6719	0.5585
YEAR	2006	-0.342	0.4027	901	-0.85	0.3961	0.05	-1.1322	0.4484
YEAR	2007	0.0063	0.2623	901	0.02	0.981	0.05	-0.5086	0.5211
YEAR	2008	-0.208	0.2456	901	-0.85	0.3975	0.05	-0.6898	0.2741
YEAR	2009	0	.	.	.	.	.	.	.
MONTH	6	-0.302	0.1867	901	-1.61	0.1068	0.05	-0.668	0.0651
MONTH	7	-0.082	0.1911	901	-0.43	0.6673	0.05	-0.4572	0.2929
MONTH	8	0.2783	0.2029	901	1.37	0.1704	0.05	-0.1198	0.6765
MONTH	9	0	.	.	.	.	.	.	.
STATE	CT	-0.651	0.9207	901	-0.71	0.4796	0.05	-2.4581	1.1557
STATE	DE	-0.213	0.2934	901	-0.73	0.4672	0.05	-0.7892	0.3624
STATE	MA	-1.061	1.5483	901	-0.69	0.4932	0.05	-4.1	1.9774
STATE	MD	-0.491	0.2779	901	-1.77	0.0774	0.05	-1.0369	0.0541
STATE	NJ	-0.578	0.2748	901	-2.1	0.0359	0.05	-1.1168	-0.0382
STATE	NY	-0.531	0.2866	901	-1.85	0.0642	0.05	-1.0936	0.0313
STATE	RI	-0.816	0.4759	901	-1.72	0.0866	0.05	-1.7504	0.1177
STATE	VA	0	.	.	.	.	.	.	.
dockrecl	1	-0.237	0.0958	901	-2.47	0.0136	0.05	-0.4249	-0.0488
dockrecl	2			0	.	.	.	.	.

Table 11. DUSKY SHARK: Correlation between binomial and poisson components is not significant

```
                    Pearson Correlation Statistics (Fisher's z Transformation)
                               With                                      p Value for
                 Variable    Variable       95% Confidence Limits        H0:Rho=0
ppos        cpue           -0.456092      0.347882        0.7620
```

Table 12. SANDBAR SHARK: Standardized relative abundance indices.
Model: **prop positive ~ YEAR+TEMP** (for proportion positive)
Model**: cpue ~ YEAR+ MONTH +STATE** (for positive catches)

year	index	LCL	UCL	CV	std index	Std LCL	Std UCL	nominal relative mean
1986	1.067	0.756	1.377	0.149	3.479	2.465	4.494	2.634
1987	0.314	0.181	0.446	0.215	1.023	0.592	1.455	1.373
1988	0.979	0.59	1.368	0.203	3.194	1.924	4.465	2.672
1989	1.159	0.875	1.443	0.125	3.782	2.856	4.708	4.050
1990	0.381	0.246	0.515	0.180	1.241	0.803	1.68	1.460
1991	0.637	0.42	0.853	0.174	2.077	1.37	2.783	1.971
1992	0.498	0.318	0.677	0.185	1.623	1.036	2.21	1.533
1993	0.254	-0.02	0.528	0.551	0.829	-0.066	1.724	0.283
1994	0.156	0.012	0.3	0.470	0.509	0.04	0.977	0.449
1995	0.135	-0.017	0.287	0.575	0.44	-0.056	0.935	0.567
1996	0.166	-0.025	0.357	0.586	0.542	-0.081	1.166	0.712
1997	0.191	0.015	0.367	0.471	0.623	0.047	1.199	0.610
1998	0.052	-0.047	0.151	0.978	0.169	-0.155	0.492	0.264
1999	0.075	-0.048	0.198	0.837	0.245	-0.157	0.647	0.528
2000	0.09	-0.062	0.242	0.861	0.294	-0.202	0.79	0.224
2001	0.374	-0.103	0.851	0.651	1.219	-0.337	2.775	1.332
2002	0.128	-0.063	0.32	0.762	0.418	-0.207	1.043	0.378
2003	0.059	-0.009	0.128	0.586	0.194	-0.029	0.417	0.237
2004	0.034	-0.01	0.077	0.664	0.11	-0.033	0.252	0.169
2005	0.145	0.013	0.277	0.464	0.473	0.043	0.903	0.644
2006	0.046	-0.025	0.118	0.788	0.151	-0.082	0.383	0.233
2007	0.102	0.014	0.191	0.441	0.334	0.045	0.623	0.491
2008	0.121	0.017	0.224	0.437	0.394	0.057	0.731	0.458
2009	0.195	0.046	0.344	0.389	0.637	0.151	1.123	0.728

Table 13. DUSKY SHARK: Standardized relative abundance indices for Dusky sharks.
Model: **prop positive ~ YEAR+ STATE** (for proportion positive)
Model: **CPUE ~ YEAR + MONTH +STATE + DOCKRECL** (for positive catches)

year	index	LCL	UCL	CV	std index	Std LCL	Std UCL	nominal relative mean
1986	1.353	1.028	1.679	0.123	2.167	1.646	2.687	2.731
1987	1.355	1.033	1.677	0.121	2.17	1.655	2.685	2.379
1988	1.148	0.478	1.819	0.298	1.839	0.765	2.912	0.787
1989	1.179	0.791	1.568	0.168	1.888	1.266	2.51	1.458
1990	0.89	0.622	1.158	0.154	1.424	0.995	1.853	1.431
1991	0.889	0.61	1.169	0.16	1.424	0.976	1.872	1.508
1992	0.284	0.121	0.446	0.292	0.454	0.194	0.714	0.483
1993	0.785	0.413	1.157	0.242	1.257	0.661	1.853	1.427
1994	0.338	0.088	0.588	0.377	0.541	0.141	0.941	0.776
1995	0.376	0.139	0.613	0.322	0.602	0.223	0.982	0.774
1996	0.616	0.119	1.114	0.412	0.987	0.191	1.783	1.045
1997	0.589	0.153	1.024	0.378	0.942	0.245	1.64	0.912
1998	0.321	0.012	0.63	0.491	0.514	0.019	1.009	0.926
1999	0.337	-0.11	0.785	0.677	0.54	-0.177	1.256	0.592
2000	0.316	-0.01	0.642	0.526	0.506	-0.016	1.028	0.512
2001	0.192	-0.056	0.439	0.658	0.307	-0.089	0.703	0.409
2002	0.403	-0.08	0.886	0.611	0.645	-0.128	1.418	0.477
2003	0.261	0.067	0.456	0.38	0.418	0.107	0.729	0.409
2004	0.384	0.13	0.637	0.337	0.615	0.209	1.02	0.504
2005	0.459	0.158	0.76	0.335	0.735	0.253	1.217	0.677
2006	0.212	0.022	0.403	0.458	0.34	0.034	0.645	0.327
2007	0.763	0.401	1.125	0.242	1.222	0.642	1.801	0.939
2008	0.925	0.547	1.303	0.208	1.481	0.876	2.086	1.605
2009	0.614	0.304	0.924	0.257	0.983	0.487	1.48	0.911

Figure 1. Map of sample observations of dusky and sandbar sharks.

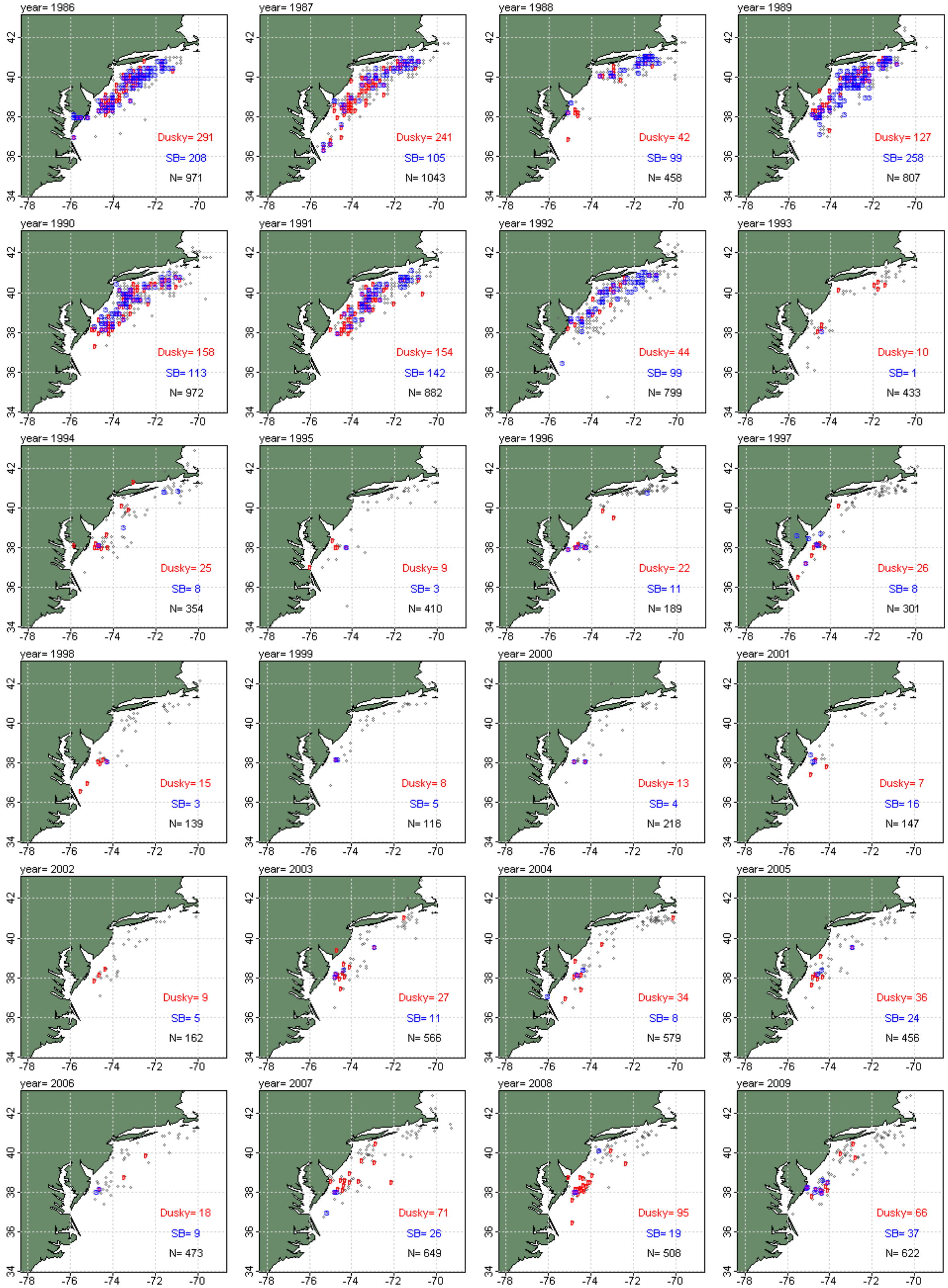

Figure 3. Historgrams of kept and released dusky and sandbar sharks for the all trips (top row) and just positive trips (bottom row).

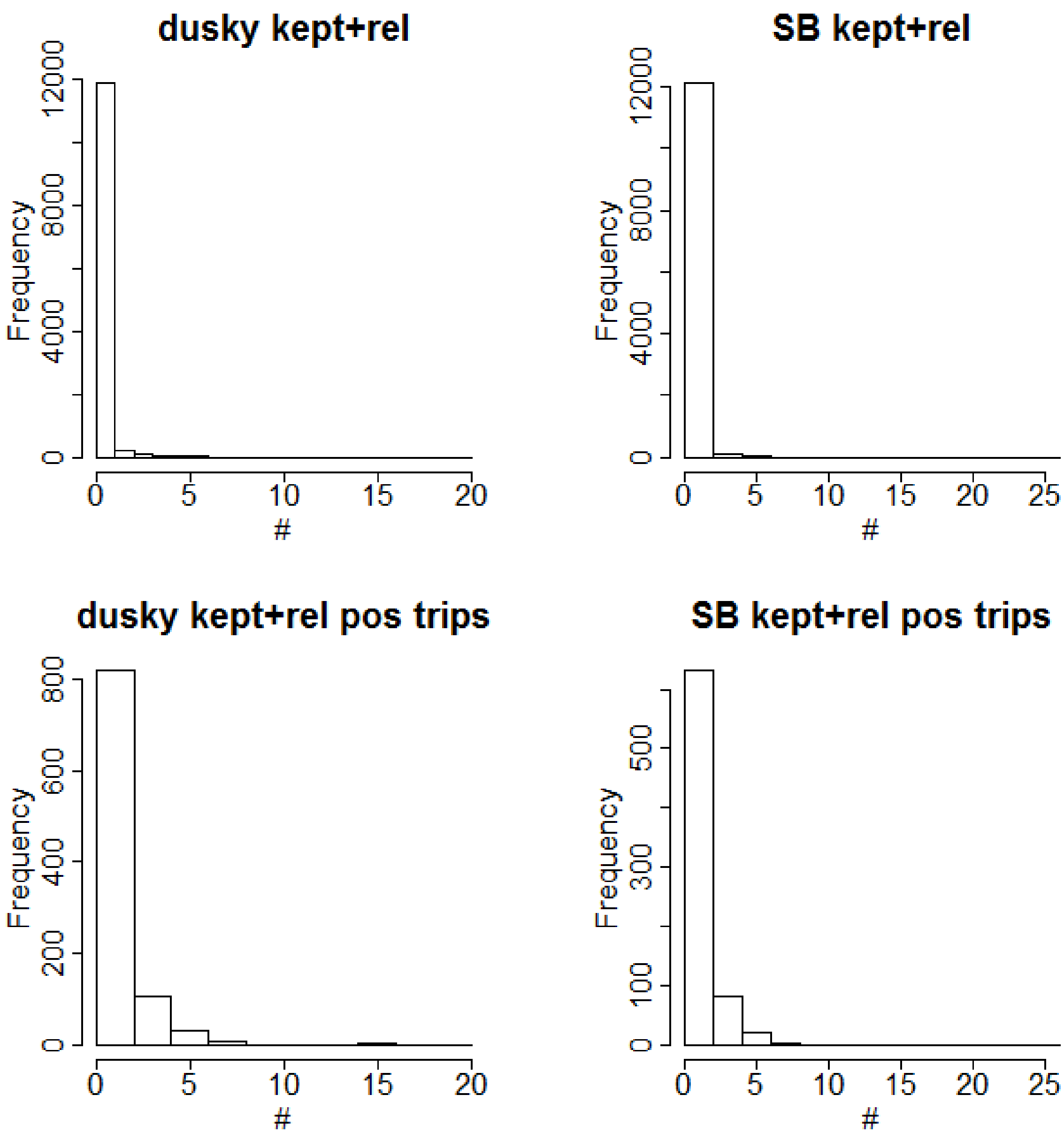

Figure 4. Plots catch rates of kept and released sharks versus miles fished offshore and water temperature.

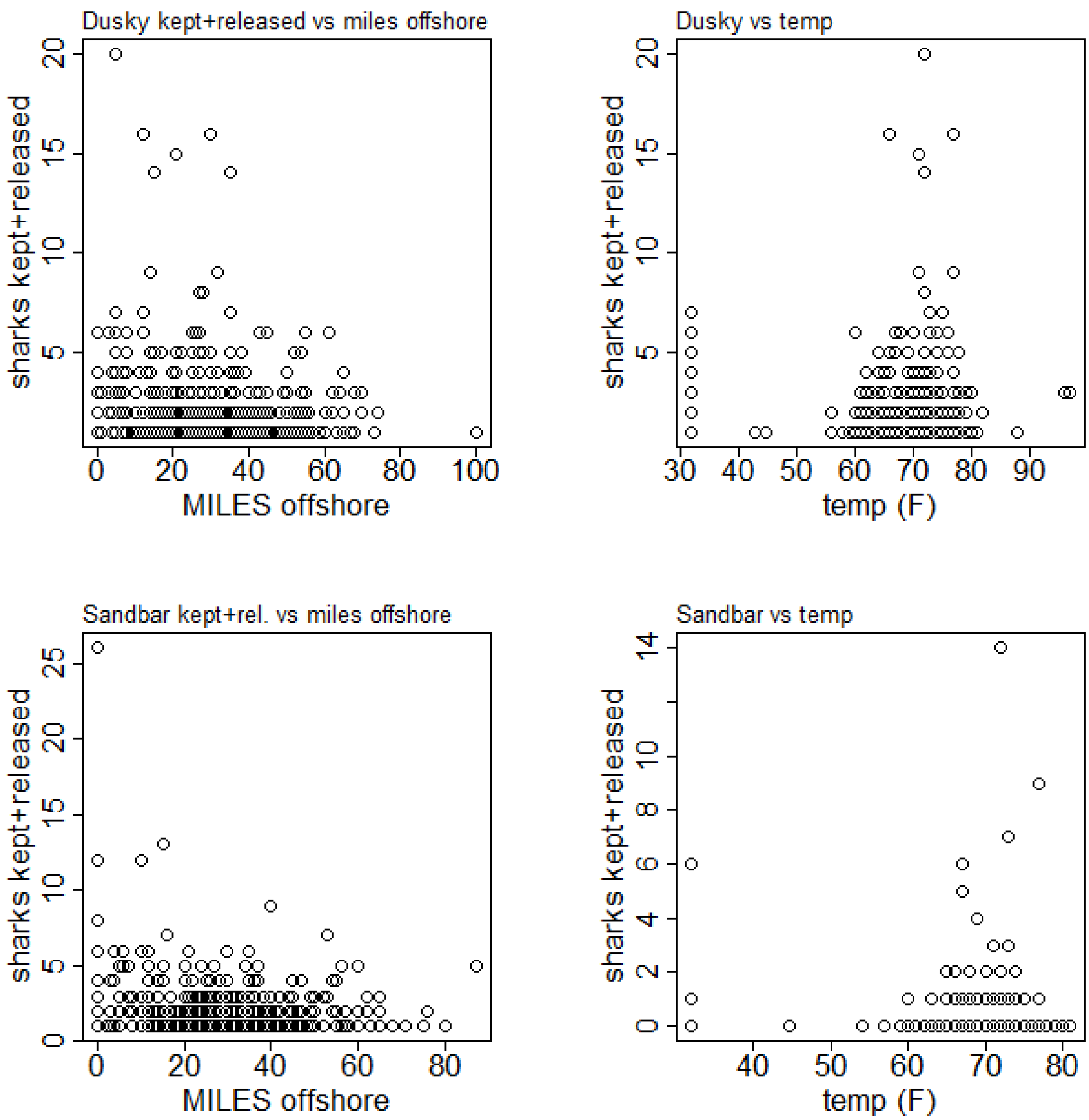

Figure 7. Sandbar shark: Chi-square residuals for the proportion positive observations (binomial component) by factor.

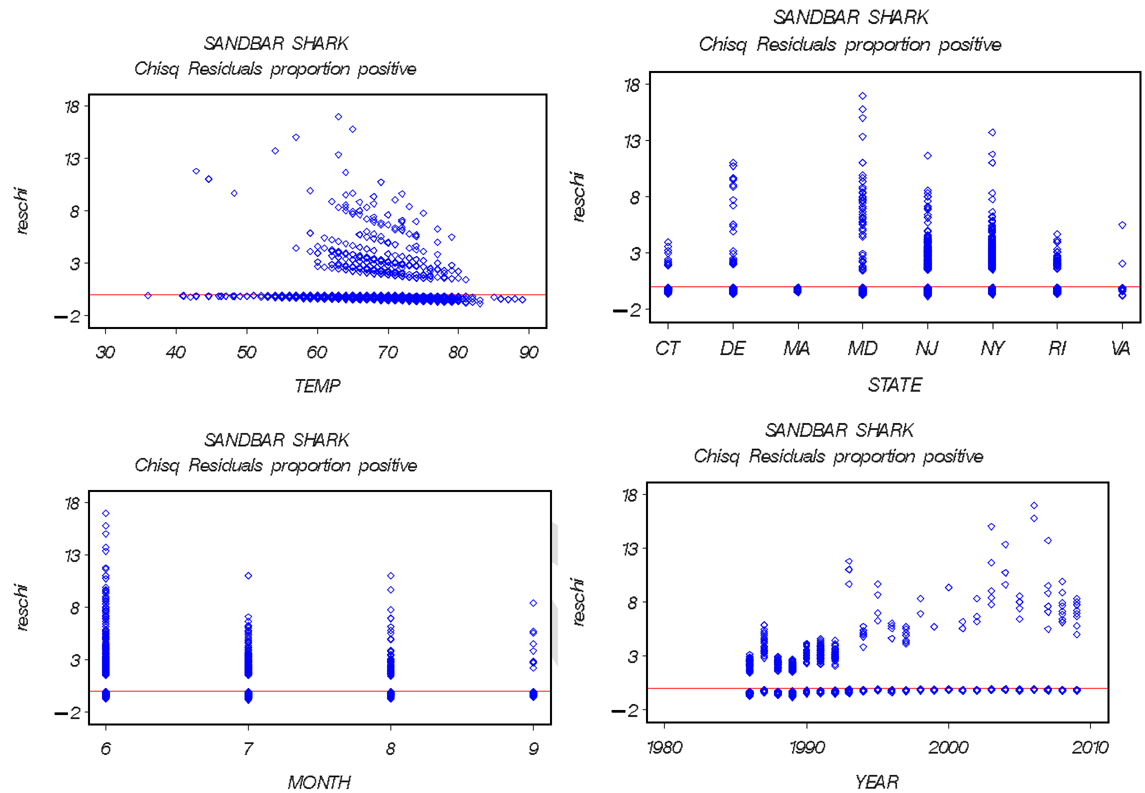

Figure 8. Sandbar shark: Chi-square residuals for the positive observations (poisson component) by factor.

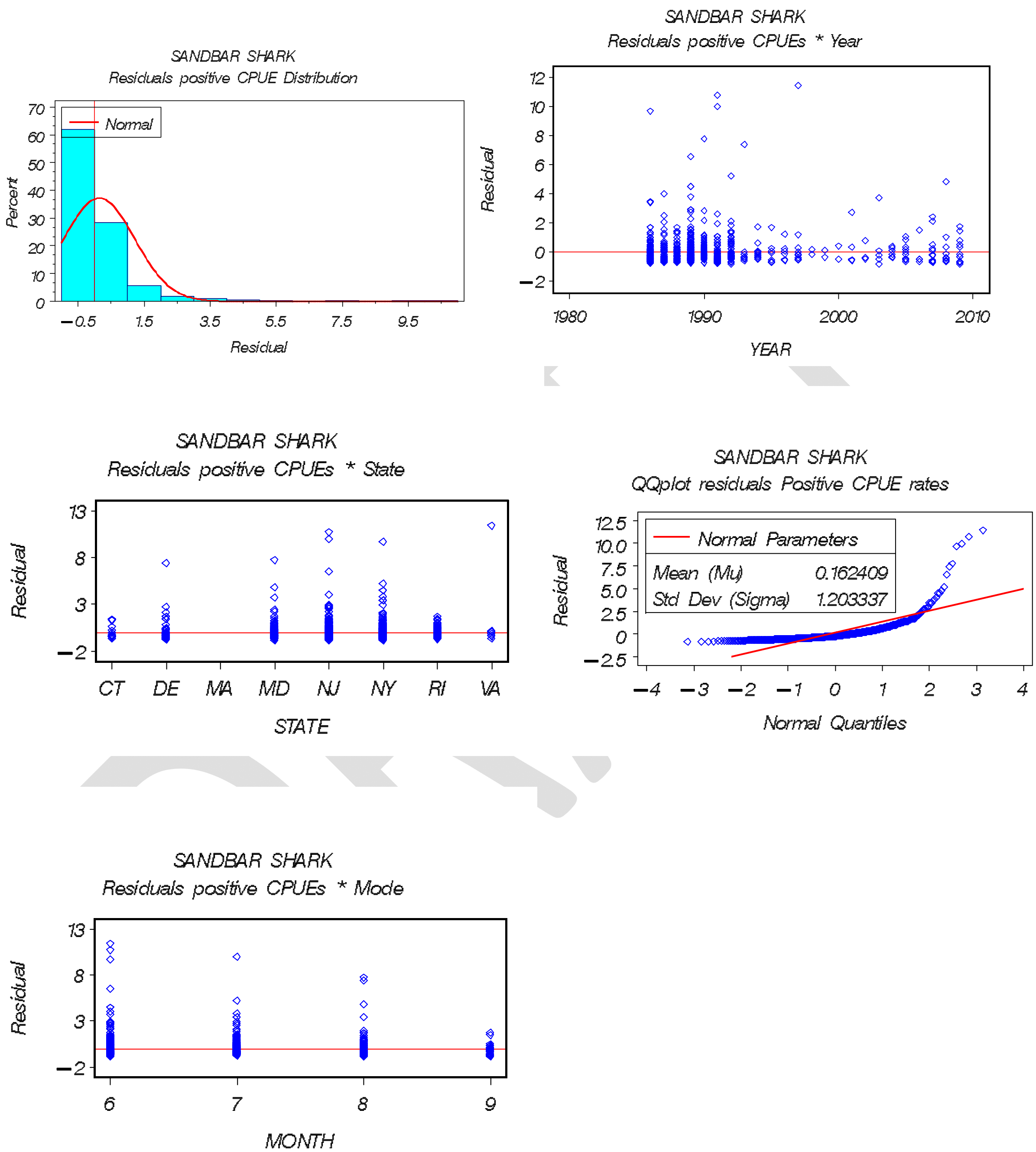

Figure 9. DUSKY shark: Chi-square residuals for the proportion positive observations (binomial component) by factor.

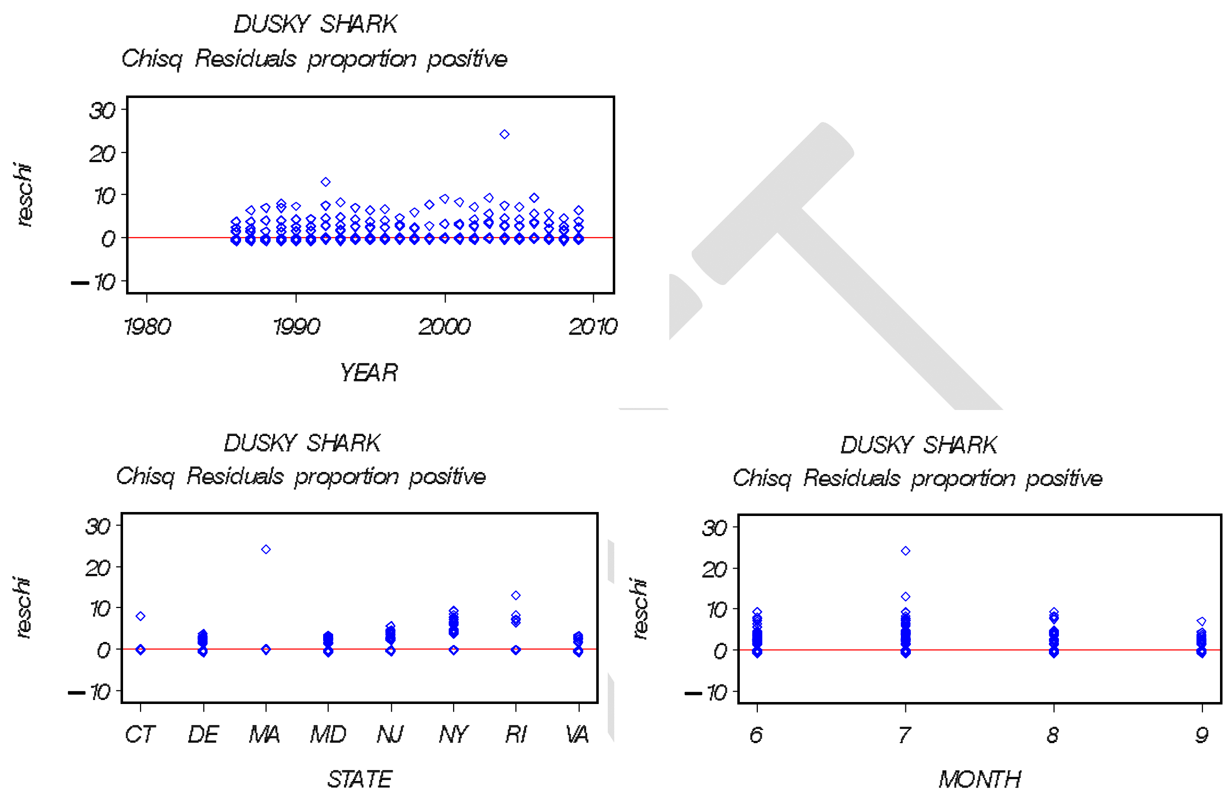

Figure 10. DUSKY shark: Chi-square residuals for the positive observations (poisson component) by factor.

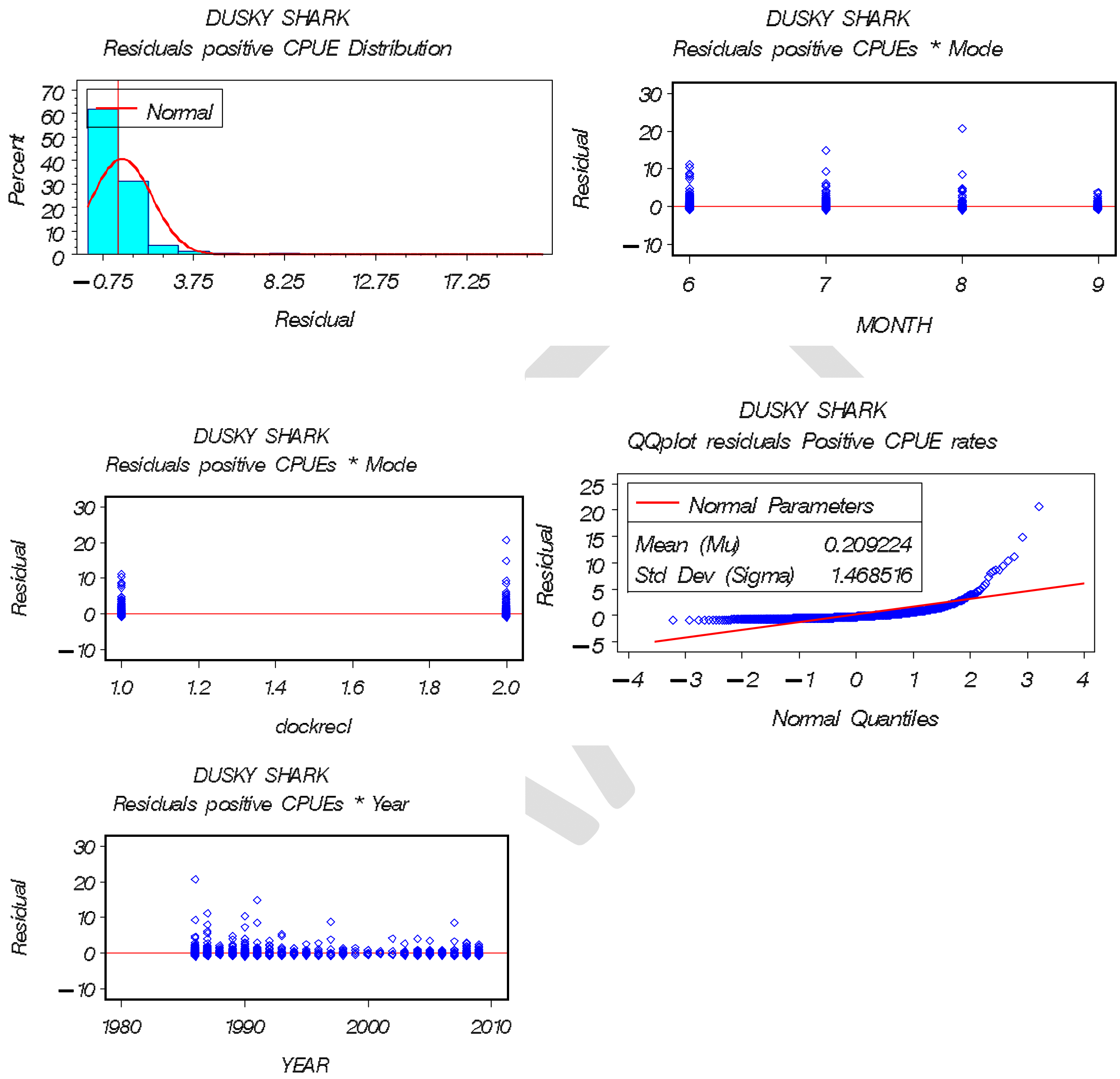

Figure 11. Relative abundance indices for SANDBAR SHARKS with approximate 95% confidence intervals.(Proportion Positive error distribution: binomial; Positive error distribution: Poisson)
Model = **YEAR+TEMP** (for proportion positive)
Model = **YEAR+MONTH + STATE** (for positive catches)

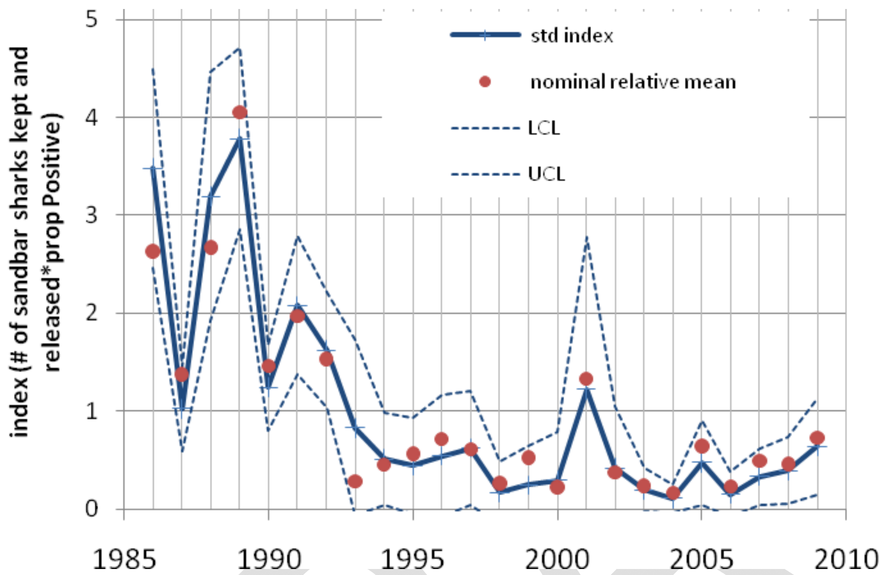

Figure 12. Relative abundance indices for Dusky SHARKS with approximate 95% confidence intervals.(Proportion Positive error distribution: binomial; Positive error distribution: Poisson)

Model = **YEAR+ STATE** (for proportion positive)

Model = **YEAR + MONTH +STATE + DOCKRECL** (for positive catches)

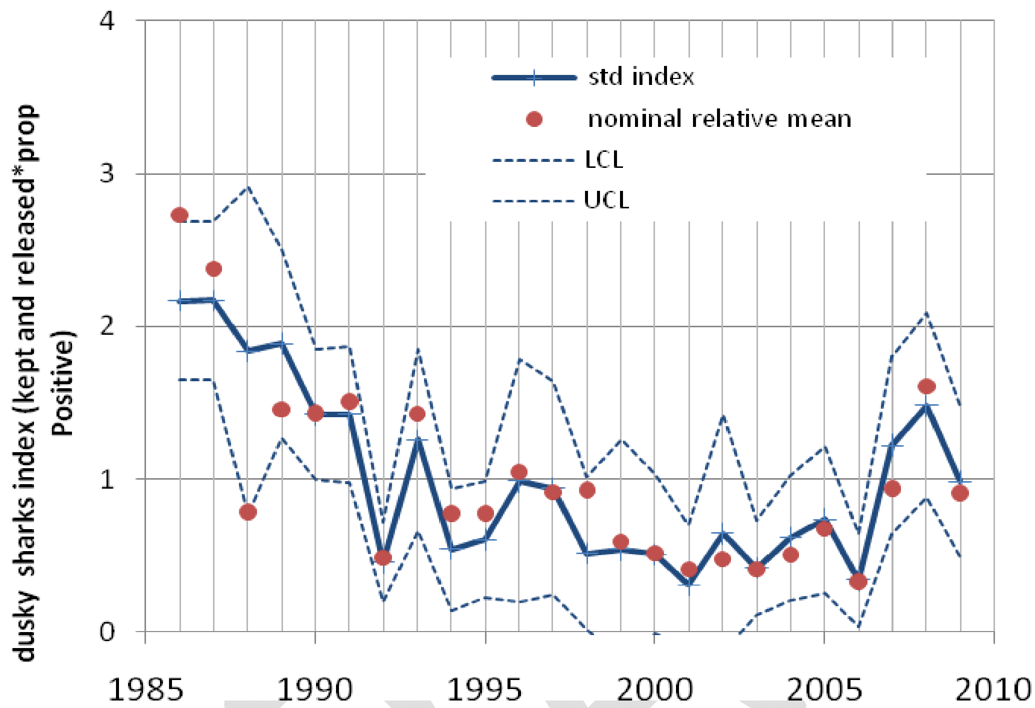

Figure 13. Comparison of 2004 index with updated 2010 index for SANDBAR SHARKS.