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STANDARDIZED CATCH RATES FOR SAILFISH (*Istiophorus platypterus*) FROM UNITED STATES RECREATIONAL FISHERY SURVEYS IN THE NORTHWEST ATLANTIC AND GULF OF MEXICO.

Mauricio Ortiz and Craig Brown[1]

SUMMARY

Indices of abundance of sailfish from the United States recreational billfish tournaments and from a general statistical survey of recreational catches are presented for the period 1973-2000. The tournament index of weight (kg) per 100 hours fishing was estimated from numbers and size of sailfish caught and reported in the logbooks submitted by recreational tournament coordinators and NMFS observers under the Recreational Billfish Survey Program. A general index of numbers of fish per angler trip was estimated from intercept surveys conducted by the Marine Recreational Fisheries Statistics Survey. The standardized indices were estimated using Generalized Linear Mixed Models under a delta lognormal model approach.

RÉSUMÉ

Le présent document fait état des indices d'abondance du voilier provenant de championnats américains de pêche sportive et d'une enquête statistique générale sur les captures sportives pour les années 1973-2000. L'indice pondéral (kg) des championnats par 100 heures de pêche a été estimé d'après le nombre et la taille des voiliers capturés et déclarés dans les carnets de pêche remis par les coordinateurs des championnats de pêche sportive et les observateurs du NMFS dans le cadre du Recreational Billfish Survey Program. Un indice général du nombre de poissons par sortie de pêche à la ligne a été estimée d'après des prospections effectuées par la Marine Recreational Fisheries Statistics Survey. Les indices standardisés ont été estimés par le modèle linéaire généralisé mixte selon une approche delta-lognormale.

RESUMEN

Se presentan los índices de abundancia del pez vela para el periodo 1973-2000, procedentes de los torneos deportivos de marlines de Estados Unidos y de una encuesta general estadística de capturas deportivas. El índice de peso (kg) por cada 100 horas de pesca de los torneos se estimó a partir de los números y la talla de los peces vela capturados y declarados en los cuadernos de pesca presentados por los coordinadores de los torneos deportivos y los observadores del NMFS según el Programa de Encuestas Deportivas de Marlines. Se estimó un índice general de números de peces por salida de pescador a partir de encuestas realizadas por el Estudio de Estadísticas de Pesquerías Deportivas Marinas. Los índices estandarizados se estimaron utilizando modelos lineales mixtos generalizados según un enfoque de modelo delta lognormal.

KEYWORDS

Catch/effort, abundance, sport fishing, pelagic fisheries, multivariate analysis

[1] U.S. Department of Commerce National Marine Fisheries Service Southeast Fisheries Science Center,75 Virginia Beach Drive, Miami, Florida 33149 U.S. email Mauricio.Ortiz@noaa.gov

1. INTRODUCTION

Information on the relative abundance of sailfish (*Istiophorus platypterus*) is necessary to tune stock assessment models. Two sources of this information were investigated in this document: 1) the Recreational Billfish Tournament Survey (RBS), and 2) the generalized Marine Recreational Fishery Statistics Survey (MRFSS).

Tournament catch and effort data from U.S. recreational tournaments along the Atlantic East coast (including the Bahamas), Gulf of Mexico, and Caribbean (U.S. Virgin Islands and Puerto Rico) have been collected by the RBS Program since 1972. Beardsley and Conser (1981), and Prince et al (1990) have described the survey. Indices of abundance for blue marlin (*Makaira nigricans*), white marlin (*Tetrapturus albidus*), and for sailfish from this survey data were previously estimated by Ortiz and Farber (2001), and Farber (1994). Catch in numbers and effort data were obtained from tournament data documented by the RBS, which were voluntarily submitted to the National Marine Fisheries Service (NMFS) and from scientific observers that monitored selected billfish tournaments. This report documents the analytical methods applied to the available RBS data through 2000 and presents correspondent standardized CPUE indices for sailfish.

Recreational catch and effort are collected during the intercept survey component of the MRFSS, in which anglers are intercepted, screened, and interviewed at assigned access sites upon completion of their fishing trips (U.S. Department of Commerce 1990). Intercepts are not conducted at tournament sites. Data from oceanic trips off the Florida East coast from 1981-2000 were used to develop standardized CPUE indices.

2. MATERIALS AND METHODS

2.1 RBS

Browder and Prince (1990) describe the main features of the recreational tournaments that take place in the West Atlantic and Caribbean, and review the available catch and effort data from RBS data. Standardized catch rate indices of sailfish were previously estimated for the 1994 stock assessment using Generalized Linear Models (GLM) (Farber 1994). The present report, updates the catch and effort information through 2000 and includes analyses of variability associated with random factor interactions, particularly for the *Year* effect, following the suggestion of the billfish working group of the ICCAT Scientific Committee of Research and Statistics (SCRS). Logbook records from the recreational tournaments have been collected since 1972 either by NMFS personal or through voluntary submission by tournament organizers. Recent changes in U.S. regulations require all recreational tournaments to register and provide catch and effort data to the NMFS (Anonymous 1999).

The RBS data comprise a total of 14,744 records dating from 1973 through 2000. Each record represents information on hooked and caught fish by tournament-day. Fishing effort is estimated from the number of boats registered in the tournament times the average-fishing hours per boat-day. Records also include total number of fish hooked, their fate (i.e. lost, release, tagged and released, or boated) by species, and morphometric information (size and weight) for boated fish. There are a total of 504 registered tournaments in the RBS database. From those the following selecting criteria were applied: a) data from tournament events only, excluding biological sampling programs and or dock sampling not associated with tournaments. And b) tournaments that have recorded at least one sailfish caught in their historical records. The final working data set included a total of 6,127 records representing 270 recreational tournaments from the North Atlantic, Gulf of Mexico, and the Caribbean. For the present analysis only recreational tournaments that have registered and submitted catch and effort information were included in analysis.

Figure 1 shows the geographical distribution of the included tournaments; markers represent the main city/port from where the tournament operated. Tournaments were classified whether sailfish is a

principal target species (sailfish tournaments), and non-sailfish tournament if sailfish is an occasional catch not targeted (i.e. blue marlin and white marlin tournaments). Tournaments were also classified into one of six geographical regions for this analysis: (1) New England (Massachusetts and Rhode Island), (2) Mid Atlantic (New York, New Jersey, Delaware, Maryland, and Virginia), (3) South Atlantic (North Carolina, South Carolina, Georgia, and the East coast of Florida), (4) The Bahamas, (5) US Gulf of Mexico (Texas, Louisiana, Mississippi, Alabama and Florida West coast, and (6) the Caribbean (Puerto Rico and US Virgin Islands). Figure 2 shows the total number of tournaments registered that have reported sailfish catch per year, and the number of participant boats per year of these tournaments. In general, an increase of recreational tournament participating fishing effort has been observed from 1973 to 1990, since then the number of tournaments and participant boats that catch sailfish has declined. To account for seasonal characteristics, 3 season were defined: (1) January through April, (2) May through August, and (3) September through December.

Tournament logbooks record numbers of fish primarily and size or weight from boated fish. As per suggestion of the Billfish SCRS working group, indices of abundance are reported in weight rather than numbers of fish. To convert numbers of fish to weight, size information on sailfish boated by recreational tournaments was retrieved from the RBS database. There were 3,764-recorded sizes for sailfish; Figure 3 shows the size frequency distributions by year. Mean size by each year area season stratum was estimated if there were 20 or more records per cell. For a cell with less than 20 fish, the annual mean size of the area was used, if for a given area-year, the number were still less than 20, the mean size by year across all areas was applied. Figure 4 shows the mean size by strata used for the conversion of numbers to weight of hooked sailfish. Mean size was converted to weight (kg) using the current size-weight relationships for sailfish-combined sex (Prager et al. 1995). Analysis of catch rates were done on the total number of hooked fish (including hooked and lost fish, caught and release fish, and boated fish) rather than the number of caught fish because of the implementation of minimum size regulations and the catch and release prevalence of US tournaments in particular for the latest years.

For the RBS tournament data, a relative index of abundance for sailfish was estimated by a Generalized Linear Modeling approach assuming a delta lognormal model distribution. The delta model estimates separately the proportion of positive trip/day assuming a binomial error distribution, and the mean catch rate of trip/day where at least one sailfish was caught assuming a lognormal error distribution. The log-transformed frequency distributions of catch rates in weight and numbers for sailfish are shown in Figure 5. The estimated proportion of successful trip/sets per stratum is assumed to be the result of *r* positive trip/days of a total *n* number of trip/days, and each one is an independent Bernoulli-type realization. The estimated proportion is a linear function of fixed effects and interactions. The logit function was used as link between the linear factor component and the binomial error. For trip/days that caught at least one sailfish (i.e. positive observations), estimated catch rates were assumed to follow a lognormal error distribution (lnHPUE) of a linear function of fixed factors and random effect interactions, particularly when the *Year* effect was within the interaction. Year, area, season and sailfish-target tournament (TourSail), and their interactions were the factors included in the analysis.

A step-wise regression procedure was used to determine the set of systematic factors and interactions that significantly explained the observed variability. Because the difference of deviance between two consecutive nested models follows a χ^2 (Chi-square) distribution; this statistic was used to test for the significance of an additional factor in the model. The number of additional parameters associated with the added factor minus one corresponds to the number of degrees of freedom in the χ^2 test (McCullagh and Nelder, 1989). Deviance analysis tables include the deviance for the proportion of positive observations (i.e. positive trips/total trips), and the deviance for the positive catch rates. Final selection of explanatory factors was conditional on: a) the relative percent of deviance explained by adding the factor in evaluation, normally factors that explained more than 5% were selected, b) the χ^2 test significance, and c) the type III test significance within the final specified model.

Once a set of fixed factors was specified, possible interactions were evaluated, in particular interactions between the *Year* effect and other factors. Selection of the final mixed model was based on the Akaike's Information Criterion (AIC), the Schwarz's Bayesian Criterion (SBC), and a chi-square test of the difference between the [–2 loglikelihood] statistic of a successive nested model formulations (Littell *et al*. 1996). Relative indices for the delta model formulation were calculated as the product of the year effect least square means (LSmeans) from the binomial and the lognormal model components. The LSmeans estimates use a weighted factor of the proportional observed margins in the input data to account for the un-balance characteristics of the data. LSmeans of lognormal positive trips were bias corrected using Lo *et al.*, (1992) algorithms. Analyses were done using the GLIMMIX and MIXED procedures from the SAS® statistical computer software (SAS Institute Inc. 1997).

2.2 MRFSS

The survey methodology of the MRFSS is described by the U.S. Department of Commerce (1990). The intercept data available for this study was restricted to the region off the eastern coast of Florida. Only oceanic fishing in the charter or private/rental modes were included. Since the MRFSS is a generalized survey of all saltwater recreational fishing and sailfish targeted effort represents only a small component of oceanic fishing, the data was further restricted to that representing effort directed at sailfish.

Observations were defined at the group level, that is, one or more individuals on a fishing trip representing the smallest number of fishers to which catch and effort could be individually assigned. In many cases, more than one group could have fished during the same boat trip; for these cases, the observations are not truly independent. However, information required to total catch and effort for an entire boat trip was not collected until 1991. If all individuals within a group were not interviewed, it was necessary to expand the reported (but not observed by the interviewer) catch of the interviewed individuals proportionally so as to be representative of the entire group. Catch rate was defined as the number of sailfish caught (kept plus released) divided by the number of angler·hours.

The available variables included year, month, county (where intercepted), trip type (charter or private/rental), and zone (< 3 miles offshore, > 3 miles offshore). Additionally, season was defined as either November-February or March-October. The geographic distribution of sailfish targeted effort (1981-2000) is shown in Figure 10; the relative catch rates at those locations are represented in Figure 11. The locations are approximate: latitude was defined based upon the mid-latitude of the intercept county and longitude was assigned at points 2 miles offshore or 15 miles offshore, depending upon zone.

Parameterization of the model was accomplished using a Generalized Linear Model (GLM) structure in a manner similar to that used for the RBS analysis: The proportion of successful (i.e. positive observations) trips per stratum was assumed to follow a binomial distribution where the estimated probability was a linearized function of fixed factors. The logit function linked the linear component and the assumed binomial distribution. Similarly, the estimated catch per angler·hour observed on positive trips was modeled as function of similar fixed factors with the log function as a link.

A stepwise approach was used 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 χ^2 (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 (including factor interactions) one at a time at each step, until no factor met the criteria for incorporation into the final model. Interactions between factors were not investigated for this analysis, which should be regarded as exploratory.

The product of the standardized proportion positives and the standardized positive catch rates was used to calculate overall standardized catch rates. For comparative purposes, each relative index of abundance was obtained dividing the standardized catch rates by the mean value in each series.

3. RESULTS AND DISCUSSION

3.1 RBS

Table 1 shows the deviance analysis for sailfish from the recreational tournament data analyses. For sailfish the factors: *Area*, *Sailfish-target*, *Season*, *Year*Area*, and *Year*Season* were the main explanatory variables for the proportion of positive trip-days. And, for sailfish mean catch rate *Area*, *Sailfish-target*, *Season*, *Year*Area*, and *Year*Season* were significant factors. Once a set of fixed factors was selected, we evaluated first levels random interaction between the *Year* and other effects.

Table 2 shows the results from the random test analyses, for both marlin species, and the three criteria statistics used for final model selection. In the case of the binomial model component, the proportion of positive/total observations estimation for white marlin did not improve by including random interaction(s) between the year, area and season factors. In contrast, for the mean catch rate of positive observations, all interactions were significant. In general area, season and sailfish-target are the main factors that correlate with catch rates for sailfish. Diagnostic plots of the fit to the proportion of positive model component (Fig 6) and fit of the positive observations model (Fig 7) corroborate the final model selection.

Standardized CPUE series for sailfish are shown in Table 3 and Figure 8. Catch rates of sailfish increase from 1973 to the highest value in 1977, follow by a decline to a minimum in 1985, since then catch rates have been stable. Coefficient of variation ranged from 26% to 34%. The standardized CPUE series using numbers of fish as dependent variable instead of weight, show similar trend (Fig 9), with the exception for year 1973, when the average sailfish mean size was the lowest of all (Fig 4).

3.2 MRFSS

The stepwise construction of the model is shown in Table 4 for the proportion positive analysis and in Table 5 for the positive catch rate analysis. The results of the model fits for the indices are shown in Tables 6 and 7. The index values are shown in Table 8 and in Figure 12.

A comparison of the RBS and MRFSS trends during the period 1981-2000 is shown in Figure 13, with each series set relative to the series mean. With the potential exceptions of 1981, 1994, and 1999-2000, the trends are quite similar.

One great difficulty in interpreting these results is the lack of data, which would accurately track fishing methodology changes implemented by the fishermen over time. For example, anecdotal reports indicate that the increased use of live bait attached to kites when targeting sailfish has resulted in improved catch rates. Unfortunately, the available data only permits the analysis of factors related to general location, time of the year, and reported target.

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Table 1. Deviance analysis table for sailfish using the delta lognormal model. Proportion positive/total observations assumed a binomial error distribution, positive catches assumed a lognormal error distribution. The dependent variable is the total hooked fish per hour (HPUE) in weight units. *p* refers to the Chi-square test probability (alpha 5%) test between two consecutive model specifications.

Recreational Billfish Survey data for Sailfish

Model factors positive catch rates values	d. f.	Residual deviance	Change in deviance	% of total deviance	*p*
1	1	7233.92			
YEAR	27	6954.54	279.4	6.3%	< 0.001
YEAR AREA	5	4726.89	2227.6	50.0%	< 0.001
YEAR AREA SEASON	2	3803.15	923.7	20.7%	< 0.001
YEAR AREA SEASON TOURSAIL	1	3215.14	588.0	13.2%	< 0.001
YEAR AREA SEASON TOURSAIL YEAR:AREA	80	2999.15	216.0	4.8%	< 0.001
YEAR AREA SEASON TOURSAIL YEAR:AREA YEAR:SEASON	54	2868.99	130.2	2.9%	< 0.001
YEAR AREA SEASON TOURSAIL YEAR:AREA YEAR:SEASON YEAR:TOURSAIL	27	2776.25	92.7	2.1%	< 0.001
Model factors proportion positive/total observations	**d. f.**	**Residual deviance**	**Change in deviance**	**% of total deviance**	***p***
1	1	8483.04			
YEAR	27	8406.21	76.8	3.2%	< 0.001
YEAR AREA	5	7402.81	1003.4	42.2%	< 0.001
YEAR AREA SEASON	2	7247.03	155.8	6.5%	< 0.001
YEAR AREA SEASON TOURSAIL	1	6541.37	705.7	29.7%	< 0.001
YEAR AREA SEASON TOURSAIL YEAR:AREA	115	6297.03	244.3	10.3%	< 0.001
YEAR AREA SEASON TOURSAIL YEAR:AREA YEAR:SEASON	54	6180.69	116.3	4.9%	< 0.001
YEAR AREA SEASON TOURSAIL YEAR:AREA YEAR:SEASON YEAR:TOURSAIL	27	6103.17	77.5	3.3%	< 0.001

Table 2. Random effects evaluation for sailfish delta lognormal mixed model specifications. (* refers to final model selected).

	Sailfish model	Numb obs	-2 REM Log likelihood	Akaike's Information Criterion	Schwartz's Bayesian Criterion	Likelihood Ratio Test	
	Proportion Positives						
*	Year TourSail Area Season	342	1275.7	-638.9	-640.7		
	Year TourSail Area Season *Year*Area*	342	1275.7	-638.9	-640.4	0	1.0000
	Year TourSail Area Season *Year*Area Year*Season*	342	1275.7	-638.9	-640.4	0	1.0000
	Positive Catch						
	Year TourSail Area Season	3192	9183.1	-4592.6	-4595.6		
	Year TourSail Area Season *Year*Area*	3192	9126.1	-4565	-4567.8	57	0.0000
*	Year TourSail Area Season *Year*Area Year*Season*	3192	9099.2	-4552.6	-4556.7	26.9	0.0000

Table 3. Nominal and standardized CPUE (kg/100 hours fishing) for sailfish from the Recreational Billfish Survey data.

Year	Num Obs	Nominal CPUE	Standard CPUE	Coeff Variation	Std Error	Index	Upp CI 95%	Low CI 95%
1973	101	49.41	41.44	33.3%	13.80	0.564	1.078	0.295
1974	101	104.05	56.00	34.1%	19.08	0.762	1.478	0.392
1975	148	108.44	63.05	27.6%	17.42	0.857	1.475	0.499
1976	165	71.46	69.76	26.6%	18.58	0.949	1.601	0.562
1977	177	96.61	73.54	26.5%	19.47	1.000	1.683	0.594
1978	183	79.73	63.75	27.3%	17.43	0.867	1.483	0.507
1979	165	90.09	53.23	30.2%	16.09	0.724	1.308	0.401
1980	211	152.23	65.85	29.2%	19.21	0.895	1.586	0.506
1981	207	41.52	52.66	29.0%	15.27	0.716	1.264	0.406
1982	189	20.50	37.60	32.6%	12.27	0.511	0.966	0.271
1983	247	23.99	42.01	26.3%	11.04	0.571	0.958	0.341
1984	264	88.80	37.50	28.2%	10.57	0.510	0.887	0.293
1985	236	35.80	24.50	31.1%	7.61	0.333	0.611	0.182
1986	238	75.80	30.39	30.4%	9.25	0.413	0.749	0.228
1987	258	71.00	28.67	30.6%	8.78	0.390	0.710	0.214
1988	311	58.25	43.49	27.5%	11.95	0.591	1.014	0.345
1989	329	46.06	29.35	31.2%	9.17	0.399	0.735	0.217
1990	315	65.64	32.82	31.7%	10.42	0.446	0.829	0.240
1991	315	57.52	36.95	28.7%	10.60	0.502	0.882	0.286
1992	307	61.58	38.47	26.7%	10.25	0.523	0.883	0.310
1993	227	39.14	34.02	30.5%	10.36	0.463	0.839	0.255
1994	217	45.63	31.25	29.2%	9.13	0.425	0.753	0.240
1995	252	75.63	38.94	27.4%	10.65	0.529	0.906	0.309
1996	243	84.21	45.50	27.3%	12.43	0.619	1.058	0.362
1997	244	71.81	35.37	29.2%	10.34	0.481	0.853	0.271
1998	169	43.80	31.02	28.6%	8.87	0.422	0.739	0.241
1999	185	60.69	34.28	29.1%	9.98	0.466	0.825	0.263
2000	123	44.22	29.63	27.2%	8.05	0.403	0.687	0.236

Table 4. Results of the stepwise procedure to develop the proportion positive catch rate model. **%** diff: percent difference in deviance/df between each factor and the null model**;** delta%: percent difference in deviance/df between the newly included factor and the previous factor entered into the model; L: log likelihood; ChiSquare: Pearson Chi-square statistic; Pr>Chi: significance level of the Chi-square statistic.

Proportion Positive Trips

FACTOR	df	deviance	deviance/df	%diff.	delta%	L	ChiSquare	Pr>Chi
NULL	1415	1942.534	1.3728			-971.27 .	.	
MONTH	1404	1782.245	1.2694	7.5	7.5	-891.12	160.2894	<0.00001
SEASON	1414	1805.099	1.2766	7.0		-902.55	137.4347	<0.00001
YEAR	1396	1830.357	1.3111	4.5		-915.18	112.1774	<0.00001
TRIPTYPE	1414	1928.007	1.3635	0.7		-964	14.5269	0.0001
COUNTY	1407	1924.784	1.368	0.3		-962.39	17.7504	0.0232
ZONE	1414	1941.599	1.3731	0.0		-970.8	0.9351	0.3335
MONTH+								
YEAR	1385	1721.04	1.2426	9.5	2.0	-860.52	61.2044	<0.00001
COUNTY	1396	1760.043	1.2608	8.2		-880.02	22.2012	0.0046
TRIPTYPE	1403	1770.184	1.2617	8.1		-885.09	12.0601	0.0005
ZONE	1403	1780.16	1.2688	7.6		-890.08	2.0845	0.1488
MONTH+YEAR+								
TRIP	1384	1708.199	1.2342	10.1	0.6	-854.1	12.8414	0.0003
COUN	1377	1703.147	1.2369	9.9		-851.57	17.8929	0.0220
ZONE	1384	1716.095	1.24	9.7		-858.05	4.9453	0.02616

FINAL MODEL: MONTH+YEAR

Table 5. Results of the stepwise procedure to develop the positive trip catch rate model. **%** diff: percent difference in deviance/df between each factor and the null model**;** delta%: percent difference in deviance/df between the newly included factor and the previous factor entered into the model; L: log likelihood; ChiSquare: Pearson Chi-square statistic; Pr>Chi: significance level of the Chi-square statistic

	Positive Trips							
FACTOR	**df**	**deviance**	**deviance/df**	**%diff.**	**delta%**	**L**	**ChiSquare**	**Pr>Chi**
NULL	620	151.4073	0.2442			-442.9342	.	.
COUNTY	613	140.2904	0.2289	6.3	6.3	-419.2558	47.3568	<0.00001
YEAR	601	140.3213	0.2335	4.4		-419.3244	47.2197	0.0003
MONTH	609	145.7731	0.2394	2.0		-431.1595	23.5494	0.0148
SEASON	619	148.286	0.2396	1.9		-436.4663	12.9359	0.0003
TRIPTYPE	619	149.6971	0.2418	1.0		-439.4071	7.0543	0.0079
ZONE	619	150.3684	0.2429	0.5		-440.7963	4.2758	0.0387
COUNTY+								
YEAR	594	131.5744	0.2215	9.3	3.0	-399.3397	39.8322	0.0034
SEASON	612	139.1119	0.2273	6.9		-416.6365	5.2386	0.0221
MONTH	602	136.9036	0.2274	6.9		-411.668	15.1757	0.1746
TRIPTYPE	612	139.971	0.2287	6.3		-418.5482	1.4152	0.2342
ZONE	612	140.2627	0.2292	6.1		-419.1947	0.1223	0.7265
COUNTY+YEAR+								
MONTH	583	126.9905	0.2178	10.8	1.5	-388.3294	22.0206	0.0242
SEASON	593	129.71	0.2187	10.4		-394.9086	8.8624	0.0029
TRIPTYPE	593	131.3232	0.2215	9.3		-398.7463	1.1868	0.2760
ZONE	593	131.5631	0.2219	9.1		-399.3132	0.0532	0.8177
COUNTY+YEAR+MONTH+								
TRIPTYPE	582	126.7957	0.2179	10.8	0.0	-387.8528	0.9533	0.3289
ZONE	582	126.9575	0.2181			-388.2487	0.1613	0.6879
FINAL MODEL: COUNTY+YEAR+MONTH								

Table 6. Results of the MRFSS analysis (1981-2000). Lo method with binomial error assumption for proportion positives.

Class Level Information

Class	Levels	Values
month	12	1 2 3 4 5 6 7 8 9 10 11 12
year	20	1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000

Criteria For Assessing Goodness Of Fit

Criterion	DF	Value	Value/DF
Deviance	1385	1721.0400	1.2426
Scaled Deviance	1385	1721.0400	1.2426
Pearson Chi-Square	1385	1409.4340	1.0176
Scaled Pearson X2	1385	1409.4340	1.0176
Log Likelihood		-860.5200	

Analysis Of Parameter Estimates

Parameter	DF	Estimate	Standard Error	Wald 95% Confidence Limits		Chi-Square	Pr > ChiSq
Intercept	1	0.7388	0.2384	0.2715	1.2061	9.60	0.0019
month 1	1	0.3956	0.2032	-0.0027	0.7938	3.79	0.0516
month 2	1	-0.0635	0.2200	-0.4948	0.3678	0.08	0.7728
month 3	1	-0.8864	0.2639	-1.4036	-0.3693	11.29	0.0008
month 4	1	-0.8491	0.2633	-1.3652	-0.3331	10.40	0.0013
month 5	1	-0.9419	0.2804	-1.4915	-0.3923	11.28	0.0008
month 6	1	-1.3801	0.2947	-1.9577	-0.8024	21.92	<.0001
month 7	1	-1.3100	0.2809	-1.8606	-0.7595	21.75	<.0001
month 8	1	-1.4222	0.3191	-2.0476	-0.7969	19.87	<.0001
month 9	1	-1.0280	0.4058	-1.8234	-0.2326	6.42	0.0113
month 10	1	-1.0257	0.3221	-1.6571	-0.3943	10.14	0.0015
month 11	1	-0.1575	0.2587	-0.6645	0.3494	0.37	0.5425
month 12	0	0.0000	0.0000	0.0000	0.0000	.	.
year 1981	1	-0.7434	0.7371	-2.1880	0.7013	1.02	0.3132
year 1982	1	-1.0281	0.8305	-2.6558	0.5996	1.53	0.2157
year 1983	1	0.0323	0.6137	-1.1705	1.2351	0.00	0.9581
year 1984	1	-0.9987	0.4814	-1.9421	-0.0552	4.30	0.0380
year 1985	1	-0.1792	0.5379	-1.2335	0.8750	0.11	0.7390
year 1986	1	-1.2361	0.3371	-1.8967	-0.5755	13.45	0.0002
year 1987	1	-0.8995	0.3175	-1.5217	-0.2772	8.03	0.0046
year 1988	1	-0.9799	0.3271	-1.6209	-0.3388	8.98	0.0027
year 1989	1	-1.1912	0.3192	-1.8168	-0.5656	13.93	0.0002
year 1990	1	-1.0558	0.3569	-1.7553	-0.3563	8.75	0.0031
year 1991	1	-0.8381	0.3228	-1.4707	-0.2054	6.74	0.0094
year 1992	1	-0.3831	0.2671	-0.9067	0.1404	2.06	0.1515
year 1993	1	-0.4409	0.3769	-1.1796	0.2978	1.37	0.2421
year 1994	1	-0.5403	0.3462	-1.2189	0.1383	2.44	0.1186
year 1995	1	-0.3363	0.3340	-0.9909	0.3183	1.01	0.3139
year 1996	1	-0.6796	0.3410	-1.3480	-0.0113	3.97	0.0463
year 1997	1	0.0319	0.2967	-0.5495	0.6133	0.01	0.9143
year 1998	1	-0.6919	0.2843	-1.2491	-0.1348	5.93	0.0149
year 1999	1	0.1890	0.2670	-0.3342	0.7123	0.50	0.4789
year 2000	0	0.0000	0.0000	0.0000	0.0000	.	.
Scale	0	1.0000	0.0000	1.0000	1.0000		

NOTE: The scale parameter was held fixed.

LR Statistics For Type 3 Analysis

Source	DF	Chi-Square	Pr > ChiSq
month	11	109.32	<.0001
year	19	61.20	<.0001

Table 7. Results of the MRFSS analysis (1981-2000). Lo method with lognormal error assumption for positive trips.

Class Level Information

Class	Levels	Values
county	8	23 24 25 26 27 29 30 32
year	20	1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000
month	12	1 2 3 4 5 6 7 8 9 10 11 12

Criteria For Assessing Goodness Of Fit

Criterion	DF	Value	Value/DF
Deviance	583	126.9905	0.2178
Scaled Deviance	583	621.0000	1.0652
Pearson Chi-Square	583	126.9905	0.2178
Scaled Pearson X2	583	621.0000	1.0652
Log Likelihood		-388.3294	

Analysis Of Parameter Estimates

Parameter	DF	Estimate	Standard Error	Wald 95% Confidence Limits		Chi-Square	Pr > ChiSq
Intercept	1	-2.2615	0.3399	-2.9277	-1.5954	44.27	<.0001
county 23	1	0.8374	0.3392	0.1725	1.5023	6.09	0.0136
county 24	1	0.8728	0.3402	0.2059	1.5396	6.58	0.0103
county 25	1	0.8936	0.3378	0.2315	1.5557	7.00	0.0082
county 26	1	0.6403	0.3416	-0.0292	1.3099	3.51	0.0609
county 27	1	0.7029	0.4067	-0.0943	1.5000	2.99	0.0839
county 29	1	0.4102	0.3729	-0.3206	1.1410	1.21	0.2713
county 30	1	0.3541	0.4106	-0.4506	1.1588	0.74	0.3884
county 32	0	0.0000	0.0000	0.0000	0.0000	.	.
year 1981	1	-0.3295	0.2772	-0.8728	0.2138	1.41	0.2345
year 1982	1	0.1343	0.3425	-0.5370	0.8056	0.15	0.6951
year 1983	1	-0.3409	0.1998	-0.7325	0.0506	2.91	0.0879
year 1984	1	0.0426	0.1696	-0.2898	0.3750	0.06	0.8016
year 1985	1	-0.1559	0.1640	-0.4773	0.1655	0.90	0.3418
year 1986	1	-0.0336	0.1209	-0.2707	0.2034	0.08	0.7810
year 1987	1	-0.0719	0.1066	-0.2808	0.1371	0.45	0.5002
year 1988	1	0.2656	0.1173	0.0357	0.4955	5.13	0.0236
year 1989	1	0.1107	0.1136	-0.1121	0.3334	0.95	0.3301
year 1990	1	0.2175	0.1299	-0.0372	0.4722	2.80	0.0942
year 1991	1	-0.0961	0.1059	-0.3036	0.1115	0.82	0.3643
year 1992	1	0.0037	0.0835	-0.1600	0.1674	0.00	0.9645
year 1993	1	-0.1601	0.1252	-0.4054	0.0852	1.64	0.2009
year 1994	1	0.1534	0.1072	-0.0568	0.3636	2.05	0.1526
year 1995	1	-0.1686	0.1008	-0.3662	0.0289	2.80	0.0943
year 1996	1	0.0848	0.1087	-0.1282	0.2979	0.61	0.4352
year 1997	1	0.0414	0.0840	-0.1232	0.2061	0.24	0.6220
year 1998	1	-0.2769	0.0883	-0.4500	-0.1039	9.84	0.0017
year 1999	1	-0.0332	0.0761	-0.1825	0.1160	0.19	0.6624
year 2000	0	0.0000	0.0000	0.0000	0.0000	.	.
month 1	1	0.0017	0.0563	-0.1086	0.1119	0.00	0.9765
month 2	1	-0.1487	0.0655	-0.2771	-0.0203	5.15	0.0233
month 3	1	-0.2309	0.0890	-0.4054	-0.0564	6.73	0.0095
month 4	1	-0.2166	0.0907	-0.3944	-0.0388	5.70	0.0170
month 5	1	0.0187	0.0984	-0.1741	0.2115	0.04	0.8492
month 6	1	-0.2474	0.1107	-0.4644	-0.0304	4.99	0.0255
month 7	1	-0.1818	0.1048	-0.3873	0.0237	3.01	0.0829
month 8	1	-0.1572	0.1227	-0.3977	0.0833	1.64	0.2002
month 9	1	-0.1965	0.1665	-0.5229	0.1298	1.39	0.2379
month 10	1	-0.1381	0.1220	-0.3772	0.1010	1.28	0.2575
month 11	1	-0.0361	0.0807	-0.1942	0.1221	0.20	0.6550
month 12	0	0.0000	0.0000	0.0000	0.0000	.	.
Scale	1	0.4522	0.0128	0.4277	0.4781		

NOTE: The scale parameter was estimated by maximum likelihood.

LR Statistics For Type 3 Analysis

Source	DF	Chi-Square	Pr > ChiSq
county	7	32.53	<.0001
year	19	46.68	0.0004
month	11	22.02	0.0242

Table 8. Relative Abundance Indices for Sailfish in the Florida East Coast Rod and Reel Fishery (based upon the MRFSS)

YEAR	INDEX	LCI	UCI	CV
1981	0.649	-0.79	2.089	1.131
1982	0.854	-1.018	2.726	1.118
1983	1.028	-0.228	2.284	0.623
1984	0.845	-0.055	1.744	0.543
1985	0.965	0.033	1.897	0.493
1986	0.735	0.218	1.251	0.359
1987	0.795	0.305	1.286	0.315
1988	1.009	0.426	1.592	0.295
1989	0.75	0.255	1.245	0.337
1990	0.958	0.292	1.624	0.355
1991	0.76	0.301	1.22	0.308
1992	1.104	0.728	1.479	0.174
1993	1.054	0.38	1.728	0.326
1994	1.219	0.633	1.805	0.245
1995	1.006	0.504	1.508	0.254
1996	1.065	0.497	1.632	0.272
1997	1.479	1.055	1.903	0.146
1998	0.736	0.368	1.104	0.255
1999	1.522	1.184	1.859	0.113
2000	1.468	1.043	1.894	0.148

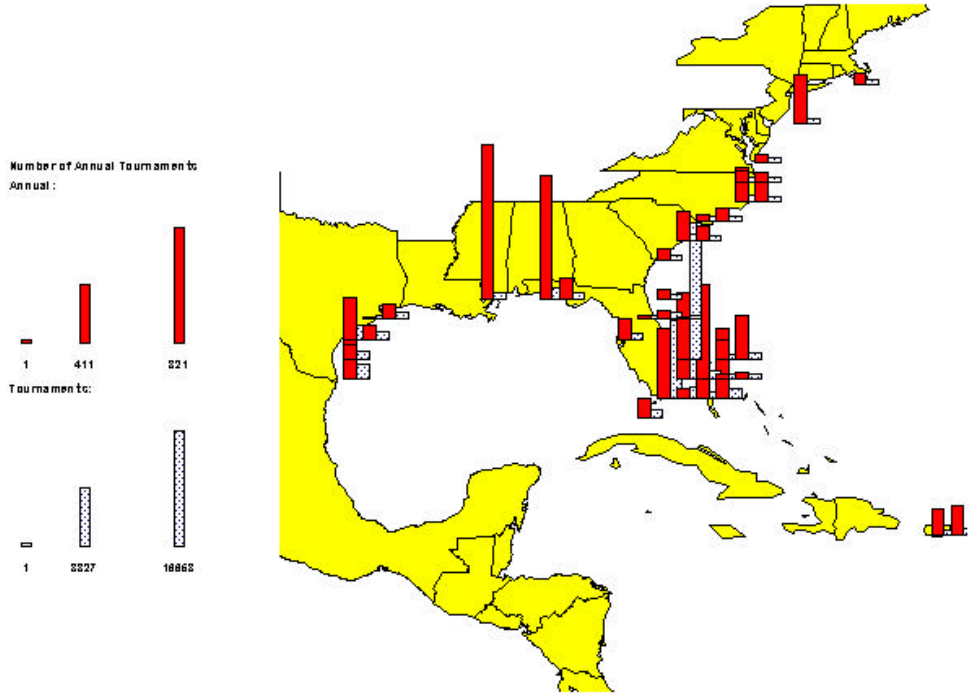


Figure 1. Geographic distribution of recreational tournaments that have reported sailfish catch. Dark bars represent the total number of annual tournaments that have taken place at each location from 1973 to 200 year. Lighte bars represent the total number of sailfish (landed, caught and release, or lost) during the same period.

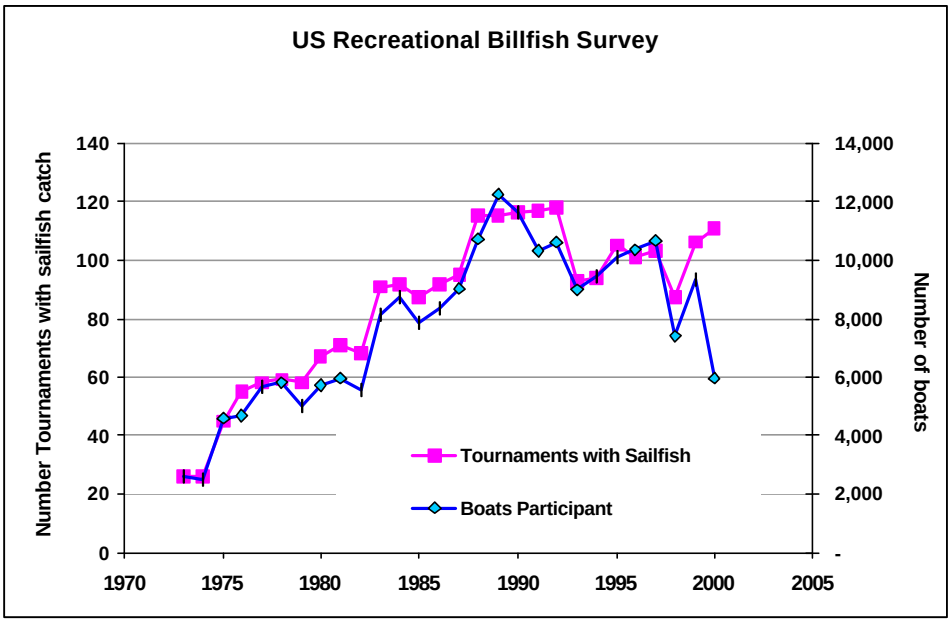


Figure 2. Total number of recreational tournaments that reported sailfish catch and number of participant boats associated by year. Data summary from the Recreational Billfish Survey (RBS).

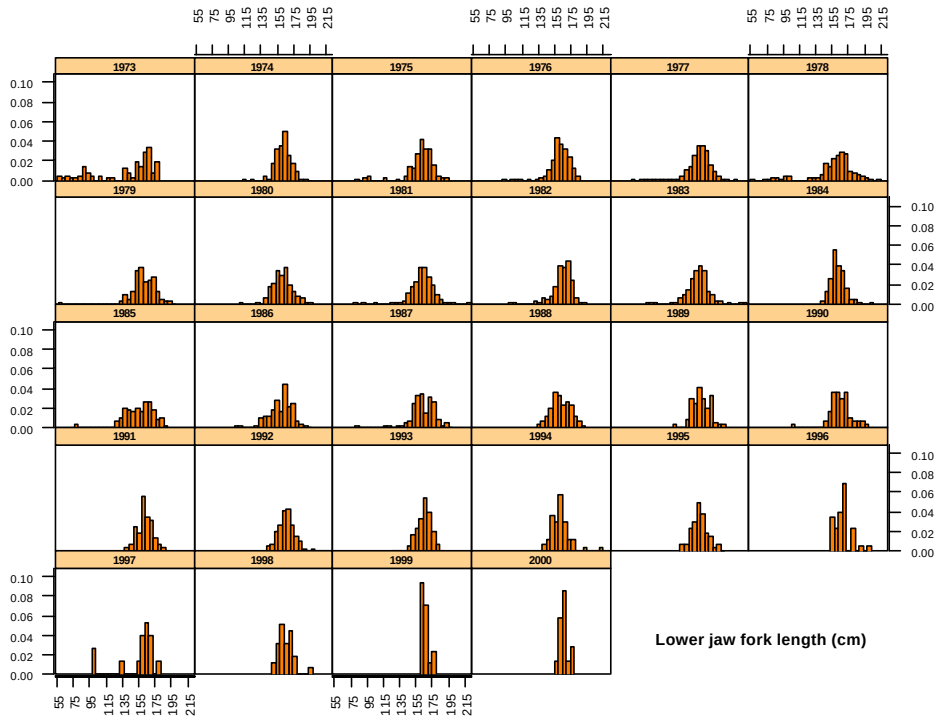


Figure 3. Size frequency distributions by year for sailfish measured from the RBS program.

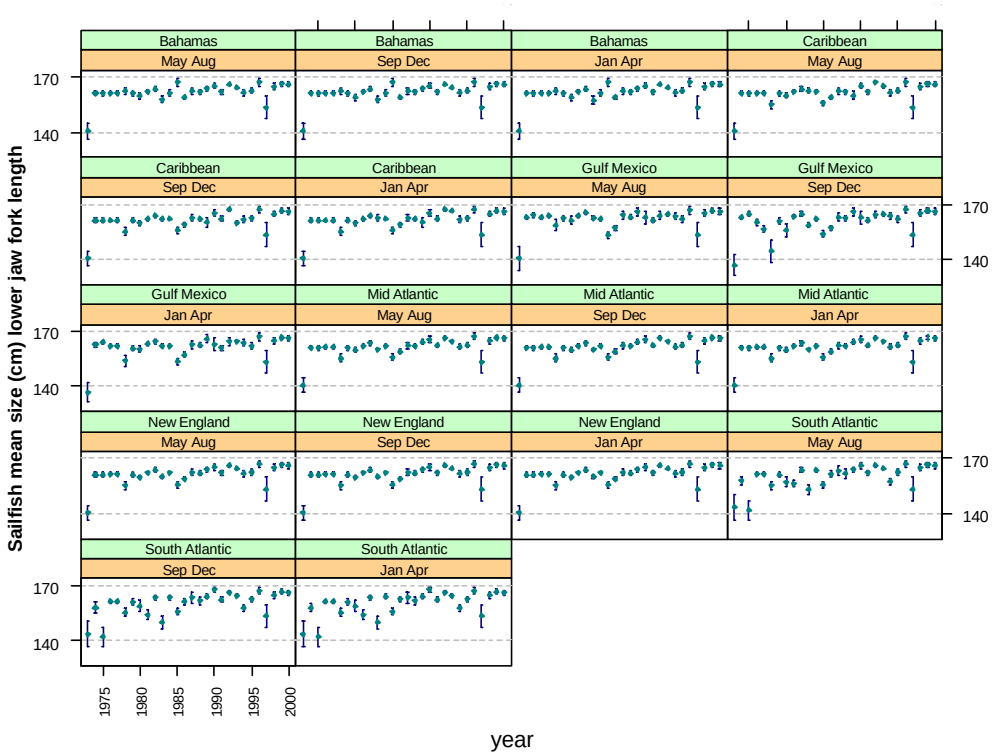


Figure 4. Estimated mean size (lower jaw fork length cm) of sailfish by strata used to convert numbers of fish to weight of fish hooked. Bars represent one standard error. .

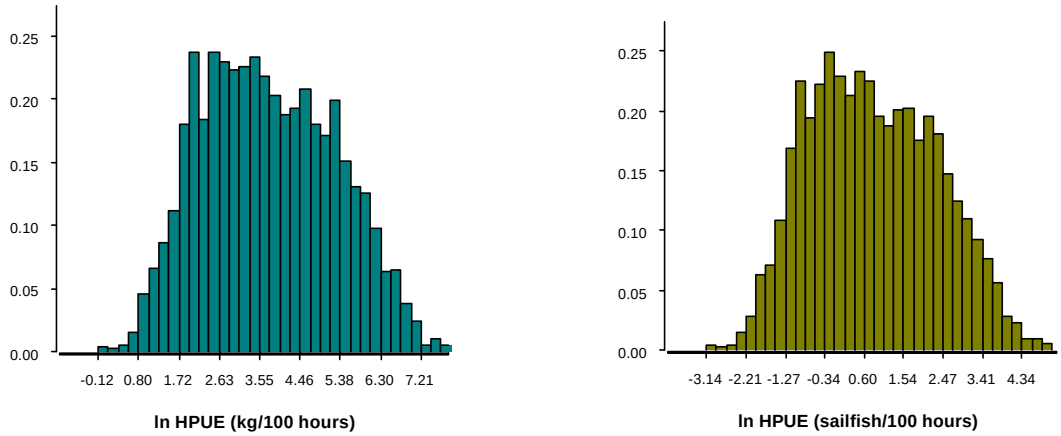


Figure 5. Frequency distribution for log transformed catch rates of sailfish. HPUE refers to total sailfish hooked per 100 hours of fishing effort, either in weight (kg) (left panel) or numbers of fish (right panel).

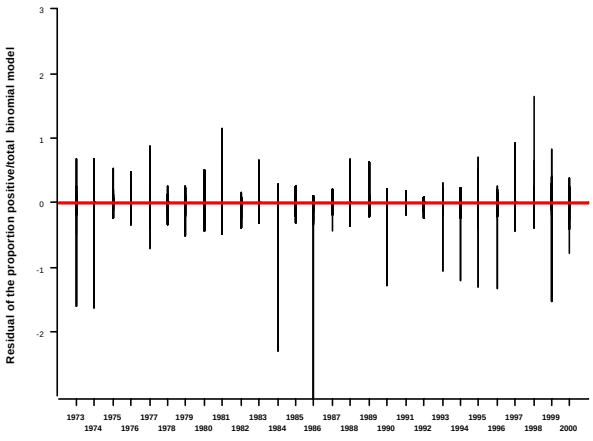


Figure 6. Residual distribution by year from the proportion of positive/total observations model fit.

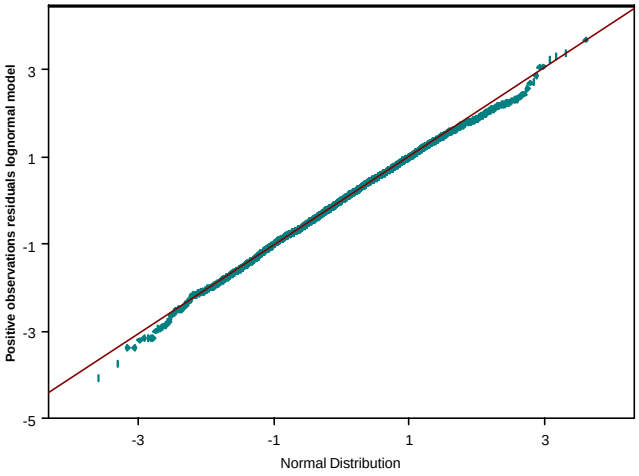


Figure 7. Normalized cumulative plot (qq-plot) of residual fit of the positive observations model fit.

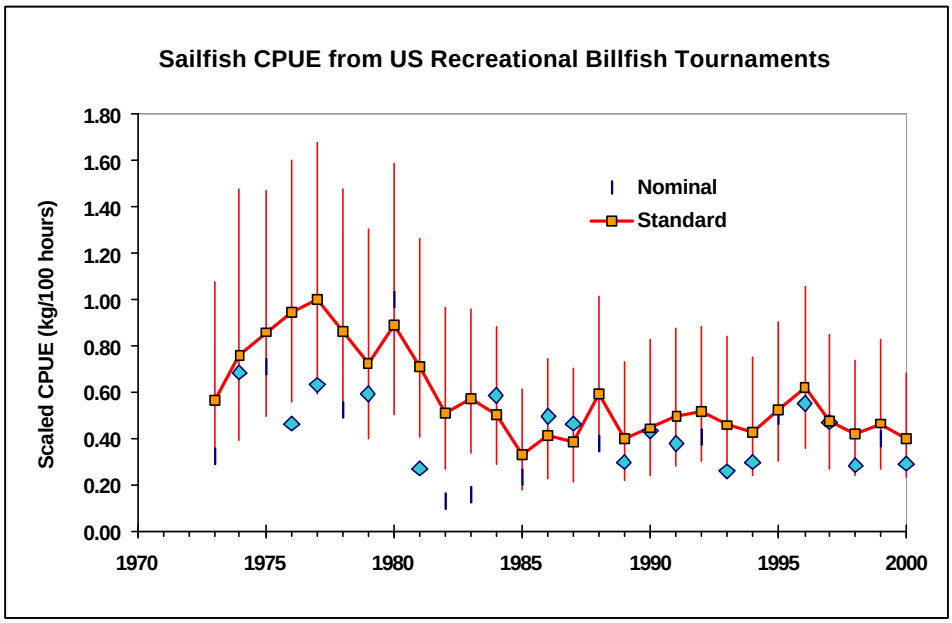


Figure 8. Nominal and standardized catch rates (HPUE) of sailfish from US recreational billfish tournaments. Standardized series are for the weight of fish catch rates (± 95% CI).

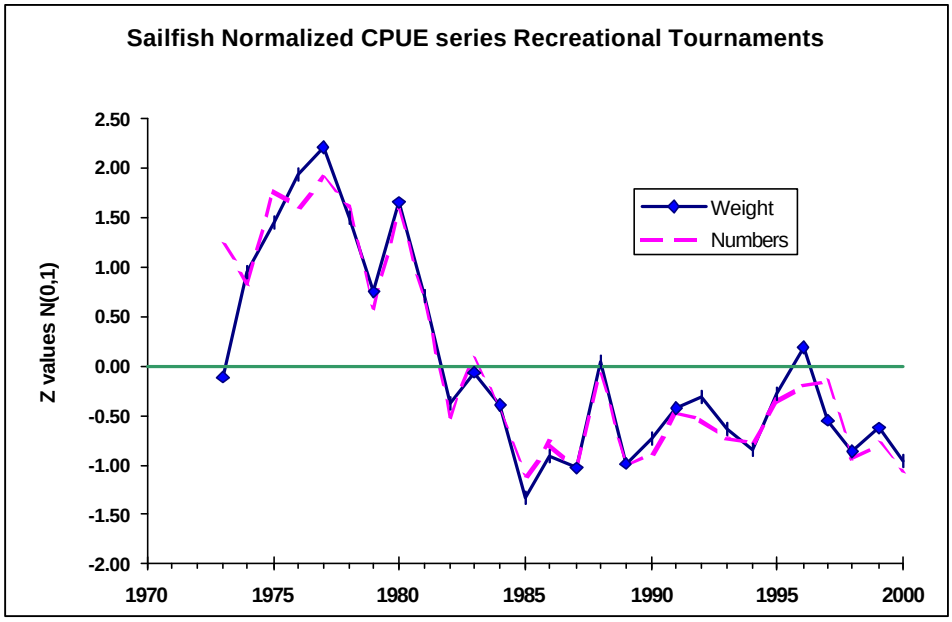


Figure 9. Comparison of normalized standard CPUE series for sailfish from recreational tournaments. Solid line and diamonds correspond to the weight CPUE (kg/100 hours) and broken line to the numbers of fish CPUE (fish/100 hours) series

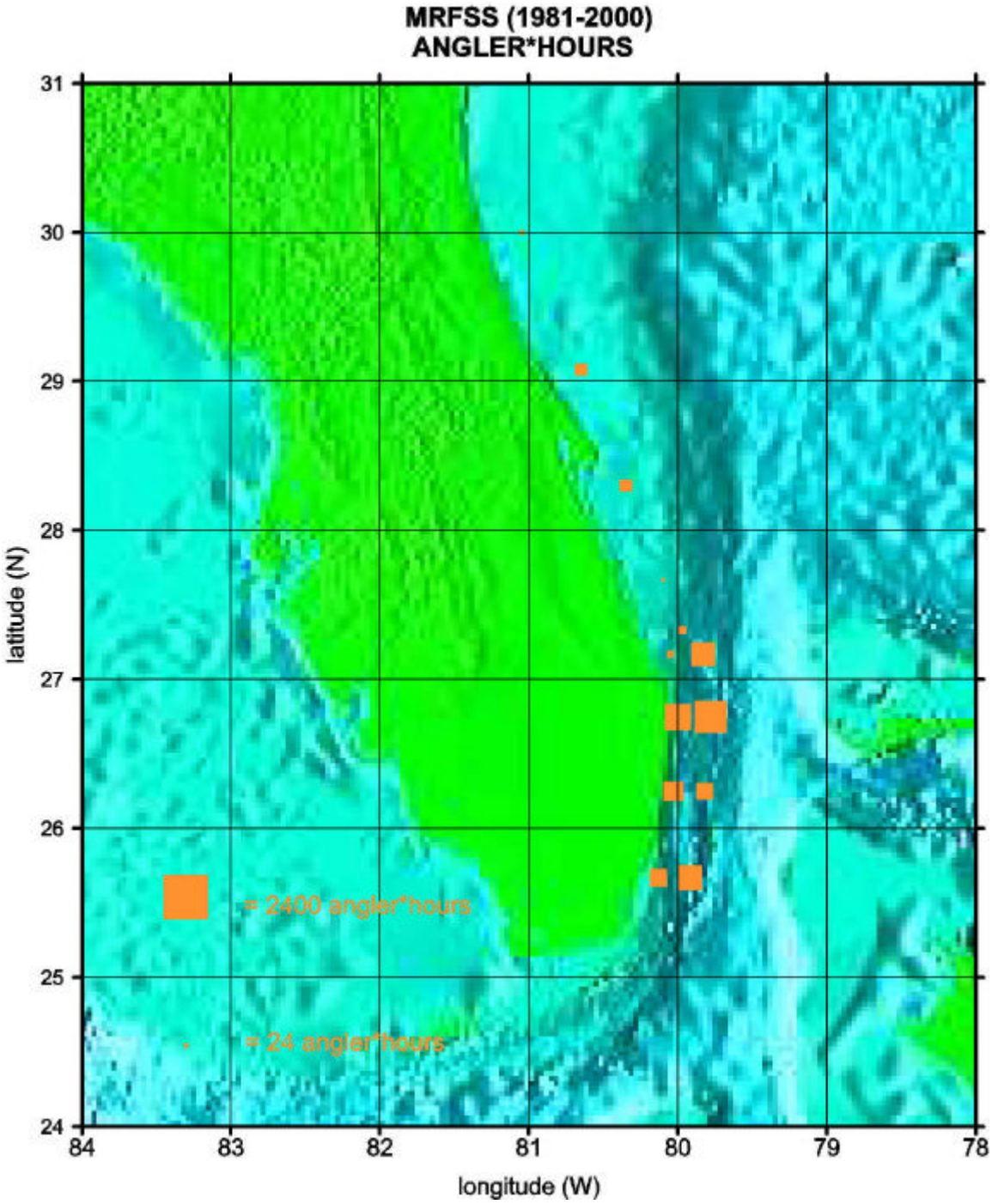


Figure 10. The geographic distribution of sailfish directed rod and reel effort off the Florida East coast (1981-2000). Each symbol is scaled to reflect the total angler*hours expended at that location. The locations are approximate: latitude was defined based upon the mid-latitude of the intercept county and longitude was assigned at points 2 miles offshore or 15 miles offshore, depending upon zone.

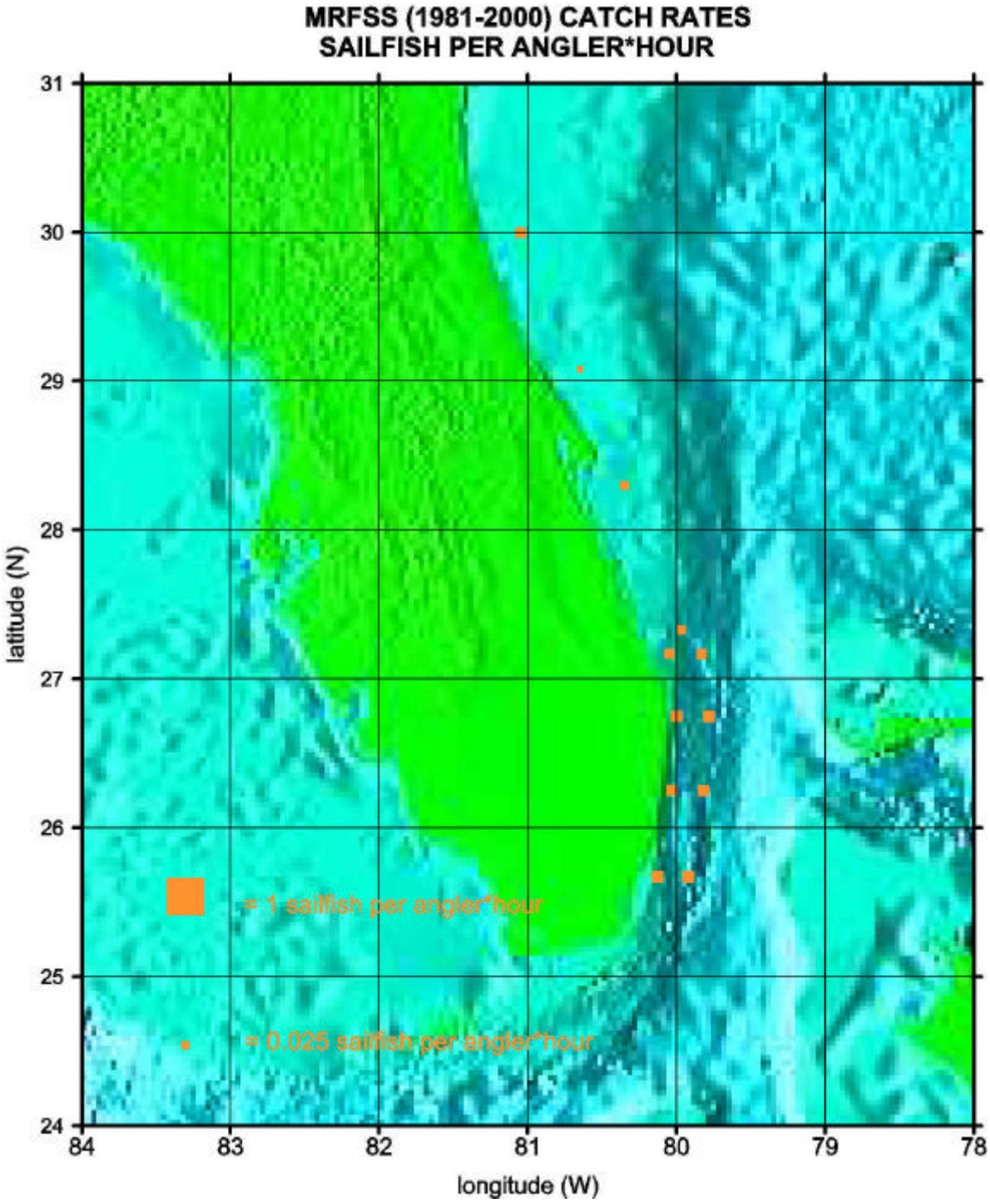


Figure 11. The catch rates at locations of sailfish directed rod and reel effort off the Florida East coast (1981-2000). Each symbol is scaled to reflect the average catch of sailfish (kept plus released) per angler*hour at that location. The locations are approximate: latitude was defined based upon the mid-latitude of the intercept county and longitude was assigned at points 2 miles offshore or 15 miles offshore, depending upon zone.

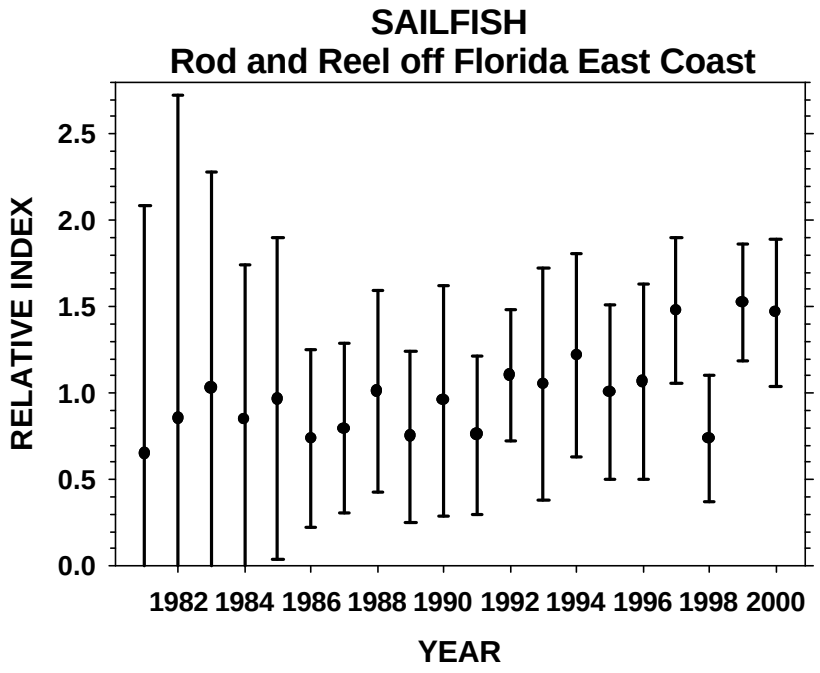


Figure 12. Relative abundance indices for sailfish in the Florida East Coast Rod and Reel Fishery (based upon the MRFSS) with approximate 95% confidence intervals. Proportion Positive Trip Model= MONTH + YEAR (error distribution: binomial) Positive Trip Model= COUNTY + YEAR + MONTH (fish caught per angler·hour, error distribution: lognormal).

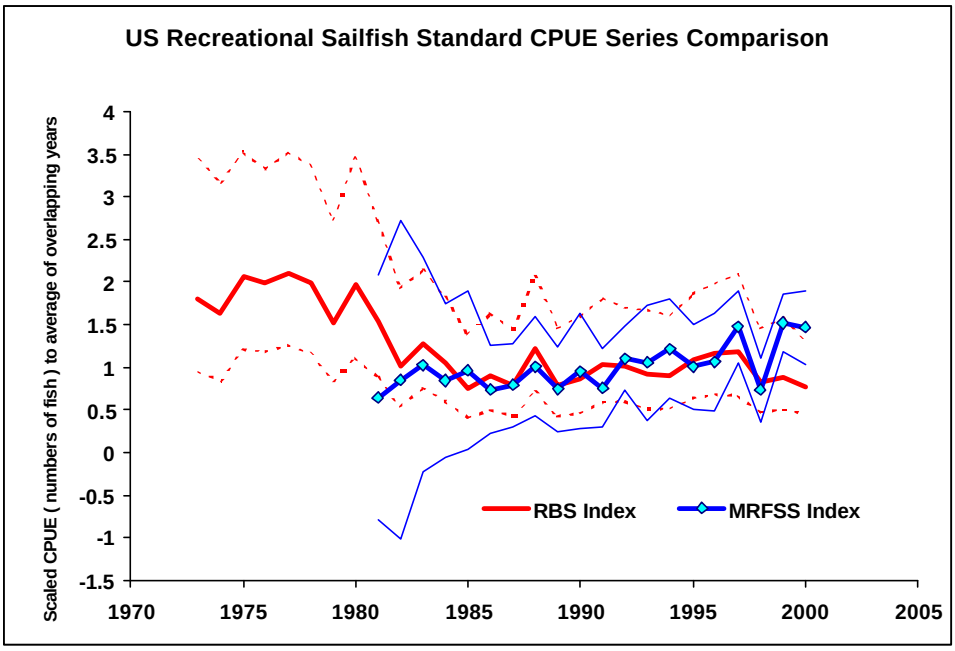


Figure 13. Comparison of relative abundance indices derived from RBS and MRFSS data. Each series is set relative to the series mean index value for the period 1981-2000.