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STANDARDIZED CATCH RATES FOR WHITE MARLIN (*Tetrapturus albidus*) FROM THE US RECREATIONAL TOURNAMENTS FISHERY IN THE NORTHWEST ATLANTIC AND THE US GULF OF MEXICO.

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SUMMARY

Update of indices of abundance for white marlin from the United States recreational billfish tournament fishery are presented for the period 1973-2001. The index of weight (kg) per 100 hours fishing was estimated from numbers of billfish caught and reported in the logbooks submitted by recreational tournament coordinators and NMFS observers under the Recreational Billfish Survey (RBS) Program. The standardization analysis procedure included the following variables; year, area, and season. The standardized index was estimated using Generalized Linear Mixed Models under a delta lognormal model approach.

KEYWORDS

Catch/effort, abundance, Fish catch statistics, logbooks, Multivariate analysis, Recreational fisheries

1. INTRODUCTION

Information on the relative abundance of white marlin (*Tetrapturus albidus*) is necessary to tune stock assessment models. Data were collected by the U.S. Recreational Billfish Survey (RBS) from U.S. recreational tournaments in the Atlantic East coast (including the Bahamas), the Gulf of Mexico, and Caribbean (U.S. Virgin Islands and Puerto Rico). Beardsley and Conser (1981) described the survey and discussed the potential for obtaining indices of abundance from survey data; and a comprehensive review of this survey was presented by Prince et al. (1990). 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. These data has been used to develop standardized catch per unit of effort (CPUE) indices of abundance for Billfish (Browder and Prince 1988, Farber et al. 1994, Jones et al. 1998, Ortiz and Farber 2001). This report documents the analytical methods applied to the available Recreational Billfish Survey data through 2001 and presents correspondent standardized CPUE indices for white marlin.

2. MATERIALS AND METHODS

Browder and Prince (1990) describe the main features of the Recreational Tournaments that take place in the West Atlantic and Caribbean, and Ortiz and Farber (2001) review the

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available catch and effort data from the RBS. The present report, update the catch and effort information until 2001 and follows the methodology and models suggested in the last stock assessment, and the billfish working group of the Scientific Committee of Research and Science for the International Commission for the Conservation of Atlantic Tunas (ICATT). Radio logbook records from the recreational tournaments have been collected since 1972 either by NMFS personal or voluntarily 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 Recreational Billfish Survey data comprises a total of 13,935 records from 1973 through 2001. Each record represents information of hooked and caught fish by tournament-day. Fishing effort is estimated from the number of boats registered in the tournament times the fishing hours per day. Records also include total number of fish hooked, and their fate (i.e. lost, release, tagged and released, or boated) by species, and morphometric information (size and weight) for boated fish. There is a total of 507 registered tournaments in the RBS database, from those the following selecting criteria were applied: a) Only U.S and the Bahamas recreational tournaments that target blue or white marlin were included (i.e. excluding sailfish tournaments particularly in the South Florida region); b) data from tournament events only, excluding biological sampling programs and or dock sampling; and c) tournaments that have at least caught one white marlin in their historical records. The final working data set include a total of 5,856 records representing 316 marlin recreational tournaments from the North Atlantic, Gulf of Mexico, and the Caribbean regions.

Figure 1 shows the geographical distribution of the included tournaments, the points represents the main city/port from where the tournament operated. The geographical regions for each tournament sampling were broken down into six 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 boats and fishing effort per year and area of Billfish recreational tournaments. In general a continue increase of recreational fishing effort has been observed, although total number of participant boats have decreased in the last two years. 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 mainly and size or weight from boated fish, as per suggestion of the Billfish SCRS working group, indices of abundance should be reported in weight rather than numbers of fish. In order to convert numbers of fish to weight, size information on blue and white marlin boated by recreational tournaments was retrieve from the RBS database. There are about 8,165 records for white marlin of size. Figure 3 shows the size frequency distributions by area and season for white marlins caught and measured from recreational tournament events. Mean size by year-area-season stratum was estimated if there were at least 20 measurements per cell. For a cell with less than 20 fish, the mean size of the area was used, if for a given year-area, the number were still less than 20, the mean size by year was applied. Mean size was converted to weight (kg) using the current size-weight relationships for combined sex (Prager et al. 1995). Analyses of catch rates were done on the total number of caught fish (including caught and released fish, and landed fish) rather than the number of landed fish because of the implementation of minimum size regulations and changes in tournament policies towards catch and release preference (Figure 4). In addition, in prior reports lost fish (fish hooked but not brought to the boat) were included in the calculation of catch rates (Ortiz and Farber, 2001; Jones et al. 1998). In recent years, because lost fish are no longer recorded on data forms, we restricted the estimation of nominal catch rates to fish caught, brought next to or in the boat and released, and landed fish.

For the RBS tournament data, relative indices of abundance for white marlin were estimated by 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 marlin was caught assuming a lognormal error distribution. The log-transformed frequency distributions of catch rates in weight for white marlin 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 marlin (positive observations), estimated catch rates were assumed to follow a lognormal error distribution (lnCPUE) of a linear function of fixed factors and random effect interactions, particularly when the *Year* effect was within the interaction. Year, area and season and their interactions were the factors included in the analyses.

A step-wise regression procedure was used to determine the set of systematic factors and interactions that significantly explained the observed variability. The difference of deviance between two consecutive 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 pp 393). Deviance analysis tables for catch rates in weight are presented for both species, each table includes 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 to: a) the relative percent of deviance explained by adding the factor in evaluation, normally factors that explained more than 5 or 10% 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 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 non-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).

3. RESULTS AND DISCUSSION

Table 1 shows the deviance analysis for white marlin from the recreational tournament data analysis. For white marlin the factors; area, season, year*area, and year*season were the main explanatory variables for the proportion of positive trip-days. While, white marlin mean catch rate was best explained by the year, area, year*area, and year*season factors. Once a set of fixed factors was selected, we evaluated first levels interaction between the year and other effects as random interactions.

Table 2 shows the results from the random test analyses of the mixed model formulations of 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 improve by including the random interaction between the area and season factors. In addition, for the white marlin mean catch rate of positive observations, all interactions were significant. In general area and year*area interaction is the main factors that correlate with catch rates for blue and white marlin (Ortiz and Farber, 2001).

Standardized CPUE series for white marlin are show in Table 3 and Figure 6. The figure show the results of the standardization analysis using the weight CPUE (kg/100 hours) as dependent variable. Catch rates of white marlin decrease from 1974 to 1977, and recover to overall highest point in 1980. Since then, however catch rates decreased reaching the lowest point in the early 1990's. Since 1987 catch rates have been below the overall average (1973-2001 mean catch rate = 32.5 kg/100 hours, horizontal reference line on the plot), and no indication of recovery with an exception of slight recovery in 1998. Last three years, 1999-2001 corresponds to the lowest estimated catch rates for white marlin from US recreational billfish tournaments.

For comparison, standardized CPUE series were estimated using both weight (kg) and numbers of fish as dependent variable, otherwise the models were similar. Using scaled values (CPUE series scaled to the overall mean), Figure 7shows the two time series, which show the same pattern whether weight or numbers of white marlin is used as dependent variable (Fig 7).

Figure 8 presents a comparison of the white marlin standardized catch rates for the two alternative dependent variables: Hooked fish (lost, caught/released and landed) versus caught fish (excluding the lost fish category). The main difference between the series if for the early years, 1972-1978 when the lost fish category was a large proportion of the total number of fish reported in the RBS (Figure 4).

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Table 1. Deviance tables for white marlin from 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 White marlin

Model factors positive catch rates values	d. f.	Residual deviance	Change in deviance	% of total deviance	*p*
1	_	4216.85			
Year	28	3874.64	342.2	19.1%	< 0.001
Year area	5	2932.32	942.3	52.6%	< 0.001
Year area season	2	2861.25	71.1	4.0%	< 0.001
Year area season Year*area	118	2563.66	297.6	16.6%	< 0.001
Year area season Year*area Year*season	55	2463.94	99.7	5.6%	< 0.001
Year area season Year*area Year*season area*season	6	2424.26	39.7	2.2%	< 0.001

Model factors proportion positive/total observations	d. f.	Residual deviance	Change in deviance	% of total deviance	*p*
1	_	1646.33			
Year	28	1504.29	142.0	10.0%	< 0.001
Year area	5	557.52	946.8	66.5%	< 0.001
Year area season	2	478.91	78.6	5.5%	< 0.001
Year area season area*season	6	456.38	22.5	1.6%	< 0.001
Year area season Year*season	56	380.84	98.1	6.9%	< 0.001
Year area season Year*area	124	221.71	257.2	18.1%	< 0.001

Table 2. Random effects evaluation for white marlin delta lognormal mixed model specifications.

White Marlin	-2 REM Log likelihood	Akaike's Information Criterion	Schwartz's Bayesian Criterion	Likelihood Ratio Test	
Proportion Positives					
Year Area Season	860.3	862.3	865.9		
Year Area Season *Year*Area*	857.2	861.2	864.3	3.1	0.0783
Year Area Season *Year*Area Year*Season*	857.2	861.2	867.3	0	1.0000
Year Area Season *Year*Area Year*Season Area*Season*	853.9	859.9	869.1	6.4	0.0114
Positive Catch					
Year Area Season	9186.1	9188.1	9194.2		
Year Area Season*Year*Area*	9059.9	9063.9	9069.9	126.2	0.0000
Year Area Seaon *Year*Area Year*Season*	9032.7	9038.7	9047.8	27.2	0.0000
Year Area Season *Year*Area Year*Season Area*Season*	8992.4	9000.4	9012.5	40.3	0.0000

Table 3. Nominal and standardized CPUE for White marlin from the Recreational Billfish Survey data.

Year	Weight (kg) /100 hours fishing				Number of fish/ 100 hours fishing			
	Nominal CPUE	Standard CPUE	*SE*	CV	Nominal CPUE	Standard CPUE	*SE*	CV
1973	21.84	42.10	15.18	36.0%	0.826	1.623	0.584	36.0%
1974	37.38	51.73	17.97	34.7%	1.541	2.096	0.727	34.7%
1975	48.42	35.38	11.10	31.4%	2.021	1.474	0.462	31.4%
1976	28.31	35.34	10.75	30.4%	1.189	1.459	0.444	30.4%
1977	24.92	32.12	9.99	31.1%	1.017	1.313	0.409	31.1%
1978	36.36	37.54	11.57	30.8%	1.498	1.553	0.478	30.8%
1979	50.45	57.67	17.41	30.2%	2.319	2.608	0.784	30.0%
1980	115.64	80.17	23.56	29.4%	4.742	3.354	0.981	29.2%
1981	98.44	55.70	15.90	28.5%	3.980	2.289	0.650	28.4%
1982	48.48	38.85	11.41	29.4%	2.045	1.647	0.481	29.2%
1983	54.27	40.49	11.15	27.5%	2.357	1.775	0.487	27.4%
1984	54.69	34.17	9.57	28.0%	2.283	1.448	0.404	27.9%
1985	36.95	36.14	10.82	29.9%	1.476	1.446	0.431	29.8%
1986	24.43	27.55	8.32	30.2%	1.015	1.146	0.345	30.1%
1987	36.83	25.25	7.15	28.3%	1.560	1.082	0.306	28.3%
1988	32.51	28.52	8.11	28.4%	1.331	1.165	0.331	28.4%
1989	28.52	19.27	5.53	28.7%	1.185	0.802	0.231	28.8%
1990	34.90	19.90	5.69	28.6%	1.363	0.779	0.224	28.7%
1991	26.60	24.18	7.04	29.1%	1.070	0.971	0.283	29.2%
1992	28.85	19.92	5.85	29.4%	1.180	0.816	0.240	29.4%
1993	28.30	18.74	5.49	29.3%	1.094	0.727	0.214	29.4%
1994	34.43	26.45	7.82	29.5%	1.390	1.066	0.315	29.6%
1995	29.07	23.69	6.85	28.9%	1.108	0.911	0.264	29.0%
1996	29.20	25.07	7.34	29.3%	1.089	0.938	0.275	29.3%
1997	24.36	24.45	7.10	29.0%	0.980	0.983	0.285	29.0%
1998	47.95	30.44	9.21	30.2%	1.600	1.015	0.307	30.2%
1999	24.32	20.18	6.06	30.0%	0.879	0.731	0.220	30.1%
2000	26.20	15.81	4.99	31.5%	1.089	0.657	0.209	31.8%
2001	27.30	16.86	5.09	30.2%	1.135	0.701	0.213	30.3%

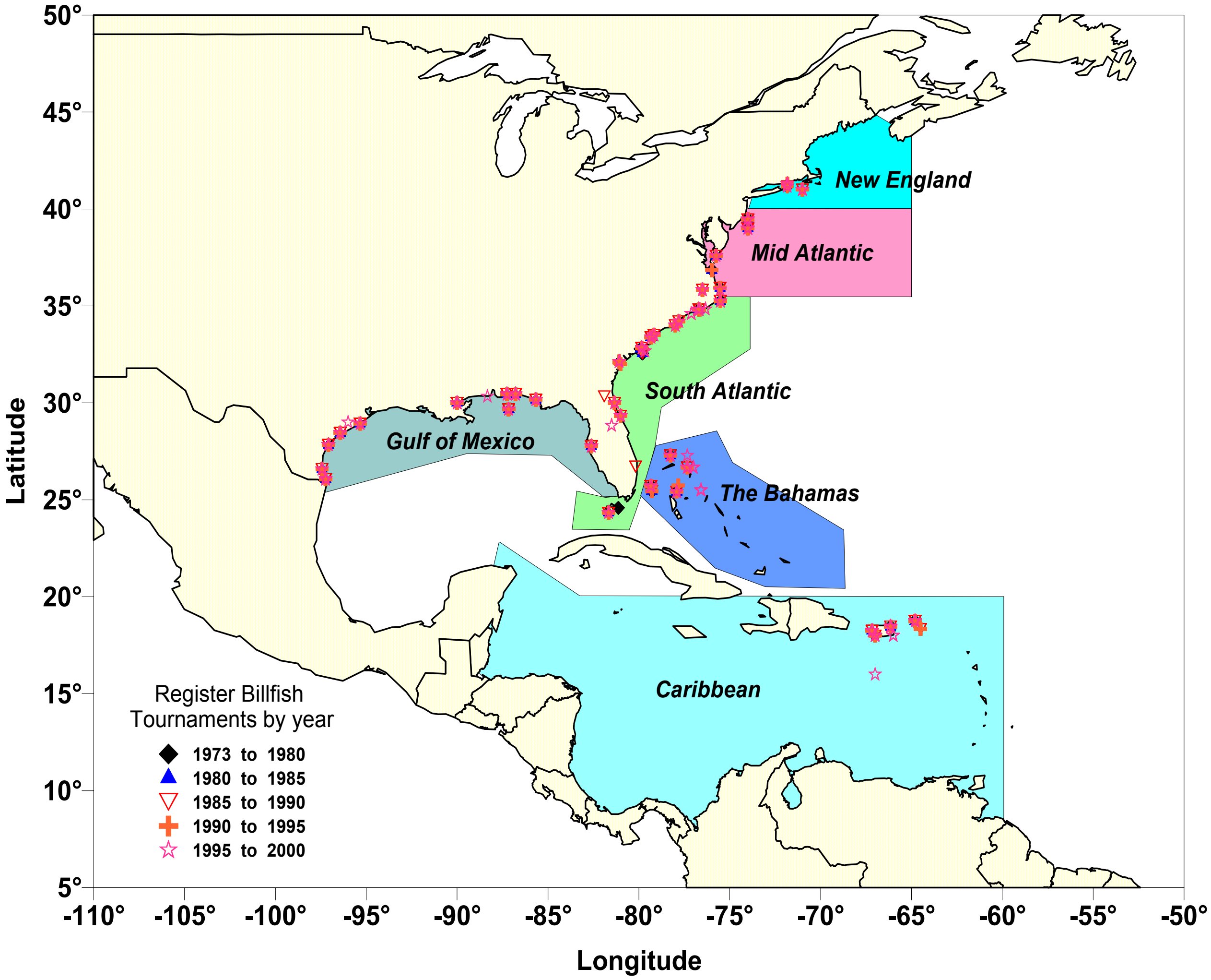
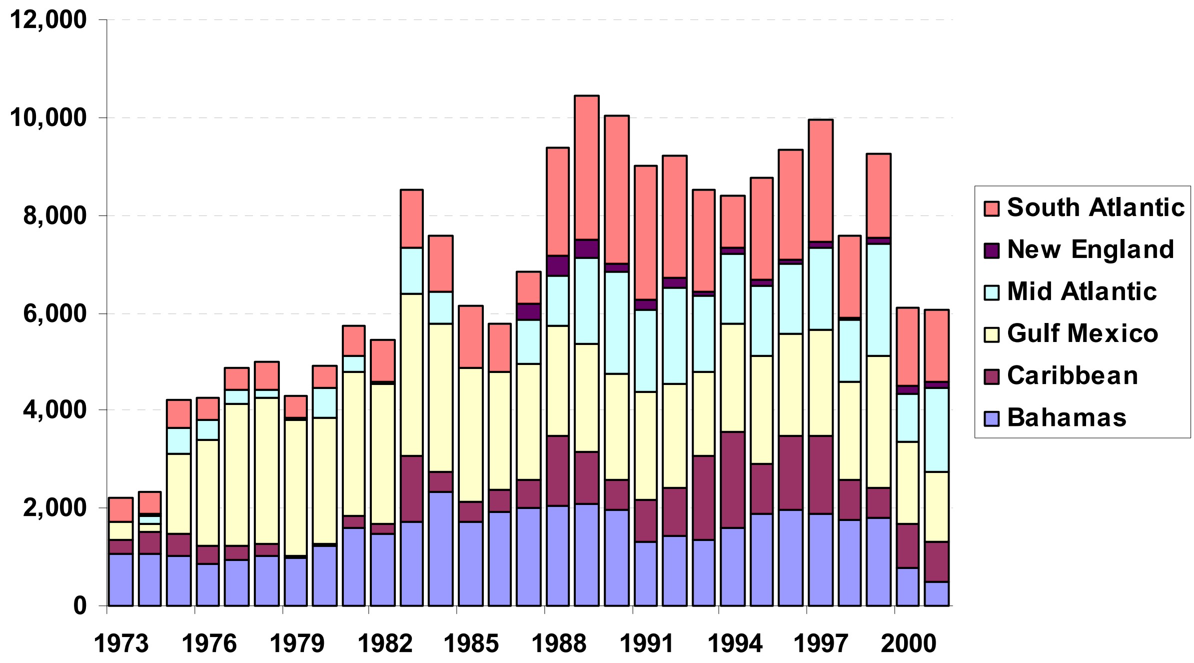


Figure 1. Geographical distribution of recreational tournaments that target marlins. The markers represent the main city/port from where the tournament operated.

Total number of boats on US Recreational Billfish marlin tournaments



Total fishing effort US Recreational Billfish marlin tournaments

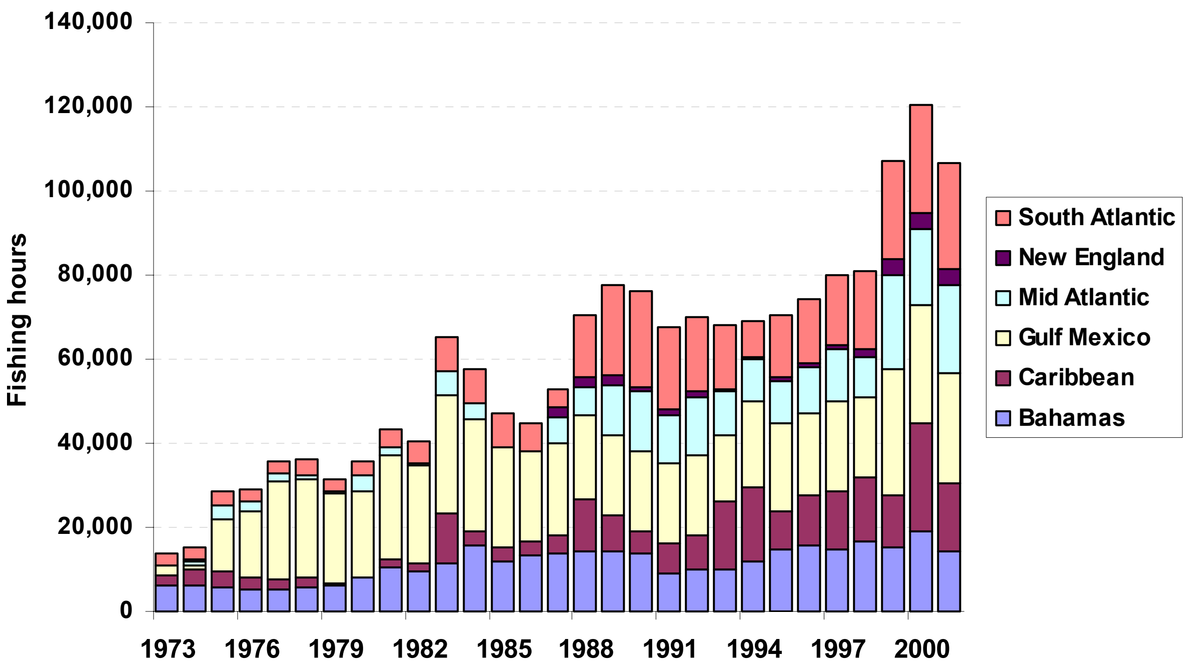


Figure 2. Number of participant boats (top) and fishing effort (bottom) from US Recreational billfish marlin tournaments by year and area.

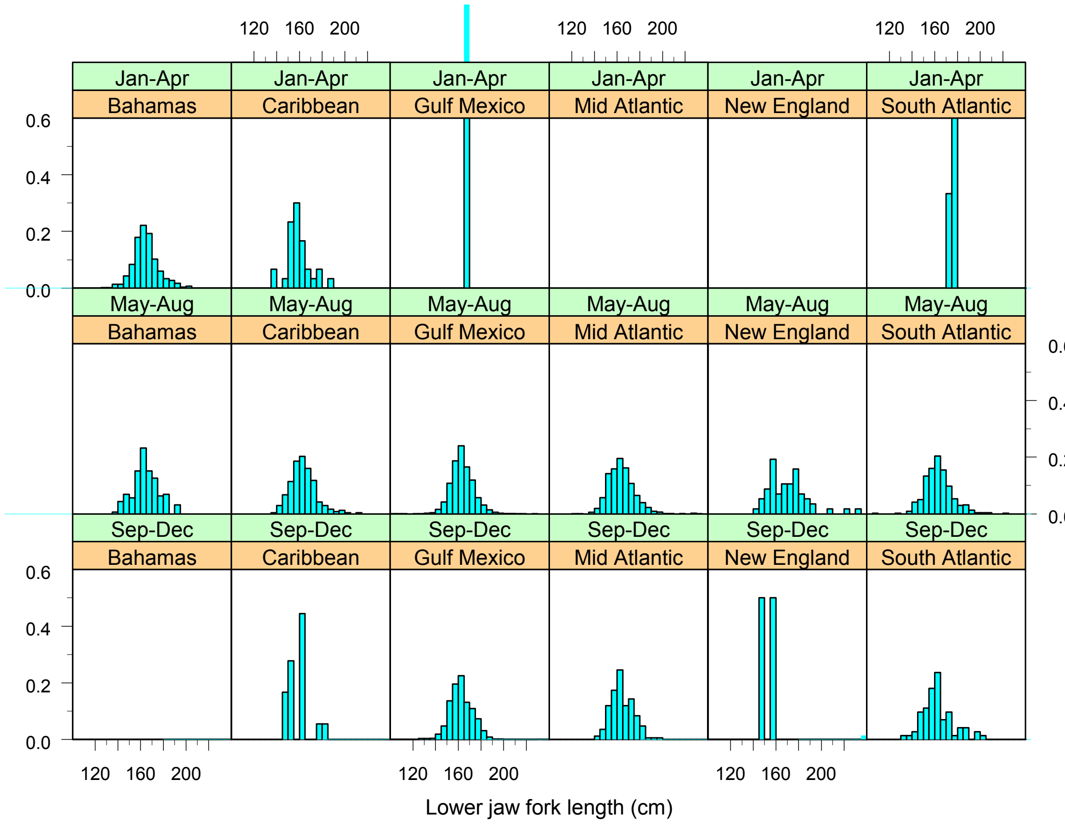


Figure 3. Size frequency distributions by Season-Area for white marlin collected from landed fish on US billfish marlin recreational tournaments.

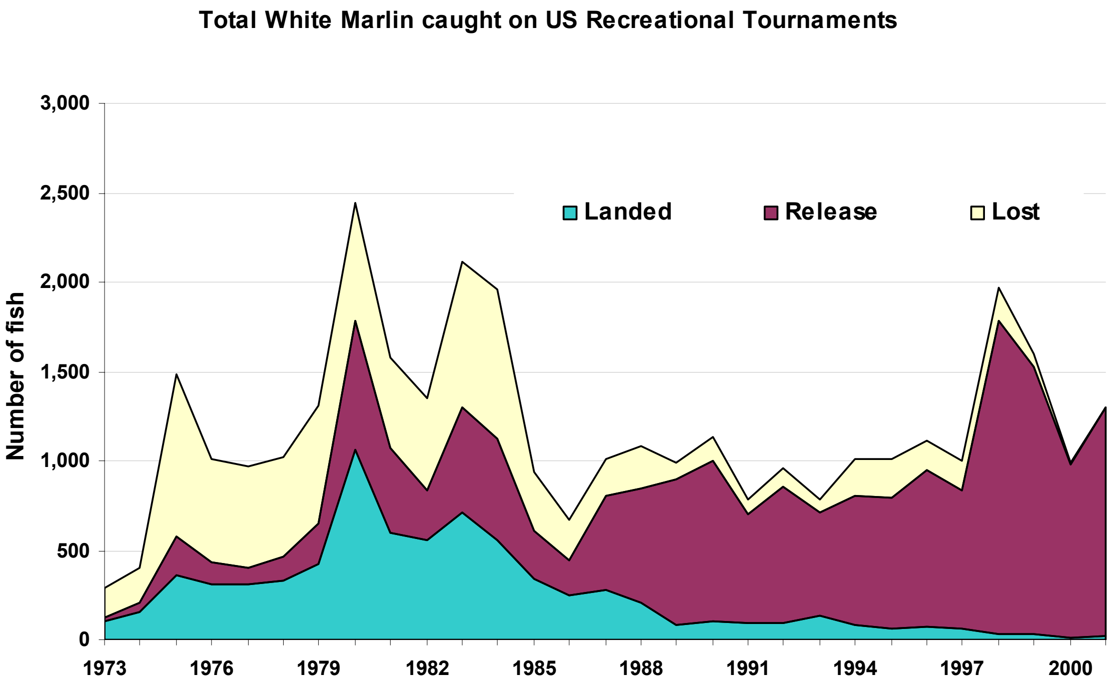
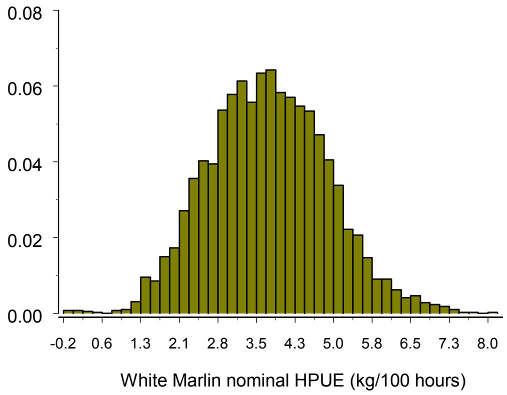


Figure 4. Fate distribution of white marlin hooked on US Recreational billfish marlin tournaments.



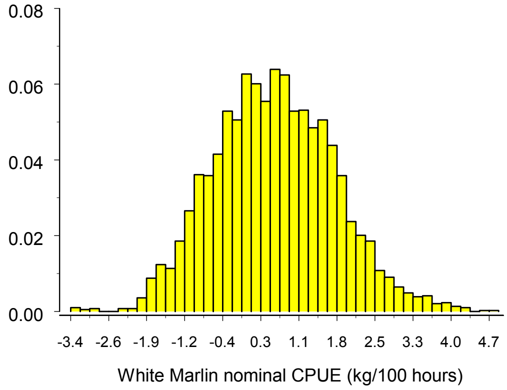


Figure 5. Frequency distribution for log-transformed catch rates of white marlin. HPUE refers to fish hooked (kg) per 100 hours fishing; CPUE refers to caught fish (kg) per 100 hours fishing.

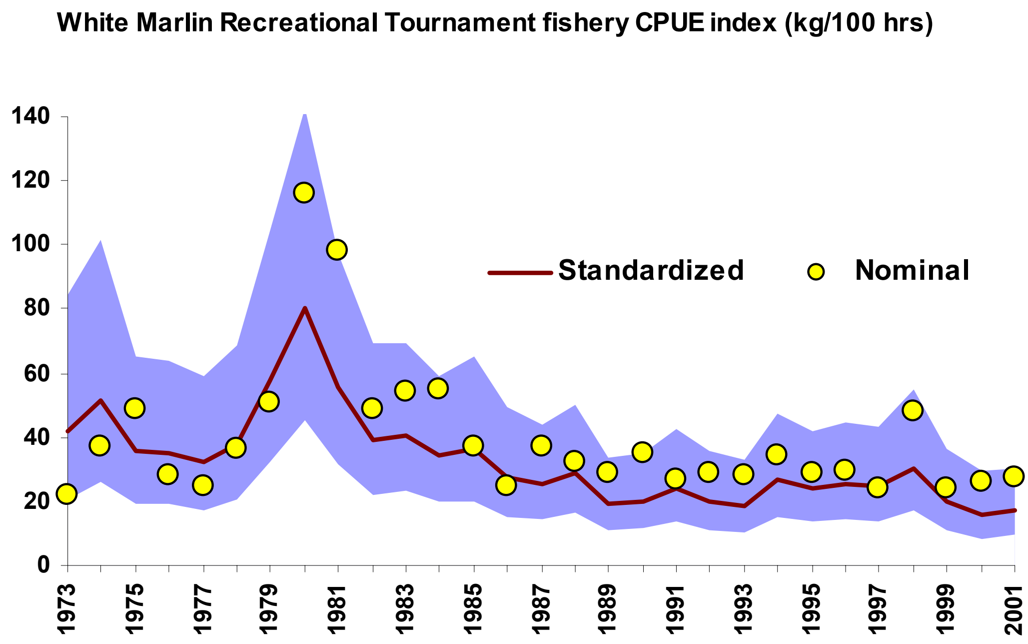


Figure 6. Nominal and standardized catch rates (CPUE) of white marlin from US recreational billfish marlin tournaments. Standardized series shows estimated upper and lower 95% confidence intervals, the solid line represents the overall average for the standard catch rate series.

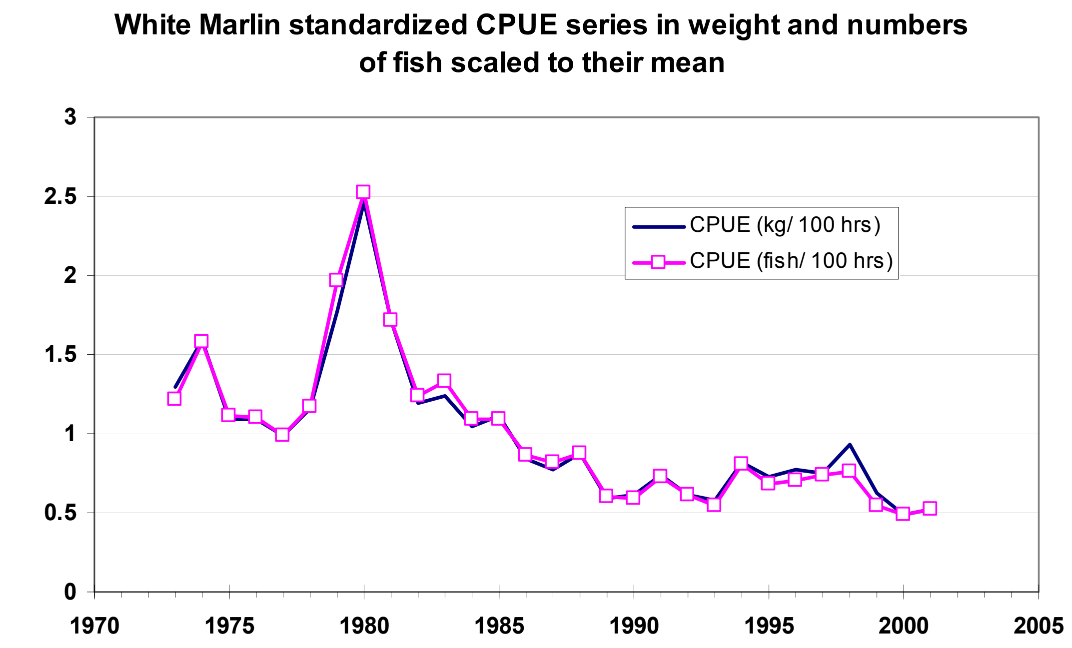


Figure 7. Comparison of weight and number of fish standardized catch rates for blue and white marlin from the US recreational billfish tournaments. Series were scaled to their respective overall mean.

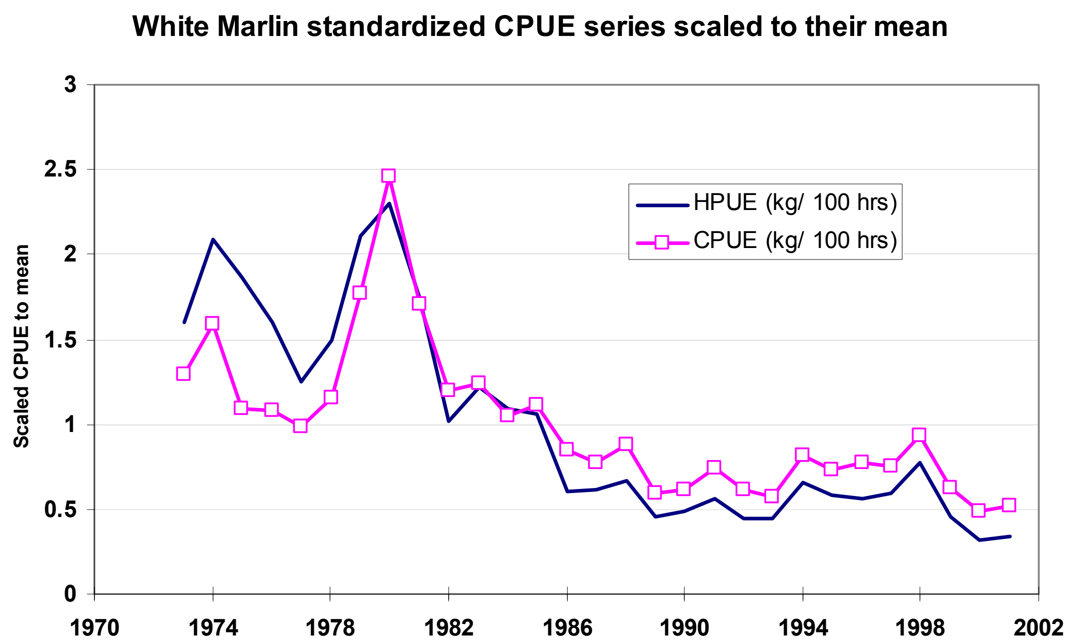


Figure 8. Comparison of white marlin standardized catch rates for two alternative dependent variables: Hooked (lost, caught-released, landed) fish per unit of effort (HPUE), and catch (caught-released and landed) fish per unit of effort (CPUE). Series were scaled to their respective overall mean.