Shark SEDAR Data Workshop Document

Standardized catch rates of large coastal sharks from the Commercial Shark Fishery Observer Program, 1994-2004

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Summary

This document examines catch rate series for several groupings/species of sharks from the Commercial Shark Fishery Observer Program (CSFOP) for the period 1994-2004: all species in the originally defined large coastal shark (LCS) complex (22 species), the LCS complex without prohibited species (11 species), and the LCS complex without prohibited species or blacktip or sandbar sharks (9 species). Additionally, separate analyses were conducted for the sandbar shark and for the blacktip shark (Gulf of Mexico, Atlantic, and the two areas combined). All series were subjected to a Generalized Linear Model (GLM) standardization technique that adjusts for factors that affect relative abundance. The approach used to estimate relative abundance indices is a Generalized Linear Mixed Model that treats separately the proportion of sets with positive catches (i.e., where at least one shark was caught) assuming a binomial error distribution with a logit link function, and the catch rates of sets with positive catches assuming a Poisson error distribution with a log link function. The three standardized LCS series considered showed a positive, statistically significant trend. The standardized series for the sandbar shark was flat and showed high variability around the mean values. the standardized series for the blacktip shark (all areas combined) showed a statistically significant upward tendency, which was also reflected in the standardized series for blacktip in the Gulf of Mexico, whereas the series for blacktip in the Atlantic fluctuated and showed no discernible trend.

1. Introduction/Background

The Commercial Shark Fishery Observer Program (CSFOP), which has been in operation since 1994, monitors the directed shark bottom-longline fishery operating off the U.S east coast. Details of the CSFOP can be found in another document (Morgan and Burgess ref.). Nominal relative abundance series from the CSFOP were previously presented at the 1998 and 2002 (Cortés 2002) Stock Evaluation Workshops and subsequently used for the 1998 and 2002 large coastal shark stock assessments, respectively, but this is the first time that the data are statistically standardized.

2. Materials and Methods

The CSFOP has been placing scientific observers on bottom longline fishing vessels targeting large coastal sharks since 1994. This NMFS-sponsored observer program covered vessels targeting large coastal sharks primarily in the Gulf of Mexico and South Atlantic regions, especially off Florida, Georgia, and South and North Carolina. The program provides information on species composition, relative abundance, and size composition by region and time of year for species in the large coastal, small coastal, and

prohibited species management groups. As of January 2002, observer coverage requirements for this fishery changed from voluntary participation to mandatory compliance (NMFS 2003). Vessels with a current directed shark permit and that have reported shark landings in the past are selected at random. Vessel selection is also made to ensure that areas with higher fishing effort have more vessels selected (NMFS 2003). The present analysis is applied to sharks in the originally defined large coastal shark (LCS) complex management group (consisting of 22 species), the LCS complex without prohibited species (11 species), and the LCS complex without prohibited species or sandbar or blacktip shark (9 species)(NMFS 2003) Additional analyses were performed for sandbar shark (1) and for blacktip shark for the Gulf of Mexico region, Atlantic region, and both areas combined (3). The period of coverage was 1994-2004.

A number of new variables for use in the analyses were created based on the fields available in the CSFOP database. Seasons (spring, summer, fall, winter) were assigned based on the month of the year the set took place; three geographical areas were defined (Eastern Gulf of Mexico, Mid Atlantic Bight, and South Atlantic) as in the original database; the time of day the set started (day, night) was defined from the time the first hook was set in the water; surface water temperature was defined as the mean of the temperatures when the first hook was set and the last hook was retrieved; bottom depth was defined as the mean depth when the first hook was set and the last hook was retrieved; because of the many different hook sizes and types recorded, a hook size variable was created by collapsing sizes and types into a few categories (small, small J hook, small C hook, medium, medium J hook, medium C hook, large, large J hook, large C hook); the type of bait used is recorded at the beginning of the set and there are several hundred types of bait or bait combinations used, thus a few bait categories were created based on the sets that used only one type of bait or a type that could easily be identified (little tunny, Atlantic sharpnose shark, other shark, other teleost, skate or ray, eel, and other). The measure of effort used was 100 hooks per hour.

The approach used to estimate relative abundance indices was a Generalized Linear Mixed Model that treats separately the proportion of sets with positive catches (i.e., where at least one shark was caught) assuming a binomial error distribution with a logit link function, and the catch rates of sets with positive catches assuming a Poisson error distribution with a log link function. The models were fitted with the SAS GENMOD procedure (SAS Institute Inc. 1999) using a forward stepwise approach in which each potential factor was tested one at a time. Initially, a null model was run with no explanatory variables (factors). Factors were then entered one at a time and the results ranked from greatest to smallest 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 if two conditions were met: 1) the effect of the factor was significant at least at the 5% level based on the results of a Chi-Square statistic of a Type III likelihood ratio test, and 2) the deviance per degree of freedom was reduced by at least 1% with respect to the less complex model. Results were summarized in the form of deviance analysis tables including the deviance for proportion of positive observations and the deviance for the positive catch rates. Once a set of fixed factors was selected with the GENMOD procedure (including

first-order interactions), the model was re-run with a computer program that utilizes the SAS GLIMMIX macro (which fits generalized linear mixed models using the SAS MIXED procedure; Wolfinger, SAS Institute Inc.) and first-level random interactions were re-evaluated, particularly those between the *year* factor and other effects. Goodness-of-fit criteria for the final mixed model included Akaike's Information Criterion (AIC), Schwarz's Bayesian Criterion (BIC), and –2* the residual log likelihood (-2Res L). The significance of each individual fixed factor was tested with a Type III test of fixed effects, which examines the significance of an effect with all the other effects in the model (SAS Institute Inc. 1999). A stepwise procedure was also used to determine which random interactions were kept in the final mixed model. As the deviance difference between two consecutive nested models follows a Chi-square distribution (Ortiz 2005), this statistic was used to test for the significance of an additional random factor or first-level random interaction in the model. The significance of random factors or interactions between nested models was evaluated using the likelihood ratio test. At each step, the factor that was kept was that whose inclusion did not affect the significance of the fixed factors as obtained with the Type III test of fixed effects, whose AIC, BIC, and -2*ResL values were the lowest, and whose likelihood ratio test was statistically significant. The final mixed model calculated relative indices as the product of the year effect least squares means (LSMeans) from the binomial and Poisson components using bias correction terms to calculate confidence intervals.

Linear regressions were fitted to the CPUE series obtained to analyze trends. The positive or negative trend of the slope and whether the linear regression was significant was noted.

3. Results and Discussion

LCS complex (22 species)—About 95% of the sets analyzed encountered large coastal sharks. The proportion of positive catches for the LCS complex was explained by the timestart (time of the day the set started), year, area, and temperature fixed factors (Table 1). The mean catch rates for positive catches were explained by the year, area, and hooktype (type of hook) fixed factors, and the area*season and area*depth random interactions (Table 1). The relative standardized catch rates showed an increasing trend, which was statistically significant (slope=0.035, SE=0.0126, P=0.022, r^2=0.46), and similar to that of the nominal series. All nominal values fell inside the 95% confidence limits of the standardized series (Fig. 1A).

LCS complex without prohibited species (11 species)—About 95% of the sets analyzed encountered large coastal sharks minus prohibited species. The proportion of positive catches was explained by the timestart and year fixed factors, and area random factor and year*area random interaction (Table 2). The mean catch rates for positive catches were explained by the year, baittype (type of bait), hooktype , and area fixed factors, and the area*season random interaction (Table 2). The relative standardized catch rates showed an increasing trend, which was statistically significant (slope=0.032,

SE=0.0137, P=0.043, r^2=0.38), and similar to that of the nominal series. All nominal values fell inside the 95% confidence limits of the standardized series, except for the 2004 value (Fig. 1B).

LCS complex without prohibited species, blacktip or sandbar (9 species)—About 87% of the sets analyzed encountered large coastal sharks minus prohibited species, blacktip, or sandbar sharks. The proportion of positive catches was explained by the temperature, timestart, and year fixed factors, and the year*timestart random interaction (Table 3). The mean catch rates for positive catches were explained by the temperature, year, area, and depth fixed factors, and the temperature*depth random interaction (Table 3). The relative standardized catch rates also showed an increasing trend, which was statistically significant (slope=0.046, SE=0.0189, P=0.038, r^2=0.40), and more dissimilar to that of the nominal series than in the other LCS scenarios considered above. All nominal values fell inside the 95% confidence limits of the standardized series (Fig. 1C).

Sandbar shark—About 73% of the sets analyzed encountered sandbar sharks. The proportion of positive catches was explained by the depth, timestart, area, temperature, baittype, and year fixed factors(Table 4). The mean catch rates for positive catches were explained by the area and year fixed factors and season random factorand area*depth and area*hooktype random interactions(Table 4). The trend of relative average standardized catch rates was flat with large variability around the mean values, and showed no direction (slope=-0.0018, SE=0.012, P=0.887, r^2=0.002). The nominal series showed some more fluctuation, with two small peaks in 1998 and 2001 (Fig. 2).

Blacktip shark (areas combined)—About 83% of the sets analyzed encountered blacktip sharks. The proportion of positive catches was explained by the area, depth, year, timestart, and season fixed factors(Table 5). The mean catch rates for positive catches were explained by the year, timestart, depth, and area fixed factors (Table 5). The relative standardized catch rates showed a positive trend, which was statistically significant (slope=0.0773, SE=0.0296, P=0.028, r^2=0.43). The nominal series was not very dissimilar, and all points except for the 2004 value, fell inside the 95% confidence limits of the standardized series (Fig. 3A).

Blacktip shark (Gulf of Mexico)—About 60% of the sets analyzed encountered blacktip sharks. The proportion of positive catches was explained by the year, depth, and season fixed factors and the year*season random interaction (Table 6). The mean catch rates for positive catches were explained by the year, depth, timestart, and hooktype fixed factors and the year*depth random interaction (Table 6). The relative standardized catch rates (ignoring year 2000, for which there were no observations) showed a positive trend, which was statistically significant (slope=0.1215, SE=0.046, P=0.030, r^2=0.47). The nominal series was not very dissimilar, and all points fell inside the 95% confidence limits of the standardized series (Fig. 3B).

Blacktip shark (Atlantic)—About 46% of the sets analyzed encountered blacktip sharks. The proportion of positive catches was explained by the year, depth, timestart, season, and baittype fixed factors and the year*temperature and depth*timestart random

interactions (Table 7). The mean catch rates for positive catches were explained by the timestart, year, and depth fixed factors and the year*depth random interaction (Table 7). The relative standardized catch rates showed fluctuations, with a peak in 2002 that was also reflected in the nominal series. The nominal series was similar, except for 1998-2001 when it showed an opposite trend to that of the standardized series (Fig. 3C). No trend was detected (slope=-0.003, SE=0.134, P=0.983, r^2=0.00).

In general, addition or deletion of a fixed factor or random interaction from the final mixed model selected had little effect on the standardized catch rates or the series trend. Table 8 lists the relative CPUE indices.

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References

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Table 1. Deviance analysis tables showing the stepwise procedure used to develop the catch rate model for the **large coastal shark** aggregate (22 species) in the Commercial Shark Fishery Observer Program (CSFOP). Proportion positive assumed a binomial error distribution, whereas positive catch rates assumed a Poisson distribution.

CSFOP

Proportion positive

Factors	d.f.	Deviance	Deviance/df	% Reduction in deviance/df	% Difference	L	Chi Square	Pr>Chi Square
NULL	1248	451.05	0.3614			-225.5229		
TIMESTART	1247	399.40	0.3203	11.38	11.38	-199.6999	51.65	<.0001
YEAR	1238	409.70	0.3309	8.43		-204.8503	41.35	<.0001
AREA	1246	421.72	0.3385	6.35		-210.8607	29.32	<.0001
SEASON	1245	425.83	0.3420	5.36		-212.92	Negative of Hessian not posit. def.	
BAITTYPE	1242	431.07	0.3471	3.97		-215.5368	19.97	0.0028
HOOKTYPE	1231	436.43	0.3545	1.91		-218.2131	Negative of Hessian not posit. def.	
DEPTH	1247	450.03	0.3609	0.14		-225.0168	1.01	0.3144
TEMPERATURE	1064	394.23	0.3705	-2.52		-197.1166	9.35	0.0022
TIMESTART+								
YEAR	1237	364.2841	0.2945	18.52	7.14	-182.1421	35.12	0.0001
AREA	1245	376.0159	0.3020	16.43		-188.0079	23.38	<.0001
SEASON	1244	380.3304	0.3057	15.41		-190.1652	Negative of Hessian not posit. def.	
HOOKTYPE	1230	383.641	0.3119	13.70		-191.8205	Negative of Hessian not posit. def.	
BAITTYPE	1241	390.3229	0.3145	12.97		-195.1614	9.08	0.16930
DEPTH	1246	398.8409	0.3201	11.43		-199.4204	0.56	0.4547
TEMPERATURE	1063	355.5777	0.3345	7.45		-177.7888	3.5	0.0615
TIMESTART+YEAR								
AREA	1235	345.5201	0.2798	22.59	4.07	-172.7601	18.76	<.0001
SEASON	1234	343.5516	0.2784	22.97		-171.7758	Negative of Hessian not posit. def.	
BAITTYPE	1231	353.6882	0.2873	20.50		-176.8441	10.6	0.1017
HOOKTYPE	1220	356.5259	0.2922	19.14		-178.263	Negative of Hessian not posit. def.	
TEMPERATURE	1236	364.2689	0.2947	18.45		-182.1345	0.02	0.9018
DEPTH	1236	364.2689	0.2947	18.45		-182.1345	0.02	0.9018
TIMESTART+YEAR+AREA+								
BAITTYPE	1229	334.8805	0.2725	24.61	2.02	-167.4403	10.64	0.1002
SEASON	1232	323.8616	0.2629	27.27		-161.9308	Negative of Hessian not posit. def.	
SEASON	1232	323.8616	0.2629	27.27		-161.9308	Negative of Hessian not posit. def.	
HOOKTYPE	1218	339.4603	0.2787	22.89		-169.7302	Negative of Hessian not posit. def.	
DEPTH	1234	345.4734	0.2800	22.54		-172.7367	0.05	0.8289
TEMP	1051	290.6134	0.2765	23.49		-145.3067	17.49	<.0001
TIMESTART+YEAR+AREA+BAITTYPE+								
TEMPERATURE	1045	278.1754	0.2662	26.35	1.74	-139.0877	16.7	<.0001
DEPTH	1228	334.874	0.2727	24.55		-167.437	0.01	0.9357
TIMESTART+YEAR+AREA+BAITTYPE+TEMPERATURE+								
TIMESTART*YEAR	1219	322.1783	0.2643	26.87	0.53	-161.0891	Negative of Hessian not posit. def.	
TIMESTART*BAITTYPE	1223	328.6171	0.2687	25.65		-164.3085	Negative of Hessian not posit. def.	
TIMESTART*AREA	1227	331.9168	0.2705	25.15		-165.9584	2.96	0.2272

FINAL MIXED MODEL RESULTS

Factors	Akaike's information criterion	Schwarz's Bayesian criterion	-2 Res L	Significance (Pr>Chi square) of theType 3 test of fixed effects for each individual factor			
				TIMESTART	YEAR	AREA	TEMP
TIMESTART+YEAR+ AREA+TEMPERATURE	8046.5	8051.4	8044.5	<0.0001	0.049	0.0108	0.0004

Positive catches

Factors	d.f.	Deviance	Deviance/df	% Reduction in deviance/df	% Difference	L	Chi Square	Pr>Chi Square
NULL	1185	33285.3701	28.0889			107875.2044		
YEAR	1175	30825.2556	26.2343	6.60	6.60	109105.2617	2460.11	<.0001
AREA	1183	32311.1913	27.3129	2.76		108362.2938	974.18	<.0001
BAITTYPE	1179	32254.1311	27.3572	2.61		108390.8239	1031.24	<.0001
HOOKTYPE	1168	32598.6958	27.9098	0.64		107689.8417	639.04	<.0001

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Factors								
SEASON	1182	33088.2669	27.9935	0.34		107973.756	197.1	<.0001
TIMESTART	1184	33223.1683	28.0601	0.10		107906.3053	62.2	<.0001
DEPTH	1184	33278.5133	28.1069	-0.06		107878.6328	6.86	0.0088
TEMPERATURE	1007	29425.3199	29.2208	-4.03		97206.0248	351.83	<.0001
YEAR+								
AREA	1173	29943.8069	25.5275	9.12	2.52	109545.986	881.45	<.0001
BAITTYPE	1169	30049.1787	25.7050	8.49		109493.3001	776.08	<.0001
HOOKTYPE	1158	30187.1729	26.0684	7.19		108895.6032	588.11	<.0001
SEASON	1172	30578.8469	26.0912	7.11		109228.466	246.41	<.0001
TIMESTART	1174	30733.6018	26.1785	6.80		109151.0886	91.65	<.0001
DEPTH	1174	30783.255	26.2208	6.65		109126.262	42.00	<.0001
TEMPERATURE	997	27099.78	27.1813	3.23		98368.80	276.54	<.0001
YEAR+AREA+								
HOOKTYPE	1156	28598.0236	24.7388	11.93	2.81	109690.1778	1257.99	<.0001
BAITTYPE	1167	29439.4595	25.2266	10.19		109798.1597	504.35	<.0001
SEASON	1170	29780.8439	25.4537	9.38		109627.4675	162.96	<.0001
DEPTH	1172	29942.597	25.5483	9.04		109546.591	1.21	0.2713
TIMESTART	1172	29943.7184	25.5492	9.04		109546.0303	0.09	0.766
TEMPERATURE	995	26308.8202	26.4410	5.87		98764.2746	19.55	<.0001
YEAR+AREA+HOOKTYPE+								
BAITTYPE	1150	28143.2942	24.4724	12.88	0.95	109917.5425	454.73	<.0001
SEASON	1153	28393.3807	24.6257	12.33		109792.4993	204.64	<.0001
DEPTH	1155	28597.9359	24.7601	11.85		109690.2217	0.09	0.7672
TIMESTART	1155	28597.8042	24.7600	11.85		109690.2875	0.22	0.6395
TEMPERATURE	979	25097.6809	25.6360	8.73		98841.1444	28.02	<.0001
YEAR+AREA+HOOKTYPE+								
YEAR*AREA	1138	24672.6085	21.6807	22.81	9.94	111652.8854	3925.42	<.0001
YEAR*SEASON	1137	26076.7102	22.9347	18.35		110950.8345	2521.31	<.0001
YEAR*TEMPERATURE	969	22330.1069	23.0445	17.96		100224.9314	2795.59	<.0001
YEAR*TIMESTART	1145	27727.7291	24.2164	13.79		110125.3251	870.29	<.0001
YEAR*BAITTYPE	1112	26935.1971	24.2223	13.77		110521.5911	1662.83	<.0001
YEAR*HOOKTYPE	1147	28189.5599	24.5768	12.50		109894.4097	408.46	<.0001
YEAR*DEPTH	1145	28211.1454	24.6386	12.28		109883.6169	386.88	<.0001
YEAR+AREA+HOOKTYPE+YEAR*AREA+								
YEAR*SEASON	1119	22873.015	20.4406	27.23	4.41	112552.6821	1799.59	<.0001
YEAR*BAITTYPE	1094	23455.3824	21.4400	23.67		112261.4984	1217.23	<.0001
YEAR*TIMESTART	1127	24273.5646	21.5382	23.32		111852.4073	399.04	<.0001
YEAR*TEMPERATURE	951	20567.7275	21.6275	23.00		101106.1211	1262.45	<.0001
YEAR+AREA+HOOKTYPE+YEAR*AREA+YEAR*SEASON+								
AREA*DEPTH	1116	21841.8669	19.5716	30.32	3.09	113068.2562	1031.15	<.0001
AREA*SEASON	1115	22276.4608	19.9789	28.87		112851.0	596.55	<.0001
AREA*HOOKTYPE	1112	22577.7135	20.3037	27.72		112700.3329	295.3	<.0001
AREA*YEAR	1119	22873.015	20.4406	27.23		112552.6821	1799.59	<.0001
AREA*BAITTYPE	1105	22699.0265	20.5421	26.87		112639.6764	173.99	<.0001
AREA*TEMPERATURE	940	19745.0703	21.0054	25.22		101517.4497	316.05	<.0001
YEAR+AREA+HOOKTYPE+YEAR*AREA+YEAR*SEASON+AREA*DEPTH+								
AREA*SEASON	1112	21118.235	18.9912	32.39	2.07	113430.0721	723.63	<.0001
SEASON*BAITTYPE	1098	21171.0058	19.2814	31.36		113403.6867	670.86	<.0001
SEASON*DEPTH	1113	21564.5561	19.3752	31.02		113206.9116	277.31	<.0001
SEASON*HOOKTYPE	1109	21675.5501	19.5451	30.42		113151.4146	none given	
HOOKTYPE*DEPTH	1110	21750.4927	19.5950	30.24		113113.9433	91.37	<.0001
HOKKTYPE*BAITTYPE	1094	21562.1524	19.7095	29.83		113208.1134	279.71	<.0001
SEASON*TEMPERATURE	936	18565.9247	19.8354	29.38		102107.0225	483.69	<.0001
HOOKTYPE*TEMP	934	18894.847	20.2300	27.98		101942.5614	154.77	<.0001
YEAR+AREA+HOOKTYPE+YEAR*AREA+YEAR*SEASON+AREA*DEPTH+AREA*SEASON+								
SEASON*BAITTYPE	1094	20612.0054	18.8410	32.92	0.53	113683.1869	506.23	<.0001
SEASON*DEPTH	1109	20913.4052	18.8579	32.86		113532.487	955.53	<.0001

FINAL MIXED MODEL RESULTS

Factors	Akaike's information criterion	Schwarz's Bayesian criterion	-2 Res L	YEAR	AREA	HOOKTYPE		
YEAR+AREA+ HOOKTYPE	2988.3	2993.3	2986.3	<0.0001	<0.0001	0.0405		

Significance (Pr>Chi square) of theType 3 test of fixed effects for each individual factor

Random interactions	AIC	BIC	-2 Res L	Pr > Chi square	Fixed factors
AREA*SEASON	2975.1	2975.9	2971.1	0.0001	all significant
AREA*SEASON+AREA*DEPTH	2963.5	2964.7	2957.5	0.0002	all significant

% Difference: percent difference in deviance/df between the newly included factor and the previous factor entered into the model;
L: log likelihood; Chi Square: Pearson Chi-square statistic; Pr>Chi Square: significance level of the Chi-square statistic

Table 2. Deviance analysis tables showing the stepwise procedure used to develop the catch rate model for the **large coastal shark** aggregate without prohibited species (11 species) in the Commercial Shark Fishery Observer Program (CSFOP). Proportion positive assumed a binomial error distribution, whereas positive catch rates assumed a Poisson distribution.

CSFOP

Proportion positive

Factors	d.f.	Deviance	Deviance/df	% Reduction in deviance/df	% Difference	L	Chi Square	Pr>Chi Square
NULL	1248	487.32	0.3905			-243.66		
TIMESTART	1247	427.00	0.3424	12.32		-213.50	60.31	<0.0001
YEAR	1238	442.88	0.3577	8.40		-221.44	44.43	<0.0001
SEASON	1245	458.43	0.3682	5.71		-229.21	Negative of Hessian not posit. def.	
AREA	1246	469.93	0.3771	3.43		-234.96	17.39	0.0002
BAITTYPE	1242	470.19	0.3786	3.05		-235.09	17.13	0.0088
HOOKTYPE	1231	470.20	0.3820	2.18		-235.10	Negative of Hessian not posit. def.	
DEPTH	1247	485.41	0.3893	0.31		-242.71	1.90	0.1678
TEMPERATURE	1064	422.91	0.3975	-1.79		-211.46	16.08	<0.0001
TIMESTART+								
YEAR	1226	388.82	0.3171	18.80	6.48	-194.41	36.80	<0.0001
SEASON	1233	404.40	0.3280	16.01		0.328	Negative of Hessian not posit. def.	
AREA	1234	416.09	0.3372	13.65		-208.04	9.53	0.0085
BAITTYPE	1230	419.86	0.3413	12.60		-209.93	5.76	0.4507
TIMESTART+YEAR								
SEASON	1223	366.16	0.2994	23.33	4.53	-183.08	Negative of Hessian not posit. def.	
BAITTYPE	1220	380.01	0.3115	20.23		-190.00	8.81	0.1845
AREA	1224	382.93	0.3128	19.90		-191.46	5.89	0.0526
TIMESTART+YEAR+BAITTYPE+								
SEASON	1217	356.51	0.2929	24.99	4.76	-178.25	Negative of Hessian not posit. def.	
AREA	1218	371.52	0.3050	21.90		-185.76	8.49	0.0143
HOOKTYPE	1214	372.23	0.3066	21.49		-186.12	Negative of Hessian not posit. def.	
TIMESTART+YEAR+BAITTYPE+AREA+								
HOOKTYPE	1212	364.77	0.3010	22.92	-2.07	-182.38	Negative of Hessian not posit. def.	
DEPTH	1217	371.47	0.3052	21.84		-185.74	0.04	0.8394
			100.00					

FINAL MIXED MODEL RESULTS

Factors	Akaike's information criterion	Schwarz's Bayesian criterion	-2 Res L	Significance (Pr>Chi square) of theType 3 test of fixed effects for each individual factor	
				TIMESTART	YEAR
TIMESTART+YEAR	8719.1	8724.2	8717.1	<0.0001	0.0135

Random effects and interactions	AIC	BIC	-2 Res L	Pr > Chi square	Fixed factors
AREA	8667	8665.0	8663.0	0.0000	all significant
*AREA+YEAR*AREA*	8487.9	8485.2	8481.9	0.0000	all significant

Positive catches

Factors	d.f.	Deviance	Deviance/df	% Reduction in deviance/df	% Difference	L	Chi Square	Pr>Chi Square
NULL	1179	31859.11	27.0221			100940.09		
YEAR	1169	29562.45	25.2887	6.41	6.41	102088.42	2296.66	<0.0001
BAITTYPE	1173	30958.66	26.3927	2.33		101390.31	900.46	<0.0001
AREA	1177	31268.67	26.5664	1.69		101235.31	590.45	<0.0001
HOOKTYPE	1162	31124.81	26.7856	0.88		100793.6754	688.77	<0.0001
SEASON	1176	31711.88	26.9659	0.21		101013.70	147.23	<0.0001
TIMESTART	1178	31803.93	26.9982	0.09		100967.68	55.18	<0.0001
DEPTH	1178	31847.64	27.0353	-0.05		100945.82	11.48	0.0007
TEMPERATURE	1001	28108.32	28.0802	-3.92		90371.82	199.46	<0.0001
YEAR+								
BAITTYPE	1152	28863.40	25.0550	7.28	0.86	101924.3799	649.80	<0.0001

Factor								
AREA	1156	28975.49	25.0653	7.24		101868.34	537.72	<0.0001
HOOKTYPE	1152	28886.79	25.0753	7.20		101912.68	626.41	<0.0001
SEASON	1155	29377.96	25.4355	5.87		101667.10	135.24	<0.0001
YEAR+BAITTYPE+								
HOOKTYPE	1146	28153.70	24.5669	9.09	1.81	102279.2301	709.70	<0.0001
AREA	1150	28507.17	24.7888	8.26		102102.4936	356.23	<0.0001
SEASON	1149	28756.70	25.0276	7.38		101977.7318	106.70	<0.0001
YEAR+BAITTYPE+HOOKTYPE+								
AREA	1144	27398.39	23.9496	11.37	2.28	102656.8855	755.31	<0.0001
SEASON	1143	28030.39	24.5235	9.25		102340.8842	123.31	<0.0001
TIMESTART	1145	28130.86	24.5684	9.08		102290.6507	22.84	<0.0001
YEAR+BAITTYPE+HOOKTYPE+AREA+								
SEASON	1141	27309.67	23.9349	11.42	0.05	102701.2462	88.72	<0.0001
TIMESTART	1143	27393.97	23.9667	11.31		102659.096	4.42	0.0355
YEAR+BAITTYPE+HOOKTYPE+AREA+								
YEAR*AREA	1126	23690.72	21.0397	22.14	10.77	104510.7218	3707.67	<0.0001
YEAR*SEASON	1125	25212.99	22.4115	17.06		103749.586	2185.40	<0.0001
AREA*SEASON	1136	26809.03	23.5995	12.67		102951.565	589.36	<0.0001
YEAR+BAITTYPE+HOOKTYPE+AREA+YEAR*AREA								
AREA*SEASON	1118	22269.72	19.9192	26.29	4.15	105221.2212	1421.00	<0.0001
YEAR*SEASON	1107	22278.41	20.1250	25.52		105216.8751	1412.31	<0.0001
YEAR+BAITTYPE+HOOKTYPE+AREA+YEAR*AREA+AREA*SEASON								
YEAR*SEASON	1103	21753.48	19.7221	27.01	0.73	105479.3402	516.24	<0.0001

FINAL MODEL RESULTS

Factors	Akaike's information criterion	Schwarz's Bayesian criterion	-2 Res L	Significance (Pr>Chi square) of the Type 3 test of fixed effects for each individual factor			
				YEAR	BAITTYPE	HOOKTYPE	AREA
YEAR+BAITTYPE+ HOOKTYPE+AREA+	2929.3	2782.6	2927.3	<0.0001	<0.0001	0.0012	<0.0001

Random interactions			AIC	BIC	-2 Res L	Pr > Chi square	Fixed factors
*AREA*SEASON*			2912.6	2912.6	2908.6	0.0000	all significant

% Difference: percent difference in deviance/df between the newly included factor and the previous factor entered into the model;
L: log likelihood; Chi Square: Pearson Chi-square statistic; Pr>Chi Square: significance level of the Chi-square statistic

Table 3. Deviance analysis tables showing the stepwise procedure used to develop the catch rate model for the **large coastal shark** aggregate without prohibited species, blacktip or sandbar (9 species) in the Commercial Shark Fishery Observer Program (CSFOP). Proportion positive assumed a binomial error distribution, whereas positive catch rates assumed a Poisson distribution.

CSFOP

Proportion positive

Factors	d.f.	Deviance	Deviance/df	% Reduction in deviance/df	% Difference	L	Chi Square	Pr>Chi Square
NULL	1248	986.38	0.7904			-493.1883		
TEMPERATURE	1064	778.02	0.7312	7.48		-389.0117	58.66	<.0001
TIMESTART	1247	917.31	0.7356	6.93		-458.6551	69.07	<.0001
SEASON	1245	950.62	0.7636	3.39		-475.31	35.75	<.0001
YEAR	1238	951.63	0.7687	2.74		-475.8131	34.75	0.0001
AREA	1246	966.91	0.7760	1.82		-483.453	19.47	<.0001
BAITTYPE	1242	968.73	0.7800	1.31		-484.3661	17.64	0.0072
HOOKTYPE	1231	965.50	0.7843	0.76		-482.7494	17.68	0.0071
DEPTH	1247	979.04	0.7851	0.66		-489.5205	7.34	0.0068
TEMPERATURE+								
TIMESTART	1063	744.944	0.7008	11.33	3.85	-372.472	33.08	<.0001
YEAR	1054	743.6521	0.7056	10.73		-371.8261	34.37	0.0002
BAITTYPE	1058	768.8998	0.7267	8.05		-384.4499	9.12	0.16680
DEPTH	1063	772.7503	0.7270	8.02		-386.3751	5.27	0.0217
HOOKTYPE	1048	765.8093	0.7307	7.54		-382.9046	10.66	0.0586
AREA	1062	776.5191	0.7312	7.49		-388.2596	1.5	0.4714
SEASON	1061	776.1102	0.7315	7.45		-388.0551	1.91	0.5906
TEMPERATURE+TIMESTART+								
YEAR	1053	712.3064	0.6765	14.41	3.08	-356.1532	32.64	0.0003
BAITTYPE	1048	730.6583	0.6972	11.79		-365.3292	12.99	0.0431
DEPTH	1053	741.8243	0.7045	10.87		-370.9121	1.83	0.1764
SEASON	1051	741.5759	0.7056	10.73		-370.7879	2.08	0.5567
AREA	1052	743.1757	0.7064	10.62		-371.5878	0.48	0.788
HOOKTYPE	1038	739.0026	0.7119	9.92		-369.5013	4.01	0.5482
TEMPERATURE+TIMESTART+YEAR+								
AREA	1051	710.8135	0.6763	14.43	0.02	-355.4068	1.49	0.4741
BAITTYPE	1047	708.021	0.6762	14.44		-354.0105	4.29	0.6381
DEPTH	1052	711.435	0.6763	14.44		-355.7175	0.87	0.3506
SEASON	1050	710.8765	0.6770	14.34		-355.4383	1.43	0.6985
HOOKTYPE	1037	708.3045	0.6830	13.58		-354.1523	3.13	0.6793
TEMPERATURE+TIMESTART+YEAR+								
TEMP*YEAR	1043	692.7809	0.6642	15.96	1.53	-346.3905	19.53	0.0341
TEMP*TIMESTART	1052	704.4467	0.6696	15.28		-352.2233	7.86	0.0051
TEMP*AREA	1051	711.1068	0.6766	14.39		-355.5534	1.2	0.5489
TEMP*DEPTH	1052	712.0419	0.6768	14.36		-356.021	0.26	0.6071
TEMP*SEASON	1050	711.5569	0.6777	14.26		-355.7785	0.75	0.8615
TEMP*BAITTYPE	1047	710.0693	0.6782	14.19		-355.0347	2.24	0.8967
TEMP*HOOKTYPE	1037	707.7708	0.6825	13.65		-353.8854	3.67	0.5982
TEMPERATURE+TIMESTART+YEAR+TEMP*YEAR+								
YEAR*TIMESTART	1033	668.5132	0.6472	18.12	2.16	-334.2566	24.27	0.0069
YEAR*BAITTYPE	1000	632.1279	0.6321	20.02		-316.0639	Negative of Hessian not posit. def.	
YEAR*DEPTH	1032	675.1643	0.6542	17.22		-337.5821	17.62	0.0909
YEAR*SEASON	1024	671.5213	0.6558	17.03		-335.7607	Negative of Hessian not posit. def.	
YEAR*AREA	1023	680.4677	0.6652	15.84		-340.2339	12.31	0.9049
YEAR*HOOKTYPE	1022	682.9065	0.6682	15.46		-341.4532	Negative of Hessian not posit. def.	
TEMPERATURE+TIMESTART+YEAR+TEMP*YEAR+YEAR*TIMESTART+								
TIMESTART*AREA	1029	659.6137	0.6410	18.90	0.78	-329.8068	8.9	0.0637
YEAR*DEPTH	1022	656.4439	0.6423	18.73		-328.2219	12.07	0.3585
TIMESTART*DEPTH	1031	667.743	0.6477	18.05		-333.8715	0.77	0.6804
TIMESTART*BAITTYPE	1021	647.7089	0.6344	19.74		-323.8544	Negative of Hessian not posit. def.	
TIMESTART*SEASON	1027	663.4288	0.6460	18.27		-331.7144	Negative of Hessian not posit. def.	
TIMESTART*HOOKTYPE	1014	657.3765	0.6483	17.97		-328.6882	Negative of Hessian not posit. def.	
FINAL MIXED MODEL RESULTS								

Factors	Akaike's information criterion	Schwarz's Bayesian criterion	Significance (Pr>Chi square) of theType 3 test of fixed effects for each individual factor			
			-2 Res L	TEMPERATURE	TIMESTART	YEAR
TEMPERATURE+ TIMESTART+YEAR	5803.8	5808.8	5801.0	<0.0001	<0.0001	0.0022

Random effects and interactions			AIC	BIC	-2 Res L	Pr > Chi square	Fixed factors
*YEAR*TIMESTART*			5759.5	5761.7	5755.5	0.0000	all significant (year at 6% level)

Positive catches

Factors	d.f.	Deviance	Deviance/df	% Reduction in deviance/df	% Difference	L	Chi Square	Pr>Chi Square
NULL	1073	13170.8732	12.2748			15812.8868		
TEMPERATURE	916	10104.916	11.0316	10.13		13492.3086	133.24	<.0001
YEAR	1063	11996.0374	11.2851	8.06		16400.3047	1174.84	<.0001
AREA	1071	12295.0233	11.4799	6.48		16250.8117	875.85	<.0001
HOOKTYPE	1056	12428.47	11.7694	4.12		16047.3972	669.39	<.0001
BAITTYPE	1067	12728.2293	11.9290	2.82		16034.2087	442.64	<.0001
SEASON	1070	12871.2896	12.0292	2.00		15962.6786	299.58	<.0001
DEPTH	1072	12987.5425	12.1152	1.30		15904.5521	183.33	<.0001
TIMESTART	1072	13077.838	12.1995	0.61		15859.404	93.03	<.0001
TEMPERATURE+								
YEAR	906	9071.9881	10.0132	18.42	8.30	14008.7725	1032.93	<.0001
AREA	914	9350.0517	10.2298	16.66		13869.7407	754.86	<.0001
BAITTYPE	910	9759.5743	10.7248	12.63		13664.9795	345.34	<.0001
SEASON	913	9798.3685	10.7321	12.57		13645.5824	306.55	<.0001
HOOKTYPE	900	9745.215	10.8280	11.79		13535.4675	285.71	<.0001
DEPTH	915	9964.4177	10.8901	11.28		13562.5577	140.5	<.0001
TIMESTART	915	10082.11	11.0187	10.23		13503.71	22.81	<.0001
TEMPERATURE+YEAR+								
AREA	904	8578.1134	9.4891	22.69	4.27	14255.7099	493.87	<.0001
DEPTH	905	8693.7205	9.6063	21.74		14197.9064	378.27	<.0001
SEASON	903	8915.8959	9.8736	19.56		14086.818	156.09	<.0001
BAITTYPE	900	8979.65	9.9774	18.72		14054.9416	92.34	<.0001
TIMESTART	905	9047.275	9.9970	18.56		14021.128	24.71	<.0001
HOOKTYPE	890	8922.859	10.0257	18.32		13946.6455	72.95	<.0001
TEMPERATURE+YEAR+AREA+								
DEPTH	903	8253.4172	9.1400	25.54	2.84	14418.058	324.70	<.0001
SEASON	901	8461.9461	9.3917	23.49		14313.7935	116.17	<.0001
HOOKTYPE	888	8364.9099	9.4199	23.26		14225.6205	136.84	<.0001
BAITTYPE	898	8523.8651	9.4921	22.67		14282.8341	54.25	<.0001
TIMESTART	903	8572.1489	9.4930	22.66		14258.6921	5.96	0.0146
TEMPERATURE+YEAR+AREA+DEPTH+								
SEASON	900	8031.4293	8.9238	27.30	1.76	14529.0519	221.99	<.0001
HOOKTYPE	887	8073.1609	9.1016	25.85		14371.495	123.64	<.0001
BAITTYPE	897	8186.1621	9.1262	25.65		14451.6856	67.26	<.0001
TIMESTART	902	8250.3233	9.1467	25.48		14419.6049	3.09	0.0786
TEMPERATURE+YEAR+AREA+DEPTH+SEASON+								
HOOKTYPE	884	7782.4542	8.8037	28.28	0.98	14516.8483	194.36	<.0001
BAITTYPE	894	7995.8754	8.9439	27.14		14546.8289	35.55	<.0001
TIMSTART	899	8030.1125	8.9323	27.23		14529.7103	1.32	0.2512
TEMPERATURE+YEAR+AREA+DEPTH+SEASON+								
TEMP*YEAR	890	7673.6149	8.6220	29.76	1.48	14707.9591	357.81	<.0001
TEMP*AREA	899	7801.7296	8.6782	29.30		14643.9018	229.7	<.0001
TEMP*HOOKTYPE	884	7767.7246	8.7870	28.41		14524.2131	209.09	<.0001
TEMP*DEPTH	898	7965.768	8.8706	27.73		14561.8826	65.66	<.0001
TEMP*SEASON	897	7980.5402	8.8969	27.52		14554.4965	50.89	<.0001
TEMP*TIMESTART	899	8031.3954	8.9337	27.22		14529.0689	0.03	0.8539
TEMP*BAITTYPE	894	7991.9535	8.9395	27.17		14548.7899	39.48	<.0001
TEMPERATURE+YEAR+AREA+DEPTH+SEASON+TEMP*YEAR+								
YEAR*AREA	872	6991.095	8.0173	34.68	4.93	15049.2191	682.52	<.0001
YEAR*BAITTYPE	848	7011.81	8.2686	32.64		15038.8616	661.8	<.0001
YEAR*DEPTH	880	7297.137	8.2922	32.45		14896.198	410.2	<.0001

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YEAR*SEASON	874	7268.2427	8.3161	32.25		14910.6453	405.37	<.0001
YEAR*HOOKTYPE	869	7334.5054	8.4402	31.24		14740.8227	281.23	<.0001
YEAR*TIMESTART	879	7549.7519	8.5890	30.03		14769.8906	123.86	<.0001
TEMPERATURE+YEAR+AREA+DEPTH+SEASON+TEMP*YEAR+YEAR*AREA+								
AREA*DEPTH	870	6763.3553	7.7740	36.67	1.98	15163.089	227.74	<.0001
AREA*SEASON	867	6940.854	8.0056	34.78		15074.340	50.24	<.0001
AREA*TEMP	870	6976.3192	8.0188	34.67		15056.607	14.78	0.0006
AREA*HOOKTYPE	851	6617.5984	7.7763	36.65		15099.2762	263.04	<.0001
AREA*BAITTYPE	858	6840.944	7.9731	35.04		15124.2946	14.44	0.0007
AREA*TIMESTART	869	6936.2354	7.9819	34.97		15076.6489	54.86	<.0001
TEMPERATURE+YEAR+AREA+DEPTH+SEASON+TEMP*YEAR+YEAR*AREA+AREA*DEPTH+								
TEMP*HOOKTYPE	854	6325.4895	7.4069	39.66	2.99	15245.3307	313.45	<.0001
TEMP*DEPTH	869	6647.2841	7.6493	37.68		15221.1245	116.07	<.0001
TEMP*SEASON	867	6725.7436	7.7575	36.80		15181.8948	37.61	<.0001
TEMP*AREA	868	6749.7995	7.7763	36.65		15169.8669	13.56	0.0011
TEMP*TIMESTART	869	6763.1142	7.7826	36.60		15163.2095	0.24	0.6235
TEMP*BAITTYPE	864	6739.2801	7.8001	36.45		15175.1265	24.08	0.0005

FINAL MIXED MODEL RESULTS

Factors	Akaike's information criterion	Schwarz's Bayesian criterion	Significance (Pr>Chi square) of the Type 3 test of fixed effects for each individual factor				
			-2 Res L	TEMPERATURE	YEAR	AREA	DEPTH
TEMPERATURE+ YEAR+AREA+DEPTH+	2573.4	2578.2	2571.4	0.0011	<0.0001	<0.0001	<0.0001

Random effects and interactions			AIC	BIC	-2 Res L	Pr > Chi square	Fixed factors
TEMP*DEPTH			2568.4	2564.4	2564.4	0.0082	all significant

% Difference: percent difference in deviance/df between the newly included factor and the previous factor entered into the model;
L: log likelihood; Chi Square: Pearson Chi-square statistic; Pr>Chi Square: significance level of the Chi-square statistic

Table 4. Deviance analysis tables showing the stepwise procedure used to develop the catch rate model for the **sandbar shark** in the Commercial Shark Fishery Observer Program (CSFOP). Proportion positive assumed a binomial error distribution, whereas positive catch rates assumed a Poisson distribution.

CSFOP

Proportion positive

Factors	d.f.	Deviance	Deviance/df	% Reduction in deviance/df	% Difference	L	Chi Square	Pr>Chi Square
NULL	1248	1448.49	1.1607			-724.2466		
DEPTH	1247	1357.46	1.0886	6.21	6.21	-678.7322	91.03	<.0001
TIMESTART	1247	1361.02	1.0914	5.96	5.96	-680.5105	87.47	<.0001
AREA	1246	1378.60	1.1064	4.67		-689.3017	69.89	<.0001
BAITTYPE	1242	1384.44	1.1147	3.96		-692.2196	64.05	<.0001
YEAR	1238	1394.11	1.1261	2.98		-697.0566	54.38	<.0001
HOOKTYPE	1231	1392.53	1.1312	2.54		-696.2674	Negative of Hessian not posit. def.	
SEASON	1245	1436.81	1.1541	0.57		-718.41	11.68	0.0086
TEMPERATURE	1064	1237.18	1.1628	-0.18		-618.5923	4.69	0.0304
DEPTH+								
TIMESTART	1246	1271.6586	1.0206	12.07	5.86	-635.8293	85.81	<.0001
AREA	1245	1280.5926	1.0286	11.38		-640.2963	76.87	<.0001
BAITTYPE	1241	1289.0469	1.0387	10.51		-644.5234	68.42	<.0001
YEAR	1237	1317.6549	1.0652	8.22		-658.8275	39.81	<.0001
TEMPERATURE	1063	1146.847	1.0789	7.05		-573.4235	11.37	0.0007
SEASON	1244	1348.8347	1.0843	6.58		-674.4173	8.63	0.0346
DEPTH+TIMESTART+								
AREA	1244	1174.5457	0.9442	18.65	6.58	-587.2728	97.11	<.0001
TEMPERATURE	1062	1047.9917	0.9868	14.98		-523.9958	27.44	<.0001
BAITTYPE	1240	1228.9774	0.9911	14.61		-614.4887	42.68	<.0001
YEAR	1236	1238.8328	1.0023	13.64		-619.4164	32.83	0.0003
SEASON	1243	1254.5724	1.0093	13.04		-627.2862	17.09	0.0007
DEPTH+TIMESTART+AREA+								
TEMPERATURE	1060	967.5223	0.9128	21.36	2.71	-483.7611	4.26	0.039
YEAR	1234	1147.1047	0.9296	19.91		-573.5524	27.44	0.0022
BAITTYPE	1238	1151.4521	0.9301	19.86		-575.7261	23.09	0.0008
SEASON	1241	1164.732	0.9385	19.14		-582.366	9.81	0.0202
DEPTH+TIMESTART+AREA+TEMPERATURE+								
BAITTYPE	1054	943.8023	0.8954	22.85	1.49	-471.9012	23.72	0.0006
YEAR	1050	943.0445	0.8981	22.62		-471.5223	24.48	0.0064
SEASON	1057	965.3054	0.9133	21.32		-482.6527	2.22	0.5286
DEPTH+TIMESTART+AREA+TEMPERATURE+BAITTYPE+								
YEAR	1044	911.8135	0.8734	24.75	1.90	-455.9068	31.99	0.0004
SEASON	1051	941.7817	0.8961	22.79		-470.8909	2.02	0.5681
DEPTH+TIMESTART+AREA+TEMPERATURE+BAITTYPE+YEAR+								
DEPTH*TEMPERATURE	1043	867.4163	0.8317	28.35	3.60	-433.7081	44.4	<.0001
DEPTH*YEAR	1034	864.652	0.8362	27.95		-432.326	47.16	<.0001
DEPTH*BAITTYPE	1038	889.7869	0.8572	26.14		-444.8935	Negative of Hessian not posit. def.	
DEPTH*TIMESTART	1043	910.6266	0.8731	24.78		-455.3133	1.19	0.2759
DEPTH*AREA	1042	911.5233	0.8748	24.63		-455.7616	0.29	0.8649
DEPTH+TIMESTART+AREA+TEMPERATURE+BAITTYPE+YEAR+DEPTH*TEMP								
DEPTH*YEAR	1033	821.3371	0.7951	31.50	3.15	-410.6686	46.08	<.0001
DEPTH+TIMESTART+AREA+TEMPERATURE+BAITTYPE+YEAR+DEPTH*TEMP+DEPTH*YEAR								
DEPTH*TEMP*YEAR	1023	806.2377	0.7881	32.10	0.60	-403.1188	15.1	0.1285

FINAL MIXED MODEL RESULTS

	Akaike's information	Schwarz's Bayesian		Significance (Pr>Chi square) of the Type 3 test of fixed effects for each individual factor

Factors	criterion	criterion	-2 Res L	DEPTH	TIMESTART	AREA	TEMP	BAITTYPE
DEPTH+TIMESTART+ AREA+TEMPERATURE+ BAITTYPE+YEAR+	5817.2	5822.1	5815.2	<.0001	<.0001	<.0001	0.0444	0.0123
					YEAR			
					0.0163			

Random interactions			AIC	BIC	-2 Res L	Pr > Chi square	Fixed factors	

Positive catches

Factors	d.f.	Deviance	Deviance/df	% Reduction in deviance/df	% Difference	L	Chi Square	Pr>Chi Square
NULL	899	26911.976	29.935			48314.799		
AREA	897	23591.880	26.301	12.14	12.14	49974.8473	3320.10	<.0001
YEAR	889	24001.662	26.9985	9.81		49769.9561	2910.3	<.0001
BAITTYPE	893	25439.071	28.4872	4.84		49051.2519	1472.91	<.0001
SEASON	896	26128.613	29.1614	2.59		48706.4809	783.36	<.0001
HOOKTYPE	894	26313.664	29.4336	1.68		48613.9551	598.31	<.0001
TIMESTART	898	26615.733	29.6389	0.99		48462.921	296.24	<.0001
DEPTH	898	26767.392	29.8078	0.43		26767.3921	144.50	<.0001
TEMPERATURE	762	22969.909	30.1442	-0.70		46812.424	1987.39	<.0001
AREA+								
YEAR	887	21434.4728	24.1651	19.28	7.13	51053.5509	2157.41	<.0001
DEPTH	896	22462.756	25.0700	16.25		50539.4095	1129.12	<.0001
HOOKTYPE	892	22520.668	25.2474	15.66		50510.4534	1071.21	<.0001
BAITTYPE	891	22934.432	25.7401	14.01		50303.5713	657.45	<.0001
SEASON	894	23063.409	25.7980	13.82		50239.083	528.47	<.0001
TIMESTART	896	23588.013	26.3259	12.06		49976.7806	3.87	0.0493
TEMPERATURE	760	21157.125	27.8383	7.01		47718.82	545.54	<.0001
AREA+YEAR+								
DEPTH	886	20615.741	23.2683	22.27	3.00	51462.9166	818.73	<.0001
HOOKTYPE	882	20587.479	23.3418	22.03		51477.0476	846.99	<.0001
SEASON	884	20830.931	23.5644	21.28		51355.3217	603.54	<.0001
BAITTYPE	881	20888.356	23.7098	20.80		51326.6094	546.12	<.0001
TIMESTART	886	21412.412	24.1675	19.27		51064.5814	22.06	<.0001
TEMPERATURE	750	18968.890	25.2919	15.51		48812.9335	478.83	<.0001
AREA+YEAR+DEPTH+								
HOOKTYPE	881	19900.1322	22.5881	24.54	2.27	51820.7212	715.61	<.0001
SEASON	883	19971.443	22.6177	24.45		51785.0656	644.30	<.0001
BAITTYPE	880	20217.4633	22.9744	23.25		51662.0556	398.28	<.0001
TIMESTART	885	20596.5193	23.2729	22.26		51472.5276	19.22	<.0001
TEMPERATURE	749	17774.2757	23.7307	20.73		49410.2408	674.30	<.0001
AREA+YEAR+DEPTH+HOOKTYPE+								
SEASON	878	19270.0916	21.9477	26.68	2.24	52135.7415	630.04	<.0001
BAITTYPE	875	19563.925	22.3588	25.31		51988.8247	336.21	<.0001
TIMESTART	880	19893.645	22.6064	24.48		51823.9649	6.49	0.0109
TEMPERATURE	744	17301.435	23.2546	22.32		49646.661	546.79	<.0001
AREA+YEAR+DEPTH+HOOKTYPE+SEASON+								
BAITTYPE	872	18990.770	21.7784	27.25	0.57	52275.4021	279.32	<.0001
TIIMESTART	877	19265.134	21.9671	26.62		52138.2203	4.96	0.0260
TEMPERATURE	741	16855.256	22.7466	24.01		49869.7508	125.6	<.0001
AREA+YEAR+DEPTH+HOOKTYPE+SEASON+								
YEAR*SEASON	864	16938.612	19.6049	34.51	7.83	53301.4811	2331.48	<.0001
AREA*YEAR	860	17009.176	19.7781	33.93		53266.1993	2260.92	<.0001
SEASON*HOOKTYPE	871	17309.500	19.8731	33.61		53116.0372	1960.59	<.0001
AREA*HOOKTYPE	871	18216.790	20.9148	30.13		52662.3925	1053.30	<.0001
AREA*SEASON	874	18349.122	20.9944	29.87		52596.226	920.97	<.0001
YEAR*DEPTH	868	18401.287	21.1996	29.18		52570.1438	868.80	<.0001
DEPTH*HOOKTYPE	873	18642.991	21.3551	28.66		52449.2916	627.10	<.0001
YEAR*HOOKTYPE	869	18588.167	21.3903	28.55		52476.7039	681.92	<.0001
AREA*DEPTH	876	19052.109	21.7490	27.35		52244.7327	217.98	<.0001
AREA+YEAR+DEPTH+HOOKTYPE+SEASON+YEAR*SEASON								
AREA*YEAR	846	15479.143	18.2969	38.88	4.37	54031.2159	1459.47	<.0001
AREA*HOOKTYPE	857	16018.404	18.6913	37.56		53761.5853	920.21	<.0001

AREA*SEASON	860	16223.380	18.8644	36.98		53659.0972	715.23	<.0001
YEAR*DEPTH	854	16301.561	19.0885	36.23		53620.007	637.05	<.0001
SEASON*HOOKTYPE	858	16739.311	19.5097	34.83		53401.1319	199.30	<.0001
DEPTH*HOOKTYPE	859	16728.021	19.4738	34.95		53406.7768	210.59	<.0001
YEAR*HOOKTYPE	855	16651.119	19.4750	34.94		53445.2278	287.49	<.0001
AREA*DEPTH	862	16798.705	19.4881	34.90		53371.4345	2253.4	<.0001
AREA+YEAR+DEPTH+HOOKTYPE+SEASON+YEAR*SEASON+AREA*YEAR+								
AREA*SEASON	842	15020.8081	17.8394	40.41	1.53	54260.3832	458.33	<.0001
YEAR*DEPTH	836	15000.3892	17.9430	40.06		54270.5926	478.75	<.0001
AREA*DEPTH	844	15181.3974	17.9874	39.91		54180.0886	297.75	<.0001
AREA*HOOKTYPE	839	15150.5745	18.0579	39.68		54195.5	328.57	<.0001
YEAR*HOOKTYPE	837	15244.401	18.2131	39.16		54148.5867	234.74	<.0001
DEPTH*HOOKTYPE	841	15316.0576	18.2117	39.16		54112.7584	163.09	<.0001
SEASON*HOOKTYPE	840	15349.661	18.2734	38.96		54095.9568	129.48	<.0001
AREA+YEAR+DEPTH+HOOKTYPE+SEASON+YEAR*SEASON+AREA*YEAR+AREA*SEASON+								
AREA*DEPTH	840	14643.984	17.4333	41.76	1.36	54448.7952	376.82	<.0001
YEAR*DEPTH	832	14525.25	17.4582	41.68		54508.1623	495.56	<.0001
AREA*HOOKTYPE	835	14701.2457	17.6063	41.19		54420.1644	319.56	<.0001
YEAR*HOOKTYPE	833	14756.0831	17.7144	40.82		54392.7457	264.72	<.0001
DEPTH*HOOKTYPE	837	14884.4469	17.7831	40.60		54328.5638	431.61	<.0001
SEASON*HOOKTYPE	836	14890.1909	17.8112	40.50		54325.6918	130.62	<.0001
AREA+YEAR+DEPTH+HOOKTYPE+SEASON+YEAR*SEASON+AREA*YEAR+AREA*SEASON+AREA*DEPTH								
YEAR*DEPTH	830	14255.6601	17.1755	42.62	0.86	54642.9572	388.32	<.0001

FINAL MIXED MODEL RESULTS

Factors	Akaike's information criterion	Schwarz's Bayesian criterion	Significance (Pr>Chi square) of theType 3 test of fixed effects for each individual factor				
			-2 Res L	AREA	YEAR	DEPTH	HOOKTYPE	SEASON
AREA+YEAR+	2267.5	2272.3	2265.5	<.0001	0.0157			

Random effects and interactions			AIC	BIC	-2 Res L	Pr > Chi square	Fixed factors
SEASON			2253.6	2252.3	2249.6	0.0001	all significant
*SEASON+AREA*DEPTH*			2243.9	2242.1	2237.9	0.0006	all significant
*SEASON+AREA*DEPTH+AREA*HOOKTYPE*			2214.4	2211.9	2206.4	0.0000	all significant (year at 6% level)

% Difference: percent difference in deviance/df between the newly included factor and the previous factor entered into the model;
L: log likelihood; Chi Square: Pearson Chi-square statistic; Pr>Chi Square: significance level of the Chi-square statistic

Table 5. Deviance analysis tables showing the stepwise procedure used to develop the catch rate model for the **blacktip shark** in the Commercial Shark Fishery Observer Program (CSFOP). Proportion positive assumed a binomial error distribution, whereas positive catch rates assumed a Poisson distribution.

CSFOP

Proportion positive

Factors	d.f.	Deviance	Deviance/df	% Reduction in deviance/df	% Difference	L	Chi Square	Pr>Chi Square
NULL	1248	1720.51	1.3786			-860.25		
AREA	1246	1593.31	1.2787	7.25	7.25	-796.65	127.20	<0.0001
YEAR	1238	1588.69	1.2833	6.91		-794.34	131.82	<0.0001
SEASON	1245	1624.09	1.3045	5.38		-812.05	96.41	<0.0001
DEPTH	1247	1632.46	1.3091	5.04		-816.231	88.04	<0.0001
TEMPERATURE	1064	1398.54	1.3144	4.66		-699.27	53.30	<0.0001
TIMESTART	1247	1666.95	1.3368	3.03		-833.48	53.55	<0.0001
BAITTYPE	1242	1675.45	1.349	2.15		-837.73	45.06	<0.0001
HOOKTYPE	1231	1678.87	1.3638	1.07		-839.44	28.27	<0.0001
AREA+								
DEPTH	1245	1457.62	1.1708	15.07	7.83	-728.81	135.69	<0.0001
YEAR	1236	1475.15	1.1935	13.43		-737.58	118.16	<0.0001
SEASON	1243	1499.23	1.2061	12.51		-749.61	94.08	<0.0001
TEMPERATURE	1062	1323.72	1.2464	9.59		-661.86	21.50	<0.0001
TIMESTART	1245	1555.79	1.2496	9.36		-777.90	37.51	<0.0001
AREA+DEPTH+								
YEAR	1235	1348.73	1.0921	20.78	5.71	-674.36	108.89	<0.0001
SEASON	1242	1392.24	1.1210	18.69		-696.12	65.38	<0.0001
TIMESTART	1244	1416.14	1.1384	17.42		-708.07	41.48	<0.0001
TEMPERATURE	1061	1214.97	1.1451	16.94		-607.48	31.47	<0.0001
AREA+DEPTH+YEAR+								
TIMESTART	1234	1309.07	1.0608	23.05	2.27	-654.53	39.66	<0.0001
SEASON	1232	1309.87	1.0632	22.88		-654.94	38.36	<0.0001
TEMPERATURE	1051	1141.75	1.0864	21.20		-570.88	15.09	0.0001
AREA+DEPTH+YEAR+TIMESTART+								
SEASON	1231	1272.42	1.0336	25.03	1.97	-636.21	36.65	<0.0001
AREA+DEPTH+YEAR+TIMESTART+SEASON+								
TEMPERATURE	1047	1082.88	1.0343	24.97	-0.05	-541.44	0.14	0.7067
AREA*YEAR	1213	1187.78	0.9792	28.97		-593.89	84.64	<0.0001
AREA*SEASON	1226	1258.30	1.0263	25.55		-629.15	14.12	0.0148
YEAR*SEASON	1215	1235.25	1.0160	26.30		Negative of Hessian not positive definite		
AREA+DEPTH+YEAR+TIMESTART+SEASON+AREA*YEAR								
AREA*SEASON	1208	1174.78	0.9725	29.46	4.48	Negative of Hessian not positive definite		
AREA+DEPTH+YEAR+TIMESTART+SEASON+AREA*YEAR								
AREA*YEAR*SEASON	1171	1096.71	0.9366	32.06	2.60	Negative of Hessian not positive definite		

FINAL MODEL RESULTS

Factors	Akaike's information criterion	Schwarz's Bayesian criterion	-2 Res L	Significance (Pr>Chi square) of theType 3 test of fixed effects for each individual factor				
				AREA	DEPTH	YEAR	TIMESTART	SEASON
AREA+DEPTH+YEAR+ TIMESTART+SEASON+	5933.6	5938.7	5931.6	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

Positive catches

Factors	d.f.	Deviance	Deviance/df	% Reduction in deviance/df	% Difference	L	Chi Square	Pr>Chi Square
NULL	565	12085.49	21.3902			7385.80		
YEAR	555	10976.82	19.7781	7.54	7.54	7940.13	1108.67	<0.0001
TIMESTART	564	11568.75	20.5120	4.11		7644.167	516.74	<0.0001
AREA	563	11673.71	20.7340	3.07		7591.69	411.78	<0.0001
SEASON	562	11863.05	21.1086	1.32		7497.02	222.44	<0.0001
BAITTYPE	559	11846.20	21.1918	0.93		7505.44	239.29	<0.0001
DEPTH	564	12005.40	21.2862	0.49		7425.84	80.09	<0.0001
HOOKTYPE	559	11989.95	21.4489	-0.27		7433.57	95.54	<0.0001
TEMPERATURE	448	9850.30	21.9873	-2.79		6259.05	604.74	<0.0001
YEAR+								
TIMESTART	554	10533.71	19.0139	11.11	3.57	8161.69	443.11	<0.0001
DEPTH	554	10613.01	19.1571	10.44		8122.04	363.81	<0.0001
AREA	553	10675.77	19.3052	9.75		8090.66	301.06	<0.0001
SEASON	552	10906.75	19.7586	7.63		7975.17	70.07	<0.0001
BAITTYPE	549	10891.90	19.8395	7.25		7982.59	84.92	<0.0001
YEAR+TIMESTART+								
DEPTH	553	10072.62	18.2145	14.85	3.74	8392.23	461.10	<0.0001
AREA	552	10183.38	18.4481	13.75		8336.85	350.34	<0.0001
SEASON	551	10453.09	18.9711	11.31		8202.00	80.62	<0.0001
YEAR+TIMESTART+DEPTH+								
AREA	551	9523.29	17.2837	19.20	4.35	8666.90	549.32	<0.0001
SEASON	550	9934.39	18.0625	15.56		8461.35	138.23	<0.0001
YEAR+TIMESTART+DEPTH+AREA+								
SEASON	548	9396.11	17.1462	19.84	0.64	8730.49	127.18	<0.0001
AREA*YEAR	534	8242.75	15.4359	27.84		9307.17	1280.54	<0.0001
YEAR*SEASON	534	8457.17	15.8374	25.96		9199.96	1066.12	<0.0001
AREA*SEASON	544	8938.55	16.43	23.18		8959.27	584.75	<0.0001
YEAR+TIMESTART+DEPTH+AREA+AREA*YEAR								
YEAR*SEASON	517	7393.87	14.3015	33.14	5.30	9731.61	848.88	<0.0001
AREA*SEASON	527	7993.98	15.1688	29.09		9431.55	248.77	<0.0001
YEAR+TIMESTART+DEPTH+AREA+AREA*YEAR+YEAR*SEASON								
AREA*SEASON	513	7210.20	14.0550	34.29	1.15	9823.45	183.68	<0.0001

FINAL MODEL RESULTS

Factors	Akaike's information criterion	Schwarz's Bayesian criterion	-2 Res L	Significance (Pr>Chi square) of theType 3 test of fixed effects for each individual factor			
				YEAR	TIMESTART	DEPTH	AREA
YEAR+TIMESTART+ DEPTH+AREA+	1203.3	1207.6	1201.3	<0.0001	<0.0001	<0.0001	<0.0001

% Difference: percent difference in deviance/df between the newly included factor and the previous factor entered into the model;
L: log likelihood; Chi Square: Pearson Chi-square statistic; Pr>Chi Square: significance level of the Chi-square statistic

Table 6. Deviance analysis tables showing the stepwise procedure used to develop the catch rate model for the **blacktip shark in the Gulf of Mexico** in the Commercial Shark Fishery Observer Program (CSFOP). Proportion positive assumed a binomial error distribution, whereas positive catch rates assumed a Poisson distribution.

CSFOP

Proportion positive

Factors	d.f.	Deviance	Deviance/df	% Reduction in deviance/df	% Difference	L	Chi Square	Pr>Chi Square
NULL	468	629.96	1.3461			-314.98		
YEAR	459	524.72	1.1432	15.07	15.07	-262.36	105.25	<0.0001
DEPTH	467	562.78	1.2051	10.47		-281.39	67.18	<0.0001
SEASON	466	594.15	1.2750	5.28		-297.08	35.81	<0.0001
HOOKTYPE	462	616.86	1.3352	0.81		-308.43	13.10	0.0414
BAITTYPE	463	618.42	1.3357	0.77		-309.21	11.55	0.0416
TIMESTART	467	629.31	1.3476	-0.11		-314.66	0.65	0.4185
TEMPERATURE	375	509.96	1.3599	-1.03		-254.979	6.8	<0.0091
YEAR+								
DEPTH	458	474.64	1.0363	23.01	7.94	-237.32	50.08	<0.0001
SEASON	457	510.4113	1.1169	17.03		-255.21	14.31	0.0008
HOOKTYPE	453	514.54	1.1358	15.62		-257.27	10.18	0.1172
BAITTYPE	454	520.30	1.1460	14.87		-260.15	4.42	0.4906
YEAR+DEPTH+								
SEASON	456	462.47	1.0142	24.66	1.64	-231.23	12.17	0.0023
BAITTYPE	453	466.27	1.0293	23.53		-233.14	8.37	0.1370
HOOKTYPE	452	466.70	1.0325	23.30		-233.35	7.95	0.2421
YEAR+DEPTH+SEASON+								
BAITTYPE	451	454.19	1.0071	25.18	0.53	-227.09	8.28	0.1415
HOOKTYPE	450	456.16	1.0137	24.69		-228.08	6.31	0.3898
TIMESTART	455	462.21	1.0159	24.53		-231.11	0.25	0.6144
YEAR+DEPTH+SEASON+								
YEAR*DEPTH	447	443.98	0.9932	26.22	1.56	-221.99	18.49	0.0299
YEAR*SEASON	443	433.36	0.9782	27.33		Negative of Hessian not positive definite		
DEPTH*SEASON	454	457.18	1.0070	25.19		-228.59	5.29	0.0710

FINAL MIXED MODEL RESULTS

Factors	Akaike's information criterion	Schwarz's Bayesian criterion	-2 Res L	Significance (Pr>Chi square) of the Type 3 test of fixed effects for each individual factor		
				YEAR	DEPTH	SEASON
YEAR+DEPTH+SEASON+	2261.7	2265.8	2259.7	<0.0001	<0.0001	0.0077

Random interactions			AIC	BIC	-2 Res L	Pr > Chi square	Fixed factors
*YEAR*SEASON*			2251.3	2253.7	2247.3	0.0004	all significant

Positive catches

Factors	d.f.	Deviance	Deviance/df	% Reduction in deviance/df	% Difference	L	Chi Square	Pr>Chi Square
NULL	282	8210.45	29.1151			5935.15		
YEAR	273	6839.98	25.0549	13.95	13.95	6620.39	1370.47	<0.0001
TIMESTART	281	7677.48	27.3220	6.16		6201.64	532.97	<0.0001
SEASON	280	7831.79	27.9707	3.93		6124.4805	378.66	<0.0001
HOOKTYPE	276	7967.73	28.8686	0.85		6056.51	242.72	<0.0001
BAITTYPE	277	8017.43	28.9438	0.59		6031.66	193.02	<0.0001
DEPTH	281	8152.89	29.0138	0.35		5963.93	57.56	<0.0001
TEMPERATURE	210	6865.70	32.6938	-12.29		5152.27	435.53	<0.0001
YEAR+								
DEPTH	272	6387.96	23.4851	19.34	5.39	6846.40	452.02	<0.0001
TIMESTART	272	6610.96	24.3050	16.52		6734.89	229.01	<0.0001
HOOKTYPE	267	6639.84	24.8683	14.59		6720.46	200.14	<0.0001
SEASON	271	6756.24	24.9308	14.37		6662.26	83.74	<0.0001

BAITTYPE	268	6704.95	25.0185	14.07		6687.90	135.03	<0.0001
TEMPERATURE	201	5725.05	28.4829	2.17		5722.60	126.36	<0.0001
YEAR+DEPTH+								
TIMESTART	271	6023.93	22.2285	23.65	4.32	7028.41	364.03	<0.0001
HOOKTYPE	266	6142.88	23.0935	20.68		6968.94	245.08	<0.0001
SEASON	270	6240.98	23.1148	20.61		6919.89	146.97	<0.0001
BAITTYPE	267	6231.16	23.337	19.85		6924.80	156.80	<0.0001
TEMPERATURE	200	4931.98	24.660	15.30		6119.13	305.07	<0.0001
YEAR+DEPTH+TIMESTART+								
HOOKTYPE	265	5701.09	21.5135	26.11	2.46	7189.83	322.84	<0.0001
BAITTYPE	266	5814.87	21.8604	24.92		7132.94	209.05	<0.0001
SEASON	269	5885.33	21.8785	24.86		7097.71	138.60	<0.0001
TEMP	199	4633.57	23.2842	20.03		6268.34	299.07	<0.0001
YEAR+DEPTH+TIMESTART+HOOKTYPE+								
BAITTYPE	260	5557.32	21.3743	26.59	0.48	7261.72	143.76	<0.0001
SEASON	263	5625.01	21.3879	26.54		7227.87	76.08	<0.0001
TEMP	196	4355.97	22.2243	23.67		6407.14	155.53	<0.0001
YEAR+DEPTH+TIMESTART+HOOKTYPE+								
YEAR*DEPTH	257	5325.61	20.7222	28.83	2.72	7377.57	375.47	<0.0001
YEAR*HOOKTYPE	261	5629.86	21.5704	25.91		7225.45	71.22	<0.0001
YEAR*TIMESTART	260	5635.71	21.6758	25.55		7222.52	65.38	<0.0001
YEAR+DEPTH+TIMESTART+HOOKTYPE+YEAR*DEPTH								
YEAR*HOOKTYPE	253	5257.50	20.7806	28.63	-0.20	7411.63	68.11	<0.0001
YEAR*TIMESTART	252	5276.74	20.9394	28.08		7402.01	48.87	<0.0001

FINAL MIXED MODEL RESULTS

Factors	Akaike's information criterion	Schwarz's Bayesian criterion	-2 Res L	Significance (Pr>Chi square) of theType 3 test of fixed effects for each individual factor			
				YEAR	DEPTH	TIMESTART	HOOKTYPE
YEAR+DEPTH+ TIMESTART+HOOKTYPE+	497.1	500.7	495.1	<0.0001	<0.0001	<0.0001	<0.0001

Random interactions			AIC	BIC	-2 Res L	Pr > Chi square	Fixed factors
*YEAR*DEPTH*			495	495.6	491	0.0429	all significant

% Difference: percent difference in deviance/df between the newly included factor and the previous factor entered into the model;
L: log likelihood; Chi Square: Pearson Chi-square statistic; Pr>Chi Square: significance level of the Chi-square statistic

Table 7. Deviance analysis tables showing the stepwise procedure used to develop the catch rate model for the **blacktip shark in the Atlantic** in the Commercial Shark Fishery Observer Program (CSFOP). Proportion positive assumed a binomial error distribution, whereas positive catch rates assumed a Poisson distribution.

CSFOP

Proportion positive

Factors	d.f.	Deviance	Deviance/df	% Reduction in deviance/df	% Difference	L	Chi Square	Pr>Chi Square
NULL	1237	1707.15	1.3801			-853.57		
YEAR	1227	1569.57	1.2792	7.31	7.31	-784.79	137.57	<0.0001
SEASON	1234	1605.67	1.3012	5.72		802.84	101.47	<0.0001
DEPTH	1236	1619.24	1.3103	5.06		-809.62	87.91	<0.0001
TEMPERATURE	1053	1382.5218	1.3129	4.87		-691.26	57.16	<0.0001
TIMESTART	1236	1654.02	1.3382	3.04		-827.01	53.12	<0.0001
BAITTYPE	1231	1658.61	1.3474	2.37		-829.30	48.54	<0.0001
HOOKTYPE	1231	1678.87	1.3638	1.18		-839.44	28.27	<0.0001
YEAR+								
DEPTH	1226	1470.91	1.1998	13.06	5.75	-735.45	98.67	<0.0001
SEASON	1224	1511.16	1.2346	10.54		-755.58	58.41	<0.0001
TEMPERATURE	1043	1289.45	1.2363	10.42		-644.72	35.70	<0.0001
BAITTYPE	1221	1510.04	1.2367	10.39		-755.02	59.53	<0.0001
TIMESTART	1226	1523.67	1.2428	9.95		-761.84	45.90	<0.0001
HOOKTYPE	1221	1551.95	1.2711	7.90		-775.98	17.62	0.0073
YEAR+DEPTH+								
TIMESTART	1225	1414.64	1.1548	16.32	3.26	-683.48	56.26	<0.0001
BAITTYPE	1220	1415.95	1.1606	15.90		-707.98	54.96	<0.0001
TEMPERATURE	1042	1211.71	1.1629	15.74		-605.86	50.44	<0.0001
SEASON	1223	1425.58	1.1656	15.54		-712.79	45.32	<0.0001
HOOKTYPE	1220	1453.00	1.1910	13.70		-233.35	17.91	0.0065
YEAR+DEPTH+TIMESTART+								
SEASON	1222	1377.24	1.1270	18.34	2.01	-688.62	37.40	<0.0001
TEMPERATURE	1041	1178.84	1.1324	17.95		-589.42	39.75	<0.0001
HOOKTYPE	1219	1397.56	1.1465	16.93		-698.78	17.08	0.009
BAITTYPE	1219	1366.95	1.2114	12.22		-227.09	47.69	<0.0001
YEAR+DEPTH+TIMESTART+SEASON+								
BAITTYPE	1216	1334.61	1.10	20.48	2.14	-667.31	42.63	<0.0001
TEMPERATURE	1038	1157.88	1.1155	19.17		-578.94	18.14	<0.0001
HOOKTYPE	1216	1359.47	1.1180	18.99		-679.74	17.77	0.0068
YEAR+DEPTH+TIMESTART+SEASON+BAITTYPE+								
TEMPERATURE	1032	1123.57	1.0887	21.11	0.64	-561.79	10.39	0.0013
HOOKTYPE	1210	1318.14	1.0894	21.06		-659.07	16.48	0.0114
YEAR+DEPTH+TIMESTART+SEASON+BAITTYPE+								
YEAR*TEMPERATURE	1022	1073.18	1.0501	23.91	3.43	-536.59	60.79	<0.0001
YEAR*BAITTYPE	1177	1257.31	1.0682	22.60		Negative of Hessian not positive definite		
YEAR*SEASON	1200	1286.45	1.0720	22.32		Negative of Hessian not positive definite		
YEAR*TIMESTART	1206	1296.05	1.0747	22.13		-648.03	38.56	<0.0001
YEAR*DEPTH	1206	1309.49	1.0858	21.32		-654.7427	25.13	0.0051
YEAR+DEPTH+TIMESTART+SEASON+BAITTYPE+YEAR*TEMPERATURE								
YEAR*TIMESTART	1022	1073.18	1.0501	23.91	0.00	-536.59	60.79	<0.0001
YEAR*DEPTH	1206	1309.49	1.0858	21.32		-654.74	25.13	0.0051

FINAL MIXED MODEL RESULTS

Factors	Akaike's information criterion	Schwarz's Bayesian criterion	-2 Res L	Significance (Pr>Chi square) of theType 3 test of fixed effects for each individual factor				
				YEAR	DEPTH	TIMESTART	SEASON	BAITTYPE
YEAR+DEPTH+TIMESTART+SEASON+BAITTYPE	5766.4	5771.5	5764.4	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

Random interactions			AIC	BIC	-2 Res L	Pr > Chi square	Fixed factors

| YEAR*TEMPERATURE | | 5054.8 | 5055.6 | 5050.8 | 0.0000 | all significant |
| YEAR*TEMPERATURE+DEPTH*TIMESTART | | 5042.4 | 5043.6 | 5036.4 | 0.0001 | all significant |

Positive catches

Factors	d.f.	Deviance	Deviance/df	% Reduction in deviance/df	% Difference	L	Chi Square	Pr>Chi Square
NULL	565	12085.49	21.3902			5935.15		
TIMESTART	564	11568.75	20.5120	4.11	4.11	7644.17	516.74	<0.0001
SEASON	562	11863.05	21.1100	1.31		7497.02	222.44	<0.0001
BAITTYPE	559	11846.20	21.1918	0.93		7505.44	239.29	<0.0001
DEPTH	564	12005.40	21.2862	0.49		7425.84	80.09	<0.0001
HOOKTYPE	559	11989.95	21.4500	-0.28		7433.57	95.54	<0.0001
TEMPERATURE	448	9850.30	21.9873	-2.79		6259.05	604.74	<0.0001
YEAR	555	10976.82	25.0549	-17.13		7940.13	1108.67	<0.0001
TIMESTART+								
YEAR	554	10533.71	19.0139	11.11	7.00	8161.69	1035.04	<0.0001
SEASON	561	11355.61	20.2417	5.37		7750.74	213.14	<0.0001
DEPTH	563	11423.52	20.2904	5.14		7716.78	145.23	<0.0001
BAITTYPE	558	11371.23	20.3786	4.73		7742.93	197.52	<0.0001
HOOKTYPE	558	11512.49	20.6317	3.55		7672.30	56.26	<0.0001
TEMPERATURE	447	9374.22	20.9714	1.96		6497.09	558.52	<0.0001
TIMESTART+YEAR+								
DEPTH	553	10072.62	18.2145	14.85	3.74	8392.23	461.10	<0.0001
SEASON	551	10453.09	18.97	11.31		8202.00	80.62	<0.0001
HOOKTYPE	548	10416.53	19.01	11.14		8220.28	117.18	<0.0001
BAITTYPE	548	10426.42	19.03	11.05		8215.33	107.29	<0.0001
TEMPERATURE	437	8637.4183	19.77	7.60		6865.49	289.43	<0.0001
TIMESTART+YEAR+DEPTH+								
SEASON	550	9934.39	18.06	15.56	0.71	8461.35	138.23	<0.0001
HOOKTYPE	547	9887.34	18.08	15.50		8484.87	185.27	<0.0001
TEMPERATURE	436	7913.11	18.15	15.15		7227.65	550.91	<0.0001
BAITTYPE	547	10011.98	18.30	14.43		8422.55	60.64	<0.0001
TIMESTART+YEAR+DEPTH+								
YEAR*DEPTH	543	9390.71	17.29	19.15	4.30	8733.19	681.90	<0.0001
TIMESTART*DEPTH	552	9922.14	17.97	15.97		8467.47	150.47	<0.0001
TIMESTART*YEAR	545	10002.07	18.35	14.20		8427.51	70.55	<0.0001
TIMESTART+YEAR+DEPTH+YEAR*DEPTH								
TIMESTART*DEPTH	542	9286.27	17.13	19.90	0.75	8785.41	104.45	<0.0001
TIMESTART*YEAR	535	9319.32	17.42	18.56		8768.88	71.39	<0.0001

FINAL MIXED MODEL RESULTS

Factors	Akaike's information criterion	Schwarz's Bayesian criterion	-2 Res L	Significance (Pr>Chi square) of theType 3 test of fixed effects for each individual factor		
				TIMESTART	YEAR	DEPTH
TIMESTART+YEAR+ DEPTH	1236.5	1240.8	1234.5	<0.0001	<0.0001	<0.0001

Random interactions			AIC	BIC	-2 Res L	Pr > Chi square	Fixed factors
YEAR*DEPTH			1237.6	1238.4	1233.6	0.3428	all significant

% Difference: percent difference in deviance/df between the newly included factor and the previous factor entered into the model;
L: log likelihood; Chi Square: Pearson Chi-square statistic; Pr>Chi Square: significance level of the Chi-square statistic

Table 8. Nominal and standardized relative CPUE indices (sharks per 100 hooks per hour) for the LCS complex (22 species), LCS excluding prohibited species (11 species), LCS excluding prohibited species or blacktip or sandbar sharks (9 species); sandbar sharks; and blacktip sharks from the Gulf of Mexico and Atlantic areas combined, Gulf of Mexico only, and Atlantic only from the Commercial Shark Fishery Observer Program (CSFOP).

LCS complex (22 species)

Year	Nominal	Standardized	LCL	UCL	CV
1994	0.580	0.669	0.230	1.109	0.335
1995	0.811	0.901	0.514	1.289	0.219
1996	0.787	0.907	0.654	1.161	0.143
1997	0.733	0.894	0.391	1.397	0.287
1998	1.150	1.134	0.739	1.529	0.178
1999	1.065	1.084	0.488	1.680	0.280
2000	1.102	1.027	0.296	1.757	0.363
2001	1.029	0.929	0.384	1.474	0.299
2002	1.313	1.269	0.610	1.929	0.265
2003	1.180	1.214	0.766	1.662	0.188
2004	1.250	0.971	0.614	1.328	0.187

LCS complex excluding prohibited species (11 species)

Year	Nominal	Standardized	LCL	UCL	CV
1994	0.583	0.676	0.361	0.991	0.238
1995	0.790	0.972	0.644	1.299	0.172
1996	0.777	0.907	0.636	1.179	0.153
1997	0.716	0.774	0.327	1.221	0.295
1998	1.133	1.113	0.737	1.489	0.172
1999	1.015	1.108	0.558	1.658	0.253
2000	1.119	1.168	0.405	1.932	0.333
2001	1.039	0.926	0.487	1.366	0.242
2002	1.348	1.187	0.814	1.560	0.160
2003	1.203	1.206	0.897	1.515	0.131
2004	1.276	0.962	0.679	1.246	0.150

LCS complex excluding prohibited species, sandbar, or blacktip (9 species)

Year	Nominal	Standardized	LCL	UCL	CV
1994	0.387	0.614	0.255	0.973	0.298
1995	0.585	0.756	0.344	1.167	0.278
1996	0.573	0.810	0.364	1.255	0.281
1997	0.720	0.903	0.388	1.418	0.291
1998	1.133	1.298	0.645	1.950	0.257
1999	1.285	1.067	0.468	1.665	0.286
2000	1.497	1.056	0.409	1.704	0.313
2001	0.766	0.983	0.448	1.517	0.278
2002	1.592	1.478	0.673	2.283	0.278
2003	1.289	0.959	0.430	1.487	0.281
2004	1.173	1.078	0.502	1.654	0.273

Sandbar shark

Year	Nominal	Standardized	LCL	UCL	CV
1994	0.799	0.961	-0.974	2.897	1.027
1995	0.882	1.132	-0.713	2.977	0.832
1996	1.000	1.065	-0.695	2.825	0.843
1997	0.956	1.055	-1.390	3.500	1.182
1998	1.292	0.903	-1.560	3.366	1.391
1999	0.849	0.871	-1.741	3.484	1.529
2000	0.744	0.855	-2.511	4.220	2.009
2001	1.650	0.922	-1.970	3.814	1.600
2002	0.865	1.197	-1.772	4.166	1.266
2003	1.007	1.141	-0.877	3.158	0.902
2004	0.955	0.898	-0.820	2.617	0.976

Blacktip shark (areas combined)

Year	Nominal	Standardized	LCL	UCL	CV
1994	0.453	0.448	-0.359	1.255	0.919
1995	0.964	1.099	0.431	1.768	0.310
1996	0.645	0.802	0.047	1.557	0.480
1997	0.157	0.460	-0.790	1.710	1.386
1998	0.767	0.796	-0.3180	1.910	0.714
1999	0.889	1.204	0.2060	2.201	0.423
2000	1.272	1.062	-0.2840	2.408	0.646
2001	0.143	0.903	-0.4050	2.211	0.739
2002	2.002	1.823	0.9670	2.6790	0.239
2003	1.496	1.083	0.2900	1.8770	0.374
2004	2.212	1.319	0.6350	2.0030	0.264

Blacktip shark (Gulf of Mexico)

Year	Nominal	Standardized	LCL	UCL	CV
1994	0.134	0.430	-0.974	1.834	1.666
1995	0.529	0.817	-0.551	2.185	0.855
1996	0.428	0.724	-1.001	2.448	1.215
1997	0.301	0.588	-2.001	3.176	2.248
1998	1.208	0.796	-1.733	3.325	1.620
1999	0.824	1.055	-1.571	3.681	1.270
2000					.
2001	0.004	0.162	-2.707	3.031	9.019
2002	1.738	2.062	0.058	4.067	0.496
2003	2.198	1.542	0.002	3.082	0.509
2004	2.637	1.824	0.391	3.257	0.401

Blacktip shark (Atlantic)

Year	Nominal	Standardized	LCL	UCL	CV
1994	1.079	0.805	-3.016	4.625	2.423
1995	1.692	2.042	-1.375	5.459	0.854
1996	1.059	1.246	-2.758	5.250	1.640
1997	0.044	0.131	-2.414	2.677	9.878
1998	0.459	0.534	-2.974	4.042	3.352
1999	1.219	0.426	-2.724	3.576	3.775
2000	2.016	0.153	-2.354	2.661	8.354
2001	0.323	0.971	-4.384	6.327	2.814
2002	2.555	4.578	3.535	5.620	0.116
2003	0.182	0.004	-0.269	0.276	39.339
2004	0.372	0.111	-1.306	1.527	6.517

Figure 1. Catch rates of (A) the LCS complex (22 species), (B) LCS complex without prohibited species (11 species), and (C) LCS complex without prohibited species, blacktip or sandbar from the Commercial Shark Fishery Observer Program (CSFOP). CPUE is the number of sharks caught per 100 hooks per hour. Vertical bars are 95% confidence limits.
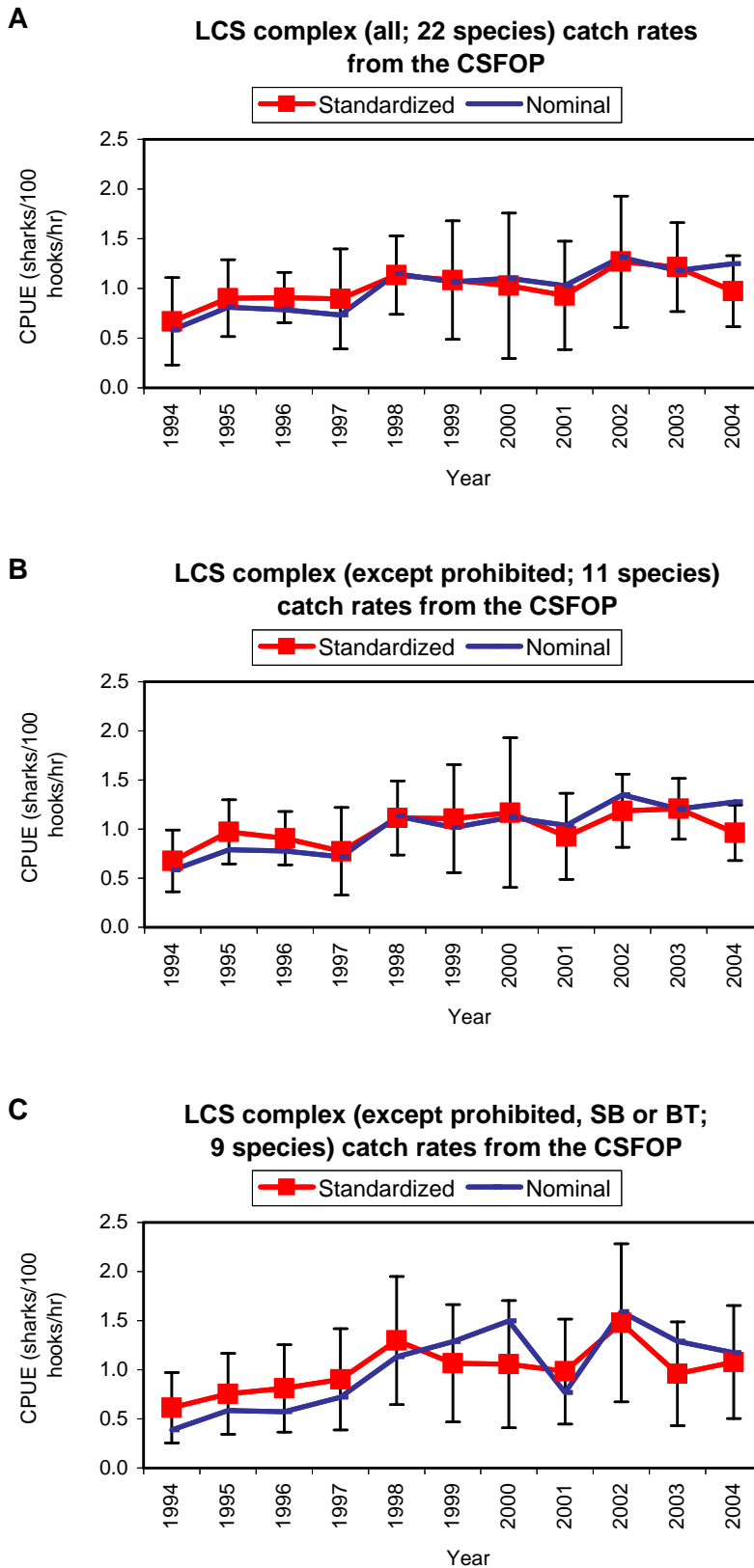
A

LCS complex (all; 22 species) catch rates from the CSFOP

B

LCS complex (except prohibited; 11 species) catch rates from the CSFOP

C

LCS complex (except prohibited, SB or BT; 9 species) catch rates from the CSFOP

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Figure 2. Catch rates of sandbar sharks from the Commercial Shark Fishery Observers Program (CSFOP). CPUE is the number of sharks caught per 100 hooks per hour. Vertical bars are 95% confidence limits.
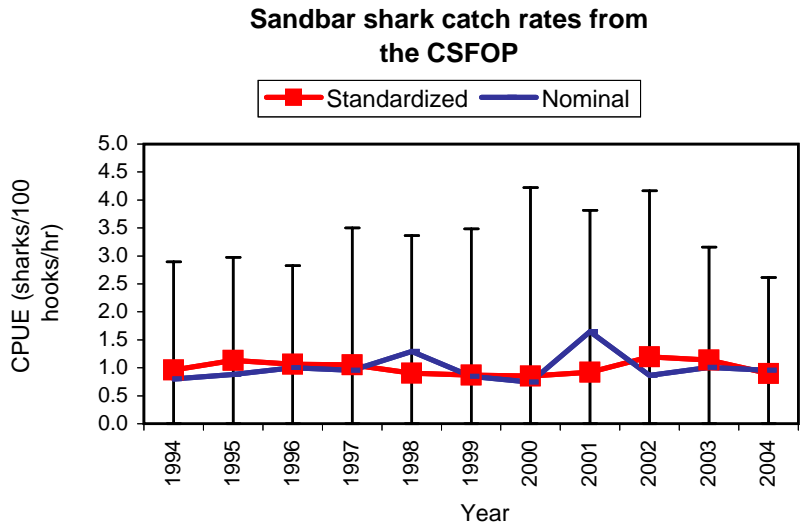
Sandbar shark catch rates from the CSFOP

Figure 3. Catch rates of (A) blacktip sharks in the Gulf of Mexico and Atlantic areas combined, (B) blacktip sharks in the Gulf of Mexico, and (C) blacktip sharks in the Atlantic from the Commercial Shark Fishery Observer Program (CSFOP). CPUE is the number of sharks caught per 100 hooks per hour. Vertical bars are 95% confidence limits.

A

Blacktip shark catch rates from the CSFOP (areas combined)

B

Blacktip shark catch rates from the CSFOP (GOM only)

C

Blacktip shark catch rates from the CSFOP (ATL only)