Technical Report

Massachusetts Division of Marine Fisheries
Technical Report TR-28

2005 Massachusetts Striped Bass Monitoring Report

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Massachusetts Division of Marine Fisheries
Department of Fish and Game
Executive Office of Environmental Affairs
Commonwealth of Massachusetts

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2005 Massachusetts Striped Bass Monitoring Report

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Annisquam River Marine Fisheries Station
Gloucester, MA

September, 2006

Massachusetts Division of Marine Fisheries
Paul Diodati, Director
Department of Fisheries, Wildlife and Environmental Law Enforcement
Dave Peters, Commissioner
Executive Office of Environmental Affairs
Robert W. Golledge, Jr., Secretary
Commonwealth of Massachusetts
Mitt Romney, Governor

Summary: During 2005, the commercial fishery for striped bass in Massachusetts harvested about 59,473 fish weighing 1,104,737 pounds. Total losses due to commercial harvesting (including release mortality) were 64,807 fish weighing 1,149,570 pounds. The recreational fishery harvested about 380,788 striped bass weighing over 5.3 million pounds. Total losses due to recreational fishing (including release mortality) were 799,767 fish weighing over 7.3 million pounds. Combined losses (including scientific losses) were 844,899 fish weighing over 8.5 million pounds, which reflects a 9.6% decrease in numbers lost and a 6.4 % decrease in weight lost compared to 2004 (939,078 fish; 9.0 million pounds). The majority of losses, 92% by number and 86% by weight, was attributed to the recreational fishery.

Introduction

This report summarizes the commercial and recreational striped bass fisheries conducted in Massachusetts during 2005. Data sources used to characterize the state fisheries come from monitoring programs of the Massachusetts Division of Marine Fisheries (DMF) and National Marine Fisheries Service (NMFS), which are considered to be essential elements of the long-term management approach described in Section 3 of the Atlantic States Marine Fisheries Commission's (ASMFC) Fisheries Management Report No. 41 (Amendment #6 to the Interstate Fishery management Plan for Atlantic Striped Bass (IFMP)).

Commercial Fishery

Season: July 12-August 17. No landings were permitted on Monday, Friday, or Saturday.

Harvest: 1,104,737 pounds (against a harvest quota of 1,094,962 pounds).

Allowable Gear Type: Hook and line.

Minimum Size: 34 inches total length.

Trip Limit: 5 fish per day on Sunday and 30 fish per day on Tuesday-Thursday.

Licensing, Reporting, and Estimation of Landings. To purchase striped bass directly from fishermen, fish dealers are required to obtain special authorization from the DMF in addition to standard seafood dealer permits. Dealer reporting requirement included weekly reporting to the DMF or SAFIS system of all striped bass purchases. If sent to DMF, all landings information is entered into SAFIS by DMF personnel. Following the close of the season, dealers are also required to provide a written transcript consisting of purchase dates, number of fish, pounds of fish, and names and permit numbers of fishermen from whom they purchased.

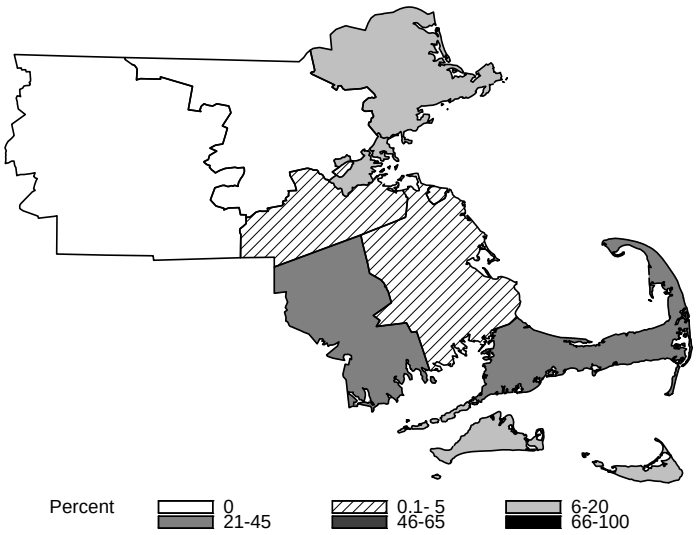
Fishermen must have a DMF commercial fishing permit (of any type) and a special striped bass fishing endorsement to sell their catch. They are required to file catch reports at the end of the season, which include the name of the dealer(s) that they sell to and extensive information describing their catch composition and catch rates. Many fishermen voluntarily provide daily fishing logs.

2005 Landings. The landings used here come from the SAFIS system. Commercial landings in 2005 were 1,104,737 pounds (59,473 fish) (Table 1). Most striped bass were sold in Barnstable,

Table 1. Attributes of the Massachusetts striped bass commercial fishery, 1990-2005.

	SEASON	HARVEST			
SEASON	LENGTH (Days)	(Pounds) 000s	(Numbers) 000s	DEALER PERMITS	FISHING PERMITS
1990	93	160.6	6.3	95	1,498
1991	59	234.8	10.4	92	1,739
1992	39	239.2	11.3	135	1,861
1993	35	262.6	13.0	152	2,056
1994	24	199.6	10.4	150	2,367
1995	57	782.0	41.2	161	3,353
1996	42	696.8	38.3	179	3,801
1997	42	785.9	44.8	173	5,500
1998	28	822.0	45.3	180	5,540
1999	40	788.2	40.8	167	3,577
2000	36	779.7	40.2	137	3,280
2001	29	815.0	40.2	164	4,241
2002	21	924.9	44.9	132	4,598
2003	21	1055.4	55.7	151	4,867
2004	19	1206.3	60.6	130	4,376
2005	22	1104.7	59.5	162	4,025

Figure 1. Percentage of total numbers of striped bass sold by commercial fishermen in Massachusett counties in 2005.



Bristol and Suffolk counties of Massachusetts (Figure 1).

Size Composition. Information from biological sampling, catch reports and voluntary logs is used to characterize disposition of the catch, catch weight, and size composition by catch category. Data from 4,308 fish sampled from the 2005 commercial harvest and 2000 DMF diet study were used to construct a length-weight equation that was used to estimate weight-at-size for individual bass. The following geometric regression was derived:

$$\log_{10}(W) = -3.4363 + 2.9875 * \log_{10}(L),$$
$$RMS = 0.0030$$

where W equals weight in pounds, L equals total length in inches, and RMS is the residual mean square error. This equation was used to estimate the arithmetic average weight for given lengths by back-transforming the geometric weight as follows:

$$W = 10^{(-3.4363+2.9875*\log_{10}(L)+RMS/2)}$$

Size composition of the commercial catch by category of disposition is presented in Appendix Tables 1A (numbers of fish) and 1B (pounds of fish). About 48% of the all fish caught had lengths ≥34 inches.

Age and Sex Composition.. Seven hundred and forty-two striped bass sampled from the 2005 commercial harvest were used to sex and age the harvested fish. The proportion that each age comprised the total samples was estimated from a sub-sample of 251 fish which guaranteed a precision of ±10% at α= 0.05. Weighted proportions at age were generated by weighting the age proportions sampled in each county by county landings. Age was determined from scales and sex was determined by visual inspection of gonadal tissue (Sykes Method). Age ranged from 7 to 16 years, and 97.7% were females. About 86.5% of the sub-sample consisted of individuals from the 1993-1997 year classes (ages 8-12) (Table 2).

Estimates of Total Catch Rates. Estimates of total catch rates (total number of fish caught per

Table 2. Age composition of the 2005 commercial harvest.

			Weighted		
Age	Year Class	Number	%	Mean Length (in.)	Mean Weight (lbs)
7	1998	5	2.0	33.2	12.8
8	1997	50	19.9	36.0	16.2
9	1996	71	28.1	36.3	16.3
10	1995	45	18.0	37.9	19.7
11	1994	34	13.7	39.7	22.1
12	1993	17	6.8	40.3	25.7
13	1992	18	7.1	41.7	22.1
14	1991	7	2.8	44.2	32.8
15	1990	3	1.2	44.6	33.2
16	1989	1	0.4	46.1	40.6

hour) for the commercial fishery were developed in order to provide an index that is more indicative of fluctuations in population abundance. On their mandatory catch reports, all fishermen are asked to record the total hours fished, number and pounds of fish caught by disposition category (i.e., released sub-legal, released legal, sold, and consumed), area fished and the fishing mode (Surf, Boat, Both) by month. This information was used under a generalized linear model (GLM) framework to generate a standardized catch rate index (Hilborn and Walter, 1992). Each record represented the summarization of a permit's monthly number of fish caught and hours fished by year, month, area fished reduced to 4 regions (Cape Cod Canal, Southern MA, Cape Cod Bay, North MA) and fishing mode. Only data from July-August were used to constraint analyses to the most recent duration of the fishing season. The catch rate for each record was calculated by dividing the total numbers caught by the total number of hours fished. The catch rate was standardized using the GLM model

$$\ln(y+1) = a + \sum_{i=1}^{n} b_i X_i + e$$

where y is the observed catch rate, a is the intercept, b_i is the slope coefficient of the ith factor, X_i is the ith categorical variable, and e is the error term. Any variable not significant at $\alpha = 0.05$ with type-III (partial) sum of squares was dropped from the initial GLM model and the analysis was repeated. First-order interactions were not considered in the analyses. The back-transformed geometric mean for each year was estimated by

$$\hat{y} = \exp^{(LSM)} - 1$$

where LSM is the least-squares natural log mean of each year. Age-specific catch rates were generated by multiplying the annual catch rates by the annual proportions-at-age in the total catch.

Results of the GLM analysis (Appendix Table 2) show that although year, sub-area, and fishing mode were significant factors, the variables accounted for only about 5% of the total variation in catch rates.

Overall commercial catch rates have been steadily increasing since 1991 (Fig. 2). Age-specific catch rates are shown in Figure 3. There were considerable fluctuations in the age-specific indices for ages 2-7, but generally indices increased through 2001 and dropped in 2002. Trends in the ages 2-7 indices show some increases in the last few year, although the age-3 index continued to decline through 2005. Indices for ages 8-9 and ages-12-13+ fluctuated greatly but without trend. For ages 10-11, indices were relatively stable over time, but declined in 2000 and have remained low through 2005.

Characterization of Other Losses. Release mortality was estimated by using a hook-release

Figure 2. Total catch rate index for the Massachusetts commercial striped bass fishery.

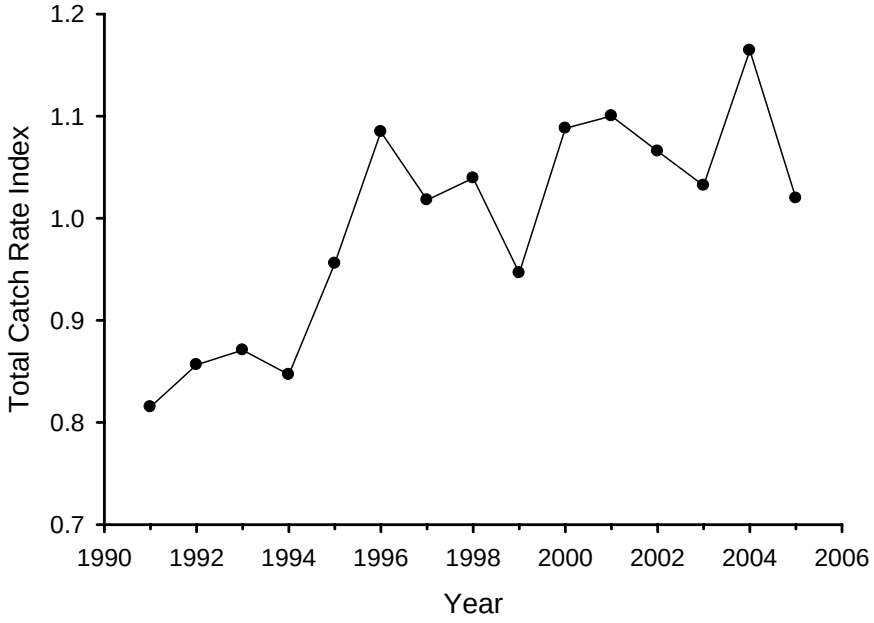
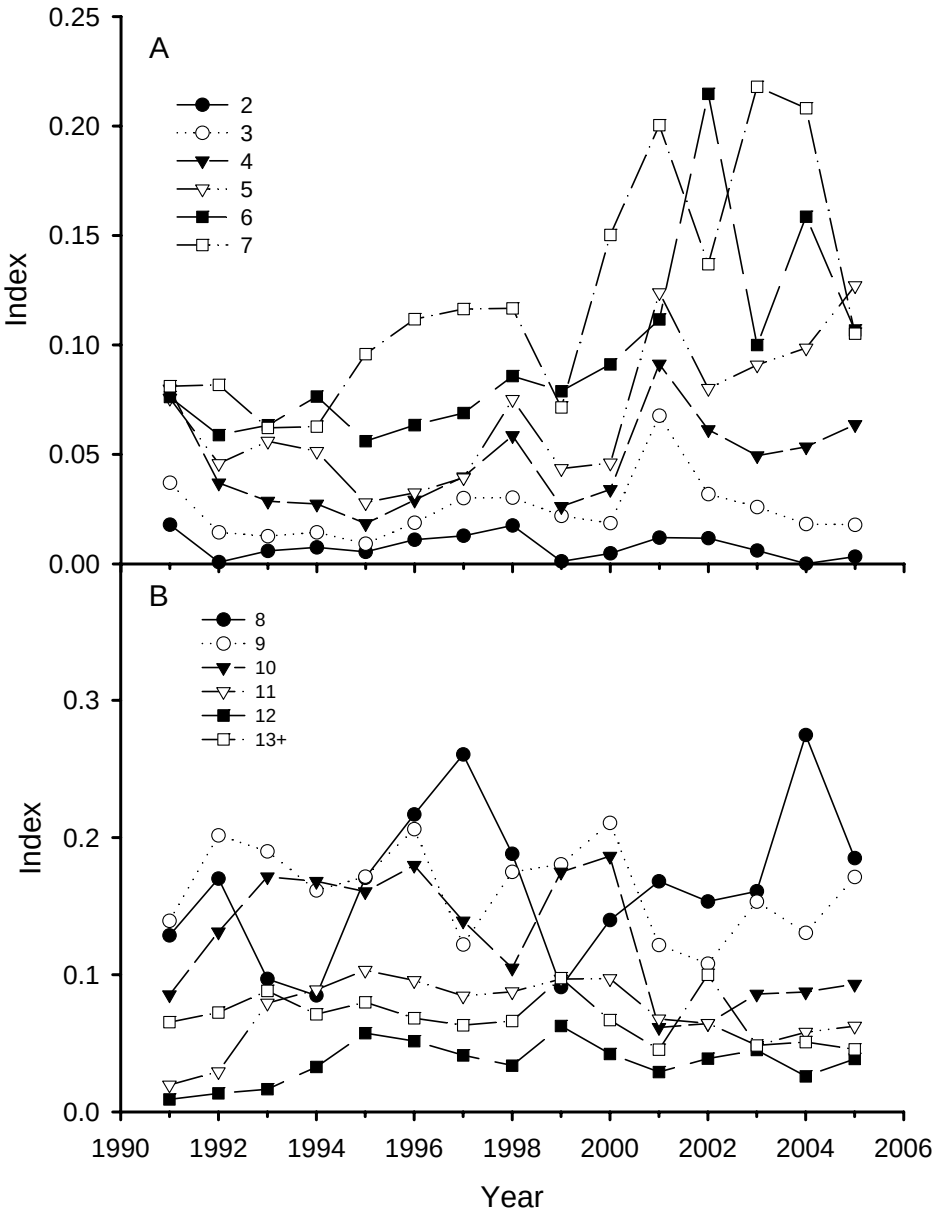


Figure 3. Age-specific total catch rate indices for A) ages 2-7 and B) ages 8-13+ striped bass.



mortality rate of 8% applied against the released fish in Appendix Tables 1A and 1B. Total losses due to release mortality were 5,334 fish weighing approximately 44,833 pounds.

Recreational Fishery

Season: None

Daily Bag Limit: Two fish per person

Allowable Gear Type: Hook and Line

Minimum Size: 28 inches total length

Licensing and Reporting Requirements: None

Harvest levels: Harvest (A+B1) and total catch (A+B1+B2) estimates (Table 3) were provided by the NMFS MRFSS. Reference should be made to Osborn and Salz (1994) for a description of the new trip estimation procedure and its effect on catch.

The MRFSS estimate of total catch (including fish released alive) in 2005 was 5,370,524 striped bass, which is lower than the 2004 estimate (Table 3). The estimate of total harvest in 2005 was 380,788, which is also lower than the 2004 estimate. Total pounds harvested was over 5.3 million in 2005 (Table 3).

The MRFSS estimates were post-stratified by county to determine where harvested bass were being landed by recreational anglers. Most landings (90%) occurred in Barnstable, Essex, Dukes/ Nantucket, and Plymouth counties (Figure 4). Only 10% of landings occurred in Bristol, Suffolk and Norfolk counties (Figure 4).

Size Composition. The length distribution of harvested fish was estimated from biological sampling conducted by the MRFSS program in Massachusetts. For released fish, volunteer recreational anglers were solicited to collect length and scale samples from striped bass that they captured each month (May-October). Each person was asked to collect a minimum of 5 scales from at least 10 fish per month and record the disposition of the each fish (released or harvested) and fishing mode. Over 2,800 samples were received from over 100 anglers. The size frequencies of measured fish are shown in Figure 5 by disposition and mode. The size frequency of released fishes was used to allocate MRFSS release numbers by mode among size classes. Numbers-at-length and weight-at-length data by disposition are summarized in

Table 3. MRFSS estimates of striped bass harvest, releases, and total catch in Massachusetts.

	Harvest (A+B1)		Released (B2)	Total (A+B1+B2)
Year	Numbers	Weight (lbs)	Numbers	Numbers
1986	29,434	298,816	442,298	471,732
1987	10,807	269,459	93,660	104,467
1988	21,050	421,317	209,632	230,682
1989	13,044	295,227	193,067	206,111
1990	20,515	319,092	339,511	360,026
1991	20,799	440,605	448,735	469,534
1992	57,084	972,116	779,814	836,898
1993	58,511	1,113,446	833,566	892,077
1994	74,538	1,686,049	2,102,514	2,177,052
1995	73,806	1,504,390	3,280,882	3,354,688
1996	68,300	1,291,706	3,269,746	3,338,046
1997	199,373	2,891,970	5,417,751	5,617,124
1998	207,952	2,973,456	7,184,358	7,392,310
1999	126,755	1,822,818	4,576,208	4,702,963
2000	181,295	2,618,216	7,382,031	7,563,326
2001	288,032	3,644,561	5,410,899	5,698,930
2002	308,749	4,304,883	5,718,984	6,027,733
2003	402,201	5,120,554	4,306,965	4,709,166
2004	406,590	5,539,086	5,878,546	6,285,136
2005	380,788	5,340,361	4,989,736	5,370,524

Figure 4. Percentage of total numbers of striped bass harvested by recreational anglers in each county of Massachusetts during 2005.

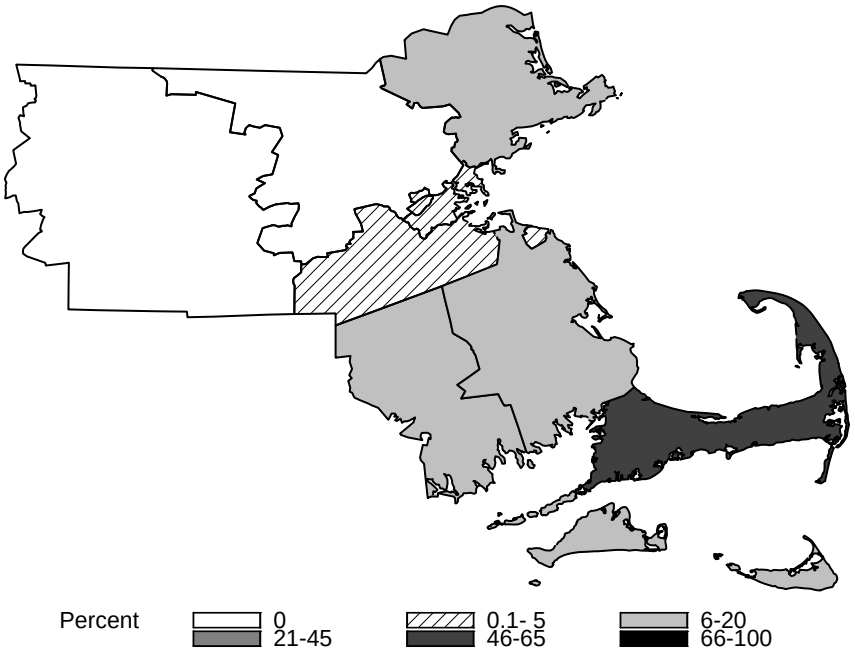
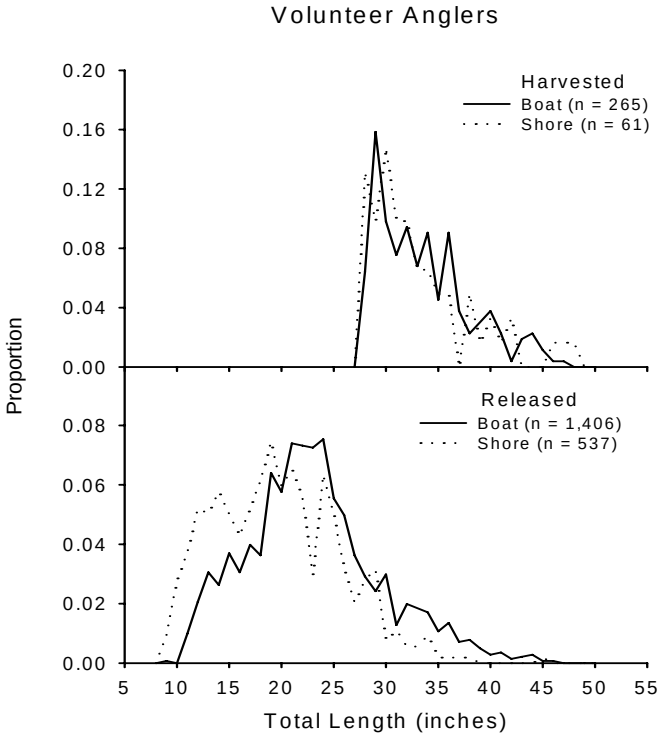


Figure 5. Sizes of striped bass caught by volunteer recreational anglers in 2005 by disposition and fishing mode.



Appendix Tables 3A and 3B.

Age Composition. A sub-sample of 483 fish from the volunteer angler survey was aged and combined with commercial and tagging samples to produce an age-length key used to convert the MRFSS size distribution into age classes. Recreational samples were selected using a weighted random design based on the total number of striped bass caught in each wave and mode stratum (as determined by MRFSS).

Trends in Catch Rates. To examine trends in recreational angler catches, standardized catch rates (total number of fish per trip) for striped bass were calculated for all fish caught using a delta-lognormal model (Lo et al., 1992) which adjusts trip catches for the effects of year, wave, county, area fished, mode fished, and time spent fishing. A delta-lognormal model was selected as the best approach to estimate year effects after examination of model dispersion (Terceiro, 2003) and standardized residual deviance plots (McCullagh and Nelder, 1989). In the delta-lognormal model, catch data is decomposed into catch success/failure and positive catch components. Each component is analyzed separately using appropriate statistical techniques and then the statistical models are recombined to obtain year estimates. The catch success/failure was modelled as a binary response to the categorical variables using multiple logistic regression:

$$\log it(p) = \log(p/1-p) = a + \sum_{i=1}^{n} b_i X_i + e$$

where p is the probability of catching a fish, a is the intercept, b_i is the slope coefficient of the ith factor, X_i is the ith categorical variable, and e is the error term. PROC LOGISTIC (SAS, 2002) was used to estimate parameters, and goodness-of-fit was assessed using concordance measures and the Hosmer-Lemeshow test (SAS, 2002).

Positive catches, transformed using the natural logarithm, were modelled assuming a normal error distribution using PROC GLM

$$\log(y) = a + \sum_{i=1}^{n} b_i X_i + e$$

where y is the observed positive catch, b_i ,and X_i are the same symbols as defined earlier, and e is the normal error term. Any variable not significant at α=0.05 with type-III (partial) sum of squares was dropped from the initial GLM model and the analysis was repeated. First-order interactions were considered in the initial analyses but it was not always possible to generate annual means by the least-square methods with some interactions included (see Searle et al., 1980); therefore, only main effects were considered.

The annual index of striped bass total catch per trip was estimated by combining the two component models. The estimate in year i from the models is given by

$$\hat{I}_i = \hat{p}_i * \hat{y}_i$$

where p_i and y_i are the predicted annual responses from the logistic and GLM models. p_i is calculated by

$$\hat{p}_i = \frac{\exp(\hat{a} + \hat{b}_i)}{1 + \exp(\hat{a} + \hat{b}_i)}$$

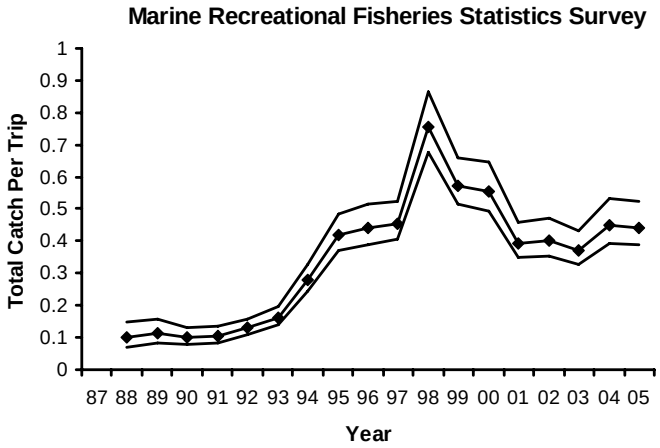
and y_i is calculated by

$$\hat{y}_i = \exp(LSM_i + \sigma^2/2)$$

where LSM_i is the least squares mean for year i and σ^2 is the mean square error. Only data for those anglers who said they targeted striped bass were used in the analyses.

Results of the logistic and GLM analyses are given in Appendix Tables 4 and 5. Standardized catch rates increased from 1993 to 1998, declined through 2003, but increased in 2004 and 2005 (Fig. 6).

Figure 6. Estimates of total catch rates (total number of fish caught per trip) of the recreational fishery for striped bass in Massachusetts waters. 95% confidence intervals are shown.



Characterization of Losses

The same methods and rates previously described in the commercial fishery section were used to estimate recreational losses. Release mortality was 399,179 fish (2,023,188 pounds).

Scientific Collections

About 125 bass were taken or killed for scientific research in 2005.

By-catch in Other Fisheries

During 1994, DMF sea-sampling efforts identified striped bass as by-catch in a Nantucket Sound springtime trawl fishery directed at long-finned squid (*Loligo pealei*). Those by-catch estimates were about 3,100 fish (17,600 pounds). Anecdotal information was also reported for this fishery which suggested that striped bass by-catch ranged from 8,000 pounds per day, with up to single tows landing 19,000 pounds. DMF personnel sea-sampled this fishery during 1995-2000 and observed only incidental catches of striped bass. Limited sampling and low catch rates make it unreasonable to extrapolate sample information. DMF will continue to monitor potential sources of striped bass by-catch during 2006.

Estimated Total Losses

Total estimated loss of striped bass during 2005 was 844,899 fish weighing 8,514,543 pounds (Table 4), which is a 9.6% decrease in numbers lost and a 6.4% decrease in weight compared to 2004 (939,078 fish; 9,061,080 pounds). The majority of losses, 92% by number and 86% by weight, was attributed to combined losses in the recreational fishery.

Removals-At-Age Matrix

The removals (numbers) due to release mortality and harvest by the recreational and commercial fisheries and scientific activities are apportioned by age and mortality source in Table 5.

Required Fishery-Independent Monitoring Programs

Massachusetts Tagging Study

The Massachusetts Division of Marine Fisheries (DMF) joined the Striped Bass Cooperative State-Federal Coast-wide Tagging Study in 1991. The study's primary objective has been to develop an integrated database of tag releases and recoveries that will provide current information related to striped bass mortality and migration rates. The majority of striped bass tagged prior to 1991 (the tagging study began in 1986) have ranged from 18 to 28 inches in length. Since Atlantic coastal fisheries had employed minimum sizes of 28-36 inches, resulting mortality estimates from these data may understate the effects fishing has on larger striped bass. The Massachusetts tagging effort has therefore focused on the tag and release of larger fish that reach coast-wide legal sizes. To accomplish this job, the DMF contracts several select charter boat captains to take DMF personnel on board to tag and release their catch during regularly scheduled fishing trips. Fish are caught in fall by trolling artificial baits in shoal areas around Nantucket Island. In 2004, spring tagging of small bass in Plum Island Sound also occurred. Floy internal anchor tags provided by the USFWS are used. Total length of each fish is recorded. Scales are removed from each fish for aging. The release data are made available to the Annapolis, Maryland office of the USFWS, which coordinates regional tagging programs of state-federal participants.

Table 4. Estimates of striped bass losses occurring in Massachusetts waters during 2005.

FISHERY	NUMBER	POUNDS	MEAN WT.
Commercial			
Harvest	59,473	1,104,737	18.6
Release Mortality	5,334	44,833	8.4
Recreational			
Harvest	380,788	5,340,361	14.0
Release Mortality	399,179	2,023,188	5.1
Scientific	125	1,423	11.4
Total	844,899	8,514,543	

Table 5. Massachusetts Striped Bass Removals-At-Age Matrix of 2005 By Source.

		Recreational		Commercial	
Age	Scientific	Release Mortality	Harvest	Release Mortality	Harvest
2	20	64999	0	33	
3	5	60348	0	177	
4	5	102893	2428	630	
5	11	81539	35667	1254	
6	13	31965	55018	1017	
7	15	16260	60007	839	1187
8	23	16633	77792	802	11852
9	19	11882	65632	432	16704
10	8	5688	33851	119	10689
11	4	2945	21837	25	8123
12	1	1708	11567	4	4069
13	1	1279	9341	1	4204
14	0	751	4212	1	1669
15	0	141	1799	0	733
16	0	95	1461	0	244
17+	0	55	175	0	0

For the analyses of survival, the ASMFC Tagging Subcommittee began using the MARK implementation of the Brownie et al. (1985) tagging models (White and Burnham 1997). The program MARK calculates maximum likelihood estimates of the multinomial parameters of survival and recovery based on an observed matrix of recaptures. The following passages were taken from ASMFC (2003) to describe the analyses of tagging data: "The analysis protocol involves the following series of steps. First, a full set of biologically-reasonable candidate models are identified prior to analysis. Various patterns of survival and recovery are used to parameterize the candidate models. These include models that allow parameters to be constant, time specific, or allow time to be modeled as a continuous variable. Other models allow time periods to coincide with changes in regulatory regimes established coastwide. These models are then fit to the tag recovery data and are arranged in order of fit by Akaike's Information Criteria (AIC). Annual survival is then calculated as a weighted average across all models, where the weight is a function of model fit. The lower the AICc (i.e., the better the fit), the higher the weight assigned to a specific model in the model averaging. Model averaging eliminates the need to select a single, best model, allowing the uncertainty of model selection to be incorporated into the variance of parameter estimates".

Summary statistics compiled since the start of this study are shown in Table 6. The recapture matrix used in the MARK modeling is shown in Table 7. Estimates from the MARK modeling showed that striped bass survival was relatively stable prior to 1994, but it dropped after the ASMFC closures were lifted in 1995. Survival has been increasing since 2000-01 (Figure 7).

Planned Management Programs in 2005

Regulations

Massachusetts' recreational bag and minimum size limits will remain at 2 fish per day and 28-inches total length, respectively. For the commercial fishery, minimum size limit and quota will remain 34-inches and 1,159,750 pounds allowed under Amendment 6, respectively. The commercial fishery quota will be monitored using the SAFIS system. In addition, the commercial season will not open until July 12 and harvesting will be allowed only on Sunday with a daily bag limit of 5 fish, and Tuesday-Thursday with a daily bag limit of 30 fish.

Monitoring Programs

All monitoring programs will continue in 2006.

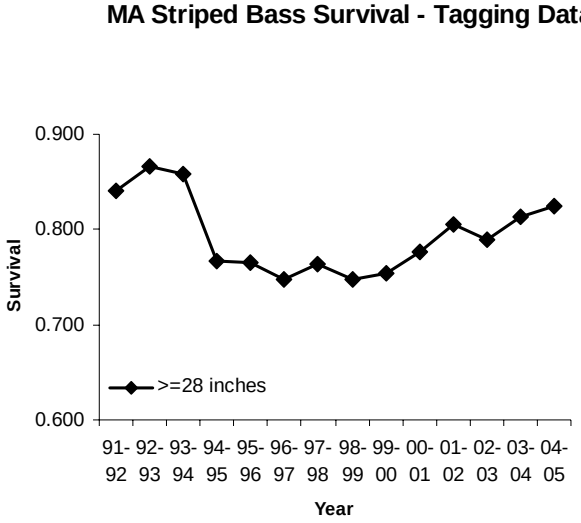
Table 6. Massachusetts tag summary statistics.

Year	Trips	Boats	Number Tagged	Ave. Length	SD	Length Range Min	Length Range Max.
1991	17	4	388	817	106.4	534	1300
1992	29	3	899	798	125.9	524	1267
1993	15	2	678	784	125.0	515	1210
1994	13	2	377	735	93.2	548	1028
1995	11	2	449	767	110.2	470	1178
1996	8	2	203	748	64.1	541	1077
1997	10	2	321	773	114.7	485	1090
1998	12	2	382	797	93.8	597	1055
1999	16	2	471	777	95.5	594	1108
2000	25	4	1095	752	102.6	510	1204
2001	14	3	456	786	102.5	503	1110
2002	12	3	239	764	103.6	487	1060
2003	15	3	655	825	92.1	602	1204
2004	25	7	784	707	193.1	316	1164
2005	19	4	752	726	210.5	299	1114

Table 7. Recapture matrix of striped bass ≥28 inches from 1991-2005 (Fall Tagging Only). A recapture year was defined as the beginning of tagging in year t to beginning of tagging in year t+1.

	Year Recaptured													
Year Tagged	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1991	16	25	11	14	8	3	1	3	3	1	1	0	0	0
1992		33	34	27	26	19	16	11	4	1	3	2	1	0
1993			20	23	29	20	17	7	2	3	2	1	1	1
1994				15	11	9	5	4	4	1	0	2	0	0
1995					21	12	16	9	10	2	2	2	0	2
1996						11	6	3	3	1	2	0	1	0
1997							14	20	8	6	4	5	0	1
1998								4	4	1	2	0	0	0
1999									10	4	8	3	4	0
2000										19	23	16	11	10
2001											25	14	15	9
2002												9	4	6
2003													30	25
2004														23
Total Released	329	612	463	219	274	118	220	59	163	411	353	172	615	542

Figure 7. Estimates of annual survival of striped bass released in coastal waters of Massachusetts.



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Appendix Table 1A. Estimated size distribution of the Massachusetts commercial striped bass catch (numbers of fish) in 2005.

TL (in.)	Kept	Released	Total	Percent	Cumulative Percent
11		0	0	0.00	0.00
12		0	0	0.00	0.00
13		0	0	0.00	0.00
14		84	84	0.07	0.07
15		21	21	0.02	0.08
16		272	272	0.22	0.30
17		440	440	0.35	0.65
18		566	566	0.45	1.10
19		566	566	0.45	1.55
20		1,111	1,111	0.88	2.43
21		734	734	0.58	3.01
22		2,096	2,096	1.66	4.67
23		1,970	1,970	1.56	6.23
24		4,989	4,989	3.95	10.19
25		3,563	3,563	2.82	13.01
26		5,638	5,638	4.47	17.48
27		5,303	5,303	4.20	21.68
28		5,010	5,010	3.97	25.65
29		2,389	2,389	1.89	27.55
30		6,309	6,309	5.00	32.55
31		4,842	4,842	3.84	36.39
32	574	8,342	8,916	7.07	43.46
33	2259	8,971	11,230	8.90	52.36
34	8395	2,138	10,533	8.35	60.71
35	7456	314	7,770	6.16	66.87
36	7894	629	8,523	6.76	73.62
37	6697	105	6,802	5.39	79.02
38	6099	126	6,225	4.93	83.95
39	4870	42	4,912	3.89	87.84
40	3289	84	3,373	2.67	90.52
41	4158	0	4,158	3.30	93.81
42	2634	0	2,634	2.09	95.90
43	1808	0	1,808	1.43	97.33
44	1739	21	1,760	1.40	98.73
45	745	0	745	0.59	99.32
46	562	0	562	0.45	99.77
47	225	0	225	0.18	99.94
48	0	0	0	0.00	99.94
49	0	0	0	0.00	99.94
50	70	0	70	0.06	100.00
51	0	0	0	0.00	100.00
52	0	0	0	0.00	100.00
Total	59,474	66,675	126,149		
Avg. Size	37.6	28.4	32.7		

Appendix Table 1B. Estimated size distribution of the Massachusetts commercial striped bass catch (pounds) I n 2005.

TL (in.)	Kept	Released	Total	Percent	Cumulative Percent
11	0	0	0	0.00	0.00
12	0	0	0	0.00	0.00
13	0	0	0	0.00	0.00
14	0	80	80	0.00	0.00
15	0	25	25	0.00	0.01
16	0	387	387	0.02	0.03
17	0	750	750	0.05	0.07
18	0	1,143	1143	0.07	0.14
19	0	1,344	1344	0.08	0.22
20	0	3,074	3074	0.18	0.41
21	0	2,349	2349	0.14	0.55
22	0	7,712	7712	0.46	1.01
23	0	8,278	8278	0.50	1.51
24	0	23,802	23802	1.43	2.94
25	0	19,207	19207	1.15	4.09
26	0	34,170	34170	2.05	6.14
27	0	35,973	35973	2.16	8.31
28	0	37,883	37883	2.28	10.58
29	0	20,067	20067	1.21	11.79
30	0	58,630	58630	3.52	15.31
31	0	49,626	49626	2.98	18.29
32	6,469	94,010	100479	6.03	24.32
33	27,908	110,831	138739	8.33	32.65
34	113,389	28,877	142265	8.54	41.20
35	109,816	4,631	114446	6.87	48.07
36	126,475	10,075	136550	8.20	56.27
37	116,450	1,822	118272	7.10	63.37
38	114,846	2,368	117214	7.04	70.41
39	99,103	853	99956	6.00	76.41
40	72,189	1,840	74029	4.45	80.86
41	98,249	0	98249	5.90	86.76
42	66,885	0	66885	4.02	90.78
43	49,254	0	49254	2.96	93.74
44	50,742	612	51354	3.08	96.82
45	23,248	0	23248	1.40	98.22
46	18,727	0	18727	1.12	99.34
47	7,995	0	7995	0.48	99.82
48	0	0	0	0.00	99.82
49	0	0	0	0.00	99.82
50	2,992	0	2992	0.18	100.00
51	0	0	0	0.00	100.00
52	0	0	0	0.00	100.00
Total	1,104,737	560,418	1,665,155		
Avg. Weight	18.6	8.4	13.2		

Appendix Table 2. Results of the GLM analyses of total catch rates for the commercial striped bass fishery.

Source	DF	Sum of Squares	Mean Square	F	P
Model	19	387.21	20.38	87.94	<.0001
Error	34559	8009.09	0.23		
Corrected Total	34578	8396.30			

R-Square 0.046117

Source	DF	Type III SS	Mean Square	F	P
Year	14	71.32	5.09	21.98	<.0001
Subarea	3	165.65	55.22	238.26	<.0001
Fishing Mode	2	93.78	46.89	202.33	<.0001

Least-Squares Means

Year	Mean	Standard Error
1991	0.596134263	0.013181867
1992	0.618652621	0.013493622
1993	0.62640443	0.012854988
1994	0.613466612	0.012820517
1995	0.67073764	0.010708046
1996	0.734593477	0.021835039
1997	0.701995721	0.010048189
1998	0.712551928	0.010523415
1999	0.665980587	0.011051444
2000	0.736184569	0.011619994
2001	0.742000052	0.011769921
2002	0.725376019	0.011523796
2003	0.709051474	0.010063716
2004	0.772084821	0.013776076
2005	0.702858257	0.011812465

Appendix Table 3A. Estimated size distribution of the Massachusetts recreational striped bass catch (numbers of fish) in 2005.

TL (in.)	Harvested	Released	Total	Percent	Cumulative Percent
9	0	9,748	9,748		
10	0	21,558	21,558	0.40	0.40
11	0	67,596	67,596	1.26	1.66
12	0	120,912	120,912	2.26	3.92
13	0	167,647	167,647	3.13	7.05
14	0	158,544	158,544	2.96	10.00
15	0	199,646	199,646	3.72	13.73
16	0	160,401	160,401	2.99	16.72
17	0	206,301	206,301	3.85	20.57
18	0	201,988	201,988	3.77	24.34
19	0	329,283	329,283	6.14	30.48
20	0	289,990	289,990	5.41	35.89
21	0	371,299	371,299	6.93	42.81
22	0	352,634	352,634	6.58	49.39
23	0	331,448	331,448	6.18	55.57
24	0	364,962	364,962	6.81	62.38
25	0	278,998	278,998	5.20	67.59
26	0	227,501	227,501	4.24	71.83
27	0	170,915	170,915	3.19	75.02
28	22,463	142,706	165,168	3.08	78.10
29	45,870	126,650	172,520	3.22	81.32
30	44,198	124,728	168,926	3.15	84.47
31	32,455	63,083	95,538	1.78	86.25
32	40,531	85,391	125,922	2.35	88.60
33	29,998	79,679	109,677	2.05	90.65
34	30,878	80,621	111,500	2.08	92.73
35	25,764	43,256	69,020	1.29	94.01
36	21,556	56,296	77,853	1.45	95.47
37	11,991	30,846	42,837	0.80	96.27
38	15,574	36,199	51,773	0.97	97.23
39	15,803	21,537	37,340	0.70	97.93
40	15,403	13,224	28,627	0.53	98.46
41	9,097	16,777	25,874	0.48	98.94
42	3,046	5,126	8,172	0.15	99.10
43	2,921	10,661	13,581	0.25	99.35
44	3,503	13,628	17,131	0.32	99.67
45	3,979	4,405	8,384	0.16	99.83
46	2,711	3,554	6,265	0.12	99.94
47	1,169	0	1,169	0.02	99.96
48	583	0	583	0.01	99.98
49	0	0	0	0.00	99.98
50	1,295	0	1,295	0.02	100.00
51	0	0	0	0.00	100.00
52	0	0	0	0.00	100.00
53	0	0	0	0.00	100.00
Total	380,788	4,989,736	5,370,524		
Avg. Size	33.6	22.3	23.1		

Appendix Table 3B. Estimated size distribution of the Massachusetts recreational striped bass catch (pounds) in 2005.

TL (in.)	Kept	Released	Total	Percent	Cumulative Percent
9	0	2,532	2,532		
10	0	7,672	7,672	0.03	0.03
11	0	31,979	31,979	0.10	0.13
12	0	74,183	74,183	0.24	0.37
13	0	130,642	130,642	0.43	0.80
14	0	154,166	154,166	0.50	1.30
15	0	238,570	238,570	0.78	2.08
16	0	232,432	232,432	0.76	2.84
17	0	358,300	358,300	1.17	4.01
18	0	416,133	416,133	1.36	5.37
19	0	797,303	797,303	2.60	7.97
20	0	818,440	818,440	2.67	10.64
21	0	1,212,358	1,212,358	3.96	14.60
22	0	1,323,085	1,323,085	4.32	18.92
23	0	1,420,213	1,420,213	4.64	23.55
24	0	1,775,838	1,775,838	5.80	29.35
25	0	1,533,632	1,533,632	5.01	34.36
26	0	1,406,016	1,406,016	4.59	38.95
27	0	1,182,367	1,182,367	3.86	42.81
28	173,229	1,100,523	1,273,752	4.16	46.97
29	392,837	1,084,658	1,477,495	4.82	51.79
30	418,866	1,182,054	1,600,920	5.23	57.02
31	339,227	659,371	998,598	3.26	60.28
32	465,795	981,341	1,447,136	4.72	65.00
33	377,947	1,003,859	1,381,806	4.51	69.51
34	425,319	1,110,489	1,535,808	5.01	74.52
35	386,980	649,715	1,036,695	3.38	77.91
36	352,209	919,824	1,272,033	4.15	82.06
37	212,632	546,980	759,612	2.48	84.54
38	299,074	695,126	994,201	3.25	87.79
39	327,949	446,958	774,907	2.53	90.32
40	344,766	295,990	640,756	2.09	92.41
41	219,210	404,265	623,475	2.04	94.44
42	78,886	132,735	211,621	0.69	95.13
43	81,140	296,174	377,313	1.23	96.37
44	104,245	405,522	509,766	1.66	98.03
45	126,631	140,166	266,797	0.87	98.90
46	92,134	120,772	212,906	0.70	99.60
47	42,362	0	42,362	0.14	99.73
48	22,483	0	22,483	0.07	99.81
49	0	0	0	0.00	99.81
50	56,442	0	56,442	0.18	99.99
51	0	0	0	0.00	99.99
52	0	0	0	0.00	99.99
53	0	0	0	0.00	99.99
Total	5,340,361	25,292,386	30,632,747		
Avg. Weight	14.0	5.1	5.7		

Appendix Table 4. Results of the logistic regression analysis of MRFSS striped bass catch success/failure.

R-Square	0.197	Max-rescaled R-Square	0.2669

Type 3 Analysis of Effects

Effect	DF	Wald Chi-Square	Pr>Chisq
YEAR	17	1468.4938	<.0001
WAVE	3	209.1073	<.0001
CNTY	7	464.5181	<.0001
AREA_X	2	171.3557	<.0001
MODE_FX	4	2780.5016	<.0001
FFDAYS12	14	888.8259	<.0001
NUM_HRSF	1	1710.8838	<.0001

Parameter		DF	Estimate	Error	Wald Chi-Square	Pr > Chisq
Intercept		1	-2.92	13.3974	0.0475	0.8275
YEAR	1988	1	-0.8882	0.1191	55.6438	<.0001
YEAR	1989	1	-0.7012	0.1031	46.2931	<.0001
YEAR	1990	1	-0.8359	0.0794	110.7902	<.0001
YEAR	1991	1	-0.9026	0.0729	153.1439	<.0001
YEAR	1992	1	-0.766	0.0552	192.4355	<.0001
YEAR	1993	1	-0.4597	0.0522	77.6785	<.0001
YEAR	1994	1	0.0189	0.0432	0.191	0.6621
YEAR	1995	1	0.3276	0.0395	68.7241	<.0001
YEAR	1996	1	0.3553	0.042	71.4228	<.0001
YEAR	1997	1	0.3598	0.038	89.7963	<.0001
YEAR	1998	1	0.8213	0.037	492.2344	<.0001
YEAR	1999	1	0.5722	0.0376	231.3104	<.0001
YEAR	2000	1	0.5099	0.0403	160.1799	<.0001
YEAR	2001	1	0.2801	0.0381	54.0898	<.0001
YEAR	2002	1	0.3385	0.0423	63.9839	<.0001
YEAR	2003	1	0.2455	0.0413	35.34	<.0001
YEAR	2004	1	0.3756	0.0481	60.8519	<.0001
WAVE	3	1	0.3255	0.0298	119.3091	<.0001
WAVE	4	1	0.0338	0.0292	1.3405	0.2469
WAVE	5	1	-0.0707	0.0309	5.2192	0.0223
CNTY	1	1	0.00954	0.0254	0.1408	0.7075
CNTY	5	1	-0.2699	0.0483	31.2356	<.0001
CNTY	7	1	-0.0991	0.0574	2.9874	0.0839
CNTY	9	1	0.4627	0.0267	299.4461	<.0001
CNTY	19	1	-0.4937	0.0803	37.782	<.0001
CNTY	21	1	0.2355	0.0517	20.7839	<.0001
CNTY	23	1	-0.03	0.0332	0.8172	0.366
AREA_X	1	1	-0.1226	0.0168	53.4601	<.0001
AREA_X	2	1	-0.0743	0.0227	10.701	0.0011
MODE_FX	3	1	0.5254	13.3974	0.0015	0.9687
MODE_FX	4	1	-9.0965	53.5892	0.0288	0.8652
MODE_FX	5	1	3.8519	13.3979	0.0827	0.7737
MODE_FX	6	1	3.0061	13.3974	0.0503	0.8225
FFDAYS12	0	1	-0.708	0.0349	412.5562	<.0001
FFDAYS12	10	1	-0.5625	0.0383	215.8722	<.0001
FFDAYS12	20	1	-0.2771	0.0388	50.9196	<.0001
FFDAYS12	30	1	-0.1805	0.0434	17.3068	<.0001
FFDAYS12	40	1	-0.0568	0.0518	1.205	0.2723
FFDAYS12	50	1	0.0756	0.0461	2.6873	0.1011
FFDAYS12	60	1	0.0336	0.0608	0.3056	0.5804
FFDAYS12	70	1	0.1238	0.0733	2.852	0.0913
FFDAYS12	80	1	0.1668	0.1039	2.5794	0.1083
FFDAYS12	90	1	-0.0612	0.111	0.3038	0.5815
FFDAYS12	100	1	0.2281	0.0489	21.7694	<.0001
FFDAYS12	150	1	0.2929	0.0786	13.8788	0.0002
FFDAYS12	200	1	0.1895	0.1023	3.4312	0.064
FFDAYS12	250	1	0.1937	0.2369	0.6688	0.4135
NUM_HRSF		1	0.2218	0.00536	1710.8838	<.0001

Appendix Table 5. Results of the GLM regression analysis of MRFSS striped bass positive catches.

Source	DF	Sum of Squares	Mean	Square	F
Model	47	1473.33174	31.347484	65.18	<.0001
Error	17554	8442.03781	0.480918		
Corrected	Total	17601	9915.369551		

R-Square
0.148591

Source	DF	Type III SS	Mean Square	F	Pr>F
YEAR	17	156.237019	9.1904129	19.11	<.0001
WAVE	3	89.4638144	29.8212715	62.01	<.0001
CNTY	7	92.8826133	13.2689448	27.59	<.0001
AREA_X	2	25.4679083	12.7339541	26.48	<.0001
MODE_FX	3	250.808239	83.6027464	173.84	<.0001
FFDAYS12	14	274.795129	19.6282235	40.81	<.0001
NUM_HRSF	1	422.171648	422.1716475	877.85	<.0001

YEAR	LSMEAN	Error	Pr>t
1988	1.257661	0.07889638	<.0001
1989	1.193681	0.06586751	<.0001
1990	1.218108	0.05381935	<.0001
1991	1.342847	0.05103031	<.0001
1992	1.390755	0.03993896	<.0001
1993	1.327882	0.03891682	<.0001
1994	1.394787	0.03268103	<.0001
1995	1.515574	0.03038919	<.0001
1996	1.542011	0.03198123	<.0001
1997	1.568456	0.02986124	<.0001
1998	1.645825	0.02899433	<.0001
1999	1.597872	0.02934413	<.0001
2000	1.629284	0.03094431	<.0001
2001	1.503311	0.03071093	<.0001
2002	1.463625	0.03206364	<.0001
2003	1.478055	0.0318958	<.0001
2004	1.538124	0.03343425	<.0001
2005	1.546846	0.03218784	<.0001