Technical Report

Massachusetts Division of Marine Fisheries
Technical Report TR-32

2006 Massachusetts Striped Bass Monitoring Report

G. A. Nelson

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

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Gary A. Nelson

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Massachusetts Division of Marine Fisheries
Paul Diodati, Director
Department of Fisheries, Wildlife and Environmental Law Enforcement
Mary B. Griffin, Commissioner
Executive Office of Energy and Environmental Affairs
Ian Bowles, Secretary
Commonwealth of Massachusetts
Deval Patrick, Governor

Summary: During 2006, the commercial fishery for striped bass in Massachusetts harvested about 69,986 fish weighing 1,312,468 pounds. Total losses due to commercial harvesting (including release mortality) were 75,955 fish weighing 1,364,392 pounds. The recreational fishery harvested about 345,105 striped bass weighing over 4.9 million pounds. Total losses due to recreational fishing (including release mortality) were 1,038,127 fish weighing over 7.3 million pounds. Combined losses (including scientific losses) were 1,114,082 fish weighing over 8.7 million pounds, which reflects a 32% increase in numbers lost and a 2.6 % increase in weight lost compared to 2005 (844,899 fish; 8.5 million pounds). The majority of losses, 93% by number and 84% by weight, was attributed to the recreational fishery. The 2001 and 2003 year-classes incurred the highest losses.

Introduction

This report summarizes the commercial and recreational striped bass fisheries conducted in Massachusetts during 2006. 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 24. No landings were permitted on Monday, Friday, or Saturday.

Harvest: 1,312,168 pounds (against a harvest quota of 1,140,807 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.

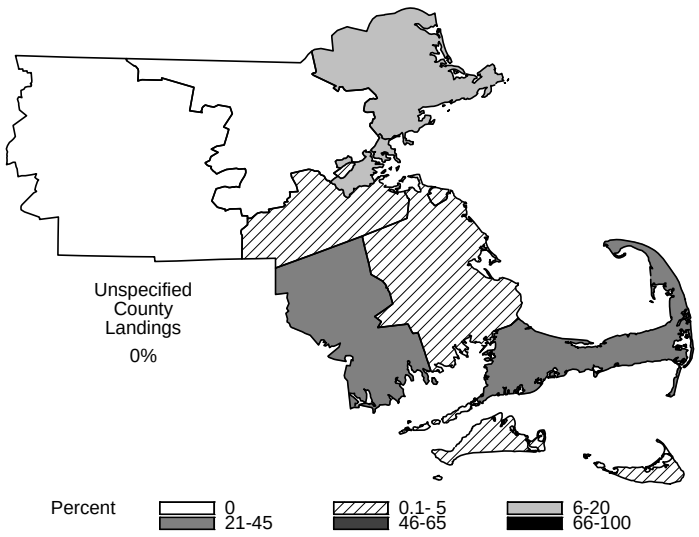
Fishermen must have a DMF commercial fishing permit (of any type) and a special striped bass fishing endorsement to sell their catch. They are required to file catch reports at the end of the season, which include the name of the dealer(s) that they sell to and extensive information describing their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

2006 Landings. The landings used here come from the SAFIS system. Commercial landings in 2006 were 1,312,168 pounds (69,986 fish) (Table 1). Most striped bass were sold in Barnstable,

Table 1. Attributes of the Massachusetts striped bass commercial fishery, 1990-2006.

	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
2006	26	1312.2	69.9	136	3,927

Figure 1. Percentage of total numbers of striped bass sold by commercial fishermen in Massachusetts counties in 2006.



Bristol and Essex 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 4,175 fish sampled from the 2006 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:

$$\log_{10}(W) = -3.4374 + 2.9896 * \log_{10}(L),$$
$$RMS = 0.0040$$

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:

$$W = 10^{(-3.4374 + 2.9896 * \log_{10}(L) + RMS/2)}$$

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 50% of all fish caught had lengths ≥34 inches.

Age and Sex Composition.. Six hundred and seven striped bass sampled from the 2006 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 306 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 17 years, and 97.7% were females. About 88.3% of the sub-sample consisted of individuals from the 1993-1997 year classes (ages 9-13) (Table 2).

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

Table 2. Age composition of the 2006 commercial harvest.

			Weighted		
Age	Year Class	Number	%	Mean Length (in.)	Mean Weight (lbs)
7	1999	2	0.7	33.4	13.0
8	1998	13	4.1	34.7	15.2
9	1997	48	15.9	35.2	15.4
10	1996	85	28.2	36.3	17.3
11	1995	66	22.2	37.6	18.3
12	1994	43	13.9	38.5	19.8
13	1993	28	8.1	40.6	23.0
14	1992	12	3.8	41.3	24.9
15	1991	4	1.5	42.3	27.6
16	1990	2	0.7	45.9	32.7
17	1989	3	1.0	45.5	35.9

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). 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. 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 remained low through 2005. In 2006, indices for ages 10-13+ increased.

Characterization of Other Losses. Release mortality was estimated by using a hook-release mortality rate of 8% applied against the released fish in Appendix Tables 1A and 1B. Total losses

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

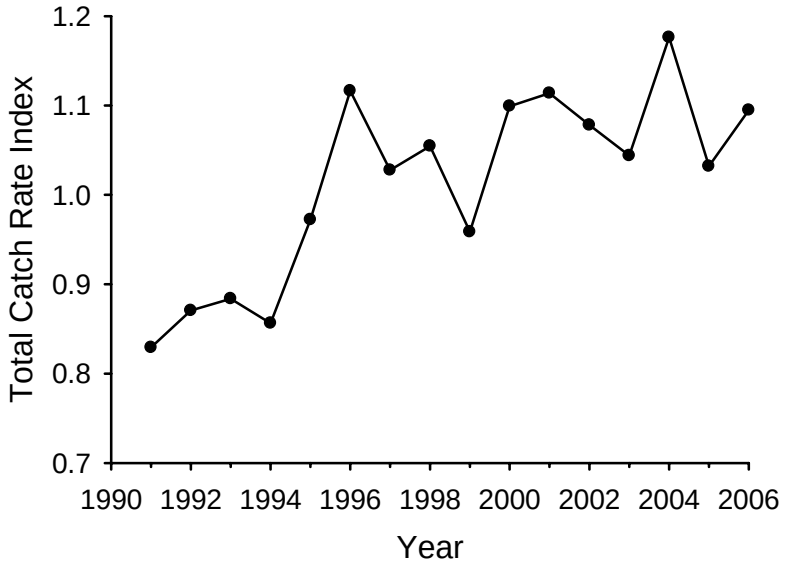
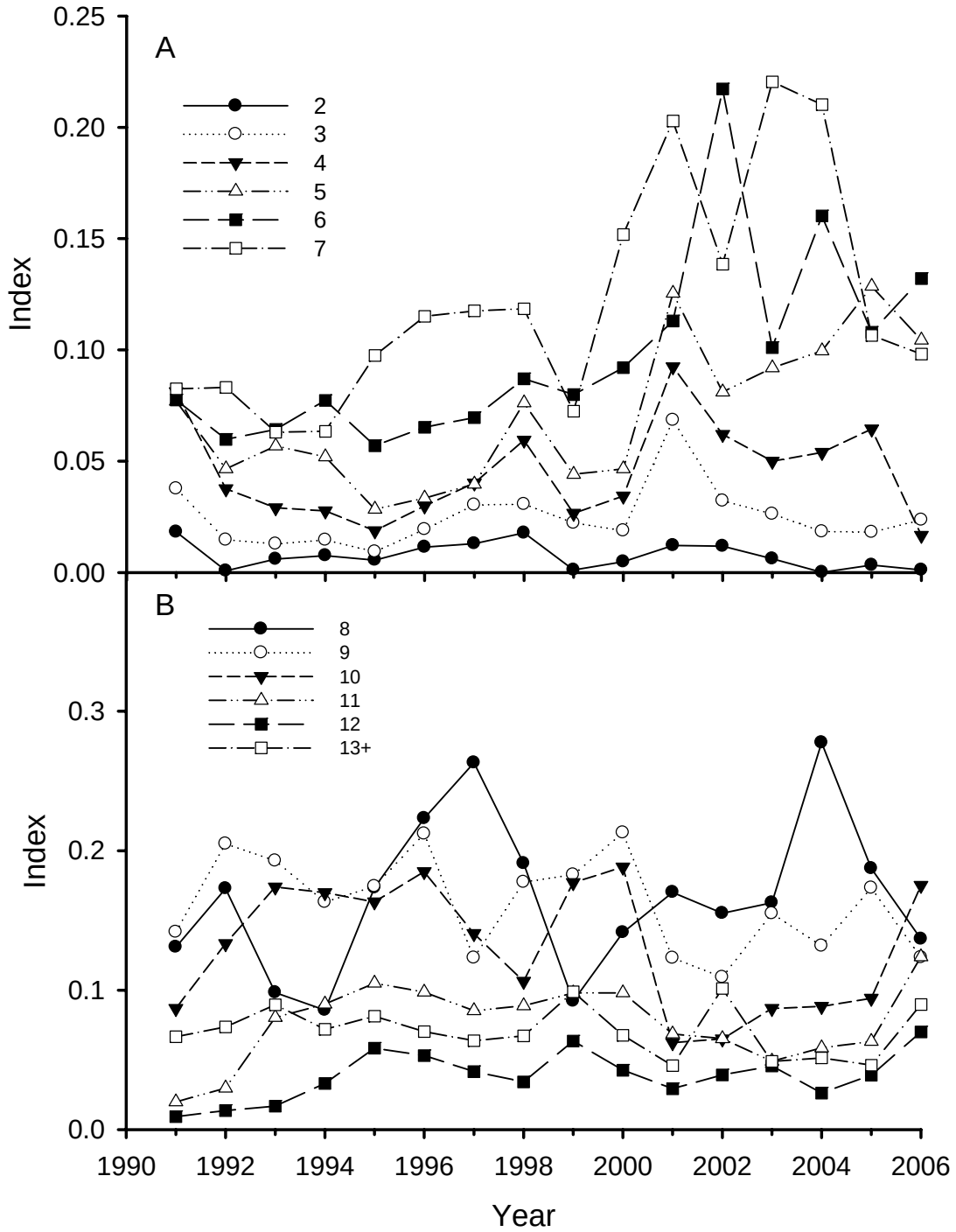


Figure 3. Age-specific total catch rate indices for A) ages 2-7 and B) ages 8-13+ striped bass.



due to release mortality were 5,969 fish weighing approximately 52,224 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 2006 was 9,007,876 striped bass, which is much higher than the 2005 estimate (Table 3). The estimate of total harvest in 2006 was 345,105, which is lower than the 2005 estimate. Total pounds harvested was over 4.9 million in 2006 (Table 3).

The MRFSS estimates were post-stratified by county to determine where harvested bass were being landed by recreational anglers. Most landings (92%) occurred in Barnstable, Plymouth, Dukes/ Nantucket, and Essex counties (Figure 4). Only 8% 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 1,700 samples were received from over 39 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 Appendix Tables 3A and 3B.

Age Composition. A sub-sample of 418 fish

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	368,422	5,093,748	4,839,752	5,208,174
2006	345,105	4,996,675	8,662,771	9,007,876

Figure 4. Percentage of total numbers of striped bass harvested by recreational anglers in each county of Massachusetts during 2006.

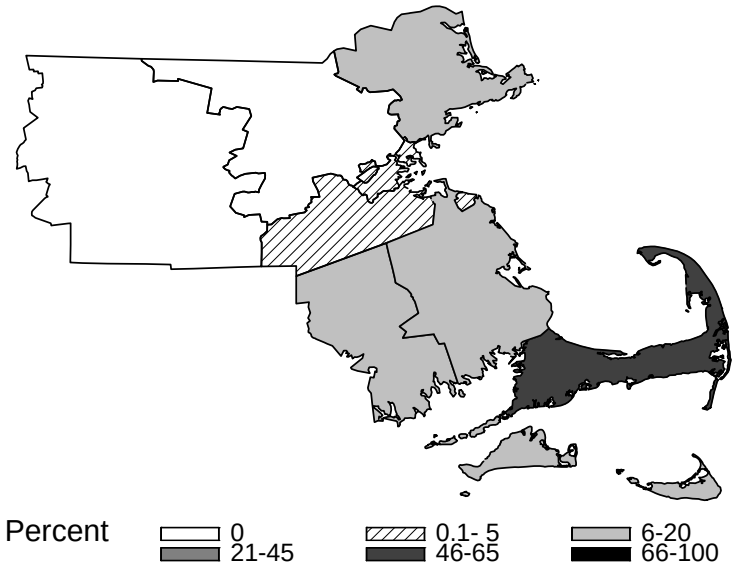
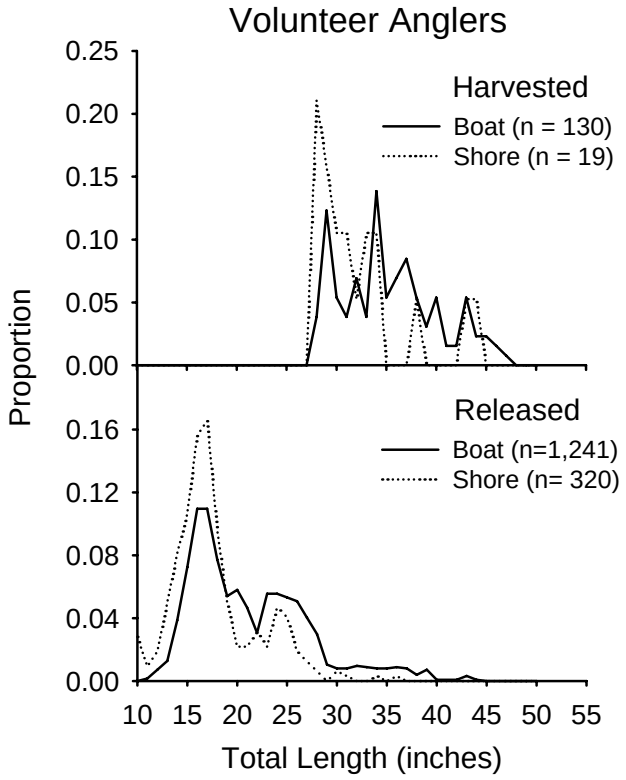


Figure 5. Sizes of striped bass caught by volunteer recreational anglers in 2006 by disposition and fishing mode.



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

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

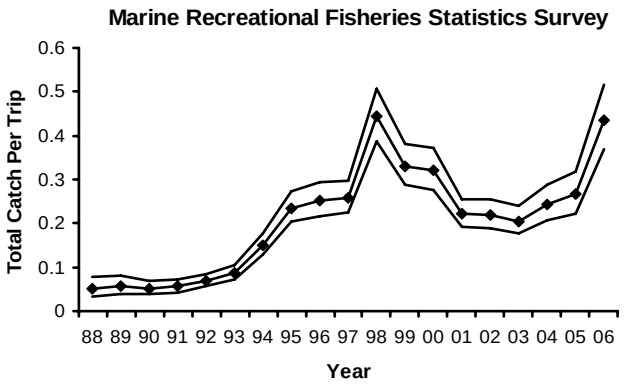
and y_i is calculated by

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

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). In 2006, catch rates jumped dramatically as the large 2003 year-class became vulnerable to the fishery.

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. Losses due to hook-and-release were 693,022 fish (2,374,954 pounds).

Scientific Collections

Based on reports from scientific collection permitees, 1 bass was taken or killed for scientific research in 2006.

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 2006 was 1,114,082 fish weighing 8,736,025 pounds (Table 4), which is a 32% increase in numbers lost and a 2.6% increase in weight compared to 2005 (844,899 fish; 8,514,543 pounds). The majority of losses, 93% by number and 84% 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. The 2001 and 2003 year-classes incurred the highest losses in 2006.

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

Table 4. Estimates of striped bass losses occurring in Massachusetts waters during 2006.

FISHERY	NUMBER	POUNDS	MEAN WT.
Commercial			
Harvest	69,986	1,312,168	18.7
Release Mortality	5,969	52,224	8.7
Recreational			
Harvest	345,105	4,996,675	14.5
Release Mortality	693,022	2,374,954	3.4
Scientific	1	4.1	4.1
Total	1,114,082	8,736,025	

Table 5. Massachusetts Striped Bass Removals-At-Age Matrix of 2006 By Source.

		Recreational		Commercial	
Age	Scientific	Release Mortality	Harvest	Release Mortality	Harvest
2	0	30649	0	12	0
3	0	291125	0	249	0
4	1	79370	0	176	0
5	0	138094	11558	1103	0
6	0	89946	32235	1387	0
7	0	18457	26771	961	460
8	0	12147	43404	1081	2868
9	0	9464	44581	507	11125
10	0	11359	69177	284	19766
11	0	6486	50245	175	15563
12	0	3330	30376	19	9697
13	0	1514	18756	8	5641
14	0	848	8802	4	2654
15	0	79	4943	1	1029
16	0	18	2251	0	476
17+	0	135	2004	0	706

tagging programs of state-federal participants.

For the analyses of survival, the ASMFC Tagging Subcommittee uses 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 declined through 1994-1995, but it has remained relatively stable since (Figure 7).

Planned Management Programs in 2007

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 will remain at 34-inches and the quota will be reduced from 1,159,750 pounds to 988,406 pounds due to overharvest in 2006. 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 2007.

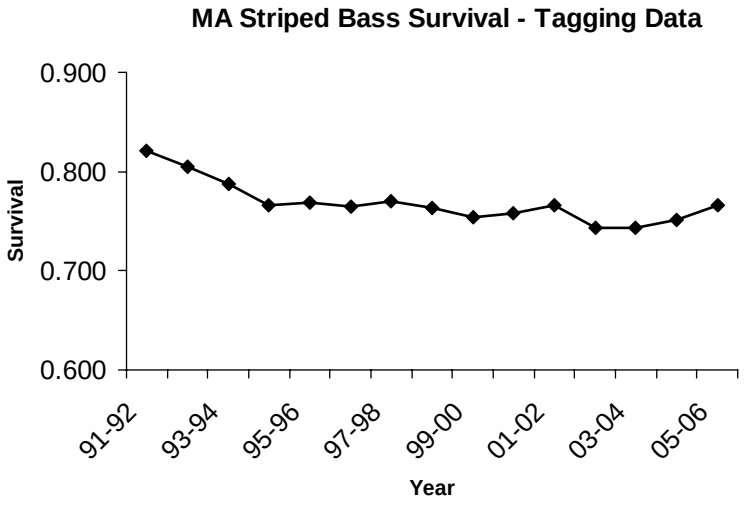
Table 6. Massachusetts tag summary statistics.

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
2006	11	4	390	813	94.2	565	1114

Table 7. Recapture matrix of striped bass ≥28 inches from 1991-2006 (Fall Tagging Only). A recapture year was defined as the beginning of tagging in year t to beginning of tagging in year t+1.

	Recapture Year														
Year Tagged	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1991	21	22	12	12	8	4	0	4	3	1	0	0	0	0	0
1992		35	32	26	29	17	17	11	2	2	2	2	1	0	0
1993			21	28	27	19	17	7	2	1	2	2	0	1	0
1994				15	12	10	4	5	3	1	1	1	0	0	1
1995					22	15	13	11	9	1	3	1	1	1	0
1996						17	6	3	3	1	2	0	1	0	1
1997							16	16	9	8	2	4	1	1	0
1998								6	3	1	1	0	0	0	0
1999									10	6	7	3	4	0	1
2000										21	23	16	9	11	3
2001											23	13	14	9	8
2002												9	3	6	6
2003													31	24	13
2004														25	25
2005															33
Total Released	329	612	463	219	274	118	220	59	163	411	353	172	615	542	510

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 2006.

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		367	367	0.25	0.25
15		157	157	0.11	0.36
16		681	681	0.47	0.83
17		1,048	1,048	0.72	1.56
18		838	838	0.58	2.14
19		681	681	0.47	2.61
20		681	681	0.47	3.08
21		1,310	1,310	0.91	3.99
22		1,048	1,048	0.72	4.71
23		1,886	1,886	1.30	6.02
24		2,358	2,358	1.63	7.65
25		3,039	3,039	2.10	9.75
26		4,192	4,192	2.90	12.65
27		4,349	4,349	3.01	15.65
28		5,816	5,816	4.02	19.68
29		4,506	4,506	3.12	22.79
30		8,960	8,960	6.20	28.99
31	109	7,073	7,182	4.97	33.96
32	0	10,689	10,689	7.39	41.35
33	1,507	11,108	12,615	8.72	50.07
34	8,203	2,148	10,351	7.16	57.23
35	9,194	314	9,508	6.58	63.81
36	10,080	472	10,552	7.30	71.10
37	9,020	524	9,544	6.60	77.70
38	6,043	105	6,148	4.25	81.96
39	7,656	0	7,656	5.29	87.25
40	5,646	157	5,803	4.01	91.26
41	2,907	0	2,907	2.01	93.27
42	3,073	0	3,073	2.13	95.40
43	2,344	105	2,449	1.69	97.09
44	2,157	0	2,157	1.49	98.59
45	1,034	0	1,034	0.72	99.30
46	348	0	348	0.24	99.54
47	447	0	447	0.31	99.85
48	0	0	0	0.00	99.85
49	217	0	217	0.15	100.00
50	0	0	0	0.00	100.00
51	0	0	0	0.00	100.00
52	0	0	0	0.00	100.00
Total	69,985	74,610	144,595		
Avg. Size	37.8	28.9	33.2		

Appendix Table 1B. Estimated size distribution of the Massachusetts commercial striped bass catch (pounds) in 2006.

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	347	347	0.02	0.02
15	0	183	183	0.01	0.03
16	0	960	960	0.05	0.08
17	0	1,771	1771	0.09	0.17
18	0	1,681	1681	0.09	0.25
19	0	1,605	1605	0.08	0.33
20	0	1,872	1872	0.10	0.43
21	0	4,164	4164	0.21	0.64
22	0	3,829	3829	0.19	0.83
23	0	7,871	7871	0.40	1.23
24	0	11,173	11173	0.57	1.80
25	0	16,271	16271	0.83	2.63
26	0	25,234	25234	1.28	3.91
27	0	29,308	29308	1.49	5.40
28	0	43,696	43696	2.22	7.62
29	0	37,599	37599	1.91	9.53
30	0	82,736	82736	4.20	13.73
31	1,110	72,046	73156	3.72	17.44
32	0	119,708	119708	6.08	23.52
33	18,504	136,390	154895	7.87	31.39
34	110,127	28,840	138966	7.06	38.45
35	134,605	4,603	139207	7.07	45.52
36	160,544	7,510	168054	8.54	54.06
37	155,924	9,057	164981	8.38	62.44
38	113,132	1,962	115093	5.85	68.28
39	154,903	0	154903	7.87	76.15
40	123,217	3,430	126647	6.43	82.58
41	68,302	0	68302	3.47	86.05
42	77,596	0	77596	3.94	89.99
43	63,502	2,839	66341	3.37	93.36
44	62,593	0	62593	3.18	96.54
45	32,090	0	32090	1.63	98.17
46	11,534	0	11534	0.59	98.76
47	15,799	0	15799	0.80	99.56
48	0	0	0	0.00	99.56
49	8,687	0	8687	0.44	100.00
50	0	0	0	0.00	100.00
51	0	0	0	0.00	100.00
52	0	0	0	0.00	100.00
Total	1,312,168	656,687	1,968,855		
Avg. Weight	18.7	8.8	13.6		

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 Value	Pr > F
Model	19	417.083674	21.951772	94.22	<.0001
Error	37348	8701.212007	0.232977		
Corrected Total	37367	9118.295681			

R-Square	Coeff Var	Root MSE	logn Mean
0.045741	61.30416	0.482677	0.787347

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Year	15	105.6526052	7.0435070	30.23	<.0001
Method	2	120.7724530	60.3862265	259.19	<.0001
Subarea	2	190.6586156	95.3293078	409.18	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Year	15	74.4364384	4.9624292	21.30	<.0001
Method	2	106.7747625	53.3873812	229.15	<.0001
Subarea	2	190.6586156	95.3293078	409.18	<.0001

Least Squares Means

year	logn LSMEAN	Standard Error	Pr > |t|
1991	0.60389033	0.01240237	<.0001
1992	0.62626364	0.01271851	<.0001
1993	0.63325862	0.01261146	<.0001
1994	0.61863048	0.01262952	<.0001
1995	0.67916106	0.01011233	<.0001
1996	0.74973315	0.02183959	<.0001
1997	0.70690359	0.00947871	<.0001
1998	0.72005766	0.00995377	<.0001
1999	0.67224270	0.01048139	<.0001
2000	0.74151826	0.01085201	<.0001
2001	0.74844298	0.01090332	<.0001
2002	0.73143056	0.01067175	<.0001
2003	0.71482681	0.00907460	<.0001
2004	0.77755749	0.01309921	<.0001
2005	0.70902148	0.01099648	<.0001
2006	0.73942967	0.00978491	<.0001

Appendix Table 3A. Estimated size distribution of the Massachusetts recreational striped bass catch (numbers of fish) in 2006.

TL (in.)	Harvested	Released	Total	Percent	Cumulative Percent
9	0	0	0		
10	0	58,292	58,292	0.65	0.65
11	0	31,868	31,868	0.35	1.00
12	0	96,204	96,204	1.07	2.07
13	0	198,310	198,310	2.20	4.27
14	0	441,433	441,433	4.90	9.17
15	0	693,878	693,878	7.70	16.87
16	0	1,007,874	1,007,874	11.19	28.06
17	0	984,303	984,303	10.93	38.99
18	0	677,011	677,011	7.52	46.51
19	0	452,155	452,155	5.02	51.53
20	0	437,338	437,338	4.86	56.38
21	0	373,328	373,328	4.14	60.52
22	0	298,319	298,319	3.31	63.84
23	0	450,332	450,332	5.00	68.84
24	0	451,234	451,234	5.01	73.85
25	0	428,914	428,914	4.76	78.61
26	0	369,391	369,391	4.10	82.71
27	0	297,271	297,271	3.30	86.01
28	11,474	208,293	219,767	2.44	88.45
29	22,066	65,360	87,426	0.97	89.42
30	17,652	73,419	91,071	1.01	90.43
31	26,479	65,566	92,045	1.02	91.45
32	22,948	73,589	96,537	1.07	92.52
33	19,418	62,212	81,630	0.91	93.43
34	27,361	62,471	89,832	1.00	94.43
35	29,127	55,994	85,121	0.94	95.37
36	23,831	75,223	99,054	1.10	96.47
37	41,483	48,425	89,908	1.00	97.47
38	21,183	31,780	52,963	0.59	98.06
39	22,066	55,622	77,688	0.86	98.92
40	16,770	2,434	19,204	0.21	99.13
41	11,474	2,434	13,908	0.15	99.29
42	6,178	2,434	8,612	0.10	99.38
43	13,239	27,625	40,864	0.45	99.84
44	6,178	2,434	8,612	0.10	99.93
45	3,530	0	3,530	0.04	99.97
46	1,765	0	1,765	0.02	99.99
47	883	0	883	0.01	100.00
48	0	0	0	0.00	100.00
49	0	0	0	0.00	100.00
50	0	0	0	0.00	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	345,105	8,662,770	9,007,875		
Avg. Size	35.4	20.4	21.0		

Appendix Table 3B. Estimated size distribution of the Massachusetts recreational striped bass catch (pounds) in 2006.

TL (in.)	Kept	Released	Total	Percent	Cumulative Percent
9	0	0	0		
10	0	18,452	18,452	0.05	0.05
11	0	13,413	13,413	0.04	0.09
12	0	52,523	52,523	0.15	0.24
13	0	137,540	137,540	0.40	0.64
14	0	382,092	382,092	1.10	1.74
15	0	738,185	738,185	2.13	3.87
16	0	1,300,418	1,300,418	3.75	7.62
17	0	1,522,366	1,522,366	4.39	12.01
18	0	1,242,221	1,242,221	3.58	15.59
19	0	975,191	975,191	2.81	18.40
20	0	1,099,556	1,099,556	3.17	21.57
21	0	1,086,021	1,086,021	3.13	24.70
22	0	997,307	997,307	2.88	27.58
23	0	1,719,474	1,719,474	4.96	32.54
24	0	1,956,694	1,956,694	5.64	38.18
25	0	2,101,326	2,101,326	6.06	44.24
26	0	2,034,851	2,034,851	5.87	50.10
27	0	1,833,157	1,833,157	5.29	55.39
28	78,883	1,431,992	1,510,874	4.36	59.74
29	168,481	499,045	667,526	1.92	61.67
30	149,155	620,373	769,528	2.22	63.89
31	246,785	611,077	857,863	2.47	66.36
32	235,171	754,140	989,311	2.85	69.21
33	218,171	698,983	917,153	2.64	71.86
34	336,112	767,416	1,103,528	3.18	75.04
35	390,198	750,120	1,140,317	3.29	78.33
36	347,302	1,096,266	1,443,568	4.16	82.49
37	656,160	765,965	1,422,125	4.10	86.59
38	362,871	544,400	907,271	2.62	89.21
39	408,521	1,029,762	1,438,283	4.15	93.35
40	334,885	48,605	383,490	1.11	94.46
41	246,682	52,329	299,011	0.86	95.32
42	142,744	56,238	198,982	0.57	95.89
43	328,183	684,800	1,012,983	2.92	98.81
44	164,043	64,630	228,673	0.66	99.47
45	100,245	0	100,245	0.29	99.76
46	53,527	0	53,527	0.15	99.92
47	28,557	0	28,557	0.08	100.00
48	0	0	0	0.00	100.00
49	0	0	0	0.00	100.00
50	0	0	0	0.00	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	4,996,675	29,686,929	34,683,604		
Avg. Weight	14.5	3.4	3.9		

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

Type 3 Analysis of Effects

Effect	DF	Wald Chi-Square	Pr > ChiSq
YEAR	18	1550.3738	<.0001
WAVE	3	255.5321	<.0001
CNTY	7	499.2664	<.0001
AREA_X	2	186.0664	<.0001
MODE_FX	4	2957.3098	<.0001
FFDAYS12	14	890.4607	<.0001
NUM_HRSF	1	1858.1701	<.0001

R-Square 0.1992 Max-rescaled R-Square 0.2694

Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	-3.2478	19.3960	0.0280	0.8670
YEAR	1988	1	-0.9164	0.1194	58.8873	<.0001
YEAR	1989	1	-0.7510	0.1040	52.1192	<.0001
YEAR	1990	1	-0.8730	0.0798	119.7109	<.0001
YEAR	1991	1	-0.9505	0.0736	166.9740	<.0001
YEAR	1992	1	-0.7984	0.0554	207.9883	<.0001
YEAR	1993	1	-0.4925	0.0523	88.7944	<.0001
YEAR	1994	1	-0.0118	0.0432	0.0752	0.7840
YEAR	1995	1	0.2947	0.0395	55.7179	<.0001
YEAR	1996	1	0.3208	0.0420	58.3647	<.0001
YEAR	1997	1	0.3249	0.0379	73.4750	<.0001
YEAR	1998	1	0.7890	0.0369	456.2767	<.0001
YEAR	1999	1	0.5423	0.0376	208.5091	<.0001
YEAR	2000	1	0.4745	0.0402	139.1362	<.0001
YEAR	2001	1	0.2397	0.0380	39.7084	<.0001
YEAR	2002	1	0.2997	0.0423	50.1872	<.0001
YEAR	2003	1	0.2090	0.0413	25.6182	<.0001
YEAR	2004	1	0.2977	0.0487	37.3595	<.0001
YEAR	2005	1	0.3567	0.0518	47.3974	<.0001
WAVE	3	1	0.3570	0.0290	151.3640	<.0001
WAVE	4	1	0.0417	0.0285	2.1399	0.1435
WAVE	5	1	-0.0634	0.0302	4.4038	0.0359
CNTY	1	1	0.00876	0.0248	0.1253	0.7233
CNTY	5	1	-0.2583	0.0472	29.9404	<.0001
CNTY	7	1	-0.1195	0.0544	4.8249	0.0281
CNTY	9	1	0.4698	0.0262	321.2007	<.0001
CNTY	19	1	-0.4949	0.0782	40.0393	<.0001
CNTY	21	1	0.2508	0.0508	24.3600	<.0001
CNTY	23	1	-0.0405	0.0322	1.5797	0.2088
AREA_X	1	1	-0.1199	0.0163	54.3037	<.0001
AREA_X	2	1	-0.0832	0.0221	14.2057	0.0002
MODE_FX	3	1	0.7845	19.3960	0.0016	0.9677
MODE_FX	4	1	-9.7994	77.5837	0.0160	0.8995
MODE_FX	5	1	3.8231	19.3961	0.0389	0.8437
MODE_FX	6	1	3.2355	19.3960	0.0278	0.8675
FFDAYS12	0	1	-0.6247	0.0367	289.1103	<.0001
FFDAYS12	10	1	-0.4790	0.0399	144.2873	<.0001
FFDAYS12	20	1	-0.1987	0.0404	24.1501	<.0001
FFDAYS12	30	1	-0.1043	0.0447	5.4457	0.0196
FFDAYS12	40	1	0.00253	0.0526	0.0023	0.9615
FFDAYS12	50	1	0.1499	0.0473	10.0249	0.0015
FFDAYS12	60	1	0.0977	0.0611	2.5588	0.1097
FFDAYS12	70	1	0.2189	0.0735	8.8691	0.0029
FFDAYS12	80	1	0.1948	0.1023	3.6244	0.0569
FFDAYS12	90	1	0.0183	0.1101	0.0276	0.8681
FFDAYS12	100	1	0.2934	0.0500	34.4230	<.0001
FFDAYS12	150	1	0.3402	0.0783	18.9020	<.0001
FFDAYS12	200	1	0.3332	0.1015	10.7747	0.0010
FFDAYS12	250	1	-0.4601	0.2865	2.5799	0.1082
NUM_HRSF		1	0.2266	0.00526	1858.1701	<.0001

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

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	48	2777.20152	57.85837	71.87	<.0001
Error	18787	15123.70952	0.80501		
Corrected Total	18835	17900.91104			

R-Square	Coeff Var	Root MSE	logtot Mean
0.155143	78.58101	0.897223	1.141781

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	18	349.5497526	19.4194307	24.12	<.0001
WAVE	3	179.7739078	59.9246359	74.44	<.0001
CNTY	7	197.3246462	28.1892352	35.02	<.0001
AREA_X	2	45.7580052	22.8790026	28.42	<.0001
MODE_FX	3	471.4476091	157.1492030	195.21	<.0001
FFDAYS12	14	485.3886742	34.6706196	43.07	<.0001
NUM_HRSF	1	756.1482830	756.1482830	939.30	<.0001

YEAR	LSMEAN	Standard Error	Pr > |t|
1988	0.81332190	0.10095487	<.0001
1989	0.73787920	0.08391713	<.0001
1990	0.76068920	0.06801394	<.0001
1991	0.93455673	0.06435657	<.0001
1992	0.98313565	0.04950021	<.0001
1993	0.90965074	0.04811310	<.0001
1994	1.00713640	0.03967147	<.0001
1995	1.15645422	0.03650944	<.0001
1996	1.19836616	0.03863731	<.0001
1997	1.21883862	0.03573073	<.0001
1998	1.32843512	0.03448187	<.0001
1999	1.26482863	0.03498064	<.0001
2000	1.29904745	0.03716628	<.0001
2001	1.14520305	0.03680458	<.0001
2002	1.08321132	0.03871378	<.0001
2003	1.10311883	0.03846804	<.0001
2004	1.18956865	0.03968197	<.0001
2005	1.22044660	0.04088478	<.0001
2006	1.44346980	0.03726156	<.0001