Technical Report

Massachusetts Division of Marine Fisheries
Technical Report TR-48

Massachusetts Striped Bass Monitoring Report for 2010

G. A. Nelson

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

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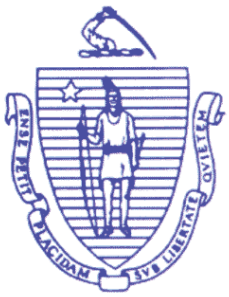

Massachusetts Striped Bass Monitoring Report for 2010

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Gloucester, MA 01930

September 2011

Commonwealth of Massachusetts
Deval Patrick, Governor
Executive Office of Energy and Environmental Affairs
Richard K. Sullivan, Jr., Secretary
Department of Fish and Game
Mary B. Griffin, Commissioner
Massachusetts Division of Marine Fisheries
Paul Diodati, Director

Summary: During 2010, the commercial fishery for striped bass in Massachusetts sold about 60,372 fish weighing 1,224,256 pounds and kept approximately 4,904 fish for personal consumption. Total losses due to commercial harvesting (including release mortality) were 71,345 fish weighing 1,355,116 pounds. The recreational fishery harvested about 354,157 striped bass weighing over 4.1 million pounds. Total losses due to recreational fishing (including release mortality) were 507,922 fish weighing over 4.9 million pounds. Combined losses (including scientific losses) were 579,299 fish weighing over 6.2 million pounds, which reflects a 4% decrease in numbers lost and a 11% decrease in weight lost compared to 2009 (605,094 fish; 7.0 million pounds). The majority of losses, 87% by number and 78% by weight, was attributed to the recreational fishery.

Introduction

This report summarizes the commercial and recreational striped bass fisheries conducted in Massachusetts during 2010. 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 13-August 22. No landings were permitted on Monday, Friday, or Saturday.

Sold: 1,224,356 pounds (against a harvest quota of 1,128,577 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.

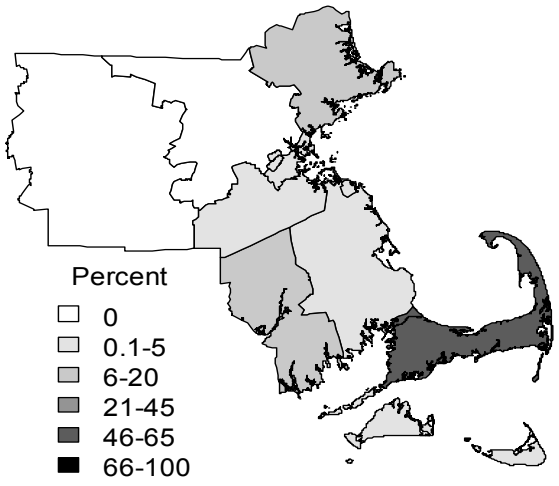
Licensing, Reporting, and Estimation of Landings. To purchase striped bass directly from fishermen, fish dealers are required to obtain special authorization from the DMF in addition to standard seafood dealer permits. Dealer reporting requirement included weekly reporting to the DMF or SAFIS system 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 monthly trip level reports which include the name of the dealer(s) that they sell to and information describing their catch composition

Table 1. Attributes of the Massachusetts striped bass commercial fishery, 1990-2010.

		Sold			
	Season	Pounds	Number	Dealer	Fishing
Year	(Days)	000s	000s	Permits	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	3,578
2000	36	779.7	40.2	137	3,283
2001	29	815.0	40.2	164	4,219
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	4,159
2006	26	1312.1	69.9	136	3,980
2007	22	1040.3	54.3	160	3,906
2008	34	1160.1	61.1	167	3,821
2009	27	1138.3	59.3	178	4,020
2010	24	1224.4	60.4	178	3,951

Figure 1. Percentage of total pounds of striped bass sold by commercial fishermen in Massachusetts counties in 2010.



and catch rates

2010 Landings. The landings used here come from the SAFIS system. Commercial anglers sold 1,224,356 pounds (60,372 fish) of striped bass in 2010 (Table 1). Most striped bass were sold in Barnstable, Bristol and Essex counties of Massachusetts (Figure 1). Commercial fishers kept an additional 4,904 fish weighing approximately 74,014 pounds for personal consumption.

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 3,468 fish sampled from the 2010 commercial harvest and 2000 DMF diet study were used to construct a length-weight equation to estimate weight-at-size for individual bass. The following geometric regression was derived:

$$\log_{10}(W) = -3.442 + 2.991 * \log_{10}(L),$$
$$RMS = 0.0027$$

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:

$$W = 10^{(-3.442 + 2.991 * \log_{10}(L) + RMS/2)}$$

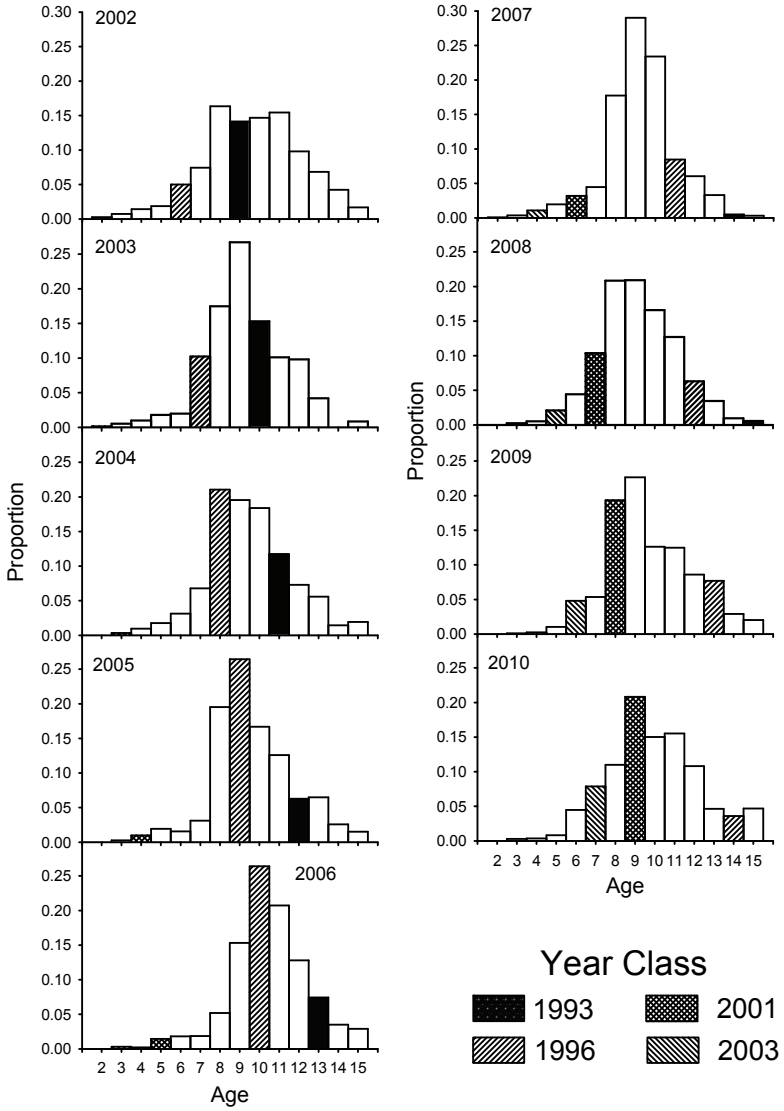
Size composition of the commercial catch by category of disposition is presented in Appendix Tables 1A (numbers of fish) and 1B (pounds of fish). About 45% of all fish caught had lengths ≥34 inches.

Age and Sex Composition.. Six hundred and twenty striped bass sampled from the 2010 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 357 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 6 to 15+ years, and 98.5% were females. About 80% of the sub-sample consisted of individuals from the 1998-2002 year classes (ages 8-12) (Table 2). Peak numbers-at-age of the total catches (harvest plus releases plus consumed) were from the 2001 year-class (Figure 2).

Table 2. Age composition of the 2010 commercial (sold) landings.

			Weighted		
Age	Year Class	Number	%	Mean Length (in.)	Mean Weight (lbs)
6	2004	1	0.7	32.4	13.5
7	2003	12	4.7	34.6	14.4
8	2002	41	11.7	35.3	15.2
9	2001	69	20.9	36.3	16.5
10	2000	56	14.3	37.6	18.4
11	1999	53	17.4	39.9	22.3
12	1998	49	12.7	40.2	23.3
13	1997	48	10.8	41.7	26.7
14	1996	13	3.7	42.1	26.9
15+	<1995	15	3.2	44.5	32.8

Figure 2. Age composition (proportion) of total catches from the Massachusetts commercial fishery.



Estimates of Total Catch and Harvest Rates. Estimates of harvest rates (pounds of fish harvested per hour) for the commercial fishery were developed in order to provide an index that may be indicative of fishing success. In 2010, DMF switched to trip-level reporting. Significant information has been lost due to the generalization of the report to cover all fisheries in Massachusetts. The only information now available is daily total hours fished, pounds of fish sold and consumed, and area fished. This information was used under a generalized linear model (GLM) framework to generate standardized indices (Hilborn and Walter, 1992). Each record represented the summarization of a permit's pounds harvested and hours fished by year, month, and area fished reduced to 4 regions (Cape Cod Canal, Southern MA, Cape Cod Bay, North MA). Only data from July-August were used to constraint analyses to the most recent duration of the fishing season. The harvest rates for each record was calculated by dividing the total pounds caught by the total number of hours fished. The harvest rate was standardized using the GLM model

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

where y is the observed total catch or harvest 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-II (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

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

where LSM is the least-squares natural log mean of each year.

Results of the GLM analyses of harvest rates are shown in Appendix Tables 2. Although factors were significant, the variables accounted for only about 9% of the total variation in harvest rates.

Harvest rates steadily increased after 1999, peaked in 2004, dropped through 2008, but increased slightly through 2010 (Fig. 3).

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 due to release mortality were 6,069 fish weighing approximately 56,745 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 2010 was 2,276,215 striped bass, which is a 19% decline compared to the 2009 estimate (Table 3). The estimate of total harvest in 2010 was 354,157, which is an increase in harvest of 5% compared to 2009. Total pounds harvested was over 4.2 million in 2010 (Table 3).

The MRFSS estimates were post-stratified by county to determine where harvested bass were being landed by recreational anglers. Most landings (88%) occurred in Barnstable, Plymouth, Essex, and Bristol counties (Figure 4). Only X% of landings occurred in Dukes, Nantucket, Suffolk and Norfolk counties (Figure 4).

Size Composition. The length distributions of harvested and released fish were estimated from biological sampling conducted by the MRFSS program in Massachusetts and from a volunteer angler program conducted by the Massachusetts Division of Marine Fisheries. 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 each fish (released or harvested) and fishing mode. Over 1,620 samples were received from 35 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

Figure 3. Total harvest rates (pounds/hour) for the Massachusetts commercial striped bass fishery, 1990-2010.

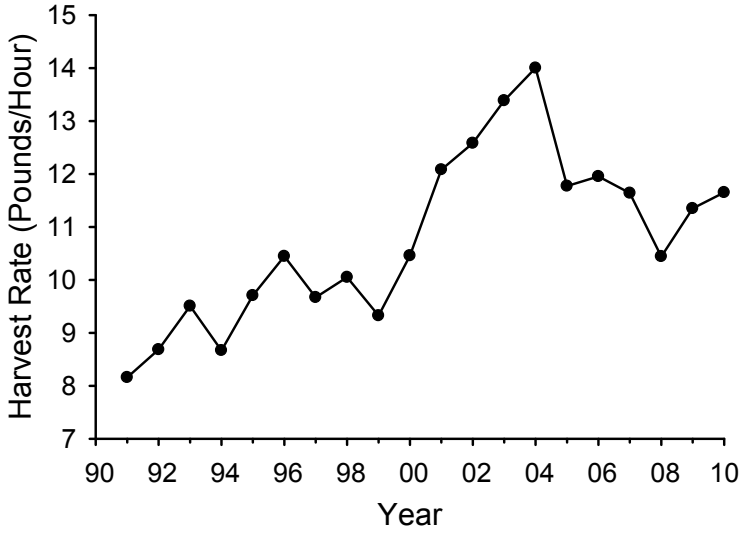


Table 3. MRFSS estimates of striped bass harvest, releases, and total catch in Massachusetts.

	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	339,994	4,907,270	8,657,473	8,997,467
2007	347,102	4,784,948	5,772,100	6,119,202
2008	343,347	5,516,183	3,641,258	3,984,605
2009	336,470	4,525,166	2,490,380	2,826,850
2010	354,157	4,062,205	1,922,058	2,276,215

Figure 4. Percentage of total numbers of striped bass harvested by recreational anglers in each county of Massachusetts during 2010.

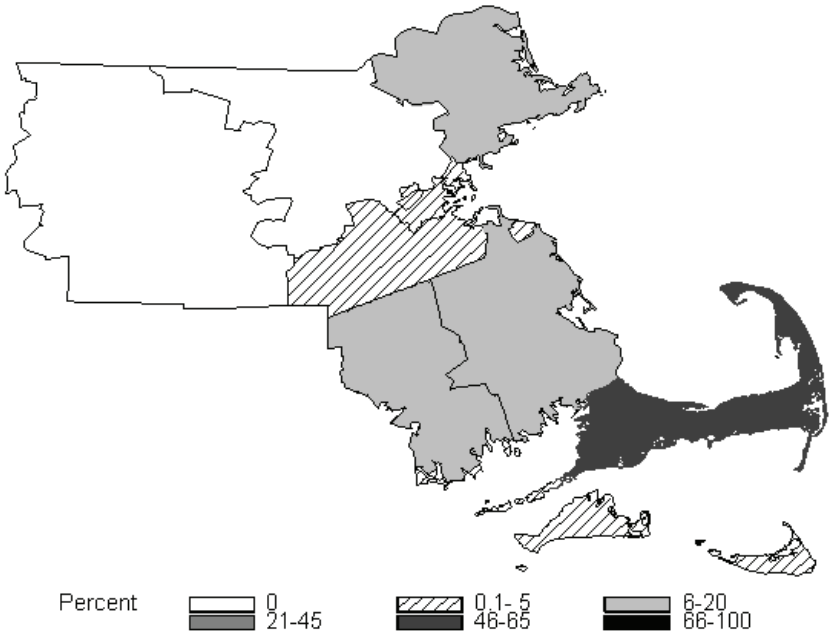
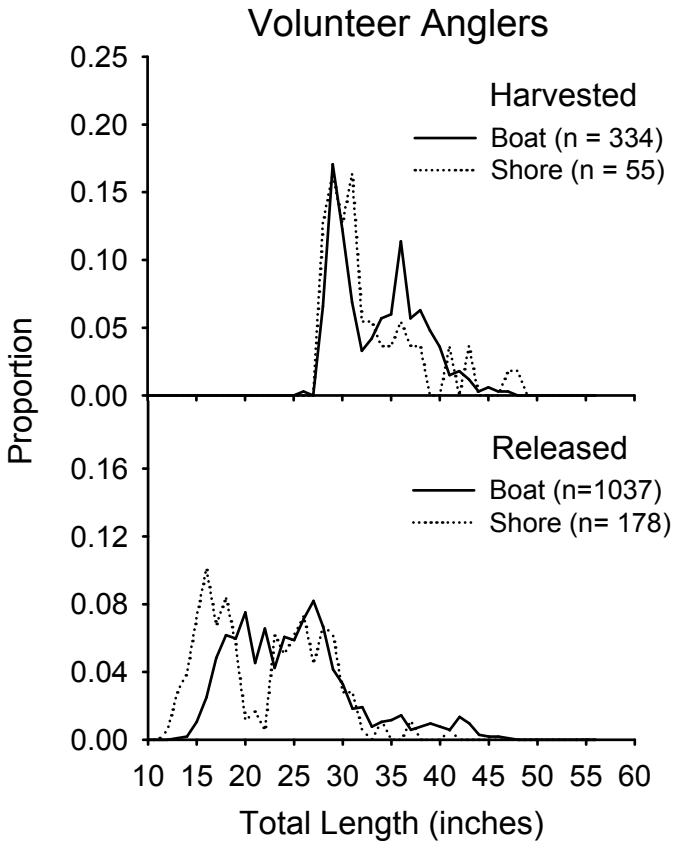


Figure 5. Sizes of striped bass caught by volunteer recreational anglers in 2010 by disposition and fishing mode.



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 544 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 and MA volunteer angler size distributions 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). Recreational catches of striped bass were comprised mostly of the 2003 and 2004 year-classes. (Figure 6).

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-Gamma model (Lo et al., 1992; Stefansson, 1996) which adjusts trip catches for the effects of year, wave, county, area fished, mode fished, and time spent fishing. A delta-Gamma 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-Gamma 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 modeled as a binary response to the categorical variables using multiple logistic regression:

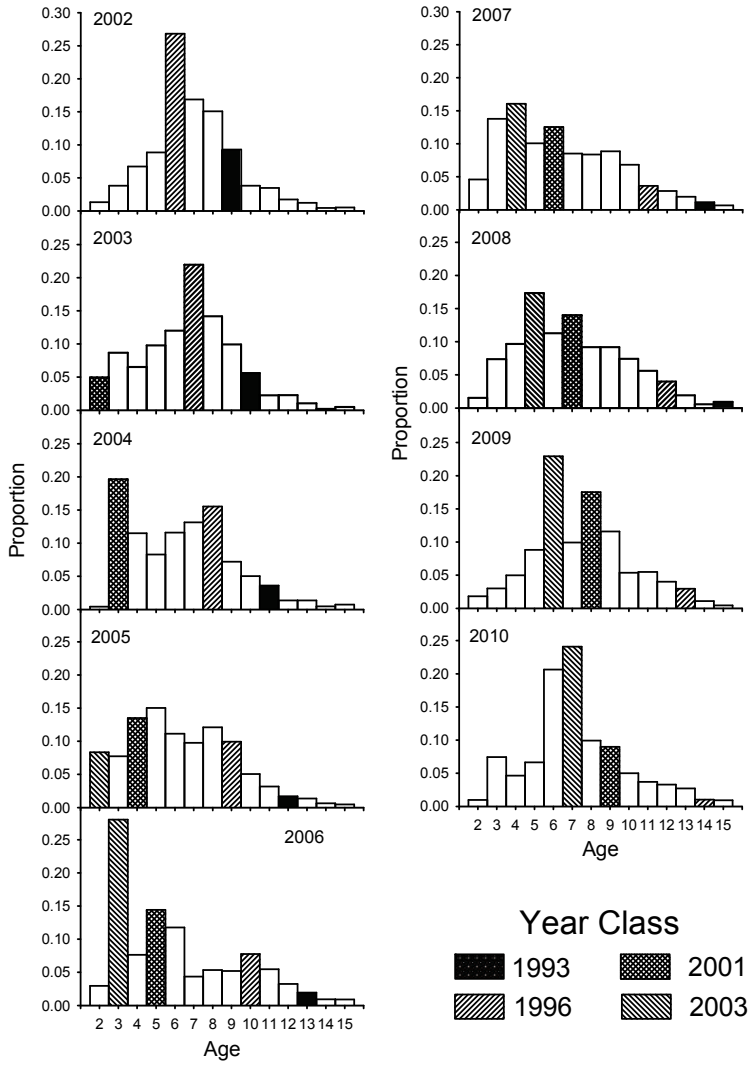
$$\text{logit}(p) = \log(p/1-p) = a + \sum_{i=1}^{n} b_i X_i + e$$

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. The function *glm* in *R* was used to estimate parameters, and goodness-of-fit was assessed using partial and empirical probability plots.

Positive catches were modeled assuming a Gamma error distribution with a log link using function *glm* in *R*

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

Figure 6. Age composition (proportion) of total catches from the Massachusetts recreational fishery.



where *y* is the observed positive catch, b_i ,and X_i are the same symbols as defined earlier, and *e* is the Gamma error term. Any variable not significant at α=0.05 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 leasts quares mean estimates from the logistic and GLM models. Only data for those anglers who said they targeted striped bass were used in the analyses.

Results of the delta-Gamma model analyses are given in Appendix Tables 4A and 4B. Standardized catch rates for striped bass in Massachusetts waters increased from 1993 to 1998, declined through 2003, but increased in 2004 and 2005 (Fig. 7). In 2006, catch rates jumped dramatically as the large 2003 year-class became vulnerable to the fishery. Since 2006, catch rates have declined (Fig. 7).

Characterization of Losses

The same methods and rates previously described in the commercial fishery section were used to estimate recreational losses. Losses due to

Table 4. Estimates of striped bass losses occurring in Massachusetts waters during 2010.

FISHERY	NUMBER	POUNDS	MEAN WT.
Commercial			
Harvest*	65,276	1,298,371	19.9
Release Mortality	6,069	56,745	9.4
Recreational			
Harvest	354,157	4,062,205	11.5
Release Mortality	153,765	870,033	5.7
Scientific	32	90	2.8
Total	579,299	6,287,444	

* includes fish taken for personal consumption

hook-and-release were 153,765 fish (870,033 pounds) (Table 4).

Scientific Collections

About 32 bass were taken for scientific research in 2010.

Bycatch 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*). The bycatch estimate was about 3,100 fish (17,600 pounds). Anecdotal information was also reported which suggested that a single tow could land up to 19,000 pounds. DMF personnel sampled this fishery at sea 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 2010.

Estimated Total Losses

Total estimated loss of striped bass during 2010 was 579,299 fish weighing 6,287,444 pounds (Table 4), which is a 4% decrease in numbers lost and a 11% decrease in weight compared to 2009 (605,094 fish; 7,047,161 pounds). The majority of

Figure 7. Index of total catch rates (total number of fish caught per trip) of the recreational fishery for striped bass in Massachusetts waters, 1987-2010.

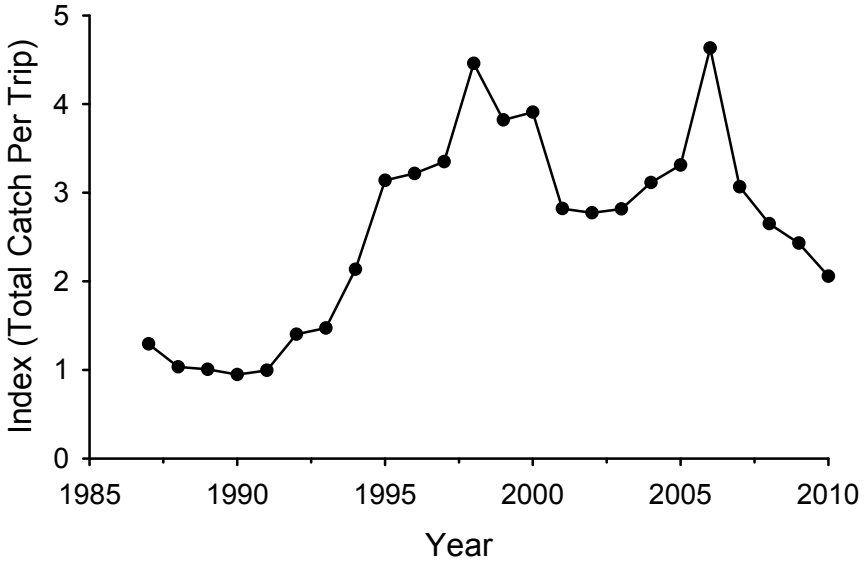


Table 5. Massachusetts Striped Bass Removals-At-Age Matrix of 2010 By Source.

		Recreational		Commercial		
Age	Scientific	Release Mortality	Harvest	Release Mortality	Harvest*	Total
2	0	5,063	0	26	0	5,089
3	17	38,873	0	220	0	39,110
4	14	24,086	85	263	0	24,447
5	1	22,103	12,168	537	76	34,885
6	0	25,129	79,682	1749	1,085	107,646
7	0	20,053	101,715	2262	4,052	128,082
8	0	4,600	45,425	658	7,947	58,631
9	0	3,937	41,237	272	13,447	58,892
10	0	2,111	23,057	62	9,018	34,248
11	0	1,988	16,602	14	10,749	29,354
12	0	1,949	14,599	5	7,901	24,454
13	0	1,992	11,647	0	6,705	20,344
14	0	1,013	4,124	0	2,293	7,430
15+	0	866	3,817	0	2,005	6,687

* includes fish taken for personal consumption

losses, 87% by number and 78% 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 2004 (age 6), 2003 (age 7) and 2001 (age 9) year-classes incurred the highest losses in 2010 (Figure 8).

Age-Length Relationship

A von Bertalanffy growth model was fitted to age (years) and total length (inches) data from samples collected in the tagging study, the recreational fishery, and commercial fishery from 2004-2010. The resulting equation and predicted relationship are shown in Figure 9.

Required Fishery-Independent Monitoring Programs

Figure 8. Total number of striped bass removals in 2010 by age. The 2004, 2003 and 2001 year-classes are indicated.

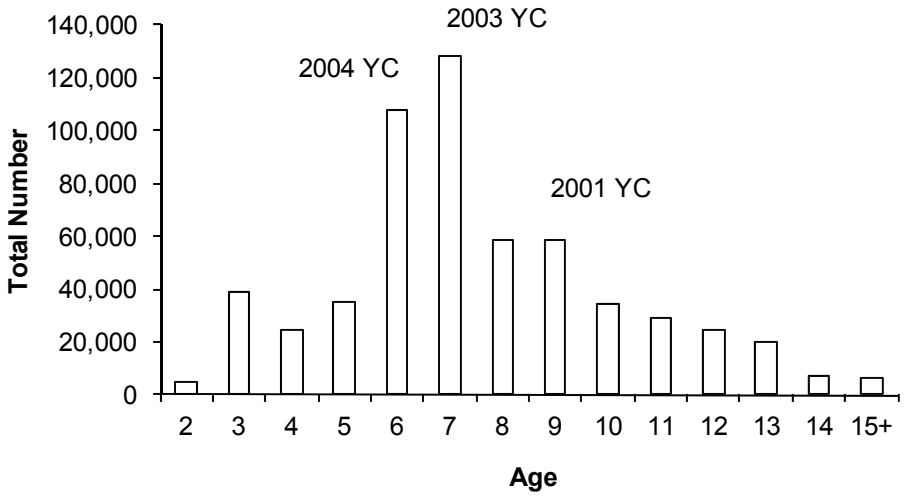
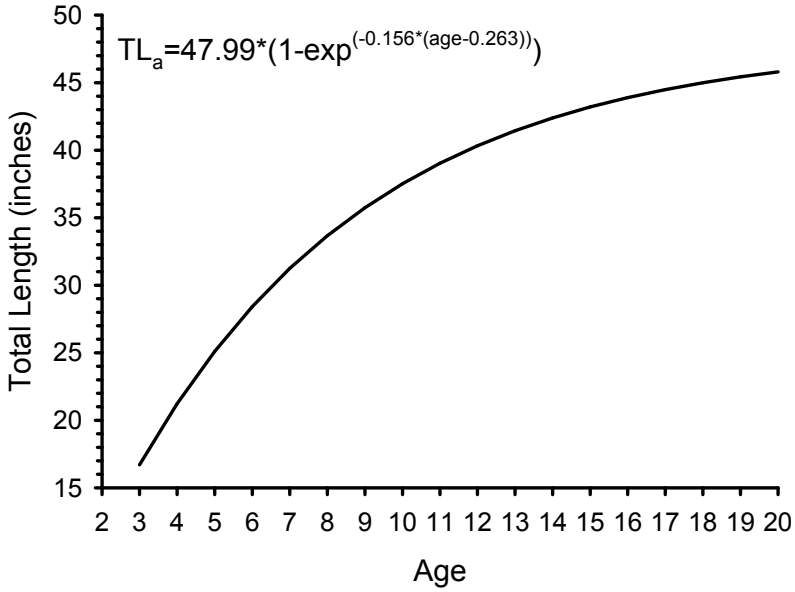


Figure 9. Age-length relationship for striped bass captured in Massachusetts.



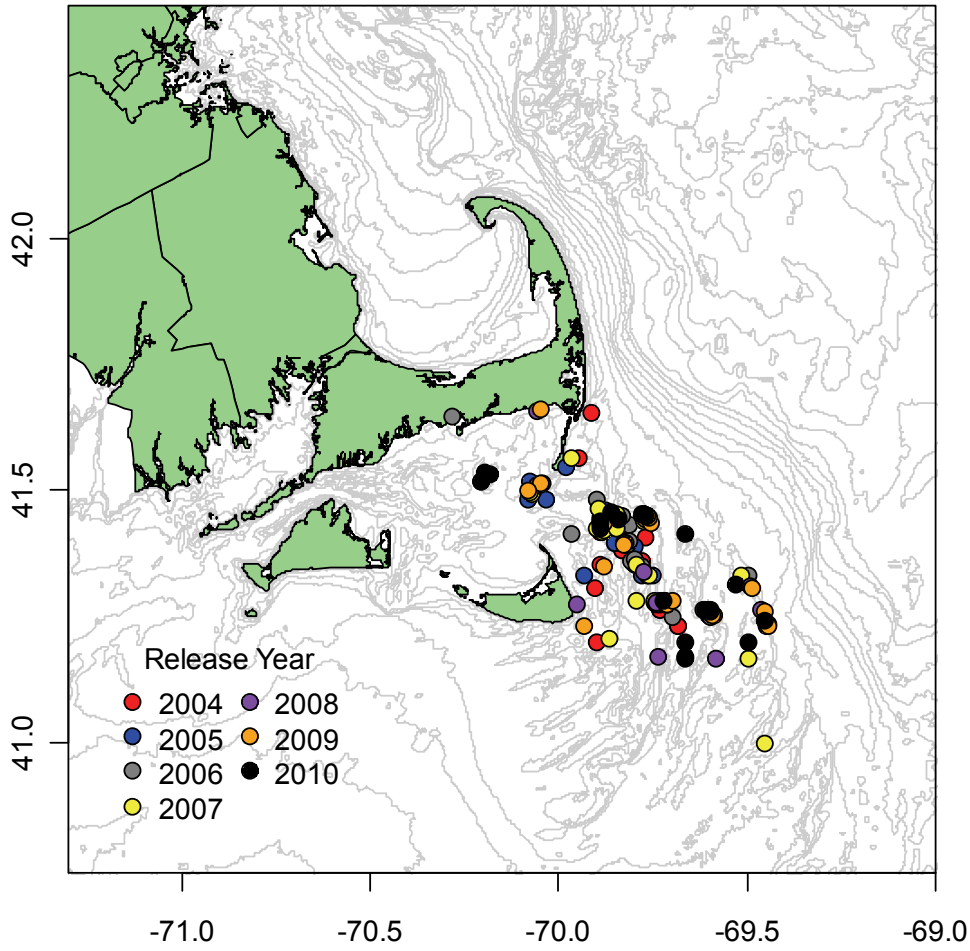
Massachusetts Tagging Study

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 Massachusetts tagging effort has focused on the tag and release of large 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 (Figure 10). 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

Table 6. Massachusetts tag summary statistics. SD = standard deviation.

			Number	Ave.		Length Range	
Year	Trips	Boats	Tagged	Length	SD	Min	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
2007	16	3	530	848	105.2	600	1225
2008	13	2	456	821	104.6	530	1202
2009	15	3	501	840	101.8	572	1146
2010	13	3	329	825	84.0	668	1095

Figure 10. Map of DMF fall tagging locations during 2004-2010.



office of the USFWS, which coordinates regional tagging programs of state-federal participants.

Summary statistics compiled since the start of this study are shown in Table 6. Striped bass released in 2004-2009 were recaptured from mainly coastal waters in North Carolina through New Hampshire (Figure 11).

Planned Management Programs in 2011

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 1,063,971 pounds due to overharvest in 2010. The commercial fishery quota will be monitored using the SAFIS system. 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.

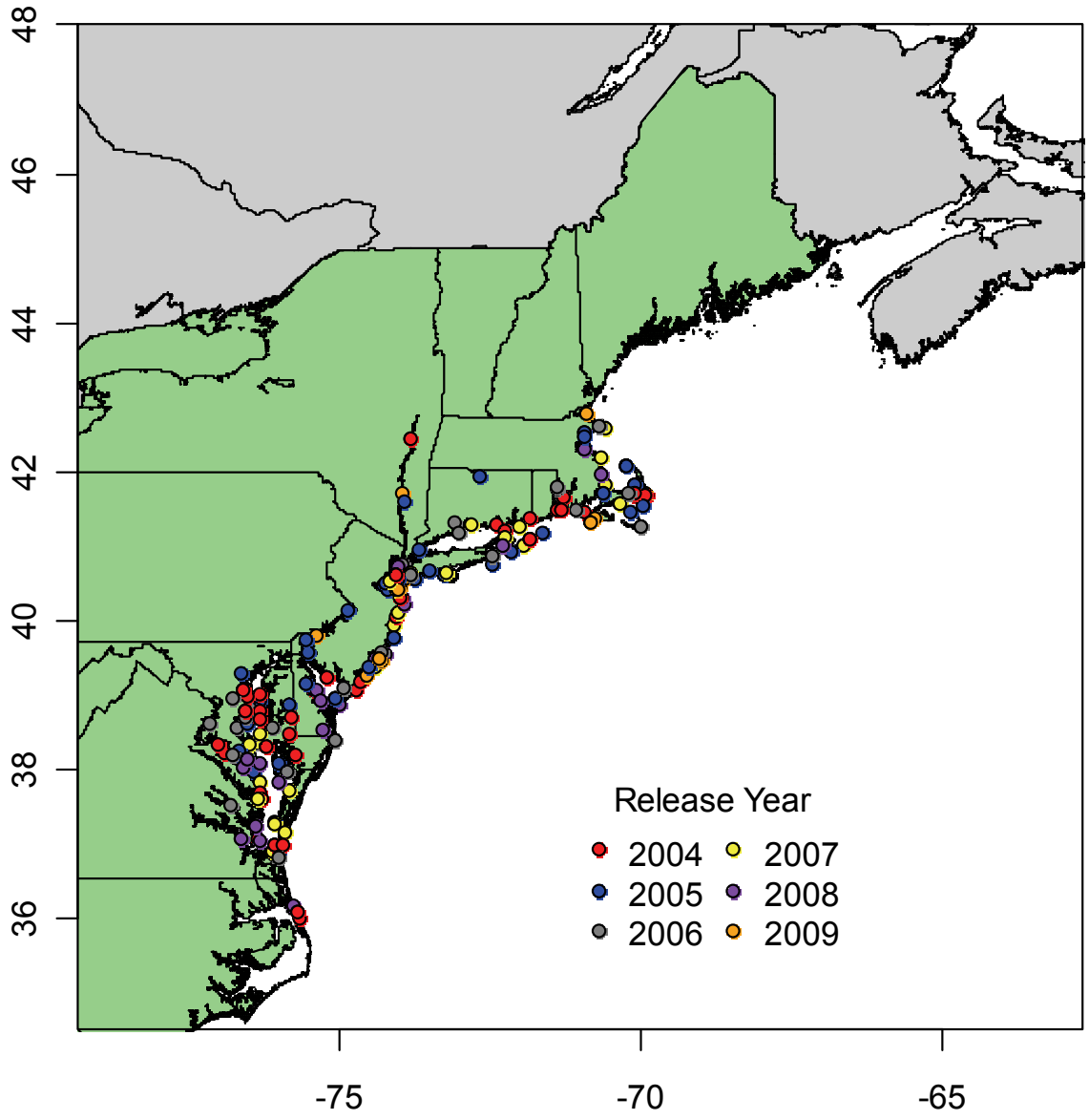
Monitoring Programs

All monitoring programs will continue in 2010.

Acknowledgements

The collection and quality of striped bass data would suffer greatly without the efforts of many DMF employees. Tom Hoopes, Micah Dean, Kim Lundy, Brant McAfee, and Story Reed assisted with the Oracle database of commercial landings, wrote SQL code to summarize the landings data, and managed catch reports. Jennifer Stritzel-Thomson coordinated the volunteer recreational angler data collection program, entered scale envelope data, and prepared data for analysis. John Boardman aged all scale samples. John Boardman, Paul Caruso, and Brad Schondelmeir conducted the commercial sampling of stripers. Paul Caruso and

Figure 11. Map of recovery locations of DMF tagged striped bass by release year, 2004-2009.



John Boardman also coordinated and conducted the USFWS cooperative tagging study. Mary Ann Fletcher, Erika Himmelberger, and Emily Somach managed monthly trip-level reports and entered data.

Funding for this effort was provided by the Massachusetts Division of Marine Fisheries and Sportfish Restoration Funds Grants F-57-R and F-48-R.

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Appendix Table 1A. Estimated size distribution of the Massachusetts commercial striped bass catch (numbers of fish) in 2010.

TL (in.)	Harvested*	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	168	168	0.12	0.12
15	0	56	56	0.04	0.16
16	0	449	449	0.32	0.48
17	0	393	393	0.28	0.76
18	0	505	505	0.36	1.11
19	0	393	393	0.28	1.39
20	0	1,291	1,291	0.92	2.31
21	0	281	281	0.20	2.51
22	0	1,067	1,067	0.76	3.26
23	0	449	449	0.32	3.58
24	0	3,144	3,144	2.23	5.81
25	0	2,021	2,021	1.43	7.24
26	0	3,032	3,032	2.15	9.39
27	0	4,941	4,941	3.50	12.89
28	170	6,457	6,627	4.70	17.59
29	312	7,356	7,667	5.43	23.02
30	369	11,511	11,879	8.42	31.44
31	340	11,623	11,963	8.48	39.91
32	588	12,578	13,166	9.33	49.24
33	1,419	6,345	7,764	5.50	54.74
34	5,556	1,628	7,185	5.09	59.83
35	7,637	56	7,693	5.45	65.28
36	9,163	56	9,219	6.53	71.82
37	9,126	0	9,126	6.47	78.28
38	5,816	56	5,872	4.16	82.44
39	5,075	0	5,075	3.60	86.04
40	4,770	0	4,770	3.38	89.42
41	4,775	0	4,775	3.38	92.80
42	4,554	0	4,554	3.23	96.03
43	1,666	0	1,666	1.18	97.21
44	1,839	0	1,839	1.30	98.51
45	1,419	0	1,419	1.01	99.52
46	248	0	248	0.18	99.69
47	185	0	185	0.13	99.82
48	46	0	46	0.03	99.86
49	202	0	202	0.14	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	65,276	75,858	141,134		
Avg. Size	37.8	29.1	33.2		

* includes fish taken for personal consumption

Appendix Table 1B. Estimated weight distribution by size of the Massachusetts commercial striped bass catch (pounds) in 2009.

TL (in.)	Harvested*	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	171	171	0.01	0.01
15	0	70	70	0.00	0.01
16	0	682	682	0.03	0.05
17	0	716	716	0.04	0.08
18	0	1,092	1092	0.05	0.14
19	0	999	999	0.05	0.18
20	0	3,830	3830	0.19	0.37
21	0	964	964	0.05	0.42
22	0	4,211	4211	0.21	0.63
23	0	2,026	2026	0.10	0.73
24	0	16,112	16112	0.80	1.53
25	0	11,707	11707	0.58	2.10
26	0	19,753	19753	0.98	3.08
27	0	36,049	36049	1.78	4.86
28	1,343	52,541	53884	2.66	7.53
29	2,735	66,495	69230	3.42	10.95
30	3,577	115,197	118774	5.87	16.82
31	3,642	128,345	131987	6.52	23.34
32	6,926	152,764	159690	7.89	31.23
33	18,315	84,517	102832	5.08	36.32
34	78,420	23,722	102143	5.05	41.36
35	117,549	892	118441	5.85	47.22
36	153,431	971	154402	7.63	54.85
37	165,871	0	165871	8.20	63.05
38	114,477	1,142	115619	5.71	68.76
39	107,975	0	107975	5.34	74.10
40	109,461	0	109461	5.41	79.51
41	117,975	0	117975	5.83	85.34
42	120,924	0	120924	5.98	91.31
43	47,474	0	47474	2.35	93.66
44	56,122	0	56122	2.77	96.43
45	46,305	0	46305	2.29	98.72
46	8,644	0	8644	0.43	99.15
47	6,877	0	6877	0.34	99.49
48	1,821	0	1821	0.09	99.58
49	8,506	0	8506	0.42	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	1,298,371	724,970	2,023,341		
Avg. Weight	19.9	9.6	14.3		

* includes fish taken for personal consumption

Appendix Table 2. Results of the GLM analyses of total catch rates (pounds/hour) for the commercial striped bass fishery., 1991-2010

```
Anova Table (Type III tests)

Response: log Pounds/Hour
             SS    Df       F    Pr(>F)
YEAR        934    19  46.982 < 2.2e-16 ***
AREA       1940     2 926.808 < 2.2e-16 ***
Residuals 51101 48838

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  1.967396   0.026739  73.577  < 2e-16 ***
YEAR1992     0.062367   0.035754   1.744   0.0811 .
YEAR1993     0.152867   0.035623   4.291 1.78e-05 ***
YEAR1994     0.060621   0.035545   1.705   0.0881 .
YEAR1995     0.173649   0.031785   5.463 4.70e-08 ***
YEAR1996     0.247209   0.051743   4.778 1.78e-06 ***
YEAR1997     0.169993   0.030746   5.529 3.24e-08 ***
YEAR1998     0.208645   0.031340   6.657 2.82e-11 ***
YEAR1999     0.133796   0.032023   4.178 2.94e-05 ***
YEAR2000     0.248355   0.032555   7.629 2.41e-14 ***
YEAR2001     0.392661   0.032620  12.037  < 2e-16 ***
YEAR2002     0.433157   0.032109  13.490  < 2e-16 ***
YEAR2003     0.495196   0.029644  16.705  < 2e-16 ***
YEAR2004     0.540083   0.035819  15.078  < 2e-16 ***
YEAR2005     0.366701   0.032408  11.315  < 2e-16 ***
YEAR2006     0.381962   0.030636  12.468  < 2e-16 ***
YEAR2007     0.355413   0.031113  11.423  < 2e-16 ***
YEAR2008     0.246757   0.031085   7.938 2.10e-15 ***
YEAR2009     0.330063   0.030834  10.705  < 2e-16 ***
YEAR2010     0.356287   0.033028  10.787  < 2e-16 ***
AREACCB     -0.004112   0.013453  -0.306   0.7599
AREASMA      0.399023   0.012081  33.030  < 2e-16 ***

Least-Squares Means

1991  8.158274
1992  8.683279
1993  9.505773
1994  8.668132
1995  9.705396
1996 10.446240
1997  9.669978
1998 10.051059
1999  9.326205
2000 10.458215
2001 12.081715
2002 12.581025
2003 13.386251
2004 14.000814
2005 11.772118
2006 11.953144
2007 11.639976
2008 10.441510
2009 11.348616
2010 11.650159
```

Appendix Table 3A. Estimated size distribution of the Massachusetts recreational striped bass catch (numbers of fish) in 2010.

TL (in.)	Harvested	Released	Total	Percent	Cumulative Percent
9	0	0	0	0.00	0.00
10	0	0	0	0.00	0.00
11	0	0	0	0.00	0.00
12	0	1,249	1,249	0.05	0.05
13	0	7,730	7,730	0.34	0.39
14	0	12,063	12,063	0.53	0.92
15	0	33,961	33,961	1.49	2.42
16	0	65,997	65,997	2.90	5.32
17	0	100,090	100,090	4.40	9.71
18	0	129,211	129,211	5.68	15.39
19	0	118,967	118,967	5.23	20.62
20	0	132,748	132,748	5.83	26.45
21	0	82,116	82,116	3.61	30.06
22	0	112,390	112,390	4.94	34.99
23	0	84,655	84,655	3.72	38.71
24	0	113,568	113,568	4.99	43.70
25	0	111,976	111,976	4.92	48.62
26	976	132,844	133,821	5.88	54.50
27	6,195	146,027	152,222	6.69	61.19
28	25,780	123,383	149,162	6.55	67.74
29	68,509	82,142	150,651	6.62	74.36
30	53,542	59,156	112,698	4.95	79.31
31	31,387	35,834	67,221	2.95	82.26
32	15,714	33,058	48,772	2.14	84.41
33	14,961	13,268	28,230	1.24	85.65
34	20,883	20,587	41,469	1.82	87.47
35	15,224	19,571	34,795	1.53	89.00
36	22,649	24,409	47,058	2.07	91.06
37	17,068	12,100	29,168	1.28	92.35
38	17,115	13,268	30,383	1.33	93.68
39	10,908	18,041	28,948	1.27	94.95
40	11,715	14,024	25,739	1.13	96.08
41	5,550	10,869	16,419	0.72	96.80
42	5,857	24,712	30,570	1.34	98.15
43	4,574	17,672	22,245	0.98	99.12
44	976	5,169	6,146	0.27	99.39
45	1,952	3,685	5,638	0.25	99.64
46	976	3,685	4,662	0.20	99.85
47	1,311	1,833	3,144	0.14	99.99
48	334	0	334	0.01	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
54	0	0	0	0.00	100.00
55	0	0	0	0.00	100.00
56	0	0	0	0.00	100.00
Total	354,157	1,922,058	2,276,215		
Avg. Size	32.9	24.7	26.0		

Appendix Table 3B. Estimated size distribution of the Massachusetts recreational striped bass catch (pounds) in 2010.

TL (in.)	Harvested	Released	Total	Percent	Cumulative Percent
9	0	0	0		
10	0	0	0	0.00	0.00
11	0	0	0	0.00	0.00
12	0	668	668	0.00	0.00
13	0	5,253	5,253	0.04	0.04
14	0	10,231	10,231	0.07	0.11
15	0	35,406	35,406	0.24	0.35
16	0	83,454	83,454	0.56	0.90
17	0	151,728	151,728	1.02	1.92
18	0	232,393	232,393	1.56	3.48
19	0	251,526	251,526	1.68	5.16
20	0	327,200	327,200	2.19	7.35
21	0	234,201	234,201	1.57	8.92
22	0	368,397	368,397	2.47	11.38
23	0	316,946	316,946	2.12	13.51
24	0	482,914	482,914	3.23	16.74
25	0	537,979	537,979	3.60	20.34
26	5,274	717,681	722,955	4.84	25.18
27	37,469	883,169	920,638	6.16	31.34
28	173,831	831,968	1,005,799	6.73	38.08
29	513,079	615,178	1,128,257	7.55	45.63
30	443,778	490,312	934,089	6.25	51.88
31	286,958	327,614	614,572	4.11	56.00
32	157,979	332,339	490,318	3.28	59.28
33	164,911	146,247	311,158	2.08	61.36
34	251,675	248,110	499,785	3.35	64.71
35	200,101	257,227	457,328	3.06	67.77
36	323,862	349,024	672,886	4.50	72.27
37	264,891	187,794	452,684	3.03	75.30
38	287,674	223,021	510,695	3.42	78.72
39	198,155	327,738	525,893	3.52	82.24
40	229,564	274,816	504,380	3.38	85.62
41	117,093	229,312	346,405	2.32	87.94
42	132,816	560,340	693,156	4.64	92.58
43	111,270	429,913	541,183	3.62	96.20
44	25,441	134,714	160,155	1.07	97.28
45	54,419	102,716	157,134	1.05	98.33
46	29,058	109,695	138,753	0.93	99.26
47	41,603	58,190	99,793	0.67	99.92
48	11,304	0	11,304	0.08	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
54	0	0	0	0.00	100.00
55	0	0	0	0.00	100.00
56	0	0	0	0.00	100.00
Total	4,062,205	10,875,413	14,937,618		
Avg. Weight	11.5	5.7	6.6		

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

```
Anova Table (Type III tests)

Response: Prop (0 or 1)
          LR Chisq Df Pr(>Chisq)
YEAR        1755.9 23  < 2.2e-16 ***
AREA_X       201.4  2  < 2.2e-16 ***
MODE_FX     3957.1  2  < 2.2e-16 ***
WAVE         558.0  4  < 2.2e-16 ***
CNTY         414.1  7  < 2.2e-16 ***
FFDAYS12C    975.1 12  < 2.2e-16 ***
HOURS       2828.1 11  < 2.2e-16 ***

Coefficients:
             Estimate Std. Error z value Pr(>|z|)
(Intercept)  -5.54066    0.27647 -20.041  < 2e-16 ***
YEAR1988     -0.05307    0.26778  -0.198 0.842894
YEAR1989      0.01270    0.26455   0.048 0.961718
YEAR1990     -0.08788    0.25348  -0.347 0.728814
YEAR1991     -0.20415    0.25219  -0.810 0.418223
YEAR1992     -0.01142    0.24637  -0.046 0.963033
YEAR1993      0.27765    0.24566   1.130 0.258368
YEAR1994      0.76470    0.24368   3.138 0.001700 **
YEAR1995      1.07536    0.24295   4.426 9.59e-06 ***
YEAR1996      1.11530    0.24344   4.581 4.62e-06 ***
YEAR1997      1.09043    0.24262   4.494 6.97e-06 ***
YEAR1998      1.57725    0.24253   6.503 7.86e-11 ***
YEAR1999      1.31250    0.24266   5.409 6.35e-08 ***
YEAR2000      1.25121    0.24324   5.144 2.69e-07 ***
YEAR2001      1.04423    0.24267   4.303 1.68e-05 ***
YEAR2002      1.07291    0.24357   4.405 1.06e-05 ***
YEAR2003      0.97395    0.24321   4.005 6.21e-05 ***
YEAR2004      1.05035    0.24461   4.294 1.76e-05 ***
YEAR2005      1.15638    0.24505   4.719 2.37e-06 ***
YEAR2006      1.40173    0.24397   5.745 9.17e-09 ***
YEAR2007      1.08564    0.24490   4.433 9.30e-06 ***
YEAR2008      0.93562    0.24597   3.804 0.000143 ***
YEAR2009      0.87538    0.24524   3.570 0.000358 ***
YEAR2010      0.67054    0.24666   2.718 0.006559 **
AREA_X2      -0.02376    0.03374  -0.704 0.481259
AREA_X5       0.30147    0.02316  13.015  < 2e-16 ***
MODE_FX6      2.62246    0.04859  53.968  < 2e-16 ***
MODE_FX7      1.14123    0.02548  44.792  < 2e-16 ***
WAVE3         1.72899    0.13029  13.271  < 2e-16 ***
WAVE4         1.37528    0.13033  10.552  < 2e-16 ***
WAVE5         1.22867    0.13102   9.378  < 2e-16 ***
WAVE6         1.16998    0.15483   7.557 4.14e-14 ***
CNTY5        -0.24448    0.04743  -5.155 2.54e-07 ***
CNTY7        -0.11877    0.05832  -2.036 0.041703 *
CNTY9         0.37339    0.02557  14.602  < 2e-16 ***
CNTY19       -0.47457    0.08508  -5.578 2.44e-08 ***
CNTY21        0.13446    0.05380   2.499 0.012451 *
CNTY23       -0.10153    0.03258  -3.116 0.001832 **
CNTY25        0.12838    0.07665   1.675 0.093968 .
```

Appendix 4A cont'd.

```
FFDAYS12C10   0.12866    0.03101    4.150 3.33e-05 ***
FFDAYS12C20   0.39750    0.03210   12.384  < 2e-16 ***
FFDAYS12C30   0.48450    0.03764   12.872  < 2e-16 ***
FFDAYS12C40   0.58095    0.04690   12.386  < 2e-16 ***
FFDAYS12C50   0.71929    0.04146   17.351  < 2e-16 ***
FFDAYS12C60   0.67924    0.05624   12.078  < 2e-16 ***
FFDAYS12C70   0.81373    0.07171   11.347  < 2e-16 ***
FFDAYS12C80   0.82924    0.10168    8.155 3.49e-16 ***
FFDAYS12C90   0.61604    0.10939    5.631 1.79e-08 ***
FFDAYS12C100  0.90235    0.04489   20.099  < 2e-16 ***
FFDAYS12C150  0.98555    0.07604   12.961  < 2e-16 ***
FFDAYS12C200  0.99935    0.08593   11.630  < 2e-16 ***
HOURS2        0.63410    0.04835   13.115  < 2e-16 ***
HOURS3        1.02937    0.04640   22.185  < 2e-16 ***
HOURS4        1.34423    0.04620   29.094  < 2e-16 ***
HOURS5        1.52829    0.04827   31.664  < 2e-16 ***
HOURS6        1.76875    0.05017   35.255  < 2e-16 ***
HOURS7        1.97725    0.06072   32.564  < 2e-16 ***
HOURS8        1.87161    0.06388   29.297  < 2e-16 ***
HOURS9        2.21788    0.10272   21.592  < 2e-16 ***
HOURS10       2.22697    0.11724   18.995  < 2e-16 ***
HOURS11       1.64911    0.22603    7.296 2.96e-13 ***
HOURS12       2.27700    0.14004   16.260  < 2e-16 ***
```

```
Year LSMEANS
1987 0.2766298
1988 0.2661366
1989 0.2791779
1990 0.2593935
1991 0.2376886
1992 0.2743508
1993 0.3354612
1994 0.4510214
1995 0.5284980
1996 0.5384393
1997 0.5322531
1998 0.6493111
1999 0.5869219
2000 0.5719885
2001 0.5207344
2002 0.5278886
2003 0.5031777
2004 0.5222622
2005 0.5486301
2006 0.6083758
2007 0.5310605
2008 0.4935947
2009 0.4785478
2010 0.4278332
```

Appendix Table 4B. Results of the Gamma regression analysis of MRFSS striped bass positive catches.

```
Anova Table (Type III tests)

Response: TOT_FISH
          LR Chisq Df Pr(>Chisq)
YEAR        350.76 23  < 2.2e-16 ***
AREA_X       38.90  2  3.581e-09 ***
MODE_FX     422.87  2  < 2.2e-16 ***
WAVE        304.96  4  < 2.2e-16 ***
CNTY        129.98  7  < 2.2e-16 ***
FFDAYS12C   576.30 12  < 2.2e-16 ***
HOURS      1013.89 11  < 2.2e-16 ***


Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)   0.34264    0.26683   1.284 0.199114
YEAR1988     -0.18545    0.25499  -0.727 0.467073
YEAR1989     -0.26049    0.24841  -1.049 0.294361
YEAR1990     -0.24752    0.23945  -1.034 0.301287
YEAR1991     -0.11117    0.23897  -0.465 0.641787
YEAR1992      0.08944    0.23220   0.385 0.700098
YEAR1993     -0.06304    0.23147  -0.272 0.785345
YEAR1994      0.01259    0.22901   0.055 0.956175
YEAR1995      0.23919    0.22822   1.048 0.294609
YEAR1996      0.24522    0.22851   1.073 0.283228
YEAR1997      0.29696    0.22799   1.302 0.192760
YEAR1998      0.38420    0.22753   1.689 0.091325 .
YEAR1999      0.33101    0.22783   1.453 0.146278
YEAR2000      0.37961    0.22825   1.663 0.096303 .
YEAR2001      0.14695    0.22804   0.644 0.519334
YEAR2002      0.11618    0.22856   0.508 0.611223
YEAR2003      0.17980    0.22848   0.787 0.431318
YEAR2004      0.24310    0.22906   1.061 0.288574
YEAR2005      0.25566    0.22933   1.115 0.264948
YEAR2006      0.48777    0.22846   2.135 0.032768 *
YEAR2007      0.21103    0.22905   0.921 0.356887
YEAR2008      0.13799    0.23029   0.599 0.549037
YEAR2009      0.08273    0.22991   0.360 0.718988
YEAR2010      0.02801    0.23112   0.121 0.903555
AREA_X2      -0.04841    0.02609  -1.855 0.063563 .
AREA_X5       0.09015    0.01878   4.802 1.58e-06 ***
MODE_FX6      0.33451    0.03542   9.444  < 2e-16 ***
MODE_FX7      0.49489    0.02307  21.451  < 2e-16 ***
WAVE3        -0.02835    0.13659  -0.208 0.835549
WAVE4        -0.32741    0.13677  -2.394 0.016681 *
WAVE5        -0.19900    0.13716  -1.451 0.146835
WAVE6         0.32160    0.15806   2.035 0.041895 *
CNTY5        -0.13315    0.03909  -3.406 0.000661 ***
CNTY7        -0.30219    0.04865  -6.211 5.36e-10 ***
CNTY9         0.10629    0.02091   5.083 3.75e-07 ***
CNTY19       -0.19717    0.07405  -2.663 0.007761 **
CNTY21        0.01175    0.04215   0.279 0.780363
```

Appendix Table 4B cont'd.

CNTY23	-0.02051	0.02716	-0.755	0.450047	
CNTY25	-0.34486	0.06273	-5.498	3.89e-08	***
FFDAYS12C10	0.05691	0.02581	2.205	0.027489	*
FFDAYS12C20	0.17984	0.02604	6.906	5.11e-12	***
FFDAYS12C30	0.18649	0.03015	6.185	6.32e-10	***
FFDAYS12C40	0.32161	0.03667	8.770	< 2e-16	***
FFDAYS12C50	0.37152	0.03209	11.577	< 2e-16	***
FFDAYS12C60	0.41969	0.04383	9.576	< 2e-16	***
FFDAYS12C70	0.45323	0.05436	8.338	< 2e-16	***
FFDAYS12C80	0.49602	0.07560	6.561	5.47e-11	***
FFDAYS12C90	0.49687	0.08711	5.704	1.18e-08	***
FFDAYS12C100	0.55740	0.03419	16.302	< 2e-16	***
FFDAYS12C150	0.57593	0.05822	9.892	< 2e-16	***
FFDAYS12C200	0.71390	0.06655	10.728	< 2e-16	***
HOURS2	0.10265	0.04835	2.123	0.033779	*
HOURS3	0.33039	0.04582	7.211	5.72e-13	***
HOURS4	0.46178	0.04516	10.225	< 2e-16	***
HOURS5	0.63246	0.04613	13.710	< 2e-16	***
HOURS6	0.68813	0.04666	14.749	< 2e-16	***
HOURS7	0.90883	0.05117	17.761	< 2e-16	***
HOURS8	0.90521	0.05405	16.748	< 2e-16	***
HOURS9	0.92059	0.07382	12.471	< 2e-16	***
HOURS10	1.07812	0.08431	12.788	< 2e-16	***
HOURS11	1.26887	0.17299	7.335	2.30e-13	***
HOURS12	1.03818	0.10121	10.257	< 2e-16	***

Year	LSMEANS
1987	4.676255
1988	3.884720
1989	3.603852
1990	3.650923
1991	4.184250
1992	5.113776
1993	4.390546
1994	4.735479
1995	5.939885
1996	5.975782
1997	6.293117
1998	6.866769
1999	6.511083
2000	6.835359
2001	5.416472
2002	5.252383
2003	5.597394
2004	5.963135
2005	6.038503
2006	7.616161
2007	5.774957
2008	5.368186
2009	5.079557
2010	4.809067