Technical Report

Massachusetts Division of Marine Fisheries
Technical Report TR-55

Massachusetts Striped Bass Monitoring Report for 2012

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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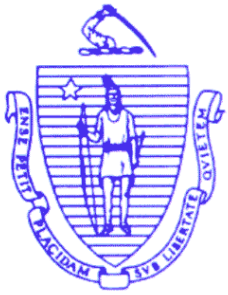

Massachusetts Striped Bass Monitoring Report for 2012

Gary Nelson
Massachusetts Division of Marine Fisheries
30 Emerson Ave.
Gloucester, MA 01930

September 2013

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 2012, the Massachusetts commercial fishery for striped bass sold about 61,509 fish weighing 1,219,665 pounds and kept approximately 4,885 fish for personal consumption. Total losses due to commercial harvesting (including release mortality) were 73,195 fish weighing 1,351,907 pounds. The recreational fishery harvested about 377,931 striped bass weighing over 5.4 million pounds. Total losses due to recreational fishing (including release mortality) were 466,987 fish weighing over 5.9 million pounds. Combined losses (including scientific losses) were 540,182 fish weighing over 7.2 million pounds, which reflects a 34% increase in numbers lost and a 37% increase in weight lost compared to 2011 (402,441 fish; 5.3 million pounds). The majority of losses, 86% by number and 81% by weight, was attributed to the recreational fishery.

Introduction

This report summarizes the commercial and recreational striped bass fisheries conducted in Massachusetts during 2012. Data sources used to characterize the state fisheries come from monitoring programs of the Massachusetts Division of Marine Fisheries (DMF) and the 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 in 2012

Season: July 12-August 9. No landings were permitted on Monday, Friday, or Saturday.

Sold: 1,219,665 pounds (against a harvest quota of 1,057,783 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 DMF in addition to standard seafood dealer permits. Dealer reporting requirement included weekly reporting to 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. DMF personnel review dealer transactions and correct entries before calculating total landings.

Fishermen must have a DMF commercial fishing permit (of any type) and a special striped bass

Table 1. Attributes of the Massachusetts striped bass commercial fishery, 1990-2012.

		Purchased			
Year	Season (Fishing Days)	Pounds 000s	Number 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	3,578
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	60.3	178	3,951
2011	18	1163.8	61.5	189	3,965
2012	17	1219.7	61.5	186	3,965

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 and catch rates.

Landings. The landings used here come from the SAFIS system. Commercial dealers bought 1,219,665 pounds (61,509 fish) of striped bass in 2012 (Table 1). Most striped bass were sold in Barnstable, Bristol, and Essex counties of Massachusetts. Commercial fishers kept an additional 4,885 fish weighing approximately 74,972 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 3,544 fish sampled from the 2012 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:

$$\log_{10}(W) = -3.462 + 3.006 * \log_{10}(L), \quad RMS = 0.0028$$

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 a given length by back-transforming the predicted weight as follows:

$$W = 10^{(-3.462 + 3.006 * \log_{10}(L) + RMS/2)}$$

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 46% of all fish caught had lengths ≥34 inches.

Age and Sex Composition.. Seven hundred and ten fish sampled from the 2012 commercial harvest were used to sex and age the harvested fish. Age composition of harvest fish was estimated from a sub-sample of 299 fish. A weighted length frequency was generated by weighting the lengths measured in each county by county landings. The resulting length frequency was then applied to the commercial age-length key to generate the number of harvested fish by age. In addition, the age composition of fish released and consumed was estimated from length data reported in commercial angler logs and age-length key developed from samples collected from the recreational fishery. Age was determined from scales and sex was determined by visual inspection of gonadal tissue (Sykes Method). Age of harvested fish ranged from 6 to 15+ years, and 99.5% were females. About 77% of the sub-sample consisted of individuals from the 2000-2004 year classes (ages 8-12) (Figure 1). Peak numbers-at-age of the total catches (harvest plus releases plus consumed) were from the 2004 year-class (Figure 1).

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 2011, 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

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

where y is the observed total catch or harvest rate, a is the intercept, b_i is the slope coefficient of the i^{th} factor, X_i is the i^{th} 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 Table 2. Although factors were significant, the variables accounted for only about 10% of the total variation in harvest rates.

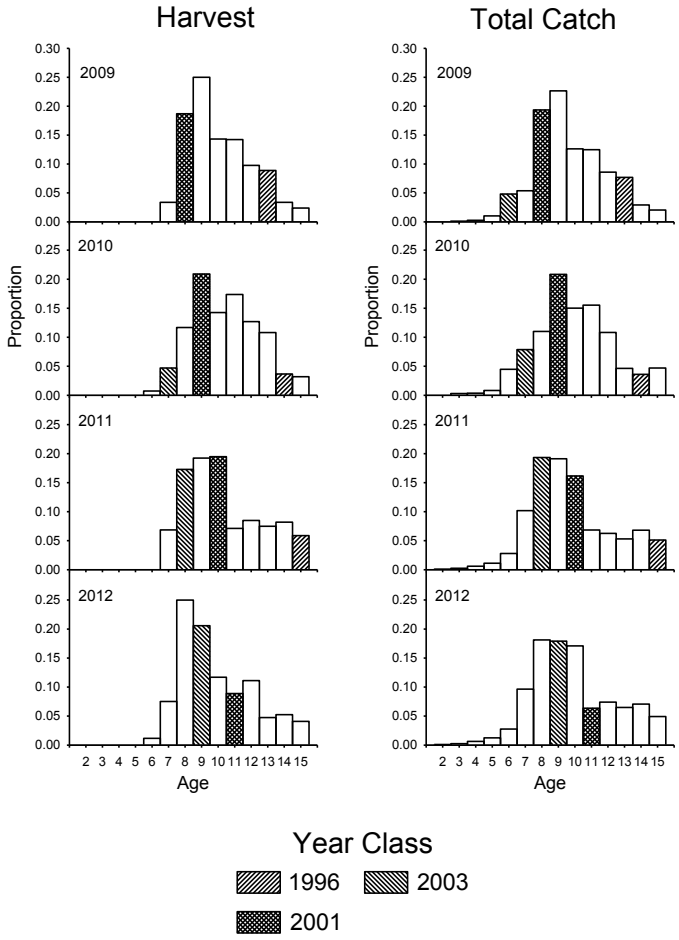

Figure 1. Age composition (proportion) of harvest and total catches from the Massachusetts commercial fishery. The large 1996, 2001, and 2003 Chesapeake Bay year-classes are highlighted.

Harvest rates steadily increased after 1999, peaked in 2004, dropped through 2008, increased slightly through 2010, and then dramatically increased in 2011 and remained at high levels in 2012 (Figure 2A). The dramatic increase in harvest rates for 2011 and 2012 is attributed to large increases in harvest rates by fishers in Cape Cod Bay and southern Massachusetts (Figure 2B). The reason for the increase was due to atypical, large concentrations of striped bass off Cape Cod, particularly Chatham, in 2011 and 2012 for unknown reasons which likely increased the vulnerability of striped bass to capture. In addition, the large 2003 year-class became nearly fully-recruited to the Massachusetts fishery (Figure 1) .

Characterization of Other Losses. Release mortality was estimated by using a hook-release mortality rate of 9% applied against the released fish in Appendix Tables 1A and 1B. Total losses due to release mortality were 6,801 fish weighing approximately 57,270 pounds.

Recreational Fishery in 2012

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: A recreational fishing permit is required in MA state waters.

Harvest levels: Harvest (A+B1) and total catch (A+B1+B2) estimates (Table 2) were provided by the NMFS Marine Recreational Information Program (MRIP). In 2011, new estimation methods were applied to data collected since 2003, but only small changes (range: -9.1 to 10.1%) were observed for Massachusetts data.

The MRIP estimate of total catch (including fish released alive) in 2012 was 1,367,440 striped bass, which is an 11% increased compared to the 2011 estimate (Table 2). The estimate of total harvest in

2012 was 377,931 fish, which is an increase in harvest of 48% compared to 2011. Total pounds harvested was over 5.4 million in 2012 (Table 2).

Size Composition. The length distributions of harvested and released fish were estimated from biological sampling conducted by MRIP in Massachusetts and from a volunteer angler program conducted by DMF. 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 1,740 samples were received from 31 anglers. The size frequencies of measured fish are shown in Figure 3 by disposition and mode. The size frequency of released fishes was used to allocate MRIP 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 626 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 MRIP 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 MRIP). Recreational harvest and total catches in 2012 catches of striped bass were comprised mostly of the 2003 and 2004 year-classes. (Figure 4).

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 i^{th} factor, X_i is the i^{th} categorical variable, and e is the error term. The function *glm* in *R* was used to estimate

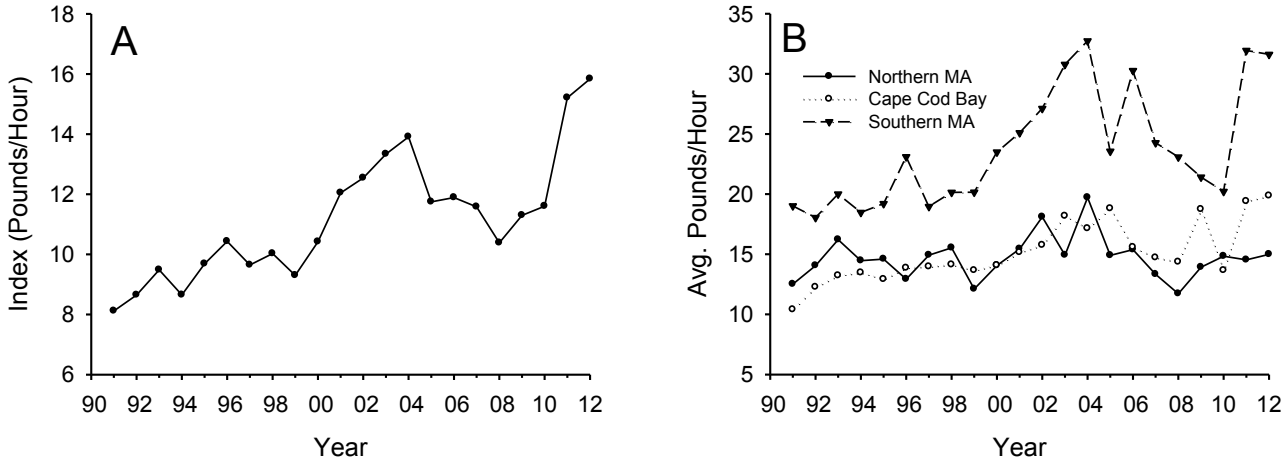

Figure 2. A) Harvest index (standardized pounds/hour) and B) average harvest rates by area for the Massachusetts commercial striped bass fishery, 1990-2011.

Table 2. MRIP 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	407,100	4,889,035	4,361,710	4,768,810
2004	445,745	6,112,746	4,979,075	5,424,820
2005	340,742	5,097,821	3,988,679	4,329,421
2006	314,988	4,832,355	7,809,777	8,124,765
2007	315,409	5,136,580	5,331,470	5,646,879
2008	377,959	5,763,763	3,649,415	4,027,374
2009	344,401	4,786,895	2,282,601	2,627,002
2010	341,046	4,270,401	1,671,437	2,012,483
2011	255,507	3,504,522	973,192	1,228,699
2012	377,931	5,441,893	989,509	1,367,440

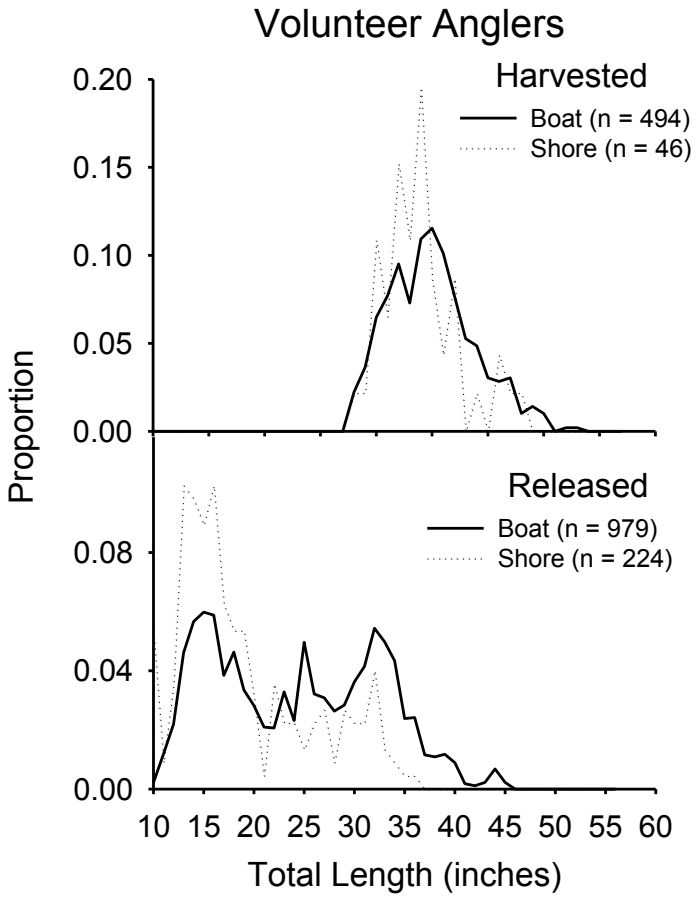

Figure 3. Sizes of striped bass caught by volunteer recreational anglers in 2012 by disposition and fishing mode.

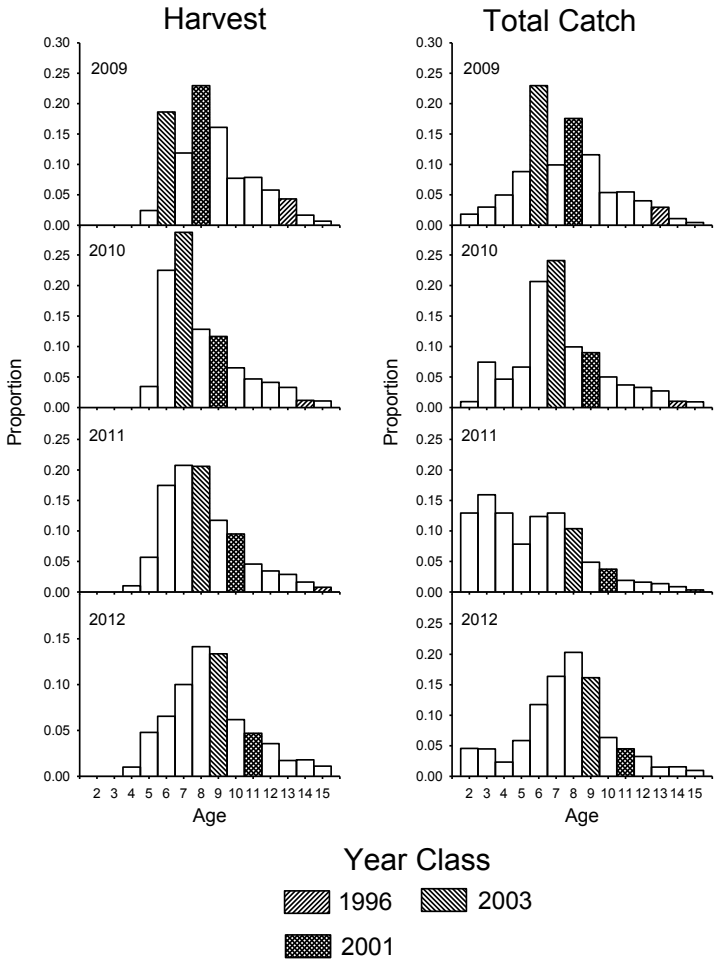

Figure 4. Age composition (proportion) of harvest and total catches from the Massachusetts recreational fishery. The large 1996, 2001, and 2003 Chesapeake Bay year-classes are highlighted.

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:*

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

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 least-squares 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 for 1986-2011. Intercept files for 2012 were not available when this report was constructed. Standardized catch rates for striped bass in Massachusetts waters increased from 1993 to 1998, declined through 2003, but increased in 2004 and 2005 (Figure 5). In 2006, catch rates jumped dramatically as the large 2003 year-class became vulnerable to the fishery. Since 2006, catch rates have declined (Figure 5).

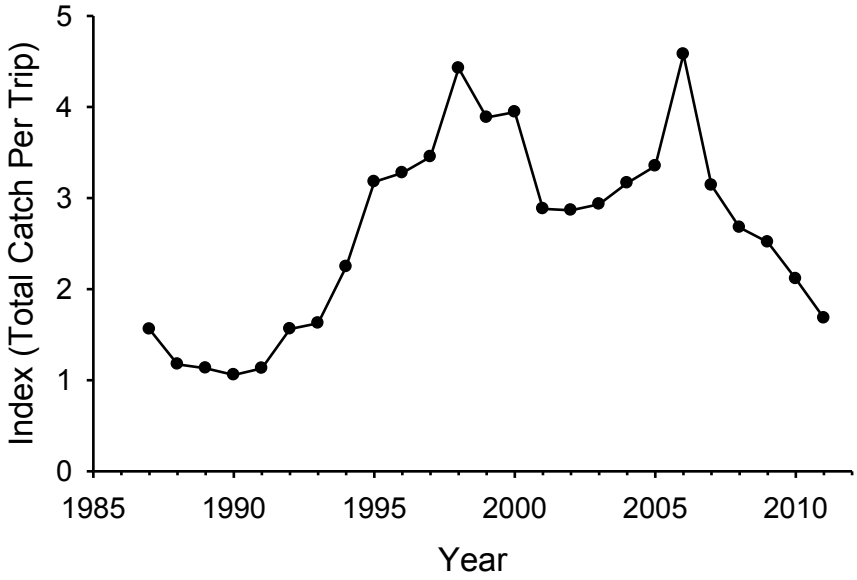

Figure 5. Standardized total catch rates (total number of fish caught per trip) of the recreational fishery for striped bass in Massachusetts waters, 1987-2011.

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 89,056 fish (465,095 pounds) (Table 3).

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 2013.

Estimated Total Losses in 2012

Total estimated loss of striped bass during 2012 was 540,182 fish weighing 7,258,896 pounds (Table 3), which is a 34% increase in numbers lost and a 37% increase in weight compared to 2011 (402,441 fish; 5,309,241 pounds). The majority of losses, 86% by number and 81% by weight, was attributed to combined losses in the recreational fishery.

Table 3. Estimates of striped bass losses occurring in Massachusetts waters during 2012.

FISHERY	NUMBER	POUNDS	MEAN WT.
Commercial			
Harvest*	66,394	1,294,637	19.5
Release Mortality	6,801	57,270	8.4
Recreational			
Harvest	377,931	5,441,893	14.4
Release Mortality	89,056	465,095	5.2
Total	540,182	7,258,896	

* includes fish taken for personal consumption

Table 4. Massachusetts striped bass removals-at-age matrix of 2012 by source.

	Recreational		Commercial		
Age	Release Mortality	Harvest	Release Mortality	Harvest*	Total
2	21,368	0	62	0	21,430
3	20,947	0	326	0	21,273
4	7,075	3,788	552	61	11,477
5	9,433	17,930	1,106	246	28,715
6	6,791	48,117	1,564	595	57,067
7	7,829	68,671	1,526	5249	83,276
8	7,562	87,293	1,084	11977	107,917
9	4,599	70,850	527	12730	88,707
10	1,301	28,391	46	12289	42,026
11	817	20,207	6	4572	25,602
12	543	14,657	1	5347	20,549
13	227	6,809	0	4677	11,714
14	318	6,977	0	5096	12,392
15	203	2,976	0	2759	5,938
16+	43	1,264	0	796	2,103

* includes fish taken for personal consumption

Removals-At-Age Matrix in 2012

The removals (numbers) due to release mortality and harvest by the recreational and commercial fisheries are apportioned by age and mortality source in Table 4. The 2003 (age 9), 2004 (age 8) and 2005 (age 7) year-classes incurred the highest losses in 2012 (Figure 6).

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 2012. The resulting equation and predicted relationship are shown in Figure 7.

Required Fishery-Independent Monitoring Programs

Massachusetts Tagging Study

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, 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

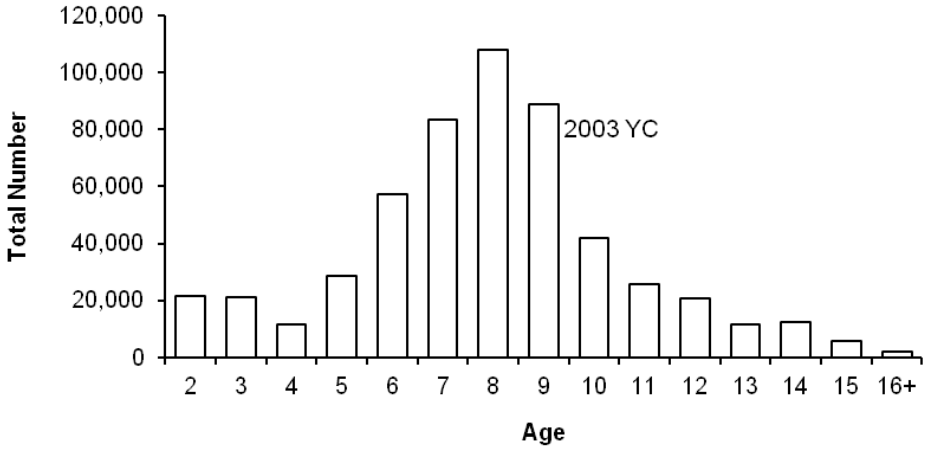

Figure 6. Total number of striped bass removals in 2012 by age. The 2003 year-class is indicated.

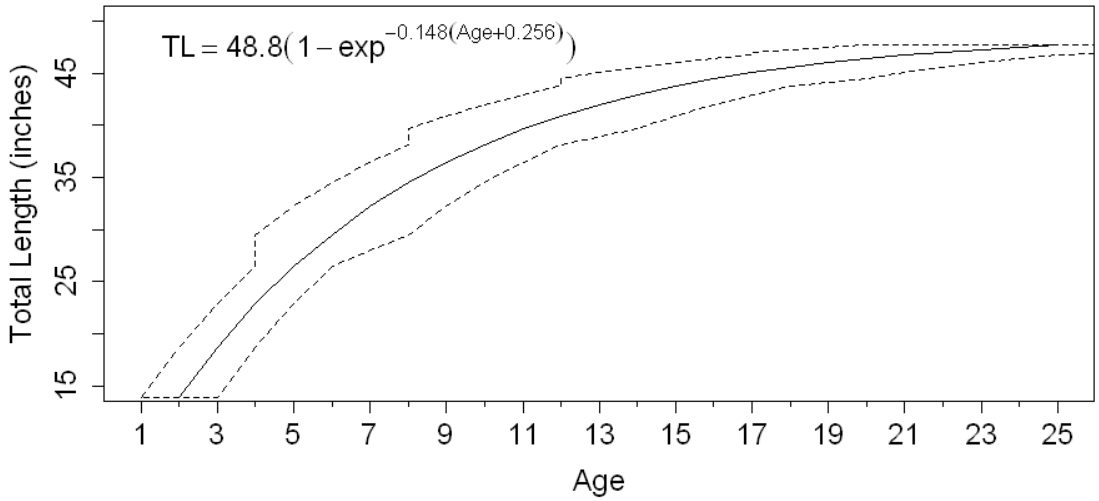

Figure 7. Mean length-age relationship (solid line) for striped bass captured in Massachusetts. Dotted lines represent the minimum and maximum ages found at a given length.

areas around Nantucket Island (Figure 8). Floy internal anchor tags provided by the United States Fish and Wildlife Service (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 USFWS, which coordinates regional tagging programs of state-federal participants.

Summary statistics compiled since the start of this study are shown in Table 5. Striped bass released in 2005-2011 were recaptured from mainly coastal waters in North Carolina through New Hampshire (Figure 9).

Planned Management Programs in 2013

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 997,869 pounds due to overharvest in 2012. The commercial fishery quota will be monitored using the SAFIS system. The commercial season will not open until July 14, 2013 and harvesting will be allowed only on Sunday with a daily bag limit of 5 fish, and Tuesday-Thursday

Table 5. Massachusetts tag summary statistics. SD = standard deviation.

			Number	Ave.	Ave.	SD	SD	Length Range			
Year	Trips	Boats	Tagged	Length (mm)	Length (in)	(mm)	(in)	Min (mm)	Min (in)	Max (mm)	Max (in)
1991	17	4	388	817	32.2	106.4	4.2	534	21.0	1300	51.2
1992	29	3	899	798	31.4	125.9	5.0	524	20.6	1267	49.9
1993	15	2	678	784	30.9	125.0	4.9	515	20.3	1210	47.6
1994	13	2	377	735	28.9	93.2	3.7	548	21.6	1028	40.5
1995	11	2	449	767	30.2	110.2	4.3	470	18.5	1178	46.4
1996	8	2	203	748	29.4	64.1	2.5	541	21.3	1077	42.4
1997	10	2	321	773	30.4	114.7	4.5	485	19.1	1090	42.9
1998	12	2	382	797	31.4	93.8	3.7	597	23.5	1055	41.5
1999	16	2	471	777	30.6	95.5	3.8	594	23.4	1108	43.6
2000	25	4	1095	752	29.6	102.6	4.0	510	20.1	1204	47.4
2001	14	3	456	786	30.9	102.5	4.0	503	19.8	1110	43.7
2002	12	3	239	764	30.1	103.6	4.1	487	19.2	1060	41.7
2003	15	3	655	825	32.5	92.1	3.6	602	23.7	1204	47.4
2004	25	7	784	707	27.8	193.1	7.6	316	12.4	1164	45.8
2005	19	4	752	726	28.6	210.5	8.3	299	11.8	1114	43.9
2006	11	4	390	813	32.0	94.2	3.7	565	22.2	1114	43.9
2007	16	3	530	848	33.4	105.2	4.1	600	23.6	1225	48.2
2008	13	2	456	821	32.3	104.6	4.1	530	20.9	1202	47.3
2009	15	3	501	840	33.1	101.8	4.0	572	22.5	1146	45.1
2010	13	3	329	825	32.5	84.0	3.3	668	26.3	1095	43.1
2011	15	3	504	831	32.7	91.9	3.6	580	22.8	1174	46.2
2012	15	3	643	852	33.5	87.7	3.5	524	20.6	1203	47.4

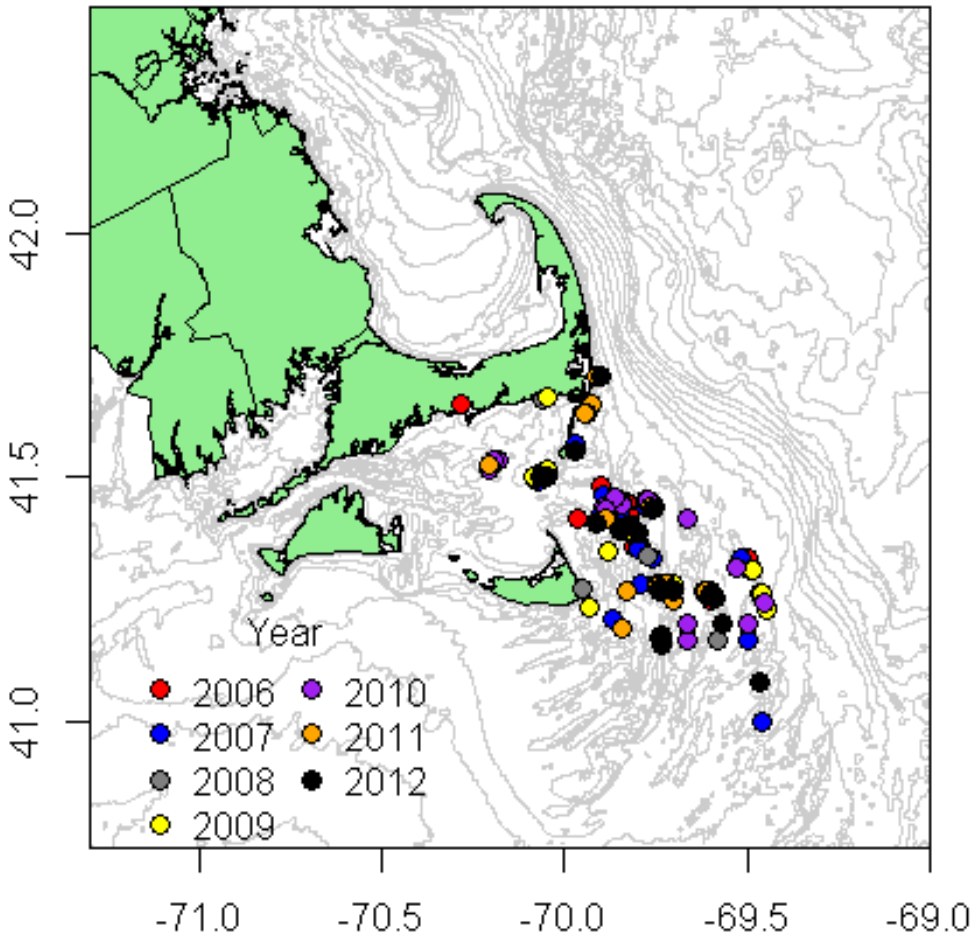

Figure 10. Map of DMF fall tagging locations during 2006-2012.

with a daily bag limit of 30 fish.

Monitoring Programs

All monitoring programs will continue in 2013.

Acknowledgements

The collection and quality of striped bass data would suffer greatly without the efforts of many DMF employees. Staff of the Fisheries Statistics section collected, entered, and compiled all commercial data. Jennifer Stritzel-Thomson coordinated the volunteer recreational angler data collection program, entered scale envelope data, and prepared data for analysis. Scott Elzey, Kate Rogers, and Kim Trull prepared scale samples. John Boardman aged all scale samples. John Boardman, Nick Buchan, and Brad Schondelmeier conducted the commercial sampling of stripers. Paul Caruso and John Boardman also coordinated and conducted the USFWS cooperative tagging study. Funding for this effort was provided by the Massachusetts Division of Marine Fisheries and Sport Fish Restoration Funds Grants F-57-R and F-48-R.

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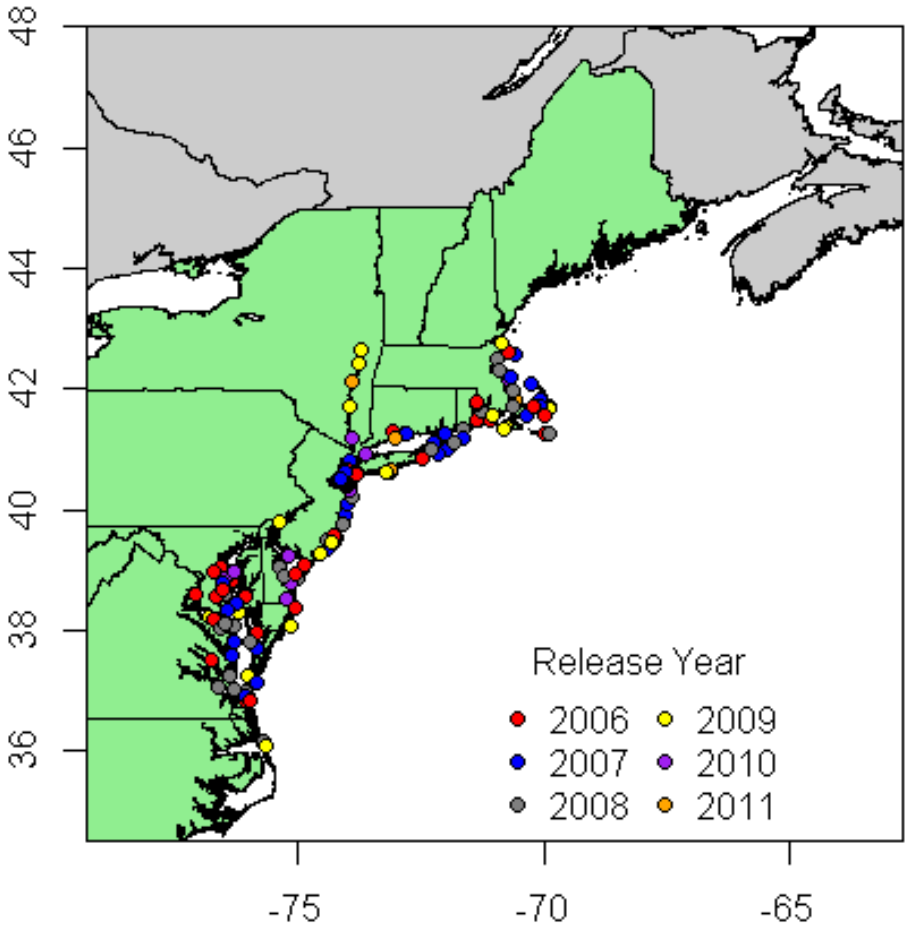

Figure 11. Map of recovery locations from 2006-2011 of DMF tagged striped bass by release year.

recreational catch rate data for some fish stocks off the northeast US coast. Fish. Bull. 101: 653-672.

Appendix

Appendix Table 1A. Estimated size distribution of the Massachusetts commercial striped bass catch (numbers of fish) in 2012.

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	164	164	0.12	0.12
15	0	55	55	0.04	0.15
16	0	438	438	0.31	0.46
17	0	657	657	0.46	0.93
18	0	328	328	0.23	1.16
19	0	547	547	0.39	1.54
20	0	930	930	0.66	2.20
21	0	328	328	0.23	2.43
22	0	876	876	0.62	3.05
23	0	438	438	0.31	3.35
24	0	3,338	3,338	2.35	5.70
25	0	1,751	1,751	1.23	6.94
26	0	2,955	2,955	2.08	9.02
27	0	4,323	4,323	3.05	12.06
28	169	7,825	7,994	5.63	17.70
29	311	5,527	5,837	4.11	21.81
30	367	9,904	10,271	7.24	29.04
31	339	9,412	9,751	6.87	35.91
32	627	15,157	15,785	11.12	47.03
33	1,737	8,098	9,836	6.93	53.96
34	8,545	1,532	10,077	7.10	61.06
35	10,141	55	10,196	7.18	68.24
36	9,711	876	10,587	7.46	75.70
37	5,842	0	5,842	4.11	79.81
38	5,353	55	5,408	3.81	83.62
39	4,981	0	4,981	3.51	87.13
40	3,520	0	3,520	2.48	89.61
41	4,359	0	4,359	3.07	92.68
42	3,117	0	3,117	2.20	94.87
43	2,795	0	2,795	1.97	96.84
44	1,838	0	1,838	1.29	98.14
45	1,565	0	1,565	1.10	99.24
46	447	0	447	0.31	99.56
47	339	0	339	0.24	99.79
48	191	0	191	0.13	99.93
49	101	0	101	0.07	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	66,394	75,568	141,962		
Avg. Size	37.6	29.4	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 2012.

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	160	160	0.01	0.01
15	0	66	66	0.00	0.01
16	0	639	639	0.03	0.04
17	0	1,149	1149	0.06	0.10
18	0	683	683	0.03	0.13
19	0	1,338	1338	0.07	0.20
20	0	2,655	2655	0.13	0.33
21	0	1,085	1085	0.05	0.39
22	0	3,328	3328	0.17	0.55
23	0	1,902	1902	0.09	0.65
24	0	16,481	16481	0.82	1.47
25	0	9,775	9775	0.49	1.95
26	0	18,560	18560	0.92	2.88
27	0	30,415	30415	1.51	4.39
28	1,330	61,418	62748	3.12	7.52
29	2,710	48,207	50916	2.54	10.05
30	3,546	95,661	99207	4.94	14.99
31	3,612	100,325	103937	5.17	20.17
32	7,357	177,754	185111	9.22	29.38
33	22,350	104,181	126531	6.30	35.68
34	120,252	21,561	141813	7.06	42.74
35	155,704	840	156545	7.79	50.54
36	162,286	14,631	176917	8.81	59.34
37	106,007	0	106007	5.28	64.62
38	105,248	1,076	106324	5.29	69.92
39	105,885	0	105885	5.27	75.19
40	80,745	0	80745	4.02	79.21
41	107,699	0	107699	5.36	84.57
42	82,798	0	82798	4.12	88.69
43	79,694	0	79694	3.97	92.66
44	56,151	0	56151	2.80	95.46
45	51,176	0	51176	2.55	98.00
46	15,611	0	15611	0.78	98.78
47	12,630	0	12630	0.63	99.41
48	7,581	0	7581	0.38	99.79
49	4,265	0	4265	0.21	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	1,294,637	713,888	2,008,526		
Avg. Weight	19.5	9.4	14.1		

Appendix Table 2. Results of the GLM analyses of total catch rates (pounds/hour) for the commercial striped bass fishery, 1991-2012.

Analysis of Deviance (Type III tests)

	SS	Df	F	Pr(>F)	
YEAR	1356	21	62.699	<0.00001	***
AREA	2232	2	1083.437	<0.00001	***
Residuals	53890	52312			

	Estimate	SE	t	Pr(>|t|)	
(Intercept)	1.94974	0.02644	73.753	0.0000	***
YEAR1992	0.06307	0.03547	1.778	0.0754	.
YEAR1993	0.15539	0.03533	4.398	0.0000	***
YEAR1994	0.06322	0.03527	1.793	0.0730	.
YEAR1995	0.17645	0.03153	5.595	0.0000	***
YEAR1996	0.25056	0.05134	4.88	0.0000	***
YEAR1997	0.17248	0.03051	5.654	0.0000	***
YEAR1998	0.21107	0.0311	6.788	0.0000	***
YEAR1999	0.1357	0.03177	4.271	0.0000	***
YEAR2000	0.24943	0.0323	7.722	0.0000	***
YEAR2001	0.39408	0.03237	12.176	0.0000	***
YEAR2002	0.43452	0.03186	13.639	0.0000	***
YEAR2003	0.49591	0.02941	16.86	0.0000	***
YEAR2004	0.53789	0.03551	15.149	0.0000	***
YEAR2005	0.3691	0.03215	11.479	0.0000	***
YEAR2006	0.3815	0.0304	12.55	0.0000	***
YEAR2007	0.35504	0.03087	11.501	0.0000	***
YEAR2008	0.24607	0.03084	7.978	0.0000	***
YEAR2009	0.33007	0.03059	10.788	0.0000	***
YEAR2010	0.35669	0.03277	10.884	0.0000	***
YEAR2011	0.62743	0.03686	17.024	0.0000	***
YEAR2012	0.66804	0.03333	20.045	0.0000	***
AREACCB	0.0105	0.01303	0.806	0.4203	
AREASMA	0.4235	0.01162	36.45	0.0000	***

Year	LSMEANS
1991	8.120635
1992	8.649326
1993	9.485825
1994	8.650604
1995	9.687683
1996	10.43297
1997	9.649309
1998	10.02898
1999	9.300879
2000	10.42116
2001	12.04312
2002	12.54011
2003	13.33404
2004	13.90565
2005	11.74589
2006	11.89251
2007	11.582
2008	10.38616
2009	11.29628
2010	11.60103
2011	15.20827
2012	15.83853

Appendix Table 3A. Estimated size distribution of the Massachusetts recreational striped bass catch (numbers of fish) in 2012.

TL (in.)	Harvested	Released	Total	Percent	Cumulative Percent
9	0	1,493	1,493	0.11	0.11
10	0	10,776	10,776	0.79	0.79
11	0	11,276	11,276	0.83	1.61
12	0	24,050	24,050	1.76	3.38
13	0	55,078	55,078	4.03	7.41
14	0	63,024	63,024	4.61	12.02
15	0	64,111	64,111	4.69	16.71
16	0	65,522	65,522	4.80	21.51
17	0	42,048	42,048	3.08	24.59
18	0	47,058	47,058	3.45	28.03
19	0	36,520	36,520	2.67	30.71
20	0	28,437	28,437	2.08	32.79
21	0	17,984	17,984	1.32	34.11
22	0	22,956	22,956	1.68	35.79
23	0	30,775	30,775	2.25	38.04
24	0	22,792	22,792	1.67	39.71
25	0	43,054	43,054	3.15	42.86
26	0	30,156	30,156	2.21	45.07
27	0	29,854	29,854	2.19	47.25
28	5,852	23,175	29,027	2.13	49.38
29	24,545	27,848	52,393	3.84	53.22
30	25,938	33,555	59,493	4.36	57.57
31	32,238	37,819	70,058	5.13	62.70
32	53,707	51,449	105,156	7.70	70.40
33	29,355	43,212	72,566	5.31	75.71
34	27,967	37,196	65,162	4.77	80.48
35	30,582	20,355	50,936	3.73	84.21
36	28,416	20,652	49,067	3.59	87.80
37	37,370	9,508	46,878	3.43	91.23
38	16,278	8,960	25,238	1.85	93.08
39	19,613	9,691	29,304	2.15	95.23
40	10,753	7,340	18,094	1.32	96.55
41	10,490	1,506	11,996	0.88	97.43
42	10,980	935	11,915	0.87	98.30
43	3,811	1,869	5,680	0.42	98.72
44	5,018	5,608	10,626	0.78	99.50
45	3,584	1,869	5,453	0.40	99.90
46	0	0	0	0.00	99.90
47	717	0	717	0.05	99.95
48	717	0	717	0.05	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	377,931	989,509	1,367,440		
Avg. Size	34.6	23.3	26.4		

Appendix Table 3B. Estimated size distribution of the Massachusetts recreational striped bass catch (pounds) in 2012.

TL (in.)	Harvested	Released	Total	Percent	Cumulative Percent
9	0	360	360		
10	0	3,565	3,565	0.03	0.03
11	0	4,968	4,968	0.04	0.08
12	0	13,765	13,765	0.12	0.20
13	0	40,101	40,101	0.36	0.55
14	0	57,340	57,340	0.51	1.06
15	0	71,777	71,777	0.64	1.70
16	0	89,069	89,069	0.79	2.49
17	0	68,590	68,590	0.61	3.10
18	0	91,156	91,156	0.81	3.91
19	0	83,232	83,232	0.74	4.65
20	0	75,618	75,618	0.67	5.32
21	0	55,380	55,380	0.49	5.82
22	0	81,305	81,305	0.72	6.54
23	0	124,585	124,585	1.11	7.64
24	0	104,865	104,865	0.93	8.58
25	0	223,962	223,962	1.99	10.57
26	0	176,505	176,505	1.57	12.13
27	0	195,734	195,734	1.74	13.87
28	42,751	169,505	212,256	1.89	15.76
29	199,272	226,348	425,621	3.78	19.54
30	233,177	302,002	535,179	4.75	24.29
31	319,853	375,654	695,506	6.18	30.47
32	586,229	562,229	1,148,458	10.20	40.68
33	351,479	517,992	869,471	7.72	48.40
34	366,311	487,752	854,063	7.59	55.99
35	437,042	291,223	728,264	6.47	62.46
36	441,987	321,597	763,583	6.78	69.24
37	631,187	160,770	791,957	7.04	76.28
38	297,899	164,161	462,060	4.11	80.38
39	388,084	191,973	580,057	5.15	85.54
40	229,606	156,915	386,522	3.43	88.97
41	241,251	34,664	275,915	2.45	91.42
42	271,498	23,144	294,642	2.62	94.04
43	101,148	49,656	150,805	1.34	95.38
44	142,711	159,660	302,371	2.69	98.07
45	109,063	56,930	165,994	1.47	99.54
46	0	0	0	0.00	99.54
47	24,860	0	24,860	0.22	99.76
48	26,484	0	26,484	0.24	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	5,441,893	5,814,051	11,255,944		
Avg. Weight	14.4	5.9	8.2		

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

Anova Table (Type III)
Response: TOT_FISH

	Chisq	Df	Pr(>Chisq)	
YEAR	396.9	24	2.20E-16	***
AREA_X	38.87	2	3.62E-09	***
MODE_FX	438.68	2	2.20E-16	***
WAVE	285.46	2	2.20E-16	***
CNTY	122.21	7	2.20E-16	***
FFDAYS12C	583.96	12	2.20E-16	***
HOURS	996.11	11	2.20E-16	***

Coefficients:

	Estimate	SE	t	Pr(>|t|)	
(Intercept)	0.310836	0.23	1.346	0.1784	
YEAR1988	-0.18701	0.26	-0.733	0.4635	
YEAR1989	-0.25296	0.25	-1.017	0.3091	
YEAR1990	-0.24759	0.24	-1.033	0.3016	
YEAR1991	-0.10989	0.24	-0.459	0.6459	
YEAR1992	0.099214	0.23	0.427	0.6695	
YEAR1993	-0.05934	0.23	-0.256	0.7977	
YEAR1994	0.011011	0.23	0.048	0.9617	
YEAR1995	0.234839	0.23	1.029	0.3037	
YEAR1996	0.248867	0.23	1.089	0.2763	
YEAR1997	0.308673	0.23	1.353	0.1760	
YEAR1998	0.396061	0.23	1.74	0.0819	.
YEAR1999	0.341672	0.23	1.499	0.1339	
YEAR2000	0.38405	0.23	1.682	0.0926	.
YEAR2001	0.144812	0.23	0.635	0.5256	
YEAR2002	0.121912	0.23	0.533	0.5939	
YEAR2003	0.188598	0.23	0.825	0.4094	
YEAR2004	0.235133	0.23	1.026	0.3050	
YEAR2005	0.249698	0.23	1.088	0.2765	
YEAR2006	0.47737	0.23	2.088	0.0368	*
YEAR2007	0.212656	0.23	0.928	0.3534	
YEAR2008	0.119693	0.23	0.519	0.6035	
YEAR2009	0.076974	0.23	0.335	0.7379	
YEAR2010	0.014504	0.23	0.063	0.9500	
YEAR2011	-0.14819	0.23	-0.638	0.5233	
AREA_X2	-0.04989	0.03	-1.918	0.0552	.
AREA_X5	0.088647	0.02	4.76	1.95E-06	***
MODE_FX6	0.356715	0.04	10.174	2.00E-16	***
MODE_FX7	0.504551	0.02	21.833	2.00E-16	***
WAVE4	-0.30408	0.02	-16.868	2.00E-16	***
WAVE5	-0.1809	0.02	-8.085	6.55E-16	***
CNTY5	-0.14173	0.04	-3.625	0.00029	***
CNTY7	-0.2966	0.05	-6.045	1.52E-09	***
CNTY9	0.100331	0.02	4.842	1.30E-06	***
CNTY19	-0.10528	0.07	-1.478	0.13935	
CNTY21	-0.00019	0.04	-0.004	0.99644	
CNTY23	-0.02383	0.03	-0.885	0.37604	
CNTY25	-0.33941	0.06	-5.382	7.46E-08	***

Appendix 4A cont'd.

Coefficients:

	Estimate	SE	t	Pr(>|t|)	
FFDAYS12C10	0.057562	0.03	2.249	0.02449	*
FFDAYS12C20	0.178966	0.03	6.913	4.86E-12	***
FFDAYS12C30	0.178405	0.03	5.951	2.71E-09	***
FFDAYS12C40	0.325176	0.04	8.88	2.00E-16	***
FFDAYS12C50	0.368813	0.03	11.523	2.00E-16	***
FFDAYS12C60	0.416569	0.04	9.502	2.00E-16	***
FFDAYS12C70	0.43873	0.05	8.058	8.17E-16	***
FFDAYS12C80	0.479514	0.08	6.356	2.11E-10	***
FFDAYS12C90	0.537219	0.09	6.183	6.39E-10	***
FFDAYS12C10(	0.557673	0.03	16.269	2.00E-16	***
FFDAYS12C15(	0.61556	0.06	10.398	2.00E-16	***
FFDAYS12C20(	0.716863	0.07	10.326	2.00E-16	***
HOURS2	0.10434	0.05	2.13	0.03315	*
HOURS3	0.332073	0.05	7.163	8.12E-13	***
HOURS4	0.471311	0.05	10.321	2.00E-16	***
HOURS5	0.627422	0.05	13.455	2.00E-16	***
HOURS6	0.684968	0.05	14.535	2.00E-16	***
HOURS7	0.898316	0.05	17.456	2.00E-16	***
HOURS8	0.899721	0.05	16.566	2.00E-16	***
HOURS9	0.921528	0.07	12.514	2.00E-16	***
HOURS10	1.064556	0.08	12.695	2.00E-16	***
HOURS11	1.274576	0.17	7.359	1.92E-13	***
HOURS12	1.047941	0.1	10.381	2.00E-16	***

Year	lsmeans
1987	4.124
1988	3.421
1989	3.203
1990	3.220
1991	3.695
1992	4.555
1993	3.887
1994	4.170
1995	5.216
1996	5.290
1997	5.616
1998	6.129
1999	5.804
2000	6.056
2001	4.767
2002	4.659
2003	4.981
2004	5.218
2005	5.294
2006	6.648
2007	5.102
2008	4.649
2009	4.454
2010	4.185
2011	3.556

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

Anova Table (Type III)
Response: 0/1

	Chisq	Df	Pr(>Chisq)	
YEAR	1796.4	24	2.20E-16	***
AREA_X	208.5	2	2.20E-16	***
MODE_FX	4153.8	2	2.20E-16	***
WAVE	403.5	2	2.20E-16	***
CNTY	420.3	7	2.20E-16	***
FFDAYS12C	976.8	12	2.20E-16	***
HOURS	2859.1	11	2.20E-16	***

Coefficients:

	Estimate	SE	Z	Pr(>|z|)	
(Intercept)	-3.72	0.25092	-14.825	2.00E-16	***
YEAR1988	-0.1504	0.27318	-0.55	0.582016	
YEAR1989	-0.1071	0.27014	-0.397	0.691688	
YEAR1990	-0.2173	0.25912	-0.838	0.401761	
YEAR1991	-0.3219	0.25787	-1.248	0.211875	
YEAR1992	-0.1517	0.25216	-0.601	0.547567	
YEAR1993	0.16743	0.25135	0.666	0.505343	
YEAR1994	0.65303	0.24943	2.618	0.008842	**
YEAR1995	0.94284	0.24873	3.791	0.00015	***
YEAR1996	0.98525	0.24916	3.954	7.68E-05	***
YEAR1997	0.96559	0.24844	3.887	0.000102	***
YEAR1998	1.4528	0.24839	5.849	4.95E-09	***
YEAR1999	1.20279	0.24849	4.84	1.30E-06	***
YEAR2000	1.12264	0.249	4.509	6.53E-06	***
YEAR2001	0.9222	0.24848	3.711	0.000206	***
YEAR2002	0.9674	0.24936	3.88	0.000105	***
YEAR2003	0.85708	0.24905	3.441	0.000579	***
YEAR2004	0.93116	0.25048	3.718	0.000201	***
YEAR2005	1.04382	0.25092	4.16	3.18E-05	***
YEAR2006	1.29284	0.24986	5.174	2.29E-07	***
YEAR2007	0.96888	0.2507	3.865	0.000111	***
YEAR2008	0.80319	0.25187	3.189	0.001428	**
YEAR2009	0.75875	0.25093	3.024	0.002497	**
YEAR2010	0.51804	0.25246	2.052	0.040174	*
YEAR2011	0.38934	0.253	1.539	0.123827	
AREA_X2	-0.0365	0.03364	-1.084	0.278272	
AREA_X5	0.30139	0.02302	13.091	2.00E-16	***
MODE_FX6	2.65579	0.04775	55.622	2.00E-16	***
MODE_FX7	1.16216	0.02556	45.471	2.00E-16	***
WAVE4	-0.3661	0.02349	-15.584	2.00E-16	***
WAVE5	-0.5179	0.02763	-18.747	2.00E-16	***
CNTY5	-0.2585	0.04765	-5.425	5.80E-08	***
CNTY7	-0.1553	0.05911	-2.627	0.008618	**
CNTY9	0.37036	0.0254	14.583	2.00E-16	***
CNTY19	-0.3947	0.08288	-4.762	1.92E-06	***
CNTY21	0.12258	0.05331	2.299	0.021484	*
CNTY23	-0.1161	0.0323	-3.595	0.000325	***
CNTY25	0.11317	0.07681	1.473	0.140651	

Appendix Table 4B cont'd.

Coefficients:

	Estimate	SE	Z	Pr(>|z|)	
FFDAYS12C1(	0.13735	0.03075	4.467	7.93E-06	***
FFDAYS12C2(	0.40299	0.03193	12.622	2.00E-16	***
FFDAYS12C3(	0.49168	0.03747	13.12	2.00E-16	***
FFDAYS12C4(	0.58443	0.04696	12.444	2.00E-16	***
FFDAYS12C5(	0.73676	0.04154	17.736	2.00E-16	***
FFDAYS12C6(	0.6883	0.05654	12.175	2.00E-16	***
FFDAYS12C7(	0.82814	0.07247	11.428	2.00E-16	***
FFDAYS12C8(	0.86549	0.10254	8.44	2.00E-16	***
FFDAYS12C9(	0.66128	0.11061	5.978	2.25E-09	***
FFDAYS12C1(	0.91623	0.04538	20.19	2.00E-16	***
FFDAYS12C1:	0.95088	0.07778	12.225	2.00E-16	***
FFDAYS12C2(	0.90118	0.08963	10.054	2.00E-16	***
HOURS2	0.66125	0.04905	13.48	2.00E-16	***
HOURS3	1.05954	0.04699	22.55	2.00E-16	***
HOURS4	1.37227	0.04672	29.374	2.00E-16	***
HOURS5	1.53838	0.04872	31.576	2.00E-16	***
HOURS6	1.79159	0.05059	35.414	2.00E-16	***
HOURS7	1.99568	0.06068	32.889	2.00E-16	***
HOURS8	1.91584	0.06418	29.853	2.00E-16	***
HOURS9	2.22326	0.10135	21.937	2.00E-16	***
HOURS10	2.27352	0.11669	19.484	2.00E-16	***
HOURS11	1.67471	0.2263	7.4	1.36E-13	***
HOURS12	2.3006	0.13918	16.53	2.00E-16	***

Year	lsmeans
1987	0.37795
1988	0.3433
1989	0.35312
1990	0.32838
1991	0.30573
1992	0.34301
1993	0.41804
1994	0.53862
1995	0.60935
1996	0.6194
1997	0.61476
1998	0.72203
1999	0.66919
2000	0.65122
2001	0.60443
2002	0.61518
2003	0.58876
2004	0.60657
2005	0.63311
2006	0.68882
2007	0.61553
2008	0.57565
2009	0.56476
2010	0.50495
2011	0.4728