Technical Report

Massachusetts Division of Marine Fisheries
Technical Report TR-59

Massachusetts Striped Bass Monitoring Report for 2013

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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 2013

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Commonwealth of Massachusetts
Charles D. Baker, Governor
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Matthew A. Beaton, Secretary
Department of Fish and Game
George N. Peterson, Jr., Commissioner
Massachusetts Division of Marine Fisheries
Paul Diodati, Director

Summary: During 2013, the Massachusetts commercial fishery for striped bass sold about 58,547 fish weighing 1,004,459 pounds and kept approximately 4,023 fish for personal consumption. Total losses due to commercial harvesting (including release mortality) were 68,172 fish weighing 1,115,281 pounds. The recreational fishery harvested about 282,170 striped bass weighing over 3.8 million pounds. Total losses due to recreational fishing (including release mortality) were 434,350 fish weighing over 4.7 million pounds. Combined losses (including scientific losses) were 502,522 fish weighing over 5.8 million pounds, which reflects a 7% decrease in numbers lost and a 19% decrease in weight lost compared to 2012 (540,182 fish; 7.2 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 2013. Data sources used to characterize the state fisheries come from monitoring programs of the Massachusetts Division of Marine Fisheries (*MarineFisheries*, the Division) and National Marine Fisheries Service (NOAA Fisheries), 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 2013

Season: July 12–August 6, September 1, and September 8. No landings were permitted on Monday, Friday, or Saturday.

Sold: 1,004,459 pounds (against a harvest quota of 997,869 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 Tuesday–Thursday.

Licensing, Reporting, and Estimation of Landings. To purchase striped bass directly from fishermen, fish dealers are required to obtain special authorization from *MarineFisheries* in addition to standard seafood dealer permits. Dealer reporting requirements included weekly reporting to the Division or SAFIS program of all striped bass purchases. If sent to Division, all landings information is entered into SAFIS by Division 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. *MarineFisheries* personnel review dealer transactions and correct entries before calculating total landings.

Fishermen must have a *MarineFisheries* 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 and catch rates.

Landings. The landings used here come from the SAFIS program. Commercial dealers bought 1,004,459 pounds (58,547 fish) of striped bass in 2013 (Table 1). Most striped bass were sold in Barnstable, Bristol, and Essex counties of Massachusetts. Commercial fishers kept an additional 4,023 fish weighing approximately 59,255 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 3,272 fish sampled from the 2013 commercial harvest and 2000 Division diet study were used to construct a length-weight equation to estimate weight-at-size for individual bass. The following geometric regression was derived:

Table 1. Attributes of the Massachusetts striped bass commercial fishery, 1990-2013.

		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	1,055.4	55.7	151	4,867
2004	19	1,206.3	60.6	130	4,376
2005	22	1,104.7	59.5	162	4,159
2006	26	1,312.1	69.9	136	3,980
2007	22	1,040.3	54.3	160	3,906
2008	34	1,160.1	61.1	167	3,821
2009	27	1,138.3	59.3	178	4,020
2010	24	1,224.4	60.3	178	3,951
2011	18	1,163.8	58.5	189	3,965
2012	17	1,219.7	61.5	186	3,965
2013	16	1,004.5	58.5	187	4,016

$$\log_{10}(W) = -3.420 + 2.973 * \log_{10}(L),$$
$$RMS = 0.0029$$

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:

$$W = 10^{(-3.340 + 2.973 * \log_{10}(L) + RMS/2)}$$

Size composition of the commercial catch by category of disposition is presented in *Tables A1a (numbers of fish) and A1b (pounds of fish). About 46% of all fish caught had lengths >34 inches.

Age and Sex Composition. Four hundred and twenty six fish sampled from the 2013 commercial harvest were used to sex and age the harvested fish. Age composition of harvest fish was estimated from a sub-sample of 297 fish. The age composition of fish released and consumed was estimated from length data reported in commercial angler logs, and an age-length key was 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 over 15 years, and 99.3% were females. About 84% of the sub-sample consisted of individuals from the 2001-2005 year classes (ages 8-12) (Figure 1). Peak numbers-at-age of the total catches (harvest plus releases plus consumed)

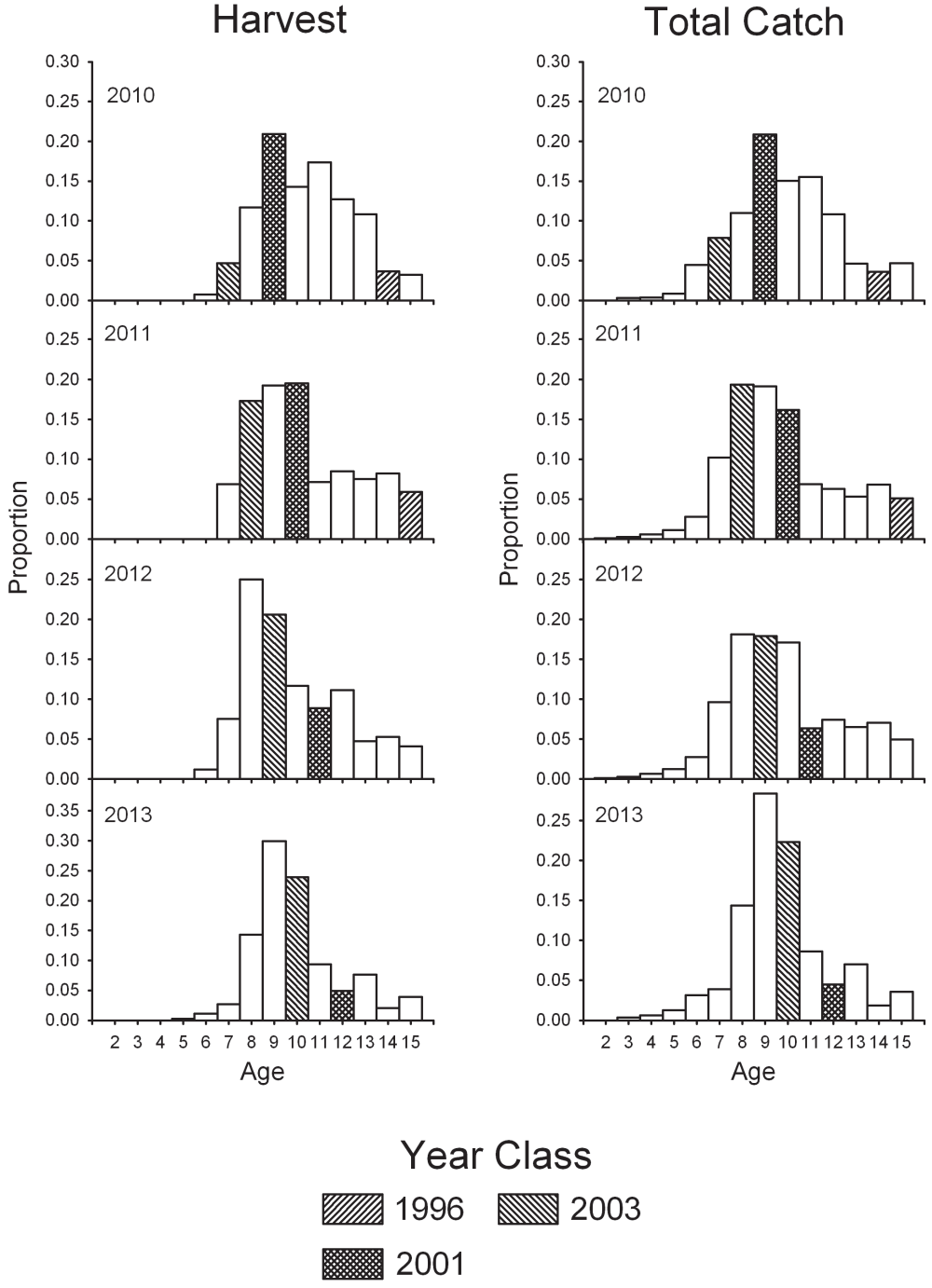

Figure 1. Age composition (proportion) of the harvest and total catches from the Massachusetts commercial fishery. The large 1996, 2001, and 2003. Chesapeake Bay year-classes are highlighted.

*Tables marked with an "A" preceeding the table number can be found in the Appendix.

were from the 2003 and 2004 year-classes.

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, *MarineFisheries* 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 Massachusetts, Cape Cod Bay, Northern Massachusetts). Only data from July and 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 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 Table A2. Although factors were significant, the variables accounted for only about 10% of the total variation in harvest rates.

Harvest rates steadily increased after 1999, peaked in 2004, dropped through 2008, increased slightly through 2010, then dramatically increased in 2011, remained at high levels in 2012 and dropped in 2013 (Figure 2a). The dramatic increase in harvest rates for 2011 and 2012 is attributed to large increases in harvest rates by fishers working in waters south of Cape Cod (Figure 2b). The reason for the increase was due to atypical, large concentrations of striped bass (likely attracted to large aggregations of sand lance in the area) off Cape Cod—particularly Chatham—in 2011, 2012, and 2013. These large concentrations 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 Tables A1a,b. Total losses due to release mortality were 5,601 fish weighing approximately 51,567 pounds.

Recreational Fishery in 2013

Season: All year

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 Massachusetts state waters.

Harvest levels: Harvest (A+B1) and total catch (A+B1+B2) estimates (Table 2) were provided by NOAA Fisheries Marine Recreational Information Program (MRIP). In 2011, new estimation methods were applied to data collected since 2004, 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 2013 was 1,973,058 striped bass, which is a 44% increase compared to the 2012 estimate. The estimate of total harvest in 2013 was 282,170 fish, which is a 25% decrease in harvest compared to 2012. Total pounds harvested was over 3.8 million in 2013 (Table 2).

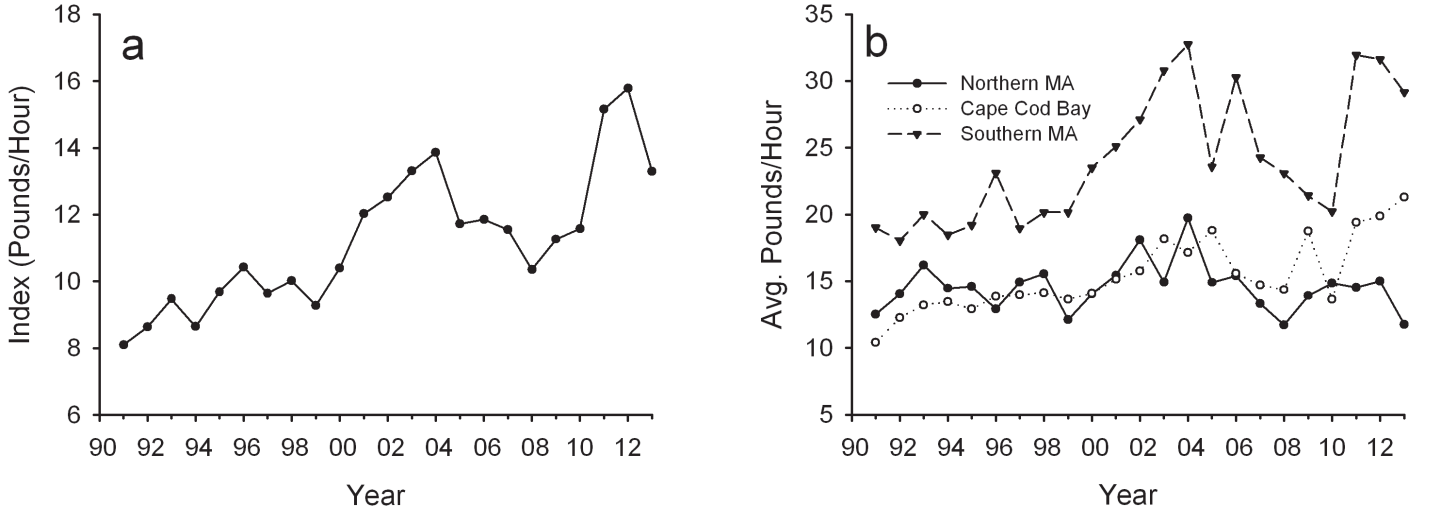

Figure 2. a) Harvest index (stadardized pounds/hour) and b) average harvest rates by area for the Massachusetts commercial striped bass fishery, 1990-2013.

Table 2. MRIP estimates of striped bass harvest, release, and total catch in Massachusetts.

Year	Harvest (A + B1) Numbers	Harvest (A + B1) Weight (lb.)	Released (B2) Numbers	Total (A + B1 + B2) 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	6,235,558	4,979,075	5,424,820
2005	340,742	5,119,345	3,988,679	4,329,421
2006	314,988	4,861,391	7,809,777	8,124,765
2007	315,409	5,099,862	5,331,470	5,646,879
2008	377,959	5,720,651	3,649,415	4,027,374
2009	344,401	4,795,791	2,282,601	2,627,002
2010	341,046	4,277,990	1,671,437	2,012,483
2011	255,507	3,504,603	973,192	1,228,699
2012	377,931	5,441,893	989,509	1,367,440
2013	282,170	3,899,919	1,690,888	1,973,058

Size Composition. The length distributions of harvested and released fish were estimated from biological sampling conducted by the MRIP program in Massachusetts and from the volunteer Sportfish Data Collection Team (SADCT) program conducted by the Division. 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 1,207 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 Tables A3a,b.

Age Composition. A sub-sample of 648 fish from the SADCT was aged and combined with commercial and tagging samples to produce an age-length key used to convert MRIP and Massachusetts SADCT 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 2013 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; Stefánsson 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 tech-

niques. Statistical models are then 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*:

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

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 $\hat{p}_i$ and y_i are the predicted annual least-squares responses 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 Tables A4a,b for 1986–2013. Standardized catch rates for

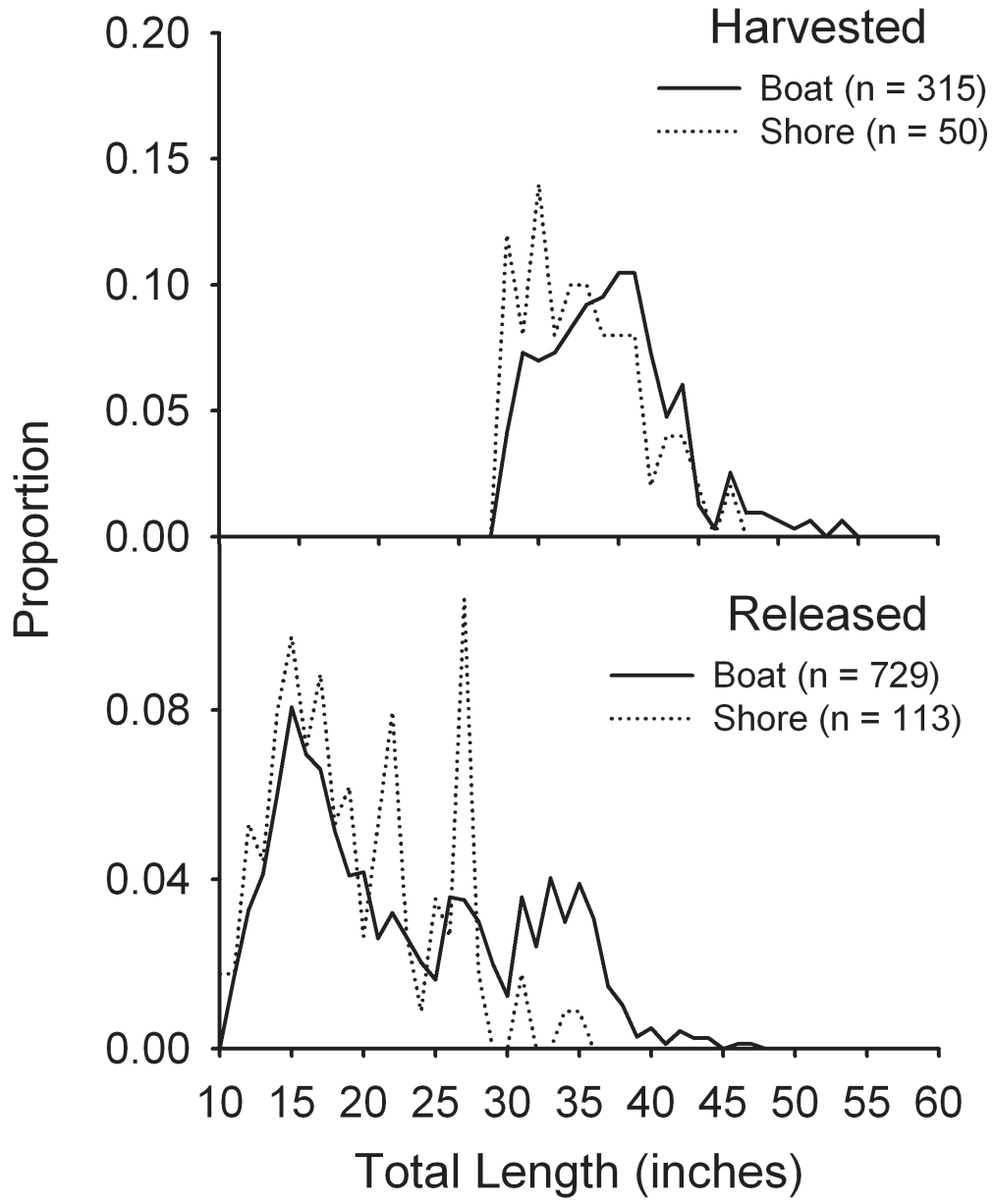

Figure 3. Sizes of striped bass caught by volunteer recreational anglers in 2013 by disposition and fishing mode.

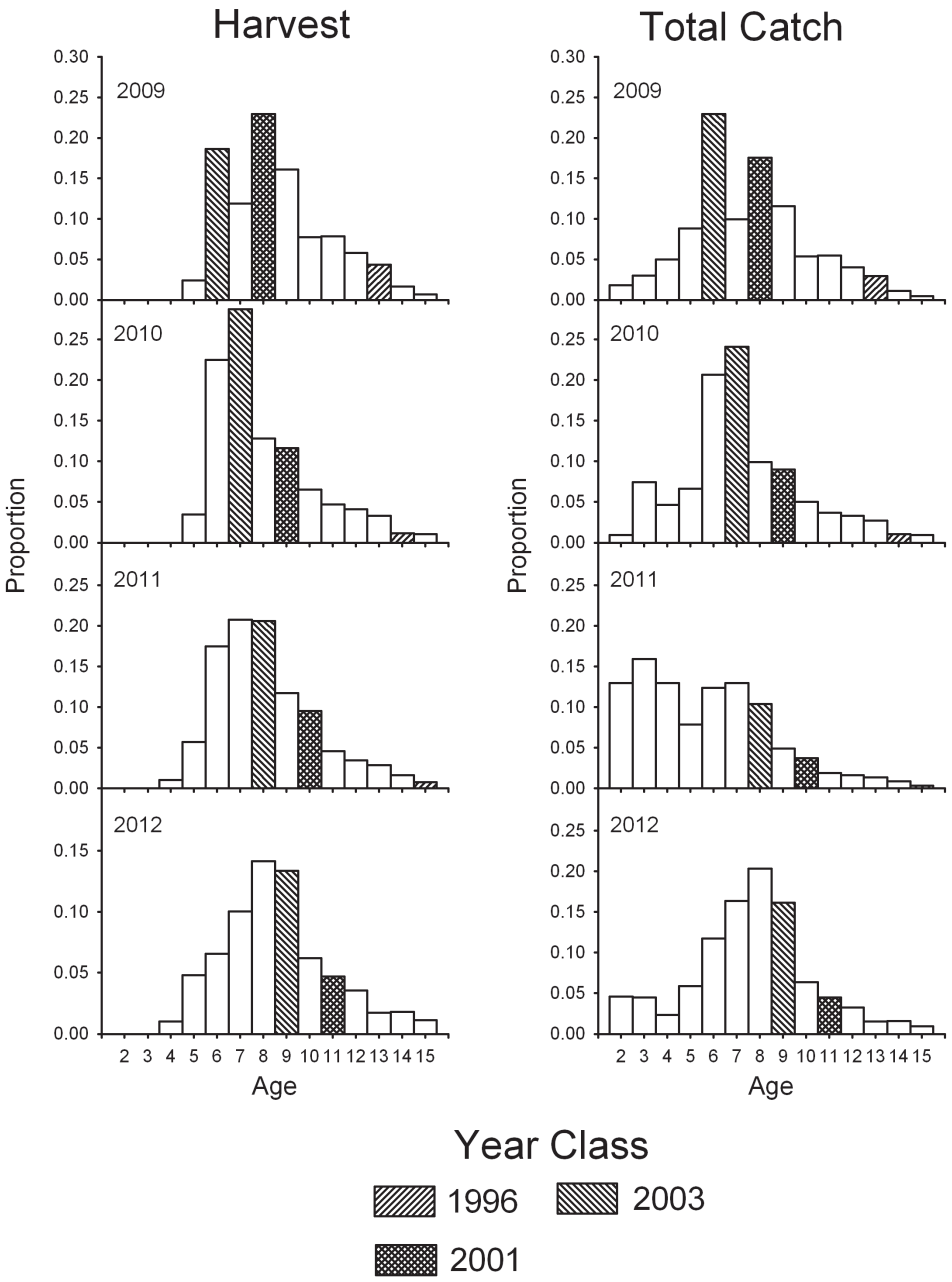

Figure 4. Age composition (proportion) of harvest and total catches from the Massachusetts recreational fishery. The large 1996, 2001, and 2003 Chesapeake Bay year-classes are highlighted.

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. Catch rates declined through 2011, but began increasing in 2012 as the 2011 year-class became vulnerable to the fishery.

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 152,180 fish (879,273 pounds) (Table 3).

Bycatch in Other Fisheries

During 1994, *MarineFisheries* 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. Division 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. *MarineFisheries* will continue to monitor potential sources of striped bass bycatch during 2014.

Estimated Total Losses in 2013

Total estimated loss of striped bass during 2013 was 502,522 fish weighing 5,894,473 pounds (Table 3), which is a 7% decrease in numbers lost and a 19% decrease in weight compared to 2012 (540,182 fish; 7,258,896 pounds). The ma-

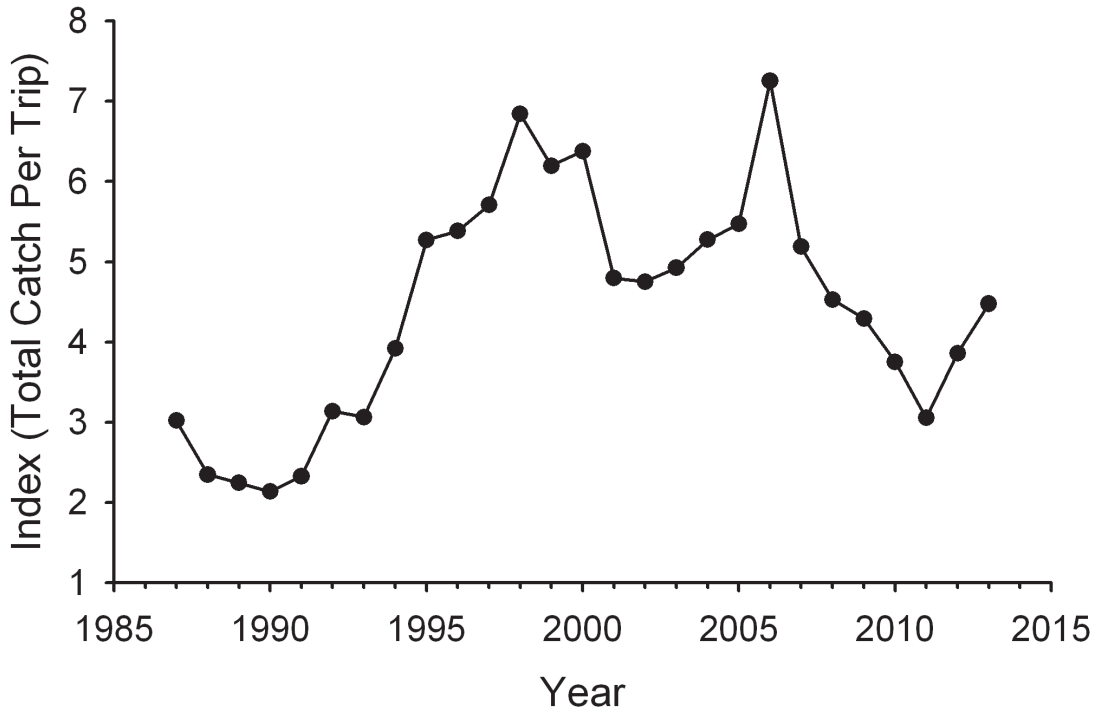

Figure 5. Standardized total catch rates (total number of fish caught per trip) of the recreational fishery for striped bass in Massachusetts waters, 1987-2011.

jority of losses, 86% by number and 81% by weight, was attributed to combined losses in the recreational fishery.

Removals-At-Age Matrix in 2013

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 2007 (age 6), 2004 (age 9), and 2003 (age 10) year-classes incurred the highest losses in 2013 (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 2013. The resulting equation and predicted relationship are shown in Figure 7.

Required Fishery-Independent Monitoring Programs

Massachusetts Tagging Study

MarineFisheries joined the state-federal coast-wide Cooperative Striped Bass 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, *MarineFisheries* contracts several select charter boat captains to take Division 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 8). Floy internal anchor tags provided by the U.S. Fish and Wildlife Service (USFWS) are used. Total length of each fish is recorded. Scales are removed from each fish for aging. The

Table 3. Estimates of striped bass losses occurring in Massachusetts waters during 2013.

FISHERY	NUMBER	POUNDS	MEAN WEIGHT
Commercial			
Harvest*	62,571	1,063,714	17.0
Release Mortality	5,601	51,567	9.2
Recreational			
Harvest	282,170	3,899,919	13.8
Release Mortality	152,180	879,273	5.8
Total	**502,522**	**5,894,473**	

*includes fish taken for personal consumption

Table 4. Massachusetts striped bass removals-at-age matrix of 2013 by source.

	Recreational		Commercial		
Age	Release Mortality	Harvest	Release Mortality	Harvest*	Total
2	37,185	0	41	0	37,226
3	39,757	606	220	3	40,586
4	19,341	5,713	416	10	25,480
5	9,911	27,159	698	167	37,936
6	11,146	53,979	1,466	685	67,277
7	6,962	36,213	981	1,676	45,832
8	7,574	40,237	843	8,951	57,606
9	9,753	46,190	646	18,711	75,300
10	6,396	35,662	254	14,960	57,273
11	1,785	11,747	29	5,864	19,424
12	749	7,686	3	3,056	11,494
13	822	7,765	2	4,785	13,374
14	339	3,390	0	1,256	4,985
15	302	3,622	1	1,317	5,243
16 and over	157	2,201	0	1,128	3,486

*includes fish taken for personal consumption

release data are made available to the Annapolis, Maryland 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 5. Striped bass released in 2007-2012 were recaptured from coastal waters in North Carolina through New Hampshire (Figure 9).

Planned Management Programs in 2014

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 1,155,100 pounds due to overharvest in 2013. The commercial fishery quota will be monitored using SAFIS. The commercial season will not open until June 24, 2014. Harvesting will be allowed only on Monday and Thursday with a daily bag limit of 2 fish for those with rod-reel or individual permits, or 15 fish for those with boat permits.

Monitoring Programs

All monitoring programs will continue in 2014.

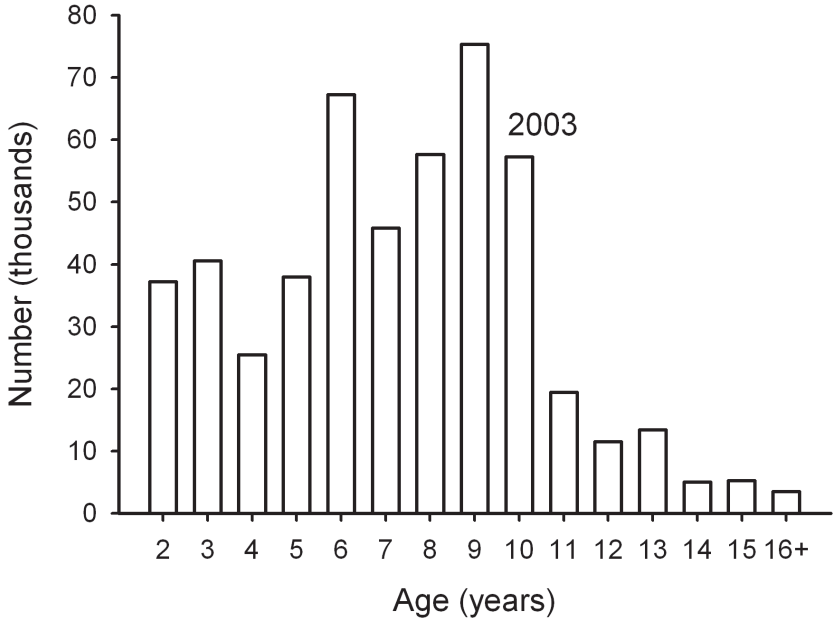

Figure 6. Total number of striped bass removals in 2013 by age. The 2003 year-class is indicated.

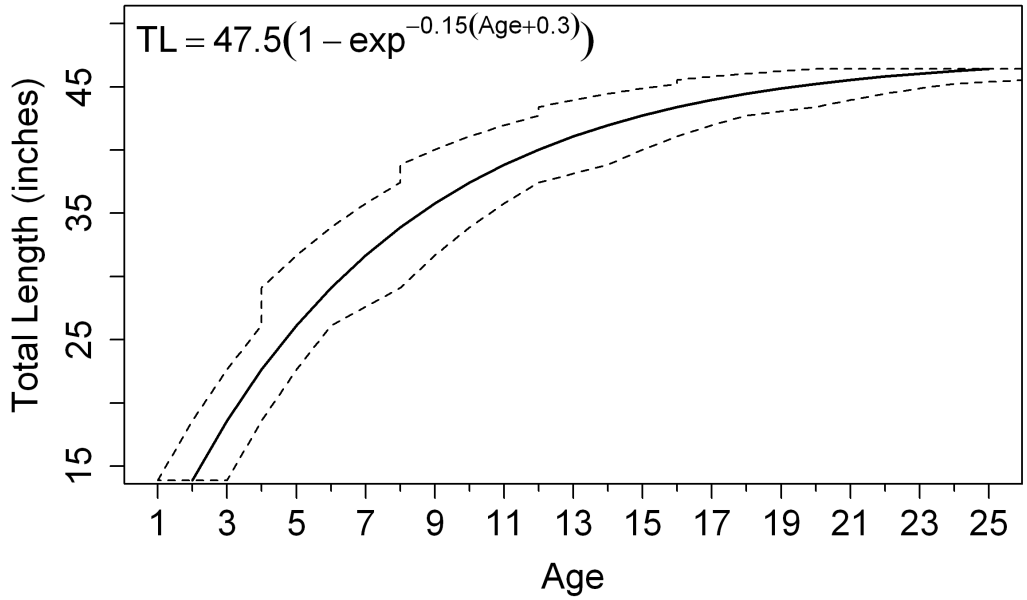

Figure 7. Mean length-age (in years) relationship (solid line) for striped bass captured in Massachusetts. Dotted lines represent the minimum and maximum ages found at a given length.

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

Year	Trips	Boats	Number Tagged	Average Length (mm)	Average Length (in.)	SD (mm)	SD (in.)	Length Range			
								Minimum (mm)	Minimum (in.)	Maximum (mm)	Maximum (in.)
1991	17	4	388	817	32.2	106.4	4.2	534	21.0	1,300	51.2
1992	29	3	899	798	31.4	125.9	5.0	524	20.6	1,267	49.9
1993	15	2	678	784	30.9	125.0	4.9	515	20.3	1,210	47.6
1994	13	2	377	735	28.9	93.2	3.7	548	21.6	1,028	40.5
1995	11	2	449	767	30.2	110.2	4.3	470	18.5	1,178	46.4
1996	8	2	203	748	29.4	64.1	2.5	541	21.3	1,077	42.4
1997	10	2	321	773	30.4	114.7	4.5	485	19.1	1,090	42.9
1998	12	2	382	797	31.4	93.8	3.7	597	23.5	1,055	41.5
1999	16	2	471	777	30.6	95.5	3.8	594	23.4	1,108	43.6
2000	25	4	1,095	752	29.6	102.6	4.0	510	20.1	1,204	47.4
2001	14	3	456	786	30.9	102.5	4.0	503	19.8	1,110	43.7
2002	12	3	239	764	30.1	103.6	4.1	487	19.2	1,060	41.7
2003	15	3	655	825	32.5	92.1	3.6	602	23.7	1,204	47.4
2004	25	7	784	707	27.8	193.1	7.6	316	12.4	1,164	45.8
2005	19	4	752	726	28.6	210.5	8.3	299	11.8	1,114	43.9
2006	11	4	390	813	32.0	94.2	3.7	565	22.2	1,114	43.9
2007	16	3	530	848	33.4	105.2	4.1	600	23.6	1,225	48.2
2008	13	2	456	821	32.3	104.6	4.1	530	20.9	1,202	47.3
2009	15	3	501	840	33.1	101.8	4.0	572	22.5	1,146	45.1
2010	13	3	329	825	32.5	84.0	3.3	668	26.3	1,095	43.1
2011	15	3	504	831	32.7	91.9	3.6	580	22.8	1,174	46.2
2012	15	3	643	852	33.5	87.7	3.5	524	20.6	1,203	47.4
2013	15	3	487	854	33.6	92.2	3.63	617	24.3	1,145	45.1

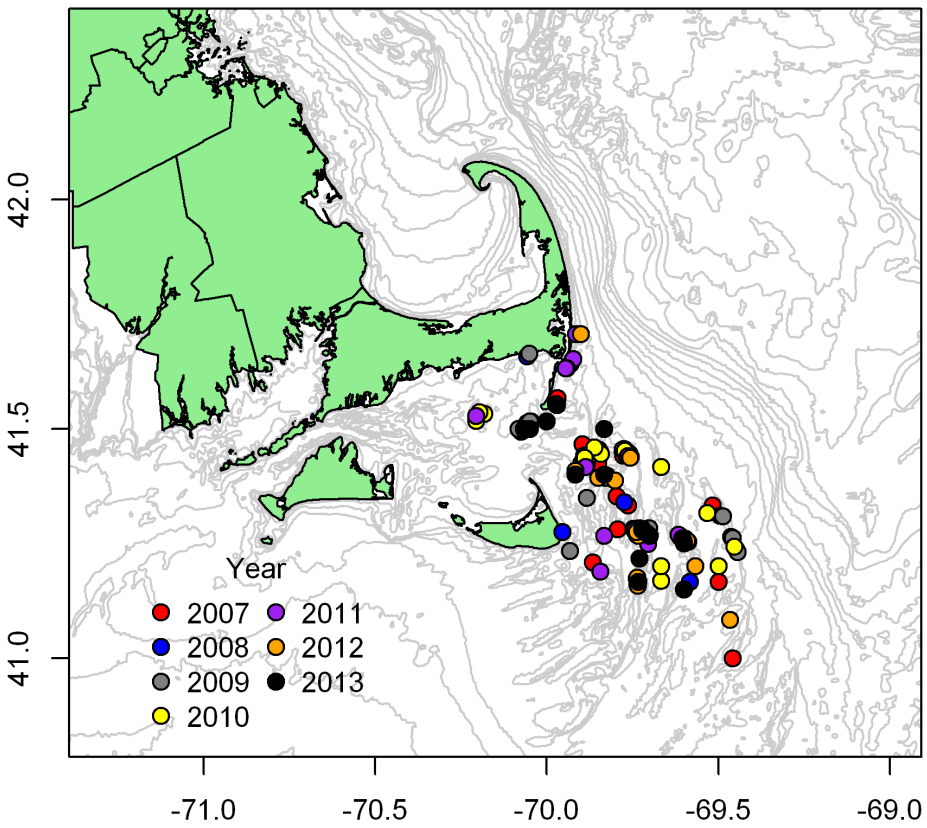

Figure 8. Map of *MarineFisheries* fall tagging locations during 2007-2013.

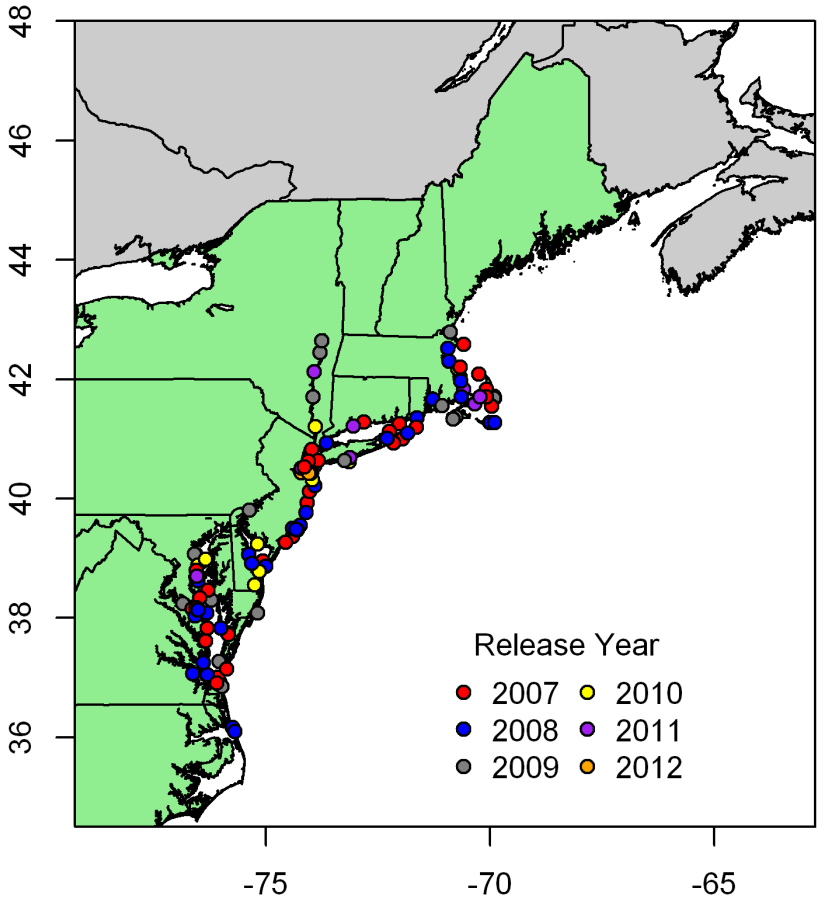

Figure 9. Map of recovery locations, 2007-2012, of *MarineFisheries* tagged striped bass by release year.

Acknowledgements

The collection and quality of striped bass data would suffer greatly without the efforts of many Division 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 Sportfish Restoration Funds Grants F-57-R and F-48-R.

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Appendix

Table A1a. Estimated size distribution of the Massachusetts commercial striped bass catch (numbers of fish) in 2013.

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	135	135	0.11	0.11
15	0	45	45	0.04	0.14
16	0	361	361	0.29	0.43
17	0	541	541	0.43	0.87
18	0	270	270	0.22	1.08
19	0	451	451	0.36	1.44
20	0	766	766	0.61	2.06
21	0	270	270	0.22	2.27
22	0	721	721	0.58	2.85
23	0	361	361	0.29	3.14
24	0	2,749	2,749	2.20	5.34
25	0	1,442	1,442	1.16	6.50
26	0	2,433	2,433	1.95	8.45
27	0	3,560	3,560	2.85	11.30
28	140	6,444	6,584	5.28	16.58
29	256	4,552	4,807	3.85	20.43
30	302	8,157	8,459	6.78	27.21
31	279	7,751	8.030	6.43	33.64
32	831	12,483	13,314	10.67	44.31
33	3,487	6,670	10,156	8.14	52.45
34	11,693	1,262	12,954	10.38	62.83
35	11,274	45	11,319	9.07	71.90
36	10,428	721	11,149	8.93	80.83
37	7,584	0	7,584	6.08	86.91
38	3,622	45	3,667	2.94	89.84
39	2,774	0	2,774	2.22	92.07
40	1,856	0	1,856	1.49	93.55
41	1,856	0	1,856	1.49	95.04
42	1,169	0	1,169	0.94	95.98
43	1,742	0	1,742	1.40	97.37
44	757	0	757	0.61	97.98
45	2,520	0	2,520	2.02	100.00
Total	**62,571**	**62,234**	**124,805**		
Average Size	**36.5**	**29.4**	**33.0**		

*includes fish taken for personal consumption

Table A1b. Estimated weight distribution by size of the Massachusetts commercial striped bass catch (pounds) in 2013.

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	130	130	0.01	0.01
15	0	53	53	0.00	0.01
16	0	515	515	0.03	0.04
17	0	925	925	0.06	0.10
18	0	548	548	0.03	0.13
19	0	1,073	1,073	0.07	0.20
20	0	2,124	2,124	0.13	0.33
21	0	867	867	0.05	0.38
22	0	2,654	2,654	0.16	0.55
23	0	1,514	1,514	0.09	0.64
24	0	13,105	13,105	0.81	1.44
25	0	7,762	7,762	0.48	1.92
26	0	14,718	14,718	0.90	2.83
27	0	24,089	24,089	1.48	4.31
28	1,052	48,582	49,634	3.05	7.36
29	2,141	38,087	40,227	2.47	9.83
30	2,798	75,492	78,291	4.81	14.64
31	2,847	79,084	81,932	5.04	19.68
32	9,317	139,969	149,287	9.18	28.86
33	42,841	81,950	124,790	7.67	36.53
34	157,002	16,943	173,945	10.69	47.22
35	165,006	660	165,666	10.18	57.40
36	165,961	11,475	177,436	10.91	68.31
37	130,945	0	130,945	8.05	76.36
38	67,694	842	68,536	4.21	80.57
39	56,010	0	56,010	3.44	84.01
40	40,412	0	40,412	2.48	86.50
41	43,491	0	43,491	2.67	89.17
42	29,427	0	29,427	1.81	90.98
43	47,024	0	47,024	2.89	93.87
44	21,876	0	21,876	1.34	95.21
45	77,870	0	77,870	4.79	100.00
Total	**1,063,714**	**563,160**	**1,626,874**		
Average Weight	**17.0**	**9.0**	**13.0**		

*includes fish taken for personal consumption

Table A2. Results of the GLM analyses of total catch rates (pounds/hour) for the commercial striped bass fishery, 1991-2012. Analysis of Deviance Table (Type III tests).

	SS	Df	F	Pr(>F)
YEAR	1410	22	62.302	2.20E-16
AREA	2406	2	1169.677	2.20E-16
Residuals	55744	54200		
	Estimate	SE	t	Pr(>|t|)
(Intercept)	1.93787	0.02637	73.498	2.00E-16
YEAR1992	0.06377	0.03544	1.799	0.072
YEAR1993	0.1567	0.0353	4.438	9.08E-06
YEAR1994	0.06501	0.03524	1.845	0.0651
YEAR1995	0.17833	0.03151	5.66	1.52E-08
YEAR1996	0.25274	0.0513	4.927	8.38E-07
YEAR1997	0.17413	0.03048	5.713	1.12E-08
YEAR1998	0.21261	0.03107	6.843	7.83E-12
YEAR1999	0.13658	0.03175	4.302	1.69E-05
YEAR2000	0.25012	0.03228	7.75	9.38E-15
YEAR2001	0.395	0.03234	12.214	2.00E-16
YEAR2002	0.43548	0.03183	13.68	2.00E-16
YEAR2003	0.49632	0.02939	16.887	2.00E-16
YEAR2004	0.53785	0.03548	15.16	2.00E-16
YEAR2005	0.37035	0.03213	11.528	2.00E-16
YEAR2006	0.38132	0.03037	12.554	2.00E-16
YEAR2007	0.35493	0.03085	11.506	2.00E-16
YEAR2008	0.24574	0.03082	7.974	1.57E-15
YEAR2009	0.33009	0.03057	10.798	2.00E-16
YEAR2010	0.35699	0.03275	10.902	2.00E-16
YEAR2011	0.62722	0.03683	17.032	2.00E-16
YEAR2012	0.66735	0.0333	20.041	2.00E-16
YEAR2013	0.49543	0.03405	14.551	2.00E-16
AREACCB	0.02198	0.01287	1.708	0.0876
AREASMA	0.43908	0.01142	38.447	2.00E-16

Year	LSMeans
1991	8.097
1992	8.631
1993	9.471
1994	8.641
1995	9.678
1996	10.426
1997	9.638
1998	10.016
1999	9.283
2000	10.399
2001	12.020
2002	12.516
2003	13.301
2004	13.865
2005	11.727
2006	11.856
2007	11.548
2008	10.353
2009	11.264
2010	11.571
2011	15.162
2012	15.783
2013	13.290

Table A3a. Estimated size distribution of the Massachusetts recreational striped bass catch (numbers of fish) in 2013.

TL (in.)	Harvested	Released	Total	Percent	Cumulative Percent
9	0	0	0	0.00	0.00
10	0	4,174	4,174	0.21	0.21
11	0	28,872	28,872	1.46	1.67
12	0	60,117	60,117	3.05	4.72
13	0	70,200	70,200	3.56	8.28
14	0	106,331	106,331	5.39	13.67
15	0	140,452	140,452	7.12	20.79
16	0	117,939	117,939	5.98	26.76
17	0	116,783	116,783	5.92	32.68
18	0	87,306	87,306	4.42	37.11
19	0	74,085	74,085	3.75	40.86
20	0	66,817	66,817	3.39	44.25
21	0	50,438	50,438	2.56	46.81
22	0	65,437	65,437	3.32	50.12
23	0	44,501	44,501	2.26	52.38
24	4,202	31,755	35,957	1.82	54.20
25	1,819	32,105	33,924	1.72	55.92
26	0	58,265	58,265	2.95	58.87
27	32,599	76,188	108,787	5.51	64.39
28	14,406	47,813	62,219	3.15	67.54
29	23,358	28,948	52,306	2.65	70.19
30	25,701	18,150	43,851	2.22	72.41
31	26,630	56,227	82,856	4.20	76.61
32	19,051	35,032	54,083	2.74	79.35
33	20,308	58,581	78,888	4.00	83.35
34	19,907	45,483	65,390	3.31	86.67
35	20,620	58,769	79,388	4.02	90.69
36	15,888	44,597	60,485	3.07	93.76
37	10,975	21,408	32,383	1.64	95.40
38	11,938	15,032	26,970	1.37	96.76
39	13,422	4,130	17,552	0.89	97.65
40	3,405	7,028	10,433	0.53	98.18
41	808	1,629	2,437	0.12	98.31
42	6,635	6,016	12,651	0.64	98.95
43	2,423	3,514	5,937	0.30	99.25
44	2,423	3,514	5,937	0.30	99.55
45	1,615	0	1,615	0.08	99.63
46	808	1,629	2,437	0.12	99.75
47	1,615	1,629	3,244	0.16	99.92
48	0	0	0	0.00	99.92
49	1,615	0	1,615	0.08	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	**282,170**	**1,690,888**	**1,973,058**		
Average Size	**32.8**	**22.3**			

Table A3b. Estimated size distribution of the Massachusetts recreational striped bass catch (pounds) in 2013.

TL (in.)	Harvested	Released	Total	Percent	Cumulative Percent
9	0	0	0	0.01	0.01
10	0	1,585	1,585	0.11	0.12
11	0	14,558	14,558	0.29	0.41
12	0	39,261	39,261	0.43	0.83
13	0	58,164	58,164	0.80	1.63
14	0	109,815	109,815	1.30	2.94
15	0	178,077	178,077	1.33	4.26
16	0	181,162	181,162	1.57	5.83
17	0	214,815	214,815	1.39	7.23
18	0	190,340	190,340	1.39	8.61
19	0	189,682	189,682	1.46	10.07
20	0	199,256	199,256	1.27	11.34
21	0	173,891	173,891	1.90	13.24
22	0	259,064	259,064	1.47	14.71
23	0	201,070	201,070	1.35	16.06
24	21,545	162,833	184,378	1.44	17.50
25	10,534	185,870	196,404	2.77	20.27
26	0	379,040	379,040	5.79	26.06
27	237,255	554,488	791,743	3.69	29.75
28	116,819	387,711	504,530	3.44	33.19
29	210,234	260,549	470,783	3.19	36.39
30	255,851	180,684	436,535	6.65	43.04
31	292,243	617,056	909,299	4.77	47.81
32	229,768	422,510	652,278	7.63	55.44
33	268,388	774,212	1,042,600	6.91	62.35
34	287,510	656,897	944,407	9.14	71.49
35	324,607	925,175	1,249,782	7.57	79.07
36	271,968	763,404	1,035,371	4.40	83.46
37	203,815	397,559	601,373	3.97	87.43
38	239,997	302,186	542,183	2.79	90.22
39	291,493	89,690	381,184	1.79	92.01
40	79,729	164,557	244,286	0.45	92.46
41	20,350	41,048	61,397	2.51	94.96
42	179,618	162,851	342,468	1.26	96.22
43	70,335	102,015	172,350	1.35	97.57
44	75,310	109,231	184,542	0.39	97.96
45	53,676	0	53,676	0.63	98.60
46	28,650	57,791	86,441	0.90	99.49
47	61,084	61,607	122,691	0.00	99.49
48	0	0	0	0.51	100.00
49	69,140	0	69,140	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	**3,899,919**	**9,769,704**	**13,669,623**		
Average Weight	**13.8**	**5.8**	**6.9**		

Table A4a. Results of the Gamma regression analysis of MRFSS striped bass catch positive checks. Analysis of Deviance Table (Type III tests).

Response: tot_fish

	LR Chisq	Df	Pr(>Chisq)	
year	492.31	26	< 2.2e-16	***
area_x	37.98	2	5.659e-09	***
mode_fx	441.71	2	< 2.2e-16	***
wave	327.12	3	< 2.2e-16	***
cnty	120.62	7	< 2.2e-16	***
ffdays12c	624.34	12	< 2.2e-16	***
hours	986.42	11	< 2.2e-16	***

Coefficients:

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	0.302450	0.230895	1.310	0.190242	
year1988	-0.180459	0.255377	-0.707	0.479799	
year1989	-0.249278	0.248967	-1.001	0.316717	
year1990	-0.240936	0.239942	-1.004	0.315320	
year1991	-0.101010	0.239442	-0.422	0.673133	
year1992	0.109777	0.232696	0.472	0.637102	
year1993	-0.056320	0.231825	-0.243	0.808053	
year1994	0.021321	0.229358	0.093	0.925935	
year1995	0.241826	0.228592	1.058	0.290114	
year1996	0.252926	0.228867	1.105	0.269116	
year1997	0.316099	0.228359	1.384	0.166305	
year1998	0.402944	0.227909	1.768	0.077072	.
year1999	0.347749	0.228182	1.524	0.127523	
year2000	0.393646	0.228607	1.722	0.085095	.
year2001	0.152943	0.228402	0.670	0.503107	
year2002	0.133229	0.228907	0.582	0.560559	
year2003	0.194956	0.228866	0.852	0.394315	
year2004	0.244475	0.229462	1.065	0.286693	
year2005	0.255442	0.229740	1.112	0.266202	
year2006	0.487241	0.228834	2.129	0.033245	*
year2007	0.219194	0.229420	0.955	0.0339371	
year2008	0.125054	0.230736	0.542	0.587840	
year2009	0.083786	0.230250	0.364	0.715941	
year2010	0.020325	0.231583	0.088	0.930063	
year2011	-0.142724	0.232411	-0.614	0.539155	
year2012	-0.129233	0.232732	-0.555	0.578704	
year2013	-0.069108	0.229610	-0.301	0.763432	
area_x2	-0.051013	0.025752	-1.981	0.047608	*
area_x5	0.083454	0.017942	4.651	3.32e-06	***
mode_fx6	0.359100	0.034001	10.561	< 2e-16	***
mode_fx7	0.494135	0.022503	21.959	< 2e-16	***
wave4	-0.299992	0.017345	-17.296	< 2e-16	***
wave5	0.179736	0.021836	-8.231	< 2e-16	***
wave6	0.995554	0.256463	3.882	0.000104	***

Table A4a continued.

cnty19	-0.118764	0.070107	-1.694	0.090269	.
cnty21	-0.003246	0.041498	-0.078	0.937649	
cnty23	-0.019551	0.026044	-0.751	0.452833	
cnty25	-0.311825	0.062464	-4.992	6.02e-07	***
cnty5	-0.118124	0.037647	-3.138	0.001705	**
cnty7	-0.305339	0.048737	-6.265	3.79e-10	***
cnty9	0.100880	0.019969	5.052	4.41e-07	***
ffdays12c10	0.062173	0.024647	2.523	0.011657	*
ffdays12c20	0.188902	0.025087	7.530	5.26e-14	***
ffdays12c30	0.196357	0.029113	6.745	1.57e-11	***
ffdays12c40	0.339976	0.035488	9.580	< 2e-16	***
ffdays12c50	0.382965	0.031175	12.284	< 2e-16	***
ffdays12c60	0.413034	0.042780	9.655	< 2e-16	***
ffdays12c70	0.451339	0.053415	8.450	< 2e-16	***
ffdays12c80	0.506935	0.073969	6.853	7.39e-12	***
ffdays12c90	0.533187	0.085981	6.201	5.70e-10	***
ffdays12c100	0.566717	0.033572	16.881	< 2e-16	***
ffdays12c150	0.609535	0.058017	10.506	< 2e-16	***
ffdays12c200	0.678184	0.064073	10.584	< 2e-16	***
hours2	0.122121	0.047155	2.590	0.009609	**
hours3	0.337859	0.044557	7.583	3.51e-14	***
hours4	0.485920	0.043940	11.059	< 2e-16	***
hours5	0.620368	0.044824	13.840	< 2e-16	***
hours6	0.683096	0.045395	15.048	< 2e-16	***
hours7	0.886036	0.049732	17.816	< 2e-16	***
hours8	0.881040	0.052446	16.799	< 2e-16	***
hours9	0.875430	0.070616	12.397	< 2e-16	***
hours10	1.054521	0.080332	13.127	< 2e-16	***
hours11	1.212367	0.162095	7.479	7.73e-14	***
hours12	1.054244	0.096936	10.876	< 2e-16	***

Year	LSMeans
1987	5.437013
1988	4.53929
1989	4.23741
1990	4.272906
1991	4.914644
1992	6.067863
1993	5.139265
1994	5.554182
1995	6.92443
1996	7.001722
1997	7.458308
1998	8.134987
1999	7.698141
2000	8.059697
2001	6.335523
2002	6.211848
2003	6.607371
2004	6.942798
2005	7.01936
2006	8.850473
2007	6.769479
2008	6.161272
2009	5.912189
2010	5.548652
2011	4.713856
2012	4.777878
2013	5.07396

Table A4b. Results of the logistic regression analysis of MRFSS striped bass success/failure. Analysis of Deviance Table (Type III tests).

Response: p

	LR Chisq	Df	Pr(>Chisq)	
year	2065.5	26	< 2.2e-16	***
area_x	222.7	2	< 2.2e-16	***
mode_fx	4232.2	2	< 2.2e-16	***
wave	473.0	3	< 2.2e-16	***
cnty	480.2	7	< 2.2e-16	***
ffdays12c	1004.9	12	< 2.2e-16	***
hours	2817.8	11	< 2.2e-16	***

Coefficients:

	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept)	-3.65775	0.24972	-14647	< 2e-16	***
year1988	-0.15519	0.27228	-0.570	0.568706	
year1989	-0.10787	0.26913	-0.401	0.688549	
year1990	-0.22303	0.25821	-0.864	0.387718	
year1991	-0.33051	0.25696	-1.286	0.198360	
year1992	-0.15689	0.25125	-0.624	0.532331	
year1993	0.16478	0.25044	0.658	0.510556	
year1994	0.64686	0.24852	2.603	0.009245	**
year1995	0.93484	0.24782	3.772	0.000162	***
year1996	0.97652	0.24825	3.934	8.37e-05	***
year1997	0.95579	0.24752	3.861	0.000113	***
year1998	1.44036	0.24747	5.820	5.87e-09	***
year1999	1.19121	0.24757	4.812	1.50e-06	***
year2000	1.10822	0.24808	4.467	7.93e-06	***
year2001	0.90839	0.24757	3.669	0.000243	***
year2002	0.95475	0.24844	3.843	0.000122	***
year2003	0.84855	0.24814	3.420	0.000627	***
year2004	0.92494	0.24956	3.706	0.000210	***
year2005	1.03642	0.25000	4.146	3.39e-05	***
year2006	1.28747	0.24894	5.172	2.32e-07	***
year2007	0.96314	0.24977	3.865	0.000115	***
year2008	0.79463	0.25094	3.167	0.001542	**
year2009	0.74929	0.25001	2.997	0.002726	**
year2010	0.51221	0.25153	2.036	0.041711	*
year2011	0.38528	0.25207	1.528	0.126390	
year2012	1,21172	0.25677	4.719	2.37e-06	***
year2013	1.78690	0.25248	7.077	1.47e-12	***
area_x2	-0.03079	0.03332	-0.924	0.355471	
area_x5	0.30524	0.02242	13.617	< 2e-16	***
mode_fx6	2.60699	0.04630	56.304	< 2e-16	***
mode_fx7	1.15089	0.02504	45.964	< 2e-16	***
wave4	-0.38018	0.02287	-16.622	< 2e-16	***
wave5	-0.52985	0.02707	-19.571	< 2e-16	***
wave6	2.64567	0.76057	3.479	0.000504	***

Table A4b continued.

cnty19	-0.41846	0.08145	-5.137	2.79e-07	***
cnty21	0.11887	0.05279	2.252	0.024340	*
cnty23	-0.12956	0.03152	-4.110	3.95e-05	***
cnty25	0.13041	0.07624	1.710	0.087199	.
cnty5	-0.26342	0.04636	-5.682	1.33e-08	***
cnty7	-0.16862	0.05853	-2.881	0.003967	**
cnty9	0.38275	0.02471	15.487	< 2e-16	***
ffdays12c10	0.13011	0.02995	4.345	1.39e-05	***
ffdays12c20	0.39929	0.03124	12.781	< 2e-16	***
ffdays12c30	0.48354	0.03668	13.184	< 2e-16	***
ffdays12c40	0.58526	0.04596	12.735	< 2e-16	***
ffdays12c50	0.72491	0.04078	17.777	< 2e-16	***
ffdays12c60	0.68406	0.05558	12.308	< 2e-16	***
ffdays12c70	0.82503	0.07144	11.549	< 2e-16	***
ffdays12c80	0.83419	0.10077	8.278	< 2e-16	***
ffdays12c90	0.65497	0.10964	5.974	3.31e-09	***
ffdays12c100	0.91384	0.04478	20.406	< 2e-16	***
ffdays12c150	0.93676	0.07689	12.183	< 2e-16	***
ffdays12c200	0.90518	0.8588	10.540	< 2e-16	***
hours2	0.64214	0.04766	13.474	< 2e-16	***
hours3	1.04291	0.04562	22.858	< 2e-16	***
hours4	1.33536	0.04540	29.411	< 2e-16	***
hours5	1.50184	0.04733	31.730	< 2e-16	***
hours6	1.74553	0.04923	35.458	< 2e-16	***
hours7	1.90980	0.05896	32.391	< 2e-16	***
hours8	1.86464	0.06261	29.780	< 2e-16	***
hours9	2.17146	0.09869	22.003	< 2e-16	***
hours10	2.20159	0.11356	19.387	< 2e-16	***
hours11	1.62651	0.21630	7.520	5.50e-14	***
hours12	2.28522	0.13713	16.665	< 2e-16	***

Year	LSMeans
1987	0.556097
1988	0.51753
1989	0.529332
1990	0.500576
1991	0.47373
1992	0.517104
1993	0.596312
1994	0.705202
1995	0.761366
1996	0.768855
1997	0.76515
1998	0.841001
1999	0.804797
2000	0.791429
2001	0.756525
2002	0.764964
2003	0.745335
2004	0.759561
2005	0.779329
2006	0.819477
2007	0.76647
2008	0.734966
2009	0.726041
2010	0.67646
2011	0.648083
2012	0.807999
2013	0.882076