Technical Report

Massachusetts Division of Marine Fisheries
Technical Report TR-68

Massachusetts Striped Bass Monitoring Report for 2017

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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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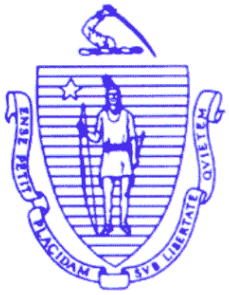

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Department of Fish and Game
Ronald Amidon, Commissioner
Massachusetts Division of Marine Fisheries
David E. Pierce, Director

Summary: During 2017, the Massachusetts commercial fishery for striped bass sold about 41,222 fish weighing 823,409 pounds. The recreational fishery harvested about 392,347 striped bass weighing over 5.6 million pounds. Total losses due to recreational fishing (including release mortality) were 1,550,258 fish weighing over 12 million pounds. Combined removals (commercial harvest plus recreational harvest and dead releases) were 1,591,480 fish weighing over 13 million pounds.

Introduction

This report summarizes the commercial and recreational striped bass fisheries conducted in Massachusetts during 2017. 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 in 2017

Season: June 26–September 1, 2017. Landings were permitted on Monday and Thursday only .

Sold: 823,409 pounds (against a harvest quota of 800,885 pounds). Overage: 22,524 pounds

Allowable Gear Type: Hook and line.

Minimum Size: 34 inches total length.

Trip Limit: 15 fish per day for fishers with a commercial lobster or boat permit and a striped bass endorsement; 2 fish per day for fishers with a commercial individual or rod & reel permit and a striped bass endorsement.

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. DMF personnel review dealer transactions and correct entries before calculating total landings.

Table 1. Attributes of the Massachusetts striped bass commercial fishery, 1990-2017.

		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	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	56.1	189	3,965
2012	17	1,219.7	61.5	186	3,965
2013	16	1,004.5	58.5	187	4,016
2014	21	1,138.5	56.1	195	3,896
2015	17	865.7	42.2	160	3,864
2016	17	938.7	48.0	173	3,875
2017	20	823.4	41.2	188	4,199

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 823,409 pounds (41,222 fish from count of commercial tags used) of striped bass in 2017 (Table 1). Most striped bass were sold in Barnstable, Bristol, Essex and Plymouth counties of Massachusetts.

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 492 fish sampled from the 2017 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:

$$\log_{10}(W) = -3.473 + 3.015 * \log_{10}(L),$$
$$RMS = 0.0027$$

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

$$W = 10^{(-3.473 + 3.015 * \log_{10}(L) + RMS/2)}$$

Size composition of the commercial harvest is presented in Appendix Table 1.

Age and Sex Composition. Four hundred and ninety two fish sampled from the 2017 commercial harvest were used to sex and age the harvested fish. Age composition of harvest fish was estimated from a sub-sample of 478 fish. Age was determined from scales. Age of harvested fish ranged from 6 to 20 years. About 80% of the sub-sample consisted of individuals from the 2004-2009 year classes (ages 8 -13) (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, *MarineFisheries* switched to trip-level reporting. Significant information has been lost due to the generalization of the trip 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 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 Table 2. Although factors were significant, the variables accounted for only about 7% of the total variation in harvest rates.

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, dropped through 2014, increased through 2016 and declined in 2017 (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 (likely attracted to large aggregations of sand lance in the area) off Cape Cod, particularly off Chatham in 2011 and 2012. These large aggregations likely increased the vulnerability of

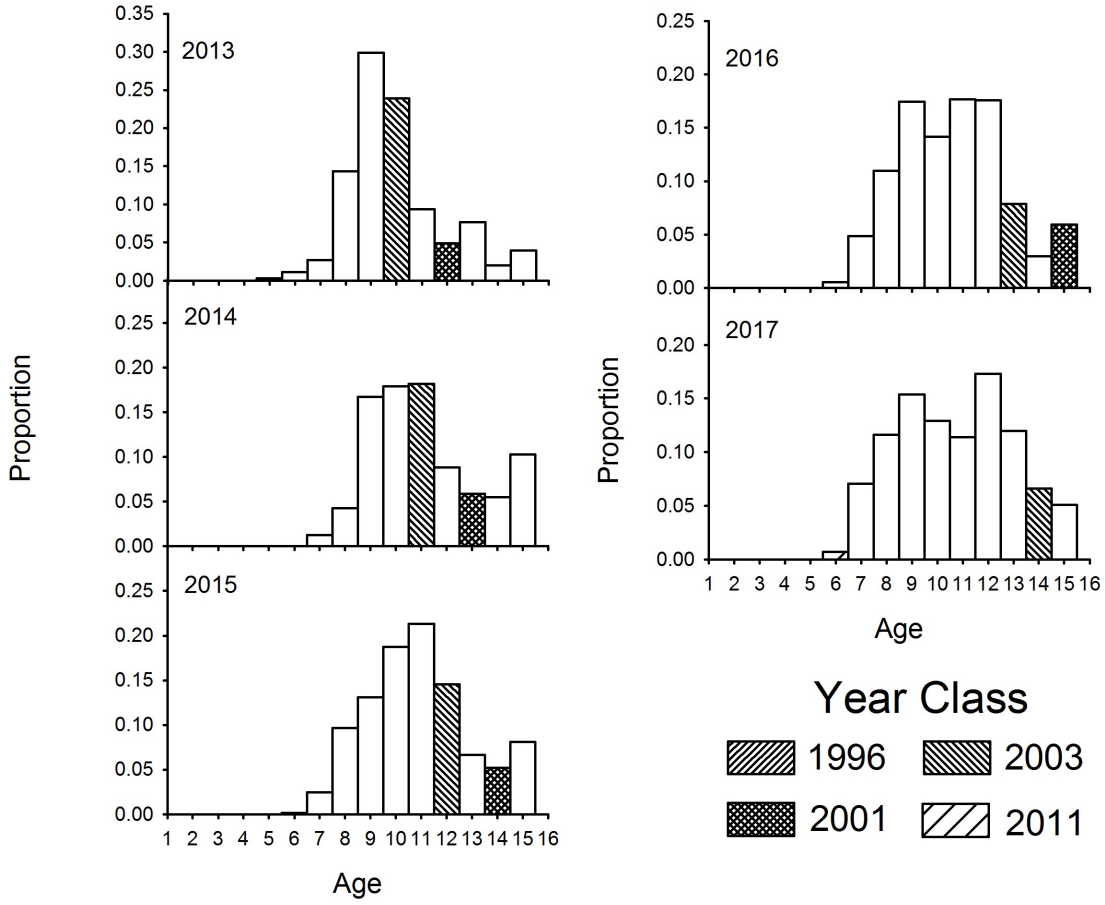

Figure 1. Age composition (proportion) of harvest from the Massachusetts commercial fishery. The large 1996, 2001, 2003 and 2011 Chesapeake Bay year-classes are highlighted.

striped bass to capture. In 2015 and 2016, catch rates in Cape Cod Bay and northern Massachusetts increased substantially likely the result of a shift in distribution of aggregated striped bass. Average catch rates dropped in all areas in 2017.

Recreational Fishery in 2017

Season: None

Daily Bag Limit: One 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 MRIP. New MRIP estimates were issued in 2018 as a result of corrected estimates of angler effort (Table 2). Massachusetts harvest and release estimates increased by 105% and 145% on average, respectively. The new MRIP estimate of total catch (including fish released alive) in 2017 was 13.2 million striped bass, which is a 50% increase compared to the 2016 estimate (Table 2). The estimate of total harvest in 2017 was 392,347 fish, which is a 70% increase in harvest compared to 2016. Total pounds harvested was over 5.6 million in 2017 (Table 2).

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) angler 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. Two thousand fifty-two samples were received from 57 anglers in 2017. 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 Table 3.

Age Composition. A sub-sample of 635 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 removals in 2017 catches of striped bass were comprised mostly of the 2011, 2014 and 2015 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 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

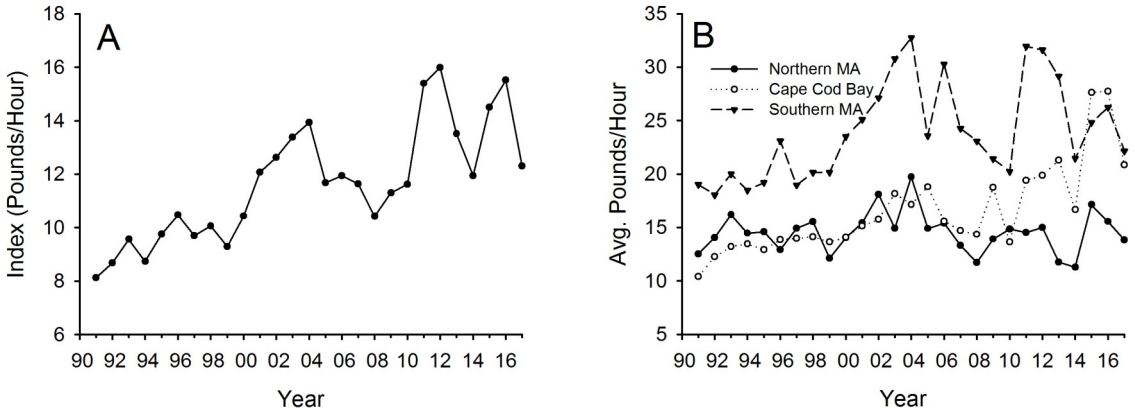

Figure 2. A) Harvest index (standardized pounds/hour) and B) average harvest rates by area for the Massachusetts commercial striped bass fishery, 1990-2017.

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

	Harvest Numbers		Harvest Weight (lbs)		Release Numbers		Total Numbers	
Year	Old	New	Old	New	Old	New	Old	New
1986	29,434	48,955	298,816	529,384	442,298	445,610	471,732	494,565
1987	10,807	30,782	269,459	872,782	93,660	233,065	104,467	263,847
1988	21,050	28,139	421,317	713,589	209,632	440,173	230,682	468,311
1989	13,044	43,594	295,227	1,185,606	193,067	480,528	206,111	524,121
1990	20,515	20,502	319,092	400,384	339,511	1,251,060	360,026	1,271,562
1991	20,799	51,069	440,605	866,326	448,735	1,290,441	469,534	1,341,510
1992	57,084	229,178	972,116	4,096,126	779,814	3,019,869	836,898	3,249,047
1993	58,511	116,384	1,113,446	1,908,614	833,566	1,942,334	892,077	2,058,719
1994	74,538	159,592	1,686,049	3,683,376	2,102,514	4,667,318	2,177,052	4,826,910
1995	73,806	124,300	1,504,390	2,738,834	3,280,882	8,427,141	3,354,688	8,551,441
1996	68,300	156,550	1,291,706	2,983,343	3,269,746	8,215,706	3,338,046	8,372,256
1997	199,373	365,611	2,891,970	5,132,817	5,417,751	10,675,648	5,617,124	11,041,260
1998	207,952	500,885	2,973,456	7,358,692	7,184,358	17,386,770	7,392,310	17,887,655
1999	126,755	327,086	1,822,818	4,995,322	4,576,208	13,434,701	4,702,963	13,761,786
2000	181,295	306,179	2,618,216	4,863,458	7,382,031	13,743,428	7,563,326	14,049,608
2001	288,032	551,038	3,644,561	7,187,897	5,410,899	10,222,067	5,698,930	10,773,105
2002	308,749	723,457	4,304,883	10,260,617	5,718,984	13,532,846	6,027,733	14,256,304
2003	407,100	797,161	4,889,035	10,251,621	4,361,710	9,787,679	4,768,810	10,584,841
2004	445,745	666,703	6,235,558	9,329,231	4,979,075	13,338,234	5,424,820	14,004,938
2005	340,742	536,058	5,119,345	7,541,049	3,988,679	9,042,756	4,329,421	9,578,814
2006	314,988	483,187	4,861,391	6,786,934	7,809,777	19,278,586	8,124,765	19,761,773
2007	315,409	471,873	5,099,862	7,009,584	5,331,470	10,839,699	5,646,879	11,311,572
2008	377,959	514,064	5,720,651	8,424,309	3,649,415	7,495,513	4,027,374	8,009,577
2009	344,401	694,992	4,795,791	9,409,753	2,282,601	5,989,390	2,627,002	6,684,381
2010	341,046	808,175	4,277,990	9,958,677	1,671,437	5,089,524	2,012,483	5,897,699
2011	255,507	873,496	3,504,603	11,953,163	973,192	4,035,634	1,228,699	4,909,129
2012	377,931	1,010,563	5,441,893	14,940,507	989,509	3,629,395	1,367,440	4,639,958
2013	282,170	658,713	3,899,919	9,024,975	1,690,888	4,670,184	1,973,058	5,328,897
2014	253,877	523,531	4,056,799	7,965,139	1,762,718	6,425,468	2,016,595	6,948,999
2015	170,770	485,317	2,701,724	7,798,768	1,546,094	4,470,735	1,716,864	4,956,051
2016	131,793	230,069	2,048,238	3,730,639	2,224,765	6,299,215	2,356,558	6,529,285
2017	181,141	392,347	2,325,778	5,666,309	3,995,814	12,865,677	4,176,955	13,258,024

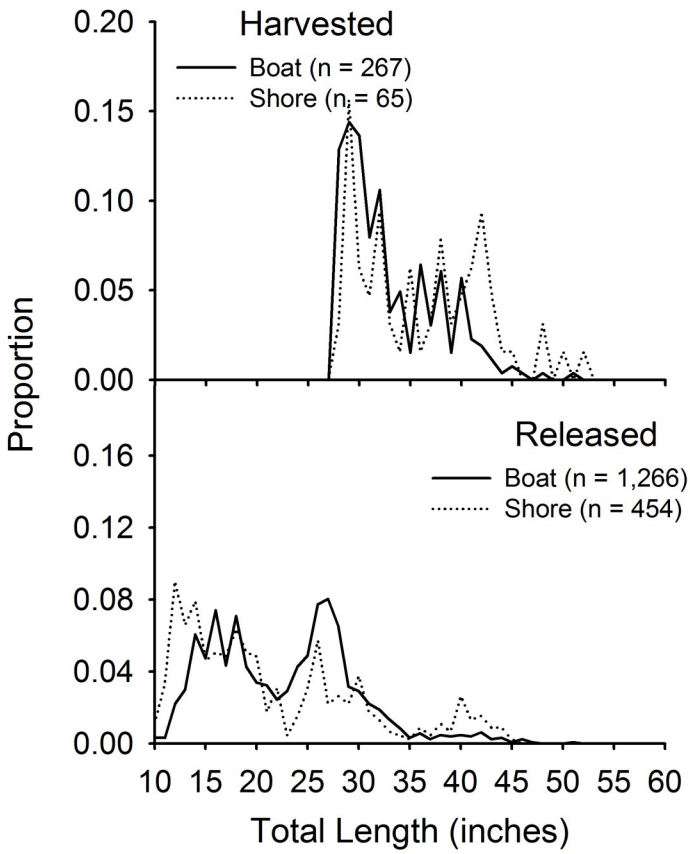

Figure 3. Sizes of striped bass caught by volunteer recreational anglers in 2017 by disposition and fishing mode.

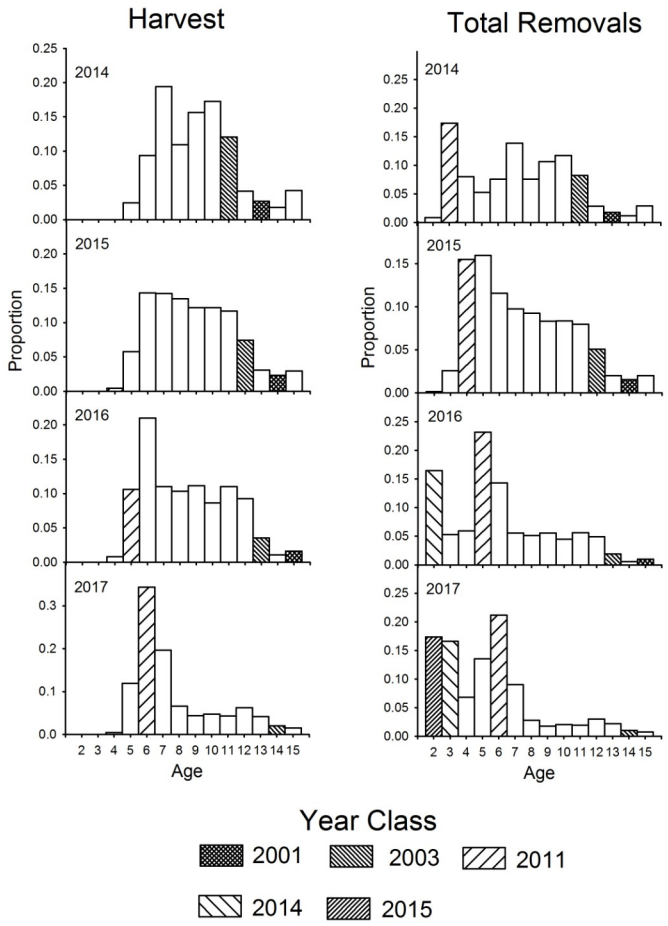

Figure 4. Age composition (proportion) of harvest and total removal (harvest plus dead releases) in 2017 from the Massachusetts recreational fishery. The large 1996, 2001, 2003, 2011, and 2015 year-classes from Chesapeake Bay and the 2014 large year-class from the Hudson River are highlighted.

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 1987-2017. Standardized catch rates for striped bass in Massachusetts waters increased from 1993 to 2000, declined in 2001, but increased through 2006 (Fig. 5). Catch rates declined through 2011 and remained low through 2015. Catch rates increased dramatically through 2017 as the 2011, 2014 and 2015 year-classes became vulnerable to the fishery (Fig. 5).

Characterization of Losses

Losses due to hook-and-release calculated by using a release mortality rate of 0.09. Losses due to hook-and-release were 1,157,911 fish (about 7 million 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

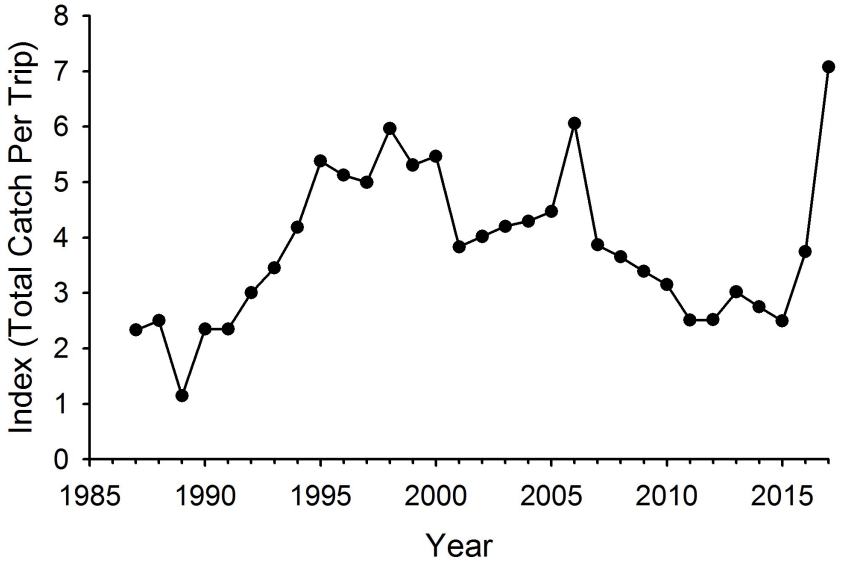

Figure 5. Standardized total catch rates (total number of fish caught per trip) of the recreational fishery for striped bass in Massachusetts waters, 1987-2017.

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 by-catch during 2017.

Estimated Total Losses in 2017

Total estimated loss (commercial harvest plus recreational harvest plus recreational dead releases) of striped bass during 2017 was 1.59 million fish weighing over 13 million pounds pounds (Table 3).

Removals-At-Age Matrix in 2017

The removals (numbers) by the recreational and commercial fisheries are apportioned by age and mortality source in Table 4. The 2014 (age 3 possibly from the Hudson River), and 2015 (age 2) and 2011 (age 5) year-classes from Chesapeake Bay incurred the highest losses in 2017 (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

Table 3. Estimates of striped bass losses occurring in Massachusetts waters during 2017.

FISHERY	NUMBER	POUNDS	MEAN WT.
Commercial			
Harvest	41,222	823,409	20.0
Recreational			
Harvest	392,347	5,666,309	14.4
Release Mortality	1,157,911	7,214,906	6.2
Total	1,591,480	13,704,624	

Table 4. Massachusetts striped bass removals-at-age matrix of 2017 by source.

	Recreational		Commercial	
Age	Release Mortality	Harvest	Harvest	Total
2	268,721	0	0	268,721
3	257,821	0	0	257,821
4	104,120	1,529	0	105,649
5	163,129	46,589	0	209,718
6	193,604	134,621	278	328,503
7	62,347	77,213	2,913	142,473
8	17,546	25,850	4,785	48,181
9	10,651	17,000	6,333	33,985
10	13,457	18,444	5,332	37,233
11	13,500	16,710	4,688	34,898
12	21,970	24,382	7,140	53,492
13	17,903	16,386	4,940	39,228
14	7,767	7,730	2,720	18,217
15+	5,374	5,894	2,094	13,362

2017. 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 areas around Nantucket Island. Floy internal anchor tags provided by the USFWS are used. Total length of each fish is recorded. Scales are removed from each fish for aging. The release data are made available to the Annapolis, Maryland office of the USFWS, which coordinates regional tagging programs of state-federal participants.

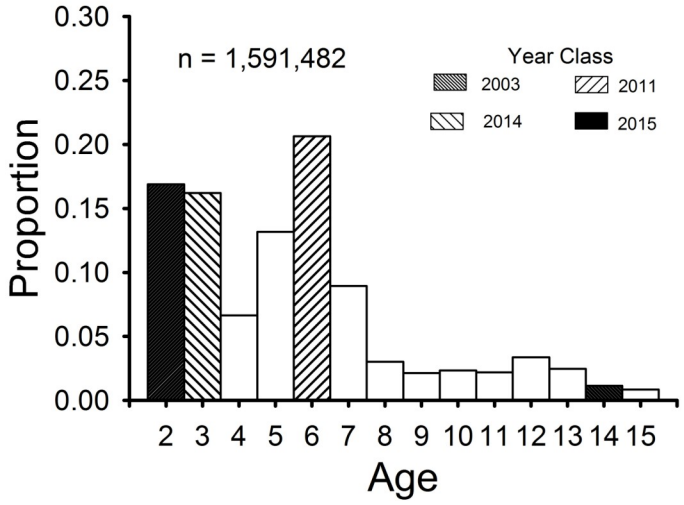

Figure 6. Proportion of striped bass total removals (commercial plus recreational) in 2017 by age. The 2003, 2011 and 2015 year-classes from Chesapeake Bay and the 2014 year-class from Hudson River are indicated.

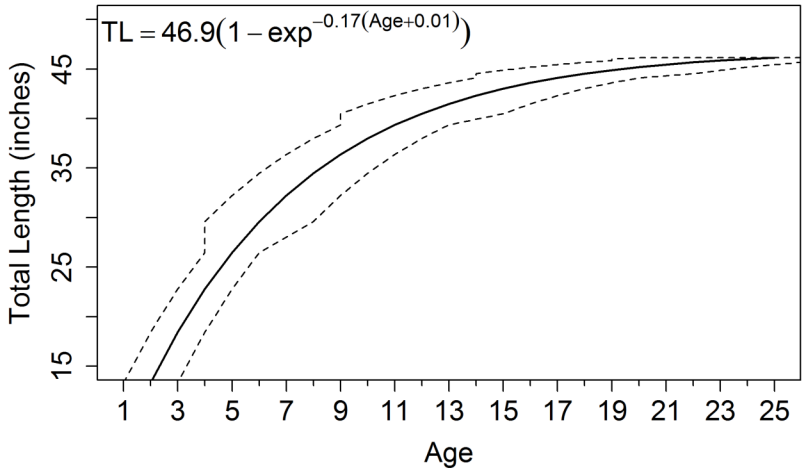

Figure 7. Mean length-age relationship (solid line) for striped bass captured in Massachusetts during 2017. Dotted lines represent the minimum and maximum ages found at a given length.

Summary statistics compiled since the start of this study are shown in Table 5. Striped bass recaptured in 2013-2017 were reported from coastal waters in North Carolina through Maine.

Planned Management Programs in 2018

Regulations

Massachusetts' recreational bag and minimum size limits will remain at 1 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 847,585 pounds because of the overage in 2017. The commercial fishery quota will be monitored using the SAFIS system. All monitoring programs will continue in 2018.

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

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
2013	15	3	487	854	33.6	92.2	3.6	617	24.3	1145	45.1
2014	15	3	455	876	34.5	98.8	3.9	536	21.1	1203	47.4
2015	15	3	348	857	33.7	90.9	3.6	597	23.5	1063	41.9
2016	14	3	711	788	31.0	108.2	4.3	523	20.6	1065	41.9
2017	10	2	381	777	30.6	97.8	3.9	518	20.4	1035	40.7

commercial data. Kim Trull coordinated the volunteer recreational angler data collection program, entered scale envelope data, and prepared data for analysis. Scott Elzey, Elise Koob, Collin Farrell and Kim Trull prepared and aged scale samples. John Boardman, Nick Buchan, and Nicole Ward conducted the commercial sampling of stripers. 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 1. Estimated size distribution of the Massachusetts commercial striped bass harvest (numbers and weight of fish) by total length (TL in inches) in 2017.

TL (in.)	Number	% Number	Weight (lbs)	% Weight
11	0	0.00	0	0.00
12	0	0.00	0	0.00
13	0	0.00	0	0.00
14	0	0.00	0	0.00
15	0	0.00	0	0.00
16	0	0.00	0	0.00
17	0	0.00	0	0.00
18	0	0.00	0	0.00
19	0	0.00	0	0.00
20	0	0.00	0	0.00
21	0	0.00	0	0.00
22	0	0.00	0	0.00
23	0	0.00	0	0.00
24	0	0.00	0	0.00
25	0	0.00	0	0.00
26	0	0.00	0	0.00
27	0	0.00	0	0.00
28	0	0.00	0	0.00
29	0	0.00	0	0.00
30	0	0.00	0	0.00
31	0	0.00	0	0.00
32	0	0.00	0	0.00
33	0	0.00	0	0.00
34	3,340	8.10	43,944	5.34
35	4,441	10.77	63,732	7.74
36	4,224	10.25	65,957	8.01
37	2,652	6.43	44,945	5.46
38	4,552	11.04	83,581	10.15
39	4,897	11.88	97,176	11.80
40	4,271	10.36	91,432	11.10
41	5,380	13.05	124,031	15.06
42	2,182	5.29	54,061	6.57
43	1,423	3.45	37,843	4.60
44	469	1.14	13,362	1.62
45	3,392	8.23	103,345	12.55
Total	41,222		823,409	
Avg. Size	38.8		20.0	

Appendix Table 2. Results of the GLM analyses of total catch rates (pounds/hour) for the commercial striped bass fishery, 1991-2017.

Analysis of Deviance Table (Type III tests)

	Sum Sq	Df	F values	Pr(>F)	
YEAR	1785	26	67.447	< 2.2e-16	***
MONTH	12	1	11.849	0.0005774	***
AREA	2380	2	1169.237	< 2.2e-16	***
Residuals	63934	62814			

	LSMEANS
1991	8.13
1992	8.68
1993	9.56
1994	8.74
1995	9.75
1996	10.48
1997	9.69
1998	10.06
1999	9.28
2000	10.43
2001	12.07
2002	12.62
2003	13.38
2004	13.93
2005	11.68
2006	11.93
2007	11.63
2008	10.42
2009	11.30
2010	11.62
2011	15.39
2012	15.98
2013	13.51
2014	11.94
2015	14.50
2016	15.51
2017	12.31

Appendix Table 3. Estimated size distribution of the Massachusetts recreational striped bass catch (numbers and weight of fish) in 2017 by disposition.

	Harvested				Released				Total			
TL (in.)	Number	% Number	Weight	% Weight	Number	% Number	Weight	% Weight	Number	% Number	Weight	% Weight
9	0	0.0	0	0.0	21,433	0.2	6,043	0.0	21,433	0.2	6,043	0.0
10	0	0.0	0	0.0	44,669	0.3	17,274	0.0	44,669	0.3	17,274	0.0
11	0	0.0	0	0.0	113,933	0.9	58,631	0.1	113,933	0.9	58,631	0.1
12	0	0.0	0	0.0	437,789	3.4	292,441	0.4	437,789	3.3	292,441	0.3
13	0	0.0	0	0.0	452,345	3.5	384,116	0.5	452,345	3.4	384,116	0.4
14	0	0.0	0	0.0	771,016	6.0	817,614	1.0	771,016	5.8	817,614	1.0
15	0	0.0	0	0.0	566,212	4.4	738,408	0.9	566,212	4.3	738,408	0.9
16	0	0.0	0	0.0	866,507	6.7	1,371,267	1.7	866,507	6.5	1,371,267	1.6
17	0	0.0	0	0.0	580,207	4.5	1,101,208	1.4	580,207	4.4	1,101,208	1.3
18	0	0.0	0	0.0	1,017,503	7.9	2,292,161	2.9	1,017,503	7.7	2,292,161	2.7
19	0	0.0	0	0.0	621,054	4.8	1,645,269	2.1	621,054	4.7	1,645,269	1.9
20	0	0.0	0	0.0	590,864	4.6	1,825,501	2.3	590,864	4.5	1,825,501	2.1
21	0	0.0	0	0.0	367,402	2.9	1,313,903	1.6	367,402	2.8	1,313,903	1.5
22	0	0.0	0	0.0	356,270	2.8	1,464,778	1.8	356,270	2.7	1,464,778	1.7
23	0	0.0	0	0.0	265,206	2.1	1,245,820	1.6	265,206	2.0	1,245,820	1.5
24	0	0.0	0	0.0	421,080	3.3	2,247,250	2.8	421,080	3.2	2,247,250	2.6
25	0	0.0	0	0.0	551,105	4.3	3,324,093	4.1	551,105	4.2	3,324,093	3.9
26	0	0.0	0	0.0	878,644	6.8	5,960,996	7.4	878,644	6.6	5,960,996	6.9
27	0	0.0	0	0.0	778,048	6.0	5,910,881	7.4	778,048	5.9	5,910,881	6.9
28	45,120	11.5	382,263	6.7	693,072	5.4	5,871,873	7.3	738,192	5.6	6,254,136	7.3
29	68,326	17.4	643,095	11.3	341,541	2.7	3,214,635	4.0	409,867	3.1	3,857,730	4.5
30	56,365	14.4	587,270	10.4	395,739	3.1	4,123,250	5.1	452,104	3.4	4,710,520	5.5
31	46,473	11.8	534,231	9.4	260,931	2.0	2,999,506	3.7	307,404	2.3	3,533,737	4.1
32	38,056	9.7	481,161	8.5	223,353	1.7	2,823,941	3.5	261,410	2.0	3,305,102	3.9
33	13,541	3.5	187,747	3.3	152,190	1.2	2,110,154	2.6	165,730	1.3	2,297,901	2.7
34	17,665	4.5	267,860	4.7	95,111	0.7	1,442,221	1.8	112,776	0.9	1,710,081	2.0
35	8,602	2.2	142,280	2.5	32,684	0.3	540,607	0.7	41,286	0.3	682,887	0.8
36	10,534	2.7	189,592	3.3	92,051	0.7	1,656,729	2.1	102,585	0.8	1,846,321	2.2
37	12,028	3.1	235,011	4.1	52,275	0.4	1,021,398	1.3	64,303	0.5	1,256,409	1.5
38	11,564	2.9	244,754	4.3	75,601	0.6	1,600,104	2.0	87,165	0.7	1,844,858	2.1
39	3,470	0.9	79,384	1.4	82,711	0.6	1,892,377	2.4	86,181	0.7	1,971,761	2.3
40	20,278	5.2	500,529	8.8	206,328	1.6	5,092,916	6.4	226,606	1.7	5,593,444	6.5
41	15,227	3.9	404,748	7.1	122,884	1.0	3,266,270	4.1	138,111	1.0	3,671,018	4.3
42	10,607	2.7	303,052	5.3	146,971	1.1	4,199,204	5.2	157,578	1.2	4,502,256	5.2
43	4,059	1.0	124,448	2.2	51,513	0.4	1,579,398	2.0	55,572	0.4	1,703,846	2.0
44	3,390	0.9	111,349	2.0	81,206	0.6	2,667,444	3.3	84,596	0.6	2,778,793	3.2
45	7,045	1.8	247,534	4.4	58,227	0.5	2,045,942	2.6	65,272	0.5	2,293,476	2.7
Total	392,349		5,666,309		12,865,678		80,165,620		13,258,027		85,831,929	
Avg. Size	32.8				22.7				23.0			

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

```
Analysis of Deviance Table (Type III tests)

Response: tot_fish
          LR Chisq Df Pr(>Chisq)
year        677.02 30  < 2.2e-16 ***
area_x       44.60  2  2.068e-10 ***
mode_fx     387.04  2  < 2.2e-16 ***
wave        423.62  3  < 2.2e-16 ***
cnty        180.10  7  < 2.2e-16 ***
ffdays12c   609.71 12  < 2.2e-16 ***
hours      1066.23 11  < 2.2e-16 ***

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)   0.232331   0.286929   0.810 0.418111
year1988     -0.091524   0.311300  -0.294 0.768756
year1989     -0.148687   0.305547  -0.487 0.626526
year1990     -0.166431   0.296534  -0.561 0.574631
year1991     -0.047751   0.295253  -0.162 0.871521
year1992      0.107739   0.289510   0.372 0.709791
year1993      0.021048   0.288837   0.073 0.941908
year1994      0.067160   0.286531   0.234 0.814685
year1995      0.309579   0.285930   1.083 0.278947
year1996      0.295242   0.286224   1.032 0.302313
year1997      0.361844   0.285728   1.266 0.205384
year1998      0.451241   0.285349   1.581 0.113807
year1999      0.392610   0.285559   1.375 0.169180
year2000      0.442978   0.285931   1.549 0.121334
year2001      0.176741   0.285818   0.618 0.536337
year2002      0.189804   0.286199   0.663 0.507214
year2003      0.235764   0.286347   0.823 0.410315
year2004      0.282785   0.287026   0.985 0.324524
year2005      0.307687   0.287274   1.071 0.284154
year2006      0.545807   0.286365   1.906 0.056664 .
year2007      0.243192   0.286862   0.848 0.396577
year2008      0.185531   0.287686   0.645 0.518993
year2009      0.123672   0.287294   0.430 0.666856
year2010      0.066527   0.288339   0.231 0.817532
year2011     -0.079099   0.289150  -0.274 0.784429
year2012     -0.056743   0.289227  -0.196 0.844463
year2013     -0.009849   0.286624  -0.034 0.972589
year2014      0.059094   0.287795   0.205 0.837312
year2015      0.011613   0.287203   0.040 0.967746
year2016      0.228681   0.287683   0.795 0.426676
year2017      0.688647   0.286302   2.405 0.016165 *
area_x2      -0.003511   0.026679  -0.132 0.895300
area_x5       0.107036   0.017192   6.226 4.86e-10 ***
mode_fx6      0.343961   0.035081   9.805  < 2e-16 ***
mode_fx7      0.452419   0.021928  20.632  < 2e-16 ***
wave4        -0.315128   0.016683 -18.889  < 2e-16 ***
wave5        -0.170265   0.021611  -7.878 3.44e-15 ***
wave6         0.506723   0.082158   6.168 7.04e-10 ***
cnty19       -0.207096   0.079421  -2.608 0.009124 **
cnty21       -0.033502   0.041350  -0.810 0.417835
cnty23       -0.053481   0.024577  -2.176 0.029559 *
cnty25       -0.324272   0.059286  -5.470 4.55e-08 ***
cnty5        -0.137708   0.036927  -3.729 0.000193 ***
cnty7        -0.364684   0.051347  -7.102 1.26e-12 ***
cnty9         0.122497   0.018957   6.462 1.05e-10 ***
ffdays12c10   0.072922   0.023830   3.060 0.002215 **
ffdays12c20   0.196186   0.024467   8.018 1.12e-15 ***
ffdays12c30   0.211124   0.028350   7.447 9.85e-14 ***
ffdays12c40   0.346294   0.034604  10.007  < 2e-16 ***
ffdays12c50   0.380343   0.030553  12.449  < 2e-16 ***
ffdays12c60   0.432154   0.041979  10.294  < 2e-16 ***
ffdays12c70   0.474524   0.051960   9.133  < 2e-16 ***
ffdays12c80   0.476977   0.073629   6.478 9.45e-11 ***
ffdays12c90   0.548705   0.084436   6.498 8.26e-11 ***
ffdays12c100  0.562314   0.032860  17.112  < 2e-16 ***
ffdays12c150  0.576093   0.057000  10.107  < 2e-16 ***
ffdays12c200  0.477501   0.046124  10.353  < 2e-16 ***
hours2        0.180429   0.044940   4.015 5.96e-05 ***
hours3        0.371598   0.042319   8.781  < 2e-16 ***
hours4        0.509826   0.041830  12.188  < 2e-16 ***
hours5        0.648125   0.042654  15.195  < 2e-16 ***
hours6        0.746534   0.043277  17.250  < 2e-16 ***
hours7        0.895858   0.047781  18.749  < 2e-16 ***
hours8        0.938340   0.050472  18.591  < 2e-16 ***
hours9        0.901822   0.067628  13.335  < 2e-16 ***
hours10       1.078734   0.078067  13.818  < 2e-16 ***
hours11       1.369839   0.158567   8.639  < 2e-16 ***
hours12       1.063897   0.091009  11.690  < 2e-16 ***
```

Appendix 4A cont'd.

Year	LSMEANS
1987	4.499867
1988	4.106306
1989	3.878158
1990	3.809955
1991	4.290044
1992	5.011756
1993	4.595585
1994	4.812456
1995	6.132649
1996	6.045353
1997	6.461696
1998	7.065956
1999	6.663586
2000	7.007814
2001	5.369792
2002	5.440397
2003	5.696273
2004	5.970512
2005	6.121059
2006	7.766774
2007	5.738738
2008	5.417198
2009	5.092250
2010	4.809410
2011	4.157647
2012	4.251638
2013	4.455766
2014	4.773798
2015	4.552430
2016	5.656065
2017	8.959324

Appendix Table 4B. 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        1610.9 30  < 2.2e-16 ***
area_x       484.5  2  < 2.2e-16 ***
mode_fx     4892.8  2  < 2.2e-16 ***
wave         519.1  3  < 2.2e-16 ***
cnty         657.8  7  < 2.2e-16 ***
ffdays12c    590.0 12  < 2.2e-16 ***
hours        478.1 11  < 2.2e-16 ***
```

Coefficients:

	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept)	-2.64555	0.34168	-7.743	9.73e-15	***
year1988	0.37140	0.37544	0.989	0.322551	
year1989	-0.94533	0.35637	-2.653	0.007986	**
year1990	0.40192	0.35869	1.121	0.262499	
year1991	0.11594	0.35294	0.328	0.742545	
year1992	0.32887	0.34671	0.949	0.342848	
year1993	1.03277	0.34673	2.979	0.002895	**
year1994	1.82744	0.34710	5.265	1.40e-07	***
year1995	1.89355	0.34456	5.496	3.89e-08	***
year1996	1.64182	0.34277	4.790	1.67e-06	***
year1997	1.15110	0.34032	3.382	0.000719	***
year1998	1.61433	0.34038	4.743	2.11e-06	***
year1999	1.28795	0.34050	3.783	0.000155	***
year2000	1.19022	0.34134	3.487	0.000489	***
year2001	0.83645	0.34004	2.460	0.013901	*
year2002	0.96398	0.34147	2.823	0.004757	**
year2003	0.95840	0.34128	2.808	0.004980	**
year2004	0.86484	0.34315	2.520	0.011726	*
year2005	0.91976	0.34319	2.680	0.007362	**
year2006	1.19230	0.34224	3.484	0.000494	***
year2007	0.64928	0.34252	1.896	0.058014	.
year2008	0.65127	0.34375	1.895	0.058145	.
year2009	0.61397	0.34289	1.791	0.073363	.
year2010	0.56718	0.34486	1.645	0.100035	
year2011	0.34601	0.34502	1.003	0.315925	
year2012	0.29948	0.34565	0.866	0.386266	
year2013	0.66807	0.34246	1.951	0.051082	.
year2014	0.23134	0.34402	0.672	0.501291	
year2015	0.11812	0.34252	0.345	0.730207	
year2016	0.59837	0.34501	1.734	0.082856	.
year2017	1.24686	0.34387	3.626	0.000288	***
area_x2	-0.21801	0.04466	-4.882	1.05e-06	***
area_x5	0.52670	0.02809	18.750	< 2e-16	***
mode_fx6	2.74995	0.05697	48.274	< 2e-16	***
mode_fx7	1.89487	0.03113	60.879	< 2e-16	***
wave4	-0.58332	0.02937	-19.861	< 2e-16	***
wave5	-0.66542	0.03509	-18.961	< 2e-16	***
wave6	-0.29600	0.10420	-2.841	0.004500	**
cnty19	-0.72868	0.09698	-7.513	5.76e-14	***
cnty21	0.39380	0.07847	5.019	5.20e-07	***
cnty23	-0.03199	0.03993	-0.801	0.422998	
cnty25	0.81333	0.11819	6.882	5.92e-12	***
cnty5	-0.50725	0.05791	-8.760	< 2e-16	***
cnty7	-0.29615	0.06975	-4.246	2.18e-05	***
cnty9	0.53215	0.03122	17.044	< 2e-16	***
ffdays12c10	0.14416	0.03765	3.829	0.000129	***
ffdays12c20	0.35037	0.04015	8.726	< 2e-16	***
ffdays12c30	0.37035	0.04678	7.917	2.43e-15	***
ffdays12c40	0.56402	0.06085	9.269	< 2e-16	***
ffdays12c50	0.74176	0.05505	13.474	< 2e-16	***
ffdays12c60	0.63240	0.07240	8.735	< 2e-16	***
ffdays12c70	0.88835	0.09768	9.095	< 2e-16	***
ffdays12c80	0.64648	0.12910	5.008	5.51e-07	***
ffdays12c90	0.65279	0.14159	4.611	4.02e-06	***
ffdays12c100	0.86551	0.05923	14.613	< 2e-16	***
ffdays12c150	1.07339	0.10180	10.544	< 2e-16	***
ffdays12c200	0.87082	0.08193	10.629	< 2e-16	***
hours2	0.36957	0.05727	6.453	1.10e-10	***
hours3	0.54538	0.05505	9.907	< 2e-16	***
hours4	0.75180	0.05547	13.553	< 2e-16	***
hours5	0.80479	0.05820	13.828	< 2e-16	***
hours6	0.95563	0.06103	15.659	< 2e-16	***
hours7	0.96092	0.07338	13.095	< 2e-16	***
hours8	0.96879	0.07806	12.411	< 2e-16	***
hours9	1.15088	0.11986	9.602	< 2e-16	***
hours10	1.27666	0.14273	8.945	< 2e-16	***
hours11	0.80991	0.27641	2.930	0.003388	**
hours12	1.41293	0.17227	8.202	2.37e-16	***

Appendix 4B cont'd.

Year	Probability
1987	0.5188172
1988	0.6098545
1989	0.2952498
1990	0.6170913
1991	0.5476650
1992	0.5996908
1993	0.7517703
1994	0.8702021
1995	0.8774883
1996	0.8477587
1997	0.7731881
1998	0.8441755
1999	0.7962886
2000	0.7799762
2001	0.7133581
2002	0.7387126
2003	0.7376340
2004	0.7191297
2005	0.7300871
2006	0.7803323
2007	0.6736163
2008	0.6740521
2009	0.6658044
2010	0.6553154
2011	0.6037975
2012	0.5926139
2013	0.6777343
2014	0.5760652
2015	0.5482051
2016	0.6623263
2017	0.7895410