Technical Report

Massachusetts Division of Marine Fisheries
Technical Report TR-81

Massachusetts Striped Bass Monitoring Report for 2022

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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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Commonwealth of Massachusetts
Maura Healey, Governor
Executive Office of Energy and Environmental Affairs
Rebecca Tepper , Secretary
Department of Fish and Game
Thomas O'Shea, Commissioner
Massachusetts Division of Marine Fisheries
Daniel J. McKiernan, Director

Summary: During 2022, the Massachusetts commercial fishery for striped bass sold about 32,989 fish weighing 770,101 pounds. The recreational fishery harvested about 479,920 striped bass weighing over 5.3 million pounds. Total losses due to recreational fishing (including release mortality) were 1,001,637 fish weighing over 9.2 million pounds. Combined removals (commercial harvest plus recreational harvest and dead releases) were 1,034,626 fish weighing over 10 million pounds.

Introduction

This report summarizes the commercial and recreational striped bass fisheries conducted in Massachusetts during 2022. 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 2022

Season: June 20–August 3. Landings were permitted on Monday, Tuesday and Wednesday only (fishing is not allowed if an open day falls on July 3, July 4 or Labor Day).

Sold: 770,101 pounds (against a harvest quota of 735,240 pounds).

Allowable Gear Type: Hook and line.

Minimum Size: 35 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. Gaffing of fish <35 inches is not allowed.

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.

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

Table 1. Attributes of the Massachusetts striped bass commercial fishery, 2005-2022. * = season closed December 31.

Year	Season (Fishing Days)	Pounds 000s	Number 000s	No. Dealers That Purchased
2005	22	1104.7	59.5	77
2006	26	1312.1	69.9	75
2007	22	1040.3	54.3	76
2008	34	1160.1	61.1	78
2009	27	1138.3	59.3	82
2010	24	1224.4	60.3	83
2011	18	1163.8	56.1	68
2012	17	1219.7	61.5	79
2013	16	1004.5	58.5	76
2014	21	1138.5	56.1	71
2015	17	865.7	42.2	76
2016	17	938.7	48.0	71
2017	20	823.4	41.2	68
2018	*	753.7	37.7	66
2019	*	584.7	29.5	57
2020	*	386.9	19.6	47
2021	46	732.0	36.8	60
2022	20	770.1	32.9	58

composition and catch rates.

Landings. The landings used here come from the SAFIS program. Commercial dealers bought 770,101 pounds (32,989 fish from count of commercial tags used) of striped bass in 2022 (Table 1), representing a 4.7% overage against the quota of 735,240 pounds. Most striped bass were sold in Barnstable (264,295 pounds), Essex (228,701 pounds) and Plymouth (128,893 pounds) counties of Massachusetts.

Size Composition. Information from biological sampling and catch reports is used to characterize disposition of the catch, catch weight, and size composition by catch category. Data from 285 fish sampled from the 2022 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:

log10(W)=-3.483+3.022*log10(L), RMSE=0.00298

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:

$$W=10^{-3.483+3.022*\log10(L)+RMSE/2}$$

An adjustment parameter is estimated and multiplied against the resulting estimates of weight so that the sum of the predicted pounds matches the actual pounds sold. Size composition of the commercial harvest is presented in Appendix Table 1.

Age and Sex Composition. Two hundred eighty five fish sampled from the 2022 commercial harvest were used to sex and age the harvested fish. Age was determined from scales. Age of harvested fish ranged from 6 to 15+ years. About 92.0% of the sub-sample consisted of individuals from the 2009-2015 year classes (ages 7-13) (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 3 regions (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

$$ln(y)=a+b_1*year+b_2*month+b_3*area+e$$

where y is the observed total catch or harvest rate, a is the intercept, bs are the factor coefficients and e is the error term. Any variable not significant at $\alpha = 0.05$ with type-III (partial) sum of squares was dropped from the initial GLM model and the analysis was repeated. First-order interactions were not considered in the analyses. The back-transformed geometric mean for each year was estimated by

$$y=e^{LSM}$$

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 5.6% 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, declined through 2019 and increased dramatically through 2022 (Figure 2A). Average catch rates in recent years dropped in all regions except Southern Massachusetts (Figure 2B). The dramatic increase in harvest rates for 2011-2012 and 2015-2016 is attributed to large increases in harvest rates by fishers in Cape Cod Bay and southern Massachusetts exploiting large concentrations of striped bass (likely attracted to large aggregations of sand lance in the area) off Cape Cod, particularly off Chatham. Similarly, the dramatic increase in 2021 was the result of exploitation of large aggregations of striped bass attracted to large schools of menhaden (pogies) throughout Massachusetts.

Recreational Fishery in 2022

Season: None

Daily Bag Limit: One fish per person

Allowable Gear Type: Hook and Line

Size Limit: 28-<35 inches total length

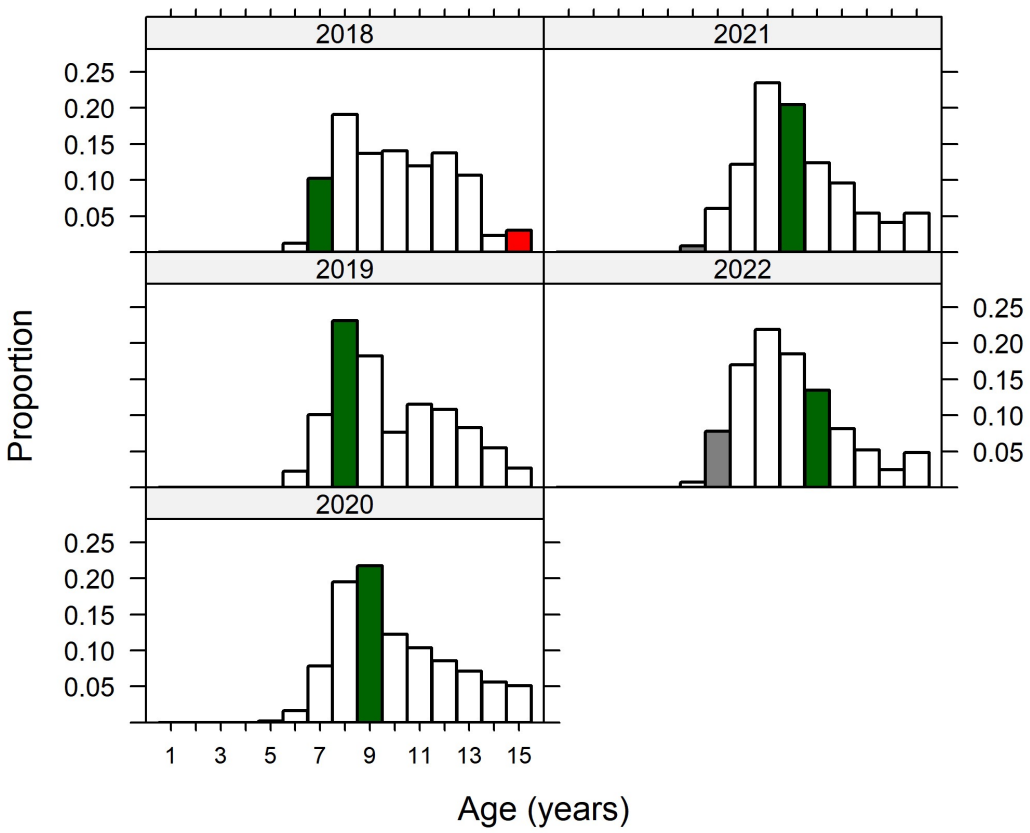

Figure 1. Age composition (proportion) of harvest from the Massachusetts commercial fishery in 2018-2022. The large 2001, 2003 2011 and 2015 Chesapeake Bay year-classes are highlighted in black, red, dark green and gray, respectively.

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. The MRIP estimate of total catch (including fish released alive) in 2022 was 6.27 million striped bass, which is a 29.3% increase compared to the 2021 estimate (Table 2). The estimate of total harvest in 2022 was 479,920 fish, which is a 168% increase compared to 2021. Total pounds harvested was 5,288,214 in 2022 (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. Eight hundred sixty nine samples were received from 39 anglers in 2022. 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 539 fish from the volunteer angler survey was aged and an age-length key was developed 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 (harvest plus dead releases) in 2022 were comprised mostly

of the 2015 year-class (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 model estimates are recombined to obtain the index. 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 was dropped from the initial GLM model and the analysis was repeated. First-order interactions were considered in the initial analyses but it was not always possible to generate annual means by the least-square methods with some interactions included (see Searle et al., 1980); therefore, only main effects were considered.

The annual index of striped bass total catch per trip was estimated by combining the two component models. The estimate in year i from the models is given by

$$\hat{I}_i = \hat{p}_i * \hat{y}_i$$

where p_i and y_i are the predicted annual responses from the 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 1988-2022. Standardized catch rates for striped bass in Massachusetts waters increased from 1993 to 2000,

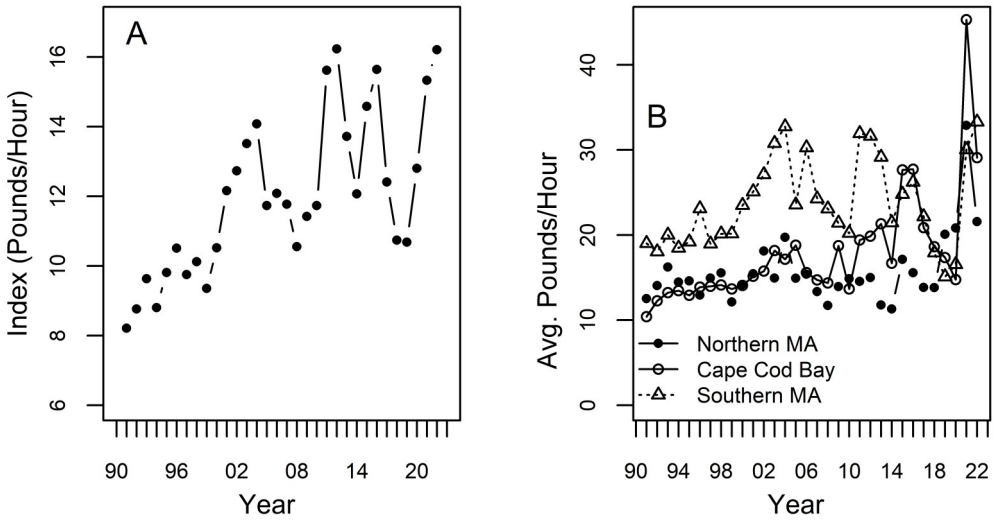

Figure 2. A) Harvest index (standardized pounds/hour) and B) average harvest rates by area for the Massachusetts commercial striped bass fishery, 1991-2022.

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

Year	Harvest (No.)	Harvest (lbs)	Releases (No.)	Total (No.)
1982	116,679	3,086,007	21,240	137,919
1983	43,403	775,008	36,425	79,828
1984	12,742	29,460	209,272	222,014
1985	542,493	7,881,533	54,321	596,814
1986	48,955	529,384	445,610	494,565
1987	30,782	872,782	233,065	263,847
1988	28,139	713,589	440,173	468,312
1989	43,594	1,185,606	480,528	524,122
1990	20,502	400,384	1,251,060	1,271,562
1991	51,069	866,326	1,290,441	1,341,510
1992	229,178	4,096,126	3,019,869	3,249,047
1993	116,384	1,908,614	1,942,334	2,058,718
1994	159,592	3,683,376	4,667,318	4,826,910
1995	124,300	2,738,834	8,427,141	8,551,441
1996	156,550	2,983,343	8,215,706	8,372,256
1997	365,611	5,132,817	10,675,648	11,041,259
1998	500,885	7,358,692	17,386,770	17,887,655
1999	327,086	4,995,322	13,434,701	13,761,787
2000	306,179	4,863,458	13,743,428	14,049,607
2001	551,038	7,187,897	10,222,067	10,773,105
2002	723,457	10,260,617	13,532,846	14,256,303
2003	797,161	10,251,621	9,787,679	10,584,840
2004	666,703	9,329,231	13,338,234	14,004,937
2005	536,058	7,541,049	9,042,756	9,578,814
2006	483,187	6,786,934	19,278,586	19,761,773
2007	471,873	7,009,584	10,839,699	11,311,572
2008	514,064	8,424,309	7,495,513	8,009,577
2009	694,992	9,409,753	5,989,390	6,684,382
2010	808,175	9,958,677	5,089,524	5,897,699
2011	873,496	11,953,163	4,035,634	4,909,130
2012	1,010,563	14,940,507	3,629,395	4,639,958
2013	658,713	9,024,975	4,670,184	5,328,897
2014	523,531	7,965,139	6,425,468	6,948,999
2015	485,317	7,798,768	4,470,735	4,956,052
2016	230,069	3,730,639	6,299,215	6,529,284
2017	392,296	5,664,393	12,865,549	13,257,845
2018	389,457	4,924,791	5,377,213	5,766,670
2019	195,608	2,697,736	5,498,550	5,694,158
2020	67,158	776,115	5,127,649	5,194,807
2021	179,116	1,826,450	4,675,035	4,854,151
2022	479,920	5,288,214	5,796,858	6,276,778

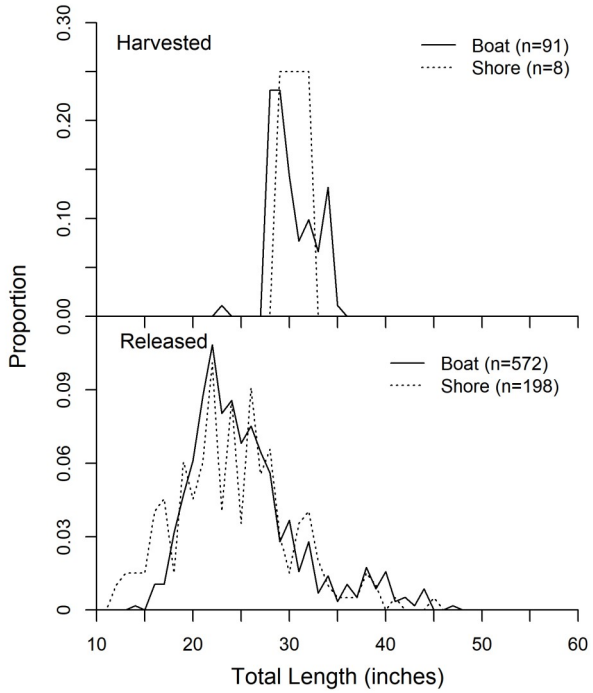

Figure 3. Sizes of striped bass caught by volunteer recreational anglers in 2022 by disposition and fishing mode.

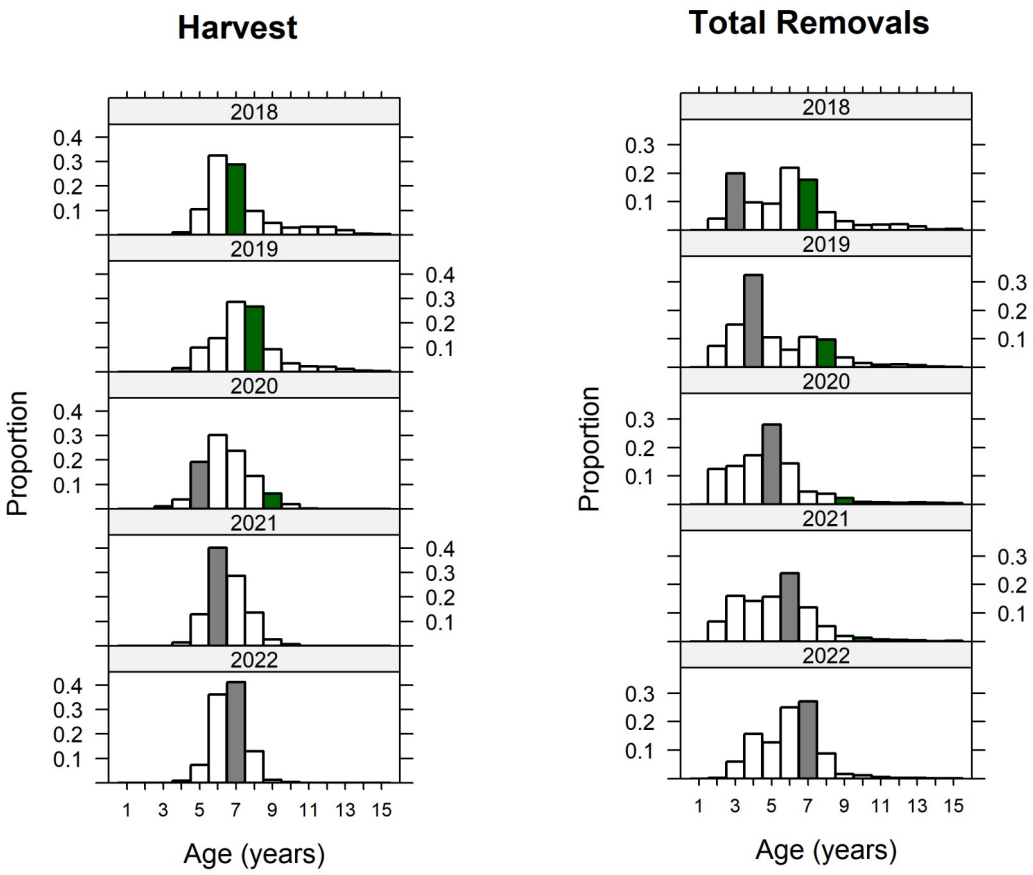

Figure 4. Age composition (proportion) of harvest and total removals (harvest plus dead releases) in 2018-2022 from the Massachusetts recreational fishery. The large 2001, 2003, 2011 and 2015 Chesapeake Bay year-classes are highlighted in black, red, dark green and gray, respectively.

declined in 2001, but increased through 2006 (Fig. 5). Catch rates declined through 2011 and remained low through 2015. Catch rates increased dramatically in 2017 as the 2011, 2014 and 2015 year-classes became vulnerable to the fishery. Catch rates have remained relatively stable since 2018, averaging 3.6 fish per trip (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 521,717 fish (about 3.9 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 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 2023.

Estimated Total Losses in 2022

Total estimated loss (commercial harvest plus recreational harvest plus recreational dead releases) of striped bass during 2022 was 1,034,626 fish weighing over 10 million pounds (Table 3).

Removals-At-Age Matrix in 2022

The removals (numbers) by the recreational and commercial fisheries are apportioned by age and mortality source in Table 4. The 2015 (age 7) year-class from Chesapeake Bay incurred the highest losses in 2022 (Figure 6).

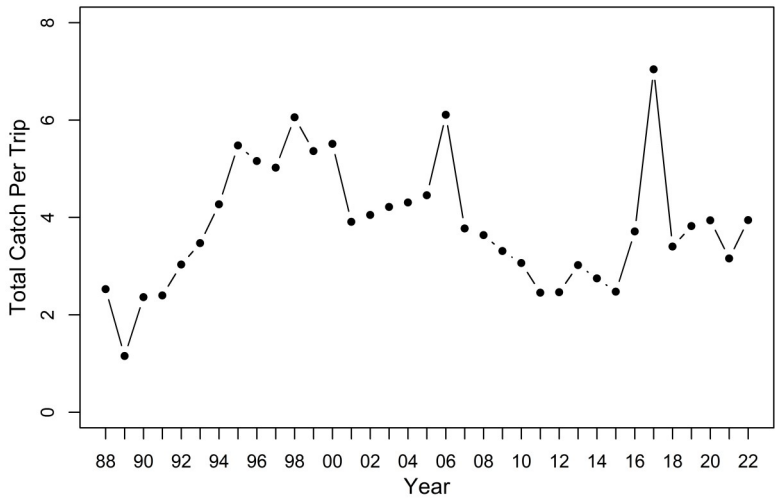

Figure 5. Standardized total catch rates (total number of fish caught per trip) of the recreational fishery for striped bass in Massachusetts waters, 1988-2022

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 2022. 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.

Summary statistics compiled since the start of

Table 3. Estimates of striped bass losses occurring in Massachusetts waters during 2022.

Fishery	Number	Pounds	Mean Wt
Commercial			
Harvest	32,989	770,101	23.3
Recreational			
Harvest	479,920	5,288,214	11.0
Dead Releases	521,717	3,963,811	7.6
Total	1,034,626	10,022,126	

Table 4. Massachusetts striped bass removals-at-age matrix of 2022 by source. There are very minor differences in total numbers due to rounding errors.

Age	Recreational Dead Releases	Recreational Harvest	Commercial Harvest	Total
1	0	0	0	0
2	2,827	0	0	2,827
3	60,544	0	0	60,544
4	154,097	4,022	0	158,119
5	92,258	35,088	0	127,346
6	77,884	173,128	233	251,245
7	73,173	197,666	2,563	273,402
8	26,332	62,093	5,607	94,032
9	10,845	6,110	7,233	24,188
10	9,321	1,814	6,114	17,249
11	6,445	0	4,453	10,898
12	2,968	0	2,682	5,650
13	2,488	0	1,712	4,200
14	1,007	0	796	1,803
15+	1,530	0	1,596	3,126
Total	521,719	479,921	32,989	1,034,629

this study are shown in Table 5.

Planned Management Programs in 2023

Regulations

Due to the recent declaration that the migratory stock is overfished and overfishing is occurring, Massachusetts' recreational bag will remain at 1 fish per day, and a slot limit of 28-<35 inches total length will be imposed.. For the commercial fishery, the minimum size limit and quota will remain at 35 inches and 735,240 pounds, respectively. The commercial fishery quota will be monitored using the SAFIS system. All monitoring programs will continue in 2023.

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. Erich Druskat provided the commercial data. Kim Trull coordinated the volunteer recreational angler data collection program, entered scale envelope data, and prepared data for analysis. Scott Elzey, Christy Draghetti

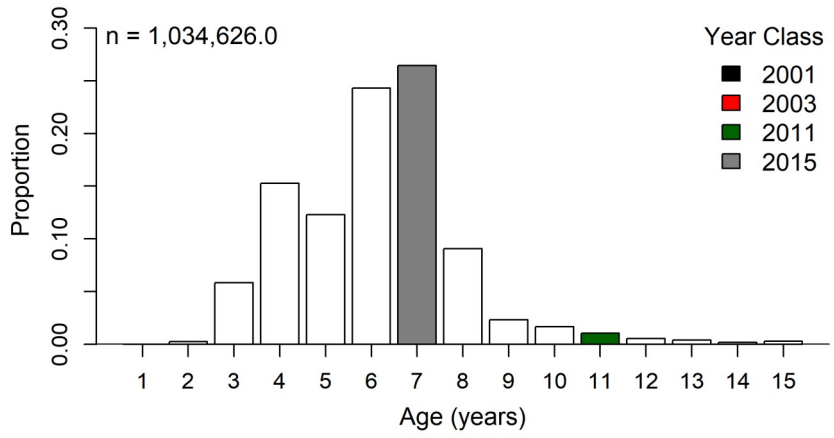

Figure 6. Proportion of striped bass total removals (commercial plus recreational) in 2022 by age. The 2011 and 2015 year-classes from Chesapeake Bay are indicated.

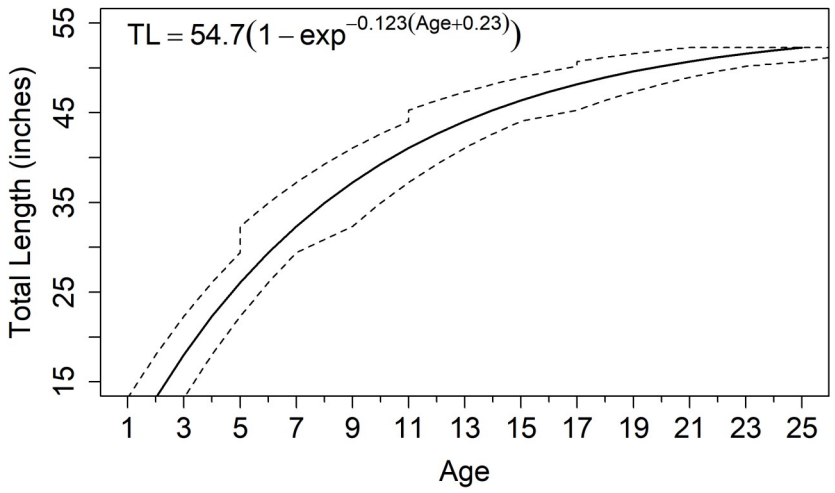

Figure 7. Mean length-age relationship (solid line) for striped bass captured in Massachusetts during 2022. Dotted lines represent the minimum and maximum ages found at a given length.

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

			Number	Ave.	Ave.	SD	SD	ngth 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
2018	10	2	394	794	31.2	90.9	3.6	489	19.2	1154	45.5
2019	10	2	416	761	29.9	121.3	4.8	540	21.2	1077	42.4
2020	Tagging not conducted due to COVID restrictions										
2021	10	2	466	734	28.9	95.3	3.8	513	20.2	1150	45.3
2022	10	2	438	768	30.2	88.4	3.5	548	21.6	1092	43.0

Kim Trull and Kara Duprey prepared and aged scale samples. John Boardman and Elise Koob 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 2022.

TL (in.)	Number	% Number	Weight (lbs)	% Weight
10	0	0.0	0	0.0
11	0	0.0	0	0.0
12	0	0.0	0	0.0
13	0	0.0	0	0.0
14	0	0.0	0	0.0
15	0	0.0	0	0.0
16	0	0.0	0	0.0
17	0	0.0	0	0.0
18	0	0.0	0	0.0
19	0	0.0	0	0.0
20	0	0.0	0	0.0
21	0	0.0	0	0.0
22	0	0.0	0	0.0
23	0	0.0	0	0.0
24	0	0.0	0	0.0
25	0	0.0	0	0.0
26	0	0.0	0	0.0
27	0	0.0	0	0.0
28	0	0.0	0	0.0
29	0	0.0	0	0.0
30	0	0.0	0	0.0
31	0	0.0	0	0.0
32	0	0.0	0	0.0
33	0	0.0	0	0.0
34	158	0.5	2,251	0.3
35	1,953	5.9	30,459	4.0
36	3,604	10.9	61,217	8.0
37	3,256	9.9	60,082	7.8
38	2,517	7.6	50,339	6.5
39	4,176	12.7	90,326	11.7
40	3,428	10.4	80,042	10.4
41	4,295	13.0	108,065	14.0
42	3,438	10.4	93,040	12.1
43	1,811	5.5	52,613	6.8
44	1,584	4.8	49,338	6.4
45	2,770	8.4	92,328	12.0
Total	32,989		770,101	
Avg. Size	39.8		23.3	

Appendix Table 2. Results of the GLM analyses of total catch rates (pounds/hour) for the commercial striped bass fishery, 1991-2021

```
Analysis of Deviance Table
Response: INDEX

      Df Deviance Resid. Df Resid. Dev        F    Pr(>F)
NULL                 69804      75765
YEAR  31  2165.03     69773      73600   68.160 < 2.2e-16 ***
MONTH  1    21.06     69772      73579   20.551 5.815e-06 ***
AREA   2  2089.81     69770      71489 1019.776 < 2.2e-16 ***
```

```
Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  1.969304   0.026333  74.785  < 2e-16 ***
YEAR1992     0.064345   0.035375   1.819   0.0689 .
YEAR1993     0.159478   0.035236   4.526 6.02e-06 ***
YEAR1994     0.068650   0.035179   1.951   0.0510 .
YEAR1995     0.177366   0.031440   5.641 1.69e-08 ***
YEAR1996     0.246989   0.051196   4.824 1.41e-06 ***
YEAR1997     0.171286   0.030418   5.631 1.80e-08 ***
YEAR1998     0.208713   0.031008   6.731 1.70e-11 ***
YEAR1999     0.129258   0.031685   4.080 4.52e-05 ***
YEAR2000     0.247460   0.032215   7.682 1.59e-14 ***
YEAR2001     0.392756   0.032278  12.168  < 2e-16 ***
YEAR2002     0.437808   0.031774  13.779  < 2e-16 ***
YEAR2003     0.497813   0.029355  16.958  < 2e-16 ***
YEAR2004     0.539176   0.035411  15.226  < 2e-16 ***
YEAR2005     0.356419   0.032059  11.118  < 2e-16 ***
YEAR2006     0.385743   0.030316  12.724  < 2e-16 ***
YEAR2007     0.359584   0.030787  11.680  < 2e-16 ***
YEAR2008     0.250484   0.030760   8.143 3.91e-16 ***
YEAR2009     0.329627   0.030514  10.803  < 2e-16 ***
YEAR2010     0.356718   0.032685  10.914  < 2e-16 ***
YEAR2011     0.642742   0.036751  17.489  < 2e-16 ***
YEAR2012     0.681071   0.033233  20.494  < 2e-16 ***
YEAR2013     0.513222   0.033981  15.103  < 2e-16 ***
YEAR2014     0.384909   0.032491  11.847  < 2e-16 ***
YEAR2015     0.574176   0.033242  17.273  < 2e-16 ***
YEAR2016     0.644144   0.033184  19.411  < 2e-16 ***
YEAR2017     0.412361   0.032969  12.507  < 2e-16 ***
YEAR2018     0.268657   0.033005   8.140 4.02e-16 ***
YEAR2019     0.262485   0.034360   7.639 2.21e-14 ***
YEAR2020     0.443392   0.043070  10.295  < 2e-16 ***
YEAR2021     0.623780   0.044885  13.897  < 2e-16 ***
YEAR2022     0.680003   0.036445  18.658  < 2e-16 ***
MONTHJuly   -0.033847   0.007768  -4.357 1.32e-05 ***
AREACCB      0.070184   0.011192   6.271 3.61e-10 ***
AREASMA      0.389963   0.010142  38.452  < 2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for gaussian family taken to be 1.02464)

    Null deviance: 75765  on 69804  degrees of freedom
Residual deviance: 71489  on 69770  degrees of freedom
  AIC: 199834
```

Appendix Table 2 cont.

	lsmeans
1991	8.21
1992	8.76
1993	9.63
1994	8.80
1995	9.81
1996	10.51
1997	9.75
1998	10.12
1999	9.35
2000	10.52
2001	12.16
2002	12.73
2003	13.51
2004	14.08
2005	11.73
2006	12.08
2007	11.77
2008	10.55
2009	11.42
2010	11.73
2011	15.62
2012	16.23
2013	13.72
2014	12.07
2015	14.58
2016	15.64
2017	12.41
2018	10.74
2019	10.68
2020	12.80
2021	15.33
2022	16.21

Appendix Table 3. Estimated size distribution of the Massachusetts recreational striped bass catch (numbers and weight of fish) in 2022 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	0	0.0	0	0.0	0	0.0	0	0.0
10	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
11	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
12	0	0.0	0	0.0	6,159	0.1	4,150	0.0	6,159	0.1	4,150	0.0
13	0	0.0	0	0.0	9,239	0.2	7,929	0.0	9,239	0.1	7,929	0.0
14	0	0.0	0	0.0	16,353	0.3	17,558	0.0	16,353	0.3	17,558	0.0
15	0	0.0	0	0.0	9,239	0.2	12,219	0.0	9,239	0.1	12,219	0.0
16	0	0.0	0	0.0	68,277	1.2	109,752	0.2	68,277	1.1	109,752	0.2
17	0	0.0	0	0.0	97,228	1.7	187,716	0.4	97,228	1.5	187,716	0.4
18	0	0.0	0	0.0	139,203	2.4	319,430	0.7	139,203	2.2	319,430	0.6
19	0	0.0	0	0.0	297,058	5.1	802,664	1.8	297,058	4.7	802,664	1.6
20	0	0.0	0	0.0	330,741	5.7	1,043,525	2.4	330,741	5.3	1,043,525	2.1
21	0	0.0	0	0.0	473,899	8.2	1,732,760	3.9	473,899	7.6	1,732,760	3.5
22	0	0.0	0	0.0	662,090	11.4	2,786,301	6.3	662,090	10.5	2,786,301	5.6
23	0	0.0	0	0.0	419,327	7.2	2,018,403	4.6	419,327	6.7	2,018,403	4.1
24	0	0.0	0	0.0	494,065	8.5	2,704,575	6.1	494,065	7.9	2,704,575	5.5
25	0	0.0	0	0.0	366,451	6.3	2,269,395	5.2	366,451	5.8	2,269,395	4.6
26	0	0.0	0	0.0	429,165	7.4	2,992,239	6.8	429,165	6.8	2,992,239	6.1
27	0	0.0	0	0.0	352,277	6.1	2,752,898	6.3	352,277	5.6	2,752,898	5.6
28	100,547	21.0	877,021	16.6	334,749	5.8	2,919,839	6.6	435,297	6.9	3,796,860	7.7
29	109,919	22.9	1,066,036	20.2	159,702	2.8	1,548,844	3.5	269,622	4.3	2,614,880	5.3
30	89,517	18.7	961,829	18.2	186,415	3.2	2,002,972	4.5	275,932	4.4	2,964,801	6.0
31	74,485	15.5	883,688	16.7	125,633	2.2	1,490,512	3.4	200,118	3.2	2,374,200	4.8
32	52,395	10.9	684,208	12.9	191,350	3.3	2,498,783	5.7	243,744	3.9	3,182,991	6.5
33	16,796	3.5	240,709	4.6	80,251	1.4	1,150,110	2.6	97,047	1.5	1,390,819	2.8
34	32,338	6.7	507,207	9.6	76,867	1.3	1,205,625	2.7	109,205	1.7	1,712,833	3.5
35	3,689	0.8	63,155	1.2	30,339	0.5	519,415	1.2	34,027	0.5	582,569	1.2
36	234	0.0	4,361	0.1	58,794	1.0	1,096,036	2.5	59,028	0.9	1,100,397	2.2
37	0	0.0	0	0.0	37,452	0.6	758,463	1.7	37,452	0.6	758,463	1.5
38	0	0.0	0	0.0	106,631	1.8	2,340,675	5.3	106,631	1.7	2,340,675	4.7
39	0	0.0	0	0.0	54,951	0.9	1,304,749	3.0	54,951	0.9	1,304,749	2.6
40	0	0.0	0	0.0	64,599	1.1	1,655,786	3.8	64,599	1.0	1,655,786	3.4
41	0	0.0	0	0.0	30,339	0.5	837,886	1.9	30,339	0.5	837,886	1.7
42	0	0.0	0	0.0	21,724	0.4	645,307	1.5	21,724	0.3	645,307	1.3
43	0	0.0	0	0.0	7,114	0.1	226,884	0.5	7,114	0.1	226,884	0.5
44	0	0.0	0	0.0	35,952	0.6	1,229,134	2.8	35,952	0.6	1,229,134	2.5
45	0	0.0	0	0.0	23,225	0.4	849,814	1.9	23,225	0.4	849,814	1.7
Total	479,920		5,288,214		5,796,858		44,042,347		6,276,778		49,330,561	
Avg. Size	30.1				25.4				25.8			

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        868.25 34  < 2.2e-16 ***
area_x      128.13  2  < 2.2e-16 ***
mode_fx     527.83  2  < 2.2e-16 ***
wave        500.49  3  < 2.2e-16 ***
cnty        165.00  7  < 2.2e-16 ***
ffdays12c   764.44 12  < 2.2e-16 ***
hours      1461.60 11  < 2.2e-16 ***
```

```
Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)   0.14372    0.12973   1.108 0.267923
year1989     -0.28773    0.16687  -1.724 0.084664 .
year1990     -0.33136    0.14949  -2.217 0.026661 *
year1991      0.10246    0.14747   0.695 0.487172
year1992      0.13892    0.13607   1.021 0.307299
year1993      0.04117    0.13469   0.306 0.759855
year1994      0.07956    0.13007   0.612 0.540761
year1995      0.40023    0.12894   3.104 0.001910 **
year1996      0.31695    0.12930   2.451 0.014238 *
year1997      0.39426    0.12843   3.070 0.002143 **
year1998      0.50928    0.12758   3.992 6.57e-05 ***
year1999      0.39343    0.12771   3.081 0.002068 **
year2000      0.48211    0.12863   3.748 0.000179 ***
year2001      0.21434    0.12847   1.668 0.095252 .
year2002      0.25823    0.12911   2.000 0.045499 *
year2003      0.25609    0.12976   1.974 0.048434 *
year2004      0.25700    0.13090   1.963 0.049606 *
year2005      0.29155    0.13150   2.217 0.026621 *
year2006      0.54097    0.12958   4.175 2.99e-05 ***
year2007      0.20559    0.13029   1.578 0.114589
year2008      0.17264    0.13271   1.301 0.193305
year2009      0.12960    0.13135   0.987 0.323831
year2010      0.00819    0.13386   0.061 0.951216
year2011     -0.09819    0.13514  -0.727 0.467490
year2012     -0.04539    0.13510  -0.336 0.736862
year2013     -0.01725    0.12975  -0.133 0.894206
year2014      0.07612    0.13200   0.577 0.564175
year2015     -0.01101    0.13101  -0.084 0.933022
year2016      0.20305    0.13198   1.538 0.123942
year2017      0.68070    0.12922   5.268 1.39e-07 ***
year2018      0.12371    0.12871   0.961 0.336506
year2019      0.27194    0.12832   2.119 0.034082 *
year2020      0.30490    0.12836   2.375 0.017537 *
year2021      0.07753    0.12864   0.603 0.546714
year2022      0.14294    0.12829   1.114 0.265210
area_x2      -0.05979    0.02395  -2.496 0.012558 *
area_x5       0.13874    0.01452   9.552  < 2e-16 ***
mode_fx6      0.44274    0.02857  15.499  < 2e-16 ***
mode_fx7      0.46791    0.01938  24.139  < 2e-16 ***
wave4        -0.30537    0.01418 -21.536  < 2e-16 ***
wave5        -0.16360    0.01867  -8.765  < 2e-16 ***
wave6         0.35957    0.07961   4.517 6.31e-06 ***
cnty19       -0.14500    0.07355  -1.971 0.048682 *
cnty21       -0.01648    0.03803  -0.433 0.664810
cnty23       -0.03781    0.02022  -1.870 0.061540 .
cnty25       -0.15162    0.04933  -3.074 0.002116 **
cnty5        -0.02703    0.03258  -0.829 0.406856
cnty7        -0.35579    0.04749  -7.492 6.95e-14 ***
cnty9         0.11953    0.01588   7.526 5.37e-14 ***
ffdays12c10   0.09763    0.02020   4.833 1.35e-06 ***
ffdays12c20   0.18313    0.02109   8.684  < 2e-16 ***
ffdays12c30   0.26616    0.02475  10.753  < 2e-16 ***
ffdays12c40   0.31417    0.02973  10.566  < 2e-16 ***
ffdays12c50   0.31555    0.02664  11.843  < 2e-16 ***
ffdays12c60   0.49432    0.03666  13.484  < 2e-16 ***
ffdays12c70   0.43012    0.04822   8.920  < 2e-16 ***
ffdays12c80   0.47025    0.06399   7.349 2.04e-13 ***
ffdays12c90   0.51558    0.07298   7.065 1.64e-12 ***
ffdays12c100  0.54941    0.02868  19.158  < 2e-16 ***
ffdays12c150  0.65350    0.05047  12.949  < 2e-16 ***
ffdays12c200  0.41294    0.03903  10.580  < 2e-16 ***
hours2        0.19112    0.03812   5.014 5.37e-07 ***
hours3        0.37412    0.03580  10.451  < 2e-16 ***
hours4        0.50543    0.03539  14.282  < 2e-16 ***
hours5        0.69218    0.03610  19.174  < 2e-16 ***
hours6        0.80511    0.03686  21.843  < 2e-16 ***
hours7        0.89324    0.04104  21.767  < 2e-16 ***
hours8        0.92002    0.04371  21.048  < 2e-16 ***
hours9        0.87953    0.05724  15.365  < 2e-16 ***
hours10       1.05289    0.06918  15.220  < 2e-16 ***
hours11       1.34734    0.13695   9.838  < 2e-16 ***
hours12       0.99174    0.08516  11.646  < 2e-16 ***
(Dispersion parameter for Gamma family taken to be 1.28421)

    Null deviance: 34440  on 33230  degrees of freedom
Residual deviance: 27738  on 33159  degrees of freedom
AIC: 164877
```

Appendix 4A cont'd.

	posabund
1988	4.272821
1989	3.204476
1990	3.067652
1991	4.733839
1992	4.909605
1993	4.452407
1994	4.626665
1995	6.375770
1996	5.866312
1997	6.337800
1998	7.110372
1999	6.332575
2000	6.919795
2001	5.294195
2002	5.531762
2003	5.519909
2004	5.524956
2005	5.719185
2006	7.339342
2007	5.248070
2008	5.078004
2009	4.864046
2010	4.307958
2011	3.873213
2012	4.083191
2013	4.199725
2014	4.610769
2015	4.226031
2016	5.234779
2017	8.439964
2018	4.835478
2019	5.608140
2020	5.796023
2021	4.617281
2022	4.929370

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        1620.5 34  < 2.2e-16 ***
area_x       748.4  2  < 2.2e-16 ***
mode_fx     5413.3  2  < 2.2e-16 ***
wave         619.4  3  < 2.2e-16 ***
cnty         760.7  7  < 2.2e-16 ***
ffdays12c    718.9 12  < 2.2e-16 ***
hours        705.2 11  < 2.2e-16 ***


Coefficients:
             Estimate Std. Error z value Pr(>|z|)
(Intercept) -1.840618   0.184316  -9.986  < 2e-16 ***
year1989    -1.640703   0.214707  -7.642 2.15e-14 ***
year1990    -0.501713   0.214897  -2.335  0.01956 *
year1991    -0.564589   0.206981  -2.728  0.00638 **
year1992    -0.236817   0.197477  -1.199  0.23045
year1993     0.368980   0.196597   1.877  0.06054 .
year1994     1.038060   0.195647   5.306 1.12e-07 ***
year1995     1.238967   0.193478   6.404 1.52e-10 ***
year1996     0.817311   0.188106   4.345 1.39e-05 ***
year1997     0.341948   0.184112   1.857  0.06327 .
year1998     0.866416   0.184242   4.703 2.57e-06 ***
year1999     0.499315   0.184134   2.712  0.00669 **
year2000     0.448156   0.185732   2.413  0.01583 *
year2001     0.058384   0.183686   0.318  0.75060
year2002     0.318329   0.186366   1.708  0.08762 .
year2003     0.145255   0.185966   0.781  0.43475
year2004     0.139385   0.189148   0.737  0.46118
year2005     0.206791   0.189545   1.091  0.27528
year2006     0.389687   0.187680   2.076  0.03786 *
year2007    -0.095048   0.188082  -0.505  0.61331
year2008    -0.154925   0.191177  -0.810  0.41772
year2009    -0.196987   0.188655  -1.044  0.29641
year2010    -0.263366   0.192224  -1.370  0.17066
year2011    -0.509413   0.192539  -2.646  0.00815 **
year2012    -0.357976   0.194064  -1.845  0.06509 .
year2013    -0.018831   0.187756  -0.100  0.92011
year2014    -0.390054   0.191189  -2.040  0.04134 *
year2015    -0.504412   0.188485  -2.676  0.00745 **
year2016    -0.102690   0.192708  -0.533  0.59412
year2017     0.607325   0.190821   3.183  0.00146 **
year2018    -0.036485   0.185828  -0.196  0.84435
year2019    -0.178456   0.184164  -0.969  0.33254
year2020    -0.091522   0.184448  -0.496  0.61976
year2021     0.007165   0.185027   0.039  0.96911
year2022     0.426531   0.186042   2.293  0.02187 *
area_x2     -0.184473   0.040585  -4.545 5.48e-06 ***
area_x5      0.588337   0.024384  24.128  < 2e-16 ***
mode_fx6     2.626549   0.047834  54.910  < 2e-16 ***
mode_fx7     1.785929   0.028095  63.567  < 2e-16 ***
wave4       -0.568762   0.025669 -22.157  < 2e-16 ***
wave5       -0.620683   0.031103 -19.956  < 2e-16 ***
wave6       -0.412060   0.102900  -4.004 6.22e-05 ***
cnty19      -0.634621   0.094649  -6.705 2.01e-11 ***
cnty21       0.383828   0.073137   5.248 1.54e-07 ***
cnty23      -0.056996   0.033529  -1.700  0.08915 .
cnty25       0.547906   0.093138   5.883 4.03e-09 ***
cnty5       -0.526224   0.051782 -10.162  < 2e-16 ***
cnty7       -0.195980   0.067068  -2.922  0.00348 **
cnty9        0.515405   0.027260  18.907  < 2e-16 ***
ffdays12c10  0.156667   0.033023   4.744 2.09e-06 ***
ffdays12c20  0.324373   0.035457   9.148  < 2e-16 ***
ffdays12c30  0.279338   0.041252   6.772 1.27e-11 ***
ffdays12c40  0.565479   0.053767  10.517  < 2e-16 ***
ffdays12c50  0.756262   0.049653  15.231  < 2e-16 ***
ffdays12c60  0.686629   0.066266  10.362  < 2e-16 ***
ffdays12c70  0.823418   0.092190   8.932  < 2e-16 ***
ffdays12c80  0.911585   0.125550   7.261 3.85e-13 ***
ffdays12c90  0.693088   0.127299   5.445 5.19e-08 ***
ffdays12c100 0.849711   0.053228  15.963  < 2e-16 ***
ffdays12c150 1.138370   0.095690  11.896  < 2e-16 ***
ffdays12c200 0.644284   0.070340   9.160  < 2e-16 ***
hours2       0.250891   0.050115   5.006 5.55e-07 ***
hours3       0.541903   0.048242  11.233  < 2e-16 ***
hours4       0.750054   0.048498  15.466  < 2e-16 ***
hours5       0.838031   0.050989  16.436  < 2e-16 ***
hours6       0.966878   0.053932  17.928  < 2e-16 ***
hours7       0.955668   0.065038  14.694  < 2e-16 ***
hours8       0.905211   0.069117  13.097  < 2e-16 ***
hours9       1.079128   0.101161  10.667  < 2e-16 ***
hours10      1.413182   0.137933  10.245  < 2e-16 ***
hours11      1.063997   0.254772   4.176 2.96e-05 ***
hours12      1.179461   0.155111   7.604 2.87e-14 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 63853  on 50027  degrees of freedom
```

Appendix 4B cont'd.

	pa
1988	0.6898812
1989	0.3012951
1990	0.5739171
1991	0.5584749
1992	0.6370879
1993	0.7628818
1994	0.8626675
1995	0.8847836
1996	0.8343637
1997	0.7579571
1998	0.8410392
1999	0.7856463
2000	0.7769050
2001	0.7022318
2002	0.7535977
2003	0.7200721
2004	0.7188874
2005	0.7323063
2006	0.7666071
2007	0.6691883
2008	0.6558015
2009	0.6462458
2010	0.6309276
2011	0.5720333
2012	0.6086373
2013	0.6858380
2014	0.6009704
2015	0.5732570
2016	0.6674944
2017	0.8032749
2018	0.6820219
2019	0.6504704
2020	0.6699685
2021	0.6914120
2022	0.7731344