Technical Report

Massachusetts Division of Marine Fisheries
Technical Report TR-41

Massachusetts Striped Bass Monitoring Report for 2009

G. A. Nelson

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

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Continued on inside back cover

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Gary A. Nelson

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

May, 2010

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

Summary: During 2009, the commercial fishery for striped bass in Massachusetts sold about 59,258 fish weighing 1,138,291 pounds and kept approximately 4,617 fish for personal consumption. Total losses due to commercial harvesting (including release mortality) were 69,362 fish weighing 1,247,088 pounds. The recreational fishery harvested about 336,470 striped bass weighing over 4.5 million pounds. Total losses due to recreational fishing (including release mortality) were 535,700 fish weighing over 5.8 million pounds. Combined losses (including scientific losses) were 605,094 fish weighing over 7 million pounds, which reflects a 14% decrease in numbers lost and a 15 % decrease in weight lost compared to 2008 (706,421 fish; 8.3 million pounds). The majority of losses, 88% by number and 82% by weight, was attributed to the recreational fishery.

Introduction

This report summarizes the commercial and recreational striped bass fisheries conducted in Massachusetts during 2009. Data sources used to characterize the state fisheries come from monitoring programs of the Massachusetts Division of Marine Fisheries (DMF) and National Marine Fisheries Service (NMFS), which are considered to be essential elements of the long-term management approach described in Section 3 of the Atlantic States Marine Fisheries Commission's (ASMFC) Fisheries Management Report No. 41 (Amendment #6 to the Interstate Fishery management Plan for Atlantic Striped Bass (IFMP)).

Commercial Fishery

Season: July 12-August 26. No landings were permitted on Monday, Friday, or Saturday.

Sold: 1,138,291 pounds (against a harvest quota of 1,107,118 pounds).

Allowable Gear Type: Hook and line.

Minimum Size: 34 inches total length.

Trip Limit: 5 fish per day on Sunday and 30 fish per day on Tuesday-Thursday.

Licensing, Reporting, and Estimation of Landings. To purchase striped bass directly from fishermen, fish dealers are required to obtain special authorization from the DMF in addition to standard seafood dealer permits. Dealer reporting requirement included weekly reporting to the DMF or SAFIS system of all striped bass purchases. If sent to DMF, all landings information is entered into SAFIS by DMF personnel. Following the close of the season, dealers are also required to provide a written transcript consisting of purchase dates, number of fish, pounds of fish, and names and permit numbers of fishermen from whom they purchased.

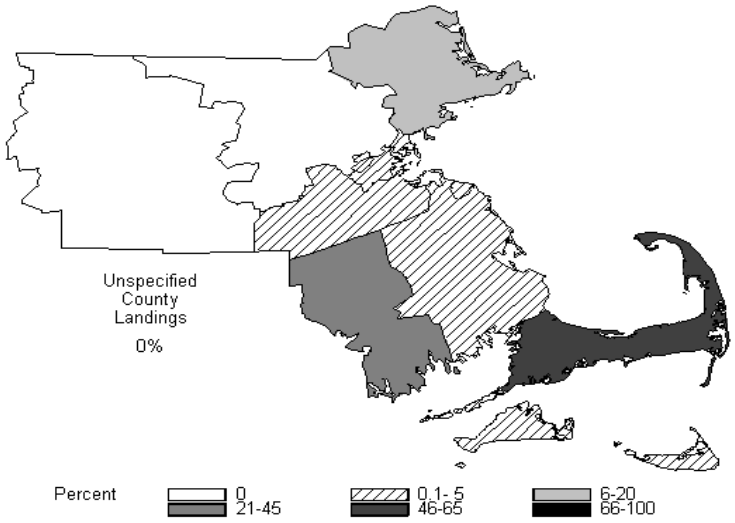
Fishermen must have a DMF commercial fishing permit (of any type) and a special striped bass fishing endorsement to sell their catch. They are required to file catch reports at the end of the season, which include the name of the dealer(s) that they sell to and extensive information describing their catch composition and catch rates. Many fishermen voluntarily provide daily fishing logs.

2009 Landings. The landings used here come from the SAFIS system. Commercial anglers sold 1,138,291 pounds (59,258 fish) of striped bass in

Table 1. Attributes of the Massachusetts striped bass commercial fishery, 1990-2009.

SEASON	LENGTH (Days)	(Pounds) 000s	(Numbers) 000s	DEALER PERMITS	FISHING PERMITS
1990	93	160.6	6.3	95	1,498
1991	59	234.8	10.4	92	1,739
1992	39	239.2	11.3	135	1,861
1993	35	262.6	13.0	152	2,056
1994	24	199.6	10.4	150	2,367
1995	57	782.0	41.2	161	3,353
1996	42	696.8	38.3	179	3,801
1997	42	785.9	44.8	173	5,500
1998	28	822.0	45.3	180	5,540
1999	40	788.2	40.8	167	3,578
2000	36	779.7	40.2	137	3,283
2001	29	815.0	40.2	164	4,219
2002	21	924.9	44.9	132	4,598
2003	21	1055.4	55.7	151	4,867
2004	19	1206.3	60.6	130	4,376
2005	22	1104.7	59.5	162	4,159
2006	26	1312.1	69.9	136	3,980
2007	22	1040.3	54.3	160	3,906
2008	34	1160.1	61.1	167	3,821
2009	27	1138.3	59.3	178	3,988

Figure 1. Percentage of total numbers of striped bass sold by commercial fishermen in Massachusetts counties in 2009.



2009 (Table 1). Most striped bass were sold in Barnstable, Bristol and Essex counties of Massachusetts (Figure 1). Commercial fishers kept an additional 4,617 fish weighing approximately 57,036 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 3,373 fish sampled from the 2009 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:

$$\log_{10}(W) = -3.459 + 3.004 * \log_{10}(L),$$
$$RMS = 0.0027$$

where W equals weight in pounds, L equals total length in inches, and RMS is the residual mean square error. This equation was used to estimate the arithmetic average weight for given lengths by back-transforming the geometric weight as follows:

$$W = 10^{(-3.459 + 3.004 * \log_{10}(L) + RMS/2)}$$

Size composition of the commercial catch by category of disposition is presented in Appendix Tables 1A (numbers of fish) and 1B (pounds of fish). About 47% of all fish caught had lengths ≥34 inches.

Age and Sex Composition.. Five hundred and twenty seven striped bass sampled from the 2009 commercial harvest were used to sex and age the harvested fish. The proportion that each age comprised the total samples was estimated from a sub-sample of 321 fish which guaranteed a precision of ±10% at α= 0.05. Weighted proportions at age were generated by weighting the age proportions sampled in each county by county landings. Age was determined from scales and sex was determined by visual inspection of gonadal tissue (Sykes Method). Age ranged from 7 to 15+ years, and 99.6% were females. About 86.6% of the sub-sample consisted of individuals from the 1996-2001 year classes (ages 8-13) (Table 2).

Estimates of Total Catch and Harvest Rates. Estimates of total catch rates (total number of fish caught per hour) and harvest rates (pounds of fish harvested per hour) for the commercial fishery were developed in order to provide an index that may be

Table 2. Age composition of the 2009 commercial (sold) landings.

			Weighted		
Age	Year Class	Number	%	Mean Length (in.)	Mean Weight (lbs)
6	2003	-	-	-	-
7	2002	8	3.4	33.7	14.0
8	2001	48	18.7	35.1	15.6
9	2000	64	25.0	36.3	16.9
10	1999	42	14.3	37.7	19.1
11	1998	40	14.2	38.7	21.1
12	1997	44	9.8	38.7	21.0
13	1996	40	8.9	40.4	23.2
14	1995	20	3.4	44.3	31.9
15+	≤1994	15	2.4	45.6	33.7

indicative of fluctuations in population abundance (total catch rate) and to provide an index of fishing success (harvest rate). On their mandatory catch reports, all fishermen are asked to record the total hours fished, number and pounds of fish caught by disposition category (i.e., released sub-legal, released legal, sold, and consumed), area fished and the fishing mode (Surf, Boat, or Both) by month. 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 monthly number of total fish caught, pounds harvested, and hours fished by year, month, area fished reduced to 4 regions (Cape Cod Canal, Southern MA, Cape Cod Bay, North MA) and fishing mode. Only data from July-August were used to constraint analyses to the most recent duration of the fishing season. The total catch and harvest rates for each record was calculated by dividing the total numbers caught and the pounds harvested by the total number of hours fished. The total catch and 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

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

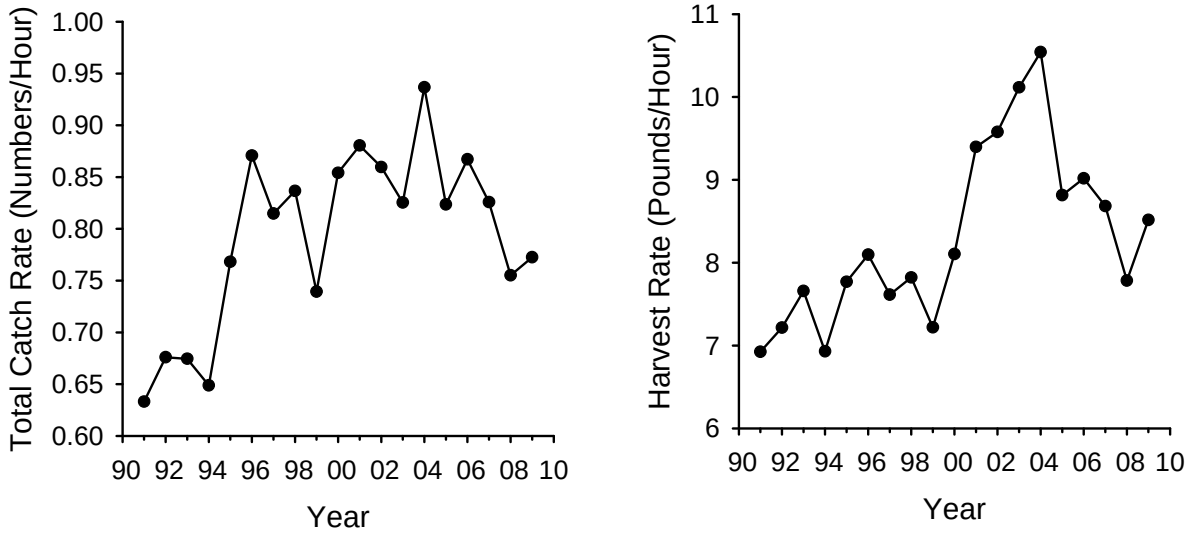
where LSM is the least-squares natural log mean of each year.

Results of the GLM analyses of total catch rates and harvest rates are shown in Appendix Tables 2A and 2B. Although factors were significant, the variables accounted for only about 5% and 8% of the total variation in total catch rates and harvest rates, respectively.

Total catch rates increased steadily from 1991 to 2001, fluctuated around 0.84 fish/hour through 2007, dropped substantially in 2008, and increased slightly in 2009 (Fig. 2). Harvest rates steadily increased after 1999, peaked in 2004, dropped through 2008, but increased in 2009 (Fig. 2).

Characterization of Other Losses. Release mortality was estimated by using a hook-release mortality rate of 8% applied against the released fish in Appendix Tables 1A and 1B. Total losses due to release mortality were 5,487 fish weighing approximately 51,761 pounds.

Figure 2. Total catch rates (numbers/hour) (left) and harvest rates (pounds/hour) (right) for the Massachusetts commercial striped bass fishery, 1990-2009.



Recreational Fishery

Season: None

Daily Bag Limit: Two fish per person

Allowable Gear Type: Hook and Line

Minimum Size: 28 inches total length

Licensing and Reporting Requirements: None

Harvest levels: Harvest (A+B1) and total catch (A+B1+B2) estimates (Table 3) were provided by the NMFS MRFSS. Reference should be made to Osborn and Salz (1994) for a description of the new trip estimation procedure and its effect on catch.

The MRFSS estimate of total catch (including fish released alive) in 2009 was 2,826,850 striped bass, which is a 29% decline compared to the 2008 estimate (Table 3). The estimate of total harvest in 2009 was 336,470, which is a 2% drop in harvest compared to 2008. Total pounds harvested was over 4.5 million in 2009 (Table 3).

The MRFSS estimates were post-stratified by county to determine where harvested bass were being landed by recreational anglers. Most landings (88%) occurred in Barnstable, Plymouth, Essex, and Bristol counties (Figure 4). Only 12% of landings occurred in Dukes, Nantucket, Suffolk and Norfolk counties (Figure 4).

Size Composition. The length distributions of harvested and released fish were estimated from biological sampling conducted by the MRFSS program in Massachusetts and from a volunteer angler program conducted by the Massachusetts Division of Marine Fisheries. Volunteer recreational anglers were solicited to collect length and scale samples from striped bass that they captured each month (May-October). Each person was asked to collect a minimum of 5 scales from at least 10 fish per month and record the disposition of each fish (released or harvested) and fishing mode. Over 1,620 samples were received from 35 anglers. The size frequencies of measured fish are shown in Figure 5 by disposition and mode. The size frequency of released fishes was used to allocate MRFSS release numbers by mode among size classes. Numbers-at-length and weight-at-length data by disposition are summarized in Appendix Tables 3A and 3B.

Age Composition. A sub-sample of 524 fish from the volunteer angler survey was aged and

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

	Harvest (A+B1)		Released (B2)	Total (A+B1+B2)
Year	Numbers	Weight (lbs)	Numbers	Numbers
1986	29,434	298,816	442,298	471,732
1987	10,807	269,459	93,660	104,467
1988	21,050	421,317	209,632	230,682
1989	13,044	295,227	193,067	206,111
1990	20,515	319,092	339,511	360,026
1991	20,799	440,605	448,735	469,534
1992	57,084	972,116	779,814	836,898
1993	58,511	1,113,446	833,566	892,077
1994	74,538	1,686,049	2,102,514	2,177,052
1995	73,806	1,504,390	3,280,882	3,354,688
1996	68,300	1,291,706	3,269,746	3,338,046
1997	199,373	2,891,970	5,417,751	5,617,124
1998	207,952	2,973,456	7,184,358	7,392,310
1999	126,755	1,822,818	4,576,208	4,702,963
2000	181,295	2,618,216	7,382,031	7,563,326
2001	288,032	3,644,561	5,410,899	5,698,930
2002	308,749	4,304,883	5,718,984	6,027,733
2003	402,201	5,120,554	4,306,965	4,709,166
2004	406,590	5,539,086	5,878,546	6,285,136
2005	368,422	5,093,748	4,839,752	5,208,174
2006	339,994	4,907,270	8,657,473	8,997,467
2007	347,102	4,784,948	5,772,100	6,119,202
2008	343,347	5,516,183	3,641,258	3,984,605
2009	336,470	4,525,166	2,490,380	2,826,850

Figure 4. Percentage of total numbers of striped bass harvested by recreational anglers in each county of Massachusetts during 2009.

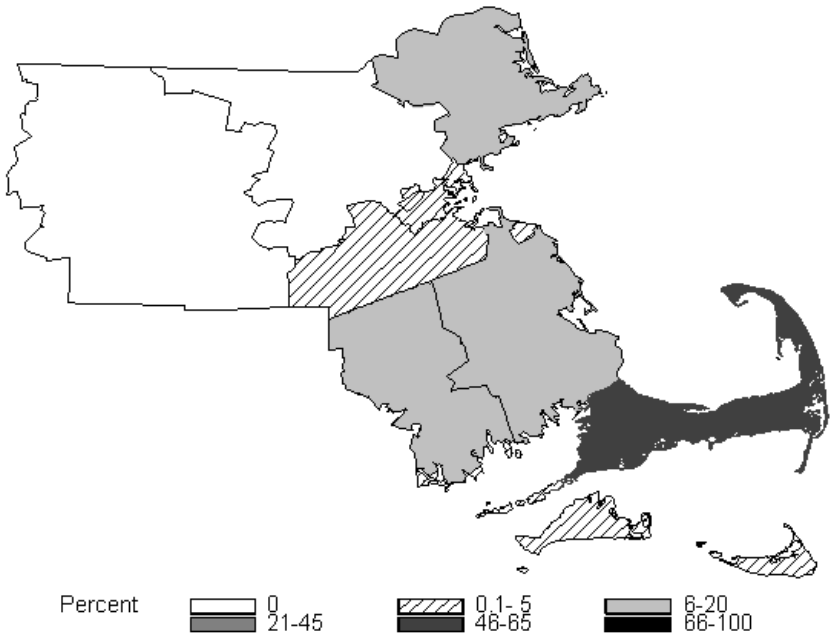
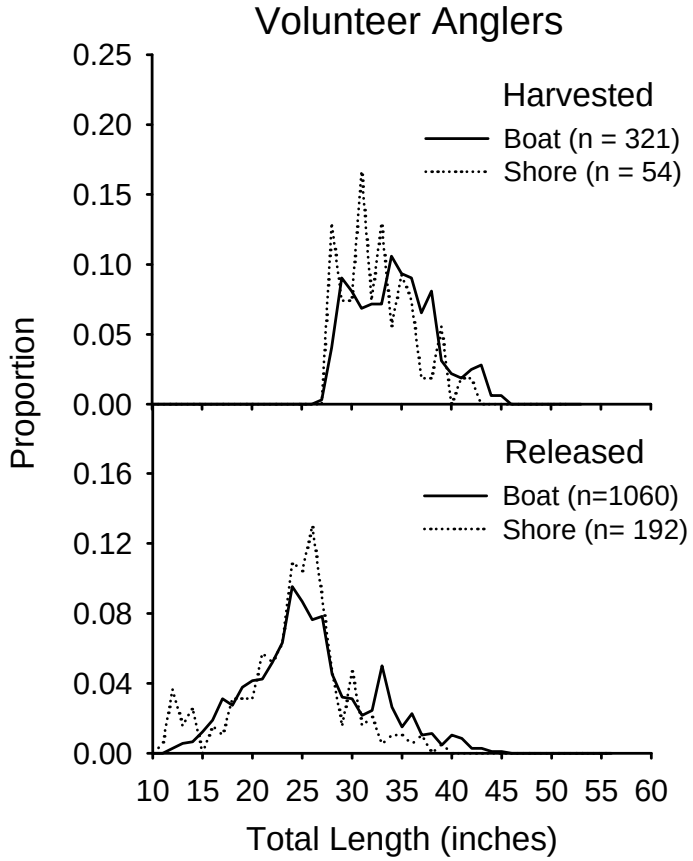


Figure 5. Sizes of striped bass caught by volunteer recreational anglers in 2009 by disposition and fishing mode.



combined with commercial samples to produce an age-length key used to convert the MRFSS and MA volunteer angler size distributions into age classes. Recreational samples were selected using a weighted random design based on the total number of striped bass caught in each wave and mode stratum (as determined by MRFSS).

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 the analysis was repeated. First-order interactions were considered in the initial analyses but it was not always possible to generate annual means by the least-square methods with some interactions included (see Searle et al., 1980); therefore, only main effects were considered.

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

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

where p_i and y_i are the predicted annual responses from the leasts quares mean estimates from the logistic and GLM models. Only data for those anglers who said they targeted striped bass were used in the analyses.

Results of the delta-Gamma model analyses are given in Appendix Tables 4A and 4B. Standardized catch rates for striped bass in Massachusetts waters increased from 1993 to 1998, declined through 2003, but increased in 2004 and 2005 (Fig. 6). In 2006, catch rates jumped dramatically as the large 2003 year-class became vulnerable to the fishery. Since 2006, catch rates have declined (Fig. 6).

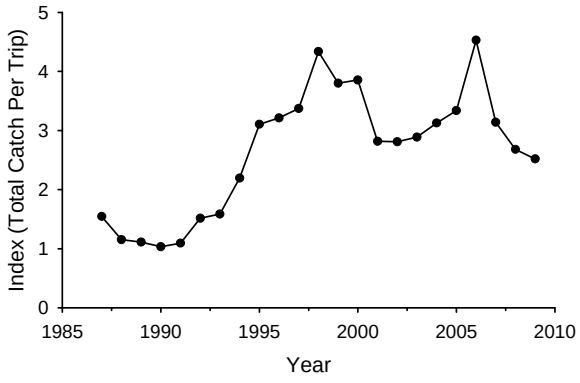
Characterization of Losses

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 199,230 fish (1.27 million pounds).

Scientific Collections

About 32 bass was taken for scientific research in 2009.

Figure 6. Index of total catch rates (total number of fish caught per trip) of the recreational fishery for striped bass in Massachusetts waters, 1987-2009.



By-catch in Other Fisheries

During 1994, DMF sea-sampling efforts identified striped bass as by-catch in a Nantucket Sound springtime trawl fishery directed at long-finned squid (*Loligo pealei*). Those by-catch estimates were about 3,100 fish (17,600 pounds). Anecdotal information was also reported for this fishery which suggested that striped bass by-catch ranged from 8,000 pounds per day, with up to single tows landing 19,000 pounds. DMF personnel sea-sampled this fishery during 1995-2000 and observed only incidental catches of striped bass. Limited sampling and low catch rates make it unreasonable to extrapolate sample information. DMF will continue to monitor potential sources of striped bass by-catch during 2010.

Estimated Total Losses

Total estimated loss of striped bass during 2009 was 605,094 fish weighing 7,047,161 pounds (Table 4), which is a 14% decrease in numbers lost and a 15% decrease in weight compared to 2008 (706,421 fish; 8,348,707 pounds). The majority of losses, 88% by number and 82% by weight, was attributed to combined losses in the recreational fishery.

Removals-At-Age Matrix

The removals (numbers) due to release mortality and harvest by the recreational and commercial fisheries and scientific activities are apportioned by age and mortality source in Table 5. The 2003 (age 6) and 2001 (age 8) year-classes incurred the highest losses in 2009 (Figure 7).

Required Fishery-Ind ependent Monit oring Programs

Massachusetts Tagging Study

The Massachusetts Division of Marine Fisheries (DMF) joined the Striped Bass Cooperative State-Federal Coast-wide Tagging Study in 1991. The study's primary objective has been to develop an integrated database of tag releases and recoveries that will provide current information related to striped bass mortality and migration rates. The majority of striped bass tagged prior to 1991 (the tagging study began in 1986) have ranged from 18 to 28 inches in length. Since Atlantic coastal fisheries had employed minimum sizes of 28-36 inches, resulting mortality estimates from these data may understate the effects fishing has on larger striped bass. The Massachusetts tagging effort has therefore focused on the tag and release of larger fish that reach coast-wide legal sizes. To accomplish this job, the DMF contracts several select charter boat captains to take DMF personnel on board to tag and release their catch during regularly scheduled fishing trips. Fish are caught in fall by trolling artificial baits in shoal areas around Nantucket Island. In 2004, spring tagging of small bass in Plum Island Sound also occurred. 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 this study are shown in Table 6.

Table 4. Estimates of striped bass losses occurring in Massachusetts waters during 2009.

FISHERY	NUMBER	POUNDS	MEAN WT.
Commercial			
Harvest*	63,875	1,195,327	18.7
Release Mortality	5,487	51,761	9.4
Recreational			
Harvest	336,470	4,525,166	13.4
Release Mortality	199,230	1,274,817	6.4
Scientific	32	90	2.8
Total	605,094	7,047,161	

		Recreational		Commercial		
Age	Scientific	Release Mortality	Harvest	Release Mortality	Harvest*	Total
2	0	9,771	0	20	0	9,791
3	17	15,991	0	85	0	16,093
4	15	26,634	0	184	0	26,833
5	0	39,137	8,124	572	144	47,977
6	0	60,295	62,649	2174	1,160	126,278
7	0	13,247	39,941	915	2,813	56,917
8	0	16,734	77,269	1110	12,317	107,430
9	0	7,935	54,155	268	15,447	77,805
10	0	2,846	25,973	59	8,702	37,580
11	0	2,870	26,491	35	8,625	38,020
12	0	2,075	19,467	32	5,928	27,502
13	0	1,285	14,552	20	5,316	21,174
14	0	304	5,568	8	2,013	7,893
15+	0	107	2,280	5	1,411	3,803

Table 5. Massachusetts Striped Bass Removals-At-Age Matrix of 2009 By Source.

Planned Management Programs in 2010

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 1,128,577 pounds due to overharvest in 2009. The commercial fishery quota will be monitored using the SAFIS system. The commercial season will not open until July 12 and harvesting will be allowed only on Sunday with a daily bag limit of 5 fish, and Tuesday-Thursday with a daily bag limit of 30 fish.

Monitoring Programs

All monitoring programs will continue in 2010.

Acknowledgements

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Figure 7. Total number of striped bass removals in 2009 by age. The 2003 and 2001 year-classes are indicated.

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

			Number	Ave.		Length Range	
Year	Trips	Boats	Tagged	Length	SD	Min	Max.
1991	17	4	388	817	106.4	534	1300
1992	29	3	899	798	125.9	524	1267
1993	15	2	678	784	125.0	515	1210
1994	13	2	377	735	93.2	548	1028
1995	11	2	449	767	110.2	470	1178
1996	8	2	203	748	64.1	541	1077
1997	10	2	321	773	114.7	485	1090
1998	12	2	382	797	93.8	597	1055
1999	16	2	471	777	95.5	594	1108
2000	25	4	1095	752	102.6	510	1204
2001	14	3	456	786	102.5	503	1110
2002	12	3	239	764	103.6	487	1060
2003	15	3	655	825	92.1	602	1204
2004	25	7	784	707	193.1	316	1164
2005	19	4	752	726	210.5	299	1114
2006	11	4	390	813	94.2	565	1114
2007	16	3	530	848	105.2	600	1225
2008	13	2	456	821	104.6	530	1202
2009	15	3	501	840	101.8	572	1146

Appendix Table 1A. Estimated size distribution of the Massachusetts commercial striped bass catch (numbers of fish) in 2009.

TL (in.)	Harvested*	Released	Total	Percent	Cumulative Percent
11	0	0	0	0.00	0.00
12	0	0	0	0.00	0.00
13	0	0	0	0.00	0.00
14	0	0	0	0.00	0.00
15	0	0	0	0.00	0.00
16	0	0	0	0.00	0.00
17	0	551	551	0.42	0.42
18	0	0	0	0.00	0.42
19	0	315	315	0.24	0.65
20	0	866	866	0.65	1.31
21	0	315	315	0.24	1.55
22	0	866	866	0.65	2.20
23	0	1,024	1,024	0.77	2.97
24	0	2,362	2,362	1.78	4.76
25	0	2,599	2,599	1.96	6.72
26	0	3,229	3,229	2.44	9.15
27	0	3,780	3,780	2.85	12.01
28	346	7,008	7,355	5.55	17.56
29	277	6,063	6,340	4.79	22.35
30	739	8,741	9,480	7.16	29.50
31	577	8,820	9,397	7.09	36.60
32	745	10,395	11,139	8.41	45.01
33	2,009	9,213	11,222	8.47	53.48
34	5,897	157	6,055	4.57	58.05
35	6,581	236	6,817	5.15	63.20
36	10,703	157	10,861	8.20	71.40
37	7,207	472	7,679	5.80	77.19
38	7,981	394	8,374	6.32	83.51
39	6,733	394	7,127	5.38	88.89
40	2,841	157	2,999	2.26	91.16
41	3,588	236	3,824	2.89	94.05
42	2,500	0	2,500	1.89	95.93
43	1,863	0	1,863	1.41	97.34
44	1,214	157	1,371	1.04	98.37
45	761	0	761	0.57	98.95
46	754	79	833	0.63	99.58
47	349	0	349	0.26	99.84
48	35	0	35	0.03	99.87
49	105	0	105	0.08	99.95
50	70	0	70	0.05	100.00
51	0	0	0	0.00	100.00
52	0	0	0	0.00	100.00
Total	63,875	68,588	132,463		
Avg. Size	37.4	29.6	33.4		

* includes fish taken for personal consumption

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

TL (in.)	Harvested*	Released	Total	Percent	Cumulative Percent
11	0	0	0	0.00	0.00
12	0	0	0	0.00	0.00
13	0	0	0	0.00	0.00
14	0	0	0	0.00	0.00
15	0	0	0	0.00	0.00
16	0	0	0	0.00	0.00
17	0	973	973	0.05	0.05
18	0	0	0	0.00	0.05
19	0	778	778	0.04	0.09
20	0	2,497	2497	0.13	0.23
21	0	1,052	1052	0.06	0.28
22	0	3,329	3329	0.18	0.46
23	0	4,498	4498	0.24	0.70
24	0	11,803	11803	0.63	1.33
25	0	14,685	14685	0.79	2.12
26	0	20,537	20537	1.10	3.22
27	0	26,942	26942	1.44	4.66
28	2,642	55,749	58391	3.13	7.79
29	2,349	53,619	55968	3.00	10.79
30	6,935	85,619	92554	4.96	15.74
31	5,979	95,373	101353	5.43	21.17
32	8,490	123,704	132193	7.08	28.24
33	25,112	120,313	145425	7.79	36.03
34	80,650	2,250	82901	4.44	40.47
35	98,185	3,684	101869	5.45	45.92
36	173,798	2,674	176472	9.45	55.37
37	127,059	8,713	135772	7.27	62.64
38	152,448	7,870	160318	8.58	71.22
39	139,060	8,511	147571	7.90	79.12
40	63,313	3,675	66988	3.59	82.71
41	86,118	5,938	92056	4.93	87.64
42	64,510	0	64510	3.45	91.09
43	51,593	0	51593	2.76	93.85
44	36,024	4,899	40923	2.19	96.05
45	24,159	0	24159	1.29	97.34
46	25,571	2,801	28372	1.52	98.86
47	12,626	0	12626	0.68	99.53
48	1,349	0	1349	0.07	99.61
49	4,305	0	4305	0.23	99.84
50	3,050	0	3050	0.16	100.00
51	0	0	0	0.00	100.00
52	0	0	0	0.00	100.00
Total	1,195,327	672,485	1,867,812		
Avg. Weight	18.7	9.8	14.1		

* includes fish taken for personal consumption

Appendix Table 2A. Results of the GLM analyses of total catch rates (numbers/hour) for the commercial striped bass fishery., 1991-2009

```
Anova Table (Type III tests)

Response: log Number/Hour
             SS    Df       F    Pr(>F)
YEAR        409    18  23.191 < 2.2e-16 ***
METHOD      587     2 299.363 < 2.2e-16 ***
AREA        973     2 496.470 < 2.2e-16 ***
Residuals 45681 46601

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) -0.44847    0.03490 -12.851  < 2e-16 ***
YEAR1992     0.06550    0.03461   1.893 0.058423 .
YEAR1993     0.06333    0.03452   1.835 0.066543 .
YEAR1994     0.02454    0.03444   0.713 0.476156
YEAR1995     0.19341    0.03081   6.277 3.48e-10 ***
YEAR1996     0.31870    0.05014   6.356 2.09e-10 ***
YEAR1997     0.25229    0.02983   8.458  < 2e-16 ***
YEAR1998     0.27870    0.03042   9.160  < 2e-16 ***
YEAR1999     0.15520    0.03109   4.991 6.02e-07 ***
YEAR2000     0.29938    0.03160   9.473  < 2e-16 ***
YEAR2001     0.32981    0.03166  10.418  < 2e-16 ***
YEAR2002     0.30582    0.03121   9.799  < 2e-16 ***
YEAR2003     0.26521    0.02886   9.190  < 2e-16 ***
YEAR2004     0.39165    0.03481  11.250  < 2e-16 ***
YEAR2005     0.26293    0.03155   8.335  < 2e-16 ***
YEAR2006     0.31456    0.02981  10.550  < 2e-16 ***
YEAR2007     0.26569    0.03031   8.767  < 2e-16 ***
YEAR2008     0.17619    0.03028   5.818 5.98e-09 ***
YEAR2009     0.19907    0.03002   6.631 3.38e-11 ***
METHODBOAT   0.08920    0.02465   3.619 0.000296 ***
METHODSURF  -0.34858    0.02940 -11.856  < 2e-16 ***
AREACCB     -0.03618    0.01335  -2.709 0.006751 **
AREASMA      0.26975    0.01196  22.556  < 2e-16 ***

Last-Squares Means
1991   0.63
1992   0.68
1993   0.67
1994   0.65
1995   0.77
1996   0.87
1997   0.81
1998   0.84
1999   0.74
2000   0.85
2001   0.88
2002   0.86
2003   0.83
2004   0.94
2005   0.82
2006   0.87
2007   0.83
2008   0.76
2009   0.77
```

Appendix Table 2B. Results of the GLM analyses of total catch rates (pounds/hour) for the commercial striped bass fishery, 1991-2009.

```
Anova Table (Type III tests)

Response: lnnum
             SS    Df       F    Pr(>F)
YEAR        628    18  33.739 < 2.2e-16 ***
METHOD     1415     2 683.479 < 2.2e-16 ***
AREA       1775     2 857.639 < 2.2e-16 ***
Residuals 48227 46601

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept)  1.8113020  0.0358586  50.512  < 2e-16 ***
YEAR1992     0.0412630  0.0355631   1.160 0.245942
YEAR1993     0.1008229  0.0354654   2.843 0.004473 **
YEAR1994     0.0009243  0.0353911   0.026 0.979165
YEAR1995     0.1151605  0.0316583   3.638 0.000275 ***
YEAR1996     0.1564209  0.0515202   3.036 0.002398 **
YEAR1997     0.0950284  0.0306494   3.100 0.001933 **
YEAR1998     0.1219744  0.0312611   3.902 9.56e-05 ***
YEAR1999     0.0416267  0.0319476   1.303 0.192593
YEAR2000     0.1574128  0.0324719   4.848 1.25e-06 ***
YEAR2001     0.3054465  0.0325277   9.390  < 2e-16 ***
YEAR2002     0.3244399  0.0320686  10.117  < 2e-16 ***
YEAR2003     0.3791306  0.0296510  12.786  < 2e-16 ***
YEAR2004     0.4203229  0.0357694  11.751  < 2e-16 ***
YEAR2005     0.2414643  0.0324142   7.449 9.54e-14 ***
YEAR2006     0.2643538  0.0306344   8.629  < 2e-16 ***
YEAR2007     0.2263601  0.0311404   7.269 3.68e-13 ***
YEAR2008     0.1170846  0.0311140   3.763 0.000168 ***
YEAR2009     0.2068393  0.0308478   6.705 2.03e-11 ***
METHODBOAT   0.2893872  0.0253235  11.428  < 2e-16 ***
METHODSURF  -0.3725250  0.0302102 -12.331  < 2e-16 ***
AREACCB      0.0394169  0.0137216   2.873 0.004073 **
AREASMA      0.4149237  0.0122878  33.767  < 2e-16 ***

Least-Squares Means
1991   6.92
1992   7.22
1993   7.66
1994   6.93
1995   7.77
1996   8.10
1997   7.61
1998   7.82
1999   7.22
2000   8.10
2001   9.40
2002   9.58
2003   10.12
2004   10.54
2005   8.82
2006   9.02
2007   8.68
2008   7.78
2009   8.52
```

Appendix Table 3A. Estimated size distribution of the Massachusetts recreational striped bass catch (numbers of fish) in 2009.

TL (in.)	Harvested	Released	Total	Percent	Cumulative Percent
9	0	0	0	0.00	0.00
10	0	0	0	0.00	0.00
11	0	1,610	1,610	0.06	0.06
12	0	19,311	19,311	0.68	0.74
13	0	18,730	18,730	0.66	1.40
14	0	17,089	17,089	0.60	2.01
15	0	24,116	24,116	0.85	2.86
16	0	39,665	39,665	1.40	4.26
17	0	51,771	51,771	1.83	6.09
18	0	44,454	44,454	1.57	7.67
19	0	79,331	79,331	2.81	10.47
20	0	93,730	93,730	3.32	13.79
21	0	112,361	112,361	3.97	17.76
22	0	137,228	137,228	4.85	22.62
23	0	148,625	148,625	5.26	27.88
24	0	249,588	249,588	8.83	36.71
25	0	232,579	232,579	8.23	44.93
26	0	211,974	211,974	7.50	52.43
27	1,172	212,993	214,165	7.58	60.01
28	17,069	128,259	145,328	5.14	65.15
29	27,260	76,362	103,622	3.67	68.81
30	25,437	88,383	113,820	4.03	72.84
31	26,097	54,424	80,521	2.85	75.69
32	23,234	66,433	89,667	3.17	78.86
33	26,484	118,055	144,539	5.11	83.97
34	33,982	66,572	100,554	3.56	87.53
35	34,080	38,237	72,317	2.56	90.09
36	29,822	53,704	83,526	2.95	93.04
37	21,540	24,658	46,198	1.63	94.68
38	25,492	24,617	50,109	1.77	96.45
39	10,875	8,469	19,344	0.68	97.14
40	5,102	22,437	27,539	0.97	98.11
41	5,746	13,897	19,643	0.69	98.80
42	9,713	4,859	14,572	0.52	99.32
43	10,252	4,859	15,111	0.53	99.85
44	1,528	500	2,028	0.07	99.93
45	1,519	500	2,019	0.07	100.00
46	0	0	0	0.00	100.00
47	39	0	39	0.00	100.00
48	28	0	28	0.00	100.00
49	0	0	0	0.00	100.00
50	0	0	0	0.00	100.00
51	0	0	0	0.00	100.00
52	0	0	0	0.00	100.00
53	0	0	0	0.00	100.00
54	0	0	0	0.00	100.00
55	0	0	0	0.00	100.00
56	0	0	0	0.00	100.00
Total	336,470	2,490,380	2,826,850		
Avg. Size	34.3	25.9	26.9		

Appendix Table 3B. Estimated size distribution of the Massachusetts recreational striped bass catch (pounds) in 2009.

TL (in.)	Harvested	Released	Total	Percent	Cumulative Percent
9	0	0	0		
10	0	0	0	0.00	0.00
11	0	684	684	0.00	0.00
12	0	10,660	10,660	0.05	0.06
13	0	13,150	13,150	0.06	0.12
14	0	14,990	14,990	0.07	0.19
15	0	26,026	26,026	0.13	0.32
16	0	51,967	51,967	0.25	0.57
17	0	81,380	81,380	0.40	0.97
18	0	82,971	82,971	0.41	1.38
19	0	174,183	174,183	0.85	2.23
20	0	240,089	240,089	1.17	3.40
21	0	333,253	333,253	1.63	5.03
22	0	468,062	468,062	2.29	7.32
23	0	579,369	579,369	2.83	10.15
24	0	1,105,660	1,105,660	5.40	15.55
25	0	1,164,757	1,164,757	5.69	21.25
26	0	1,194,332	1,194,332	5.84	27.08
27	7,394	1,344,168	1,351,562	6.61	33.69
28	120,155	902,882	1,023,036	5.00	38.69
29	213,232	597,323	810,556	3.96	42.65
30	220,311	765,487	985,798	4.82	47.47
31	249,429	520,170	769,599	3.76	51.23
32	244,287	698,500	942,788	4.61	55.84
33	305,434	1,361,506	1,666,940	8.15	63.99
34	428,681	839,810	1,268,491	6.20	70.19
35	469,040	526,257	995,296	4.86	75.05
36	446,689	804,414	1,251,102	6.11	81.17
37	350,327	401,035	751,362	3.67	84.84
38	449,182	433,769	882,951	4.32	89.15
39	207,185	161,343	368,528	1.80	90.95
40	104,890	461,231	566,121	2.77	93.72
41	127,213	307,677	434,890	2.13	95.85
42	231,197	115,655	346,852	1.70	97.54
43	261,893	124,128	386,021	1.89	99.43
44	41,831	13,686	55,517	0.27	99.70
45	44,478	14,642	59,120	0.29	99.99
46	0	0	0	0.00	99.99
47	1,318	0	1,318	0.01	100.00
48	1,001	0	1,001	0.00	100.00
49	0	0	0	0.00	100.00
50	0	0	0	0.00	100.00
51	0	0	0	0.00	100.00
52	0	0	0	0.00	100.00
53	0	0	0	0.00	100.00
54	0	0	0	0.00	100.00
55	0	0	0	0.00	100.00
56	0	0	0	0.00	100.00
Total	4,525,166	15,935,217	20,460,383		
Avg. Weight	13.4	6.4	7.2		

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

```
Anova Table (Type III tests)

Response: TOT_FISH (0 or 1)
          LR Chisq Df Pr(>Chisq)
YEAR        1703.8 22  < 2.2e-16 ***
AREA_X       195.9  2  < 2.2e-16 ***
MODE_FX     3664.1  2  < 2.2e-16 ***
WAVE         345.9  2  < 2.2e-16 ***
CNTY         437.4  7  < 2.2e-16 ***
FFDAYS12C    910.5 12  < 2.2e-16 ***
HOURS       2674.1 11  < 2.2e-16 ***

Coefficients:
              Estimate Std. Error z value Pr(>|z|)
(Intercept)  -3.705695   0.250049 -14.820  < 2e-16 ***
YEAR1988     -0.157425   0.272099  -0.579 0.562887
YEAR1989     -0.109092   0.268858  -0.406 0.684917
YEAR1990     -0.226491   0.257970  -0.878 0.379956
YEAR1991     -0.339474   0.256761  -1.322 0.186122
YEAR1992     -0.169489   0.251025  -0.675 0.499556
YEAR1993      0.155499   0.250216   0.621 0.534297
YEAR1994      0.640242   0.248296   2.579 0.009922 **
YEAR1995      0.928285   0.247595   3.749 0.000177 ***
YEAR1996      0.972257   0.248025   3.920 8.86e-05 ***
YEAR1997      0.951578   0.247302   3.848 0.000119 ***
YEAR1998      1.437476   0.247246   5.814 6.10e-09 ***
YEAR1999      1.189624   0.247352   4.809 1.51e-06 ***
YEAR2000      1.105129   0.247866   4.459 8.25e-06 ***
YEAR2001      0.905913   0.247349   3.662 0.000250 ***
YEAR2002      0.953031   0.248220   3.839 0.000123 ***
YEAR2003      0.847311   0.247906   3.418 0.000631 ***
YEAR2004      0.926666   0.249320   3.717 0.000202 ***
YEAR2005      1.043145   0.249758   4.177 2.96e-05 ***
YEAR2006      1.289183   0.248710   5.183 2.18e-07 ***
YEAR2007      0.971517   0.249537   3.893 9.89e-05 ***
YEAR2008      0.804045   0.250707   3.207 0.001341 **
YEAR2009      0.755987   0.249784   3.027 0.002474 **
AREA_X2      -0.008893   0.034022  -0.261 0.793800
AREA_X5       0.307549   0.023633  13.013  < 2e-16 ***
MODE_FX6      2.572654   0.049999  51.454  < 2e-16 ***
MODE_FX7      1.150766   0.026122  44.054  < 2e-16 ***
WAVE4        -0.356057   0.024177 -14.727  < 2e-16 ***
WAVE5        -0.488327   0.028372 -17.211  < 2e-16 ***
CNTY5        -0.254676   0.049562  -5.139 2.77e-07 ***
CNTY7        -0.149654   0.060189  -2.486 0.012904 *
CNTY9         0.397278   0.026147  15.194  < 2e-16 ***
CNTY19       -0.464215   0.086817  -5.347 8.94e-08 ***
CNTY21        0.161958   0.054784   2.956 0.003113 **
CNTY23       -0.088547   0.033151  -2.671 0.007562 **
CNTY25        0.149967   0.077880   1.926 0.054154 .
FFDAYS12C10   0.122989   0.031574   3.895 9.81e-05 ***
FFDAYS12C20   0.398692   0.032715  12.187  < 2e-16 ***
FFDAYS12C30   0.488151   0.038506  12.677  < 2e-16 ***
FFDAYS12C40   0.567042   0.047986  11.817  < 2e-16 ***
FFDAYS12C50   0.725815   0.042485  17.084  < 2e-16 ***
FFDAYS12C60   0.688521   0.057958  11.880  < 2e-16 ***
FFDAYS12C70   0.814247   0.074464  10.935  < 2e-16 ***
```

Appendix 4A cont'd.

```
FFDAYS12C80   0.863748   0.105386   8.196 2.48e-16 ***
FFDAYS12C90   0.609570   0.113402   5.375 7.65e-08 ***
FFDAYS12C100  0.906356   0.046297  19.577  < 2e-16 ***
FFDAYS12C150  0.931795   0.079168  11.770  < 2e-16 ***
FFDAYS12C200  0.854961   0.091604   9.333  < 2e-16 ***
HOURS2        0.653287   0.050260  12.998  < 2e-16 ***
HOURS3        1.044042   0.048147  21.685  < 2e-16 ***
HOURS4        1.346893   0.047879  28.131  < 2e-16 ***
HOURS5        1.528864   0.049932  30.619  < 2e-16 ***
HOURS6        1.775160   0.051807  34.265  < 2e-16 ***
HOURS7        1.980271   0.062320  31.776  < 2e-16 ***
HOURS8        1.874096   0.065718  28.517  < 2e-16 ***
HOURS9        2.269579   0.105716  21.469  < 2e-16 ***
HOURS10       2.271830   0.120405  18.868  < 2e-16 ***
HOURS11       1.650456   0.230559   7.158 8.16e-13 ***
HOURS12       2.312843   0.143111  16.161  < 2e-16 ***

Year LSMEANS
1987 0.3762996
1988 0.3401312
1989 0.3510614
1990 0.3248051
1991 0.3005336
1992 0.3374288
1993 0.4134344
1994 0.5336884
1995 0.6042009
1996 0.6146669
1997 0.6097575
1998 0.7175197
1999 0.6647066
2000 0.6456206
2001 0.5988387
2002 0.6101034
2003 0.5846828
2004 0.6038137
2005 0.6313145
2006 0.6865197
2007 0.6144916
2008 0.5741396
2009 0.5623494
```

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

```
Anova Table (Type III tests)

Response: TOT_FISH
          LR Chisq Df Pr(>Chisq)
YEAR        332.25 22  < 2.2e-16 ***
AREA_X       33.39  2  5.603e-08 ***
MODE_FX     433.38  2  < 2.2e-16 ***
WAVE        264.85  2  < 2.2e-16 ***
CNTY        122.64  7  < 2.2e-16 ***
FFDAYS12C   569.40 12  < 2.2e-16 ***
HOURS       993.32 11  < 2.2e-16 ***

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)   0.296759   0.231237   1.283  0.19938
YEAR1988     -0.192308   0.255167  -0.754  0.45106
YEAR1989     -0.259830   0.248756  -1.045  0.29626
YEAR1990     -0.256130   0.239731  -1.068  0.28535
YEAR1991     -0.120729   0.239250  -0.505  0.61383
YEAR1992      0.089273   0.232502   0.384  0.70101
YEAR1993     -0.069363   0.231627  -0.299  0.76459
YEAR1994      0.001226   0.229179   0.005  0.99573
YEAR1995      0.224079   0.228404   0.981  0.32657
YEAR1996      0.240687   0.228678   1.053  0.29258
YEAR1997      0.297789   0.228175   1.305  0.19188
YEAR1998      0.386088   0.227717   1.695  0.09000 .
YEAR1999      0.330639   0.228009   1.450  0.14704
YEAR2000      0.373854   0.228433   1.637  0.10173
YEAR2001      0.135759   0.228228   0.595  0.55196
YEAR2002      0.114234   0.228730   0.499  0.61748
YEAR2003      0.184593   0.228671   0.807  0.41954
YEAR2004      0.231969   0.229267   1.012  0.31165
YEAR2005      0.252222   0.229533   1.099  0.27185
YEAR2006      0.473624   0.228651   2.071  0.03833 *
YEAR2007      0.218298   0.229241   0.952  0.34097
YEAR2008      0.128024   0.230553   0.555  0.57870
YEAR2009      0.086457   0.230077   0.376  0.70709
AREA_X2      -0.043517   0.026320  -1.653  0.09827 .
AREA_X5       0.085700   0.019113   4.484 7.37e-06 ***
MODE_FX6      0.321009   0.036475   8.801  < 2e-16 ***
MODE_FX7      0.506832   0.023525  21.545  < 2e-16 ***
WAVE4        -0.301893   0.018550 -16.274  < 2e-16 ***
WAVE5        -0.166346   0.022910  -7.261 3.98e-13 ***
CNTY5        -0.132598   0.040518  -3.273  0.00107 **
CNTY7        -0.285665   0.050300  -5.679 1.37e-08 ***
CNTY9         0.110501   0.021250   5.200 2.01e-07 ***
CNTY19       -0.168281   0.075886  -2.218  0.02660 *
CNTY21        0.019862   0.042649   0.466  0.64142
CNTY23       -0.018084   0.027535  -0.657  0.51134
CNTY25       -0.338170   0.063422  -5.332 9.81e-08 ***
FFDAYS12C10   0.062381   0.026200   2.381  0.01728 *
FFDAYS12C20   0.181397   0.026408   6.869 6.64e-12 ***
FFDAYS12C30   0.190084   0.030664   6.199 5.79e-10 ***
FFDAYS12C40   0.330619   0.037358   8.850  < 2e-16 ***
FFDAYS12C50   0.377917   0.032616  11.587  < 2e-16 ***
FFDAYS12C60   0.414080   0.044745   9.254  < 2e-16 ***
FFDAYS12C70   0.447054   0.055732   8.022 1.10e-15 ***
```

Appendix Table 4B cont'd.

```
FFDAYS12C80   0.506595   0.077221   6.560 5.49e-11 ***
FFDAYS12C90   0.494240   0.089627   5.514 3.54e-08 ***
FFDAYS12C100  0.564624   0.034868  16.193  < 2e-16 ***
FFDAYS12C150  0.595722   0.060185   9.898  < 2e-16 ***
FFDAYS12C200  0.743705   0.071261  10.436  < 2e-16 ***
HOURS2        0.111900   0.050113   2.233  0.02556 *
HOURS3        0.338842   0.047430   7.144 9.35e-13 ***
HOURS4        0.471611   0.046732  10.092  < 2e-16 ***
HOURS5        0.642396   0.047695  13.469  < 2e-16 ***
HOURS6        0.699716   0.048178  14.524  < 2e-16 ***
HOURS7        0.923134   0.052642  17.536  < 2e-16 ***
HOURS8        0.920137   0.055593  16.551  < 2e-16 ***
HOURS9        0.936697   0.075218  12.453  < 2e-16 ***
HOURS10       1.094222   0.085630  12.779  < 2e-16 ***
HOURS11       1.293657   0.175239   7.382 1.61e-13 ***
HOURS12       1.042261   0.102458  10.173  < 2e-16 ***

Year LSMEANS
1987 4.107928
1988 3.389255
1989 3.167963
1990 3.179705
1991 3.640748
1992 4.491523
1993 3.832648
1994 4.112969
1995 5.139717
1996 5.225789
1997 5.532873
1998 6.043644
1999 5.717650
2000 5.970156
2001 4.705245
2002 4.605045
2003 4.940725
2004 5.180429
2005 5.286417
2006 6.596524
2007 5.110087
2008 4.668991
2009 4.478892
```

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TR-34 Nelson, G. A. 2008. **2007 Massachusetts striped bass monitoring report**.
TR-35 Barber, J. S., K. A. Whitmore, M. Rousseau, D. M. Chosid, and R. P. Glenn. 2009. **Boston Harbor artificial reef site selection and monitoring program.**
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