Technical Report

Massachusetts Division of Marine Fisheries
Technical Report TR-36

Massachusetts Striped Bass Monitoring Report for 2008

G. A. Nelson

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

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Annisquam River Marine Fisheries Station
Gloucester, MA

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Massachusetts Division of Marine Fisheries
Paul Diodati, Director
Department of Fisheries, Wildlife and Environmental Law Enforcement
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Executive Office of Energy and Environmental Affairs
Ian Bowles, Secretary
Commonwealth of Massachusetts
Deval Patrick, Governor

Summary: During 2008, the commercial fishery for striped bass in Massachusetts sold about 61,076 fish weighing 1,160,122 pounds and kept approximately 4,255 fish for personal consumption. Total losses due to commercial harvesting (including release mortality) were 71,773 fish weighing 1,268,542 pounds. The recreational fishery harvested about 343,347 striped bass weighing over 5.5 million pounds. Total losses due to recreational fishing (including release mortality) were 634,648 fish weighing over 7 million pounds. Combined losses (including scientific losses) were 706,421 fish weighing over 8.3 million pounds, which reflects a 19% decrease in numbers lost and a 8% increase in weight lost compared to 2007 (871,837 fish; 7.7 million pounds). The majority of losses, 90% by number and 85% by weight, was attributed to the recreational fishery.

Introduction

This report summarizes the commercial and recreational striped bass fisheries conducted in Massachusetts during 2008. 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-September 9. No landings were permitted on Monday, Friday, or Saturday.

Sold: 1,160,122 pounds (against a harvest quota of 1,107,828 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.

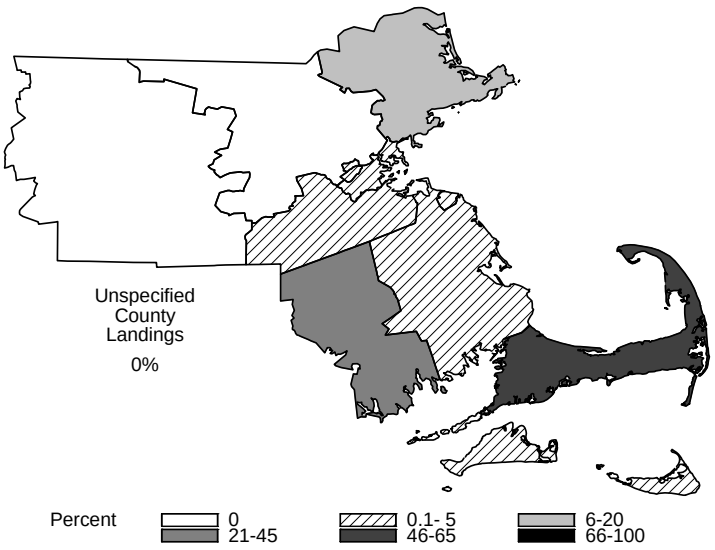
Fishermen must have a DMF commercial fishing permit (of any type) and a special striped bass fishing endorsement to sell their catch. They are required to file catch reports at the end of the season, which include the name of the dealer(s) that they sell to and extensive information describing their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

2008 Landings. The landings used here come from the SAFIS system. Commercial anglers sold 1,160,122 pounds (61,076 fish) of striped bass in

Table 1. Attributes of the Massachusetts striped bass commercial fishery, 1990-2008.

	SEASON	Sold			
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	3,952
2007	22	1040.3	54.3	160	3,900
2008	34	1160.1	61.1	167	3,599

Figure 1. Percentage of total numbers of striped bass sold by commercial fishermen in Massachusetts counties in 2008.



2008 (Table 1). Most striped bass were sold in Barnstable, Bristol and Essex counties of Massachusetts (Figure 1). Commercial fishers kept an additional 4,255 fish weighing approximately 53,344 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 3,561 fish sampled from the 2008 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:

where W equals weight in pounds, L equals total

$$\log_{10}(W) = -3.476 + 3.017 * \log_{10}(L),$$

$$RMS = 0.0026$$

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:

$$W = 10^{(-3.476 + 3.017 * \log_{10}(L) + RMS/2)}$$

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 42% of all fish caught had lengths ≥34 inches.

Age and Sex Composition. Seven hundred and seventeen striped bass sampled from the 2008 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 330 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 6 to 17 years, and 98.7% were females. About 92.4% of the sub-sample consisted of individuals from the 1996-2001 year classes (ages 7-12) (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

Table 2. Age composition of the 2008 commercial (sold) landings.

			Weighted		
Age	Year Class	Number	%	Mean Length (in.)	Mean Weight (lbs)
6	2002	2	1.0	33.3	13.5
7	2001	25	7.4	34.5	14.1
8	2000	63	22.2	35.6	15.9
9	1999	66	22.9	36.8	17.6
10	1998	67	18.9	38.1	19.8
11	1997	55	14.6	38.4	20.3
12	1996	29	7.2	39.7	23.2
13	1995	14	4.0	41.8	27.6
14	1994	5	1.1	44.2	35.8
15	1993	3	0.5	45.1	34.9
16	1992	0	0.0	-	-
17	1991	1	0.2	49.9	45.2

developed in order to provide an index that may be 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 rate 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

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

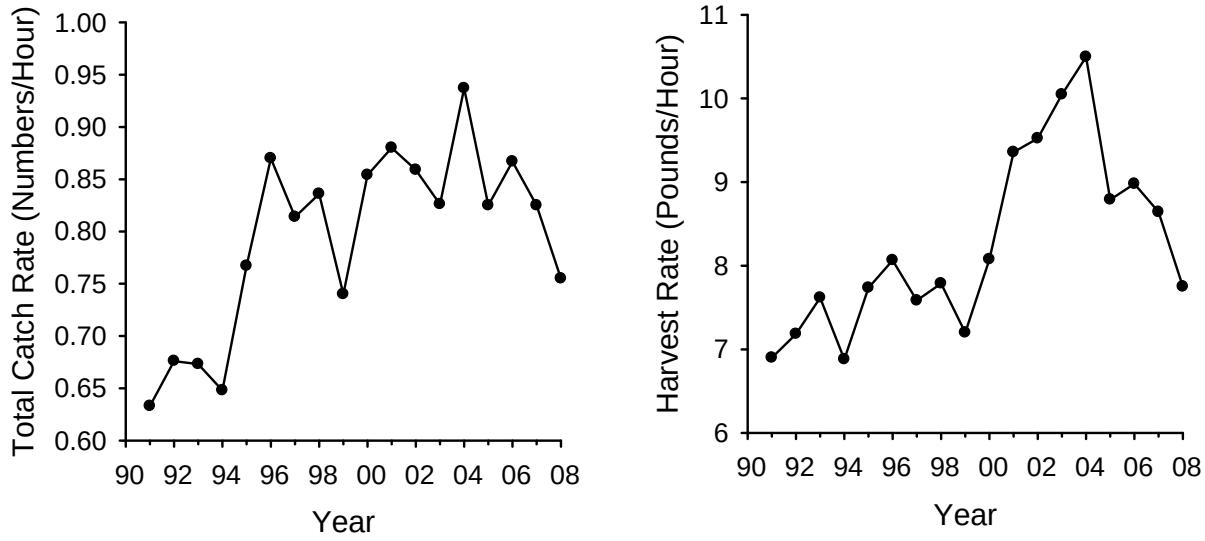
where LSM is the least-squares natural log mean of each year.

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 and dropped substantially in 2008 (Fig. 2). Harvest rates steadily increased after 1999, peaked in 2004, and have since declined (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 6,442 fish weighing approximately 55,076 pounds.

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



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 2008 was 3,641,258 striped bass, which is a 37% decline compared to the 2007 estimate (Table 3). The estimate of total harvest in 2008 was 343,347, which is 1% drop compared to harvest in 2007. Total pounds harvested was over 5.5 million in 2008 (Table 3).

The MRFSS estimates were post-stratified by county to determine where harvested bass were being landed by recreational anglers. Most landings (98%) occurred in Barnstable, Plymouth, Essex, and Bristol counties (Figure 4). Only 2% 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 1,200 samples were received from 37 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 398 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

Figure 4. Percentage of total numbers of striped bass harvested by recreational anglers in each county of Massachusetts during 2008.

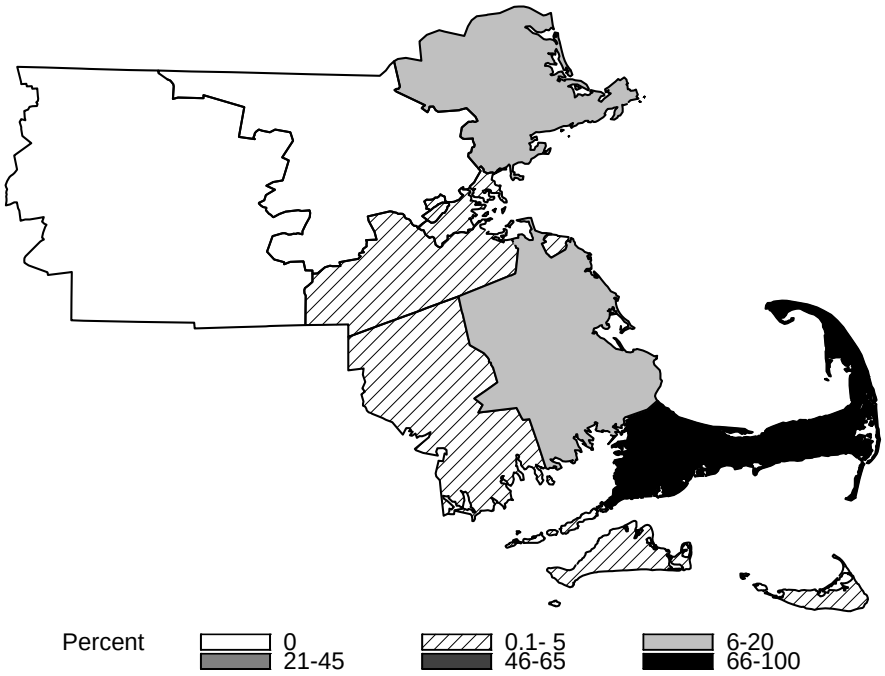
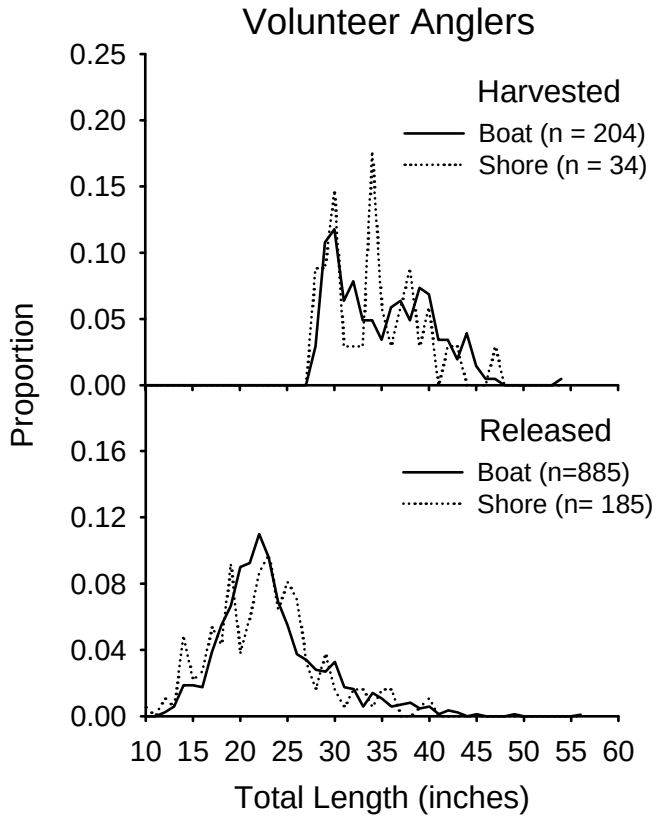


Figure 5. Sizes of striped bass caught by volunteer recreational anglers in 2008 by disposition and fishing mode.



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:

where p is the probability of catching a fish, a is the

$$\text{logit}(p) = \log(p/1-p) = a + \sum_{i=1}^{n} b_i X_i + e$$

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).

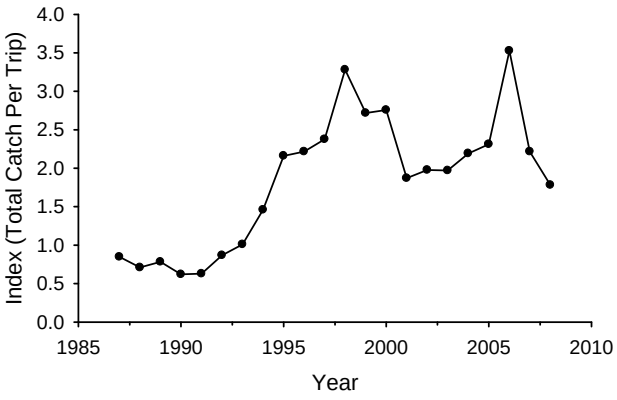
Characterization of Losses

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 291,301 fish (1.56 million pounds).

Scientific Collections

About 1 bass was taken for scientific research in 2008.

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



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 2009.

Estimated Total Losses

Total estimated loss of striped bass during 2008 was 706,421 fish weighing 8,348,707 pounds (Table 4), which is a 19% decrease in numbers lost and a 7% increase in weight (due to larger fish being harvest and released) compared to 2007 (871,837 fish; 7,714,493 pounds). The majority of losses, 90% by number and 85% 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 5) and 2001 (age 7) year-classes incurred the highest losses in 2008.

Required Fishery-Independent Monitoring 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 2008.

FISHERY	NUMBER	POUNDS	MEAN WT.
Commercial			
Harvest*	65,331	1,213,466	18.6
Release Mortality	6,442	55,076	8.6
Recreational			
Harvest	343,347	5,516,183	16.1
Release Mortality	291,301	1,563,976	5.4
Scientific	1	5	5.4
Total	706,421	8,348,707	

* includes fish taken for personal consumption

Table 5. Massachusetts Striped Bass Removals-At-Age Matrix of 2008 By Source.

		Recreational		Commercial		
Age	Scientific	Release Mortality	Harvest	Release Mortality	Harvest*	Total
2	0	9,796	0	18	0	9,814
3	0	46,790	0	171	0	46,961
4	1	58,225	3,126	335	43	61,730
5	0	97,526	12,501	1,324	189	111,540
6	0	27,769	43,773	1,533	1,643	74,718
7	0	22,642	66,285	1,745	5,697	96,369
8	0	10,216	48,042	696	14,266	73,220
9	0	7,202	51,099	406	14,607	73,314
10	0	4,351	42,714	108	11,789	58,962
11	0	3,495	32,090	60	9,046	44,691
12	0	1,955	23,341	45	4,468	29,810
13	0	837	11,320	0	2,479	14,636
14	0	142	3,499	0	689	4,330
15	0	238	3,914	0	277	4,430
16+	0	116	1,642	0	138	1,896

* includes fish taken for personal consumption

Planned Management Programs in 2009

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 1,107,456 pounds due to overharvest in 2008. 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 2009.

Acknowledgements

The collection and quality of striped bass data would suffer greatly without the efforts of many DMF employees. Tom Hoopes, Micah Dean, Kim Lundy, and Story Reed assisted with the Oracle database of commercial landings, wrote SQL code to summarize the landings data, and managed catch reports. Jennifer Stritzel-Thomson coordinated the volunteer recreational angler data collection program, entered scale envelope data, and preprared data for analysis. John Boardman aged all scale samples. John Boardman, Paul Caruso, and Brant McAfee conducted the commercial sampling of stripers. Paul Caruso and John Boardman also coordinated and conducted the USFWS cooperative tagging study. Mary Ann Fletcher managed catch reports and entered data.

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Table 6. Massachusetts tag summary statistics.

Year	Trips	Boats	Number Tagged	Ave. Length	SD	Length Range	
						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	820.6	104.6	530	1202

Appendix Table 1A. Estimated size distribution of the Massachusetts commercial striped bass catch (numbers of fish) in 2008.

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	203	203	0.14	0.14
15	0	0	0	0.00	0.14
16	0	745	745	0.51	0.65
17	0	271	271	0.19	0.84
18	0	203	203	0.14	0.98
19	0	406	406	0.28	1.25
20	0	677	677	0.46	1.72
21	0	948	948	0.65	2.37
22	0	1,625	1,625	1.11	3.48
23	0	3,047	3,047	2.09	5.57
24	0	4,470	4,470	3.06	8.64
25	0	4,740	4,740	3.25	11.89
26	0	6,298	6,298	4.32	16.20
27	0	6,163	6,163	4.23	20.43
28	319	7,585	7,904	5.42	25.85
29	255	4,944	5,199	3.56	29.41
30	681	10,226	10,907	7.48	36.89
31	532	5,621	6,153	4.22	41.11
32	765	8,871	9,636	6.61	47.72
33	2,436	12,731	15,168	10.40	58.12
34	7,954	339	8,293	5.69	63.80
35	7,080	203	7,284	4.99	68.80
36	10,536	68	10,604	7.27	76.07
37	7,084	68	7,151	4.90	80.97
38	8,222	68	8,290	5.68	86.65
39	6,253	0	6,253	4.29	90.94
40	3,104	0	3,104	2.13	93.07
41	3,848	0	3,848	2.64	95.71
42	1,750	0	1,750	1.20	96.91
43	2,219	0	2,219	1.52	98.43
44	1,378	0	1,378	0.94	99.38
45	322	0	322	0.22	99.60
46	212	0	212	0.15	99.74
47	80	0	80	0.05	99.80
48	0	0	0	0.00	99.80
49	244	0	244	0.17	99.96
50	53	0	53	0.04	100.00
51	0	0	0	0.00	100.00
52	0	0	0	0.00	100.00
Total	65,329	80,520	145,849		
Avg. Size	37.2	28.5	32.4		

* includes fish taken for personal consumption

Appendix Table 1B. Estimated weight distribution by size of the Massachusetts commercial striped bass catch (pounds) in 2008.

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	194	194	0.01	0.01
15	0	0	0	0.00	0.01
16	0	1,064	1064	0.06	0.07
17	0	464	464	0.02	0.09
18	0	414	414	0.02	0.11
19	0	975	975	0.05	0.16
20	0	1,896	1896	0.10	0.26
21	0	3,075	3075	0.16	0.42
22	0	6,067	6067	0.32	0.74
23	0	13,008	13008	0.68	1.43
24	0	21,692	21692	1.14	2.57
25	0	26,022	26022	1.37	3.93
26	0	38,914	38914	2.05	5.98
27	0	42,669	42669	2.24	8.22
28	2,466	58,606	61072	3.21	11.43
29	2,193	42,465	44658	2.35	13.78
30	6,478	97,298	103776	5.45	19.23
31	5,587	59,043	64630	3.40	22.63
32	8,845	102,556	111400	5.85	28.48
33	30,904	161,497	192401	10.11	38.60
34	110,405	4,700	115105	6.05	44.64
35	107,262	3,078	110340	5.80	50.44
36	173,771	1,117	174888	9.19	59.63
37	126,898	1,213	128111	6.73	66.37
38	159,640	1,315	160955	8.46	74.83
39	131,301	0	131301	6.90	81.73
40	70,357	0	70357	3.70	85.42
41	93,965	0	93965	4.94	90.36
42	45,960	0	45960	2.42	92.78
43	62,555	0	62555	3.29	96.06
44	41,637	0	41637	2.19	98.25
45	10,412	0	10412	0.55	98.80
46	7,325	0	7325	0.38	99.19
47	2,949	0	2949	0.16	99.34
48	0	0	0	0.00	99.34
49	10,201	0	10201	0.54	99.88
50	2,355	0	2355	0.12	100.00
51	0	0	0	0.00	100.00
52	0	0	0	0.00	100.00
Total	1,213,466	689,341	1,902,808		
Avg. Weight	18.6	8.6	13.0		

* 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.

```
Anova Table (Type III tests)

Response: lnnum
             SS    Df      F    Pr(>F)
year        407    17  24.21 < 2.2e-16 ***
method      563     2 284.88 < 2.2e-16 ***
area        943     2 477.19 < 2.2e-16 ***
Residuals 42898 43411


Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) -0.40668    0.02588 -15.715  < 2e-16 ***
year1992     0.06466    0.03475   1.861 0.062799 .
year1993     0.06155    0.03466   1.776 0.075752 .
year1994     0.02257    0.03459   0.653 0.514064
year1995     0.19136    0.03094   6.185 6.27e-10 ***
year1996     0.31713    0.05035   6.299 3.03e-10 ***
year1997     0.25081    0.02995   8.373  < 2e-16 ***
year1998     0.27783    0.03055   9.094  < 2e-16 ***
year1999     0.15536    0.03122   4.976 6.53e-07 ***
year2000     0.29891    0.03173   9.419  < 2e-16 ***
year2001     0.32919    0.03179  10.355  < 2e-16 ***
year2002     0.30457    0.03134   9.718  < 2e-16 ***
year2003     0.26525    0.02898   9.153  < 2e-16 ***
year2004     0.39134    0.03496  11.194  < 2e-16 ***
year2005     0.26410    0.03169   8.335  < 2e-16 ***
year2006     0.31369    0.02994  10.476  < 2e-16 ***
year2007     0.26474    0.03044   8.698  < 2e-16 ***
year2008     0.17533    0.03041   5.765 8.21e-09 ***
methodBOTH  -0.09153    0.02508  -3.650 0.000262 ***
methodSURF  -0.43799    0.01841 -23.797  < 2e-16 ***
areaNMA      0.05882    0.01384   4.250 2.14e-05 ***
areaSMA      0.32014    0.01137  28.168  < 2e-16 ***

Least-sqaures Means
   year lsmeans
1  1991   0.633
2  1992   0.676
3  1993   0.673
4  1994   0.648
5  1995   0.767
6  1996   0.870
7  1997   0.814
8  1998   0.836
9  1999   0.740
10 2000   0.854
11 2001   0.880
12 2002   0.859
13 2003   0.826
14 2004   0.937
15 2005   0.825
16 2006   0.867
17 2007   0.825
18 2008   0.755
```

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

```
Anova Table (Type III tests)

Response: ln pounds/hour
             SS    Df        F  Pr(>F)
year        622    17  35.2501 < 2e-16 ***
month         5     1   4.6501 0.03106 *
method     1361     2 655.7258 < 2e-16 ***
area       1714     2 825.7347 < 2e-16 ***
Residuals 45047 43410

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  2.118968   0.027080  78.248  < 2e-16 ***
year1992     0.040550   0.035612   1.139 0.254854
year1993     0.099210   0.035518   2.793 0.005221 **
year1994    -0.002617   0.035464  -0.074 0.941186
year1995     0.114534   0.031706   3.612 0.000304 ***
year1996     0.156376   0.051595   3.031 0.002440 **
year1997     0.094796   0.030696   3.088 0.002015 **
year1998     0.121289   0.031310   3.874 0.000107 ***
year1999     0.042758   0.031998   1.336 0.181465
year2000     0.157751   0.032521   4.851 1.23e-06 ***
year2001     0.305025   0.032576   9.363  < 2e-16 ***
year2002     0.322359   0.032124  10.035  < 2e-16 ***
year2003     0.376057   0.029732  12.648  < 2e-16 ***
year2004     0.419846   0.035824  11.720  < 2e-16 ***
year2005     0.242550   0.032470   7.470 8.18e-14 ***
year2006     0.263700   0.030684   8.594  < 2e-16 ***
year2007     0.225403   0.031191   7.227 5.04e-13 ***
year2008     0.116554   0.031166   3.740 0.000184 ***
monthJuly    0.021420   0.009933   2.156 0.031056 *
methodBOTH  -0.297469   0.025696 -11.577  < 2e-16 ***
methodSURF  -0.661811   0.018861 -35.089  < 2e-16 ***
areaNMA     -0.025403   0.014182  -1.791 0.073266 .
areaSMA      0.389234   0.011647  33.419  < 2e-16 ***

Least-Squares Means
   year lsmeans
1  1991    6.90
2  1992    7.18
3  1993    7.62
4  1994    6.88
5  1995    7.73
6  1996    8.07
7  1997    7.58
8  1998    7.79
9  1999    7.20
10 2000    8.08
11 2001    9.36
12 2002    9.52
13 2003   10.05
14 2004   10.50
15 2005    8.79
16 2006    8.98
17 2007    8.64
18 2008    7.75
```

Appendix Table 3A. Estimated size distribution of the Massachusetts recreational striped bass catch (numbers of fish) in 2008.

TL (in.)	Harvested	Released	Total	Percent	Cumulative Percent
9	0	0	0	0.00	0.00
10	0	4,899	4,899	0.12	0.12
11	0	0	0	0.00	0.12
12	0	17,814	17,814	0.45	0.57
13	0	15,580	15,580	0.39	0.96
14	0	77,506	77,506	1.95	2.91
15	0	67,071	67,071	1.68	4.59
16	0	80,298	80,298	2.02	6.60
17	0	159,903	159,903	4.01	10.62
18	0	214,543	214,543	5.38	16.00
19	0	284,510	284,510	7.14	23.14
20	0	276,466	276,466	6.94	30.08
21	0	341,064	341,064	8.56	38.64
22	0	346,188	346,188	8.69	47.33
23	0	342,409	342,409	8.59	55.92
24	0	251,821	251,821	6.32	62.24
25	0	216,290	216,290	5.43	67.67
26	0	155,808	155,808	3.91	71.58
27	0	112,656	112,656	2.83	74.41
28	11,005	74,443	85,448	2.14	76.55
29	31,914	98,703	130,617	3.28	79.83
30	38,516	109,034	147,550	3.70	83.53
31	29,713	52,829	82,542	2.07	85.60
32	22,009	52,395	74,404	1.87	87.47
33	20,909	24,310	45,219	1.13	88.61
34	19,808	42,754	62,562	1.57	90.18
35	13,206	45,536	58,742	1.47	91.65
36	19,808	27,975	47,783	1.20	92.85
37	24,210	27,181	51,391	1.29	94.14
38	22,009	27,174	49,183	1.23	95.37
39	25,311	18,333	43,644	1.10	96.47
40	20,909	35,375	56,284	1.41	97.88
41	8,804	3,665	12,469	0.31	98.19
42	9,904	16,874	26,778	0.67	98.87
43	6,603	11,837	18,440	0.46	99.33
44	9,904	1,911	11,815	0.30	99.63
45	3,301	1,754	5,055	0.13	99.75
46	2,201	0	2,201	0.06	99.81
47	2,201	0	2,201	0.06	99.86
48	0	0	0	0.00	99.86
49	0	4,351	4,351	0.11	99.97
50	0	0	0	0.00	99.97
51	0	0	0	0.00	99.97
52	1,100	0	1,100	0.03	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	343,347	3,641,260	3,984,607		
Avg. Size	35.0	23.3	24.3		

Appendix Table 3B. Estimated size distribution of the Massachusetts recreational striped bass catch (pounds) in 2008.

TL (in.)	Harvested	Released	Total	Percent	Cumulative Percent
9	0	0	0		
10	0	1,698	1,698	0.01	0.01
11	0	0	0	0.00	0.01
12	0	10,702	10,702	0.04	0.05
13	0	11,917	11,917	0.05	0.10
14	0	74,135	74,135	0.30	0.39
15	0	78,999	78,999	0.32	0.71
16	0	114,909	114,909	0.46	1.17
17	0	274,751	274,751	1.10	2.26
18	0	438,015	438,015	1.75	4.01
19	0	683,778	683,778	2.73	6.74
20	0	775,652	775,652	3.09	9.83
21	0	1,108,637	1,108,637	4.42	14.26
22	0	1,294,849	1,294,849	5.17	19.42
23	0	1,464,522	1,464,522	5.84	25.26
24	0	1,224,637	1,224,637	4.89	30.15
25	0	1,189,705	1,189,705	4.75	34.90
26	0	964,678	964,678	3.85	38.74
27	0	781,622	781,622	3.12	41.86
28	85,206	576,392	661,598	2.64	44.50
29	274,694	849,578	1,124,272	4.49	48.99
30	367,231	1,039,572	1,406,803	5.61	54.60
31	312,751	556,069	868,820	3.47	58.07
32	254,955	606,939	861,895	3.44	61.50
33	265,770	309,001	574,771	2.29	63.80
34	275,512	594,657	870,169	3.47	67.27
35	200,462	691,236	891,697	3.56	70.83
36	327,366	462,331	789,697	3.15	73.98
37	434,594	487,919	922,513	3.68	77.66
38	428,187	528,663	956,850	3.82	81.47
39	532,557	385,739	918,296	3.66	85.14
40	474,860	803,395	1,278,255	5.10	90.24
41	215,405	89,673	305,078	1.22	91.45
42	260,605	443,996	704,601	2.81	94.27
43	186,519	334,375	520,894	2.08	96.34
44	299,872	57,860	357,732	1.43	97.77
45	106,970	56,832	163,801	0.65	98.42
46	76,202	0	76,202	0.30	98.73
47	81,310	0	81,310	0.32	99.05
48	0	0	0	0.00	99.05
49	0	182,276	182,276	0.73	99.78
50	0	0	0	0.00	99.78
51	0	0	0	0.00	99.78
52	55,154	0	55,154	0.22	100.00
53	0	0	0	0.00	100.00
54	0	0	0	0.00	100.00
55	0	0	0	0.00	100.00
56	0	0	0	0.00	100.00
Total	5,516,183	19,549,706	25,065,889		
Avg. Weight	16.1	5.4	6.3		

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

```
Anova Table (Type III tests)

Response: TOT_FISH
          LR Chisq Df Pr(>Chisq)
YEAR       1516.81 21  < 2.2e-16 ***
AREA_X      191.42  2  < 2.2e-16 ***
MODE_FX    1914.06  1  < 2.2e-16 ***
WAVE        291.33  2  < 2.2e-16 ***
CNTY        452.91  7  < 2.2e-16 ***
FFDAYS12C   905.82 12  < 2.2e-16 ***
HOURS      2486.91 11  < 2.2e-16 ***

Coefficients:
              Estimate Std. Error z value Pr(>|z|)
(Intercept)  -3.869235   0.286453 -13.507  < 2e-16 ***
YEAR1988     -0.041760   0.306041  -0.136 0.891464
YEAR1989      0.123969   0.303974   0.408 0.683401
YEAR1990     -0.121561   0.293913  -0.414 0.679171
YEAR1991     -0.244495   0.292211  -0.837 0.402757
YEAR1992     -0.047301   0.287038  -0.165 0.869110
YEAR1993      0.277133   0.286267   0.968 0.332997
YEAR1994      0.751895   0.284471   2.643 0.008214 **
YEAR1995      1.013007   0.283865   3.569 0.000359 ***
YEAR1996      1.039410   0.284265   3.656 0.000256 ***
YEAR1997      1.059748   0.283652   3.736 0.000187 ***
YEAR1998      1.518305   0.283582   5.354 8.60e-08 ***
YEAR1999      1.270487   0.283645   4.479 7.49e-06 ***
YEAR2000      1.188795   0.284115   4.184 2.86e-05 ***
YEAR2001      0.965561   0.283692   3.404 0.000665 ***
YEAR2002      1.039382   0.284475   3.654 0.000259 ***
YEAR2003      0.930385   0.284379   3.272 0.001069 **
YEAR2004      0.981515   0.286088   3.431 0.000602 ***
YEAR2005      1.063760   0.286806   3.709 0.000208 ***
YEAR2006      1.375350   0.285355   4.820 1.44e-06 ***
YEAR2007      0.999107   0.286764   3.484 0.000494 ***
YEAR2008      0.875815   0.287594   3.045 0.002324 **
AREA_X2      -0.026172   0.036958  -0.708 0.478847
AREA_X5       0.314625   0.024633  12.773  < 2e-16 ***
MODE_FX7      1.133822   0.026745  42.394  < 2e-16 ***
WAVE4        -0.347067   0.025529 -13.595  < 2e-16 ***
WAVE5        -0.474643   0.030092 -15.773  < 2e-16 ***
CNTY5        -0.247993   0.051293  -4.835 1.33e-06 ***
CNTY7        -0.068152   0.067287  -1.013 0.311129
CNTY9         0.444553   0.027122  16.391  < 2e-16 ***
CNTY19       -0.590950   0.115507  -5.116 3.12e-07 ***
CNTY21        0.194224   0.056214   3.455 0.000550 ***
CNTY23       -0.008538   0.034418  -0.248 0.804087
CNTY25        0.166954   0.078589   2.124 0.033638 *
FFDAYS12C10   0.147868   0.033086   4.469 7.85e-06 ***
FFDAYS12C20   0.431314   0.033969  12.697  < 2e-16 ***
FFDAYS12C30   0.513788   0.039709  12.939  < 2e-16 ***
FFDAYS12C40   0.608766   0.049300  12.348  < 2e-16 ***
FFDAYS12C50   0.755726   0.043473  17.384  < 2e-16 ***
FFDAYS12C60   0.707042   0.059580  11.867  < 2e-16 ***
FFDAYS12C70   0.846657   0.075820  11.167  < 2e-16 ***
FFDAYS12C80   0.895260   0.107723   8.311  < 2e-16 ***
FFDAYS12C90   0.659625   0.115749   5.699 1.21e-08 ***
```

Appendix 4A cont'd.

```
FFDAYS12C100  0.921518   0.047410  19.437  < 2e-16 ***
FFDAYS12C150  0.959674   0.081174  11.822  < 2e-16 ***
FFDAYS12C200  0.882000   0.093120   9.472  < 2e-16 ***
HOURS2        0.686455   0.053272  12.886  < 2e-16 ***
HOURS3        1.091838   0.051181  21.333  < 2e-16 ***
HOURS4        1.381999   0.050956  27.121  < 2e-16 ***
HOURS5        1.568546   0.052756  29.732  < 2e-16 ***
HOURS6        1.804897   0.054754  32.964  < 2e-16 ***
HOURS7        2.029354   0.065844  30.821  < 2e-16 ***
HOURS8        1.908383   0.068822  27.729  < 2e-16 ***
HOURS9        2.297350   0.109138  21.050  < 2e-16 ***
HOURS10       2.329639   0.123911  18.801  < 2e-16 ***
HOURS11       1.665410   0.237732   7.005 2.46e-12 ***
HOURS12       2.311979   0.145767  15.861  < 2e-16 ***
```

Year	Lsmeans
1987	0.220
1988	0.213
1989	0.242
1990	0.200
1991	0.181
1992	0.212
1993	0.272
1994	0.375
1995	0.438
1996	0.444
1997	0.449
1998	0.563
1999	0.502
2000	0.481
2001	0.426
2002	0.444
2003	0.417
2004	0.430
2005	0.450
2006	0.528
2007	0.434
2008	0.404

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

```
Anova Table (Type III tests)

Response: TOT_FISH
               SS    Df       F    Pr(>F)
YEAR        423.3    21  14.842 < 2.2e-16 ***
AREA_X       30.7     2  11.319 1.223e-05 ***
MODE_FX     499.1     1 367.448 < 2.2e-16 ***
WAVE        301.5     2 111.002 < 2.2e-16 ***
CNTY        168.7     7  17.741 < 2.2e-16 ***
FFDAYS12C   687.0    12  42.152 < 2.2e-16 ***
HOURS      1316.3    11  88.109 < 2.2e-16 ***
Residuals 24570.5 18091
Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept)   0.225165   0.287733   0.783  0.43390
YEAR1988     -0.145738   0.308834  -0.472  0.63701
YEAR1989     -0.175514   0.305291  -0.575  0.56536
YEAR1990     -0.216706   0.296178  -0.732  0.46438
YEAR1991     -0.103890   0.294909  -0.352  0.72463
YEAR1992      0.060020   0.289053   0.208  0.83551
YEAR1993     -0.034784   0.288362  -0.121  0.90399
YEAR1994      0.011229   0.286101   0.039  0.96869
YEAR1995      0.249117   0.285498   0.873  0.38291
YEAR1996      0.259725   0.285781   0.909  0.36345
YEAR1997      0.318047   0.285309   1.115  0.26497
YEAR1998      0.413909   0.284921   1.453  0.14632
YEAR1999      0.341430   0.285156   1.197  0.23119
YEAR2000      0.397542   0.285527   1.392  0.16385
YEAR2001      0.131668   0.285414   0.461  0.64457
YEAR2002      0.145297   0.285789   0.508  0.61117
YEAR2003      0.203977   0.285921   0.713  0.47560
YEAR2004      0.281371   0.286997   0.980  0.32690
YEAR2005      0.288358   0.287645   1.002  0.31613
YEAR2006      0.551570   0.286178   1.927  0.05395 .
YEAR2007      0.282200   0.287493   0.982  0.32631
YEAR2008      0.135187   0.288412   0.469  0.63927
AREA_X2      -0.020873   0.030335  -0.688  0.49140
AREA_X5       0.085829   0.020624   4.162 3.18e-05 ***
MODE_FX7      0.488407   0.024338  20.068  < 2e-16 ***
WAVE4        -0.302240   0.020309 -14.882  < 2e-16 ***
WAVE5        -0.170526   0.025372  -6.721 1.86e-11 ***
CNTY5        -0.134241   0.042913  -3.128  0.00176 **
CNTY7        -0.385336   0.063375  -6.080 1.22e-09 ***
CNTY9         0.107838   0.022530   4.786 1.71e-06 ***
CNTY19       -0.339928   0.117220  -2.900  0.00374 **
CNTY21        0.020531   0.044746   0.459  0.64635
CNTY23       -0.003937   0.029367  -0.134  0.89335
CNTY25       -0.348755   0.065320  -5.339 9.45e-08 ***
FFDAYS12C10   0.059496   0.028444   2.092  0.03648 *
FFDAYS12C20   0.170960   0.028270   6.047 1.50e-09 ***
FFDAYS12C30   0.174266   0.032548   5.354 8.70e-08 ***
FFDAYS12C40   0.325859   0.039207   8.311  < 2e-16 ***
FFDAYS12C50   0.373726   0.034189  10.931  < 2e-16 ***
FFDAYS12C60   0.411822   0.047286   8.709  < 2e-16 ***
FFDAYS12C70   0.437291   0.057834   7.561 4.19e-14 ***
FFDAYS12C80   0.501064   0.080678   6.211 5.39e-10 ***
FFDAYS12C90   0.480934   0.093324   5.153 2.58e-07 ***
```

Appendix Table 4B cont'd.

FFDAYS12C100	0.555006	0.036703	15.122	< 2e-16	***
FFDAYS12C150	0.595471	0.062923	9.463	< 2e-16	***
FFDAYS12C200	0.748742	0.073720	10.157	< 2e-16	***
HOURS2	0.151917	0.054765	2.774	0.00554	**
HOURS3	0.396427	0.052108	7.608	2.92e-14	***
HOURS4	0.543269	0.051448	10.560	< 2e-16	***
HOURS5	0.727219	0.052128	13.951	< 2e-16	***
HOURS6	0.781708	0.052769	14.814	< 2e-16	***
HOURS7	1.022865	0.057650	17.743	< 2e-16	***
HOURS8	1.014582	0.060260	16.837	< 2e-16	***
HOURS9	0.998023	0.079811	12.505	< 2e-16	***
HOURS10	1.172401	0.089764	13.061	< 2e-16	***
HOURS11	1.395261	0.182463	7.647	2.16e-14	***
HOURS12	1.129732	0.107185	10.540	< 2e-16	***

Year	Lsmeans
1987	3.85
1988	3.33
1989	3.23
1990	3.10
1991	3.47
1992	4.09
1993	3.72
1994	3.89
1995	4.94
1996	4.99
1997	5.29
1998	5.82
1999	5.41
2000	5.73
2001	4.39
2002	4.45
2003	4.72
2004	5.10
2005	5.13
2006	6.68
2007	5.10
2008	4.40