Technical Report

Massachusetts Division of Marine Fisheries
Technical Report TR-53

Massachusetts Striped Bass Monitoring Report for 2011

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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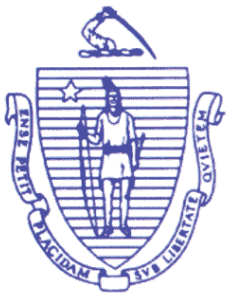

Massachusetts Striped Bass Monitoring Report for 2011

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30 Emerson Ave.
Gloucester, MA 01930

August 2012

Commonwealth of Massachusetts
Deval Patrick, Governor
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Richard K. Sullivan, Jr., Secretary
Department of Fish and Game
Mary B. Griffin, Commissioner
Massachusetts Division of Marine Fisheries
Paul Diodati, Director

Summary: During 2011, the Massachusetts commercial fishery for striped bass sold about 58,648 fish weighing 1,163,865 pounds and kept approximately 4,662 fish for personal consumption. Total losses due to commercial harvesting (including release mortality) were 69,079 fish weighing 1,292,845 pounds. The recreational fishery harvested about 255,507 striped bass weighing over 3.5 million pounds. Total losses due to recreational fishing (including release mortality) were 333,362 fish weighing over 4 million pounds. Combined losses (including scientific losses) were 402,441 fish weighing over 5.3 million pounds, which reflects a 27% decrease in numbers lost and a 17% decrease in weight lost compared to 2010 (548,664 fish; 6.3 million pounds). The majority of losses, 83% by number and 76% by weight, was attributed to the recreational fishery.

Introduction

This report summarizes the commercial and recreational striped bass fisheries conducted in Massachusetts during 2011. 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 2011

Season: July 12-August 10. No landings were permitted on Monday, Friday, or Saturday.

Sold: 1,163,865 pounds (against a harvest quota of 1,061,898 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. DMF personnel review dealer transactions and correct entries before calculating total landings.

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 monthly trip level reports which

Table 1. Attributes of the Massachusetts striped bass commercial fishery, 1990-2011.

		Purchased			
Year	Season (Fishing Days)	Pounds 000s	Number 000s	Dealer Permits	Fishing Permits
1990	93	160.6	6.3	95	1,498
1991	59	234.8	10.4	92	1,739
1992	39	239.2	11.3	135	1,861
1993	35	262.6	13.0	152	2,056
1994	24	199.6	10.4	150	2,367
1995	57	782.0	41.2	161	3,353
1996	42	696.8	38.3	179	3,801
1997	42	785.9	44.8	173	5,500
1998	28	822.0	45.3	180	5,540
1999	40	788.2	40.8	167	3,578
2000	36	779.7	40.2	137	3,283
2001	29	815.0	40.2	164	4,219
2002	21	924.9	44.9	132	4,598
2003	21	1055.4	55.7	151	4,867
2004	19	1206.3	60.6	130	4,376
2005	22	1104.7	59.5	162	4,159
2006	26	1312.1	69.9	136	3,980
2007	22	1040.3	54.3	160	3,906
2008	34	1160.1	61.1	167	3,821
2009	27	1138.3	59.3	178	4,020
2010	24	1224.4	60.3	178	3,951
2011	18	1163.8	58.6	189	3,965

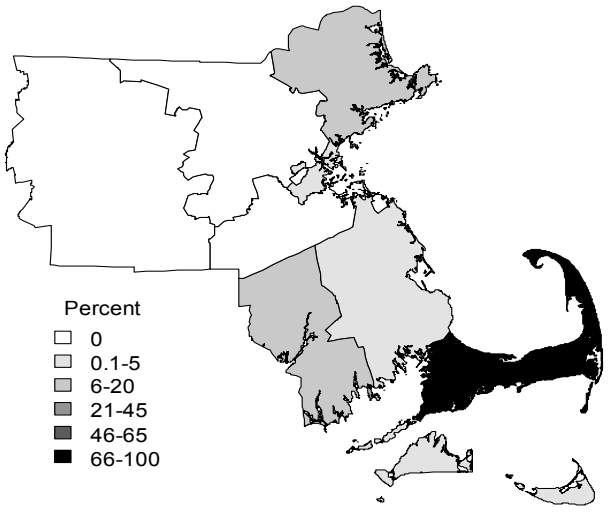

Figure 1. Percentage of total pounds of striped bass purchased by fish dealers in Massachusetts counties in 2011.

include the name of the dealer(s) that they sell to and information describing their catch composition and catch rates.

Landings. The landings used here come from the SAFIS system. Commercial dealers bought 1,163,865 pounds (58,648 fish) of striped bass in 2011 (Table 1). Most striped bass were sold in Barnstable, Bristol and Essex counties of Massachusetts (Figure 1). Commercial fishers kept an additional 4,662 fish weighing approximately 73,109 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 2,848 fish sampled from the 2011 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:

$$\log_{10}(W) = -3.463 + 3.007 * \log_{10}(L), \qquad RMS = 0.0027$$

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:

$$W = 10^{(-3.463 + 3.007 * \log_{10}(L) + RMS/2)}$$

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 43% of all fish caught had lengths ≥34 inches.

Age and Sex Composition.. Four hundred and fourteen striped bass sampled from the 2011 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 358 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 16+ years, and 99.7% were females. About 80% of the sub-sample consisted of individuals from the 1999-2003 year classes (ages 8-12) (Table 2). Peak numbers-at-age of the total catches (harvest plus releases plus consumed) were from the 2003 year-class (Figure 2).

Table 2. Age composition of the 2011 commercial (purchased by dealers) landings.

			Weighted		
Age	Year Class	Number	%	Mean Length (in.)	Mean Weight (lbs)
6	2005	-	-	-	-
7	2004	10	6.9	33.6	13.3
8	2003	51	17.3	34.6	14.9
9	2002	56	19.2	35.9	16.6
10	2001	64	19.5	37.8	19.0
11	2000	34	7.1	38.4	21.4
12	1999	44	8.5	40.1	23.5
13	1998	41	7.5	41.5	25.6
14	1997	38	8.2	43.1	29.7
15	1996	15	4.6	43.6	32.2
16+	≥1995	5	1.2	42.0	24.0
Total		358			

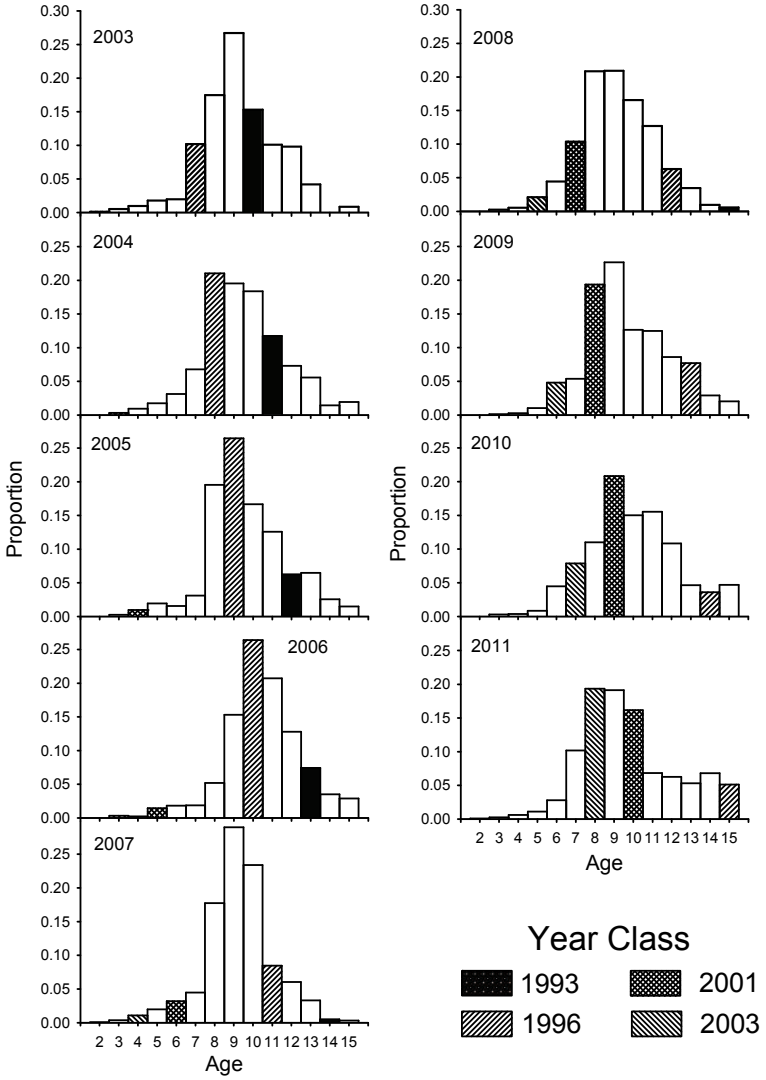

Figure 2. Age composition (proportion) of total catches from the Massachusetts commercial fishery. The large 1993, 1996, 2001 and 2003 Chesapeake Bay year-

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, DMF switched to trip-level reporting. Significant information has been lost due to the generalization of the report to cover all fisheries in Massachusetts. The only information now available is daily total hours fished, pounds of fish sold and consumed, and area fished. This information was used under a generalized linear model (GLM) framework to generate standardized indices (Hilborn and Walter, 1992). Each record represented the summarization of a permit's pounds harvested and hours fished by year, month, and area fished reduced to 4 regions (Cape Cod Canal, Southern MA, Cape Cod Bay, North MA). Only data from July-August were used to constraint analyses to the most recent duration of the fishing season. The harvest rates for each record was calculated by dividing the total pounds caught by the total number of hours fished. The harvest rate was standardized using the GLM model

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

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

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

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

Results of the GLM analyses of harvest rates are shown in Appendix Tables 2. Although factors were significant, the variables accounted for only about 9% 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 (Figure 3A). The dramatic increase in harvest rates for 2011 is attributed to large increases in harvest rates by fishers in Cape Cod Bay and Southern Massachusetts (Figure 3B). The reason for the increase was due to atypical, large concentrations of striped bass off Cape Cod, particularly Chatham, in 2011 for unknown reasons which likely increased the vulnerability of striped bass to capture. In addition, the large 2003 year-class became nearly fully-recruited to the Massachusetts fishery (Figure 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 5,769 fish weighing approximately 55,870 pounds.

Recreational Fishery in 2011

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 MRIP. In 2011, new estimation methods were applied to data collected since 2003, but only small changes (range: -9.1 to 10.1%) were observed for Massachusetts data.

The MRIP estimates of total catch (including fish released alive) in 2011 was 1,228,699 striped bass, which is a 38% decline compared to the 2010 estimate (Table 3). The estimate of total harvest in 2011 was 255,507 fish, which is a decrease in harvest of 25% compared to 2010. Total pounds harvested was over 3.5 million in 2011 (Table 3).

The MRIP estimates were post-stratified by county to determine where harvested bass were being landed by recreational anglers. Most landings (90%) occurred in Barnstable, Plymouth, Essex, and Bristol counties (Figure 4). Only 10% 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 MRIP

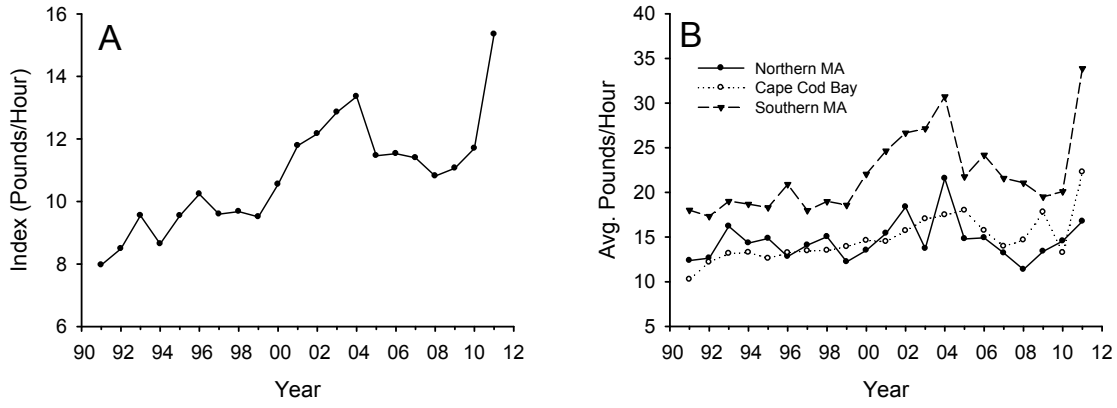

Figure 3. A) Harvest index (standardized pounds/hour) and B) average harvest rates by area for the Massachusetts commercial striped bass fishery, 1990-2011.

Table 3. MRIP 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	407,100	4,889,035	4,361,710	4,768,810
2004	445,745	6,112,746	4,979,075	5,424,820
2005	340,742	5,097,821	3,988,679	4,329,421
2006	314,988	4,832,355	7,809,777	8,124,765
2007	315,409	5,136,580	5,331,470	5,646,879
2008	377,959	5,763,763	3,649,415	4,027,374
2009	344,401	4,786,895	2,282,601	2,627,002
2010	341,046	4,270,401	1,671,437	2,012,483
2011	255,507	3,504,522	973,192	1,228,699

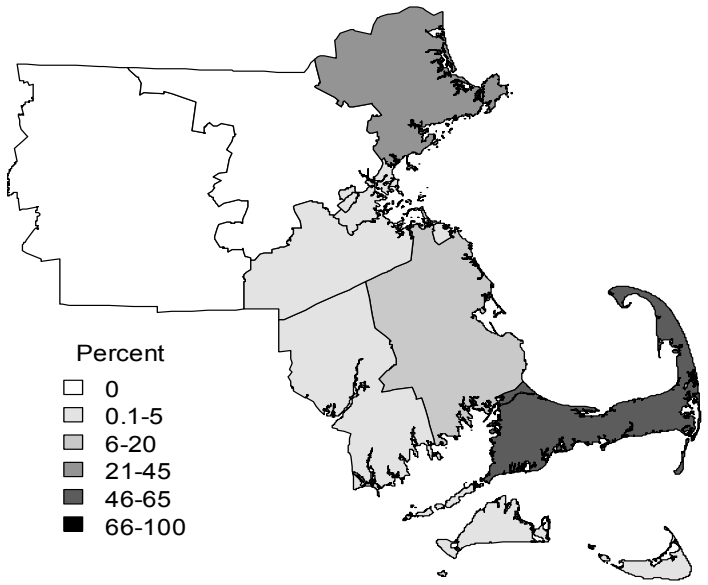

Figure 4. Percentage of total numbers of striped bass harvested by recreational anglers in each county of Massachusetts during 2011.

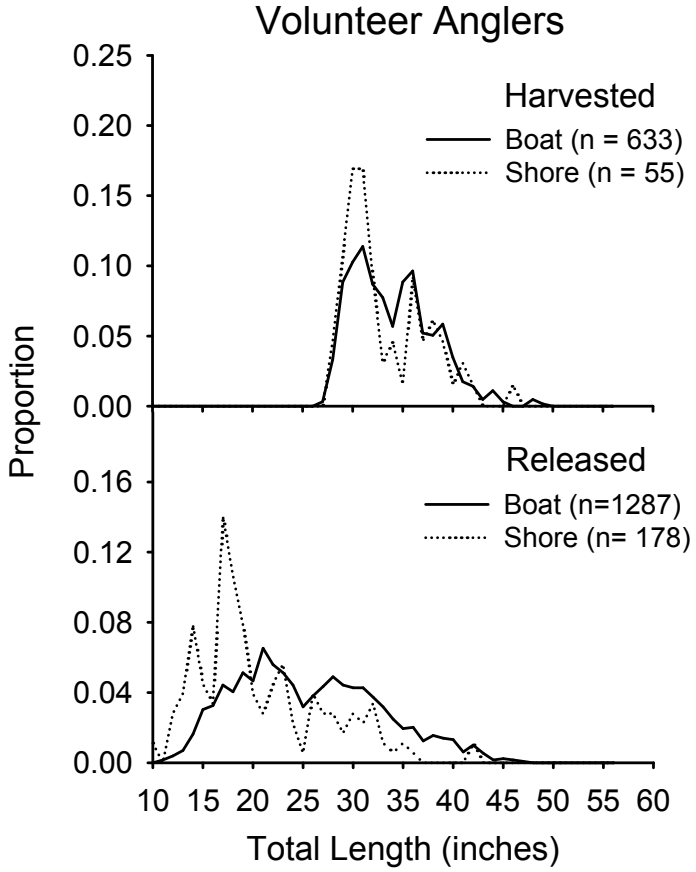

Figure 5. Sizes of striped bass caught by volunteer recreational anglers in 2011 by disposition and fishing mode.

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 2,160 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 MRIP 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 567 fish from the volunteer angler survey was aged and combined with commercial and tagging samples to produce an age-length key used to convert the MRIP and MA volunteer angler size distributions into age classes. Recreational samples were selected using a weighted random design based on the total number of striped bass caught in each wave and mode stratum (as determined by MRIP). Recreational catches of striped bass were comprised mostly of the 2003 and 2004 year-classes. (Figure 6).

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

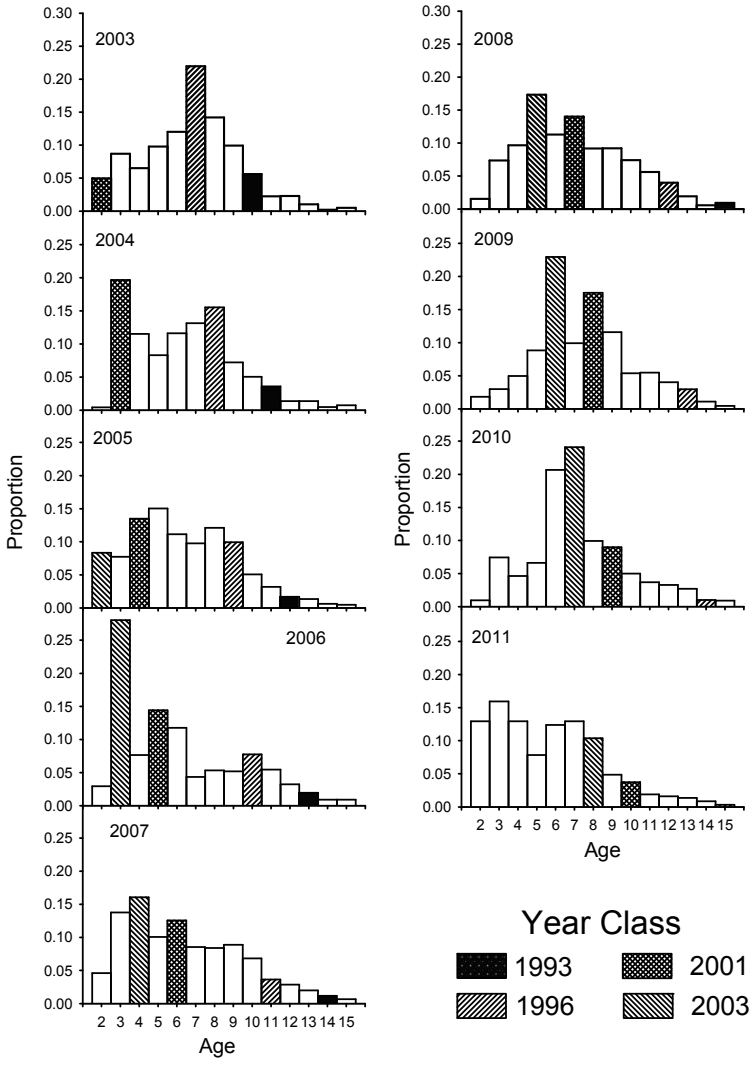

Figure 6. Age composition (proportion) of total catches from the Massachusetts recreational fishery. The large 1993, 1996, 2001 and 2003 Chesapeake Bay year

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 least-squares mean estimates from the

Table 4. Estimates of striped bass losses occurring in Massachusetts waters during 2011.

FISHERY	NUMBER	POUNDS	MEAN WT.
Commercial			
Harvest*	63,310	1,236,975	19.5
Release Mortality	5,769	55,870	9.7
Recreational			
Harvest	255,507	3,504,522	13.7
Release Mortality	77,855	511,875	6.6
Total	402,441	5,309,241	

* includes fish taken for personal consumption

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. 7). In 2006, catch rates jumped dramatically as the large 2003 year-class became vulnerable to the fishery. Since 2006, catch rates have declined (Fig. 7).

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 77,855 fish (511,875 pounds) (Table 4).

Bycatch 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*). 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. DMF personnel sampled this fishery at sea during 1995-

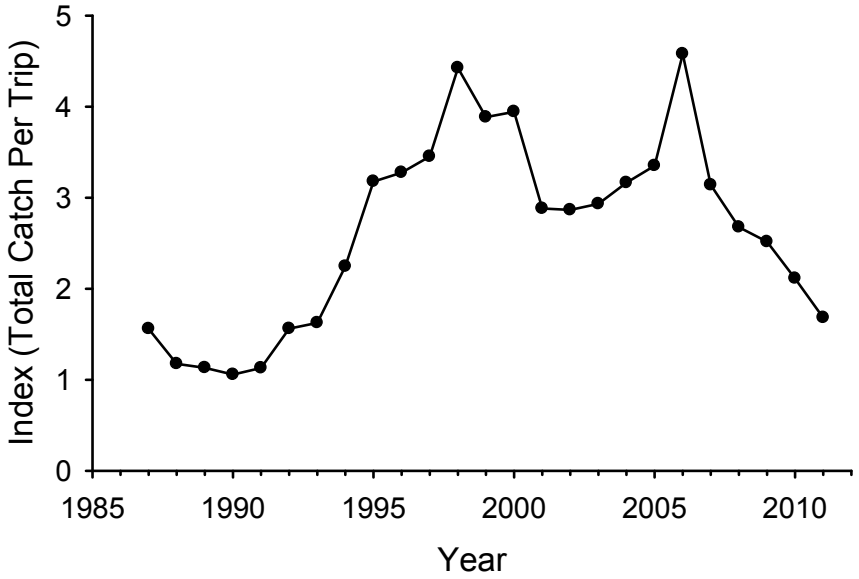

Figure 7. Index of standardized total catch rates (total number of fish caught per trip) of the recreational fishery for striped bass in Massachusetts waters, 1987-2011.

Table 5. Massachusetts striped bass removals-at-age matrix of 2011 by source.

	Recreational		Commercial		
Age	Release Mortality	Harvest	Release Mortality	Harvest*	Total
2	12,723	0	71	0	12,794
3	15,657	0	176	0	15,832
4	12,508	2,561	393	35	15,497
5	6,547	14,523	652	132	21,854
6	8,590	44,610	1,398	562	55,160
7	8,481	53,023	1,712	4933	68,149
8	5,978	52,623	1,104	11321	71,026
9	2,395	29,985	193	11953	44,526
10	1,721	24,297	47	11888	37,954
11	931	11,667	18	4367	16,983
12	872	8,779	2	5148	14,802
13	761	7,336	1	4550	12,648
14	526	4,153	0	4927	9,605
15	104	1,450	0	2752	4,306
16+	63	500	0	741	1,305

* includes fish taken for personal consumption

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 2011.

Estimated Total Losses in 2011

Total estimated loss of striped bass during 2011 was 402,441 fish weighing 5,309,241 pounds (Table 4), which is a 27% decrease in numbers lost and a 17% decrease in weight compared to 2010 (548,664 fish; 6,377,464 pounds). The majority of losses, 83% by number and 76% by weight, was attributed to combined losses in the recreational fishery.

Removals-At-Age Matrix in 2011

The removals (numbers) due to release mortality and harvest by the recreational and commercial fisheries are apportioned by age and mortality source in Table 5. The 2003 (age 8), 2004 (age 7) and 2005 (age 6) year-classes incurred the highest losses in 2011 (Figure 8).

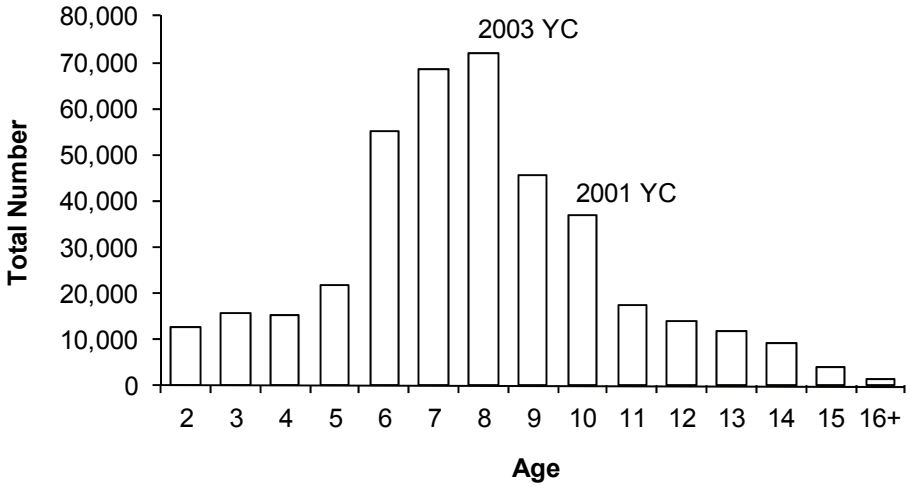

Figure 8. Total number of striped bass removals in 2011 by age. The 2003 and 2001 year-classes are indicated.

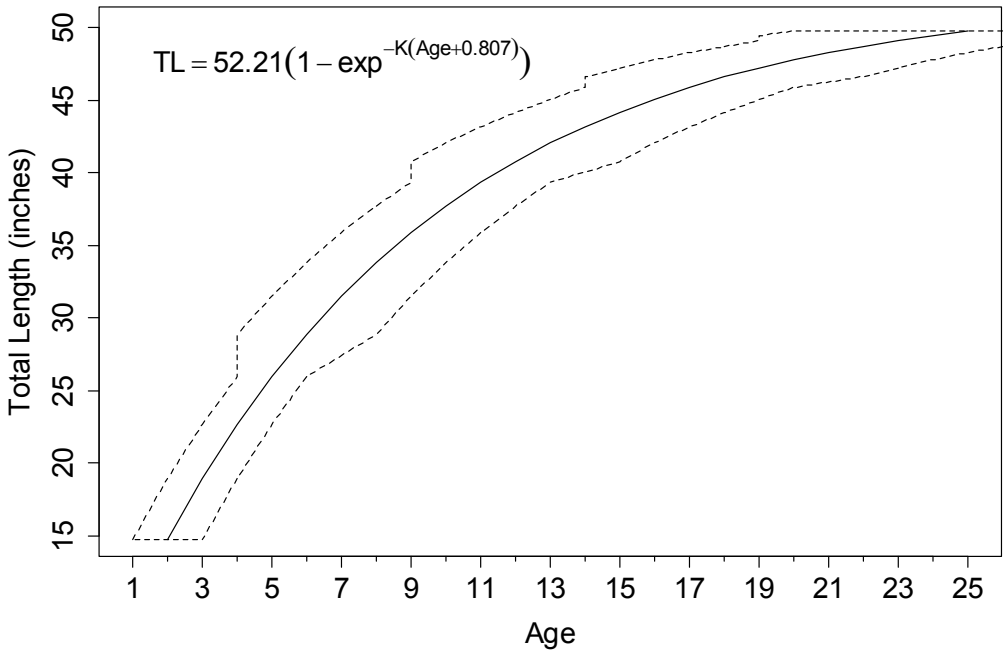

Figure 9. Mean length-age relationship (solid line) for striped bass captured in Massachusetts. Dotted lines represent the minimum and maximum ages found at a given length.

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 2004-2011. The resulting equation and predicted relationship are shown in Figure 9.

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

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

			Number	Ave.	Ave.	SD	SD	Length Range			
Year	Trips	Boats	Tagged	Length (mm)	Length (in)	(mm)	(in)	Min (mm)	Min (in)	Max (mm)	Max (in)
1991	17	4	388	817	32.2	106.4	4.2	534	21.0	1300	51.2
1992	29	3	899	798	31.4	125.9	5.0	524	20.6	1267	49.9
1993	15	2	678	784	30.9	125.0	4.9	515	20.3	1210	47.6
1994	13	2	377	735	28.9	93.2	3.7	548	21.6	1028	40.5
1995	11	2	449	767	30.2	110.2	4.3	470	18.5	1178	46.4
1996	8	2	203	748	29.4	64.1	2.5	541	21.3	1077	42.4
1997	10	2	321	773	30.4	114.7	4.5	485	19.1	1090	42.9
1998	12	2	382	797	31.4	93.8	3.7	597	23.5	1055	41.5
1999	16	2	471	777	30.6	95.5	3.8	594	23.4	1108	43.6
2000	25	4	1095	752	29.6	102.6	4.0	510	20.1	1204	47.4
2001	14	3	456	786	30.9	102.5	4.0	503	19.8	1110	43.7
2002	12	3	239	764	30.1	103.6	4.1	487	19.2	1060	41.7
2003	15	3	655	825	32.5	92.1	3.6	602	23.7	1204	47.4
2004	25	7	784	707	27.8	193.1	7.6	316	12.4	1164	45.8
2005	19	4	752	726	28.6	210.5	8.3	299	11.8	1114	43.9
2006	11	4	390	813	32.0	94.2	3.7	565	22.2	1114	43.9
2007	16	3	530	848	33.4	105.2	4.1	600	23.6	1225	48.2
2008	13	2	456	821	32.3	104.6	4.1	530	20.9	1202	47.3
2009	15	3	501	840	33.1	101.8	4.0	572	22.5	1146	45.1
2010	13	3	329	825	32.5	84.0	3.3	668	26.3	1095	43.1
2011	15	3	504	831	32.7	91.9	3.6	580	22.8	1174	46.2

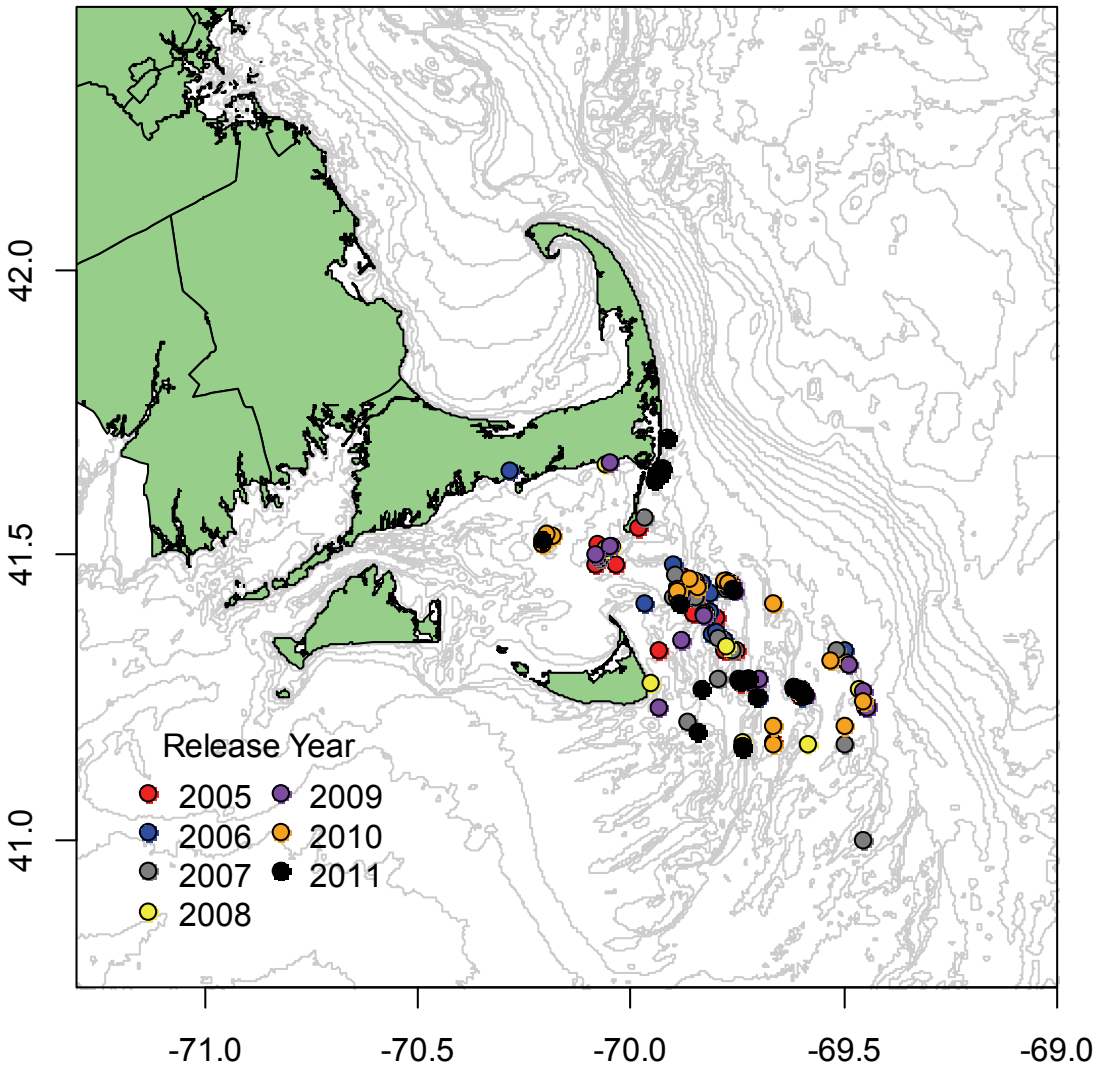

Figure 10. Map of DMF fall tagging locations during 2005-2011.

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 (Figure 10). 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. Striped bass released in 2005-2010 were recaptured from mainly coastal waters in North Carolina through New Hampshire (Figure 11).

Planned Management Programs in 2011

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 1,057,783 pounds due to overharvest in 2011. 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.

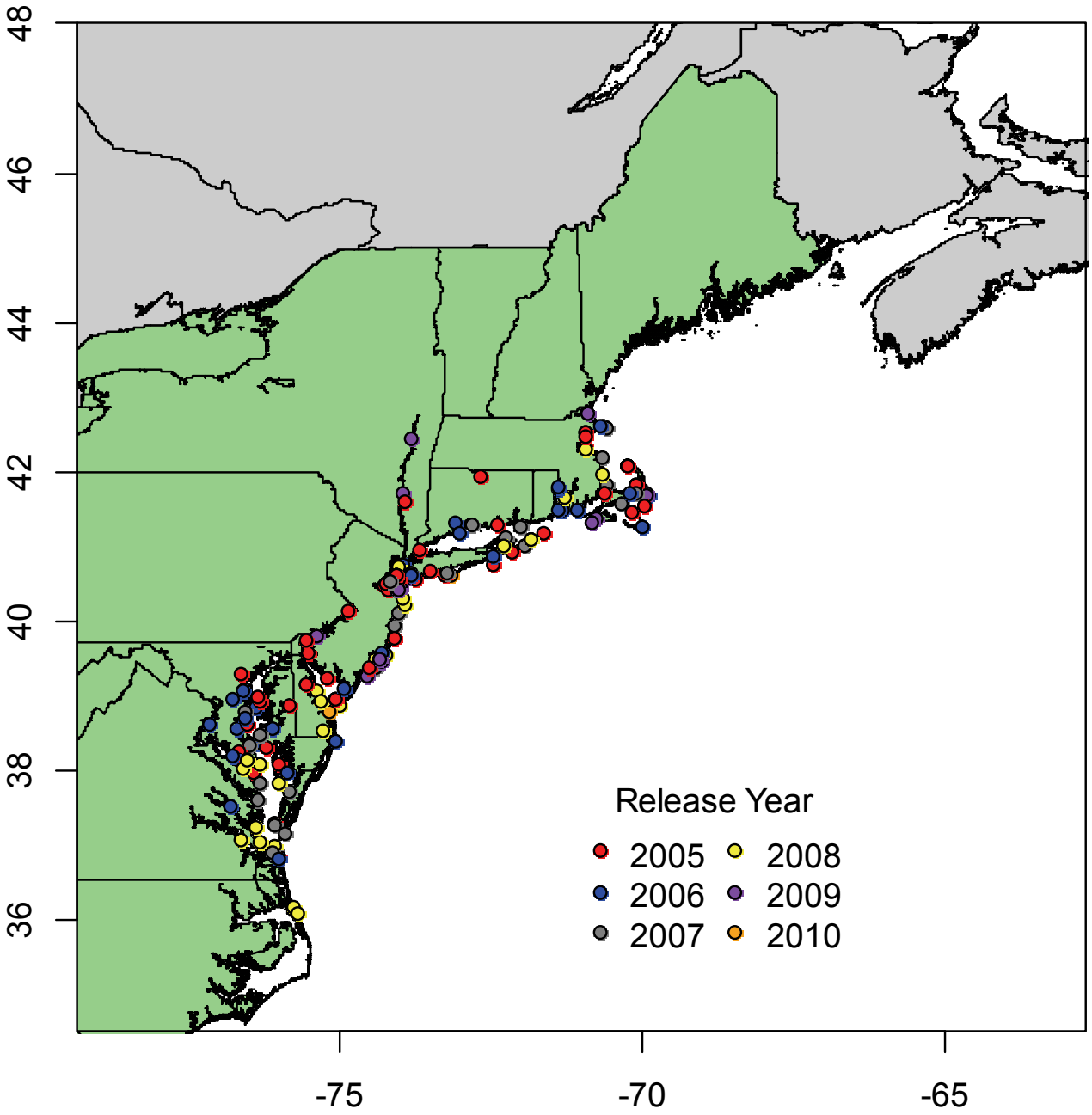

Figure 11. Map of recovery locations of DMF tagged striped bass by release year, 2005-2010.

Monitoring Programs

All monitoring programs will continue in 2012.

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. Jennifer Stritzel-Thomson coordinated the volunteer recreational angler data collection program, entered scale envelope data, and prepared data for analysis. John Boardman aged all scale samples. John Boardman, Nick Buchan, and Brad Schondelmeier conducted the commercial sampling of stripers. Paul Caruso and John Boardman also coordinated and conducted the USFWS cooperative tagging study. Funding for this effort was provided by the Massachusetts Division of Marine Fisheries and Sportfish Restoration Funds Grants F-57-R and F-48-R.

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Tables Appendix

Appendix Table 1A. Estimated size distribution of the Massachusetts commercial striped bass catch (numbers of fish) in 2011.

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	157	157	0.12	0.12
15	0	52	52	0.04	0.15
16	0	418	418	0.31	0.46
17	0	627	627	0.46	0.93
18	0	313	313	0.23	1.16
19	0	522	522	0.39	1.54
20	0	888	888	0.66	2.20
21	0	313	313	0.23	2.43
22	0	835	835	0.62	3.05
23	0	418	418	0.31	3.35
24	0	3,185	3,185	2.35	5.71
25	0	1,671	1,671	1.23	6.94
26	0	2,820	2,820	2.08	9.02
27	0	4,125	4,125	3.05	12.07
28	162	7,467	7,629	5.63	17.70
29	296	5,274	5,570	4.11	21.82
30	350	9,451	9,801	7.24	29.05
31	323	8,981	9,305	6.87	35.92
32	2,693	14,464	17,157	12.67	48.59
33	4,466	7,728	12,194	9.00	57.60
34	10,793	1,462	12,255	9.05	66.65
35	5,396	52	5,449	4.02	70.67
36	4,415	835	5,251	3.88	74.55
37	6,536	0	6,536	4.83	79.37
38	5,305	52	5,357	3.96	83.33
39	5,681	0	5,681	4.19	87.53
40	3,911	0	3,911	2.89	90.41
41	2,695	0	2,695	1.99	92.40
42	3,594	0	3,594	2.65	95.06
43	2,689	0	2,689	1.99	97.04
44	1,834	0	1,834	1.35	98.40
45	1,692	0	1,692	1.25	99.65
46	176	0	176	0.13	99.78
47	68	0	68	0.05	99.83
48	167	0	167	0.12	99.95
49	34	0	34	0.03	99.97
50	34	0	34	0.03	100.00
51	0	0	0	0.00	100.00
52	0	0	0	0.00	100.00
Total	63,310	72,110	135,420		
Avg. Size	37.3	29.4	33.1		

* includes fish taken for personal consumption

Appendix Table 1B. Estimated weight distribution by size of the Massachusetts commercial striped bass catch (pounds) in 2011.

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	156	156	0.01	0.01
15	0	64	64	0.00	0.01
16	0	623	623	0.03	0.04
17	0	1,121	1121	0.06	0.10
18	0	666	666	0.03	0.14
19	0	1,306	1306	0.07	0.20
20	0	2,590	2590	0.13	0.34
21	0	1,058	1058	0.05	0.39
22	0	3,246	3246	0.17	0.56
23	0	1,855	1855	0.10	0.66
24	0	16,078	16078	0.83	1.49
25	0	9,536	9536	0.49	1.98
26	0	18,106	18106	0.94	2.92
27	0	29,672	29672	1.53	4.45
28	1,297	59,916	61213	3.17	7.62
29	2,643	47,028	49671	2.57	10.19
30	3,459	93,322	96781	5.01	15.19
31	3,524	97,871	101395	5.24	20.44
32	32,287	173,408	205695	10.64	31.08
33	58,737	101,633	160371	8.29	39.37
34	155,280	21,034	176314	9.12	48.49
35	84,706	820	85525	4.42	52.91
36	75,430	14,273	89703	4.64	57.55
37	121,246	0	121246	6.27	63.82
38	106,625	1,050	107675	5.57	69.39
39	123,460	0	123460	6.39	75.78
40	91,720	0	91720	4.74	80.52
41	68,073	0	68073	3.52	84.04
42	97,604	0	97604	5.05	89.09
43	78,378	0	78378	4.05	93.15
44	57,283	0	57283	2.96	96.11
45	56,543	0	56543	2.92	99.03
46	6,284	0	6284	0.33	99.36
47	2,590	0	2590	0.13	99.49
48	6,777	0	6777	0.35	99.84
49	1,468	0	1468	0.08	99.92
50	1,560	0	1560	0.08	100.00
51	0	0	0	0.00	100.00
52	0	0	0	0.00	100.00
Total	1,236,975	696,431	1,933,406		
Avg. Weight	19.5	9.7	14.3		

* includes fish taken for personal consumption

Appendix Table 2. Results of the GLM analyses of total catch rates (pounds/hour) for the commercial striped bass fishery., 1991-2011.

ANOVA Table (Type III)

Response log(pounds/hours)

	SS	Df	F	Pr(>F)	
YEAR	1087	20	52.204	2.20E-16	***
AREA	2078	2	998.337	2.20E-16	***
Residuals	52288	50235			

Coefficients:

	Estimate	SE	t	Pr(>|t|)	
(Intercept)	1.958469	0.026625	73.558	2.00E-16	***
YEAR1992	0.062568	0.035655	1.755	0.0793	.
YEAR1993	0.154454	0.035518	4.349	1.37E-05	***
YEAR1994	0.061921	0.035451	1.747	0.0807	.
YEAR1995	0.175077	0.031698	5.523	3.34E-08	***
YEAR1996	0.248936	0.051607	4.824	1.41E-06	***
YEAR1997	0.171257	0.030665	5.585	2.35E-08	***
YEAR1998	0.209907	0.031258	6.715	1.90E-11	***
YEAR1999	0.135005	0.031936	4.227	2.37E-05	***
YEAR2000	0.248912	0.032469	7.666	1.80E-14	***
YEAR2001	0.393398	0.032534	12.092	2.00E-16	***
YEAR2002	0.433834	0.032024	13.547	2.00E-16	***
YEAR2003	0.49559	0.029566	16.762	2.00E-16	***
YEAR2004	0.537928	0.03569	15.072	2.00E-16	***
YEAR2005	0.368054	0.032322	11.387	2.00E-16	***
YEAR2006	0.381676	0.030556	12.491	2.00E-16	***
YEAR2007	0.355174	0.031031	11.446	2.00E-16	***
YEAR2008	0.246349	0.031003	7.946	1.97E-15	***
YEAR2009	0.330056	0.030753	10.732	2.00E-16	***
YEAR2010	0.356475	0.032942	10.821	2.00E-16	***
YEAR2011	0.627708	0.037048	16.943	2.00E-16	***
AREACCB	0.002608	0.013283	0.196	0.8444	
AREASMA	0.411757	0.01188	34.66	2.00E-16	***

Year	lsmeans
1991	7.964509
1992	8.485613
1993	9.550318
1994	8.6441
1995	9.542914
1996	10.23562
1997	9.595566
1998	9.67646
1999	9.507581
2000	10.54795
2001	11.78396
2002	12.16555
2003	12.85662
2004	13.35618
2005	11.46134
2006	11.53278
2007	11.39734
2008	10.81363
2009	11.06598
2010	11.69685
2011	15.34782

Appendix Table 3A. Estimated size distribution of the Massachusetts recreational striped bass catch (numbers of fish) in 2011.

TL (in.)	Harvested	Released	Total	Percent	Cumulative Percent
9	0	0	0	0.00	0.00
10	0	3,199	3,199	0.26	0.26
11	0	1,479	1,479	0.12	0.38
12	0	11,165	11,165	0.91	1.29
13	0	15,729	15,729	1.28	2.57
14	0	34,740	34,740	2.83	5.40
15	0	33,480	33,480	2.72	8.12
16	0	24,546	24,546	2.00	10.12
17	0	64,770	64,770	5.27	15.39
18	0	53,861	53,861	4.38	19.77
19	0	55,091	55,091	4.48	24.26
20	0	42,241	42,241	3.44	27.70
21	0	53,008	53,008	4.31	32.01
22	0	48,338	48,338	3.93	35.94
23	0	46,833	46,833	3.81	39.76
24	0	34,029	34,029	2.77	42.53
25	0	23,963	23,963	1.95	44.48
26	0	38,680	38,680	3.15	47.62
27	7,682	41,384	49,066	3.99	51.62
28	5,781	47,422	53,204	4.33	55.95
29	30,081	37,730	67,811	5.52	61.47
30	23,756	41,307	65,064	5.30	66.76
31	35,531	38,714	74,245	6.04	72.80
32	24,470	38,059	62,529	5.09	77.89
33	19,098	27,614	46,712	3.80	81.69
34	11,169	18,697	29,866	2.43	84.13
35	12,768	18,169	30,937	2.52	86.64
36	23,206	16,846	40,052	3.26	89.90
37	11,733	8,914	20,647	1.68	91.58
38	18,361	11,407	29,769	2.42	94.01
39	10,009	9,664	19,673	1.60	95.61
40	8,030	9,918	17,948	1.46	97.07
41	4,452	3,728	8,180	0.67	97.73
42	3,457	10,557	14,014	1.14	98.87
43	1,055	3,320	4,375	0.36	99.23
44	2,462	1,280	3,742	0.30	99.54
45	704	1,821	2,524	0.21	99.74
46	291	750	1,041	0.08	99.83
47	0	740	740	0.06	99.89
48	1,055	0	1,055	0.09	99.97
49	352	0	352	0.03	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	255,507	973,192	1,228,699		
Avg. Size	33.5	24.5	26.4		

Appendix Table 3B. Estimated size distribution of the Massachusetts recreational striped bass catch (pounds) in 2011.

TL (in.)	Harvested	Released	Total	Percent	Cumulative Percent
9	0	0	0		
10	0	1,103	1,103	0.01	0.01
11	0	679	679	0.01	0.02
12	0	6,662	6,662	0.07	0.09
13	0	11,939	11,939	0.12	0.21
14	0	32,950	32,950	0.33	0.54
15	0	39,076	39,076	0.39	0.93
16	0	34,786	34,786	0.35	1.28
17	0	110,143	110,143	1.11	2.40
18	0	108,768	108,768	1.10	3.49
19	0	130,893	130,893	1.32	4.82
20	0	117,100	117,100	1.18	6.00
21	0	170,169	170,169	1.72	7.72
22	0	178,476	178,476	1.80	9.52
23	0	197,648	197,648	2.00	11.52
24	0	163,220	163,220	1.65	13.16
25	0	129,948	129,948	1.31	14.48
26	0	236,014	236,014	2.38	16.86
27	52,445	282,860	335,305	3.39	20.25
28	44,031	361,587	405,618	4.10	24.34
29	254,595	319,703	574,298	5.80	30.14
30	222,644	387,575	610,219	6.16	36.30
31	367,497	400,885	768,382	7.76	44.06
32	278,452	433,575	712,027	7.19	51.25
33	238,393	345,084	583,477	5.89	57.14
34	152,516	255,590	408,106	4.12	61.26
35	190,224	271,001	461,225	4.66	65.92
36	376,296	273,478	649,775	6.56	72.48
37	206,592	157,145	363,737	3.67	76.16
38	350,300	217,883	568,183	5.74	81.89
39	206,473	199,579	406,052	4.10	85.99
40	178,749	221,031	399,781	4.04	90.03
41	106,746	89,486	196,231	1.98	92.01
42	89,120	272,437	361,557	3.65	95.66
43	29,197	91,954	121,151	1.22	96.89
44	73,001	37,994	110,996	1.12	98.01
45	22,316	57,813	80,129	0.81	98.82
46	9,877	25,432	35,309	0.36	99.17
47	0	26,769	26,769	0.27	99.44
48	40,643	0	40,643	0.41	99.85
49	14,414	0	14,414	0.15	100.00
50	0	0	0	0.00	100.00
51	0	0	0	0.00	100.00
52	0	0	0	0.00	100.00
53	0	0	0	0.00	100.00
54	0	0	0	0.00	100.00
55	0	0	0	0.00	100.00
56	0	0	0	0.00	100.00
Total	3,504,522	6,398,434	9,902,956		
Avg. Weight	13.7	6.6	8.1		

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

Anova Table (Type III)
Response: TOT_FISH

	Chisq	Df	Pr(>Chisq)	
YEAR	396.9	24	2.20E-16	***
AREA_X	38.87	2	3.62E-09	***
MODE_FX	438.68	2	2.20E-16	***
WAVE	285.46	2	2.20E-16	***
CNTY	122.21	7	2.20E-16	***
FFDAYS12C	583.96	12	2.20E-16	***
HOURS	996.11	11	2.20E-16	***

Coefficients:

	Estimate	SE	t	Pr(>|t|)	
(Intercept)	0.310836	0.23	1.346	0.1784	
YEAR1988	-0.18701	0.26	-0.733	0.4635	
YEAR1989	-0.25296	0.25	-1.017	0.3091	
YEAR1990	-0.24759	0.24	-1.033	0.3016	
YEAR1991	-0.10989	0.24	-0.459	0.6459	
YEAR1992	0.099214	0.23	0.427	0.6695	
YEAR1993	-0.05934	0.23	-0.256	0.7977	
YEAR1994	0.011011	0.23	0.048	0.9617	
YEAR1995	0.234839	0.23	1.029	0.3037	
YEAR1996	0.248867	0.23	1.089	0.2763	
YEAR1997	0.308673	0.23	1.353	0.1760	
YEAR1998	0.396061	0.23	1.74	0.0819	.
YEAR1999	0.341672	0.23	1.499	0.1339	
YEAR2000	0.38405	0.23	1.682	0.0926	.
YEAR2001	0.144812	0.23	0.635	0.5256	
YEAR2002	0.121912	0.23	0.533	0.5939	
YEAR2003	0.188598	0.23	0.825	0.4094	
YEAR2004	0.235133	0.23	1.026	0.3050	
YEAR2005	0.249698	0.23	1.088	0.2765	
YEAR2006	0.47737	0.23	2.088	0.0368	*
YEAR2007	0.212656	0.23	0.928	0.3534	
YEAR2008	0.119693	0.23	0.519	0.6035	
YEAR2009	0.076974	0.23	0.335	0.7379	
YEAR2010	0.014504	0.23	0.063	0.9500	
YEAR2011	-0.14819	0.23	-0.638	0.5233	
AREA_X2	-0.04989	0.03	-1.918	0.0552	.
AREA_X5	0.088647	0.02	4.76	1.95E-06	***
MODE_FX6	0.356715	0.04	10.174	2.00E-16	***
MODE_FX7	0.504551	0.02	21.833	2.00E-16	***
WAVE4	-0.30408	0.02	-16.868	2.00E-16	***
WAVE5	-0.1809	0.02	-8.085	6.55E-16	***
CNTY5	-0.14173	0.04	-3.625	0.00029	***
CNTY7	-0.2966	0.05	-6.045	1.52E-09	***
CNTY9	0.100331	0.02	4.842	1.30E-06	***
CNTY19	-0.10528	0.07	-1.478	0.13935	
CNTY21	-0.00019	0.04	-0.004	0.99644	
CNTY23	-0.02383	0.03	-0.885	0.37604	
CNTY25	-0.33941	0.06	-5.382	7.46E-08	***

Appendix 4A cont'd.

Coefficients:

	Estimate	SE	t	Pr(>|t|)	
FFDAYS12C10	0.057562	0.03	2.249	0.02449	*
FFDAYS12C20	0.178966	0.03	6.913	4.86E-12	***
FFDAYS12C30	0.178405	0.03	5.951	2.71E-09	***
FFDAYS12C40	0.325176	0.04	8.88	2.00E-16	***
FFDAYS12C50	0.368813	0.03	11.523	2.00E-16	***
FFDAYS12C60	0.416569	0.04	9.502	2.00E-16	***
FFDAYS12C70	0.43873	0.05	8.058	8.17E-16	***
FFDAYS12C80	0.479514	0.08	6.356	2.11E-10	***
FFDAYS12C90	0.537219	0.09	6.183	6.39E-10	***
FFDAYS12C10(	0.557673	0.03	16.269	2.00E-16	***
FFDAYS12C15(	0.61556	0.06	10.398	2.00E-16	***
FFDAYS12C20(	0.716863	0.07	10.326	2.00E-16	***
HOURS2	0.10434	0.05	2.13	0.03315	*
HOURS3	0.332073	0.05	7.163	8.12E-13	***
HOURS4	0.471311	0.05	10.321	2.00E-16	***
HOURS5	0.627422	0.05	13.455	2.00E-16	***
HOURS6	0.684968	0.05	14.535	2.00E-16	***
HOURS7	0.898316	0.05	17.456	2.00E-16	***
HOURS8	0.899721	0.05	16.566	2.00E-16	***
HOURS9	0.921528	0.07	12.514	2.00E-16	***
HOURS10	1.064556	0.08	12.695	2.00E-16	***
HOURS11	1.274576	0.17	7.359	1.92E-13	***
HOURS12	1.047941	0.1	10.381	2.00E-16	***

Year	lsmeans
1987	4.124
1988	3.421
1989	3.203
1990	3.220
1991	3.695
1992	4.555
1993	3.887
1994	4.170
1995	5.216
1996	5.290
1997	5.616
1998	6.129
1999	5.804
2000	6.056
2001	4.767
2002	4.659
2003	4.981
2004	5.218
2005	5.294
2006	6.648
2007	5.102
2008	4.649
2009	4.454
2010	4.185
2011	3.556

Appendix Table 4B. Results of the logistic regression analysis of MRFSS striped bass success/failure.

Anova Table (Type III)
Response: 0/1

	Chisq	Df	Pr(>Chisq)	
YEAR	1796.4	24	2.20E-16	***
AREA_X	208.5	2	2.20E-16	***
MODE_FX	4153.8	2	2.20E-16	***
WAVE	403.5	2	2.20E-16	***
CNTY	420.3	7	2.20E-16	***
FFDAYS12C	976.8	12	2.20E-16	***
HOURS	2859.1	11	2.20E-16	***

Coefficients:

	Estimate	SE	Z	Pr(>|z|)	
(Intercept)	-3.72	0.25092	-14.825	2.00E-16	***
YEAR1988	-0.1504	0.27318	-0.55	0.582016	
YEAR1989	-0.1071	0.27014	-0.397	0.691688	
YEAR1990	-0.2173	0.25912	-0.838	0.401761	
YEAR1991	-0.3219	0.25787	-1.248	0.211875	
YEAR1992	-0.1517	0.25216	-0.601	0.547567	
YEAR1993	0.16743	0.25135	0.666	0.505343	
YEAR1994	0.65303	0.24943	2.618	0.008842	**
YEAR1995	0.94284	0.24873	3.791	0.00015	***
YEAR1996	0.98525	0.24916	3.954	7.68E-05	***
YEAR1997	0.96559	0.24844	3.887	0.000102	***
YEAR1998	1.4528	0.24839	5.849	4.95E-09	***
YEAR1999	1.20279	0.24849	4.84	1.30E-06	***
YEAR2000	1.12264	0.249	4.509	6.53E-06	***
YEAR2001	0.9222	0.24848	3.711	0.000206	***
YEAR2002	0.9674	0.24936	3.88	0.000105	***
YEAR2003	0.85708	0.24905	3.441	0.000579	***
YEAR2004	0.93116	0.25048	3.718	0.000201	***
YEAR2005	1.04382	0.25092	4.16	3.18E-05	***
YEAR2006	1.29284	0.24986	5.174	2.29E-07	***
YEAR2007	0.96888	0.2507	3.865	0.000111	***
YEAR2008	0.80319	0.25187	3.189	0.001428	**
YEAR2009	0.75875	0.25093	3.024	0.002497	**
YEAR2010	0.51804	0.25246	2.052	0.040174	*
YEAR2011	0.38934	0.253	1.539	0.123827	
AREA_X2	-0.0365	0.03364	-1.084	0.278272	
AREA_X5	0.30139	0.02302	13.091	2.00E-16	***
MODE_FX6	2.65579	0.04775	55.622	2.00E-16	***
MODE_FX7	1.16216	0.02556	45.471	2.00E-16	***
WAVE4	-0.3661	0.02349	-15.584	2.00E-16	***
WAVE5	-0.5179	0.02763	-18.747	2.00E-16	***
CNTY5	-0.2585	0.04765	-5.425	5.80E-08	***
CNTY7	-0.1553	0.05911	-2.627	0.008618	**
CNTY9	0.37036	0.0254	14.583	2.00E-16	***
CNTY19	-0.3947	0.08288	-4.762	1.92E-06	***
CNTY21	0.12258	0.05331	2.299	0.021484	*
CNTY23	-0.1161	0.0323	-3.595	0.000325	***
CNTY25	0.11317	0.07681	1.473	0.140651	

Appendix Table 4B cont'd.

Coefficients:

	Estimate	SE	Z	Pr(>|z|)	
FFDAYS12C1(	0.13735	0.03075	4.467	7.93E-06	***
FFDAYS12C2(	0.40299	0.03193	12.622	2.00E-16	***
FFDAYS12C3(	0.49168	0.03747	13.12	2.00E-16	***
FFDAYS12C4(	0.58443	0.04696	12.444	2.00E-16	***
FFDAYS12C5(	0.73676	0.04154	17.736	2.00E-16	***
FFDAYS12C6(	0.6883	0.05654	12.175	2.00E-16	***
FFDAYS12C7(	0.82814	0.07247	11.428	2.00E-16	***
FFDAYS12C8(	0.86549	0.10254	8.44	2.00E-16	***
FFDAYS12C9(	0.66128	0.11061	5.978	2.25E-09	***
FFDAYS12C1(	0.91623	0.04538	20.19	2.00E-16	***
FFDAYS12C1:	0.95088	0.07778	12.225	2.00E-16	***
FFDAYS12C2(	0.90118	0.08963	10.054	2.00E-16	***
HOURS2	0.66125	0.04905	13.48	2.00E-16	***
HOURS3	1.05954	0.04699	22.55	2.00E-16	***
HOURS4	1.37227	0.04672	29.374	2.00E-16	***
HOURS5	1.53838	0.04872	31.576	2.00E-16	***
HOURS6	1.79159	0.05059	35.414	2.00E-16	***
HOURS7	1.99568	0.06068	32.889	2.00E-16	***
HOURS8	1.91584	0.06418	29.853	2.00E-16	***
HOURS9	2.22326	0.10135	21.937	2.00E-16	***
HOURS10	2.27352	0.11669	19.484	2.00E-16	***
HOURS11	1.67471	0.2263	7.4	1.36E-13	***
HOURS12	2.3006	0.13918	16.53	2.00E-16	***

Year	lsmeans
1987	0.37795
1988	0.3433
1989	0.35312
1990	0.32838
1991	0.30573
1992	0.34301
1993	0.41804
1994	0.53862
1995	0.60935
1996	0.6194
1997	0.61476
1998	0.72203
1999	0.66919
2000	0.65122
2001	0.60443
2002	0.61518
2003	0.58876
2004	0.60657
2005	0.63311
2006	0.68882
2007	0.61553
2008	0.57565
2009	0.56476
2010	0.50495
2011	0.4728