Technical Report

Massachusetts Division of Marine Fisheries
Technical Report TR-34

2007 Massachusetts Striped Bass Monitoring Report

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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

July, 2008

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 2007, the commercial fishery for striped bass in Massachusetts sold about 54,266 fish weighing 1,040,328 pounds and kept approximately 3,369 fish for personal consumption. Total losses due to commercial harvesting (including release mortality) were 62,932 fish weighing 1,117,513 pounds. The recreational fishery harvested about 347,102 striped bass weighing over 4.7 million pounds. Total losses due to recreational fishing (including release mortality) were 808,870 fish weighing over 6.5 million pounds. Combined losses (including scientific losses) were 871,837 fish weighing over 7.7 million pounds, which reflects a 22% decrease in numbers lost and a 12 % decrease in weight lost compared to 2006 (1,114,082 fish; 8.7 million pounds). The majority of losses, 93% by number and 86% by weight, was attributed to the recreational fishery.

Introduction

This report summarizes the commercial and recreational striped bass fisheries conducted in Massachusetts during 2007. 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 15 plus August 29 & 30. No landings were permitted on Monday, Friday, or Saturday.

Sold: 1,040,328 pounds (against a harvest quota of 988,406 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.

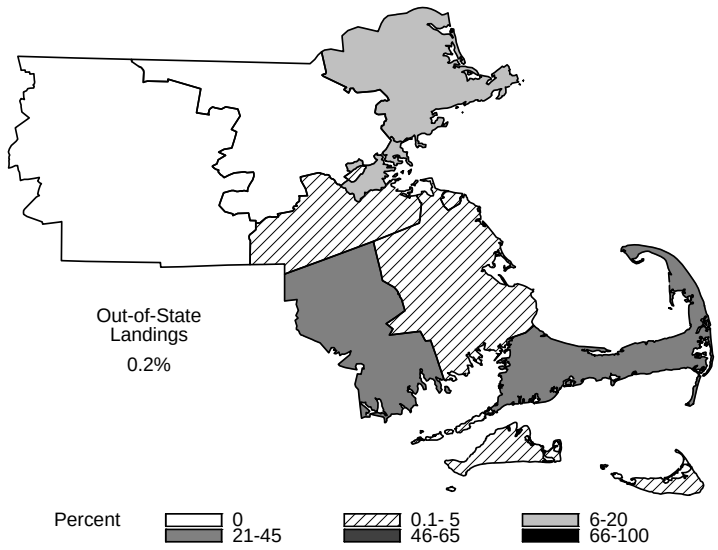
Licensing, Reporting, and Estimation of Landings. To purchase striped bass directly from fishermen, fish dealers are required to obtain special authorization from the DMF in addition to standard seafood dealer permits. Dealer reporting requirements included weekly reporting to the DMF or SAFIS system 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.

Table 1. Attributes of the Massachusetts striped bass commercial fishery, 1990-2007.

SEASON	SEASON LENGTH (Days)	Sold (Pounds) 000s	Sold (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	3,577
2000	36	779.7	40.2	137	3,280
2001	29	815.0	40.2	164	4,241
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	4,163
2006	26	1312.1	69.9	136	3,954
2007	22	1040.3	54.3	160	3,883

Figure 1. Percentage of total numbers of striped bass sold by commercial fishermen in Massachusetts counties in 2007.



2007 Landings. The landings used here come from the SAFIS system. Commercial anglers sold 1,040,328 pounds (54,266 fish) of striped bass in 2007 (Table 1). Most striped bass were sold in Barnstable, Bristol and Essex counties of Massachusetts (Figure 1). Commercial fishers kept an additional 3,369 fish weighing approximately 40,120 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 3,382 fish sampled from the 2007 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:

$$\log_{10}(W) = -3.467 + 3.014 * \log_{10}(L),$$

$$RMS = 0.003$$

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:

$$W = 10^{(-3.467 + 3.014 * \log_{10}(L) + RMS/2)}$$

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 46% of all fish caught had lengths ≥34 inches.

Age and Sex Composition.. Five hundred and sixty-one striped bass sampled from the 2007 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 328 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 98.0% were females. About 87.8% of the sub-sample consisted of individuals from the 1996-1999 year classes (ages 8-11) (Table 2).

Estimates of Total Catch Rates. Estimates of total catch rates (total number of fish caught per hour) for the commercial fishery were developed in

Table 2. Age composition of the 2007 commercial (sold) landings.

			Weighted		
Age	Year Class	Number	%	Mean Length (in.)	Mean Weight (lbs)
7	2000	10	2.1	34.7	14.9
8	1999	60	18.1	35.5	15.7
9	1998	105	32.1	37.3	18.7
10	1997	83	26.3	38.3	20.4
11	1996	32	9.6	39.6	22.5
12	1995	23	7.0	40.3	23.7
13	1994	12	3.8	42.6	29.4
14	1993	2	0.6	45.0	20.6
15	1992	1	0.4	48.0	12.9
16	1991	0	0.0	0.0	0.0
17	1990	0	0.0	0.0	0.0

order to provide an index that may be indicative of fluctuations in population abundance. 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, Both) by month. This information was used under a generalized linear model (GLM) framework to generate a standardized catch rate index (Hilborn and Walter, 1992). Each record represented the summarization of a permit's monthly number of total fish caught 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. Since season duration has varied during the time series, only data from July-August were used for in the analyses for consistency among years. The catch rate for each record was calculated by dividing the total numbers caught by the total number of hours fished. The catch rate was standardized using the GLM model

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

where y is the observed catch 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

$$\hat{y} = \exp^{(LSM)} - 1$$

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

Results of the GLM analysis (Appendix Table 2) show that although year, sub-area, and fishing mode were significant factors, the variables accounted for only about 5% of the total variation in catch rates.

Commercial catch rates increased steadily from 1991 to 2001, but since 2002, they have fluctuated around 1.07 fish/hour (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 5,297 fish weighing approximately 37,064 pounds.

Recreational Fishery

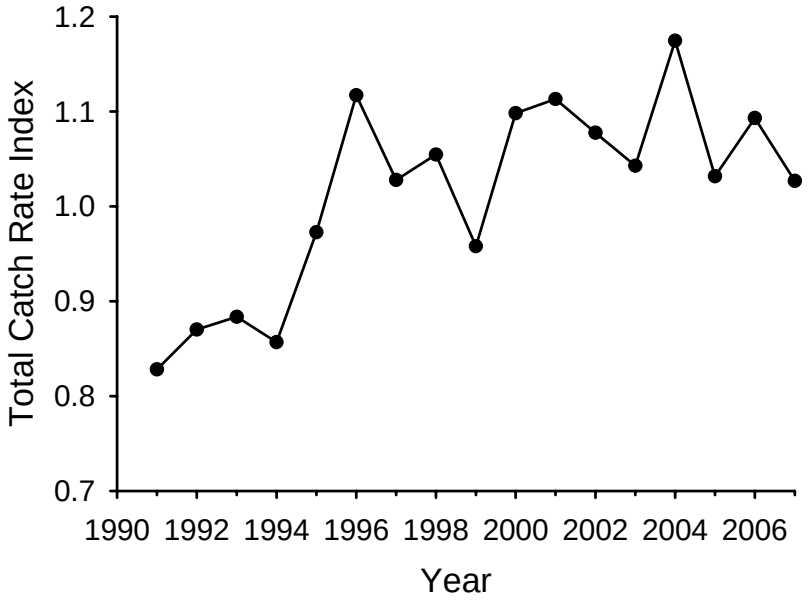
Season: None

Daily Bag Limit: Two fish per person

Allowable Gear Type: Hook and Line

Minimum Size: 28 inches total length

Figure 2. Total catch rate index for the Massachusetts commercial striped bass fishery.



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 2007 was 6,119,202 striped bass, which is lower than the 2006 estimate (Table 3). The estimate of total harvest in 2007 was 347,102, which is slightly higher than the 2006 estimate. Total pounds harvested was over 4.7 million in 2007 (Table 3).

The MRFSS estimates were post-stratified by county to determine where harvested bass were being landed by recreational anglers. Most landings (95%) occurred in Barnstable, Plymouth, Essex, and Bristol counties (Figure 4). Only 5% 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 the each fish (released or harvested) and fishing mode. Over 1,500 samples were received from 39 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 435 fish from the volunteer angler survey was aged and 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).

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

Figure 4. Percentage of total numbers of striped bass harvested by recreational anglers in each county of Massachusetts during 2007.

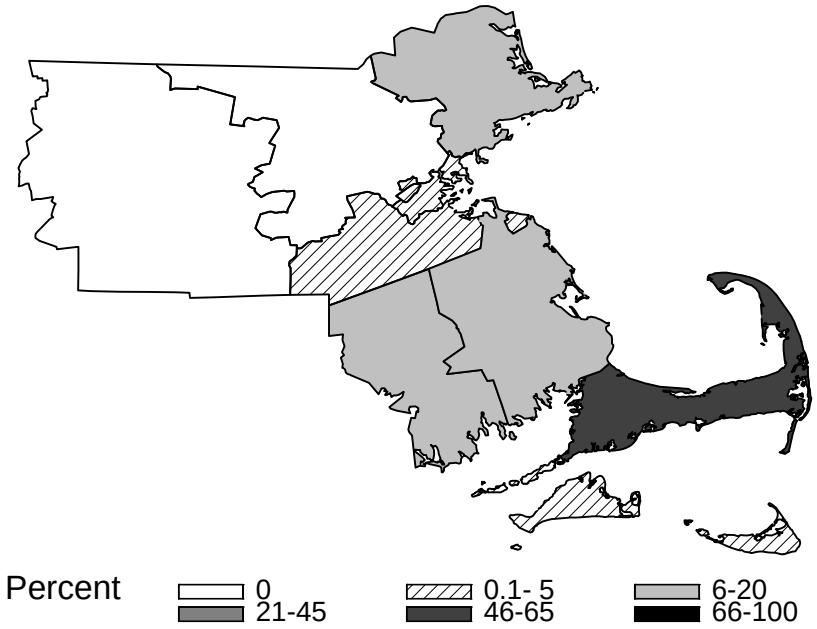
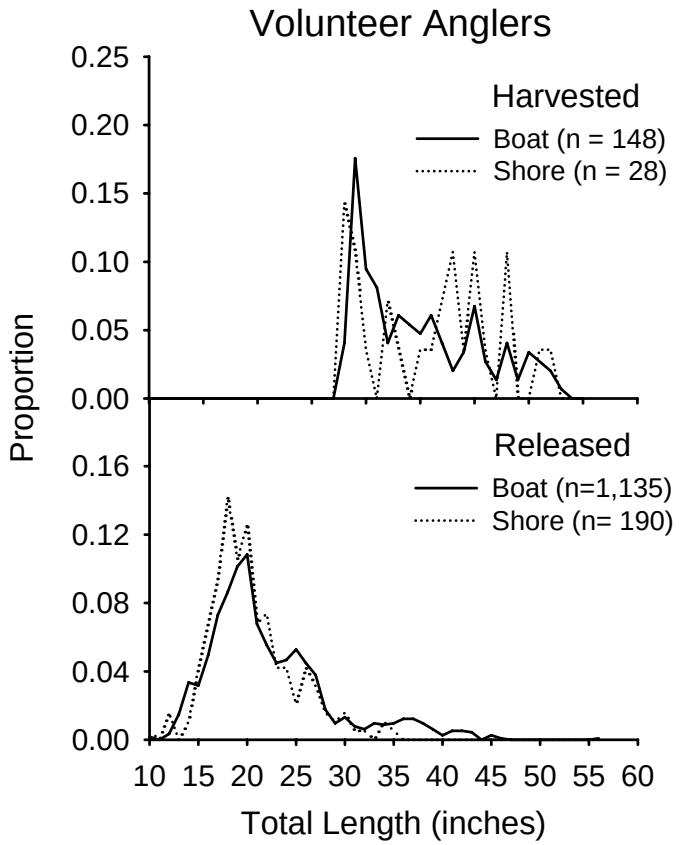


Figure 5. Sizes of striped bass caught by volunteer recreational anglers in 2007 by disposition and fishing mode.



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:

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

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 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 4 and 5. 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. Catch rates dropped in 2007.

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 461,768 fish (1.81 million pounds).

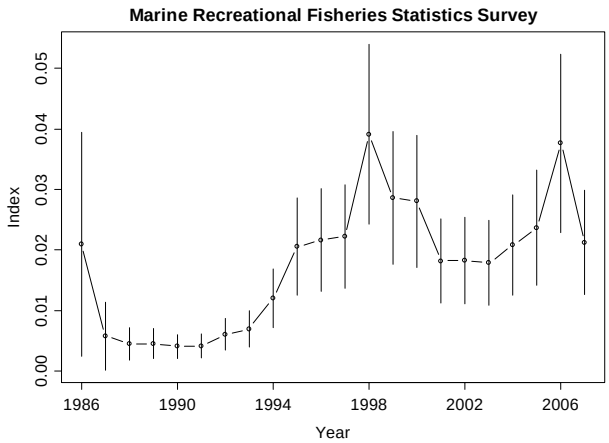
Scientific Collections

About 35 bass were taken or killed for scientific research in 2007.

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

Figure 6. Estimates of total catch rates (total number of fish caught per trip) of the recreational fishery for striped bass in Massachusetts waters. 95% confidence intervals



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 2008.

Estimated Total Losses

Total estimated loss of striped bass during 2007 was 871,837 fish weighing 7,714,493 pounds (Table 4), which is a 22% decrease in numbers lost and a 12% decrease in weight compared to 2006 (1,114,082 fish; 8,736,025 pounds). The majority of losses, 93% by number and 86% 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 and 2005 year-classes incurred the highest losses in 2007.

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.

Planned Management Programs in 2008

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 1,107,828 pounds due to overharvest in 2007. 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 2008.

Table 4. Estimates of striped bass losses occurring in Massachusetts waters during 2007.

FISHERY	NUMBER	POUNDS	MEAN WT.
Commercial			
Harvest*	57,635	1,080,449	18.7
Release Mortality	5,297	37,064	7.0
Recreational			
Harvest	347,102	4,784,948	13.8
Release Mortality	461,768	1,811,887	3.9
Scientific	35	145	4.1
Total	871,837	7,714,493	

* includes fish taken for personal consumption

Table 5. Massachusetts Striped Bass Removals-At-Age Matrix of 2007 By Source.

		Recreational		Commercial		
Age	Scientific	Release Mortality	Harvest	Release Mortality	Harvest*	Total
2	3	37,275	0	54	0	37,332
3	8	111,424	0	233	0	111,665
4	11	129,833	0	685	0	130,529
5	8	69,823	11,569	1,088	156	82,644
6	5	50,483	51,155	1,402	616	103,661
7	0	19,213	49,851	933	1,877	71,874
8	0	14,046	53,782	531	10,637	78,996
9	0	11,817	59,893	268	17,988	89,966
10	0	9,551	45,668	87	14,633	69,940
11	0	4,129	25,211	8	5,319	34,667
12	0	2,284	20,814	5	3,803	26,907
13	0	1,252	14,842	0	2,080	18,174
14	0	357	9,149	1	322	9,829
15	0	242	4,040	1	203	4,486
16+	0	38	1,128	0	0	1,166

* includes fish taken for personal consumption

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 and entered scale envelope data. 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

Appendix Table 1A. Estimated size distribution of the Massachusetts commercial striped bass catch (numbers of fish) in 2007.

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	516	516	0.42	0.42
15	0	282	282	0.23	0.64
16	0	282	282	0.23	0.87
17	0	422	422	0.34	1.21
18	0	939	939	0.76	1.97
19	0	845	845	0.68	2.65
20	0	3,707	3,707	2.99	5.65
21	0	2,581	2,581	2.08	7.73
22	0	2,675	2,675	2.16	9.89
23	0	2,018	2,018	1.63	11.52
24	0	4,458	4,458	3.60	15.12
25	0	5,772	5,772	4.66	19.78
26	0	5,772	5,772	4.66	24.44
27	0	4,599	4,599	3.71	28.15
28	253	5,537	5,790	4.68	32.83
29	202	4,130	4,332	3.50	36.33
30	539	6,147	6,686	5.40	41.72
31	656	4,786	5,443	4.39	46.12
32	371	5,209	5,579	4.51	50.62
33	870	3,848	4,718	3.81	54.43
34	3,285	657	3,942	3.18	57.62
35	5,923	282	6,204	5.01	62.63
36	7,756	328	8,084	6.53	69.15
37	7,902	282	8,184	6.61	75.76
38	7,989	47	8,036	6.49	82.25
39	5,319	0	5,319	4.30	86.54
40	4,351	0	4,351	3.51	90.06
41	3,890	0	3,890	3.14	93.20
42	3,128	0	3,128	2.53	95.72
43	2,466	94	2,560	2.07	97.79
44	944	0	944	0.76	98.55
45	782	0	782	0.63	99.18
46	652	0	652	0.53	99.71
47	213	0	213	0.17	99.88
48	79	0	79	0.06	99.95
49	67	0	67	0.05	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
Total	57,635	66,213	123,848		
Avg. Size	37.9	26.8	32.0		

* includes fish taken for personal consumption

Appendix Table 1B. Estimated weight distribution by size of the Massachusetts commercial striped bass catch (pounds) in 2007.

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	469	469	0.03	0.03
15	0	315	315	0.02	0.05
16	0	383	383	0.02	0.08
17	0	689	689	0.04	0.12
18	0	1,820	1820	0.12	0.24
19	0	1,928	1928	0.12	0.36
20	0	9,875	9875	0.64	1.00
21	0	7,964	7964	0.52	1.52
22	0	9,496	9496	0.62	2.13
23	0	8,190	8190	0.53	2.66
24	0	20,572	20572	1.33	4.00
25	0	30,122	30122	1.95	5.95
26	0	33,902	33902	2.20	8.14
27	0	30,265	30265	1.96	10.10
28	1,856	40,664	42519	2.75	12.86
29	1,650	33,709	35359	2.29	15.15
30	4,874	55,578	60452	3.92	19.07
31	6,548	47,770	54318	3.52	22.58
32	4,070	57,205	61275	3.97	26.55
33	10,484	46,367	56851	3.68	30.24
34	43,304	8,662	51965	3.37	33.60
35	85,214	4,051	89265	5.78	39.38
36	121,476	5,145	126621	8.20	47.59
37	134,423	4,790	139213	9.02	56.60
38	147,270	865	148135	9.60	66.20
39	106,048	0	106048	6.87	73.07
40	93,617	0	93617	6.06	79.13
41	90,165	0	90165	5.84	84.97
42	77,964	0	77964	5.05	90.02
43	65,984	2,511	68496	4.44	94.46
44	27,071	0	27071	1.75	96.22
45	23,997	0	23997	1.55	97.77
46	21,378	0	21378	1.38	99.15
47	7,452	0	7452	0.48	99.64
48	2,945	0	2945	0.19	99.83
49	2,658	0	2658	0.17	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
Total	1,080,449	463,306	1,543,755		
Avg. Weight	18.7	7.0	12.5		

* includes fish taken for personal consumption

Appendix Table 2. Results of the GLM analyses of total catch rates for the commercial striped bass fishery.

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	20	448.657732	22.432887	97.04	<.0001
Error	40381	9334.540991	0.231162		
Corrected Total	40401	9783.198724			

R-Square	Coeff Var	Root MSE	logn Mean
0.045860	60.88906	0.480793	0.789621

Source	DF	Type I SS	Mean Square	F Value	Pr > F
year	16	108.2256396	6.7641025	29.26	<.0001
method	2	125.1964642	62.5982321	270.80	<.0001
subarea	2	215.2356287	107.6178144	465.55	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
year	16	74.2206465	4.6387904	20.07	<.0001
method	2	111.5339165	55.7669582	241.25	<.0001
subarea	2	215.2356287	107.6178144	465.55	<.0001

Least Squares Means

year	logn LSMEAN	Standard Error	Pr > |t|
1991	0.60325372	0.01233477	<.0001
1992	0.62597385	0.01264990	<.0001
1993	0.63315488	0.01254304	<.0001
1994	0.61881286	0.01256001	<.0001
1995	0.67935945	0.01004866	<.0001
1996	0.75006179	0.02174079	<.0001
1997	0.70697409	0.00941273	<.0001
1998	0.72002962	0.00988546	<.0001
1999	0.67185612	0.01040999	<.0001
2000	0.74108204	0.01078010	<.0001
2001	0.74815886	0.01083159	<.0001
2002	0.73119045	0.01059682	<.0001
2003	0.71431198	0.00899527	<.0001
2004	0.77680030	0.01301722	<.0001
2005	0.70884396	0.01091574	<.0001
2006	0.73865573	0.00970463	<.0001
2007	0.70646816	0.01011542	<.0001

Appendix Table 3A. Estimated size distribution of the Massachusetts recreational striped bass catch (numbers of fish) in 2007.

TL (in.)	Harvested	Released	Total	Percent	Cumulative Percent
9	0	0	0		
10	0	9,055	9,055	0.15	0.15
11	0	0	0	0.00	0.15
12	0	51,502	51,502	0.84	0.99
13	0	103,077	103,077	1.68	2.67
14	0	161,969	161,969	2.65	5.32
15	0	165,650	165,650	2.71	8.03
16	0	262,591	262,591	4.29	12.32
17	0	481,430	481,430	7.87	20.19
18	0	614,844	614,844	10.05	30.23
19	0	619,801	619,801	10.13	40.36
20	0	594,374	594,374	9.71	50.08
21	0	354,722	354,722	5.80	55.87
22	0	279,680	279,680	4.57	60.44
23	0	258,562	258,562	4.23	64.67
24	0	283,364	283,364	4.63	69.30
25	0	245,191	245,191	4.01	73.31
26	0	261,140	261,140	4.27	77.57
27	0	216,442	216,442	3.54	81.11
28	12,352	87,942	100,294	1.64	82.75
29	50,645	69,523	120,168	1.96	84.71
30	30,881	68,686	99,567	1.63	86.34
31	16,058	52,277	68,335	1.12	87.46
32	19,764	42,755	62,519	1.02	88.48
33	19,764	51,687	71,451	1.17	89.65
34	16,058	53,122	69,180	1.13	90.78
35	17,293	58,122	75,415	1.23	92.01
36	23,470	60,776	84,246	1.38	93.39
37	24,705	66,387	91,092	1.49	94.88
38	17,293	53,622	70,915	1.16	96.03
39	14,823	43,866	58,689	0.96	96.99
40	22,234	14,055	36,289	0.59	97.59
41	11,117	13,665	24,782	0.40	97.99
42	2,470	42,556	45,026	0.74	98.73
43	16,058	18,610	34,668	0.57	99.29
44	6,176	0	6,176	0.10	99.40
45	9,882	6,510	16,392	0.27	99.66
46	7,411	1,955	9,366	0.15	99.82
47	6,176	0	6,176	0.10	99.92
48	1,235	0	1,235	0.02	99.94
49	0	0	0	0.00	99.94
50	0	0	0	0.00	99.94
51	0	0	0	0.00	99.94
52	1,235	0	1,235	0.02	99.96
53	0	0	0	0.00	99.96
54	0	0	0	0.00	99.96
55	0	0	0	0.00	99.96
56	0	2,600	2,600	0.04	100.00
Total	347,102	5,772,110	6,119,212		
Avg. Size	35.4	22.0	22.7		

Appendix Table 3B. Estimated size distribution of the Massachusetts recreational striped bass catch (pounds) in 2007.

TL (in.)	Harvested	Released	Total	Percent	Cumulative Percent
9	0	0	0		
10	0	2,667	2,667	0.01	0.01
11	0	0	0	0.00	0.01
12	0	26,160	26,160	0.10	0.11
13	0	66,512	66,512	0.24	0.35
14	0	130,434	130,434	0.48	0.82
15	0	163,956	163,956	0.60	1.42
16	0	315,218	315,218	1.15	2.57
17	0	692,751	692,751	2.53	5.09
18	0	1,049,595	1,049,595	3.83	8.92
19	0	1,243,679	1,243,679	4.53	13.45
20	0	1,390,316	1,390,316	5.07	18.52
21	0	960,041	960,041	3.50	22.02
22	0	869,888	869,888	3.17	25.19
23	0	918,505	918,505	3.35	28.54
24	0	1,143,193	1,143,193	4.17	32.71
25	0	1,117,587	1,117,587	4.07	36.78
26	0	1,338,361	1,338,361	4.88	41.66
27	0	1,241,774	1,241,774	4.53	46.19
28	79,008	562,492	641,499	2.34	48.53
29	359,762	493,867	853,629	3.11	51.64
30	242,767	539,966	782,732	2.85	54.49
31	139,240	453,296	592,537	2.16	56.65
32	188,436	407,643	596,079	2.17	58.82
33	206,594	540,290	746,884	2.72	61.55
34	183,527	607,129	790,656	2.88	64.43
35	215,537	724,408	939,945	3.43	67.85
36	318,217	824,045	1,142,263	4.16	72.02
37	363,558	976,959	1,340,517	4.89	76.90
38	275,611	854,597	1,130,208	4.12	81.02
39	255,315	755,566	1,010,881	3.68	84.71
40	413,085	261,124	674,209	2.46	87.17
41	222,367	273,329	495,696	1.81	88.97
42	53,106	914,797	967,903	3.53	92.50
43	370,347	429,202	799,549	2.91	95.42
44	152,576	0	152,576	0.56	95.97
45	261,086	171,998	433,084	1.58	97.55
46	209,113	55,160	264,273	0.96	98.51
47	185,833	0	185,833	0.68	99.19
48	39,581	0	39,581	0.14	99.34
49	0	0	0	0.00	99.34
50	0	0	0	0.00	99.34
51	0	0	0	0.00	99.34
52	50,282	0	50,282	0.18	99.52
53	0	0	0	0.00	99.52
54	0	0	0	0.00	99.52
55	0	0	0	0.00	99.52
56	0	132,086	132,086	0.48	100.00
Total	4,784,948	22,648,588	27,433,536		
Avg. Weight	13.8	3.9	4.5		

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

Anova Table (Type III tests)

LR	Chisq	Df	Pr(>Chisq)
YEAR	1715.7	21	< 2.2e-16 ***
AREA_X	191.9	2	< 2.2e-16 ***
MODE_FX	3203.8	2	< 2.2e-16 ***
WAVE	283.4	3	< 2.2e-16 ***
CNTY	459.1	7	< 2.2e-16 ***
FFDAYS12C	908.7	12	< 2.2e-16 ***
HOURS	2434.9	11	< 2.2e-16 ***

Coefficients:

	Estimate	SE	t value	Pr(>|z|)	
(Intercept)	-2.866101	0.221502	-12.94	2.00E-16	***
YEAR1987	-0.957968	0.321619	-2.98	0.002896	**
YEAR1988	-1.013857	0.246976	-4.11	4.04E-05	***
YEAR1989	-0.942204	0.243548	-3.87	0.000109	***
YEAR1990	-1.059915	0.231718	-4.57	4.78E-06	***
YEAR1991	-1.181414	0.230536	-5.13	2.98E-07	***
YEAR1992	-0.993499	0.224372	-4.43	9.52E-06	***
YEAR1993	-0.690855	0.223288	-3.09	0.001975	**
YEAR1994	-0.209544	0.221183	-0.95	0.343446	
YEAR1995	0.102379	0.220459	0.46	0.642368	
YEAR1996	0.131422	0.220741	0.60	0.551598	
YEAR1997	0.119697	0.219936	0.54	0.586279	
YEAR1998	0.592428	0.219824	2.70	0.007039	**
YEAR1999	0.343117	0.21999	1.56	0.118833	
YEAR2000	0.259611	0.22078	1.18	0.239642	
YEAR2001	0.053557	0.220082	0.24	0.807734	
YEAR2002	0.100699	0.221096	0.46	0.648783	
YEAR2003	0.008873	0.220744	0.04	0.967937	
YEAR2004	0.104436	0.222357	0.47	0.638585	
YEAR2005	0.20633	0.222876	0.93	0.35457	
YEAR2006	0.451874	0.22162	2.04	0.041454	*
YEAR2007	0.136068	0.222947	0.61	0.541653	
AREA_X2	0.005338	0.03458	0.15	0.877314	
AREA_X5	0.316743	0.024244	13.07	2.00E-16	***
MODE_FX6	2.525442	0.053244	47.43	2.00E-16	***
MODE_FX7	1.124216	0.026676	42.14	2.00E-16	***
WAVE4	-0.334362	0.025142	-13.30	2.00E-16	***
WAVE5	-0.43374	0.029343	-14.78	2.00E-16	***
WAVE6	-0.63782	0.095895	-6.65	2.91E-11	***
CNTY5	-0.264931	0.051068	-5.19	2.13E-07	***
CNTY7	-0.112211	0.06098	-1.84	6.57E-02	.
CNTY9	0.429519	0.027098	15.85	2.00E-16	***
CNTY19	-0.498957	0.090332	-5.52	3.32E-08	***
CNTY21	0.191734	0.056483	3.40	0.000688	***
CNTY23	-0.064265	0.034202	-1.88	0.060247	.
CNTY25	0.174064	0.078177	2.23	2.60E-02	*
FFDAYS12C10	0.136666	0.032613	4.19	2.78E-05	***
FFDAYS12C20	0.411699	0.03377	12.19	2.00E-16	***
FFDAYS12C30	0.497004	0.039553	12.57	2.00E-16	***
FFDAYS12C40	0.605998	0.049141	12.33	2.00E-16	***
FFDAYS12C50	0.741364	0.043291	17.13	2.00E-16	***
FFDAYS12C60	0.694784	0.059062	11.76	2.00E-16	***
FFDAYS12C70	0.833267	0.074599	11.17	2.00E-16	***
FFDAYS12C80	0.842664	0.106454	7.92	2.46E-15	***
FFDAYS12C90	0.608566	0.114532	5.31	1.08E-07	***
FFDAYS12C100	0.913204	0.046938	19.46	2.00E-16	***
FFDAYS12C150	0.965702	0.080452	12.00	2.00E-16	***
FFDAYS12C200	0.968173	0.090648	10.68	2.00E-16	***
HOURS2	0.631565	0.051422	12.28	2.00E-16	***
HOURS3	1.020658	0.049273	20.71	2.00E-16	***
HOURS4	1.297837	0.049087	26.44	2.00E-16	***
HOURS5	1.490186	0.051105	29.16	2.00E-16	***
HOURS6	1.737436	0.052927	32.83	2.00E-16	***
HOURS7	1.955887	0.063921	30.60	2.00E-16	***
HOURS8	1.799739	0.06681	26.94	2.00E-16	***
HOURS9	2.236185	0.107961	20.71	2.00E-16	***
HOURS10	2.232933	0.123186	18.13	2.00E-16	***
HOURS11	1.592913	0.237134	6.72	1.85E-11	***
HOURS12	2.309231	0.144457	15.99	2.00E-16	***

Appendix Table 5. Results of the Gamma regression analysis of MRFSS striped bass positive catches.

Anova Table (Type III tests)

LR	Chisq	Df	Pr(>Chisq)
YEAR	312.28	21	< 2.2e-16 ***
AREA_X	28.91	2	5.268e-07 ***
MODE_FX	399.88	2	< 2.2e-16 ***
WAVE	261.67	3	< 2.2e-16 ***
CNTY	124.57	7	< 2.2e-16 ***
FFDAYS12C	523.09	12	< 2.2e-16 ***
HOURS	994.81	11	< 2.2e-16 ***

Coefficients:

	Estimate	SE	t value	Pr(>|t|)	
(Intercept)	0.658651	0.208683	3.16	1.60E-03	**
YEAR1987	-0.342397	0.305163	-1.12	0.26187	
YEAR1988	-0.539774	0.235454	-2.29	2.19E-02	*
YEAR1989	-0.604072	0.228624	-2.64	0.00824	**
YEAR1990	-0.604073	0.218876	-2.76	5.79E-03	**
YEAR1991	-0.467195	0.218152	-2.14	3.22E-02	*
YEAR1992	-0.268365	0.210968	-1.27	2.03E-01	
YEAR1993	-0.422992	0.209927	-2.02	0.04392	*
YEAR1994	-0.351597	0.207285	-1.70	0.08986	.
YEAR1995	-0.122873	0.206415	-0.60	0.55167	
YEAR1996	-0.112794	0.206581	-0.55	0.58507	
YEAR1997	-0.067152	0.206099	-0.33	0.74456	
YEAR1998	0.022901	0.205627	0.11	0.91132	
YEAR1999	-0.027137	0.205956	-0.13	0.89518	
YEAR2000	0.017578	0.206674	0.09	0.93222	
YEAR2001	-0.21916	0.206306	-1.06	0.28811	
YEAR2002	-0.239292	0.206912	-1.16	0.24749	
YEAR2003	-0.171155	0.206848	-0.83	0.408	
YEAR2004	-0.105721	0.207631	-0.51	0.61064	
YEAR2005	-0.081684	0.207941	-0.39	0.69445	
YEAR2006	0.140622	0.206788	0.68	0.49649	
YEAR2007	-0.123202	0.207945	-0.59	0.55354	
AREA_X2	-0.041979	0.027107	-1.55	0.12149	
AREA_X5	0.083312	0.019851	4.20	2.72E-05	***
MODE_FX6	0.279844	0.038989	7.18	7.35E-13	***
MODE_FX7	0.496904	0.024171	20.56	2.00E-16	***
WAVE4	-0.302669	0.019495	-15.53	2.00E-16	***
WAVE5	-0.155903	0.023896	-6.52	7.00E-11	***
WAVE6	0.280047	0.091947	3.05	2.32E-03	**
CNTY5	-0.097298	0.04232	-2.30	2.15E-02	*
CNTY7	-0.321017	0.051801	-6.20	5.86E-10	***
CNTY9	0.124768	0.022189	5.62	1.90E-08	***
CNTY19	-0.138102	0.080432	-1.72	8.60E-02	.
CNTY21	0.054239	0.044148	1.23	0.21925	
CNTY23	0.002074	0.028736	0.07	0.94248	
CNTY25	-0.337062	0.064155	-5.25	1.50E-07	***
FFDAYS12C10	0.068296	0.027331	2.50	1.25E-02	*
FFDAYS12C20	0.194788	0.027534	7.08	1.55E-12	***
FFDAYS12C30	0.19074	0.031816	6.00	2.07E-09	***
FFDAYS12C40	0.332033	0.038481	8.63	2.00E-16	***
FFDAYS12C50	0.378097	0.033589	11.26	2.00E-16	***
FFDAYS12C60	0.412839	0.046228	8.93	2.00E-16	***
FFDAYS12C70	0.444905	0.056605	7.86	4.04E-15	***
FFDAYS12C80	0.516589	0.079328	6.51	7.59E-11	***
FFDAYS12C90	0.479639	0.092046	5.21	1.90E-07	***
FFDAYS12C100	0.55517	0.035845	15.49	2.00E-16	***
FFDAYS12C150	0.591326	0.061828	9.56	2.00E-16	***
FFDAYS12C200	0.742947	0.07087	10.48	2.00E-16	***
HOURS2	0.087718	0.051745	1.70	9.01E-02	.
HOURS3	0.304723	0.049002	6.22	5.12E-10	***
HOURS4	0.458594	0.048349	9.49	2.00E-16	***
HOURS5	0.64671	0.049258	13.13	2.00E-16	***
HOURS6	0.686192	0.049705	13.81	2.00E-16	***
HOURS7	0.93236	0.05435	17.16	2.00E-16	***
HOURS8	0.910883	0.057412	15.87	2.00E-16	***
HOURS9	0.952917	0.077461	12.30	2.00E-16	***
HOURS10	1.10642	0.088361	12.52	2.00E-16	***
HOURS11	1.248622	0.182688	6.84	8.46E-12	***
HOURS12	1.028662	0.104551	9.84	2.00E-16	***