TO: Atlantic Striped Bass Management Board

FROM: Wilson Laney, Atlantic Striped Bass Technical Committee Chair

DATE: January 27, 2010

RE: Executive Summary, Technical Committee Response to Board Tasks

The Striped Bass Technical Committee (TC) met by conference call in December and January to develop and approve the attached reports responding to the Management Board's five tasks from November 2009. Based on the reports and TC discussion, the following summary is provided.

Task 1: Juvenile Abundance Index Trigger

The TC advises against using truncated time series for evaluating each JAI relative to the management trigger. The complete time series are more representative of the range of natural variation in recruitment and include years that are thought to typify recruitment failure which could serve as reference for defining poor recruitment events. The TC also recommends the use of confidence intervals to limit comparison of index values to those that are significantly different, and the use of fixed time series for the trigger. In addition, the TC proposes a work plan, for completion by May 2010, to further review each JAI and the definitions for recruitment failure and the trigger (Attachment 1).

Task 2: Implications of Mycobacteriosis

The TC previously evaluated the effect of an increase in natural mortality (M) on the age-based model results through sensitivity runs for the 2007 benchmark stock assessment. Changing the input parameter for the base run of future assessments will require empirical evidence from field studies currently underway. Two of the tag-based models used to assess the stock do not require an assumption of the value of M. Here, the TC evaluated the effect of increasing M at age from 1999-2008 on the 2009 age-based assessment results. The variable M run resulted in higher recruitment and total abundance for all years; higher spawning stock biomass, age 8+ abundance and biomass, and total biomass for all years except 2007 and 2008; and lower fishing mortality for most years except 2007 and 2008 (Attachment 2). Stock projections with an increasing M would likely result in more significant effects than the short-term effects modeled. If M is as high as simulated, management has limited options to control stock dynamics via regulations because fishing mortality represents a small proportion of total mortality.

Task 3: Potential MRFSS Bias

The TC evaluated the effect of potential overestimation of recreational catch data using two approaches. Based on a suggested adjustment factor in Crecco (2009), two revised timeseries of recreational removals were used to re-run the 2009 age-based assessment model (Attachment 3). Based on two suggested adjustment methods in Crecco (2010), the original and two revised timeseries of recreational removals were used to estimate fishing mortality and abundance via an index-based approach (Crecco 2010; Attachment 4). Both approaches using reduced recreational removals resulted in lower estimates of stock size and fishing mortality. If recreational removals have been misestimated in recent stock assessments as simulated, the (not) overfishing stock determination of striped bass does not change. The TC did not attempt to validate methods used by Crecco (2009, 2010) because the Board task did not make this request. The TC recommends a review of the report by MRFSS scientists because of the potential significant impact on stock assessments for striped bass and other recreationally exploited species if the conclusions of the analysis are confirmed.

Task 4: Poaching Estimates

The TC has not included poaching removals in the catch-at-age for stock assessments because estimates (per year and at age) are not available. There is no requirement for estimating poaching as part of the management program. The only data available to the TC are for the "honest sublegals" as measured through the MRFSS, and these are not adequate for estimating intentional recreational poaching or any illegal commercial harvest. The Law Enforcement Committee has provided a separate memorandum on the inadequacy of available illegal harvest data and the hindrances to collecting data to accurately estimate poaching. The TC believes that a workshop of law enforcement and technical representatives would be necessary to design appropriate methods for the collection of poaching data for assessment purposes, if possible. Lacking the necessary data, the TC simulated poaching through 10, 20 and 30 percent increases in the catch-at-age. This simple approach (assumes poaching is constant across years and the same proportion at age of other removals) lead to an increase in estimated recruitment and spawning stock biomass and no change in fishing mortality (Attachment 5).

Task 5: Distribution Shifts

The TC reviewed data from the NEFSC Trawl Survey, the Massachusetts Acoustic Telemetry Study, and the Cooperative Winter Tagging Cruises. The average and minimum distance from shore that striped bass have been caught in the NEFSC Trawl Survey does not appear to have systematically changed in the 21 years of data reviewed (Attachment 6). The majority (91%) of striped bass tagged in the EEZ off Massachusetts in 2008 and 2009 were detected entering state waters, generally within several weeks of release (Attachment 7). The Cooperative Winter Tagging Cruise (1988-2009) is not a survey and tow effort and location have varied considerably through the time series, precluding any conclusive statement about abundance in state waters versus the EEZ. It does appear, though, that winter distribution during the last three years has shifted to the north, and during 2009, concentrations of fish encountered were much further offshore, but only continued sampling will indicate whether this is a long-term trend. The TC concludes that very little information is available regarding striped bass inshore-offshore movements. Reliable conclusions about striped bass distribution offshore could be made only if a well designed study is funded and completed.

Response to ASMFC Striped Bass Management Board Task 1: Juvenile Abundance Index Trigger

Alexei Sharov, Rob O'Reilly, Charlton Godwin, Carol Hoffman, and Vic Crecco

At its last meeting, the Striped Bass Management Board requested Technical Committee (TC) advice on the suitability of using all values in a juvenile abundance index (JAI) time series versus an abbreviated time series of yearly JAI values that occurred when the SSB levels were above the threshold or above the target, to determine recruitment failure. This request originated from the concern about recent low recruitment events in some striped bass stocks, as occurred in New York (2004-06) and in Maryland (2006 and 2008).

The juvenile abundance index trigger is defined, by Amendment 6, as follows. If the JAI of any system falls below 75% of all other values in the dataset, for three consecutive years, then appropriate action should be recommended to the Management Board. None of the recent JAI indices caused the trigger to fire (the Hudson JAI of 2004-06 triggered discussion, but the 2007 value was the highest in the time series, so no action was taken). Following the Management Board request, the TC discussed whether the shorter time series that includes only years with SSB above the threshold (1995-2008) or above the target (1996-2008) is more suitable for assessing recruitment failure. A trigger recalculated with 1995-2008 JAI data (SSB above threshold) and 1996-2008 JAI data (SSB above target) resulted in three index values qualifying for recruitment failure (NJ 2006, MD 2006, and VA 2008); however, there was no three consecutive years (the management trigger did not fire).

The TC finds that the complete time series of recruitment indices are more representative of the range of natural variation in striped bass recruitment and encompasses years that are thought to typify recruitment failure, and, as such, could serve as reference periods for the definition of poor recruitment events. For example, a comparison of quartiles for Maryland JAI full time series which covers over a 50 year period (1957-2008) shows that the first quartile includes years with JAIs at or below 1.6 (Table 1). Defining years with JAIs falling in the first quartile as years of recruitment failure agrees well with the empirical evidence. As a result of striped bass overfishing in Chesapeake Bay, the JAI was below 2.0 for most of the years during 1976-1991 (Figure 1). When the 1995-2008 or 1996-2008 truncated time series were used to determine poor recruitment threshold, the quartile values have increased significantly (Table 1) because this period is characterized by frequent, exceptionally high JAI values. If the truncated time series is used and the 25th percentile of the series is defined as a threshold for recruitment failure, more than 50% of years in the full time series would have to be defined as years of recruitment failure. A similar analysis was completed for the North Carolina JAI data (Table 2), whereby a truncated data set also resulted in higher quartile values. The TC agrees that it is not advisable to use a truncated time series of JAIs, such as 1995-2008 or 1996-2008.

In addition to the length of the time series to be used, the TC identified the following related issues:

- The TC recommends using the indices' confidence intervals to limit comparisons to values that are statistically different from the index value. Currently, only the annual means are used in the analysis and the measurement error (variance) is ignored when JAIs for various years are compared.

- The TC recommends using a fixed time series of JAIs, for each survey, for future determination of recruitment failure. Currently, the time series of JAIs is updated annually, and new means and quartiles are being calculated each year, thus making the JAI trigger an ever-changing value.
- The TC discussed the background of the JAI trigger and recognized that it has been carried forward in amendments, since Amendment 4, a time when the JAI was all that was available to monitor the stock. It served as an early warning indication of population status but was also used as an arbiter of improvement in the health of the striped bass population, under Amendment 4. As such, the reopening of fisheries in 1990 occurred because the 3-year running average of the Maryland JAI index achieved the target of 8. The TC indicates the 25^{th} percentile, as a threshold level, was selected arbitrarily. The three-year, running average approach may have been based on the two-year lag between young-of-year and their recruitment to the Chesapeake Bay fishery. The TC suggests that other possible thresholds be investigated and a requirement of three consecutive years of poor recruitment should be reviewed.
- Based on TC discussion the following research plan was proposed:
    1. For each program, validate that the JAI is an indicator of future year class strength.
    2. For each program, a complete JAI time series will be reviewed, and periods of low recruitment will be identified.
    3. A best suited criterion for the definition of recruitment failure will be suggested. This could be done using frequency distributions, correlations with periods thought to typify poor recruitment or any other methods.
    4. A probability of two or three consecutive years of poor recruitment in existing time series will be determined and evaluated as an indicator of consistent recruitment failure.
    5. Various lengths of fixed time series will be tried to determine the most suitable fixed period to be used as a reference for future determination of a recruitment failure event.
    6. System-specific confidence intervals around JAI values will be selected for future comparisons of annual JAI values and determination of their statistical differences.

This analysis can be conducted from January through April 2010, and results reported to the Management Board at its May 2010 meeting.

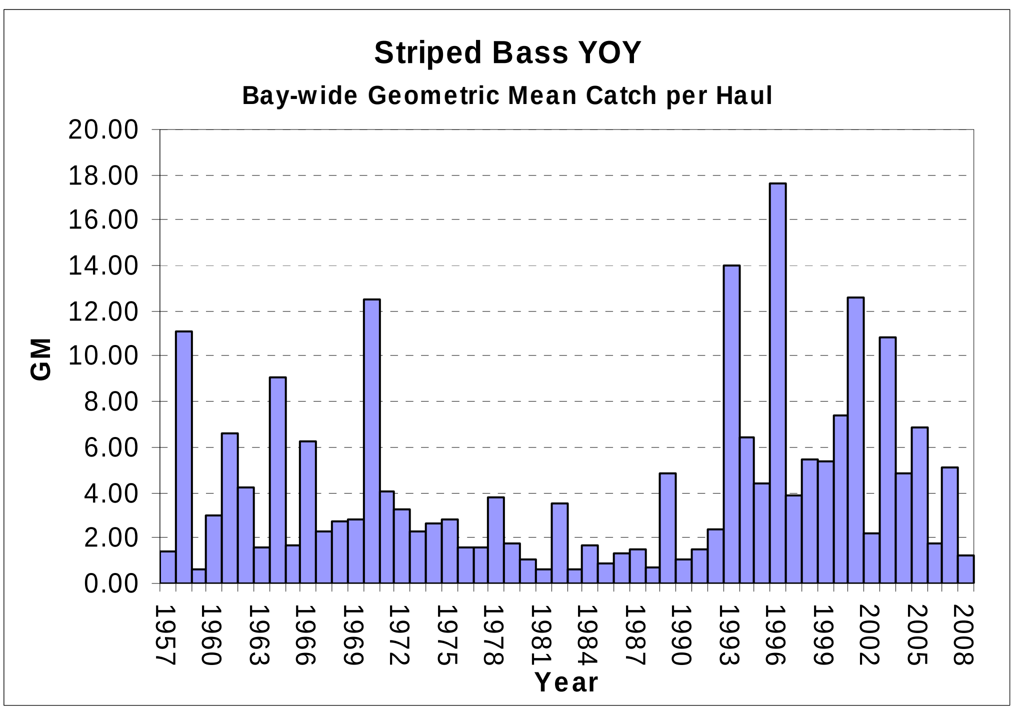
Table 1. Maryland juvenile index values (geometric means), by quartiles, for full time series (1957 – 2008) and truncated time series (1995-2008)

Quartile	1957 -2008 time series JI	1995-2008 time series JI
0-25%	1.60	4.04
26-50%	2.81	5.23
51-75%	5.38	7.29
75-100%	17.61	17.61

Table 2. North Carolina juvenile index values (arithmetic mean), by quartiles, for full time series (1955 – 2008) and truncated time series (1995-2008)

Quartile	1955 -2008 time series JI	1995-2008 time series JI
0-25%	1.48	3.08
26-50%	3.95	6.80
51-75%	9.40	9.25
75-100%	58.80	58.80

Figure 1. Maryland striped bass geometric mean of Age 0 for 1957 -2008. Note consistently low recruitment during 1976 -1991 period



Response to ASMFC Striped Bass Management Board Task 2: Implications of Mycobacteriosis

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The ASMFC Striped Bass Management Board requested information regarding the potential impact of the mycobacteriosis outbreak on the striped bass stock and stock assessment (Task # 2). There are currently no empirical data available to determine the increase in natural mortality from the disease outbreak although field studies are underway. Nevertheless we can evaluate the implications in the statistical catch at age (SCA) model results if natural mortality (M) has increased over time as suggested in some tag based models. Previous sensitivity runs of the SCA model have evaluated changes in M. The intent of this analysis is to examine changes in M that correspond to an increased incidence of mycobacteriosis (myco) in Chesapeake Bay.

Although a recent paper documents the presence of myco in coastal populations, the primary outbreak appears to be centered on the resident population in Chesapeake Bay. Migration information suggests that females begin emigration around age 3. We do not have a good estimate of the proportion of Chesapeake fish in the overall population so for the purposes of this analysis I will assume that an increasing M applies to all stocks. Myco reports suggest that the disease began influencing natural mortality sometime around 1999.

The original model was modified (G. Nelson, MA DMF) to accommodate M at age. The base model uses a constant M of 0.15 across all ages and years. Using the modified model, I incorporated an increased M at ages 1 and 2 (0.3 and 0.2, respectively). From 1999 to 2008, M was increased 10% per year and age, beginning at age 2 (Table 1, Figure 1). Consequently by 2008 the average M at age equaled 0.39 whereas 1982-1998 the average equaled 0.17 (Figure 2). Spawning stock biomass, recruitment, total abundance and age 8+ abundance, total biomass and age 8+ biomass, and fishing mortality at age 8 to 11 and 3 to 8 were estimated using the altered natural mortality estimates.

Compared to the base model, the variable M model increased to a higher SSB in 2003 but declined to a lower level in 2008 (Figure 3). Recruitment patterns were very similar but the scale was higher for the variable M recruitment estimate (Figure 4). Total abundance was also scaled higher through 2006, but was equivalent to the base model in 2007 and 2008 (Figure 5). Similarly age 8+ abundance was higher through 2004 but decreased faster to 2008, ending with a lower abundance by the terminal year (Figure 6). Total biomass and age 8+ biomass followed a similar patter as abundance (Figures 7 and 8). Fishing mortality was similar for both models until the terminal years (Figures 9 and 10). At that point the variable M model had higher Fs in 2007 and 2008 for both age 8-11 F and 3-8 F. F in 2008 for age 8-11 in the variable M was 0.31 compared to 0.22 in the base model whereas the 3-8 F was 0.22 with variable M compared to 0.15 for the base model.

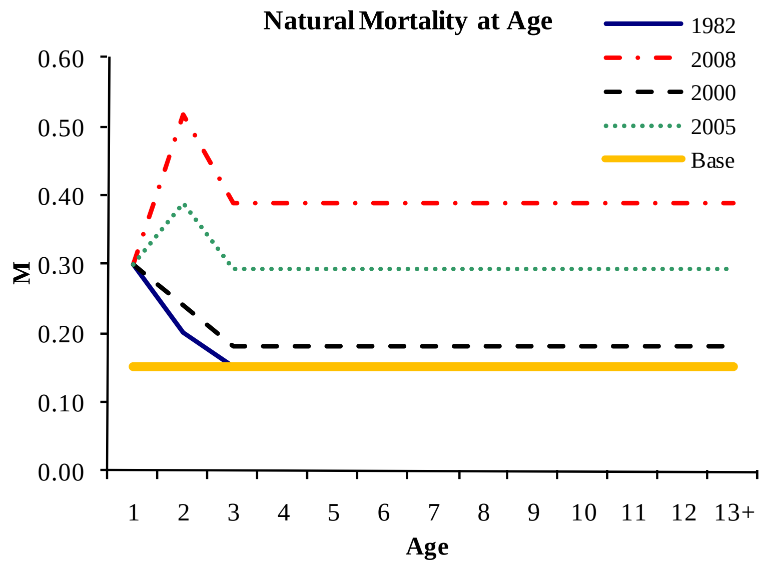

Figure 1. Variable estimates of M at age used in the variable M model

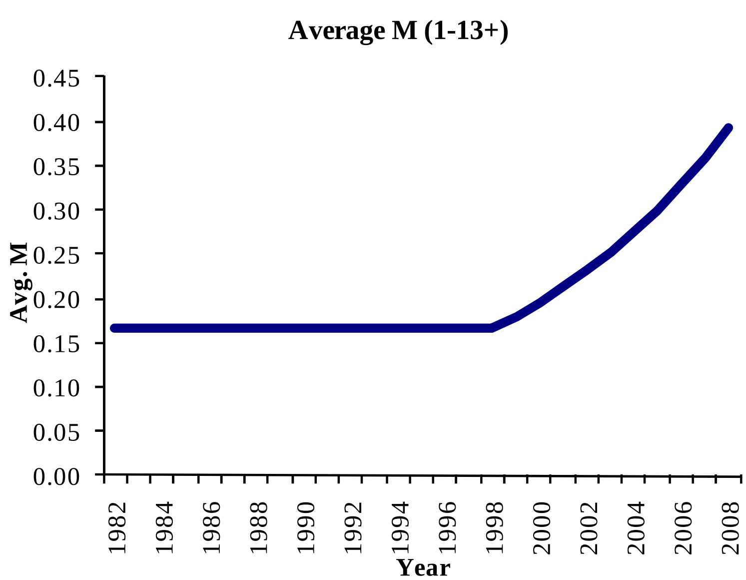

Figure 2. Average M at age used in the variable M model

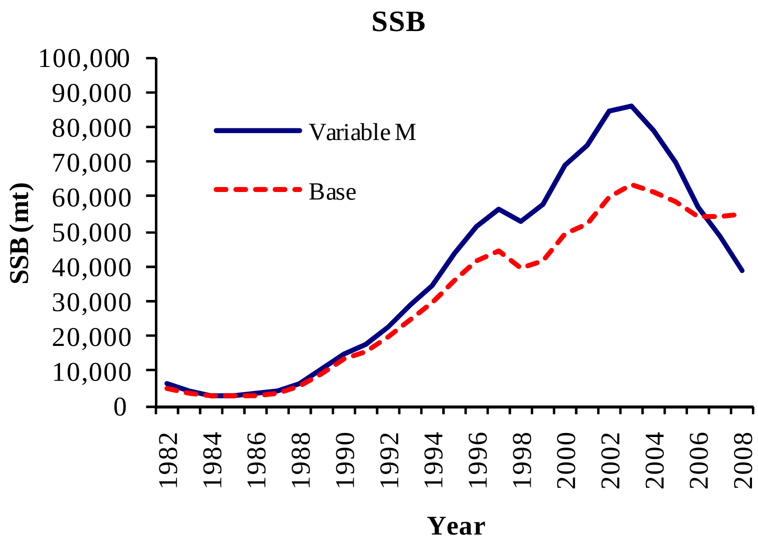

Figure 3. Spawning stock biomass for base model and variable M model

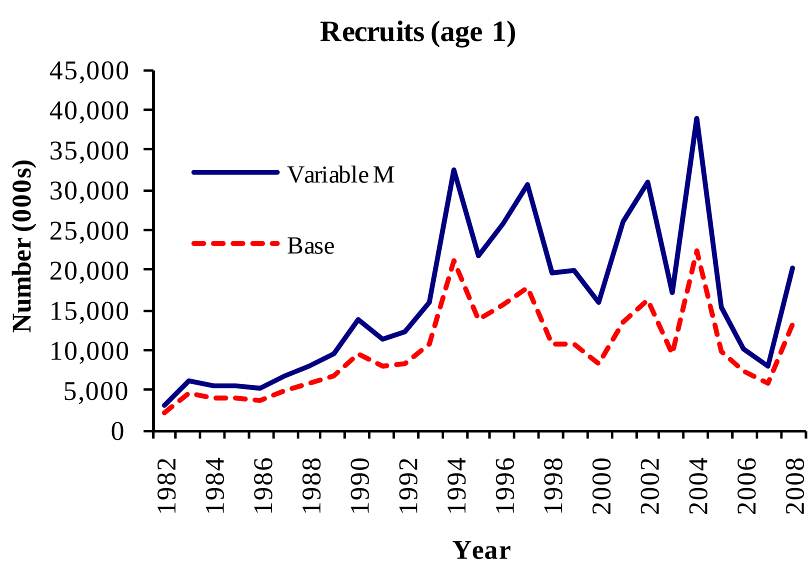

Figure 4. Abundance (000s) of age 1 recruits for base model and variable M model

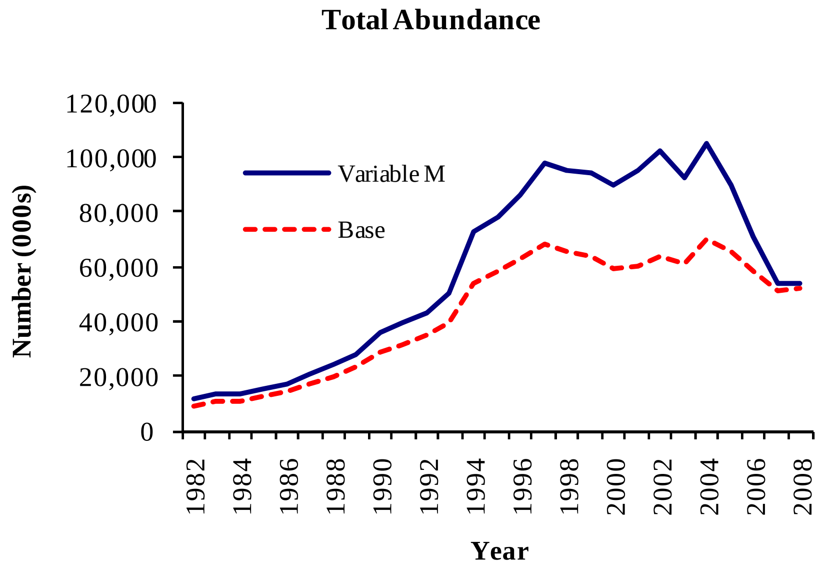

Figure 5. Total striped bass abundance for base model and variable M model

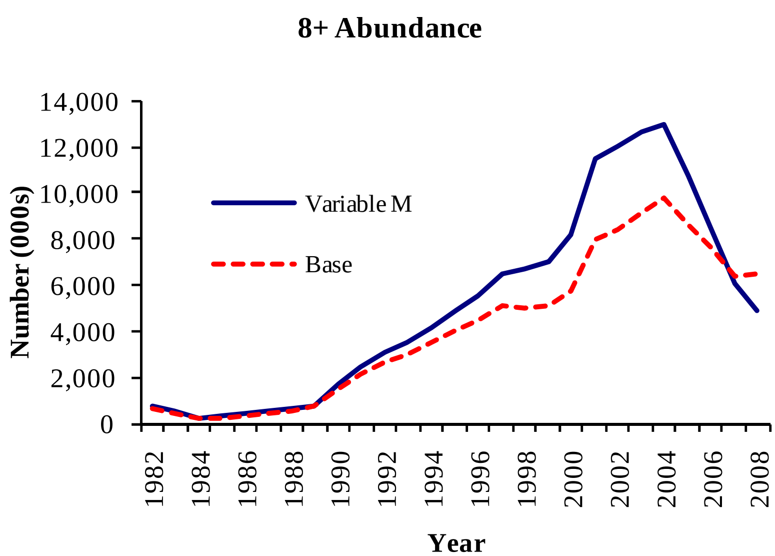

Figure 6. Age 8+ striped bass abundance for base model and variable M model

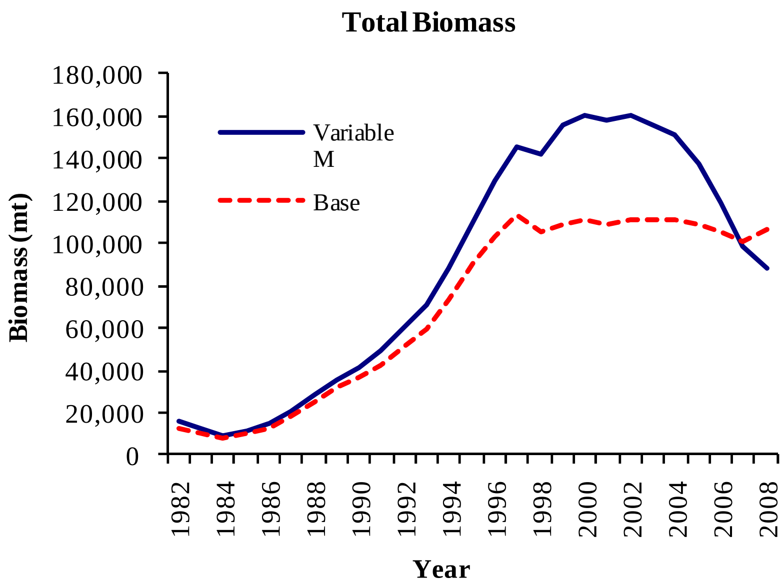

Figure 7. Total striped bass biomass for base model and variable M model

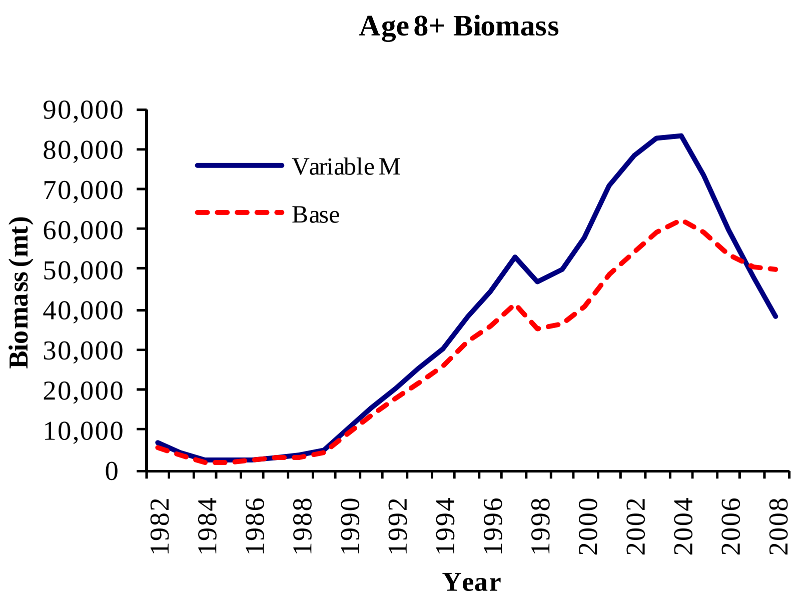

Figure 8. Age 8+ striped bass biomass for base model and variable M model

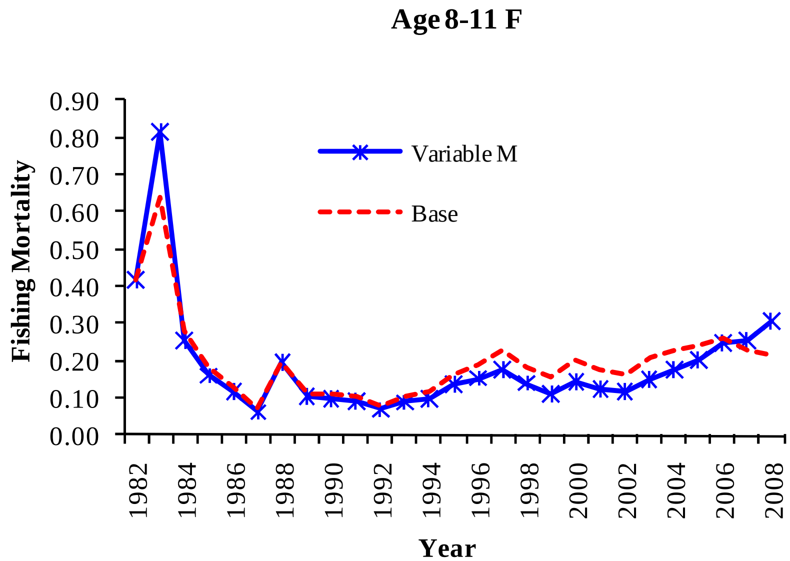

Figure 9. Striped bass fishing mortality for ages 8 to 11 for base model and variable M model

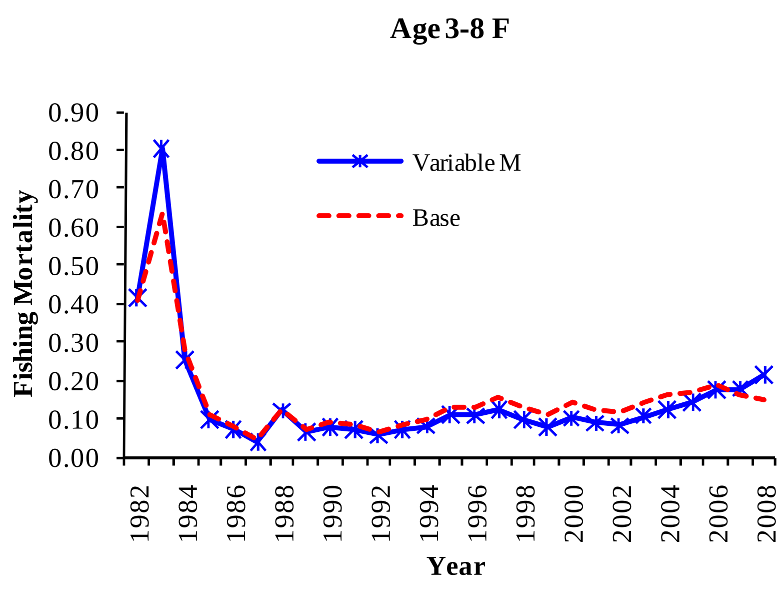

Figure 10. Striped bass fishing mortality for ages 3 to 8 for base model and variable M model

Table 1. Natural mortality at age matrix used in variable M model

	Age											
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13+**
1982	0.30	0.20	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
1983	0.30	0.20	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
1984	0.30	0.20	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
1985	0.30	0.20	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
1986	0.30	0.20	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
1987	0.30	0.20	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
1988	0.30	0.20	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
1989	0.30	0.20	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
1990	0.30	0.20	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
1991	0.30	0.20	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
1992	0.30	0.20	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
1993	0.30	0.20	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
1994	0.30	0.20	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
1995	0.30	0.20	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
1996	0.30	0.20	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
1997	0.30	0.20	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
1998	0.30	0.20	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
1999	0.30	0.22	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
2000	0.30	0.24	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
2001	0.30	0.27	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
2002	0.30	0.29	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
2003	0.30	0.32	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
2004	0.30	0.35	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27
2005	0.30	0.39	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
2006	0.30	0.43	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32
2007	0.30	0.47	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
2008	0.30	0.52	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39

Response to ASMFC Striped Bass Management Board Task 3: Potential MRFSS Bias

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The Striped Bass Management Board requested an analysis to examine the impact of mis-estimation of recreational striped bass catch since 1997 as suggested in Crecco (2009). The catch at age was re-estimated using an adjustment to the total recreational catch. New catch estimates were based on the average of two alternative adjustment equations presented in the Crecco paper. The changes began in 1997 and increased to an overestimate factor of 2.42 in 2008. The altered catch at age assumed the same proportion at age as the original 2009 assessment. In addition, a recreational catch adjustment was made excluding the party-charter (PC) component of the striped bass catch after 2004 because the MRFSS has adopted a specific survey for party-charter fisheries since 2005.

A decrease in estimates of recreational landings as suggested resulted in a decrease up to 41% of total catch. The alternative non-PC adjustment resulted in a decrease of 33% by 2008. As would be expected, the results were a decrease in biomass (total, 8+ and SSB). Fishing mortality was similar to the original runs, with the exception of 2008 where F dropped from 0.21 to 0.14 and 0.17, respectively for adjustments 1 and 2. In both cases, the changes did not result in a change in stock status; F remained well below Fmsy and SSB well above SSB threshold.

Table 1. Striped bass catch before and after adjustments for MRFSS

Year	Original Total Removals	MRFSS overestimate factor	Adjusted Total Removals	Proportion non-P/C	Adjusted Removals w/o PC
1982	766,200	1.00	766,200		766,200
1983	727,700	1.00	727,700		727,700
1984	1,084,900	1.00	1,084,900		1,084,900
1985	400,800	1.00	400,800		400,800
1986	384,900	1.00	384,900		384,900
1987	239,100	1.00	239,100		239,100
1988	444,900	1.00	444,900		444,900
1989	479,900	1.00	479,900		479,900
1990	921,300	1.00	921,300		921,300
1991	988,400	1.00	988,400		988,400
1992	986,900	1.00	986,900		986,900
1993	1,437,000	1.00	1,437,000		1,437,000
1994	1,866,600	1.00	1,866,600		1,866,600
1995	2,999,700	1.00	2,999,700		2,999,700
1996	3,376,200	1.00	3,376,200		3,376,200
1997	4,580,100	1.04	4,481,843		4,481,843
1998	4,118,300	1.07	3,944,849		3,944,849
1999	3,704,300	1.17	3,357,649		3,357,649
2000	5,044,400	1.26	4,359,696		4,359,696
2001	4,344,001	1.37	3,498,835		3,498,835
2002	3,893,529	1.48	2,898,302		2,898,302
2003	4,842,029	1.61	3,442,064		3,442,064
2004	5,278,600	1.75	3,571,363		3,571,363
2005	5,602,048	1.89	3,788,451	79%	4,161,474
2006	6,094,640	2.06	3,618,484	82%	4,057,602
2007	5,413,650	2.23	3,395,459	74%	3,910,809
2008	4,590,380	2.42	2,722,048	81%	3,075,128

Table 2. Striped bass SSB before and after adjustments for MRFSS

Year	SSB Original	Adj 1	Adj 2
1982	5276.0	4725.38	4767.7
1983	3542.0	3211.92	3237.25
1984	2529.0	2402.97	2412.93
1985	2772.0	2593.13	2606.46
1986	2975.0	2750.81	2767.23
1987	3646.0	3341.26	3363.37
1988	5593.0	5096.38	5132.25
1989	9369.0	8534.97	8591.07
1990	13059.0	11808	11891.2
1991	15703.0	14040.5	14150.9
1992	19595.0	17336.9	17485.7
1993	24902.0	21827.1	22029.1
1994	29302.0	25390.2	25644.7
1995	36297.0	30995	31334.7
1996	41655.0	34764.7	35198
1997	44272.0	35793.7	36318.7
1998	39630.0	30901.7	31445.1
1999	41634.0	31558.6	32199.7
2000	49190.0	36669	37507.9
2001	52579.0	38690.5	39711.5
2002	60115.0	44101.4	45430.4
2003	63516.0	47017.4	48616.5
2004	61588.0	46371.8	48213.9
2005	59059.0	45733.2	47770.8
2006	54514.0	43770.6	45116.4
2007	54574.0	46692.8	47253.2
2008	55500.0	49657.1	49110.1

Table 3. Striped bass biomass (total and age 8+) before and after MRFSS adjustments

	Biomass-total			Biomass-8+		
Year	Original	Adj 1	Adj 2	Original	Adj 1	Adj 2
1982	12,779	11,424	11,529	5,273.2	4,720.3	4,762.7
1983	9,828	8,866	8,940	3,502.6	3,160.3	3,186.4
1984	8,580	8,075	8,115	2,101.6	2,001.3	2,009.3
1985	9,968	9,231	9,286	2,065.1	1,936.3	1,945.9
1986	12,905	11,842	11,920	2,470.8	2,289.7	2,303.0
1987	18,193	16,581	16,699	2,812.7	2,584.2	2,600.7
1988	25,101	22,777	22,945	3,332.9	3,043.4	3,064.2
1989	31,563	28,637	28,837	4,460.0	4,077.2	4,102.2
1990	36,585	33,024	33,264	9,531.1	8,642.1	8,700.2
1991	42,255	37,793	38,091	13,407.9	12,009.8	12,101.8
1992	52,021	46,148	46,534	17,728.3	15,699.2	15,832.6
1993	60,176	52,969	53,440	21,855.2	19,154.0	19,331.7
1994	72,998	63,485	64,096	25,671.9	22,223.4	22,448.3
1995	90,206	77,294	78,109	31,843.7	27,182.1	27,482.2
1996	103,448	86,774	87,810	35,841.9	29,906.9	30,281.7
1997	113,363	92,780	94,043	41,351.3	33,433.8	33,924.8
1998	105,537	83,716	85,077	35,291.0	27,407.3	27,898.8
1999	109,632	84,675	86,307	36,145.2	27,182.1	27,751.8
2000	111,223	84,501	86,331	40,633.1	30,002.6	30,710.4
2001	108,923	81,520	83,554	49,017.5	35,882.3	36,838.2
2002	111,431	82,871	85,242	54,372.4	39,630.6	40,840.6
2003	111,578	83,484	86,180	59,405.8	43,709.0	45,201.0
2004	112,079	85,202	88,326	62,497.1	46,832.2	48,681.4
2005	109,951	85,663	89,196	59,356.4	45,755.2	47,886.2
2006	105,792	84,799	87,313	54,030.7	43,119.0	44,540.2
2007	101,916	86,229	87,504	50,727.8	43,346.7	43,963.9
2008	108,289	94,713	94,359	50,515.0	45,172.2	44,683.8

Table 4. Age one striped bass recruits before and after MRFSS adjustments

	Age 1 (000s)		
Year	Original	Adj 1	Adj 2
1982	2175.0	1982.6	1997.6
1983	4730.0	4382.5	4409.3
1984	4069.0	3711.8	3738.2
1985	4047.0	3674.7	3701.9
1986	3676.0	3322.3	3347.4
1987	4850.0	4378.7	4411.1
1988	5800.0	5229.3	5267.8
1989	6740.0	6038.0	6084.2
1990	9606.0	8548.2	8616.6
1991	7934.0	7001.8	7061.5
1992	8306.0	7243.3	7309.7
1993	10724.0	9197.4	9290.6
1994	21166.0	17728.4	17937.1
1995	13684.0	11178.1	11332.1
1996	15588.0	12397.4	12598.7
1997	17823.0	13925.8	14190.1
1998	10849.0	8368.2	8553.1
1999	10598.0	8140.0	8345.1
2000	8201.0	6256.2	6438.4
2001	13603.0	10415.8	10746.5
2002	16207.0	12613.8	13030.4
2003	9435.0	7468.9	7694.1
2004	22707.0	18473.7	18894.0
2005	10020.0	8382.9	8497.7
2006	7377.0	6292.4	6342.5
2007	5769.0	4883.2	4938.5
2008	13282.0	11112.4	11274.4

Table 5. Striped bass fishing mortality (age 8-11 avg.) before and after MRFSS adjustments

	F ages 8-11		
Year	Original	Adj 1	Adj 2
1982	0.42	0.41	0.41
1983	0.64	0.59	0.59
1984	0.28	0.30	0.30
1985	0.18	0.19	0.19
1986	0.13	0.14	0.14
1987	0.07	0.07	0.08
1988	0.20	0.19	0.20
1989	0.11	0.12	0.12
1990	0.11	0.12	0.12
1991	0.10	0.11	0.11
1992	0.08	0.09	0.09
1993	0.10	0.12	0.12
1994	0.12	0.13	0.13
1995	0.16	0.19	0.19
1996	0.19	0.22	0.22
1997	0.22	0.27	0.27
1998	0.18	0.22	0.22
1999	0.15	0.18	0.18
2000	0.20	0.23	0.23
2001	0.18	0.19	0.19
2002	0.16	0.16	0.16
2003	0.20	0.19	0.19
2004	0.23	0.20	0.20
2005	0.24	0.21	0.22
2006	0.26	0.19	0.21
2007	0.22	0.18	0.20
2008	0.21	0.14	0.17

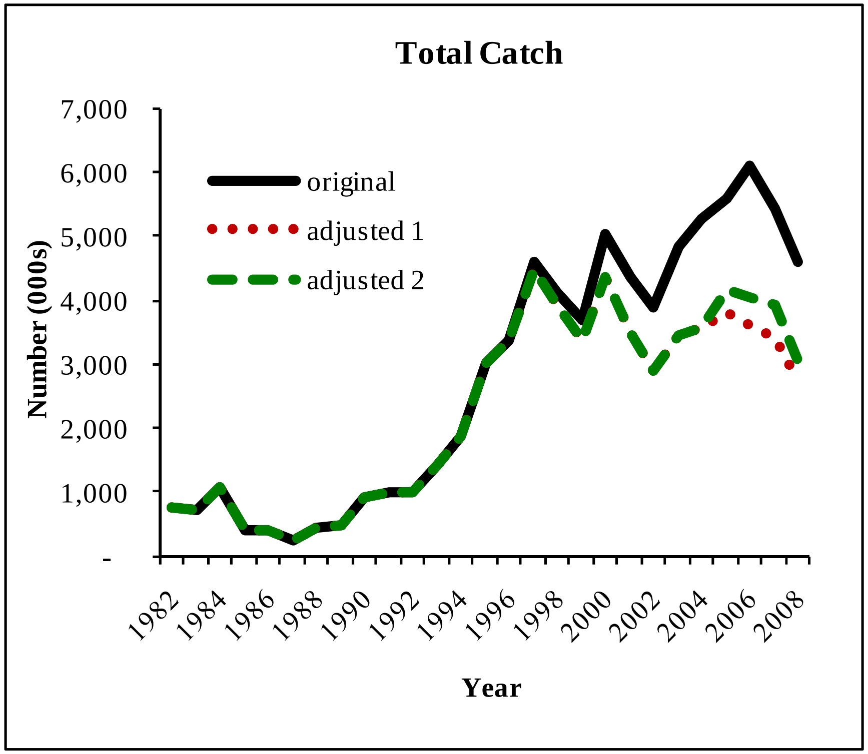

Figure 1. Striped bass catch by year before and after MRFSS adjustments

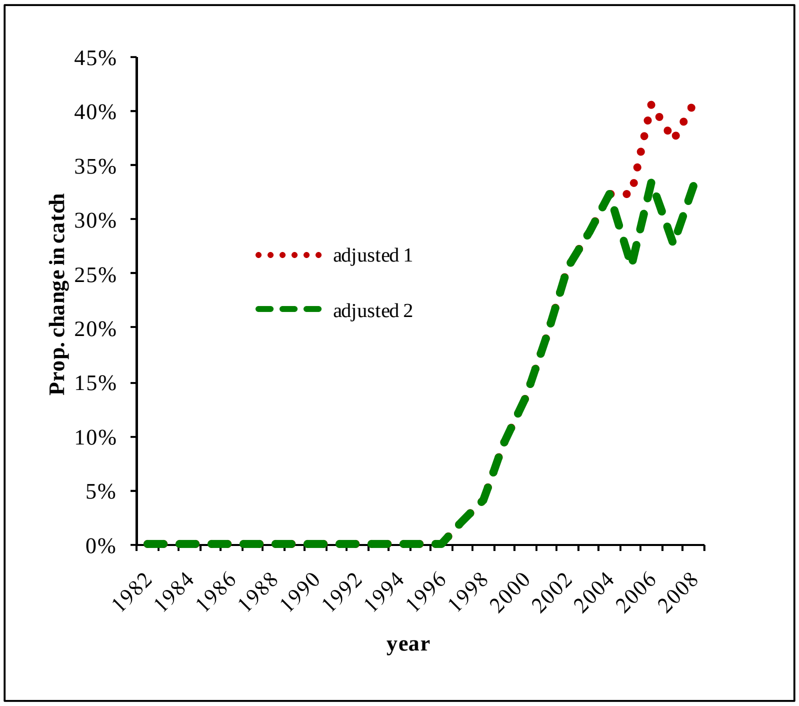

Figure 2. Proportional change in total catch over time with adjustments

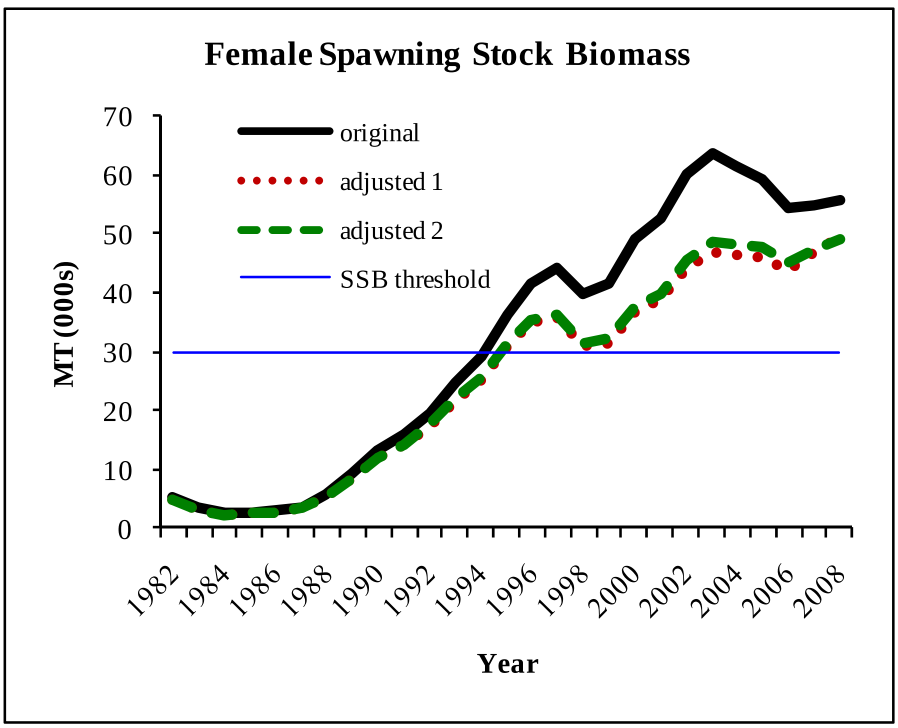

Figure 3. Striped bass female spawning stock biomass before and after recreational catch adjustment

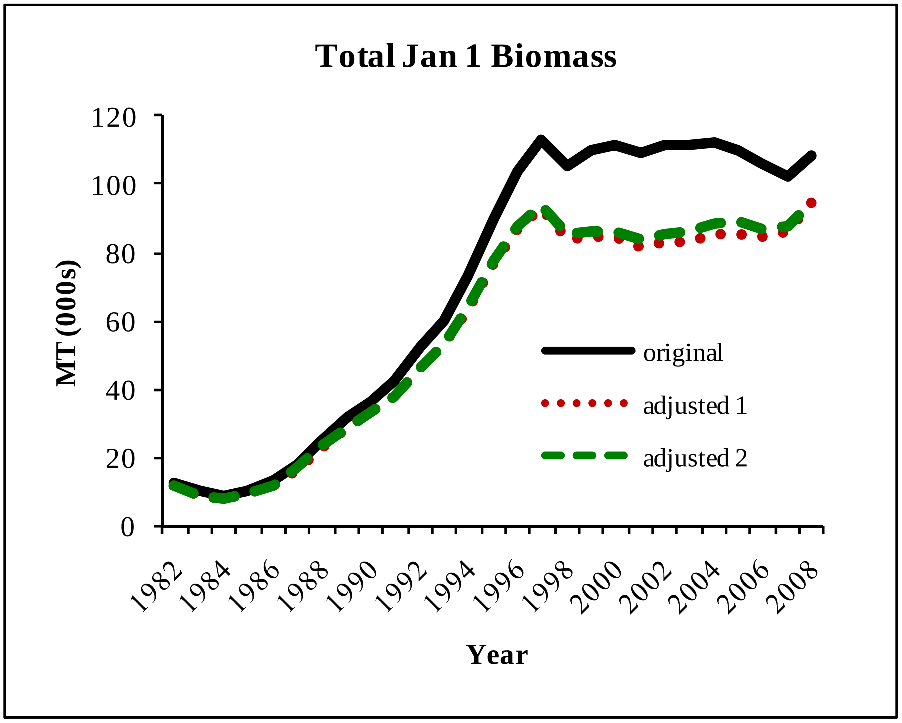

Figure 4. Striped bass total biomass before and after recreational catch adjustments

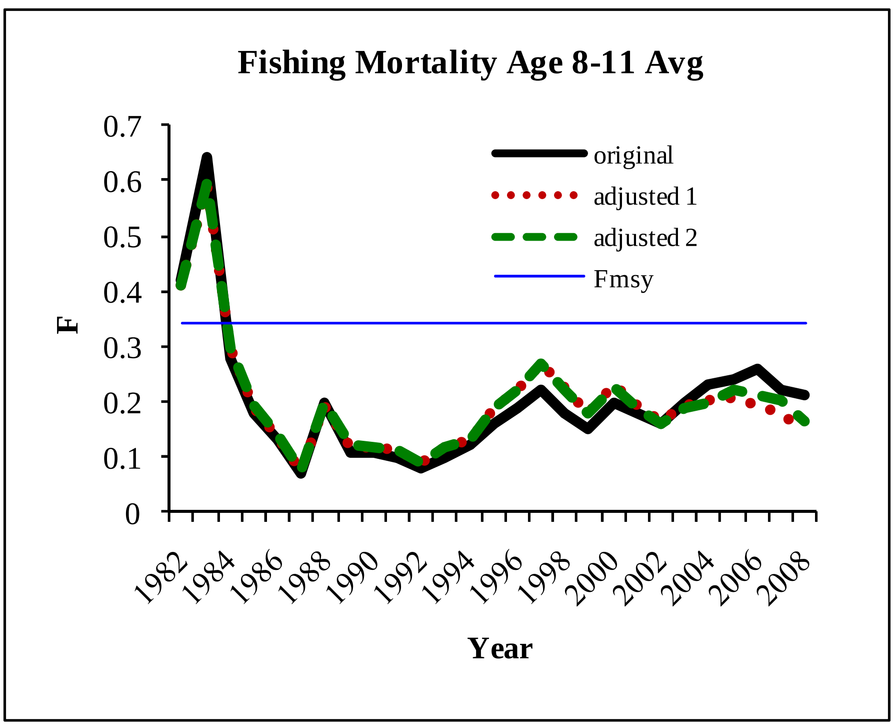

Figure 5. Striped bass fishing mortality (age 8-11 avg.) before and after recreational catch adjustments

Adjustment to Striped Bass Recreational Catch, Harvest and Fishing Mortality (F) due to Systematic Bias in the MRFSS from 1982 to 2008

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January 12, 2010

Report to the ASMFC Striped Bass Technical Committees

EXECUTIVE SUMMARY

Recreational finfish landings estimates from the Marine Recreational Fisheries Statistics Survey (MRFSS) are essential components in finfish stock assessments, in landings allocation issues among stakeholders and in setting annual harvest quotas for many fully exploited finfish stocks. Recently, Crecco (2009) reported that the MRFSS has overestimated recent (2000-2008) recreational angler, trip and catch estimates by at least a factor of 2.0. In this report, the systematic bias in MRFSS striped bass recreational catch and harvest from 1982 to 2008 was quantified using two scenarios about the long-term (1982-2008) trend in recreational fishing trips from Maine to North Carolina. The original and bias corrected striped bass recreational catch, harvest and discard estimates were used to determine the how the bias would affect age aggregated (ages 7+) fishing mortality (F), ages 7+ stock size and coast-wide percentage contribution (allocation) of commercial landings to total landings. After the bias correction in scenario 1, coast-wide striped bass recreational catches would have dropped by 33% to 51% from 1982 to 1998 and by 50% to 62% from 1999 to 2008. Under scenario 2, with an assumed 2.5% annual drop in trips after 1998, coast-wide recreational catches from 1999 to 2008 would have declined by 55 to 70%. Following bias correction, ages 7+ F on striped bass would have fallen by 38% to 54%. Current (2008) ages 7+ F was 0.27 based on original (uncorrected) MRFSS harvest estimates, 0.16 after bias correction under scenario 1 and 0.14 after bias correction under scenario 2. Despite the severe bias in MRFSS recreational landings and discards, all recent (2000-2008) F estimates, derived either before and after bias correction, would have remained well below our current overfishing threshold for striped bass (i.e. $F < F_{msy} = 0.40$). Since MRFSS recreational landings of striped bass are likely overestimated by 45% to 70% after 1999, the current (2008) coast-wide commercial landings composition would have increased from 31% under the original MRFSS landing to 52% under the scenario 1 bias correction, and further to 59% following bias correction under scenario 2. Ages 7+ stock size estimates from the index-based approach closely followed the trend and magnitude of ages 7+ striped bass stock sizes derived recently in the 2008 SCA model. Because the MRFSS bias inflated both the original recreational landings and F estimates by a similar magnitude, the magnitude and trend in ages 7+ striped bass stock size from 1982 to 2008 remained unchanged after the bias corrections.

Given the severe and wide-spread bias in MRFSS catch and landings, recreational landings estimates for other exploited finfish should not be used in stock assessments and quota-based management until they undergo bias correction.

INTRODUCTION

Recreational finfish catch and harvest estimates from the Marine Recreational Fisheries Statistical Survey (MRFSS) have played a pivotal role in setting fisheries management regulations along the Atlantic coast. These mean recreational catch (A, B1 and B2) and harvest (A, B1) estimates have been used directly to derive recreational discards and are directly tied to quota-based management of scup, black sea bass and summer flounder. In nearly all single species assessments, including striped bass, recreational harvest and discard estimates from the MRFSS are routinely merged with commercial landings/discards in catch-at-age models to estimate current fishing mortality (F) and stock size estimates. The statistical consequences, of merging mean recreational catch estimates under an assumed normal error structure with commercial census data that have no known error structure, have not been adequately addressed in catch-at-age models. Finally, recreational harvest estimates are often used in concert with commercial landings to establish allocation strategies between sport and commercial stakeholders. Despite the unconditional and wide-spread use of MRFSS recreational catch and harvest estimates, a recent National Research Council (NRC 2006) review of the MRFSS concluded, among other things, that the MRFSS random digitized telephone survey of coastal household telephones was severely flawed. They (NRC 2006) recommended that the current MRFSS landline telephone survey be replaced by a more targeted telephone survey of licensed saltwater anglers. This angler registry has already been in place since 2004 for the Pacific coast states of Oregon, Washington and California (Cahalan et al 2007). The NRC (2006) review was clear that a registry of licensed anglers was needed to “improve” upon the accuracy of recreational catch and harvest estimates, and this recommendation has been widely embraced by both MRFSS staff and State fisheries managers. However, the NRC provided no guidance on the degree of sampling bias associated with the current MRFSS telephone survey, nor did the NRC attempt to directly compare MRFSS trip, angler and catch estimates to estimates from other survey designs.

Although MRFSS trip and recreational harvest estimates are still regarded as “best available” data by fishery managers, a recent report by Crecco (2009) has shown that a growing discrepancy exists between saltwater angler estimates from MRFSS, saltwater license sales from certain states and angler estimates made periodically by the US Fish and Wildlife Service (USFWS) from 1991 to 2006. If recent (post 1999) saltwater angler and fishing trip estimates from the MRFSS are overestimated by at least a factor of 2.0 as reported by Crecco (2009) then, by extension, the MRFSS has also seriously inflated recent recreational catch, discards and harvest estimates among all recreationally-caught fish species. Errors in recreational landings of this magnitude would adversely affect our ability to provide sound management advice across all species lines.

In this report, the systematic bias in striped bass recreational catch and harvest from 1982 to 2008 was quantified and adjustments were made to the original striped bass recreational catch, landings and discards. To quantify the potential effects of the bias in our striped bass stock assessment, bias corrected MRFSS catch and landings were compared to original striped bass recreational catch, landings and discard estimates. The original and bias corrected recreational harvest and discards were then used to re-estimate the time series (1982-2008) of age aggregated (ages 7+) fishing mortality (F), ages 7+ stock size and coast-wide shift in allocation of commercial landings to the total coast-wide landings.

METHODS

MRFSS Angler, Trip and Catch Estimates

The MRFSS estimates saltwater recreational catch statistics such as mean catch/trip, avidity (mean trips/angler) and total trips each year since 1981 by merging data from two independent surveys. The MRFSS survey estimates catch/trip and other metrics on the proportion of the catch that is harvest (A, B1), released (B2) and size measurements (length and weight of the harvest) from a random access intercept survey. A random digit telephone survey of fishing and non-fishing households in coastal counties was designed to estimate the number of saltwater anglers, their avidity (average trips per angler) and total number of fishing trips. The random telephone survey accesses information from only landline telephones, so the survey excludes households with no telephone and households having only a cell phone. The MRFSS access intercept survey does include a question on cell phone use, but it is unclear how these cell phone data are used to qualify the angler data from the telephone survey. The MRFSS survey includes all minors above 5 years of age, whereas the USFWS survey does not include minors who are under 16 years of age in their total angler estimates. The proportional standard errors (PSE) about the marine angler estimates are roughly comparable between the MRFSS and USFWS methods (4-12% for the MRFSS and 4-16% for the USFWS). In its simplest form, MRFSS estimates mean total annual catch (CATCH) for each finfish species as the product of mean catch /trip of each species (CPUE) via the access intercept survey and mean total fishing trips (TRIPS) derived from the random digitized telephone survey as follows:

$$\mathbf{CATCH = CPUE * TRIPS} \qquad \mathbf{(1)}$$

MRFSS staff has always maintained that annual recreational catch and harvest estimates at the sub-regional level (i. e. N. Atlantic, M. Atlantic and S. Atlantic) are derived with relatively high precision (proportional standard error (PSE) < 20% of the mean). The MRFSS also stratifies catch and harvest estimates by area (state), wave (two month periods), and mode (shore, private boat and party/charter) with a corresponding drop in relative precision (> PSE’s) around these finer scale estimates. Despite the loss of precision, State and Federal fisheries managers have widely used these finer scaled recreational catch and harvest estimates to address state-specific quota and allocation issues. This policy is broadly accepted even though PSE levels around wave-specific catch estimates are often so high (PSE > 0.45) that wave-specific catch estimates do not differ significantly ($P > 0.05$) from zero. In this analysis, striped bass catch and harvest estimates from 1982 to 2008 were adjusted annually at the coast-wide level (combined N. Atlantic, M. Atlantic and North Carolina) rather than at a finer scale such as area (state), wave and mode. A finer scale adjustment in striped bass recreational catch and landings is clearly warranted at some point, but a more detailed breakdown of the data would have further complicated my analysis.

Bias in MRFSS Trip and Angler Estimates

Migratory striped bass are most often harvested by recreational and commercial fisheries between Maine and North Carolina, where MRFSS coast-wide estimates of anglers, trips, striped bass catch and harvest should be measured with high precision (PSE's < 0.10). Despite the high precision about the MRFSS sub-regional and annual recreational angler and trip estimates, the accuracy of these estimates appear to be low and getting worse. The MRFSS annual saltwater angler estimates for coastal states between Maine and North Carolina have always exceeded the corresponding USFWS estimates by an average of 43% prior to 2000 (Crecco 2009). After 1999, MRFSS trip and angler estimates have risen sharply and are now at least twice the magnitude of USFWS saltwater angler estimates which have remained steady since 1999 (Crecco 2009). In addition, MRFSS saltwater angler estimates in Virginia, Maryland and Florida from 1985 to 2008 have always been at least 30 to 90% greater than the adjusted (taking into account noncompliance and lack of coverage) number of saltwater fishing licenses sold annually from theses states (Figure 1 to 3). Moreover, MRFSS saltwater angler estimates in 2008 from the states of Florida, North Carolina, Delaware, Maryland Virginia and Connecticut (in 2009) have greatly exceeded (by a factor of 2.0 to 3.0) the corresponding saltwater license sales even after observed license sales were inflated two to three fold to reflect noncompliance and lack of coverage (Table 1). By contrast, adjusted saltwater license sales from Florida, Maryland and Virginia closely approximated the magnitude and trend of saltwater angler estimates based on the USFWS from 1991 to 2006 (Figures 4-6).

Critics of my previous report (Crecco 2009) have been pointed out that the MRFSS survey directly estimates fishing trip and avidity (mean trips/angler) rather than saltwater anglers. Saltwater anglers are estimated indirectly as a ratio of fishing trips to avidity so angler estimates have no direct relevancy to catch estimates in equation 1. Although angler estimates are an emergent property of trip and avidity estimates, the angler estimates play a vital role in measuring bias in trip estimates. The problem is that the degree of bias in total trip and angler avidity estimates is very difficult to measure directly because a long time series of trip and avidity estimates from independent sources with which to compare with MRFSS estimates is not readily available. By contrast, state-specific estimates of saltwater anglers have been published by the USFWS and annual saltwater license sales are available from selected States with which to serve as "ground truth" against angler estimates from the MRFSS. Moreover, our power to statistically distinguish ($P < 0.05$) between angler estimates is very high because state-specific angler estimates from both the MRFSS and USFWS are measured with high relative precision (PSE < 15%) and there is no PSE's around total counts of state-specific saltwater license sales. Moreover, the parallel increase in trip and angler estimates after 1999 (Pearson r = 0.65, P < 0.0001) from Maine to North Carolina (see Figures 2 and 3, pages 16 and 17 in Crecco 2009) strongly suggests that the source of bias in trip estimates was mainly due to systematic errors in angler estimates rather than in avidity (mean trips/angler) estimates. Angler avidity estimates have exhibited little variation over time (range in mean annual avidity for N. Atlantic 4.7 to 7.1 trips/angler) (see Figure 1 page 16 in Crecco 2009) and, unlike the angler and trip estimates, show no systematic increase since 1999. Because recreational fishing trips are estimated directly from the random telephone survey, the MRFSS telephone survey has increasingly overestimated coastal fishing households, leading to a systematic bias in saltwater anglers and fishing trips. By contrast, catch/trip estimates from the access intercept survey appear to be more reliable, given that mean striped bass catch/trip from the private boat sector from 1982 to 2001 was highly correlated (Pearson r = 0.85, P <0.0001) with striped bass abundance estimates from the SCA model (Crecco 2007), and with relative abundance estimates from the Maryland spawning stock survey (Figure 7). My findings that there is severe bias around MRFSS angler, trip and, by extension, catch estimates are consistent with those from a recent Pacific coast study (Cahalan et al 2007). From 2003 to 2005, Cahalan et al (2007) conducted side by side comparisons of avidity (mean trips/angler) and trip estimates from the MRFSS telephone survey and a telephone survey of the license angler registry in Washington, Oregon and California. This study revealed that avidity estimates were very similar between the MRFSS and the license registry across all modes (shore, private boat, party/charter), but trip estimates for shore and private boat modes from the MRFSS were at least twice as high as trip estimates from the angler registry. If avidity estimates are relatively accurate and MRFSS trip estimates are overestimated then angler estimates must also be inflated given that angler estimates are expressed as a ratio between trips and avidity.

Bias Corrections to Striped Bass Recreational Catch and Trip Estimates

Based on the aforementioned analyses, saltwater angler and trip estimates from MRFSS from 1982 to 1999 were assumed to be overestimated by a fixed average of 43% from 1982 to 1999. Thus, the long-term (1982-1999) mean adjusted trips of 26.0 million was reduced by 43% to 14.8 million and is thereafter regarded as the expected coast-wide trip estimates for the 1982-1999 time series (Table 2, Figure 8). The fact that sampling error around MRFSS trip estimates appears random prior to 2000 is based on the residual plot between annual trip estimates (trips*1000) and the 1982-1999 long-term mean trips (long-term mean = 26 million trips) (Figure 9). In this plot (Figure 9) the 1982-1999 residuals appear random across years but the post 1999 residuals all turn positive, indicating a rapid rise in trip and angler estimates after 1999. In this analysis, I assumed that the true post 1999 trend in fishing trips is either flat or declining slightly (Table 2, Figure 8) so that the apparent post 1999 rise in MRFSS angler and trip estimates is regarded here as a statistical artifact due to rising sampling bias in the telephone survey.

To examine the nature of this bias more closely, two scenarios were chosen with which to bracket the range of uncertainty around the trip estimates from 1982 to 2008. In the first scenario (Figure 8), the trend in total coast-wide fishing trips (sum of trips from Maine to North Carolina) was assumed to remain stable at 14.8 million trips from 1982 to 2008 as indicated by the uniform trends in the Virginia, Maryland and Florida saltwater license data (Figures 1 and 3). In the second scenario, total coast-wide fishing trips were assumed to remain flat at 14.8 million trips through 1999, but thereafter, trips were assumed to have dropped slightly by an annual rate of 2.5% (see Table 2, Figure 8) as indicated by the recent drop in freshwater license sales after 1999 from eight Atlantic coast states from New Hampshire to Maryland (Figures 10 and 11) and by the post 1996 drop in the estimated number of saltwater anglers from Maine to North Carolina based on the USFWS (see Table 3, page 12 in Crecco 2009).

Adjusted Estimates of Striped Bass Catch, Harvest and Discards

Once the two time series (1982-2008) of total adjusted fishing trips were established from scenarios 1 and 2 (Figure 8), adjusted total coast-wide striped bass recreational catch (ADJCATCH) for the first scenario was estimated annually from 1982 to 2008 by equation (1) using coast-wide CPE estimates and Trips (Table 2). Having total adjusted recreational catches (A, B1 and B) for scenario 1 via equation 1, several additional equations were used to estimate adjusted number of released bass (ADJB2), total adjusted harvest (ADJHARV), and adjusted recreational discards (ADJDISC) as follows:

$$\mathbf{ADJB2 = (ADJCATCH / CATCH) * B2}, \quad (2)$$

$$\mathbf{ADJHARV = (ADJCATCH / CATCH) * RECH}, \quad (3)$$

$$\mathbf{ADJDISC = ADJB2 * 0.08}, \quad (4)$$

where: CATCH, RECH and B2 in equations 2-4 represent the original (uncorrected) MRFSS total striped bass catch, harvest and released portion of the catch, respectively (Table 3). Note that the fraction 0.08 in equation 4 represents the assumed fixed hook-release mortality rate on released (B2) striped bass. These adjusted recreational striped bass catch, harvest and discard estimates for scenario 1 from 1982 to 2008 are given in Table 4. The same set of equations (equations 1-4) were used to estimate ADJCATCH2, ADJB22, ADJHARV2, and ADJDISC2 in scenario 2 with the integer “2” added to reflect recreational catch and harvest estimates for scenario 2. The time series (1982-2008) of adjusted catch, harvest and discard estimates for scenario 2 are given in Table 5.

Relative and Instantaneous (ages 7+) Fishing Mortality

In this analysis, relative fishing mortality estimates (RelF) were derived on ages 7+ striped bass from 1982 to 2008 using observed recreational landings and discards (RelF) and adjusted recreational landings under scenarios 1 (RelF1) and 2 (RelF2). The theoretical foundation of the relative F approach is based on a simple re-arrangement of the Baranov catch equation (Ricker 1975, page 13, equation 1.17) with respect to F:

$$\mathbf{F = (Harvest + Discards)/\ Mean\ Stock\ Size,} \quad \mathbf{(5)}$$

where: mean relative stock size is the average of relative abundance indices in years t and t+1. In this analysis, RelF from original MRFSS harvest and discards was based on the ratio of coast-wide annual (commercial and recreational landings plus discards) landings (numbers) of striped bass in year t to some corresponding blended striped bass abundance index (RelNt, RelNt+1) in year t and t+1:

$$\mathbf{RelF = (HARV+DISC+COMM+COMMDISC)/\ [(RelNt + RelNt{+}1)/2].} \quad \mathbf{(6)}$$

where; HARV = reported MRFSS striped bass recreational harvest;

DISC = reported recreational discards;

COMM and COMMDISC = reported commercial landings and discards.

To determine how bias adjustments might affect the trend and magnitude of relative F, adjusted recreational harvest (ADJHARV, ADJHARV2) and discard (ADJDISC, ADJDISC2) estimates from scenarios 1 and 2 (Tables 4 and 5) were substituted into Equation (6) in place of HARV and DISC, thereby generating adjusted relative F estimates for scenarios 1 and 2 (RelF1, RelF2). The striped bass relative index (RelNt) in the denominator of equation 6 represents a blended index composed of the recreational private boat cpue index from Maine to North Carolina and annual ages 7+ spawning stock indices from the annual Maryland gillnet spawning survey. These relative abundance indices are discussed below.

The first striped bass relative abundance index in numbers (BCPE) was developed annually from 1982 to 2008 (Table 6) as a recreational catch-effort ratio:

$$\mathbf{BCPE = BOATN\ /\ Effort.} \qquad \mathbf{(7)}$$

The coast-wide (Maine to North Carolina) recreational striped bass catches (BOATN, numbers) (type A, B1 and B2) and fishing effort estimates (Effort in millions of trips) in equation (7) were based on MRFSS private boat catch and effort data. Catch and fishing effort data were confined to private boats because private boat catches represent the major (> 80%) component of the total coast-wide recreational striped bass catches which are measured with high relative precision (annual CV values < 0.13). Moreover, the private boat recreational fishery is highly mobile and capable of catching striped bass of all sizes throughout their range. On the surface, it would appear that the accuracy of MRFSS boat indices (BCPE) would be adversely affected by the bias in MRFSS recreational catch and effort. However, since the MRFSS bias overestimates both catch and effort by the same magnitude and direction, the bias cancels out, leaving the recreational boat index as a reliable abundance index. In fact, the time series (1982 to 2001) of recreational abundance indices (BCPE) was shown to be highly correlated (Pearson r = 0.89, P < 0.0001) over time with ages 7+ striped bass abundance from the converged portion (1982 to 2001) of the 2007 Statistical Catch-at-Age (SCA) model run (Crecco 2007) and with the 2008 SCA run (Figure 7). Although recreational cpue data were used to tune the SCA model and are thus not independent of SCA output, the trend in striped bass stock size from the converged portion (1982-2001) of SCA is largely a function of the catch-at-age data rather than the tuning indices.

The proposed recreational boat abundance index (BCPE) for striped bass is fishery dependent and thus partially included in the total (sport, commercial and discards) coast-wide landings. However, the problem of colinearity between the recreational indices and total coast-wide landings should be relatively minor since auto-correlation between the relative abundance indices (BCPE) and total recreational and commercial striped bass landings is minimized because private boat recreational catches (type A, B1 and B2) rather than harvest (type A and B1) were used to derive the BCPE. This is important because striped bass catches taken annually in the private boat fishery are usually 8 to 10 times greater than the harvest.

An additional age 7+ striped bass abundance index (MDSSN) is available (mean N/gillnet set) from 1985 to 2008 (Table 6) based on the Maryland spring spawning stock survey from several tributaries of Chesapeake Bay (Durell et al 2009). Crecco (2007) noted that the time series (1985-2007) of ages 7+ MDSSN were highly correlated (Pearson r = 0.74, P <0.0001) to the recreational boat indices (BCPE) and to age 7+ abundance (Pearson r = 0.86, P < 0.0001) from the converged portion (1982-2001) of the 2007 SCA model run, as well as to the 2008 SCA run (Figure 7). Other striped bass abundance indices are also available from the New York haul seine survey, New Jersey trawl survey, Connecticut trawl survey, NEFSC trawl survey and the Massachusetts commercial cpue, these other indices were not used here because the trends in theses survey indices were weakly correlated (Pearson r < 0.60) to abundance estimates from the converged portion of SCA (Crecco 2007).

Given that the recreational boat indices (BCPE) and MDSSN were highly correlated with ages 7+ abundance from SCA, the most representative coast-wide abundance index (RelNt) was a blended (scaled and averaged) index based on the recreational private boat index (BCPE) and the Maryland spawning survey index (MDSSN) (Table 6). Before the two data sets indices were merged into a coast-wide index **(RelNt)**, the time series from each survey were standardized to equivalent abundance units. Equivalent units were established in a three-step process. First, the long-term mean abundance index was derived separately for the recreational boat cpue and the MDSSN. Second, a scalar was derived as a ratio of the long-term average MDSSN to the long-term average recreational private boat index (catch/trip). Finally, the annual MDSSN index was then multiplied times the scalar, thereby transforming the units of the MDSSN indices to relative units of the recreational private boat indices (Table 6). Note that the MDSSN indices began in 1985. For this reason, the 1982 – 1984 recreational private boat indices (BCPE) were used to reflect coast-wide abundance (RelNt) during those years (Table 6).

The relative F estimates from equation 6 are age aggregated (ages 7+) and do not reflect temporal and spatial shifts in the age structure. The strength of the relative F method, however, is in its transparency and intuitive appeal, allowing scientists to used observed quantities (catch and abundance indices) to evaluate how the bias in MRFSS recreational landings and discard estimates might affect the magnitude and trend in relative F estimates. More importantly, since RelFt estimates are expressed as a ratio of annual harvest to mean relative abundance, the trends in relative F are not confounded by the assumption of constant natural mortality (M = 0.15) used explicitly to derive instantaneous fishing mortality (F = Z – 0.15) for striped bass and for nearly all other exploited finfishes from ADAPT and SCA models. Moreover, tag-based estimates of striped bass natural mortality (M) indicated that the assumption of a fixed M of 0.15 across years has been violated since the late 1990's (Sadler 2009). The relative F approach was also used recently in the Peer Reviewed Weakfish Stock assessment (Crecco 2009b) to partition total mortality (Z) into natural (M) and fishing mortality (F).

The magnitude of relative F estimates from equation 6 is expressed in non-descript units, so the final step in this analysis was to transform these relative estimates to units of instantaneous fishing mortality (F). This unit transformation was carried out by a scalar that consisted of the average ratios of F to relative F across some known time period. The instantaneous fishing mortality (F) rates used for scaling consisted of the average producer area ages 7+ F estimates from 2000 to 2008 based on the instantaneous rates model (Table 25, page 91 in Sadler 2009). The ages 7+ F estimates from the catch-at-age (SCA) model were not used because F estimates from SCA are plagued by errors due to violations in the constant M assumption and from MRFSS bias in recreational harvest and discard estimates. By contrast, the tag-based F estimates based on the instantaneous and catch equation models are free from these sources of bias although the accuracy of tag-based F estimates are compromised by systematic changes in tag reporting and in the distribution of tagged fish along the coast. We currently assume a fixed coast-wide tag reporting rate of 0.43, but recent tag reporting rate studies using high reward tags in Chesapeake Bay (Goshorn et al 1999) and, more recently, among all striped bass producer areas (Sadler 2009), indicated that tag reporting rates have exceeded 0.60. If so, then current F estimates from both the instantaneous rates and catch equation models are overestimated. Since tag-based F estimates are already free from bias associated with the MRFSS recreational landings, the relative F estimates (RelF1) from scenario 1, where recreational harvest and discards have been adjusted for bias, were used to set the scalar. The scalar consisted of the ratio between the long-term (2000-2008) average ages 7+ F from the instantaneous rates model (average ages 7+ F = 0.13, SE = 007) to the corresponding (2000-2008) average RelF1 values from scenario 1 (average RelF1 =

3357.3 units). This resulted in a scalar of 0.00004 from which RelF, RelF1 and RelF2 estimates were converted to units of instantaneous fishing mortality (F).

RESULTS

The trend in the original MRFSS coast-wide recreational catches (before bias correction) of striped bass rose steadily from a low of about 0.5 million stripers in 1984 (Table 3) to peak catches of nearly 29 million stripers in 2006 . Striped bass recreational catches dropped abruptly thereafter to 19 and 14 million fish, respectively, in 2007 and 2008. After recreational catches were adjusted for bias correction in scenario 1, coast-wide striped bass recreational catches would have dropped by 33 to 51% from 1982 to 1998 and by 50% to 62% from 1999 to 2008 (Tables 3 and 4). After the scenario 2 bias correction, with an assumed 2.5% annual drop in trips after 1998, coast-wide recreational catches from 1999 to 2008 would have declined by 55 to 70% (Tables 3 and 5). If the original MRFSS trip and striped bass catch estimates are overestimated at levels suggested by scenarios 1 and 2, the magnitude of coast-wide recreational catches would have dropped substantially since 1982, although the overall trend in striped bass catches would have persisted after the bias corrections were imposed (Tables 3, 4 and 5).

The original MRFSS coast-wide recreational harvest of striped bass also rose steadily over time from a low harvest of about 44 thousand stripers in 1987 (Table 3) to a peak harvest of 2.7 million stripers in 2006 . MRFSS striped bass harvest dropped slightly thereafter to 2.3 and 2.2 million fish, respectively, in 2007 and 2008. If coast-wide trips from MRFSS were corrected for bias as per scenarios 1 and 2 (Table 4), coast-wide recreational harvest would have dropped by the same magnitude as those reported for total recreational catches in scenarios 1 and 2 (Tables 3, 4 and 5). Similarly, MRFSS recreational discards (B2*0.08) of striped bass from 1982 to 2008 would have been reduced by the same percentage as the catch and harvest following bias corrections under scenarios 1 and 2 (Tables 3, 4 and 5).

Based on the index-based approach (equation 6), total ages 7+fishing mortality (Ft) estimates on stripers using original (unadjusted) MRFSS harvest and discard estimates were very high (Ft range: 1.00- 1.77) from 1982 to 1984 (Table 7) and would have clearly exceeded our overfishing threshold (Fmsy = 0.40) for striped bass. This indicated that severe overfishing had occurred on striped bass before 1985. The magnitude of Ft estimates, however, dropped abruptly thereafter to less than 0.10 by 1992 (Table 7, Figure 12), and Ft levels rose only slightly from 1996 to 2008 to 0.17 to 0.29. The current (2008) Ft estimate on ages 7+ stripers without bias correction is 0.27 (Table 7) which is still well below the overfishing threshold (Fmsy = 0.40) (Figure 12). When recreational landings were corrected for bias under scenario 1, scaled F1 estimates on striped bass would have dropped further by 6.0% to 23% (F1 range 0.81 to 1.67) from 1982 to 1984, by 8.0% to 32% from 1985 to 1999 (F1 range: 0.08 to 0.29) and by 38% to 48% from 2000 to 2008 (Table 7). Under scenario 1, the adjusted 2008 F1 estimate on ages 7+ striped bass would be 0.16. The magnitude of F2 estimates following bias correction under scenario 2 from 2000 to 2008 would have dropped by an additional 1% to 6% relative to the F estimates from scenario 1 (Table 7). Under scenario 2, the 2008 F2 level on ages 7+ striped bass would be 0.14. The results strongly suggest that a severe overestimation in striped bass recreational harvest and discards by the MRFSS has inflated recent (2000-2008) fishing mortality rates on striped bass by an average of 42%, although the overall trend in F from 1982 to 2008 would have been maintained even after the landings were corrected for the MFRSS bias. Finally, it is important to note that all recent (2000-2008) F estimates, that were derived before and after bias correction, remained well below our current overfishing threshold for striped bass (i.e. F < Fmsy= 0.40) (Figure 12). Clearly, striped bass from the Hudson, Chesapeake and Delaware stocks have not been overfished since the early 1980's. However, other exploited finfish stocks (i.e. summer flounder, winter flounder and tautog), that are believed to be fully or over exploited, may in fact, be exploited at much lower levels if MRFSS recreational harvest and discards for these stocks were subject to bias correction.

The percentage allocation of coast-wide commercial striped bass landings and discards to total coast-wide striped bass landings would have been significantly altered following the bias correction of the MRFSS recreational landings. Under the original MRFSS recreational landings, commercial landings and discards comprised between 42 to 86% of the total coast-wide landings from 1982 to 1993 (Figure 13). The percentage of commercial landings fell to 21% to 37% from 1994 to 2008. The current (2008) contribution of coast-wide commercial landings is about 31% of the total. After bias corrections under scenario 1, the percentage of commercial landings would have risen particularly after 1999 by 44% to 60% (Figure 13). Furthermore, the current (2008) coast-wide commercial landings allocation would have increased from 31%, under the original MRFSS landing to 52% following the scenario 1 bias correction, and further to 59% after the imposition of bias correction under scenario 2.

The average annual stock size (millions of fish) of ages 7+ stripers was also estimated from 1982 to 2008 as a ratio of ages 7+ recreational and commercial landings and ages 7+ F from the index-based approach. The trend and magnitude of these ages 7+ stock size estimates (Figure 14) closely followed the trend and magnitude of ages 7+ striped bass stock sizes derived recently in the 2008 SCA model by Nelson (2009). Since the MRFSS bias overestimated the original recreational landings and F by a similar magnitude, both the magnitude and trend in striped bass stock size remained unchanged after bias correction.

Literature Cited

Cahalan, J and 12 other authors. 2007. Comparison of effort estimates from Pacific Coast Marine Recreational Fisheries Surveys: 2003-2005. Prepared by the Pacific RecFIN Statistical Subcommittee for the RecFin Technical Committee. April 2007, 91 pages.

Crecco, V. 2007. Estimating fishing mortality (F) on ages 8+ striped bass based on landings and survey indices from 1982 to 2006. Report to the ASMFC Striped Bass Stock Assessment Subcommittee, August 19, 2007, 25 pages.

Crecco, V. 2009. Correction for systematic bias in recreational catch, harvest and trip estimates from the MRFSS since the year 2000. Report to the ASMFC Striped Bass and Weakfish Stock Assessment Subcommittees, August 19, 2009, 21 pages.

Crecco, V. 2009b. Terms of reference #4 for the Peer Review of Atlantic coast weakfish. Evaluation of the relative F approach. Report to the 48th Stock Assessment Workshop, Stock Assessment Review Committee, June 2009, 22 pages.

Durell, E. A. Guiliano and J. Horn. 2009. Maryland Striped Bass Compliance Report to ASMFC. Fisheries Service, Maryland DNR, June 2009, 29 pages.

Goshorn, C. and four other authors. 1999. Revised estimates of the 1997 striped bass rate of fishing mortality in Chesapeake Bay. Maryland DNR, February 1999, 29 pages.

National Research Council, 2006. Review of the Recreational Fisheries Survey Methods. National Research Council Report to the National Academies of Sciences, 88 pages.

Nelson, G. 2009. 2008 fishing mortality (F) and stock size estimates for striped bass based on the Statistical Catch-at-Age (SCA) model. Report to the ASMFC Striped Bass Stock Assessment Subcommittee, August 15, 2009, 41 pages.

Ricker, W. E. 1975. Computation and Interpretation of Biological Statistics of Fish Populations. J. Fish. Res.Bd. Can. Bull. 191, 382 pages.

Sadler, P. 2009. ASMFC Striped Bass Tagging Subcommittee Summary of the USFWS Cooperative Tagging Program results. Report to the ASMFC Striped bass Technical Committee, September 15, 2009, 185 pages.

Table 1. Recent saltwater license sales for the states of Connecticut, Delaware, Maryland, Virginia, North Carolina, and Florida, the 2006 USFWS estimates of saltwater anglers for each of these state and 2008 saltwater angler estimates from the MRFSS for each state.

State	2008 License Sales	Adjusted Licenses	2006 USFWS	2008 MRFSS
CT	41,581*	124,743 /1	157,000	504,276
DE	87,708	112,944 /2	117,000	315,077
MD	175,363	350,726 /3	372,000	1,200,163
VA	122,350	244,700 /3	352,000	891,349
NC	411,886	823,772 /3	519,000	1,969,675
FL	1,417,433	2,834,866/3	2,002,000	5,869,681

- Connecticut initiated a saltwater license on July 1, 2009

1/ The 2009 Connecticut saltwater license sales were tripled

2/ Delaware ‘all waters’ license sales were increased by 25% to reflect non-licensed saltwater anglers

3/ Maryland, Virginia, North Carolina and Florida saltwater license sales were doubled to reflect lack of coverage and non-compliance to license possession

Table 2. Coast-wide striped bass catch per effort (RECCPE), original coast-wide trips (TEFFORT), adjusted trips (ADJEFFORT) for scenario 1 and adjusted trips (ADJEFFORT2) for scenario 2.

YEAR	RECCPE	TEFFORT	ADJEFFORT	ADJEFFORT2
1982	0.03852	25976.8	14834.3	14834.3
1983	0.02287	30228.3	14834.3	14834.3
1984	0.02187	24887.5	14834.3	14834.3
1985	0.0204	25196.3	14834.3	14834.3
1986	0.03783	29299.3	14834.3	14834.3
1987	0.03086	24369.6	14834.3	14834.3
1988	0.04309	25400.2	14834.3	14834.3
1989	0.05831	21245.9	14834.3	14834.3
1990	0.07982	22762.6	14834.3	14834.3
1991	0.12523	26540.6	14834.3	14834.3
1992	0.1646	22287.6	14834.3	14834.3
1993	0.18199	26231.8	14834.3	14834.3
1994	0.30702	27687.5	14834.3	14834.3
1995	0.39893	27241.5	14834.3	14834.3
1996	0.49967	27287.4	14834.3	14834.3
1997	0.5886	29787.4	14834.3	14834.3
1998	0.64694	25710.1	14834.3	14834.3
1999	0.56557	25141.3	14834.3	14834.3
2000	0.54667	34676.3	14834.3	14463.44
2001	0.42283	36890.1	14834.3	14092.59
2002	0.51123	30823.4	14834.3	13721.73
2003	0.49461	35163.6	14834.3	13350.87
2004	0.57829	34421.3	14834.3	12980.01
2005	0.5775	36856.7	14834.3	12609.16
2006	0.74909	38253.4	14834.3	12238.3
2007	0.48699	39396	14834.3	11867.44
2008	0.38119	36964.4	14834.3	11496.58

Table 3. Time series of observed total striped bass recreational catch (N*1000), recreational harvest (RECH), releases (B2), recreational discards (DISC), commercial harvest (N*1000) and commercial discards (COMMDISC) and total coast-wide harvest (THARV) from 1982 to 2008).

YEAR	CATCH	RECH	B2	DISC	COMM	COMM DISC	THARV
1982	1000.5	217.3	783.2	62.66	428.6	57.7	766.26
1983	691.3	307.1	384.2	30.74	357.5	32.3	727.64
1984	544.4	118.0	426.4	34.11	870.9	61.9	1084.91
1985	514.1	139.5	374.6	29.97	174.6	56.7	400.77
1986	1108.3	115.6	992.7	79.42	17.7	172.2	384.92
1987	752.0	43.8	708.2	56.66	13.6	125.1	239.16
1988	1094.4	92.5	1001.9	80.15	33.3	238.9	444.85
1989	1238.9	38.1	1200.8	96.06	7.4	338.4	479.96
1990	1816.8	163.2	1653.6	132.29	115.6	510.1	921.19
1991	3323.8	262.5	3061.3	244.90	153.8	327.2	988.40
1992	3668.6	300.5	3368.1	269.45	230.7	186.3	986.95
1993	4773.9	428.7	4345.2	347.62	312.9	347.9	1437.12
1994	8500.7	565.7	7935.0	634.80	307.4	359.0	1866.90
1995	10867.5	1108.6	9758.9	780.71	534.9	576.7	3000.91
1996	13634.6	1200.0	12434.6	994.77	766.5	426.6	3387.87
1997	17532.9	1648.1	15884.8	1270.78	1058.2	616.3	4593.38
1998	16633.0	1457.1	15175.9	1214.07	1223.8	243.1	4138.07
1999	14219.1	1446.4	12772.7	1021.82	1103.8	153.0	3725.02
2000	18956.6	2025.1	16931.5	1354.52	1057.7	616.9	5054.22
2001	15598.3	2085.1	13513.2	1081.06	941.7	241.6	4349.46
2002	15757.7	1973.2	13784.5	1102.76	654.1	166.8	3896.86
2003	17392.2	2545.1	14847.1	1187.77	869.0	253.3	4855.17
2004	19905.6	2615.6	17290.0	1383.20	907.5	366.3	5272.60
2005	21284.8	2335.4	18949.4	1515.95	968.2	776.8	5596.35
2006	28655.1	2750.9	25904.2	2072.34	1049.6	216.8	6089.64
2007	19185.3	2316.2	16869.1	1349.53	1019.6	340.2	5025.53
2008	14090.3	2235.7	11854.6	948.37	1006.7	395.4	4586.17

Table 4. Adjusted striped bass recreational catch (Adjcatch, N*1000), adjusted harvest (Adjharv), adjusted B2 (AdjB2) and adjusted discards (Adjdisc) based on scenario 1, 1982-2008

YEAR	ADJCATCH	ADJHARV	ADJB2	ADJDISC
1982	571.35	124.09	447.25	35.78
1983	339.25	150.71	188.54	15.083
1984	324.49	70.33	254.16	20.333
1985	302.68	82.13	220.55	17.644
1986	561.13	58.53	502.61	40.208
1987	457.76	26.66	431.1	34.488
1988	639.15	54.02	585.13	46.811
1989	865.02	26.6	838.42	67.074
1990	1184	106.36	1077.64	86.212
1991	1857.77	146.72	1711.05	136.884
1992	2441.77	200.01	2241.76	179.341
1993	2699.68	242.43	2457.25	196.58
1994	4554.47	303.09	4251.38	340.111
1995	5917.87	603.69	5314.19	425.135
1996	7412.2	652.36	6759.84	540.788
1997	8731.49	820.76	7910.72	632.858
1998	9596.96	840.72	8756.24	700.499
1999	8389.8	853.43	7536.37	602.909
2000	8109.51	866.32	7243.19	579.455
2001	6272.41	838.46	5433.95	434.716
2002	7583.67	949.64	6634.03	530.723
2003	7337.16	1073.69	6263.48	501.078
2004	8578.57	1127.23	7451.35	596.108
2005	8566.83	939.97	7626.87	610.149
2006	11112.17	1066.77	10045.4	803.632
2007	7224.1	872.15	6351.95	508.156
2008	5654.62	897.22	4757.41	380.593

Table 5. Adjusted striped bass recreational catch (Adjcatch2, N*1000), adjusted harvest (Adjharv2), adjusted B2 (AdjB22) and adjusted discards (Adjdisc2) based on scenario 2, 1982-2008

YEAR	adjcatch2	ADJHARV2	ADJB22	ADJDISC2
1982	571.35	124.09	447.25	35.78
1983	339.25	150.71	188.54	15.08
1984	324.49	70.33	254.16	20.33
1985	302.68	82.13	220.55	17.64
1986	561.13	58.53	502.61	40.21
1987	457.76	26.66	431.10	34.49
1988	639.15	54.02	585.13	46.81
1989	865.02	26.60	838.42	67.07
1990	1184.00	106.36	1077.64	86.21
1991	1857.77	146.72	1711.05	136.88
1992	2441.77	200.01	2241.76	179.34
1993	2699.68	242.43	2457.25	196.58
1994	4554.47	303.09	4251.38	340.11
1995	5917.87	603.69	5314.19	425.14
1996	7412.20	652.36	6759.84	540.79
1997	8731.49	820.76	7910.72	632.86
1998	9596.96	840.72	8756.24	700.50
1999	8389.80	853.43	7536.37	602.91
2000	7906.77	844.67	7062.11	564.97
2001	5958.79	796.54	5162.25	412.98
2002	7014.89	878.41	6136.48	490.92
2003	6603.45	966.32	5637.13	450.97
2004	7506.25	986.32	6519.93	521.59
2005	7281.81	798.97	6482.84	518.63
2006	9167.54	880.09	8287.45	663.00
2007	5779.28	697.72	5081.56	406.53
2008	4382.33	695.34	3686.99	294.96

Table 6. Private boat striped bass relative abundance (BCPE), Maryland (MDSSN) gill net index (ages 7+), blended relative abundance index (RelN) and SCA abundance of ages 7+ striped bass (SCAMN) for the converged portion (1982-2001) of the SCA model.

YEAR	BCPE	MDSSN	SCAMN	RELN
1982	0.03		589	0.03
1983	0.03		432	0.03
1984	0.02		254	0.02
1985	0.03	1.9	249	0.03
1986	0.04	6.6	373	0.05
1987	0.03	3.4	465	0.03
1988	0.08	4.6	566	0.06
1989	0.08	0.3	694	0.04
1990	0.13	32.4	1523	0.20
1991	0.18	34.1	2162	0.24
1992	0.26	55.5	2662	0.37
1993	0.28	73.9	3017	0.46
1994	0.56	73.8	3510	0.60
1995	0.70	74.4	4042	0.67
1996	0.79	115.9	4436	0.90
1997	1.03	77.9	5131	0.85
1998	1.05	72.2	5005	0.84
1999	0.95	31.9	5087	0.61
2000	0.97	48.3	5762	0.69
2001	0.75	83.1	8016	0.73
2002	0.89	76.8		0.77
2003	0.90	124.1		0.98
2005	1.04	105.9		0.98
2006	1.28	95.4		1.05
2007	0.85	64.2		0.70
2008	0.62	87.7		0.69

Table 7. Ages 7+ fishing mortality (F) based on original MRFSS harvest, ages 7+ fishing mortality (ADJF) under scenario 1 and ages 7+ fishing mortality (ADJF2) under scenario 2, 1982-2008.

YEAR	ADJF	F	ADJF2
1982	0.8474	1.0049	0.8474
1983	0.8081	1.0584	0.8081
1984	1.6652	1.7652	1.6652
1985	0.3529	0.4272	0.3529
1986	0.2833	0.3778	0.2833
1987	0.1749	0.2093	0.1749
1988	0.2924	0.3487	0.2924
1989	0.1440	0.1573	0.1440
1990	0.1490	0.1677	0.1490
1991	0.1011	0.1308	0.1011
1992	0.0773	0.0958	0.0773
1993	0.0834	0.1089	0.0834
1994	0.0827	0.1179	0.0827
1995	0.1095	0.1535	0.1095
1996	0.1094	0.1553	0.1094
1997	0.1485	0.2180	0.1485
1998	0.1664	0.2288	0.1664
1999	0.1665	0.2286	0.1665
2000	0.1752	0.2838	0.1732
2001	0.1306	0.2312	0.1272
2002	0.1049	0.1776	0.0998
2003	0.0996	0.1793	0.0938
2004	0.1110	0.1953	0.1030
2005	0.1301	0.2210	0.1210
2006	0.1433	0.2782	0.1283
2007	0.1579	0.2896	0.1420
2008	0.1560	0.2670	0.1393

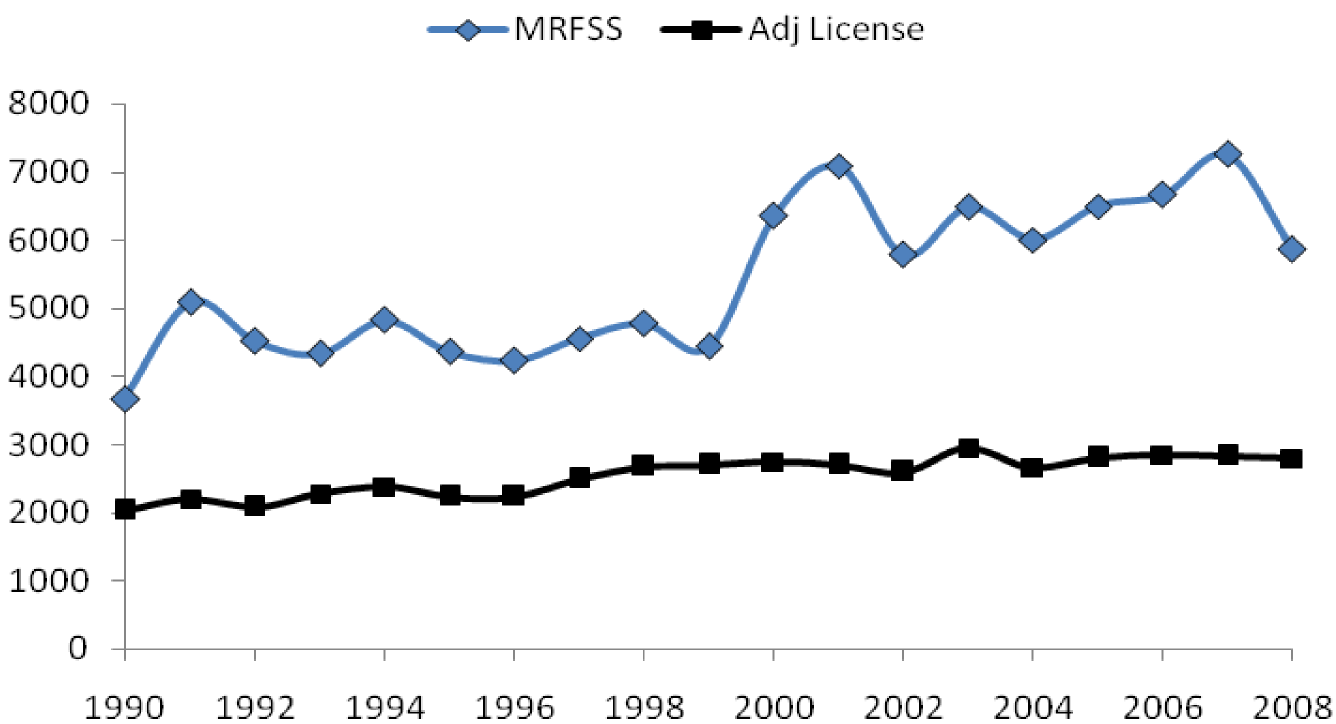


Figure 1. Adjusted Florida saltwater license sales (N*1000) as compared to MRFSS Florida saltwater angler estimates (N*1000), 1990-2008. Note that Florida saltwater licenses sales were doubled.

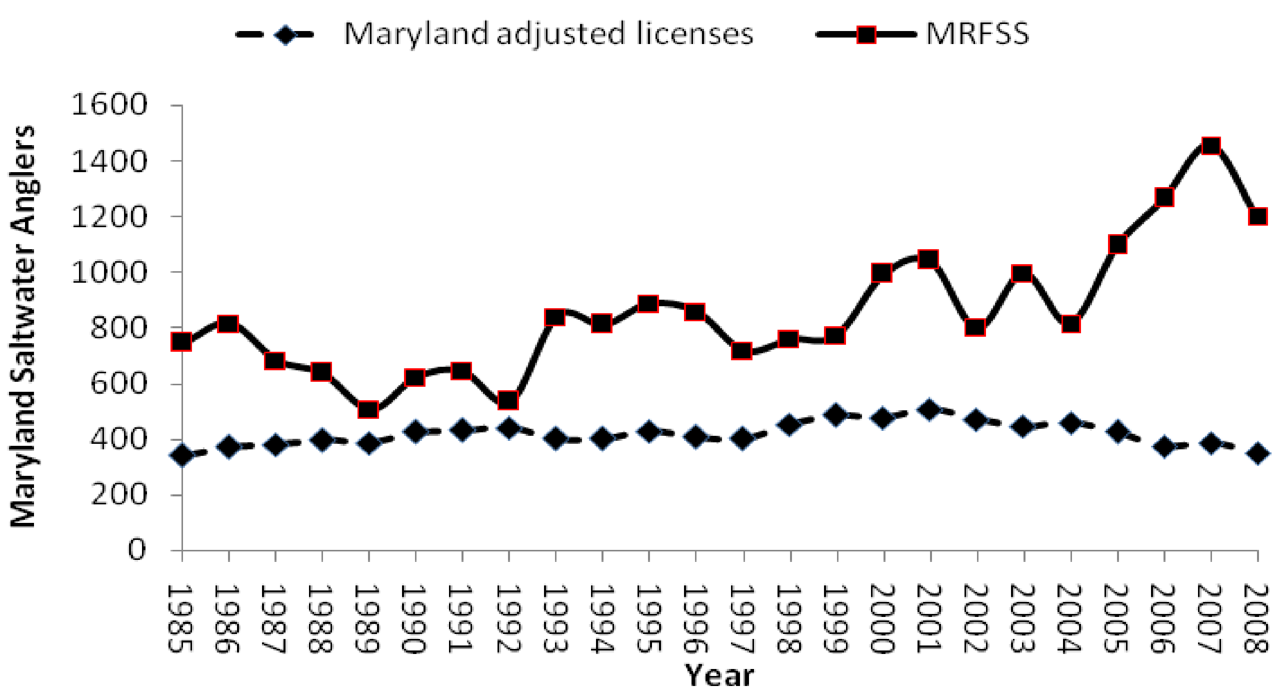


Figure 2. Plot of Maryland saltwater license sales*2.0 (N*1000) and the MRFSS saltwater angler estimates from Maryland. Note that license sales were doubled

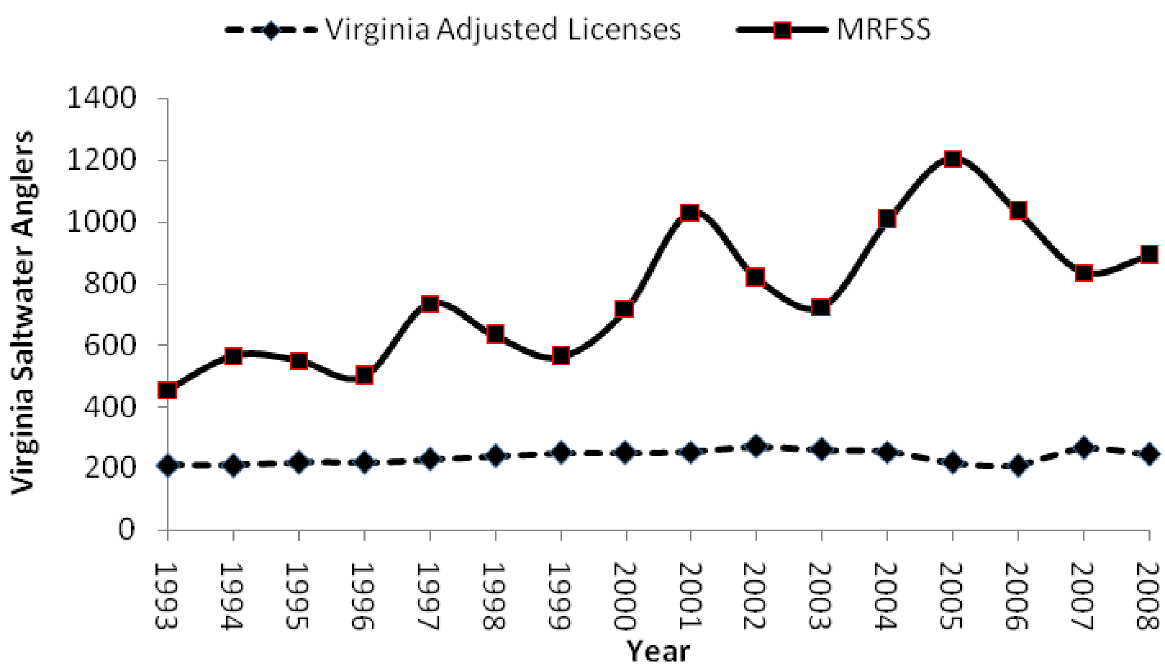


Figure 3.Plot of Virginia saltwater license sales *2.0 (N*1000) and the MRFSS angler estimates from Virginia. Note that license sales were doubled

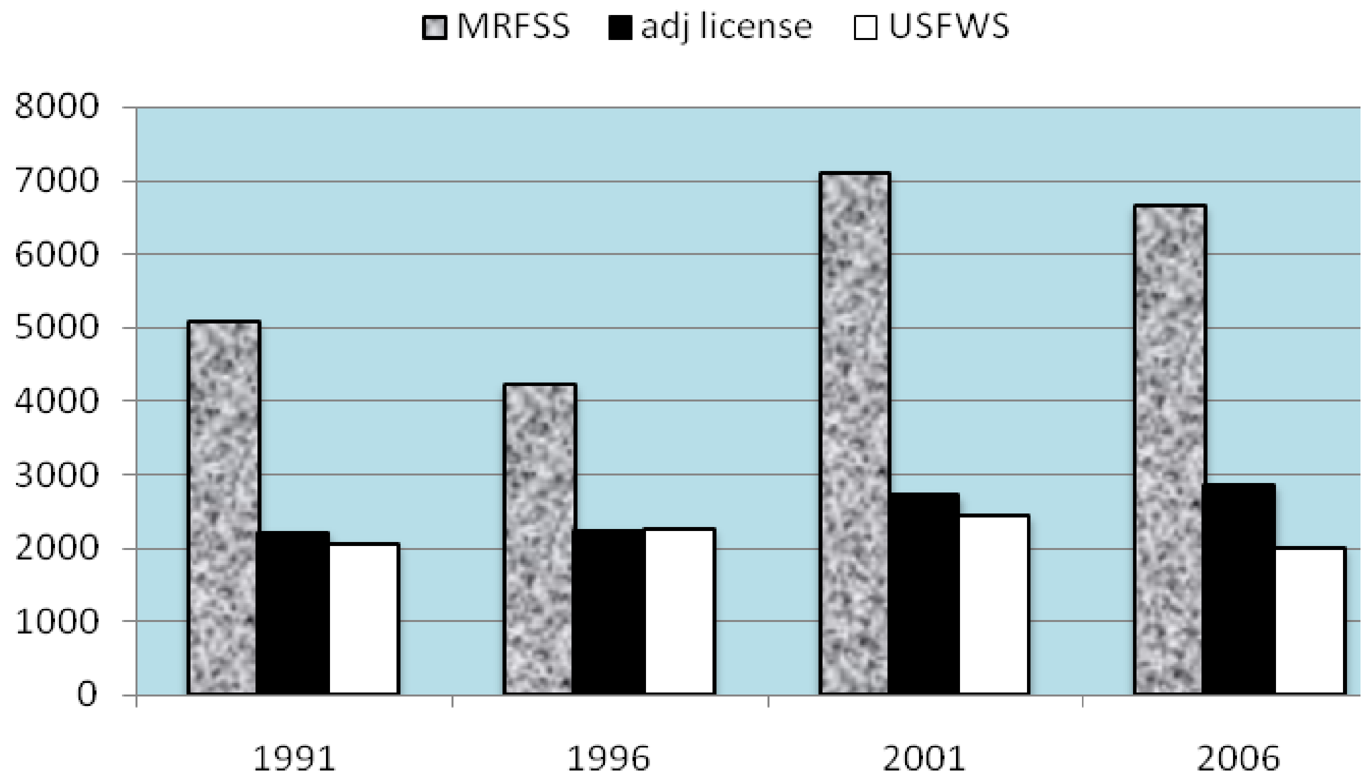


Figure 4. Comparison among Florida adjusted saltwater license sales (N*1000), USFWS Florida adjusted saltwater anglers and MRFSS Florida saltwater anglers. Note the numbers of licenses and anglers are in thousands.

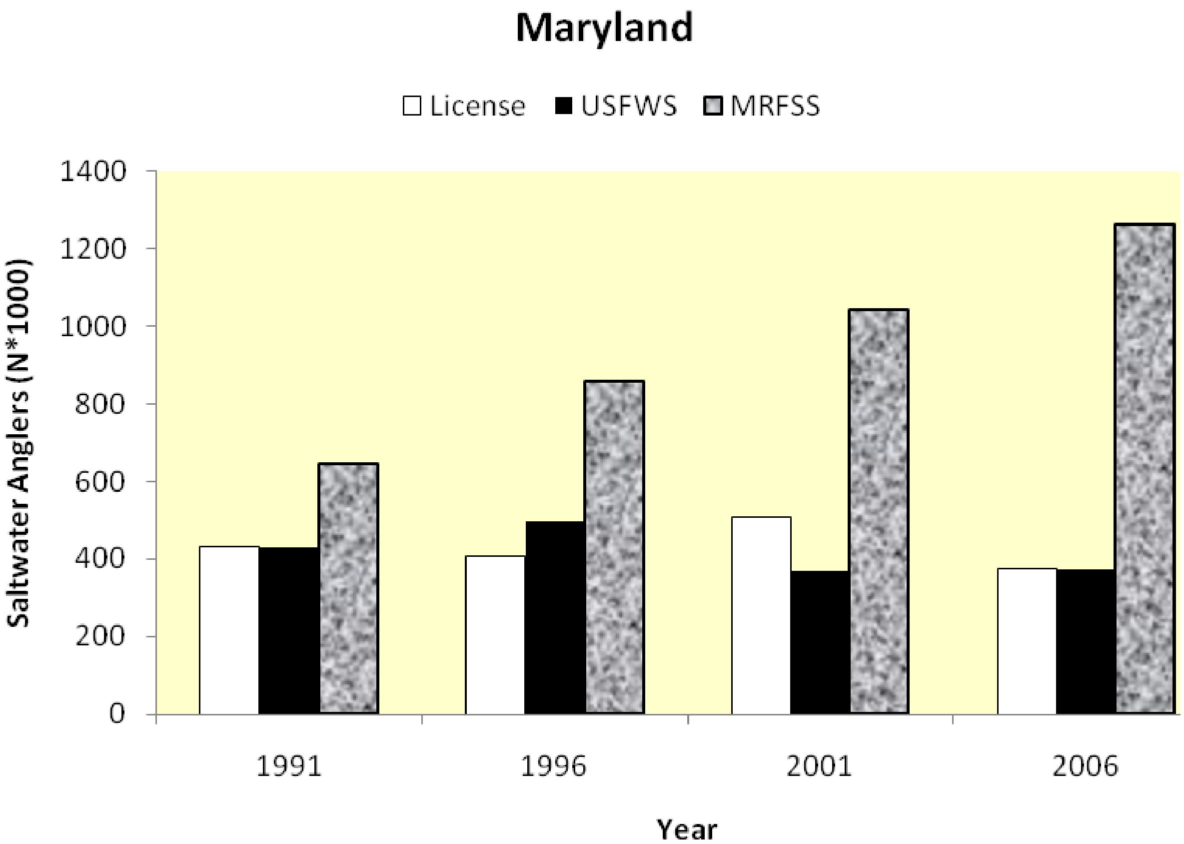


Figure 5.Plot of Maryland adjusted saltwater license sales *2.0 (n*1000), USFWS saltwater angler estimates for Maryland and the MRFSS

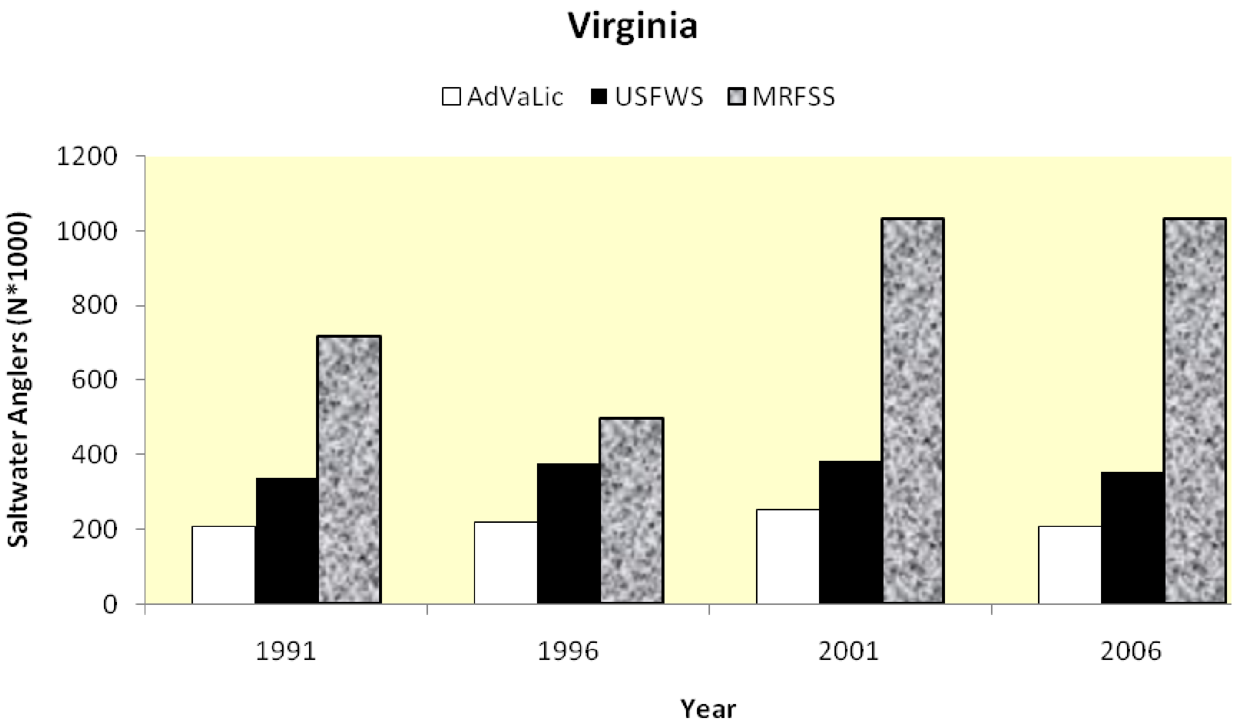


Figure 6. Plot of Virginia adjusted saltwater license sales*2.0 (n*1000), the USFWS saltwater angler estimates for Virginia and the MRFSS saltwater angler estimates for Virginia.

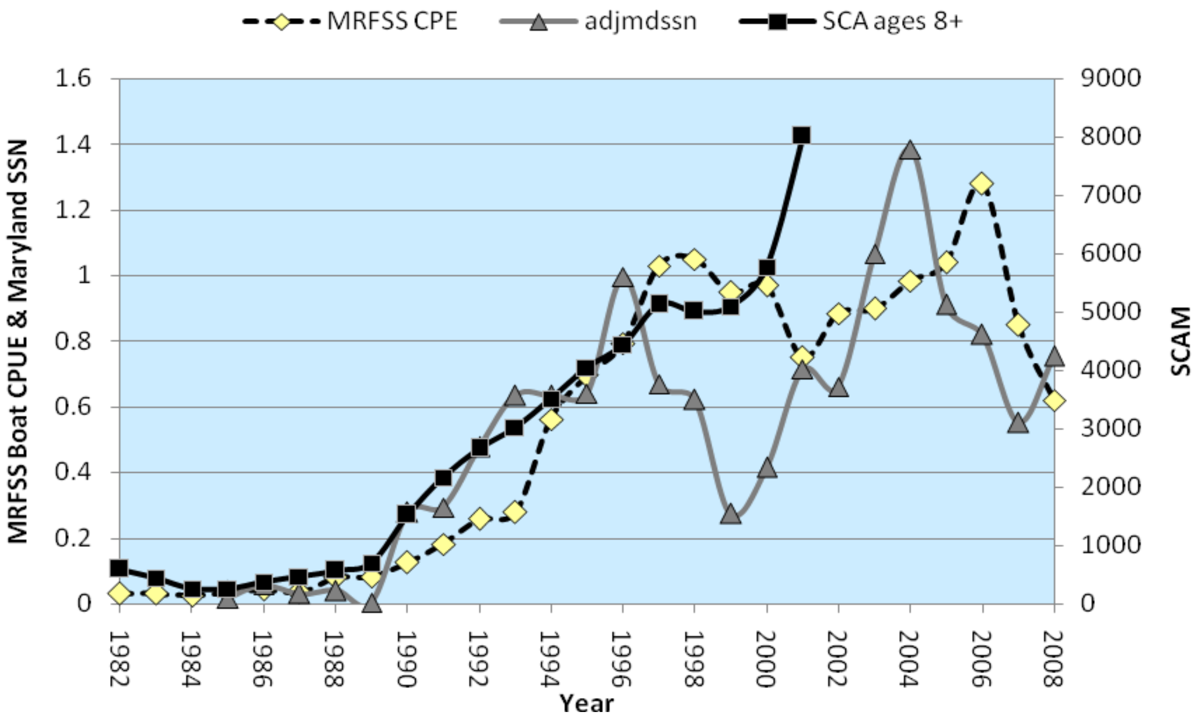


Figure 7. Comparison of MRFSS private boat CPE, Maryland SSN (ages 7+) from 1982-2008 and SCA estimate (SCAMN) of ages 7+ stripers from 1982-2001.

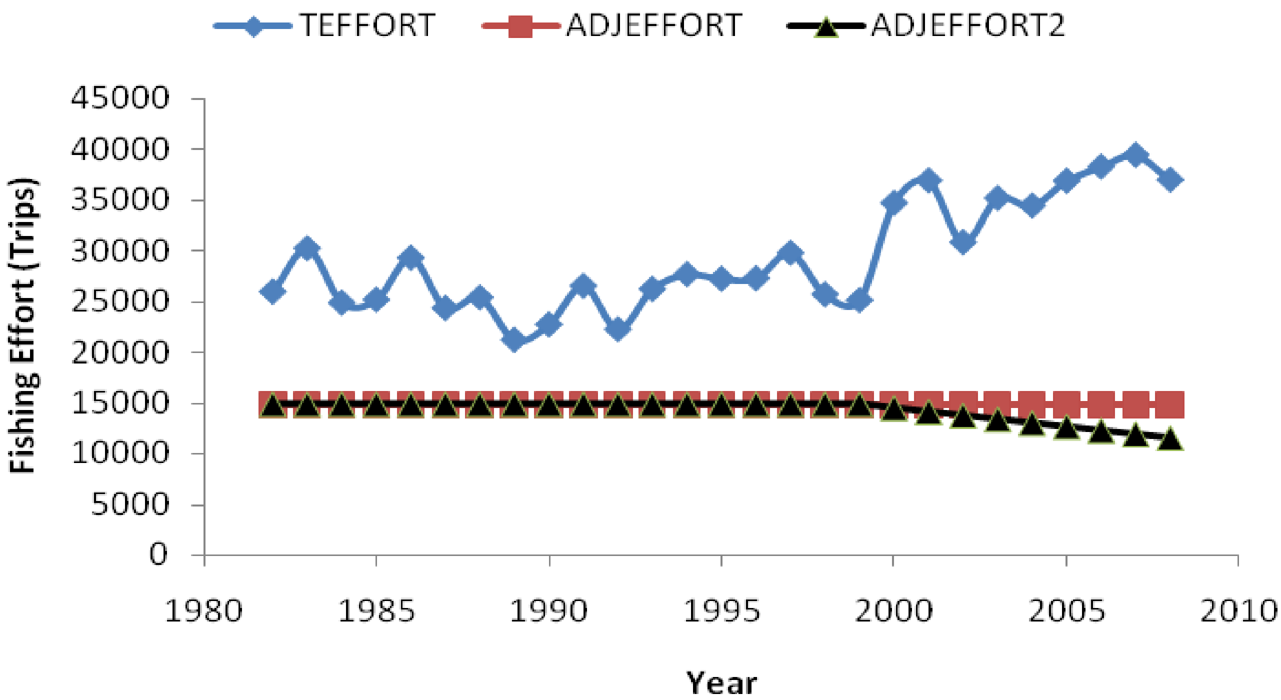


Figure 8. MRFSS total fishing (Trips*1000) effort (Teffort) from the combined North and Mid-Atlantic sub-regions plus North Carolina and adjusted trips (scenario 1) with constant fishing effort from 1982-2008 assuming that MRFSS ovestimates trips by 43% from 1982-1999 then fishing effort falls annually by 2.5% from 2000-2008 (scenario 2).

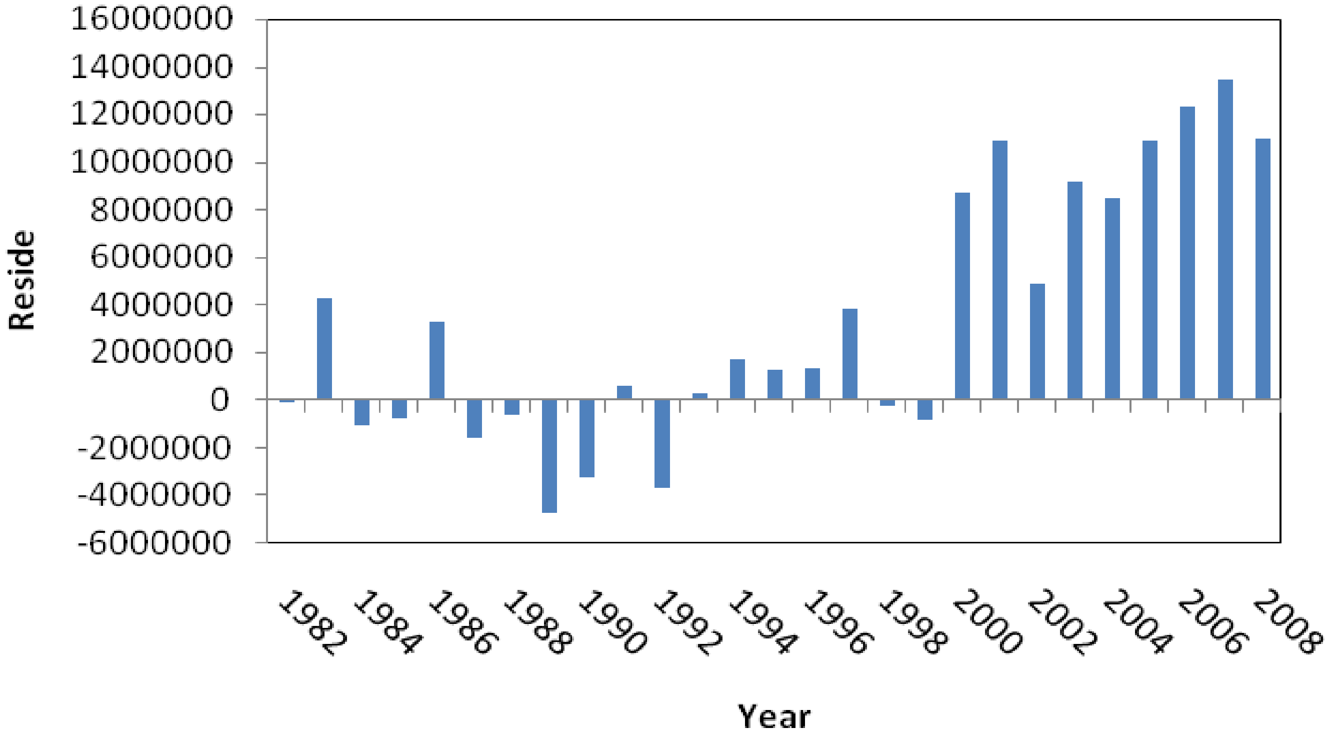


Figure 9. Residual plot between annual total trip estimates (*1000) and the long-term mean trips from 1982-2008.

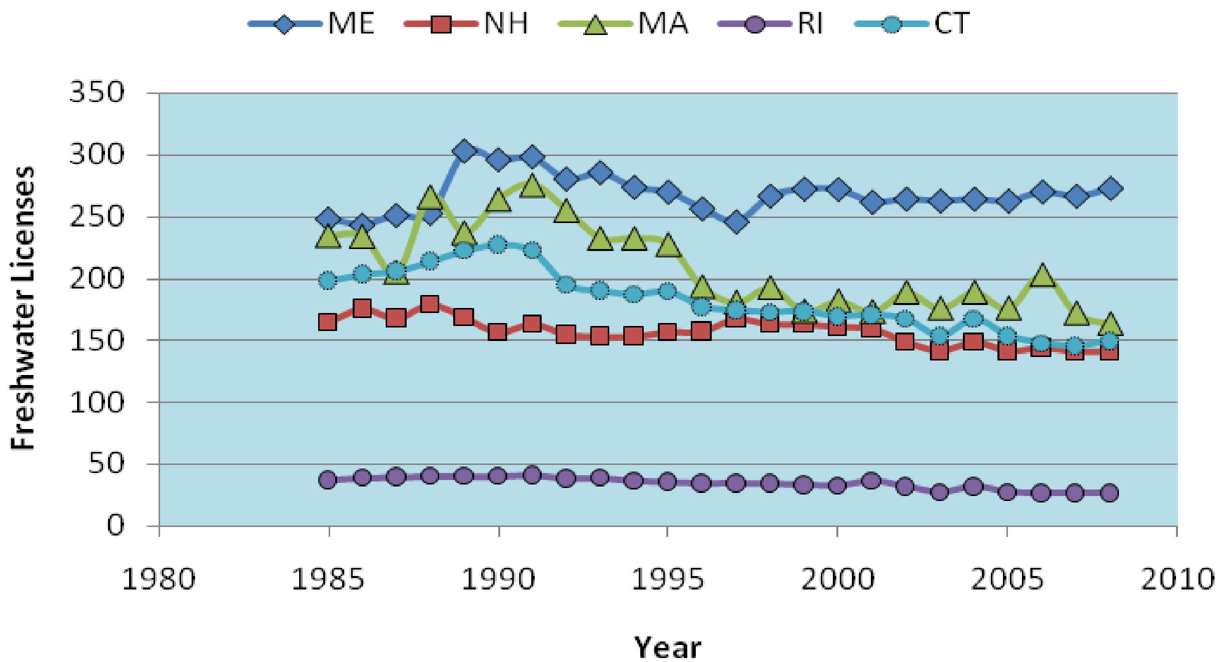


Figure 10. Trend plot of freshwater fishing licenses sales (n*1000) from North Atlantic states, 1985-2008.

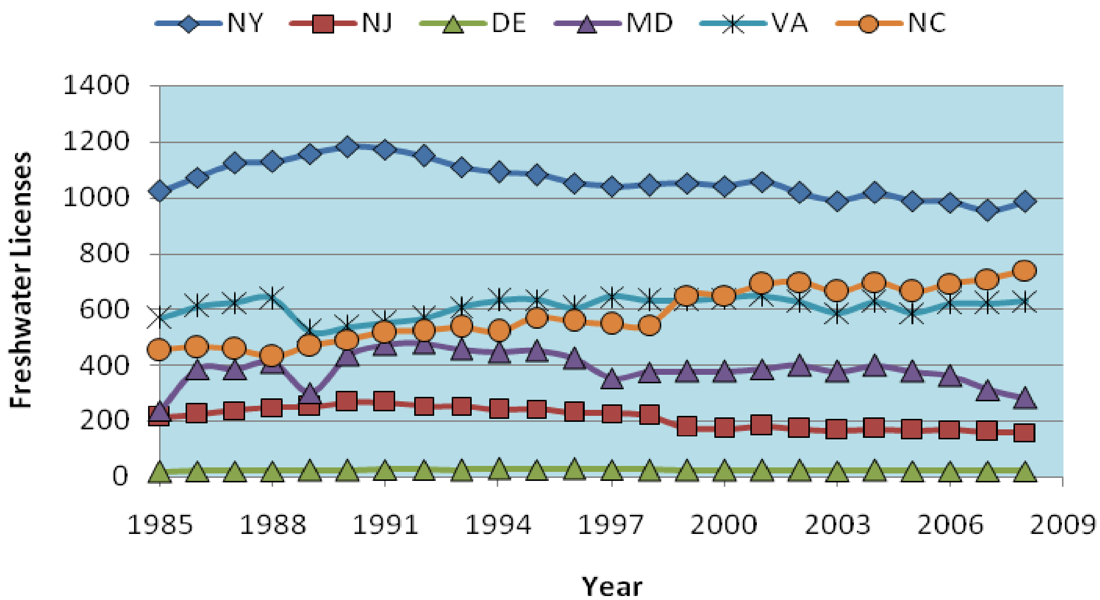


Figure 11. Trend plot of freshwater fishing license sales from Mid Atlantic states and North Carolina (N*1000), 1985-2008.

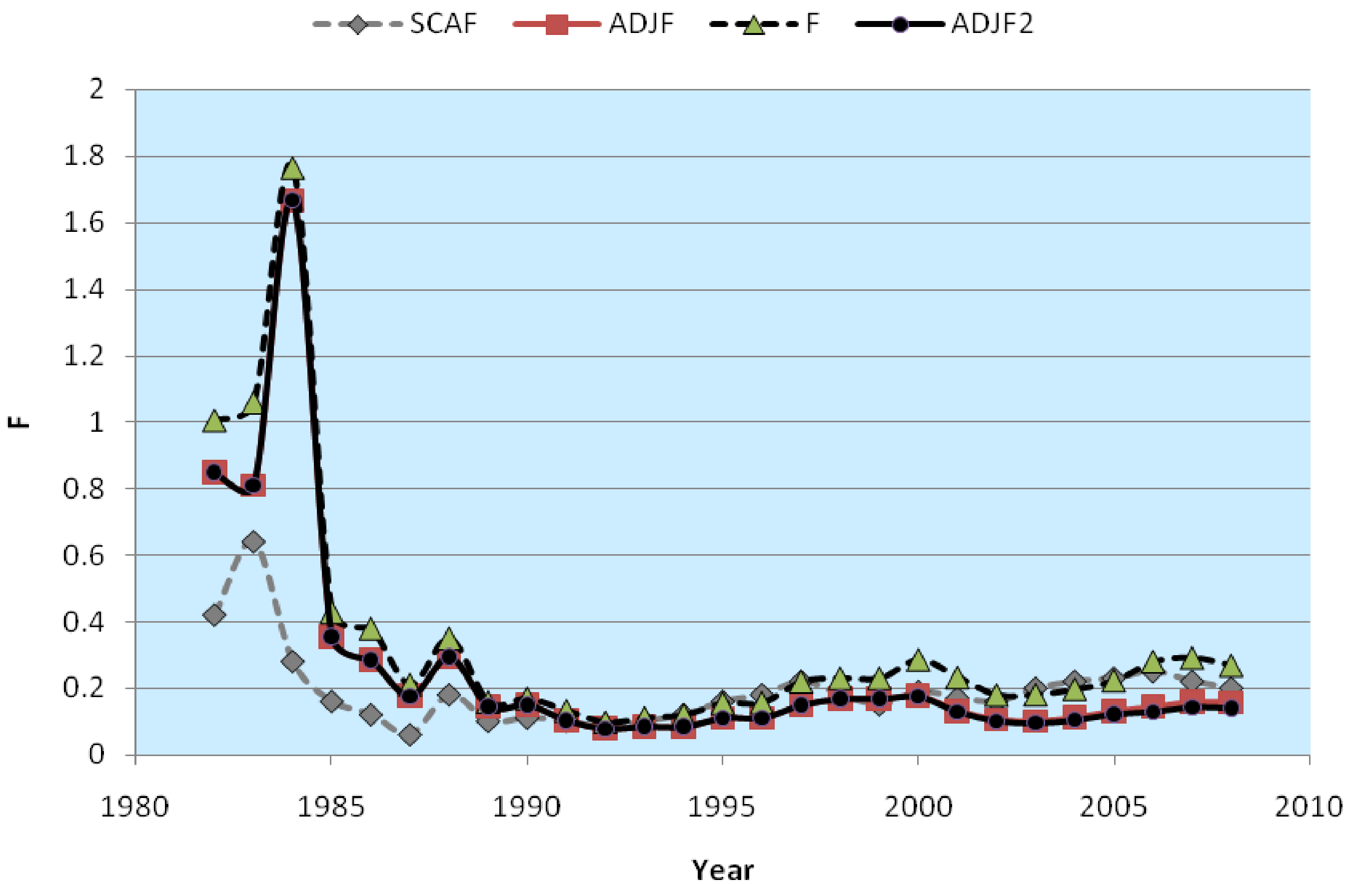


Figure 12. Comparison among (ages 7 +) fishing mortality estimates with no adjustment to MRFSS catches (F), adjustments consistent with scenario 1 (ADJF) and 2 (ADJF2), and SCA estimates of ages 7+ F (SCAF).

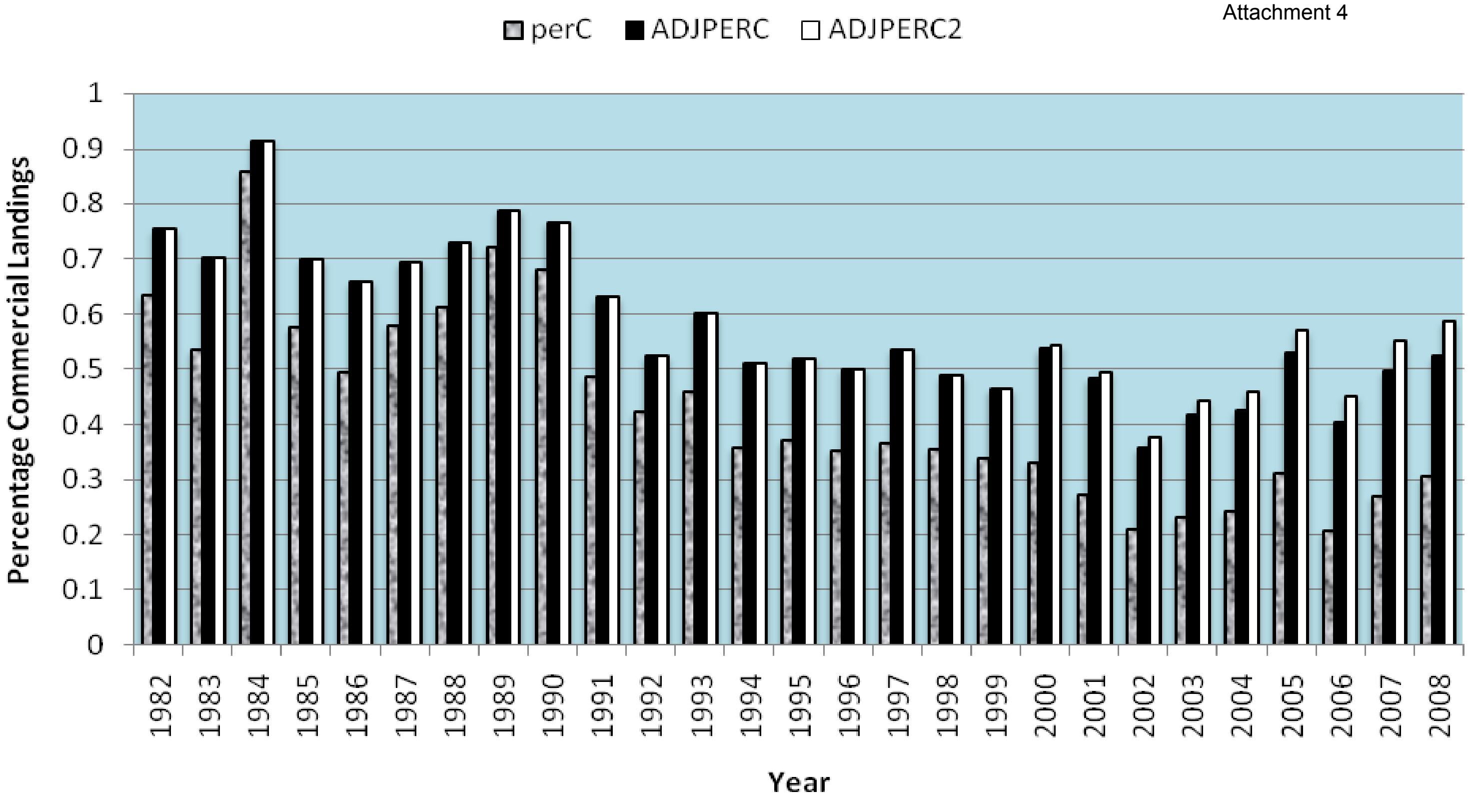


Figure 13. Bar Graph showing temporal changes in the percentage contribution of striped bass commercial landings and discards to total landings, 1982-2008 under current recreational landings (PERC) and under adjusted recreational landings via scenarios 1 (ADJPERC) and 2 (ADJPERC2).

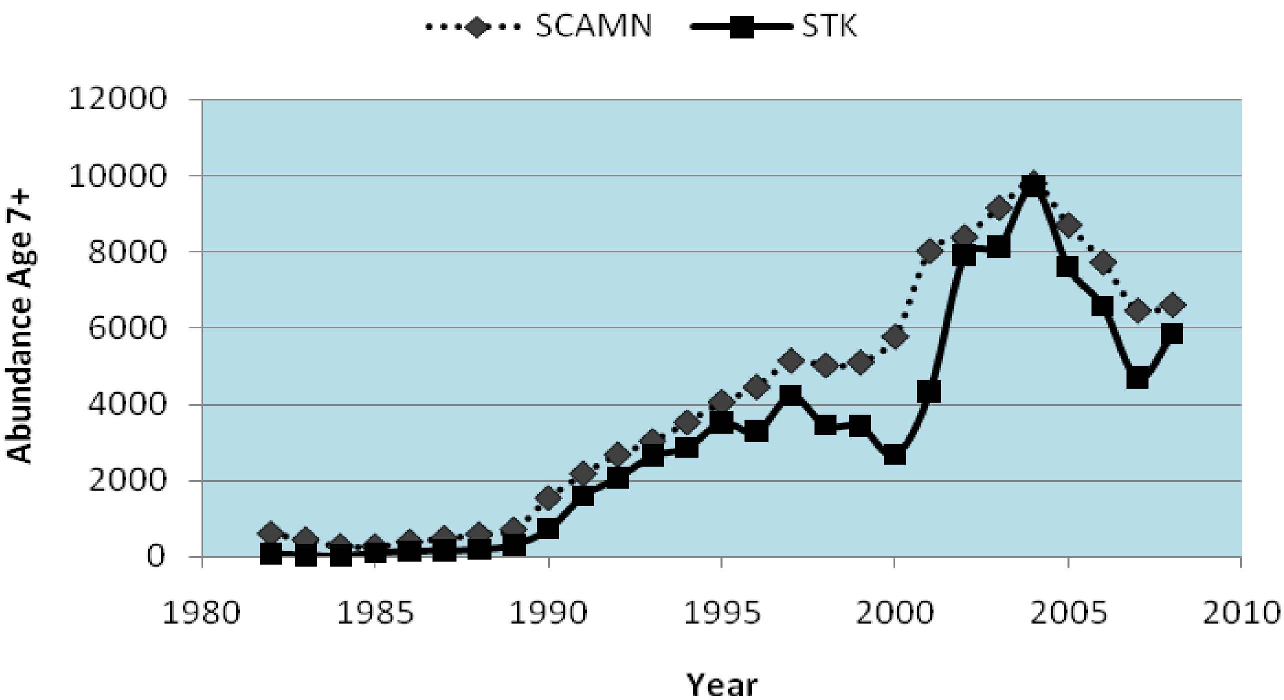


Figure 14. Estimates of ages 7+ striped bass abundance in thousands from SCA (SCAMN) and ages 7+ abundance from the index based approach.

Response to ASMFC Striped Bass Management Board Task 4: Poaching Estimates

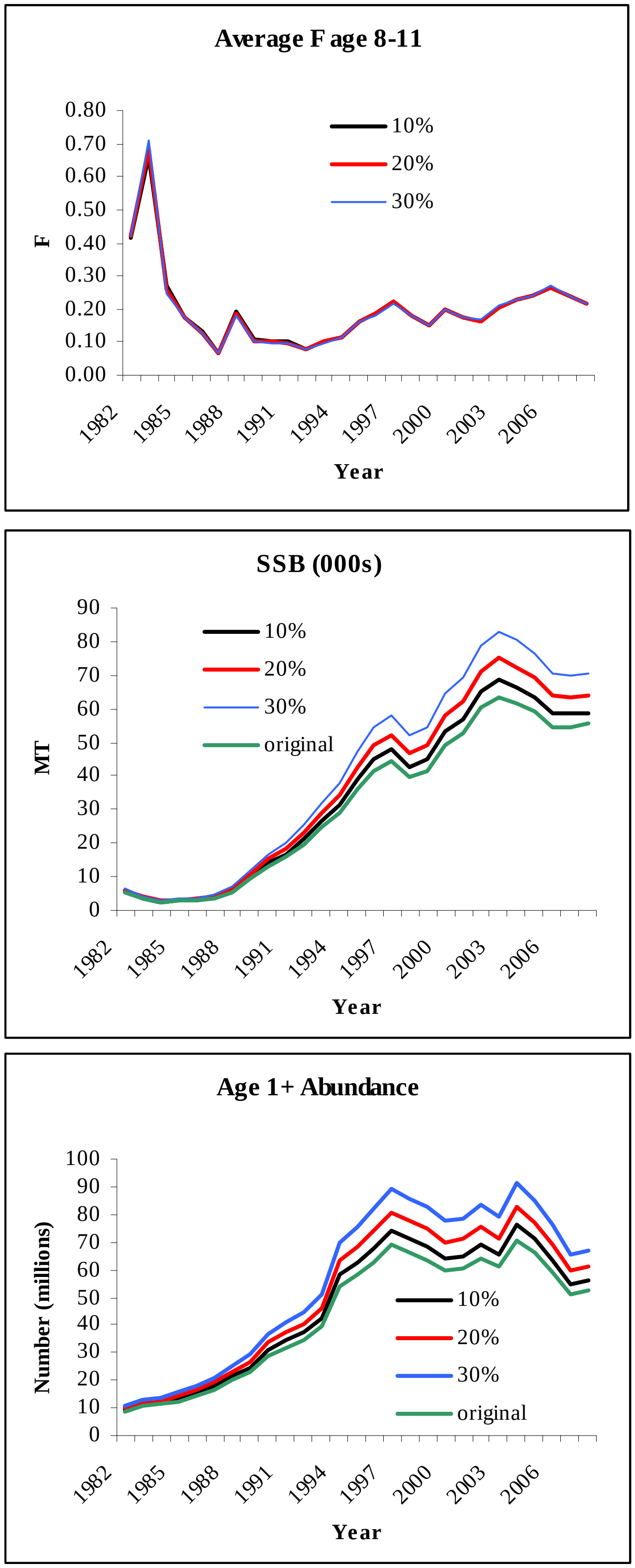
Gary R. Shepherd
Northeast Fisheries Science Center
Woods Hole, MA 02543

The Striped Bass management board requested an analysis to examine the sensitivity in the SCA catch at age model of excluding illegally caught striped bass. The catch at age was re-estimated using an adjustment to the total catch. Since there are no annual estimates of poaching catch estimates were adjusted upward by 10%, 20% and 30% across all ages and years.

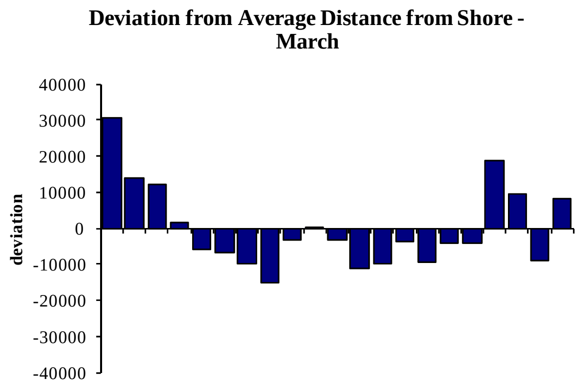
As would be expected, the constant increase in catch estimates results in a proportional increase in abundance and SSB. Fishing mortality remained unchanged because catch in the model influences the scale, not rate, of removals. The relationship was not one to one (10% increase did not produce a 10% increase in N). The relationship between N and the % increase was described by a linear function:

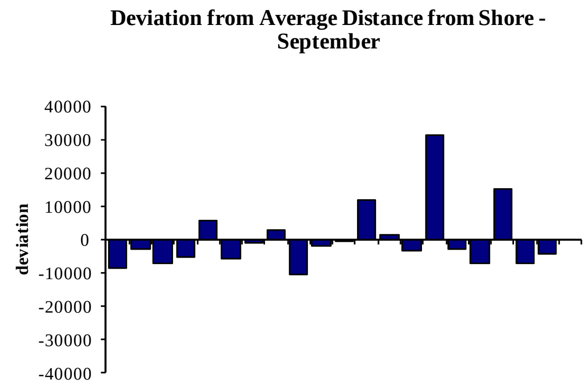
$$\%\text{increase in N} = 1.0426*(\text{percent increase})-0.0371$$

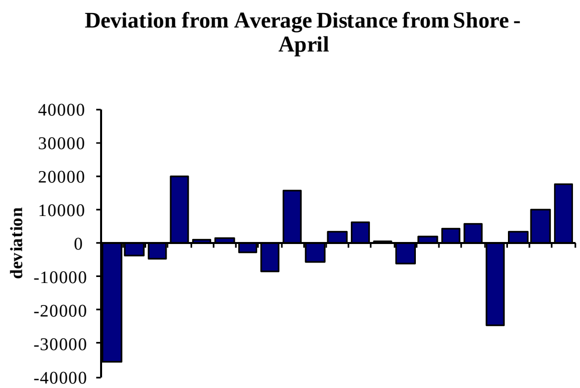
Figure 1. SCA model estimates of F, 1+ N and SSB with proportion increases in catch

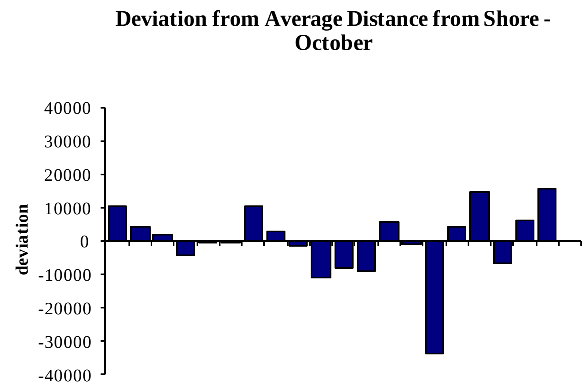


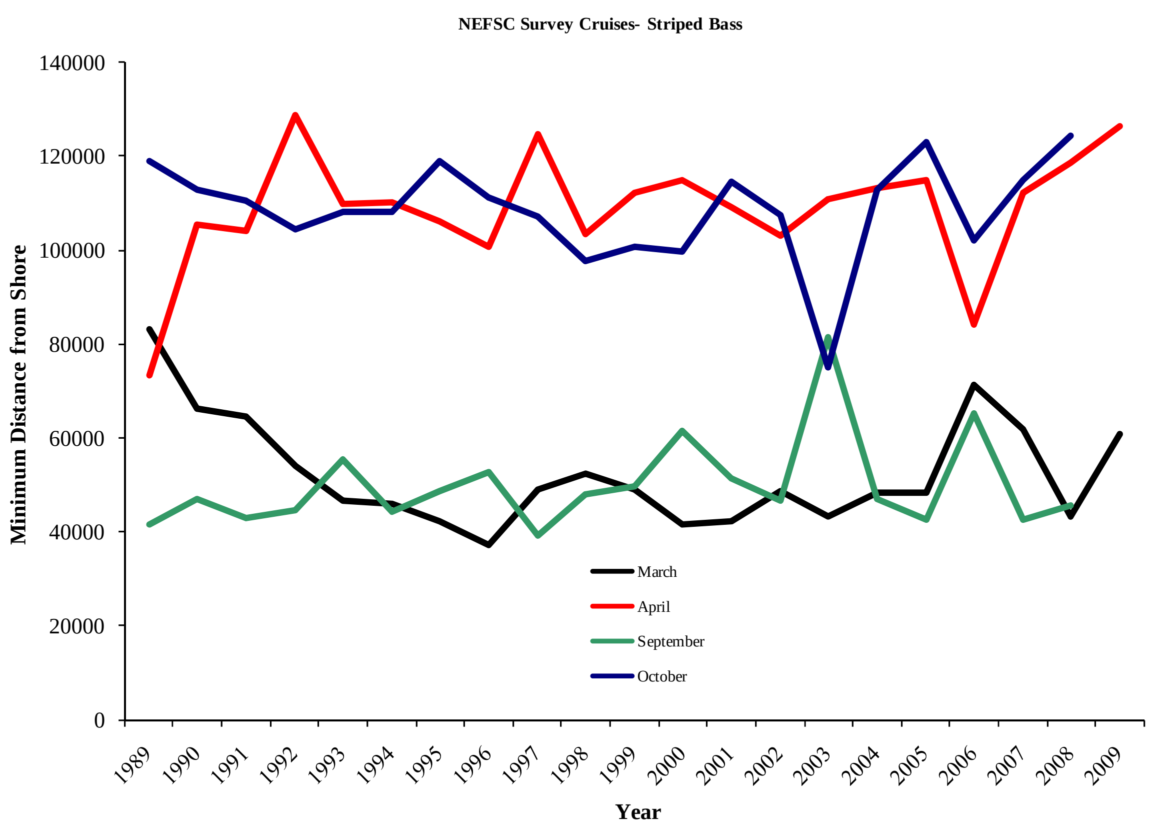
Distribution of Striped Bass Caught in the NEFSC Trawl Surveys











Massachusetts Division of Marine Fisheries Acoustic Telemetry Study:
William Hoffman, Micah Dean, Gary Nelson, and Michael Armstrong

Striped bass (*Morone saxatilis*) is an anadromous fish that is distributed along the Atlantic coast from Florida to the Canadian St. Laurence estuary and historically in the Gulf of Mexico. The Atlantic migratory coastal stocks, which originate in the Chesapeake Bay, Delaware River, Hudson River and Roanoke River/Albemarle Sound (Rago et al. 1989), undergo seasonal coastal migrations ranging from North Carolina to Nova Scotia, while stocks to the north of Nova Scotia and south of North Carolina remain within their natal rivers or estuaries (Shepherd 2006 in http://www.nefsc.noaa.gov/sos/spsyn/af/sbass). The coastal and near coastal waters off Massachusetts are one of the primary summering grounds for the Atlantic migratory coastal stock, where they feed off the nutrient-rich forage base that is inherent to these cool waters. Previous tagging studies have shown that although some smaller striped bass arrive in Massachusetts waters in early May, the main body of fish arrives in Massachusetts by the first week of June.

Through present and former tagging studies, the latitudinal movements of striped bass with season have been well documented. The inshore-offshore movements, however, are not as well known as these tagging studies were not designed to provide data to answer this question explicitly. This lack of information on movements of striped bass has an impact on management regulations as managers must rely on public perception and anecdotal information to assess the efficacy of the regulations.

In May of 2008, the Division of Marine Fisheries (Ma DMF) initiated a two phase, multi-year, study to provide fisheries managers with information that can be used to enhance evaluations of current fishing mortality and the impact of the current prohibition of recreational fishing in Federal Exclusive Economic Zone (EEZ). The primary objective of the study is to determine if striped bass located in the EEZ, adjacent to Massachusetts, enter Massachusetts territorial waters. The secondary objectives are to identify the spatiotemporal patterns of local striped bass movements, confirm if the Cape Cod Canal is an important passageway for striped bass migration, and further investigate the temperature and depth preferences of migrating striped bass.

The study is being conducted in Massachusetts state waters from Cape Ann south to the Cape Cod Canal, with tagging sights on Stellwagen Bank, which is in the Federal EEZ approximately 17 miles east of Boston, Massachusetts. The movements of striped bass are being monitored using Vemco's © underwater acoustic telemetry tracking system which includes the V16P-6H transmitters (tags) and VR2W receivers. Moorings for the VR2W receivers were designed by Ma DMF staff with contributions from collaborating researchers and local commercial fishermen.

The first year of the study (2008) was a pilot phase and its purpose was to develop tagging techniques, mooring systems, and gain a better understanding of the range, effectiveness and durability of the Vemco© system. The second and third years of the study (2009 and 2010) are dedicated for data collection. During the 2009 season, the acoustic arrays were extended and the number of striped bass tagged increased. It is anticipated that in the third year of the study (2010) the 2009 tagging efforts and arrays will be replicated with minor improvements being made to the Massachusetts Bay (MA Bay) array. If funding is available and additional data collection is warranted, the study may be extended beyond the initially planned three years.

In year one of the study, the pilot phase (2008), we tagged 25 striped bass with a minimum size of 68 cm and a median size 92 cm in the southwest portion of Stellwagen Bank. Tags were surgically implanted in the animals over a 3-week period and no more than 12 tags were deployed during one day. An array consisting of 32 receivers designed to detect tagged striped bass entering state waters from the EEZ, was moored in state waters 1000m from the Massachusetts territorial line located north of Provincetown, MA. To investigate the migration routes used by striped bass leaving Massachusetts state waters, and confirm when the tagged fish left the study area at the end of the season, two more arrays were also deployed. One extended perpendicular from shore on the eastern side of Cape Cod off of Truro, MA, and a second that encompassed the eastern end of the Cape Cod Canal.

In year two (2009), the data collection phase was initiated. Fifty striped bass, with a minimum size of 79 cm and a median size 95 cm were tagged on the northern portion of Stellwagen Bank. Adjustments to the Truro and Cape Cod Canal array were made, and the original array off the northern tip of Cape Cod was discontinued. Two new arrays were deployed, one across the entire Massachusetts Bay and a second perpendicular to Cape Ann in Rockport, MA. The Cape Ann array was designed to investigate migration patterns and detect tagged striped bass leaving the study area to the north, and the Massachusetts Bay array was designed to detect tagged striped bass entering MA territorial waters from the EEZ.

Data from the first two years of the study have been evaluated and although an additional year of data collection will be beneficial towards completing our analysis, patterns and trends are already becoming apparent.

Combined in 2008 and 2009, 75 striped bass were tagged on Stellwagen Bank. Sixty eight (91%) of those fish tagged entered state waters in 2008 and 2009 combined and 23 out of 25 (92%) of the fish tagged in 2008 entered state waters in 2008 and 2009 combined (Table 1). Seventeen (68%) of the fish tagged in 2008 returned in 2009 and 45 (90%) of the fish tagged in 2009 entered state waters in 2009 (Table 1).

Although in 2008 the Truro gate was at times porous due to loss of receivers, and is limited because it cannot be extended further from shore, information on southern migration from waters off of Massachusetts has been obtained. Truro gate, which includes both Highland and Peaked Hill arrays, accounted for the highest number of detections with 11 (44%) of the 2008 tagged fish and 31 (62%) of the fish tagged in 2009 being detected (Table 2). The Cape Cod Canal, was also confirmed as a corridor for migrating fish, but it was used less than the Truro gate area. In 2008 7 (28%) of the 2008 tagged fish were detected, and in 2009 9 (18%) of the 2009 tagged fish were detected in the Cape Cod Canal (Table 2).

The study has also begun to elucidate areas, or corridors, of migration. Striped bass tagged on the northern portion of Stellwagen Bank in 2009 showed a tendency to move towards Cape Ann and entered state waters at four receivers located south of Gloucester, MA. These same fish were also detected exiting the Cape Ann array to the north, at or near the territorial state line (Figure 1). During late summer and early fall of both 2008 and 2009, the main corridor of travel was approximately 1500m (which was the second receiver from shore) from the Truro shoreline. In 2008, 8 out of 25 (32%) tagged fish were detected passing the second receiver in the Truro gate (Figure 2) and in 2009, 25 out of 50 (50%) tagged fish were detected (Figure 1).

The mean time that the 2009 fish remained in the EEZ after tagging and before entering state waters was 15 days (SD=34). In 2008, the mean number of days that it took striped bass tagged on the southern portion of Stellwagen Bank to enter state waters was 11 days (SD=21).

The high proportion of fish that were detected entering state waters during the first two years of the study confirms that striped bass off the shores of Massachusetts do not exclusively stay in the EEZ. In fact, it is most likely that some of the striped bass that entered Massachusetts territorial waters went undetected and that the reported proportion of tagged fish may be artificially low. This is because in 2009 we were limited to the number of receivers available to deploy. The Ma Bay array was designed to have a theoretical efficiency of 50%. After the 2010 data collection season, analysis will be done to calculate the actual efficiency of the Ma Bay array and the proportion of tagged striped bass entering state waters may be adjusted.

The design and organization of the 2010 study is currently underway. With another season of data collection, we are optimistic that more information will be available to augment our datasets and enhance analysis to complete the goals of the study. Additional analysis will be completed in 2010 to determine spatiotemporal movements of striped bass, preferred corridors for migration, and examine the use of the Cape Cod Canal as a corridor of striped bass migration.

Literature Cited

Rago, P. J., R. M. Dorazio, D. G. Duel, and R. A. Richards. 1989. Emergency striped bass research study. USFWS, and Dept Commerce, Washington, DC. 61 pp.

Table 1. Striped bass entering Massachusetts territorial waters

Year Tagged		# (total tagged fish)	P
2008	entered state waters in 2008	23 (25)	92%
2008	entered state waters in 2009	17 (25)	68%
2009	entered state waters in 2009	45 (50)	90%
2008/2009	entered state waters in 2008/2009	68 (75)	91%

Table 2. Southern movements of striped bass by array.

Year Tagged	Array Name	# (total tagged fish)	P
2008	Highland	11 (25)	44%
2008	Cape Cod Canal	7 (25)	28%
2009	Peaked Hill	31 (50)	62%
2009	Cape Cod Canal	9 (50)	18%

Figure 1. Detections by receiver in 2009.

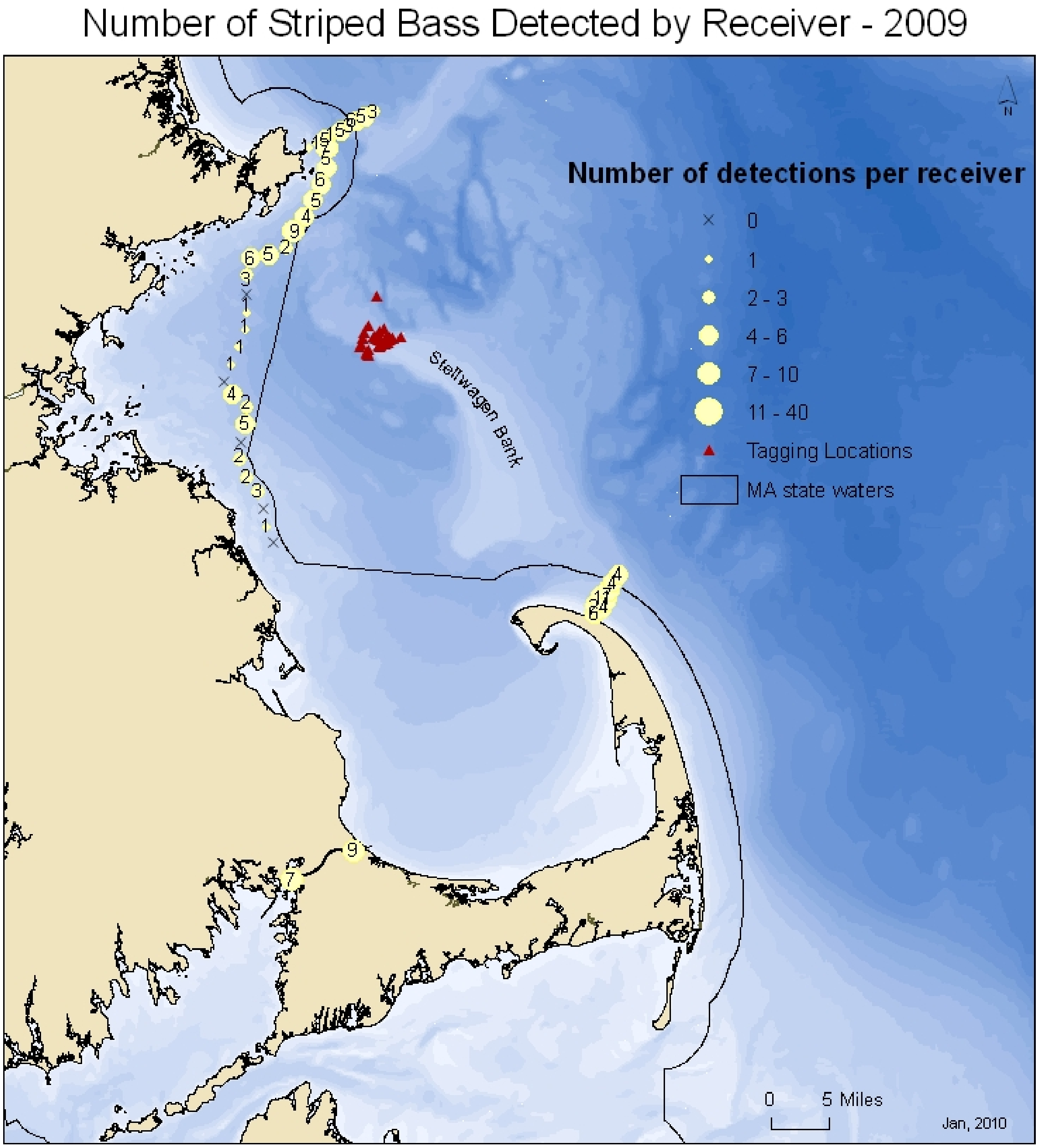


Figure 2. Detections by receiver in 2008.

Number of Striped Bass Detected by Receiver - 2008