Final Report to the Striped Bass Management Board in Response to Seven Tasks

ASMFC Striped Bass Technical Committee
Desmond M. Kahn, Chair
April 28, 2009

A Cautionary Introductory Comment

A number of the analyses presented below include estimates based on the terminal year value of fishing mortality from the Statistical Catch-at-Age (SCA) model for 2006, F = 0.31. There are several reasons to regard this estimate with a large grain of salt. These include, first, that past model performance suggests that this estimate for 2006 may decline as additional years of data are added to it (retrospective pattern or bias). To quote the summary from the 2006 stock assessment,

> "Results from retrospective analysis in the SCA suggest that the 2006 F estimate is likely over-estimated and the SSB estimate is likely under-estimated; therefore, F could decrease and SSB could increase with the addition of future years of data."

Second, we have evidence suggesting that the MRFSS recreational landings could be increasingly overestimated in recent years. Third, we have accumulating evidence that the mycobacteriosis epidemic could be causing an increase in natural mortality, in contrast to the SCA model assumption that natural mortality is constant. Fourth, recent research on the effect of using otolith ages for older fish in virtual population analysis shows that under-ageing by the use of scale ages causes an over-estimate of fishing mortality, and this could also be true for SCA modeling. Fifth, the tag-recapture estimates of fishing mortality are considerably lower than the SCA estimates for recent years; for 2006, the coastwide average fishing mortality was only 0.13. Looking at current estimates for earlier years, the SCA estimates are quite similar to those from the tag-recapture models. While the tag-recapture estimates are not exactly comparable to the SCA estimates, because they are for fish greater than 28” as opposed to fish of certain ages, they should still be roughly comparable.

Task 1. Evaluate the effect of a range of percent increases (e.g., 15%, 20%, 25%) in the coastwide [coastal] commercial quota on the fishing mortality rate

The two previously reported analyses were revised to include the commercial quotas allocated to New Jersey (321,750 lbs), Connecticut (23,750 lbs), New Hampshire (5,750 lbs), and Maine (250 lbs). None of these allocations, totaling 351,500 lbs. are currently used commercially. New Jersey, however, does use part of its quota allocation for its recreational bonus fish program, although it has never used more than 38% of that allocation. In 2007, it used only 4%. The analysis results reported below effectively double-count part of the New Jersey quota, since the laborious process of separating the bonus catch from the recreational catch-at-age input matrix was not attempted. It is important to note, then, that the new analysis presented here overstates the impact of the stated quota increases.

Regardless, both analyses indicate that the effect on fishing mortality would be an increase of about 0.01. The risk associated with this amount of increase depends on the estimate of fishing mortality it would be added to. There is uncertainty in the 2006 estimate of fishing mortality and there is no current estimate of fishing mortality available. Consequently, the Technical Committee (TC) would prefer to have the results of the 2009 Stock Assessment in hand before fully assessing the impacts of such an increase.

Analysis 1 by Dr. Gary Nelson, MA Division of Marine Fisheries:

Quotas (converted to numbers using state specific average weight per fish) not used by ME, NH, CT, and NJ from 2003-2006 were added to the original commercial harvest numbers-at-age and the statistical catch at age (SCA) model was run to get a new time series of fishing mortality estimates (named Orig). The commercial harvest numbers at-age for each year from 2003 to 2006 were then used to-calculate the numbers-at-age that results from a 15-30% increase in quotas. Resulting numbers were added to the catch-at-age matrix, and the total catch and catch proportions were calculated from it for inclusion in the SCA model. The SCA model was run for each percent increase and the estimates of the average F of ages 8-11 were obtained (Table 1). It was assumed that no reduction or increase in discards occurred with the increase in landings. Note that selectivity pattern for 1996-2006 also changed slightly because increases in harvest changed the proportions-at-age of total removals.

Table 1. Average F of ages 8-11 with commercial harvest increased 15-30% from 2003-2006.

	2006	15% Inc.	20% Inc.	25% Inc	30% Inc.
Year	Avg F Orig	Avg F	Avg F	Avg F	Avg F
1982	0.45	0.45	0.45	0.45	0.45
1983	0.42	0.42	0.42	0.42	0.42
1984	0.31	0.31	0.31	0.31	0.31
1985	0.21	0.21	0.21	0.21	0.21
1986	0.15	0.15	0.15	0.15	0.15
1987	0.08	0.08	0.08	0.08	0.08
1988	0.14	0.14	0.14	0.14	0.14
1989	0.10	0.10	0.10	0.10	0.10
1990	0.12	0.12	0.11	0.11	0.11
1991	0.11	0.11	0.11	0.11	0.11
1992	0.09	0.09	0.09	0.09	0.09
1993	0.11	0.11	0.11	0.11	0.11
1994	0.12	0.12	0.12	0.12	0.12
1995	0.17	0.17	0.17	0.17	0.17
1996	0.19	0.19	0.19	0.19	0.19
1997	0.23	0.23	0.23	0.23	0.23
1998	0.19	0.19	0.19	0.19	0.19
1999	0.16	0.16	0.16	0.16	0.16
2000	0.22	0.21	0.21	0.21	0.21
2001	0.19	0.19	0.19	0.19	0.19
2002	0.18	0.18	0.18	0.18	0.18
2003	0.23	0.24	0.24	0.24	0.24
2004	0.26	0.27	0.27	0.27	0.27
2005	0.28	0.29	0.29	0.29	0.29
2006	0.32	0.32	0.33	0.33	0.33

Increases in total removals under the expected increase in commercial harvest are as follows:

15% increase in commercial harvest = 2.6% increase in total removals
20% increase in commercial harvest = 3.4% increase in total removals
25% increase in commercial harvest = 4.3% increase in total removals
30% increase in commercial harvest = 5.0% increase in total removals

Analysis 2 by Dr. Alexi Sharov, Maryland Fisheries Service:

This analysis was completed through the following steps.

1. Total coastal commercial quota was calculated as the sum of state specific coastal commercial fishery quotas as defined by the Amendment 6 (Table 2). The coastwide coastal commercial quota adjusted for conservation equivalency changes in NY and MD is 3,217,384 lb.
2. An average weight of striped bass in coastal harvest in 2007 was estimated at 12.9 lb. This estimate was used to calculate quota increase in numbers of fish. Total commercial quota was converted in to the number of fish as 3,217,384 / 12.9= 249,410 fish.
3. Quota increases were calculated at 5% increments as 10, 15, 20 and 25% of total increase (Table 3).
4. New quotas expressed in the number of fish were compared to the total harvest of 7+ and 8+ old fish (an approximation of the total number of harvested fish with total length 28 inches and larger, Table 4) for the period 2003-2006.
5. Assuming that 7+ or 8+ old fish (TL ≥ 28 inches) experience full fishing mortality (PR = 1, which is close to the last assessment results), the harvest (C) and full F in any particular year are related according to the classical Baranov's catch equation:
6.

$$C = N\frac{F}{F+M}(1-e^{-F-M})$$

where N is the population size of fish ≥ 28 inches in length and M is natural mortality. An increase in commercial quota will lead to the increase in total catch and F. New catch (C_n) and fishing mortality (F_n) will be related in the same fashion

$$C_n = N\frac{F_n}{F_n+M}(1-e^{-F_n-M})$$

The ratio of observed and increased harvest C_n/C is equal to

$$\frac{C_n}{C} = \frac{F_n}{F_n+M}\frac{F+M}{F}\frac{(1-e^{-F_n-M})}{(1-e^{-F-M})}$$

This equation can be solved iteratively to estimate new F that would be generated if an increased quota was harvested. The estimates of observed full F and new F that would have been generated in the commercial quota was increased in 2003 -2006 are presented in table 5.

Conclusion

An increase in commercial coastal quota in the range of 10 - 25% leads to a very small increase of full F, not exceeding the value of 0.02 year $^{-1}$. Such increase would not be possible to detect given the uncertainty in the catch at age and relative indices of abundance.

Table 2. Coastal commercial quotas by state (lb) defined in Amendment 6 and adjusted for conservation equivalency

State	Amendment 6 quota, lb	Amendment 6 quota with adjustments, lb
ME	250	250
NH	5750	5750
MA	1,159,750	1,159,750
RI	243,625	239,963
CT	23,750	23,750
NY	1,061,060	828,293
NJ	321,750	321,750
DE	193,447	193,447
MD	131,560	126,936
VA	184,853	184,853
NC	480,480	480,480
total	3,806,275	3,565,222

Table 3. Adjusted for % increase total coastal commercial quota

% quota increase	total, pounds	total, # fish
0	3,565,222	276,374
10	3,921,744	304,011
15	4,100,005	317,830
20	4,278,266	331,649
25	4,456,528	345,467

Table 4. Total number of harvested or otherwise killed fish of age 7 and older and 8 and older (as an approximation of total number of fish with TL ≥ 28 inches) in 2003 -2006

	# fish	
year	Age 7+	Age 8+
2003	2,164,373	1,456,986
2004	2,435,321	1,918,330
2005	2,126,643	1,701,492
2006	2,225,131	1,864,732

Table 5. Changes in Full F as a result of increase in coastal commercial quota

	% increase in quota	0	10	15	20	25
	year	F	F	F	F	F
age 7+	2003	0.24	0.251	0.253	0.255	0.257
	2004	0.27	0.278	0.280	0.282	0.284
	2005	0.29	0.303	0.306	0.308	0.310
	2006	0.32	0.331	0.334	0.336	0.339
age 8+	2003	0.24	0.247	0.249	0.250	0.252
	2004	0.27	0.277	0.278	0.280	0.281
	2005	0.29	0.301	0.302	0.304	0.306
	2006	0.32	0.330	0.332	0.334	0.336

Task 2. Determine which recreational size limit options are conservation neutral in terms of SSB/R to two fish at 28” that maintain the two fish creel limit but allow for one smaller fish and one larger fish to be kept.

Analysis by Dr. Victor Crecco, Connecticut Bureau of Marine Fisheries:

In this analysis the Thompson-Bell Yield-Per-Recruit (YPR) model was used with a constant M of 0.15 for all ages (ages 1-20). It was assumed that current full F is 0.20. Because the request calls for equivalent conservation against a two fish creel at a 28” minimum size, a partial recruitment vector (PR) was used that most closely corresponded to a 28” minimum size limit based on results from Shepherd (1999). The PR vector for all other size limit combinations were also taken from this report. At a 28” minimum size at an F of 0.2, SSB/R was equal to 6.07 kg/R. When the lower boundary of the dual minimum size was 18” with a one fish creel limit, the upper size limit corresponded to 40” and one fish creel in order to generate an SSB/R that was approximately (within 10%) equivalent to 6.07 kg/R. In order to achieve an exact equivalency to the SSB/R of 6.07 kg/R at 28 inches, the dual size limits, currently expressed in whole inches, would have to be interpolated into tenths of an inch (i.e., 18.2” and 40.3”). Expressing minimum sizes at this more refine level does not seem practical given the uncertainty and simplicity surrounding the equilibrium assumptions of YPR models. Given below are the dual size limit results:

18” minimum size- one fish creel, 40” minimum size- one fish creel
19” minimum size- one fish creel, 38” minimum size -one fish creel
20” minimum size -one fish creel, 36” minimum size- one fish creel
21” minimum size -one fish creel, 35” minimum size- one fish creel
22” minimum size -one fish creel, 34” minimum size -one fish creel
23” minimum size- one fish creel, 33” minimum size- one fish creel
24” minimum size- one fish creel, 32” minimum size- one fish creel

These results from equivalent conservation analysis were very robust to changes in the choice of constant M, to the choice of current F (between 0.1 and 0.3), and to the inclusion of density-dependent effects (use of stock-recruitment). The model results are sensitive to major (+/-20%) shifts in growth, as well as to changes in hook-and-release mortality. The results were particularly sensitive to a systematic rise in natural mortality over time and to time varying changes in somatic growth (weight-at-age) that might accompany the presence of a mycobacteria disease outbreak.

Some members of the TC raised questions about the approach used in this analysis. It is, however, the basic Conservation Equivalency method used by Crecco to develop quite a few alternative regulations that have been implemented by various states. One comment was that there would be an increase in catch with a smaller size limit. That point is countered, however, by the fact that there are many more smaller fish available, so the exploitation rate would not necessarily increase. Also, while it is more likely that anglers would be able to keep a fish at the lower minimum size limit, it is also less likely that they would be able to keep a second fish at the higher minimum size limit. While the total number of anglers landing striped bass may increase, the proportion of those anglers landing two striped bass may decrease. Other comments involved uncertainty regarding changes in angler behavior. The TC recommends that the above results serve as a guide and that any state wishing to implement alternative coastal recreational regulations still be required to develop and submit a proposal for review by the TC.

A few TC members raised concerns that these slot limit options would encourage anglers to keep larger fish, possibly exposing them to higher levels of contaminants such as mercury and PCBs. The Committee has compiled consumption advisories from various states to inform the Board on this issue (see Appendix 1).

Task 3. Determine how wide the gap between point estimates of Ftarget and Fthreshold must be to ensure that they are statistically different and advise on how estimates of terminal F should be compared to the reference points particularly when the point estimate of terminal F is above Ftarget but below Fthreshold.

At this point, for any given set of estimates, the Board would have to make a decision in any given situation, with advice from the Technical Committee, whether an estimate of F is above a reference point. There are several considerations.

1) Uncertainty in the terminal estimate of F due to a retrospective pattern of changing estimates.
Note that the Committee has determined that the SCA model has a retrospective bias or pattern. This means that the estimates of fishing mortality have declined as additional years of data have been added to the model. The most recent years' estimates are the most uncertain. In general, the influence of the tuning indices declines and the influence of the catch-at-age data increases as additional years of data are added. Our last assessment report indicated that the 2002 estimate of fishing mortality had declined from about 0.23 to about 0.17 after the addition of five more years of data (Figure 1). If the same pattern holds, the most recent estimate of F in 2006 = 0.31 could decline to about 0.25 with five years of additional data. If that occurs, then if we determined that overfishing was occurring based on $F_{2006} = 0.31$, we would be in error, because when additional data was incorporated, the model would estimate $F_{2006} = 0.25$.

2) Uncertainty around the terminal year estimate due to 95% confidence interval.
Statistical catch at age models produce confidence limits around the estimates, such that for the terminal estimate of F for 2006 from our last assessment, the 95% confidence interval ranged from 0.23 to 0.40 (Figure 2). While 0.31 was the point estimate, there was a 95% probability that fully recruited F was greater than 0.22 and less than 0.41. Note that the point estimate of the overfishing threshold $F_{MSY} = 0.34$ does fall in this range. If, in fact, the estimate of 0.31 was accurate and unbiased, the figure indicates there is a 30% chance that the reference point was exceeded. In fact, we have strong reason to suspect that the 2006 F estimate is too high.

3) Uncertainty around the reference point itself.
We have just looked at a demonstration of the uncertainty around the terminal year estimate of fishing mortality (not even considering the retrospective pattern). Biological reference points also have uncertainty around them, although this is not often discussed. Helser, Sharov, and Kahn (2000) portrayed the uncertainty around an overfishing reference point for the Delaware Bay blue crab stock. Sharov and Helser used a similar approach to portray the uncertainty around a similar overfishing threshold for striped bass based on stock-recruitment data. Here we look at any overlap between the two distributions, and then the question is, at what point would we decide that the distribution of the F estimate significantly exceeded the distribution of the reference point.

4) The estimate from the tag-recapture F estimates should be part of the consideration.
Over time, the tag-recapture F estimates have sometimes been higher than those produced by SCA (Figure 3). In recent years, the SCA estimate has trended higher, while the tag estimate has not increased, but declined to some extent. The two methods rely on different data. SCA relies on accurate catch information, but the tag-recapture estimates do not. The coastwide average tag-recapture F was only 0.13 for 2006. The tagging F estimate is somewhat different than that from the age-structured model, and the recent Peer Review Panel said that it was not strictly comparable to the reference point, which is based on the F of the ages considered fully-recruited, while the tag data applies to all fish over 28”. The peer review panel’s contention is not shared by all members of the TC, however.

5) In evaluating the current status of the stock and fishery, other information can come into play, such as recent recruitment levels and age structure. This information can be evaluated because of the uncertainty involved in trying to estimate recent fishing mortality.

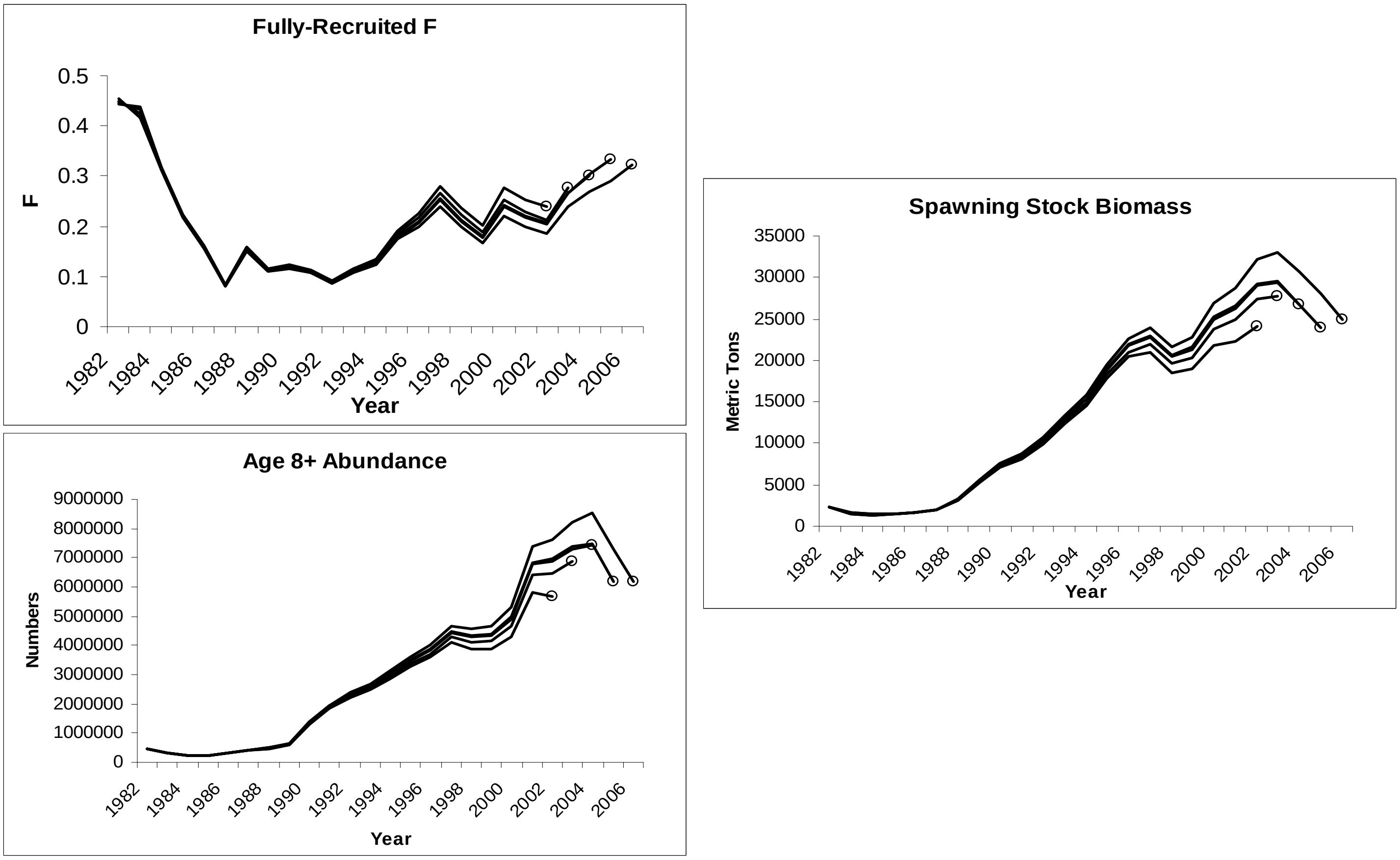

Figure 1. Retrospective analysis of fully-recruited fishing mortality, age 8+ abundance, and spawning stock biomass from the SCA model (Figure A7.14 from the 2007 Stock Assessment).

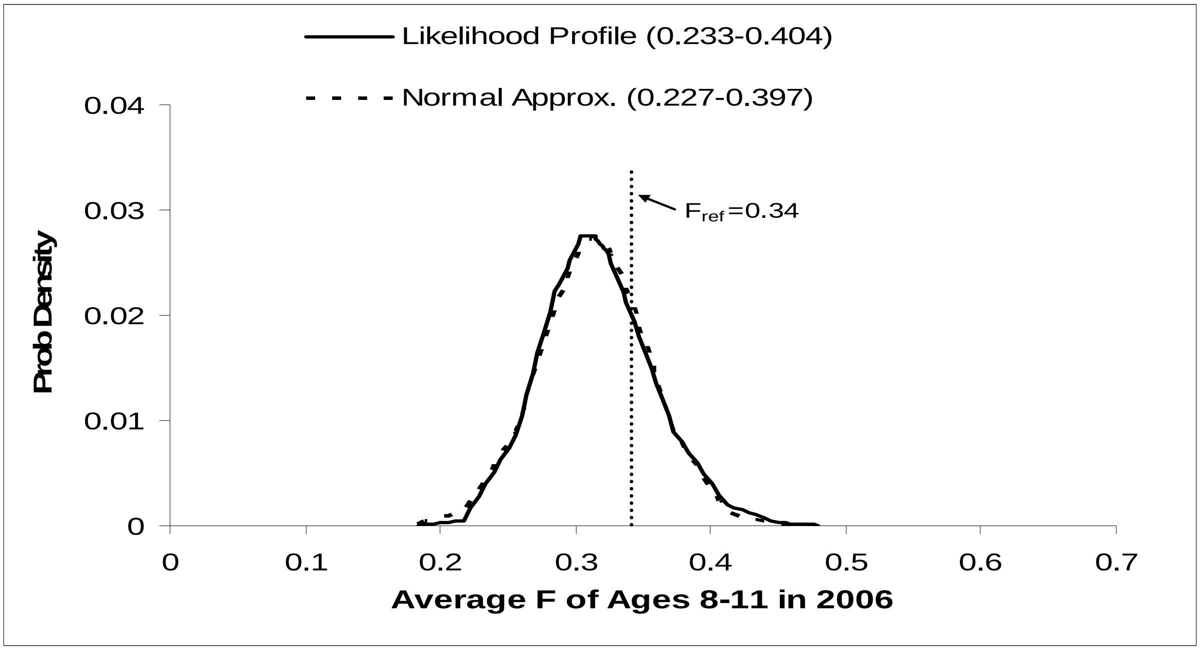

Figure 2. Confidence interval around the estimate of 2006 fully-recruited fishing mortality and the overfishing threshold F_{MSY} = 0.34.

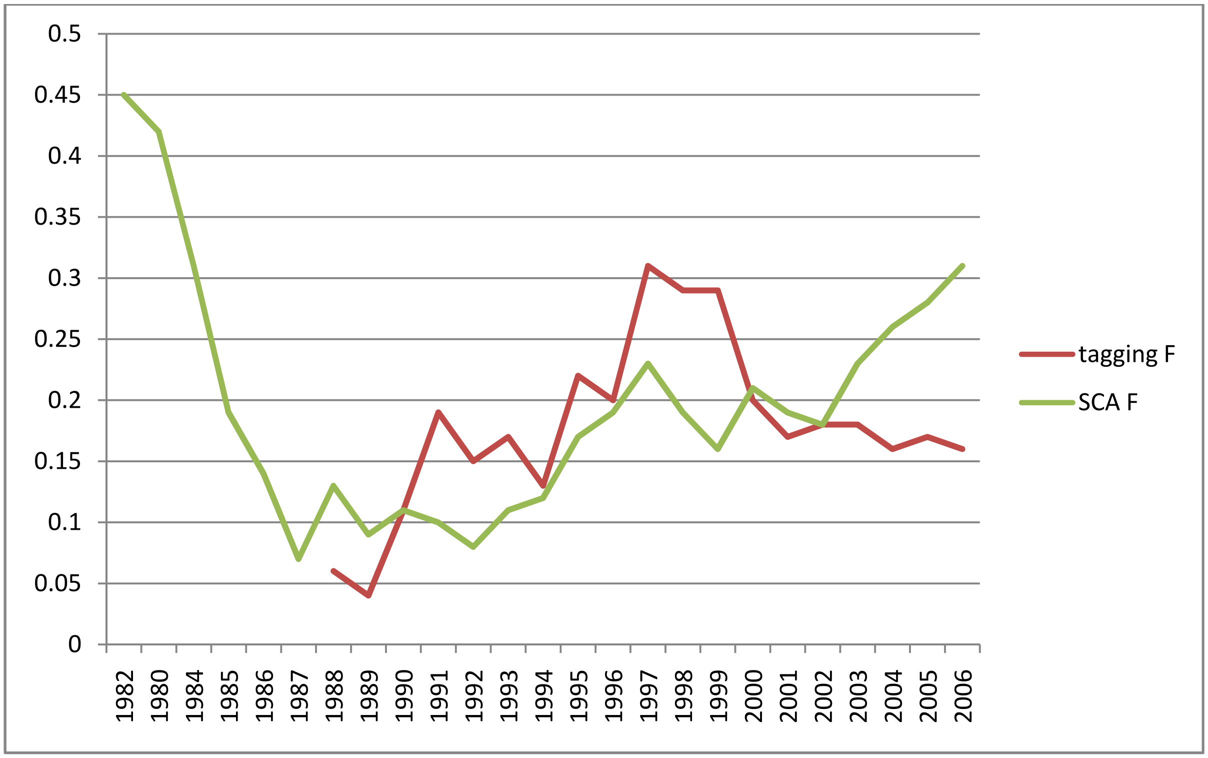

Figure 3. Time series of fishing mortality estimates from the SCA model and the tag-recapture model.

Task 4. Analyze catch data from the wave 1 winter fisheries off North Carolina, Virginia, and Maryland to determine how this fishery affects the existing age structure of the striped bass population.

The Striped Bass Stock Assessment Subcommittee has estimated wave 1 recreational harvest for Virginia from 1996 to 2006 and for North Carolina from 1996 to 2004. Wave 1 estimates in North Carolina have been estimated by MRFSS beginning in 2005. These estimates through 2006 were included in the recreational catch at age for the 2007 striped bass stock assessment. The SAS has not attempted to estimate wave 1 harvest in Maryland because anecdotal information has not indicated significant fisheries there as were reported beginning off North Carolina and Virginia in the mid to late 1990s.

In general, due to the lack of MRFSS coverage of Virginia and Maryland during wave 1, any estimates developed by the SAS are exceedingly rough and have very high uncertainty. The best that can be done is to develop rough estimates based on the ratio of recaptures of tagged fish in North Carolina to the MRFSS catch estimate in NC during the last two years, and assuming the same ratio would occur in Virginia, estimate the VA landings based on the number of tag returns reported from Virginia in Wave 1.

To answer this task literally would require extensive work involving running the SCA model with and without these roughly estimated landings. This work could be conducted during the stock assessment update later this year. Instead, a more simple but informative analysis of the age structure of the NC/VA wave 1 harvest was undertaken (see below).

It is important for the Board to realize that coverage of the recreational fishery in wave 1 is needed in Virginia. If the Board thinks the impact is potentially important, the Technical Committee needs reliable estimates of the landings, which we do not have. Note that the rough estimates, based on tag returns, do indicate quite high landings in Virginia in the last two years.

Analysis by Dr. Gary Nelson, MA Division of Marine Fisheries:

The 2006 harvest numbers-at-age for NC/VA in wave 1 were divided by the total removals and total harvest numbers-at-age and multiplied by 100 to obtain the percentage that the NC/VA harvest comprises the total removals and total harvest-at-age (Table 6). The 2006 numbers-at-age for NC/VA over the ages were also summed and the percentage of total removals and total harvest for 2006 were calculated. As a percentage of total removals, the NC/VA wave 1 harvest is 2.8%; as a percent age of total harvest, the NC/VA wave 1 harvest is 4.4%.

Table 6. Wave 1 NC/VA Harvest as Percent of Total Removals and Harvest, at age, in 2006

Age												
1	2	3	4	5	6	7	8	9	10	11	12	13+
Percent of Total Removals at Age in 2006												
0	0	0	0	0.1	0.2	1.0	4.7	9.7	10.6	11.1	9.2	6.7
Percent of Total Harvest At Age in 2006												
0	0	0	0	0.1	0.3	1.2	5.6	11.0	11.8	12.1	10.1	7.2

Analysis by Robert O'Reilly, VMRC (abridged):

This analysis attempted to come up with potential harvest estimates for Virginia in wave 1 for 2007-2008 using two different methods. First, the method previously employed by the

Stock Assessment Subcommittee was used, and another attempt modified that method for a second set of estimates. Both sets of estimates are highly uncertain.

The first method is based on the ratio of North Carolina harvest to the number of tag returns from NC in wave 1. The same ratio is used to scale up the Virginia tag returns to an estimate of absolute harvest. This method depends on several unverified assumptions. Because of low tag returns in NC in 2007-2008, the VA 2007-2008 wave 1 harvest estimates are drastically higher than those estimated in 2005-2006 (Table 7), which prompted the development of a modified method.

Table 7. Method 1 Estimates for VA Wave 1 Harvest in 2007 and 2008

Year	NC Harvest (N)	NC Tag Returns	VA Tag Returns	Estimated VA Harvest (N)
2005	71,962	14	8	41,121
2006	85,884	23	22	82,150
2007	36,382	**3**	30	363,820
2008	41,741	**2**	41	855,690

The second method uses an averaging approach. The ratio of NC 2005/06 average harvest to NC 2005/06 average tag returns was used to determine that the NC 2007/08 average harvest of 39,061 fish would correspond to an NC 2007/08 average tag returns of nine. That average tag return (9) was used to estimate the 2007 and 2008 VA harvests (Table 8).

Table 8. Method 2 Estimates for VA Wave 1 Harvest in 2007 and 2008

Year	NC Harvest (N)	NC Tag Returns	VA Tag Returns	Estimated VA Harvest (N)
Avg. 2005/06	78,923	19		
2007	36,382	**9**	30	121,273
2008	41,741	**9**	41	190,153

Task 5. Assess the long-term effects of recreational and commercial discards on the striped bass population and how changes in these rates would affect the age structure and female spawning stock biomass.

Analysis by Gary Shepherd, NMFS NEFSC:

Evaluating the effects of increased discarding on the age structure and spawning stock biomass (SSB) is not a straightforward analysis. Specifically, altering the discards requires a separate selectivity vector for discards and landings; however, the striped bass SCA model was developed with a single selectivity for fishery removals. In addition, the effect on SSB is dependent on the location of the removals. Since the migration differs between sexes, the mature females are affected more by coastal fisheries than estuarine fisheries. Consequently evaluating SSB requires a selectivity and partial F for coastal fisheries, which does not exist in the current model. There is also the question of possible compensation for discards (e.g., if discards increase does that imply landings decrease or simply that the mortality rate of discards increases?).

To analyze the requested scenario, the long term implications of an increase in fishing mortality presumably due to increased losses from discards were evaluated. This approach assumes the same selectivity as the overall fisheries projected from the SCA terminal year population estimates at age. Starting stock size at age is drawn from a distribution of N values generated from the terminal year values in SCA and the corresponding standard deviation. Recruitment was based on the average recruitment from the period 1990-2006 (when recruitment was relatively stable relative to SSB). Random recruits were drawn from 1000 values of a normal distribution developed using the recruitment time series mean (12,745,000) and standard deviation (1,045,064) (Figure 4). Five discrete values of F were evaluated; 0.2, 0.25, 0.32 which is the fully recruited F in the terminal year of SCA, 0.34 which is the current estimate of Fmsy, and 0.4 which represents a previous estimate of Fmsy. Population size, SSB, and 8+ abundance (to reflect age structure) were estimated through 500 iterations (Figures 5-7). Mean and 95% CI were calculated for each year 2007 through 2017. Years prior to 2007 were the results from the latest assessment using the catch at age model.

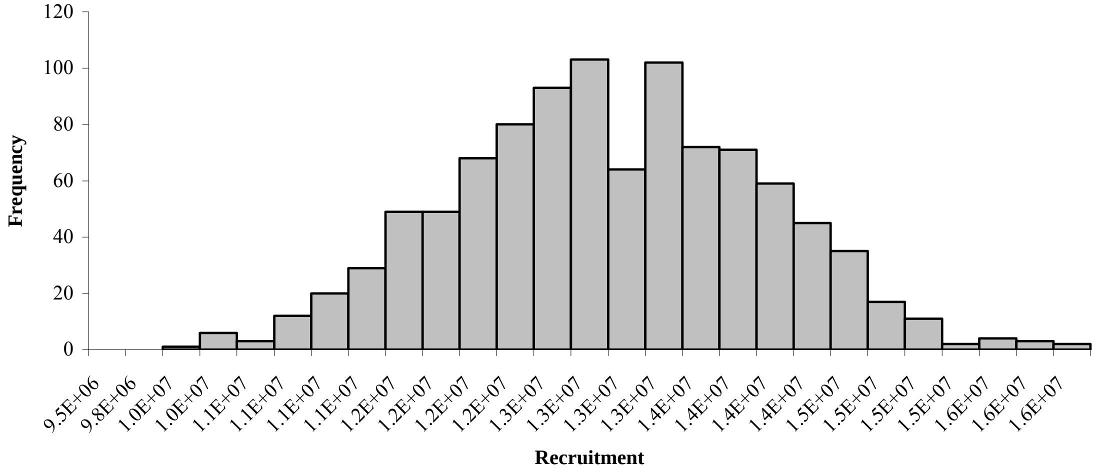

Figure 4. Distribution of recruits randomly selected for 500 iterations

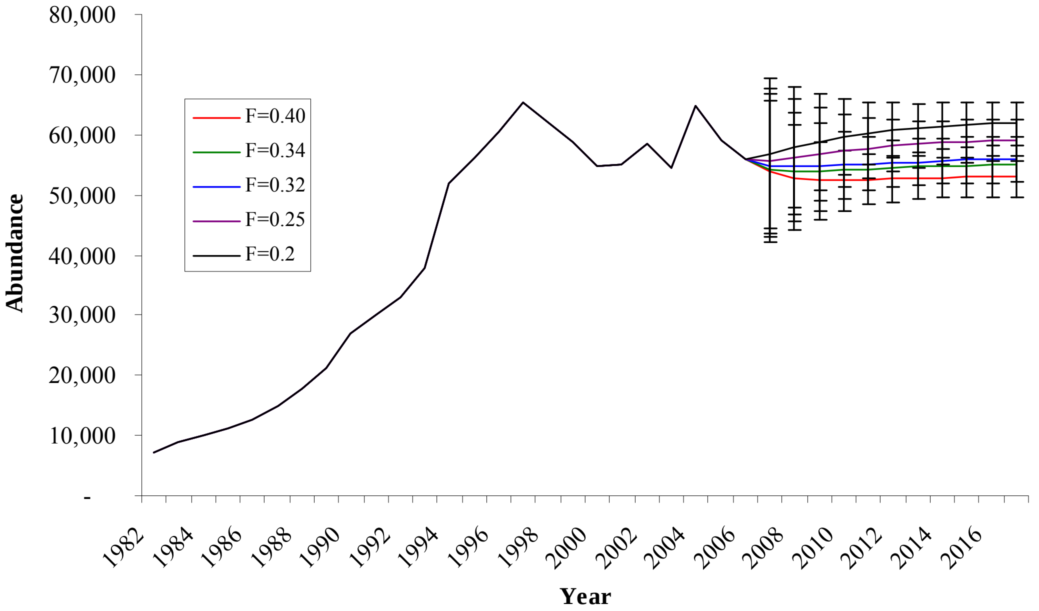

Figure 5. Total population abundance projected under fishing mortalities of 0.2, 0.25, 0.32, 0.34 and 0.4; includes 95% confidence intervals

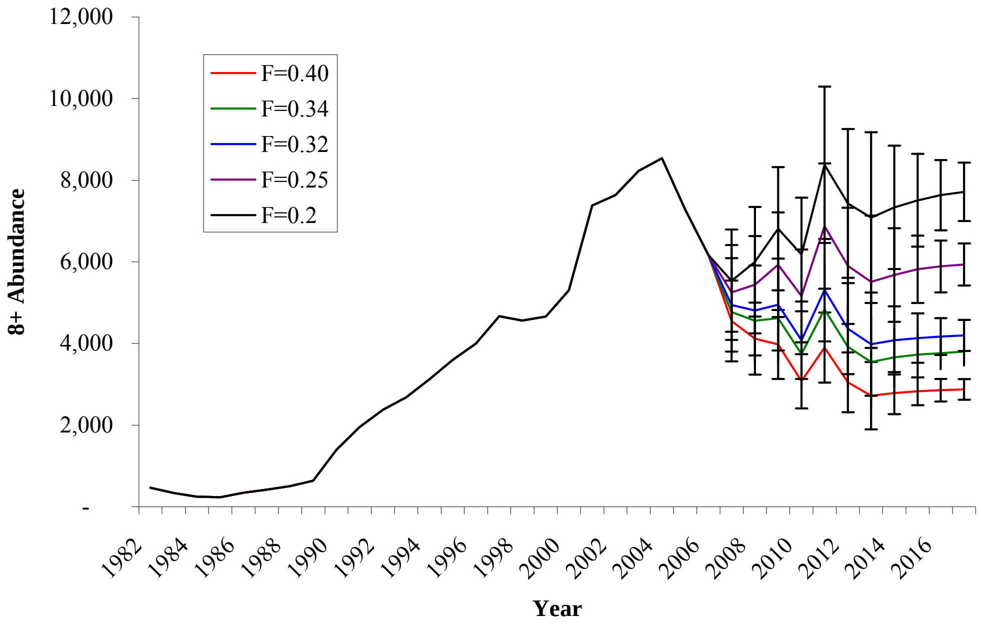

Figure 6. Abundance of fish age 8 and greater (000s) projected under fishing mortalities of 0.2, 0.25, 0.32, 0.34 and 0.4; includes 95% confidence intervals

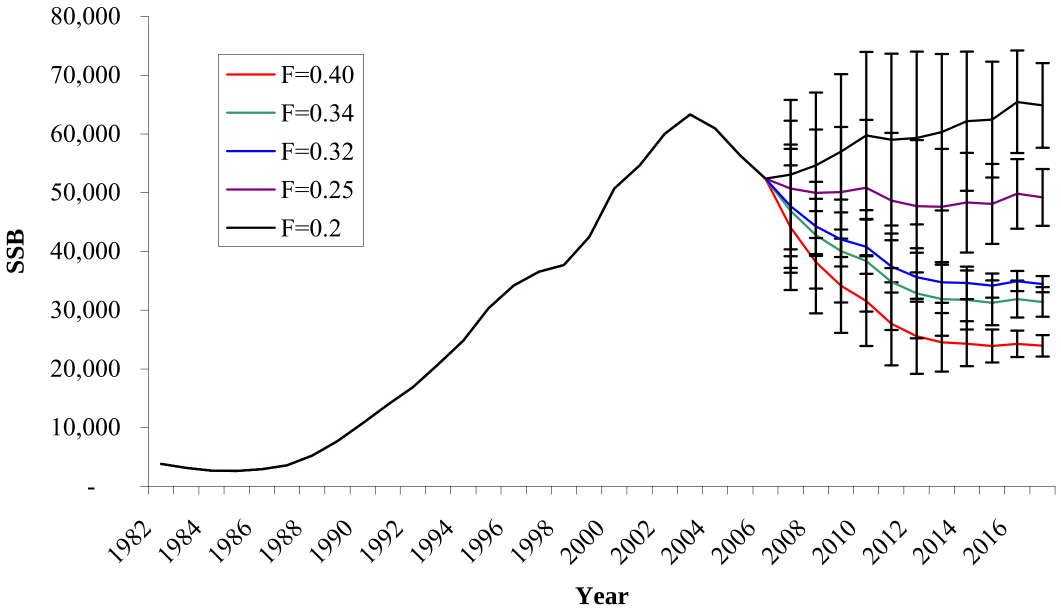

Figure 7. Female SSB (mt) projected under fishing mortalities of 0.2, 0.25, 0.32, 0.34 and 0.4; includes 95% confidence intervals

Task 6. Analyze recreational regulatory options that could increase the proportion of age 15+ striped bass in the population to 3% and 5% using size and bag restrictions.

This analysis uses the Harvest Control Model, which employs the Maryland Juvenile Indices, and essentially grows striped bass up, while decrementing for natural and fishing mortality. Dr. Crecco used the time series of fishing mortality from the tag-recapture modeling, as he regards those estimates as more reliable than the estimates from the catch-at-age models. He also used fishing mortality estimates for an earlier period from a surplus production model developed in 2000 by Mark Gibson.

Analysis by Dr. Victor Crecco, Connecticut Bureau of Marine Fisheries (abridged):

The results from the Harvest Control Model (HCM), under a fixed M scenario, strongly suggest that raising the coastal minimum size from 28" to 29" and from 28" to 30" in 2009 will boost future average abundance of ages 15+ striped bass by about 3% and 5%, respectively.

If higher natural mortality rates (M) among age 1-5 stripers in the Bay ostensibly due to an enhanced Mycobacteriosis outbreak since 1997 were to persist through 2015, overall abundance of ages 15+ stripers would be 60% to 80% lower by 2015 relative to ages 15+ abundance under the fixed M scenario (Figure 8). Nevertheless, the projected percentage increases in ages 15+ striped bass in the HCM of around 3%, 5% and 7%, respectively, by 2015 would still occur if the coastal minimum size increased from 28" to 29", from 28" to 30", and from 28" to 31". Keep in mind that the projected abundance of ages 15+ stripers from 2010 to 2015 would be considerably reduced under a rising M scenario than under the fixed M scenario.

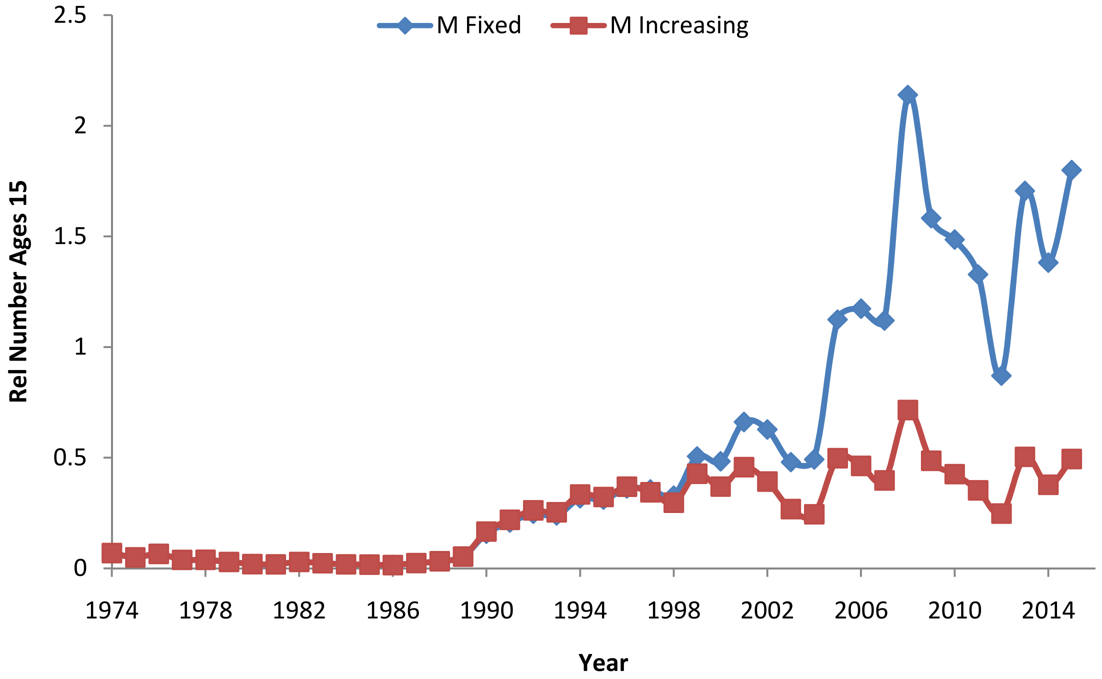

Figure 8. Projected relative abundance of ages 15+ bass from 1974 to 2015 under a 28 inch coastal size limit under fixed M=0.15 and under rising M (0.25 to 0.35) from 1997 to 2015

Task 7. Refine the age-length data used for the 2007 assessment using the stored otolith/scale samples processed in 2008 from striped bass 31 inches and larger.

Two separate analyses bear on this question. Excerpts from each are presented below. In general, the analyses both show that our use of scale ages causes under-ageing and bias in the catch-at-age matrix. This is particularly important in a relatively long-lived fish such as striped bass. Work in the second analysis presented below explored the effect of this difference on assessment results using ADAPT virtual population analysis, as opposed to the statistical catch at age model we use currently. One limitation of this analysis is presented below (use of only Virginia otolith age-length data). That work indicates, however, that use of the scale ages appears to have introduced bias in VPA results, such that the scale-based analysis underestimated abundance and spawning stock biomass and overestimated fishing mortality. Scale ages also produced smearing of year classes due to ageing error, which underestimated the variation between year classes in abundance.

While the effect of otoliths may differ in statistical catch at age analysis, partly due to the forward projecting method, these results raise potentially disturbing implications for our current stock assessments. If the biases implied by the analysis are actually present, then our assessments would be overestimating fishing mortality and underestimating abundance and spawning biomass. There are problems with implementing a switch to otoliths, however, including use of past years data based on scales and the additional cost and fish mortality required for otolith collection. Funding may be required to states for otolith collection.

Analysis by Andrea Hoover and Dr. Alexi Sharov, Maryland Fisheries Service (abridged):

Multiple studies have shown that scale based readings tend to underestimate fish age, whereas otoliths result in much less bias and better precision for many species (Barber and McFarlane 1987, Heidinger and Clodfelter 1987, Lowerre-Barbieri et al. 1994, Brown et al. 2004, Brouder 2005, Decicco and Brown 2006), including striped bass (Secor et al. 1995a; Welch et al. 1993, Liao et al. in prep).

Therefore, the ASMFC made funds available in 2008 to process and subsequently age 300 otoliths for otolith – scale age comparison. Otolith samples were solicited from any state, coast-wide, that had a collection program. Approximately 100 otoliths each were provided by Massachusetts, Maryland, and New Jersey and were processed and aged by Old Dominion University (ODU). Following ASMFC ageing workshop recommendations, otoliths submitted for processing were from fish greater than or equal to 800 mm in total length, both male and female fish, and ideally with a paired scale sample if available. Samples from all states were typically collected from 2003 to 2007, and were pooled across all years and sexes to increase sample size. In addition, ODU processes and ages otoliths on an annual basis for the Virginia Marine Resources Commission (VMRC), and VMRC allowed data for 2003-2008 to be available as well. As an example, plots comparing otolith and scale based age estimates from Virginia samples are in Figure 9.

To demonstrate the potential effect of reported bias in scale based ages, we converted the 2006 state-specific, scale-based catch at age into an otolith-based catch at age by applying a scale – otolith conversion matrix derived from the distribution of scale and otolith ages in state specific samples. The Virginia example is in Table 9. For all states, the distribution in the catch shifted to fewer fish generally in the 7 to 12 year old fish, but larger catches in the older fish, typically older than 12 years.

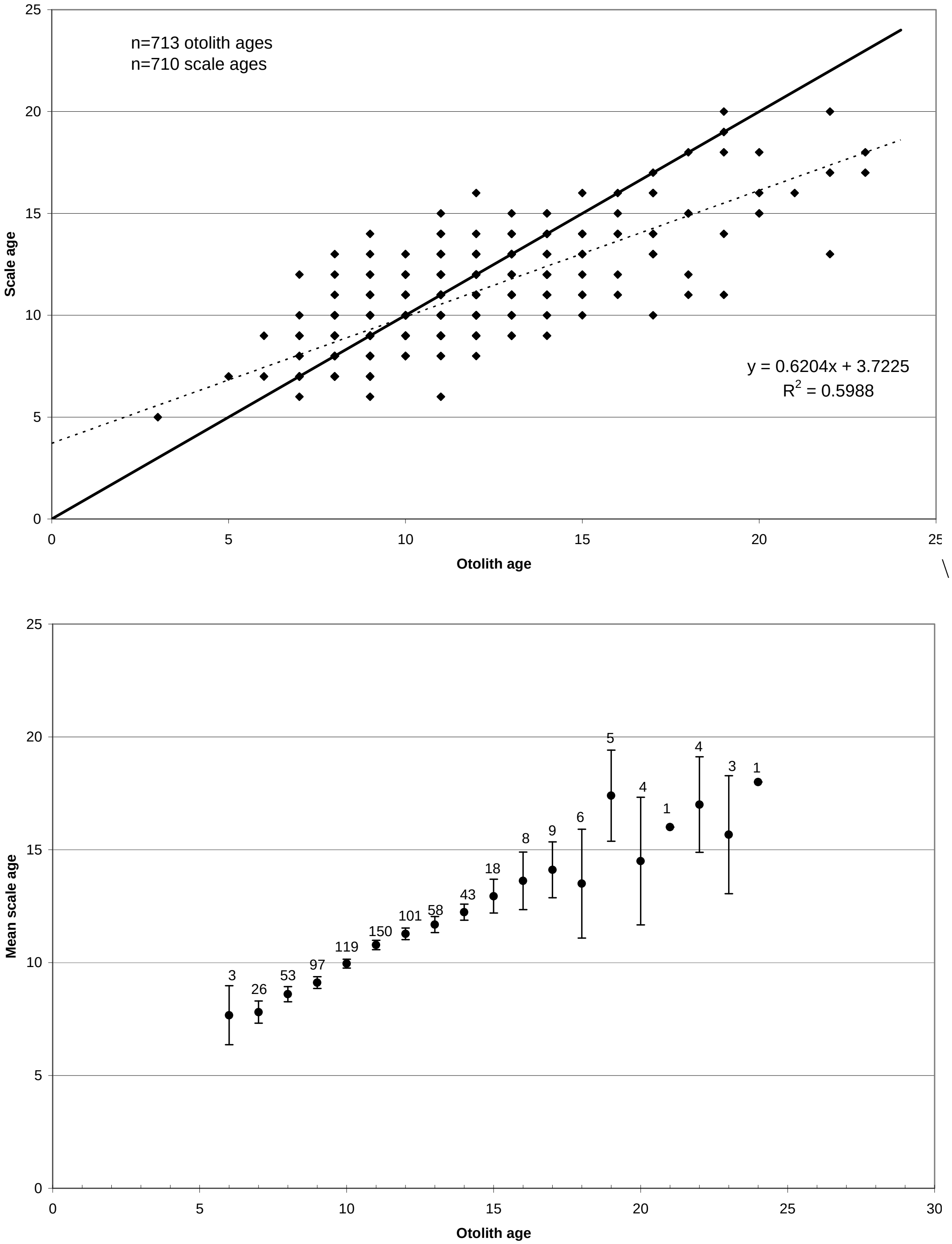

Figure 9. Comparison of otolith age to scale age of samples from Virginia. Scale ages that match otolith ages fall on the one to one solid line. Mean scale ages presented with 95% confidence intervals and number of samples at each otolith age are shown above the intervals.

Table 9. Virginia statewide fishery catch at age as derived by scale ages in the ADAPT-VPA for the 2006 stock assessment compared to an otolith based catch at age. Values in grey were copied from the catch at scale age because no otolith samples were available at those ages.

Age	Scale based catch at age	Otolith based catch at age	Difference (Otolith catch at age - Scale catch at age)
0	0	0	0
1	12,003	12,003	0
2	45,582	45,582	0
3	97,359	97,359	0
4	99,688	99,688	0
5	101,755	101,755	0
6	104,342	3,493	-100,850
7	44,817	61,392	16,575
8	42,535	36,896	-5,639
9	47,410	87,311	39,901
10	75,790	53,580	-22,210
11	43,444	89,549	46,105
12	24,948	34,415	9,467
13	13,998	17,948	3,950
14	4,937	12,718	7,781
15	8,179	4,637	-3,543
16	4,794	2,884	-1,910
17	1,682	3,156	1,474
18	0	2,584	2,584
19	0	1,487	1,487
20	0	1,208	1,208
21	0	685	685
22	0	1,849	1,849
23	0	1,087	1,087
24	0	0	0
Total catch (all ages)	773,263	773,263	0
Total (ages 6-24)	416,876	416,876	0

Additional analysis by Hank Liao and Cynthia Jones, Old Dominion University, and Alexei Sharov, Maryland Fisheries Service (abridged):

In a manuscript in preparation, Liao et al. have developed an alternative catch-at-age matrix for the whole coast, using Virginia otolith age-length data. It should be pointed out that the baseline catch-at-age matrix developed for the assessment for the whole coast used scale age-length data from many states, whereas, in their analysis, Liao et al. used only age-length data from Virginia otoliths. Liao et al. then employed the two matrices (baseline, used in the 2007 stock assessment, and corrected, using Virginia otolith data for older fish) in ADAPT VPA, as the Stock Assessment Subcommittee used to do.

Clear differences emerged, primarily as a result of the more extended age structure in the otolith-based catch-at-age (CAA) matrix (Figure 10). The upper left hand panel labeled "Number of fish (millions)" on the vertical axis shows that use of the otolith-based CAA matrix resulted in increasing the estimate of total abundance by approximately 10 million fish. Similarly, the upper right panel, labeled "Spawning stock biomass" on the vertical axis shows that use of the otolith CAA matrix resulted in an increase of about 5,000 metric tons in the estimate of SSB. The lower left hand panel, labeled "Fishing mortality" on the vertical axis, indicates that use of the otolith CAA matrix reduced the estimate of fishing mortality in the most recent years by about 0.10 or more. Finally, the lower right panel shows that the estimation of annual recruitment shows more variation among years using the otolith data. That can be explained by the known phenomenon that ageing error causes smearing of year classes, thus reducing variation among them.

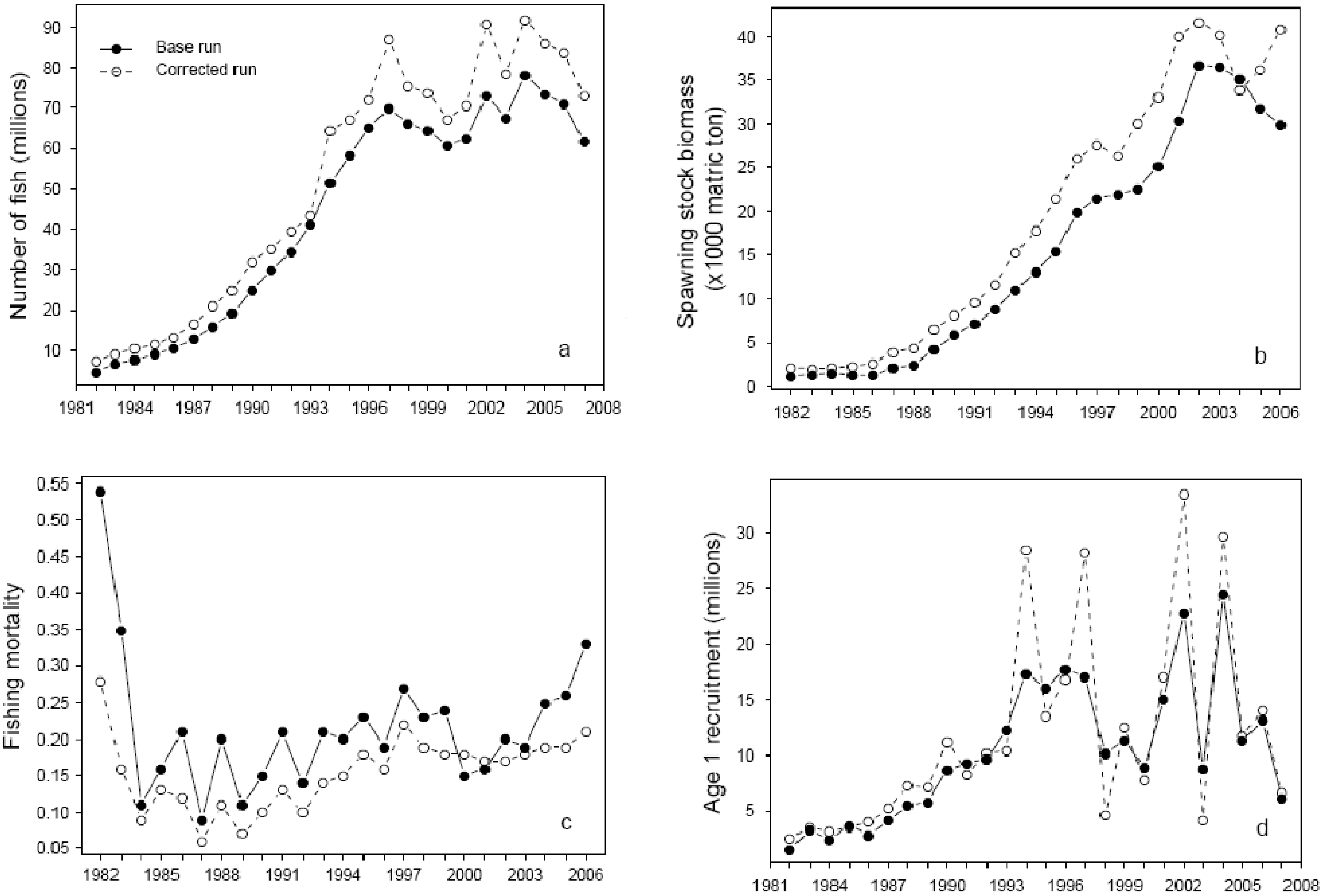

Figure 10. Base vs. Corrected VPA output of (a) abundance, (b) spawning stock biomass, (c) fishing mortality, and (d) age-1 recruitment

Appendix 1. Overview of consumption advisories for migratory striped bass (ME-NC) from ASMFC member jurisdictions. The consumption advisories are based on striped bass sampled in member jurisdictional waters containing levels of PCB, dioxins, and/or mercury which may exceed human dietary limits (see attached references). Only MA, DE, and MD jurisdictions presently have specific references to the fact that larger striped bass may contain higher concentrations of some contaminants, or should be consumed less often.

JURISDICTION	**ADVISORY INFORMATION**	**WEB SITE(S)**
Maine	Eat no more than two meals of striped bass per month.	http://www.maine.gov/dhhs/eohp/fish/saltwater.htm
New Hampshire	Eat no more than two 8-oz. meals of striped bass per month.	http://www.wildlife.state.nh.us/Fishing/sw_fish_consumption.htm
Massachusetts	Pregnant women, women planning a pregnancy, nursing mothers, and children under 12 should eat no more than two 6-oz. meals a week of striped bass; species in which large individuals tend to be high in mercury concentration include...striped bass (Smith 1996).	http://www.mass.gov/dph/fishadvisories/ http://www.mass.gov/dep/toxics/stypes/hgch6.htm#conc
Rhode Island	Pregnant women, nursing women, women planning a pregnancy, and children under age 6, should not eat striped bass.	http://www.health.ri.gov/environment/risk/fish.php
Connecticut	Pregnant women, nursing women, women planning a pregnancy, and children under age 6, should not eat striped bass; all others should eat no more than one striped bass meal per two months.	http://www.ct.gov/dph/cwp/view.asp?a=3140&q=387460&dphNav_GID=1828&dphPNavCtr=|#47464
New York	Women of childbearing age and children under age 15 should eat no fish from Hudson River, New York Harbor, Raritan Bay, and western Long Island Sound; others should eat no more than one meal per month of striped bass from all these waters, except for areas of the Hudson River north of Catskill. (They should eat no fish from waters at the Route 9 bridge in South Glens Falls to the bridge at Catskill, and no more than one meal per week from waters of the Corinth Dam to the Route 9 bridge, and the Sherman Island Dam to the feeder dam, in South Glens Falls.) All persons should eat no more than one meal per week of striped bass from waters of eastern Long Island Sound, Long Island South Shore, Jamaica Bay, Peconic Bay, Gardiners Bay, and Block Island Sound.	http://www.health.state.ny.us/environmental/outdoors/fish/docs/fish.pdf
New Jersey	For striped bass statewide, estuarine and marine waters, general population should eat no more than one 8-oz. meal per month; high risk individuals (infants, children, pregnant women, nursing mothers , and women of childbearing age) should eat none; more specific advice is provided for striped bass in the following waterbodies: Newark Bay complex, Hudson River, Raritan Bay complex, and Delaware Estuary and Bay.	http://www.state.nj.us/dep/dsr/njmainfish.htm

JURISDICTION	ADVISORY INFORMATION	WEB SITE(S)
Pennsylvania	No more than one meal per month of striped bass from the Delaware Estuary, including the tidal portion of all PA tributaries and the Schuylkill River to the Fairmount Dam.	http://www.depweb.state.pa.us/watersupply/cwp/view.asp?a=1261&q=453946
Delaware	For striped bass over 28 inches from Delaware Bay (C&D Canal to mouth of Bay), no consumption for women of childbearing age and children; all others eat no more than one meal per year. No striped bass from upstream of the C&D Canal should be consumed.	http://www.fw.delaware.gov/Fisheries/Pages/Advisories.aspx
Maryland	Chesapeake Bay and Tributaries: for striped bass under 28", children under 6 years of age should eat no more than 15 3-oz. meals per year, women of childbearing age no more than 19 6-oz. meals, and the general population no more than 25 8-oz meals; for striped bass over 28", children should eat no meals per year, women of childbearing age no more than 6 6-oz. meals, and the general population no more than 9 9-oz. meals.	http://www.mde.state.md.us/CitizensInfoCenter/FishandShellfish/home/index.asp
District of Columbia	Limited consumption of Anacostia and Potomac River fish is urged; striped bass are not listed; consumption of "other fish" is recommended as being no more than 8 oz. per week.	http://doh.dc.gov/doh/cwp/view,a,1374,q,584650,dohNav_GID,1837.asp
Potomac River Fisheries Commission	With regard to striped bass consumption advisories, the PRFC site references the Maryland site.	http://www.prfc.state.va.us/index/sitemap.htm
Virginia	In Chesapeake Bay, James River Basin, Potomac River Basin, Rappahannock River Basin, and York River Basin, no more than two meals per month of striped bass are recommended.	http://www.vdh.virginia.gov/epidemiology/DEE/PublicHealthToxicology/Advisories/index.htm
North Carolina	Striped bass are not specifically mentioned in any NC literature.	http://www.epi.state.nc.us/epi/fish/index.html
US Environmental Protection Agency	The USEPA web site provides access to all ASMFC member jurisdiction sites except for the PRFC.	http://www.epa.gov/waterscience/fish/
US Food and Drug Administration	The USFDA web site references a "saltwater bass" as a mid-range species with regard to methylmercury concentrations in commercially sold fish (see U.S. Department of Health and Human Services 2009a)	http://www.cfsan.fda.gov/~dms/admehg3.html#FDA_Fish_Consumption_Website

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