APPENDIX C

DT: August 10, 2005
TO: Striped Bass Stock Assessment Sub-Committee
FR: Joseph Grist, ASMFC

RE: Wave-1 total recreational catch for NC and VA final calculations

Based on the report presented to the Striped Bass TC on July 11, 2005 concerning the North Carolina and Virginia MRFSS wave-1 recreational catch, Table 1 contains calculations for total catch for each state.

North Carolina: Wave-1 total catch for 1996-2003 is based on the NC specific 2004 wave-1 ratio of tag returns to MRFSS total catch numbers. There were 47 tags returned during the wave-1 fishery period for the ocean fishery. The MRFSS reported catch (A+B1) was 177,288 striped bass during the same period. This resulted in a 2004 ratio tags to catch of 0.000265. This ratio was applied to the wave-1 tag returns for the NC ocean fishery to provide a back-calculated total catch for wave-1 in NC.

Virginia: Unlike NC, a 2004 wave-1 total catch was not reported. However, analysis of the tag returns suggested that a winter fishery similar to that of North Carolina occurred off VA during 2004. The July 11th report to the TC did indicate that VA wave-6 tag returns were positively correlated to catch and implied biological significance, though wave-2 analysis did not. Personal communication with Sara Winslow (NCDMF) confirmed that the winter fishery begins in the latter half of wave-6 and continues into wave-1 in northeastern NC, and similar trends would be expected for southeastern VA. Anecdotally, this suggested that wave-6 and wave-1 catch would show some level of correlation in fishing activity. Using known wave-1 tag returns, a mean ratio (0.000167) of tag returns to catch for VA wave-6, 1996-2004, was utilized to back-calculate the total wave-1 catch.

Table 1.

Year	**Total catch values (projected)**	
	NC	VA
1996	18,860	5,985
1997	49,037	83,793
1998	15,088	89,778
1999	18,860	107,734
2000	7,544	53,867
2001	18,860	53,867
2002	75,442	89,778
2003	79,214	53,867
2004	177,288*	155,616

*actual catch

Appendix D

Analysis and Discussion of the
1998-2002 Striped Bass Coastwide Weight-at-Age

Prepared for the

Striped Bass Stock Assessment Sub-Committee Meeting

August 9 – 11, 2005

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Introduction

A crucial element of the yearly catch-age based virtual population analyses (VPA) of Atlantic striped bass is the calculation of biomass of the mixed coastal stock. This calculation requires coastwide weight-at-age (WAA). The coastwide WAA has consistently been calculated as a weighted mean:

State WAA = Σ (state WAA * % state CAA by numbers)   Eqn. 1

Coastwide WAA = Σ (State WAA * state % coastwide CAA)   Eqn. 2

The current VPA analysis uses a time series dating back to 1982. The yearly values were not calculated on a yearly basis, however. In 1997, the values for 1982-1997 were developed. These values were developed using data from all states, subdividing each year into quarterly time periods to account for growth, and weighting by numbers of fish. (Details of developing weights at age for 1982 to 1996 can be found in NEFSC Lab Ref. 98-03.) Coastwide WAA was not re-calculated in 1998 or 1999. Instead, the 1997 values were used as these years' values. The 2000, 2001 and 2002 coastwide WAA were developed at the Stock Assessment Subcommittee Workshops, weighted by total weight of fish, using readily available data sets. Therefore, the methodology and data sets used for these calculations were not consistent, either with the methodology used for the 1982-1997 WAA or with each other. The 2000-2002 values showed an apparent decline in WAA, but it was impossible to determine if this apparent trend was due to the change in method or a true change in WAA.

In 2004, a standardized report format was developed that calculated WAA as part of the CAA calculations. The 2003 coastwide WAA was developed using all states' data:

- Maine and New Hampshire recreational harvest and discards,
- Massachusetts recreational and commercial catch,

- Rhode Island recreational and commercial catch,
- Connecticut recreational catch,
- New York recreational catch and commercial landings,
- New Jersey recreational catch,
- Delaware recreational and commercial catch,
- Maryland recreational and commercial catch,
- Virginia recreational and commercial catch, and
- North Carolina recreational and commercial catch.

An apparent decline was observed between the 2001and 2002 coastwide WAA – only 2 of 13 age-classes of harvested fish did not show a reduction in WAA (Table 1). Due to concerns about this apparent decrease in coastwide WAA and the inability to compare 1998-2002 with the rest of the time series, the subcommittee decided to re-calculate these coastwide WAA values.

Methods: Recalculation of the 1998-2002 values.

All states were requested to provide the 1998-2002 time series of WAA, landings and discards. Because information was not received from all states, it was decided to develop the coastwide WAA from information for states with greatest catch. For 1998-2001, the coastwide WAA was calculated using the 5 major harvester states (MA, NY, NJ, MD, VA), NH and CT (Table 2). For 2002, data were available to include RI and DE (Table 3). WAA was calculated as the weighted mean, weighted by numbers for commercial harvest, recreational harvest, and recreational discard. Annual state removals were taken from the time series tables for commercial harvest, recreational harvest and recreational discard numbers in the 2004 coastwide compliance report summary prepared by Gary Sheppard if not provided by state. WAA for the nearest neighboring state was used if that state's WAA was not available. The oldest age group was designated "13+", and 1982-1997 "13+" values were recalculated as the arithmetic averages of 13- to 15-year-old age class values. A constraint imposed by the 1998-2002 data was that an annual time frame was used for all calculations, as opposed to the finer time frame used in the 1982-1997 and 2003 calculations. The time series matrix of WAA including re-calculated values is presented in Table 4.

Discussion

The apparent decrease in WAA from 2000 - 2002 within the "old" WAA time series. Most age classes showed a decrease between 2000 and 2002 (14 of 15 age-classes) (Table 2). However, examination of the development of the WAA revealed that this decrease was due to differences in the development of the values. Because average WAA greater for coastal than Chesapeake Bay states for all harvested age classes, calculations are skewed if the harvest proportion is not used in the WAA calculations.

Evaluation of the apparent decline between 2001-2002 values. The 1982-1997 coastwide WAA time series was developed using all states' data. In contrast, the 2001 coastwide WAA was developed without data from RI, CT, MD and NC. Due to comparatively low harvest, RI, CT and NC do not contribute strongly to the coastwide WAA. However, the exclusion of MD data from the 2001 calculation had a major influence on the coastwide value. Without the MD numbers factoring in to the average, the coastwide WAA was disproportionately weighted by MA (Figure 1, Table 5). This is significant because MD is a Chesapeake Bay harvest state and

MA is a coastal harvest state. Based on data from 1982-1997, the majority of fish harvested in Chesapeake Bay (ages 3–11) were, on average, 2.6 kg (5.7 lb) smaller than coastal fish (Table 6). The unnaturally strong contribution of MA in the 2001 WAA, followed by the strong contribution of MD fish in the 2002 WAA, certainly contributed to the observed decline in the coastwide WAA.

Patterns in WAA from 2000 – 2003 within the recalculated WAA time series. Coastwide WAA values for 2000 to 2002 were recalculated using a consistent method that was considered functionally equivalent to the method used for earlier calculations. Although a subset of states was used, these states constitute the majority of the harvest and therefore maintained the overall harvest proportion throughout the WAA calculations. In contrast to the earlier values, these values showed a consistent increase across the 2000–2003 time frame (Table 4). Between 2000 and 2001, 11 of the 13 age classes showed an increase in WAA, between 2002 and 2003, 12 of the 13 age classes showed an increase in WAA. The 2003 WAA was developed from information provided by all states for the 2003 stock assessment. Comparison of the 2003 WAA against the mean values for 2000-2002 showed an increase in 11 of 13 age classes.

Comparison of "old" vs. recalculated WAA values from 2000 – 2002. Although the recalculated WAA values showed an increase across the 2000-2003 time frame, these values were lower than the mean of the 1982-1996 time series (Table 7).

Future Work.

Future years' WAA will be calculated from information provided in stock assessment "Compliance Report Template", and will therefore include all states' data. No recommendations are suggested to improve calculation methodology for future years.

It would be useful to determine if there truly was a decrease between the 1982-96 WAA and the 1998-2003 WAA. However, data are not available to recalculate 1982-2002 WAA using the current method, nor are data available to recalculate 2000-03 using the earlier method.

Figure 1. **Composition of Striped Bass Coastwide WAA by State.**
1982-1997 coastwide WAA shows a fairly even distribution from the 5 major harvest (by numbers) states (MA, NY, NJ, MD, VA). 2001 WAA is dominated by MA. 2002 WAA shows a strong contribution from MD and VA (Chesapeake Bay harvest states).

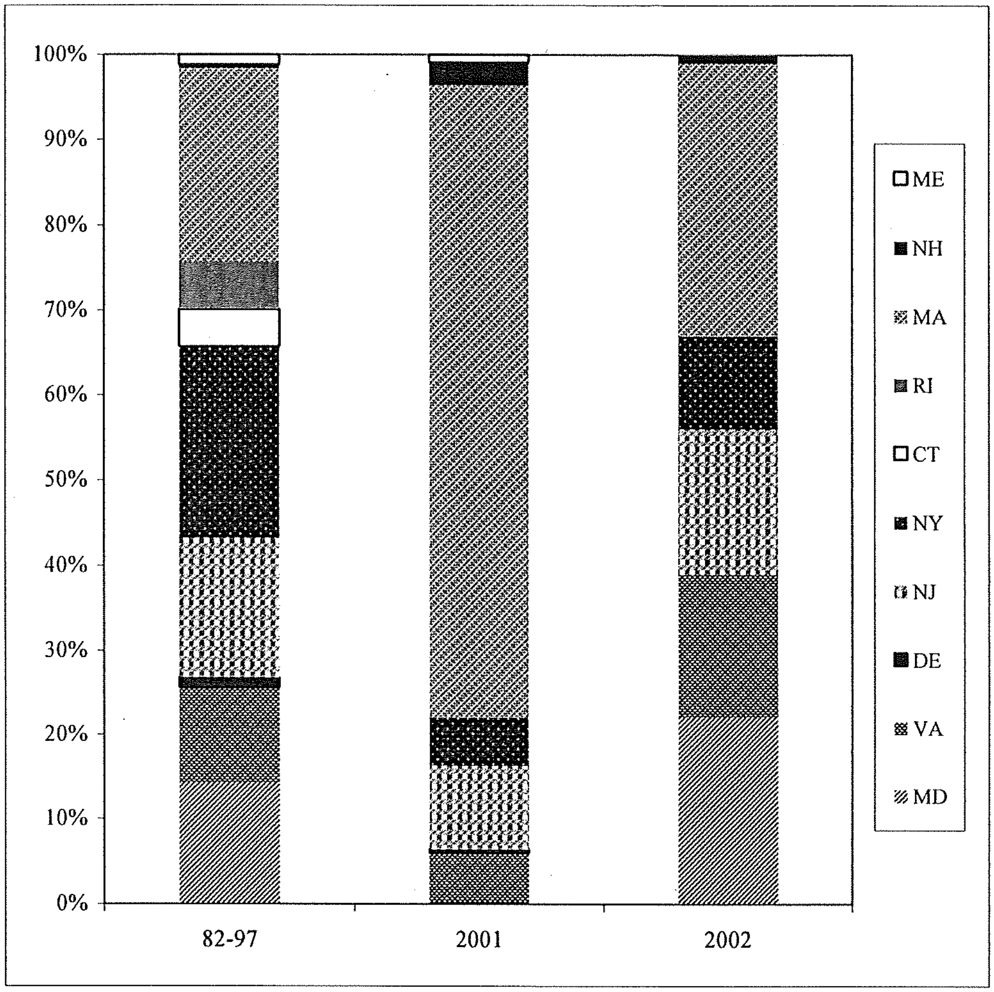


Table 1. Striped Bass Coastwide WAA (kg) Time Series Used for the 2002 Stock Assessment. 1997-1999 values are identical. Note the apparent decline in WAA between 2001-2002.

	Age														
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1982	0.13	0.64	1.09	1.54	2.42	3.75	4.83	5.79	6.20	8.68	10.80	11.20	12.97	13.26	15.91
1983	0.20	0.55	0.94	1.37	2.37	3.29	3.77	5.36	6.01	8.10	9.57	10.39	11.11	11.10	11.12
1984	0.24	0.60	1.69	1.62	2.67	3.39	5.07	5.65	6.76	7.76	8.41	12.65	10.65	11.75	14.75
1985	0.06	0.61	1.07	1.66	2.19	3.59	4.91	5.46	6.77	7.45	9.00	10.69	11.42	14.34	15.98
1986	0.14	0.57	1.27	2.40	2.44	3.12	3.95	5.05	5.44	6.09	7.75	9.16	10.97	11.55	15.83
1987	0.20	0.77	1.41	2.11	2.50	2.91	3.61	4.74	5.52	6.49	7.77	9.78	11.38	11.62	16.46
1988	0.31	0.91	1.10	1.98	3.12	4.02	4.38	4.70	5.24	5.62	8.58	10.40	11.50	11.31	17.00
1989	0.16	0.83	1.22	2.23	3.06	4.53	5.37	6.23	6.04	8.68	8.94	9.74	13.04	9.93	17.11
1990	0.08	0.89	1.14	2.05	2.35	3.83	4.91	5.96	5.70	5.97	7.44	9.08	9.36	10.80	17.65
1991	0.21	0.92	1.29	2.17	2.62	3.17	4.81	5.64	6.46	6.24	9.46	8.30	9.62	15.96	17.09
1992	0.10	0.69	1.31	1.93	2.81	3.67	4.90	5.79	6.96	8.15	9.77	12.44	13.10	11.15	17.65
1993	0.07	0.76	1.31	1.99	2.77	3.58	4.80	6.11	7.03	8.01	9.53	10.76	14.45	13.85	15.36
1994	0.24	1.05	1.69	2.21	2.85	3.50	4.94	6.20	6.80	7.53	9.73	10.69	11.38	9.06	17.75
1995	0.28	0.70	1.35	2.18	2.77	3.65	5.38	6.16	7.27	8.86	7.57	9.73	13.97	15.65	20.37
1996	0.14	1.05	1.47	2.32	3.23	4.52	6.39	7.11	7.81	9.20	9.31	10.10	11.36	12.45	17.30
1997	0.13	0.62	1.18	2.46	2.81	3.64	4.51	5.07	6.73	9.17	9.94	10.24	11.94	14.49	17.92
1998	0.13	0.62	1.18	2.46	2.81	3.64	4.51	5.07	6.73	9.17	9.94	10.24	11.94	14.49	17.92
1999	0.13	0.62	1.18	2.46	2.81	3.64	4.51	5.07	6.73	9.17	9.94	10.24	11.94	14.49	17.92
2000	0.14	1.05	1.47	2.32	3.23	4.52	6.39	7.11	7.81	9.20	9.31	10.10	11.36	12.45	17.30
2001	0.13	0.62	1.17	2.46	2.81	3.63	4.51	5.07	6.73	9.17	9.94	10.24	11.94	14.49	17.92
2002	0.82	0.81	1.25	1.75	2.47	3.30	4.16	5.48	6.36	7.45	8.75	8.89	9.99	11.03	13.95

Table 2. Revised Time Series of Striped Bass Coastwide WAA (kg).

Year	Age												
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13+**
1982	0.1	0.6	1.1	1.5	2.4	3.7	4.8	5.8	6.2	8.7	10.8	11.2	14.0
1983	0.2	0.6	0.9	1.4	2.4	3.3	3.8	5.4	6.0	8.1	9.6	10.4	11.1
1984	0.2	0.6	1.7	1.6	2.7	3.4	5.1	5.7	6.8	7.8	8.4	12.7	12.4
1985	0.1	0.6	1.1	1.7	2.2	3.6	4.9	5.5	6.8	7.4	9.0	10.7	13.9
1986	0.1	0.6	1.3	2.4	2.4	3.1	4.0	5.0	5.4	6.1	7.8	9.2	12.8
1987	0.2	0.8	1.4	2.1	2.5	2.9	3.6	4.7	5.5	6.5	7.8	9.8	13.2
1988	0.3	0.9	1.1	2.0	3.1	4.0	4.4	4.7	5.2	5.6	8.6	10.4	13.3
1989	0.2	0.8	1.2	2.2	3.1	4.5	5.4	6.2	6.0	8.7	8.9	9.7	13.4
1990	0.1	0.9	1.1	2.1	2.4	3.8	4.9	6.0	5.7	6.0	7.4	9.1	12.6
1991	0.2	0.9	1.3	2.2	2.6	3.2	4.8	5.6	6.5	6.2	9.5	8.3	14.2
1992	0.1	0.7	1.3	1.9	2.8	3.7	4.9	5.8	7.0	8.2	9.8	12.4	14.0
1993	0.1	0.8	1.3	2.0	2.8	3.6	4.8	6.1	7.0	8.0	9.5	10.8	14.6
1994	0.2	1.1	1.7	2.2	2.9	3.5	4.9	6.2	6.8	7.5	9.7	10.7	12.7
1995	0.3	0.7	1.3	2.2	2.8	3.7	5.4	6.2	7.3	8.9	7.6	9.7	16.7
1996	0.1	1.0	1.5	2.3	3.2	4.5	6.4	7.1	7.8	9.2	9.3	10.1	13.7
1997	0.1	0.6	1.2	2.5	2.8	3.6	4.5	5.1	6.7	9.2	9.9	10.2	14.8
1998	0.4	0.8	1.2	1.6	2.2	2.9	4.7	5.7	6.8	7.0	7.8	9.9	11.9
1999	0.6	0.9	1.1	1.4	1.9	2.5	3.4	5.0	6.6	7.8	8.7	9.8	12.0
2000	0.4	0.6	1.1	1.5	2.0	2.8	3.9	5.1	7.1	7.4	9.7	10.7	13.6
2001	0.2	0.4	1.1	1.8	2.2	3.2	4.1	5.0	6.4	7.8	8.6	8.3	10.9
2002	0.1	0.3	1.1	1.5	2.2	3.2	4.2	5.5	6.0	7.6	9.1	9.7	11.5

Table 3. Comparison of 2001& 2002 Data Used to Develop Striped Bass Coastwide WAA.

STATE	2001			2002		
	SURVEYS	% WAA	% HARVEST	SURVEYS	% WAA	% HARVEST
ME	COMM (harv, discards)	1	1	X	0	2
NH	COMM (harv, discards)	3	1	REC	1	1
MA	COMBINED	74	16	COMBINED	32	20
RI	X	0	5	X	0	5
CT	X	0	3	X	0	3
NY	COMM & REC	6	13	COMM & REC	11	13
NJ	REC	10	23	REC	17	19
DE	COMM	<1	2	X	0	1
MD	X	0	17	COMM (C.BAY)	22	15
VA	COMM & REC	6	17	COMM & REC	17	19
NC	X	0	3	X	0	3

Table 4. Comparison of Average Striped Bass WAA (lb) for "Coastal" (MA, NY, NJ) and "Chesapeake Bay" (MD and VA) States, based 1982-1997 Values.

Age	Coastal	CBay	Δ
1	1.8		
2	1.9	2.3	-0.4
3	3.3	2.4	0.9
4	4.7	2.7	2.0
5	6.7	3.5	3.2
6	8.3	5.5	2.8
7	10.1	7.4	2.8
8	12.9	10.4	2.5
9	14.9	12.3	2.6
10	17.4	14.1	3.4
11	20.4	17.3	3.0
12	22.8	14.9	7.8
13	24.9	17.7	7.2
14	27.9	19.4	8.5
15	35.1	15.8	19.4

Table 5. Information Used to Calculate 1998-2002 Striped Bass Coastwide WAA.

REMOVAL	YEARS	HARVEST-AT-AGE	Pre-calculated WAA
NH Rec landings	98-02	supplied	used MA
NH Rec discards	98-02	supplied	used MA
MA Rec landings	98-02	supplied	supplied
MA Rec discards	98-02	supplied	supplied
MA Com landings	98-02	supplied	supplied
MA Com discards	98-02	supplied	supplied
RI Com landings	2002	supplied	used MA
RI Rec landings	2002	supplied	used MA
RI Rec discards	2002	supplied	used MA
CT Rec landings	98-02	GaryN CAA[3]	used MA
CT Rec discards	98-00,02	GaryN CAA[3]	used MA
NY all	98-00		
NY Com landings	01-02	01,02 Ann. Rpts.	01,02 Ann. Rpts.
NY Rec landings	01-02	01,02 Ann. Rpts.	01,02 Ann. Rpts.
NY Rec discards	01-02	01,02 Ann. Rpts.	01,02 Ann. Rpts.
NJ Rec landings	98-01		
NJ Rec discards	98-01	% of harvest #s[1]	% of harvest WAA[2]
NJ ALL	2002	supplied	supplied
Del Com landings	2002	GaryN CAA[3]	used NY
Del Rec landings	2002	GaryN CAA[3]	used NJ
MD Com landings	98-02	supplied	supplied
MD Rec landings	98-02		
MD Rec discards	98-02		
VA Com landings	98-00,02	GaryN CAA[3]	used MD
VA Rec landings	98-00,02	GaryN CAA[3]	used MD
VA Rec discards	98-00,02	GaryN CAA[3]	used MD
VA ALL	2001	GaryN CAA[3]	used MD

[1] (rec harvest-at-age)*(rec discard-at-age)/(total harvest)
[2] Ages 2-5: discard WAA = 0.8*harvest WAA, Ages 6+: discard WAA = 0.9*harvest WAA
[3] Coastwide summary CAA document supplied by Gary Nelson

Table 6. Removals Used to Calculate 1998-2002 Striped Bass Coastwide WAA.

1998	1999	2000	2001	2002
NH Rec landings	NH Rec landings	NH Rec landings	NH Rec landings	NH Rec landings
NH Rec discards	NH Rec discards	NH Rec discards	NH Rec discards	NH Rec discards
MA Rec landings	MA Rec landings	MA Rec landings	MA Rec landings	MA Rec landings
MA Rec discards	MA Rec discards	MA Rec discards	MA Rec discards	MA Rec discards
MA Com landings	MA Com landings	MA Com landings	MA Com landings	MA Com landings
MA Com discards	MA Com discards	MA Com discards	MA Com discards	MA Com discards
				RI Com landings
				RI Rec landings
				RI Rec discards
CT Rec landings	CT Rec landings	CT Rec landings	CT Rec landings	CT Rec landings
CT Rec discards	CT Rec discards	CT Rec discards		CT Rec discards
NY all	NY all	NY ALL	NY Com landings	NY Com landings
			NY Rec landings	NY Rec landings
			NY Rec discards	NY Rec discards
NJ Rec landings	NJ Rec landings	NJ Rec landings	NJ Rec landings	NJ ALL
NJ Rec discards	NJ Rec discards	NJ Rec discards	NJ Rec discards	
				Del Com landings
				Del Rec landings
MD Com landings	MD Com landings	MD Com landings	MD Com landings	MD Com landings
MD Rec landings	MD Rec landings	MD Rec landings	MD Rec landings	MD Rec landings
MD Rec discards	MD Rec discards	MD Rec discards	MD Rec discards	MD Rec discards
VA Com landings	VA Com landings	VA Com landings	VA ALL	VA Com landings
VA Rec landings	VA Rec landings	VA Rec landings		VA Rec landings
VA Rec discards	VA Rec discards	VA Rec discards		VA Rec discards

[1] (rec harvest-at-age)*(rec discard-at-age)/(total harvest)
[2] Ages 2-5: discard WAA = 0.8*harvest WAA, Ages 6+: discard WAA = 0.9*harvest WAA
[3] Coastwide summary CAA document supplied by Gary Nelson

Table 7. Comparison of "Old" and "New", or Recalculated Striped Bass Coastwide WAA (kg) for 2000-2003.

	YEAR / AGE	1	2	3	4	5	6	7	8	9	10	11	12	13/13+	14	15
OLD	2000	0.14	1.05	1.47	2.32	3.23	4.52	6.39	7.11	7.81	9.2	9.31	10.1	11.36	12.45	17.3
	2001	0.13	0.62	1.17	2.46	2.81	3.63	4.51	5.07	6.73	9.17	9.94	10.24	11.94	14.49	17.92
	2002	0.82	0.81	1.25	1.75	2.47	3.3	4.16	5.48	6.36	7.45	8.75	8.89	9.99	11.03	13.95
	MEAN 00-02	0.36	0.83	1.30	2.18	2.84	3.82	5.02	5.89	6.97	8.61	9.33	9.74	11.10	12.66	16.39
	Δ 2002 - 2001	0.69	0.19	0.08	*-0.71*	*-0.34*	*-0.33*	*-0.35*	0.41	*-0.37*	*-1.72*	*-1.19*	*-1.35*	*-1.95*	*-3.46*	*-3.97*
	Δ 2002 - 2000	0.68	*-0.24*	*-0.22*	*-0.57*	*-0.76*	*-1.22*	*-2.23*	*-1.63*	*-1.45*	*-1.75*	*-0.56*	*-1.21*	*-1.37*	*-1.42*	*-3.35*
NEW	2000	0.2	0.6	0.9	1.4	1.9	2.8	4	4.9	6.1	6	8.8	9.8	12.8		
	2001	0.1	0.4	0.8	1.7	2.2	3.2	4	5	5.9	7.2	8.1	7.4	10.6		
	2002	0.1	0.3	1.1	1.5	2.2	3.2	4.2	5.5	6.0	7.6	9.1	9.7	11.5		
	2003	0.1	0.6	1.0	1.4	2.2	3.2	4.1	5.2	6.1	7.2	8.5	9.4	11		
NEW VS. OLD	Δ 2000(N) - 2000(O)	0.06	*-0.45*	*-0.57*	*-0.92*	*-1.33*	*-1.72*	*-2.39*	*-2.21*	*-1.71*	*-3.2*	*-0.51*	*-0.3*	1.44		
	Δ 2001(N) - 2001(O)	*-0.03*	*-0.22*	*-0.37*	*-0.76*	*-0.61*	*-0.43*	*-0.51*	*-0.07*	*-0.83*	*-1.97*	*-1.84*	*-2.84*	*-1.34*		
	Δ 2002(N) - 2002(O)	*-0.72*	*-0.51*	*-0.15*	*-0.25*	*-0.27*	*-0.10*	0.04	0.02	*-0.36*	0.15	0.35	0.81	*-0.16*		
	MEAN 82-96	0.2	0.8	1.3	2.0	2.7	3.6	4.8	5.7	6.4	7.5	8.9	10.3	13.5		
	Δ 2003 - MEAN 82-96	*-0.07*	*-0.17*	*-0.29*	*-0.58*	*-0.48*	*-0.43*	*-0.7*	*-0.53*	*-0.3*	*-0.32*	*-0.41*	*-0.94*	*-2.5*		

Negative values emphasized by italics.

Appendix E **A Coastwide MRFSS Index**

Methods

Generalized linear modelling (McCullagh and Nelder, 1989) was used to derive annual mean catch-per-hour estimates by adjusting the number of caught fish per trip for the classification variables of state, year, two-month sampling wave, number of days fished in the past 12 months (as a measure of avidity), and number of hours fished. In the analyses, I used only data from anglers who said they targeted striped bass to insure methods used among anglers are as consistent as possible and to identify those targeting anglers that did not catch striped bass (zero catches). Also, only data from private boats fishing in the Ocean during waves 3-6 from 1988 to 2004 were used.

A delta-lognormal model (Lo et al., 1992) was selected as the best approach to estimate year effects after examination of model dispersion (Terceiro, 2003) and standardized residual deviance versus linear predictor plots (McCullagh and Nelder, 1989). In the delta-lognormal model, catch data is decomposed into catch success/failure and positive catch components. Each component is analyzed separately using appropriate statistical techniques and then the statistical models are recombined to obtain estimates of the variable of interest. The catch success/failure was modelled as a binary response to the categorical variables using multiple logistic regression.

$$\log it(p) = \log(p/1-p) = \alpha + \sum_{i=1}^{n} \beta_i X_i + \varepsilon$$

where p is the probability of catching a fish, α is the intercept, β_i is the slope coefficient of the *i*th factor, X_i is the *i*th categorical variable (coded as 0 or 1), and ε is the error term. PROC LOGISTIC (SAS, 2000) was used to estimate parameters, and goodness-of-fit was assessed using concordance measures and the Hosmer-Lemeshow test (SAS, 2000).

Positive catches, transformed using the natural logarithm, were modelled assuming a normal error distribution using PROC GLM.

$$\log(y) = \alpha + \sum_{i=1}^{n} \beta_i X_i + \varepsilon$$

where *y* is the observed positive catch, β_i ,and X_i are the same symbols as defined earlier, and ε is the normal error term. Any variable not significant at α=0.05 with type-III (partial) sum of squares was dropped from the initial GLM model and the analysis was repeated. First-order interactions were considered in the initial analyses but it was not always possible to generate annual means by the least-square methods with some interactions included (see Searle et al., 1980); therefore, only main effects were considered.

The annual index of striped bass releases was estimated by combining the two component models. The estimate in year *i* from the models is given by

$$\hat{I}_i = \hat{p}_i * \hat{y}_i$$

where p_i and y_i are the predicted annual responses from the logistic and GLM. p_i is

$$\hat{p}_i = \frac{\exp(\hat{\alpha} + \hat{\beta}_i)}{1 + \exp(\hat{\alpha} + \hat{\beta}_i)}$$

calculated by

and y_i is calculated by

$$\hat{y}_i = \exp(LSM_i + \sigma^2 / 2)$$

where LSM_i is the least squares mean for year *i* and σ^2 is the mean square error.

Results

See Table 1 and 2 for the logistic and GLM outputs. Figure 1 is the index.

Gary Nelson
August 2005

Table 1. Logistic regression output .

The LOGISTIC Procedure

Model Information

Data Set	WORK.GREG
Response Variable	fish
Number of Response Levels	2
Model	binary logit

Model Convergence Status

Convergence criterion (GCONV=1E-8) satisfied.

The LOGISTIC Procedure

Model Fit Statistics

Criterion	Intercept Only	Intercept and Covariates
AIC	39866.962	35611.685
SC	39875.252	35993.037
-2 Log L	39864.962	35519.685

R-Square 0.1372 Max-rescaled R-Square 0.1850

Testing Global Null Hypothesis: BETA=0

Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	4345.2772	45	<.0001
Score	4036.5689	45	<.0001
Wald	3497.0463	45	<.0001

Type 3 Analysis of Effects

Effect	DF	Wald Chi-Square	Pr > ChiSq
ST	10	1081.0620	<.0001
YEAR	16	978.3635	<.0001
WAVE	3	123.4292	<.0001
AREA_X	1	7.4265	0.0064
FFDAYS12	14	746.4967	<.0001
NUM_HRSF	1	1085.2290	<.0001

Analysis of Maximum Likelihood Estimates

Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	-1.3372	21.2414	0.0040	0.9498
ST	9	1	12.2184	146.1	0.0070	0.9333
ST	10	1	-0.1587	21.2415	0.0001	0.9940
ST	23	1	-0.2962	21.2414	0.0002	0.9889
ST	24	1	-11.5237	155.7	0.0055	0.9410
ST	25	1	0.2298	21.2413	0.0001	0.9914
ST	33	1	-0.4359	21.2414	0.0004	0.9836

The SAS System 14:08 Tuesday, August 2, 2005 318

The LOGISTIC Procedure

Analysis of Maximum Likelihood Estimates

Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
ST	34	1	-0.3430	21.2414	0.0003	

0.9871
0.9574
0.9759
0.9901
<.0001
<.0001
<.0001
<.0001
<.0001
<.0001
0.0992
<.0001
<.0001
<.0001
<.0001
<.0001
<.0001
<.0001
<.0001
0.0009
<.0001
0.1808
<.0001
0.0064
<.0001
<.0001
<.0001
<.0001
0.7484
0.1440
0.8193
0.0170
0.3849
0.6564
0.0004
0.0008
0.0006
0.2024
<.0001

ST	36	1	1.1345	21.2413	0.0029
ST	37	1	-0.6415	21.2415	0.0009
ST	44	1	-0.2648	21.2413	0.0002
YEAR	1988	1	-0.8334	0.1435	33.7481
YEAR	1989	1	-0.9190	0.1316	48.7483
YEAR	1990	1	-1.1577	0.1010	131.4949
YEAR	1991	1	-0.7938	0.0733	117.3083
YEAR	1992	1	-0.4884	0.0605	65.2007
YEAR	1993	1	-0.2823	0.0553	26.0993
YEAR	1994	1	0.0882	0.0535	2.7185
YEAR	1995	1	0.3101	0.0487	40.6102
YEAR	1996	1	0.4545	0.0477	90.6630
YEAR	1997	1	0.4584	0.0439	109.2775
YEAR	1998	1	0.6835	0.0448	233.1300
YEAR	1999	1	0.6541	0.0477	188.3026
YEAR	2000	1	0.6240	0.0507	151.3509
YEAR	2001	1	0.4612	0.0410	126.2967
YEAR	2002	1	0.4055	0.0505	64.4420
YEAR	2003	1	0.1549	0.0466	11.0659
WAVE	3	1	0.2164	0.0266	66.2843
WAVE	4	1	-0.0319	0.0238	1.7912
WAVE	5	1	-0.2054	0.0229	80.4647
AREA_X	1	1	0.0429	0.0157	7.4265
FFDAYS12	0	1	-0.8178	0.0422	375.0404
FFDAYS12	10	1	-0.6060	0.0451	180.4223
FFDAYS12	20	1	-0.3029	0.0449	45.4748
FFDAYS12	30	1	-0.2894	0.0499	33.6695
FFDAYS12	40	1	-0.0180	0.0560	0.1029
FFDAYS12	50	1	-0.0764	0.0523	2.1349
FFDAYS12	60	1	0.0158	0.0693	0.0522
FFDAYS12	70	1	0.1926	0.0807	5.6996
FFDAYS12	80	1	-0.0928	0.1068	0.7549
FFDAYS12	90	1	-0.0552	0.1240	0.1979
FFDAYS12	100	1	0.2013	0.0566	12.6289
FFDAYS12	150	1	0.3078	0.0919	11.2079
FFDAYS12	200	1	0.4412	0.1293	11.6511
FFDAYS12	250	1	0.3365	0.2639	1.6251
NUM_HRSF		1	0.2253	0.00684	1085.2290

Association of Predicted Probabilities and Observed

Responses

Percent Concordant	71.9	Somers' D	0.441
Percent Discordant	27.8	Gamma	0.442
Percent Tied	0.3	Tau-a	0.213
Pairs	209763914	c	0.720

Table 2. GLM output

The GLM Procedure

Class Level Information

Class	Levels	Values
YEAR	17	1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004
WAVE	4	3 4 5 6
ST	11	9 10 23 24 25 33 34 36 37 44 51
AREA_X	2	1 2
MODE_FX	1	7
FFDAYS12	15	0 10 20 30 40 50 60 70 80 90 100 150 200 250 300

Number of Observations Read 12082
Number of Observations Used 12082

Dependent Variable: logtot

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	44	1090.02228	24.77323	32.74	<.0001
Error	12037	9108.70262	0.75673		
Corrected Total	12081	10198.72490			

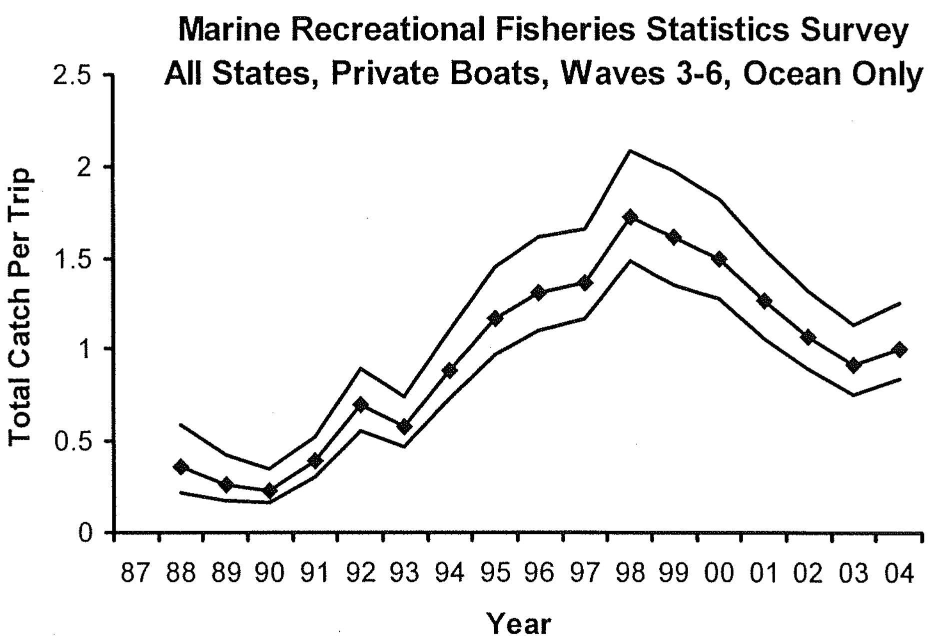
R-Square	Coeff Var	Root MSE	logtot Mean
0.106878	83.19786	0.869900	1.045579

Source	DF	Type I SS	Mean Square	F Value	Pr > F
ST	10	258.0235556	25.8023556	34.10	<.0001
YEAR	16	155.8872713	9.7429545	12.88	<.0001
WAVE	3	76.5444416	25.5148139	33.72	<.0001
FFDAYS12	14	288.3477562	20.5962683	27.22	<.0001
NUM_HRSF	1	311.2192537	311.2192537	411.27	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
ST	10	221.1009308	22.1100931	29.22	<.0001
YEAR	16	150.8842719	9.4302670	12.46	<.0001
WAVE	3	73.8469641	24.6156547	32.53	<.0001
FFDAYS12	14	291.5233657	20.8230976	27.52	<.0001
NUM_HRSF	1	311.2192537	311.2192537	411.27	<.0001

The GLM Procedure
Least Squares Means

YEAR	logtot LSMEAN	Standard Error	Pr > |t|
1988	0.87115273	0.12364562	<.0001
1989	0.64504701	0.11751929	<.0001
1990	0.73978321	0.09831961	<.0001
1991	0.92486174	0.07810480	<.0001
1992	1.22925291	0.07121558	<.0001
1993	0.87196348	0.06831894	<.0001
1994	0.99212787	0.06668443	<.0001
1995	1.10485998	0.06469854	<.0001
1996	1.11781190	0.06316001	<.0001
1997	1.15689303	0.06223858	<.0001
1998	1.23720682	0.06133543	<.0001
1999	1.18550815	0.06266735	<.0001
2000	1.13429729	0.06397751	<.0001
2001	1.07562958	0.06191667	<.0001
2002	0.94729993	0.06493991	<.0001
2003	0.97453148	0.06407868	<.0001
2004	1.05500478	0.06371743	<.0001



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A.S.M.F.C. Striped Bass Tagging Subcommittee
Summary of U.S.F.W.S. Cooperative Tagging Program Results

September 23, 2005

Desmond Kahn, Delaware Division of Fish and Wildlife, Chair

Introduction

This report summarizes the results of analysis by the ASMFC Striped Bass Tagging Subcommittee (SBTS) of tagging data from the U.S.F.W.S. Cooperative Striped Bass Tagging Program through the 2004 tagging year. These results now include two different sets of estimates of instantaneous fishing mortality (F) rates, one of which is based on the protocol previously employed by the SBTS (Smith et al. 2000), where we employ tag recovery models to estimate annual survival; survival is then converted to total instantaneous mortality, Z. Estimates of survival are corrected for bias due to live release of striped bass, because the tag recovery models assume all recoveries are of dead animals (Smith et al. 2000). The final step is subtraction of an assumed constant value of natural mortality, M, to estimate F.

The new protocol, introduced into our report for the fist time, is based on a formulation of Baranov's catch equation in Ricker (1975) and was proposed by Pollock et al. (1991). Crecco (2003) first applied this method to the striped bass tag results, as well as to combinations of tag and virtual population estimates. In this protocol, we do not assume a constant value of M. Instead, F is estimated as a function of both Z and the exploitation rate, μ. Following F estimation, M is estimated by subtraction of F from Z. Also presented are length structure of tagged striped bass, age structure of recaptures, geographic distributions of recaptures by month, and estimates of catch and exploitation rates by program.

A second change in the report is that we have added a new regulatory period to our period models, extending them from 3 periods to 4 periods. The new period is based on Addendum 1 to Amendment 6, which began in 2000, with a goal of reducing F on larger fish. Analysis of this change was conducted in advance by V. Vecchio, NY DEC, for the SBTS. The new period provided generally better fits to the tag-recovery data than the previous 3 period models.

Finally, we present two time series of Atlantic coastwide total abundance estimates for age 3+ striped bass, and two time series of estimates of age 7+ striped bass. These are based on the form of the catch equation: Kill = F * (average N). One series is produced using the F estimates generated assuming constant M, and the other set of estimates was based on the F series produced via the catch equation.

Description of Tagging Programs:

Eight tagging programs provided information for this report, and have been in progress for at least 11 years. Most producer area and coastal programs tag striped bass (mostly >= 18 inches total length) during routine state monitoring programs. Producer area tagging programs operate mainly during spring spawning, and use many capture gears, such as pound nets, gill nets, seines and electroshocking. Producer area programs are as follows: 1. Delaware and Pennsylvania (DE-PA) with fish tagged primarily in April and May, 2. Hudson River (HUDSON) with fish tagged in May, 3. Maryland (MDDNR) with fish tagged primarily in April and May, and 4. Virginia spawning stock program (VARAP) with fish tagged in the Rappahannock River during April and May. Coastal programs tag striped bass from mixed stocks during fall, winter, or early spring and use several gears including hook & line, seine, gill net, and otter trawl. The coastal tagging programs are as follows: 1. Massachusetts (MADFW) with fish tagged during fall months, 2. North Carolina winter trawl survey (NCCOOP) with fish tagged primarily in January, 3. New Jersey Delaware Bay (NJDEL) with fish tagged in March and April, and 4. New York ocean haul survey (NYOHS) with fish tagged during fall months.

Tag release and recapture data are exchanged between the U.S. Fish and Wildlife Service (USFWS) office in Annapolis, MD, and the cooperating tagging agencies. The USFWS maintains the tag release/recovery database and provides rewards to fishermen who report the recapture of tagged fish. Through July of 2004, a total of 426,576 striped bass have been tagged and released, with 75,930 recaptures reported and recorded in the USFWS database (Tina McCrobie, personal comm.).

Background of Analysis Methods:

The Striped Bass Tagging Committee's analysis protocol is based on assumptions described in Brownie et al. (1985) and elaborated for striped bass in Smith et al. (2000). The tag recovery data is analyzed in program MARK (White, 1999). Important assumptions of the tagging programs (as reported in Brownie 1985) are as follows:

1. The sample is representative of the target population.
2. There is no tag loss.
3. Survival rates are not affected by the tagging itself.
4. The year of tag recoveries is correctly tabulated.

Other assumptions related to the modeling component of the analyses include:

5. The fate of each tagged fish is independent of the fate of other tagged fish.
6. The fate of a given tagged fish is a multinomial random variable.
7. All tagged individuals of an identifiable class (age, sex) in the sample have the same annual survival and recovery rates.

The analysis protocol follows an information-theoretic approach based on Kullback-Leibler information theory and Akaike's information criterion (Burnham and Anderson 2003), and involves the following steps. First, a set of biologically-reasonable candidate models are identified prior to analysis (Table 1; see section on *Justification of candidate models*). Various patterns of survival and recovery are used to parameterize the candidate models. These models allow parameters to be constant, time specific, or allow time to be modeled as a continuous variable. Other models allow time periods to coincide with changes in regulatory regimes.

Table 1. Candidate models used in the analyses of striped bass tag recoveries.

S(.) r(.)	Constant survival and reporting
S(t) r(t)	Time specific survival and reporting

S(.) r(t)	Constant survival and time specific reporting
S(p) r(t)	*Regulatory period based survival and time specific reporting
S(p) r(p)	*Regulatory period based survival and reporting
S(.) r(p)	*Constant survival and regulatory period based reporting
S(t) r(p)	*Time specific survival and regulatory period reporting
S(d) r(p)	**Regulatory period based survival with unique terminal year and regulatory period based reporting
S(v) r(p)	***Regulatory period based survival with 2 terminal years unique and regulatory period based reporting
S(Tp) r(Tp)	*Linear trend within regulatory period for both survival and reporting
S(Tp) r(p)	*Linear trend within regulatory period survival and regulatory period based reporting (no trend)
S(Tp) r(t)	*Linear trend within regulatory period survival and time specific reporting (no trend)
S(Va) r(Va)	Three period model for VA program (1990-1992, 1993-1994, 1995-2003)
* Periods (p)	1 = {1987-1989}, 2 = {1990-1994}, 3 = {1995- 1999} 4 = {2000-2004}
** Periods (d)	1 = {1987-1989}, 2 = {1990-1994}, 3 = {1995- 1999}, 4 = {2000-2002}, 5 = 2004
*** Periods (v)	1 = {1987-1989}, 2 = {1990-1994}, 3 = {1995- 1999}, 4 = {2000-2002}, 5 = {2003-2004}

Justification of candidate models

Candidate models (selected before analysis) are based on biologically-reasonable hypotheses. The global model {S(t)r(t), i.e., full parameterized model} is a time saturated model, and is used to estimate over-dispersion and model fit statistics (see section on *Diagnostic procedures*). Models that parameterize survival as constant within time periods {S(p)r(p), S(p)r(t), S(d)r(p), and S(v)r(p)}are based on regulatory changes within the time series (1987 - 2004). Four regulatory periods are defined as follows: moratorium years (1987-1989), an interim fishery (1990-1994), a full fishery under Amendment 5 (1995 – 1999) and the recent changes introduced in 2000, which were designed to reduce F on older fish (2000-2004). Given the importance of recent years for management, we also model the terminal year separately {S(d)r(p)}and the most recent two years separately {S(v)r(p)}. The Virginia tagging program models an additional period-specific model (1990-1992, 1993-1994, 1995-2003). Although changes within the striped bass fishery are addressed with time and period-specific models, we believe that constant models are also reasonable. Selection of a constant model {S(.)r(.), S(.)r(p), S(.)r(t)} does not mean *"no"* variation in survival across the time series, but suggests that year-to-year variation in annual survival is "...relatively small in relation to the information contained in the sample data" (Burnham and Anderson 2003).

Models parameterized with covariates are also included within the candidate set. Selection of models with time as a covariate within regulatory periods {S(Tp)r(Tp), S(Tp)r(t), S(Tp)r(p)} support increasing or decreasing monotonic trends in survival within survival. These models are reasonable given increases in fishing effort during the time series. There is a concern that trend models may over or underestimate the terminal year estimate of survival, and analyses of simulated data are needed to address this issue.

Diagnostic procedures

Model adequacy is a major concern when deriving inference from a model or a suite of models. Over-dispersion, inadequate data (such as low sample size), or poor model structure may cause a lack of model fit. Over-dispersion is expected in striped bass tagging data, given that a lack of independence may result from schooling behavior. If over-dispersion is detected, then an estimate of the variance inflation factor (i.e., c-hat) is used to adjust AICc (after adjustment, AICc is called QAICc; Anderson et al (1994)). We estimate c-hat by dividing the observed Pearson Chi-square value (goodness-of-fit statistic of the global model) by the expected Pearson Chi-square value (derived from a bootstrap analysis of the global model). The goodness-of-fit probability of the global model is examined with a bootstrap-derived p-value based on model deviance (Burnham and Anderson 2003). A low p-value (< 0.15) and a large estimate of c-hat (> 4), in part, imply inadequate model structure (Burnham and Anderson 2003). A low bootstrap-derived p-value (< 0.15) combined with a moderate estimate of c-hat (>1 and < 4) supports over-dispersion (and not inadequate model structure). Over-dispersion is corrected with c-hat adjustment (as described above).

Estimates of survival

The tagging committee calculates maximum likelihood estimates of the multinomial parameters of survival and recovery based on an observed matrix of recaptures (using Program MARK). Candidate models are fit to the tag recovery data and arranged in order of fit by the second-order adjustment to Akaike's information criterion (AICc) (Akaike, 1973; Burnham and Anderson, 1992). Annual survival rates are estimated for two size groups (fish >= 18 inches TL and fish >= 28 inches TL). Annual survival is calculated as a weighted average across all models, where weight is a function of model fit (Buckland et al. 1997). Model averaging eliminates the need to select the single "best" model, allowing the uncertainty of model selection to be incorporated into the variance of parameter estimates (Burnham and Anderson 2003). Survival is inestimable for the terminal year in the fully time saturated {S(t)r(t)} model, so the time saturated model is excluded from the model averaged survival estimate for the terminal year. A weighted average of unconditional variances (conditional on the set of models) is estimated for the model-averaged estimates of survival (Buckland et al. 1997).

Bias-adjusted estimates of survival

Because we model dead recoveries, survival estimates are adjusted by annual estimates of live-release bias (Smith et al. 2000),

$$bias = -\left[\frac{\theta \cdot P_L \cdot \frac{f}{\lambda}}{(1-(1-\theta \cdot P_L)\frac{f}{\lambda}} \right],$$

where θ = 0.92 (based on an 8% hook-and-release mortality rate, Diodati and Richards 1996), P_L = annual proportion of tagged striped bass released alive, f = annual recovery rate estimated with a Brownie recovery model (Brownie et al. 1985), and λ = reporting rate. Annual and geographic-based reporting rates are desirable, but unavailable; consequently we use a constant reporting rate of 0.43 based on a high-reward tag study of the recreational fishery in Delaware Bay (Kahn and Shirey 2000). Gear-specific tagging mortality is not included in bias adjustment because estimates are unavailable for most gears types, such as trawls, pound nets, gill nets, and electrofishing. Estimates of tag-induced mortality are low (0%, Goshorn et al. 1998; 1.3% Rugolo and Lange 1993) and excluded from bias adjustments. Additionally, we do not correct for tag loss given low estimates of 0% (Goshorn et al.1998), 2% (Dunning et al. 1987), and 2.6% (Sprankle et al. 1996).

Estimates of F based on constant M

For each tagging program, instantaneous fishing mortality (F) is estimated by converting the adjusted survival (S) to total mortality (Z) and subtracting a constant value (M = 0.15) for natural mortality, where F= - LN(S) - 0.15. Using this technique, natural mortality is held fixed, and any change in total mortality (Z) results in an equal change in fishing mortality (F). Uncertainty in estimates of F (95% confidence intervals) are calculated from model-averaged unconditional variances of the adjusted survival estimates. We estimate an average F for coastal programs, and a weighted-average of F for producer area programs. Weights for producer area averages (based on the estimated proportion of fish contributed to the coast-wide stock, G. Shepherd, pers. comm. and D. Kahn, pers. comm.) are as follows: Hudson (0.13); Delaware (0.09); and Chesapeake Bay (0.78), with MD (0.67) and VA (0.33).

Estimates of F based on exploitation rate and the catch equation

Ricker (1975, p. 11) presents a formulation of Baranov's catch equation which he recommends for Type 2 fisheries, in which fishing and natural mortality occur concurrently. This is the case for striped bass, where the fishery operates over much of the year. The equation is set up to solve for the exploitation rate, μ. Pollock et al. (1991) solve the same formulation for F as follows

$$F = \mu/A*Z,$$

where A = (1 – S), the annual total mortality rate. We obtain Z from the bias-corrected survival rates developed from the MARK tag-recovery models described above. Instead of assuming that M is constant and subtracting it from Z, however, we rely on the catch equation, which shows that F is a function of both the exploitation rate and Z. Essentially, this formulation is a ratio equation, showing that the ratio of μ to A equals the ratio of F to Z. We have estimates of the exploitation rate (see below), Z and A, with the latter two simple functions of the survival rate estimates obtained via the tag-recovery models. Once F is estimated, we can estimate M by subtracting F from Z. This is the approach used by Crecco (2003).

Encounter and exploitation rates

In addition to estimates of S and F, we estimated annual catch rates and annual exploitation rates for two length groups (>= 18 inches and >= 28 inches) with tag recoveries of striped bass released by eight agencies (1987 - 2004) of the Cooperative Striped Bass Tagging Program. Each time series of annual catch rates and annual exploitation rates reflects trends in total catch rate (including releases) and harvest rate, respectively. Estimates of annual catch rates and annual exploitation rates are independent among years; fish at large after the first recovery-year are not used in the analysis. All of the estimates are calculated using a tag reporting rate estimate of 0.43 from a 2000 study conducted on the Delaware River stock, but employing tag returns from the whole Atlantic coast. This estimate is identical to one developed independently and presented in Smith et al. (2000). The reporting rate is the proportion of tagged, recaptured fish whose tag is actually reported to the U. S. F and W. S. Thus we assume that the same tag reporting rate was operative along the whole coast. Annual catch rates and annual exploitation rates are adjusted R/M ratios as described below, where R is the number of tags reported as recaptured over the year from the number tagged at the beginning of the year (the recovery rate) and M is the number of fish tagged or marked at the beginning of the year (reporting rate = 0.43, hooking mortality rate = 0.08, R_k = killed recaptures, R_L = recaptures released alive):

(1) Annual catch rate = (R / 0.43) / M
(2) Annual exploitation rate = $((R_k + R_L * 0.08) / 0.43) / M$

Stock size estimation

Using the form of Baranov's catch equation, catch = F * (average stock size), we were able to estimate stock size since we have estimates of total kill and estimates of F. Note that the total kill includes discards, which are generally of the same magnitude as the total landings in number. These estimates were developed for 18 inch plus fish, which in practice is usually fish 18" or above, corresponding roughly to 3 year old and older striped bass.

Two separate time series of stock sizes were developed. The first was based on the F estimates that assumed constant M for 18 inch plus fish, while the second was based on the estimates generated via the catch equation. Since the F estimates are based on total survival for the constant M estimates, and in the case of the catch equation estimates, exploitation rate that includes discard mortality from released fish that were recaptured, the total kill is the correct variable to employ here.

Results

Exploitation Rate and Total Catch Rate

The exploitation rate estimates for 28 inch fish are presented by program and as an unweighted mean (Table 1A). For 2004, the two Chesapeake Bay programs, Virginia and Maryland, had the lowest estimates of 0.08. The highest estimate was from the Delaware River stock, but it was only 0.22. For the whole time series, coastwide average exploitation rates peaked from 1997 and 1998 at 0.24 and have declined substantially since then. The coastwide, unweighted average for 2004 was 0.13.

The total catch rates on the coast averaged 0.19 for 2004 (Table 1B). This is continues a declining trend since a peak of 0.34 in 1991. The catch rate estimate for 1997 was 0.31, over 50% of the 2004 estimate.The difference between the total catch rate and the exploitation rate suggests that the live release rate was 0.06. This estimate could be biased low because anglers may be less likely to notice tags on fish they have released. They could also be less likely to recover tags they do notice, since they are releasing the fish. This value of 0.06 is the estimate of release rate since 1997. Prior to 1997, the release rate estimate was substantially higher, as high as 0.21 in 1991.

For 18 inch plus fish, exploitation rate was lower than for 28 inch fish, and declined to 0.09 in 2004 (Table 1C). Catch rate for 18 inch plus fish was also slightly lower than for 28 inch fish, and for 2004 = 0.17. These two values for 2004 were again part of a continuing decline.

Fish >= 28 inches: Estimates of F assuming constant M and stock size of fish aged 7+

Uncorrected survival and F estimates, together with the bias-corrected estimates and confidence intervals for bias-corrected fishing mortality are presented by program in Table 2. The models receiving the higher weights in the final estimate are shown by program in Table 3.

Summaries of the F estimates assuming constant M are in Table 4. The 2004 estimates of F for the four mixed-stock coastal programs (Massachusetts, New York Ocean Haul, New Jersey, and North Carolina winter trawl) were 0.10, 0.02, 0.72, and 0.26, respectively, with an unweighted-mean F of 0.27 (Table 4).The New Jersey Delaware Bay estimates are very erratic among years and the 2004 value of 0.72 has a large influence on the coastal average and the coastwide average. This is the highest F estimate in the time series for the coastal programs. The 2004 estimates for producer area programs Hudson River, Delaware River, and Chesapeake Bay (HUDSON, DE/PA, MDDNR, VARAP) were 0.27, 0.32, 0.34, and 0.25, respectively, with a weighted mean fishing mortality (F) of 0.31, again the highest in the time series. The Delaware River and Maryland Chesapeake estimates were relatively high, with the Hudson and Virginia estimates at a lower level. The average of the coastal and producer programs is the coastwide 2004 estimate for the fully-recruited fish, assuming constant M, F =0.29.

While this estimate is the highest in the time series, it is still slightly below the target F = 0.30. Variation in these F rates as additional data has been added is portrayed in Figure 1.

Stock size estimates of 7+ fish developed using this series of F estimates increased to 10.5 million in 2002, then declined slightly to 8.2 million in 2004 (Table 4).

Fish >= 28 inches: Estimates of F from the catch equation

Estimates of fully-recruited F for 2004 from the catch equation average only about half the level of the constant M estimates. The 2004 estimates of F for the four mixed-stock coastal programs (Massachusetts, New York Ocean Haul, New Jersey, and North Carolina winter trawl) were 0.10, 0.10, 0.23, and 0.15, respectively, with an unweighted-mean F of 0.15 (Tables 5, 6). The New Jersey estimate was the highest for 2004, as in the constant M estimates, because the survival estimate was low (Table 2). The 2004 estimates for producer area programs Hudson River, Delaware River, and Chesapeake Bay were 0.22, 0.26, 0.11 and 0.09, respectively, with a weighted mean fishing mortality (F) of 0.13 (Table 6). The average of the coastal and producer programs is the coastwide 2004 estimate for the fully-recruited fish, assuming constant M, and equals 0.14 (Table 6). The estimates of total abundance obtained with the catch equation F estimates are higher than those obtained with the constant M estimates, because the F estimates are lower, so if the same kill occurs with a lower F, it implies the total stock is larger. These estimates peak in 2004 at 17 million age 7+ fish (Table 6).

18 inch plus fish: Estimates of F assuming constant M and stock size estimates from 1990-2004

Estimates of uncorrected survival and fishing mortality by program, assuming constant M, with bias-corrected estimates of these parameters are in Table 7. The F estimates produced under this method were almost as high as those for fully recruited fish for the producer areas, while the coastal program estimates were actually slightly higher than those for the 28 inch coastal F estimates. These estimates were much higher than F estimates produced for 18 inch plus fish using the catch equation method.

Table 8 presents the weights used in averaging the models into the final survival estimates presented in Table 7. F estimates are summarized and stock size estimates are presented in Table 9. The 2004 estimates for producer area programs of Hudson River, Delaware River, Maryland Chesapeake Bay, and Virginia Rappahannock River are 0.25, 0.29, 0.36 and 0.06, respectively, with the average F = 0.26. Among producer areas, the Maryland estimates were the highest, at 0.36 for 2004. The coastal program F estimates are erratic, except for the Massachusetts results, which are very low and stable. Results of coastal programs in terms of F estimates for 2004 for Massachusetts, New York Long Island, New Jersey Delaware Bay, and North Carolina winter trawl are 0.10, 0.30, 0.68 and 0.18, with an average of 0.31. The coastwide averages, including both coastal and producer areas, have the highest F estimate in 2000 at F = 0.40, then decline to F = 0.29 for 2004, identical to that for the 28 inch fish.

Estimated stock sizes using these F estimates are somewhat erratic, with the peak year in 1995 at 48 million fish (Table 9), due to the very low estimate of F = 0.06 in 1995. Since 1997, the estimates were more stable and lower, ranging between 12.5 and 15.8 million. The 2004 estimate is the largest of this recent period at 18 million.

18 inch plus fish: estimates of F using the catch equation and stock size estimates from 1990-2004

Using the catch equation method, the estimates of fishing mortality were lower for 18 inch plus fish than they were assuming constant natural mortality (Tables 10, 11). The producer area average for 2004 was 0.13 and the coastal average was 0.08. These results are lower than those made with an assumption of constant M because they do not assume that M = 0.15 and they are dependent on the exploitation rate estimates, which are generally relatively low for 18 inch plus fish. With this method, the coastwide F estimate for 18 inch plus fish in 2004 was only F = 0.11. The peak F estimates in this time series occurred in 1997-1998 at F = 0.16. F has declined in recent years Table 11.

The stock size estimates computed from this F series are more reasonable than the previous set of estimates in that they exhibit more stability (Table 11). A moderately consistent stock growth is apparent, with some declines, until about 2000, when stock growth becomes rapid. The estimate for 2004 is the highest in the time series at 48.5 million fish.

Length frequency, age, and geographic distribution of recaptures

Total length frequencies of fish tagged in 2004 and age distributions of fish recaptured in 2004 were tabulated by program (Tables 12 and 13). Total length frequencies represent the length of fish at the time of tagging. Age distributions are based on a subsample of the total number of tagged fish, because not 18 inch plus fish are aged. Ages (from scales) estimated at the time of tagging are adjusted to the recovery date. For each tagging program, geographic distributions of all recaptures during 2004 (from fish tagged and released during the full time series) were depicted by state and month (Table 14).

Sources of uncertainty in the tag-based estimates of fishing mortality rate

Confidence intervals have not yet been developed for the estimates based on the catch equation, but will be implemented for next years report.

Violations of the basic assumptions have been investigated in detail for the Virginia tag data set and only very minor violations of the assumption of complete mixing was detected, which did not affect the results of the analysis (J. Hoenig, personal communication). The major concern is that the tagged fish be representative of the stocks.

The estimate of reporting rate employed needs to be re-estimated. This is the rate at which tags are reported in, once tagged fish are recaptured. The current estimate of 0.43 was based on a study in 1999 conducted on the Delaware River spawning stock, employing tag returns from the Atlantic Coast (Kahn and Shirey 2000). If the estimate is too high, then the exploitation rate and the F estimate would be underestimated.. If the rate is too low, then F would be overestimated. A research grant proposal is currently in submission to conduct a high reward tagging study to develop a more current estimate of the reporting rate.

The assumption of constant natural mortality has been contradicted for the Chesapeake Bay stock by two alternative analyses (Crecco 2003, Hoenig, personal communication), both of which found that natural mortality had increased for the resident stock. The catch equation method introduced in this report was used to avoid the assumption of a constant value of M.

Finally, the estimates of F vary somewhat from year-to-year as additional tag returns are added in subsequent years. This variation primarily occurs during the most recent years F estimates. Some of the coastal programs results for 18 inch plus fish are fairly erratic and seem to lack some credibility, but the Tagging Subcommittee has not been able to determine a cause or violation of assumptions as the source of the erratic estimates.

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