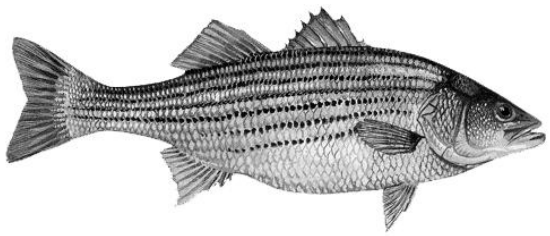
Chapter 10
Striped Bass



Morone saxatilis

INTRODUCTION

We aged a total of 1132 striped bass, *Morone saxatilis*, using their scales collected by the VMRC's Biological Sampling Program in 2008. Of 1132 aged fish, 645 and 487 fish were collected in Chesapeake Bay (bay fish) and Atlantic waters (ocean fish) of Virginia, respectively. The average age for the bay fish was 8.8 years with a standard deviation of 3.3 and a standard error of 0.13. Seventeen age classes (3 to 18 and 22) were represented in the bay fish, comprising fish from the 1986, 1990 through 2005 year classes. The year class of 1993 was dominant in the bay fish sample in 2008 followed by the year classes of 1995 through 2002. The average age for the ocean fish was 9.9 years with a standard deviation of 2.6 and a standard error of 0.12. Fourteen age classes (5 to 17 and 20) were represented in the ocean fish, comprising fish from the 1988, 1991 to 2003 year classes. The year class of 1991 was dominant in the ocean fish sample in 2008, followed by the year classes of 1995 through 2000. We also aged a total of 258 fish using their otoliths in addition to ageing their scales. The otolith ages were compared to the scale ages to examine how close both ages were to one another (please see details in Results).

METHODS

Sample size for ageing — We estimated sample sizes for ageing striped bass collected in both Chesapeake Bay and Atlantic waters of Virginia in 2008, respectively, using a two-stage random sampling method (Quinn and Deriso 1999) to increase precision in estimates of age composition from fish sampled efficiently and effectively. The basic equation is:

$$A = \frac{V_a}{\theta_a^2 CV^2 - B_a / L}, \qquad (1)$$

where A is the sample size for ageing striped bass in 2008; θ_a stands for the proportion of age a fish in a catch. V_a and B_a represent variance components within and between length intervals for age a, respectively; CV is coefficient of variance; L is a subsample from a catch and used to estimate length distribution in the catch. θ_a, V_a, B_a, and CV were calculated using pooled age-length data of striped bass collected from 2002 to 2007 and using equations in Quinn and Deriso (1999). For simplicity, the equations are not listed here. L was the total number of striped bass used by VMRC to estimate length distribution of the caches from 2002 to 2007. The equation (1) indicates that the more fish that are aged, the smaller the CV (or higher precision) that will be obtained. Therefore, the criterion to decide A (number of fish) is that A should be a number above which there is only a 1% CV reduction achieved by aging an additional 100 or more fish.

Handling of collection — Sagittal otoliths (hereafter, referred to as "otoliths") and scales were received by the Age & Growth Laboratory in labeled coin envelopes. Once in our hands, they were sorted based on date of capture, their envelope labels were verified against VMRC's collection data, and each fish assigned a unique Age and Growth Laboratory identification number. All otoliths and scales were stored dry within their original labeled coin envelopes; otoliths were contained inside protective Axygen 2.0 ml microtubes.

Preparation —

Scales – Striped bass scales were prepared for age and growth analysis by making acetate impressions of the scale microstructure. Due to extreme variation in the size and shape of scales from individual fish, we selected only those scales that had even margins and which were of uniform size. We selected a range of four to six preferred scales (based on overall scale size) from each fish, making sure that only non-regenerated scales were used. Scale impressions were made on extruded clear acetate sheets (25 mm x 75 mm) with a Carver Laboratory Heated Press (model "C"). The scales were pressed with the following settings:

Pressure:	15000 psi
Temperature:	77°C (170°F)
Time:	5 to 10 min

Striped bass scales that were the size of a quarter (coin) or larger, were pressed individually for up to twenty minutes. After pressing, the impressions were viewed with a Bell and Howell microfiche reader and checked again for regeneration and incomplete margins. Impressions that were too light, or when all scales were regenerated a new impression was made using different scales from the same fish.

Otoliths — We used a thin-section and bake technique to process striped bass otoliths for age determination. Otolith preparation began by randomly selecting either the right or left otolith. The otolith was mounted with Crystalbond™ 509 adhesive. The otoliths were viewed by eye, and when necessary, under a stereo microscope to identify the location of the core, and the position of the core marked using a pencil across the otolith surface. At least one transverse cross-section (hereafter "thin-section) was then removed from the marked core of each otolith using a Buehler® IsoMet™ low-speed saw equipped with two, three inch diameter, Norton® Diamond Grinding Wheels(hereafter, referred to as "blades"), separated by a stainless steel spacer of 0.4mm (diameter 2.5"). The otolith was positioned so that the blades straddled each side of the otolith focus pencil mark. It was crucial that this cut be perpendicular to the long axis of the otolith. Failure to do so resulted in "broadening" and distortion of winter growth zones. A proper cut resulted in annuli that were clearly defined and delineated. Once cut, the otolith thin-section was placed into a ceramic "Coors" spot plate well and baked in a Thermolyne 1400 furnace at 400^{o}C. Baking time was dependent on otolith size and gauged by color, with a light, caramel color desired. Once a suitable color was reached the baked thin-section was placed on a labeled glass slide and covered with a thin layer of Flo-texx® mounting medium, which provided enhanced contrast and greater readability by increasing light transmission through the sections.

Readings — The CQFE system assigns an age class to a fish based on a combination of reading the information contained in its otolith, the date of its capture, and the species-specific period when it deposits its annulus. Each year, as the fish grows, its otoliths grow and leave behind markers of their age, called annuli. Technically, an otolith annulus is the combination of both the opaque and the translucent bands. In practice, only the opaque bands are counted as annuli. The number of these visible dark bands replaces "x" in our notation, and is the initial "age" assignment of the fish.

Second, the otolith section is examined for translucent growth. If no translucent growth is visible beyond the last dark annulus, the otolith is called "even" and no modification of the assigned age is made. The initial assigned age, then, is the age class of the fish. Any growth beyond the last annulus can be interpreted as either being toward the next age class or within the same age class. If translucent growth is visible beyond the last dark annulus, a "+" is added to the notation.

By convention all fish in the Northern Hemisphere are assigned a birth date of January 1. In addition, each species has a specific period during which it deposits the dark band of the annulus. If the fish is captured after the end of the species-specific annulus deposition period and before January 1, it is assigned an age class notation of "x + x", where "x" is the number of dark bands in the otolith.

If the fish is captured between January 1 and the end of the species-specific annulus deposition period, it is assigned an age class notation of "x + (x+1)". Thus, any growth beyond the last annulus, after its "birthday", but before the dark band deposition period, is interpreted as being toward the next age class.

For example, striped bass otolith deposition occurs between April and June (Secor et al. 1995). A striped bass captured between January 1 and June 30, before the end of the species' annulus formation period, with three visible annuli and some translucent growth after the last annulus, would be assigned an age class of "x + (x+1)" or 3 + (3+1), noted as 3 + 4. This is the same age-class assigned to a fish with four visible annuli captured after the end of June 30, the period of annulus formation, which would be noted as 4 + 4.

Striped bass scales are also considered to have a deposition period of April through June (Secor et al. 1995), and age class assignment using these hard-parts is conducted in the same way as otoliths.

All striped bass samples (scale pressings and sectioned otoliths) were aged by two different readers in chronological order based on collection date, without knowledge of previously estimated ages or the specimen lengths. When the readers' ages agreed, that age was assigned to the fish. When the two readers disagreed, both readers sat down together and re-aged the fish again without any knowledge of previously estimated ages or lengths, then assigned a final age to the fish. When the age readers were unable to agree on a final age, the fish was excluded from further analysis.

Scales - We determined fish age by viewing acetate impressions of scales (Figure 1) with a standard Bell and Howell R-735 microfiche reader equipped with 20 and 29 mm lenses. Annuli on striped bass scales are identified based on two scale microstructure features, "crossing over" and circuli disruption. Primarily, "crossing over" in the lateral margins near the posterior\anterior interface of the scale is used to determine the origin of the annulus. Here compressed circuli (annulus) "cross over" the previously deposited circuli of the previous year's growth. Typically annuli of the first three years can be observed transversing this interface as dark bands. These bands remain consistent throughout the posterior field and rejoin the posterior\anterior interface on the opposite side of the focus. Annuli can also be observed in the anterior lateral field of the scale. Here the annuli typically reveal a pattern of discontinuous and suddenly breaking segmented circuli. This event can also be distinguished by the presence of concentric white lines, which are typically associated with the disruption of circuli.

Figure 1. Scale impression of a 5-year-old male striped bass.

Annuli can also be observed bisecting the perpendicular plain of the radial striations in the anterior field of the scale. Radii emanate out from the focus of the scale towards the outer corner margins of the anterior field. These radial striations consist mainly of segmented concave circuli. The point of intersection between radii and annuli results in a "straightening out" of the concave circuli. This straightening of the circuli should be consistent throughout the entire anterior field of the scale. This event is further amplified by the presence of concave circuli neighboring both directly above and below the annulus. The first year's annulus can be difficult to locate on some scales. It is typically best identified in the lateral field of the anterior portion of the scale. The distance from the focus to the first year's annulus is typically larger with respect to the following annuli. For the annuli two through six, summer growth generally decreases proportionally. For ages greater than six, a crowding effect of the annuli near the outer margins of the scale is observed. This crowding effect creates difficulties in edge interpretation. At this point it is best to focus on the straightening of the circuli at the anterior margins of the scale.

When ageing young striped bass, zero through age two, extreme caution must be taken as not to over age the structure. In young fish there is no point of reference to aid in the determination of the first year; this invariably results in over examination of the scale and such events as hatching or saltwater incursion marks (checks) may be interpreted as the first year.

Otoliths – All thin-sections were aged by two different readers using a Nikon SMZ1000 stereo microscope under transmitted light and dark-field polarization at between 8 and 20 times magnification (Figure 2).

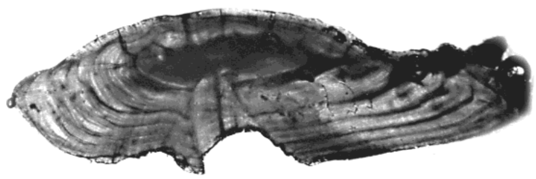


Figure 2. Otolith thin-section of a 5-year-old male striped bass.

By convention an annulus is identified as the narrow opaque zone, or winter growth. Typically the first year's annulus can be determined by first locating the focus of the otolith. The focus is generally located, depending on preparation, in the center of the otolith, and is visually well defined as a dark oblong region. The first year's annulus can be located directly below the focus, along the outer ridge of the sulcal groove on the ventral and dorsal sides of the otolith. This insertion point along the sulcal ridge resembles a check mark (not to be confused with a false annulus). Here the annulus can be followed outwards along the ventral and dorsal surfaces where it encircles the focus. Subsequent annuli also emanate from the sulcal ridge; however, they do not encircle the focus, but rather travel outwards to the distal surface of the otolith. To be considered a true annulus, each annulus must be rooted in the sulcus and travel without interruption to the distal surface of the otolith. The annuli in striped bass have a tendency to split as they advance towards the distal surface. As a result, it is critical that reading path proceed in a direction down the sulcal ridge and outwards to the distal surface.

Comparison Tests — A symmetric test (Hoenig et al. 1995) and coefficient of variation (CV) analysis were used to detect any systematic difference and precision on age readings, respectively, for following comparisons: 1) between the two readers in the current year; 2) within each reader in the current year; 3) time-series bias between the current and previous years within each reader; and 4) between scale and otoliths ages. The readings from the entire sample for the current year were used to examine the difference between two readers. A random sub-sample of 50 fish from the current year was selected for second readings to examine the difference within a reader. Fifty otoliths randomly selected from fish aged in 2000 were used to examine the time-series bias within each reader. A figure of 1:1 equivalence was used to illustrate those differences (Campana et al. 1995). All statistics analyses and figures were made using R (R Development Core Team 2009).

RESULTS

We estimated a sample size of 628 for ageing the bay striped bass in 2008, ranging in length interval from 7 to 53 inches (Table 1). This sample size provided a range in CV for age composition approximately from the smallest CV of 10% for age 9 and 10 to the largest CV of 23% for age 3 and 13 of the bay fish. We randomly selected and aged 645 fish from 905 striped bass collected by VMRC in Chesapeake Bay in 2008. We fell short in our over-all collections for this optimal length-class sampling estimate by 101 fish, mainly in the very small and large length intervals (Table 1), as a result, the precision for the estimates of the majority of age categories would not be influenced significantly.

We estimated a sample size of 501 for ageing the ocean striped bass in 2008, ranging in length interval from 14 to 53 inches (Table 2). This sample size provided a range in CV for age composition approximately from the smallest CV of 8% for age 9 and 10 to the largest CV of 25% for age 6 of the ocean fish. We aged all 487 striped bass collected by VMRC in Atlantic waters of Virginia in 2008. We fell short in our over-all collections for this optimal length-class sampling estimate by 175 fish, from among the small, medium, and large length intervals (Table 2), as a result, the precision for the estimates of all age groups would be influenced significantly.

Scales — The measurement of reader self-precision was good for both readers. There is no significant difference between the first and second readings for Reader 1 with a CV = 4.9% (test of symmetry: $\chi^2 = 14$, df = 12, $P = 0.3007$). There is no significant difference between the first and second readings for Reader 2 with a CV = 2.2% (test of symmetry: $\chi^2 = 8$, df = 9, $P = 0.5341$). There was an evidence of systematic disagreement between Reader 1 and Reader 2 with a CV of 4.1% (test of symmetry: $\chi^2 = 129.37$, df = 45, $P < 0.0001$) (Figure 3). The CV of 4.1% was fair. The between-reader agreement for scale for one year or less was 89% of all aged fish very similar to 90% in 2006.

There is no time-series bias for both readers. 88% of the age readings by Reader 1 in 2008 had either an agreement with or one-year difference from those fish aged in 2000 with a CV of 8.3% (test of symmetry: $\chi^2 = 12.3$, df = 14, $P = 0.5822$). The age readings of 97% fish by Reader 2 in 2008 had either an agreement with or one-year different from those fish aged in 2000 with a CV of 5.7% (test of symmetry: $\chi^2 = 15$, df = 12, $P = 0.2414$).

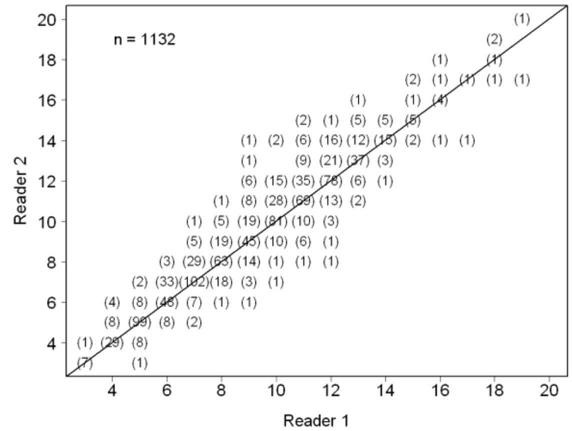


Figure 3. Between-reader comparison of scale age estimates for striped bass collected in Chesapeake Bay and Virginia waters of the Atlantic in 2008.

Of the 645 bay striped bass aged with scales, 17 age classes (3 to 18 and 22) were represented (Table 3). The average age for the sample was 8.8 years. The standard deviation and standard error were 3.3 and 0.13, respectively. Year-class data (Figure 4) indicates that recruitment into the fishery in Chesapeake Bay begins at age 3, which corresponds to the 2005 year-class for striped bass caught in 2008. The year class of 2003 (age 5) striped bass was dominated in the sample in 2008. The sex ratio of male to female was 1:1.21 for the bay fish.

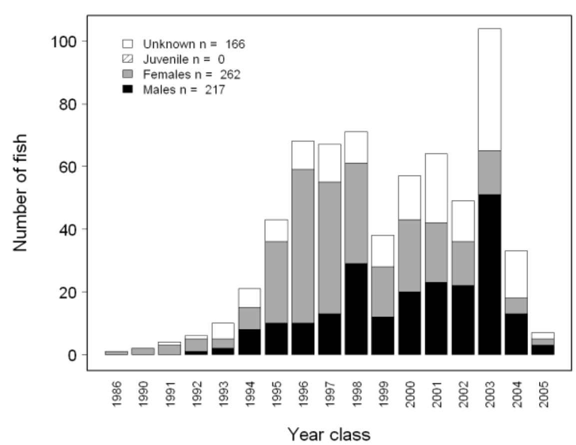


Figure 4. Year-class frequency distribution for

striped bass collected in Chesapeake Bay of Virginia for ageing in 2008. Distribution is broken down by sex and estimated using scale ages. "Unknown" is used for specimen that were not eligible for gonad extraction, or, during sampling, the sex was not examined.

Of the 487 ocean striped bass aged with scales, 14 age classes (5 to 17 and 20) were represented (Table 4). The average age for the sample was 9.9 years. The standard deviation and standard error were 2.6 and 0.12, respectively. Year-class data (Figure 5) indicates that recruitment into the fishery in Atlantic waters of Virginia begins at age 5, which corresponds to the 2003 year-class for striped bass caught in 2005. The year class of 2001 (age 7) striped bass was dominated in the sample in 2008. The sex ratio of male to female was 1:2.64 for the ocean fish.

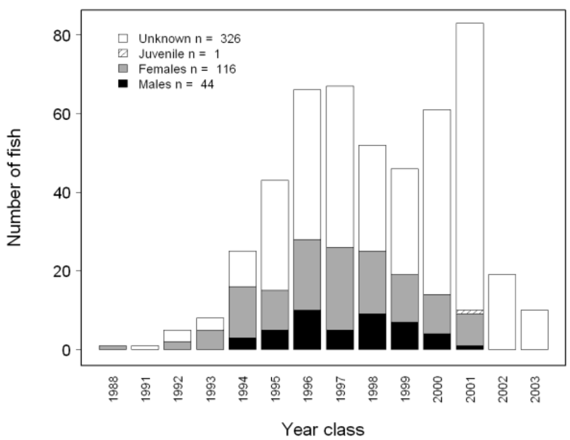


Figure 5. Year-class frequency distribution for striped bass collected in Virginia waters of Atlantic for ageing in 2008. Distribution is broken down by sex and estimated using scale ages. "Unknown" is used for specimen that were not eligible for gonad extraction, or, during sampling, the sex was not examined.

Otoliths — The measurement of reader self-precision was very good for both readers. There is no significant difference between the first and second readings for Reader 1 with a CV of 0.5% and an agreement of 92% (test of symmetry: $\chi^2 = 4$, df = 4, P = 0.4060). There is no significant difference between the first and second readings for Reader 2 with a CV of 0.9% and an agreement of 90% (test of symmetry: $\chi^2 = 5$, df = 5, P = 0.4159). There was no evidence of systematic disagreement between Reader 1 and Reader 2 with an agreement of 84% and a CV of 1.1% (test of symmetry: $\chi^2 = 17.94$, df = 17, P = 0.3927) (Figure 6).

There is no time-series bias for both readers. Reader 1 had an agreement of 85% with the fish aged in 2003 with a CV of 1.5% (test of symmetry: $\chi^2 = 9$, df = 8, P = 0.3423). Reader 2 had an agreement of 88% with the fish aged in 2003 with a CV of 1.5% (test of symmetry: $\chi^2 = 7$, df = 4, P = 0.1359).

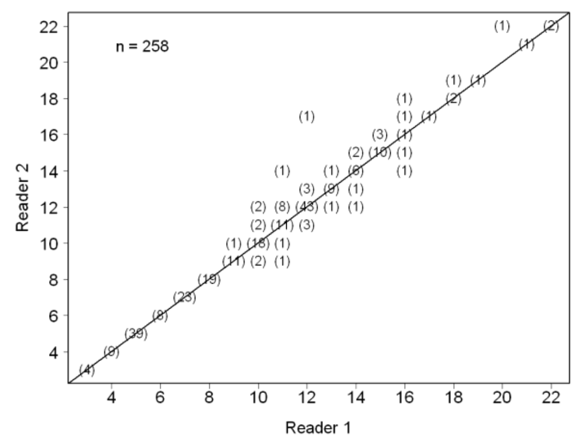


Figure 6. Between-reader comparison of otolith age estimates for striped bass collected in Chesapeake Bay and Virginia waters of theAtlantic in 2008.

Of 258 fish aged with otoliths, 21 age classes (3 to 23) were represented for striped bass aged with otoliths. The average age for the sample was 9.9 years. The standard deviation and standard error were 3.9 and 0.24, respectively.

Comparison of Scale and Otolith Ages — We aged 258 striped bass using both their scales and otoliths. There was evidence of systematic disagreement between otolith and scale ages (test of symmetry: $\chi^2 = 91.3$, df = 44, $P < 0.0001$) with an average CV of 7.4%. There was an agreement of 42% between scale and otoliths ages whereas scales were assigned a lower and higher age than otoliths for 35% and 23% of the fish, respectively (Figure 7). There was also evidence of bias between otolith and scale ages using an age bias plot (Figure 8), with scale generally assigned higher ages for younger fish and lower ages for older fish than otoliths age estimates.

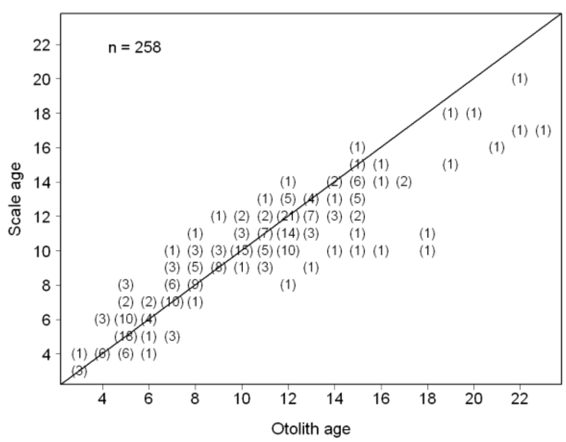


Figure 7. Comparison of scale and otolith age estimates for striped bass collected in Chesapeake Bay and Virginia waters of the Atlantic in 2008.

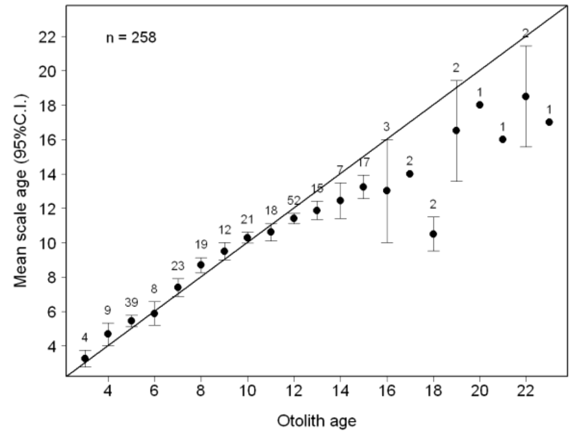


Figure 8. Age-bias plot for striped bass scale and otolith age estimates in 2008.

Age-Length-Key (ALK) — We developed an age-length-key for both bay (Table 5) and ocean fish (Table 6) using scale ages, separately. The ALK can be used in the conversion of numbers-at-length in the estimated catch to numbers-at-age using scale ages. The table is based on VMRC's stratified sampling of landings by total length inch intervals.

RECOMMENDATIONS

We recommend that VMRC and ASMFC use otoliths for ageing striped bass. Although preparation time is greater for otoliths compared to scales, nonetheless as the mean age of striped bass increases in the recovering fishery, otoliths should provide more reliable estimates of age. We will continue to compare the age estimates between otoliths and scales.

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Table 1. Number of striped bass collected in the Chesapeake Bay of Virginia in 2008 and scale-aged in each 1-inch length interval. “Target” represents the sample size for ageing estimated for 2008, "Collected" represents number of fish with both total length and otoliths, and “Need” represents number of fish that were not obtained in each length interval compared to the optimum sample size for ageing and number of fish aged.

Interval	Target	Collected	Aged	Need
7 - 7.99	5	1	0	5
8 - 8.99	5	0	0	5
9 - 9.99	5	0	0	5
10 - 10.99	5	0	0	5
11 - 11.99	5	0	0	5
12 - 12.99	5	0	0	5
13 - 13.99	5	0	0	5
14 - 14.99	5	0	0	5
15 - 15.99	5	0	0	5
16 - 16.99	5	0	0	5
17 - 17.99	5	1	1	4
18 - 18.99	9	18	14	0
19 - 19.99	18	46	36	0
20 - 20.99	20	27	24	0
21 - 21.99	24	33	33	0
22 - 22.99	29	25	24	5
23 - 23.99	33	29	29	4
24 - 24.99	31	41	34	0
25 - 25.99	30	29	29	1
26 - 26.99	24	28	28	0
27 - 27.99	23	22	22	1
28 - 28.99	19	42	31	0
29 - 29.99	15	24	16	0
30 - 30.99	15	26	18	0
31 - 31.99	16	33	19	0
32 - 32.99	21	26	21	0
33 - 33.99	22	39	23	0
34 - 34.99	28	48	32	0
35 - 35.99	28	60	34	0
36 - 36.99	38	88	46	0
37 - 37.99	31	97	40	0
38 - 38.99	15	36	20	0
39 - 39.99	10	31	17	0
40 - 40.99	9	20	19	0
41 - 41.99	5	8	8	0
42 - 42.99	5	7	7	0
43 - 43.99	5	6	6	0
44 - 44.99	5	4	4	1
45 - 45.99	5	5	5	0
46 - 46.99	5	2	2	3
47 - 47.99	5	2	2	3
48 - 48.99	5	0	0	5
49 - 49.99	5	0	0	5
50 - 50.99	5	0	0	5
51 - 51.99	5	0	0	5
52 - 52.99	5	1	1	4
53 - 53.99	5	0	0	5
Totals	628	905	645	101

Table 2. Number of striped bass collected in Virginia waters of Atlantic in 2008 and scale-aged in each 1-inch length interval. "Target" represents the sample size for ageing estimated for 2008, "Collected" represents number of fish with both total length and otoliths, and "Need" represents number of fish that were not obtained in each length interval compared to the optimum sample size for ageing and number of fish aged.

Interval	Target	Collected	Aged	Need
14 - 14.99	5	0	0	5
21 - 21.99	5	0	0	5
26 - 26.99	5	0	0	5
27 - 27.99	5	5	5	0
28 - 28.99	10	33	33	0
29 - 29.99	10	51	51	0
30 - 30.99	17	51	51	0
31 - 31.99	21	32	32	0
32 - 32.99	32	24	24	8
33 - 33.99	51	22	22	29
34 - 34.99	59	23	23	36
35 - 35.99	62	34	34	28
36 - 36.99	57	46	46	11
37 - 37.99	56	53	53	3
38 - 38.99	21	37	37	0
39 - 39.99	11	33	33	0
40 - 40.99	9	22	22	0
41 - 41.99	5	6	6	0
42 - 42.99	5	5	5	0
43 - 43.99	5	4	4	1
44 - 44.99	5	3	3	2
45 - 45.99	5	1	1	4
46 - 46.99	5	0	0	5
47 - 47.99	5	0	0	5
48 - 48.99	5	0	0	5
49 - 49.99	5	0	0	5
50 - 50.99	5	0	0	5
51 - 51.99	5	0	0	5
52 - 52.99	5	2	2	3
53 - 53.99	5	0	0	5
Totals	1002	487	487	676

Table 3. The number of striped bass assigned to each total length-at-age category for 645 fish sampled for scale age determination in Chesapeake Bay of Virginia during 2008.

	Age																	
Interval	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**22**	**Totals**
17 - 17.99	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
18 - 18.99	0	3	6	5	0	0	0	0	0	0	0	0	0	0	0	0	0	14
19 - 19.99	2	12	17	2	3	0	0	0	0	0	0	0	0	0	0	0	0	36
20 - 20.99	0	3	15	4	2	0	0	0	0	0	0	0	0	0	0	0	0	24
21 - 21.99	1	5	18	6	3	0	0	0	0	0	0	0	0	0	0	0	0	33
22 - 22.99	0	3	14	5	1	0	1	0	0	0	0	0	0	0	0	0	0	24
23 - 23.99	2	3	15	4	1	4	0	0	0	0	0	0	0	0	0	0	0	29
24 - 24.99	0	2	10	6	10	2	3	1	0	0	0	0	0	0	0	0	0	34
25 - 25.99	0	1	7	7	5	6	0	1	2	0	0	0	0	0	0	0	0	29
26 - 26.99	1	1	2	5	8	6	0	3	1	1	0	0	0	0	0	0	0	28
27 - 27.99	0	0	0	1	12	4	3	0	2	0	0	0	0	0	0	0	0	22
28 - 28.99	0	0	0	3	5	9	0	8	4	0	1	0	0	0	1	0	0	31
29 - 29.99	0	0	0	1	3	3	4	1	2	1	1	0	0	0	0	0	0	16
30 - 30.99	0	0	0	0	3	4	3	2	2	2	1	1	0	0	0	0	0	18
31 - 31.99	0	0	0	0	4	5	2	3	0	2	0	2	0	1	0	0	0	19
32 - 32.99	0	0	0	0	2	5	1	8	1	2	2	0	0	0	0	0	0	21
33 - 33.99	0	0	0	0	1	3	6	6	2	1	1	2	0	1	0	0	0	23
34 - 34.99	0	0	0	0	1	6	4	8	8	1	1	1	2	0	0	0	0	32
35 - 35.99	0	0	0	0	0	0	9	10	7	3	3	2	0	0	0	0	0	34
36 - 36.99	0	0	0	0	0	0	2	9	12	17	6	0	0	0	0	0	0	46
37 - 37.99	0	0	0	0	0	0	0	8	11	14	6	0	1	0	0	0	0	40
38 - 38.99	0	0	0	0	0	0	0	1	6	9	3	1	0	0	0	0	0	20
39 - 39.99	0	0	0	0	0	0	0	1	3	5	3	5	0	0	0	0	0	17
40 - 40.99	0	0	0	0	0	0	0	0	3	6	7	2	1	0	0	0	0	19
41 - 41.99	0	0	0	0	0	0	0	1	0	2	3	1	1	0	0	0	0	8
42 - 42.99	0	0	0	0	0	0	0	0	0	1	1	1	3	1	0	0	0	7
43 - 43.99	0	0	0	0	0	0	0	0	0	1	1	1	1	2	0	0	0	6
44 - 44.99	0	0	0	0	0	0	0	0	1	0	2	0	0	0	0	0	1	4
45 - 45.99	0	0	0	0	0	0	0	0	0	0	0	2	1	1	0	1	0	5
46 - 46.99	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	2
47 - 47.99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2
52 - 52.99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Totals	7	33	104	49	64	57	38	71	67	68	43	21	10	6	4	2	1	645

Table 4. The number of striped bass assigned to each total length-at-age category for 487 fish sampled for scale age determination in Virginia waters of Atlantic during 2008.

Interval	Age													
	5	6	7	8	9	10	11	12	13	14	15	16	17	20	Totals
27 - 27.99	0	0	2	2	1	0	0	0	0	0	0	0	0	0	5
28 - 28.99	2	1	15	9	6	0	0	0	0	0	0	0	0	0	33
29 - 29.99	4	7	22	6	8	2	0	2	0	0	0	0	0	0	51
30 - 30.99	2	9	19	12	4	1	2	2	0	0	0	0	0	0	51
31 - 31.99	2	2	11	8	2	3	2	2	0	0	0	0	0	0	32
32 - 32.99	0	0	8	4	6	3	2	1	0	0	0	0	0	0	24
33 - 33.99	0	0	3	7	4	3	2	2	1	0	0	0	0	0	22
34 - 34.99	0	0	0	3	4	7	3	3	2	0	1	0	0	0	23
35 - 35.99	0	0	1	5	2	10	8	2	2	3	0	1	0	0	34
36 - 36.99	0	0	2	4	3	10	10	9	7	1	0	0	0	0	46
37 - 37.99	0	0	0	1	5	6	13	13	10	5	0	0	0	0	53
38 - 38.99	0	0	0	0	1	3	12	10	8	2	1	0	0	0	37
39 - 39.99	0	0	0	0	0	2	10	11	6	4	0	0	0	0	33
40 - 40.99	0	0	0	0	0	2	2	5	5	6	2	0	0	0	22
41 - 41.99	0	0	0	0	0	0	1	2	0	0	1	1	1	0	6
42 - 42.99	0	0	0	0	0	0	0	0	2	2	0	1	0	0	5
43 - 43.99	0	0	0	0	0	0	0	1	0	1	1	1	0	0	4
44 - 44.99	0	0	0	0	0	0	0	1	0	0	2	0	0	0	3
45 - 45.99	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
52 - 52.99	0	0	0	0	0	0	0	0	0	0	0	1	0	1	2
Totals	10	19	83	61	46	52	67	66	43	25	8	5	1	1	487

Table 5. Age-Length key, as proportion-at-age in each 1-inch length interval, based on scale ages for striped bass sampled in Chesapeake Bay of Virginia during 2008.

	Age																
Interval	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**22**
17 - 17.99	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18 - 18.99	0	0.214	0.429	0.357	0	0	0	0	0	0	0	0	0	0	0	0	0
19 - 19.99	0.056	0.333	0.472	0.056	0.083	0	0	0	0	0	0	0	0	0	0	0	0
20 - 20.99	0	0.125	0.625	0.167	0.083	0	0	0	0	0	0	0	0	0	0	0	0
21 - 21.99	0.03	0.152	0.545	0.182	0.091	0	0	0	0	0	0	0	0	0	0	0	0
22 - 22.99	0	0.125	0.583	0.208	0.042	0	0.042	0	0	0	0	0	0	0	0	0	0
23 - 23.99	0.069	0.103	0.517	0.138	0.034	0.138	0	0	0	0	0	0	0	0	0	0	0
24 - 24.99	0	0.059	0.294	0.176	0.294	0.059	0.088	0.029	0	0	0	0	0	0	0	0	0
25 - 25.99	0	0.034	0.241	0.241	0.172	0.207	0	0.034	0.069	0	0	0	0	0	0	0	0
26 - 26.99	0.036	0.036	0.071	0.179	0.286	0.214	0	0.107	0.036	0.036	0	0	0	0	0	0	0
27 - 27.99	0	0	0	0.045	0.545	0.182	0.136	0	0.091	0	0	0	0	0	0	0	0
28 - 28.99	0	0	0	0.097	0.161	0.29	0	0.258	0.129	0	0.032	0	0	0	0.032	0	0
29 - 29.99	0	0	0	0.062	0.188	0.188	0.25	0.062	0.125	0.062	0.062	0	0	0	0	0	0
30 - 30.99	0	0	0	0	0.167	0.222	0.167	0.111	0.111	0.111	0.056	0.056	0	0	0	0	0
31 - 31.99	0	0	0	0	0.211	0.263	0.105	0.158	0	0.105	0	0.105	0	0.053	0	0	0
32 - 32.99	0	0	0	0	0.095	0.238	0.048	0.381	0.048	0.095	0.095	0	0	0	0	0	0
33 - 33.99	0	0	0	0	0.043	0.13	0.261	0.261	0.087	0.043	0.043	0.087	0	0.043	0	0	0
34 - 34.99	0	0	0	0	0.031	0.188	0.125	0.25	0.25	0.031	0.031	0.031	0.062	0	0	0	0
35 - 35.99	0	0	0	0	0	0	0.265	0.294	0.206	0.088	0.088	0.059	0	0	0	0	0
36 - 36.99	0	0	0	0	0	0	0.043	0.196	0.261	0.37	0.13	0	0	0	0	0	0
37 - 37.99	0	0	0	0	0	0	0	0.2	0.275	0.35	0.15	0	0.025	0	0	0	0
38 - 38.99	0	0	0	0	0	0	0	0.05	0.3	0.45	0.15	0.05	0	0	0	0	0
39 - 39.99	0	0	0	0	0	0	0	0.059	0.176	0.294	0.176	0.294	0	0	0	0	0
40 - 40.99	0	0	0	0	0	0	0	0	0.158	0.316	0.368	0.105	0.053	0	0	0	0
41 - 41.99	0	0	0	0	0	0	0	0.125	0	0.25	0.375	0.125	0.125	0	0	0	0
42 - 42.99	0	0	0	0	0	0	0	0	0	0.143	0.143	0.143	0.429	0.143	0	0	0
43 - 43.99	0	0	0	0	0	0	0	0	0	0.167	0.167	0.167	0.167	0.333	0	0	0
44 - 44.99	0	0	0	0	0	0	0	0	0.25	0	0.5	0	0	0	0	0	0.25
45 - 45.99	0	0	0	0	0	0	0	0	0	0	0	0.4	0.2	0.2	0	0.2	0
46 - 46.99	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0.5	0
47 - 47.99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
52 - 52.99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0

Table 6. Age-Length key, as proportion-at-age in each 1-inch length interval, based on scale ages for striped bass sampled in Virginia waters of Atlantic during 2008.

	Age													
Interval	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**20**
27 - 27.99	0	0	0.4	0.4	0.2	0	0	0	0	0	0	0	0	0
28 - 28.99	0.061	0.03	0.455	0.273	0.182	0	0	0	0	0	0	0	0	0
29 - 29.99	0.078	0.137	0.431	0.118	0.157	0.039	0	0.039	0	0	0	0	0	0
30 - 30.99	0.039	0.176	0.373	0.235	0.078	0.02	0.039	0.039	0	0	0	0	0	0
31 - 31.99	0.062	0.062	0.344	0.25	0.062	0.094	0.062	0.062	0	0	0	0	0	0
32 - 32.99	0	0	0.333	0.167	0.25	0.125	0.083	0.042	0	0	0	0	0	0
33 - 33.99	0	0	0.136	0.318	0.182	0.136	0.091	0.091	0.045	0	0	0	0	0
34 - 34.99	0	0	0	0.13	0.174	0.304	0.13	0.13	0.087	0	0.043	0	0	0
35 - 35.99	0	0	0.029	0.147	0.059	0.294	0.235	0.059	0.059	0.088	0	0.029	0	0
36 - 36.99	0	0	0.043	0.087	0.065	0.217	0.217	0.196	0.152	0.022	0	0	0	0
37 - 37.99	0	0	0	0.019	0.094	0.113	0.245	0.245	0.189	0.094	0	0	0	0
38 - 38.99	0	0	0	0	0.027	0.081	0.324	0.27	0.216	0.054	0.027	0	0	0
39 - 39.99	0	0	0	0	0	0.061	0.303	0.333	0.182	0.121	0	0	0	0
40 - 40.99	0	0	0	0	0	0.091	0.091	0.227	0.227	0.273	0.091	0	0	0
41 - 41.99	0	0	0	0	0	0	0.167	0.333	0	0	0.167	0.167	0.167	0
42 - 42.99	0	0	0	0	0	0	0	0	0.4	0.4	0	0.2	0	0
43 - 43.99	0	0	0	0	0	0	0	0.25	0	0.25	0.25	0.25	0	0
44 - 44.99	0	0	0	0	0	0	0	0.333	0	0	0.667	0	0	0
45 - 45.99	0	0	0	0	0	0	0	0	0	1	0	0	0	0
52 - 52.99	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0.5