1981

Assessment of larval striped bass, Morone saxatilis (Walbaum), stocks in Maryland and Virginia waters. Part II. Assessment of spawning activity in major Virginia rivers. Segment 1. Distribution and abundance of striped bass eggs and larvae in the upper York River system, Virginia, during spring 1980

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Grant No. NA80FAD-VA1B

FINAL REPORT

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Introduction

The Pamunkey and Mattaponi rivers unite at West Point, Virginia, to form the York River, one of the major Virginia tributaries to the Chesapeake Bay (Fig. 1). The utilization of these two tidal, but largely freshwater rivers, as spawning grounds for striped bass populations was first documented by Tresselt (1952) in a limited survey of Virginia rivers during spring months of 1950. His sampling for striped bass eggs was temporally limited to April 4-13 on the Pamunkey R. and to April 13-30 on the Mattaponi, ater which he shifted sampling to the Chickahominy, James and Rappahannock rivers, successively. Largest numbers of eggs were taken 17 miles above the mouth of the Pamunkey and nine miles above the mouth of the Mattaponi, where local fishermen confirmed that these were the historic centers of successful fishing for striped bass during spring months.

Larvae reported only as *Roccus* sp. were reported in April-June 1961 by Massmann, Joseph and Norcross (1962), but a concerted effort at quantitatively collecting and identifying striped bass eggs and larvae awaited the unpublished study of Rinaldo (1971) on the spawning run of 1966 in the Pamunkey River. That study delimited the spawning area in the Pamunkey to the main channel from 5 to 30 miles above the river mouth at West Point, Virginia. In 1966, spawning took place between April 24 and May 13. Rinaldo (1971) also concluded that the nursery

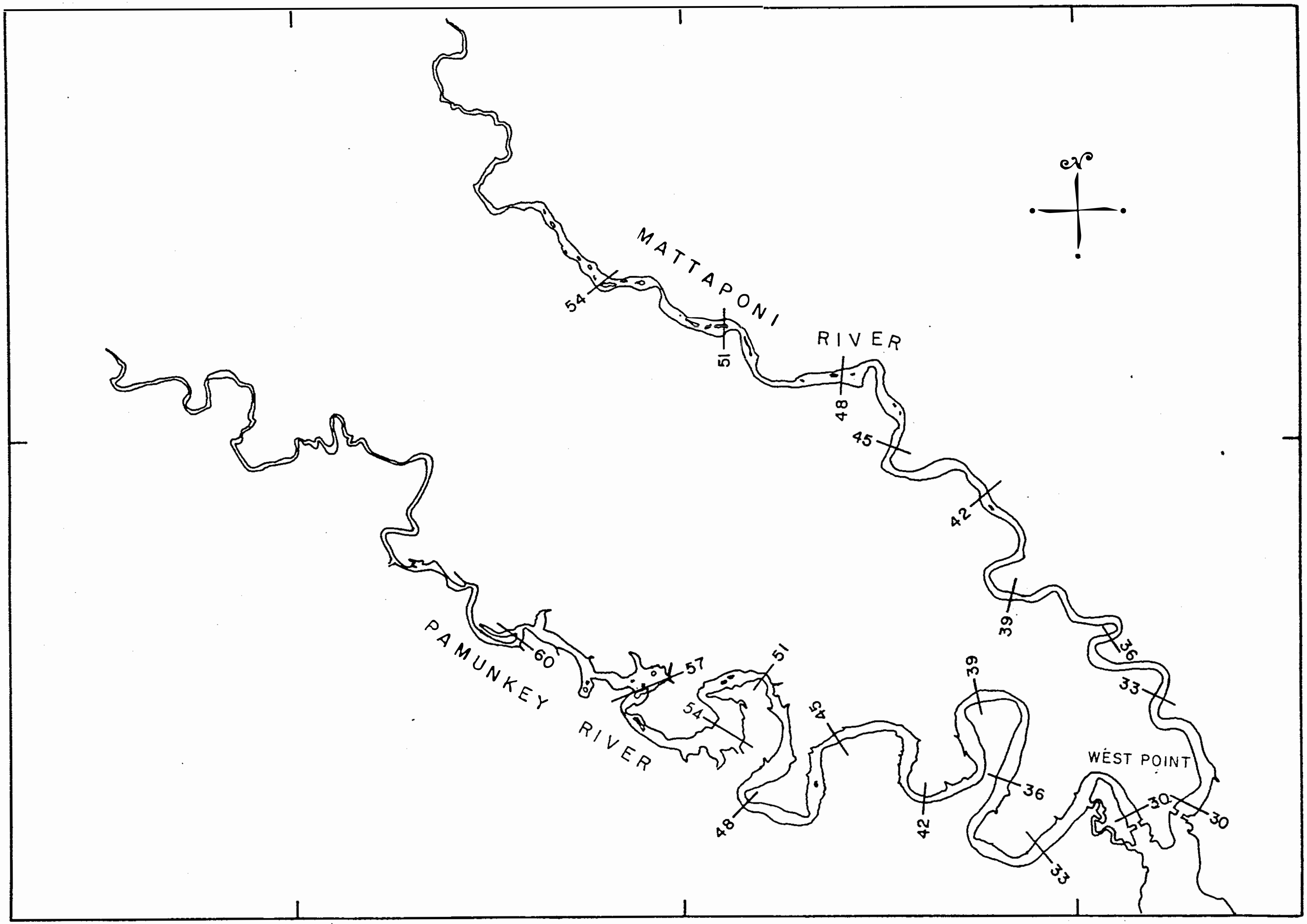

Fig. 1. The Pamunkey and Mattaponi rivers, principal tributaries to the York River, Virginia. River miles indicated are in nautical miles above the mouth of the York River.

area for yolk-sac and larger larvae was essentially the same as the spawning area, with the center of distribution 10 miles above West Point. Juveniles, on the other hand, moved downstream into the York and lower Pamunkey rivers. Striped bass were found to spawn in fresh water when temperatures reached 16°C.

The present study was designed to document the distribution and abundance of striped bass eggs and larvae in both the Pamunkey and Mattaponi rivers during spring 1980, in response to the objectives of the Emergency Striped Bass Study (Chafee Amendment to the Anadromous Fish Act).

Methods and Materials

Field Methods

Both rivers were divided into 3-mile strata, from which stations were randomly selected prior to each sampling trip. Sampling was initiated on April 16 in the Pamunkey River and full surveys consisting of 6-10 stations were repeated at intervals of 2-10 days until June 13, for a total of 12 surveys. Sampling of the Mattaponi River started on April 18 and 13 surveys of 6-9 stations were conducted at intervals of 2-12 days until June 14 (Tables 1 and 2).

Regular collections at each station consisted of 2-6 minute stepped-oblique tows of a 60 cm bongo sampler, equipped with paired 333 μm mesh nets. All nets were metered with G-O flowmeters for volumetric estimates (Tables 3 and 4). Length of tows depended on station depth and detritus load. Catches from the paired nets were combined on board and preserved in 5-8% buffered formalin. All regular surveys were conducted in daylight hours. Ancillary data collected at each station included surface and bottom measurements of temperature, salinity and dissolved oxygen; maximum depth of visibility was determined by Secchi disc.

In addition to the regular survey collections, comparison replicate tows were also made: (1) day *vs*. night tows (N=12) were made at a mid-river location on the Mattaponi River on May 20-21; (2) stepped oblique vs. bottom horizontal tows (N=8); and (3) mid-channel vs. shoal water tows (N=12), the latter two series at an upriver Pamunkey location on June 3-5. Discrete-depth collections (N=6) were taken at surface, mid-depth and near-bottom at one location in each river, using a modified Tucker trawl (Tucker, 1951), fitted with 60 cm bongo nets (333 μm mesh), and opened and closed with a double-trip mechanism.

Laboratory Processing of Collections

Whole collections were sorted for *Morone* fish eggs and larvae. All fish eggs and larvae were removed until it became evident that the process was too time-consuming. The collections were laden with detritus and very abundant larvae of fishes other than *Morone saxatilis*, necessitating selection of only *M. saxatilis* eggs and *Morone* spp. larvae from approximately one-half the collections. Many collections contained as much as a gallon of detritus & mixed plankton. Collection sorters separated eggs and larvae into vials for further examination and identification.

Identification of Eggs and Larvae

Positive identification of striped bass eggs from the present collections was relatively easy, based on descriptions by Mansueti (1958) and Pearson (1938) and benefitting from the absence of any similar eggs on these spawning grounds. Most of these large eggs, however, were damaged in collection and transfer, so that fragments of the chorionic tissue and embryonic larvae separated from ruptured yolks were often found. In these cases, we elected a conservative estimate of abundance, talleying only intact eggs and separated embryos.

Separation of the very similar larvae of white perch and striped bass presented a more difficult problem, necessitating close examination of hundreds of the predominant _M. americanus_ larvae. We found yolk-sac larvae of the two congeners separable according to Drewry and Mihursky (1980) and those above 13 mm SL easily separated by the relative thickness of the second anal spine. For those larvae lacking yolk material and <13 mm, we found it necessary to clear and stain larvae (Fritzsche and Johnson, 1979) to reveal differences in osteology shown by the same authors in a later paper (1980). These osteological characters as well as additional traits useful in identification are discussed in a later section.

RESULTS

Twenty-six surveys, 13 in each of the Mattaponi and Pamunkey rivers, were completed between 16 April and 14 June 1980. From six to ten stations were sampled on each of these surveys, and additional collections were obtained in attempts to examine differences in catches during day and night, in channels and shallows, and with depth. Exact locations of stations within river-mile strata, measurements of physical characteristics of sampled water and volumes of water sampled for each collection are provided in Tables 1-4.

Physical Characteristics of the Rivers

Temperature

The complete range of water temperature during surveys was 13.8-26.1°C. Temperatures below 15.0°C were limited to upriver stations in the Pamunkey River on the first day of sampling. Temperatures reached and remained above 20.0°C in both rivers by mid-May. Little or no stratification of temperature with depth was observed in either river and measurements provided in Appendix Tables 1 and 2 are means of the water column.

Salinity

Both the Pamunkey and Mattaponi are tidal rivers throughout their sampled length. No attempt was made to sample at particular tidal stages (because of the intensity of surveys), so salinity observations in Appendix Tables 1 and 2 reflect movement of saline water up and down the rivers with time. The above comments on lack of stratification in temperature apply equally to salinity.

Using 0.5 $^{o}/oo$ salinity as the upper limit for fresh water, the entire river was fresh in the Pamunkey on the initial survey of 16 April. All of the Mattaponi R. was fresh on 23 April and 1 May. The furthest upstream penetration of salt water occurred in river-mile stratum 36-38 on the Pamunkey on three occasions (May 8 and 16, June

13), and in stratum 33-35 on the Mattaponi R. on May 9 and 27, 1980. The highest mean salinity in the lowest river stratum occurred on May 23 in the Pamunkey R. (6.27 $^{o}/oo$) and on April 29 in the Mattaponi R. (3.91 $^{o}/oo$).

Dissolved Oxygen

As in the case of salinity and temperature, dissolved oxygen measurements showed little evidence of water column stratification. Mean concentrations at each station are provided in Appendix Tables 1 and 2. Beyond the seasonal reduction in concentrations to be expected with increasing water temperatures, there was no significant reduction in dissolved oxygen noted. The survey-wide low mean concentration occurred at the mouth of the Pamunkey River (influence of pulp mill effluent?) on May 8 (4.4 mg/l). Other mean measurements ranged from 5.5 to 9.6 mg/l in the Pamunkey R. and from 5.4 to 8.8 mg/l in the Mattaponi R.

pH

Scattered observations on pH showed a range of 5.8-7.1 in the Pamunkey and 5.3-7.1 in the Mattaponi River. Most measurements were on the acidic side of neutrality.

Water Transparency

Water transparency, as measured by Secchi disk, generally was reduced in the lower part of the rivers. Readings ranged from 0.3 m (at river-mile 30 to 36 on three dates) to 1.1 m at mile 46 on 23 May in the Pamunkey; in the Mattaponi, the range was from 0.1 m at mile 31 on 18 April to 1.6 m at mile 51 and 54 on 23 April. The upper Pamunkey appeared to be more turbid than comparable reaches of the Mattaponi River.

Egg Distribution and Abundance

Striped bass eggs were found on our initial surveys of the Pamunkey and Mattaponi rivers (Fig. 2) indicating that spawning activity was initiated sometime prior to first sampling. Although eggs were present in the lowermost stratum of each river, later observations on the relationship of egg distribution to the location of fresh and salt water interfaces suggest that few additional eggs would have occurred below the mouths of these two major tributaries to the York River.

Pamunkey River

The maximum seasonal density of eggs observed in the Pamunkey River occurred on the second survey (>100/100 m^3) at mile 34, just above the salt-freshwater interface on April 22. These data indicated an upstream progression in the occurrence of eggs. A secondary peak of abundance occurred well upstream at mile 45.

On the next two sampling dates, 24 and 30 April, lesser peaks occurred at mile 38 and 40, respectively, just above the limit of salt water. On the 2nd of May, fresh water again covered most of the river and eggs were distributed throughout the range of sampling. Eggs from surveys on May 8 and 16 were limited to upstream locations, following a return of saline water, and in decreasing abundance. No eggs were found after the latter date.

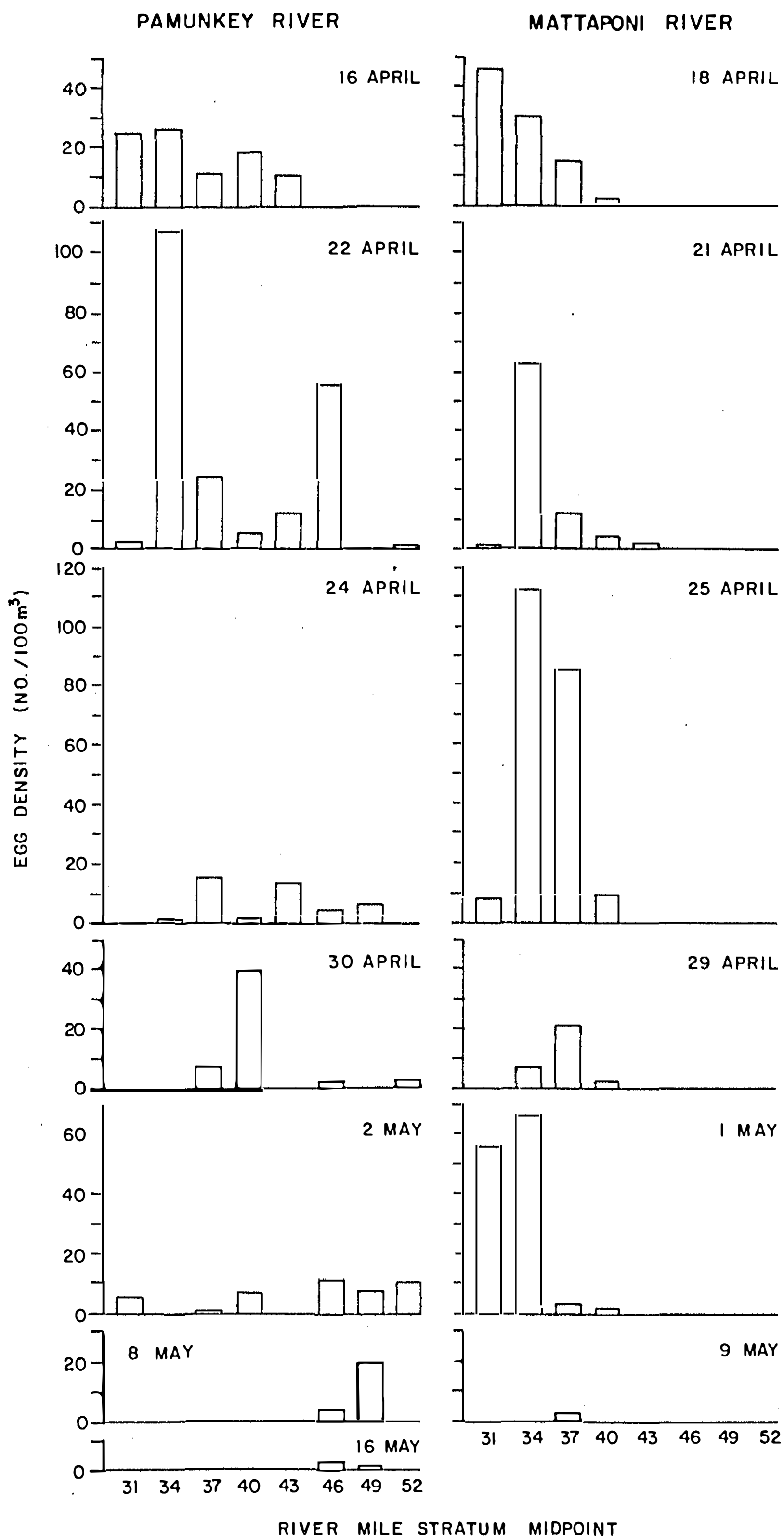

Fig. 2. Distribution and abundance of Morone saxatilis eggs in the Pamunkey and Mattaponi rivers, 1980. Abundance in numbers per 100 m^3; river miles in nautical miles above the mouth of the York River.

Mattaponi River

Surveys on the 18th and 21st of April yielded eggs distributed similarly to those in the Pamunkey River, i.e. to the mouth of the river on the initial date, but shifted upstream above the intruded salt-freshwater interface on the 21st. However, in this river there was no progressive upstream displacement of eggs with time. Eggs were restricted to the lower reaches of the river (below mile 42) throughout the survey. Salt water was not found above mile 33, however, in contrast to the hydrographic regime of the Pamunkey. The seasonal peak of egg abundance (>110/100 m^3) occurred on the third survey (25 April) and spawning terminated a week earlier than in the Pamunkey River.

Distribution and Abundance of Larvae

Larvae were also present on our initial surveys, but all were in the yolk-sac stage of development. Absence of larger larvae on first surveys is supportive of a conjecture that successful spawning had not commenced much earlier than the first or second week of April. Distribution and abundance of larvae on the two rivers are shown in Fig. 3.

Pamunkey River

Distributional peaks of striped bass larvae were initially displaced somewhat upriver from peaks of egg abundance, occurring at river miles 37-38 on April 16 and 22. Peaks in egg and larval abundance coincided more closely on other dates. Following collections of May 2, larvae were restricted to the upper portion of the Pamunkey River. On May 21, after cessation of spawning, larvae were found only in the

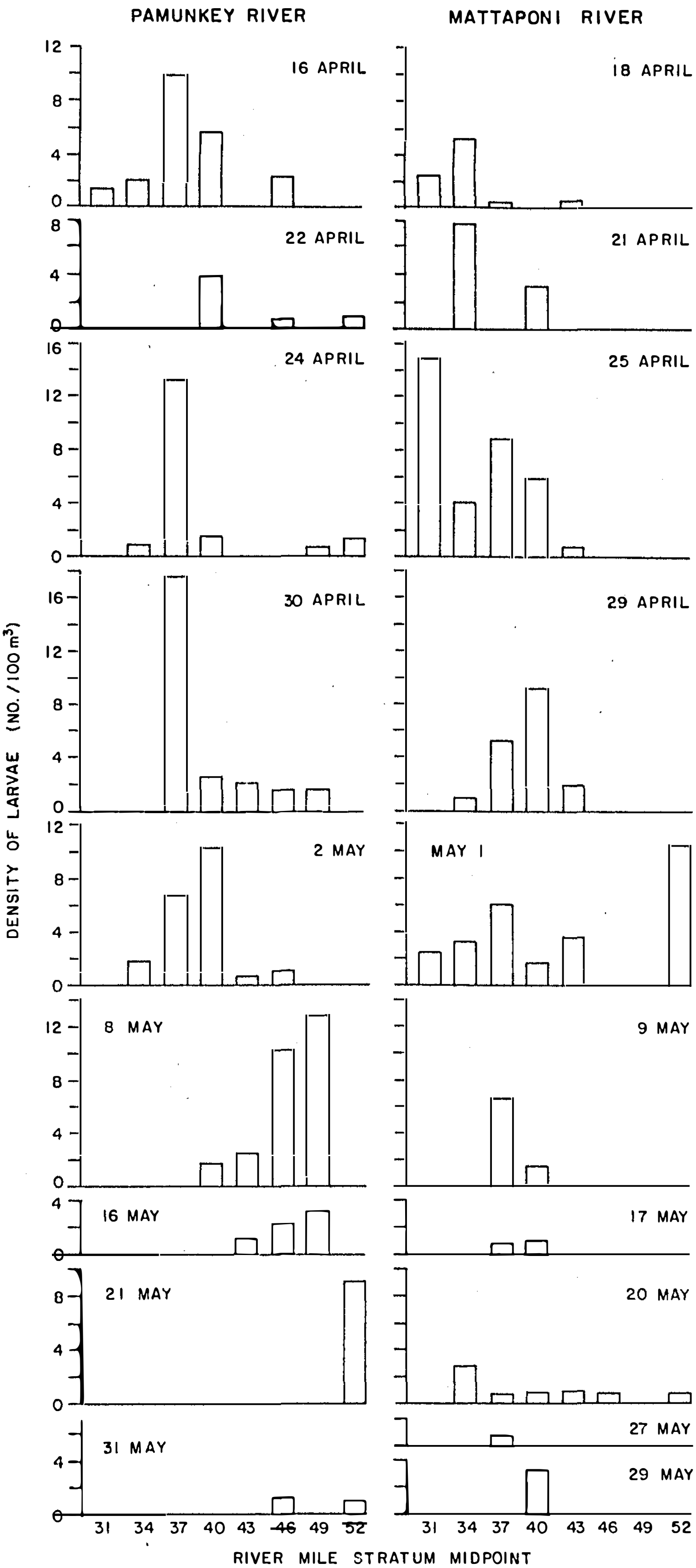

Fig. 3. Distribution and abundance of Morone saxatilis larvae in the Pamunkey and Mattaponi rivers, 1980. Abundance in numbers per 100 m^3; river miles in nautical miles above the mouth of the York River.

uppermost stratum at station P52. No larvae were found during regular surveys after May 31.

Maximum abundance of striped bass larvae observed during this survey was less than 18/100 m^3 at station P38 on April 30.

Mattaponi River

Striped bass larvae in the Mattaponi did not shift upstream later in the season as observed in the Pamunkey River. After an abundance of larvae was found far upriver on May 1, lesser peaks were observed at lower and mid-river locations throughout May. None occurred after the regular survey of May 29. Maximum abundance (ca. 15/100 m^3) occurred at station M31 on April 25.

Size Distribution of Larvae

Few yolk-sac larvae were obtained after the fourth week of sampling, which included May 8 and 9 surveys of the Pamunkey and Mattaponi rivers, respectively. In the Pamunkey River there was a noticeable lack of larvae in the 10-13 mm SL range that might have been expected in the fifth week of sampling, assuming that larvae 14-17 mm SL in the sixth week were survivors of earliest April spawning. Similarly, larvae 7-11 mm SL were missing in the sixth and seventh weeks, if the few late occurring 12-15 mm SL specimens were from early May spawning.

In the Mattaponi River, earlier larvae could be traced more easily through the final 7th week of successful collections. A possible secondary pulse of spawning in early May (4th week) terminated with larvae 5-7 mm NL in the sixth week. Larvae from this later pulse of spawning may not have survived.

Overall size distribution of captured striped larvae is shown in Figs. 4 and 5 for the Pamunkey and Mattaponi rivers, respectively. Modal length in both rivers was 5 mm NL, the length of typical striped bass yolk-sac larvae. Most of the larvae 7-8 mm SL in length were identified on the basis of the presence of yolk material or oil drops in developing larvae. In the Pamunkey River, May 16 marked the date of division between larvae less than 11 mm SL and those exceeding this size (no overlap). That date corresponds to the observed termination in egg occurrence, suggesting that late spawning lacked survival (all larvae after May 16 were 12 mm SL or larger). Some specimens 5-7 mm NL occurred as late as May 20 in the Mattaponi River, but all larvae after that date were at least 10 mm SL. A few larvae 9-11 mm SL had occurred earlier in May, presumably from April spawning. Those 5-7 mm NL larvae observed on May 20 probably resulted from May spawning that is believed to have failed beyond the yolk-sac stage.

Use of Osteological Characters in Distinguishing Striped Bass and White Perch Larvae

Review of the literature revealed a gap at a certain stage of development for which no useful taxonomic characters have been described to facilitate separation of white perch and striped bass larvae. This gap occurs between the absorption of yolk material and the formation of pre-dorsal bones (Fig. 6) in striped bass and includes larvae 8 and 9 mm in standard length. External characters are of dubious use between yolk-sac absorption and a standard length of 12-13 mm, when thickening of the second anal spine in white perch becomes obvious.

The clearing and staining technique modified by Fritzsche and Johnson (1979), and applied to an examination of the problematical

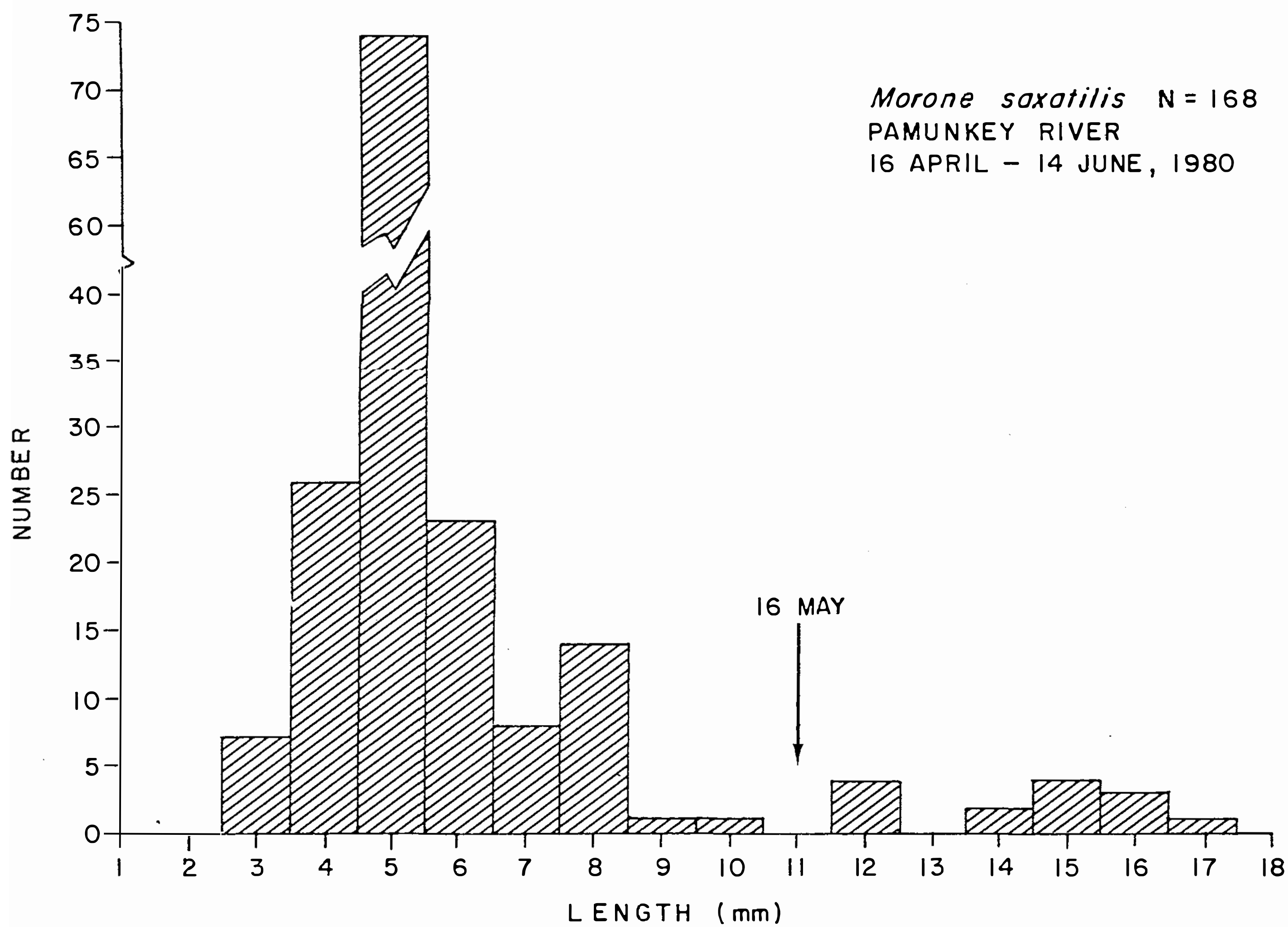

Fig. 4. Length frequency of striped bass larvae collected from the Pamunkey River. Indicated date (May 16) was the last date of collection of larvae <11 mm.

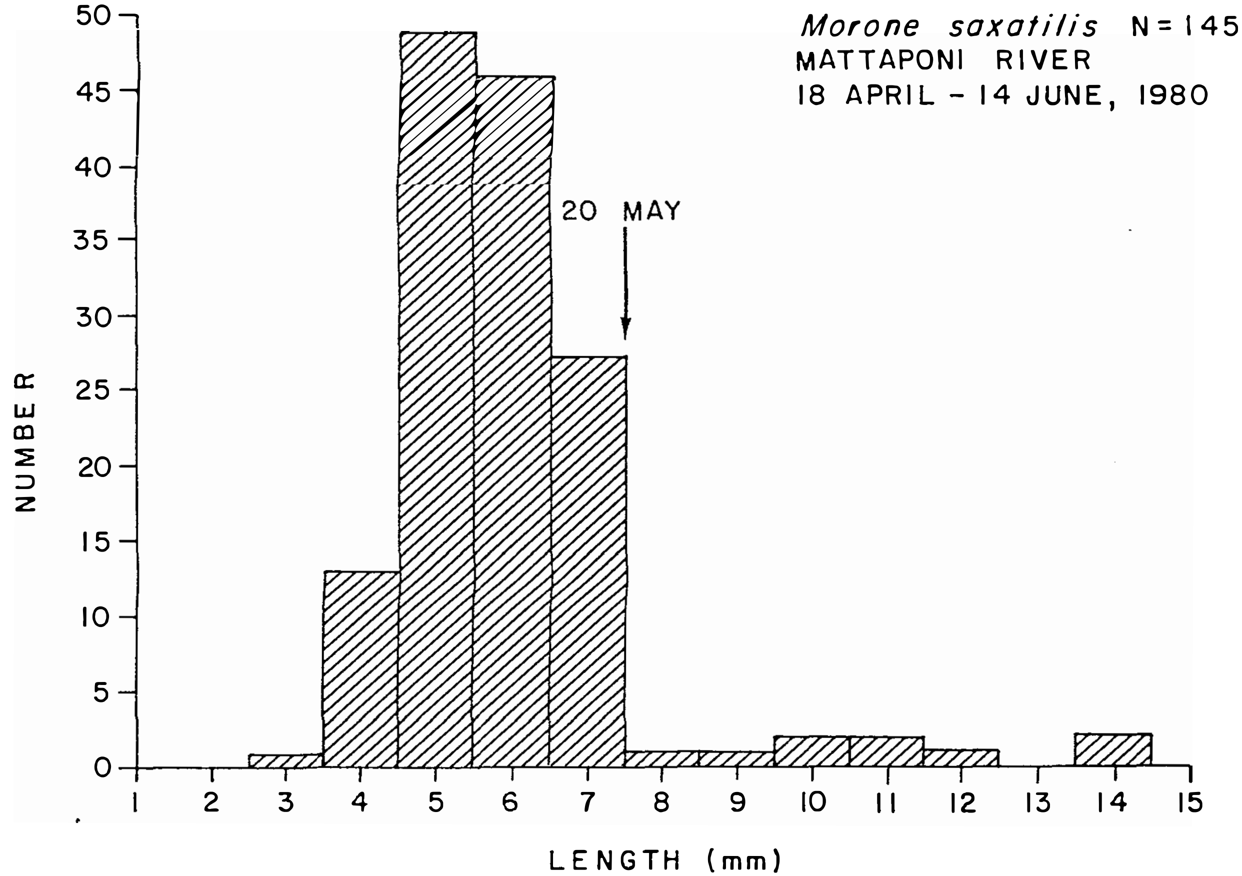

Fig. 5. Length frequency of striped bass larvae collected from the Mattaponi River. Indicated date (May 20) was the last date of collection of larvae <8 mm.

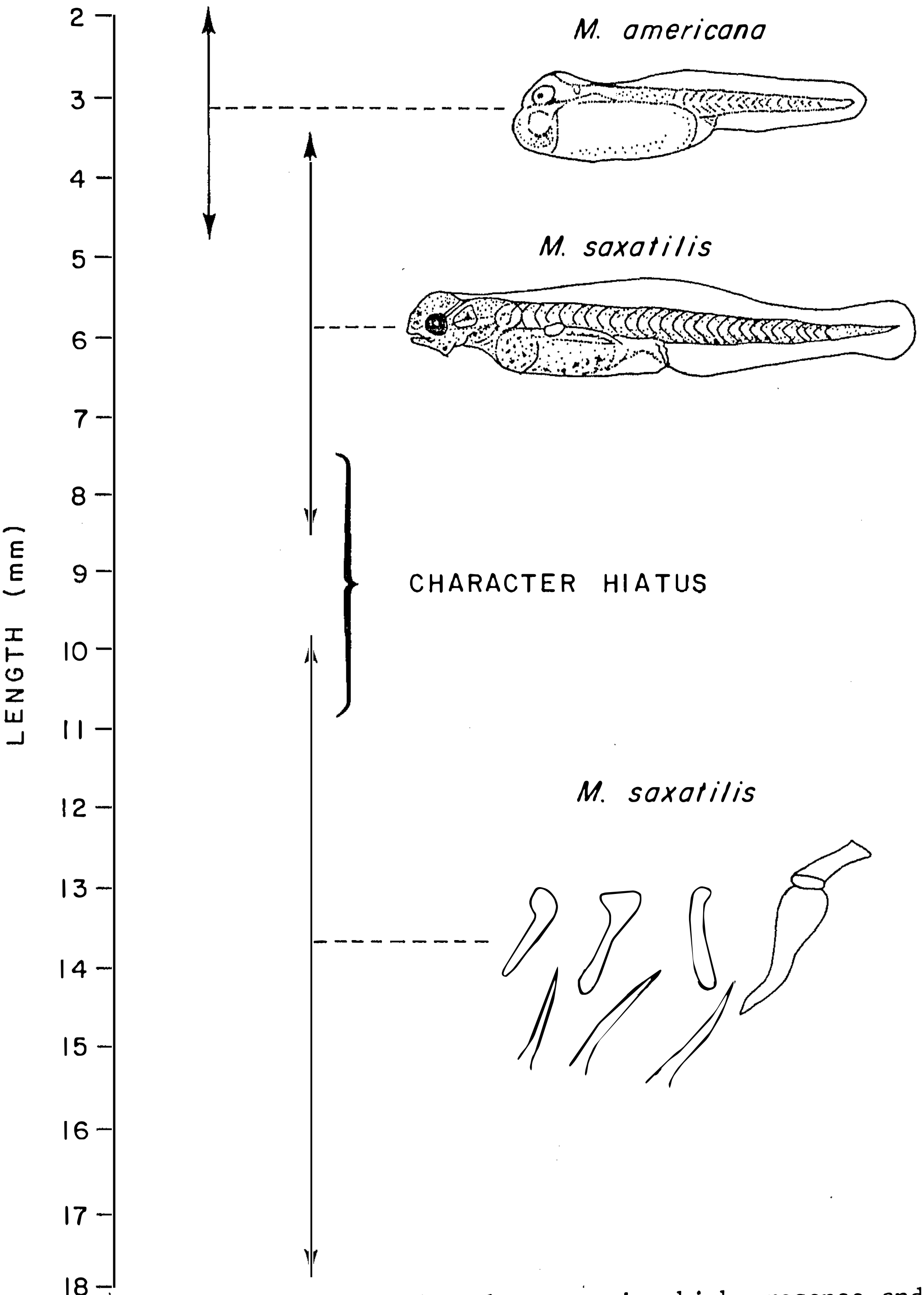

Fig. 6. Summary of length ranges in which presence and shape of yolk material and arrangement of pre-dorsal bones are useful in separating larvae of white perch and striped bass. Range of sizes where good, reliable characters are lacking is broadly indicated.

Morone species in their 1980 paper, has provided a positive method of distinguishing striped bass larvae from those of white perch. In utilizing this method for collections in this study, we have confirmed (using wild material) the observations of Fritzsche and Johnson (1980) which were based on cultured specimens. In addition, we have successfully used a new character which, although somewhat variable, aids separation of the two species within the gap of 8-9 mm specimens recounted above. This is the arrangement of anal fin pterygiophores in relation to haemal spines.

Among those characters treated by Fritzsche and Johnson (1980), we found no diversion from their description of the appearance and formation of pre-dorsal bones. However, the first pre-dorsal bone does not form in striped bass until approximately 9.0 mm SL and may often be only faintly stained. The dorsal formula, following earlier work on tunas (Potthof, 1974), cannot be determined before complete formation of pre-dorsals and dorsal pterygiophores, which occurs at a length of about 10 mm in field collected striped bass. In an examination of 23 striped bass and 58 white perch larvae, we found no overlap in the following dorsal formulae:

	0/0/0/2+1/	0/0/0/2/	0/0/0+2/	0/0+0/2/
Str. Bass	22	1	0	0
Wh. Perch	0	0	55	3

Larvae used in this examination were 10.5-17.1 mm SL (striped bass) and 9.4-20.1 mm SL (white perch). We did not observe the white perch formula 0/0/0+2/1 in striped bass as did Fritzsche and Johnson (1980).

Anal fin formulae were more variable and overlapped approximately 7.5% between species:

	3/1+1+1/	3+1/1+1/	3/1+1/	3/1/_
Str. Bass	19	6	2	0
Wh. Perch	2	3	59	2

In this case, determinations could be made for 8 white perch and 4 striped bass in which dorsal formulae could not be determined. Size ranges were 9.0-17.1 mm SL (striped bass) and 8.0-20.1 mm SL (white perch). The character (see Fig. 7) is particularly useful as confirmation when only a single pre-dorsal bone has formed.

Discussion

Egg Distribution and Abundance

In a 1950 survey of Virginia spawning grounds, Tresselt (1952) sampled the Pamunkey River from April 4 to 13 and the Mattaponi River during the remainder of April. In the Pamunkey River, he found striped bass eggs only near Morgan's Landing (approximately river mile 45). Largest numbers were collected on the last date of sampling, April 13. This fact, together with comparisons with our results and the temperatures sampled by Tresselt (surface 12.2-14.4°C), suggests that peak spawning occurred after the cessation of Tresselt's sampling in the Pamunkey during 1950. Tresselt's nets were not towed, but set in the current for periods of 1 to 3 hours, and unmetered, so abundance comparisons with our data are not possible. Although some current measurements were made, they were omitted from the station of maximum catch. He reported (Tresselt, 1950) a total

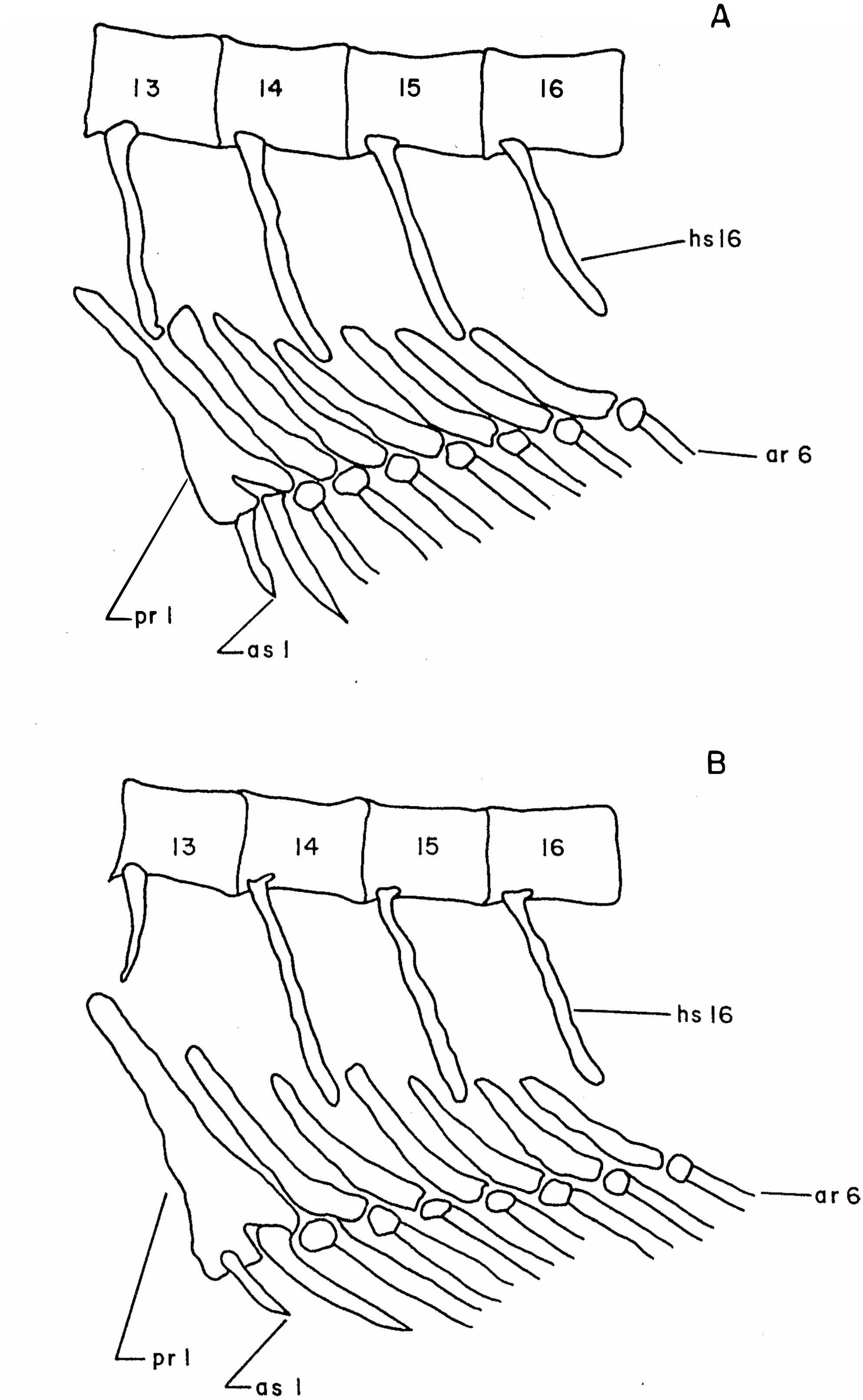

Fig. 7. Predominant anal fin configurations for striped bass (A) and white perch (B) larvae, drawn from specimens 10.9 and 10.1 mm SL, respectively. Formulae shown are 3/1+1+1/ for striped bass and 3/1+1/ for white perch; hs 16 = haemal spine 16, pr1 = first proximal radial, as1 = first anal spine, ar6 = sixth anal ray.

of 72 eggs, 71 of which were taken in surface nets despite greater effort at bottom collecting, and calculated an overall index of 0.8 eggs/net hour.

Rinaldo (1971) also sampled the Pamunkey River for striped bass eggs in the spring of 1966. In that year eggs occurred in small numbers from the beginning of sampling on April 13 and in somewhat greater abundance on April 27 and May 10, after which none were found. This seasonal distribution agrees well with our findings in 1980, when peak density occurred on April 22 and the last eggs were found on May 16. However, maximum concentrations of eggs were calculated by Rinaldo at approximately 3 per 100 m^3, well below our maximum of >100/100 m^3. This is surprising in view of the relative strength of year classes during the late 1960's compared with present population levels (Grant and Joseph, 1969; Grant et al., 1970; Grant, 1974). The 1966 year class was a moderately strong one in the York River system. It appears likely that Rinaldo, in his weekly to biweekly sampling, may have missed peak concentrations or otherwise underestimated abundance of eggs in 1966.

Comparison of our observations on striped bass eggs in the Mattaponi River with those of previous workers is limited to the early work of Tresselt (1950, 1952), who found striped bass eggs in abundance on the last day of sampling, April 30, 1950. Surface temperatures on that date were between 16.6 and 17.7°C at the stations yielding most eggs, temperatures that are near optimal for striped bass spawning. In contrast to the earlier index of 0.8 eggs per net hour calculated for the Pamunkey River, Tresselt (1950) captured 140.8 eggs per net hour, overall, in the Mattaponi. Tresselt (1950) measured current speeds of 0.6-2.0 ft/sec at stations at which eggs were captured. A current speed of 1.1 ft/sec. at the station of maximum abundance would provide a sampling volume of 948 m^3 in one hour using one meter diameter nets and assuming 100% efficiency. Three hours of surface towing at that station produced 5,600 striped bass eggs, an estimated density of 197 eggs/100 m^3, well above our estimated maximum density in the Mattaponi River in 1980 of ca. 110/100 m^3 (oblique bottom to surface tow, April 25, 1980 at river mile 34). The 1950 year class, based on analysis of commercial landings in Virginia (Grant, 1974), was apparently not a very successful one and contributed to the dip in landings of 1952-3. If the 1980 year class, based only on the limited comparisons of egg abundance available to us, is indeed only half the strength of the 1950 year class, then it will be a very poor year class, continuing a long series of years lacking a single strong year class (1971-1980).

Distribution and Abundance of Larvae

Larger postlarvae (>15-17 mm) and juveniles of striped bass are not available to the sampling gear employed on our survey, either because of an increasing ability to escape 60-cm bongo nets or because of their movement out of river channels into shoals with developing changes in feeding habits. In the 1980 survey of the Pamunkey and Mattaponi rivers, no striped bass larger than 17 mm SL were captured and except for a few postlarvae captured during intensive comparative tows in early June, regular surveys produced no larvae after May 30. Further assessment of the year class must depend on small trawl or beach seine surveys. In the Pamunkey River, we found a maximum density of

<18 striped bass/100 m^3 on April 30 at river mile 38. This is less than half the maximum observed by Rinaldo (1971) for the 1966 year class (39/100 m^3 on April 27, 1966 at river mile 40). In both cases, remarkably similar in calendar date and location, the catch consisted mostly of yolk-sac larvae. In contrast to the 1980 study, Rinaldo (1971) reported postlarvae as late as June 15, 1966. There is a decided possibility that Rinaldo's (1971) collections of April 27 might have been an admixture of striped bass and white perch larvae (mean length of 8.6 mm reported), because the clearing-and-staining technique available to us had not been developed at that time and the mean size falls directly into the most difficult size range for discriminating the two species. Any such error would reduce the difference in density estimates between the 1966 and 1980 year classes.

There are no available comparisons for our observations on *Morone saxatilis* larvae in the Mattaponi River during 1980. We observed a maximum density of approximately 15/100 m^3 at river mile 31 on April 25 and a disappearance of larvae from our regular survey collections after May 29.

Separation of Striped Bass and White Perch Larvae

The osteological characters described by Fritzsche and Johnson (1980) for separation of laboratory cultured *Morone americana* and *M. saxatilis* were tested based on wild material obtained in our 1980 collections from the Pamunkey and Mattaponi rivers. These characters, in particular the development and arrangement of pre-dorsal bones, together with more familiar external characters, such as anal spines and pigment patterns have proven to be reliable traits for species recognition within certain size ranges. However, it is apparent from York R. material that there exists a small size range of larvae within which good characters for separation are lacking. Those larvae between yolk absorption and formation of pre-dorsal cartilage (8-10 mm in striped bass) are particularly difficult to reliably separate. We have narrowed that size range of often inseparable larvae by use of counts and arrangement of anal pterygiophores. Although overlap between anal fin formulae of the two species was found to be more prevalent than between dorsal fin formulae, anal fin structure is developed somewhat earlier, thereby providing an additional aid to separation in larvae less than 10 mm SL. The anal fin formula is of particular use as confirmation of identification when only a single, faintly-stainable pre-dorsal is present.

Miscellanea

Comparative studies (day vs. night tows, channel vs. shoals, gear comparisons, etc.) were inconclusive because of the general lack of striped bass larvae late in the spring season. Insufficient numbers of such larvae were included in catches for statistically valid analysis. Any further studies need to be conducted earlier in the season during peak abundance, i.e. in late April. Surveys of these spawning grounds also need to be initiated earlier in the season, preferably in mid- to late March, so as to assure assessment of earliest spawning. Ideally, two to three negative surveys should be experienced prior to initiation of spawning to assure investigators that they are indeed including the entire spawning run in their assessment.

Future monitoring of striped bass spawning in the York River system could, to conserve effort and expense, concentrate on the Pamunkey River. Differences in seasonal distribution and abundance of eggs and larvae in the Pamunkey and Mattaponi rivers were found to be negligible. A greater restriction of spawning to lower river sections of the Mattaponi River is due to the smaller size of that river; this principal difference in spawning distribution would not prevent sole use of the Pamunkey River for monitoring purposes.

REFERENCES

Drewry, G. E. and J. A. Mihursky. 1980. Morone identification in power plant related ichthyoplankton surveys 1975-1978: quality control data for the Chesapeake Bay region. Univ. Maryland, CEES-Chesapeake Biological Laboratory, Ref. No. UMCEES 79-88-CBL, 40 pp.

Fritzsche, R. A. and G. D. Johnson. 1979. Striped bass vs. white perch: application of a new morphological approach to ichthyoplankton taxonomy. Pp. 19-29, in: R. Wallus and C. W. Voigtlander (eds.), Proceedings of a Workshop on Freshwater Larval Fishes. Tennessee Valley Authority, Norris, Tenn.

Fritzsche, R. A. and G. D. Johnson. 1980. Early osteological development of white perch and striped bass with emphasis on identification of their larvae. Trans. Amer. Fish. Soc. 109:387-406.

Grant, G. C. 1974. The age composition of striped bass catches in Virginia rivers, 1967-1971, and a description of the fishery. Fish. Bull. 72:193-199.

Grant, G. C., V. G. Burrell, Jr., C. E. Richards and E. B. Joseph. 1970. Preliminary results from striped bass tagging in Virginia, 1968-1969. Proc. 23rd Ann. Conf. Southeast. Assoc. Game Fish Comm., pp. 558-570.

Grant, G. C. and E. B. Joseph. 1969. Comparative strength of the 1966 year class of striped bass, Roccus saxatilis (Walbaum), in three Virginia rivers. Proc. 22nd Ann. Conf. Southeast. Assoc. Game Fish Comm., pp. 501-509.

Mansueti, R. J. 1958. Eggs, larvae and young of the striped bass, _Roccus saxatilis._ Md. Dept. Res. Educ., Chesapeake Biological Lab., Contrib. 112, 35 pp.

Massmann, W. H., E. B. Joseph and J. J. Norcross. 1962. Fishes and fish larvae collected from Atlantic plankton cruises of R. V. _Pathfinder,_ March 1961 - March 1962. Virginia Institute of Marine Science, Spec. Sci. Rept. No. 33, 3 pp. + Tables.

Pearson, J. C. 1938. The life history of the striped bass, or rockfish, _Roccus saxatilis_ (Walbaum). U.S. Bur. Fish., Bull. 49(28):825-851.

Potthof, T. 1974. Osteological development and variation in young tunas, genus _Thunnus_ (Pisces, Scombridae), from the Atlantic Ocean. Fish. Bull. 72:563-588.

Rinaldo, R. G. 1971. Analysis of _Morone saxatilis_ and _Morone americanus_ spawning and nursery area in the York-Pamunkey River, Virginia. M.A. thesis, College of William and Mary, Williamsburg, VA, 56 pp.

Tresselt, E. F. 1950. Spawning grounds of the striped bass or rock, _Roccus saxatilis_ (Walbaum), in Virginia. Masters thesis, College of William and Mary, 29 pp.

Tresselt, E. F. 1952. Spawning grounds of the striped bass or rock, _Roccus saxatilis_ (Walbaum), in Virginia. _Bull. Bingham Oceanogr. Coll._ 14(1):98-110.

Tucker, G. H. 1951. Relation of fishes and other organisms to the scattering of underwater sound. _J. mar. Res._ 10:215-238.

TABLES

Table 1. Physical data from striped bass egg and larvae survey of the Pamunkey River (upper York R., Virginia system), spring 1980. Mean temperatures (°C) salinities (°/oo) dissolved oxygen concentrations (mg/l) and pH values are given. Secchi disc depth in meters.

River Mile Stratum	Cruise: / Date:	1 4/16-17	2 4/22	3 4/24	4 4/30	5 5/2	6 5/8	7 5/16	8 5/21	9 5/23	10 5/28	11 5/30	12 6/3	12A 6/5	13 6/13
30-32	River Mile	32	30	32	30	30	30	--	31	30	31	31	32	--	--
	Temperature	15.1	17.1	17.3	17.7	17.4	18.5		21.1	21.6	22.3	23.2	25.0		
	Salinity	0.35	2.93	5.76	4.57	0.49	7.71		5.67	6.27	0.63	2.15	1.33		
	Dissolved Oxygen	8.1	8.0	6.8	6.8	7.6	4.4		5.8	6.8	6.7	6.0	7.4		
	pH	6.5	--	--	--	--	--		6.8	--	6.5	--	--		
	Secchi Disc	0.6	0.4	0.6	0.5	0.3	0.9		0.6	0.6	0.4	0.4	0.4		
33-35	River Mile	35	34	35	33	33	35	33	33	34	33	33	33	--	35
	Temperature	15.5	16.9	17.7	18.0	18.5	19.2	21.0	21.1	21.9	22.4	23.5	25.0		24.4
	Salinity	0.19	0.17	2.06	0.71	0.11	3.80	5.14	3.56	1.64	0.14	1.02	0.37		5.02
	Dissolved Oxygen	8.5	8.6	7.5	7.1	8.2	5.7	6.2	5.5	5.8	6.8	6.5	5.9		--
	pH	6.6	--	--	--	--	--	6.5	6.9	--	6.3	--	--		--
	Secchi Disc	0.3	0.4	0.6	0.5	0.6	0.7	0.4	0.4	0.5	0.4	0.4	0.4		0.6
36-38	River Mile	38	37	38	38	36	37	36	36	37	37	38	37	--	38
	Temperature	15.5	17.4	17.8	18.2	18.3	18.7	21.2	21.0	21.3	22.6	23.7	25.3		24.3
	Salinity	0.06	0.05	0.13	0.28	0.06	1.52	1.13	0.67	0.15	0.05	0.08	0.05		1.95
	Dissolved Oxygen	8.7	9.3	9.0	8.1	8.6	6.8	7.1	6.3	6.8	8.2	7.5	7.1		--
	pH	6.6	--	--	--	--	--	6.5	7.1	--	6.2	--	--		--
	Secchi Disc	0.6	0.7	0.5	0.7	0.6	0.7	0.3	0.4	0.5	0.6	0.7	0.5		0.6
39-41	River Mile	39	41	41	40	39	40	40	39	40	39	40	40	--	40
	Temperature	15.2	17.2	17.9	18.2	18.8	19.0	20.9	20.9	21.7	22.5	23.7	25.4		24.7
	Salinity	0.06	0.05	0.08	0.29	0.06	0.09	0.08	0.11	0.06	0.05	0.19	0.05		0.48
	Dissolved Oxygen	8.8	9.3	9.1	8.3	8.8	9.0	8.0	6.6	6.6	7.9	8.0	7.9		--
	pH	6.1	--	--	--	--	--	6.5	--	--	6.2	--			--
	Secchi Disc	0.7	0.6	0.7	0.6	0.5	1.0	0.4	0.5	0.8	0.6	0.7	0.7		0.4

Table 1 (continued)

River Mile Stratum	Cruise: / Date:	1 4/16-17	2 4/22	3 4/24	4 4/30	5 5/2	6 5/8	7 5/16	8 5/21	9 5/23	10 5/28	11 5/30	12 6/3	12A 6/5	13 6/13
42-44	River Mile	42	44	42	44	42	43	43	43	43	43	43	44	--	42
	Temperature	15.2	17.2	18.3	18.0	18.4	18.5	21.1	21.1	21.7	22.8	23.8	25.9		24.2
	Salinity	0.05	0.05	0.10	0.41	0.08	0.07	0.05	0.05	0.05	0.05	0.18	0.04		0.10
	Dissolved Oxygen	8.6	9.1	9.4	8.6	8.4	8.7	9.1	7.0	7.3	9.1	8.6	8.3		--
	pH	5.8	--	--	--	--	--	6.3	--	--	6.3	--	--		--
	Secchi Disc	0.6	0.7	0.6	0.7	0.8	0.7	0.7	0.5	0.9	0.4	0.7	0.6		0.6
45-47	River Mile	45	45	45	45	45	47	46	45	46	45	45	45	--	46
	Temperature	15.8	17.5	18.5	18.0	18.5	19.2	21.2	21.5	22.3	23.0	23.9	25.8		24.9
	Salinity	0.05	0.04	0.06	0.27	0.05	0.07	0.07	0.05	0.04	0.05	0.07	0.04		0.05
	Dissolved Oxygen	8.8	9.2	9.4	8.4	8.0	8.8	9.1	7.3	7.6	9.6	8.8	8.0		--
	pH	6.4	--	--	--	--	--	6.5	--	--	6.5	--	--		--
	Secchi Disc	--	0.8	0.8	0.8	0.8	0.9	0.7	0.7	1.1	0.5	0.5	0.6		0.7
48-50	River Mile	48	50	48	49	50	49	50	49	49	50	48	50	--	50
	Temperature	15.6	18.1	18.6	17.9	18.0	18.7	21.0	21.4	22.1	22.9	24.1	26.1		24.4
	Salinity	0.05	0.05	0.07	0.06	0.05	0.11	0.05	0.05	0.05	0.05	0.09	0.04		0.05
	Dissolved Oxygen	8.6	9.1	9.6	7.6	7.3	8.4	9.7	7.6	7.5	9.1	8.6	7.6		--
	pH	6.5	--	--	--	--	--	6.5	--	--	6.2	--	--		--
	Secchi Disc	0.6	0.7	0.7	0.6	0.7	0.8	0.6	0.5	0.6	0.5	0.5	0.6		0.6
51-53	River Mile	52	52	53	53	53	53	--	52	51	51	52	53	53	53
	Temperature	14.7	18.1	19.8	17.4	17.4	19.8		21.5	22.2	22.7	23.9	26.0	25.3	23.7
	Salinity	0.05	0.04	0.09	0.06	0.07	0.07		0.06	0.05	0.04	0.21	0.05	0.08	0.10
	Dissolved Oxygen	8.6	8.9	9.4	6.6	6.8	8.7		7.7	7.8	9.2	8.8	6.8	8.2	--
	pH	6.2	--	--	--	--	--		--	--	--	--	--	--	--
	Secchi Disc	0.6	0.9	0.6	0.4	0.7	0.7		0.6	1.0	0.6	0.5	0.6	--	0.8

Table 1 (concluded)

River Mile Stratum	Cruise: / Date:	1 4/16-17	2 4/22	3 4/24	4 4/30	5 5/2	6 5/8	7 5/16	8 5/21	9 5/23	10 5/28	11 5/30	12 6/3	12A 6/5	13 6/13
54-56	River Mile	55	55	54	--	--	--	--	--	--	--	--	--	--	--
	Temperature	14.0	18.2	19.2											
	Salinity	0.05	0.05	0.12											
	Dissolved Oxygen	8.4	8.0	8.3											
	pH	6.5	--	--											
	Secchi Disc	0.6	0.8	0.8											
57-59	River Mile	57	57	57	--	--	--	--	--	--	--	--	--	--	--
	Temperature	13.8	18.2	19.9											
	Salinity	0.06	0.08	0.09											
	Dissolved Oxygen	8.3	7.7	7.6											
	pH	6.2	--	--											
	Secchi Disc	0.6	1.0	1.0											

Table 2. Physical data from striped bass egg and larvae survey of the Mattaponi River (upper York R., Virginia system), spring 1980. Mean temperatures (°C), salinities (°/oo), dissolved oxygen concentrations (mg/l) and pH values are given. Secchi disc depth in meters.

River Mile Stratum		Cruise:	1	2	3	4	5	6	7	8	9	10	11	12	13
		Date:	4/18	4/21	4/25	4/29	5/1	5/9	5/17	5/20	5/22	5/27	5/29	6/2	6/14
30-32	River Mile		31	30	31	30	30	32	--	31	32	31	30[5/]	31	31
	Temperature		15.3	17.0	18.6	18.3	17.2	18.0		21.3	20.9	22.0	21.9	24.7	23.9
	Salinity		0.80	3.05	0.30	3.91	0.20	3.42		1.13	1.99	2.98	1.02	0.61	2.41
	Dissolved Oxygen		7.7	7.7	7.9	7.8	7.1	6.0		5.7	5.7	6.0	5.5	5.7	6.5
	pH		6.4	--	--	--	--	6.6		6.9	--	6.3	--	--	--
	Secchi Disc		0.1	--	0.5	--	0.5	0.7		0.5	0.5	0.5	0.4	0.4	0.7
33-35	River Mile		33	35	34	35	33	33	35	34	35	33	34	35	35
	Temperature		15.7	17.0	18.3	18.2	17.4	18.2	20.3	21.0	20.9	22.0	21.8	24.2	23.9
	Salinity		0.27	--	0.05	0.16	0.05	2.79	0.16	0.11	0.14	0.62	0.05	0.05	0.22
	Dissolved Oxygen		7.8	8.0	8.6	7.0	7.6	6.1	6.5	5.9	5.8	5.7	6.1	5.8	6.4
	pH		6.6	--	--	--	--	6.3	6.8	7.0	--	6.7	--	--	--
	Secchi Disc		0.3	0.4	0.7	0.4	0.8	0.6	0.3	0.5	0.4	0.5	0.6	0.6	0.5
36-38	River Mile		38	37	37	36	37	38	38	36	38	37	36	36	37
	Temperature		15.4	16.9	18.4	18.4	17.7	18.3	20.6	21.4	21.0	22.0	22.8	24.5	24.1
	Salinity		0.18	0.04	0.04	0.09	0.05	0.15	0.05	0.07	0.05	0.05	0.05	0.04	0.06
	Dissolved Oxygen		8.0	8.2	8.8	8.1	6.9	7.7	6.8	6.1	5.9	6.1	6.1	5.9	6.4
	pH		6.5	5.4	--	--	--	6.3	6.9	7.1	--	6.8	--	--	--
	Secchi Disc		0.7	0.6	0.9	0.5	1.0	1.0	0.5	0.7	0.4	0.7	0.6	0.7	0.7
39-41	River Mile		39	39	39	41	39	39	41	39	39	39	39	40	39
	Temperature		15.5	16.9	18.8	18.0	17.8	19.0	21.0	21.3	21.1	22.7	22.9	24.7	24.0
	Salinity		0.22	0.04	0.04	0.05	0.05	0.05	0.04	0.06	0.04	0.04	0.04	0.04	0.05
	Dissolved Oxygen		8.0	8.1	8.6	8.1	6.9	7.5	6.4	6.0	6.2	6.1	5.8	5.7	6.6
	pH		6.2	5.4	--	--	--	6.4	6.8	7.1	--	6.6	--	--	--
	Secchi Disc		0.6	0.8	0.9	0.9	1.0	0.9	0.6	0.8	0.6	0.8	--	0.8	--

Table 2 (continued)

River Mile Stratum		Cruise: Date:	1 4/18	2 4/21	3 4/25	4 4/29	5 5/1	6 5/9	7 5/17	8 5/20	9 5/22	10 5/27	11 5/29	12 6/2	13 6/14
42-44	River Mile		44	42	43	44	43	42[2/]	44	42	43	43	43	43	44
	Temperature		16.1	17.3	18.9	18.2	17.5	19.0	21.0	21.3	21.4	22.5	22.7	25.2	24.1
	Salinity		0.14	0.04	0.04	0.04	0.05	0.13	0.04	0.07	0.04	0.04	0.04	0.04	0.04
	Dissolved Oxygen		8.1	7.7	7.8	7.1	6.5	6.6	7.0	5.9	5.8	5.6	5.4	5.7	5.9
	pH		6.1	5.5	--	--	--	6.3	6.9	6.7	--	6.4	--	--	--
	Secchi Disc		1.0	1.0	0.9	0.8	1.0	0.9	1.0	0.9	0.8	1.0	0.9	1.0	1.2
45-47	River Mile		45	46	47	45	47	45	45	45[3/]	47	45	46	47	46
	Temperature		15.5	17.3	19.4	18.1	16.9	19.2	21.1	21.9	21.5	22.4	22.8	25.3	24.5
	Salinity		0.15	0.04	0.04	0.04	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
	Dissolved Oxygen		8.1	7.8	7.1	6.5	6.8	6.9	6.6	5.8	5.8	5.8	5.4	5.5	5.7
	pH		6.4	6.3	--	--	--	6.3	6.8	6.4	--	6.2	--	--	--
	Secchi Disc		0.9	1.1	1.7	0.7	1.1	0.9	1.1	0.8	0.8	0.9	1.0	1.0	1.3
48-50	River Mile		--	49	50	49	49	50	50	--	48	48	48	49	49
	Temperature			17.2	19.8	17.5	16.6	19.0	21.2		21.3	22.1	22.6	25.5	24.5
	Salinity			0.04	0.04	0.04	0.05	0.04	0.04		0.04	0.05	0.04	0.04	0.05
	Dissolved Oxygen			7.7	6.9	6.6	6.9	6.1	7.1		5.9	6.0	5.8	5.7	6.5
	pH			5.3	--	--	--	6.2	6.9		--	6.2	--	--	--
	Secchi Disc			--	1.5	0.8	0.8	1.1	1.3		0.8	1.1	1.1	1.1	1.1
51-53	River Mile		--	53[1/]	51	53	51	51	--	53[4/]	53	52	51	51	52
	Temperature			17.2	20.4	15.9	16.4	19.0		21.9	20.5	21.6	22.4	25.2	24.0
	Salinity			0.05	0.04	--	0.04	0.04		0.06	0.04	0.04	0.04	0.04	0.04
	Dissolved Oxygen			7.9	6.9	7.1	6.9	6.7		6.0	6.6	5.8	5.9	5.7	6.9
	pH			6.1	--	--	--	6.3		6.3	--	6.0	--	--	--
	Secchi Disc			1.3	1.6	0.6	0.8	1.0		1.2	0.7	1.1	1.1	1.0	1.4

Table 2 (concluded)

River Mile Stratum	Cruise: / Date:	1 4/18	2 4/21	3 4/25	4 4/29	5 5/1	6 5/9	7 5/17	8 5/20	9 5/22	10 5/27	11 5/29	12 6/2	13 6/14
54-56	River Mile	--	--	54	--	--	--	--	--	--	--	--	--	--
	Temperature			20.2										
	Salinity			0.04										
	Dissolved Oxygen			7.1										
	pH			--										
	Secchi Disc			1.6										

1/ Plus River Mile 51, temp 17.3, sal. 0.04, DO 8.0, pH 5.5, Secchi 1.4

2/ M43 sampled later, temp 19.0, sal. 0.04, DO 6.4, pH 6.3

3/ M47 Day-night comparisons: day - temp 22.0, sal. 0.08, DO 5.8, pH 6.4
night - temp 21.6, sal. 0.05, DO 5.4, pH 6.6

4/ Plus River Mile 51, temp 21.9, sal. 0.07, DO 6.1, pH 6.3, Secchi 1.0

5/ Plus River Mile 31, temp 21.8, sal. 0.18, DO 5.6, Secchi 0.4

Table 3. Volumes of water filtered (m^3), Pamunkey River, spring 1980. All collections from combined oblique tows of 60 cm bongo nets (333 µm mesh) unless otherwise indicated.

River Mile Stratum	Cruise: / Date:	1 4/16-17	2 4/22	3 4/24	4 4/30	5 5/2	6 5/8	7 5/16	8 5/21	9 5/23	10 5/28	11 5/30	12 6/3	12A 6/5	13 6/13
30-32	River Mile	32	30	32	30	30	30	--	31	30	31	31	32	--	--
	Coll. No.	Z80-179	Z80-204	Z80-225	Z80-250	Z80-259	Z80-267	--	Z80-327	Z80-343	Z80-359	Z80-376	Z80-392		
	Volume (m^3)	144.16	137.64	141.18	106.59	75.80	105.11*	--	54.46*	47.84*	132.99	141.79	108.46		
33-35	River Mile	35	34	35	33	33	35	33	33	34	33	33	33	—	35
	Coll. No.	Z80-180	Z80-205	Z80-226	Z80-249	Z80-260	Z80-268	Z80-300	Z80-328	Z80-344	Z80-360	Z80-377	Z80-393		Z80-425
	Volume (m^3)	95.76	75.01	117.14	135.42	109.40	112.04	121.89	82.21	123.82	83.48	91.65	97.43		106.94*
36-38	River Mile	38	37	38	38	36	37	36	36	37	37	38	37	--	38
	Coll. No.	Z80-181	Z80-206	Z80-227	Z80-248	Z80-261	Z80-269	Z80-299	Z80-329	Z80-345	Z80-361	Z80-378	Z80-394		Z80-424
	Volume (m^3)	100.35	83.00	53.21	153.76	89.30	163.52	96.53	85.59	103.82	72.91	83.68	74.79		224.90
39-41	River Mile	39	41	41	40	39	40	40	39	40	39	40	40	--	40
	Coll. No.	Z80-182	Z80-207	Z80-228	Z80-247	Z80-262	Z80-270	Z80-298	Z80-330	Z80-346	Z80-362	Z80-379	Z80-395		Z80-423
	Volume	105.08	130.34	66.73	113.80	87.61	120.77	97.40	74.34	110.91	77.79	89.01	113.22		141.75
42-44	River Mile	42	44	42	44	42	43	43	43	43	43	43	44	--	42
	Coll. No.	Z80-183	Z80-208	Z80-229	Z80-246	Z80-263	Z80-271	Z80-297	Z80-331	Z80-347	Z80-363	Z80-380	Z80-396		Z80-422
	Volume	144.91	139.39	115.35	144.89	139.44	120.67	88.14	61.71	83.77	85.62	95.75	122.02		225.95
45-47	River Mile	45	45	45	45	45	47	46	45	46	45	45	45	--	46
	Coll. No.	Z80-188	Z80-209	Z80-230	Z80-245	Z80-264	Z80-272	Z80-296	Z80-332	Z80-348	Z80-364	Z80-381	Z80-397		Z80-421
	Volume	124.49	142.11	147.15	122.44	90.63	183.66	87.88	77.18	86.30	97.55	83.84	112.48		189.92
48-50	River Mile	48	50	48	49	50	49	50	49	49	50	48	50	--	50
	Coll. No.	Z80-187	Z80-210	Z80-231	Z80-244	Z80-265	Z80-273	Z80-295	Z80-333	Z80-349	Z80-365	Z80-382	Z80-398		Z80-420
	Volume	108.97	169.71	143.77	129.59	96.53	171.62	126.65	90.59	122.28	107.62	95.06	104.57		213.94

Table 3 (concluded)

River Mile Stratum		Cruise: Date:	1 4/16-17	2 4/22	3 4/24	4 4/30	5 5/2	6 5/8	7 5/16	8 5/21	9 5/23	10 5/28	11 5/30	12 6/3	12A 6/5	13 6/13
51-53	River Mile		52	52	53	53	53	53		52	51	51	52	53[2/]	53[3/]	53
	Coll. No.		Z80-186	Z80-211	Z80-232	Z80-243	Z80-266	Z80-274	--	Z80-334	Z80-350	Z80-366	Z80-383	Z80-399		Z80-419
	Volume		93.17	117.34	161.62	169.88	146.01	197.91		77.32	117.21	95.53	104.68	71.34*		234.47
54-56	River Mile		55	55	54	--	--	--	--	--	--	--	--	--	--	--
	Coll. No.		Z80-185	Z80-212	Z80-233											
	Volume		206.87	100.50	124.01											
57-59	River Mile		57	57	57	--	--	--	--							
	Coll. No.		Z80-184	Z80-213	Z80-234											
	Volume		86.19	134.30	163.28											

* one net only

1/ additional tows: Z80-275, Tucker trawl, bottom horizontal, 91.99 m^3
Z80-276, " " , surface " , 160.37 m^3
Z80-277, " " , mid-depth " , 81.56 m^3

2/ additional tows: Z80-400, paired oblique kept separate, 72.43 m^3
Z80-401, bottom horizontal, 53.38 m^3
Z80-402, " " , 51.63 m^3
Z80-403, " " , 55.62 m^3
Z80-404, " " , 104.77 m^3
Z80-405, paired oblique kept separate, 64.86 m^3
Z80-406, " " " " , 67.27 m^3

3/ Cruise 12A: series of tows at P53
Z80-407,-408; Z80-409,-410; and Z80-411,-412, paired tows shallow west side of river; volumes, respectively: 36.83, 36.44, 23.77, 23.79, 38.42, 37.58 m^3 Z80-413,-414; Z80-415,-416; and Z80-417,-418, paired tows in channel; volumes, respectively: 50.73, 45.07, 45.30, 45.34, 40.13, 38.89 m^3

Table 4. Volumes of water filtered (m^3), Mattaponi River, spring 1980. All collections from combined oblique tows of 60 cm bongo nets (333 μm mesh) unless otherwise indicated.

River Mile Stratum	Cruise: / Date:	1	2	3	4	5	6	7	8	9	10	11	12	13
		4/18	4/21	4/25	4/29	5/1	5/9	5/17	5/20	5/22	5/27	5/29	6/2	6/14
30-32	River Mile	31	30	31	30	30	32	--	31	32	31	30[5/]	31	31
	Coll. No.	Z80-189	Z80-203	Z80-223	Z80-242	Z80-251	Z80-281		Z80-307	Z80-335	Z80-351	Z80-367	Z80-384	Z80-426
	Volume (m^3)	76.50	93.74	74.07	167.14	124.57	166.18		110.61	126.45	82.79	99.55	91.23	66.49
33-35	River Mile	33	35	34	35	33	33	35	34	35	33	34	35	35
	Coll. No.	Z80-190	Z80-202	Z80-222	Z80-241	Z80-252	Z80-282	Z80-301	Z80-308	Z80-336	Z80-252	Z80-369	Z80-385	Z80-427
	Volume (m^3)	83.49	63.85	148.21	231.89	124.27	156.90	136.04	107.43	106.89	92.80	116.48	87.68	139.78
36-38	River Mile	38	37	37	36	37	38	38	36	38	37	36	36	37
	Coll. No.	Z80-191	Z80-201	Z80-221	Z80-240	Z80-253	Z80-283	Z80-302	Z80-309	Z80-337	Z80-353	Z80-370	Z80-386	Z80-428
	Volume (m^3)	182.99	83.94	136.53	134.45	184.52	181.93	132.00	138.72	169.76	138.74	96.71	104.29	161.80
39-41	River Mile	39	39	39	41	39	39	41	39	39	39	39	40	39
	Coll. No.	Z80-192	Z80-200	Z80-220	Z80-239	Z80-254	Z80-284	Z80-303	Z80-310	Z80-338	Z80-354	Z80-371	Z80-387	Z80-429
	Volume (m^3)	153.48	154.42	119.12	153.35	174.68	196.87	190.50	124.24	89.46	107.15	94.38	113.74	155.78
42-44	River Mile	44	42	43	44	43	42[2/]	44	42	43	43	43	43	44
	Coll. No.	Z80-193	Z80-199	Z80-219	Z80-238	Z80-255	Z80-285	Z80-304	Z80-311	Z80-339	Z80-355	Z80-372	Z80-388	Z80-430
	Volume (m^3)	143.55	178.73	151.78	161.61	112.64	155.44	230.36	106.32	146.77	84.63	81.50	117.43	156.36
45-47	River Mile	45	46	47	45	47	45	45	45[3/]	47	45	46	47	46
	Coll. No.	Z80-194	Z80-198	Z80-218	Z80-237	Z80-256	Z80-286	Z80-305	Z80-312	Z80-340	Z80-356	Z80-373	Z80-389	Z80-431
	Volume (m^3)	138.33	249.25	135.07	132.53	173.46	138.31	141.77	140.31	126.03	70.28	102.93	154.34	117.47
48-50	River Mile	--	49	50	49	49	50	50	--	48	48	48	49	49
	Coll. No.		Z80-197	Z80-217	Z80-236	Z80-257	Z80-287	Z80-306		Z80-341	Z80-357	Z80-374	Z80-390	Z80-432
	Volume (m^3)		133.34	124.76	114.68	112.18	162.15	251.59		139.70	148.45	93.63	83.21	141.60

Table 4 (concluded)

River Mile Stratum		Cruise: Date:	1 4/18	2 4/21	3 4/25	4 4/29	5 5/1	6 5/9	7 5/17	8 5/20	9 5/22	10 5/27	11 5/29	12 6/2	13 6/14
51-53	River Mile		--	53 1/	51	53	51	51		53 4/	53	52	51	51	52
	Coll. No.			Z80-195	Z80-216	Z80-235	Z80-258	Z80-288	--	Z80-319	Z80-342	Z80-358	Z80-375	Z80-391	Z80-433
	Volume (m^3)			125.00	90.81	133.02	115.02	222.70		66.43	125.82	108.84	113.72	82.91	117.41
54-56	River Mile		--	--	54	--	--	--	--	--	--	--	--	--	--
	Coll. No.				Z80-215										
	Volume (m^3)				118.83										

1/ Plus Z80-196 at M51, 124.99 m^3

2/ Plus Tucker tows at M43: Z80-289 (bottom), 53.73 m^3; Z80-290 (surface), 81.79 m^3 Z80-291 (mid-depth), 59.83 m^3

3/ Day-night comparisons at M47

Day:	Z80-313	Z80-314	Z80-315	Z80-316	Z80-317	Z80-318
Vol (m^3):	79.34	79.48	63.37	62.99	82.91	85.54
Night:	Z80-321	Z80-322	Z80-323	Z80-324	Z80-325	Z80-326
Vol (m^3):	89.79	96.40	80.95	82.33	63.10	64.99

4/ Plus Z80-320 at M51, 119.76 m^3

5/ Plus M31, Z80-368, 101.02 m^3