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## The fishes of the tidewater section of the Pamunkey River, Virginia

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ICHTHYOLOGY.—*The fishes of the tidewater section of the Pamunkey River, Virginia.* EDWARD C. RANEY and WILLIAM H. MASSMANN, Cornell University and Virginia Fisheries Laboratory.<sup>1</sup>

The distribution of the fish fauna of the tidewater section of most of the rivers that flow into Chesapeake Bay is poorly known. Indeed, this is true for practically all the great rivers tributary to the Atlantic from the Hudson southward to the Savannah. The few investigations usually have concentrated on commercial species and our understanding of distribution has been inferred from the knowledge of nearby Coastal Plain streams reported in such studies as those by Hildebrand and Schroeder (1928), Fowler (1945), Raney (1950), and Massmann, Ladd, McCutcheon (1952).

In 1949 the junior author began a study of the spawning and early life history of shad in the Pamunkey and other nearby Virginia rivers and collected with seines at numerous locations in the tidal area. After exploratory seining, many of the stations were visited at almost weekly intervals during the period June 28 to September 29, 1949. Since that time additional collections have been made at established stations on the Pamunkey indicated on the map (Fig. 1).

A minnow seine, 20 feet long and 4 feet in depth, was used in all but six collections when a net 75 by 6 feet was employed. All seines had a bar mesh size of  $\frac{1}{4}$  inch. The collections included 113 samples taken by minnow seine, 15 by surface trawl, 6 by rotenone, 4 by bottom trawl, and a series of plankton net collections which often contained small fishes. Continuous observations were made on the commercial and sport fisheries. Many of the collections were sent to the senior author, who is responsible for the identification of all but the clupeid fishes. A total of 59 species were taken in the Coastal Plain region of the Pamunkey River and its tributaries; 52 were limited to the tidewater section.

DESCRIPTION OF THE LOWER  
PAMUNKEY RIVER

The Pamunkey River (Fig. 1) originates on the Piedmont plateau at the confluence of the North and South Anna Rivers, 5 miles northeast of Ashland, Va., and empties into the York River at West Point. The tidal region extends about 42 nautical miles upstream to the vicinity of Bassett Bar. At West Point, salinities ranging from 0 to

<sup>1</sup> Contribution from the Virginia Fisheries Laboratory, No. 48.

12.6 parts per thousand have been recorded; the river generally becomes fresh between West Point and Romancock at a point 8 miles upstream. The precise boundary between fresh and brackish water varies with river runoff, wind, and tide, as does the head of the tide itself. The tidal range averages about 3 feet. Turbidities, as measured with a Secchi disk, range from 27 to 61 cm; the upper sections of the river are generally clearer than the lower reaches. Submergent vegetation, of which the predominant form is *Nitella*, although sparse in the river, is found in abundance in a few protected coves.

The tidal portion of the river may be divided into three rather homogeneous physiographic areas each approximately 15 miles in length. Area I (Fig. 1) is characterized by a wide channel which is from 20 to 60 feet deep and rather steep mud banks. It is surrounded by extensive tidal marshes. Eight small gravel and/or sand

beaches are present in this section. Area II is centered near Lester Manor. Here the river generally is wider, and is fed by many marsh creeks. Shoal areas, less than 5 feet in depth, are extensive, and numerous coves are present. The shoreline is mostly wooded. About a dozen sand and/or gravel beaches suitable for seining are present. Area III has an average depth of 12 feet, and few shoal areas, which are located in the mouths of tributary creeks. The muddy banks are rather steep and only about six small sand and/or gravel beaches are suited to seining. The shoreline is generally forested.

#### FISHERIES OF THE PAMUNKEY RIVER

The American shad and catfishes (*Ictalurus*) are the major species of commercial importance on the Pamunkey River. Shad are caught during the spawning run in spring, mainly with drift gill nets, although a few set or stake gill nets are fished at West Point. In depth the drift nets may be

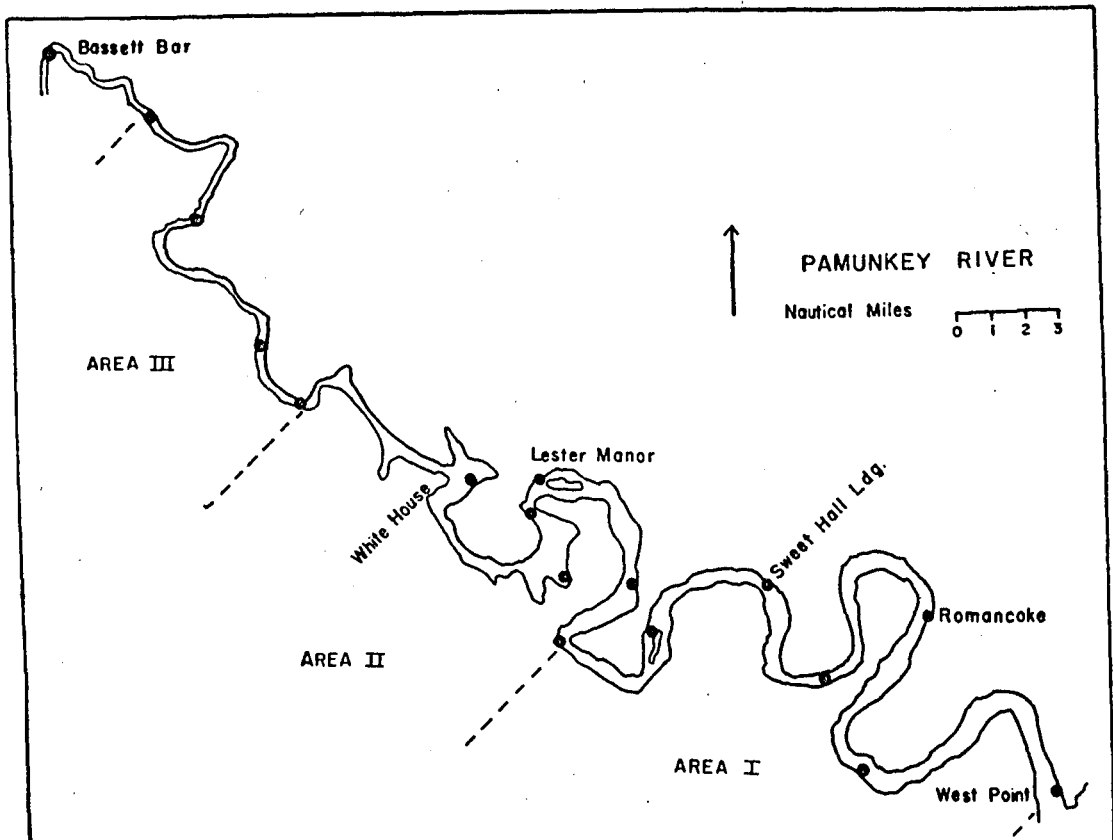


FIG. 1.—The tidewater section of the Pamunkey River between its mouth at West Point and Bassett Bar a point approximately 42 nautical miles upstream, showing localities mentioned in text

as much as 25 feet, depending on the water depths being fished; in length they vary from one-quarter to one-half the width of the channel. In area I, striped bass are often taken in shad nets. The alewife, glut herring, and hickory shad are also captured but generally, because of their smaller size, these fishes escape through the meshes of shad nets. A few small hoop fyke nets are fished in area I and their catch includes white perch, glut herring, alewife, and catfishes. In the vicinity of Lester Manor, a single haul seine operates and takes white perch, carp, striped bass, gizzard shad, and redhorse sucker. Catfishes are generally taken in catfish pots although two fishermen still use the more primitive trot lines. With the exception of catfish pots, White House is the upper limit of commercial fishing on the Pamunkey, since the river beyond that point is not suited to the use of commercial nets.

To obtain small quantities of fish for local consumption herring drift nets and set gill nets are sometimes used. Extensive angling is not carried on, but striped bass, large-mouth bass, catfishes, white perch, yellow perch and sunfishes are taken.

ANNOTATED LIST OF FISHES

The following annotated list includes only those fishes taken in the tidewater section. Their distribution in the several areas of the river is given in Table 1. The number appearing at the end of each species account represents the percentage frequency of occurrence in seine hauls. (See also Table 2.)

PETROMYZONTIDAE

*Petromyzon marinus* Linnaeus: Sea Lamprey

Although no sea lamprey was caught or observed during the survey, it has been seen in the adjacent Chickahominy and Rappahannock Rivers. Local fishermen reported its capture in past years when nets of smaller mesh were commonly used.

ACIPENSERIDAE

*Acipenser oxyrhynchus* (Mitchill): Atlantic Sturgeon

A small specimen was taken in a shad drift net at Lester Manor. Formerly common, it is now seldom seen.

TABLE 1.—Phylogenetically arranged list of the Coastal Plain fishes of the Pamunkey River system. Areas I, II, and III are from the tidewater section of the lower Pamunkey River as shown in Fig. 1. Area IV represents collections from tributaries to the tidewater section and the upstream Pamunkey River from Bassett Bar to the Fall Line. Species marked by an asterisk were also collected in the Piedmont region of the Pamunkey River system. Type of record: X—collected, O—observed, R—reliably reported by fishermen.

Species	Area			
	I	II	III	IV
<i>Petromyzon marinus</i> .....		R		
<i>Acipenser oxyrhynchus</i> .....		O		
<i>Lepisosteus o. osseus</i> .....	X	X		
<i>Amia calva</i> .....		X	X	
<i>Alosa mediocris</i> .....	X	X		
<i>Alosa aestivalis</i> .....	X	X	X	
<i>Alosa pseudoharengus</i> .....	X	X	X	
<i>Alosa sapidissima</i> .....	X	X	X	
<i>Brevoortia tyrannus</i> .....	X	X		
<i>Dorosoma cepedianum</i> .....	X	X		
<i>Anchoa m. mitchilli</i> .....	X	X		
<i>Erimyzon o. oblongus</i> *.....				X
<i>Mozostoma macrolepidotum</i> *.....	X	X	X	
<i>Cyprinus carpio</i> .....		O		
<i>Semotilus corporalis</i> *.....	X		X	X
<i>Semotilus a. atromaculatus</i> *.....				X
<i>Hypopsis leptocephalus</i> *.....				X
<i>Notemigonus c. crysoleucas</i> .....	X	X	X	X
<i>Notropis amoenus</i> .....			X	
<i>Notropis hudsonius saludanus</i> .....	X	X	X	X
<i>Notropis analostanus</i> *.....	X	X	X	X
<i>Hypognathus nuchalis regius</i> .....	X	X	X	X
<i>Ictalurus catus</i> .....	X	X	X	X
<i>Ictalurus p. punctatus</i> .....	X	X	X	
<i>Ameiurus natalis erebennus</i> .....	X	X		X
<i>Ameiurus n. nebulosus</i> *.....	X			X
<i>Schilbeodes mollis</i> .....	X	X	X	
<i>Schilbeodes m. marginatus</i> *.....		X		X
<i>Umbra pygmaea</i> .....				X
<i>Esox niger</i> *.....	X		X	X
<i>Esox americanus</i> *.....			X	X
<i>Anguilla rostrata</i> .....	X	X	X	X
<i>Fundulus heteroclitus macrolepidotus</i> .....	X	X	X	
<i>Fundulus d. diaphanus</i> .....	X	X	X	X
<i>Gambusia affinis holbrooki</i> .....	X	X	X	X
<i>Aphredoderus s. sayanus</i> *.....				X
<i>Strongylura marina</i> .....		X	X	
<i>Roccus saxatilis</i> .....	X	X	X	X
<i>Morone americana</i> .....	X	X	X	X
<i>Perca flavescens</i> .....	X	X	X	X
<i>Etheostoma nigrum olmstedii</i> .....	X	X	X	X
<i>Micropterus s. salmoides</i> .....	X	X	X	X
<i>Lepomis gibbosus</i> *.....	X	X	X	X
<i>Lepomis m. macrochirus</i> *.....	X	X	X	X
<i>Lepomis auritus</i> *.....	X	X	X	X
<i>Centrarchus macropterus</i> .....				X
<i>Pomoxis nigromaculatus</i> .....	X	X	X	X
<i>Enneacanthus gloriosus</i> .....	X	X	X	X
<i>Enneacanthus obesus</i> .....	X			
<i>Acantharcus pomotis</i> *.....				X
<i>Menidia beryllina</i> .....	X	X	X	
<i>Menidia menidia</i> .....	X	X		
<i>Peprilus alepidotus</i> .....	X			
<i>Cynoscion regalis</i> .....	X			
<i>Leiostomus xanthurus</i> .....	X			
<i>Micropogon undulatus</i> .....	X	X		
<i>Gobiosoma boscii</i> .....	X			
<i>Paralichthys dentatus</i> .....	X			
<i>Trinectes maculatus</i> .....	X	X	X	

## LEPISOSTEIDAE

*Lepisosteus osseus osseus* (Linnaeus):  
Eastern Longnose Gar

Numerous in areas I and II. On one boat trip large numbers of adults were observed near the surface between West Point and White House. One shad fishing reach near Lester Manor is seldom used because the gar, which damage shad nets, is so abundant in the area. Only three young gar were taken by minnow seine. 4.

## AMIIDAE

*Amia calva* Linnaeus: Bowfin

Several were observed on the beach at the Pamunkey Indian Reservation where they had been discarded from gill net catches, and two were collected near Bassett Bar. Fishermen reported an increase in abundance in recent years.

## CLUPEIDAE

*Alosa mediocris* (Mitchill):  
Hickory Shad

It migrates into the Pamunkey in spring to spawn and females in various stages of ripeness, and spent specimens were frequently seen although Hildebrand and Schroeder (1928, p. 84) reported to the contrary. This species was observed in commercial catches from West Point to White House. Although only three juveniles were collected while seining, 91 young were taken in two 15-minute hauls with a surface trawl in area I. 2.

*Alosa aestivalis* (Mitchill):  
Glut Herring

The most abundant of the river herrings. It generally spawns in tidal waters, but sometimes also in the tributaries. The main spawning migration follows that of the American shad, and usually occupies about three weeks. During this short but heavy run, canneries are often supplied with more herring than they can utilize, hence the common name, glut herring. However, this herring generally is not taken commercially on the Pamunkey since almost the entire fishing effort is directed toward the more valuable American shad. Juveniles are present in large numbers during the summer months and probably constitute one of the most important forage fishes. Young glut herring were collected at most stations from brackish waters to the head of tide-water. 35.

*Alosa pseudoharengus* (Wilson): Alewife

The main spawning run generally precedes that of the American shad by several weeks. Spawning often takes place in tributaries, but also in tidal waters. Young have been taken from all sections of the river. 17.

*Alosa sapidissima* (Wilson): American Shad

The main spawning run arrives in April although a few adult shad have been observed in the commercial catch from November to July. Spawning takes place in the freshwater tidal section of the river but is most concentrated in area II, as reported by Massmann (1952). Young shad were taken at most stations in fresh tidal waters. Greater numbers of young shad have been collected in the Pamunkey than in the Mattaponi or Rappahannock rivers. 57.

*Brevoortia tyrannus* (Latrobe): Menhaden

Although the menhaden is primarily a marine species, young are often found in fresh water. From area I, postlarval menhaden 20 to 30 mm. in length were collected in plankton nets during April, 1950. In the summer young menhaden were seined at stations in areas I and II. Collections from the Rappahannock River indicate that large numbers of young may be found in fresh-water during the summer months. 5.

*Dorosoma cepedianum* (LeSueur): Gizzard Shad

Observed at Lester Manor, where a few were taken in shad nets. Juveniles were collected in the mouth of a tidal creek, one mile south of Sweet Hall Landing. Fishermen reported that this species has become scarce in the past ten years.

## ENGRAULIDIDAE

*Anchoa mitchilli mitchilli* (Valenciennes):  
Anchovy

Although typically marine, all stages of this anchovy from post-larvae to adult, may be present in large numbers in the rivers. The occurrence of postlarval specimens in fresh water suggests that it may spawn in or near the Pamunkey. It was collected from areas I and II. 16.

## CATOSTOMIDAE

*Moxostoma macrolepidotum* (LeSueur):  
Eastern Redhorse Sucker

This is the common sucker of the region. It

was found in all parts of the river. Young and juveniles were taken in seines, and adults were noted in summer gill net catches. 20.

CYPRINIDAE

*Cyprinus carpio* (Linnaeus): Carp

Occasionally taken in the haul seine operated from Lester Manor. Not common in the Pamunkey but the carp is fished commercially in both the Chickahominy and James rivers.

*Semotilus corporalis* (Mitchill): Fallfish

Two juveniles were taken from area I and fourteen adults were caught in one-half hour of angling at Bassett Bar. However, the favorite habitat of this form is upstream from the Fall Line. 2.

*Notemigonus crysoleucas crysoleucas* (Mitchill): Eastern Golden Shiner

A sluggish water form which was taken more frequently in coves than from the river channel. Collected at many locations between brackish water and the head of tidewater. 6.

*Notropis amoenus* (Abbott): Attractive Shiner

A single juvenile was taken in area III. Typically found upstream in pools usually near moving water. 1.

*Notropis hudsonius saludanus* (Jordan and Brayton): Southern Spottail Shiner

This gregarious shiner, one of the most common fishes in the shore zone, was taken in all sections of the river. It is probably an important forage fish. 63.

*Notropis analostanus* (Girard): Satinfish Shiner

This shiner was slightly more abundant than the spottail shiner in collections made during 1949, 1950, and 1951. In 1952 the spottail shiner appeared in approximately the same abundance as in previous years, but the satinfish shiner was scarce. It is an excellent bait minnow. 60.

*Hybognathus nuchalis regius* (Girard): Eastern Silvery Minnow

This common minnow, taken from all three river areas was generally more abundant in the river proper than in coves. 20

AMEIURIDAE

*Ictalurus catus* Linnaeus: White Catfish

An important commercial species and common in most of the river. It was seined about as frequently as the channel catfish. Fishermen reported that the white catfish will not enter catfish pots as readily as the channel catfish, and often used underwater fyke nets in areas where the former is more abundant. 12.

*Ictalurus punctatus punctatus* (Rafinesque): Channel Catfish

This introduced species is of about equal importance commercially as the native white catfish. The catfish fishery on the Chickahominy River was described by Menzel (1943). 10.

*Ameiurus natalis erebennus* Jordan: Southern Yellow Bullhead

Adults and young, taken in only three collections, were found in areas I and II. This species is common in the Chickahominy River.

*Ameiurus nebulosus nebulosus* (LeSueur): Northern Brown Bullhead

Collected only once in the Pamunkey at Sweet Hall Landing. It is common in some of the ponds near the tidewater section and was taken frequently in collections from the Rappahannock River. Fishermen reported that it occasionally was taken on the mud flats by set gill nets.

*Schilbeodes mollis* (Hermann): Tadpole Madtom

Adults and young were taken from all three areas and it was more abundant in coves than in the river proper. 6.

*Schilbeodes marginatus marginatus* (Baird): Common Eastern Madtom

One adult was taken in a plankton net at Lester Manor. The species is typically found in riffles at or above the Fall Line where it is fairly common. It is probably to be considered a straggler in the lower river.

ESOCIDAE

*Esox niger* (LeSueur): Chain Pickerel

Adults were taken from a cove at Sweet Hall Landing and a creek mouth at Bassett Bar. This species seems to avoid tidal waters where local fishermen also reported it as rare. It is fairly

common in the tributaries and upstream from the Fall Line.

**Esox americanus** Gmelin: Bulldog Pickerel

Like the chain pickerel this species is seldom seen in the tidal section of the river. Several were collected at the mouth of a tidal creek near Bassett Bar.

ANGUILLIDAE

**Anguilla rostrata** (Le Sueur): American Eel

This eel was collected at almost every locality on the Pamunkey River. Many eelers were taken in plankton nets during the spring. 17.

CYPRINODONTIDAE

**Fundulus heteroclitus macrolepidotus**  
(Walbaum): Mummichog

A more typically marine killifish which was taken most frequently near saltwater, but was found throughout the tidewater section. 7.

**Fundulus diaphanus diaphanus** (Le Sueur):  
Eastern Banded Killifish

Slightly more than one-half of the seine collections contained this killifish. It was common in hauls from stations near brackish water to the head of the tide. 55.

POECILIIDAE

**Gambusia affinis holbrooki** (Girard):  
Eastern Mosquitofish

A typical quiet water Coastal Plain form, which more frequently appeared in hauls made in coves and backwaters. It was taken in each of the three river areas. 18.

BELONIDAE

**Strongylura marina** (Walbaum):  
Atlantic Needlefish

This marine species was collected only in areas II and III, but undoubtedly occasionally occurred in area I. One specimen 23 mm. in length was taken by dip net at Lester Manor in April. This species and other members of the Belonidae are well known for their habit of entering freshwaters and are sometimes found far from the sea. 2.

SERRANIDAE

**Roccus saxatilis** (Walbaum): Striped Bass

Young were taken in seine collections from all

three river areas. Tresselt (1952) found striped bass eggs only in area I. Adults, often taken in the spring by shad fishermen, occur most frequently downriver from Lester Manor. However, anglers have taken striped bass in June ten miles above Bassett Bar. The species appears to be more abundant in both the Mattaponi and Rappahannock rivers than in the Pamunkey. 35.

**Morone americana** (Gmelin): White Perch

A common and widely distributed species collected in more than half of the seine hauls between brackish water and the head of the tide. Although frequently seined it does not appear to be as abundant in the Pamunkey as in the James or Rappahannock rivers. In the past it was taken in set gill nets fished near Lester Manor in January or February but this fishery has been discontinued. Most of the white perch now taken are captured in hoop fyke nets located in area I. 54.

PERCIDAE

**Perca flavescens** (Mitchill): Yellow Perch

Collected mostly in coves and creek mouths from all three river areas. 12.

**Etheostoma nigrum olmstedii** (Storer): Tessellated  
Johnny Darter

Common and widespread, this species was taken in more than one-half the seine collections in all areas of the river. 53.

CENTRARCHIDAE

**Micropterus salmoides salmoides** (Lacépède):  
Northern Largemouth Bass

Taken in collections from all three areas, but appears to prefer creeks and coves to the river proper. 7.

**Lepomis gibbosus** (Linnaeus): Pumpkinseed  
Sunfish

Captured in samples from all areas and was taken about one-half as often as the bluegill. 16.

**Lepomis macrochirus macrochirus** Rafinesque:  
Common Bluegill

A widespread and common species which apparently exceeds the other sunfishes in abundance. 36.

**Lepomis auritus** (Linnaeus): Yellowbelly Sunfish

Found throughout the river. It appears to be

more typically a river fish than are the other centrarchids, for it was more abundant in collections from the main stream than in coves. However, it also is widespread in its upstream distribution and is often common in small tributaries. 22.

**Pomoxis nigromaculatus** (LeSueur):  
Black Crappie

Occurred in scattered collections from all three river areas. 10.

**Enneacanthus gloriosus** (Holbrook):  
Bluespot Sunfish

Taken in collections from brackish waters to the head of the tide. It was more abundant in coves than in the river proper. 11.

**Enneacanthus obesus** (Girard): Banded Sunfish

Taken only once in the mouth of a creek at Sweet Hall Landing.

ATHERINIDAE

**Menidia beryllina** (Cope): Glassy Silverside

Collections from all areas of the river included this species and it appears to be more abundant in the tidal freshwaters than in salt water. Although abundant in collections from the river course, it was seldom taken in coves. 24.

**Menidia menidia** (Linnaeus): Atlantic Silverside

Occurred in areas I and II and is common in Chesapeake Bay. This species occasionally is found in freshwater. 6.

STROMATEIDAE

**Peprilus alepidotus** (Linnaeus): Harvestfish

Several were taken by surface trawl 5 miles upriver from West Point. When collected at high tide the surface salinity was 8.9 parts per thousand but on the succeeding low tide the water at that location became fresh. Harvest fish have been collected from waters of even lower salinity in the Mattaponi River but have not yet been found by us in water that was completely fresh.

SCIAENIDAE

**Cynoscion regalis** (Bloch and Schneider):  
Gray Squeteague

Young were taken by surface trawl in the freshwaters of area I. This species is generally found in salt water, but was recorded from freshwater by Gunter (1942).

**Leiostomus xanthurus** Lacépède: Spot

Young spot 20 to 40 mm. in length were taken in plankton nets while juveniles were collected by seine and surface trawl in area I. Spot was taken in both fresh and brackish waters. In the Rappahannock River it was collected 23 miles above brackish water and young have also been taken in the freshwaters of Mattaponi River. 3.

**Micropogon undulatus** Linnaeus: Atlantic Croaker

Young 20 to 30 mm. in length were collected in plankton nets in area I and small specimens were taken in plankton nets set at Lester Manor (area II) in March, 1949. Both croaker and spot have been recorded previously from freshwater by Gunter (1942). Their occurrence in freshwater at such a small size is unusual, for both species are believed to spawn in the ocean outside of Chesapeake Bay. Young of both species have also been taken in plankton nets in freshwaters of the Mattaponi River.

GOBIIDAE

**Gobiosoma boscii** Lacépède: Naked Goby

Several specimens were collected in one seine haul five miles above West Point. This species is commonly taken near oyster beds which are not found in the Pamunkey River. 1.

HIPPOGLOSSIDAE

**Paralichthys dentatus** (Linnaeus):  
Summer Flounder

A single specimen of this typically salt-water species was seined 5 miles above West Point. It is commonly caught commercially in the York River below West Point. 1.

ACHIRIDAE

**Trinectes maculatus** (Bloch and Schneider):  
Hogchoker

Young were especially common in the tidal freshwaters. It was taken in many samples from the mouth of the Pamunkey River to the head of the tide. 28.

FISHES OF ADJACENT SECTIONS

Scattered collections were made in small streams tributary to the tidewater section and from the Coastal Plain area of the Pamunkey upstream from the limit of Bassett Bar (area III). The tributary streams were typically clear and shallow with sand



bottom and slight gradient, and all flow through wooded areas. Two of the best stations were located in pools just below mill dams. The stations in the Pamunkey River above area III were deep with steep banks which made seining difficult. Fishes taken in the above situations were *Erimyzon oblongus oblongus* (Mitchill), eastern creek chubsucker; *Semotilus atromaculatus atromaculatus* (Mitchill), northern creek chub; *Hybopsis leptocephalus* (Girard), Carolina chub; *Umbra pygmaea*, eastern mudminnow; *Aphredoderus sayanus sayanus* (Gilliams), eastern pirateperch; *Centrarchus macropeterus* (Lacépède), flier; and *Acantharcus pomotis* (Baird), mud sunfish.

In five collections made in Pamunkey River and tributaries above the Fall Line in Louisa and Hanover counties, 12 additional forms not listed in Table 1 were captured. They are as follows: *Catostomus c. commersoni* (Lacépède), *Hypentelium nigricans* (LeSueur), *Hybopsis micropogon* (Cope), *Exoglossum maxillingua* (LeSueur), *Chrosomus oreas* Cope, *Clinostomus vandoisulus* (Valenciennes), *Notropis cornutus cornutus* (Mitchill), *Notropis procne procne* (Cope), *Hadropterus notogrammus* Raney and Hubbs, *Hadropterus peltatus peltatus* (Stauffer), *Etheostoma nigrum* Rafinesque subsp., *Etheostoma vitrea* (Cope). These limited data on Piedmont fish distribution indicate that in this respect the Pamunkey River is much like the James River, as reported by Raney (1950, p. 189).

RELATIVE ABUNDANCE

The abundance of fishes is sometimes measured by their frequency of occurrence in collections made by seine hauls. This method has some limitations especially in large rivers. Recent investigations on the clupeid fishes reported by Massmann, Ladd, and McCutcheon (1952) has indicated that seining is not always a reliable measure of abundance. Other groups, such as the catfishes, are primarily nocturnal, and therefore estimations of abundance based on daytime seine hauls may be erroneous. Fishes such as the hogchoker and eel often burrow in the mud where they are easily missed by minnow seines. The young of several species, such as longnose gar, bowfin and carp rarely

TABLE 2.—Fishes taken in the tidewater section of the Pamunkey River arranged in order by frequency of occurrence in percentage of seine hauls. Some species are included here with full realization that seine collections do not reveal their true relative abundance.

Species	Frequency of occurrence in percent	Species	Frequency of occurrence in percent
<i>Notropis hudsonius saludanus</i> .....	63	<i>Anchoa m. mitchilli</i> .....	16
<i>Notropis analostanus</i> ...	60	<i>Lepomis gibbosus</i> .....	16
<i>Alosa sapidissima</i> .....	57	<i>Ictalurus catus</i> .....	12
<i>Fundulus d. diaphanus</i> ...	55	<i>Perca flavescens</i> .....	12
<i>Morone americana</i> .....	54	<i>Enneacanthus gloriosus</i> ...	11
<i>Etheostoma nigrum olmstedii</i> .....	53	<i>Ictalurus punctatus</i> .....	10
<i>Lepomis m. macrochirus</i> .....	36	<i>Pomoxis nigromaculatus</i> ...	10
<i>Alosa aestivalis</i> .....	35	<i>Fundulus heteroclitus macrolepidotus</i> .....	7
<i>Roccus saratilis</i> .....	35	<i>Micropterus s. salmoides</i> ...	7
<i>Trinectes maculatus</i> .....	28	<i>Menidia menidia</i> .....	6
<i>Menidia beryllina</i> .....	24	<i>Notemigonus c. crysoleucas</i> .....	6
<i>Lepomis auritus</i> .....	22	<i>Schilbodes mollis</i> .....	6
<i>Moxostoma macrolepidotum</i> .....	20	<i>Brevoortia tyrannus</i> .....	5
<i>Hybognathus nuchalis regius</i> .....	20	<i>Lepisosteus o. osseus</i> .....	4
<i>Gambusia affinis holbrooki</i> .....	18	<i>Leiostomus xanthurus</i> ....	3
<i>Anguilla rostrata</i> .....	17	<i>Strongylura marina</i> .....	2
<i>Alosa pseudoharengus</i> ...	17	<i>Semotilus corporalis</i> .....	2
		<i>Alosa mediocris</i> .....	2
		<i>Notropis amoenus</i> .....	1
		<i>Gobiosoma boscii</i> .....	1
		<i>Paralichthys dentatus</i> ....	1

TABLE 3.—Relative abundance of the most common Pamunkey fishes seined in coves and in the river proper. The numbers are the ratios between the percentages of occurrence in seine hauls at the two habitats.

Species	River proper	Coves
<i>Menidia beryllina</i> .....	4.7	1.0
<i>Hybognathus nuchalis regius</i> .....	3.7	1.0
<i>Trinectes maculatus</i> .....	3.3	1.0
<i>Lepomis auritus</i> .....	3.0	1.0
<i>Roccus saratilis</i> .....	2.0	1.0
<i>Moxostoma macrolepidotum</i> .....	1.6	1.0
<i>Anchoa m. mitchilli</i> .....	1.5	1.0
<i>Notropis hudsonius saludanus</i> .....	1.4	1.0
<i>Fundulus heteroclitus macrolepidotus</i> ...	1.3	1.0
<i>Etheostoma nigrum olmstedii</i> .....	1.1	1.0
<i>Alosa aestivalis</i> .....	1.0	1.1
<i>Notropis analostanus</i> .....	1.0	1.1
<i>Ictalurus catus</i> .....	1.0	1.1
<i>Morone americana</i> .....	1.0	1.1
<i>Pomoxis nigromaculatus</i> .....	1.0	1.1
<i>Anguilla rostrata</i> .....	1.0	1.2
<i>Alosa sapidissima</i> .....	1.0	1.4
<i>Fundulus d. diaphanus</i> .....	1.0	1.4
<i>Gambusia affinis holbrooki</i> .....	1.0	1.6
<i>Micropterus s. salmoides</i> .....	1.0	1.7
<i>Enneacanthus gloriosus</i> .....	1.0	2.5
<i>Perca flavescens</i> .....	1.0	2.9
<i>Lepomis gibbosus</i> .....	1.0	3.7
<i>Lepomis m. macrochirus</i> .....	1.0	4.0
<i>Schilbodes mollis</i> .....	1.0	5.0
<i>Alosa pseudoharengus</i> .....	1.0	5.5
<i>Notemigonus c. crysoleucas</i> .....	1.0	13.0

are taken in minnow seines, in Virginia rivers, even though adults may be numerous. Densely schooling fishes such as the glut herring and menhaden may be far more abundant than their percentage of occurrence in seine hauls would indicate merely because these schools may be met infrequently while fishes of more uniform distribution would ordinarily be taken more often. Anadromous species, which make up a considerable part of the fish fauna in tidal rivers, may be present for only part of the year in any given ontogenetic stage, and sampling therefore is representative only of the season when collecting occurred.

The percentage of seine collections in which the various species occurred is given in Table 2. The spottail shiner was taken most frequently followed by satinfin shiner, American shad, banded killifish, white perch, and johnny darter, all of which appeared in more than one-half of the seine hauls. Next in order of frequency of capture are the bluegill sunfish, glut herring, striped bass, hogchoker, glassy silverside and yellowbelly sunfish. The remaining fishes occurred in 20 per cent or fewer seine hauls.

#### DISTRIBUTION

The habitat in which sampling is done is of considerable importance in determining the species that are taken. Even in a tidal river, where the various habitats tend to be unified by the influence of a mass of water of rather uniform physical and chemical characteristics (excluding the brackish waters), there are some differences in the environmental preferences of fishes.

A distinct contrast is evident between coves, where the water is not affected by tidal currents, and the river proper where the effect of such currents is pronounced. The occurrence of fishes at cove and river stations is summarized in Table 3. Glassy silverside, silvery minnow, hogchoker, yellowbelly sunfish, and striped bass were

collected more frequently in the river while golden shiner, alewife, tadpole madtom, bluegill sunfish, pumpkinseed sunfish, yellow perch and bluespot sunfish occurred more often in coves. The other species were intermediate. With the exception of the alewife, those fishes favoring the cove habitat are generally found in sluggish water or ponds throughout their range, while those common to the river may or may not be found in still water in other parts of their range.

It seems evident that the species of fishes obtained by sampling rivers was determined in part by the type of habitat sampled. Therefore, care must be exercised in selecting various locations that are adequately representative of all conditions. This is a difficult problem in rivers where sampling locations, especially by seine, are limited by water depth and bottom type.

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