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The distribution and ecology of the Gammaridea (Crustacea : Amphipoda) of the lower Chesapeake estuaries

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ABSTRACT

Gammarid amphipods of three tidal rivers entering Chesapeake Bay were studied for ten months, particularly in the York River where 40 species were recorded during the period. Several species moved up or down the rivers with changing salinity. The more abundant species had longer breeding seasons.

The number of described species from lower Chesapeake Bay is now 42 and the presence of 10 undescribed species and of several which bracket the region indicates that much remains to be learned about amphipods in the Bay. Nineteen of these have a boreal affinity and seven are limited to the Virginian subprovince.

A reference to the most recent significant work on each species is given and a key is included as an appendix.

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INTRODUCTION

This study on amphipods of the Suborder Gammaridea attempted to relate their ecology and distribution to certain environmental conditions in the lower Chesapeake Bay area. It was largely confined to the James, York and Rappahannock rivers, which contribute about 22% of the freshwater inflow to Chesapeake Bay. Particular attention was focused on the York River and its tributary, the Pamunkey River.

Estuaries have long been recognized as important areas for ecological study since they represent transition zones between the freshwater environment of the river and the marine environment of the sea. Now generally defined as extensions of the sea in which the mixing and dilution of seawater by riverwater are controlled by the flood and ebb of tides, estuaries are regions of sharp and variable gradients.

Chesapeake Bay is the largest estuarine system in North America and supports both cool and warm temperate fauna. However, other than faunal checklists of Cowles (1930) and Wass (1965) and some brief remarks on the ecology of local amphipods in otherwise non-ecological papers, no distributional or ecological study has been made on the amphipods of this region.

Ecological studies of estuarine amphipods in England have been done by Crawford (1937a, 1937b), Goodhart (1941), Reid (1941), Bassindale (1942) and Spooner (1949). In Europe, Hartog (1963a, 1963b, 1964) has started an ecological investigation of the amphipods of the deltaic region of the Rhine, Meuse and Scheldt rivers.

In North America, Holmes (1905) and Kunkel (1918) gave species habitats, where known, but their papers were primarily taxonomic. Bousfield (1958a) related the distribution of Canadian terrestrial talitrids to several environmental factors. Cronin, Daiber and Hulbert (1962), in a quantitative seasonal study of zooplankton of the Delaware River, found a single species of amphipod. Sanders, Mangelsdorf and Hampson (1965) included two species of amphipods in their study of the bottom fauna in relation to salinity in the Pocasset River, Massachusetts, a fluctuating estuary. They observed that marine infauna are able to penetrate farther up the estuary than do the epifauna because of the higher and less fluctuating salinities of the bottom sediment as opposed to the more varied and generally lower salinities of the overlying water column.

A few investigators have studied the ecology of a single species or genus, and others have included ecological notes while listing the species of an estuary. Mills (1963, 1964a, 1967a, 1967b) has described the ecology of several species of *Ampelisca* found in eastern North America in conjunction with examining their taxonomy. Bousfield (1969) described as new two species of *Gammarus* and briefly discussed the ecology of other members of the genus found in Chesapeake Bay. Croker (1967) and Dexter (1967) studied niche diversity in haustoriids. Amphipods rank among the principal members of estuarine macrofauna in numbers of species and individuals and in their importance as fish food. However, their small size, frequent congeneric similarity and general difficulty of identification have inhibited studies essential to understanding the ecology of estuaries. The recent systematic work of Barnard (1969) should encourage further work on this diverse and abundant order.

This study was greatly enhanced by the interest and services of Dr. E. L. Bousfield of the National Museum of Canada, who identified many species and suggested the organization by habitat types. Appreciation is extended also to Mrs. Jane Davis for providing the final figures and to Mr. Victor Burrell and the crews of the VIMS vessels R/V *Langley* and R/V *Pathfinder* for their assistance in collecting. Mrs. Beverly Ripley carefully edited and typed the manuscript, a most exacting task.

DESCRIPTION OF THE RIVERS

The James, York and Rappahannock rivers have been adequately described by several authors and only brief descriptions follow. The data for the geomorphological descriptions were obtained from several sources but primarily from the Virginia State Planning Board (1935) and Pritchard (1952).

The James, the southernmost and largest of the three rivers, has the greatest drainage basin, 25,600 km^2. Rising in the Alleghany Mountains in the extreme western part of Virginia, it flows for 544 km in a generally southeasterly direction to its mouth at Hampton Roads, 24 km from the Virginia Capes. Using Pritchard's (1967a) definition of an estuary as that portion of the river in which the intruding seawater is measurably diluted by the freshwater runoff, the extreme upper limit of the estuarine region of the James is approximately at Jamestown Island, 51 km from its mouth. The James accounts for about 16% of the freshwater inflow in the Bay.

The York and Pamunkey rivers, with a combined drainage basin of 4,480 km^2, are located between the Rappahannock on the north and the James on the south. The Pamunkey River has its headwaters in the Blue Ridge mountains of Western Virginia and flows through the Piedmont Plateau and Coastal Plains provinces before joining with the Mattaponi at West Point to form the York River. The latter is 46 km long and is characterized by its straightness, deep channel and average width of about 3 km. Flowing in a southeasterly direction, it enters Chesapeake Bay 24 km above Hampton Roads. The estuarine portion of these rivers extends approximately 64 km upriver. Two per cent of the freshwater inflow into Chesapeake Bay comes from the York River.

The Rappahannock is the northernmost of the three rivers and, like the York, has its headwaters in the Blue Ridge mountains and flows southeasterly. It drains 6,963 km^2, has a length of 224 km, and enters Chesapeake Bay 91 km above Hampton Roads. Its estuarine portion, 113 km, approximately equals in length those of the other two rivers. A rather high sill, maximum depth 40 feet, inhibits exchange of saline water and thus oxygenation in the channel. Its freshwater flow is only 4% of that entering Chesapeake Bay.

The estuarine portions of all three rivers are located in the Coastal Plains Province of Virginia. These estuaries, characteristic of the Atlantic and Gulf coasts, are formed from drowned river valleys (Pritchard, 1967a). They approximate closely what Pritchard (1967b) described as moderately stratified estuaries, which have a horizontally stratified water column. As a result of Coriolis' force, water on the right side of the estuary, looking upriver, is generally more saline than on the left side.

The bottoms of the estuarine portions of these rivers are similar. The deeper portions are mostly composed of silty-clay or sandy-silt overlain by an abundant growth of hydroids and ectoprocts, notably *Aeverrillia armata*, *Amathia vidovici*, *Calyptospadix cerulea*, *Sertularia argentea*, and *Victorella pavida*. The nearshore sediments are sandy and characterized by *Zostera marina* beds plus an assortment of algae. The Pamunkey differs sharply from the York in that its bottom has very little epifauna and flora; rather it is almost entirely mud with much vegetative debris from the adjoining marshes. Scattered throughout these estuaries, particularly in the James, are natural oyster bars or "rocks" that provide a hard substrate for epifaunal organisms. Tributary tidal creeks and smaller rivers usually have soft bottoms.

MATERIALS AND METHODS

Amphipods were collected by a variety of methods. Most frequently a fine-mesh, weighted net was drawn over the bottom. In soft bottom it usually sank enough to collect infauna at all depths sampled. Whenever possible, samples of larger epifauna and flora were also collected and examined. In deep water, attached biota was taken with a semi-balloon otter trawl. Occasionally, amphipods were collected by sifting, through a 1.0 mm sieve, sediments obtained with a Petersen grab or dug near shore. No attempt was made to take quantitative samples because a feasible method for epifauna was lacking. Quantitative comments, such as abundant, common, and scarce, are thus subjective.

Determinations of salinity by an RS-7A salinometer, water temperature by a stem thermometer, and, frequently, dissolved oxygen content by the modified Winkler method were made for most collection sites. In deep water this was done for both surface and bottom.

Samples were immediately preserved in 5% formalin buffered with seawater. In the laboratory, the amphipods were identified, counted and, when possible, sexed. Notes were made of the type of bottom, and the epifauna or flora were identified and weighed wet after blotting on paper. Specimens from Dr. Wass' collections and from meter-net, surface and bottom plankton samples collected by the Ichthyology and Crustaceology departments of VIMS were also examined.

The extent of collecting is shown in Figure 1. Samples were taken once a month from September 1966 to June 1967 in the York-Pamunkey river system at the following statute mile stations in the channel: Y10, Y15, Y20, Y25, P30, P35, P40, P50. The number following the letter represents the number of miles from the mouth of the York River to the station. This form of notation was also used on the James and Rappahannock rivers. The uppermost station (P50) is at an almost permanently freshwater point of the Pamunkey River. At each of these stations, samples were taken with the small net and a semi-balloon otter trawl.

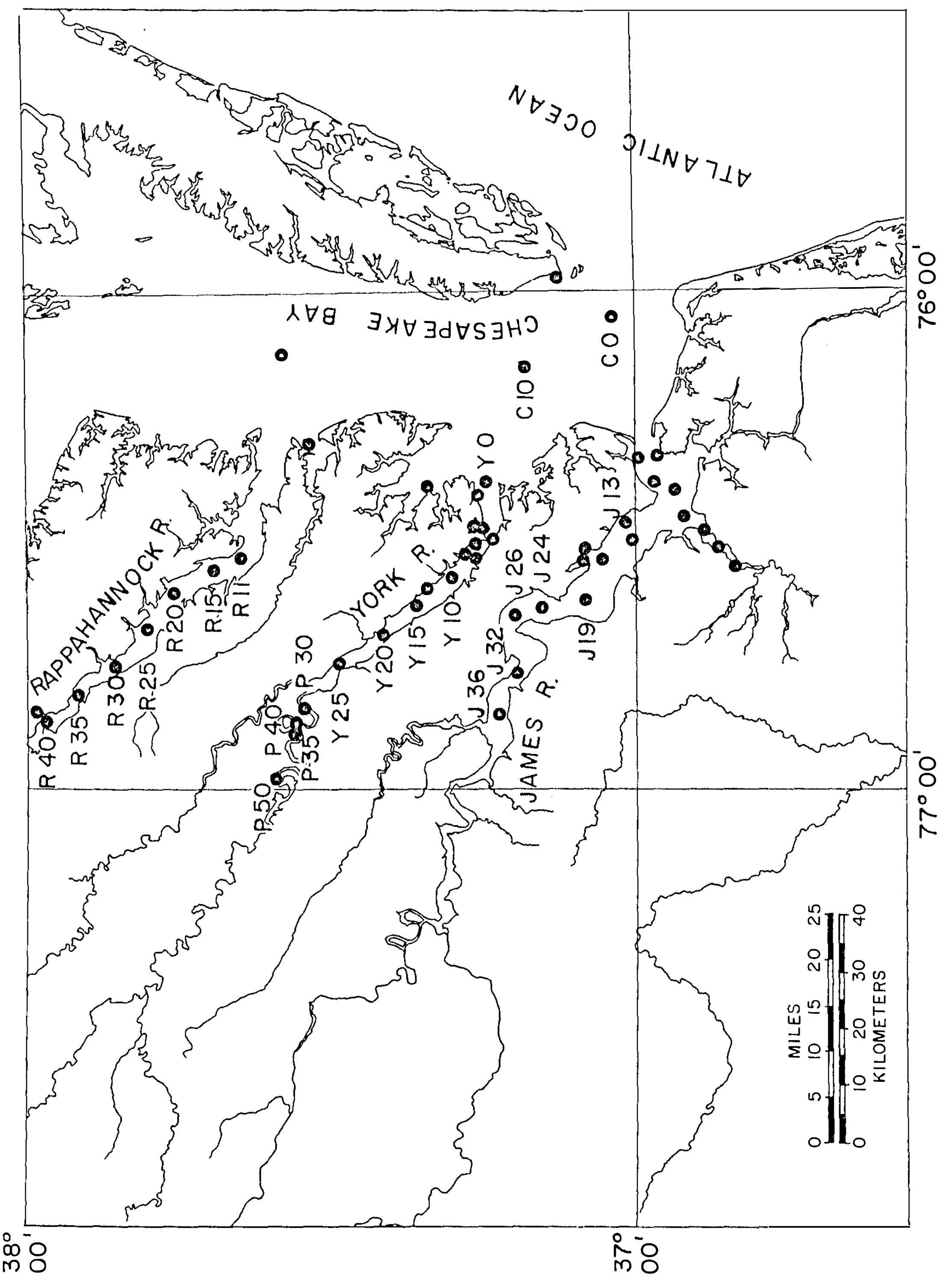

Figure 1. Locations sampled at least once during the study.

RESULTS

The following section contains those species belonging to the Suborder Gammaridea found to date in the lower Chesapeake Bay region. Although some were not collected during the course of the study, representatives of all species were examined and, when necessary, sent to Dr. E. L. Bousfield of the National Museum of Canada for determination.

The species appear by genera according to substrate type. The best recent reference for identifying each species is given, along with its distribution and a brief ecological account. A key to species is presented in the Appendix.

EPIFAUNAL GENERA

The genera placed here occupy primarily a habitat on algae and sessile animals rather than on or in the bottom proper. The group can be further distinguished between those which construct tubes and those which do not.

Tube Builders

Family AMPITHOIDAE

Ampithoe longimana Smith, 1873

Ampithoe longimana, Mills, 1964b, p. 12-15, figs. 2-3; Barnard, 1965, p. 15, fig. 8.

DISTRIBUTION--The range of this species includes the southwestern Gulf of St. Lawrence (Bousfield, personal communication), the east coast of the United States, Bermuda, and parts of southern and lower California (Barnard, 1959).

A. longimana was taken in the lower portions of the James, York and Piankatank rivers and from Cape Charles at the mouth of Chesapeake Bay.

ECOLOGY--The ecology of *A. longimana* has been studied by Holmes (1901) and our findings generally agree with his. It is a shallow-water species living among *Zostera*, *Ceramium*, and *Ulva*. Holmes reported its constructing tubular nests on algae from a secretion and bits of seaweed, to which it retired when not feeding.

A. longimana has the same distribution as does the ampithoid *Cymadusa compta*. Marsh (1970) found it the most abundant amphipod in eelgrass, outnumbering *C. compta* 2 to 1. Nagle (1968) found that *A. longimana* feeds upon diatoms, while *C. compta* is a preferential detritus feeder.

Ampithoe valida Smith, 1873

Ampithoe valida, Mills, 1964b, p. 17-20, fig. 4; Barnard, 1965, p. 34-35, figs. 22-23.

DISTRIBUTION--This species has previously been reported on this coast only from New Jersey and Long Island Sound (Mills, 1964b). It appears to have its optimum habitat in shallow oligohaline waters. At Leonardtown, Calvert County, Maryland, S. L. H. Fuller collected 11 males and 12 females (11 ovigerous) in June 1969. These, plus a male and female taken in the Warwick River, Virginia, were identified by James K. Lowry.

ECOLOGY--The Warwick River specimens were on fouling plates.

Cymadusa compta (Smith, 1873)

Cymadusa compta, Mills, 1964b, p. 21-25, figs. 5-6; Shoemaker, 1935, p. 245-249, figs. 4-5 (as *Grubia filosa*).

DISTRIBUTION--Mills (1964b) redescribed *C. compta* and gave its range as from New England to North Carolina and possibly as far south as Key West, Florida.

C. compta is found primarily in the lower regions of the three tributaries, although it was taken in the York-Pamunkey system at P40 in September, when freshwater runoff is at a minimum and saltwater intrusion greatest.

ECOLOGY--*C. compta* is one of the most abundant shallow-water amphipods in this area but, as previously mentioned, it is occasionally replaced by *A. longimana*. Like the latter, it is polyhaline and forms tubes on *Zostera* and algae.

Family COROPHIIDAE

Cerapus tubularis Say, 1817

Cerapus tubularis, Kunkel, 1918, p. 160-161, fig. 48.

DISTRIBUTION--This species, described from Egg Harbor, New Jersey, is known on the east coast of the United States only from Vineyard Sound, Massachusetts (Kunkel, 1918), to Chesapeake Bay (Cowles, 1930; Wass, 1965).

Cowles' specimens were from near Cape Charles and Wass (1965) found *C. tubularis* occasionally abundant at Gloucester Point in silt-clay. An 0.5 mm sieve is needed to adequately sample this soft bottom species. It has been found from the mouth of Chesapeake Bay to J13 in the James River and to Y15 in the York River.

ECOLOGY--This species is remarkable in that, unlike most other tube-dwelling amphipods, it carries its thin cylindrical tube about as it moves over the bottom. It is a polyhaline species (Fig. 2) common near the river mouths but scarce in the Bay. Kunkel (1918) states that this species occurs "in eel-grass to depths of 10 fms (sic)." However, we found C. tubularis only at depths greater than 8 m, well below the maximum depth of Zostera. It was most often associated with the ectoprocts Aeverrillia armata and Victorella pavida and the hydroid Sertularia argentea. Marsh (1970) found none in an exhaustive study of eelgrass epifauna.

Corophium acherusicum Costa, 1857

Corophium acherusicum, Shoemaker, 1947, p. 53, figs. 2-3.

DISTRIBUTION--This is a cosmopolitan species (Shoemaker, 1947). Bousfield (personal communication) has found it northward to estuaries in the Gulf of Maine.

C. acherusicum was found only twice in this area. Two ovigerous females were taken by an oyster dredge at Middle Ground (ca. J5) in the James River and seven specimens, including some ovigerous females, were taken from pilings of the Chesapeake Bay Bridge-Tunnel (CO). Additional specimens were examined from pilings at Wachapreague Inlet on the ocean side of Virginia's Eastern Shore. More recently, Marsh (1970) found 306 specimens on Zostera, and D. F. Boesch (personal communication) has found it common in Hampton Roads.

ECOLOGY--The apparent preference of C. acherusicum for a firm substrate, such as shell or cement pilings, has been reported elsewhere. It constructs nests of mud tubes among the attached algae and hydroids. The occurrence of this species on ships' bottoms, as at Sheerness, England (Crawford, 1937a), and Hong Kong (Shoemaker, 1947), may account for its wide distribution. Although polyhaline, it is more likely to be found in the quieter bays and rivers than in the open ocean (Crawford, 1937a).

Corophium lacustre Vanhoffen, 1911

Corophium lacustre, Bousfield, 1962, p. 43, 52, 58.

DISTRIBUTION--C. lacustre is a brackish-water species common in the estuaries of western Europe and of the United States east coast from the Hudson River to Florida (Shoemaker, 1947). Bousfield (1962) gives its range in North America to include the St. John estuary in New Brunswick.

This species is abundant at all depths in the upper estuarine portions of the James, York-Pamunkey and Rappahannock rivers. Occasional specimens taken in the lower portions of the rivers were probably flushed down.

ECOLOGY--Crawford (1937a) stated that "*C. lacustre* builds muddy tubes upon submerged plants or animals, especially *Cordylophora lacustris*." In the York-Pamunkey system, it was most abundant from P30 to P40 where herbaceous debris and mud are deposited in many places, with coarse sand in a few areas of scour. A single specimen was taken at P50, where the bottom was covered with tree leaves and chunks of wood. However, several specimens occurred at P60, which has a mud and gravel bottom. Others occurred in sand and gravel at Cat Point Creek above Tappahannock, Virginia.

C. lacustre is oligohaline, being found from freshwater up to about 22 o/oo (Fig. 2) in the York-Pamunkey system but most often at salinities below 10 o/oo. At P60, the limit of occurrence of this amphipod in the Pamunkey River, the water is tidal but always fresh.

Corophium simile Shoemaker, 1934

Corophium simile, Shoemaker, 1947, p. 63, fig. 12.

DISTRIBUTION--*C. simile* has been found at only a few points between Vineyard Sound, Massachusetts, and Apalachicola Bay, Florida. The type is a male taken by the *Fish Hawk* in May River, South Carolina. Specimens were first taken in Chesapeake Bay by R. V. Truitt in Tangier Sound. Others were found on the Bay beach near Norfolk (Shoemaker, 1934). Marsh (1970) collected 123 specimens near the Mumfort Islands in the York River.

ECOLOGY--The specimens from the Norfolk area were taken from sponges washed up on the beach. Marsh found his on eelgrass throughout the year.

Corophium tuberculatum Shoemaker, 1934

Corophium tuberculatum, Shoemaker, 1947, p. 53, fig. 5.

DISTRIBUTION--*C. tuberculatum* occurs on the east coast of North America, in the mouths of rivers and harbors from Nantucket, Massachusetts, to South Carolina (Shoemaker, 1947). Most recently, Bousfield and Leim (1960) reported it from Minas Basin, Canada.

Local sampling supports Shoemaker (1947) in that *C. tuberculatum* was found only at the mouths of the James, York and Piankatank rivers and in Chesapeake Bay. We have also found it in soft sediment offshore of Virginia with a density of 225 per m^2.

ECOLOGY--Not as scarce in this area as *C. acherusicum*, *C. tuberculatum* is present throughout the year in small numbers. According to Crawford (1937a), it is often found in material washed from oysters. Locally, it generally was associated with mud bottoms covered by an abundant growth of epifauna and flora, at the bases of which it occupied mud tubes.

C. tuberculatum is polyhaline, the lowest salinity in which it was found being 15.6 o/oo (Fig. 2). It occurred at all depths. Marsh (1970) found only one specimen on eelgrass.

Ericthonius brasiliensis (Dana, 1853)

Ericthonius brasiliensis, Barnard, 1955, p. 37-38.

DISTRIBUTION--E. brasiliensis is another cosmopolitan member of the Family Corophiidae (Shoemaker, 1935), being known from many warm temperate and tropical places in both hemispheres.

This species is common in Chesapeake Bay and the mouths of its tributaries.

ECOLOGY--E. brasiliensis occupies tubes affixed to hydroids and ectoprocts. However, unlike other corophiids, its tubes are located on the stems and branches rather than at the bases. Also, its tubes differ in their construction, being only a little longer than the animal and composed of less mud and more secretory material. In Newport Bay, California, Barnard (1961) noted these amphipods inhabiting the sandy tubes of phragmatopomid polychaetes in the open sea off southern California, but this habit was not observed here.

During the winter months, E. brasiliensis is found exclusively on the hydroid Sertularia argentea. When S. argentea dies during the summer, E. brasiliensis builds new tubes on the ectoprocts Aeverrillia armata, Amathia vidovici, and Victorella pavida. It does not normally occur on eelgrass (Marsh, 1970).

While this polyhaline amphipod has been taken in salinities as low as 15.6 o/oo, it is most frequently found above 19 o/oo (Fig. 2). It also prefers deep water. Barnard (1961) reported it from oceanic depths up to 200 m.

Family ISCHYROCERIDAE

Jassa falcata (Montagu, 1808)

Jassa falcata, Sexton and Reid, 1951, p. 29-91, figs. 1-27.

DISTRIBUTION--Sexton and Reid (1951) in their imposing monograph on this species state that it is the most widely distributed of all the Amphipoda, being nearly cosmopolitan. However, it is essentially a temperate zone species, reaching its northern limit in the boreal region (Bousfield and Leim, 1960).

J. falcata apparently is much more common on the ocean side of the Eastern Shore of Virginia and at the mouth of Chesapeake Bay. It has been found only twice in the York River at its mouth and once in the James River in Hampton Roads near Newport News. In contrast, it is extremely abundant in samples collected off pilings of the Chesapeake Bay Bridge-Tunnel and off a buoy at Wachapreague Inlet.

ECOLOGY--Locally, this is a polyhaline amphipod found most often on pilings or buoys. This preference for firm substrates has probably aided its dispersal throughout the world since it often occurs on the hulls of ships anchored in harbors (Sexton and Reid, 1951). J. falcata constructs a mud and silt tube open at both ends. It is also found in shallow water, living at the base of sponges or among masses of hydroids and ectoprocts. It is a suspension feeder, preying upon small crustaceans and ostracods (Nagle, 1968).

Non-tube Builders

Family BATEIDAE

Batea catharinensis Muller, 1865

Batea catharinensis, Shoemaker, 1926, p. 2-9, figs. 1-4.

DISTRIBUTION--Muller described this species from Brazil. In addition, Shoemaker (1926) examined specimens from Woods Hole, Massachusetts, southward to the West Indies.

B. catharinensis is abundant in this area, ranging from offshore into the Chesapeake Bay and well up its tributaries.

ECOLOGY--While found quite far up the rivers, especially during the summer, B. catharinensis is most abundant in higher salinities towards the mouths of the rivers and Chesapeake Bay. It ranges from oceanic salinity to as low as 13.6 o/oo in the York River (Fig. 2). It has been found from intertidal areas, among Zostera, to as deep as 100 m offshore. An epifaunal amphipod, it occurs most often in clumps of hydroids, ectoprocts and sponges.

Family COLOMASTIGIDAE

Colomastix sp.

We have identified this tiny (<2 mm) amphipod as a Colomastix, with which Bousfield (personal communication) agrees. It definitely is not C. pusilla Grube.

DISTRIBUTION--This undescribed species has been found at Gloucester Point in the York River and at Hampton Roads in the James River.

ECOLOGY--The ecology of this species is unique in that it has only been found in association with the sponges Halichondria bowerbanki and Haliclona permollis. It is obviously a commensal since all attempts to find it elsewhere failed. Although it is frequently overlooked because of its small size, it appears to be fairly abundant in this area, as indicated by the 110 specimens found by Marsh (1970) on Zostera.

Family GAMMARIDAE

Elasmopus levis Smith, 1873

Elasmopus levis, Kunkel, 1918, p. 103-105, fig. 24; Miner, 1950, p. 472.

DISTRIBUTION--Kunkel (1918) gives the range of E. levis as Massachusetts to New Jersey.

Locally the most abundant member of the Gammaridae in higher salinities, E. levis is frequently taken in the lower portions of the James and York rivers. Specimens were also collected from the mouth of the Piankatank River, from Mobjack Bay, and from Cape Charles at the mouth of Chesapeake Bay. In the York-Pamunkey system it ranges during the summer all the way to P30, otherwise being more or less confined to below Y20. In the James River, it is most abundant in the lower portion but has been found up to J36.

ECOLOGY--E. levis is plentiful among hydroids and ectoprocts in deeper waters but is perhaps most abundant on Zostera, as evidenced by the total of 7,611 found by Marsh (1970).

Gammarus daiberi Bousfield, 1969

Gammarus daiberi, Bousfield, 1969, p. 3-8.

DISTRIBUTION--Amphipods identified as G. fasciatus from the Delaware River by Cronin et al. (1962) and as G. annulatus from the York River by Wass (1965) were found upon examination by Bousfield (1969) to be a new species near G. tigrinus and G. fasciatus. In addition, specimens from South Carolina, although slightly different morphologically, have tentatively been placed by Bousfield in this species.

G. daiberi is the most abundant amphipod in the oligohaline and mesohaline portions of the three rivers investigated.

ECOLOGY--Ecologically, it seems to occupy a niche between the strictly freshwater G. fasciatus and the mesohaline G. tigrinus. Although G. tigrinus has been recorded from the northern Chesapeake Bay (Bousfield, 1969), it has not yet been found in the lower part of the Bay. On a few occasions both G. fasciatus and G. daiberi were found in the same sample; however, G. daiberi definitely is not a freshwater amphipod. Its salinity range in the York-Pamunkey system is from freshwater up to 18 o/oo, but it is more abundant at the lower end of this range. Cronin et al. (1962) found the highest concentrations in the Delaware River between 1 o/oo and 5 o/oo, with strays taken in salinities as high as 26.8 o/oo.

This amphipod is predominantly found among hydroids and ectoprocts in river channels. During the winter it is exceedingly abundant among dormant stolons of the hydroid Calyptospadix cerulea.

Gammarus fasciatus Say, 1818

Gammarus fasciatus, Bousfield, 1958b, p. 69-72, fig. 4.

DISTRIBUTION--This species is the most widespread and abundant freshwater gammarid in eastern North America (Bousfield, 1958b). Although reported from brackish water by several authors, these records must now be suspect as a result of the recent discovery of G. tigrinus and G. daiberi by Bousfield in these areas. Its freshwater range includes the North American continent east of the Mississippi River from New England southward at least to Virginia (Bousfield, 1969).

G. fasciatus is abundant in the upper, permanently freshwater regions of the Pamunkey River and is mentioned here only because strays were taken at P50 and P40. It is probably found in the tidal freshwater regions of all the rivers but these were not investigated.

ECOLOGY--Clemens (1950) has presented a thorough ecological description in his monograph on G. fasciatus which the few local findings confirm. Essentially, it is found upon sessile epifauna and algae or among pebbles in gravel bottoms.

Gammarus mucronatus Say, 1818

Gammarus mucronatus, Bousfield, 1969, p. 4.

DISTRIBUTION--Restricted to the east coast of North America, G. mucronatus ranges all the way from the southwestern Gulf of St. Lawrence to Florida and the Gulf of Mexico (Shoemaker, 1930; Bousfield, personal communication).

This species is found in shallow water in all the principal tributaries and from Cape Charles.

ECOLOGY--G. mucronatus lives in Zostera beds, algae and debris, especially in shallow water. Marsh (1970) found it the fourth most abundant amphipod in eelgrass. It has a salinity range in the York River from 22 o/oo to 13.6 o/oo (Fig. 2), although Bousfield (personal communication) states he has found it in lower salinity waters, especially in salt marshes.

Several specimens of a very small Gammarus were found with G. mucronatus in samples taken from the York and James rivers. These were morphologically similar to G. mucronatus but lacked any dorsal mucronations. The fact that they were sexually mature rules out their being juveniles of G. mucronatus. Bousfield (1969) has listed these as "Gammarus sp. I" until further information is available.

Gammarus palustris Bousfield, 1969

Gammarus palustris, Bousfield, 1969, p. 9-14.

DISTRIBUTION--Bousfield lists G. palustris from northern Florida to New Hampshire, including many places in the Maryland portion of Chesapeake Bay and from Mobjack Bay, where it was taken between tides by the Fish Hawk expedition.

ECOLOGY--Bousfield states that it is most often found intertidally, particularly in salt marsh areas. D. F. Boesch of VIMS collected specimens from seaweed debris at West Point, Virginia. We have never taken it in grab or net samples.

Melita appendiculata (Say, 1818)

Melita appendiculata, Barnard, 1955, p. 13-14.

DISTRIBUTION--Barnard (1955) reports this species as cosmopolitan in tropical and subtropical seas, although absent from the eastern Atlantic.

M. appendiculata apparently reaches its northern limit on the east coast of North America in Chesapeake Bay. It is found in the lower portions of the three principal tributaries although, as with several other amphipods, it may occasionally be found at P30 in the Pamunkey River during the summer. Specimens were also taken from Mobjack Bay and from Cape Charles at the mouth of Chesapeake Bay.

ECOLOGY--M. appendiculata is a polyhaline amphipod. The minimum salinity at which it has been taken in the York River is 13.6 o/oo (Fig. 2). It is found at all depths on hydroids, ectoprocts and sponges. Marsh (1970) found it the sixth most common amphipod on eelgrass although rare in shallow-water beds.

Melita nitida Smith, 1873

Melita nitida, Mills, 1964b, p. 5-7.

DISTRIBUTION--Mills (1964b) lists M. nitida only from the Western Hemisphere, both on the Pacific coast from South America to Mexico and on the Atlantic coast from Nova Scotia to Louisiana.

M. nitida was thought to be scarce in this area until it was recently found in abundance at Terrapin Point Marsh near Y25.

ECOLOGY--This species is found living at the bases of clumps of hydroids and ectoprocts in close association with muddy bottoms in deeper water. Its salinity range for the York River is 3.0 to 21.3 o/oo (Fig. 2). Samples have been collected from mud on the bay side of Cedar Island, Virginia, where the salinity was 30 o/oo. Although M. nitida and M. appendiculata occurred in the same sample occasionally, one was always much more abundant than the other. Marsh (1970) found 383 specimens of M. appendiculata but only one of M. nitida. It may prove to be most common in salt marsh creeks.

Family PLEUSTIDAE

Parapleustes sp.

DISTRIBUTION--Bousfield (personal communication) has identified this species from material collected in the Patuxent River, Maryland, a tributary of the northern part of Chesapeake Bay, and locally from the York River at Y20.

ECOLOGY--The few York River specimens were collected from hydroids and ectoprocts taken in the channel at a salinity of approximately 20 o/oo.

Sympleustes glaber (Boeck, 1861)

Sympleustes glaber, Shoemaker, 1930, p. 309-310.

DISTRIBUTION--S. glaber formerly had been recorded only in the subarctic and boreal zoogeographical provinces (Shoemaker, 1930). Its presence in the Chesapeake Bay is thus a new southern record.

It has been found in the York-Pamunkey system from Y0 to P40 during the summer, although it is most abundant year round from Y0 to Y20. In the James River, S. glaber ranges from Hampton Roads, where it is most abundant, to J19. It has been found only between R25 and R30 in the Rappahannock River. Unaccountably, it was never taken in samples from Chesapeake Bay itself. It also occurs at Wachapreague Inlet on the Eastern Shore of Virginia but is unknown from offshore Virginia.

ECOLOGY--S. glaber was found only at depths greater than 6 m where it lives among clumps of hydroids or ectoprocts. It is quite euryhaline, ranging from near oceanic salinity down to 6 o/oo at P40 (Fig. 2).

Family STENOTHOIDAE

Parametopella cypris (Holmes, 1903)

Stenothoe cypris, Kunkel, 1918, p. 79-81, fig. 14.

DISTRIBUTION--Previous to Cowles' (1930) and Wass' (1965) reports of its presence in this area, the only other records of this species were from Woods Hole and Long Island Sound (Holmes, 1905; Kunkel, 1918).

A rare species locally, P. cypris was found only at the mouth of the James River and from Y10 to Y15 in the York River. In addition, Cowles (1930) recorded it from off New Point Comfort and at the mouth of the Potomac River.

ECOLOGY--P. cypris was found in deep water in samples containing hydroids, ectoprocts, and sponges. In the York River, it has been found only from a narrow salinity range (Fig. 2). Since this range is at the high end for the York River, the species may be polyhaline.

Stenothoe minuta Holmes, 1903

Stenothoe minuta, Kunkel, 1918, p. 81-82, fig. 15.

Barnard (1962) states that his listing (1958) of S. minuta as having been transferred to Parametopella was a technical error and it rightly belongs to Stenothoe.

DISTRIBUTION--S. minuta is found at Woods Hole and Long Island Sound (Kunkel, 1918) to Beaufort, North Carolina (Schmitz, 1959). Due to its small size, its relative abundance is easily overlooked. In the James River it has been found in the lower portions, with one specimen taken at J36. In the York-Pamunkey system it occurred from Gloucester Point to P30. However, it was most often collected from Y15 to Y20. Specimens were also identified from Wachapreague on the Eastern Shore of Virginia and from offshore.

ECOLOGY--This species exhibits sharp seasonal fluctuations. The highest number was taken in December at Y15, and it is generally more abundant in the fall and winter than during the rest of the year. It lives in deep water among hydroids and ectoprocts at oceanic salinity to about 10 o/oo in the York River (Fig. 2).

Stenothoe gallensis (Walker, 1904)

Stenothoe gallensis, Reid, 1951, p. 228-229, fig. 27.

DISTRIBUTION--This species, described from Ceylon and subsequently taken on the west coast of Africa, is seemingly nowhere common. Specimens taken by S. H. Hopkins on Virginia's Eastern Shore were identified by T. E. Bowman. Recently, two were found on eelgrass (Marsh, 1970). Because of its rarity, one might assume it to be a commensal.

Family TALITRIDAE

Orchestia grillus Bosc, 1802

Orchestia grillus, Bousfield, 1958a, p. 885, figs. 1d, 10c.

DISTRIBUTION--O. grillus ranges from Newfoundland (Bousfield, 1958a) to Georgia (Teal, 1962).

In the lower Chesapeake Bay region, specimens have been collected from the York River at Gloucester Point and from Hampton Creek which flows into the mouth of the James River. Specimens have also been collected from the ocean side of the Eastern Shore of Virginia at Cedar Island.

ECOLOGY--O. grillus is the typical salt marsh amphipod of this region and is found among Spartina at or slightly above high water level. It was found once on a sandy beach under eelgrass wrack at Gloucester Point.

Orchestia platensis Kroyer, 1844

Orchestia platensis, Bousfield, 1958a, p. 883-885, figs. lc, l0b.

DISTRIBUTION--O. platensis is found along both sides of the North Atlantic. On the North American coast it is present from Newfoundland (Bousfield, 1958a) southward to at least Georgia (Teal, 1962).

In this area, O. platensis has been collected in abundant numbers on the beach at Gloucester Point. It has also been collected from salt marshes adjoining Mobjack Bay and the lower York River.

ECOLOGY--This species tends to be more of an open beach species than O. grillus, being primarily found under wrack at high water and burrowing in the sand to some extent.

INFAUNAL GENERA

This section includes those amphipods found living in the bottom. These can be loosely subdivided into tube builders, commensal tube dwellers, and non-tube dwellers.

Tube Builders

Family AMPELISCIDAE

Ampelisca abdita Mills, 1964

Ampelisca abdita, Mills, 1964a, p. 559-575, figs. 1-2.

DISTRIBUTION--Mills (1964a) reports this species from Maine to South Carolina and probably Georgia. It is also found in the Mississippi Delta and on the west coast of Florida. Like the sibling A. vadorum, it is absent from the east coast of Florida.

A. abdita is much more common than A. vadorum in this area. In the James River it was taken on the Newport News side of Hampton Roads and at J13. A. abdita was also collected in the Nansemond River, a tributary of the lower James. Its range in the York River is from Y10 to Y25 and in the Rappahannock River from R11 to R25. Other specimens came from Mobjack Bay and Cape Charles at the mouth of Chesapeake Bay.

ECOLOGY--A. abdita prefers muddy bottoms, in which it constructs mud tubes. Like A. vadorum, it is polyhaline, but it is not strictly a shallow-water amphipod, being frequently taken at all depths.

Ampelisca vadorum Mills, 1963

Ampelisca vadorum, Mills, 1963, p. 972-978, 984-987, figs. 1-3.

DISTRIBUTION--Mills (1963) gives the range of A. vadorum as from New Brunswick, Canada, to South Carolina, possibly Georgia, and from off the west coast of Florida at a depth of 24 fathoms.

The local distribution has been poorly known due to the great difficulty in separating A. vadorum from the very similar A. abdita. The present authors have positively identified specimens of A. vadorum from Nansemond Ridge (ca. J8) in the James River and in the York River from its mouth at Y0 to Y10.

ECOLOGY--The specific name indicates this amphipod's preference for shallow water (Mills, 1963) which agrees with its local distribution. Although polyhaline, it is not found off the coast. It occurs with A. abdita but is much less common and apparently favors substrate with finer particles. Like the other members of this family, it is infaunal and constructs silt or sand mucoid tubes.

Ampelisca verrilli Mills, 1967

Ampelisca verrilli, Mills, 1967b, p. 636-639, fig. 1.

DISTRIBUTION--Mills (1967b) has shown that what was formerly identified as Ampelisca macrocephala along the east coast of North America south of Cape Cod is a separate species which he has named A. verrilli. A. macrocephala is now restricted by Mills to north of Cape Cod. The range of A. verrilli is given by him as extending from Cape Cod southward to at least North Carolina and probably to the Gulf of Mexico.

Locally, Wass (1965) listed A. macrocephala (now A. verrilli) as abundant in the lower York River. However, it is usually rare as compared with the other local representatives of this genus. Specimens were occasionally found in the lower portion of the York River and once from Mobjack Bay.

ECOLOGY--A. verrilli is a polyhaline amphipod found on sandy bottoms and frequently among Zostera beds but probably never at depths greater than 50 m (Mills, 1967b). Mills' statement that its distribution partially overlaps with A. vadorum where the sand grain size is reduced is borne out in this area.

Commensal Tube Dwellers

Family LILJEBORGIIDAE

Listriella clymenellae Mills, 1962

Listriella clymenellae, Mills, 1962, p. 158-162, figs. 1-2.

DISTRIBUTION--This commensal species occurs on the east coast of North America from Barnstable Harbor, Massachusetts, south to at least Beaufort, North Carolina (Mills, 1962).

Specimens have been collected from silty-sand in the York River at Gloucester Point and from *Zostera* beds at Hampton Roads and Chincoteague. Only four were found in over 600 grab samples from Chesapeake Bay off the Rappahannock River.

ECOLOGY--This infaunal amphipod is commensal with the polychaete *Clymenella torquata* (Mills, 1962). Experiments performed by Mills showed that whenever a *C. torquata* tube was presented to a specimen of *L. clymenellae*, the amphipod immediately sought out and descended into the tube alongside the polychaete. Locally, *C. torquata* or its tubes were always present in bottom samples containing *L. clymenellae*. Its food habits are unknown.

Listriella barnardi Wigley, 1966

Listriella barnardi, Wigley, 1966, p. 267-270, figs. 5-8.

DISTRIBUTION--Wigley (1966) recorded this species from Lake Tashmoo, Martha's Vineyard, Massachusetts, and the Mystic River estuary, Connecticut. Its presence in Chesapeake Bay thus represents a southern extension. Specimens were taken from Chesapeake Bay near the Rappahannock Shoals channel in 1963 and again in 1967.

ECOLOGY--Since *L. clymenellae* is known to live in tubes of *C. torquata*, Wigley (1966) suspected *L. barnardi* might also be commensal with a polychaete. While he did not find it living in polychaete tubes, the tubes of *C. torquata* were present in his grab samples. In this area, tubes of another maldanid, *Maldanopsis elongata*, were present at both times *L. barnardi* was taken.

Idunella sp.

DISTRIBUTION--An ovigerous female collected in 1961 from the York River at Gloucester Point was subsequently identified by Bousfield (personal communication), who is describing it, as *Idunella* sp., the first report of this genus in North America. In March 1963, nine specimens, five males and four ovigerous females, were collected from Hog Island Bay on the ocean side of the Eastern Shore of Virginia. It is now known south to Wrightsville Sound, North Carolina (Bousfield, personal communication).

ECOLOGY--No record was made of the habitat occupied by the 10 specimens of this locally rare species. Bousfield (personal communication) suspects it may occur commensally in burrows of large polychaetes and callianassids.

Family COROPHIIDAE

Unciola irrorata Say, 1818

Unciola irrorata, Shoemaker, 1945, p. 446-450, figs. 1-2.

DISTRIBUTION--Unfortunately, since the original description of U. irrorata was vague and the holotype was destroyed in a fire, several authors have erroneously ascribed morphologically similar species to irrorata. Shoemaker (1945) redescribed U. irrorata and designated a neotype. Its range is now limited to bays and shallow waters from Newfoundland to southern South Carolina.

U. irrorata occurs in lower Chesapeake Bay, Hampton Roads, and in the York River to Y20. Additional specimens were taken offshore.

Shoemaker (1945) listed three additional species of Unciola previously identified as irrorata for the lower Chesapeake Bay. These three are U. inermis, U. serrata, and U. spicata. U. inermis and U. spicata are both known from "the mouth of Chesapeake Bay, where a few specimens were taken by the Fish Hawk in 1920," north to New Jersey for U. spicata and the Bay of Fundy for U. inermis. U. serrata occurs from Vineyard Sound, Massachusetts, to St. Simons Island, Georgia, including "the lower part of Chesapeake Bay." None of these were found during this study.

ECOLOGY--It occurs on sand and silt bottoms where it is fairly frequent although seldom common. Smith (1874) states that it does not build tubes of its own but is often found in the tubes of other amphipods and annelids. A sample taken offshore of Virginia contained a few specimens of U. irrorata occupying tubes of the polychaete Prionospio sp. It was frequently found on bottoms lacking attached flora and fauna. It is polyhaline (Fig. 2) and only found in the deep areas of the rivers. Although brightly colored, its reputed tube-dwelling seems dubious.

Family AORIDAE

Lembos smithi (Holmes, 1903)

Lembos smithi, Kunkel, 1918, p. 136-138, fig. 39.

DISTRIBUTION--Kunkel (1918) gives L. smithi's range as the east coast of North America from Cape Cod, Massachusetts, to Hatteras, North Carolina. Schmitz (1959) lists it as from Cape Cod to Florida.

This species is rare in this area, four specimens being found in February 1967 in the York River at Gloucester Point. It had previously been reported from the Eastern Shore of Virginia (Wass, 1965).

ECOLOGY--The York River specimens were in shallow water among *Zostera* roots and algal detritus. Some members of this genus construct burrows which they reinforce with a secretion from the first and second pereiopods (Enequist, 1950). Although the specimens from Gloucester Point fit the description given by Kunkel (1918), the eyes were round rather than oval as figured by him. Miner (1950) described the distinctive color markings. It is tentatively placed in this ecological grouping because of its distinctive coloration and scarcity.

Rudilemboides sp.

This littoral genus, heretofore monotypic for a species described from the California coast by Barnard (1959), was discovered in the York River by Marsh (1970) who found 137 specimens on eelgrass. It thus seems clear that the ecology of this undescribed species is closely associated with *Zostera marina*. Nagle (1968) has found the same species on the coast of Texas.

Non-tube Dwellers

Family HAUSTORIIDAE

Acanthohaustorius millsi Bousfield, 1965

Acanthohaustorius millsi, Bousfield, 1965, p. 199-201, figs. 16, 3f, 4b, 22, 23.

DISTRIBUTION--Bousfield (1965) reported this species from Casco Bay, Maine, to Cape Cod, Massachusetts, although he suspected its range actually extended much farther south. Since then, Dexter (1967) has found it to be the second most abundant haustoriid along the North Carolina coast.

Two immature specimens were identified by Bousfield (personal communication) from material collected in the York River.

ECOLOGY--Bousfield (1965) lists the habitat of this species as the lower intertidal zone to depths of 27 fathoms and in salinities from estuarine to fully marine. Locally, it is found in sand, the preferred substrate of haustoriids.

Acanthohaustorius intermedius Bousfield, 1965

Acanthohaustorius intermedius, Bousfield, 1965, p. 202-203, figs. 1c, 3e, 4a, 24, 25.

DISTRIBUTION--At the time of its description, A. intermedius was known only from the Cape Cod area out to a depth of over 20 fathoms on Georges Bank. It has since been taken south to Bogue Sound, North Carolina (Dexter, 1967). D. F. Boesch has collected specimens in Hampton Roads at Newport News Bar and Sewell's Point Spit.

ECOLOGY--This haustoriid is subtidal and breeds in the spring (Dexter, 1967).

Bathyporeia sp.

DISTRIBUTION--A single specimen, subsequently examined by E. L. Bousfield, was taken by D. F. Boesch, February 1969, in Hampton Roads. The species will be described by Bousfield in his work on New England amphipods.

Haustorius sp.

Haustorius sp., Croker, 1967, p. 173-200, fig. 2.

DISTRIBUTION--This is an undescribed species occurring southward from New England (Bousfield, personal communication). It is closely related to H. canadensis Bousfield, differing most noticeably from the latter by the possession of a long rostrum (Croker, 1967).

ECOLOGY--Croker (1967) has described the ecology of this haustoriid in Georgia, where it occurs in well oxygenated intertidal sands of ocean beaches. However, its local ecology is unknown other than that it occurs in sand.

Lepidactylus dytiscus Say, 1818

Lepidactylus dytiscus, Croker, 1967, p. 173-200, fig. 1.

DISTRIBUTION--Croker (1967) lists L. dytiscus as a common intertidal estuarine species present in Georgia and Florida.

Collections made by the Academy of Natural Sciences of Philadelphia and examined by us indicate that L. dytiscus is abundant in northern Chesapeake Bay. One specimen was taken in The Gulf on the eastern shore of the lower Bay and identified by E. L. Bousfield. A second was taken at Hog Point in the James River by T. D. Cain. Its presence in Chesapeake Bay represents a new northern limit.

ECOLOGY--Croker (1967) has thoroughly described the ecology and relationship of L. dytiscus to other intertidal haustoriid amphipods found on Sapelo and Blackbeard islands, Georgia. Its presence on the outer coasts of Sapelo Island and in northern Chesapeake Bay indicates it is a polyhaline species.

Bousfield (personal communication) has specimens of another haustoriid, Neohaustorius schmitzi, from the upper Chesapeake Bay. It has not been found in the lower Bay, but, as with L. dytiscus, this is probably due to insufficient sampling. Bousfield states its ecological requirements are similar to L. dytiscus but that their distributions seldom overlap. N. schmitzi ranges from Cape Cod to northern Florida (Croker, 1967). It and L. dytiscus comprised 78.1% of the total number of haustoriids collected from Sapelo and Blackbeard islands, with L. dytiscus alone making up about 50%.

Family AORIDAE

Leptocheirus plumulosus Shoemaker, 1932

Leptocheirus plumulosus, Shoemaker, 1932, p. 548-551, figs. 1-2.

DISTRIBUTION--This North American species has been reported from the Pocasset River, Massachusetts, by Sanders et al. (1965), and from the Chesapeake Bay region (Shoemaker, 1932). Cowles' record (1930) of Leptocheirus sp. from off Sandy Point, Maryland (Chesapeake Bay), was very probably L. plumulosus. L. plumulosus is very abundant in the oligohaline and mesohaline portions of three principal tributaries of this region and in their adjoining creeks and rivers.

Two members of the genus Leptocheirus are found in Virginia waters, but only one, L. plumulosus, is found in the estuary. The other, L. pinguis, is restricted to offshore and possibly along the coast of the Eastern Shore of Virginia.

ECOLOGY--Wass (1965) stated that L. plumulosus apparently formed sand-encrusted tubes at Bells Rock (Y25) in the York River. However, upon further examination, these tubes were found to belong to the polychaete Sabellaria sp., the amphipod being only a nestler among the concreted tubes. Although Enequist (1950) states that another member of this genus, L. pilosus, constructs capsules of mud and algal fragments, no mention of this is made by Sanders et al. (1965) in regard to L. plumulosus nor were capsules ever observed locally. Rather, Sanders et al. (1965) describe L. plumulosus as forming burrows in the upper 5-7 cm of the bottom. This infaunal species prefers muddy bottoms and is most common in shallow water. Sanders et al. (1965) found L. plumulosus active in experimental salinities from 3 to 33 o/oo. Thus, its presence in the lower salinity regions of the Chesapeake estuary may categorize it as a fugitive species (Hutchinson, 1951), inasmuch as we have also taken it from a variety of substrates.

Family LYSIANASSIDAE

Lysianassa alba (Holmes, 1903)

Lysianopsis alba, Shoemaker, 1933, p. 23-24.

DISTRIBUTION--Wass' (1965) listing of L. alba from the York River is the only record south of New England, where it is unreported north of Woods Hole. It has been found locally from both sides of the York River at Gloucester Point and from the mouth of Chesapeake Bay at Cape Charles.

ECOLOGY--We found L. alba only in shallow water with sandy-mud bottoms. This uncommon infaunal species burrows in the top few centimeters of sediment. Local distribution suggests it is polyhaline.

Family OEDICEROTIDAE

Monoculodes edwardsi Holmes, 1903

Monoculodes edwardsi, Bousfield, 1962, p. 51.

DISTRIBUTION--Other than Cowles' (1930) and Wass' (1965) listing of M. edwardsi from the Chesapeake Bay region, this species is unreported from south of New England. Although it is also known from Hudson Bay, Ungava Bay, and the Gulf of St. Lawrence, Bousfield (personal communication) believes all records of M. edwardsi from arctic areas are erroneous and that it is essentially a warm-temperate species ranging from the Gulf of Maine to the St. Johns River, Florida.

M. edwardsi was scarce in the lower York but second only to Gammarus daiberi in the upper York and Pamunkey rivers. It was taken as far upriver as P50 in the summer, being most abundant on an annual basis between Y20 and P35. M. edwardsi was present in the James River from Hampton Roads to J36 and, as in the York, was most abundant in the upper portion from J32 to J36. In the Rappahannock River it occurred only between R25 and R40, but numerous specimens were taken from Stove Point at the mouth of the Piankatank River. M. edwardsi seems uncommon in Chesapeake Bay proper, although Cowles (1930) reported specimens taken near the mouth of the Potomac River and 22 were found in a VIMS survey made in 1963 off the mouth of the Rappahannock. Specimens have also been found in plankton collected offshore by VIMS personnel.

ECOLOGY--M. edwardsi is quite euryhaline (Fig. 2), occupying the entire York-Pamunkey estuary. According to Bousfield (personal communication), it is also found throughout the salinity spectrum in the St. Johns River, Florida. Literature references mention it as most often associated with sand or rock bottom; however, it was taken both in sand at Stove Point and in mud with much vegetative detritus at P35 in the Pamunkey River. M. edwardsi occurred at all depths and was noted in the uppermost layers of the bottom and on the surface.

Although Holmes (1905) described this species without stating the sex of the holotype, it was obviously a female. The male is readily distinguished from the female by having a less robust body and a second antenna with 15 articular segments as compared with 10 in the female.

Family PHOXOCEPHALIDAE

Paraphoxus epistomus (Shoemaker, 1938)

Paraphoxus epistomus, Barnard, 1960, p. 205-209, plates 6-8.

DISTRIBUTION--Barnard (1960) gives the range as the Eastern Pacific from California to Panama and the Western Atlantic from New Hampshire to South Carolina. Collections offshore of Virginia show this species to be quite abundant. In the Chesapeake Bay it has been found at the mouths of the York and James rivers.

ECOLOGY--The presence of P. epistomus at the mouth of tributaries in this area indicates its preference for coarse sand, a substrate type common offshore but rather scarce in Chesapeake Bay.

P. epistomus is polyhaline and was found from shallow water to depths of 20 feet. D. F. Boesch (personal communication) has taken specimens from off Cape Lookout, North Carolina, at a depth of 600 feet. Although locally restricted in distribution, P. epistomus is abundant in optimal substrates.

Family TALITRIDAE

Talorchestia longicornis (Say, 1818)

Talorchestia longicornis, Bousfield, 1958a, p. 889-890, 894-898, figs. 1b, 5a, 6-9, 10f.

DISTRIBUTION--This species is widely distributed in estuarine regions along the east coast of North America. It is the common "beach hopper" in the lower Chesapeake and is abundant in the high intertidal zone of inner coast sandy beaches.

ECOLOGY--Bousfield (1958a) has presented the ecological factors affecting the distribution of T. longicornis. Locally, it is most frequently found under clumps of dead eelgrass washed ashore. Bousfield noted that this species may penetrate upriver to where the salinity frequently falls to 0 o/oo during freshets.

DISCUSSION

Cowles (1930) listed seven species of gammarid amphipods from the Chesapeake Bay based on a single cruise of the Fish Hawk made in May 1920. Although he believed other species were undoubtedly present, he erroneously assumed that further sampling would reveal a paucity of species in the Chesapeake Bay area since Buzzards Bay, which he considered similar, had a very low diversity as compared with Vineyard Sound. On the contrary, an increase in sampling and systematic study has revealed a wealth of gammaridean species.

The number of species known from the lower Chesapeake Bay now stands at 42 in 25 genera and 15 families. In addition, seven species in the genera Bathyporeia, Colomastix, Gammarus, Haustorius, Idunella, Parapleustes and Rudilemboides are probably new to science. Of these 49 species, 29 were collected in the 10-month period of regular sampling by Feeley. Five other species are known from the northern Chesapeake Bay. These are Gammarus tigrinus, Neohaustorius schmitzi, and three undescribed species reported by Bousfield (1969), Gammarus sp. 2, Rivulogammarus sp. 1 and sp. 2. Thus to date, 54 presumed species belonging to 33 genera and 16 families have been found in Chesapeake Bay. Considering the rarity of some of those found, it seems likely that other species may occur in the Chesapeake estuarine system, particularly at the lower end. Bousfield (personal communication) has mentioned two talitrids--Orchestia uhleri and Talorchestia megalophthalma--which have distributions bracketing Virginia and thus may certainly be expected to occur here.

For eleven of the described species, Chesapeake Bay is the southern limit. These are Ampithoe valida, Cerapus tubularis, Elasmopus levis, Gammarus fasciatus, Leptocheirus plumulosus, Listriella barnardi, Lysianassa alba, Parametopella cypris, Sympleustes glaber, Unciola inermis and Unciola spicata. Only three species, Melita appendiculata, Lepidactylus dytiscus and Stenothoe gallensis, are known to reach their northern limit here. It seems improbable that any species is endemic to the Bay. However, only intensive collecting can determine the ranges of the ten possibly new species. Of the 42 described brackish and marine amphipods now known from the lower Chesapeake system, 19 may be termed Boreal-Carolinian since their ranges extend northward of Cape Cod. Of the remaining 23, only 16 have ranges known to extend below Cape Hatteras. The 7 which are mainly confined to the Virginian subprovince of the Carolinian province may well include several species which will have their known ranges extended in the future. The 10 undescribed species, one of which (Haustorius sp.) is already known to range to Georgia (Croker, 1967), are probably most likely to range southward. Since the Boreal or Acadian Province has been well studied by Bousfield

Table 1. Occurrence of gammarid amphipods in the lower Chesapeake estuarine system (+ indicates species reported from tributary; O indicates species not as yet reported).

SPECIES	ESTUARY York-Pamunkey	James	Rappahannock	Chesapeake Bay
1. *Acanthohaustorius intermedius*	O	+	O	+
2. *Acanthohaustorius millsi*	+	O	O	O
3. *Ampelisca abdita*	+	+	+	+
4. *Ampelisca vadorum*	+	+	O	O
5. *Ampelisca verrilli*	+	O	O	+
6. *Ampithoe longimana*	+	+	O	+
7. *Ampithoe valida*	O	+	O	O
8. *Batea catharinensis*	+	+	+	+
9. *Bathyporeia* sp.	O	+	O	+
10. *Cerapus tubularis*	+	+	O	+
11. *Colomastix* sp.	+	+	O	O
12. *Corophium acherusicum*	O	+	O	+
13. *Corophium lacustre*	+	+	+	O
14. *Corophium simile*	+	O	O	+
15. *Corophium tuberculatum*	+	+	+	+
16. *Cymadusa compta*	+	+	O	O
17. *Elasmopus levis*	+	+	O	O
18. *Ericthonius brasiliensis*	+	+	+	+
19. *Gammarus daiberi*	+	+	+	O
20. *Gammarus fasciatus*	+	O	O	O
21. *Gammarus mucronatus*	+	+	+	+
22. *Gammarus palustris*	+	O	O	+
23. *Gammarus* sp. I	+	+	O	O
24. *Haustorius* sp.	+	O	O	O
25. *Idunella* sp.	+	O	O	O

Table 1 continued

SPECIES	York-Pamunkey	James	Rappahannock	Chesapeake Bay
	ESTUARY			
26. *Jassa falcata*	+	+	O	+
27. *Lembos smithi*	+	O	O	O
28. *Lepidactylus dytiscus*	O	O	O	+
29. *Leptocheirus plumulosus*	+	+	+	O
30. *Listriella barnardi*	O	O	O	+
31. *Listriella clymenellae*	+	+	O	+
32. *Lysianassa alba*	+	O	O	+
33. *Melita appendiculata*	+	+	+	+
34. *Melita nitida*	+	+	+	O
35. *Monoculodes edwardsi*	+	+	+	O
36. *Orchestia grillus*	+	+	O	O
37. *Orchestia platensis*	+	O	O	+
38. *Parametopella cypris*	+	+	O	+
39. *Paraphoxus epistomus*	+	+	O	+
40. *Parapleustes* sp.	+	O	O	O
41. *Rudilemboides* sp.	+	O	O	O
42. *Stenothoe gallensis*	+	O	O	O
43. *Stenothoe minuta*	+	+	+	O
44. *Sympleustes glaber*	+	+	+	O
45. *Talorchestia longicornis*	+	O	O	O
46. *Unciola inermis*	O	O	O	+
47. *Unciola irrorata*	+	+	O	+
48. *Unciola serrata*	O	O	O	+
49. *Unciola spicata*	O	O	O	+
Totals	40	30	13	26

and others while the Carolinian has not been, further southern affinities are more likely to be found. Nevertheless, for predominantly estuarine species, Chesapeake Bay could prove to be as good a change point as Cape Hatteras but less so than Cape Cod.

Of the three principal tributaries investigated during the study, the York-Pamunkey system has the greatest number of species, 40, followed by the James with 30 and the Rappahannock with only 13 species (Table 1). Two species found by D. F. Boesch (personal communication) in the James (Hampton Roads) and yet unknown in the York are Acanthohaustorius intermedius and Bathyporeia sp. The greater number found in the York must be partly due to more intensive sampling, although greater freshwater inflow and pollution may lower diversity in the James. The York and the James, being closest to the mouth of the Bay, have several polyhaline species unable to tolerate the lower salinities of the Rappahannock. Likewise, although Table 1 lists only 26 species for the lower Chesapeake Bay proper, less sampling has been done there.

Several factors likely to limit the distribution of amphipods were investigated. These were salinity, substrate preference, water temperature, dissolved oxygen concentration, and pollution. Monthly values from September 1966 to June 1967 for salinity, temperature, and dissolved oxygen in the York-Pamunkey system are summarized in Figures 2 and 3. In addition to these limiting effects, there exists the possibility of interspecific competition, but until a study is made of the feeding habits, this must remain an inference only.

As expected, salinity definitely plays the largest role in limiting the distribution of the local estuarine amphipods. This is seen in the diversity between the three tributaries.

As Carriker (1967) points out, there are several salinity oscillations of varying duration and amplitude superimposed upon the broad salinity gradient from the mouth of an estuary to its head. These are caused by such phenomena as daily and lunar tidal cycles and seasonal differences in precipitation and evaporation. Seasonal changes in salinity pose the most serious limiting factor.

The same species of amphipods found only in lower portions of the James and Rappahannock rivers are present throughout most of the York-Pamunkey system, extending as far as P35 during summer and fall when freshwater runoff is at its minimum. The York-Pamunkey system contributes only 2% of the total annual freshwater inflow to the Chesapeake Bay. The changes in distribution (Fig. 4) for the more common species in this system indicate definite seasonal shifts in abundance. In the late summer and fall the populations are found considerably farther up the estuary, but during the winter and spring when freshwater runoff reaches its maximum, all common species apparently move downriver. The minimum salinity tolerance for most polyhaline species seems to be approximately 13 o/oo (Fig. 5). A comparison of the monthly ranges of amphipods (Fig. 4) and monthly isohalines in the York-Pamunkey system (Fig. 6) indicates that amphipods move up and down the river in accordance with their minimal survival salinities.

Although less frequently sampled, the James and Rappahannock rivers also exhibited this seasonal shift.

In the late fall, many amphipods are apparently swept down-river by the increased inflow of freshwater runoff. Those remaining have their numbers quickly decimated, presumably as a result of predation, reduced salinities, and the general cessation of reproductive activity during winter months.

In late spring, reproductive activity provides large numbers of juveniles to repopulate upriver portions. These juveniles may actively follow the gradual upriver movement of the isohalines as river discharge decreases but more likely they are passively transported up the estuary by the inflowing bottom water. Bousfield (1955) in his study of the Miramichi estuary described the transport of barnacle larvae up the estuary in this manner. Pritchard (1953) credits the same mechanism for restocking oyster beds in the upper James River by larvae from seed beds located in the lower part of the James. This inflowing seawater likely aids in the upriver transport of amphipods as well.

Cronin et al. (1962) postulate that reservoirs of species may be present along the more slowly flushed shoal margins of an estuary which could contribute toward the re-establishment of channel populations. No such reservoirs were found during this study, but species normally most abundant in eelgrass were taken from *Zostera* detritus in the York River at a depth of 25 feet in an earlier study (unpublished data).

The second most important limiting factor of local amphipod distribution is substrate preference. This affects both infaunal and epifaunal forms. No species is completely indiscriminant in its choice of substrates although some do appear to be less selective. The preferred substrate of each species is given in the Results.

A secondary effect of substrate preference results from the occurrence of hydroids and ectoprocts primarily in deep water and *Zostera* and algae in the shallower littoral areas. Restriction of many amphipod habitats to a particular group of sessile organisms has divided the amphipod population into deep-water and shallow-water forms.

Water temperature has a negligible effect on the local distribution of amphipods since they are poikilothermic and independent of normal temperatures (Carriker, 1967). Although seasonal thermal oscillations are great in the area, the temperature is fairly uniform throughout the entire estuarine system (Figs. 2 and 3).

As in most shallow-water estuaries with good mixing, dissolved oxygen values were normally very high in this area and for the most part had no limiting effect on amphipod distribution (Figs. 2 and 3). In summer, anaerobic conditions occasionally develop in deeper parts of the Rappahannock River and in a few small creeks, but the long-term effects of these temporary conditions on the biota have not been studied. The smaller tidal creeks typically exhibit low diversity, e.g., Sarah Creek, located just below Gloucester Point, had only one species of amphipod, *Leptocheirus plumulosus*, present and it only in small numbers. Softness

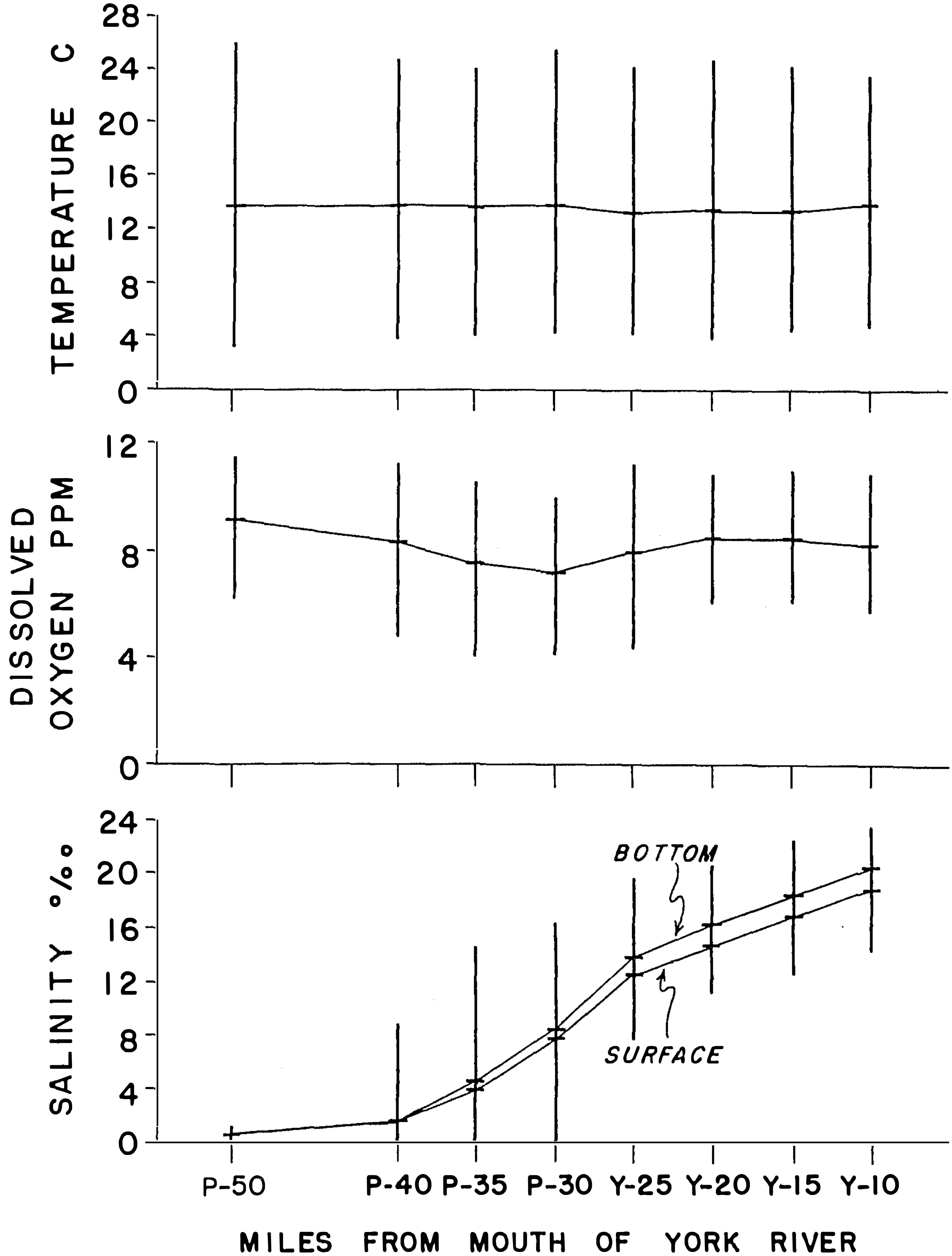

Figure 2. Range and mean values for temperature, dissolved oxygen, and salinity for all stations in the York-Pamunkey system from September 1966 to June 1967.

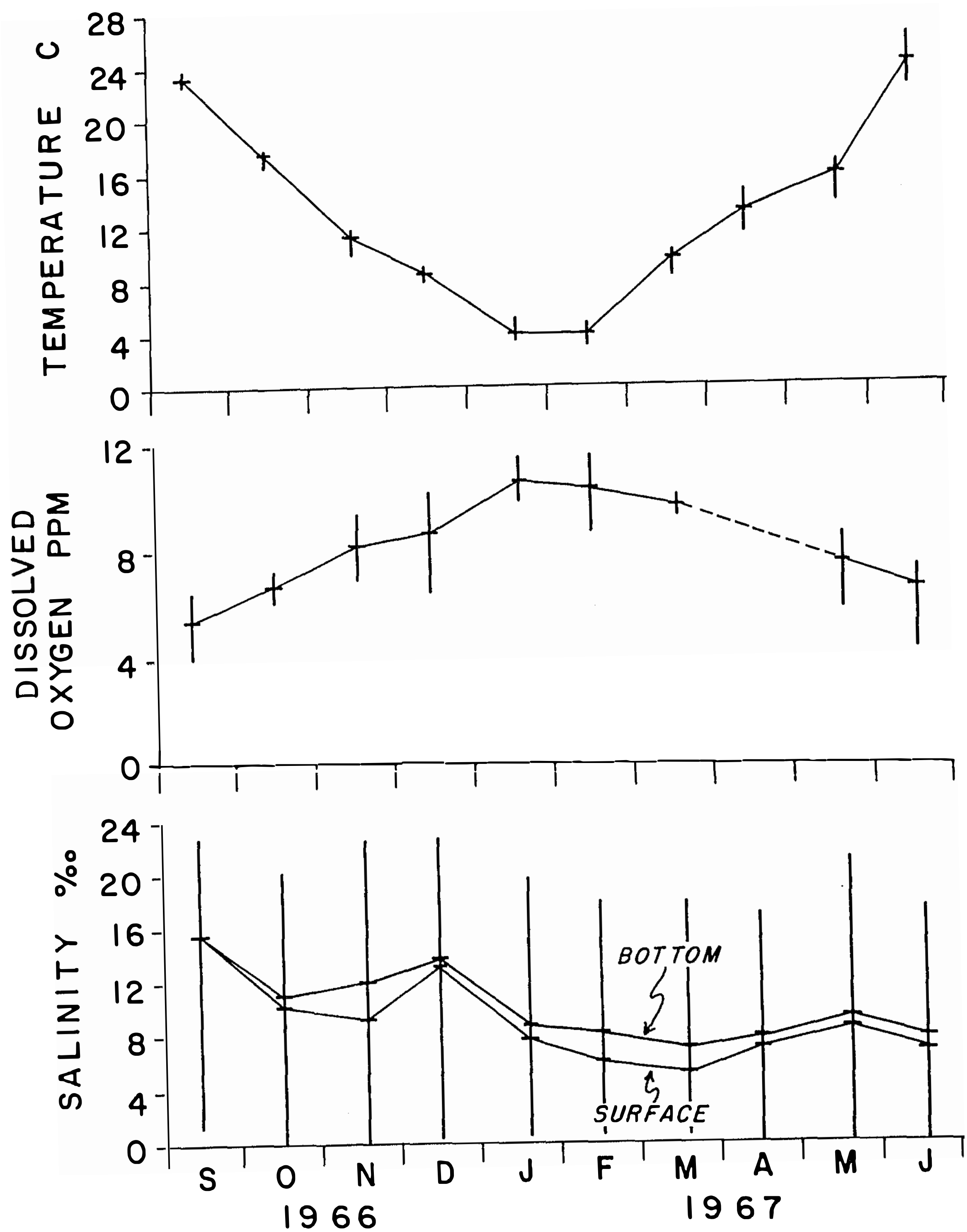

Figure 3. Range and mean values for temperature, dissolved oxygen, and salinity for each month from September 1966 to June 1967 in the York-Pamunkey system.

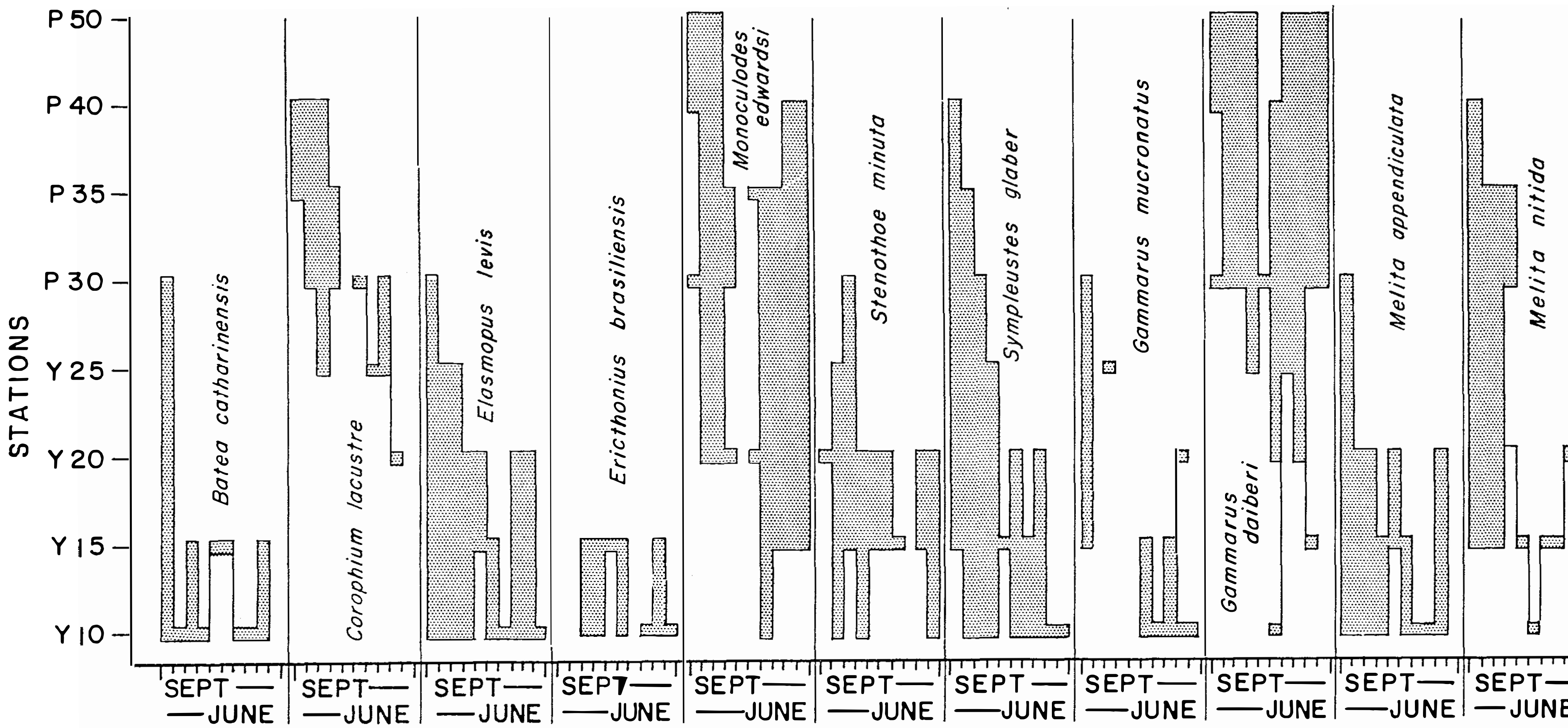

Figure 4. Monthly ranges of the eleven most common species in the York-Pamunkey system from September 1966 to June 1967.

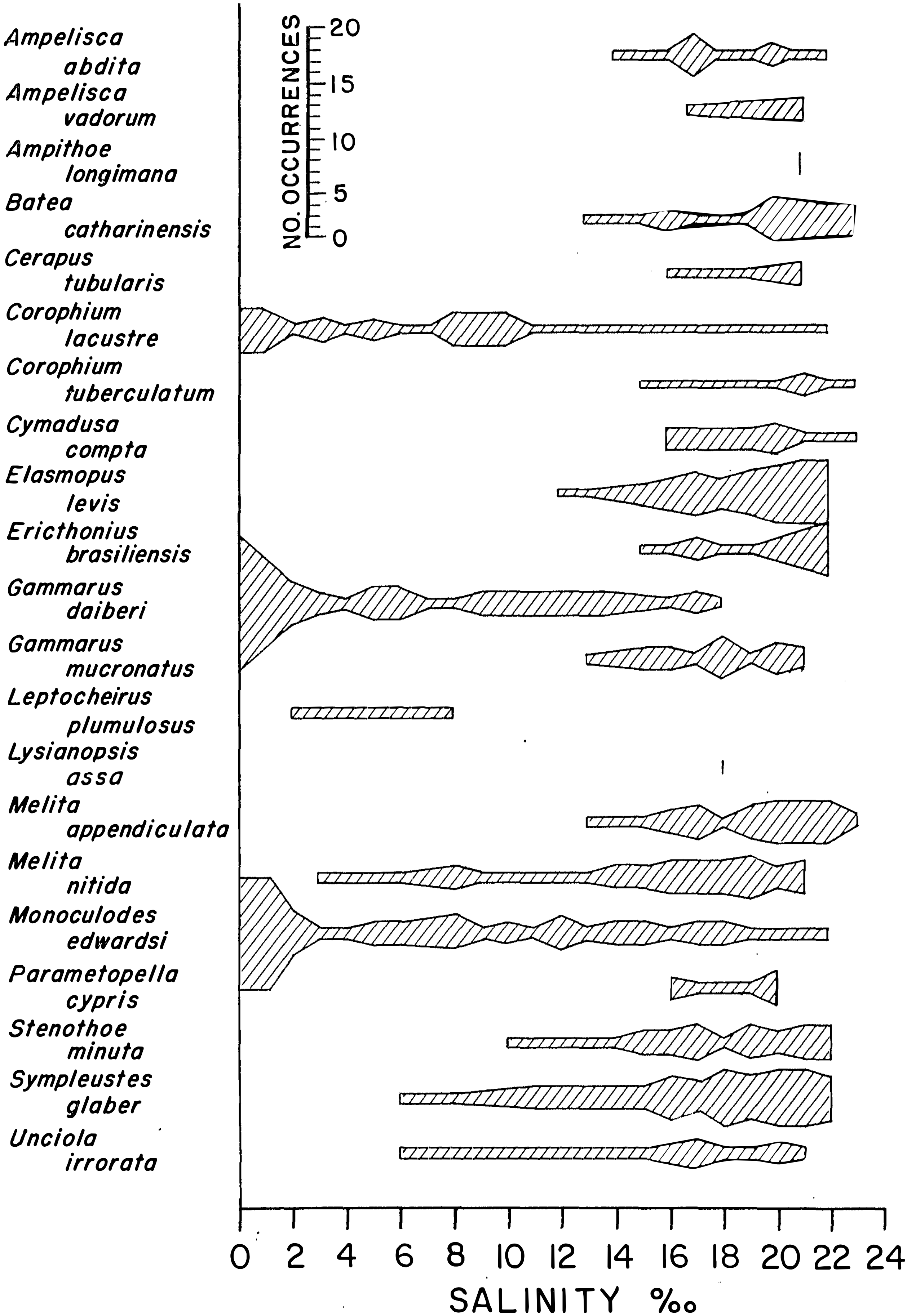

Figure 5. Salinity ranges for 21 species found in the York-Pamumkey system as determined from bottom salinities taken at the time of sampling.

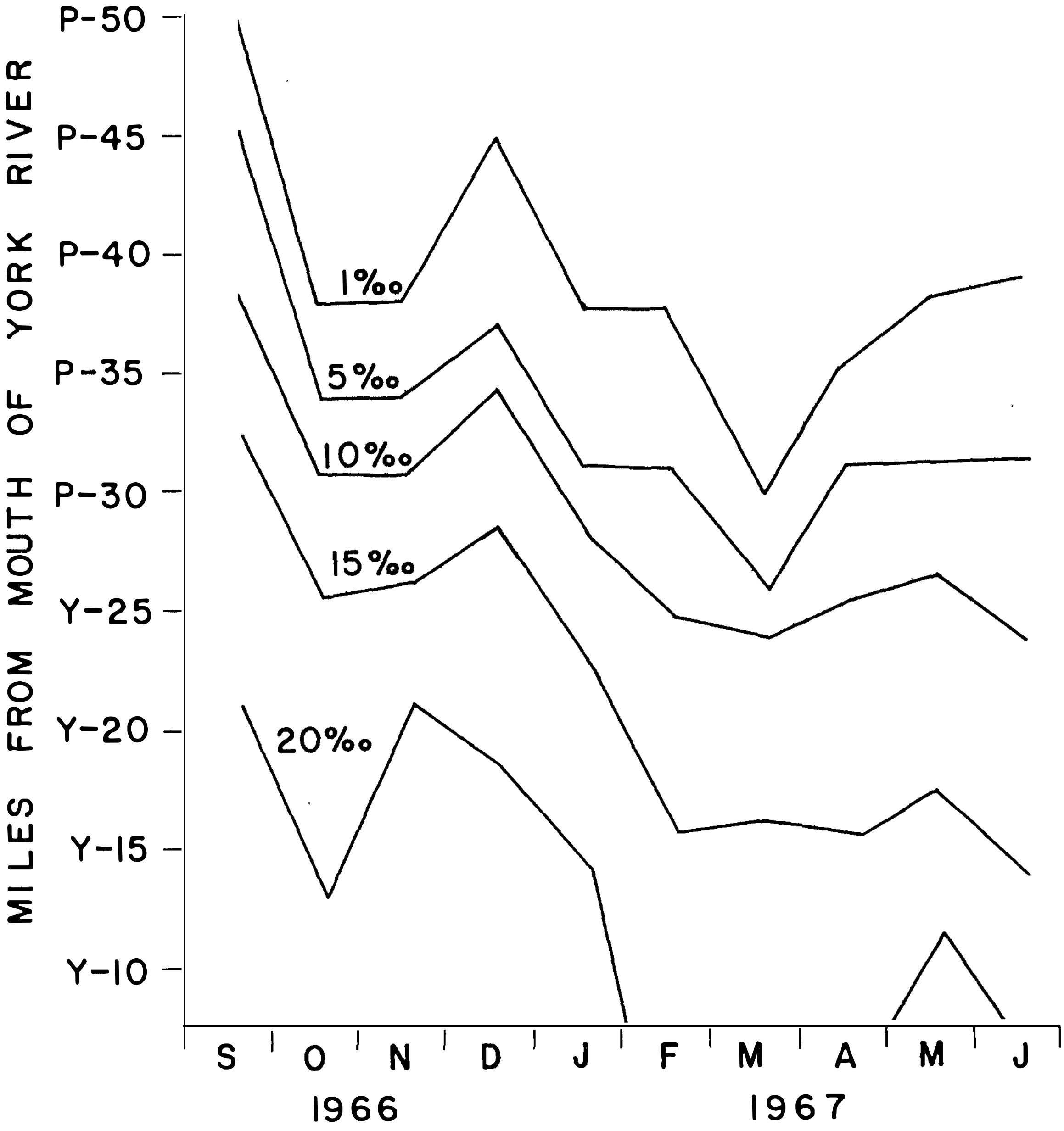

Figure 6. Isohalines for the York-Pamunkey system from September 1966 to June 1967.

Table 2. Occurrence of ovigerous females (+ indicates ovigerous females present, 0 indicates ovigerous females absent; - indicates species not found).

SPECIES	MONTHS S	O	N	D	J	F	M	A	M	J
1. *Ampelisca abdita*	0	0	0	0	-	-	0	+	+	+
2. *Ampelisca verrilli*	0	-	-	-	-	-	0	-	-	-
3. *Ampelisca vadorum*	+	-	-	-	-	0	0	0	-	+
4. *Ampithoe longimana*	0	-	-	-	-	0	-	-	-	+
5. *Batea catharinensis*	+	+	0	0	0	0	0	0	+	-
6. *Cerapus tubularis*	0	0	0	-	-	0	0	0	-	-
7. *Corophium acherusicum*	-	-	-	-	-	+	-	-	-	-
8. *Corophium lacustre*	+	0	0	0	-	0	0	+	0	-
9. *Corophium tuberculatum*	+	-	-	0	0	0	0	0	+	0
10. *Cymadusa compta*	+	+	0	-	-	0	0	0	-	+
11. *Elasmopus levis*	+	+	0	0	0	0	0	0	+	+
12. *Ericthonius brasiliensis*	0	0	0	0	0	0	0	0	+	+
13. *Gammarus daiberi*	+	+	0	0	0	+	+	+	+	+
14. *Gammarus fasciatus*	-	-	0	0	-	0	+	-	-	+
15. *Gammarus mucronatus*	+	0	0	-	-	0	0	0	+	+
16. *Jassa falcata*	-	-	-	-	-	0	0	-	-	+
17. *Lembos smithi*	-	-	-	-	-	0	-	-	-	-
18. *Leptocheirus plumulosus*	-	-	0	-	-	-	+	-	0	0
19. *Listriella barnardi*	-	-	-	-	-	-	-	-	0	-
20. *Listriella clymenellae*	-	-	-	-	0	-	-	-	-	-
21. *Lysianassa alba*	-	-	-	-	-	0	0	-	-	0
22. *Melita appendiculata*	+	0	0	0	0	0	0	0	+	+
23. *Melita nitida*	+	0	0	0	0	0	0	0	+	+
24. *Monoculodes edwardsi*	+	+	+	+	-	+	+	+	+	+
25. *Parametopella cypris*	+	+	-	-	0	-	0	0	-	0
26. *Stenothoe minuta*	+	0	0	+	+	0	0	-	+	+
27. *Sympleustes glaber*	+	+	+	+	+	+	0	+	+	+
28. *Unciola irrorata*	0	0	0	0	-	0	0	+	+	-

of the bottom and the resultant lack of sessile epifauna may partially account for this.

Pollution does not yet pose serious problems for the estuarine amphipod fauna of these tributaries. The upper James and Rappahannock rivers are heavily polluted by wastes discharged by the cities of Richmond and Hopewell on the former and Fredericksburg on the latter, but water quality is restored before the estuarine portions are reached. The decrease in dissolved oxygen values at P30 on the Pamunkey River (Fig. 2) is undoubtedly caused by effluent from the large pulp and paper mill at West Point. However, no adverse effects were observed among the amphipod fauna at this station.

Warinner and Brehmer (1966) studied the effect of thermal pollution on planktonic and benthic organisms from the heated effluent of the Virginia Electric and Power Company's generating plant located on the York River below Yorktown. Their studies showed a decrease in diversity and numbers during the summer months up to 400 m from the discharge. However, the affected area is slight since the heated effluent rises above the bottom as it flows offshore and thus presents no serious widespread threat.

The occurrence of ovigerous females among the amphipods of this area is shown in Table 2. Nagle (1968), in his study of the epibiota of macroepibenthic plants at Woods Hole, Massachusetts, observed common amphipods exhibiting almost continuous sexual activity, whereas scarcer forms bred only once a year. Such a pattern seems also to occur among the amphipod fauna of the lower Chesapeake Bay. There appear to be two patterns of sexual activity. Most species, including all the scarcer forms, are restricted to breeding during the warmer months. A few abundant species (Gammarus daiberi, Monoculodes edwardsi, Stenothoe minuta, and Sympleustes glaber) exhibit continuous sexual activity. However, these do have one or more peaks of fecundity throughout the year. G. daiberi and M. edwardsi have a peak of fecundity in April. S. minuta appears to have a peak in December and S. glaber has two peaks, one in the summer and the other in winter. Nagle concludes that staggering of these peaks and the resulting swells in populations often enable similar species to occupy the same niche but at different times of the year.

An estuary represents a rigorous environment with stress conditions becoming particularly severe as one moves up the estuary to the "gradient" zone (Rochford, 1951). This results in a low diversity of species and a high number of individuals among the biota in this region near the head of the estuary (Carriker, 1967). Such is the case with the amphipod population of the local estuaries. That this occurs can be shown by two means.

One is by Sanders' (1968) "Rarefaction Method." This method is unique in that it allows one to compare the diversity of different areas even though the samples are of unequal sizes. This is accomplished by using several simple calculations which make it possible to determine from a single sample of any area with a known number of species and individuals what the hypothetical diversity would be for any other sample from the same area as long as the number of individuals used is less than the original number. A regression can thus be constructed for each area showing the expected number of species for any number of individuals. If the regressions for several areas are plotted on one graph, it is then possible to compare the differences in their diversities. The limitations of this method are that the same group of organisms must be compared, the habitats must be similar, and the sampling procedure should be similar. By comparing only the amphipod fraction of the fauna collected from different sites within the York-Pamunkey system, these limitations were observed.

Using this "Rarefaction Method," the diversity regressions were calculated for each sampling site on the York-Pamunkey system from Y10 to P50. The initial sample for each site was obtained by summing all the monthly samples from September 1966 through April 1967. The results are presented in Figure 7. Since the closer a curve approaches the abscissa the lesser is the diversity, it is apparent that diversity drops from Y10 to P50. Although Sanders (1968) states it is meaningless to attempt to assign confidence limits to the curves, a distinct drop in diversity between the York River and the Pamunkey River is certainly apparent. This is more or less expected since the Pamunkey with its low salinity and rather poor bottom substrate offers a much more rigorous environment than does the York.

To compare the affinity of species between each collecting site on the York-Pamunkey system, a trellis diagram was constructed according to a method explained by Warinner and Brehmer (1966). In this method "correlation coefficients" were obtained by listing all the species found at each of the collecting sites from September 1966 through April 1967. In each column representing a separate site, the abundance of a particular species was recorded as a percentage of the total number of all individuals collected at that site. These total numbers can be obtained from Figure 7 by looking at the extreme point for each sampling site and then reading the corresponding sample size on the abscissa. To compare any two sites as to species affinity, a sum was made of the lesser percentages for each species common to both samples. In this correlation method the relative affinity between two sites is reflected in the final percentage obtained. Since these percentages are based on fairly large sample sizes, there is reasonable certainty that they approximate the actual percentages. The higher the percentage, the greater the affinity. It is apparent from Table 3 that the Pamunkey has a much more homogeneous population than does the York. This agrees with and substantiates the results obtained from Sanders' "Rarefaction Method." Except during late summer, the population of the Pamunkey River is composed of only five species--*Gammarus daiberi*, *Monoculodes edwardsi*, *Corophium lacustre*, *Leptocheirus plumulosus*, and *Melita nitida*, in order of decreasing abundance.

As do all diversity indices, these two, while generally accurate, are subject to weaknesses from sampling methods. In addition, both methods of measuring diversity are only valid when the fauna in question is randomly or evenly dispersed rather than aggregated. Thus, it must be emphasized that these results are based on the assumption that the amphipod fauna of the York-Pamunkey system is randomly dispersed or nearly so.

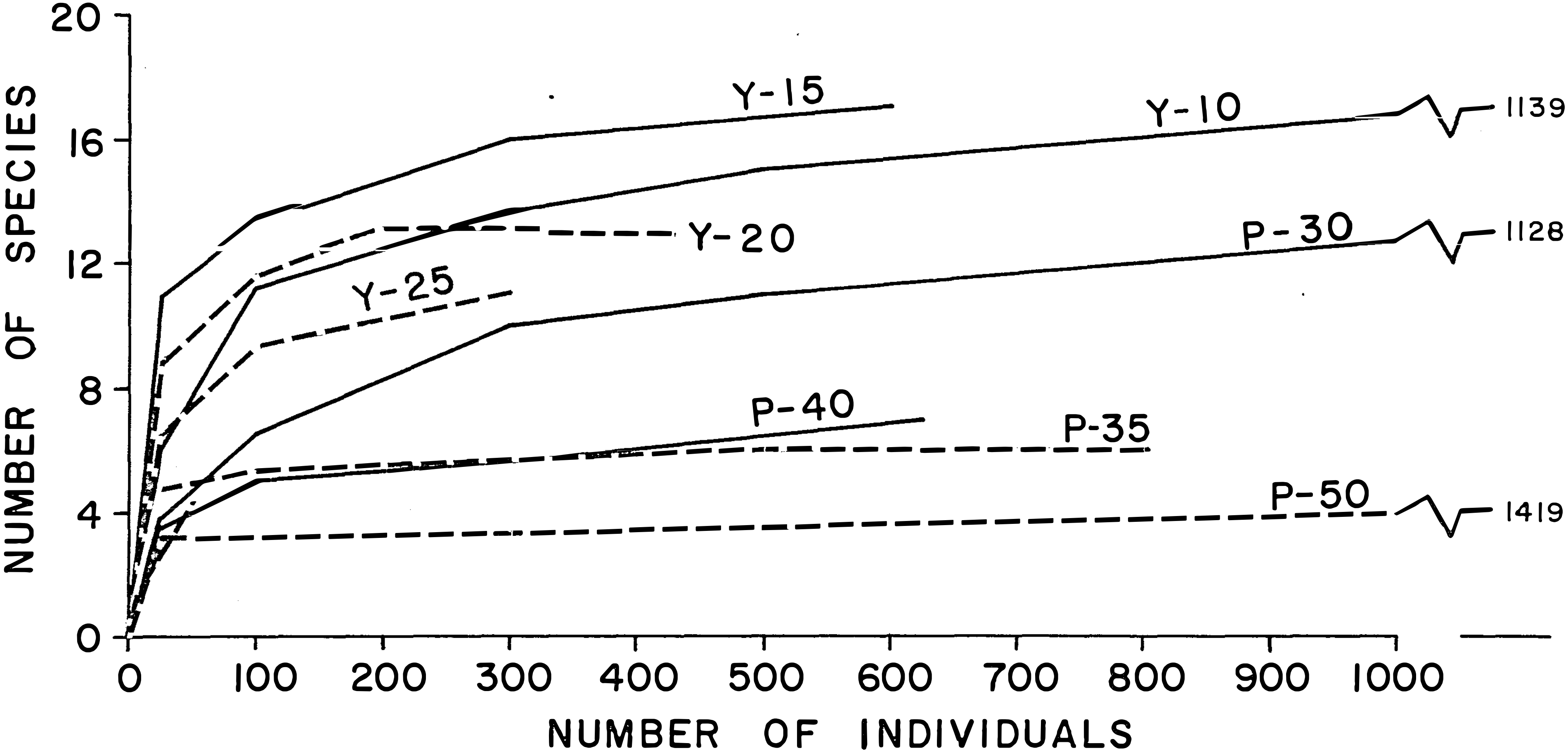

Figure 7. Diversity of amphipod species of the York-Pamunkey system as estimated by Sanders' "Rarefaction Method."

Table 3. Correlation coefficients of York-Pamunkey system sampling sites.

	Y10	Y15	Y20	Y25	P30	P35	P40	P50
Y10	100							
Y15	52	100						
Y20	19	34	100					
Y25	8	23	34	100				
P30	2	3	11	22	100			
P35	4	17	40	42	65	100		
P40	4	6	48	31	46	67	100	
P50	0	0	38	21	69	79	70	100

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APPENDIX

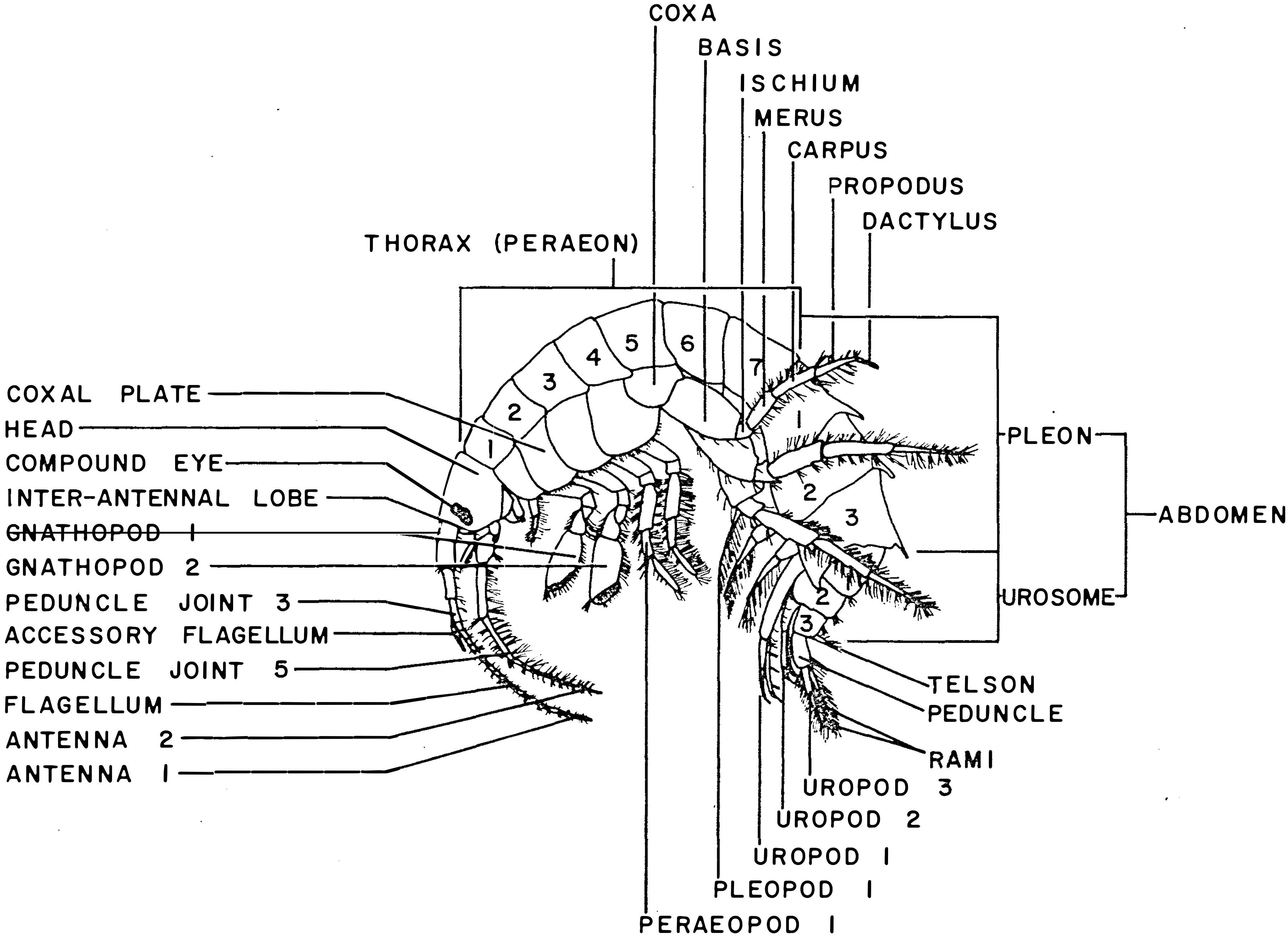

Figure 8. Gammarus mucronatus (after Kunkel, 1918).

APPENDIX

The following key is intended to be used only as a means for quickly separating gammarid amphipods present in the lower Chesapeake Bay and its adjacent waters by persons not expert in amphipod taxonomy. It should not be construed as a definitive taxonomic description of these species and their families. External structures referred to in the key are shown in Figure 8.

KEY TO THE SUBORDER GAMMARIDAE OF THE LOWER CHESAPEAKE BAY

Key to the Families

1. Eyes four, each with a simple lens..............Ampeliscidae
   Eyes two, compound, may be rudimentary, absent, or, in one case, united..2

2. Abdomen flattened dorsoventrally............................3
   Abdomen not flattened dorsoventrally........................4

3. Antennal flagella uniarticulate; adult less than 2mm long ....Colomastigidae, Colomastix sp.
   Antennal flagella multiarticulate; adult more than 2mm long ....Corophiidae

4. Terminal uropods uniramous..................................5
   Terminal uropods biramous, inner ramus may be minute.......6

5. First and second antennae nearly equal; coxal plates greatly enlarged......................................Stenothoidae
   First antenna shorter than peduncle of second antenna; coxal plates not enlarged............................Talitridae

6. Terminal uropods with short rami not equaling peduncle, the outer uncinate..7
   Terminal uropods with at least one ramus equal to or longer than peduncle, uncini lacking...........................8

7. Inter-antennal lobes small; outer lobes of lower lip notched; antenna 1 longer than antenna 2................Ampithoidae
   Inter-antennal lobes prominent; outer lobes of lower lips entire; antenna 1 shorter than antenna 2...Ischyroceridae, ...Jassa falcata

8. Accessory flagellum present, may be of only one minute article 9
   Accessory flagellum lacking................................12

9. Either pair of gnathopods well developed..................10
   Gnathopods poorly developed................................14

10. Antenna 1 short, 1/5 body length..............Liljeborgiidae
    Antenna 1 greater than 1/5 body length....................11

11. Gnathopods equal or second larger than first......Gammaridae
Gnathopods not equal, first larger than second.......Aoridae

12. Eyes united, forming one diamond-shaped eye; eye sometimes bleached in preserved specimens but ommatidia visible..... ....Oedicerotidae, Monoculodes edwardsi
Eyes not united..13

13. Antenna 1 shorter than antenna 2; eyes very large; telson cleft.......................Bateidae, Batea catharinensis
Antenna 1 longer than antenna 2; eyes distinct; telson entire...Pleustidae

14. Rostrum expanded into hood over the antennae................ ....Phoxocephalidae, Paraphoxus epistomus
Rostrum not expanded into hood over the antennae..........15

15. Appendages abundantly setose; telson cleft......Haustoriidae
Appendages sparsely setose; telson entire................... ....Lysianassidae, Lysianassa alba

Key to Species Arranged by Families

Ampeliscidae

1. Antenna 1 in female usually shorter than peduncle of antenna 2; head about as long as first three segments of thorax... ....Ampelisca verrilli
Antenna 1 in female exceeding peduncle of antenna 2 by one-half; head markedly shorter than first three segments of thorax..2

2. Posterodorsal angle of segment 3 of urosome sharply upturned; lateral margin of outer ramus of uropod 2 with 3-5 spines ....Ampelisca vadorum
Posterodorsal corners of urosome segment 3 rounded; uropod 2 with 1-2 spines on margin of outer ramus. Ampelisca abdita

Ampithoidae

1. Accessory flagellum a single minute article; gnathopods with plumose setae.............................Cymadusa compta
Accessory flagellum absent; gnathopods lacking plumose setae. 2

2. Antenna 1 as long as body; gnathopod 2 propodus nearly twice as long as wide, palm oblique...........Ampithoe longimana
Antenna 1 half as long as body; gnathopod 2 massive, nearly as wide as long, palm oblique.............Ampithoe valida

Aoridae

1. Gnathopods subchelate in one or both pairs...............2
   Gnathopods scarcely subchelate...........*Rudilemboides* sp.

2. Gnathopods subchelate in male and in gnathopod 1 of female ....*Lembos smithi*
   Gnathopod 2 simple................*Leptocheirus plumulosus*

Corophiidae

1. Accessory flagellum present; body white with pink patterning....................................*Unciola irrorata*
   Accessory flagellum absent; body darkly patterned........2

2. Second antenna conspicuously larger than first...........3
   Second antenna not conspicuously larger than first.......7

3. Uropods one and two attached ventrally; urosome with raised lateral margins forming a ridge and lacking notches....4
   Uropods one and two inserted in notches in lateral margins of urosome; latter lacking raised margins..............5

4. Antenna 2, segment 4, with setose dorsal surface, and in both sexes possessing two unequally large, anteriorly directed, distal teeth; entire urosome covered with a velvety pubescence; polyhaline species..............*Corophium simile*
   Antenna 2, segment 4, with sparsely setose dorsal surface, and only male possesses two distal teeth; female bearing one weak tooth on antenna 2, segment 4; urosome not covered by a pubescence; very common oligohaline species........ ....*Corophium lacustre*

5. Antenna 2, segment 4 with a large terminal tooth and a smaller one above (males)..................................6
   Antenna 2, segment 4 armed only with spines (females)....7

6. Antenna 2, segment 4 quite setose; rostrum obtusely rectangular........................*Corophium tuberculatum* male
   Antenna 2, segment 4 with few short setae; rostrum minute ....*Corophium acherusicum* male

7. Antenna 2, segment 5 without spines...................... ....*Corophium tuberculatum* female
   Antenna 2, segment 5 with one or two spines............... ....*Corophium acherusicum* female

8. First segment of antenna 1 greatly enlarged; carries tube which it constructs; uropods 2 and 3 uniramous; eyes dull ....*Cerapus tubularis*
   First segment of antenna 1 not greatly enlarged; only rudimentary uropod 3 uniramous; eyes often red.............. ....*Ericthonius brasiliensis*

1. Antenna 2 scarcely longer than peduncle of first; terminal uropods projecting little beyond the others...Elasmopus levis
   Antenna 2 much longer than peduncle of first; terminal uropods flattened, projecting well beyond the others...2

2. Eyes oval; inner ramus of terminal uropods minute........3
   Eyes reniform; inner ramus of terminal uropods distinct..4

3. Left or right gnathopod 2 of male greatly enlarged; posterior borders of abdominal segments forming spines.......................................Melita appendiculata
   Neither second gnathopod of male larger than other; posterior borders of abdominal segments smooth..Melita nitida

4. Pleon segments with a conspicuous dorsomedial spine projecting backward to form a sharply acute tooth (sometimes missing in young specimens); antennal peduncular segments weakly setose........................Gammarus mucronatus
   Pleon segments without a medial spine; antennal peduncular segments strongly setose...............................5

5. Coxal plate 1 with several very short setae lining anteroventral margin, urosome segments dorsally flattened, with short dorsomedial spines..............Gammarus palustris
   Coxal plate 1 with several(5-8)long setae at anteroventral angle; urosome segments dorsally raised, with ~~distinct dor-~~somedial spines.......................................6

6. Urosome segments with distinct dorsal "hump"; antenna 1, peduncular segment 2 with only one major cluster of posterior marginal setae; antenna 2 bearing straight setae in males and females; freshwater......Gammarus fasciatus
   Urosome segments with only small dorsal elevation; antenna 1, peduncular segment 2 with 3-5 groups of posterior marginal setae; antenna 2 and peraeopods with curly setae in male; oligohaline to mesohaline........................7

7. Antenna 1, basal flagellar segments with alternate posterior setae longer than twice the width of respective segments; antenna 2, peduncular segments 4, 5-6 setae per cluster; most abundant oligohaline Gammarus in lower Chesapeake tributaries.........................Gammarus daiberi
   Antenna 1, basal flagellar segments with alternate posterior setae short, scarcely exceeding width of segment; antenna 2, peduncular segments 4,5 with about 3 setae per cluster; predominantly mesohaline..........Gammarus tigrinus

Haustoriidae

1. Body slender, peraeon segments lacking lateral lobes, rostrum lacking, eyes easily seen Bathyporeia sp.
   Body broad, peraeon segments laterally lobate, rostrum distinct, eyes not evident....................................2

2. Rostrum elongate..............................Haustorius sp.
   Rostrum short, triangulate..................................3

3. Rostrum shorter than anterolateral angles..................4
   Rostrum exceeding anterolateral angles.....................5

4. Peraeopod 3, segment 5 narrow, posterodistal margin with 2 spines, uropod 2 uniramous.........Neohaustorius schmitzi
   Peraeopod segment 5 broad distally, posterodistal margin with 8 spines, uropod uniramous.....Lepidactylus dytiscus

5. Pleosome 3 with posterodorsal subconic process, side plate with weak spine; peraeopod 5, coxal plate posteriorly quadrate.........................Acanthohaustorius intermedius
   Pleosome 3, posterodistal margin normally rounded behind, side plate with large spine; peraeopod 5, coxal plate posteriorly acute...................Acanthohaustorius millsi

Liljeborgiidae

1. Antenna 1 shorter than peduncle of antenna 2; gnathopod 1 larger than gnathopod 2......................Idunella sp.
   Both antennae short and subequal to each other, gnathopod 2 larger than gnathopod 1.................................2

2. Propodus of gnathopod 2 with large square projection near attachment of dactyl; dactyl of peraeopod 5 short, subconical............................Listriella clymenellae
   Propodus of gnathopod 2 smooth near attachment of dactyl; dactyl of peraeopod 5 slender, elongate..................
   ....Listriella barnardi

Pleustidae

1. Mandible possessing ridged molar tubercle; common species
   ....Sympleustes glaber
   Mandible lacking molar tubercle; very rare.................
   ....Parapleustes sp.

Stenothoidae

1. Pereopods 4 and 5: article 2 linear; fourth pair of coxal plates greatly enlarged..............Parametopella cypris
   Pereopods 4 and 5: article 2 expanded; fourth pair of coxal plates not greatly enlarged.............................2

2. Palm of gnathopod 2 in male only 1/2 length of propodus; latter convex ventrally..................*Stenothoe minuta*
Palm of gnathopod 2 in male extending full length of propodus; latter concave ventrally......*Stenothoe gallensis*

Talitridae

1. Female gnathopod 1 simple..................................2
Female gnathopod 1 subchelate..............................3

2. Eye covering about 1/10 of side of head, antenna length 1/3 of body in female, equal to body in male; male gnathopod 2 propodus nearly twice as long as deep.................... ....*Talorchestia longicornis*
Eye covering about 1/2 of side of head; antennae much shorter than in *longimanus*; male gnathopod 2 propodus nearly as deep as long..................*Talorchestia megalophthalma*

3. Propodus of male gnathopod 1 with dactyl reaching only to base of distal rounded lobe..............*Orchestia uhleri*
Dactyl reaching extremity of distal lobe of propodus......4

4. Outer ramus of uropod 1 smooth except for terminal spines. ....*O. platensis*
Outer ramus of uropod 1 with lateral spines......*O. grillus*

INDEX TO SPECIES BY GENERA