1968

Hydrozoa of Southern Chesapeake Bay

Dale R. Calder
College of William and Mary - Virginia Institute of Marine Science

HYDROZOA OF SOUTHERN CHESAPEAKE BAY

A Thesis

Presented to

The Faculty of the School of Marine Science

The College of William and Mary in Virginia

In Partial Fulfillment

Of the Requirements for the Degree of

Doctor of Philosophy

By

Dale Ralph Calder

1968

APPROVAL SHEET

This thesis is submitted in partial fulfillment of

the requirements for the degree of

Doctor of Philosophy

Dale Ralph Calder

Dale Ralph Calder

Approved, July 1968

M. L. Brehmer, Ph.D., Major Professor

J. D. Andrews

J. D. Andrews, Ph.D.

W. J. Hargis, Jr., Ph.D.

M. M. Nichols

M. M. Nichols, Ph.D.

Marvin L. Wass

M. L. Wass, Ph.D.

W. J. Hargis, Jr., Ph.D.
Dean, School of Marine Science

DEDICATION

This thesis is dedicated with heartfelt thanks to my parents, Mr. and Mrs. Wilfred Calder, for their many sacrifices on my behalf.

ACKNOWLEDGMENTS

It is a pleasure to acknowledge with gratitude the help of Dr. M. L. Brehmer, Virginia Institute of Marine Science, under whose supervision this research was conducted. His patience, assistance, encouragement, and ready provision of the necessities required for the study are sincerely appreciated. Thanks are due the following hydrozoan specialists for their aid: Dr. Sears Crowell, Indiana University; Dr. P. L. Kramp and Dr. K. W. Petersen, Universitetets Zoologiske Museum, Copenhagen, Denmark; Dr. N. A. H. Millard, Zoology Department, University of Cape Town, South Africa; and the late Dr. W. J. Rees, British Museum (Natural History), London, England. I am indebted to the following staff members of VIMS for their loan of apparatus used in the project: Mr. D. S. Haven, Dr. E. B. Joseph, Mr. R. Morales-Alamo, and Mr. W. I. Simmonds. Mr. M. Castagna and Mr. P. E. Chanley of the VIMS Wachapreague Laboratory aided in providing compressed air for SCUBA early in the study. Miss Evelyn Wells, VIMS librarian, is to be thanked for her assistance in procuring the necessary literature. Salinities were determined by Mr. Weston Eayrs of VIMS. I am grateful to the following persons who either provided specimens or aided in their collection: Victor Burrell, Elizabeth Calder, Harold Cones, James Feeley, James Greene, Sarah Haigler, William Johnson, Gail Mackiernan, Alex Marsh, James Melvin, Morris Roberts, W. A. Van Engel, Dr. M. L. Wass, and particularly Reinaldo Morales-Alamo for his large collection made during 1959-1961. I am obligated to my wife, Elizabeth, for her patience throughout the study and for typing the original manuscript. Mrs. Beverly Ripley is to be thanked for typing the final copy. The constructive criticisms of the manuscript by Dr. J. D. Andrews, Dr. M. L. Brehmer, and Dr. M. L. Wass are greatly appreciated.

This study was supported in part by contract NBy-46710 from the Bureau of Yards and Docks, United States Navy.

TABLE OF CONTENTS

	Page
ACKNOWLEDGMENTS	iv
LIST OF TABLES.	vii
LIST OF FIGURES	ix
LIST OF PLATES.	x
ABSTRACT.	xi
INTRODUCTION.	2
MATERIALS AND METHODS . .	7
RESULTS	
Taxonomic Account. .	13
Life History	
Dipurena strangulata. .	90
Bougainvillia rugosa. . .	95
Proboscidactyla ornata. . .	99
Lovenella gracilis.	102
Phenology.	109
DISCUSSION.	125
LITERATURE CITED.	144
APPENDIX.	156
VITA	

LIST OF TABLES

Table		Page
1.	Data on *Moerisia lyonsi* medusae from the James River, Virginia	28
2.	Comparison between *Clytia paulensis* hydroids from the York River, Virginia, and the south coast of South Africa . . .	61
3.	Comparison between *Obelia geniculata* hydroids from Chesapeake Bay, Virginia, with colonies from Deer Island in Passamaquoddy Bay, Canada	66
4.	Hydroids reported from the Virginia Institute of Marine Science (Virginia Fisheries Laboratory) collection up to 1959	88
5.	Data on laboratory-reared *Bougainvillia rugosa* medusae of different ages. .	98
6.	Summary of gross morphological differences between *Proboscidactyla ornata* populations from Virginia and the Gulf of Naples. . . .	103
7.	Occurrence of hydromedusae at Gloucester Point during 1966-1967.	116
8.	Number of hydroid cultures showing growth after 192 hours under two regimes of temperature	119

Table | Page

9. Influence of temperature on growth after 192 hours in laboratory cultures of hydroids 120

10. Influence of temperature on growth after 192 hours in laboratory cultures of hydroids. 121

11. Water temperatures at the beginning and end of activity for several species of hydroids 124

12. Zoogeographic comparisons of the hydroid fauna along the eastern United States . . 134

13. List of hydroids from Chesapeake Bay, with their east coast distribution. . . 135

14. Comparison of the neritic hydromedusae in the three provinces of Kramp's (1959) West Atlantic Boreal region 139

15. Zoogeographic comparisons of the neritic hydromedusae along the eastern United States. 140

16. List of hydromedusae known from Chesapeake Bay, and their east coast distribution. . 141

LIST OF FIGURES

Figure | Page

1. Southern Chesapeake Bay and adjacent waters. . . . .

2. Water temperature at Gloucester Point, 1966-1967 110

3. Salinity at Gloucester Point, 1966-1967 111

4. Seasonality of athecate hydroids in southern Chesapeake Bay. 113

5. Seasonality of thecate hydroids in southern Chesapeake Bay. 114

6. Seasonality of fixed gonophores 115

LIST OF PLATES

Plate

1. Hydroids, *Moerisia lyonsi* to *Cordylophora lacustris*.
2. Hydroids, *Turritopsis nutricula* to *Amphinema dinema*.
3. Hydroids, *Proboscidactyla ornata* to *Obelia bicuspidata*.
4. Hydroids, *Obelia commissuralis* to *Opercularella lacerata*.
5. Hydroids, ?"*Campanopsis*" sp. to *Halopteris tenella*.
6. Hydromedusae, *Moerisia lyonsi* to *Turritopsis nutricula*.
7. Hydromedusae, *Hydractinia arge* to *Obelia* sp.
8. Hydromedusae, *Eucheilota ventricularis* to *Cunina octonaria*.

ABSTRACT

Hydrozoans of southern Chesapeake Bay and its tributaries were studied from April 1965 until March 1968 to determine faunal diversity, seasonality and reproductive periodicities. Laboratory culture techniques were used in describing unknown or inadequately known stages in the life history of several species and as an aid in identification. A total of 55 species was identified, including 43 hydroids and 32 medusae. Of these, 22 hydroids and 15 medusae are reported in Chesapeake Bay for the first time. Two species earlier reported from the bay, Eudendrium carneum and Blackfordia virginica, were not found. Clytia paulensis and the hydroid of Proboscidactyla ornata are previously unreported in North America, and the hydroid of Amphinema dinema is recorded for the first time from the North American Atlantic coast. The southern range of Hybocodon prolifer, Obelia longissima and Opercularella pumila is extended, as is the northward range of Podocoryne minima, Clytia kincaidi and Phialucium carolinae. Both hydroids and hydromedusae show an affinity with the Carolinian Zoogeographic Province; 76% of the hydroids and 77% of the hydromedusae occur south of Cape Hatteras, while 59% of the hydroids and 35% of the hydromedusae occur north of Cape Cod. The hydroid of Dipurena strangulata and the older medusae of Bougainvillia rugosa and Lovenella gracilis are described for the first time. Partial life histories are described for four other species. The genus Calyptospadix Clarke, 1882 is placed in synonymy with Bimeria Wright, 1859.

Hydroids are shown to be characteristically seasonal in occurrence due to the annual water temperature range, which varies from approximately 2 C to 28 C. During seasons of inactivity, laboratory-tested species, Ectopleura dumortieri, Bougainvillia rugosa and Eudendrium ramosum, remained in a dormant state in the stems, stolons, or both, until favorable temperatures returned. Field observations on other hydroid species indicated a similar phenomenon. Dormant stages are resistant to unfavorable temperatures and may have important implications on hydrozoan zoogeography. In nature, the temperature at which renewed growth commenced in spring for winter-dormant species was higher than that at which regression occurred in autumn, and the converse was true for summer-dormant species. This may be an adaptive mechanism insuring favorable conditions for growth once development has begun. Of 23 hydroids whose seasonality was studied in detail, 16 were "summer" species and 7 were "winter" species. Among the hydromedusae, seasonality was typically less prolonged, with a maximum diversity in late summer and early autumn and a minimum diversity in winter. Although undescribed species or endemics to the bay were not found, two unidentified hydroids, "Campanulina" sp. and

?"Campanopsis" sp., are not included in the literature for this coast and should not be ruled out as being new species, endemics, or both, until more is known about their biology.

HYDROZOA OF SOUTHERN CHESAPEAKE BAY

TAXONOMY, KEYS TO IDENTIFICATION, PHENOLOGY AND ZOOGEOGRAPHY, WITH LIFE HISTORIES OF FOUR SPECIES

INTRODUCTION

The Hydrozoa, a class in the phylum Coelenterata or Cnidaria, are characterized by non-cellular mesoglea, ectodermal gonads, tetramerous or polymerous radial symmetry, and craspedote medusae. The life cycle may include a polyp or hydroid stage only, a medusa stage only, or a metagenesis between the two. The hydroids reproduce asexually, are generally sessile, and may be solitary or colonial. The medusae reproduce sexually and are usually solitary and planktonic. A fertilized egg develops into a planula larva which settles and produces a polypoid phase, or develops into the medusa without an intermediate stage.

Metagenesis in the hydrozoans has caused much synonymy. Students of the plankton developed one system of nomenclature for the medusae, while benthic workers developed a separate one based on the hydroid. Mayer (1910a) noted that the medusae of an expedition usually went to one authority, while the hydroids were examined by another. Failure to appreciate the taxonomic significance of both stages, so prevalent in early work, no longer seems to be the case. Rees (1939a) stressed that both hydroid and medusa must be given equal consideration for taxonomic purposes. Russell (1953) attempted, where possible, to employ a unified system in his survey of the British Isles hydromedusae. On a worldwide basis, however, numerous life history studies are necessary before the problems of synonymy are resolved. Further confusion has resulted from the failure of certain North American systematists, notably Fraser, to adopt the taxonomic advances made by European workers. In this study, the classifications in Marine Biological Association (1957), Rees (1957a, 1966) and Vervoort (1946) have been followed.

Systematic study of North American Atlantic hydroids has proceeded with few interruptions since 1854 when Stimpson gave a synopsis of the marine invertebrates of Grand Manan Island, New Brunswick. Nevertheless, the work has been done by a relatively small number of scientists and few areas have been thoroughly investigated (Fraser, 1946). Early studies were made by Leidy (1855), Dawson (1858), McCrady (1858), and Packard (1863). Louis and Alexander Agassiz included the hydroids in their investigations, but much of their work is of little present value since many of their generic and specific descriptions, being inadequate, have been discarded or synonymized. According to Fraser (1944), their major contribution rested in their encouragement and support of marine research, the founding of the Penekese Laboratory and the Museum of Comparative Zoology at Harvard, and their association with the United States Fish Commission, all of which stimulated interest in marine life, including hydrozoans. Between 1870 and 1900, Verrill contributed a number of papers dealing at least in part with the Hydrozoa. Collections from the BLAKE, HASSLER, BACHE, and ALBATROSS were examined by Pourtales, Allman, Clarke, and Fewkes. In 1876 Clark reported briefly on New England hydroids, and in 1882 (as Clarke) published a paper on several Chesapeake Bay hydroids. Fewkes was active, particularly during the 1880's, at various locations from Tortugas, Florida, to New England and

Grand Manan Island. Kingsley (1901, 1910), Whiteaves (1872, 1901) and Stafford (1912) investigated the hydroids of boreal waters, while Versluys (1899) studied specimens from the West Indies region. During the early twentieth century, Nutting and Hargitt were the leading investigators. Nutting's (1900, 1904, 1915) monographs are notable for their thorough descriptions and excellent illustrations. The Bermudas fauna was studied by Verrill (1900), Congdon (1907), Smallwood (1910), and Bennitt (1922). During the 1930's, Leloup conducted a number of significant studies on American hydroids. The studies of Fraser (1910, 1912, 1913, 1915, 1918, 1921, 1924, 1926, 1927, 1931, 1937b, 1940, 1941, 1943, 1944, 1945, 1946, 1947) represent the most significant contribution to hydroid taxonomy and distribution on this coast. His 1944 monograph summarized most of the known species and their distribution along the coast up to its publication date and is invaluable despite its obsolete systematics. Zoogeography and relationships in American hydroids were given in his 1946 book.

In the two decades since Fraser's (1944) monograph, the hydroids of the east coast have been largely neglected except as material for physiological studies. However, a number of papers are of value since hydroids were included as part of a faunal survey (Behre, 1950; Bousfield and Leim, 1960; Ferguson and Jones, 1949; Pearse and Williams, 1951; Smith, 1964; Wass, 1965; Whitten, Rosene and Hedgpeth, 1950). A few papers have appeared discussing only one or two species of hydroids (Berrill, 1948b; Crowell, 1945, 1947; Crowell and Darnell, 1955). Since hydroids are of major importance in marine fouling, various fouling papers are a source of information (Calder and Brehmer, 1967; Cory, 1967; Fuller, 1946;

McDougall, 1943; Weiss, 1948; WHOI, 1952). In the Gulf of Mexico and Caribbean Sea, systematic work has proceeded uninterrupted, with reports by Fraser (1947), Deevey (1950, 1954), Fincher (1955), and Van Gemerden-Hoogeveen (1965). Recently, Vervoort (1968) reported on a collection from the Caribbean and included a check-list of the hydroids of the region.

The works of Mayer (1910a, 1910b) represent the major contribution to a knowledge of the hydromedusae of this coast. His monographs included most of the previously published information. Bigelow in his various papers, particularly those of 1915 and 1918, added to knowledge of species along the Mid-Atlantic. Sears (1954) summarized the species known from the Gulf of Mexico. In the last decade little has been done on the hydromedusae except for the work of Allwein (1967) at Beaufort, North Carolina.

Nothing has been written exclusively on the hydrozoans of Chesapeake Bay since Clarke (1882) described five new species from the area. Cowles (1930) briefly discussed the hydroids taken from the offshore waters of the bay, but little information was given other than the species collected. Mayer (1910a, 1910b) included a number of medusae from the bay but did not conduct an intensive study. Consequently, little is known about the species or seasonality of hydrozoans in Chesapeake Bay.

The primary goals of this investigation were to determine the hydroids occurring in the lower bay and its tributaries; to relate seasonal occurrence and reproductive periodicities of the more common species; and by laboratory culture techniques to complete undescribed phases in the life history of several species. Although plankton samples were collected regularly as an aid in life history work, it was not within the scope of this study to conduct an exhaustive survey of Chesapeake Bay hydromedusae, and samples were taken regularly only at Gloucester Point, Virginia.

MATERIALS AND METHODS

To determine the diversity of hydroids in southern Chesapeake Bay, collections were made from over 50 different stations in the bay and its tributaries from April 1965 until March 1968 (Appendix A). Additional information was obtained from a hydroid collection made at Gloucester Point from 1959 to 1961 by Mr. R. Morales-Alamo of VIMS. Specimens and data from a fouling survey conducted in Hampton Roads from May 1964 until May 1966 were also used. This involved test panel surveys (Calder and Brehmer, 1967) and dredging operations at selected stations in the harbor.

The region of study extended from the Rappahannock River on the north, southward to the Chesapeake Bay Bridge-Tunnel at the entrance of the bay, and included the Rappahannock, York, and James river estuaries (Fig. 1). Occasional collections were made on the bay side of Virginia's eastern shore. Collecting was undertaken at intervals of approximately one month at the following stations:

Rappahannock River..........Hog House Ground
..........Bowler's Rock
York River..................Page's Rock
..................Bell Rock
Elizabeth River.............Hospital Point
James River.................Nansemond Ridge
.................Middle Ground
.................Deep Water Shoal

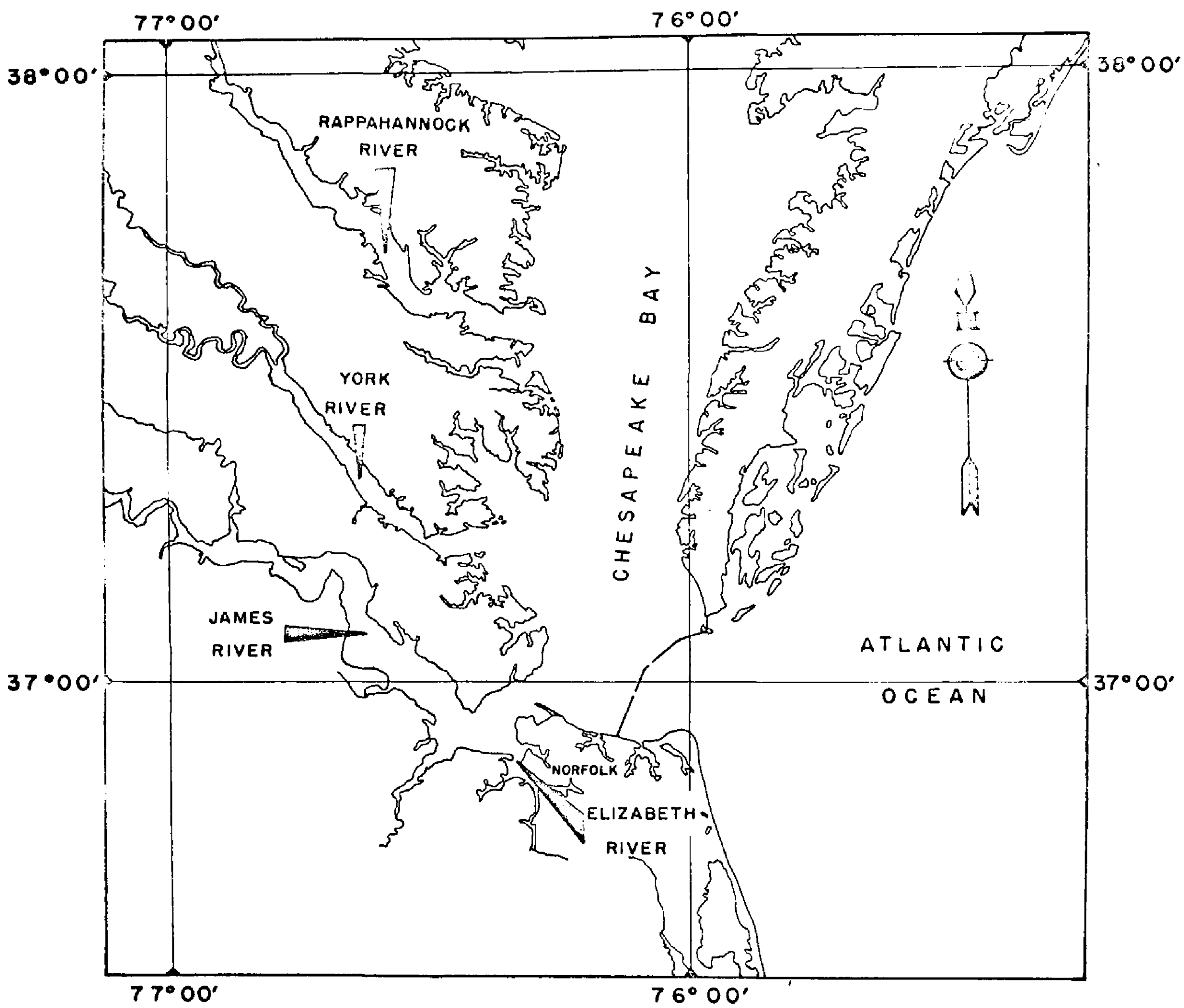


Fig. 1. Southern Chesapeake Bay and adjacent waters.

Dredging, manual collecting and diving were the principal methods used in collection. Dredging was usually conducted from an outboard boat, although occasional collections were made aboard the R/V LANGLEY. When using a small boat, modified oyster dredges were used. Diving with and without SCUBA permitted in situ examination and collection of specimens on submerged substrates. Test panels were employed, but no attempt was made to quantify the results. Acrylic plastic and asbestos fiber test panels were mounted on a wooden fouling rack and submerged to a depth of 2.5 m from the VIMS west pier. From February until June 1966, the panels were examined and replaced with clean substrates twice monthly. From June until October 1966, the panels were examined and returned to the fouling rack with the fouling assemblage intact. Nine wooden test panels were submerged from an experimental piling secured from the VIMS west pier beginning January 1967. The piling supported three panels at each of three depths: mean low water, 1 m and 2 m below MLW. In each series, one panel was mounted horizontally, one vertically, and one inclined at 45° from the horizontal. The following substrate angles were thus provided: 0° (upper surface of horizontal panel), 180° (lower surface of horizontal panel), 90° (vertical panel, both surfaces), 45° (upper surface of inclined panel), and 135° (lower surface of inclined panel). Panels were removed and examined at intervals of approximately one month, then replaced on the piling and re-submerged.

Most collected specimens were returned to the laboratory in water-filled containers and examined alive. This not only resulted in better specimens for identification, but allowed for culture of hydroids whose identity was uncertain.

The seasonality of the more common species was determined by frequent field studies. Most of the species were readily available at Gloucester Point, and collecting was conducted regularly to determine activity-inactivity cycles. Reproductive periodicities were determined at the same time by noting the presence or absence of gonosomes.

The method of survival during seasons of inactivity and the effect of temperature on seasonal activity cycles was studied in three species: Ectopleura dumortieri, Bougainvillia rugosa and Eudendrium ramosum. Experiments were conducted in late February and early March 1967 when these species were inactive in nature. Stems lacking hydranths were cultured at temperatures characteristic of summer to determine whether exposure would result in growth and hydranth formation. Experimental groups were cultured in a constant temperature bath at 25±1 C, while a control was maintained concurrently in a bath at 5±1 C, a characteristic winter water temperature in the study area. Experimental and control groups each consisted of 10 stems of the three species tested. Each stem was placed in a bottle (65 ml capacity) filled with filtered seawater of 20.0 o/oo salinity. Water was changed every 48 hours to minimize differences in dissolved oxygen content. Any specimens developing hydranths were fed once daily to prevent possible regression due to starvation. Artemia nauplii cultured in filtered 20.0 o/oo seawater were used as food. After 192 hours, presence or absence of growth and hydranths was recorded. In the second phase of the experiment, five bottles of each species were removed from the 25 C bath and placed in the 5 C bath, and vice versa, to check the temperature effects observed in the first phase. Five bottles of each species were kept at the original temperature as controls. Procedures employed in the first phase were repeated, and final observations were again recorded after 192 hours. Results were treated statistically using the chi-square test as outlined in Alder and Roessler (1962).

Laboratory culture was necessary for identification of several hydroids encountered; in some cases medusae were necessary for specific or generic determination. In those species producing free medusae, hydroid colonies were usually isolated in large fingerbowls containing filtered seawater. The liberated medusae were examined or, if further rearing was necessary, were removed to jars or petri dishes containing filtered seawater of a known salinity and maintained either in an air conditioned room or a constant temperature room at a selected temperature. Seawater was changed daily, and medusae were fed *Artemia* nauplii, larvae of *Arenicola marina*, or pieces of enchytraeid worms.

Nematocysts were examined by dipping live specimens in distilled water and staining with methylene blue. Weill's (1934) classification was followed in identification. All measurements were made with an ocular micrometer.

Weekly plankton samples were taken from the east and west piers at VIMS from September 1966 through December 1967. A #20 mesh plankton net with a diameter of 11.5 cm was employed in collecting. The net was either secured to the pier and allowed to strain water during flood or ebb tide, or was pulled by hand for several lengths of the pier. Collections were examined alive or were preserved in formalin and examined later. As a supplement, selected samples in the VIMS plankton collection were examined, mainly those from the entrance and southeastern regions of the bay. A collection of the hydromedusae previously sorted from the collections was examined as well.

All salinities were determined using an Industrial Instruments Inc. model RS-7A induction salinometer. Temperatures were measured by stem thermometers. Dissolved oxygen values were obtained by the Winkler method. The classification of salinity followed was that of Rodriguez (1963) whose system was that approved by the Venice Symposium on the Classification of Brackish Waters. The system is as follows:

Euhaline..........................40-30 o/oo

Mixohaline

Polyhaline...................30-18 o/oo

Mesohaline...................18-5 o/oo

Oligohaline..................5-0.5 o/oo

Limnetic..........................less than 0.5 o/oo

Original descriptions or re-descriptions were made from living or freshly preserved specimens. Most other descriptions were made from formalin-preserved specimens in the author's collection. Drawings were made from photomicrographs or with the aid of camera lucida or microprojector.

RESULTS

TAXONOMIC ACCOUNT

A total of 55 species of hydrozoans, including 43 hydroids and 32 medusae, are reported for southern Chesapeake Bay in the following list. Of these, *Eudendrium carneum*, a hydroid, and *Blackfordia virginica*, a hydromedusa, are included from literature records only; the remainder were identified from specimens examined during this survey.

The range given in the narrative section refers to the North American Atlantic coast only.

Phylum Cnidaria

Class Hydrozoa

Order Anthomedusae (Athecata)

Suborder Capitata

Family Moerisiidae

Moerisia lyonsi	hydroid & medusa

Family Tubulariidae

Ectopleura dumortieri	hydroid & medusa
Hybocodon prolifer	medusa
Tubularia crocea	hydroid, no medusa produced

Family Halocordylidae

Halocordyle tiarella	hydroid & medusa

Family Corynidae

Dipurena strangulata	hydroid & medusa

Sarsia tubulosa	hydroid & medusa
Linvillea agassizi	hydroid & medusa
Family Zancleidae	
Zanclea costata	hydroid & medusa
Suborder Filifera	
Family Clavidae	
Cordylophora lacustris	hydroid, no medusa produced
Turritopsis nutricula	hydroid & medusa
Family Hydractiniidae	
Hydractinia arge	hydroid & medusa
Hydractinia echinata	hydroid, no medusa produced
Podocoryne minima	medusa
Family Rathkeidae	
Rathkea octopunctata	medusa
Family Bougainvilliidae	
Bougainvillia carolinensis	medusa
Bougainvillia rugosa	hydroid & medusa
Bimeria cerulea	hydroid, no medusa produced
Bimeria franciscana	hydroid, no medusa produced
Aselomaris michaeli	hydroid, no medusa produced
Nemopsis bachei	medusa
Family Pandeidae	
Amphinema dinema	hydroid & medusa
Family Proboscidactylidae	
Proboscidactyla ornata	hydroid & medusa
Family Eudendriidae	
Eudendrium album	hydroid, no medusa produced

Eudendrium carneum	hydroid, no medusa produced
Eudendrium ramosum	hydroid, no medusa produced

Order Leptomedusae (Thecata)

Family Haleciidae

Halecium gracile	hydroid, no medusa produced

Family Campanulariidae

Clytia cylindrica	hydroid
Clytia edwardsi	hydroid, young medusa
Clytia hemisphaerica	hydroid
Clytia kincaidi	hydroid
Clytia paulensis	hydroid, young medusa
Obelia bicuspidata	hydroid, young medusa
Obelia commissuralis	hydroid, young medusa
Obelia dichotoma	hydroid, young medusa
Obelia geniculata	hydroid, young medusa
Obelia longicyatha	hydroid
Obelia longissima	hydroid, young medusa
Gonothyraea loveni	hydroid, no medusa produced
Hartlaubella gelatinosa	hydroid, no medusa produced

Family Lovenellidae

Eucheilota ventricularis	medusa
Lovenella gracilis	hydroid & medusa

Family Phialellidae

Opercularella pumila	hydroid, no medusa produced
Opercularella lacerata	hydroid, no medusa produced

Family Phialuciidae

Phialucium carolinae	medusa

Incertae Sedis

Blackfordia virginica	medusa
?"*Campanopsis*" sp.	hydroid
"*Campanulina*" sp.	hydroid, young medusa

Family Eutimidae

Eutima mira	medusa

Family Sertulariidae

Dynamena cornicina	hydroid, no medusa produced
Sertularia argentea	hydroid, no medusa produced

Family Plumulariidae

Halopteris tenella	hydroid, no medusa produced

Order Trachymedusae

Family Geryonidae

Liriope tetraphylla	medusa, no hydroid stage

Family Rhopalonematidae

Aglantha digitale	medusa

Order Narcomedusae

Family Cuninidae

Cunina octonaria	medusa, no hydroid stage

KEY TO CHESAPEAKE BAY HYDROIDA

1. Hydrotheca absent. . . . . (2)

   Hydrotheca present . . . .(23)

2. Hydranth with capitate tentacles . . . . (3)

   Hydranth with filiform tentacles only. . . . . (7)

3. Hydranth with filiform and capitate tentacles . . . . (4)

   Hydranth with capitate tentacles only. . . . . (5)

4. Filiform tentacles well developed, more than 4 in number, capitate tentacles in several regular distal whorls . . . . . <u>Halocordyle tiarella</u>

   Filiform tentacles reduced, 4 in number, capitate tentacles in one distal whorl. .<u>Dipurena strangulata</u>

5. Hydranth longer than stem, capitate tentacles short, scattered over hydranth. <u>Zanclea costata</u>

   Stem longer than hydranth, capitate tentacles scattered over hydranth . . . (6)

6. Hydranth clavate, tentacles 10-20, scattered over entire hydranth, medusa with 4 tentacles developed at liberation. <u>Sarsia tubulosa</u>

   Hydranth with a bulbous base bearing the tentacles, tentacles numerous, often 30 or more, medusa with 2 tentacles developed at liberation . . . . .<u>Linvillea agassizi</u>

7. Hydroids bilaterally symmetrical, with 2 tentacles only, commensal with sabellid polychaetes . . . .<u>Proboscidactyla ornata</u>

   Hydroids radially symmetrical, tentacles numerous. . . . . (8)

8. Filiform tentacles scattered . . . . (9)

   Filiform tentacles in one or more distinct whorls . . . .(11)

9. Colony regularly branched with well-developed stem, annulations present, gonophores fixed . . . . *Cordylophora lacustris*

Colony slightly branched or unbranched . . . .(10)

10. Perisarc thick, hydranth elongate. . . . *Turritopsis nutricula*

Perisarc thin, hydranth ovate. . . . . *Moerisia lyonsi*

11. Tentacles in two clearly distinct whorls, proximal whorl larger and longer than distal. . . . .(12)

Tentacles either in two close whorls or a single whorl . . . .(13)

12. Free medusae formed. . . . . *Ectopleura dumortieri*

Fixed gonophores formed, apical processes of gonophores laterally compressed. . . . . *Tubularia crocea*

13. Perisarc about zooids very thin or absent, zooids arising singly from a stolonal mat . . . .(14)

Zooids protected by thick perisarc . . . .(16)

14. Zooids tiny (1 mm or less), tentacles about 16, web absent at base of tentacles . . . .?"*Campanopsis*" sp.

Zooids several mm in height. . . . .(15)

15. Tentacles absent on gonozooids, spines present, sporosacs formed. . . . .*Hydractinia echinata*

Tentacles present on gonozooids, spines absent, degenerate medusae formed. . . . . *Hydractinia arge*

16. Free medusae formed. . . . .(17)

Fixed sporosacs formed . . . .(18)

17. Stem fascicled, medusa buds borne on the hydranth pedicels, medusa with 3 tentacles in each cluster at liberation. . . . . *Bougainvillia rugosa*

Zooids arising singly from a creeping stolon, medusa buds given off from the stolon, medusa with 2 tentacles only at liberation . . . .*Amphinema dinema*

18. Zooids arising singly from the stolon. . . . (19)

Colony forming an upright stem with branches. . . . . (20)

19. Hypostome conical, sporosacs given off from hydranth pedicel only. . . . . *Aselomaris michaeli*

Hypostome trumpet-shaped, sporosacs given off from the base of the hydranth. *Eudendrium album*

20. Stem simple. . . . . (21)

Stem fascicled . . . . (22)

21. Each female gonophore with numerous planulae. . . . . *Bimeria cerulea*

Each female gonophore with a single planula . . . . *Bimeria franciscana*

22. Hydranths bright red, hydranths bearing gonophores aborted. . . . . *Eudendrium carneum*

Hydranth whitish with red endoderm, hydranths with gonophores little or not aborted . . . . *Eudendrium ramosum*

23. Hydrothecae free from stem, supported on a pedicel. . . . . (24)

Hydrothecae adnate on stem . . . . (41)

24. Hydrotheca saucer-shaped, not capable of covering hydranth, internodes long, stem straight . . . . *Halecium gracile*

Hydrotheca capable of covering hydranth. . . . . (25)

25. Hydrotheca campanulate, operculum absent . . . . (26)

Hydrotheca turbinate, operculum present. . . . . (38)

26. Stolon network with pedicels upright, occasionally branched; medusa free with 4 tentacles at liberation. . . . . . . (27)

Stolon network with upright stems, medusae or fixed sporosacs produced . . . . (31)

27. Hydrothecal margin strongly pleated, hydrotheca 450-540 u long, 172-218 u wide, pedicel thin. . . . . *Clytia kincaidi*

Hydrothecal margin not strongly pleated. . . . . (28)

28. Teeth on hydrothecal margin bicuspidate, hydrotheca 410-600 u long, 140-180 u wide. . . . . *Clytia paulensis*

Teeth on hydrothecal margin simple . . . .(29)

29. Hydrothecae very large, 750-1050 u long, 427-488 u wide, teeth 10-12, branching common, colonies up to 2 cm in height. . . . . *Clytia edwardsi*

Hydrothecae distinctly smaller . . . .(30)

30. Teeth 7-10, hydranth 300-435 u long, 172-248 u wide. . . . . *Clytia cylindrica*

Teeth about 12, hydranth 405-615 u long, 240-338 u wide. . . . .*Clytia hemisphaerica*

31. Teeth on hydrothecal margin truncate, sporosacs extruded into sac at top of gonangium. . . . .*Gonothyraea loveni*

Teeth on hydrothecal margin bicuspidate, simple, indistinct or absent. . . . .(32)

32. Gonophores producing fixed sporosacs, teeth about 10, each with a V-shaped indentation . . . . *Hartlaubella gelatinosa*

Gonophores producing medusae with 8 or more tentacles at liberation . . . . . .(33)

33. Diaphragm very thick, stem geniculate, usually unbranched, pedicels very short, arising from a distinct internodal shoulder, hydrothecal margin entire . . . . *Obelia geniculata*

Diaphragm thin . . . .(34)

34. Hydrothecal margin wavy. . . . .(35)

Hydrothecal margin entire or with bicuspidate teeth . . . .(36)

35. Colony large, 25 cm, much branched, hydrothecae 585-662 u long, 339-431 u wide. . . . . *Obelia longissima*

Colony small, 4 cm, little branched, hydrothecae 375-428 u high, 225-300 u wide. . . . .*Obelia dichotoma*

36. Hydrothecal margin entire, hydrothecae 285-428 u high, 185-285 u wide, branches present. . . . . *Obelia commissuralis*

Hydrothecal margin with bicuspidate teeth . . . .(37)

37. Colony small (a few cm), hydrotheca 360-385 u long, 188-210 u wide. . . . . . *Obelia bicuspidata*

Colony often large (up to 25 cm), hydrotheca 480-563 u long, 188-225 u wide. *Obelia longicyatha*

38. Stem divided into cylindrical internodes by evenly spaced indentations, gonangia elongate, tapering gradually, several medusae per gonangium . . . . *Lovenella gracilis*

Stem annulated or wrinkled . . . .(39)

39. Opercular segments distinct, pedicels annulated throughout, occasionally branched, gonangia fusiform . . . . *Opercularella pumila*

Opercular segments rather indistinct, perisarc wrinkled . . . .(40)

40. Tentacles about 16, web absent at tentacle base, stem branched. . . . . . *Opercularella lacerata*

Tentacles 20-21, web present at base of tentacles, gonophores each producing 1 medusa . . . . "*Campanulina*" sp.

41. Nematophores present, hydrothecae on stem and branches, branching alternate, hydrocladia with (1) short internode lacking nematophores, node transverse at both ends, (2) longer internode, node transverse proximally, oblique distally, (3) thecate internode, node oblique proximally, transverse distally . . . . . *Halopteris tenella*

Nematophores absent, hydrothecae adnate on both sides of stem and branches. . . . .(42)

42. Colony usually unbranched, small (5 cm or less), hydrothecae opposite, perisarcal projections from base, hydrothecae contiguous for half their length in front, well apart but parallel in back, gonangia oval, rugose . . . .*Dynamena cornicina*

Hydrothecae alternate, stem much branched, colonies large (up to 25 cm), gonangia oval, two prominent shoulder spines . . . . *Sertularia argentea*

KEY TO CHESAPEAKE BAY HYDROMEDUSAE

1. Radial canals absent, margin divided into lobes, periphery with 8 square pouches . . . .*Cunina octonaria*

   Radial canals present, margin entire . . . . (2)

2. Ocelli present . . . . (3)

   Ocelli absent. . . . .(10)

3. Oral tentacles present . . . . (4)

   Oral tentacles absent. (6)

4. Oral tentacles unbranched, 3 marginal tentacles in each marginal cluster, ocelli typically fewer than marginal tentacles . . . .*Bougainvillia rugosa*

   Oral tentacles branched. . . . . (5)

5. Marginal tentacles all filiform, gonads only on manubrium, oral tentacles with long base and divided twice . . . .*Bougainvillia carolinensis*

   Two capitate marginal tentacles in each cluster, gonads extending along radial canals . . . . *Nemopsis bachei*

6. Marginal tentacles all filiform. . . . . (7)

   Marginal tentacles all capitate. . . . . (9)

7. Manubrium simple, tubular, extending out of velar opening in adult . . . . *Sarsia tubulosa*

   Manubrium cruciform, lips present. . . . . (8)

8. Endoderm cells above manubrium greatly vacuolated, mesoglea thin . . . *Turritopsis nutricula*

   Endoderm cells not greatly vacuolated, mesoglea thick, gonads extending along radial canals. . . . . *Moerisia lyonsi*

9. Manubrium tubular, extending out of velar opening in adult, gonad in two rings on manubrium. . . . .*Dipurena strangulata*

   Manubrium cruciform, swollen, not extending out of velar opening. . . . .*Linvillea agassizi*

10. Medusa with fewer than four marginal tentacles . . . .(11)

Medusa with four or more marginal tentacles . . . .(12)

11. Of four tentacle bulbs only one bearing marginal tentacles, marginal tentacles 1-3, apex rounded, umbrella somewhat asymetrical . . . .*Hybocodon prolifer*

Of four tentacle bulbs, 2 or 3 bearing one marginal tentacle each, margin with warts . . . .*Amphinema dinema*

12. Medusa somewhat degenerate, marginal tentacles all rudimentary . . . .(13)

Medusa well-developed. . . . .(14)

13. Rudimentary tentacles 4. . . . .*Halocordyle tiarella*

Rudimentary tentacles 8. . . . .*Hydractinia arge*

14. Marginal tentacles with stalked nematocyst capsules, exumbrellar nematocyst tracks present . . . . *Zanclea costata*

Nematocysts on marginal tentacles not stalked, exumbrellar nematocyst tracks present or absent. . . . .(15)

15. Eight meridional nematocyst tracks on exumbrella, manubrium simple and tubular . . . . *Ectopleura dumortieri*

Exumbrellar nematocysts, if present, not in eight meridional tracks. . . . . . .(16)

16. Radial canals branched, primary radial canals four. . . . .*Proboscidactyla ornata*

Radial canals unbranched . . . .(17)

17. Statocysts absent. . . . .(18)

Statocysts present in the form of marginal vesicles or sensory clubs. . . . . .(19)

18. Four marginal tentacles, medusa buds on manubrium, gastric peduncle well-developed. . . . . *Podocoryne minima*

Eight tentacular bulbs each with 2-5 tentacles, medusa buds and gastric peduncle present. . . . .*Rathkea octopunctata*

19. Velum rudimentary, medusa flat, gonads round, tentacles numerous, 8 closed adradial marginal vesicles . . . . _Obelia_ spp.

Velum well-developed . . . .(20)

20. Manubrium considerably below velar opening on long gastric peduncle. . . . .(21)

Manubrium within subumbrellar cavity . . . .(22)

21. Gonads 8, ribbon-like, along both peduncle and radial canals, marginal warts present, marginal vesicles 8, tentacles 4 . . . . _Eutima mira_

Gonads 4, leaf-like, tentacles 8 . . . . . . _Liriope tetraphylla_

22. Radial canals 8, elongate gonads 8, pendant from radial canals near manubrium . . . . _Aglantha digitale_

Radial canals 4, gonads attached along entire length . . . .(23)

23. Lateral cirri present. . . . .(24)

Lateral cirri absent . . . .(25)

24. Medusa large (up to 10 mm wide), marginal vesicles 8 with numerous concretions, gonads 4 . . . . _Eucheilota ventricularis_

Medusa small (up to 3 mm wide), gonads when young 2, later 4; marginal vesicles variable in number with few concretions . . . . . _Lovenella gracilis_

25. Gonads extending from manubrium along radial canals, marginal vesicles 1-2 between successive tentacles . . . . _Blackfordia virginica_

Gonads along distal portion of radial canal, marginal vesicles 4 between successive tentacles. . . . . _Phialucium carolinae_

Order Anthomedusae

Suborder Capitata

Family Moerisiidae

Moerisia lyonsi Boulenger, 1908

Plate 1, Fig. A; Plate 6, Fig. A

Synonymy: Refer to Kramp (1961)---*Moerisia lyonsi*

Collection Records:

James River--Hog Island, Deep Water Shoal.

Substrates: Plant detritus, *Brachidontes recurvus* shells.

Description:

Hydroid--Tentacles arising 4/5 of distance apically, extensible, to 2.5 mm, numbering 4-10, all filiform. Polyp 1.3 mm high, 0.4 mm wide, girth maximal below tentacles in mid-region. Frustule-like buds forming below tentacles, growing outward and constricting off to settle and develop tentacles. Well-developed medusa buds not observed but apparently given off near base of tentacles.

Nematocysts:

stenoteles............10-12 x 8-10 u (undischarged)

desmonemes...........6-8 x 3-4 u (undischarged)

atrichous isorhizas...7.5-10 x 2.5-3.5 u (undischarged)

Medusa--Young medusa bell-shaped with four perradial tentacles and tentacle bulbs, diameter 0.5 mm, height 0.4 mm, manubrium short. One red ocellus per tentacle bulb. Radial canals 4, ring canal present. Nematocysts in rings about tentacles, some scattered over exumbrella. Mesoglea thin, velum broad, tentacle bulbs and manubrium cream-colored. Four interradial protuberances (precursors of interradial tentacle bulbs and tentacles) appearing in medusae of 0.7 mm diameter and height. Gonads developing in medusae of 1.1 mm diameter.

Nematocysts of young adult:

stenoteles............	8-12 x 7-9 u	(undischarged)
desmonemes............	7-8 x 3.5-4.5 u	(undischarged)
haplonemes............	7-9 x 3-4 u	(undischarged)

Data on adult medusae presented in Table 1. With increasing size, tentacles added continuously and diameter increased relative to height. Manubrium small, quadrangular. Perradial lips in large specimens occasionally crenulated, lips undeveloped in smaller specimens. Gonad surrounding manubrium, extending outward along the 4 radial canals nearly to ring canal, hanging down from radial canals into subumbrellar cavity, shape linear or slightly folded. Radial canals forming narrow median line, visible dorsally, along entire length of gonad lobes.

Remarks: *Moerisia lyonsi*, the only known representative of the family Moerisiidae in North America, was first reported from this continent by Calder and Burrell (1967). The specimens were found in plankton samples from low salinity waters of the James and Pamunkey rivers, Virginia, during the summer of 1965. No specific search for *M. lyonsi* was made after 1965 on the Pamunkey River, but the species is evidently established and capable of survival in Virginia since medusae were collected in this study during the summers of 1966 and 1967 in the James River near Hog Island.

Of the five presently recognized genera in the Moerisiidae, only *Moerisia* has more than one species. Distributionally, *M. lyonsi* is known from Lake Qurun in Egypt and from Virginia, *M.*

Table 1. Data on Moerisia lyonsi medusae from the James River, Virginia. Specimens captured during 1965 using a Clarke-Bumpus plankton net.

Character	Statistic	Collection date 29-VII-65	Collection date 14-VIII-65
	N	25	25
Tentacle number	mean	26	41
	mode	32	32
	range	16-37	29-64
	S.D.	5.80	9.81
Diameter (mm)	mean	3.2	5.2
	mode	3.2	5.0
	range	1.4-5.1	2.4-8.4
	S.D.	1.17	1.54
Height (mm)	mean	2.8	4.4
	mode	2.7	4.7
	range	1.2-4.6	1.8-7.0
	S.D.	1.01	1.28

pallasi occurs in the Caspian Sea, and *M. gangetica* was described from a single specimen collected in the Ganges estuary. Kramp (1961) considered *Ostroumovia horii* from Japan to be a *Moerisia*, and *Odessia maeotica* from the Black Sea, Mediterranean, and Atlantic coast of Morrocco may eventually be referred to *Moerisia* (Kramp, personal communication). The status of the various *Moerisia* species is uncertain at present since the original description of *M. lyonsi* was inadequate and detailed taxonomic study of the group is needed. Identification of Virginia specimens as *M. lyonsi* was made by Dr. W. J. Rees of the British Museum (Natural History). Representative medusae from Virginia have been deposited in the Universitetets Zoologiske Museum, Copenhagen, and in the British Museum (Natural History), London.

The Moerisiidae were placed by Kramp (1938a) in the order Limnomedusae, having the following features in common with other representatives of the order:

1. stomach quadrate.
2. tentacles hollow or with an endodermal core of more than one cell row.
3. tentacles with an endodermal root indicated.

Rees (1957b), noting that morphologically the Moerisiidae resembled the Capitata, found also that the cnidome was capitate-like, and as such, unlike that of other Limnomedusae. Rees (1958) removed the family to the Capitata but erected a new superfamily, the Moerisioidea, for the Moerisiidae since he regarded them as more primitive than other capitate Anthomedusae.

Moerisiid medusae are particularly well represented in the Middle East but have also been reported from western Europe, India, Japan, Australia, North America and South America. This widespread distribution poses a zoogeographical enigma since all but two genera, Tiaricodon and Odessia, have been found only in low salinity or fresh water. Saraber (1962) suggested that shipping was a possible means by which Ostroumovia inkermanica was introduced into the Netherlands. He believed the polyps, being more eurytolerant than the medusae, might survive in the crust of organisms on a ship's bottom, and once in favorable regions could produce medusae. Unfortunately, the range of temperature, salinity, and other important factors tolerated by moerisiid polyps has not been precisely determined experimentally either in the laboratory or in the field.

Family Tubulariidae

Ectopleura dumortieri (Van Beneden, 1844)

Plate 1, Fig. B; Plate 6, Fig. B

Synonymy: Refer to Kramp (1961)---Ectopleura dumortieri

Collection Records:

Rappahannock River--Hog House Ground.

York River--Tue Marsh light, Gloucester Point, Page's Rock, Aberdeen Creek.

James River--Sewell's Point, Hampton Bar, Norfolk Navy Base Pier 12, Middle Ground.

Substrates: rope, wood fouling rack, wire crab trap, fish nets, wood pilings, test panels (asbestos fiber, acrylic plastic), Halichondria bowerbanki, Crassostrea virginica shells, Balanus improvisus shell, Molgula manhattensis test.

Remarks: Ectopleura dumortieri is difficult to distinguish from certain Tubularia species when immature, but when mature, medusae are produced rather than actinulae. The hydroid was first identified in Chesapeake Bay by Dr. J. L. Wood of VIMS during October 1963 from specimens collected on rope suspended from a pier. The species was positively identified during this study on numerous occasions during 1966 and 1967. The hydroids were active from April until early January but showed marked seasonal changes in abundance. Colonies were common in spring, autumn, and early winter, being much less evident during summer. Additionally, most specimens collected during summer were small in size relative to spring and early winter hydroids. Medusae, not previously reported from the bay, were common in plankton samples during autumn. The hydroid evidently thrives in the mesohaline environment of the lower river estuaries, and on occasion may be collected in dense colonies. Fraser (1946) reported _E._ _dumortieri_ to be a small hydroid reaching little more than 1 cm in height, yet on 11 January 1967 specimens were collected which measured 26 cm in height. These specimens were collected at a depth of 5 m from a gill net stake just below Bell Rock, York River. Examined colonies commonly measured 3-5 cm in height.

Known Range:

Hydroid--Massachusetts to Chesapeake Bay.

Medusa--Massachusetts to Florida.

Hybocodon _prolifer_ L. Agassiz, 1862

Plate 6, Fig. C

Synonymy: Refer to Kramp (1961)---_Hybocodon_ _prolifer_

Collection Records:

Chesapeake Bay entrance, Station C-00.

Remarks: The record of this species is based on a single medusa taken in a Clarke-Bumpus plankton sample collected 29 February 1968 by V. G. Burrell, Jr. H. prolifer is a boreal species previously reported south to Delaware Bay where Deevey (1960) found it in February and April.

Known Range:

Hydroid--New England.

Medusa--Greenland to Chesapeake Bay.

Tubularia crocea A. Agassiz, 1862

Plate 1, Fig. C

Synonymy: Refer to Fraser (1944)---Tubularia crocea

Collection Records:

Chesapeake Bay--Kiptopeke, Fisherman's Island, pilings and islands of the Chesapeake Bay Bridge-Tunnel.

Substrates: rock, concrete, wood pilings, Mytilus edulis shells.

Remarks: The hydroids identified as T. crocea by Calder (1966) from Hampton Roads may have been Ectopleura dumortieri since the type specimen from that study, collected at Sewell's Point on 23 September 1965, was subsequently found to be E. dumortieri. Data from that study have not been included here for either species. Specimens of T. crocea were found in abundance during summer 1967 on the Chesapeake Bay Bridge-Tunnel, particularly along the eastern-most quarter of the span. In August it was the most conspicuous hydroid on pilings at Fisherman's Island but was not collected in the York River and is evidently limited to the southernmost part of the bay. Ferguson and Jones (1949) reported T. crocea from Norfolk but did not remark on its abundance.

Known Range:

Hydroid--Maritime Provinces to Florida and northern Gulf of Mexico.

Family Halocordylidae

Halocordyle tiarella (Ayres, 1854)

Plate 1, Fig. D; Plate 6, Fig. D

Synonymy: Refer to Fraser (1944)---*Pennaria tiarella*

Collection Records:

York River--Perrin, Gloucester Point.

James River--Norfolk Navy Base Pier 12.

Chesapeake Bay--Cape Charles.

Substrates: rope, wood pilings, asbestos fiber test panels, *Zostera marina*.

Remarks: During July and August 1967, the hydroid was common to abundant on the eelgrass bed in front of VIMS at Gloucester Point. After August no active colonies were found on eelgrass but were collected from rope and wood substrates adjacent to the VIMS piers. The species is active only during summer in Chesapeake Bay, as is also the case at Woods Hole (Hargitt, 1900) and Beaufort, North Carolina (McDougall, 1943). Hargitt noted that it evidently occurs in two conditions--an early phase on rockweed, piles, and similar substrates, usually in deeper water, and a later phase on eelgrass in shallow water. He was unable to find constant distinctive morphological differences between the two. According to Vervoort (1959), *H. tiarella* is probably a juvenile form of *H. disticha*, a species showing extreme variability under differing ecological conditions.

Known Range:

Hydroid--Massachusetts to the Caribbean Sea.

Medusa--Massachusetts to Florida.

Family Corynidae

Dipurena strangulata McCrady, 1858

Plate 1, Fig. E; Plate 6, Fig. E

Synonymy: Refer to Kramp (1961)---*Dipurena strangulata*

Collection Records:

York River--Gloucester Point, Page's Rock.

Substrate: *Microciona prolifera*.

Remarks: Although the medusa *D. strangulata* is moderately well known, its hydroid, described later in this report, has not previously been found. The hydroid was first observed on 18 June 1967, but the presence of medusa buds on specimens collected at that time suggests that the hydroid had been active for some time. Specimens were collected regularly at Gloucester Point in depths from 1.5 to 4 m throughout the rest of the summer and reappeared in collections made 13 May 1968. During its observed interval of activity, water temperatures ranged from a high of 28 C to a low of 10 C, and salinities varied roughly from 18 to 24 o/oo. Medusae were first collected in plankton samples on 29 June 1967, and throughout the summer *D. strangulata* was one of the most abundant medusae in the samples.

Known Range:

Hydroid--Chesapeake Bay.

Medusa--Massachusetts to Florida.

Sarsia tubulosa (M. Sars, 1835)

Plate 1, Fig. F; Plate 6, Fig. G

Synonymy: Refer to Fraser (1944)---*Syncoryne mirabilis*

Kramp (1961)---*Sarsia tubulosa*

Collection Records:

York River--Gloucester Point.

Substrates: Fiberglass wet table lining, *Bougainvillia rugosa* stems, *Crassostrea virginica* shells.

Remarks: The hydroid of this species was reported from the bay by Dr. W. G. Hewatt (Wass, 1965), but the record is suspect on seasonality grounds since Hewatt's record was for August (Table 4) and *S. tubulosa* is strictly a winter form in this area. It is probable that hydroids of *Linvillea agassizi* were misinterpreted as *S. tubulosa* since tht two are similar morphologically.

In light of the medusa's known distribution, the records of *S. tubulosa* hydroids in tropical and subtropical waters are subject to verification. Russell (1953) stated that *S. tubulosa* was a circumpolar boreal neritic species.

Known Range:

Hydroid--Greenland to Gulf of Mexico.

Medusa--Arctic Ocean to Chesapeake Bay.

Linvillea agassizi (McCrady, 1858)

Plate 1, Fig. G; Plate 6, Fig. F

Synonymy: Refer to Fraser (1944)---*Corynitis agassizii*

Collection Records:

York River--Gloucester Point, Page's Rock.

Substrates: *Cliona* sp., *Haliclona permollis*, *Microciona prolifera*, *Lissodendoryx isodictyalis*, *Halichondria bowerbanki*, *Crassostrea virginica* shells.

Remarks: The generic name *Linvillea* was erected by Mayer (1910c) to replace *Corynitis* and *Corynetes*, both of which were preoccupied. The hydroid of *Linvillea agassizi* is similar to certain species of *Sarsia*, but the medusa is readily distinguishable morphologically, having but two well developed tentacles at liberation. Mature medusae also have a cruciform manubrium and eight rows of exumbrellar nematocysts. There has been considerable confusion over this species at Woods Hole, where *Zanclea costata* has been confused for *L. agassizi*. According to Hargitt (1908), this error dated to L. Agassiz (1862) and A. Agassiz (1865) and was continued by subsequent writers (Murbach, 1899; Nutting, 1901; Hargitt, 1904). In Chesapeake Bay it is one of the more conspicuous capitate hydroids, reaching peak abundance in August and September.

Known Range:

Hydroid--Massachusetts to South Carolina.

Medusa--Massachusetts to South Carolina.

Family Zancleidae

Zanclea costata Gegenbaur, 1856

Plate 1, Fig. H; Plate 6, Fig. H

Synonymy: Refer to Fraser (1944)---*Zanclea costata*
---*Zanclea gemmosa*
Kramp (1961)----*Zanclea costata*

Collection Records:

Chesapeake Bay--Fisherman's Island.

Substrate: Schizoporella unicornis.

Remarks: This hydroid was found only once, on 29 August 1967. Specimens were collected on bryozoans adhering to pier pilings in 2-3 m of water where the salinity was 23.95 o/oo and the water temperature was 25 C. Medusa buds were present on these polyps. The hydroid was not found on the same substrate collected from Willoughby Bank and Gloucester Point and is possibly limited to the southeastern corner of the bay where salinities are maximal. The two species included by Fraser (1944) for the American Atlantic, Z. costata and Z. gemmosa, are synonymous (Russell, 1953).

Known Range:

Hydroid--Massachusetts to the Caribbean Sea.

Medusa--Massachusetts to the Caribbean Sea.

Suborder Filifera

Family Clavidae

Cordylophora lacustris Allman, 1884

Plate 1, Fig. I

Synonymy: Refer to Fraser (1944)---Cordylophora lacustris

Collection Records:

Rappahannock River--near Tappahannock.

Mattaponi River--near Indian Reservation.

James River--Deep Water Shoal, Lawnes Point, Hog Island Point, Jamestown Island.

Substrates: rock, wood pilings, other C. lacustris stems, Rangia cuneata, Crassostrea virginica shells.

Remarks: Several systematists have maintained that C. lacustris is a synonym of C. caspia (Pallas, 1771), but Vervoort (1968) retained

C. lacustris for the Caribbean form, and it is retained here.

The upper estuaries of the Chesapeake Bay system should provide a favorable habitat for *C. lacustris* since it is usually found in fresh or low salinity water. The species has been reported previously in the bay from Baltimore (Ward and Whipple, 1959) and from the Patuxent River by Cory (1967), where profuse colonies were found on test panels at Lower Marlboro. Cory observed attachment from June to October, with peak sets during June and July. In the present study insufficient data were collected to determine its seasonality, but colonies were observed during May, June, and January.

Known Range:

Hydroid--Quebec to the Caribbean Sea.

Turritopsis nutricula McCrady, 1856

Plate 2, Fig. A; Plate 6, Fig. I

Synonymy: Refer to Fraser (1944)---*Turritopsis nutricula*

Collection Records:

York River--Tue Marsh light, Gloucester Point, Page's Rock.

James River--Middle Ground.

Chesapeake Bay--Fisherman's Island.

Substrates: *Haliclona permollis*, *Halichondria bowerbanki*, *Hydroides hexagona* tubes, *Crassostrea virginica* shell, *Balanus improvisus* shell.

Remarks: The hydroid *T. nutricula* is common on sponges throughout the summer in polyhaline environments of Chesapeake Bay. Medusae were common in plankton samples during late summer and early autumn and were frequently parasitized by actinulae of *Cunina octonaria*.

Known Range:

Hydroid--Massachusetts to the Caribbean Sea.

Medusa--Massachusetts to the Caribbean Sea.

Family Hydractiniidae

Hydractinia arge (Clarke, 1882)

Plate 2, Fig. B; Plate 7, Fig. A

Synonymy: Refer to Fraser (1944)---*Stylactis arge*

Collection Records:

Rappahannock River--near R. O. Norris Bridge.

York River--Perrin, Gloucester Point.

Substrates: *Enteromorpha* sp., *Zostera marina*, *Bittium* sp.

Description:

Hydroid--Zooids of two types, gastrozooids and gonozooids. Gastrozooids arising singly from hydrorhizal mat, capable of considerable extension and contraction, reaching 4 cm, though most much less. Hydranth somewhat bulbous and rugose below the tentacles, hypostome club-shaped. Tentacles all filiform, extensible, occurring in two verticils, one usually extending outward 90° from zooid, the other about 60° from horizontal. Some gastrozooids showing distal constriction and stolon processes, with hydranth and stolons eventually constricting off. Liberated portion settling, forming new colony. Spines absent, stolon network usually covered by periphyton. Defensive zooids absent, although resembled by zooids with autotomized hydranths.

Gastrozooid nematocysts:

microbasic euryteles....9-11.5 x 3.5-5 u (undischarged)

desmonemes.............6-7 x 3.5-4 u (undischarged)

Gonozooids usually shorter and more slender than gastrozooids, reaching 1 cm high. Tentacles fewer, ranging from 4-13, hydranth base not bulbous or rugose. Gonozooids usually on inside fringe of colony, never at periphery. Medusa buds developing 3/4 of distance to apex of zooid. Four medusa buds usually developing concurrently but occasionally as many as 10. Sexes separate.

Gonozooid nematocysts:

microbasic euryteles....10-12 x 4-5 u (undischarged)

desmonemes..............6-6.5 x 3.5-4 u (undischarged)

Medusa--Degenerate, with 8 vestigeal tentacle bulbs, 4 radial canals. Brownish manubrium extending 3/4 distance from apex to velar opening. Gonads present, fully developed before liberation, forming ring about manubrium. Medusa 0.8 mm high and wide at liberation, mesoglea very thin. Medusae short-lived, none living longer than 12 hours in laboratory. Gametes released within 2 hours after liberation.

Exumbrellar nematocysts:

microbasic euryteles....8.5-9 x 3.5-4 u (undischarged)

desmonemes..............6.5-8 x 3.5-5 u (undischarged)

Remarks: *Hydractinia arge* was described by Clarke (1882) from Crisfield, Maryland, on *Zostera marina*. Cowles (1930) did not collect it in his faunal survey of Chesapeake Bay but stated that it was known from the Fort Wool region. While several of Clarke's hydroids were found at Fort Wool, *H. arge* was not, and Cowles' report is evidently in error since no reference to another record of the species was given. It was listed by Fraser (1944) only from its type locality. Thus, the present report evidently constitutes the first Chesapeake Bay record since Clarke's description.

Fraser (1944) believed there was little difference between *H. arge* and the better known *H. hooperi* from Long Island Sound and New England. He believed Mayer (1910a) had seen these species, but Mayer did not claim to have seen *H. arge*, and only related the characteristics listed by Clarke (1882). A critical comparison between the two species has not been made, and no specimens of *H. hooperi* were obtained during this study for comparison. Both species should be retained pending a thorough comparison of the two and determination of possible character variation and overlap. Present knowledge suggests *H. arge* is distinct from *H. hooperi* in having longer gastrozooids, no spines, a double row of tentacles, and the occasional presence of stolon-like processes and a constriction at the distal end of a zooid. Should the two subsequently be found synonymous, the name *H. arge* will have priority over *H. hooperi*, described by Sigerfoos (1899). The medusae of both are degenerate and inseparable from present descriptions alone.

Crowell (1947) discussed a *Hydractinia* of uncertain systematic position obtained at Woods Hole. He suggested that it might be *H. arge*, a new species, or specimens illustrating the variation within a single species. Like *H. arge*, his specimens lacked spines, had tentacles in two verticils, and bore medusa buds about 3/4 of the distance apically. The only basis for regarding it as a new species was the reported presence of tentaculozooids, not previously reported in either *H. arge* or *H. hooperi*. These "tentaculozooids" might well have been gastrozooids with autotomized hydranths, commonly observed in *H. arge* colonies. There were no typically *H. hooperi* characteristics mentioned and Crowell's hydroid does not appear to illustrate overlap of characteristics between *H. hooperi* and *H. arge* as suggested. His specimen is interpreted here as a record of *H. arge*, the first such report outside Chesapeake Bay.

Hydractinia echinata (Fleming, 1828)

Plate 2, Fig. C

Synonymy: Refer to Fraser (1944)---*Hydractinia echinata*

Collection Records:

York River--Guinea Neck.

James River--Norfolk Navy Base Pier 12.

Chesapeake Bay--New Point Comfort, Cape Charles, Kiptopeke Beach, Fisherman's Island.

Substrates: wood pilings, asbestos fiber test panels, *Crassostrea virginica* shells, gastropod shells inhabited by *Pagurus longicarpus* and *P. pollicaris*, *Balanus eburneus* shells.

Remarks: *H. echinata* was common in polyhaline waters of Chesapeake Bay on shells inhabited by hermit crabs. At Guinea Neck and Fisherman's Island large colonies covering several dm^2 were observed on pilings and adhering shells. Clarke (1882) reported it in abundance from low water to the bottom on certain wharf piles at Fort Wool, Virginia.

Known Range:

Hydroid--Labrador to Florida and northern Gulf of Mexico.

Podocoryne minima (Trinci, 1903)

Plate 7, Fig. B

Synonymy: Refer to Kramp (1961)---*Podocoryne minima*

Collection Records:

Gloucester Point plankton sampling station.

Remarks: This medusa was recently found in North America by Hopkins (1966) and Allwein (1967). This is the first record of the species north of Cape Hatteras. A closely related species, *P. minuta*, is also known from Beaufort and Florida, but was not collected in Chesapeake Bay. The principal difference between the two is in the number of marginal tentacles, *P. minuta* having eight and *P. minima* four. Russell (1953) believed that subsequent study may show *P. minuta* to have four tentacles early in development and that the two could be conspecific. Vannucci (1966) noted that *P. minima* from Brazil occurs in salinities below 35 o/oo and in temperatures above 20 C. Her specimens of *P. minuta* from Naples were all from high salinity and some, at least, occurred in waters of 14-15 C. Vannucci was aware that different forms might be induced under different environmental conditions, but she believed the two were distinct. At this time no publication comparing the two in detail has appeared, and the question of possible synonymy is unresolved. During its autumn appearance in the plankton at Gloucester Point, salinities were about 23 o/oo, and temperatures ranged from 21 C to 18 C. The hydroid was not found in this study and is unknown to science.

Known Range:

Medusa--Chesapeake Bay to Florida.

Family Rathkeidae

Rathkea octopunctata (M. Sars, 1835)

Plate 7, Fig. C

Synonymy: Refer to Kramp (1961)---*Rathkea octopunctata*

Collection Records:

Gloucester Point plankton sampling station.

Remarks: *R. octopunctata* was the most abundant hydromedusa in the early winter plankton at Gloucester Point during 1966 and 1967. The hydroid, first described by Rees and Russell (1937), was never collected. Littleford (1939) observed this species in the Patuxent River during December 1938 and noted a sudden decrease in its abundance late in the month. He found evidence indicating the decrease was due to predation by *Cyanea*.

Known Range:

Medusa--Arctic Ocean to Chesapeake Bay and Bermuda.

Family Bougainvilliidae

Bougainvillia carolinensis (McCrady, 1858)

Plate 7, Fig. D

Synonymy: Refer to Kramp (1961)---*Bougainvillia carolinensis*

Collection Records:

Chesapeake Bay at Kiptopeke.

Remarks: The hydroid of *B. carolinensis* was not collected and has not otherwise been reported from the bay. The medusa was identified from plankton samples in a VIMS meter net collection taken 10 October 1961. Cowles (1930) also reported the medusa from the bay's offshore waters.

Known Range:

Hydroid--Maritime Provinces to South Carolina and Louisiana.

Medusa--New England to Florida.

Bougainvillia rugosa Clarke, 1882

Plate 2, Fig. D; Plate 7, Fig. E

Synonymy: Refer to Fraser (1944)---*Bougainvillia rugosa*

Collection Records:

York River--Ellen Island, Gloucester Point.

James River--Hampton Bar, Norfolk Navy Base Pier 12, Middle Ground.

Substrates: rope, wood (pilings, fouling rack), test panels (acrylic plastic, asbestos fiber), *Lissodendoryx isodictyalis*, *Alcyonidium verrilli*, *Hydroides hexagona* tubes, *Crassostrea virginica* shells, *Libinia* sp. carapace, *Molgula manhattensis* test.

Remarks: At Gloucester Point, *B. rugosa* hydroids are active from April until December but colonies attain greatest size during autumn when the species is one of the predominant hydroids on ropes and pilings. Old stems remain attached to rope, pilings, and similar substrates throughout the winter, and new growth begins in spring from these colonies.

Known Range:

Hydroid--Chesapeake Bay to the Caribbean Sea.

Medusa--Chesapeake Bay to South Carolina.

Bimeria cerulea (Clarke, 1882)

Plate 2, Fig. E

Synonymy: Refer to Fraser (1944)---*Calyptospadix cerulea*

Collection Records:

James River--Norfolk Navy Base Pier 12.

Substrates: rope, asbestos fiber test panels.

Remarks: *B. cerulea* was first described from Fort Wool in Hampton Roads by Clarke (1882) as *Calyptospadix cerulea*. It is proposed here that the monotypic genus *Calyptospadix* be placed in synonymy with *Bimeria* Wright, 1859, there being no feature in Clarke's description, or in specimens observed in this study, to distinguish the two. Clarke's original description of *Calyptospadix* was as follows:

> Trophosome. Hydrophyton consisting of a branching hydrocaulus rooted by a creeping, filiform hydrorhiza. Hydranths fusiform with filiform tentacles which are arranged in a single verticil round the base of a conical hypostome. Perisarc developed into large hydrotheca-like processes.
>
> Gonosome. Sporosacs developed on the ultimate ramuli beneath the terminal hydranths.

The pseudohydrotheca, which Fraser (1944) reported to cover much of the hydranth, does so only when the hydranth is contracted. The same feature applies to *Bimeria*.

The following definition of *Bimeria*, from Browne (1907), is nearly identical to Torrey's (1902) description which broadened *Bimeria* to include the genus *Garveia* Wright, 1859:

> Trophosome - hydrocaulus well developed, usually erect and branching; hydranths fusiform.
>
> Gonosome - gonophores in the form of sporosacs developed upon the hydrophyton.

The genera *Bimeria* and *Garveia* have been united by some systematists and kept separate by others. The basis of their separation is the presence or absence of periderm at the proximal portion of the tentacles in *Garveia*. I am in agreement with Browne (1907) and others who regard this basis to be one more in line with specific than generic distinction and consider *Garveia* a junior subjective synonym of *Bimeria*. Nevertheless, as Rees (1938) noted, a revision of the hydroids in these genera is desirable.

B. cerulea and *B. franciscana* are very similar species morphologically and were not distinguished until the end of the survey. Consequently, the collection records reported here for the two species, based on re-examined specimens in the author's collection, are wholly inadequate in emphasizing the abundance and widespread occurrence of *Bimeria* hydroids in the study area. During summer and autumn, *Bimeria* is very abundant in meso- and oligohaline waters of the James, York, and Rappahannock rivers, but which species is represented, or whether both are present, is unknown. However, Cory's (1967) data from the Patuxent River, coupled with the present record of *B. franciscana* from low salinities and Deevey's (1950) distribution records, suggest that the abundant *Bimeria* of low salinities is *B. franciscana*.

Morphologically, *B. cerulea* is distinct in having the spadix curved around the egg, and in having numerous planulae, rather than one, developing in each female gonophore. The blue color of the female gonophores, eggs, and young planulae, thought to be unique to this species (Hargitt, 1909), was also observed in *B. franciscana*.

Known Range:

Hydroid--New Brunswick to Chesapeake Bay.

Bimeria franciscana Torrey, 1902

Plate 2, Figs. F, G

Synonymy: Refer to Vervoort (1964)---*Garveia franciscana*

Collection Records:

James River--Deep Water Shoal.

Substrates: wood pilings, *Crassostrea virginica*.

Remarks: Originally described by Torrey (1902) from San Francisco Bay, California, *B. franciscana* was first recorded on this coast in Louisiana by Fraser (1943) as *B. tunicata*. Shortly thereafter it was found in the Potomac River by Frey (1946). Deevey (1950) compared hydroids from Louisiana and Texas with specimens from San Francisco Bay and synonymized *B. tunicata* with *B. franciscana*.

Elsewhere in Chesapeake Bay, Cory (1967) found this species to be abundant on test panels in the mid-estuary of the Patuxent River, Maryland.

Known Range:

Hydroid--Chesapeake Bay to the Gulf of Mexico.

Aselomaris michaeli Berrill, 1948

Plate 2, Fig. H

Collection Records:

York River--Gloucester Point.

James River--Norfolk Navy Base Pier 12.

Substrates: asbestos fiber test panel, pontoon float, stern of skiff, fiberglass wet table lining, plastic trays, *Zostera marina*.

Remarks: Berrill (1948b) redefined the genus *Aselomaris* to include bougainvilliid hydroids with hydranths arising singly from creeping stolons, and with gonophores reduced to sporosacs arising only from the hydranth stalk. The genus was redefined to include *A. michaeli*, a species found by Berrill throughout the Boothbay Harbor region of Maine. It is distinguishable from its closest relative, _A. arenosa_, in lacking a pseudohydrotheca and gelatinous perisarc. Berrill believed _A. michaeli_ was either an extremely local species or had been overlooked elsewhere and suggested it was a northern species extending to but not south of Cape Cod. The first report of _A. michaeli_ outside its general type locality was for Hampton Roads (Calder and Brehmer, 1967). It was a fairly common hydroid throughout the winters of 1966 and 1967 at Gloucester Point, particularly just below the water line of objects floating at the surface. _A. michaeli_ was also identified in the collection of R. Morales-Alamo, who obtained it from VIMS' Malacology Department water-warming jugs on 15 January 1962.

Known Range:

Hydroid--Maine to Chesapeake Bay.

Nemopsis bachei L. Agassiz, 1849

Plate 7, Fig. F

Synonymy: Refer to Kramp (1961)---_Nemopsis bachei_

Collection Records:

Gloucester Point plankton sampling station, Chesapeake Bay entrance at Station C-00 to the York River at P-30, Rappahannock River at Urbanna, James River in Hampton Roads.

Remarks: This species is the most conspicuous hydromedusa in southern Chesapeake Bay because of its relatively large adult size and periodic abundance. During 1966 and 1967, it was collected at Gloucester Point eight months of the year, being absent only during February-March and September-October.

Collection records indicate *N. bachei* is extremely euryhaline. Simmons (1957) reported it in abundance at 45 o/oo in the Laguna Madre, Texas, and along the Mississippi coast, Moore (1962) found it in salinities as low as 5.64 o/oo. According to Moore (1962), it apparently does not occur around southern Florida, but he was uncertain whether it is a disjunct species or if it had been introduced recently to the gulf coast.

Despite the abundance of the medusa, its hydroid was not collected. Mayer (1910a) included a description of the hydroid based on observations by Brooks, who found it growing on a submerged piece of wood in Newport River, North Carolina. Fraser (1944) did not include it in his monograph. Very young medusae of *N. bachei* were obtained at Gloucester Point, indicating the probable presence of the hydroid in the area.

Known Range:

Hydroid--North Carolina.

Medusa--Nova Scotia to Florida and the Northern Gulf of Mexico.

Family Pandeidae

Amphinema dinema (Peron and Lesueur, 1809)

Plate 2, Fig. I; Plate 7, Fig. G

Synonymy: Refer to Kramp (1961)---*Amphinema dinema*

Fraser (1937a)-*Perigonimus serpens*

Collection Records:

Chesapeake Bay--Cape Charles, Fisherman's Island.

Substrate: *Alcyonidium verrilli*.

Remarks: Very little is known about this hydroid in Chesapeake Bay, all records having been made from the eastern shore during summer 1967. It was first collected on 10 August 1967 at Cape Charles in 2 m of water. Medusa buds were present, and medusae were released from the hydroid after about 48 hours in the laboratory. Medusae were reared in petri dishes containing 21.5 o/oo seawater in a constant temperature room at 20 C. The water was changed daily and *Artemia* nauplii were used as food. One-day-old medusae had two opposite tentacles and were 0.6 mm wide and 0.7 mm high. After development of gonads, it was possible to identify the medusae as *Amphinema dinema*. Two of the three medusae cultured longer than 10 days developed three marginal tentacles; the third, beginning as a small process, was nearly as well-developed as the original two within two to three weeks. All specimens were preserved after 25 days. The hydroid is previously unreported from this coast.

The medusa *Amphinema dinema* was linked to the hydroid *Perigonimus serpens* in life cycle studies by Rees and Russell (1937) at Plymouth. The generic name *Perigonimus* is no longer valid since Rees (1956) showed its type species is a *Bougainvillia* and the remaining *Perigonimus* hydroids must be placed in other genera.

Known Range:

Hydroid--Chesapeake Bay.

Medusa--Massachusetts to Florida.

Family Proboscidactylidae

Proboscidactyla ornata (McCrady, 1858)

Plate 3, Fig. A; Plate 7, Fig. H

Synonymy: Refer to Kramp (1961)---*Proboscidactyla ornata*

Collection Records:

York River--Gloucester Point.

James River--Nansemond Ridge, Hampton Flats.

Substrate: *Sabella microphthalma* tubes.

Remarks: *Proboscidactyla* hydroids have been found exclusively in association with sabellid polychaetes; in this study they were found only on *Sabella microphthalma*. *Proboscidactyla*-bearing worm tubes were common on long-term test panels exposed from the VIMS west pier at a depth of 2.5 m. They were also common at depths of 2-4 m on pilings of the same pier, among sponges, hydroids, bryozoans, and ascidians. Colonies from the James River were obtained on sabellids attached to shells of *Crassostrea virginica* and *Mercenaria mercenaria* in 3 m of water. *P. ornata* medusae are relatively common during summer at Gloucester Point. The hydroid has not previously been reported in North America.

Known Range:

Hydroid--Chesapeake Bay.

Medusa--Massachusetts to the Caribbean Sea.

Family Eudendriidae

Eudendrium album Nutting, 1898

Plate 3, Fig. B

Synonymy: Refer to Fraser (1944)---*Eudendrium album*

Collection Records:

York River--Gloucester Point, Page's Rock.

James River--Hampton Flats, Middle Ground, Newport News Bar.

Substrates: wire mesh, *Halichondria bowerbanki*, *Sertularia argentea* stems, *Crassostrea virginica* and *Mercenaria mercenaria* shells, *Balanus improvisus* shells.

Remarks: The commonest *Eudendrium* encountered during the survey was *E. album*, one of the smallest species in the genus. It was particularly common in Hampton Roads during summer. Although inconspicuous due to its size, careful examination of such substrates as oyster shells and *Sertularia argentea* stems frequently resulted in its collection.

Known Range:

Hydroid--Maritime Provinces to Florida.

Eudendrium carneum Clarke, 1882

Synonymy: Refer to Fraser (1944)---*Eudendrium carneum*

Remarks: *E. carneum* was described by Clarke (1882) from Hampton Roads, where he reported "immense quantities" on piles at Fort Wool during summer. There is no other record of the hydroid in Chesapeake Bay, although Cowles (1930) noted it was known from Fort Wool, obviously in reference to Clarke's paper. While colonies were seen during this survey at Beaufort, N. C., it was never encountered in Chesapeake Bay. The hydroid is large and conspicuous because of its bright red hydranths and is not easily overlooked. Evidently the species has been eliminated from the bay by some factor or combination of factors. A similar situation in reverse was recorded by Hargitt (1908) at Woods Hole for *E. ramosum*. While he found various *Eudendrium* species to be common, none was more conspicuous or abundant than *E. ramosum*. However, Hargitt found it curious that neither Louis nor Alexander Agassiz reported it from the region. Hargitt speculated that either it was overlooked earlier or had only recently been introduced.

Known Range:

Hydroid--Maritime Provinces to the Caribbean Sea.

Eudendrium ramosum Linnaeus, 1759

Plate 3, Fig. C

Synonymy: Refer to Fraser (1944)---*Eudendrium ramosum*

Collection Records:

York River--off VEPCO at Yorktown.

James River--Middle Ground.

Substrates: *Leptogorgia virgulata*, *Anadara transversa* and *Crassostrea virginica* shells, *Molgula manhattensis*.

Remarks: This hydroid was identified from specimens lacking gonosomes; consequently, the identification must be regarded with some reservation. *Eudendrium* is a large genus containing many species readily distinguishable only when the gonosome is present. The largest colony observed was 15 cm high, collected in the dormant state 9 January 1967 at Middle Ground, Hampton Roads. After six days at 19-20 C in a constant temperature room, extensive growth and abundant hydranths were noted. The only feature distinguishing the colony from *E. carneum* was the color of the hydranths, which, in common with other specimens of the type collected during this study, were not bright red but whitish to greenish with pink endoderm.

Known Range:

Hydroid--Labrador to the Caribbean Sea.

Order Leptomedusae

Family Haleciidae

Halecium gracile Verrill, 1874

Plate 3, Fig. D

Synonymy: Refer to Fraser (1944)---*Halecium gracile*

Collection Records:

Chesapeake Bay--Station C-00.

Remarks: Four unattached fragments of this hydroid were found in a bottom plankton sample taken 13 December 1967 by V. G. Burrell. The gonosome was absent. Fraser (1944) regarded *H. gracile* as definitely a tropical species, despite its extended range into the northwest Atlantic, where it occurs as far north as the Gulf of St. Lawrence.

Known Range:

Hydroid--Gulf of St. Lawrence to the Gulf of Mexico.

Family Campanulariidae

The family Campanulariidae is in need of a comprehensive revision. Among hydroid systematists, the number of genera included in the family ranges from two by Broch (1918) and others who recognized only *Campanularia* and *Laomedea*, to Stechow (1923) and others who admitted at least 17 genera. Among students of the medusae, Kramp (1961) recognized five genera--*Agastra*, *Eucopella*, *Gastroblasta*, *Obelia*, and *Phialidium*. To date no major attempt has been made to unite campanulariid hydroids and the medusae they liberate under the same genus.

For this work, hydroids liberating *Obelia* medusae are retained in *Obelia*, and hydroids liberating *Phialidium* medusae are placed in *Clytia* for priority reasons. Other campanulariid genera of medusae or medusa-producing hydroids were not found, and no further union of hydroid and medusa under the same genus is advanced here. However, two species of hydroids in this family which do not liberate medusae were found. These were *Gonothyraea loveni* and *Hartlaubella* gelatinosa; their synonymies will be discussed elsehwere. The genus Laomedea has been dropped from this work on the advice of Rees (personal communication), who pointed out that it is a synonym of Obelia. In summary, the campanulariid hydrozoans of Chesapeake Bay fall in the genera Clytia, Obelia, Gonothyraea, and Hartlaubella.

Clytia cylindrica L. Agassiz, 1862

Plate 3, Fig. E

Synonymy: Refer to Fraser (1944)---Clytia cylindrica

Collection Records:

York River--Tue Marsh light, Perrin, VEPCO (Yorktown) outfall, Gloucester Point.

James River--Hampton Flats.

Substrates: Zostera marina, Bimeria sp., Sertularia argentea, Hydroides hexagona tubes, Crassostrea virginica shells.

Remarks: Ralph (1957), working along the entire New Zealand coast, found considerable variability in Clytia johnstoni (= C. hemisphaerica) and suggested C. cylindrica as a probable synonym of that species. However, Vervoort (1968) retained C. cylindrica as a separate species, as has been done here. Specimens of the two species from Chesapeake Bay differ in the following respects:

	Clytia cylindrica	Clytia hemisphaerica
hydranth		
Length	300-435 u	405-615 u
Width	172-248 u	240-338 u
number of teeth	7-10	12-14

Known Range:

Hydroid--New Brunswick to the Caribbean Sea.

Clytia edwardsi (Nutting, 1901)

Plate 3, Fig. F

Synonymy: Refer to Fraser (1944)---Clytia edwardsi

Collection Records:

York River--Gloucester Point, Bell Rock.

James River--Middle Ground, Norfolk Navy Base Pier 12.

Chesapeake Bay--Willoughby Bank, Thimble Shoal, Chesapeake Bay Bridge-Tunnel (Virginia Beach span).

Substrates: wood piling, rubber tire, test panels (acrylic plastic, asbestos fiber), Zostera marina, Microciona prolifera, Halichondria bowerbanki, Bougainvillia rugosa, Bimeria sp., Sertularia argentea stems, Alcyonidium verrilli, Hydroides hexagona tubes, Mytilus edulis, Mercenaria mercenaria, Crassostrea virginica, Urosalpinx cinerea shells, Balanus improvisus shell.

Remarks: This is the largest species of the genus in southern Chesapeake Bay. It is evidently quite eurythermal and sporadically abundant but most common in winter and spring. Little is known about its reproductive seasonality since gonangia were observed only during April, both in 1966 and 1967. Asexual reproduction by stolonization appears to be relatively common.

Known Range:

Hydroid--New Brunswick to Chesapeake Bay.

Clytia hemisphaerica (Linnaeus, 1767)

Plate 3, Fig. G

Synonymy: Refer to Fraser (1944)---Clytia johnstoni

Collection Records:

Pamunkey River--P-35.

James River--Middle Ground, Deep Water Shoal, Hog Island.

Substrates: Bimeria sp., Sertularia argentea.

Remarks: European Clytia johnstoni has long been known to be the hydroid of the medusa Phialidium hemisphaericum, but only recently (Millard, 1966) has the name Clytia hemisphaerica been put forward for the hydroid. Vervoort (1968) concurred with Millard in proposing the name change. Curiously, the medusa, very common and well known in Europe, has never been reported on this coast, while the hydroid, reported as Clytia johnstoni by Fraser (1944) and others, is well known. This discrepancy suggests that the North American Clytia johnstoni (= Clytia hemisphaerica) may actually belong to another species and merits taxonomic study.

In this study the hydroid was observed in abundance only in oligohaline waters and the gonosome was never seen.

Known Range:

Hydroid--Arctic Ocean to the Caribbean Sea.

Clytia kincaidi (Nutting, 1899)

Plate 3, Fig. H

Synonymy: Refer to Fraser (1944)---Clytia kincaidi

Collection Records:

York River--Gloucester Point.

James River--Hampton Flats.

Substrates: Sertularia argentea, Crassostrea virginica.

Remarks: This hydroid was observed only twice, and in both collections very few hydranths were represented. The species is very small, the stem resembling that of *Clytia paulensis*. The hydranth margin was quite distinctive, bearing pleats and about 7 teeth. The pleated margin gave the hydranth a superficial resemblance to operculate forms with the opercular segments open. It was collected only in September 1966 and July 1967 and gonosomes were never observed.

Nutting (1899) originally described this species from Alaska and Puget Sound. The only other record of the species for this coast is from the Lesser Antilles (Leloup, 1935).

Known Range:

Hydroid--Chesapeake Bay to the Caribbean Sea.

Clytia paulensis (Vanhoffen, 1910)

Plate 3, Fig. I

Synonymy: Refer to Millard (1966)---*Clytia paulensis*

? Fraser (1937a)---*Clytia longitheca*

Collection Records:

York River--Tue Marsh light, Ellen Island, off VEPCO at Yorktown, Gloucester Point, Page's Rock.

James River--Old Point Comfort, Hampton Flats, Newport News Bar, Middle Ground.

Chesapeake Bay--Chesapeake Bay Bridge-Tunnel mid-span.

Substrates: *Halichondria bowerbanki*, *Ectopleura dumortieri*, *Obelia bicuspidata*, *Sertularia argentea*, *Amathia vidovici*, *Hydroides hexagona*, *Sabellaria vulgaris* tubes, *Mercenaria mercenaria*, *Mytilus edulis*, *Anadara transversa*, *Crassostrea virginica* shells.

Remarks: Hydroids from Chesapeake Bay were compared with specimens of *C. paulensis* from South Africa provided by Dr. N. A. H. Millard (Table 2). The two populations are very similar morphologically, and there can be little doubt that they are conspecific. The hydrothecae of Chesapeake Bay specimens tended to have about one less marginal tooth, but even in this apparent difference there was overlap between the two populations. Millard (1966) noted that the size and proportions of the hydrotheca are very variable from region to region.

This species has not been previously reported from this hemisphere, being known from South Africa, Australia, and Antarctica. However, there is nothing in Fraser's (1914) description of *Clytia longitheca* to distinguish it from *C. paulensis* and the two species may be synonymous. Verification of this must await a critical examination of Fraser's specimens. *C. longitheca* is known from British Columbia to San Francisco Bay (Fraser, 1937a). *C. ulvae* Stechow, 1919 from Marseilles may also be synonymous with *C. paulensis* (Millard, 1966).

This relatively small species was not found until 22 September 1966; subsequent collections indicate it is common to abundant in the lower bay, reaching a peak in late summer.

Obelia bicuspidata Clark, 1876

Plate 3, Fig. J

Synonymy: Refer to Deevey (1950)---*Obelia bicuspidata*

Collection Records:

York River--VEPCO (Yorktown) outfall.

James River--Hampton Bar.

Table 2. Comparison between *Clytia paulensis* from the York River, Virginia, and the south coast of South Africa. Measurements are in microns.

	Virginia	South Africa	South Africa Millard (1966)
Pedicel			
length	560-1760	450-2200	480-1820
diameter	30-45	35-60	35-60
Hydrotheca			
length	410-600	490-640	350-720
diameter	140-180	150-210	150-330
Gonotheca			
length	670-950		660-1000
diameter	170-300		300-360

Substrate: Bimeria sp.

Remarks: Bicuspidate campanularian hydroids are among the most widely distributed and abundant thecates in southern Chesapeake Bay, yet the possibility of two species being represented was not discovered until after field collections were terminated. The two species, Obelia bicuspidata and O. longicyatha, are not separable from the ecological data recorded, and the only information presented here is that from specimens preserved in the hydroid collection.

Distinguishing features between Chesapeake Bay specimens of the two species include:

	Obelia bicuspidata	Obelia longicyatha
hydrotheca		
length	360-385 u	480-563 u
width	188-210 u	188-225 u
colony size	small (about 1 cm)	large (up to 25 cm)

Such apparent differences may represent only a gradation in form, and it is possible that the two are actually conspecific. Both are retained here on the basis of insufficient data and the absence of a thorough comparative study of the two. Deevey (1950) noted that O. bicuspidata is a morphologically variable species probably known under many names. Vervoort (1968), who encountered O. bicuspidata and O. longicyatha from Caribbean collections, expressed no doubts as to the validity of both. He reported the general shape of the hydrothecae similar in both, although those of O. longicyatha were much larger and relatively more slender.

In the preserved hydroid collection made during this study, the only specimens corresponding to O. bicuspidata were those collected on 26 September 1967 from the VEPCO Yorktown outfall.

Water temperature was 27 C, 7 C above ambient water temperature in the York River. Specimens collected on 29 July 1958 from Hampton Bar and identified by Dr. W. G. Hewatt as *Clytia cylindrica* were re-examined and found to be *O. bicuspidata*.

The gonophores of this hydroid were not described until 1910 by Fraser, who found them to be very small, ovate or oval in shape, with the top truncated or inverted at the apex. In this study, gonothecae were of moderate size, about 0.7 mm high and 0.2 mm maximum width. The shape was oblong-ovate and a collar was present terminally.

Known Range:

Hydroid--Maine to the Caribbean Sea.

Obelia commissuralis McCrady, 1858

Plate 4, Fig. A

Synonymy: Refer to Fraser (1944)---*Obelia commissuralis*

Collection Records:

York River--Gloucester Point.

James River--Norfolk Navy Base Pier 12.

Chesapeake Bay--mid-span, Chesapeake Bay Bridge-Tunnel; mid bay--37°15'N, 76°10'W.

Substrates: steel barrel, asbestos fiber test panels, *Mytilus edulis*, *Crassostrea virginica* shells, *Balanus eburneus*, *Molgula manhattensis*.

Remarks: In collections from the river estuaries of the western bay, this species was rare, being abundant only in the middle and lower bay. Little is known about its seasonality, although it appears to be a summer form. The best specimens observed were collected 15 June 1966 from 37°15'N, 76°10'W. At this station, water temperature was 21 C and salinity was 17.11 o/oo.

Known Range:

Hydroid--Maritime Provinces to South Carolina, possibly to Tortugas, Florida.

Obelia dichotoma (Linnaeus, 1758)

Plate 4, Fig. B

Synonymy: Refer to Fraser (1944)---Obelia dichotoma

Collection Records:

York River--Tue Marsh light, Gloucester Point.

Chesapeake Bay--New Point Comfort, Kiptopeke Beach.

Substrates: wood pilings, Zostera marina, Halichondria bowerbanki, Bougainvillia rugosa, Balanus eburneus shells, Crassostrea virginica shells, Molgula manhattensis tests.

Remarks: Specimens of this species collected at VIMS on 29 October 1966 were examined and verified as O. dichotoma by Dr. K. W. Petersen. The hydroid is common at Gloucester Point during summer, particularly near mean low water on pilings and adhering invertebrates. On a worldwide basis, O. dichotoma is one of the more widespread hydroids.

Known Range:

Hydroid--Quebec to the Caribbean Sea.

Obelia geniculata (Linnaeus, 1758)

Plate 4, Fig. C

Synonymy: Refer to Fraser (1944)---Obelia geniculata

Collection Records:

York River--Tue Marsh light, Guinea Neck, Perrin, Gloucester Point.

Chesapeake Bay--New Point Comfort, Cape Charles.

Substrates: Zostera marina.

Remarks: This hydroid was found in greatest abundance on eelgrass near the York River entrance, but in the river per se was observed solely on unattached eelgrass. It was collected sporadically elsewhere, suggesting a limited abundance and restricted distribution in Chesapeake Bay.

Chesapeake Bay specimens differ from descriptions of other O. geniculata from North America. The most striking dissimilarity is the shape of the stem perisarc. In typical O. geniculata colonies, the perisarc is markedly expanded, particularly on the outer side of each internode, and the thickening is maximal just below the pedicel insertion (Nutting, 1915). In Chesapeake Bay specimens the perisarc is not expanded but lies closely applied to the coenosarc, such that the internode is uniform in width throughout. A comparison of Chesapeake Bay colonies with typical O. geniculata hydroids from Deer Island, New Brunswick, is given in Table 3.

Obelia geniculata is a morphologically variable species, as noted by Ralph (1956). In New Zealand she found that colonies from the subantarctic were eight times taller than colonies from the subtropics. A poleward increase in branching and in the size of the internodes and gonothecae were also noted. Ralph redefined the species to encompass her observations but did not mention any variation from the typical condition in which the perisarc is inflated.

Table 3. Comparison between *Obelia geniculata* hydroids from Chesapeake Bay, Virginia, with colonies from Deer Island in Passamaquoddy Bay, Canada.

	Passamaquoddy Bay	Chesapeake Bay
Substrate	*Laminaria* sp.	*Zostera marina*
Maximum observed height	2.0 cm	1.5 cm
Internode		
length	0.60-0.75 mm	0.75-1.1 mm
width	0.15-0.30 mm	0.12-0.15 mm
annulations	0-2	1-3
Annulations in pedicel		
proximally	5-6	2-6
distally	2-3	2
Hydrotheca		
length	0.28-0.41 mm	0.28-0.35 mm
width	0.24-0.35 mm	0.27-0.30 mm
Mature gonotheca		
position	axillary	axillary
length	0.83-0.86 mm	0.70-0.83 mm
girth	0.30-0.33 mm	0.30-0.33 mm
terminal collar	present	present

Although the unusual stem morphology of Chesapeake Bay specimens is a real and constant feature, it is apparent that the bay population should be retained in the same species as the more typical *O. geniculata*. Differences other than the perisarc form appear to be insignificant, and there can be little doubt that it is closely related and conspecific to populations with inflated perisarc.

Known Range:

Hydroid--Labrador to the Caribbean Sea.

Obelia longicyatha Allman, 1877

Plate 4, Fig. D

Synonymy: Refer to Fraser (1944)---*Clytia longicyatha*

Collection Records:

York River--Gloucester Point.

James River--Hampton Bar.

Substrates: rope.

Remarks: The similarity between and confusion over this species and *O. bicuspidata* have already been discussed. *O. longicyatha* is probably much more widely distributed than the above records indicate. Although it is impossible to determine from the recorded data, either or both *O. bicuspidata* and *O. longicyatha* were widespread on numerous substrates in the Rappahannock, York, James and Elizabeth rivers, as well as in the bay itself. Frey (1946) found *O. longicyatha* widely dispersed in small numbers on oyster bars in the Potomac River, especially in late summer and autumn.

Known Range:

Hydroid--Massachusetts to the Caribbean Sea.

Obelia longissima (Pallas, 1766)

Plate 4, Fig. E

Synonymy: Refer to Fraser (1944)---*Obelia longissima*

Collection Records:

Chesapeake Bay--Fisherman's Island.

Substrates: *Mytilus edulis*.

Remarks: This species was collected only on 27 March 1968 when it was relatively common on *Mytilus edulis*. The largest colony collected was unattached, entangled in a piece of rope hanging from a pound net stake. The hydroids were healthy, gonosomes were abundant, and medusae were later liberated from the hydroids in the laboratory. Surface water temperature at the collection site was 8 C.

Known Range:

Hydroid--Arctic Ocean to Chesapeake Bay.

Gonothyraea loveni (Allman, 1859)

Plate 4, Fig. F

Synonymy: Refer to Fraser (1944)---*Gonothyraea loveni*

Collection Records:

Rappahannock River--Hog House Ground, Bowler's Rock.

York River--Ellen Island, Gloucester Point, Cheatham Annex, Page's Rock, Bell Rock.

James River--Sewell's Point Spit, Sewell's Point, Norfolk Navy Base Pier 12, Hampton Flats, Middle Ground, Pig Point, Nansemond Ridge.

Elizabeth River--Hospital Point.

Chesapeake Bay--Chesapeake Bay Bridge-Tunnel, mid-span.

Substrates: rope, wood pilings, test panels (wood, asbestos fiber, acrylic plastic), brick casing, glass bottle, metal rod, rubber hose, rocks, *Gracilaria* sp., *Zostera marina*, *Lissodendoryx isodictyalis*, *Halichondria bowerbanki*, *Ectopleura dumortieri*, *Bougainvillia rugosa*, *Sertularia argentea*, *Leptogorgia virgulata*, *Alcyonidium verrilli*, *Anguinella palmata*, *Membranipora tenuis*, *Sabellaria vulgaris* tubes, mollusk shells (*Anadara transversa*, *Anomia simplex*, *Crassostrea virginica*, *Mercenaria mercenaria*, *Mya arenaria*, *Busycon canaliculatum*), *Balanus eburneus*, *Balanus improvisus* shells, *Molgula manhattensis*.

Remarks: In recent years *Gonothyraea* has been placed in synonymy with *Laomedea* by many systematists. Since *Laomedea* is synonymous with *Obelia*, as discussed earlier, and *Obelia* hydroids liberate medusae, *Gonothyraea* has been retained here because these hydroids have fixed gonophores. Retention of *Gonothyraea* is in accord with advice from Dr. W. J. Rees (personal communication).

Gonothyraea loveni is one of the more conspicuous winter hydroids, being widespread in occurrence and present on numerous substrates. It is particularly abundant in shallow water on pilings and shells. The species is not known south of Chesapeake Bay, but its abundance in this area, coupled with its eurythermy, suggest that it may occur in lower latitudes. The hydroid has been found active in the southern bay at temperatures from 0 C to 24.5 C.

Known Range:

Hydroid--Quebec to Chesapeake Bay.

Hartlaubella gelatinosa (Pallas, 1766)

Plate 4, Fig. G

Synonymy: Refer to Fraser (1944)---Campanularia gelatinosa

Collection Records:

York River--Gloucester Point, Page's Rock.

James River--Sewell's Point Spit, Hampton Bar, Middle Ground, Nansemond Ridge, Brown Shoal.

Chesapeake Bay--Thimble Shoal, Willoughby Bank, Chesapeake Bay Bridge-Tunnel, mid-span.

Substrates: rock, rope, wood pilings, Sertularia argentea, Sabellaria vulgaris tubes, Crassostrea virginica and Ensis directus shells.

Remarks: This species has had a difficult taxonomic history, having been placed at various times in such genera as Sertularia, Laomedea, Obelia, Campanularia, Obelaria, and Hartlaubella. As presently defined, the species clearly does not fall in either Sertularia or Obelia. It was placed in Obelaria by Hartlaub (1897) who found its gonosome to be so unlike any other campanulariid that it merited placement in a separate genus. Unfortunately, Obelaria was used by Haeckel (1879) in reference to another coelenterate, and a new generic name, Hartlaubella, was erected by Poche (1914). Since Laomedea is synonymous with Obelia, and Campanularia is defined by Millard (1959) as hydroids with an annular thickening rather than a true diaphragm as in this hydroid, Hartlaubella is recognized here as a valid genus.

Known Range:

Hydroid--Arctic Ocean to South Carolina.

Family Lovenellidae

Eucheilota ventricularis McCrady, 1858

Plate 8, Fig. A

Synonymy: Refer to Kramp (1961)---*Eucheilota ventricularis*

Collection Records:

Gloucester Point plankton sampling station.

Remarks: In addition to this record, *E. ventricularis* medusae were reported by Mayer (1910b) from Hampton Roads. In some of the Gloucester Point specimens, there were black areas interradially on the manubrium as in the European species, *E. maculata*. However, the gonads, tentacle bulbs and manubrium were all bright green, not reddish brown. Although the two species are very similar morphologically, Russell (1953) reported development of the gonads to occur early in *E. maculata*, later in *E. ventricularis*. Nevertheless, a rigorous comparison of the two might be in order.

Known Range:

Medusa--Arctic Ocean to Florida.

Lovenella gracilis Clarke, 1882

Plate 4, Fig. H; Plate 8, Figs. B, C

Synonymy: Refer to Fraser (1944)---*Lovenella gracilis*

Collection Records:

York River--Ellen Island, Perrin, Gloucester Point, Page's Rock, Bell Rock.

James River--Hampton Flats.

Substrates: *Agardhiella tenera*, *Zostera marina*, *Sertularia argentea*, *Crassostrea virginica*, *Crepidula fornicata* shells.

Remarks: Clarke (1882) described *L. gracilis* from Chesapeake Bay without recording the substrate or exact location. Cowles (1930) stated it was known from the Fort Wool region, evidently referring to Clarke's description. While several of Clarke's hydroids were collected at Fort Wool, others were not, and the assumption should not be made that *L. gracilis* was found there. Fraser (1944) included the locality for this area only as Chesapeake Bay.

Known Range:

Hydroid--Massachusetts to North Carolina and Mississippi.

Medusa--Chesapeake Bay to North Carolina.

Family Phialellidae

Opercularella pumila Clark, 1876

Plate 4, Fig. I

Synonymy: Refer to Fraser (1944)---*Opercularella pumila*

Collection Records:

York River--Gloucester Point.

James River--Sewell's Point Spit, Sewell's Point, Hampton Bar, Hampton Flats, Middle Ground, Nansemond Ridge, Brown Shoal.

Substrates: *Lissodendoryx isodictyalis*, *Bougainvillia rugosa*, *Eudendrium ramosum*, *Hartlaubella gelatinosa*, *Gonothyraea loveni*, *Sertularia argentea*, *Anguinella palmata*, *Amathia vidovici*, *Aeverrillia armata*, *Crassostrea virginica* shells, *Molgula manhattensis*.

Remarks: Other than the present Chesapeake Bay record, *O. pumila* is known from only four locations, all on this coast, unless Fraser (1918) is correct in synonymizing *O. nana* Hartlaub, 1897 with this species. It was described by Clark (1876) from Portland, Maine, and Montauk Point, Long Island, N. Y. Specimens were found near Woods Hole in March 1908 by F. B. Sumner, and discussed briefly by Hargitt (1909) and Sumner, Osburn and Cole (1913). Fraser (1918) obtained specimens at St. Andrews Island, N. B. Berrill (1949) described the development and morphology of the species but did not mention the collection locale of his specimens. It was also reported in WHOI (1952) to foul buoys, but without location records. Nutting (1901), who never collected the species or observed the types, expressed doubt that it was different from _O. lacerata_, a more widespread and relatively common species. Hargitt's (1909) specimens of _O. pumila_ and those from Chesapeake Bay conform with Clark's description and, as such, are distinct morphologically from _O. lacerata_. Fraser (1918) felt the two were different beyond question. The most distinguishing feature is the shape of the gonothecae, those of _O. lacerata_ being oval or cylindrical, those of _O. pumila_ being fusiform with a tubular distal end. Fraser found the hydrothecae to be about half as long in _O. pumila_ (0.25 mm) as in _O. lacerata_ (0.45 mm). Hydrothecae of specimens from Chesapeake Bay are comparable in size (0.30 mm) with Fraser's _O. pumila_ from St. Andrews. _O. pumila_ is usually much less branched than _O. lacerata_ and occurs in the bay as both branched and unbranched colonies.

Although _O. pumila_ is rather inconspicuous due to its size, it would be difficult to overlook in Hampton Roads where it is abundant during winter, especially on _Sertularia argentea_.

Known Range:

Hydroid--New Brunswick to Chesapeake Bay.

Opercularella lacerata (Johnston, 1847)

Plate 4, Fig. J

Synonymy: Refer to Fraser (1944)---*Opercularella lacerata*

Collection Records:

York River--Tue Marsh light.

Substrates: rock.

Remarks: The hydroid was collected once only, at Tue Marsh light on 14 August 1967 in 3 m of water. Although this species was identified with some reservation because the gonosome was never seen, most morphological evidence supports the identification. In overall colony shape the specimens resembled hydroids identified elsewhere in this work as "*Campanulina*" sp. However, the hydranths had fewer tentacles (about 16) than those of "*Campanulina*" sp. and lacked the web at the base of the tentacles. The specimens were indistinguishable from Fraser's (1944) description of *O. lacerata* and the length of the hydrotheca (about 0.5 mm) corresponds to Fraser's (1946) measurement (0.4-0.5 mm).

Known Range:

Hydroid--Arctic Ocean to the Caribbean Sea.

Family Phialuciidae

Phialucium carolinae (Mayer, 1900)

Plate 8, Fig. D

Synonymy: Refer to Kramp (1961)---*Phialucium carolinae*

Collection Records:

Gloucester Point plankton sampling station.

Remarks: This medusa, occurring in late summer at Gloucester Point, has not been reported north of Cape Hatteras previously.

Mayer (1910b) found it in great abundance in Charleston Harbor, S. C., during early September 1897 and in June 1898.

Known Range:

Medusa--Chesapeake Bay to the Caribbean Sea.

Incertae Sedis

Blackfordia virginica Mayer, 1910

Synonymy: Refer to Kramp (1961)---*Blackfordia virginica*

Remarks: Although this medusa was originally described from Virginia by Mayer (1910b), it was not identified during this study. Mayer found an abundance of the medusa in Hampton Roads and Norfolk Harbor during October and November of 1904. Cowles (1930) reported it as *B. virginiana* from Chesapeake Bay, and Cronin, Daiber, and Hulbert (1962) found it sporadically in Delaware Bay during summer.

Kramp (1958) examined *B. virginica* medusae from Norfolk Harbor, the Black Sea, and the Ganges estuary, and was convinced that all belonged to the same species. He believed that further study might show *B. manhattensis*, a similar medusa described from New Jersey by Mayer (1910b), to be identical with *B. virginica*.

Known Range:

Medusa--Delaware Bay to Chesapeake Bay.

?"*Campanopsis*" sp.

Plate 5, Fig. A

Collection Records:

York River--Gloucester Point.

Substrates: *Halichondria bowerbanki*, *Hydroides hexagona* tubes, *Crassostrea virginica* shells.

Remarks: The specific identity of this tiny hydroid was never determined since medusa buds or medusae were never seen. As a result, practically nothing is known regarding its biology. The hydroid was collected sporadically from July to November, but this may not be an accurate indication of its seasonality as it is easily overlooked. Specimens from Gloucester Point were examined by Dr. K. W. Petersen, who suggested it might be a "*Campanopsis*," the hydroid of a eutimid medusa. No medusae of the family Eutimidae were collected at Gloucester Point during this survey. Petersen (personal communication) found a very similar hydroid at Naples and believed it was possibly the hydroid of *Octorchis gegenbauri*. However, *O. gegenbauri* hydroids evidently have a web at the base of the tentacles (Russell, 1953), and this web was absent in the Naples and Virginia hydroids. Complete life history studies will be necessary to elucidate the exact identity of this organism.

"*Campanulina*" sp.

Plate 5, Fig. B; Plate 8, Fig. E

Collection Records:

York River--Page's Rock, Bell Rock.

Pamunkey River--West Point, P-35.

James River--Pig Point, Bennett's Creek, Deep Water Shoal, Hog Island.

Nansemond River--Newman's Point.

Substrates: wood pilings, *Bimeria* sp. stems, *Brachidontes recurvus*, *Crassostrea virginica* shells, *Balanus improvisus* shells, *Molgula manhattensis* test.

Description:

<u>Hydroid</u>--Colony consisting of stolon network with single hydranth pedicels or alternately branched stems with 3-4 hydranths. Length of fully extended hydranth 0.7 mm, diameter 0.1 mm. Maximum colony height about 2.5 mm, usually shorter. Single whorl of 20-21 tentacles, length about 0.6 mm, united 1/4 their length by a web. Hydrotheca thin, cylindrical, length 0.5 mm, base square, tip pointed with indistinct opercular segments. Perisarc imperfectly annulated. Gonophore arising from hydranth pedicel or stolon network, base connected by short, imperfectly annulated pedicel. Gonotheca obconic, height about 0.6 mm, width 0.2 mm, containing one medusa. Gonotheca collapsing with release of medusa but later regaining original shape. Hydroids whitish in life.

Nematocysts:

atrichous isorhizas.......7-8 x 2-3 u (undischarged)

<u>Medusa</u>--Newly liberated medusa bell-shaped, with 4, occasionally 3, well-developed perradial tentacles and 8 closed adradial marginal vesicles containing 1 concretion each. Primordia of 4 additional tentacles present interradially. Mesoglea very thin, medusa height and width 0.5 mm. Nematocysts scattered over exumbrella. Radial canals narrow, 4, ring canal and well-developed velum present. Manubrium about 0.2 mm long, mouth with 4 simple lips. Gonads absent. Medusa colorless except for manubrium and tentacle bulbs which are golden yellow.

Remarks: The hydrozoan genus <u>Campanulina</u> Van Beneden, 1847 was erected for <u>C</u>. <u>tenuis</u>, a hydroid bearing a web at the base of the tentacles but not having an operculum. Additional species later added to the genus included a number of heterogeneous hydroids whose medusae often were placed in different genera or families. In a revision of the genus, Rees (1939a) retained Campanulina solely for C. tenuis, since none of the other species were congeneric with it. Earlier, Hincks (1868) had removed a Campanulina hydroid with fixed gonophores to a new genus, Opercularella. Rees recognized this genus and placed other Campanulina species producing medusae in a number of other genera: Aequorea, Campomma, Eirene and Phialella.

Specimens of a "Campanulina-type" hydroid were found in samples from the Pamunkey River, Virginia, during August 1965 and were collected at frequent intervals from several locations in the state from then until 1967. In July and August 1967, colonies with medusa buds were obtained, but attempts to raise the liberated medusae were unsuccessful and the identity of the organism remains in doubt.

The hydroid is common in waters of reduced salinity in both James and York rivers, Virginia. It reaches peak abundance in the autumn and evidently becomes dormant in mid-winter, reappearing in spring. Medusa buds have been observed only in July and August. While the species may be local, more likely it has been overlooked in collections elsewhere since the hydroid is relatively small. Possible restriction to reduced salinity waters may be partly responsible since this environment has received less attention than marine or freshwater habitats.

There is some evidence suggesting that the organism may be Blackfordia virginica. The medusa of this species was described by Mayer (1910b) from Hampton Roads and Norfolk Harbor, where it was abundant during October and November of 1904. Valkanov (1935) later found the medusa in brackish waters of the Black Sea and linked it to its hydroid, a *Campanulina* bearing a web at the base of the tentacles.

Blackfordia virginica was believed by Thiel (1935) to be indigenous to the Black Sea and concluded that its occurrence in North America was due to transport via ships. Kramp (1958) considered the reasoning behind Thiel's hypothesis valid and also attributed the occurrence of the species in the Ganges estuary of India to shipping. Notably, all records of *B. virginica* have been from brackish waters, namely the Black and Caspian seas, Chesapeake and Delaware bays, and the Ganges estuary.

Family Eutimidae

Eutima mira McCrady, 1858

Plate 8, Fig. F

Synonymy: Refer to Kramp (1961)---*Eutima mira*

Collection Records:

Chesapeake Bay at Kiptopeke.

Remarks: Several specimens of *E. mira* were found in a VIMS plankton sample collected by meter net on 10 October 1961. Mayer (1910b) reported the medusa common at Beaufort, N. C., Charleston, S. C., and Tortugas, Fla. Mayer also collected it occasionally at Newport, R. I., and Woods Hole, where it was rare some years and abundant during others. This report constitutes the first Chesapeake Bay record of the species.

Known Range:

Medusa--Massachusetts to Florida.

Family Sertulariidae

Dynamena cornicina McCrady, 1858

Plate 5, Fig. C

Synonymy: Refer to Fraser (1944)---*Sertularia cornicina*

Collection Records:

York River--Tue Marsh light, Perrin, Gloucester Point, Page's Rock.

James River--Hampton Bar.

Chesapeake Bay--Little Creek Jetty, Cape Charles.

Substrates: rubber hose, rubber tire, wood pilings, asbestos fiber test panels, metal oyster trays, *Agardhiella tenera*, *Champia parvula*, *Zostera marina*, *Mytilus edulis* shells.

Remarks: Usually this species is relatively small, but Fraser (1944) found robust specimens of *Dynamena* from the west coast of Florida which were identical to *D. cornicina* in all morphological respects and concluded that it was the same species. The typical small form reaches 1.5 cm in height, while the robust form found by Fraser reached 5 cm. In Chesapeake Bay, *D. cornicina* colonies normally range in size from 1 cm to 5 cm. Vervoort (1962) described pinnate specimens from the Red Sea and Gulf of Aqaba ranging from 3 cm to 10 cm in height. Representative specimens from the York River were examined and verified as *D. cornicina* by Dr. K. W. Petersen.

Though colonies were usually unbranched, in exceptional cases branching was noted but no more than one branch per stem was ever observed. Branching was unlike that described by Vervoort (1962) for the pinnate forms. The branches in Virginia specimens arose from a point where a hydrotheca would normally have occurred. No axillary hydrothecae were present and on both stems and branches the hydrothecae were strictly opposite.

Gonangia are usually borne on the stolon, but on occasion were noted arising from the stem at a position usually occupied by a hydrotheca.

This species is abundant during summer in the lower bay, particularly on eelgrass.

Known Range:

Hydroid--Massachusetts to the Caribbean Sea.

Sertularia argentea Linnaeus, 1758

Plate 5, Figs. D, E

Synonymy: Refer to Fraser (1944)---*Thuiaria argentea*

Hancock *et al*. (1956)---*Sertularia argentea*

Collection Records:

Rappahannock River--Hog House Ground.

York River--Tue Marsh light, Ellen Island, Gloucester Point, Page's Rock, Y-20.

James River--X-Ray Station, Sewell's Point Spit, Sewell's Point, Hampton Flats, Hampton Bar, Norfolk Navy Base Pier 12, Middle Ground, Newport News Bar, Nansemond Ridge, Brown Shoal, Deep Water Shoal.

Chesapeake Bay--Cape Charles, Cherrystone Channel, Kiptopeke Beach, Chesapeake Bay Bridge-Tunnel, Thimble Shoal, Willoughby Bank.

Substrates: rock, *Bougainvillia rugosa*, *Pectinaria gouldii*, *Sabellaria vulgaris* tubes, *Anadara transversa*, *Mytilus edulis*, *Crassostrea virginica*, *Mercenaria mercenaria*, Ensis directus, Cyrtopleura costata shells, Xiphosura polyphemus, Libinia sp. carapace, Balanus improvisus test.

Remarks: During winter, S. argentea is the most abundant hydroid on sandy and shelly bottoms in polyhaline waters of Chesapeake Bay. With increasing water temperatures in spring, hydranths begin to regress, smaller branches break off, and by mid- and late summer the only remnants are the long, tough main stems. In autumn as temperatures drop to 20 C and below, new growth begins from tissue in the old stems, hydranths are formed, and growth proceeds rapidly. Reproduction, development and growth in this hydroid have been well studied and described by Hancock, Drinnan and Harris (1956) from Thames estuary material.

There has been considerable taxonomic confusion over the relationship between S. argentea and S. cupressina. The two were described as separate species by Linnaeus (1758), but later Linnaeus (1767) placed S. argentea as a variety of S. cupressina. Some subsequent students have recognized the two as separate species, including Hincks (1868), Nutting (1904), von Reitzenstein (1913), Fraser (1944), and additional authors, while others have united them as one species, S. cupressina (Broch, 1918; Kramp, 1938b; Leloup, 1938). Broch (1918) felt that the characters upon which separation was based were too variable to be used as indicative of specific differences. Hancock et al. (1956) presented evidence indicating the two were distinct, particularly in the manner of branching. Based on their research, the two species are considered separate here.

In addition to confusion over the species problem in this case, these organisms have been placed in either of two genera, *Sertularia* or *Thuiaria* (on rare occasions in 19th century literature also in *Dynamena*). These species do not belong to the genus *Thuiaria* as it was originally described. However, Nutting (1904), Fraser (1944) and others, following a modified description of *Thuiaria* by Allman (1874), placed *S. cupressina* and *S. argentea* in *Thuiaria*. Unless and until a revision of the genus *Thuiaria* is made, the two species should be retained in the genus *Sertularia*. The two genera are distinguished by the number of opercular flaps, *Thuiaria* having one and *Sertularia* two.

Known Range:

Hydroid--Arctic Ocean to North Carolina, Louisiana.

Family Plumulariidae

Halopteris tenella (Verrill, 1874)

Plate 5, Figs. F, G

Synonymy: Refer to Fraser (1944)---*Schizotricha tenella*

Collection Records:

Rappahannock River--Hog House Ground.

York River--Tue Marsh light, Gloucester Point, Page's Rock.

James River--Sewell's Point Spit, Sewell's Point, Hampton Bar, Hampton Flats, Norfolk Navy Base Pier 12, Middle Ground, Nansemond Ridge.

Chesapeake Bay--Willoughby Bank, Cape Charles, Little Creek Jetty.

Substrates: brick casing, rope, wood pilings, metal oyster trays, test panels (asbestos fiber, acrylic plastic), glass bottle, *Zostera marina*, *Halichondria bowerbanki*, *Alyconidium verrilli*, *Hydroides hexagona*, *Anomia simplex*, *Mercenaria mercenaria*, *Crassostrea virginica* shells, *Balanus eburneus* tests, *Libinia* sp., *Molgula manhattensis*.

Remarks: Millard (1962) reviewed the systematics of the family Plumulariidae and erected a new subfamily, the Halopterinae, to which *Halopteris tenella* belongs. The subfamily is distinguished from the Kirchenpauerinae, Plumulariinae and Aglaopheniinae by the presence of cauline hydrothecae. Though Vervoort (1968) retained *H. tenella*, he noted that it is similar to and probably identical with *H. diaphana*.

H. tenella is one of the most abundant hydroids in the lower bay during summer, covering ropes, pilings, and similar substrates from MLW to the bottom in shallow water. Colonies up to 10 cm in height were collected at Gloucester Point, twice the maximum height recorded by Fraser (1944).

Known Range:

Hydroid--Massachusetts to the Caribbean Sea.

Order Trachymedusae

Family Geryonidae

Liriope tetraphylla (Chamisso and Eysenhardt, 1821)

Plate 8, Fig. G

Synonymy: Refer to Kramp (1961)---*Liriope tetraphylla*

Collection Records:

Gloucester Point plankton sampling station.

Remarks: Numerous species of *Liriope* have been described, but it is now generally agreed that all represent one species, *L. tetraphylla*.

L. tetraphylla is probably not autochthonous to Chesapeake Bay. Evidence to support this may be found in its absence from the plankton at Gloucester Point during 1967, whereas during late summer and early autumn of 1966 the medusa was very abundant. Kramp (1959) regarded *L. tetraphylla* as an oceanic rather than a neritic species. Appearance of this hydromedusa in the bay would then be dependent upon offshore currents and the factors, including wind and runoff patterns, which determine the water circulation. Harrison *et al.* (1967) found evidence for a July 1964 inshore meander of the Gulf Stream, and a shoreward spiral of warm surface or near-surface water along 37°00'N. Indications were that the shoreward spiral continued during August 1964 as well. Such a circulation pattern could carry offshore species toward and into the bay. Coincident with the absence of *L. tetraphylla* in the 1967 plankton, Gail Mackiernan (personal communication) noted an absence of certain offshore dinoflagellates that had been present at Gloucester Point in 1966.

Known Range:

Medusa--Gulf of Maine to the Caribbean Sea.

Family Rhopalonematidae

Aglantha digitale (O. F. Muller, 1776)

Plate 8, Fig. H

Synonymy: Refer to Kramp (1961)---*Aglantha digitale*

Collection Records:

Chesapeake Bay entrance, Station C-00.

Remarks: A few small specimens of *A. digitale* were found in a sample from the VIMS plankton collection taken 13 March 1961 with a Gulf III plankton sampler. The specimens were readily identifiable but in rather poor condition. The medusa was earlier reported in Chesapeake Bay by Cowles (1930).

Known Range:

Medusa--Arctic Ocean to Chesapeake Bay.

Order Narcomedusae

Family Cuninidae

Cunina octonaria McCrady, 1858

Plate 8, Fig. I

Synonymy: Refer to Kramp (1961)---*Cunina octonaria*

Collection Records:

Gloucester Point plankton sampling station.

Remarks: In September and October of both 1966 and 1967 *C. octonaria* medusae were common in the plankton at Gloucester Point. Its larva, often parasitic on other hydromedusae, was frequently seen on *Turritopsis nutricula*. The unusual life history of this organism has been well summarized by Mayer (1910b).

Known Range:

Medusa--New Jersey to the Caribbean Sea.

ERRONEOUS OR DOUBTFUL RECORDS

Cowles' (1930) coverage of the Chesapeake Bay Hydrozoa was insufficiently documented and evidently contains much erroneous information. Nutting (1901) is purported by Cowles to have described *Thuiaria argentea*, *T. cupressina*, and *T. plumulifera* from the bay but Nutting's work was for the Woods Hole region, and no mention was made of these species for Chesapeake Bay. Further, *T. plumulifera* is not listed in Nutting's paper at all. Nutting (1904) did report it, but from shelf waters off Chesapeake Bay, not in the bay itself. Cowles further includes *Campanularia* sp., *Thuiaria cupressina*, *Aglaophenia rigida*, *Cladocarpus flexilis*, *Antennularia americana*, *A. antennina*, *A. simplex*, *Plumularia floridana* and *Plumularia* "near *alternata*," but no exact locations or ecological data were provided. The list was obtained by Cowles from Dr. Waldo L. Schmitt of the United States National Museum. Again, these records may be for coastal waters and not for the bay. All of the above, except *A. antennina* and *Plumularia* "near *alternata*," were identified by Nutting. However, Nutting (1900, 1901, 1904, 1915) did not report any of them from the bay, although several were found offshore in shelf waters. Fraser (1944), who had the collection of the United States National Museum at his disposal, did not report any of the above except *Thuiaria argentea* (= *Sertularia argentea*) from inside the Chesapeake Bay.

A list of hydroids identified by VIMS personnel up to December 1959 is given in Table 4. The only specimens available from that collection were those identified as *Halecium beani* and *Clytia cylindrica*. The *H. beani* were actually *Bimeria* sp. in very poor condition and the *C. cylindrica* were actually *Obelia bicuspidata*. While no specimens now exist for verification, *Bougainvillia inaequalis*, *Campanularia neglecta*, *Plumularia diaphana*, and *Sertularia stookeyi* are probably incorrectly identified, being very similar to species discussed elsewhere in this report. The record of *Thuiaria cupressina* from 100 fathoms indicates that it was not taken anywhere in the bay. Although *Sarsia tubulosa* does occur in the bay, the record of its hydroid, "*Syncoryne mirabilis*,"

Table 4. Hydroids reported from the Virginia Institute of Marine Science (Virginia Fisheries Laboratory) collection up to 1959.

Species	Date of collection	Location	Identified by
Syncoryne mirabilis	August 1958	VFL Ferry Pier York River	
Bougainvillia rugosa	August 21, 1958	VFL Ferry Pier York River	
Bougainvillia inaequalis	July 1957	Ferry dock pilings Gloucester Point	
Pennaria tiarella	July 1957	Eelgrass VFL beach	
	July 29, 1958	Hampton Roads Bar	W.G. Hewatt
Clytia cylindrica	July 29, 1958	Hampton Bar	
Obelia geniculata	July 28, 1958	New Point Comfort	
Campanularia neglecta	August 1957	Ferry dock pilings Gloucester Point	
Plumularia diaphana	July 28, 1958	Hampton Roads Bar	W.G. Hewatt
	August 1958	VFL oyster trays Gloucester Point	
Thuiaria argentea	June 19, 1958	Station B-9 York River	W.G. Hewatt
Thuiaria cupressina	June 26, 1958	Cape Henry, Va. (100 fathoms)	W.G. Hewatt
Sertularia stookeyi	July 1957	VFL beach Gloucester Point	
Halecium beani	July 29, 1958	Hampton Bar Hampton Roads, Va.	W.G. Hewatt

is suspect on seasonality grounds. Further, the hydroid is rather easily confused with *Linvillea agassizi* hydroids.

Three other species on the VIMS invertebrate check list (Wass, 1965) require comment. Hydroids identified as *Stylactis hooperi* from *Zostera* at Gloucester Point were examined and found to be indistinguishable from *Hydractinia arge*. *Podocoryne carnea*, reported from VIMS pier pilings, was re-identified here as *Hydractinia echinata*. *Clytia fragilis*, identified from the Yorktown VEPCO plant, was re-identified as *Obelia bicuspidata*.

Clava leptostyla, reported by Calder (1966) from test panels in Hampton Roads, has been re-examined and found to be young *Turritopsis nutricula*. The hydroid identified as *Clytia* sp. (*coronata*?) was found to be *Clytia edwardsi*.

Among Chesapeake Bay hydromedusae, Cowles (1930) included two provisionally identified specimens, *Bougainvillia ramosa* and *Liriope scutigera*. *Liriope scutigera* is now considered synonymous with *L. tetraphylla*, a species which does occur in Chesapeake Bay. Allwein (1967) reported the nearest previous record of three medusae found at Beaufort, N. C., *Aequorea aequorea*, *Aglaura hemistoma* and *Rhopalonema velatum*, as Florida and Chesapeake Bay. The Chesapeake Bay records stem from collections from Bigelow (1915, 1918) and were for the shelf waters offshore. Bigelow's (1915) closest station to the bay entrance was 37°00'N, 75°38'W, while his closest station recorded in the 1918 paper was 36°12'N, 74°25'W.

LIFE HISTORY

Dipurena strangulata

In 1858 McCrady established the genus *Dipurena* for medusae collected in Charleston Harbor, South Carolina. Although it was subsequently shown to be synonymous with the genus *Slabberia* of Forbes (1846), *Dipurena* has been retained since the name *Slabberia* was preoccupied (Mayer, 1910c).

Kramp (1961) discussed seven species of *Dipurena* but considered at least two of them (*D. brownei* and *D. dolichogaster*) doubtful. A third species, *D. pyramis*, is somewhat aberrant and of uncertain systematic position. Kramp (1959) also doubted its validity as a species. The remaining four species--*D. halterata*, *D. ophiogaster*, *D. reesi* and *D. strangulata*--are relatively well known and recognized. A preliminary description of an additional species, *D. simulans*, was given by Bouillon (1965). Of the latter five species, both the hydroid and medusa are known for all but *D. strangulata*, whose medusa is rather common along the temperate North American Atlantic coast but whose hydroid has remained unknown. During this survey, hydroids of the genus *Dipurena* were found growing on a sponge in the York River, Virginia. After obtaining specimens with medusa buds and rearing the medusae to maturity, it was possible to identify the organism as *D. strangulata*.

Description:

Hydroid--Zooids of one type, arising singly from stolon network, proximal whorl of 4 filiform tentacles and distal whorl of 4-6 capitate tentacles. When extended, hydranths nearly tubular but short. Capitate and filiform tentacles stiff, showing little motion. Hypostome dome-shaped, capitate tentacles usually extending above it. Perisarc terminating slightly below filiform tentacles, annulations absent. When extended, hydroid reaching 0.8-1.0 mm above sponge substrate. Maximum diameter 0.15-0.20 mm at distal end. Capitate tentacles 0.2 mm long, 0.05 mm wide, with 8-11 endodermal cells. Filiform tentacles 0.15-0.17 mm long, 0.03 mm wide, occurring 1/3 of distance apically. Terminal knobs of capitate tentacles cone-shaped, 0.08-0.10 mm wide, silvery. Manubrium whitish, gastrodermis salmon-pink.

Nematocysts:

stenoteles

large.......13-15 x 9.5-10 u (undischarged)

small.......9-12 x 5.5-8.5 u (undischarged)

Medusa--Medusa buds attached via short stalk, developing on hydranth just distal to filiform tentacles, or on blastostyles. Maximum of two medusa buds observed concurrently on single hydranth. Tentacles 4, well developed before liberation. Tentacle bulbs 4, of moderate size, each with one dark red adaxial ocellus. Velum broad, mesoglea thin; radial and ring canals present and thin. Gonads absent. Manubrium tubular, tapering from bulbous base. Nematocysts scattered over exumbrella. Manubrium and tentacle bulbs orange. At liberation, medusa bell-shaped, 0.55-0.60 mm high, 0.50-0.55 mm wide. Each tentacle terminating in single knob. Manubrium 0.25 mm long.

Nematocysts:

stenoteles.......5.5-8 x 4-5.5 u (undischarged)

desmonemes.......6-7 x 3-4 u (undischarged)

Gonads appearing 3 days after liberation. Manubrium with constriction appearing after 4 days, mouth extending outside velar opening after 6 days.

The genus Dipurena, belonging to the family Corynidae, is characterized by having the gonads divided into two or more distinct rings about the manubrium of the medusa and by Coryne-like hydroids, having all tentacles capitate, or with both capitate and reduced filiform tentacles (Russell, 1953). Of the described Dipurena hydroids, D. strangulata most closely resembles D. reesi. The two differ markedly from other species of the genus in having a single oral whorl of capitate tentacles, lacking the additional scattered capitate tentacles present in other species of the genus. The hydroids of both species are more difficult to distinguish from Cladonema radiatum. Brinckmann and Petersen (1960), finding it practically impossible to distinguish D. reesi and C. radiatum from the descriptions alone, studied the hydroids of both and discovered that differences existed in: 1) the shape of the knob on the capitate tentacles, 2) the number of endodermal cells in these tentacles, 3) the morphology and complement of nematocysts, and 4) the position and shape of the filiform tentacles. In having stenoteles only, rather than stenoteles and microbasic euryteles, and in having no terminal swelling at the distal end of the filiform tentacles, D. strangulata, like D. reesi, differs from C. radiatum. In certain other characteristics, however, D. strangulata differs from D. reesi and is similar to C. radiatum: 1) having the filiform tentacles about 1/3 of the distance apically, rather than half-way, 2) having fewer endodermal cells in the capitate tentacles (7-8 in C. radiatum, 8-11 in D. strangulata, and about 18 in D. reesi), 3) having a cone-shaped rather than button-shaped terminal knob on the capitate tentacles. The newly liberated medusae of D. strangulata are readily distinguishable from D. reesi in having a single terminal knob at the end of each tentacle.

Although the hydroids of C. radiatum, D. reesi and D. strangulata may be similar, the morphological differences between their medusae are such that the more highly evolved and specialized C. radiatum is placed in a separate family (Rees, 1957a). Rees noted a greater diversity of form occurring generally in medusae because of the free planktonic phase, while the hydroids, being sedentary, frequently persist in a somewhat simpler form.

A thorough description of the adult medusa of D. strangulata was given by Mayer (1910a), but his description of the young medusa does not agree with observations recorded in this paper. He reported the bell as cylindrical with vertical sides and a slight apical projection. He also reported two of the four tentacles as undeveloped and represented by basal bulbs. Evidently no laboratory culture of these medusae was undertaken by Mayer. Errors could easily be made in piecing together the life history from stages in the plankton and Mayer's description and figure agree perfectly with that of young Linvillea agassizi medusae obtained from the hydroid at Gloucester Point. Additionally, L. agassizi was reported by him to be abundant in Charleston Harbor during summer and early autumn along with an abundance of D. strangulata. Hence, it is believed that he mistook the young medusa of L. agassizi for D. strangulata. All Dipurena species have four tentacles developed at liberation in contrast to Linvillea.

While it may occur on other substrates, the hydroid of D. strangulata was found only in association with the sponge Microciona *prolifera*. Interestingly, two other species of the genus were originally described from sponge substrate. Rees (1939b) described *D. halterata* found on the sponge "*Chalina montagui*" (= *Haliclona cancellata*), and Bouillon (1965) reported that *D. simulans* developed in the oscula of the sponge *Adocia simulans*. Vannucci (1956) found *D. reesi* growing on glass and *Ulva* in an aquarium, and *D. ophiogaster* was found on the stipe of an alga (Rees, 1941).

Along the Atlantic coast of North America, a number of *Dipurena* species have been reported. In addition to *D. strangulata*, McCrady (1858) described *D. cervicata* from Charleston Harbor. Mayer (1910a), after a careful study of the medusae at Charleston, concluded the two were actually a single species and the name *D. strangulata* was retained. *Dipurena conica*, a species described by A. Agassiz (1862) from Naushon, Buzzard's Bay, Massachusetts, was synonymized by Mayer (1910a) with *D. strangulata*. Separation of these two was based primarily on shape of the bell and length of the manubrium, characters which Mayer showed to vary widely in specimens of *D. strangulata* from Charleston. Mayer (1900) described two species from Tortugas, Florida, both of which have since been placed in synonymy: *Dipurena picta* was synonymized by Mayer (1910a) with *D. catenata*, which in turn is considered synonymous with *D. halterata* (Kramp, 1961); the second species, *D. fragilis*, was relegated to a subspecies of *D. strangulata* by Mayer (1910a) but Kramp (1961) considered it fully synonymous. Hargitt's (1904) report of *Dipurella clavata* is also considered to be *D. strangulata*. Consequently, two species occur on the east coast of the United States, *D. strangulata* from New England to Florida and *D. halterata* from Florida.

Bougainvillia rugosa

The genus Bougainvillia is represented by several species along the east coast of the United States, but in southwestern Chesapeake Bay only one species, B. rugosa, is common. While the hydroid of this species has been reported from Virginia to St. Thomas, D.W.I., its medusa is less well known, having been found only in Chesapeake Bay, at Beaufort, N. C., and possibly in Charleston Harbor, S. C. The species is common in its type locality of Hampton Roads and the lower Chesapeake Bay, yet little is known about its life history, particularly regarding the older medusae. Clarke's (1882) original description was adequate for identification, but his account of the medusa was sketchy. The description of an atypical B. rugosa medusa by Mayer (1910a) from Charleston Harbor and his mistaken assumption that it was a juvenile contributed to some confusion over the organism, leading Kramp (1959) to regard it as a doubtful species. The purpose of this report is to: 1) supplement previous descriptions of both hydroid and medusa; 2) place Mayer's (1910a) medusa in proper perspective; 3) note the morphological variations occurring within the species; and 4) describe the life history of B. rugosa in southwestern Chesapeake Bay.

Description:

Hydroid--Stems arising from stolon network adhering to substrate. Colony with stem and main branches fascicled, growth monopodial with terminal hydranths, branching irregular, branches numerous. Hydranths given off from main stem and branches, relatively long and tubular when fully extended; hypostome conical, single whorl of 8-16 filiform tentacles. Perisarc wrinkled at hydranth base, occasionally elsewhere, distinct annulations absent. Live hydranths translucent, endoderm orange. Stems and branches brown, color often accentuated by adhering particulate matter. Largest colony observed 25 cm high, most considerably smaller.

Nematocysts:

desmonemes............4-5 x 2.5-3 u (undischarged)

microbasic euryteles...6.5-7.5 x 3-4 u (undischarged)

Medusa--Medusa buds borne below hydranths on pedicels only, absent on main stem and branches. Medusae pyriform at liberation, 4 narrow radial canals. Nematocysts scattered over exumbrella, velum well developed. Manubrium short, bearing gonads even in newly liberated medusae. Oral tentacles 4, unbranched, with nematocysts at tips. Tentacle bulbs 4, round, relatively small. All newly liberated medusae with 12 marginal tentacles, 3 per bulb. Abaxial ocelli red, usually 8 but number variable. Ocelli in definite position, one at base of each of first 2 tentacles in each bulb, arranged clockwise about oral end of medusa. Additional ocelli frequently small. Umbilicus present in most 12-hour medusae, absent in most 24-hour specimens. Maximum of 12 ocelli per individual observed. Eleven marginal tentacles observed in occasional specimens attributed in all cases to loss through injury. Infrequently, 13 tentacles observed in older medusae.

Medusae are evidently rather short-lived, since none were kept alive in the laboratory longer than 20 days. The largest medusa collected in the plankton samples measured 1.3 mm high and 1.25 mm wide, corresponding roughly to six-day-old laboratory-raised specimens, assuming equal conditions of nutrition. The largest laboratory-raised medusa was a 10-day-old specimen 2.2 mm high and 2.0 mm wide. Eighteen medusae from plankton samples had a mean diameter and height of 0.77 mm and 0.80 mm, respectively. With increasing age and size, a slight increase in the number of ocelli occurs (Table 5) but the number of marginal and oral tentacles does not increase and branching of the oral tentacles does not occur.

Bougainvillia rugosa hydroids show a regular seasonal activity-inactivity cycle in lower Chesapeake Bay (Calder, 1967). Growth begins and hydranths appear in early April and continues until early December, with medusae being produced from late May until early November. Hydroids reach peak abundance in the autumn, at which time the medusa is most common in the plankton. The hydroid is inactive from December through March, but stems and stolons remain on pilings and other substrates.

Compared with other Bougainvillia hydroids from the North American Atlantic, B. rugosa in its large size and general morphology is most similar to B. carolinensis, the species from which it may have been derived (Fraser, 1946). The two species differ markedly in the nature of their medusae. Also, B. rugosa differs from B. carolinensis in having perisarcal rugosities at the hydranth base, medusa buds only on the hydranth pedicels, and in lacking distinct annulations. The medusa of B. rugosa is distinct from any other species of the genus in having usually but eight or nine ocelli and 12 marginal tentacles throughout life. Other than B. rugosa, only two other described species of Bougainvillia, B. multicilia and B. prolifera, have unbranched oral tentacles and both were regarded by Kramp (1961) as doubtful species.

Mayer (1910a) was probably correct in reporting the medusa of B. rugosa from Charleston Harbor, although his specimen was

Table 5. Data on laboratory-reared *Bougainvillia rugosa* medusae of different ages. Values other than N are expressed as the mean.

Age	0 hrs	6 hrs	12 hrs	1 day	3 days	5 days	7 days	10 days	15 days
N	30	30	30	30	15	15	10	10	10
Height (mm)	.56	.71	.77	.90	1.0	1.2	1.7	1.9	1.7
Diameter (mm)	.56	.69	.76	.87	.95	1.1	1.6	1.8	1.9
Marginal tentacles	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
Ocelli	8.1	8.6	8.1	8.2	8.5	9.3	9.0	9.6	9.8
Oral tentacles	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0

anomalous if correctly identified. His medusa bore the typical 12 marginal tentacles and four unbranched oral tentacles, but 12 ocelli were also present. Since *B. rugosa* medusae are sexually mature at liberation, in Chesapeake Bay specimens at least, it is unlikely that his specimen was a juvenile as reported, particularly since it was 1.5 mm in height.

Proboscidactyla ornata

The hydrozoan genus *Proboscidactyla* Brandt, 1834 comprises a peculiar group of organisms whose hydroid stages have been found only in association with sabellid polychaetes. Possibly because they are relatively inconspicuous, the hydroids are less well-known than the medusae. The only common representative of the genus along the Atlantic coast of the United States is the medusa of *P. ornata*, a species reported by Kramp (1959) to be circumglobal in warm coastal waters. Although *P. ornata* medusae have been separated on occasion into a number of different varieties or even species based on presence or absence as well as position of medusa buds, Kramp (1965) recognized no distinct races since he regarded the bases of these distinctions to be of no systematic importance.

While the medusa of *P. ornata* is well known, its hydroid was not described until recently by Brinckmann and Vannucci (1965). Although a *Proboscidactyla* hydroid was collected in Long Island Sound by Deevey (Hand, 1954), its specific identity was not determined. Following collections of *P. ornata* medusae in June 1966 from the York River, Virginia, a search was begun for the hydroid. Colonies of a *Proboscidactyla* hydroid were first collected in October 1966 from tubes of Sabella microphthalma attached to asbestos fiber test panels in 2.5 m of water at Gloucester Point. The colonies were active until January 1967 when the zooids regressed without having produced medusae in the three-month interval of observation. Th zooids reappeared in early April and increased rapidly in number and size. The gonozooids began development in mid-May and lasted until late August. Rearing of their medusae revealed the hydroid as that of P. ornata. This report, the first record of the hydroid in North America, discusses the morphology of the Virginia specimens and contrasts these with specimens described by Brinckmann and Vannucci from the Gulf of Naples.

Description:

Hydroid--Colony consisting of 2-tentacled gastrozooids and tentacleless gonozooids, color cream to golden or orange. Gastrozooids in single row at margin of sabellid tube, usually forming complete ring about orifice. Filiform tentacles arising from common area 3/4 distance apically. Height of gastrozooids 1.3 mm, width 0.2 mm, girth maximal in mid-region. Tentacles extensible to 1.5 mm. Manubrium separated by constricted region and curved to face center of worm tube. Gonozooids smaller, 1 mm high, 0.1 mm wide, terminating in mouthless knob. Gonozooids usually originating near proximal end of gastrozooid, occasionally several mm down the worm tube, remaining in contact via stolon network. Medusa buds developing 1/2-1/3 of distance apically. Four buds per gonozooid, usually developing concurrently, 5 noted in one case.

Nematocysts:

macrobasic euryteles....20.5-23.5 x 11.5-13 u (undischarged) microbasic euryteles

small.....5.5-6.5 x 2.5-3 u (undischarged)

large.....8-9 x 3.5-4.5 u (undischarged)

desmonemes....7-8 x 4-4.5 u (undischarged)

Macrobasic euryteles difficult to distinguish from macrobasic mastigophores, terminal dilation of butt often being indistinct.

Medusa--Just before liberation, medusa with 4 unbranched radial canals, 4 perradial tentacles and tentacle bulbs, 4 interradial cnidothalacies. Velum well developed, ring canal and gonads absent. Manubrium simple, short; tentacle bulbs and manubrium golden or orange. At liberation, medusae 0.6 mm high and wide. Mesoglea thin, umbilicus present, disappearing within 24 hours.

Nematocysts:

macrobasic euryteles

large.......18-21 x 11-13 u (undischarged)

small.......8.5-10 x 5.5-6 u (undischarged)

desmonemes......5-6 x 4-5 u (undischarged)

The large macrobasic euryteles were present only in the cnidothalacies.

In life, the gastrozooids are quite active, expanding and waving the tentacles, and bobbling forward and backward. When the worm is extended from its tube, the tentacles comb the branchial filaments. Gonozooids show little, if any, motion except as a result of being moved by medusae or gastrozooids. The medusae pulsate vigorously for some time before they become free from the gonozooid.

In his synopsis, Kramp (1961) listed 10 species of Proboscidactyla medusae, but evidently considered only six of them valid. One species he regarded as doubtful, *P. occidentalis*, was shown by Hand (1954) to be valid. Of the seven presently recognized species, the hydroids are known for *P. stellata*, *P. circumsabella*, *P. occidentalis*, and *P. ornata*. Similar morphological features occur in several species and there appears to be no precise way to separate the hydroids of the various species. Even the nematocysts are of little aid, although those of *P. ornata* appear smaller than in the other known hydroids.

While specimens of *P. ornata* from Virginia agreed with the description of Brinckmann and Vannucci (1965) in most respects, a number of differences were noted. The nematocysts of Virginia specimens differed from those of Gulf of Naples hydroids in having 1) larger macrobasic euryteles, 2) slightly larger small microbasic euryteles, 3) slightly wider large microbasic euryteles. In the newly liberated medusae, Virginia specimens had larger desmonemes and longer but narrower small macrobasic euryteles. The large macrobasic euryteles of the cnidothalacies were evidently not measured by Brinckmann and Vannucci. A number of other differences were noted in the descriptions of the two populations (Table 6), but these are characteristics subject to wider variation and are not considered particularly significant. None of the differences appear to be sufficient basis for separating the two populations into separate races at this time.

Lovenella gracilis

The name *Lovenella gracilis* was given by Clarke (1882) to a hydroid and its newly liberated medusa from Chesapeake Bay, yet Clarke was not fully certain that it was specifically distinct from

Table 6. Summary of gross morphological differences between *Proboscidactyla ornata* populations from Virginia and the Gulf of Naples.

	Virginia specimens	Gulf of Naples specimens (Brinckmann and Vannucci, 1965)
Size of medusa at liberation	0.6 mm high 0.6 mm wide	0.98 mm high 0.78 mm wide
Height attained by hydroid	1.3 mm	1.8 mm
Host	*Sabella microphthalma*	*Branchiomma vesiculosum* plus an unidentified species.

the European *L. clausa*. Fraser (1910, 1912) used *L. clausa* for specimens from Bogue Sound, North Carolina, and Newport, Rhode Island, but after examining additional material later, became convinced that *L. gracilis* was a separate species (Fraser, 1944). The first European record of the hydroid *L. gracilis* was by Huvé (1952) from the French Mediterranean, and he recognized it as distinct from *L. clausa*. Huvé believed that *Dipleuron parvum*, a hydromedusa described by Brooks (1882) from North Carolina, was actually the medusa of *L. gracilis*, based on similarities between the descriptions by Brooks and Clarke. This link was not verified by rearing of medusae from the hydroid.

This study was begun in the summer of 1967 to elucidate the proper systematic position of the organism through life history work in the laboratory. The development and morphology of the medusa are described and the reasons for retaining the species in the genus *Lovenella* are discussed.

Description:

Hydroid--Hydrocaulus commonly 3 cm high, slightly branched or unbranched, divided into internodes by transverse septa at more or less regular intervals. Hydrothecae alternate, 0.6 mm high, 0.3 mm wide, on annulated pedicels, with 14, often more tentacles lacking basal web. Opercular Plates 8, hinged at base. Gonothecae 1.2 mm long, 0.25 mm wide, truncate terminally, given off from base of hydrothecal pedicel, medusa buds numerous.

Nematocysts:

basitrichous haplonemes or

microbasic mastigophores...10-12 x 2.5-3 u (undischarged)

Medusa--At liberation, 4 narrow radial canals, wide velum, short manubrium, 4 closed marginal vesicles each with one concretion. Tentacle bulbs 4, 2 alternate bearing tentacles and with lateral cirri beside bulbs. Gonads present mid-way only on two radial canals leading to tentacle-bearing bulbs. Mesoglea thin, mouth simple, nematocysts scattered over exumbrella. Medusa 0.45-0.50 mm high, 0.50-0.55 mm wide. Viewed laterally, medusa hemispherical with flattened sides, viewed orally, medusa oval in outline, being wider in line through gonads. Gonads, tentacle bulbs and manubrium pale straw-colored. Changes occurring with growth are as follows:

2 days. Two tentacles absent at liberation developed. Medusa 0.75 mm wide, 0.65 mm high.

4 days. Lateral cirri appear beside two recently developed tentacles. Medusa 1.0 mm wide, 0.85 mm high.

6 days. Four tentacles equally developed. Medusa 1.4 mm wide, 1.2 mm high.

7 days. Eight adradial closed marginal vesicles present in addition to 4 large interradial vesicles, all containing 1 concretion.

10 days. Interradial tentacle bulbs and tentacles beginning development. Medusa 1.7 mm wide, 1.2 mm high.

Nematocysts:

basitrichous haplonemes or microbasic mastigophores

large....9.5-11.5 x 3-4 u (undischarged)

small....7.5-9.0 x 2-2.5 u (undischarged)

Only 2 medusae out of 20 at start lived longer than 10 days.

11 days. Interradial tentacles developed, one specimen developing adradial tentacle bulbs.

13 days. Gonads still 2, but medusa round in shape due to size increase. Mesoglea thin, velar opening large.

15 days. Marginal vesicles 20, one vesicle with 2 concretions. One medusa with 8 tentacles, one with 14, with 5, 3, 4, 2 tentacles in respective quadrants. Medusae 2.0 mm wide, 1.3 mm high.

20 days. Medusae 2.3 mm wide, 1.6 mm high.

25 days. No morphological change, medusa with 8 tentacles preserved.

27 days. Remaining specimen developing 2 additional gonads. Medusa 3.0 mm wide, marginal tentacles 20.

30 days. Medusa everted due to water movements in culture flask. Marginal vesicles 23.

42 days. Medusa, with 4 gonads, 21 tentacles, 33 marginal vesicles, preserved.

Medusae raised in this study from the hydroid _Lovenella gracilis_ are indistinguishable from Brooks' (1882) _Dipleuron parvum_ early in their development, and I concur with Huvé (1952) that the two are probably conspecific. To rectify the problem of synonymy, Huvé resurrected Brooks' genus _Dipleuron_, claiming that _Lovenella_ need not be retained as a generic name. He based this opinion on the fact that Russell (1936) had linked the type hydroid of the genus _Lovenella_, _L. clausa_, with the medusa _Eucheilota hartlaubi_. However, _Eucheilota_ and _Lovenella_ are not congeneric, and the medusa _E. hartlaubi_ has since been shown to be a _Lovenella_, the name _L. clausa_ being recognized for the species by Russell (1953), Kramp (1959, 1961), and others. Mayer (1910b) relegated _Dipleuron parvum_ to a variety of _Eucheilota duodecimalis_, basing its variety ranking on the fewer number of gonads. Since *Eucheilota* medusae differ from *Lovenella* in having a definite rather than an indefinite number of marginal vesicles, medusae reared to an advanced stage in this study demonstrate that the organism is a *Lovenella*. The generic name *Dipleuron* must be considered a junior synonym of *Lovenella*. The specific name of the hydroid and medusa remains *L. gracilis*, Clarke's (1882) description of the hydroid published in January having priority over Brooks' (1882) account of the medusa which appeared in March.

A number of other hydrozoans resemble *Lovenella gracilis* to some extent in one stage or another, but the degree of relationship is presently uncertain due to the paucity of information available on their life histories. Stechow (1914) described a hydroid from Rio de Janeiro under the name *Gonothyraea* (?) *nodosa*, which is at least superficially similar to *L. gracilis*. Reproduction in this species is evidently unknown. Torrey (1909) described the medusa *Phialium bakeri* from California which resembles young *Lovenella gracilis*. This medusa was reportedly liberated from the hydroid *Clytia bakeri* described by Torrey (1904). The medusa is not a campanularian, but his hydroid, like campanularians, did not have an operculum. Nutting (1915) also collected the species and did not show an operculum in the figures or mention it in the description. Either the link between hydroid and medusa is in error, or the operculum of the hydroid was lost, as Huvé (1952) suggested. Nutting found his specimens on the clam *Donax*, so damage and loss of the operculum is a possibility. Torrey's medusa was placed in the genus *Eucheilota* by Mayer (1910b) and Kramp (1961).

Other than its occurrence in Chesapeake Bay, the hydroid of *Lovenella gracilis* has been reported from Woods Hole, Massachusetts, to Beaufort, North Carolina, and the Mississippi Sound on this coast, and from the French Mediterranean. The medusa has been reported from Chesapeake Bay and Cape Fear and Beaufort, North Carolina. The medusa was not found by Huvé (1952) in Europe.

PHENOLOGY

Most studies on hydroids along this coast have given little or no consideration to seasonal distribution, and even less attention has been paid to reproductive periodicities. Such information necessitates collecting at frequent intervals over a period of one or more years and requires prior knowledge of the species and their occurrence. Some information on hydroid seasonality is present in various marine fouling papers, but most of these studies involved collection by immersion of short-term test panels. Hydroids appear on such substrates only following sexual or asexual reproduction from colonies active elsewhere, so are less precise in determining appearance than is examination of objects submerged for longer periods. Likewise, panels fail to develop hydroids if immersed after a species has completed reproduction, yet the hydroid may still be active on adjacent substrates. As noted by Millard (1959), test panels often are poor indicators of hydroid diversity in an area since relatively few species are found on them, so even their value in studying reproductive periods is limited. For this reason, collections were made many times from many substrates, natural and man-made, including objects submerged for periods up to many years.

The lower Chesapeake Bay is characterized by extreme seasonal differences in water temperature (Fig. 2) and a somewhat less pronounced salinity variation (Fig. 3). A temperature range from about 2 C in winter to 28 C in summer is not uncommon in the river estuaries of the western shore. From January through mid-March, temperatures are quite uniformly cold, rising rapidly from mid-March through June and falling rapidly from September through December. During periods of rapid temperature change, appearance and

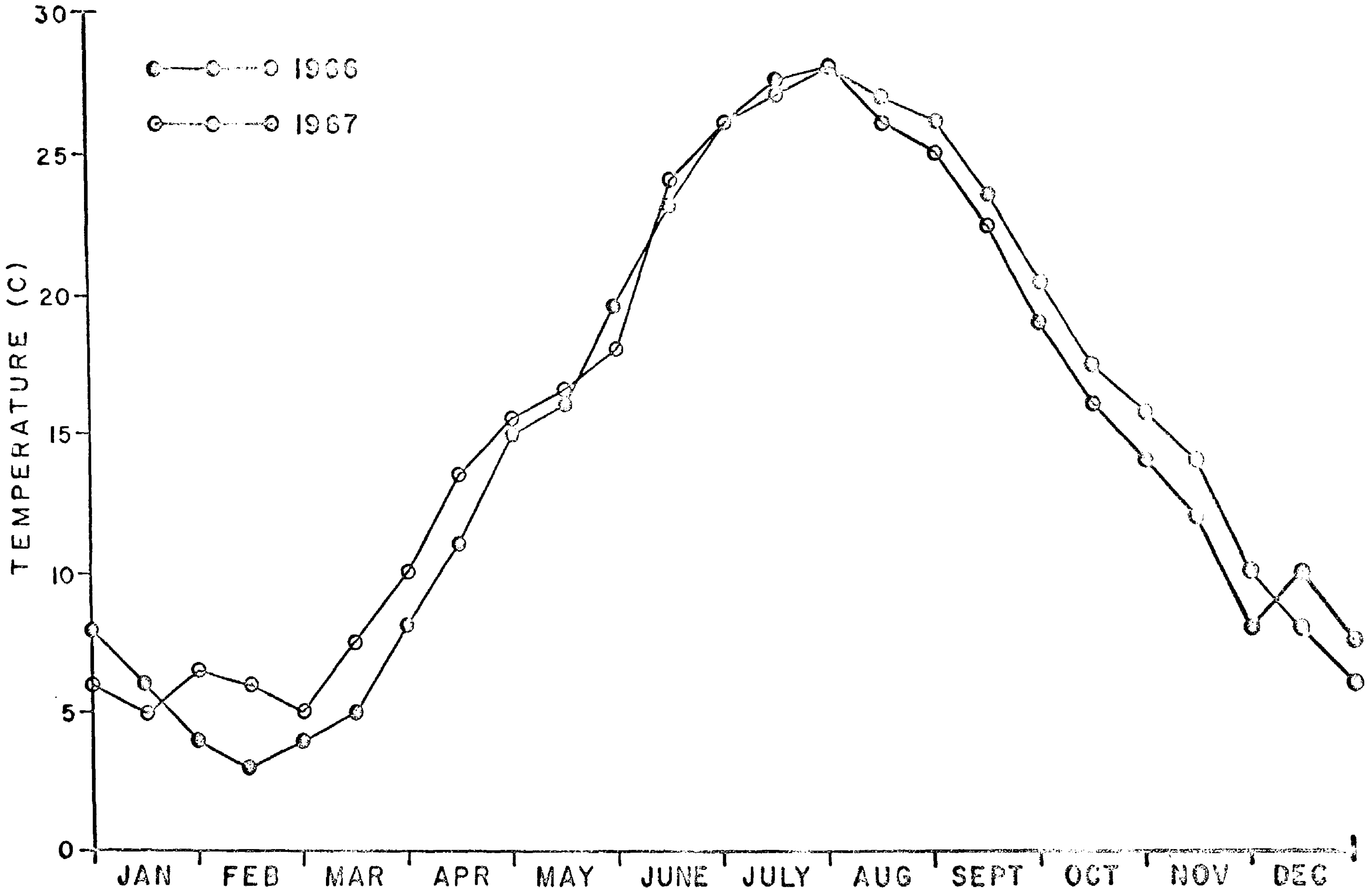


Fig. 2. Water temperature at Gloucester Point, 1966-1967.

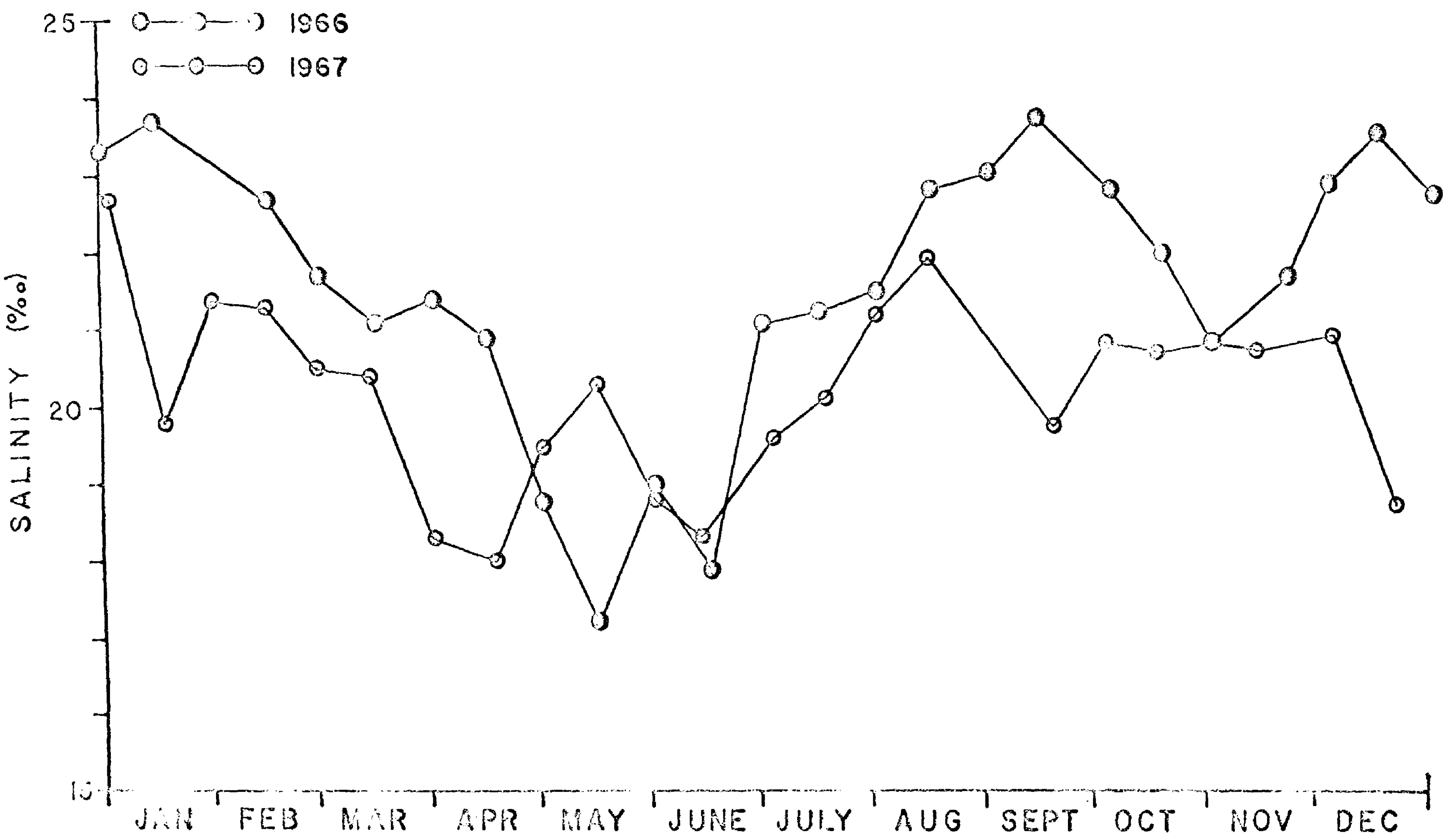


Fig. 3. Salinity at Gloucester Point, 1966-1967.

disappearance of species is often abrupt, suggesting that temperature is a major factor in their seasonality. Such conditions are unfavorable to stenothermal species and all those studies presented a distinct seasonality. From their seasonal occurrence, Chesapeake Bay hydroids can be divided basically into a summer fauna and a winter fauna. Of the 23 species for which adequate seasonal data are available, 16 may be regarded as summer species and seven as winter species (Figs. 4 and 5). The greatest number of species occurred in May when 21 of the 23 species considered were recorded, the fewest in February and March when only eight were found. May-June and November-December were the intervals when faunal change was most pronounced and overlap of summer and winter forms was greatest during these periods.

Seasonal distribution of sporosacs (Fig. 6) and medusae was even more restricted. None of the medusae whose seasonality was studied occurred in the water throughout the year. Maximum numbers of species and individuals occurred during summer and autumn, while fewest were present in winter. Table 7 shows the seasonal occurrence of the various species of medusae from observations at Gloucester Point during 1966-1967. Several species, Liriope tetraphylla and Cunina octonaria, do not have hydroid stages. Hydroids of Rathkea octopunctata and Nemopsis bachei are known but were not found in this study. The hydroids of Podocoryne minima, Phialucium carolinae and Eucheilota ventricularis are unknown.

The regular seasonal appearance and disappearance of hydroid species in southern Chesapeake Bay raises the question of how these organisms suddenly reappear at a certain time of year. Although repopulation from other regions is possible for some species during

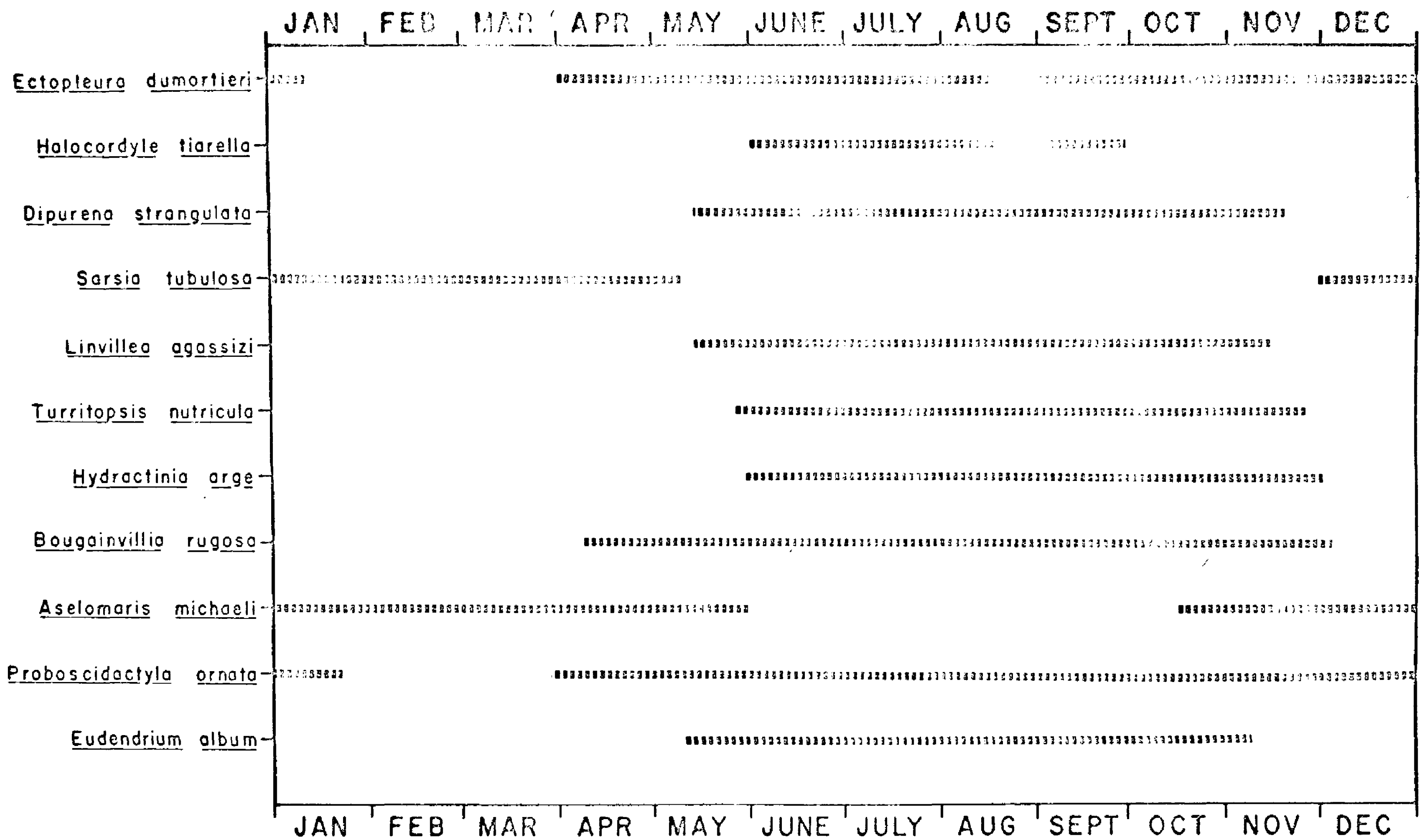


Fig. 4. Seasonality of athecate hydroids in southern Chesapeake Bay.

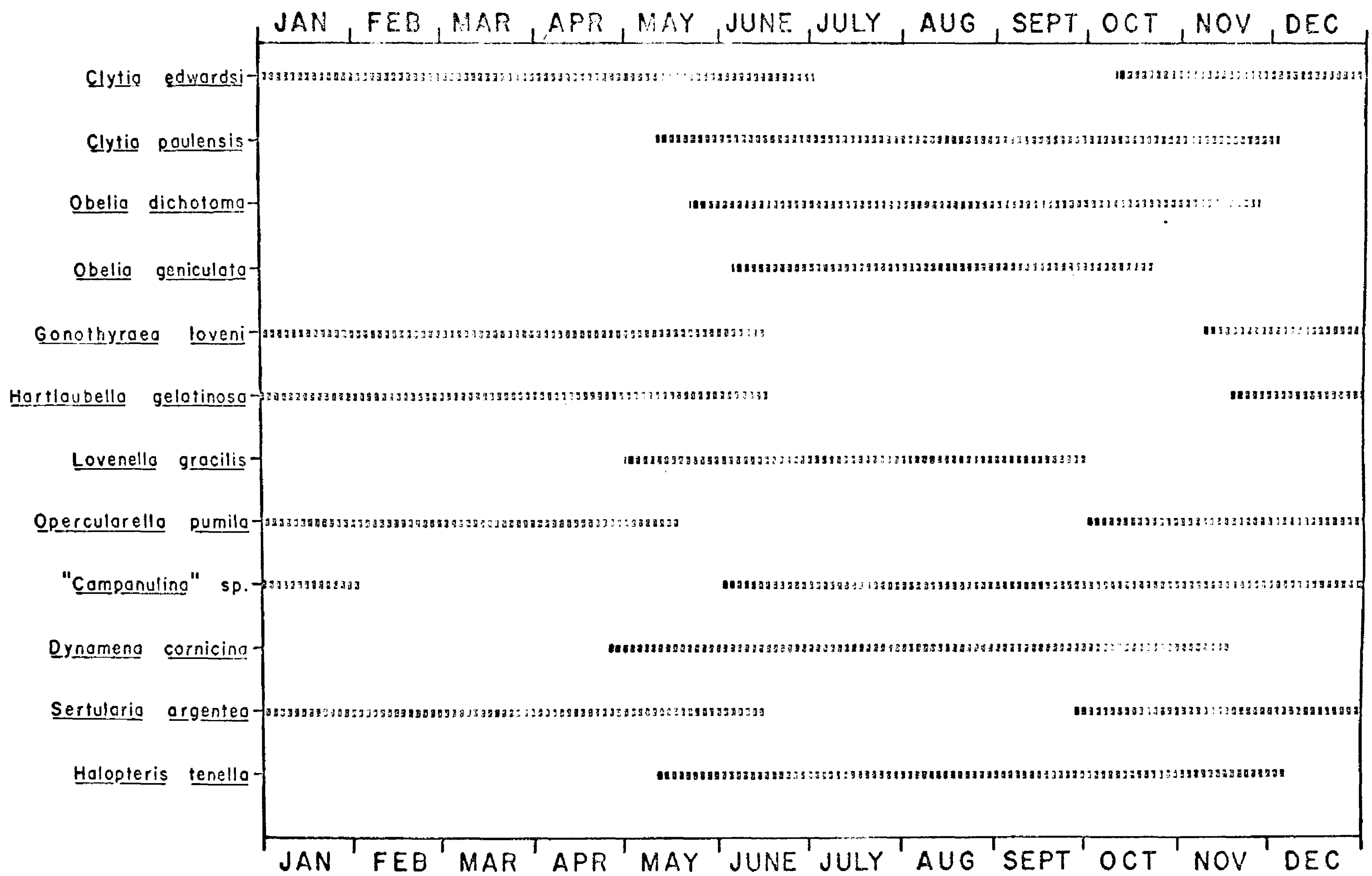


Fig. 5. Seasonality of thecate hydroids in southern Chesapeake Bay.

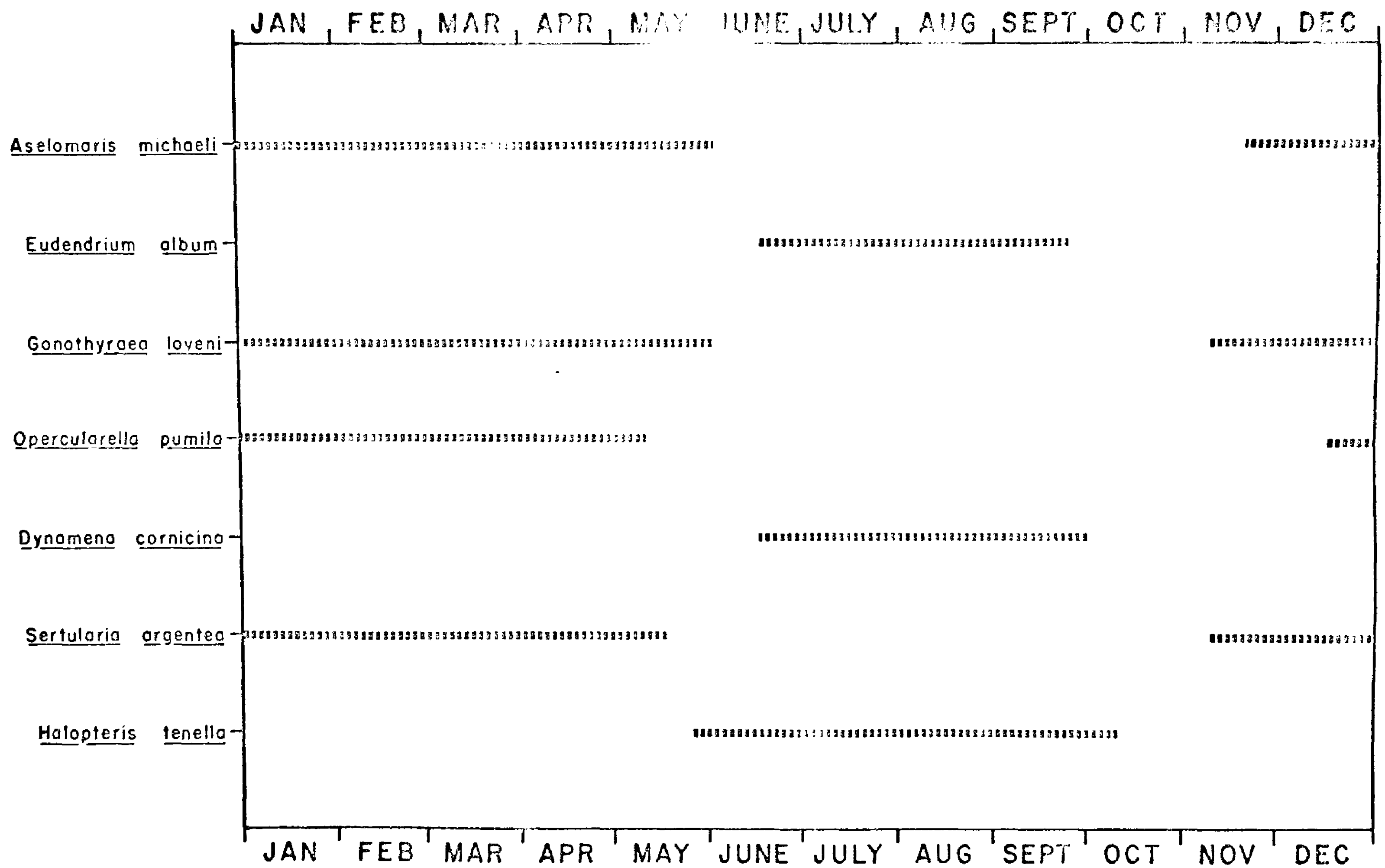


Fig. 6. Seasonality of fixed gonophores.

Table 7. Occurrence of hydromedusae at Gloucester Point during 1966-1967. Presence is indicated by +.

Species	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Ectopleura dumortieri				+	+	+	+	+	+	+	+	+
Halocordyle tiarella						+	+	+	+			
Dipurena strangulata								+	+			
Sarsia tubulosa												
Linvillea agassizi								+	+			
Turritopsis nutricula								+	+			
Hydractinia arge								+	+			
Podocoryne minima												
Rathkea octopunctata												
Bougainvillia rugosa							+					
Nemopsis bachei						+	+	+				
Proboscidactyla ornata						+	+	+	+			
Obelia spp.							+	+	+			

Table 7 continued

Species	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Eucheilota ventricularis									+	+		
Lovenella gracilis								+	+			
Phialucium carolinae								+	+			
Liriope tetraphylla								+	+			
Cunina octonaria									+	+		

unfavorable months, the predictability of appearance at a given water temperature and time of year for a given species suggests the importance of a stage capable of surviving unfavorable seasonal extremes. Data in Table 8 show that new growth can occur from dormant tissue in old stems or stolons under favorable conditions of temperature in the three species tested. After 192 hours of culture, none of the controls at 5 C showed growth, while from 80% to 100% showed growth at 25 C. Reversal of half the specimens of each species from one temperature regime to the other gave similar results at the end of an additional 192 hours (Table 9). While the controls left at 25 C showed no regression, growth was halted at 5 C, and regression occurred in 100% of these at the end of 192 hours. Tentacles became shortened, and the hydranths shrank. Hydranths were still present in some cases for E. ramosum after 192 hours, but were considerably reduced. Hydranths of E. dumortieri underwent some resorption and became detached in less than 192 hours. Several were lost during the water changing process, although none were lost this way in the 25 C bath. B. rugosa hydranths were resorbed. Comparable results were again obtained following transfer of specimens from 5 C to 25 C (Table 10). From no growth after 192 hours at 5 C, removal to 25 C resulted in from 20% to 80% growth after 192 hours. The controls left at 5 C continued in the dormant state. Culturing 192 hours seemed sufficient time for growth to occur at 25 C since little difference was noted between 192 hours and 384 hours for any species.

The extremes of 5 C and 25 C used in laboratory work were chosen since they represent temperatures normally occurring in the study area during winter and summer, respectively. The lowest mean

Table 8. Number of hydroid cultures showing growth after 192 hours under two regimes of temperature. N = 10 for each species at each temperature.

	E. dumortieri		*B. rugosa*		*E. ramosum*	
Culture temperature (C)	0 hrs	192 hrs	0 hrs	192 hrs	0 hrs	192 hrs
5	0	0	0	0	0	0
25	[illegible]	10	[illegible]		[illegible]	
Chi-square P ≤		0.01		0.01		0.02

Table 9. Influence of temperature on growth after 192 hours in laboratory cultures of hydroids. Prior to start, specimens were cultured 192 hours at 25 C.

			E. dumortieri		*B. rugosa*		*E. ramosum*	
Group	Temp (C)	N	start	end	start	end	start	end
Experimental	5	5	5	0	5	0	5	0
Control	25	5	5	5	4	4	3	3
Chi-square $P \leq$			-	0.05	-	0.05	-	0.10

Table 10. Influence of temperature on growth after 192 hours in laboratory culture of hydroids. Prior to start, specimens were cultured 192 hours at 5 C.

			E. dumortieri		*B. rugosa*		*E. ramosum*	
Group	Temp (C)	N	start	end	start	end	start	end
Experimental	25	5	0	4	0	3	0	1
Control	5	5	0	0	0	0	0	0
Chi-square P ≤			-	0.05	-	0.10	-	0.50

daily temperature for any month at Gloucester Point over a 10-year period (1953-1962) was 3.2 C for January, while the highest mean daily temperature for any month was 27.2 C for July and August (VIMS unpublished data). Factors other than temperature were not manipulated. Although temperature has been emphasized here as a factor influencing hydroid seasonality, it is not the only one. Brinckmann (1964) noted that colonies of *Staurocladia portmanni* kept at constant temperature for a year exhibited a definite seasonality both in activity and in the production of medusa buds. It has been shown that oxygen concentration influences hydroid regeneration (Barth, 1940), low concentrations being less favorable to growth than moderately high ones. While dissolved oxygen was the same for all bottles in both baths at the start of each 48-hour interval, due to water change from the same source, the final average percent saturation was 9%, 28% and 35% lower at 25 C than at 5 C for *E. dumortieri*, *B. rugosa*, and *E. ramosum*, respectively. Lowered oxygen content at 25 C could have inhibited growth to some extent, but clearly could not be considered the trigger which resulted in growth at this temperature. The greater oxygen utilization at 25 C was believed to be due to increased metabolism of the hydroids plus increased bacterial activity.

Field observations supported the information obtained in laboratory studies. Growth and hydranth development was observed beginning from old stems, stolons, or both, with the onset of favorable conditions in nature for the above species plus *Cordylophora lacustris*, *Bimeria* sp., *Eudendrium album*, *Dynamena cornicina*, *Sertularia argentea*, and *Halopteris tenella*. The temperature at which renewed activity began varied from species to species (Table 11). These data also show that the temperature at which growth begins in spring is higher than the temperature at which regression occurs in autumn for summer species. The reverse was true for S. argentea, a winter species. This suggests that the trigger for growth to begin is a temperature somewhat above the lower limit tolerable for activity in summer species and below the upper limit tolerable for activity in winter species. This has definite adaptive significance since it minimizes the possibility of energy waste due to growth followed by regression should temperatures revert in the critical direction. Once growth has been triggered, the organism has a "buffer" of three or more degrees should temperatures change toward the incipient limit. The annual date of appearance or disappearance varies slightly since water temperatures may vary from year to year on a given date.

Table 11. Water temperatures at the beginning and end of activity for several species of hydroids.

Species	Temperature at appearance (C)	Temperature at disappearance (C)
Ectopleura dumortieri	10	6
Bougainvillia rugosa	12	6
Bimeria sp.	13	9
Eudendrium album	16	12
Eudendrium ramosum	17	
Dynamena cornicina	15	12
Sertularia argentea	20	23
Halopteris tenella	13	9

DISCUSSION

While this survey was conducted intensively, there is little doubt that additional species of hydrozoans occur in the bay, particularly in the case of hydromedusae where a less exhaustive study was possible. With the importance of shipping in the area, notably in the ports of Hampton Roads, introductions are to be expected. Nevertheless, the hydroid fauna of lower Chesapeake Bay is probably relatively impoverished in terms of species. Only 50% of the families listed by Fraser (1944) for the Atlantic coast of America were represented and such large families as the Sertulariidae and Plumulariidae had but one or two representatives each. Whereas 43 hydroid species were identified from the bay in this study, Fraser (1910) at Beaufort, N. C., identified 51 species during a two-week study. For the Woods Hole region, Smith (1964) included a partial list of 39 species, but these were evidently only the more common forms, as Fraser's (1944) data indicate a much richer fauna.

The low diversity of species in the bay is attributed to a number of factors, some of which may work in combination, notably temperature and salinity. The shoreline and bottom is predominantly sand and mud, providing unfavorable substrate both for hydroids and organisms which are hydroid substrates. Absence of rocks (except on man-made islands and jetties), tidepools and heavy algal mats limit substrate and niche diversity. Nishihira (1964) showed that while Chlorophyta support few hydroids, macroscopic Phaeophyta are especially favorable, and this taxon is greatly reduced in the bay. Sargassaceae, particularly favorable as substrates, do not grow in Chesapeake Bay, and little is normally carried in by currents. Based on evidence of marked hydroid-algal substrate relationships, Nishihira proposed that distribution of certain hydroids along the Japanese coast was influenced by the distribution of suitable algal species. Field observations on Sertularella miurensis demonstrated that positive selection of algal substrates by the planulae occurred (Nishihira, 1967). The most common firm substrates for hydroids in Chesapeake Bay included Zostera marina, sponges, mollusk shells, arthropod exoskeletons, tunicate tests, and such substrates as rock islands, buoys, rope, concrete blocks, pilings, or other objects of human endeavor. Waters of the bay are turbid, and turbidity intensifies progressively toward the head of the tributaries. Substrates not swept by moderate currents rapidly become covered with silt, making planula settlement difficult. On artificial substrates such as test panels, competition for space with other epibenthos was noted, most notably during summer when heavy set and rapid growth of the ascidians Molgula manhattensis and Botryllus schlosseri occurred. Although little is known regarding the salinity tolerance of most hydroids, the number of species may be reduced under the bay's estuarine conditions. The range of salinity and temperature occurring at a given location over a year is such that only eurytolerant species are able to survive, and the species present display a marked seasonality. Absence from the fauna during certain seasons indicates the probable importance of dormant stages.

Periods of dormancy in response to critical temperatures are well documented for hydroids (Morse, 1909; Riddle, 1911; Elmhirst, 1922; Moore, 1939; Berrill, 1948a; Kinne, 1956; Tardent, 1963). Following the return of favorable conditions, new growth occurs and new hydranths are regenerated. Huxley and DeBeer (1923) indicated that in hydroids there is a coexistence of two systems, a zooid system and a stolon system, with different metabolic rates but with a physiological equilibrium normally existing between the two. They noted that under conditions more adverse to one system than the other, differential inhibition will occur, with resorption, dedifferentiation, or both taking place. Huxley and DeBeer stated that the zooids, being more specialized and less plastic than the stolon, may not be able to survive under conditions which do not appreciably affect the stem. Limited attention has been given to regression, followed by dormancy in the stem or stolons, as a method of survival during unfavorable seasons, and most present knowledge is based on either laboratory or field observation rather than a combination of both. Hargitt (1900) observed that *Halocordyle tiarella* thrived in summer at Woods Hole, but declined in vigor during autumn. The coenosarc receded into the perisarc, and a more or less prolonged period of quiescence followed. A similar process for *H. tiarella* was observed at Beaufort, N. C., by McDougall (1943). *Halocordyle cavolinii* (= *H. disticha*), active only during summer in the Mediterranean, survives the rest of the year as an inconspicuous system of stolons, which are firmly attached to the substrate (Tardent, 1963). Broch (1925) cited work by Bjorn Foyn who showed that while polyps of *Clava* perish during winter in the Oslofjord, the stolon network remains. The coenosarc in the stolon rests encapsulated within the perisarc until favorable weather returns, at which time a new colony is regenerated. Both *Bougainvillia ramosa* and *Obelia longissima* form resting spores with the onset of cold winter conditions (Broch, 1925). Broch also noted that a highly specialized resting spore is known in several Campanulariidae. Haddow (1937) observed a retraction of tissue into the stolon of Sertularia (= Dynamena) pumila during autumn and winter, followed by reformation of polyps in the old hydrothecae. Rees (1957a) mentioned that prolonged encystment of the fertilized egg occurs in capitate hydroids. Other reports of seasonal dormancy have been observed for Tubularia crocea (Hyman, 1920; Moore, 1939; McDougall, 1943), T. indivisa (Elmhirst, 1922), Eudendrium (Bumpus, 1898), Obelia (Hammett and Hammett, 1945), and Margelopsis haeckeli (Werner, 1954, 1955).

Intervals of dormancy during critical environmental conditions are common in several aquatic taxa besides the Cnidaria. This has been particularly well documented for certain fresh-water animals, which produce resting stages of various types during certain seasons. While marine environments are generally more stable, dormancy may be more widespread than generally realized, particularly in rigorous habitats or regions with considerable seasonal variation. Wells et al. (1964) observed gemmule formation in three species of marine sponges during unfavorable seasons. Nasonov (Hyman, 1951) observed regeneration of the calyx in the entoproct Arthropodaria kovalevskii following a winter absence evidently due to a seasonal fresh-water influx. A number of gymnolaemate bryozoans form resting stages which later re-establish the colonies, and the phoronid Phoronis hippocrepia degenerates seasonally to fragments in the tubes, which regenerate the worms at the return of favorable conditions (Hyman, 1959). Huxley (1921) showed that dedifferentiated tissues in the ascidian Perophora provide material for new processes which form new zooids.

These examples of dormancy from a number of diverse animal phyla illustrate its probable ecological significance.

The importance of a dormant stage in hydroids should be determined in studies for such factors as salinity, pollutants, or other short- or long-term adverse environmental conditions. Such a resistant stage may be of selective value in the dispersal of hydroids. The widespread genus Moerisia, reported recently in North America (Calder and Burrell, 1967), suggests the zoogeographic significance of a resistant phase in hydrozoan life cycles. Moerisia medusae are limited to oligohaline waters, yet the genus is known from the Caspian Sea, Egypt, India, Australia, Japan, and two Chesapeake Bay tributaries. This distribution, coupled with its apparent salinity tolerance, indicates the possibility of a stage resistant to oceanic salinity. As Broch (1925) noted, detailed study on the formation and biology of resistant stages is unavoidably necessary for the understanding of many biogeographical phenomena.

From observations on the influence of temperature on seasonality, it might be assumed that species would occur at different times of the year in different latitudes. While this may be true in some cases, with the boreal species Aselomaris michaeli and Gonothyraea loveni being typical winter forms in Chesapeake Bay, it does not always apply. At Woods Hole, Hargitt (1900) noted active Halocordyle tiarella hydroids from June until November. In Chesapeake Bay it is present from June until September, and while colonies of the species were expected and specifically looked for prior to June, collections before that month yielded only dormant stolons. At Beaufort, McDougall (1943) reported H. tiarella active from mid-April until late November. Obelia geniculata, one of the most cosmopolitan of all hydroids, occurs as a summer species in Chesapeake Bay, not having been found below 15 C, yet during this study it was collected with gonophores at 10 C during summer in Passamaquoddy Bay, New Brunswick. This demonstrates that a species may not tolerate within a given area the range of temperature that it tolerates geographically, and that seasonality in a given area cannot always be predicted from its temperature tolerance or seasonality in another region. It is generally believed by physiologists that Tubularia crocea does not remain active in temperatures above 20-21 C (Moore, 1939; Mackie, 1966). Unless specimens from Chesapeake Bay were incorrectly identified, the species was healthy, abundant, and reproducing at 24 C on rock islands and pilings of the Chesapeake Bay Bridge-Tunnel, and on pilings along the southern bay shore of Northampton County, Virginia, during the summer of 1967. McDougall (1943) found that 20 C was clearly not the critical temperature for autotomy in T. crocea at Beaufort. He believed that successive summer generations showed increased tolerance for high temperatures compared with winter and spring generations. Populations present during July and August survived temperatures up to 30 C. It should also be noted that a species may not occur in an area although temperature may be seasonally favorable. While the wide range of temperature in Chesapeake Bay makes it theoretically possible, considering temperature alone, for a large number of hydroid species to occur, the fauna of the bay is typically that of temperate regions.

Although temperature is the most important feature determining the distribution of marine organisms (Hutchins, 1947), attempts to base animal distribution solely on physical factors is invalid, as noted by Crisp (1965), and few typically sub-polar or tropical species are present in the bay even during their respective temperature optima. Possible factors responsible for this include:

1) Organisms may not survive the unfavorable environmental extremes.
2) Paucity or absence of favorable substrates.
3) Physical barriers intermediate between the bay and the given species' range.
4) Existing current patterns may not be conducive to dispersal of organisms or their larvae into the bay.
5) Brief duration of the seasons. Summer temperatures above 25 C may be too short to permit "preconditioning," growth and reproduction. Similar patterns of low temperatures may not be adequate to permit successful colonization by certain boreal species.
6) Under local conditions, such factors as salinity, depth, turbidity, current or food may determine the presence or absence of a species.

The Chesapeake Bay is an interesting region for zoogeographical comparison with other regions because of its wide range of environmental conditions from location to location and from season to season. The bay does not correspond readily with any of the proposed zones delineated on the basis of temperature since temperatures may vary in extreme cases from 0 C in winter to 30 C in summer. Among the several zoogeographic divisions of the Atlantic coast, one of the better known is that of Stephenson and Stephenson (1954). Included in their scheme were the following provinces:

1) Arctic, with a southern limit probably lying north of Labrador.

2) Subarctic or Syrtensian, including Labrador, most of Hudson Bay, the southern tip of Greenland, Northern Newfoundland and the Gulf of St. Lawrence.

3) Acadian, extending from Cape Cod northward to the Subarctic Province.

4) Carolinian, extending from Cape Hatteras to Cape Kennedy.

5) Tropical, from Cape Kennedy southward.

The Virginian, extending from Cape Cod to Cape Hatteras, was not considered a distinct province but an overlapping region with some Acadian forms and some Carolinian forms.

Fraser (1946), considering distribution of hydroids, divided the American Atlantic coast into three major regions between the Maritime Provinces and Florida. The first region, from the Bay of Fundy to Cape Cod, was divided into three main parts: 1) Bay of Fundy, 2) Gulf of Maine, 3) Coast of Massachusetts. A number of hydrographic features characterize each area and influence the faunal composition. Fraser believed that strong tidal action in the Bay of Fundy acted as a deterrent to settling planulae, except in sheltered waters such as those of Passamaquoddy Bay, N. B., and Digby Gut, N. S., where the hydroid fauna is rich. Strong currents also occur in the Gulf of Maine, and the influence of the Labrador Current is still felt, although conditions suitable for hydroids occur in sheltered areas such as the Mount Desert Island and Casco Bay regions. Along the Massachusetts coast, fewer suitable regions occur, although the area is protected somewhat by Cape Cod and Georges Bank. Fraser's second region, extending from Cape Cod to Cape Hatteras, was also divided into a number of different parts. The first, from Cape Cod to the western end of Long Island Sound, has several offshore islands, and most of the region is favorable for hydroid habitation despite the sandy or muddy bottom in shallow waters of Vineyard Sound and Buzzard's Bay. From New York southward, conditions for hydroid development are less favorable, except in Delaware Bay and Chesapeake Bay. Sand predominates farther south, But Sargassum provides a substrate for hydroids. Fraser regarded the area from Cape Hatteras to Key West as a tropical section. The Gulf of Mexico and Caribbean Sea faunas were combined into one unit by Fraser. Examination of collections from the northern Gulf by Deevey (1950, 1954) make this seem a questionable procedure.

Fraser (1944) stated that no distinct interruption in distribution occurs anywhere along the coast, even in areas where a particular order or family displays a definite break. A comparison of the hydroids in the Acadian with the Virginian indicates that Cape Cod is ineffective as a barrier to hydroid distribution (Table 12). However, Cape Hatteras appears to be a more effective breaking point since the Virginian and Carolinian faunas are somewhat distinct. Fraser's (1944) data suggest a boreal fauna from Cape Hatteras northward to the Maritime Provinces, and a tropical fauna from Cape Hatteras southward. However, Chesapeake Bay hydroids show a slightly greater affinity with those of the Carolinian Province (Table 13). Of these species, 76% occur south of Cape Hatteras, while 59% occur north of Cape Cod. Forty-one percent of the species occur both north of Cape Cod and south of Cape Hatteras.

From Tampa Bay along the northern Gulf coast to Texas, Deevey (1954) listed 57 species of hydroids. The fauna is chiefly tropical in affinity, despite the ecological variability of the northern Gulf. However, Deevey noted that many of the recorded species from the Gulf

Table 12. Zoogeographic comparisons of the hydroid fauna along the eastern United States. Data from Fraser (1944) and Deevey (1954).

	Acadian Province	Virginian Province
Number of species	126	153
Percent in common	75%	62%
	Virginian Province	Carolinian Province
Number of species	153	164
Percent in common	39%	36%
	Southern Chesapeake Bay	Northern Gulf of Mexico
Number of species	43	57
Percent in common	28%	21%

Table 13. List of hydroids from Chesapeake Bay, with their east coast distribution. Presence is indicated by +; (+) indicates record of medusa only.

Species	Acadian Province	Carolinian Province
Moerisia lyonsi		
Ectopleura dumortieri		(+)
Tubularia crocea	+	+
Halocordyle tiarella	(+)	+
Dipurena strangulata		(+)
Sarsia tubulosa		+
Linvillea agassizi		+
Zanclea costata		+
Cordylophora lacustris		+
Turritopsis nutricula		
Hydractinia arge		
Hydractinia echinata		
Bougainvillia rugosa		
Bimeria cerulea		
Bimeria franciscana		
Aselomaris michaeli		
Amphinema dinema		(+)
Proboscidactyla ornata		(+)
Eudendrium album		+
Eudendrium carneum		+
Eudendrium ramosum		

Table 13 continued

Species	Acadian Province	Carolinian Province
Halecium gracile	+	+
Clytia cylindrica	+	
Clytia edwardsi	+	
Clytia hemisphaerica		
Clytia paulensis		
Clytia kincaidi		
Obelia bicuspidata		
Obelia commissuralis		
Obelia dichotoma		
Obelia geniculata		
Obelia longicyatha		
Obelia longissima		
Gonothyraea loveni		
Hartlaubella gelatinosa		
Lovenella gracilis		
Opercularella pumila		
Opercularella lacerata		
Dynamena cornicina		
Sertularia argentea		
Halopteris tenella		

are Sargassum-borne and may not be true residents. A comparison of the fauna with that of Chesapeake Bay is given in Table 12. For the entire Gulf of Mexico, Deevey (1954) listed 183 species. Despite this number, Deevey felt that the hydroid fauna of the Gulf was not well known, and he believed that possibly half of the species occurring in the Gulf have yet to be reported. Of the 183 presently known, 95 also occur in the Caribbean.

The various families of hydroids show differing patterns in number of species from one region to another. The Plumulariidae are well represented in the tropics but thin out markedly toward the poles. Fraser (1944) listed 62 species from the Carolinian, 18 from the Virginian and five from the Acadian. The only representative of the family in Chesapeake Bay is Halopteris tenella. The number of hydroid species overall does not show any great increase in number of species toward the equator, and Deevey (1950) observed that habitats for hydroids are no more extensive in the tropics than elsewhere. Fraser (1944) listed 129 species from the Arctic and Subarctic, 126 from the Acadian, 153 from the Virginian, 163 from the Carolinian, and 202 from the Caribbean, West Indies, and Gulf of Mexico.

In a study of the hydromedusae along the eastern American seaboard, Kramp (1959) included two zoogeographic zones between Newfoundland and the tropics. The West-Atlantic Boreal zone included the region from Newfoundland to Cape Hatteras, and the West-Atlantic Tropical extended from Cape Hatteras south to Montevideo, Uruguay. Kramp divided the first region into three provinces: 1) Newfoundland to the south shore of Nova Scotia, 2) Gulf of Maine, 3) Cape Cod to Cape Hatteras. He divided the tropical region into five provinces: 1) Cape Hatteras to Florida, 2) the Gulf of Mexico, 3) the Caribbean Sea, 4) Trinidad to Cape San Roque, 5) Cape San Roque to Montevideo. Kramp did not discuss the Gulf of Mexico in detail because of insufficient information. Sears (1954) listed the species recorded from the entire Gulf but did not give their locale of collection, so the paper is of little zoogeographical value. However, the hydromedusae of the St. Andrew Bay system of Florida have been studied by Hopkins (1966).

Combining Kramp's (1959) distribution data on the boreal neritic species, and including two species not listed by Kramp for the Cape Cod to Cape Hatteras area shows that the first "province" has 60% of its 15 species also present in the second "province," while of 28 species in the second province, only 32% occur in the first province (Table 14). This suggests that the first is merely a sector of province two and should not be regarded as separate using the 50% endemism criterion. Combining the species from provinces one and two into one province, the Acadian, and comparing it with province three, the Virginian, indicates that the fauna of the two regions is distinct, and that the Cape Cod vicinity appears to be an effective barrier to distribution of neritic hydromedusae (Table 15). Fully 69% of the Virginian species are also present in the Carolinian Province, indicating that the hydromedusae of the Virginian are principally warm-temperate species, capable of surviving north of Cape Hatteras.

Overall, the hydromedusae of Chesapeake Bay show a greater affinity with the Carolinian than the Acadian (Table 16). Of these, 77% occur in the Carolinian, while 35% occur in the Acadian. Twenty-three percent occur in both provinces. As presently known,

Table 14. Comparison of the neritic hydromedusae in the three provinces of Kramp's (1959) West Atlantic Boreal region.

	1. Nfld.-N.S.	2. Gulf of Maine	3. Cape Cod-Cape Hatteras
Number of species	15	28	36
Percent in common with	2-60%	1-32%	1-6%
Percent in common with	3-13%	3-39%	2-31%

Table 15. Zoogeographic comparisons of the neritic hydromedusae along the eastern United States. Data from Kramp (1959).

	Acadian	Virginian
Number of species	34	36
Percent in common	32%	31%

	Virginian	Carolinian
Number of species	36	83
Percent in common	69%	30%

Table 16. List of hydromedusae known from Chesapeake Bay, and their east coast distribution. Presence is indicated by +; (+) indicates record of hydroid only.

Species	Acadian Province	Carolinian Province
Moerisia lyonsi		
Ectopleura dumortieri		
Hybocodon prolifer		
Halocordyle tiarella		
Dipurena strangulata		+
Sarsia tubulosa		(+)
Linvillea agassizi		+
Zanclea costata		+
Turritopsis nutricula		
Hydractinia arge		
Podocoryne minima		
Rathkea octopunctata	+	
Bougainvillia carolinensis	(+)	
Bougainvillia rugosa		
Nemopsis bachei		
Amphinema dinema		
Proboscidactyla ornata		
Obelia spp.		
Eucheilota ventricularis		
Lovenella gracilis		
Phialucium carolinae		

Table 16 continued

Species	Acadian Province	Carolinian Province
Blackfordia virginica		
Eutima mira		
Liriope tetraphylla		
Aglantha digitale		
Cunina octonaria		

the fauna of Chesapeake Bay typifies the Virginian transitional zone. Seasonality unfortunately is ignored in such zoogeographic analyses since few records include the dates of season of collection. It seems possible that the Virginian region, characterized by wide seasonal temperature variation, has primarily an Acadian fauna in winter and a Carolinian fauna in summer, but data to test this hypothesis are not readily available.

LITERATURE CITED

Agassiz, A. 1862. In: L. Agassiz. Contributions to the natural history of the United States of America. Vol. 4. Little, Brown, and Co., Boston. 380 p.

Agassiz, A. 1865. North American Acalephae. Cat. Mus. Comp. Zool. Harvard 2:1-234.

Agassiz, L. 1862. Contributions to the natural history of the United States of America. Vol. 4. Little, Brown, and Co., Boston. 380 p.

Alder, H. L. and E. B. Roessler. 1962. Introduction to probability and statistics, 2nd Edition. W. H. Freeman and Co., San Francisco. 289 p.

Allman, G. J. 1874. Diagnoses of new genera and species of Hydroida. J. Linnaean Soc. 12:251-284.

Allwein, J. 1967. North American hydromedusae from Beaufort, North Carolina. Vidensk. Medd. Dansk Naturh. Foren. 130: 117-136.

Barth, L. G. 1940. The process of regeneration in hydroids. Biol. Rev. 15:405-420.

Behre, E. H. 1950. Annotated list of the fauna of the Grand Isle region 1942-1946. Louisiana State Univ. Mar. Lab. Occas. Pap. 6. 66 p.

Bennitt, R. 1922. Additions to the hydroid fauna of the Bermudas. Proc. Amer. Acad. Arts Sci. 57:239-259.

Berrill, N. J. 1948a. Temperature and size in the reorganization of *Tubularia*. J. Exp. Zool. 107:455-464.

Berrill, N. J. 1948b. The life cycle of *Aselomaris michaeli*, a new gymnoblastic hydroid. Biol. Bull. 95:289-295.

Berrill, N. J. 1949. Growth and form in calyptoblastic hydroids. J. Morph. 85:297-335.

Bigelow, H. B. 1915. Exploration of the coast water between Nova Scotia and Chesapeake Bay, July and August 1913, by the U. S. Fisheries schooner "Grampus." Oceanography and Plankton. Bull. Mus. Comp. Zool. Harvard 59:149-359.

Bigelow, H. B. 1918. Some medusae and siphonophorae from the western Atlantic. Bull. Mus. Comp. Zool. Harvard 62:365-442.

Bouillon, J. 1965. Diagnoses préliminaires de trois hydroides de Roscoff. Edit. Stat. Biol. Roscoff, 1965:54.

Bousfield, E. L. and A. H. Leim. 1960. The fauna of the Minas Basin and Minas Channel. Bull. Nat. Mus. Canada 166. 30 p.

Brinckmann, A. 1964. Observations on the biology and development of Staurocladia portmanni sp. n. (Anthomedusae, Eleutheridae). Canadian J. Zool. 42:693-705.

Brinckmann, A. and K. W. Petersen. 1960. On some distinguishing characters of Dipurena reesi Vannucci 1956 and Cladonema radiatum Dujardin 1834. Pubbl. Staz. Zool. Napoli 31:386-392.

Brinckmann, A. and M. Vannucci. 1965. On the life-cycle of Proboscidactyla ornata (Hydromedusae, Proboscidactylidae). Pubbl. Staz. Zool. Napoli 34:357-365.

Broch, H. 1918. Hydroida. Part II. Danish Ingolf-Exped. 5: 1-205.

Broch, H. 1925. Biogeographie vom Tier aus. Naturwissenschaften 13:447-452.

Brooks, W. K. 1882. List of medusae found at Beaufort, N. C., during the summers of 1880 and 1881. Stud. Biol. Lab., Johns Hopkins Univ. 2:135-146.

Browne, E. T. 1907. The hydroids collected by the "Huxley" from the north side of the Bay of Biscay in August, 1906. J. Mar. Biol. Ass. U. K. 8:15-36.

Bumpus, H. C. 1898. The breeding of animals at Woods Hole during the month of May, 1898. Science 8:58-61.

Calder, D. R. 1966. Ecology of marine invertebrate fouling organisms in Hampton Roads, Virginia. M.A. Thesis, College of William and Mary, Williamsburg, Va. 66 p.

Calder, D. R. 1967. Activity-inactivity cycles in some south-western Chesapeake Bay Hydrozoa. Virginia J. Sci. 18 n.s.: 156.

Calder, D. R. and M. L. Brehmer. 1967. Seasonal occurrence of epifauna on test panels in Hampton Roads, Virginia. Int. J. Oceanol. Limnol. 1:149-164.

Calder, D. R. and V. G. Burrell, Jr. 1967. Occurrence of Moerisia lyonsi (Limnomedusae, Moerisiidae) in North America. Amer. Midland Natur. 78:540-541.

Clark, S. F. 1876. Descriptions of new and rare species of hydroids from the New England coast. Trans. Conn. Acad. Sci. 3:58-66.

Clarke, S. F. 1882. New and interesting hydroids from Chesapeake Bay. Mem. Boston Soc. Natur. Hist. 3:135-142.

Congdon, E. D. 1907. The hydroids of Bermuda. Proc. Amer. Acad. Arts Sci. 49:463-485.

Cory, R. L. 1967. Epifauna of the Patuxent River Estuary, Maryland, for 1963 and 1964. Chesapeake Sci. 8:71-89.

Cowles, R. P. 1930. A biological study of the offshore waters of Chesapeake Bay. Bull. U. S. Bur. Fish. 46:277-381.

Crisp, D. J. 1965. Observations on the effects of climate and weather on marine communities, p. 63-77. In: The biological significance of climatic changes in Britain. Academic Press, New York.

Cronin, L. E., J. C. Daiber, and E. M. Hulbert. 1962. Quantitative seasonal aspects of zooplankton in the Delaware River Estuary. Chesapeake Sci. 3:63-93.

Crowell, S. 1945. A comparison of the shells utilized by *Hydractinia* and *Podocoryne*. Ecology 26:207.

Crowell, S. 1947. A new form of the hydroid *Stylactis*. Biol. Bull. 93:206.

Crowell, S. and R. M. Darnell. 1955. Occurrence and ecology of the hydroid *Bimeria franciscana* in Lake Pontchartrain, Louisiana. Ecology 36:516-518.

Dawson, J. W. 1858. Sea anemones and hydroid polyps from the Gulf of St. Lawrence. Canadian Natur. Geol. 3:401-409.

Deevey, E. S., Jr. 1950. Hydroids from Louisiana and Texas, with remarks on the Pleistocene biogeography of the western Gulf of Mexico. Ecology 31:334-367.

Deevey, E. S., Jr. 1954. Hydroids of the Gulf of Mexico. U. S. Fish. Bull. 55:267-272.

Deevey, G. B. 1960. The zooplankton of the surface waters of the Delaware Bay region. Bull. Bingham Oceanogr. Coll. 17:5-53.

Elmhirst, R. 1922. Cyclic conditions and rejuvenation in hydroids. Nature 109:208-209.

Ferguson, F. F. and E. R. Jones. 1949. A survey of the shoreline fauna of the Norfolk peninsula. Amer. Midland Natur. 41:436-446.

Fincher, J. A. 1955. Notes on the hydroids of the Mississippi Sound. J. Alabama Acad. Sci. 27:91-92.

Forbes, E. 1846. On the pulmograde medusae of the British seas. Ann. Mag. Natur. Hist., Ser. 1, Vol. 18:284-287.

Fraser, C. M. 1910. Some hydroids of Beaufort, North Carolina. Bull. U. S. Bur. Fish. 30:339-387.

Fraser, C. M. 1912. Notes on New England hydroids. Bull. Lab. Natur. Hist., State Univ. Iowa 1912:39-48.

Fraser, C. M. 1913. Hydroids from Nova Scotia. Canadian Geol. Surv., Victoria Mem. Mus. Bull. 1:157-186.

Fraser, C. M. 1914. Some hydroids of the Vancouver Island region. Trans. Roy. Soc. Canada (3) 8, Sect. 4:99-216.

Fraser, C. M. 1915. Pelagic hydroids. Bull. Mus. Comp. Zool. Harvard 59:306-314.

Fraser, C. M. 1918. Hydroids of eastern Canada. Contrib. Canadian Biol. 1910-1917:329-367.

Fraser, C. M. 1921. Key to the hydroids of eastern Canada. Contrib. Canadian Biol. 1918-1920:137-180.

Fraser, C. M. 1924. _Acaulis primarius_ Stimpson. Trans. Roy. Soc. Canada 18:209-214.

Fraser, C. M. 1926. Hydroids of the Miramichi estuary, collected in 1918. Trans. Roy. Soc. Canada 18:165-173.

Fraser, C. M. 1927. The hydroids of the Cheticamp expedition of 1917. Contrib. Canadian Biol. Fish. 6:477-481.

Fraser, C. M. 1931. Hydroids of Hudson Bay and Hudson Strait. Contrib. Canadian Biol. Fish. 6:477-481.

Fraser, C. M. 1937a. Hydroids of the Pacific coast of Canada and the United States. Univ. Toronto Press, Toronto. 207 p.

Fraser, C. M. 1937b. New species of hydroids from the Puerto Rican region. Smithsonian Misc. Coll. 91:1-7.

Fraser, C. M. 1940. Seven new species and one new genus of hydroids, mostly from the Atlantic Ocean. Proc. U. S. Nat. Mus. 88:575-580.

Fraser, C. M. 1941. New species of hydroids, mostly from the Atlantic Ocean, in the United States National Museum. Proc. U. S. Nat. Mus. 91:77-89.

Fraser, C. M. 1943. Distribution records of some hydroids in the collection of the Museum of Comparative Zoology at Harvard College, with descriptions of new genera and species. Proc. New England Zool. Club 22:75-98.

Fraser, C. M. 1944. Hydroids of the Atlantic coast of North America. Univ. Toronto Press, Toronto. 451 p.

Fraser, C. M. 1945. Notes on some recently collected hydroids in the United States National Museum, with descriptions of three new species. J. Washington Acad. Sci. 35:21-23.

Fraser, C. M. 1946. Distribution and relationship in American hydroids. Univ. Toronto Press, Toronto. 464 p.

Fraser, C. M. 1947. Hydroids of the 1939 Allan Hancock Caribbean Sea Expedition. Allan Hancock Atlantic Exped. 4. 24 p.

Frey, D. G. 1946. Oyster bars of the Potomac River. U. S. Fish and Wildlife Service, Spec. Sci. Rep. 32. 93 p.

Fuller, J. S. 1946. Season of attachment and growth of sedentary marine organisms at Lamoine, Maine. Ecology 27:150-158.

Gemerden-Hoogeveen, G. C. H. van. 1965. Hydroids of the Caribbean: Sertulariidae, Plumlulariidae and Aglaopheniidae. Stud. Fauna Curaçao Caribb. Isl. 22:1-87.

Haddow, A. J. 1937. The growth of Sertularia. Rep. Scot. Mar. Biol. Ass. 1936-1937:8-9.

Haeckel, E. 1879. Das System der Medusen. Erster Theil einer Monographie der Medusen. Denkschr. Ges., Jena. 360 p.

Hammett, F. S. and D. W. Hammett. 1945. Seasonal changes in Obelia colony composition. Growth 9:55-145.

Hancock, D. A., R. E. Drinnan, and W. N. Harris. 1956. Notes on the biology of Sertularia argentea L. J. Mar. Biol. Ass. U. K. 35:307-325.

Hand, C. 1954. Three Pacific species of "Lar" (including a new species), their hosts, medusae, and relationships (Coelenterata, Hydrozoa). Pacific Sci. 8:51-67.

Hargitt, C. W. 1900. A contribution to the natural history and development of Pennaria tiarella McCrady. Amer. Natur. 34: 387-416.

Hargitt, C. W. 1904. The medusae of the Woods Hole region, Massachusetts. Bull. U. S. Bur. Fish. 24:21-79.

Hargitt, C. W. 1908. Notes on a few coelenterates of Woods Holl. Biol. Bull. 14:95-120.

Hargitt, C. W. 1909. New and little known hydroids of Woods Hole. Biol. Bull. 17:369-385.

Harrison, W., J. J. Norcross, N. A. Pore, and E. M. Stanley. 1967. Circulation of shelf waters off the Chesapeake Bight. ESSA Professional Paper 3, 82 p.

Hartlaub, C. 1897. Die Hydromedusen Helgolands. Wiss. Meersunters. Deutsch. Meere nF 1, Bd. 2:449-536.

Hincks, T. 1868. A history of the British hydroid zoophytes. John van Voorst, London. 338 p.

Hopkins, T. L. 1966. The plankton of the St. Andrew Bay system, Florida. Pub. Inst. Mar. Sci. Univ. Texas 11:12-64.

Hutchins, L. W. 1947. The bases for temperature zonation in geographical distribution. Ecol. Monogr. 11:325-335.

Huvé, P. 1952. Révision des polypes campanulinides méditerranéens. 2me partie. Dipleuron gracilis (Clarke) 1882, nouvel hydraire campanulinide europeen. Vie et Milieu 3:389-396.

Huxley, J. S. 1921. Studies in dedifferentiation. II. Dedifferentiation and resorption in Perophora. Quart. J. Microscop. Sci. 65:643-697.

Huxley, J. S. and G. R. DeBeer. 1923. Studies in dedifferentiation. IV. Resorption and differential inhibition in Obelia and Campanularia. Quart. J. Microscop. Sci. 67:473-475.

Hyman, L. H. 1920. The axial gradients in Hydrozoa. III. Experiments on the gradient of Tubularia. Biol. Bull. 38: 353-403.

Hyman, L. H. 1951. The invertebrates. III. Acanthocephala, Aschelminthes, and Entoprocta. McGraw-Hill, New York. 572 p.

Hyman, L. H. 1959. The invertebrates. V. Smaller coelomate groups. McGraw-Hill, New York. 783 p.

Kingsley, J. S. 1901. Preliminary catalogue of the marine invertebrata of Casco Bay, Maine. Proc. Portland Soc. Natur. Hist. 2:161-163.

Kingsley, J. S. 1910. A synopsis of the fixed hydroids of New England. Tufts College Stud. 3:13-38.

Kinne, O. 1956. Zur Oekologie der Hydroidpolypen des Nordostseekanals. Z. Morph. Okol. Tiere 45:217-249.

Kramp, P. L. 1938a. Die meduse von Ostroumovia inkermanica (Palt.-Ostroumova 1925) und die systematische Stellung der Olindiiden. Zool. Anz. 122:103-108.

Kramp, P. L. 1938b. Marine Hydrozoa. a. Hydroida. Zool. Iceland, Vol. 2, part 5a. 82 p.

Kramp, P. L. 1958. Hydromedusae in the Indian Museum. Rec. Indian Mus. 53:339-376.

Kramp, P. L. 1959. The hydromedusae of the Atlantic Ocean and adjacent waters. Dana Rep. 46:1-283.

Kramp, P. L. 1961. Synopsis of the medusae of the world. J. Mar. Biol. Ass. U. K. 40:1-469.

Kramp, P. L. 1965. The hydromedusae of the Pacific and Indian oceans. Dana Rep. 63:1-161.

Leidy, J. 1855. Contribution towards a knowledge of the marine invertebrate fauna of the coasts of Rhode Island and New Jersey. J. Acad. Natur. Sci. Philadelphia 3:135-138.

Leloup, E. 1935. Hydraires calyptoblastique des Indes Occidentales. Mém. Mus. Hist. Natur. Belg. 2:1-73.

Leloup, E. 1938. Quelques hydraires des Cotes orientale et occidentale. Mém. Mus. Hist. Natur. Belg. 14:1-9.

Linnaeus, C. 1758. Systema Naturae. 10th ed. Lipsaiae.

Linnaeus, C. 1767. Systema Naturae. 12th ed. Holmiae.

Littleford, R. A. 1939. Distribution of Rathkea. Nature 143: 1070-1071.

Mackie, G. O. 1966. Growth of the hydroid Tubularia in culture, p. 397-412. In: Rees, W. J. (Ed.) The Cnidaria and their evolution. Academic Press, Aberdeen.

Marine Biological Association. 1957. Plymouth marine fauna. Mar. Biol. Ass. U. K. 457 p.

Mayer, A. G. 1900. Some medusae from the Tortugas, Florida. Bull. Mus. Comp. Zool. Harvard 37:13-82.

Mayer, A. G. 1910a. Medusae of the world. I. The Hydromedusae. Carnegie Inst. Washington Pub. 109:1-230.

Mayer, A. G. 1910b. Medusae of the world. II. The Hydromedusae. Carnegie Inst. Washington Pub. 109:231-498.

Mayer, A. G. 1910c. Medusae of the world. III. The Scyphomedusae. Carnegie Inst. Washington Pub. 109:499-735.

McCrady, J. 1858. Gymnophthalmata of Charleston Harbour. Proc. Elliot Soc. Natur. Hist. 1:103-221.

McDougall, K. D. 1943. Sessile marine invertebrates of Beaufort, North Carolina. Ecol. Monogr. 13:321-374.

Millard, N. A. H. 1959. Hydrozoa from ships' hulls and experimental plates in Cape Town docks. Ann. South African Mus. 45:239-256.

Millard, N. A. H. 1962. The Hydrozoa of the south and west coasts of South Africa. Part I. The Plumulariidae. Ann. South African Mus. 46:261-319.

Millard, N. A. H. 1966. The Hydrozoa of the south and west coasts of South Africa. Part III. The Gymnoblastea and small families of Calyptoblastea. Ann. South African Mus. 48:427-487.

Moore, D. R. 1962. Occurrence and distribution of Nemopsis bachei Agassiz (Hydrozoa) in the northern Gulf of Mexico. Bull. Mar. Sci. Gulf and Caribbean 12:399-402.

Moore, J. A. 1939. The role of temperature in hydranth formation in Tubularia. Biol. Bull. 76:104-107.

Morse, M. 1909. The autotomy of the hydranth of Tubularia. Biol. Bull. 16:172-182.

Murbach, L. 1899. Hydroids from Woods Hole, Mass. Hypolytus peregrinus, a new unattached marine hydroid; Corynitis agassizii and its medusa. Quart. J. Microscop. Sci. n.s. 42:341-360.

Nishihira, M. 1964. The association between Hydrozoa and their attachment substrata with special reference to algal substrates. Bull. Mar. Biol. Sta. Asamushi 12:75-92.

Nishihira, M. 1967. Observations on the selection of algal substrata by hydrozoan larvae, Sertularella miurensis in nature. Bull. Mar. Biol. Sta. Asamushi 13:35-48.

Nutting, C. C. 1899. Hydroida from Alaska and Puget Sound. Proc. U. S. Nat. Mus. 21:741-753.

Nutting, C. C. 1900. American hydroids. I. The Plumularidae. Smithsonian Inst., U. S. Nat. Mus. Spec. Bull. 142 p.

Nutting, C. C. 1901. The hydroids of the Woods Hole region. Bull. U. S. Bur. Fish. 19:325-386.

Nutting, C. C. 1904. American hydroids. II. The Sertularidae. Smithsonian Inst., U. S. Nat. Mus. Spec. Bull. 151 p.

Nutting, C. C. 1915. American hydroids. III. The Campanularidae and Bonneviellidae. Smithsonian Inst., U. S. Nat. Mus. Spec. Bull. 118 p.

Packard, A. S. 1863. A list of animals dredged from Caribou Island, southern Labrador. Canadian Natur. Geol. 8:401-429.

Pearse, A. S. and L. G. Williams. 1951. The biota of the reefs off the Carolinas. J. Elisha Mitchell Sci. Soc. 67:133-161.

Poche, F. 1914. Das System der Coelenterata. Arch. Naturgesch. 80:47-129.

Ralph, P. M. 1956. Variation in Obelia geniculata (Linnaeus, 1758) and Silicularia bilabiata (Coughtrey, 1875) (Hydroida, F. Campanulariidae). Trans. Roy. Soc. N. Z. 84:279-296.

Ralph, P. M. 1957. New Zealand thecate hydroids. Part I. Campanulariidae and Campanulinidae. Trans. Roy. Soc. N. Z. 84:811-854.

Rees, W. J. 1938. Observations on British and Norwegian hydroids and their medusae. J. Mar. Biol. Ass. U. K. 23:1-42.

Rees, W. J. 1939a. A revision of the genus Campanulina van Beneden, 1847. Ann. Mag. Natur. Hist. Ser. 11, 3:433-447.

Rees, W. J. 1939b. The hydroid of the medusa Dipurena halterata (Forbes). J. Mar. Biol. Ass. U. K. 23:343-346.

Rees, W. J. 1941. Notes on British and Norwegian hydroids and medusae. J. Mar. Biol. Ass. U. K. 25:129-141.

Rees, W. J. 1956. A revision of the hydroid genus Perigonimus. Bull. British Mus. (Natur. Hist.) 3:337-350.

Rees, W. J. 1957a. Evolutionary trends in the classification of capitate hydroids and medusae. Bull. British Mus. (Natur. Hist.) 4:455-534.

Rees, W. J. 1957b. Status of Moerisia lyonsi Boulenger and related hydroids. Nature 180:445.

Rees, W. J. 1958. The relationships of Moerisia lyonsi Boulenger and the family Moerisiidae with capitate hydroids. Proc. Zool. Soc. London 130:537-545.

Rees, W. J. 1966. The evolution of the Hydrozoa, p. 199-222. In: Rees, W. J. (Ed.) The Cnidaria and their evolution. Academic Press, Aberdeen.

Rees, W. J. and F. S. Russell. 1937. On rearing the hydroids of certain medusae, with an account of the methods used. J. Mar. Biol. Ass. U. K. 22:61-82.

Reitzenstein, E. von. 1913. Das Seemoos und das Korallenmoos, ihre Fischerei, ihre Lebens. Abh. Deutsch. Seefisch. Ver. 12:1-50.

Riddle, O. 1911. On the cause of autotomy in Tubularia. Biol. Bull. 21:389-395.

Rodriguez, G. 1963. The intertidal estuarine communities of Lake Maracaibo, Venezuela. Bull. Mar. Sci. 13:197-218.

Russell, F. S. 1936. On the first stage of the medusa Eucheilota clausa (Hincks) (= E. hartlaubi Russell). J. Mar. Biol. Ass. U. K. 21:131-133.

Russell, F. S. 1953. The medusae of the British Isles. Cambridge Univ. Press, Cambridge. 530 p.

Saraber, J. G. A. M. 1962. Ostroumovia inkermanica in the Netherlands. Beaufortia 9:117-120.

Sears, M. 1954. Hydromedusae of the Gulf of Mexico. In: Galtsoff, P. S. (Ed.) Gulf of Mexico, its origin, waters, and marine life. U. S. Fish. Bull. 55:273-274.

Sigerfoos, C. C. 1899. A new hydroid from Long Island Sound. Amer. Natur. 33:801-807.

Simmons, E. G. 1957. An ecological survey of the upper Laguna Madre of Texas. Pub. Inst. Mar. Sci. Univ. Texas 4:156-200.

Smallwood, W. M. 1910. Notes on the hydroids and the nudibranchs of Bermuda. Proc. Zool. Soc. London 1:137-145.

Smith, R. I. (Ed). 1964. Keys to marine invertebrates of the Woods Hole region. Mar. Biol. Lab. (Woods Hole), Syst.-Ecol. Progr. No. 11. 208 p.

Stafford, J. 1912. On the fauna of the Atlantic coast of Canada. Contrib. Canadian Biol. 1906-1910:69-78.

Stechow, E. 1914. Zur Kenntnis neuer oder Seltener Hydroidpolypen, meist Campanulariden, aus Amerika and Norwegen. Zool. Anz. 45:120-136.

Stechow, E. 1923. Zur Kenntnis der Hydroidenfauna des Mittelmeeres, Amerikas und anderer Gebiete. II. Zool. Jahrb. 47:29-270.

Stephenson, T. A. and Anne Stephenson. 1954. Life between the tide-marks in North America. IIIB. Nova Scotia and Prince Edward Island: the geographical features of the region. J. Ecol. 42:46-70.

Stimpson, W. 1854. Synopsis of the marine invertebrata of Grand Manan. Smithsonian Contrib. Knowledge 6:8-11.

Sumner, F. B., R. C. Osburn and L. J. Cole. 1913. A biological survey of the waters of Woods Hole and vicinity. Bull. Bur. Fish. 31:549-860.

Tardent, P. 1963. Regeneration in the Hydrozoa. Biol. Rev. 38: 293-333.

Thiel, M. E. 1935. Zur Kenntnis der Hydromedusenfauna des Schwarzen Meeres. Zool. Anz. Bd. III:161-174.

Torrey, H. B. 1902. The Hydroida of the Pacific coast of North America, with special reference to the species in the collection of the University of California. Univ. California Publ. Zool. 1:1-104.

Torrey, H. B. 1904. The hydroids of the San Diego region. Univ. California Publ. Zool. 2:1-43.

Torrey, H. B. 1909. The Leptomedusae of the San Diego region. Univ. California Publ. Zool. 6:11-31.

Valkanov, A. 1935. Notizen über die Brackwässer Bulgariens. I. Annu. Univ. Sofia, Fac. Phys.-Math. 31:249-303.

Vannucci, M. 1956. Biological notes and description of a new species of Dipurena (Hydrozoa, Corynidae). Proc. Zool. Soc. London 127:479-487.

Vannucci, M. 1966. Total net plankton volume and hydromedusae from fixed stations in the Gulf of Naples, p. 675-697. In: Barnes, Harold (Ed.) Some contemporary studies in marine science. George Allen and Unwin Ltd., London.

Verrill, A. E. 1900. Additions to the Anthozoa and Hydrozoa of the Bermudas. Trans. Connecticut Acad. Arts Sci. 10:551-572.

Versluys, J. 1899. Hydraires calyptoblastes récuellis dans la Mer des Antilles, pendant l'une les croisières accomplies par la compte R. de Dalmas sur son yacht CHAZALIE. Mem. Soc. Zool. France 12:29-58.

Vervoort, W. 1946. Hydrozoa. A. Hydropolypen. Fauna van Nederland. Leiden. 14:1-336.

Vervoort, W. 1959. The Hydroida of the tropical west coast of Africa. Atlantide Rep. 5:211-325.

Vervoort, W. 1962. The Hydroida and Chondrophora of the Israel South Red Sea Expedition, 1962. Rep. Israel South Red Sea Exped. 25:18-54.

Vervoort, W. 1964. Note on the distribution of Garveia franciscana (Torrey, 1902) and Cordylophora caspia (Pallas, 1771) in the Netherlands. Zool. Meded. 39:125-146.

Vervoort, W. 1968. Report on a collection of Hydroida from the Caribbean region, including an annotated checklist of Caribbean hydroids. Zool. Verh. 92. 124 p.

Ward, H. B. and G. C. Whipple. 1959. Fresh-water biology. W. T. Edmondson, Ed. 2nd Edition. John Wiley and Sons, Inc., New York. 1248 p.

Wass, M. L. 1965. Check list of the marine invertebrates of Virginia. Va. Inst. Mar. Sci. Spec. Sci. Rep. 24 (3rd rev.). 55 p.

Weill, R. 1934. Contribution à l'étude des cnidaires et leurs nematocystes. Trav. Sta. Zool. Wimereux 10, 11:1-701.

Weiss, C. M. 1948. The seasonal occurrence of sedentary marine organisms in Biscayne Bay, Florida. Ecology 29:153-172.

Wells, H. W., M. J. Wells, and I. E. Gray. 1964. Ecology of sponges in Hatteras Harbor, North Carolina. Ecology 45:752-767.

Werner, B. 1954. On the development and reproduction of the anthomedusan, Margelopsis haeckeli Hartlaub. Trans. N. Y. Acad. Sci. 16:143-146.

Werner, B. 1955. On the development and reproduction of the anthomedusan Margelopsis haeckeli Hartlaub. Ann. N. Y. Acad. Sci. 62:1-30.

Whiteaves, J. F. 1872. Notes on a deep sea dredging expedition round the Island of Anticosti in the Gulf of St. Lawrence. Ann. Mag. Natur. Hist. 10:341-354.

Whiteaves, J. F. 1901. Catalogue of the marine invertebrates of eastern Canada. Geol. Surv. Canada. p. 18-29.

Whitten, H. L., H. F. Rosene and J. W. Hedgpeth. 1950. The invertebrate fauna of Texas coast jetties; a preliminary survey. Publ. Inst. Mar. Sci. Univ. Texas 1:53-87.

Woods Hole Oceanographic Institution. 1952. Marine fouling and its prevention. U. S. Naval Inst., Annapolis. 388 p.

APPENDIX A

COORDINATES OF THE STATIONS SAMPLED

Rappahannock River	
Near R. O. Norris Bridge	37°37'N, 76°27'W
Hog House Ground	37°38'N, 76°33'W
Waterview	37°44'N, 76°36'W
Bowler's Rock	37°50'N, 76°44.5'W
Tappahannock	37°55.5'N, 76°51'W
York River	
Tue Marsh Light	37°14'N, 76°23'W
Guinea Neck (York Spit)	37°16'N, 76°20'W
Perrin	37°16'N, 76°25'W
Ellen Island	37°15'N, 76°25'W
VEPCO (Yorktown) outfall	37°13'N, 76°28'W
off VEPCO (Yorktown)	37°13.5'N, 76°28'W
Gloucester Point	37°15'N, 76°29.5'W
Page's Rock	37°18.6'N, 76°35.2'W
Cheatham Annex	37°17.5'N, 76°34.6'W
Aberdeen Rock	37°20.2'N, 76°36.1'W
Y-20	37°25.1'N, 76°41.5'W
Bell Rock	37°29'N, 76°45'W
West Point	37°30'N, 76°48'W
Mattaponi River	
near Indian Reservation	37°39'N, 76°55'W

James River

Old Point Comfort	37°00'N, 76°18.5'W
X-Ray Station	36°58.4'N, 76°21'W
Sewell's Point Spit	36°58.8'N, 76°18.8'W
Sewell's Point	36°58'N, 76°19.5'W
Hampton Bar	37°00'N, 76°21'W
Hampton Flats	36°59.5'N, 76°22.5'W
Norfolk Navy Base Pier 12	36°57.5'N, 76°19.8'W
Newport News Bar	36°58.5'N, 76°23.8'W
Middle Ground	36°56.6'N, 76°23.5'W
Nansemond Ridge	36°54.3'N, 76°28.5'W
Pig Point	36°54'N, 76°27.5'W
Bennett's Creek Entrance	36°52.8'N, 76°29'W
Bennett's Creek	36°52'N, 76°29'W
Brown Shoal	37°01.5'N, 76°29'W
Deep Water Shoal	37°09'N, 76°38.1'W
Lawnes Point	37°08.5'N, 76°39.5'W
off Hog Island	37°11.5'N, 76°40'W
Jamestown Island	37°12'N, 76°47'W

Elizabeth River

Hospital Point	36°50.8'N, 76°18.1'W

Nansemond River

Newman's Point	36°52'N, 76°30.7'W
N-13	36°46'N, 76°33.8'W

Chesapeake Bay

C-00	37°04'N, 76°05'W
Fisherman's Island	37°05.5'N, 75°59'W

Chesapeake Bay Bridge-Tunnel	
mid-span	37°00'N, 76°06'W
Virginia Beach span	36°57.5'N, 76°07'W
Kiptopeke	37°09'N, 75°59'W
Little Creek Jetty	36°56'N, 76°11'W
Cape Charles	37°16'N, 76°01.5'W
Cherrystone Channel	37°17'N, 76°01.5'W
Willoughby Bank	36°59'N, 76°16'W
Thimble Shoal	37°01'N, 76°14.5'W
New Point Comfort	37°17.5'N, 76°17.3'W
Mid-Bay Station	37°15'N, 76°10'W

PLATE 1

Figure

A. *Moerisia lyonsi*.

B. *Ectopleura dumortieri*.

C. *Tubularia crocea*.

D. *Halocordyle tiarella*.

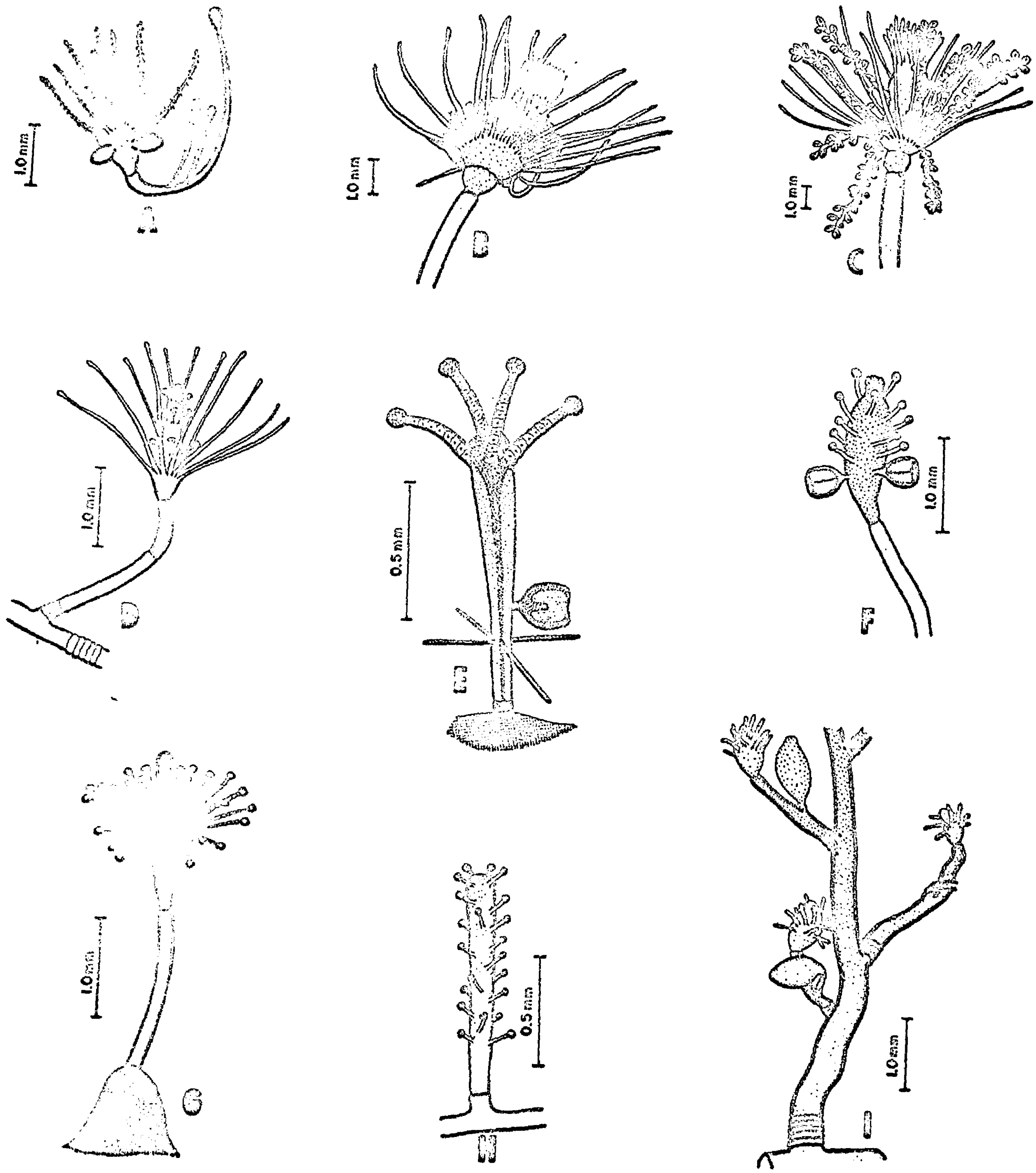
E. *Dipurena strangulata*.

F. *Sarsia tubulosa*.

G. *Linvillea agassizi*.

H. *Zanclea costata*.

I. *Cordylophora lacustris*.



1.0 mm
A
1.0 mm
B
1.0 mm
C
1.0 mm
D
0.5 mm
E
1.0 mm
F
1.0 mm
G
0.5 mm
H
1.0 mm
I

PLATE 2

Figure

A. *Turritopsis nutricula*.

B. *Hydractinia arge*.

C. *Hydractinia echinata*.

D. *Bougainvillia rugosa*.

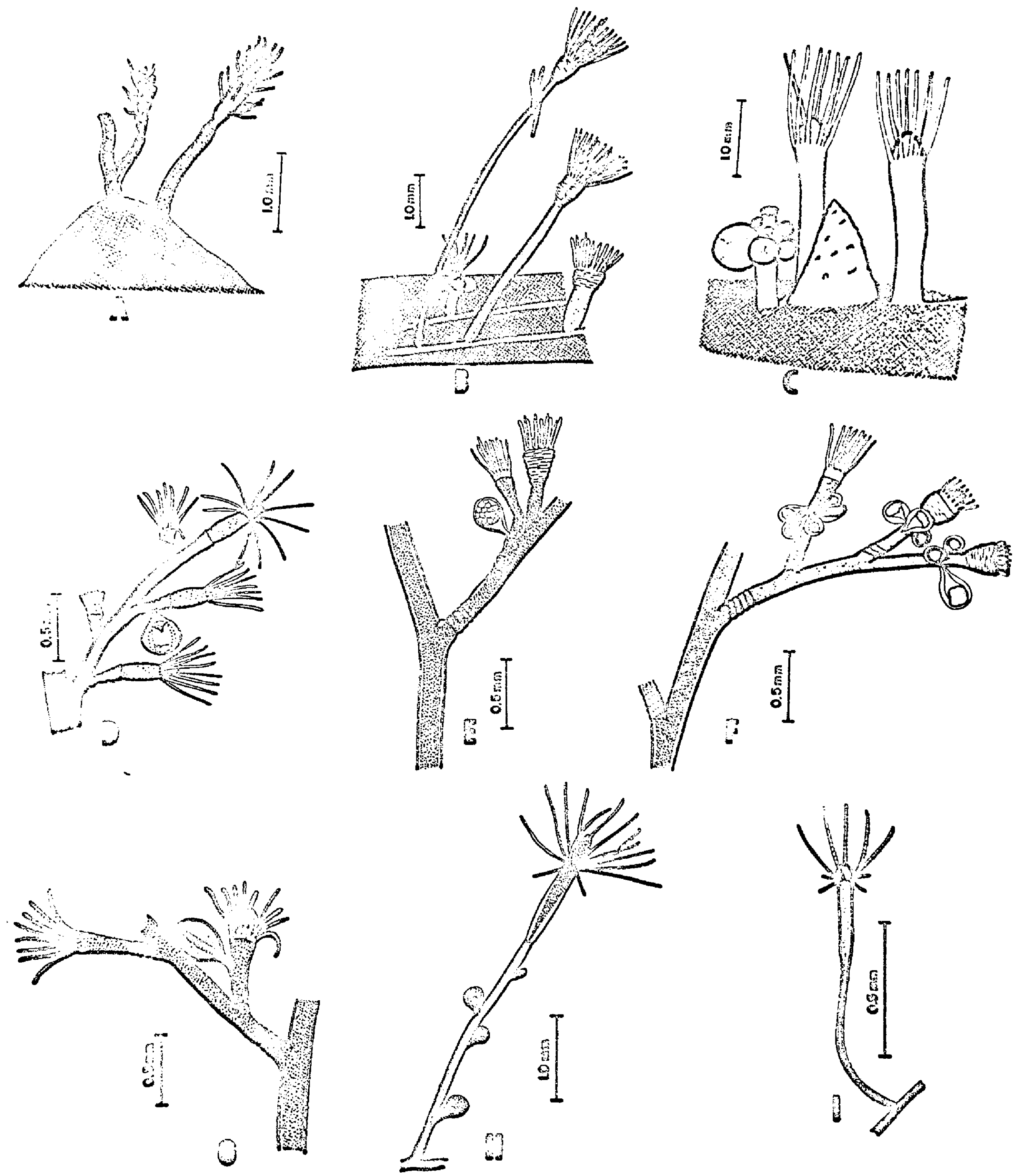
E. *Bimeria cerulea*, female.

F. *Bimeria franciscana*, female.

G. *Bimeria franciscana*, male.

H. *Aselomaris michaeli*.

I. *Amphinema dinema*.



1.0mm
0.5mm
0.5mm
B
C
E
F

PLATE 3

Figure

A. *Proboscidactyla ornata*.

B. *Eudendrium album*.

C. *Eudendrium ramosum*.

D. *Halecium gracile*.

E. *Clytia cylindrica*.

F. *Clytia edwardsi*.

G. *Clytia hemisphaerica*.

H. *Clytia kincaidi*.

I. *Clytia paulensis*.

J. *Obelia bicuspidata*.

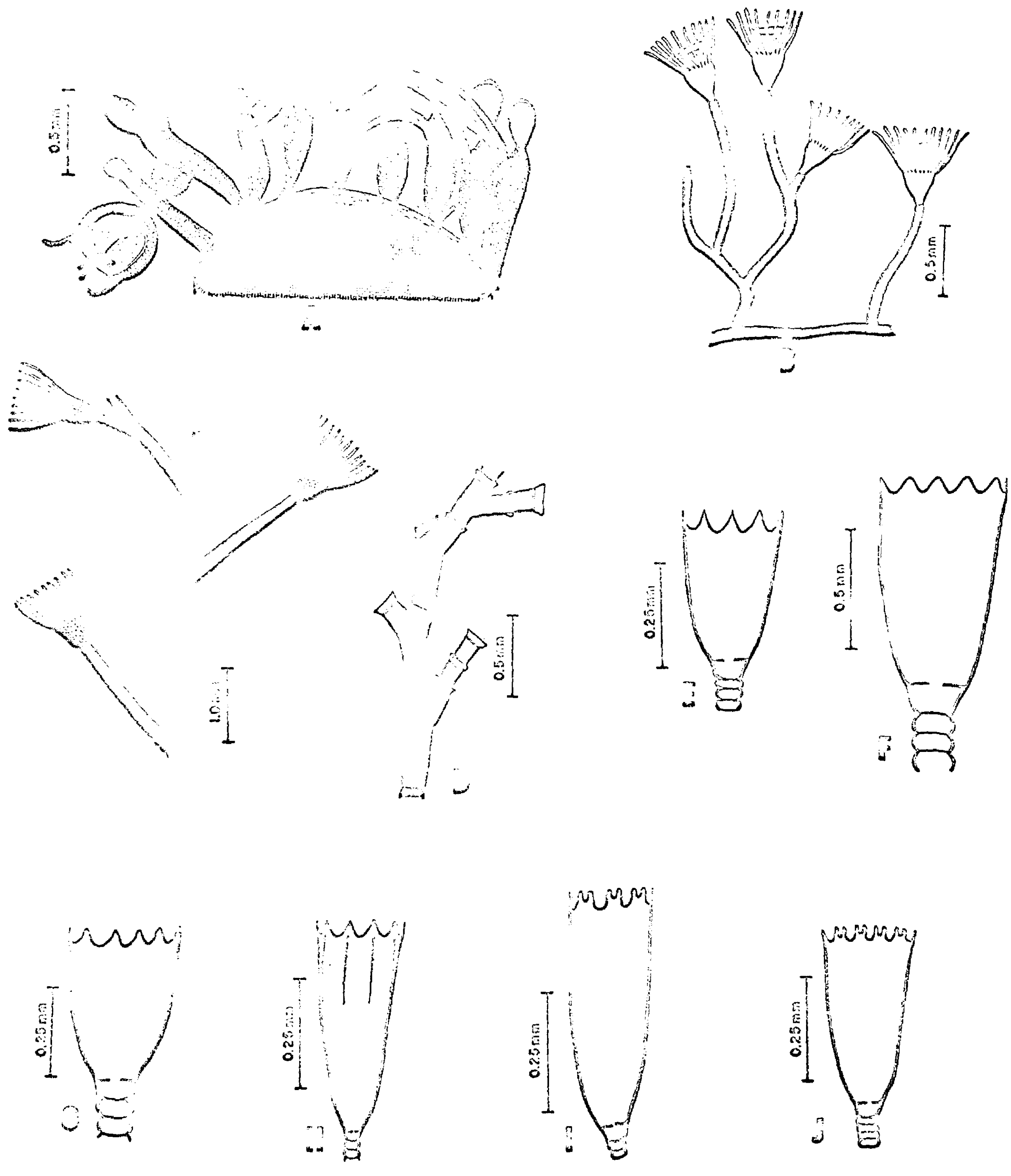

0.5 mm
0.5 mm
1.0 mm
0.5 mm
0.25 mm
0.5 mm
0.25 mm
0.25 mm
0.25 mm
0.25 mm

PLATE 4

Figure

A. *Obelia commissuralis*.

B. *Obelia dichotoma*.

C. *Obelia geniculata*.

D. *Obelia longicyatha*.

E. *Obelia longissima*.

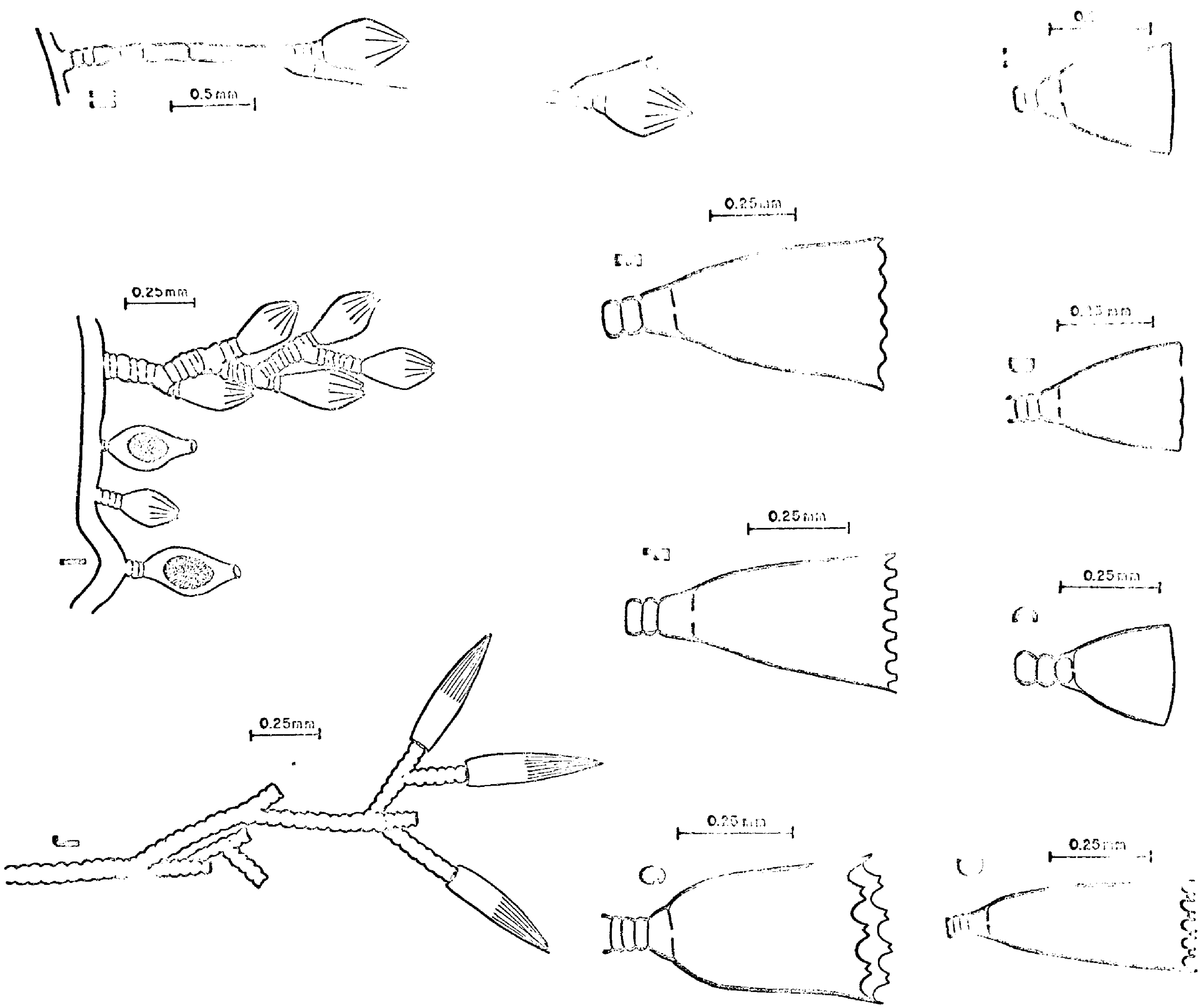
F. *Gonothyraea loveni*.

G. *Hartlaubella gelatinosa*.

H. *Lovenella gracilis*.

I. *Opercularella pumila*.

J. *Opercularella lacerata*.



0.5mm
0.25mm
0.25mm
0.25mm
0.25mm
0.25mm
0.25mm
0.25mm

PLATE 5

Figure

A. ?"*Campanopsis*" sp.

B. "*Campanulina*" sp.

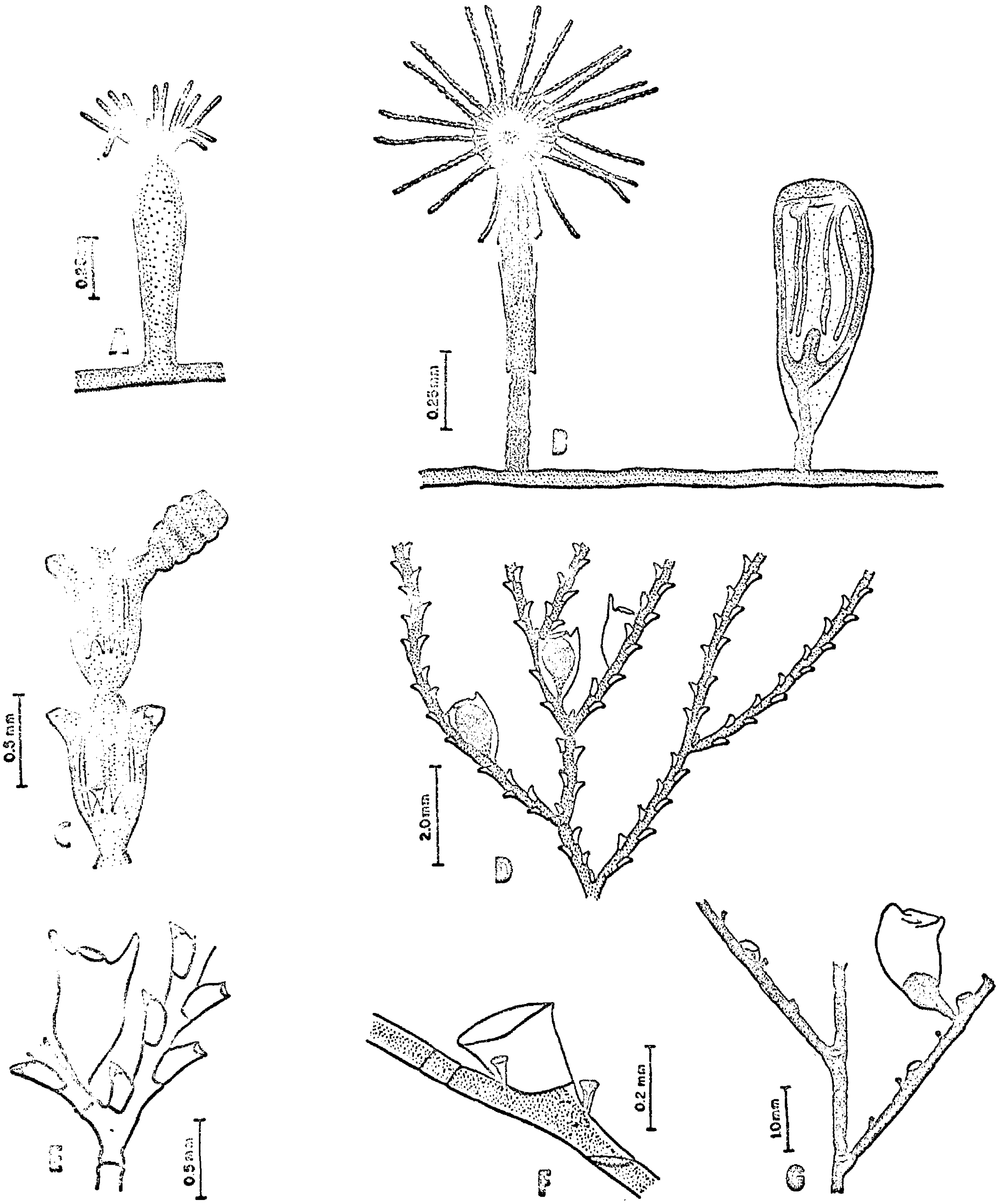
C. *Dynamena cornicina*.

D. *Sertularia argentea*.

E. *Sertularia argentea*.

F. *Halopteris tenella*.

G. *Halopteris tenella*.



A
0.25 mm
C
0.5 mm
D
2.0 mm
0.5 mm
F
0.2 mm
G
10 mm

PLATE 6

Figure

A. *Moerisia lyonsi*.

B. *Ectopleura dumortieri*.

C. *Hybocodon prolifer*.

D. *Halocordyle tiarella*.

E. *Dipurena strangulata* juvenile.

F. *Linvillea agassizi* juvenile.

G. *Sarsia tubulosa*.

H. *Zanclea costata* (After Mayer, 1910a).

I. *Turritopsis nutricula*.

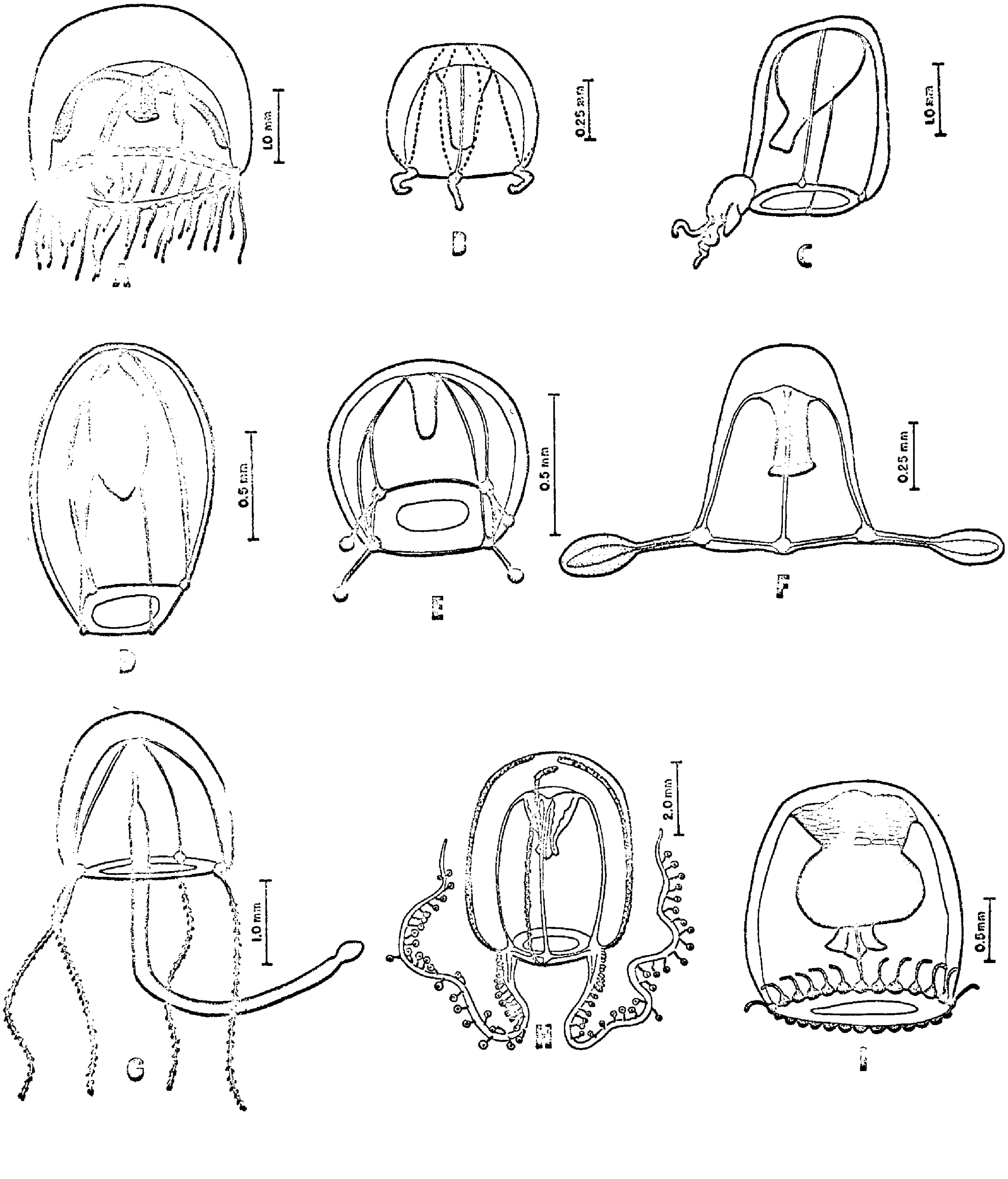

1.0 mm
0.25 mm
1.0 mm
C
0.5 mm
0.5 mm
E
0.25 mm
F
1.0 mm
G
2.0 mm
H
0.5 mm

PLATE 7

Figure

A. *Hydractinia arge*.

B. *Podocoryne minima*.

C. *Rathkea octopunctata*.

D. *Bougainvillia carolinensis*.

E. *Bougainvillia rugosa*.

F. *Nemopsis bachei*.

G. *Amphinema dinema*.

H. *Proboscidactyla ornata*.

I. *Obelia* sp. Juvenile.

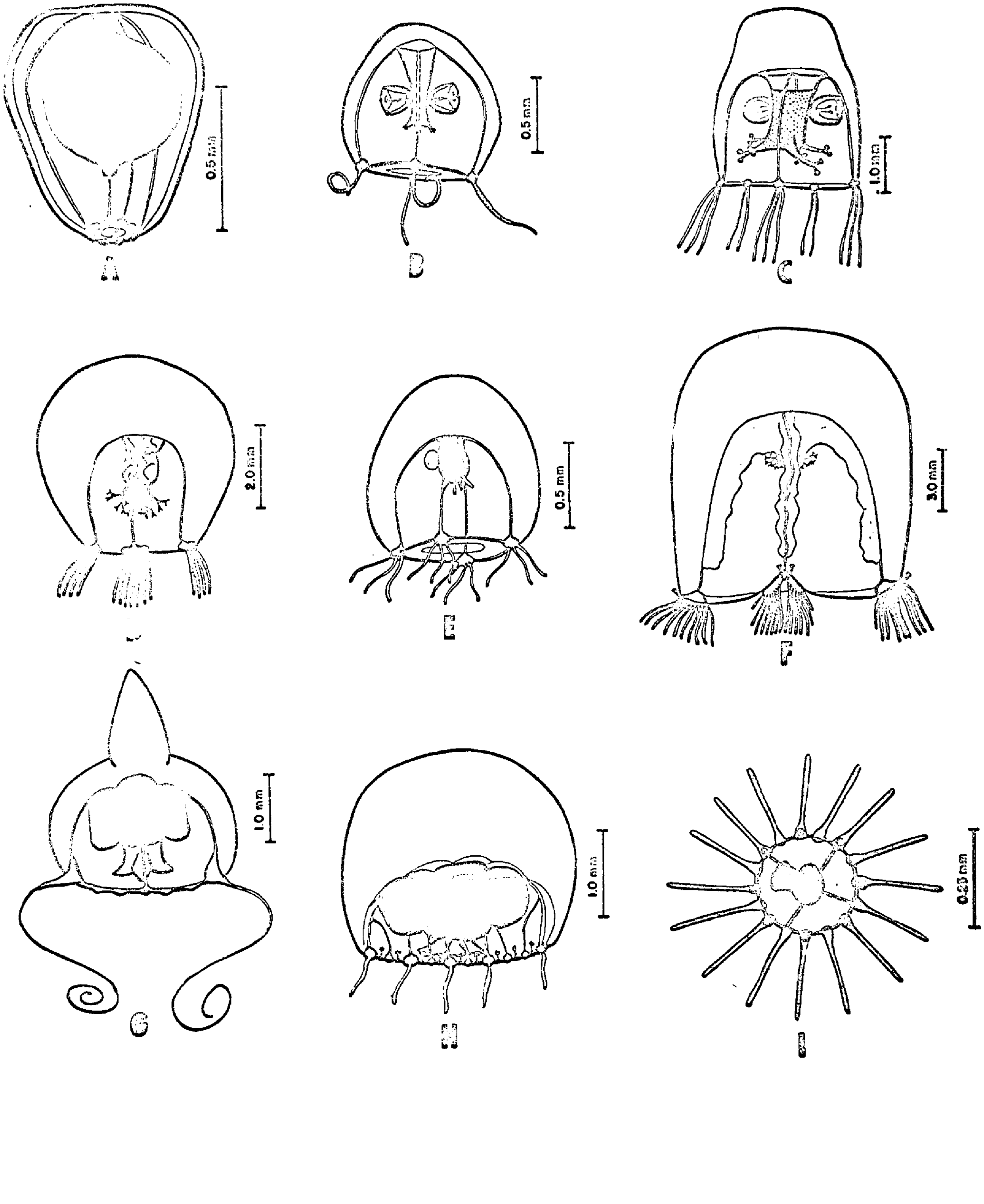

0.5 mm
B
0.5 mm
C
1.0 mm
2.0 mm
E
0.5 mm
F
3.0 mm
1.0 mm
1.0 mm

PLATE 8

Figure

A. *Eucheilota ventricularis*.

B. *Lovenella gracilis*, 2 days old.

C. *Lovenella gracilis*, 25 days old.

D. *Phialucium carolinae*.

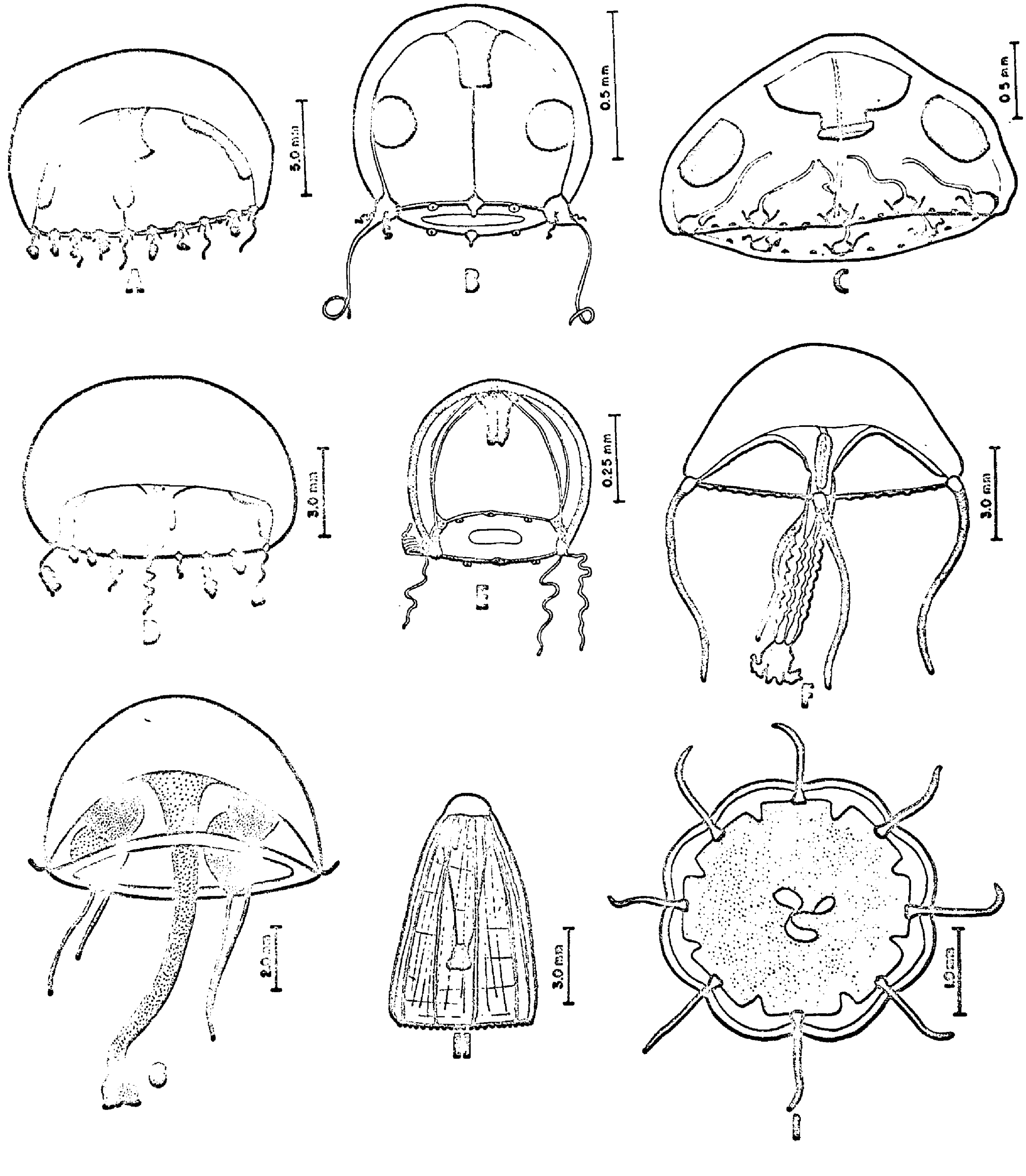
E. "*Campanulina*" sp., young medusa.

F. *Eutima mira*.

G. *Liriope tetraphylla*.

H. *Aglantha digitale*, specimen in poor condition.

I. *Cunina octonaria*.


A
3.0 mm
B
0.5 mm
C
0.5 mm
D
3.0 mm
E
0.25 mm
F
3.0 mm
G
2.0 mm
H
3.0 mm
I
1.0 mm

VITA

Dale Ralph Calder

Born in St. Stephen, New Brunswick, Canada, 16 April 1941. Graduated from United Baptist Bible Training School, Moncton, New Brunswick, June 1960. B.Sc., Acadia University, Wolfville, Nova Scotia, Canada, May 1964.

Entered the School of Marine Science of the College of William and Mary in Virginia, September 1964, with a graduate assistantship in the Ecology-Pollution Department. M.A., College of William and Mary in Virginia, June 1966.