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INVESTIGATIONS OF INNER CONTINENTAL SHELF WATERS OFF LOWER CHESAPEAKE BAY. PART V. SEASONALITY OF THE DIATOM GENUS *CHAETOCEROS*[1]

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ABSTRACT

Twenty-five species of *Chaetoceros* were taken from monthly samples during one year in the Atlantic Ocean off the Virginia capes. Results indicate the fall–winter period to be the most productive in numbers and species diversity. The *Chaetoceros* population was primarily a mixture of cold- and warm-water forms, with two species, *C. decipiens* and *C. didymus*, being most abundant and widespread. A cyclic seasonal pattern based on past records is suggested for the genus along the east coast of the United States. Seasonality, temperature, and salinity ranges for each species are presented.

INTRODUCTION

This study represents part of a comprehensive survey dealing with the physical and biological properties of the shelf waters off lower Chesapeake Bay. The initial program was begun late in 1959 (Joseph, Massmann, and Norcross 1960).

Literature dealing with the seasonality of *Chaetoceros* along the east coast of the United States indicates generally large populations in the spring, summer, and fall months in the Woods Hole region to the north (McMurrich 1917; Fritz 1921; Fish 1925; Bigelow 1926; Gran and Braarud 1935) and in the fall, winter, and spring in the southern region along the coast of Florida (Davis 1950; Curl 1959). Plankton samples taken off both the east and west coasts of Florida (Davis 1950) indicate that diatoms were most numerous in December and January, with *C. decipiens* being the dominant form on the west coast in December. Curl (1959), reporting on samples taken from Apalachee Bay and the northeastern Gulf of Mexico, listed 18 species of *Chaetoceros*. He concluded that this genus was one of two responsible for most of the phytoplankton biomass during the year, with *C. decipiens* being the most abundant winter diatom. Samples from the St. Andrews area near the Bay of Fundy (McMurrich 1917; Fritz 1921) indicated a maximum *Chaetoceros* population in the summer. McMurrich listed the genus as most abundant between mid-June and September, and Fritz, as abundant in July and August, with greatest numbers occurring in September. Gran and Braarud (1935) found significant populations of *Chaetoceros* from April through the summer in the Bay of Fundy and Gulf of Maine. They listed *C. debilis* as the most common neritic species and *C. decipiens* as the most common oceanic species over the entire area for all seasons. The Woods Hole region (Fish 1925) provided 20 species of this genus. Two of these, *C. decipiens* and *C. didymus*, were encountered often enough to be classified as abundant during the winter, summer, and fall periods. The more offshore waters of the Gulf of Maine (Bigelow 1926) indicated a low frequency of *Chaetoceros* in December and early January, with *C. decipiens* occurring most consistently during the fall months. Lillick (1940), also working in the Gulf of Maine area, found that diatoms constituted the major portion of the plankton community, with forms of *Chaetoceros* being dominant in February and March. *C. decipiens* was listed as the most persistent form throughout the year.

The species *C. decipiens*, *C. didymus*, *C. danicus*, *C. lorenzianus*, and *C. debilis* have been listed as common in both Florida and New England (Curl 1959; Bigelow 1926; Lillick 1940). Certain species, however, occur only in one or the other area. The northern area, for example, sometimes

[1] Contribution No. 148 from the Virginia Institute of Marine Science. Illustrations of all species mentioned are available from author.

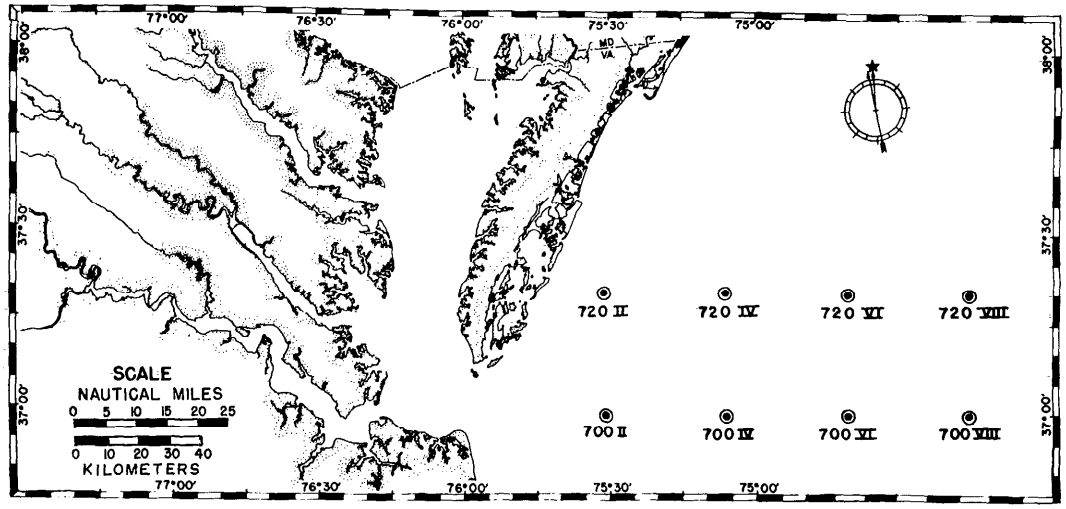

FIG. 1. Chart showing collecting stations.

supports large communities of *C. criophilum* (*C. concavicornis*), *C. laciniosus*, *C. atlanticus*, *C. convolutus*, and *C. compressus* (Fish 1925; Lillick 1940), which appear either rarely or not at all in the southern region (Curl 1959). On the other hand, *C. glandazi* (*rostratus*), *C. peruvianus*, *C. affinis*, and *C. messanensis* are reported from the southern region (Curl 1959), but rarely or not at all from the northern area.

From the above, one can readily see that the literature contains considerable data concerning coastal and oceanic diatom seasonality from parts of the east coast of the United States. The Virginia offshore waters, however, have been neglected in previous studies.

MATERIALS AND METHODS

Stations

From March 1961 through March 1962, samples were obtained monthly from eight offshore stations (Fig. 1) designated below. Roman numerals following station numbers represent nautical miles from shore (e.g., II = 20 miles or 37 km, IV = 40 miles or 74 km). The numbers 700 and 720 denote latitudes 37°00′ and 37°20′ N, respectively.

700	II	(37°00′, 75°35′)
700	IV	(37°00′, 75°10′)
700	VI	(37°00′, 74°45′)
700	VIII	(37°00′, 74°21′)
720	II	(37°20′, 75°35′)
720	IV	(37°20′, 75°10′)
720	VI	(37°20′, 74°45′)
720	VIII	(37°20′, 74°21′)

Sampling

Samples were obtained under way with a calibrated pump from a depth of 1 m and strained through a net of No. 20 bolting cloth. All samples were preserved in formalin to give a final concentration of 4%. Salinities and temperatures were determined with an induction conductivity-temperature indicator (Esterson 1957).

Slide preparation

A well-mixed aliquot from each sample was transferred to a slide smeared with Haupt's adhesive. The slides were allowed to dry, after which they were processed through an ethanol series to xylene and mounted in hyrax.

Identification

Identifications were made using a 97× objective with a 10× or 15× eyepiece with either bright-field or phase arrangements.

TABLE 1. *Monthly occurrence, temperature, and salinity ranges of species of* Chaetoceros

Species	Temperature range (C)	Salinity range (‰)	Months present (x) J F M A M J J A S O N D
C. decipiens Cleve	5.5 to 18.0	30.81 to 34.87	x x x x x x
C. didymus Ehrenberg	4.8 to 20.0	28.64 to 34.87	x x x x x x
C. affinis Lauder	6.2 to 25.2	28.64 to 33.19	x x x x x x x x
C. eibenii Grunow	8.2 to 18.0	32.07 to 32.95	x x x x
C. rostratus Lauder	11.7 to 24.5	29.09 to 32.95	x x x x
C. debilis Cleve	6.5 to 7.8	32.57 to 34.87	x
C. densus Cleve	5.5 to 27.0	28.90 to 32.95	x x x x x
C. peruvianus Brightwell	5.3 to 23.0	28.64 to 33.19	x x x x x
C. pseudocurvisetus Mangin	15.1 to 18.0	28.64 to 32.95	x x
C. compressus Lauder	5.7 to 18.0	28.64 to 34.87	x x x x
C. laciniosus Schutt	7.8 to 18.0	28.64 to 34.87	x x x
C. danicus Cleve	4.8 to 17.4	28.64 to 33.19	x x x x
C. lorenzianus Grunow	16.5 to 18.0	28.64 to 32.95	x x
C. radicans Schutt	6.5 to 18.0	31.49 to 34.87	x x
C. atlanticus Cleve	7.8 to 18.0	31.02 to 34.87	x x x
C. concavicornis Mangin	8.0 to 10.6	32.81 to 33.24	x x
C. borealis Bailey	6.2 to 16.8	31.49 to 34.87	x x x
C. messanensis Castracane	15.9 to 18.0	32.36 to 32.95	x x x
C. coarctatus Lauder	16.8 to 18.0	31.49 to 32.92	x
C. subtilis Cleve	7.7 to 17.4	29.22 to 31.02	x x
C. similis Cleve	5.7 to 10.6	30.81 to 33.24	x x x
C. curvisetus Cleve	5.3 to 7.7	29.22 to 31.49	x x
C. convolutus ? Castracane	18.0	32.92	x
C. mitra ? (Bailey) Cleve	6.2 to 8.0	32.81 to 33.19	x x
C. teres ? Cleve	18.0	32.92	x

Drawings

Drawings were made from sample material with a Zeiss camera lucida under 10× or 43× objectives and a 15× wide-field eyepiece.

RESULTS

A total of 25 species of *Chaetoceros* were found in Virginia offshore waters from March 1961 through March 1962. Species accounts (Table 1) are approximately in descending order of abundance. Temperature and salinity ranges observed for each species are included.

Chaetoceros decipiens *Cleve*

This species was among the most common and abundant of the genus for the sampling period.

In October 1961, a few cells were noticed on the more offshore stations (VI to VIII on both sections). The frustules were relatively small, falling within the range of 9–26 μ wide (apical axis). From November through January, the species was present from 74 to 148 km offshore. Again, most were less than 30 μ wide, but many had very heavily punctate setae. In March 1962, at this form's most abundant period, chains were found on all stations, with greatest numbers occurring on the more inshore stations, especially along the 720 transect. At this time, the cells were in their most robust state, up to 60 μ wide.

Chaetoceros didymus *Ehrenberg*

In October 1961, this form was found on all stations, being most common in the more inshore samples. Sizes of from 12 to 38 μ were observed. Many cells had heavily bristled terminal setae. In some cases offshore forms had weakly striated setae.

From November 1961 through March 1962, the species slowly diminished in abundance, and by the end of March it had virtually disappeared from the plankton community.

Chaetoceros eibenii *Grunow*

This species has often been confused with *C. densus* Cleve and *C. borealis* Bailey. The taxonomic differences are based

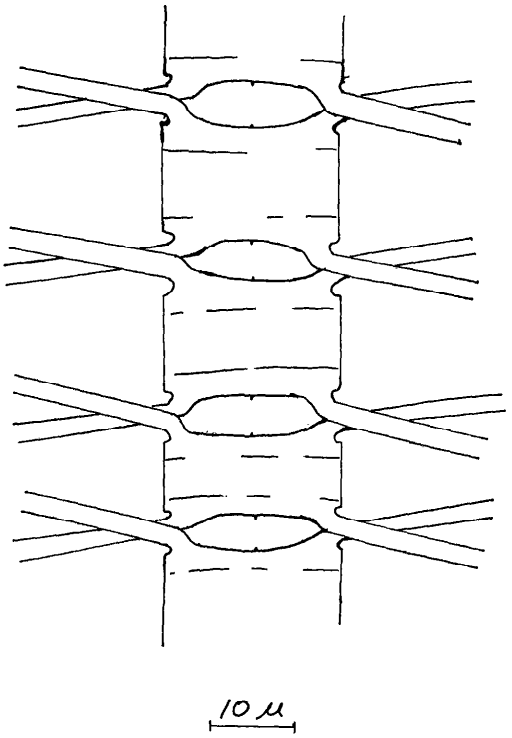

FIG. 2. *Chaetoceros eibenii* Grunow. Chain in broad girdle view.

on aperture distances, presence or absence of a small spine between valves, and presence or absence of bristles on setae. In samples where only parts of chains are observed, they could easily be confused with any of the three species. *C. eibenii* (Fig. 2) was common in our material from October 1961 through January 1962. At station 700 VI in December, it was among the most abundant members of the genus.

Chaetoceros rostratus *Lauder*

This species has been referred to in most of the literature as *C. glandazi* Mangin and appears to be the same as the one Hustedt (1930) called *C. rostratus* (Fig. 3). It was observed in July 1961 and from October through December 1961. In July, and again in October, the form was common on all stations. In November and December, it occurred only on Stations IV and VI on each section. It was among the

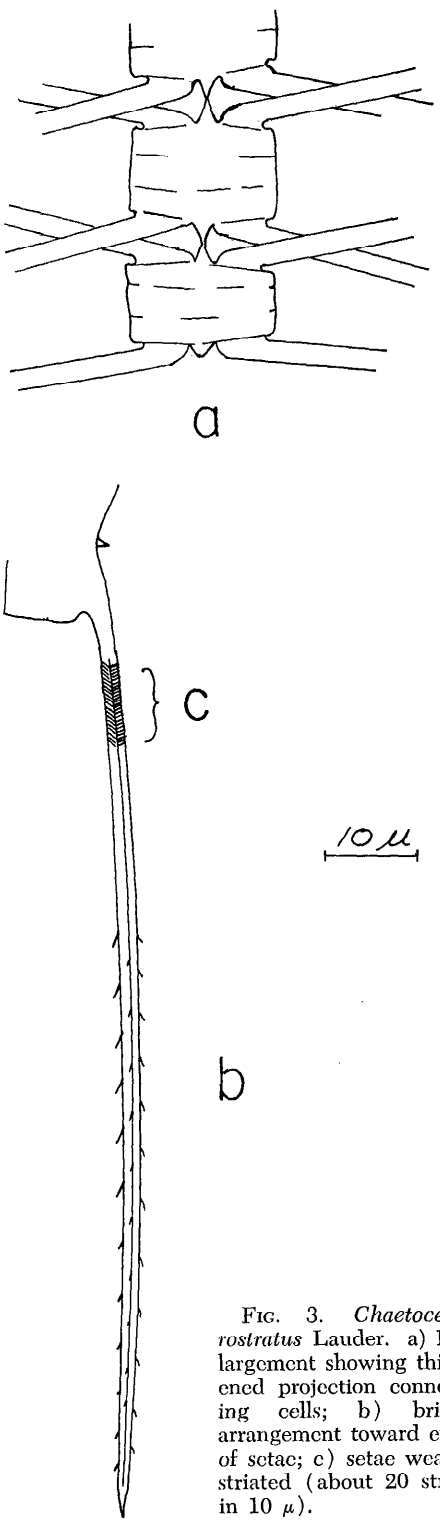

FIG. 3. *Chaetoceros rostratus* Lauder. a) Enlargement showing thickened projection connecting cells; b) bristle arrangement toward ends of setae; c) setae weakly striated (about 20 striae in 10 μ).

most abundant species of the genus on Stations IV through VIII, both sections, in October 1961.

DISCUSSION

The principal features of the *Chaetoceros* populations as evidenced by previous workers are: 1) a predominantly fall–winter–spring population in the southern region (Davis 1950; Curl 1959), and a spring–summer–fall population in the northern region (McMurrich 1917; Fritz 1921; Fish 1925; Gran and Braarud 1935); 2) cosmopolitan species found both in the northern and southern regions and regional species found in one or the other areas; and 3) dominance by *C. decipiens* in both areas (Davis 1950; Curl 1959; Fish 1925; Bigelow 1926; Lillick 1940; Gran and Braarud 1935).

When considering the seasonality of this genus in the offshore waters of Virginia, it becomes obvious that the fall–winter period is the most important in numbers and species diversity. Only a few species were represented in July, August, and September, but 23 of the 25 species observed were present in October. Two species, *C. decipiens* and *C. didymus*, dominated the *Chaetoceros* community, with the former being the most widespread and abundant species of the genus. A rather slow elimination of the species occurred from this October bloom period until there was virtual disappearance of the genus by April.

This predominantly fall population of the Virginia shelf appears to represent a mixed population of cold- and warm-water species. The fall population seems to reflect the beginning of the fall–winter–spring (F–W–Sp) community to the south, while from the north it reflects the declining spring–summer–fall (Sp–Su–F) population. This situation is diagramed below, where A = appearance of the genus; M = maximum abundance; and D = the decline of the genus:

	W	Sp	Su	F	W	Sp
North		A	M	D		
Virginia			A	M	D	
South				A	M	D

The listing suggests a cyclic seasonal pattern for this genus along the east coast of the United States (from Florida to the Gulf of Maine).

Of the 25 species of *Chaetoceros* identified in these offshore waters, 19 are considered temperate forms, 4 as tropical, and 2 as arctic. The majority of the forms was neritic, with only 9 oceanic forms represented. The influx of the 4 tropical forms was probably a direct result of Gulf Stream influence, while the arctic species may possibly have been derived from a countercurrent of the Gulf Stream (Miller 1952). The arctic and tropical forms encountered here indicate an overlap of those species which have previously been found to the north or south of Virginia. These regional forms such as *C. messanensis*, *C. coarctatus*, *C. rostratus* (*C. glandazi*), *C. compressus*, and *C. laciniosus* occurred together in the fall population off the Virginia capes. However, certain forms are not similarly restricted by temperature and fall into the category of cosmopolitan species. For example, *C. decipiens* and *C. didymus* have often been reported as common from both the northern and southern regions. The dominance exhibited by *C. decipiens* along the entire east coast during the fall–winter–spring periods is indicative of a cosmopolitan species with preference for colder waters.

The striking morphological variation within this species, not only in size range but also in the presence of punctae along the setae, was quite apparent from the material on numerous occasions. This adaptive ability may account in part for its wide distribution. However, to detect these adaptations, one must examine numerous samples and specimens. Sporadic sampling at wide intervals can in many cases result in incorrect identifications unless the intermediate forms are available.

REFERENCES

BIGELOW, H. B. 1926. Plankton of the offshore waters of the Gulf of Maine. Bull. U.S. Bur. Fisheries, **40** (2). 509 p.

CURL, H., JR. 1959. The phytoplankton of Apalachee Bay and the northeastern Gulf

of Mexico. Publ. Inst. Marine Sci. Univ. Texas, **6**: 277–320.

DAVIS, C. C. 1950. Observations of plankton taken in marine waters of Florida in 1947 and 1948. Quart. J. Florida Acad. Sci., **12**: 67–103.

ESTERSON, G. L. 1957. The induction conductivity indicator, a new method for conductivity measurements at sea. (Unpublished manuscript.) Chesapeake Bay Inst. Tech. Rept., 14. 183 p.

FISH, C. J. 1925. Seasonal distribution of the plankton of the Woods Hole region. Bull. U.S. Bur. Fisheries, **41**: 91–179.

FRITZ, C. W. 1921. Plankton diatoms, their distribution and bathymetric range in St. Andrews waters. Contrib. Can. Biol. 1918–1920: 49–62.

GRAN, H. H., AND T. BRAARUD. 1935. A quantitative study of the phytoplankton in the Bay of Fundy and the Gulf of Maine. J. Biol. Board Can., **1**: 279–467.

HUSTEDT, FRIEDRICH. 1930. Die Kieselalgen. *In* L. Rabenhorst's Kryptogamen-Flora. Bd. **7**, 1 Teil. Akad. Verlagsges., Leipzig. 920 p.

JOSEPH, E. B., W. H. MASSMANN, AND J. J. NORCROSS. 1960. Investigations of inner continental shelf waters off lower Chesapeake Bay. Part I. General introduction and hydrography. Chesapeake Sci., **1**: 155–167.

LILLICK, LOIS C. 1940. Phytoplankton and planktonic protozoa of the offshore waters of the Gulf of Maine. Part II. Qualitative composition of the planktonic flora. Trans. Am. Phil. Soc., **31**: 193–257.

MCMURRICH, J. P. 1917. The winter plankton in the neighborhood of St. Andrews, 1914–1915. Contrib. Can. Biol. 1915–1916: 1–8.

MILLER, A. R. 1952. A pattern of surface coastal circulation inferred from surface salinity-temperature data and drift bottle recoveries. (Unpublished manuscript.) Woods Hole Oceanographic Inst. Tech. Rept. No. 52–28, 32 p.