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Phytoplankton Within the Virginia Barrier Island Complex

Harold G. Marshall and **Cindy E. Shomers**
Department of Biological Sciences
Old Dominion University, Norfolk, Virginia 23529

ABSTRACT

Phytoplankton populations within channels of the Virginia barrier islands are characterized as neritic and similar in dominant species, general composition and seasonal growth patterns to populations of the coastal waters in the mid-Atlantic bight. Differences in composition increase along a decreasing salinity gradient when compared to populations in a saline pond and an oligohaline lake.

Key words: Phytoplankton, Barrier Islands, Virginia

INTRODUCTION

Phytoplankton represent the major autotrophic component within marine and most estuarine habitats. One of the more dynamic and unique assortments of habitats for phytoplankton development is present in the Virginia barrier islands complex. Behind the seaward band of barrier islands are numerous low elevation islands consisting of nothing more than tidal wetlands and mud flats. These wetlands contain numerous channels of natural origin and varied depth that are tidally flushed daily, with the bordering wetlands inundated during spring tides and major storm periods. Numerous deep inlets between the barrier islands connect these inner waterways to the ocean and provide direct exchange passage for waters entering and leaving this area. The region provides a high energy system, where the water masses are continually being transferred and are well-mixed, oxygenized, and exposed to nutrient rich drainage from upland and wetlands sites. Plankton and other biota are continually brought to the area from coastal waters and are flushed out again. The phytoplankton in these waterways may come from offshore, the wetlands, or upland drainage from the islands or mainland. The purpose of this paper is to characterize the phytoplankton composition within the barrier island complex and compare the seasonal dominants and growth patterns from several of these habitats.

COASTAL PHYTOPLANKTON

The phytoplankton in the offshore waters of the Barrier Islands between Cape Henry, Virginia and Cape May, New Jersey have been identified by Marshall and Cohn (1987*a*). They identified 103 taxa for this region, with the near shore flora composed mainly of chain-forming diatoms, dinoflagellates, and pico-nanoplankton. This last category was dominated by cyanobacteria less than 3 microns in size. There were numerous diatom pulses during the year, sometimes several per season, with *Skeletonema costatum, Leptocylindrus minimus, Thalassiosira nordenskioldii*, and *Asterionella glacialis* common and abundant. The spring bloom typically followed an early winter low, with rapid growth beginning in late winter and reaching peak development in early spring. A late fall growth often blends into the spring bloom during mild winter conditions. Late spring and summer populations generally changed to a different diatom assemblage of *Cerataulina pelagica*, *Guinardia flaccida*, *Leptocylindrus danicus*, and several *Chaetoceros* spp. The abundant dinoflagellates included *Prorocentrum minimum*, *P. micans*, *Ceratium fusus*, *C. lineatum* and *C. tripos*. Also common in coastal waters were cryptomonads, euglenoids and chrysophytes. The chrysophytes included several silicoflagellates (*Dityocha fibula*, *Distephanus speculum*), plus *Calycomonas ovalis* and *C. gracilis*. In general, the phytoplankton is similar to that found in coastal waters along the entire mid-Atlantic bight (Marshall and Cohn, 1987*a*, *b*).

Although the phytoplankton composition is similar along the mid-Atlantic bight, there are differences in cell concentrations. Marshall and Cohn (1987*a*) reported a decline in abundance from New York Bay southward to Chesapeake Bay, although a slight increase in concentrations appears associated with the Delaware Bay plume. In general, this region is situated between more productive areas of the New York Bight and those south of the Chesapeake Bay entrance. The Delaware Bay plume enhances cell concentrations in the vicinity of Cape May and toward the barrier islands, but a major increase in abundance is not found until south of the Chesapeake Bay. Phytoplankton from the Delaware plume is also similar to the coastal waters of the shelf. In the barrier islands, the inner channels are connected to numerous inlets between the barrier islands that allow coastal waters to enter the channels and transport predominantly marine phytoplankton comparable to the Delaware Bay and local shelf waters into this complex.

CHANNEL PHYTOPLANKTON

A characteristic neritic phytoplankton flora similar to populations in the mid-Atlantic bight are consistantly found within the barrier island channels. Salinity within these channels is typically between 25 and 33 ^{o}/oo. Marshall *et al*., (1981) identified 192 species in these channels, with seasonal dominants the same as those noted over the shelf. However, many of the average cell concentrations were greater within the channels than reported for the coastal waters. For instance, Marshall and Cohn (1987*a*) found the annual mean concentration of the dominant *Skeletonema costatum* to be 37 x 10^2 cells/l in the coastal waters. Marshall *et al*., (1981) found that it reached bloom status (1.95 x 10^6) in the barrier island channels. For comparison, *S. costatum* averaged 556 x 10^3 cells/l in the Chesapeake Bay plume (Marshall and Lacouture, 1987).

Unfortunately, there are little data on comparable seasonal samples from channels and offshore waters. However, there is a nine-month overlap between the channel collections of 1978-1979 by Marshall *et al.* (1981) and the collections in coastal waters from 12 cruises between 1979 and 1981 by Marshall and Cohn (1987*a*). The channels had a spring pulse in January and a larger development in March 1979, when average cell counts reached 1.89 x 10^6 cells/l. There was a decline into early summer, followed by a more modest pulse in late summer, with lowest mean concentrations in winter (1.7 x 10^5 cells/l). Mean cell concentrations offshore from the barrier islands ranged from 10^5 to 10^7 cells/l during the spring months. In addition, the seasonal periods contained the same dominants as in the channels. The average offshore spring pulse occurred by February, declined from mid-spring to summer, before it increased again by late summer or early fall. Of interest was the increased representation of cyanobacteria within the channels in comparison with adjacent offshore waters. These included a variety of colonial and filamentous forms that may have originated from the wetlands marshes of this region and daily seeded the tidal and offshore waters. Higher concentrations of pennate diatoms, associated with the benthos and mud algae, were also found in the channels. However, there were also numerous chlorophycean, cyanophycean and euglenophycean species reported in the tidal creeks of the nearby mainland by Nemeth (1969) that were not observed in the channels.

Nesius *et al.* (1983) reported on primary production within the barrier island channels. Monthly production rates followed a seasonal pattern, being lowest in winter and highest in summer. The annual production rate in these channels was 178 g $C/m^2/yr$. Rates ranged from winter lows of approximately 1 mg $C/m^2/hr$ (February) to a summer high of 290 mg $C/m^2/hr$ in June. In comparison, O'Reilly and Busch (1987) reported the productivity rate of offshore waters east of the barrier islands as 360 g $C/m^2/yr$. Other east coast estuaries show a wide range of productivity rates. These include: 53-67 g $C/m^2/yr$ in Beaufort N.C. (Williams, 1966) to 546 g $C/m^2/yr$ in the Allamaha River in Georgia (Thomas, 1966). Sellner *et al.* (1976) reported annual phytoplankton production at North Inlet, South Carolina as 346 g C/m^2. These comparisons indicate the channels of the barrier islands to be productive, but with annual rates less than what has been reported in the nearby coastal waters and in several of the more productive estuaries on the east coast.

POND AND LAKE PHYTOPLANKTON

Ponds of various sizes are common on the barrier islands. The larger islands have elevations capable of supporting permanent stands of water. Many of the ponds are temporary and associated with periods of increased rainfall in late winter and spring. After major storms, small lagoons are also common in interior swales, but generally these have a short period of existence. The largest concentration of standing water is Goose Lake on Parramore Island, with an area of 0.07 km^2 (Marshall, 1980). Parramore is approximately 13.3 x 3 km in size, with its long axis oriented in a general northeast direction. The island's topography decreases in elevation along the southern and western margin where an extensive wetland has developed. The elevation of the island changes dramatically along an east-west transect because there are a series of raised relict dunes (up to 9.1 m above mean low water) separated by areas of lesser elevation. It is within one of these lowland areas that Goose Lake was formed. It is oligohaline (less than 5 $^{o}/oo$), but subject to higher salinities under storm conditions. At this time salt water frequently floods the southern lowlands and may enter Goose Lake. Under such conditions in October 1978 Goose Lake salinity averaged 20 $^{o}/oo$.

Marshall (1980) reported 154 phytoplankton species in Goose Lake with diatoms and chlorophyceans the most diversified and abundant groups. There were summer and fall maxima in cell concentrations with lowest numbers in winter. The average abundance during a June (summer) pulse was 1.5×10^6 cells /l. In winter the phytoplankton was characterized by pennate diatoms and chlorophyceans, but both pennate and centric diatoms were dominant in spring. The composition changed in summer to mainly centric diatoms and cyanobacteria.

The fall assemblage was dominated by centric diatoms, cryptomonads, euglenoids and chlorophyceans. The common centrics were *Cyclotella striata, C. caspia* and *C. meneghiniana*. In general, the lake contained both freshwater and marine flora. The marine flora composition was enriched after periods of storm flooding. The freshwater flora became more abundant and diversified after periods of precipitation which lowered salinity values. Ubiquitous in Goose Lake throughout the seasons was a pico- nanoplankton component of unidentified cyanobacteria.

The phytoplankton in a permanent saline pond on Smith Island was reported by Marshall (1983). Located between Fisherman and Myrtle Islands, Smith Island is approximately 12 km in length and 0.85 km wide. It consists of a series of parallel ridges separated by swales, some containing salt marsh and small ponds. The saline pond studied is approximately 80 x 1.5 - 3.5 meters in size, with a maximum depth of 0.6 m. It is surrounded by salt marsh vegetation and has an annual salinity that ranged from 12 to 30 $^{o}/oo$. There were 146 species identified for this pond, plus a pico-nanoplankton component (less than 3 microns in size) that represented the most abundant cells in the samples. Diatoms and chlorophyceans were numerous and dominated by estuarine and marine species, and several freshwater species in low concentrations. Also common were the euryhaline species that included the diatoms *Cyclotella caspia, C. glomerata, C. meneghiniana* and *Melosira distans*. There was a diversified assemblage of cyanobacteria including filamentous (*Oscillatoria* spp.) and colonial (*Anacystis* spp.) forms.

There is a direct relationship between the percentage of the species which occur at a site and its salinity, with the salinity decreasing from the shelf into the channels and less from the saline pond to Goose Lake. For instance, 56% of the shelf species were in the inner channels, 22% in the Smith Island pond, and 13% in Goose Lake (Table 1). In contrast, 38% of the species noted in oligohaline Goose Lake were in the Smith Island pond, 17% in the channels, and 9% in shelf waters.

DISCUSSION

The barrier islands complex offers a variety of habitats for phytoplankton development. Atlantic coastal waters border the eastern margin of the islands, with the western flank exposed to an array of channels and wetland islands that extend westward to the mainland. Small bodies of standing water with abundant phytoplankton are common on the barrier islands, with the largest inland water body being Goose Lake on Parramore Island. More stable environmental conditions and consistent floral composition are associated with the coastal and channel waters surrounding these islands, in contrast to the temporary and permanent ponds which are subject to more severe and changing environmental conditions. These events would include storm induced flooding, salt spray, severe temperature and salinity ranges, and variable rainfall and evaporation patterns. Due to these changes there are greater fluctuations in different phytoplankton population abundance and composition within these ponds. For instance, it was not uncommon to find summer blooms of phytoplankton in one pond but not in ponds located nearby. The variation and extremes in salinity, temperature, and nutrients influence the different taxa within the ponds either favorably or not favorably, and these changes in abundance and composition are not necessarily repeated annually or similarly

TABLE 1. Phytoplankton species overlap among four sites in the Virginia barrier islands. Numbers represent the percent of the total number that are shared between sites.

SITES	Goose Lake	Smith Pond	Channels	Shelf
GOOSE LAKE	-	38	17	9
SMITH POND	40	-	28	17
CHANNELS	16	23	-	30
SHELF	13	22	56	-

in different standing waters. Each pond represents a unique habitat, with the floral expression an indication of the degree of differences between those sites and the waters they contain. In contrast, the phytoplankton in the channels of the barrier islands complex are characterized as neritic flora, most similar in composition and development to species of the inner shelf waters of the mid-Atlantic bight. Many of neritic species decline in their number, abundance, and degree of expression in local lower salinity habitats. Conversely, there is a similar reduction in the presence and expression of species from oligohaline sites to those of increased salinity. However, there is continued interaction of floral transport and presence between these areas. Phytoplankton entry into the channels is enhanced by the daily tidal flushing and local storms. Land or island-derived populations do not represent a significant source of channel species. However, the extensive mud flats and benthic substrate within the wetlands provide a seeding source for a variety of cyanobacteria and mud algae (e.g., pennate diatoms) that are common in channel waters.

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