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Phytoplankton assemblages associated with water quality and salinity regions in Chesapeake Bay, USA

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Abstract

Based on an 18-year data base (1984–2002), seasonal (spring, summer) phytoplankton relationships to specific environmental determinants were identified within different salinity regions of Chesapeake Bay. Growth conditions in these areas were identified as either less favorable (Impaired) or favorable (Least Impaired) for phytoplankton development. Diatoms represented the greatest cellular abundance and biomass during spring in different salinity regions and water quality conditions. In contrast, the dominant summer floral biomass was produced by a combination of diatoms, chlorophytes, and cyanobacteria in tidal freshwater and oligohaline waters, with diatoms and dinoflagellates representing the major algal biomass in mesohaline and polyhaline regions. Chlorophyte and cyanobacteria abundance and biomass decreased with the increasing salinities of the mesohaline and polyhaline regions, in contrast to increased biomass and abundance by dinoflagellates and diatoms. The common background taxa and an additional biomass source throughout these seasons were cryptophytes. Increased summer cyanobacteria abundance and biomass in the Impaired water of the tidal fresh and oligohaline regions were associated with reduced light availability and higher nutrient concentrations. The summer diatoms and dinoflagellates had increased mean cell sizes in the Least Impaired mesohaline and polyhaline waters compared to their populations in Impaired regions. This relationship was enhanced by increased abundance of neritic diatoms and dinoflagellates entering the Bay from Atlantic coastal waters. The data suggested a general reduction of existing nutrient levels and improved light availability in the Impaired waters would still continue the dominance of diatom flora over any additional cyanobacteria development.

Keywords: Chesapeake Bay; phytoplankton; water quality; salinity

1. Introduction

The Chesapeake Bay is the largest estuary in the United States, with an area of 6.5×10^3 km^2 and a mean depth of 8.4 m (Schubel and Pritchard, 1987). The phytoplankton composition is characterized by a major spring diatom bloom, followed by a diverse assemblage of diatoms, cyanobacteria, and dinoflagellates during summer and autumn (Marshall, 1994). The autotrophic picoplankton typically has a single major pulse from summer to early autumn with reduced cell concentration in winter and spring, and these cells are major contributors to the summer algal productivity (Marshall, 1995; Marshall and Nesius, 1996). Differences in the composition and abundance of these phytoplankton components occur seasonally and annually (Marshall and Lacouture, 1986; Marshall, 1994; Marshall et al., 2003; Marshall and Burchardt, 2004a). Therefore, long-term data sets were considered the most valuable data source to identify relationships between the components of these changing assemblages and water quality parameters that influence their development.

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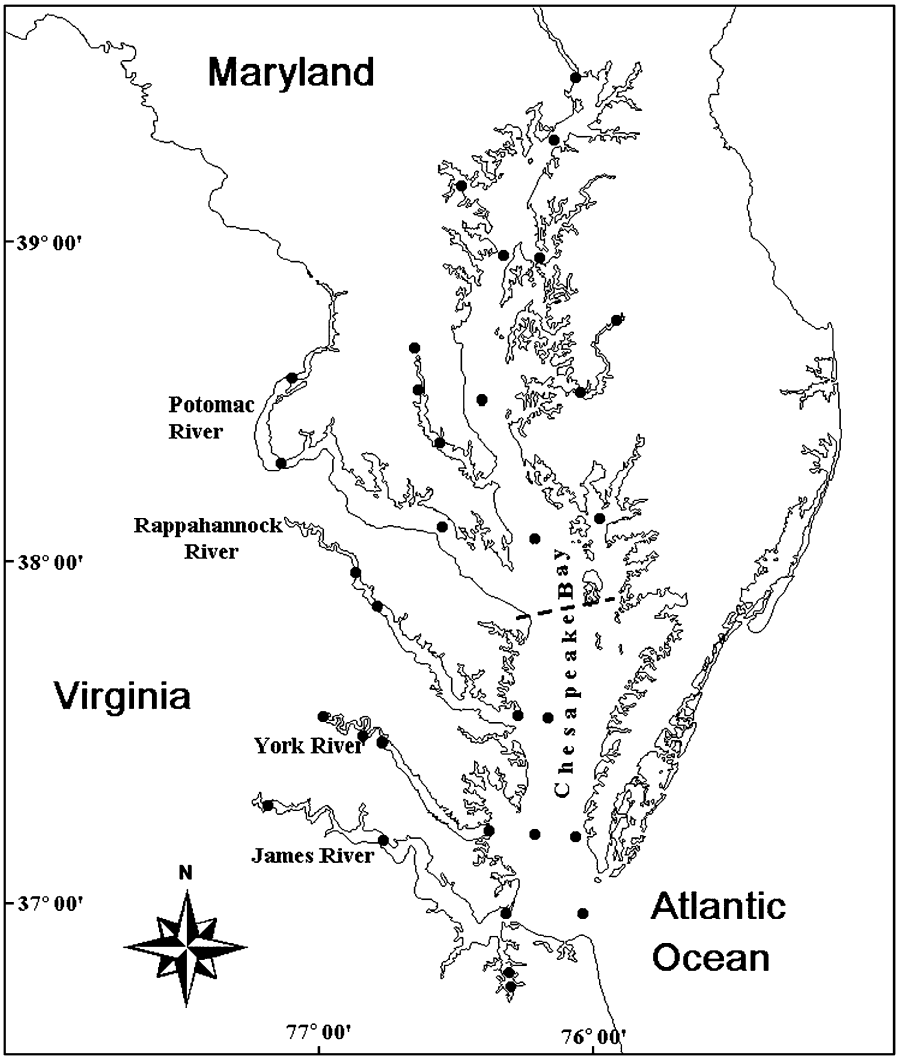

Fig. 1. Location of Virginia and Maryland phytoplankton sampling stations in Chesapeake Bay and its major tributaries, 1984–2002. (Dotted line represents Virginia/ Maryland border).

The objectives of this paper were to identify phytoplankton taxa in greatest abundance and biomass within different salinity regions of Chesapeake Bay in reference to specific water quality conditions. A long-term data set (1984–2002) was used to identify these relationships during spring and summer. These seasons were selected because it is during these periods that many of the most dynamic responses to environmental conditions generally occur in Chesapeake Bay (Buchanan et al., 2005).

2. Materials and methods

2.1. Field and laboratory methods

Monthly phytoplankton and water quality samples used in this report were collected above the pycnocline from 1984 through 2002 at 32 stations in Chesapeake Bay and its major tidal tributaries as part of the Chesapeake Bay Water Quality and Phytoplankton Monitoring Program in Virginia and Maryland (Fig. 1). On station, a composite water sample was taken from five equidistant depths above the pycnocline by means of a hose lowered to and collecting 3 liters of water at each depth, which was then pumped into a carboy on deck. A second series of water samples were collected at these depths to produce another 15 l composite sample. Water within each carboy was gently mixed, with a 500 ml sub-sample removed from each and fixed with Lugol's solution. In the absence of a pycnocline the series of water collections were taken from the upper third section of the water column at that particular station. The 500 ml samples were transported to the laboratory where formalin was added as a preservative. Prior to laboratory analysis, the paired samples were mixed, and a single 500 ml sample taken and processed through a series of settling and siphoning steps to obtain a 40 ml concentrate which was analyzed using Utermöhl procedures described by Marshall and Alden (1990) in Virginia. A modified protocol was followed in the Maryland collections, where an initial composite sub-sample