Headlines

Microscopic Phytoplankton Can Cause Big Problems for Estuaries

A Decade of Research Forms the Basis for Fundamental Principles for How Phytoplankton Affects the Water Quality of Coastal Ecosystems

In September 2004, San Francisco Bay, California, had the largest red tide that U.S. Geological Survey (USGS) scientists have observed since they began monitoring phytoplankton, nutrients, chlorophyll, and other water-quality indicators in San Francisco Bay in the late 1970s. "Red tides" are caused by blooms of phytoplankton (suspended microscopic algae) with reddish pigments (dinoflagellates). With sufficient numbers of these phytoplankton, the water will appear to be colored red. Some red tides are associated with phytoplankton that produce toxins, but fortunately for San Francisco Bay the algal bloom dissipated within a week before any harmful effects occurred.

Microscopic view of a phytoplankton cell (Akashiwo sanguinea) collected during the September 2004 algal bloom in San Francisco Bay, California

Why are phytoplankton so important? What do they have to do with the quality of water? Phytoplankton photosynthesis drives many chemical and ecological processes in lakes, estuaries, and the ocean. For example, dynamic changes in pH, trace metal concentrations, and concentrations of dissolved gases (oxygen, carbon dioxide, methane), nutrients (nitrate, phosphate, silicate), and organic compounds (amino acids, organosulfur compounds) are all closely associated with fluctuations in phytoplankton photosynthesis. Toxic chemicals that phytoplankton absorb can also be magnified up the food chain to larger organisms in a process called bioaccumulation.

Water-resource managers worldwide are dealing with algal blooms, red tides, eutrophication, and other problems associated with phytoplankton in coastal ecosystems. To deal with these problems, water-resource managers need answers to fundamental questions such as:

- How do phytoplankton communities respond to changes in nutrient concentrations?
- How do phytoplankton communities change when new species are introduced?
- Why are some phytoplankton species toxic, whereas other similar species are a nutritious food?

- Why do some phytoplankton species fuel food webs that support fisheries, whereas others contribute little energy to food webs?
- Why is there so much variation in the effect that phytoplankton species have on atmospheric carbon dioxide (CO_2) concentrations and the cycling of carbon in the environment?
- How do physical changes to estuaries create or prevent harmful algal blooms?

USGS scientist James E. Cloern and his colleague Richard Dufford have summarize over a decade of research on the phytoplankton ecology of San Francisco Bay. In addition they have provided a synthesis of contemporary understanding of the processes that shape phytoplankton communities by proposing eight fundamental principles (see side bar). These principles address controls on phytoplankton species that are key to understanding the relation between phytoplankton and water quality, possible adverse effects of large blooms on wildlife and human health, causes of eutrophication, and fisheries productivity in aquatic ecosystems. Scientists, educators, and regulators can use these principles to help understand the complex influences of phytoplankton communities on coastal water quality and habitat quality.

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Eight Principles of Phytoplankton Community Assembly

1. Cell size is determined by nutrient supply and selective grazing
2. Diatoms respond rapidly to nutrient pulses
3. Pelagic habitats (open or deep water habitats as opposed to near shore habitats) select phytoplankton species on the basis of their form and function
4. Pelagic communities are shaped by species interactions across trophic levels
5. Phytoplankton species have mixed nutritional modes (some feed on other algae in addition to photosynthesizing their own food)
6. Phytoplankton species have variable life histories
7. Pelagic ecosystems are open
8. Communities respond to large-scale climatic periodicity

Cloern and Dufford, 2005

References

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More Information

- Water Quality of San Francisco Bay
- Plankton Dynamics in Tidal Estuaries
- Varied Human Influences on Estuaries -- San Francisco Bay , California
- Phytoplankton Response to the Invasion of the Asian Clam in North and South San Francisco Bay, California
- Phytoplankton Blooms in San Francisco Bay – Frequently Asked Questions
- Comparison of Phytoplankton Blooms in San Francisco Bay and Chesapeake Bay

Related Headlines

- A Tool for Predicting the Effect of Invasive Species on Aquatic Food Webs

Information on Red Tides and Other Harmful Algal Blooms

- Chapter 36 Algal Toxins (pdf) of the Field Manual of Wildlife Diseases--General Field Procedures and Diseases of Birds, USGS Information and Technology Report 1999–001
- Toxic "Red Tide" Populations in the Western Gulf of Maine: Sources, Transport, and Nutrient Environment, USGS Coastal and Marine Geology Program
- Cloern, J.E., 2001, Our evolving conceptual model of the coastal eutrophication problem http://toxics.usgs.gov: Marine Ecology Progress Series, v. 210, p. 223-253.
- Marine and Freshwater Algae, Our Living Resources, A Report to the Nation on the Distribution, Abundance, and Health of U.S. Plants, Animals, and Ecosystems, USGS
- Harmful Algal Bloom Forecasting System, National Oceanic and Atmospheric Administration (NOAA)
- The Harmful Algae Page, Woods Hole Oceanographic Institution
- Harmful Algae Digital Library, National Sea Grant Library
- The IOC Harmful Algal Bloom Programme, Intergovernmental Oceanographic Commission (IOC), United Nations Educational, Scientific and Cultural Organization (UNESCO)
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