We frequently document extensive algal blooms, Noctiluca, because of its proximity to the cold, nutrient-rich Pacific Ocean. Phytoplankton respond to nutrient availability, composition, and the physical character of the water column. Through our long-term monitoring program (Fig. 1) and aerial surveys, we found that nutrient concentrations in Puget Sound have significantly increased and nutrient ratios have steadily changed over the last 13 years (Fig. 3) despite the strong influence of the ocean on Puget Sound water quality (Fig. 2).

We frequently document extensive algal blooms, Noctiluca, and jellyfish masses at the surface (Fig. 4). Many of the phytoplankton blooms show high abundances of autotrophic flagellates. In contrast, depth-integrated algal biomass (chlorophyll a) shows a significant steady decline from 1999 to 2011 (Fig. 3C). These seemingly opposing observations - high algal biomass and Noctiluca at the surface and decreasing biomass below the surface - could be clues to a shifting food-web structure and nutrient fluxes in Puget Sound. The cause and impacts of these trends are discussed in the context of human pressures, climatic and oceanic boundary conditions, and planktonic food-web structure.

Findings and Summary

• Ocean boundary conditions significantly drive water quality in Puget Sound (Fig. 2), yet macro-nutrients continued to steadily increase independent of ocean variability (Fig. 3A).

• Changes in the Si:DIN ratio are considered a sign of human nutrient inputs (Harashima, 2007).

• A decline in the silicate to dissolved inorganic nitrogen (Si:DIN) ratio (Fig. 3B) paired with an increase in nitrate (Fig. 3A) will increasingly favor the growth of non-silicified phytoplankton species such as the dinoflagellate Noctiluca.

• Over the last two years, the Department of Ecology’s Eyes Over Puget Sound reports (EOPS) have documented extensive near-surface blooms of Noctiluca and other dinoflagellates in Puget Sound (Fig. 4D, E).

• Noctiluca is frequently associated with eutrophication of coastal environments (Vasas et al., 2007).

• Noctiluca blooms reduce chlorophyll a concentrations in the water column. The impact of Noctiluca grazing on phytoplankton biomass appears in Ecology’s Victoria Clipper ferry transect data (Fig. 4A, B).

• Despite large, frequent surface blooms of dinoflagellates, chlorophyll a concentrations have significantly declined (Fig. 3C) and sub-surface clarity has significantly increased (Fig. 3D).

• Changes in the lower food web structure may have much larger implications for ecosystem functioning.

References


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