Multiple Scenarios for Fisheries to Increase Potentially Toxin-Producing Cyanobacteria Populations in Selected Oregon Lakes

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Introduction

The dominance of cyanobacteria in lakes is often associated with external loads of phosphorus from activities in the watersheds. However, we have identified multiple pathways in selected Oregon lakes whereby fisheries management activities play a crucial role in promoting cyanobacteria populations.

Hypotheses

The proliferation of cyanobacteria in freshwater environments is aided by increased availability of phosphorus. Phosphorus availability is increased by alteration of native food-webs, thus changing the trophic dynamics of nutrient cycling in lakes. Fisheries management can alter food webs numerous ways.

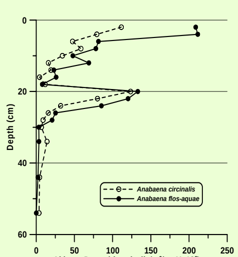
Methods

Several Oregon lakes were investigated through the use of paleolimnological techniques. Sediment cores were dated using 210Pb and changes in water quality and cyanobacterial populations were examined using akinetes (resting cells) preserved in the sediments.

Results

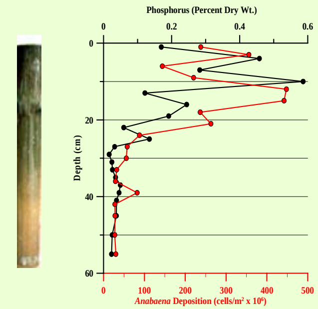
Fish populations were shown to alter trophic structure and thus increase phosphorus availability in several ways.

(1) In **Diamond Lake**, the inadvertent introduction of a minnow (tui chub, *Gila bicolor*) native to an adjoining basin led to increased fish biomass and translocation of nutrients from the shallow waters to the pelagic zone. Diamond Lake was treated with rotenone in 1954, thus eliminating all fish and resulting in an immediate drop in cyanobacteria populations. The cyanobacteria densities in Diamond Lake have increased in recent years with the reintroduction of the tui chub and leading to lake closures.



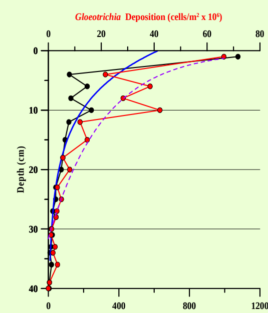
The figure shows the akinete deposition rate of *Anabaena* taxa in the sediments of Diamond Lake. The first peak near 20 cm depth corresponds with the period when tui chub were first introduced, probably as bait fish. The *Anabaena* populations declined dramatically after the rotenone treatment in 1954. Tui chub are present once again, causing another increase in *Anabaena.* Cell counts have exceeded 250,000 cells/mL and the lake experienced closures from 2001-2003.

(2) In **Odell Lake**, the State intentionally introduced kokanee (land-locked sockeye salmon, *Oncorhynuchus nerka*) to enhance a native salmonid fishery. The kokanee became the dominant fish and increased nutrient cycling by consuming large quantities of zooplankton in the metalimnion and recycling nutrients back into the photic zone. The native salmonids occupy the hypolimnion during the summer, providing relatively little opportunity for returning phosphorus back to the photic zone in the summer.



This figure illustrates the increase in sediment akinetes of *Anabaena* and the closely correlated increase in phosphorus retention in the lake. The digitally-enhanced image of the sediment core adjacent to the plot illustrates the change to a lake previously dominated by diatoms (light tan sediment) to one dominated in the summer by cyanobacteria. Odell Lake has had cell counts exceeding 330,000 cells of *Anabaena flos-aquae* the last two summers.

(3) **Devils Lake** is a shallow coastal lake with a native salmonid fishery and introduced centrarchids. In an effort to reduce the abundant macrophyte growth throughout much of the lake, the local lake district (with permission of the State) introduced triploid grass carp (*Ctenopharyngoden idella*). The stocking were successful and the grass carp eventually ate all submerged macrophytes in the lake. Once the macrophytes were eliminated, cyanobacterial populations increased dramatically most likely because of reduced light shading, reduced competition for nutrients, and increased nutrient supply associated with disturbance of the sediment by the grass carp.



This figure shows the abrupt increase in deposition of both *Anabaena* and *Gloeotrichia* akinete cells in the sediments of Devils Lake following the elimination of submerged macrophytes in 1994 by the grass carp.

(4) **Crane Prairie Reservoir** is a shallow impoundment in central Oregon and historically was a rainbow trout fishery. It currently has five introduced, non-native fish species and is experiencing major blooms of cyanobacteria. The zooplankton community has been greatly altered by the predation of the introduced fish, most likely contributing to the intense blooms of *Anabaena* (up to 225,000 cells/mL)

Conclusions

Alteration of fish populations can contribute to increases in cyanobacteria densities in multiple ways:

1. Translocation of phosphorus from the littoral zone to the pelagic zone by illegally introduced omnivores as seen in Diamond Lake.
2. Recycling of nutrients in the photic zone by an intentional introduction of a planktivorous salmonid in a lake such as Odell Lake, filling a niche that was formerly poorly utilized.
3. Legal introduction of a herbivorous fish as in Devils Lake, resulting in reduced competition for nutrients, greater availability of light, and greater recycling of phosphorus from the sediments.
4. Disruption of zooplankton grazing by illegal introduction of centrarchids as in Crane Prairie Reservoir.