Plankton Communities and Summertime Declines in Algal Abundance Associated with Low Dissolved Oxygen in the Tualatin River, Oregon

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Study Abstract

Phytoplankton populations in the Tualatin River are an important component of the dissolved oxygen (DO) budget. During summer low-flow, phytoplankton typically develop in the lower river, maintaining DO concentrations despite high rates of sediment oxygen demand. Recent declines in phytoplankton result in low oxygen conditions that may harm aquatic life. This study characterized the plankton communities in the river and evaluated a number of possible hypotheses to explain the declines in phytoplankton. Longitudinal plankton surveys were conducted at six mainstem sites at 2- to 3-week intervals, augmenting an extensive water-quality and flow monitoring network. Plankton community composition, streamflow, and water-quality data were analyzed using multivariate statistical techniques. Results indicate that algal populations are influenced by factors including the magnitude and sources of streamflow, light available for photosynthesis, turbidity, upstream algal inocula or "seed", zooplankton grazing, and phosphorus concentrations. These factors determine which algae species are dominant, when blooms form, how large they become, how long they last, and in some cases explain particular boom crashes.

Tualatin River Basin

- 712 square mile basin (FIG. 1) drains the east slope of the Coast Range in northeastern Oregon
- Mostly private land-commercial forestry, agriculture, rural residential, and high density urban
- Low gradient river cuts through a sediment filled valley
- Low summertime flow contributes to water quality problems including warm temperatures, algal blooms, low DO, high pH, and poor aesthetic conditions
- Long history of agency efforts and regulation (upgrades to WWTFs, Hagg Lake created) to improve flow and water quality

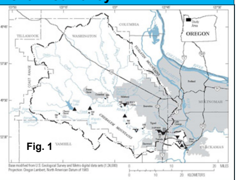

Fig. 1

Recent Declines in Phytoplankton Abundance

- For many years an upstream → downstream increase in phytoplankton biomass was typical during the growing season
- In recent years (2002–09) biomass has been much lower (FIG 2).
- Biomass declines observed farther upstream than expected (RM 38)
- End result is more frequent violations in the dissolved oxygen minimum standard in the lower river at Oswego Dam (RM 3.4)
- Low dissolved oxygen conditions may persist for weeks or months until cooler weather and higher flows arrive in autumn

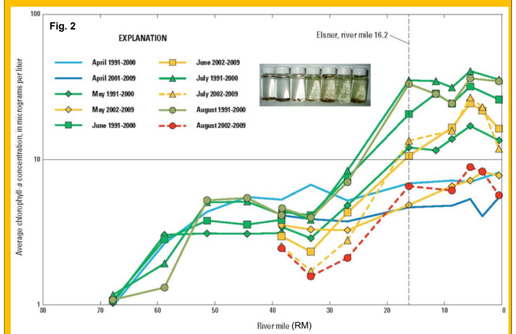

Fig. 2

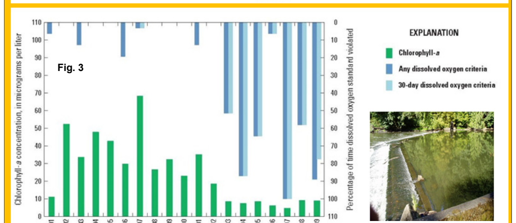

Fig. 3

Oswego Dam, RM 3.4

Study Objectives

- Characterize the plankton during the 2006-08 growing seasons
- Examine how plankton assemblages respond to flow, sources of flow (natural flow, reservoir augmentation, and wastewater), weather, zooplankton, and selected water-quality parameters (nutrients)
- Investigate why phytoplankton populations abruptly decline during summer when conditions are apparently favorable

Sampling Approach

- Longitudinal sampling: plankton, water quality conditions
- Network of continuous gages: streamflow and water-quality monitors
- Multivariate analyses: to determine the factors most influencing phytoplankton abundance and species composition

Plankton Assemblages

- Diverse mix of filamentous centric diatoms (*Stephanodiscus*, *Cyclotella*, *Melosira*), small flagellates (*Cryptomonas* and *Rhodomonas*), green and blue-green algae (*Anabaena* and *Aphanizomenon*)
- Zooplankton (Cladocerans, copepods, and rotifers) abundant during the lowest flows

Algal Photosynthesis and Dissolved Oxygen

- Dissolved oxygen is largely controlled by chlorophyll-a levels (FIG. 4)
- Photosynthesis typically sustains DO, but phytoplankton declines cause the DO to drop below the standard (FIG. 5)

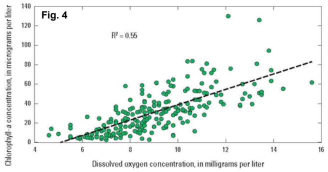

Fig. 4

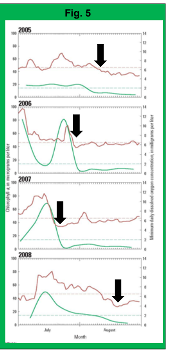

Fig. 5

Key Factors Explaining Phytoplankton Declines

1. Light available for algal photosynthesis. Cloudy weather reduces algal photosynthesis, and the highest biomass (chlorophyll-*a*) occurs when the turbidity is less than 5-10 NTUs (**FIG. 6**)

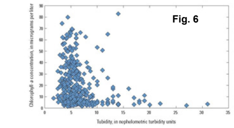

Fig. 6

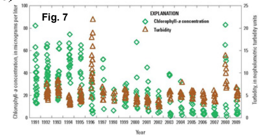

Fig. 7

- Higher turbidity at Elsner (RM 16.2, **FIG. 7**) since 2003 coincides with lower chlorophyll-*a*

2. Reduced algal "seed source" to inoculate the river. Small reductions in chlorophyll-*a* concentrations in the upper river have led to downstream declines (**FIG. 2**). Although such inoculation is important for maintaining DO, inputs of nuisance algae can be problematic. The inoculation of blue-green algae in June 2008 translated into a large bloom of toxin-producing blue-green algae (*Anabaena*) in the lower river -- the largest in decades (below right).

3. Higher streamflow. Streamflows lower than about 250 ft^3/s are typically required to allow enough time (2-3 weeks) for phytoplankton to develop significant populations (**FIG. 8**). Higher flows cause "hydraulic washout" (**FIG. 9**).

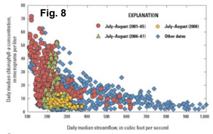

Fig. 8

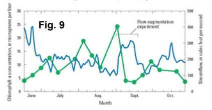

Fig. 9

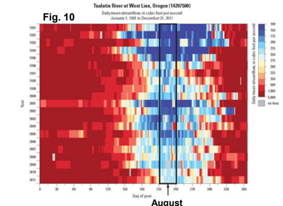

Fig. 10

- August flows are now higher (**FIG. 10**)

4. Change in the source of flow. Greater amounts of reservoir releases (**FIG. 11**) and higher discharges of treated wastewater effluent from RC WWTF (**FIG. 12**) result in a lower proportion of natural flow. This change is associated with lower chlorophyll-*a* and reduced diatom biovolume levels (**FIG.13**).

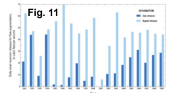

Fig. 11

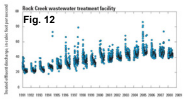

Fig. 12

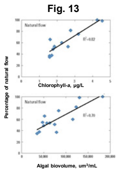

Fig. 13

5. Zooplankton grazing. Evidence of top down control of phytoplankton by zooplankton at times (**FIG. 14**).

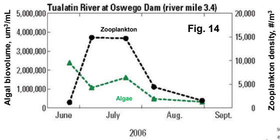

Fig. 14

Skistodiaptomus reighardti

6. Phosphorus limitation. Aggressive P removal at the WWTFs and uptake by phytoplankton lower concentrations to limiting levels (**FIG. 15**).

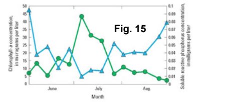

Fig. 15

The full USGS Scientific Investigations Report 2013-5037 is available at *http://pubs.usgs.gov/sir/2013/5037/*

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