2015 Accomplishments

National Park Service
U.S. Department of the Interior

North Cascades National Park

Skagit Environmental Endowment Commission Projects at North Cascades National Park

Monitoring Ross Lake Water Quality

Introduction

The upper Skagit watershed spans the U.S./Canada border and encompasses 1,018 square miles (2,637 square km). Over the past ten years, an average of 302,940 people a year visited the Ross Lake National Recreation Area. This area supports a renowned rainbow trout fishery, and it is also home to one of the most protected and robust populations of bull trout in the lower United States. These factors combine to make the upper Skagit a unique area supporting exceptional recreational fishing opportunities and the conservation of a federally threatened species.

While the majority of the land in the watershed is protected as park lands or wilderness, the aquatic resources in this area still face threats from past and current land-use practices, mining, climate change, as well as the atmospheric deposition and run-off of pollutants. To assess the impacts of these stressors and guide management activities, North Cascades National Park, with support from the Skagit Environmental Endowment Commission, is monitoring the water quality and ecological conditions of Ross Lake and six of the major tributaries in the watershed.

Figure 1. North Cascade National Park staff collect zooplankton in Ross Lake.

Study Objectives

1. Assess the current water quality conditions and determine the trophic status of Ross Lake.
2. Characterize the seasonal variation of the water quality conditions in Ross Lake.
3. Develop a context for interpreting how the ecological integrity of Ross Lake is responding to fluctuations in nutrient levels, the atmospheric deposition and run-off of pollutants, climate change and introduced non-native species.
4. Determine and verify the long-term trends in the water quality and trophic status of Ross Lake.

Summary of Project Activities

In May 2009, four water quality monitoring stations were established at equally spaced locations along the length of Ross Lake (Figure 2). Each of these stations has been continuously monitoring water temperature in the lake since that time. Also, water chemistry, chlorophyll-*a,*

and zooplankton samples are collected at three of these stations (Table 1) during the height of biological productivity from May through November. Additionally, vertical profiles determining how temperature, pH and dissolved oxygen change throughout the water column are taken. As of November 2015, a total of 138 sample events have been conducted, and the information generated from these samples has been used to assess nutrient availability, acid neutralizing capacity, trophic status and the ecological condition of the lake. All field operations, laboratory procedures and analytical techniques follow the guidance outlined in the North Coast and Cascade Network Water Quality Monitoring Protocol developed as part of the NPS's Inventory and Monitoring Program.

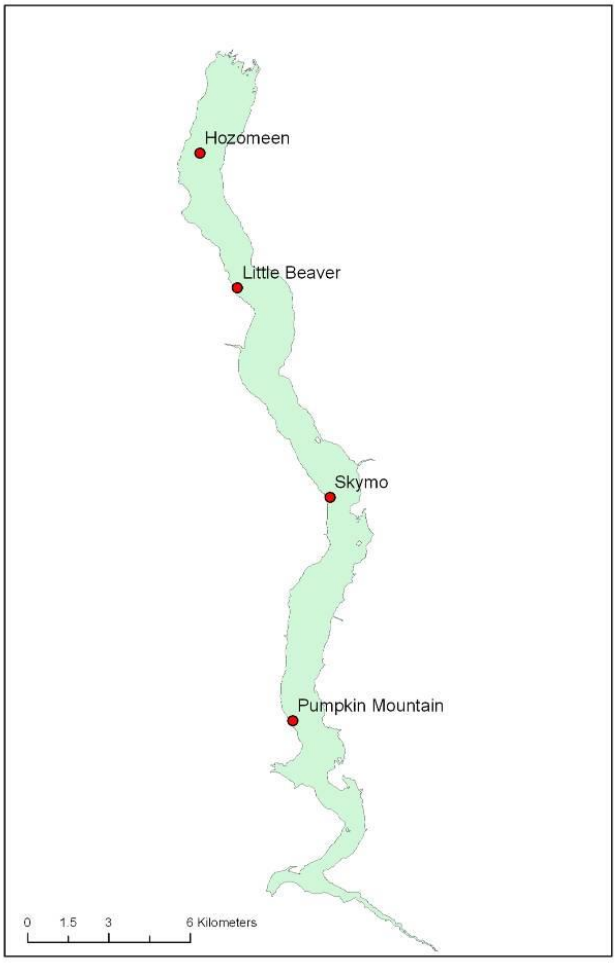

Figure 2. Locations of water quality monitoring stations in Ross Lake.

Table 1. The distribution of the parameters measured at each of the Ross Lake water quality stations.

	Continuous Temperature	Water Chemistry	Zooplankton
Pumpkin Mountain	✓	✓	✓
Skymo Creek	✓	✓	✓
Little Beaver Creek	✓	✓	✓
Hozomeen	✓		

Status Report of 2015 Activities

This was the seventh year of data collection for the Ross Lake water quality monitoring project. The commitment to long-term monitoring is beginning to pay off as our understanding of the seasonal and annual cycles in Ross Lake increases.

At this time, we have received water chemistry results through 2015 and have received the zooplankton results through 2014. These results have enabled us to make a preliminary assessment of the trophic status of the reservoir.

Planned Activities for 2016

1. Conduct monthly monitoring activities from May through November.
2. Attend a course focusing on time series analysis methods.
3. Conduct seven-year trend analysis and complete a state of the resource report for first seven-year rotation of data collection on Ross Lake.

Preliminary Results

Water Temperature

Water temperature in the upper 20 meters of Ross Lake routinely exceeds 12°C during the summer months. This temporarily can reduce the area of the reservoir used by bull trout, a species that thrives in cold water. Bull trout are known to seek out cold water, as needed, and the population in Ross Lake is among the largest in the US. Nonetheless, it is unknown at this time how shallow water temperatures in Ross Lake may be changing as a result of climate change and what effect this may have on aquatic species.

Water Chemistry

One of the primary interests that initiated the water quality monitoring in Ross Lake was to study nutrient availability in this aging reservoir. This has been documented in other reservoirs, where inflows are naturally nutrient-poor, and organic matter in the reservoir degrades and is flushed out over time. Surveys conducted by the Washington Department of Fish and Wildlife prior to 2009 indicated that fish size had decreased and the incidence of parasites had increased over time, raising the question whether reduced nutrients could be reducing productivity in the water and the condition of the individual fish.

We used two indicators to assess the productivity of Ross Lake. The first was total phosphorous (TP) concentrations. Phosphorous in lakes is often the limiting factor in algae growth and lake productivity. Lakes are considered ultra-oligotrophic, or nutrient poor, with TP concentrations <5 µg/L and oligotrophic with concentrations of 5 to 10 µg/L.

The second indicator we used was the Carlson Trophic State Index (TSI). This index combines three measures of water quality including: transparency (using Secchi disk depth recordings), chlorophyll-a concentrations (algal biomass), and total phosphorus levels. This index ranges from 0 to 100 and oligotrophic lakes are considered to have TSI values below 30.

The TP concentrations in Ross Lake ranged as high as 8 µg/L in 2009, however TP concentrations are typically below 2 µg/L and the highest concentration measured in 2015 was 3 µg/L. These results indicate phosphorous is likely a limiting factor for productivity. Similarly, TSI values in Ross Lake are below 30 and also indicate low levels of productivity (Figure 6). However, TSI values are not greatly below 30 indicating that other nutrients, possibly nitrogen, may be driving some of the productivity in the system.

Oligotrophy is a common water quality condition in Cascade mountain lakes and streams and is typically considered an optimum condition for salmonid species. Other physical and biotic factors in Ross Lake, such as the potential increase in water temperatures, the recent spike in the presence of red-side shiner, and observed shifts in the relative size and abundance of rainbow trout and bull trout, suggest that this is a complex environment requiring ongoing monitoring and evaluation in the future.

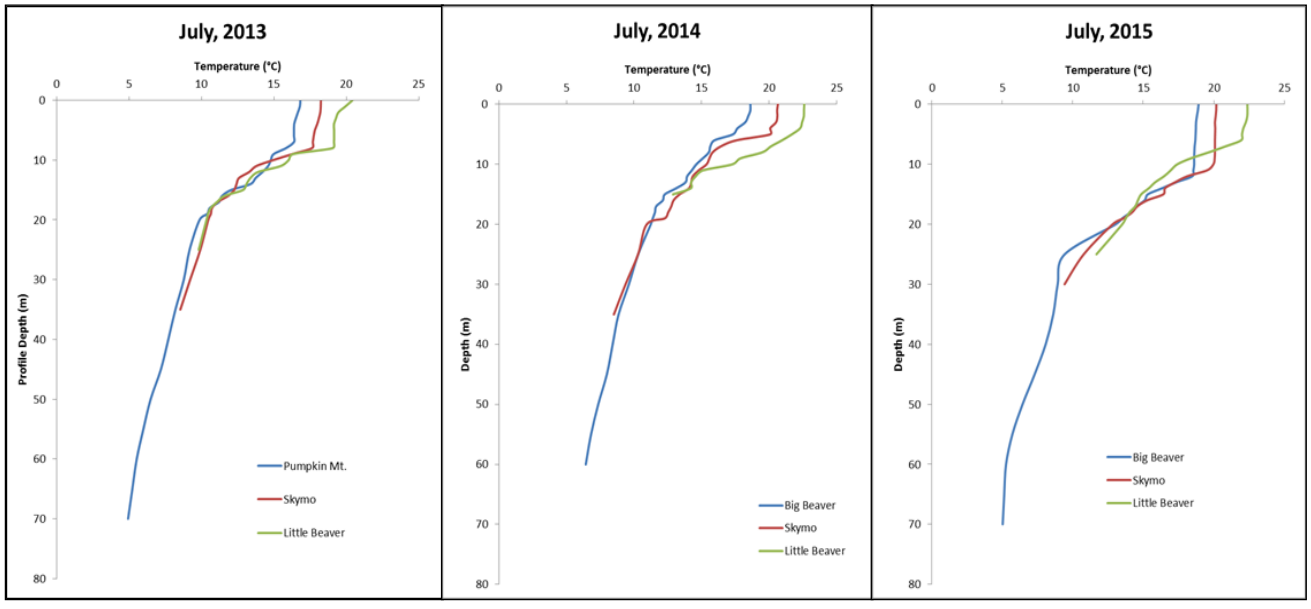

Figure 3. July temperature profiles measured from the three water quality stations in Ross Lake. Shows typical "stratification" of warm water near the surface or "epilimnion.

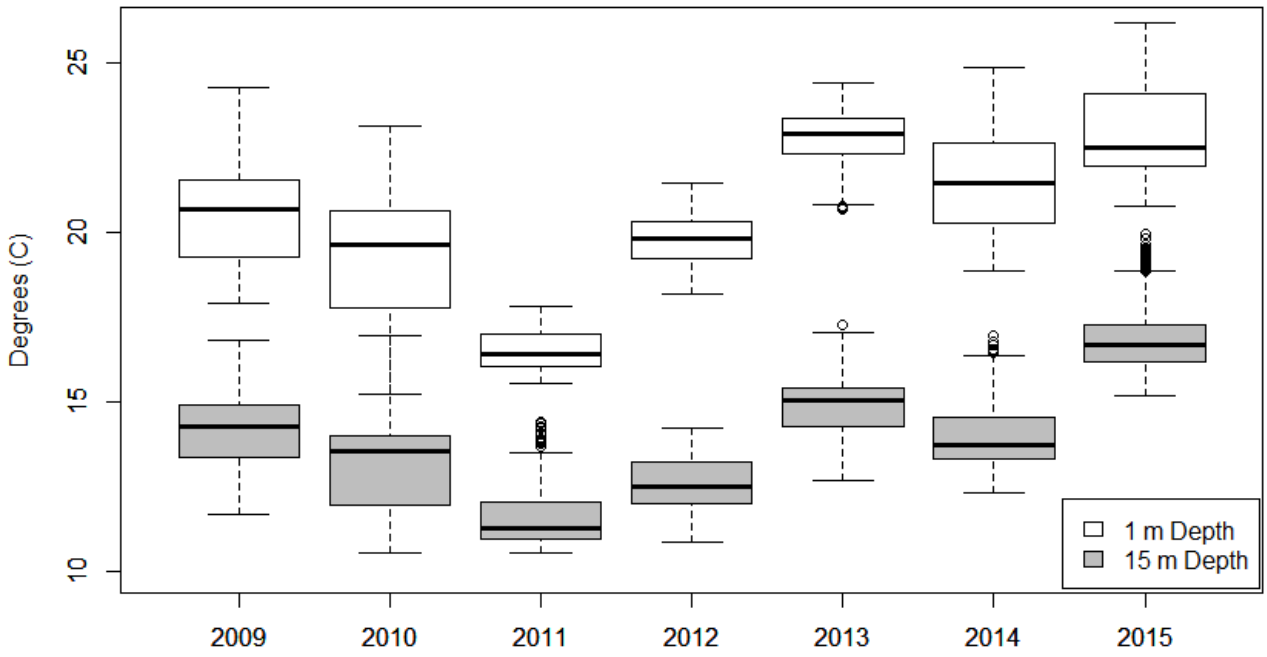

Figure 4. Boxplots of July water temperatures measured at the Hozomeen water quality stations in Ross Lake from 2009 to 2015. Maximum depth at this location is 16 meters.

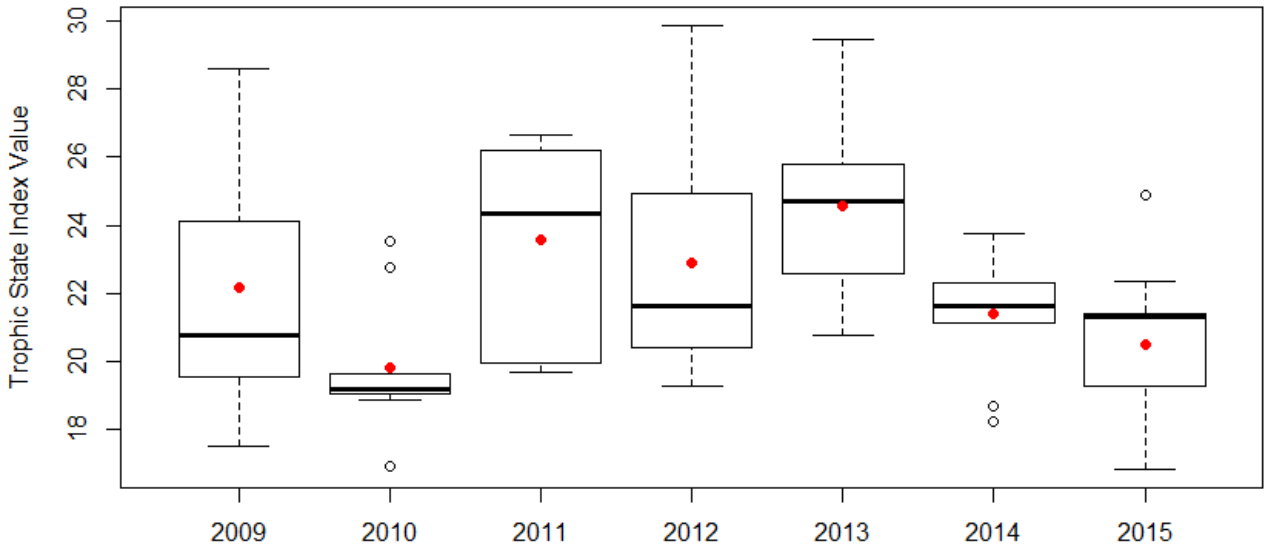

Figure 5. Boxplots and mean (red points) of Carlson's Trophic State Index values for Ross Lake measured from 2009 to 2015. Values below 30 are categorized as "oligotrophic" or nutrient limited.