

# KOOTENAY LAKE NUTRIENT RESTORATION PROGRAM MEASUREMENTS

All measurements below are provided by the Ministry of Forests, Lands, Natural Resource Operations and Rural Development that manages the Nutrient Restoration Program in Kootenay Lake.

- The North Arm nutrient additions are primarily funded by the Fish & Wildlife Compensation Program, with additional funding from BC Hydro.
- The South Arm nutrient additions are primarily funded by the Kootenai Tribe of Idaho that receives funding from the Bonneville Power Administration.

## Secchi disc Measurements

**What: Measures water clarity**

Comments:

- Note that the depth (metres) decreases as you go up the 'Y' axis. The way to look at this, therefore, is to imagine that the title of the graph is close to the surface of the lake and you are looking down into the water – thus the further away the Secchi disk is viewed, the deeper it is in the water. The higher the number, the clearer the water is. (E.g. In 2016 the water was clearer, on average, than in 2017).
- These are averages for the season (April to November). Secchi disk measurements vary throughout the year: they will be deeper in the winter then tend to be shallower in the spring and summer with increased sunlight, warmth and plankton growth.
- With phytoplankton - the microscopic plant matter at the base of the food chain that the nutrient additions are targeting - there are "good" and "bad" types. What makes a good edible vs. inedible phytoplankton is based on size as zooplankton can eat only a particular size of phytoplankton. Some phytoplankton (e.g. blue-green algae) are too large or form chains that make it difficult for zooplankton to consume.

Kootenay Lake Annual Secchi Depth by Arm

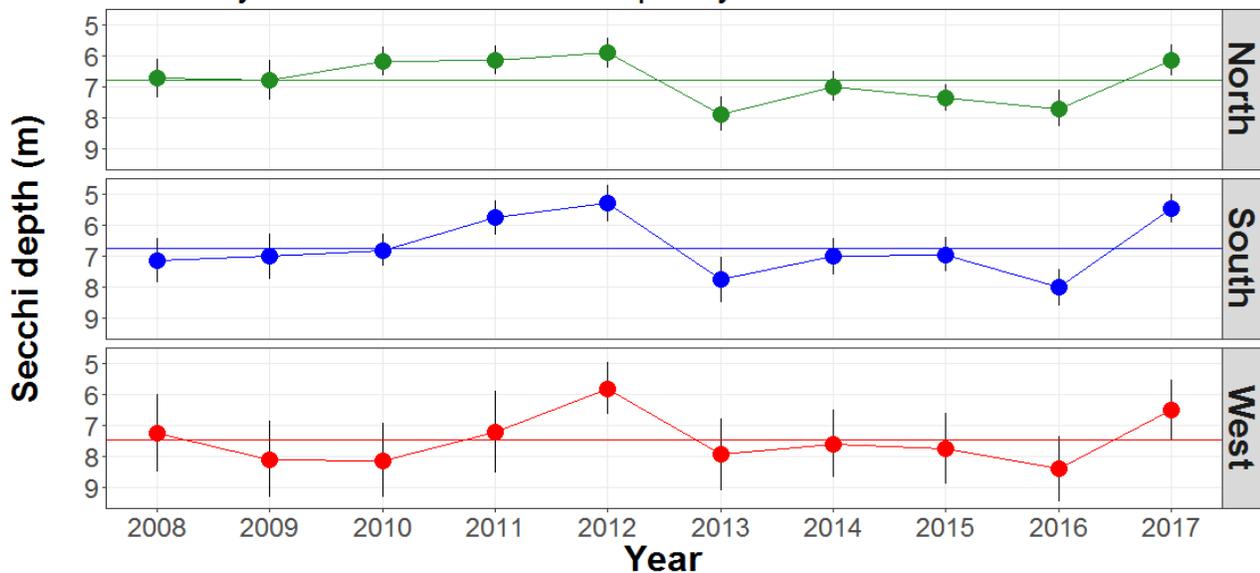


Figure 1. Kootenay Lake average Secchi depth (m) by Arm from 2008-2017. Secchi was sampled monthly April-November. North Arm (blue), South Arm (red) and West Arm (green). Note: no November sampling in 2017. Means ± Standard Error and line represents long-term average from 2008-2017

## Turbidity

**What:** As with the Secchi disc, it provides a measurement of water clarity, but turbidity metrics provide precise measure of suspended particles in the water.

Comments:

- The 'NTU' stands for Nephelometric Turbidity Unit (measure light refraction)
- Turbidity is also a measurement of water clarity by measuring the amounts of total suspended particles.
- This has to meet standard provincial water quality guidelines (for drinking water)
- Can be affected by landslides in the tributaries (reducing clarity and increasing turbidity)
- While an increase in sediments might seem like a positive impact for the food chain, high turbidity actually decreases the efficiency of the nutrients being taken up by the food chain. The nutrients can attach themselves to the particulates and may sink. For example, adding nutrients to the lake following the Johnson's Landing land slide in 2012 would have only had a minimal positive impact on the food chain.
- While turbidity can impact fish, the levels in the graph below do not come close to conditions where fish cannot see their prey.

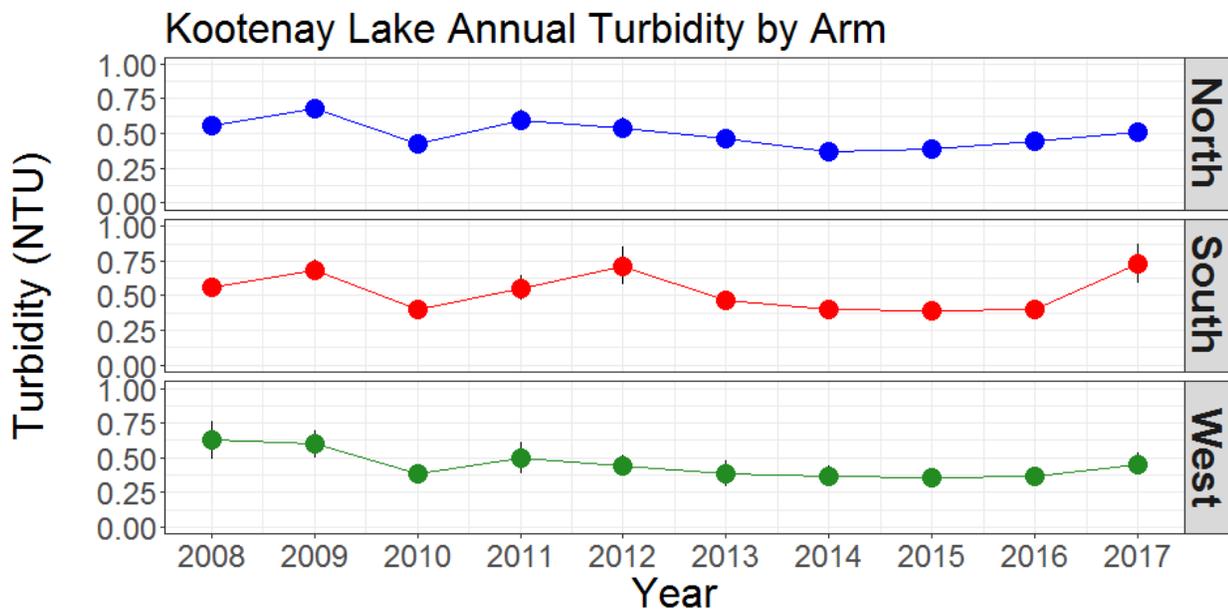


Figure 2. Kootenay Lake annual monthly turbidity (NTU) by Arm from 2008-2017. Sampled monthly April-November. North Arm (blue), South Arm (red) and West Arm (green). Note: no November sampling in 2017. Means  $\pm$  Standard Error.

## Kootenay Lake phosphorus measurements

**What:** Measures the level of phosphorus in the water; phosphorus is one of the essential nutrients for productivity.

### Comments

- Measurement is mass by volume: micrograms of phosphorus per litre of water.
- Phosphorus is added as part of the Nutrient Restoration Program, in the form of liquid agricultural grade fertilizer: 10-34-0.
- Adding too much phosphorus may not benefit the ecosystem because it will not be taken up by the food chain and/or can lead to unwanted algae blooms.
- Water quality guidelines in B.C. allow a maximum of 10 µg/L.
- Phosphorus is typically at higher concentrations in the spring from freshet, or spring run-off.
- In Kootenay Lake there is more variability than in Arrow Lakes Reservoir due to the inflow of Kootenay River.
- The difference between phosphorus and nitrogen:
  - Phosphorus typically comes from the land through natural erosion
  - Nitrogen comes from the atmosphere, through rain and snow fall
- If nitrogen is too low relative to phosphorus, the wrong type of algae can be produced. The balance between nitrogen and phosphorus is closely monitored in the NRP program.

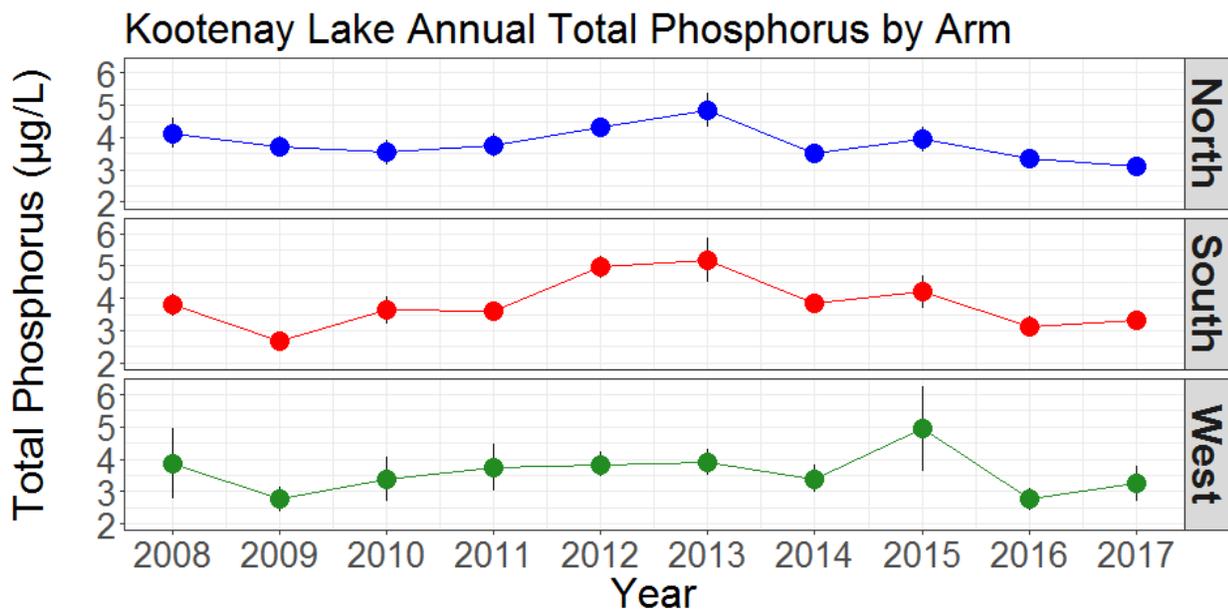


Figure 3. Kootenay Lake annual monthly Total Phosphorus (µg/L) by Arm from 2008-2017. Sampled monthly April-November. North Arm (blue), South Arm (red) and West Arm (green). Note: no November sampling in 2017. Means ± Standard Error.

## Kootenay Lake Zooplankton biomass

What: Measures the monthly (Apr-Oct) annual average biomass of Zooplankton, to help determine level of food source in the system available for Kokanee.

### Comments

- Beneficial Zooplankton largely consist of large-bodied *Daphnia* and are a primary food source for Kokanee
- Measurement is biomass of Zooplankton per litre of water
- Higher Zooplankton measurements can mean:
  - The nutrients being added are effectively moving up the food chain
  - Relative lack of grazing pressure from Kokanee
- South Arm nutrient additions started in 2004

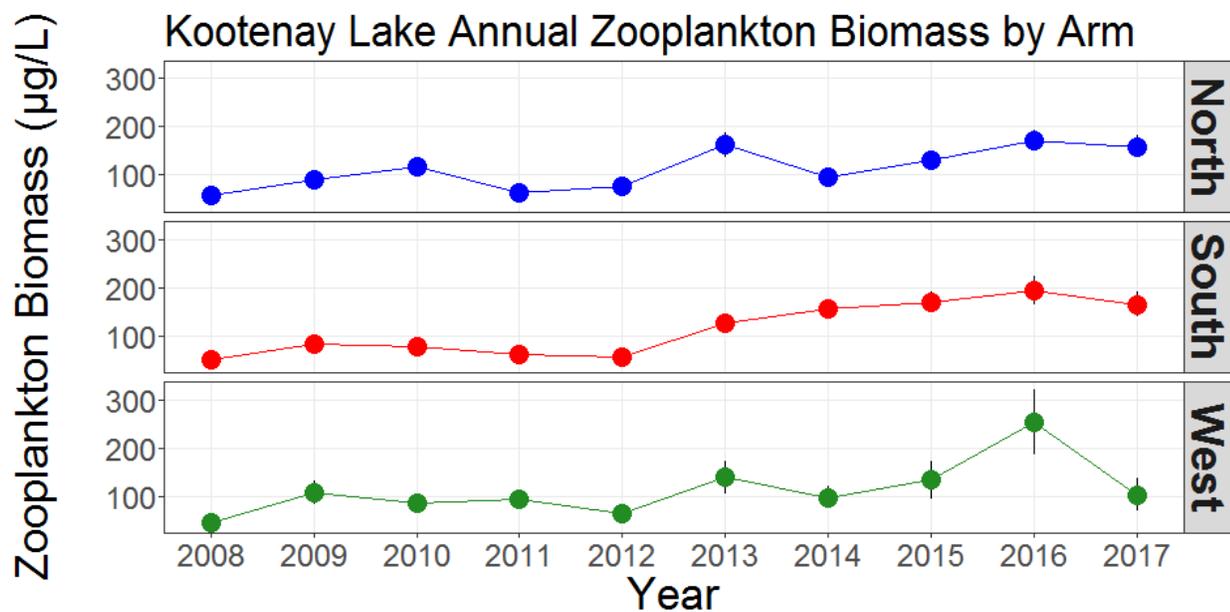


Figure 4. Annual monthly (April-Oct) zooplankton biomass ( $\mu\text{g/L}$ ) in Kootenay Lake from 2008-2017. North Arm (blue), South Arm (red) and West Arm (green). Means  $\pm$  Standard Error.

## Kootenay Lake Mysids

What: Measures the monthly (Apr-Oct) annual average density of mysids in the lake.

### Comments

- Mysids are the species *Mysis diluviana*, an exotic crustacean introduced into Kootenay Lake in 1949 as a food source for fish
- Measurement is number of individuals per square metre of water
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- Fish predation on mysids is limited by the daily vertical migration of mysids in deep lakes and reservoirs. Mysids spend daylight hours at the bottom, rising to feed after dusk (when fish have finished feeding) and descending before dawn.
- Mysid densities are lower in the West Arm because it is shallow and mysids can't hide in the deep as they do in the main lake, and are more susceptible to predators such as West Arm Kokanee.
- Mysids results are under close evaluation in current conditions of high zooplankton in Kootenay Lake.

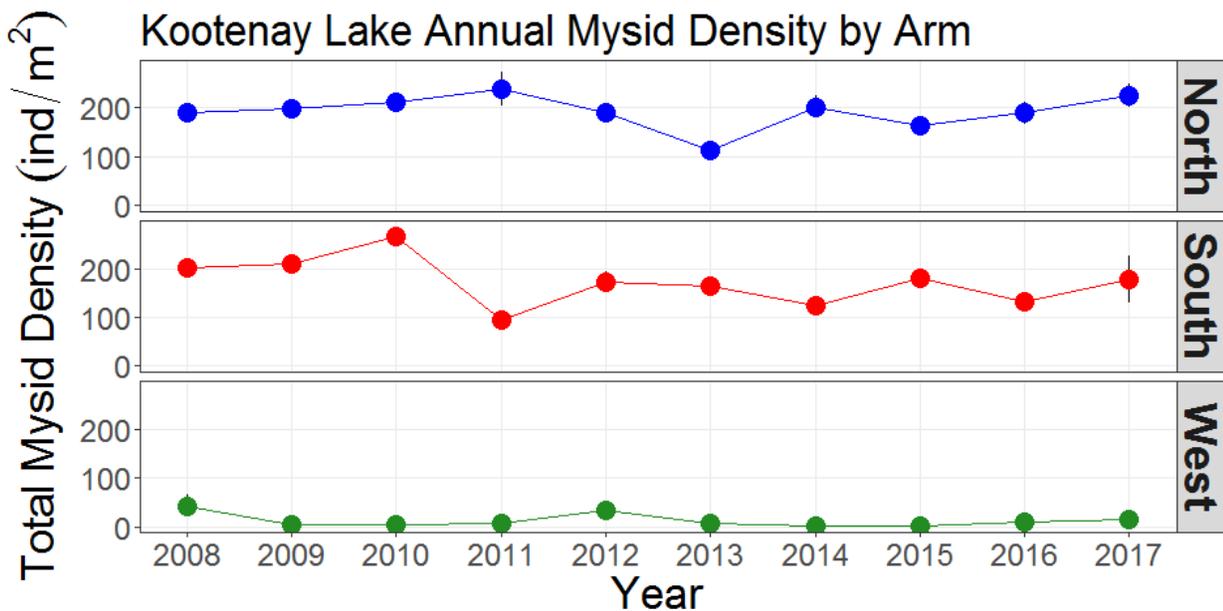


Figure 5. Annual monthly (April-Oct) mysid density (individual/m<sup>2</sup>) in Kootenay Lake from 2008-2017. North Arm (blue), South Arm (red) and West Arm (green). Means ± Standard Error.