BC Lake Stewardship and Monitoring Program

Cusheon Lake 2003 - 2006

A partnership between the BC Lake Stewardship Society and the Ministry of Environment

The Importance of Cusheon Lake & its Watershed

British Columbians want lakes to provide good water quality, aesthetics and recreational opportunities. When these features are not apparent in recreational lakes, questions arise. People begin to wonder if the water quality is getting worse, if the lake has been affected by land development, and what conditions will result from more development within the watershed.

The BC Lake Stewardship Society, in partnership with the Ministry of Environment, has designed a program, entitled *The BC Lake Stewardship and Monitoring Program*, to help answer these questions. Through regular water sample collections, we can begin to understand a lake's current water quality, identify the preferred uses for a given lake, and monitor water quality changes resulting from land development within the lake's watershed. There are different levels of lake monitoring and assessment. The level appropriate for a particular lake depends on funding and human resources available. In some cases, data collected as part of a Level I or II program can point to the need for a more in-depth Level III program. This report provides the results of a Level II program for Cusheon Lake.

Through regular status reports, this program can provide communities with monitoring results specific to their local lake and with educational material on lake protection issues in general. This useful information can help communities play a more active role in the protection of the lake resource. Finally, this program allows government to use its limited resources efficiently thanks to the help of area volunteers and the BC Lake Stewardship Society.

The watershed area of Cusheon Lake is 10.65 km^2. A **watershed** is defined as the entire area of land that moves the water it receives to a common waterbody. The term watershed is misused when describing only the land immediately around a waterbody or the waterbody itself. The true definition represents a much larger area than most people normally consider.

Watersheds are where much of the ongoing hydrological cycle takes place and play a crucial role in the purification of water. Although no "new" water is ever made, it is continuously recycled as it moves through watersheds and other hydrologic compartments. The quality of the water resource is largely determined by a watershed's capacity to buffer impacts and absorb pollution.

Every component of a watershed (vegetation, soil, wildlife, etc.) has an important function in maintaining good water quality and a healthy aquatic environment. It is a common misconception that detrimental land use practices will not impact water quality if they are kept away from the area immediately surrounding a water body. Poor land-use practices anywhere in a watershed can eventually impact the water quality of the downstream environment.

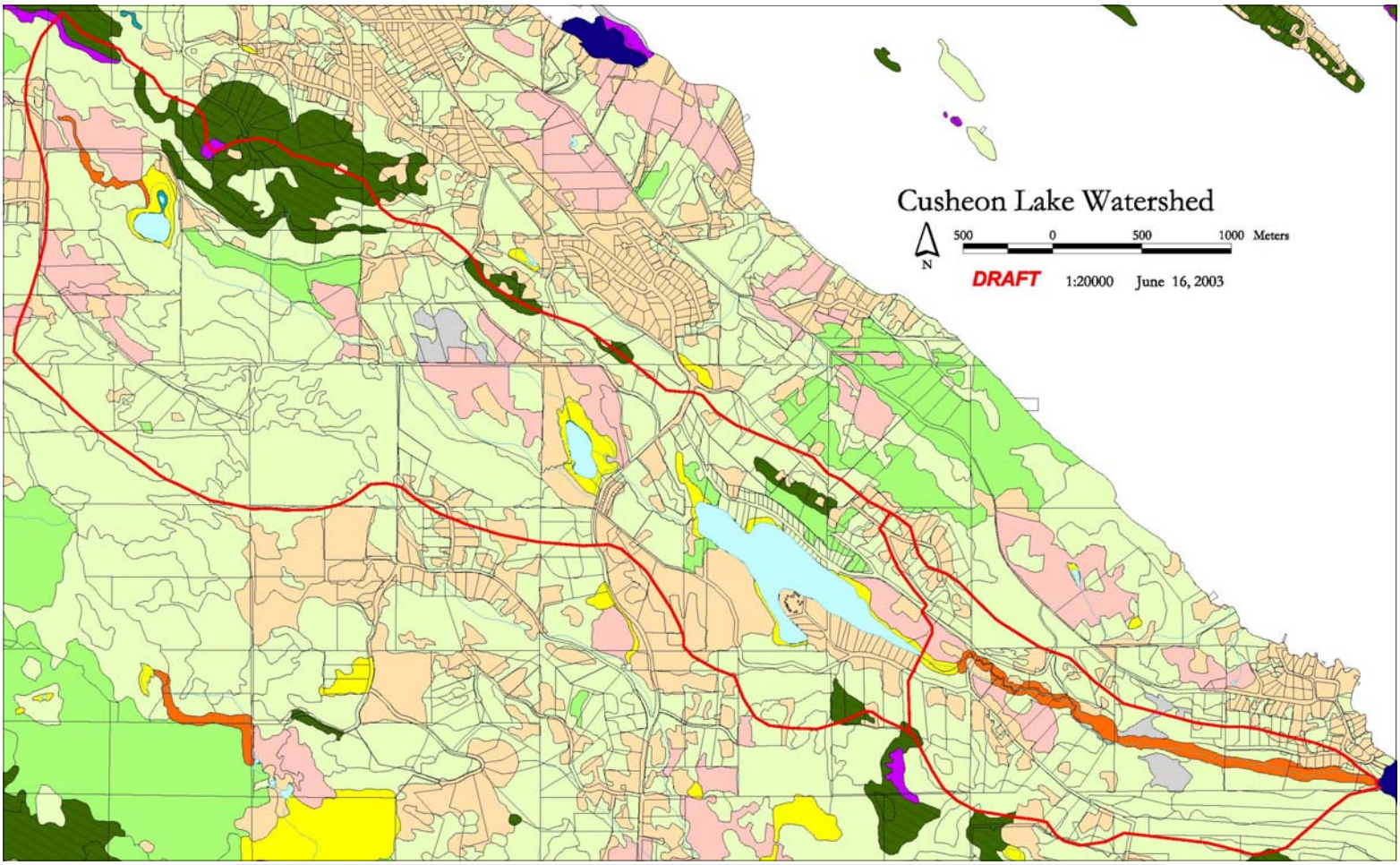
Human activities that impact water bodies range from small but widespread and numerous *non-point* sources throughout the watershed to large *point* sources of concentrated pollution (e.g. waste discharge outfalls, spills, etc). Undisturbed watersheds have the ability to purify water and repair small amounts of damage from pollution and alterations. However, modifications to the landscape and increased levels of pollution impair this ability.

Cusheon Lake is located on Salt Spring Island, part of the southern Gulf Islands, off Vancouver Island. The lake has a surface area of 31 ha with a perimeter of 3.95 km and lies at an elevation of 91.4 m. The mean and maximum depths of Cusheon lake are 4.4 m and 9.5 m, respectively. The lake contains cutthroat trout (freshwater and anadromous), rainbow trout, sculpin, smallmouth bass, and threespine stickleback. The lake is stocked annually with cutthroat trout.

The retention time (turnover or flushing rate) of a lake is the average length of time water resides in a lake, ranging from several days in small impoundments to many years in larger lakes. Flushing rate is important in determining the impact of nutrient inputs. Long retention times result in recycling and greater nutrient retention in most lakes. The flushing rate of Cusheon Lake is 11 months, indicating that Cusheon lake has a moderate ability to assimilate nutrients. However it should also be noted that most of this flushing occurs during the fall and winter months as there is little to zero outflow from Cusheon Lake to Cusheon Creek during the months June to October.

The Cusheon Lake watershed is the second largest supply of drinking water to Saltspring Island residents. Some residents use ground water as a drinking water source. The primary water uses for Cusheon Lake are: domestic consumption, recreation, irrigation, aquatic and wildlife, and industrial.

Cusheon Lake Watershed Map



Non-Point Source Pollution and Cusheon Lake

Point source pollution originates from municipal or industrial effluent outfalls. Other pollution sources exist over broader areas and may be hard to isolate as distinct effluents. These are referred to as non-point sources of pollution (NPS). Shoreline modification, urban stormwater runoff, onsite septic systems, agriculture, and forestry are common contributors to NPS pollution. One of the most detrimental effects of NPS pollution is phosphorus loading to water bodies. The amount of total phosphorus (TP) in a lake can be greatly influenced by human activities. If local soils and vegetation do not retain this phosphorus, it will enter watercourses where it will become available for algal production.

Agriculture

Agriculture including grains, livestock, and mixed farming, can alter water flow and increase sediment and chemical/ bacterial/parasitic input into water bodies.

Onsite Septic Systems and Grey Water

Onsite septic systems effectively treat human waste water and wash water (grey water) as long as they are properly located, designed, installed, and maintained. When these systems fail, they become significant sources of nutrients and pathogens. Poorly maintained pit privies, used for the disposal of human waste and grey water, can also be significant contributors.

All residents living around Cusheon Lake rely on septic tanks for sewage disposal. Properly located and maintained septic tanks do not pose a threat to the environment, however, mismanaged or poorly located tanks can result in a health hazard and/or excessive nutrients getting into the lake. Excessive nutrients such as phosphorus can cause a variety of problems including increased plant growth and algal blooms. Approximately 23% of the nutrients entering Cusheon Lake comes from septic sources (Sprague 2006).

Stormwater Runoff

Lawn and garden fertilizer, sediment eroded from modified shorelines or infill projects, oil and fuel leaks from vehicles, lawnmowers and weed eaters, road salt, and litter can all be washed by rain and snowmelt from properties and streets into watercourses. Phosphorus and sediment are of greatest concern, providing nutrients and/or a rooting medium for aquatic plants and algae. Pavement prevents water infiltration to soils, collects hydrocarbon contaminants during dry weather and increases direct runoff of these contaminants to lakes during storm events.

Forestry

Timber harvesting can include clear cutting, road building, and land disturbances, which alter water flow and potentially increase sediment and phosphorus inputs to water bodies.

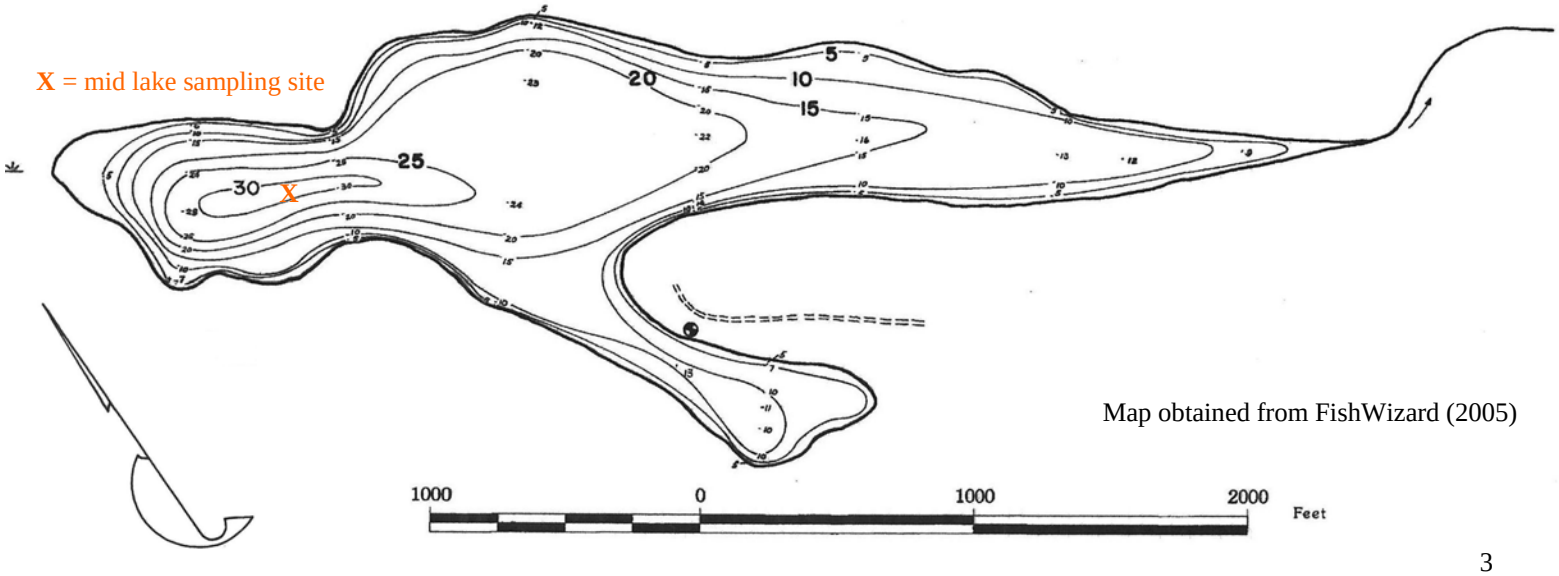
Boating

Oil and fuel leaks are the main concerns of boat operation on small lakes. With larger boats, sewage and grey water discharges are issues. Other problems include the spread of aquatic plants and the dumping of litter. In shallow water operations, the churning up of bottom sediments and nutrients is a serious concern. With concern for the problems stated above, and the fact that Cusheon Lake is a community water supply, there has been a ban on all outboard motors and aircraft on Cusheon Lake. This federally regulated ban only allows electric motors and emergency aircraft on the water

Land Development

Residential development generally includes clear-cutting and other vegetation removal for placement of structures. This can be limited to just the building site requirements or can include removal of riparian vegetation, land clearing for lawns or agricultural activities, shoreline protection structures and docks. All of these land disturbance activities can alter water flow, and potentially increase sediment and phosphorus inputs to water bodies. It has been estimated that these activities alone account for more than 50% of the phosphorus loading to Cusheon Lake (Sprague, 2006).

Cusheon Lake Bathymetric Map



Map obtained from FishWizard (2005)

What's Going on Inside Cusheon Lake?

Temperature

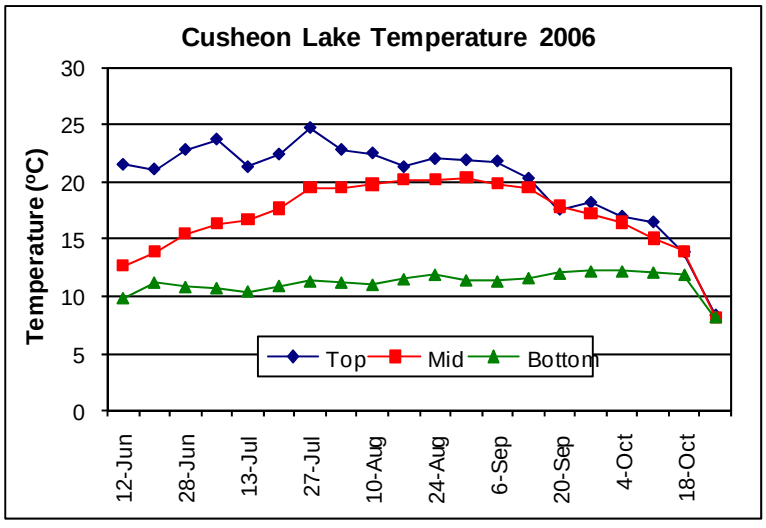
Lakes show a variety of annual temperature patterns based on their location and depth. Most interior lakes form layers (stratify), with the coldest water near the bottom. Because colder water is more dense, it resists mixing into the warmer, upper layer for much of the summer. When the warmer oxygen rich surface water distinctly separates from the cold oxygen poor water in the deeper parts of the lake, it is said to create a thermocline, a region of rapid temperature change between the two layers.

In spring and fall, these lakes usually mix from top to bottom (overturn) as wind energy overcomes the reduced temperature and density differences between surface and bottom waters. In the winter, lakes re-stratify under ice with the densest water (4°C) near the bottom. Because these types of lakes turn over twice per year, they are called dimictic lakes. These are the most common type of lake in British Columbia.

Coastal lakes in BC are more often termed warm monomictic lakes. These lakes turn over once per year. Warm monomictic lakes have temperatures that do not fall below 4°C. These lakes generally do not freeze and circulate freely in the winter at or above 4°C and stratify in the summer. Cusheon Lake is a warm monomictic lake and is usually mixed (no thermal stratification) from November to April.

Temperature stratification patterns are very important to lake water quality. They determine much of the seasonal oxygen, phosphorus, and algal conditions. When abundant, algae can create problems for lake users. Continuously monitored surface temperature can provide us with information not only on algal blooms, but also provide important data to climate change studies.

The following figure illustrates Cusheon Lake's temperature patterns in 2006. The lake was stratified on the first sampling date (June 12th) and was isothermal by the end of October.

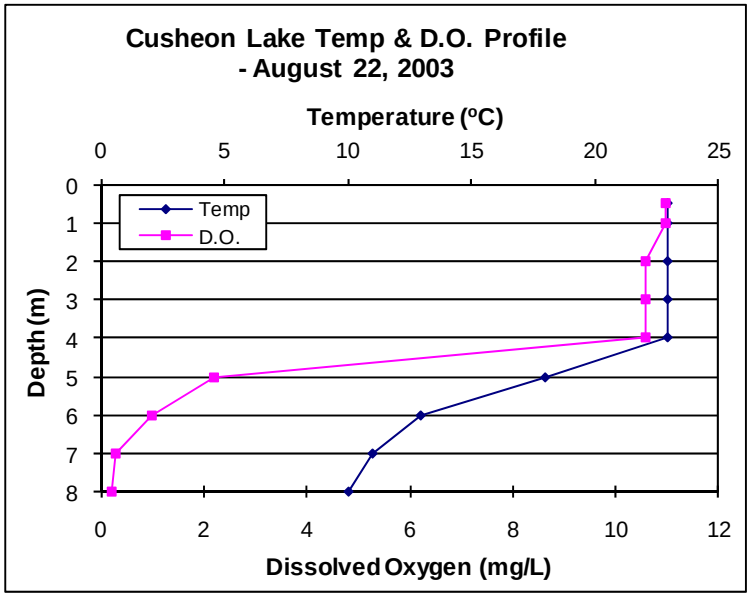


The timing of freeze up and break up of BC lakes is important information for climate change research. BCLSS is interested in this information. If these dates have been recorded in the past, please send the information to BCLSS so that it can be incorporated into climate change studies.

Dissolved Oxygen

Oxygen is essential to life in lakes. It enters lake water from the air by wind action and also through plant photosynthesis. Oxygen is consumed through respiration from plants and, animals including the decomposition of dead organisms by bacteria. A great deal can be learned about the health of a lake by studying oxygen patterns and levels.

Lakes that are less productive (oligotrophic) will have sufficient oxygen to support life at all depths throughout the year. But as lakes become more productive (eutrophic) and increasing quantities of plants and animals respire and decay, more oxygen consumption occurs, especially near the bottom where dead organisms accumulate. In productive lakes, oxygen in the isolated bottom layer may deplete rapidly (often to anoxia), forcing fish to move into the upper layer (fish are stressed when oxygen levels fall below about 20% saturation) where temperatures may be too warm. Fish kills can occur when decomposing or respiring algae use up the oxygen. In the summer, this can happen on calm nights after an algal bloom, but most fish kills occur during late winter or at initial spring mixing.



The graph above shows the dissolved oxygen and temperature pattern for Cusheon Lake on Aug 22, 2003. The lake is stratified as evidenced by the start of the thermocline at 4 m depth. As the graph shows, the oxygen depletes to near zero in the bottom metre. In reviewing the sample data, this is a common occurrence during the stratified period in Cusheon Lake.

Trophic Status

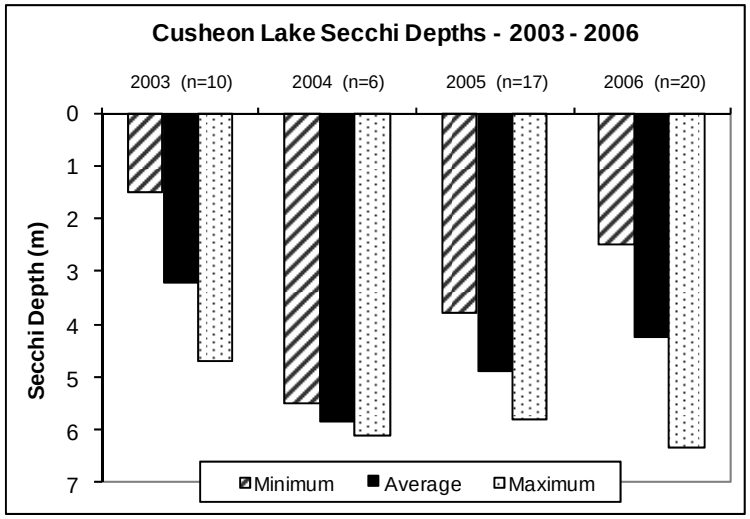
The term *trophic status* is used to describe a lake's level of productivity which is often determined by measuring levels of phosphorus, algal chlorophyll *a* (the green photosynthetic pigment), and water clarity. Establishing the trophic condition of a lake allows inter-lake comparisons and general biological and chemical attributes of a lake to be estimated.

Lakes of low productivity are referred to as ***oligotrophic***, meaning they are typically clear water lakes with low nutrient

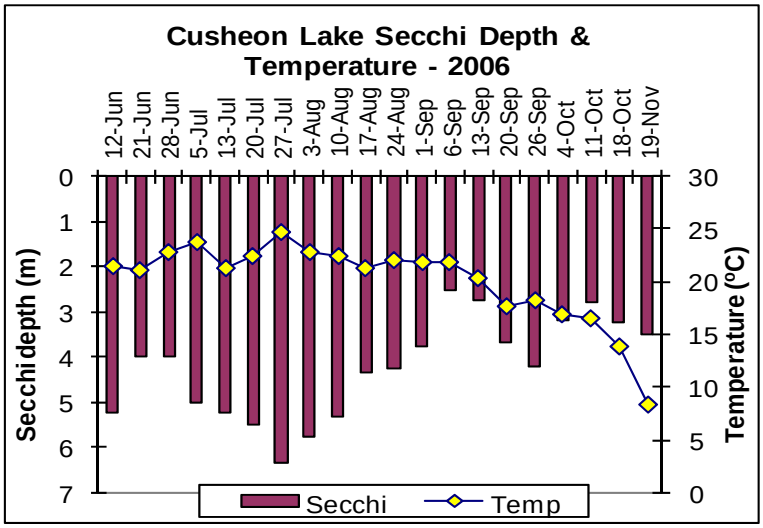
levels (1-10 µg/L TP), sparse plant life (0-2 µg/L chl. *a*) and low fish production. Lakes of high productivity are ***eutrophic***. They have abundant plant life (>7 µg/L chl. *a*) including algae, because of higher nutrient levels (>30 µg/L TP). Lakes with an intermediate productivity are called ***mesotrophic*** (10-30 µg/L TP and 2-7 µg/L chl. a) and generally combine the qualities of oligotrophic and eutrophic lakes.

Water Clarity

As mentioned in the previous section, one method of determining productivity is water clarity. The more productive a lake is, the higher the algal growth and, therefore, the less clear the water becomes. The clarity of the lake water can be evaluated by using a Secchi disk, a black and white disk that measures the depth of light penetration.



The graph above shows the minimum, average and maximum Secchi depths recorded on Cusheon Lake from 2003 to 2006, as well as the number of readings for each year (n). The average Secchi depth measurements are considered mesotrophic for 2003 (3.2 m), 2005 (4.9 m) and 2006 (4.2 m). The 2004 average (5.9 m) falls into the oligotrophic range as it is greater than 5 m. However since there were only 6 samples collected between early July and September, the mesotrophic classification from the other years is likely more accurate.

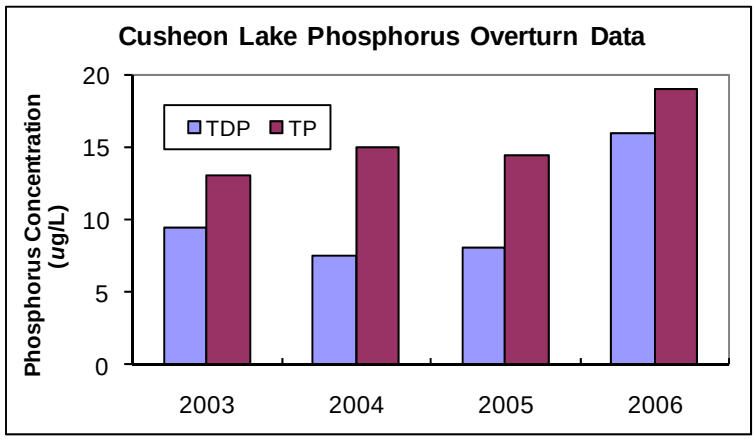


Natural variations and trends in Secchi depth and temperature not only occur between years, but also throughout one season. The Secchi depth and surface temperature for Cusheon Lake in 2006 are shown in the previous graph. In general as temperature increases during the summer months, the Secchi depth decreases. As temperature increases, so do some species of algae. When there is an increase in algae, the water clarity decreases and the Secchi depth decrease. This pattern is not strongly evident in the Cusheon Lake data.

Phosphorus

As mentioned previously, productivity can also be determined by measuring nutrient (i.e. phosphorus) levels. Phosphorus concentrations measured during spring overturn can be used to predict summer algal productivity. In most lakes, phosphorus accelerates algae growth and may artificially age a lake. Total phosphorus (TP) in a lake can be greatly influenced by human activities.

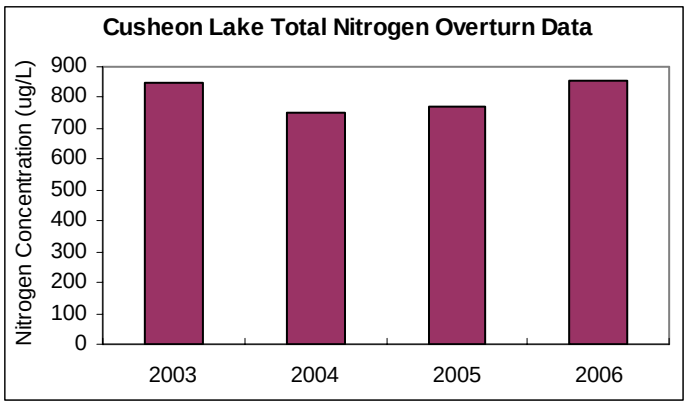
Lake sediments can themselves be a major source of phosphorus. If deep-water oxygen becomes depleted, a chemical shift occurs in bottom sediments. This shift causes sediment to release phosphorus to overlying waters. This *internal loading* of phosphorus can be natural but is often the result of phosphorus pollution. Lakes displaying internal loading have elevated algal levels and generally lack recreational appeal.



Low elevation lakes in coastal British Columbia, such as Cusheon Lake, remain isothermal throughout the winter. Therefore, spring overturn sampling is done in late winter/ early spring prior to a thermocline forming. The chemistry data from Cusheon Lake was collected at the mid lake site in February for all years. As the previous graph shows, TP levels have remained relatively stable over the sampling period. The phosphorus data for Cusheon Lake indicates mesotrophic conditions. In "State of Water Quality of Cusheon Lake, 1974 - 1999" (Holms, 1999) slight increases in spring overturn phosphorus were noted over the study period. Phosphorus data was also sampled during summer stratification in 2004 and 2005, and shows surface amounts to be in the low mesotrophic range, but bottom depth samples indicate internal loading, with TP concentrations reaching 335 µg/L on July 7, 2004. As dissolved oxygen levels in the bottom depths commonly approach anoxia (see previous), internal loading events are occurring. The phosphorus loading study conducted by Sprague (2006) estimated 21% of the nutrients in Cusheon lake were regenerated from the bottom sediments.

Nitrogen

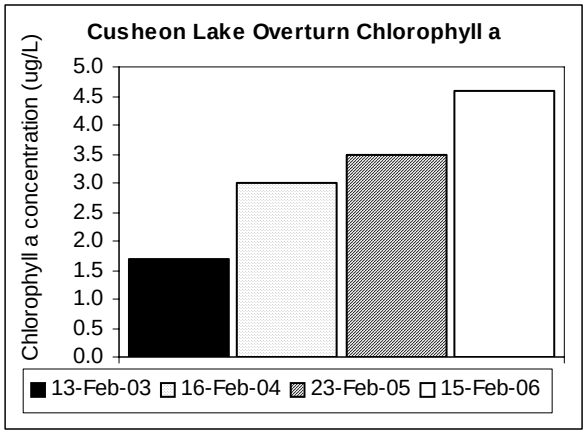
Nitrogen is the second most important nutrient involved in lake productivity. In BC lakes, nitrogen is rarely the limiting nutrient for algae growth (see phosphorus). From the figure to the right, the average spring overturn total nitrogen (TN) concentrations have remained relatively stable since 2003.



In most lakes, the ratio of nitrogen to phosphorus is well over 15:1, meaning excess nitrogen is present. In lakes where the N:P ratio is less than 5:1, nitrogen becomes limiting to algae growth and can have major impacts on the amount and species of algae present. The N:P ratio in Cusheon Lake is approximately 53:1, which means the lake is a phosphorus limited system. Although an increase in nitrogen should not increase algae biomass, it could result in a change to the species of algae present, possibly leading to a less desirable species.

Chlorophyll a

Chlorophyll *a* is the common green pigment found in almost all plants. In lakes, it occurs in plants ranging from algae (phytoplankton) to rooted aquatic forms (macrophytes). Chlorophyll captures the light energy that drives the process of photosynthesis. While several chlorophyll pigments exist, chlorophyll *a* is the most common. The concentration of chlorophyll *a* in lake water is an indicator of the density of algae present in the same water.



Chlorophyll *a* data for Cusheon Lake was collected quarterly from 2003 to 2006, with the exception of spring and fall 2004. Spring overturn values for all sampling years are presented in the adjacent graph. The graph shows an increasing trend over the sampling years however all values fall within the mesotrophic classification, supporting the water clarity and phosphorus data.

Aquatic Plants

Aquatic plants are an essential part of a healthy lake. Factors that affect the type and amount of plants found in a lake include the level of nutrients (i.e. phosphorus), temperature, and introduction of invasive species. Plant species surveyed in Cusheon Lake include: *Potamogeton* (pondweeds), *Nymphaea* and *Nuphar* (water lilies), *Scirpus* (bulrush), *Lemna* (small duckweed), and *Ceratophyllum* (hornwort). *Elodea Canadensis* (Canadian waterweed), a common native aquatic plant, was identified in Cusheon Lake in 1978. This aquatic plant has a history of population explosions and sudden declines.

Elodea and other aquatic plants play an important role in the lifecycles of aquatic insects, providing food and shelter from predators for young fish, in addition to providing food for waterfowl, beavers and muskrats.

Many aquatic plant species can spread between lakes via boaters potentially resulting in species introductions. Be sure to check for and remove all aquatic plant fragments from boats and trailers before entering or when leaving a lake.

Cusheon Lake Watershed Management Planning

As the second largest supply of drinking water to Saltspring Island residents, a watershed management plan steering committee was formed in 2002 to deal with the deteriorating water quality in Cusheon Lake. The committee was comprised of local and provincial government (Islands Trust, Capital Regional District, Vancouver Island Health Authority, and Ministry of Environment), stewardship groups and residents from within the watershed, and local technical experts. The Cusheon Lake Watershed Management Plan was completed in November 2006.

The goal of the plan is to restore and protect the sources of water in the Cusheon Lake watershed, so that Cusheon Lake will provide potable water after reasonable treatment, algal blooms will be reduced and fish and wildlife habitat will be improved. To achieve this goal the group focused on five main objectives which relate to identifying, reducing and monitoring phosphorus levels in the watershed. The largest source of nutrient loading to Cusheon Lake is from land run-off (53.5%) both directly to the lake and via upstream inputs (Sprague, 2006). Septic systems and shoreline effects from residences near the lake contribute about 23% and internal recycling of phosphorus from bottom sediments, caused by enrichment and lack of oxygen in deep waters, contributes about 21% of the total nutrient load (Sprague, 2006). Only about 2% comes from precipitation (Sprague, 2006).

Improving the water quality of Cusheon Lake must include measures that address both land and water management activities. Recommendations include, but are not limited to, riparian protection and replanting, prevention of soil removal and tree cutting,

encouraging best management practices around development, environmental farm planning, up-zoning and subdivision issues, ditch clearing, and education and outreach programs. Many of the recommendations involve changes to current zoning and bylaws in place by local government. Island Trust, the local governing body, is currently undergoing an official community plan review process and hopes to address many of these concerns.

Should Further Monitoring Be Done on Cusheon Lake?

The water quality in Cusheon Lake has remained relatively constant over the four year sampling period. The lake is classified as a mesotrophic lake (moderately enriched) with excursions into eutrophic (highly enriched) as it experiences both algal and cyanobacterial blooms. On a few occasions, these blooms have caused prohibitions on use of the water (i.e. boil water advisories).

The Ministry of Environment, along with the Cusheon Watershed Steering Committee, recommends the continuation of the dissolved oxygen, temperature and Secchi disk sampling program (from April to October) to compare future data against the baseline data presented here. In addition, spring overturn sampling is recommended for monitoring total phosphorus concentrations in the lake. This sampling should reflect changes to land use activities and ultimately the reduction of nutrient inputs to the watershed. The MoE will be using the data collected to produce water quality objectives specific to Cusheon Lake. These objectives will help local government in the protection of the watershed and should be completed by spring 2008.

Tips to Keep Cusheon Lake Healthy

Yard Maintenance, Landscaping & Gardening

- Minimize the disturbance of shoreline areas by maintaining natural vegetation cover.
- Minimize high-maintenance grassed areas.
- Replant lakeside grassed areas with native vegetation.
- Do not import fine fill.
- Use paving stones instead of pavement.
- Stop or limit the use of fertilizers and pesticides.
- Do not use fertilizers in areas where the potential for water contamination is high, such as sandy soils, steep slopes, or compacted soils.
- Do not apply fertilizers or pesticides before or during rain due to the likelihood of runoff.
- Hand pull weeds rather than using herbicides.
- Use natural insecticides such as diatomaceous earth. Prune infested vegetation and use natural predators to keep pests in check. Pesticides can kill beneficial and desirable insects, such as lady bugs, as well as pests.
- Compost yard and kitchen waste and use it to boost your garden's health as an alternative to chemical fertilizers.

Agriculture

- Locate confined animal facilities away from waterbodies. Divert incoming water and treat outgoing effluent from these facilities.
- Limit the use of fertilizers and pesticides.
- Construct adequate manure storage facilities.
- Do not spread manure during wet weather, on frozen ground, in low-lying areas prone to flooding, within 3 m of ditches, 5 m of streams, 30 m of wells, or on land where runoff is likely to occur.
- Install barrier fencing to prevent livestock from grazing on streambanks and lakeshore.
- If livestock cross streams, provide graveled or hardened access points.
- Provide alternate watering systems, such as troughs, dugouts, or nose pumps for livestock.
- Maintain or create a buffer zone of vegetation along a streambank, river or lakeshore and avoid planting crops right up to the edge of a waterbody.

Onsite Sewage Systems

- Inspect your system yearly, and have the septic tank pumped every 2 to 5 years by a septic service company. Regular pumping is cheaper than having to rebuild a drain-field.
- Use phosphate-free soaps and detergents.
- Don't put toxic chemicals (paints, varnishes, thinners, waste oils, photographic solutions, or pesticides) down the drain. They can kill the bacteria at work in your onsite sewage system and can contaminate waterbodies.
- Conserve water: run the washing machine and dishwasher only when full and use only low-flow showerheads and toilets.

Auto Maintenance

- Use a drop cloth if you fix problems yourself.
- Recycle used motor oil, antifreeze, and batteries.
- Use phosphate-free biodegradable products to clean your car. Wash your car over gravel or grassy areas, but not over sewage systems.

Boating

- Do not throw trash overboard or use lakes or other waterbodies as toilets.
- Use biodegradable, phosphate-free cleaners instead of harmful chemicals.
- Conduct major maintenance chores on land.
- Use absorbent bilge pads to soak up minor leaks or spills.
- Check for and remove all aquatic plant fragments from boats and trailers before entering or leaving a lake. Eurasian milfoil is an aggressive invasive aquatic weed. Be sure to familiarize yourself with this plant and remove and discard any fragments.
- Do not use metal drums in dock construction. They rust, sink and become unwanted debris. Use blue or pink closed-cell extruded polystyrene billets or washed plastic barrel floats. All floats should be labeled with the owner's name, phone number and confirmation that barrels have been properly emptied and washed.

Who to Contact for More Information

Ministry of Environment
2080-A Labieux Road
Nanaimo, BC V9T 6J9
Phone: (250) 751-3100
Fax: (250) 751-3103

Cusheon Lake
Cusheon Lake Stewardship Committee
C/O 120 Hillview Place
Salt Spring Island, BC V8K 2W1

The BC Lake Stewardship Society
#4 - 552 West Ave.
Kelowna, BC V1Y 4Z4

Phone: 1-877-BC-LAKES or (250) 717-1212
Fax: (250) 717-1226
Email : bclss@shaw.ca
Website: www.bclss.org

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BC Lake Stewardship Society

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Bart Terweil and Osman Phillips (2005)

Bathymetric Map:
FishWizard
(www.fishwizard.com)

Watershed Map:
Islands Trust

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