BC Lake Stewardship and Monitoring Program

Big Bar Lake 2001, 2003 & 2004

A partnership between the BC Lake Stewardship Society and the Ministry of Water, Land, and Air Protection

The Importance of Big Bar 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 Water, Land, and Air Protection, 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 Big Bar Lake for the years 2001, 2003 and 2004.

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.

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.

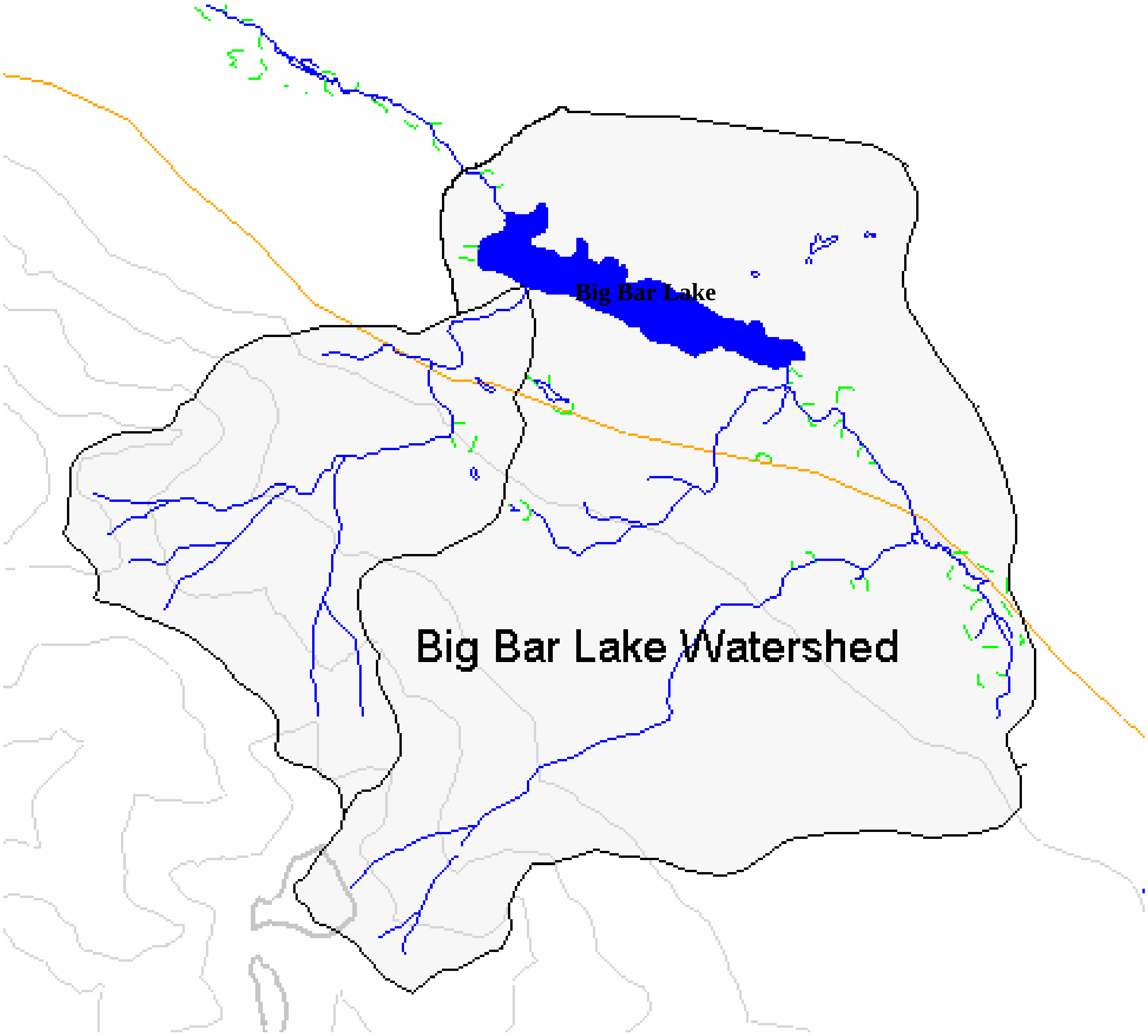
Every component of a watershed (vegetation, soil, wildlife, etc.) has an important function in maintaining good water quality and a healthy aquatic environment. It is a common misconception that detrimental land use practices will not impact water quality if they are kept away from the area immediately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

Big Bar Lake is located approximately 42 km northwest of Clinton off Highway 97 and lies at an elevation of 1106 metres. The lake is roughly 4.6 km long, has a maximum width of 680 m and a maximum depth of 21.3 m. Its surface area is 228.7 hectares and the shoreline perimeter is 11.4 km. Big Bar Lake contains a monoculture of rainbow trout.

Land use in the watershed includes roughly one hundred lakeshore residences, most of which are used on a recreational basis, forest harvesting, and cattle grazing. The lake is used for general recreational purposes and there is a provincial park located on the south side of the lake comprising approximately 330 hectares. A control structure is located on the outlet to store water for irrigation use downstream.

Big Bar Lake Watershed Map



WATERSHED CHARACTERISTICS

Percent Land Usage:

2% Residential (Developed)
50% Agricultural
10% Forestry
38% Undisturbed

Non-Point Source Pollution and Big Bar 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.

The greatest challenge to Big Bar Lake is phosphorus (nutrient) loading. This loading may promote summer algal blooms and the spread of aquatic plants.

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.

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.

Stormwater Runoff

Lawn and garden fertilizer, sediment eroded from modified shorelines or infill projects, oil and fuel leaks from vehicles, snowmobiles and boats, 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.

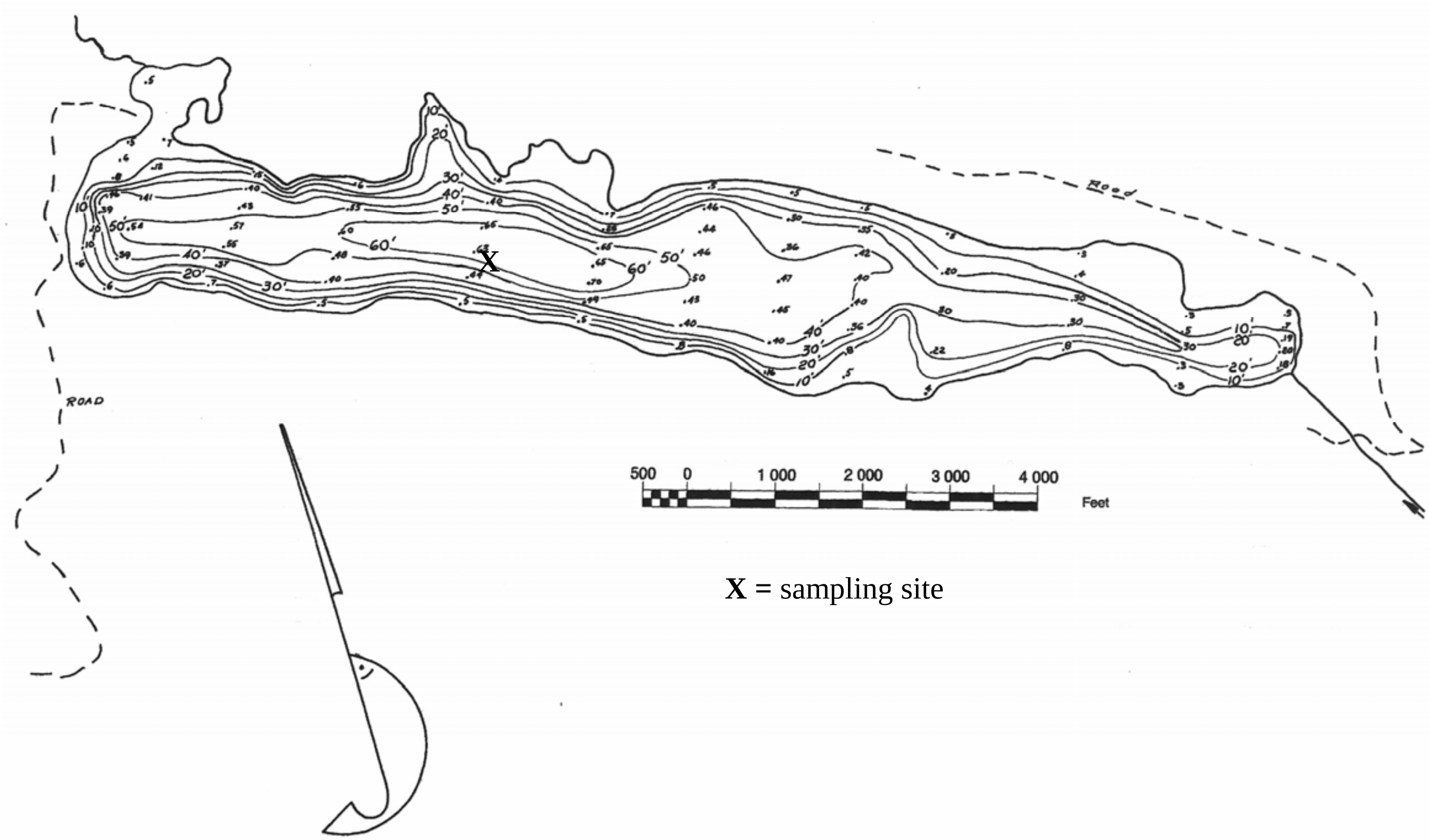
Forestry

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.

Big Bar Lake Bathymetric Map



X = sampling site

Map obtained from www.fishwizard.com (2005)

What's Going on Inside Big Bar Lake?

Temperature

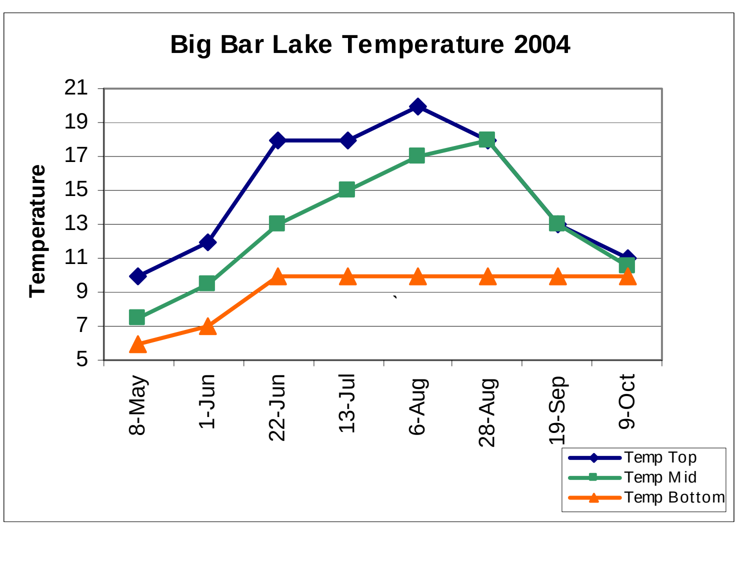
Lakes show a variety of annual temperature patterns based on their location and depth. Most interior lakes form layers (stratify), with the coldest water near the bottom. Because colder water is more dense, it resists mixing into the warmer, upper layer for much of the summer. When the warmer oxygen 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.

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 Big Bar Lake's temperature patterns for 2004. The lake was stratified by early May. The surface and mid-depth temperatures rose consistently until August 28 when they became isothermal (uniform temperature) while the bottom temperature rose until June 22 and then stabilized at 10^{o}C. By October 9 the lake was nearly isothermal, indicating fall overturn.



The maximum surface temperature reached in 2004 was 20^{o}C on August 6. The maximum surface temperature in 2001 and 2003 was also 20^{o}C on August 17 and 8, respectively.

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.

Trophic Status

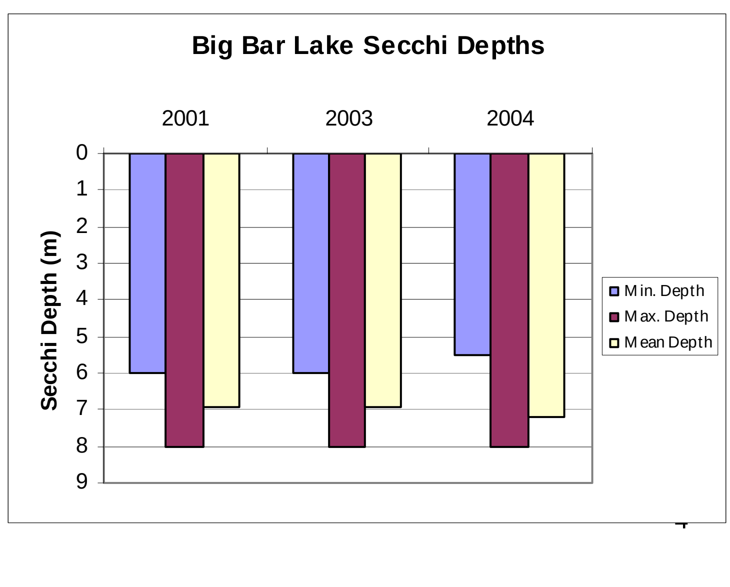
The term *trophic status* is used to describe a lake's level of productivity which is often determined by measuring levels of phosphorus, algal chlorophyll A (the green photosynthetic pigment), and water clarity. Establishing the trophic condition of a lake allows inter-lake comparisons and general biological 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 *u*g/L TP), sparse plant life (0-2 *u*g/L Chl. A) and low fish production. Lakes of high productivity are ***eutrophic***. They have abundant plant life (>7 *u*g/L Chl. A) including algae, because of higher nutrient levels (>30 *u*g/L TP). Lakes with an intermediate productivity are called ***mesotrophic*** (10-30 *u*g/L TP and 2-7 *u*g/L Chl. A) and generally combine the qualities of oligotrophic and eutrophic lakes.

Water Clarity

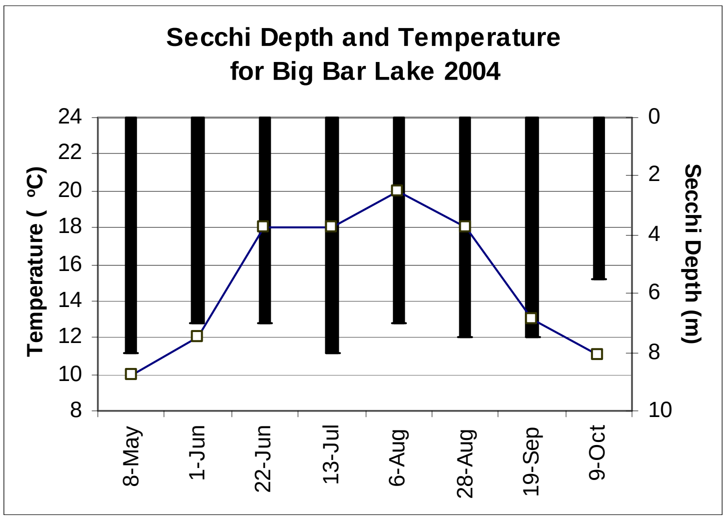
As mentioned in the previous section, one method of determining productivity is water clarity. The more productive a lake is, the higher the algal growth and, therefore, the less clear the water becomes. The clarity of the lake water can be evaluated by using a Secchi disk, a black and white disk that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

The average Secchi depth for Big Bar Lake ranged from 6.9m to 7.19m from 2001 to 2004, indicating that there was



little change during these years of data collection. The average Secchi depth measurements were above the minimum of 5 meters for oligotrophic lakes. Water clarity was good throughout the 2004 sampling period but did decrease to a low of 5.5 meters in the fall. There were no Secchi depth readings collected in 2002.

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 Big Bar Lake in 2004 are shown below.



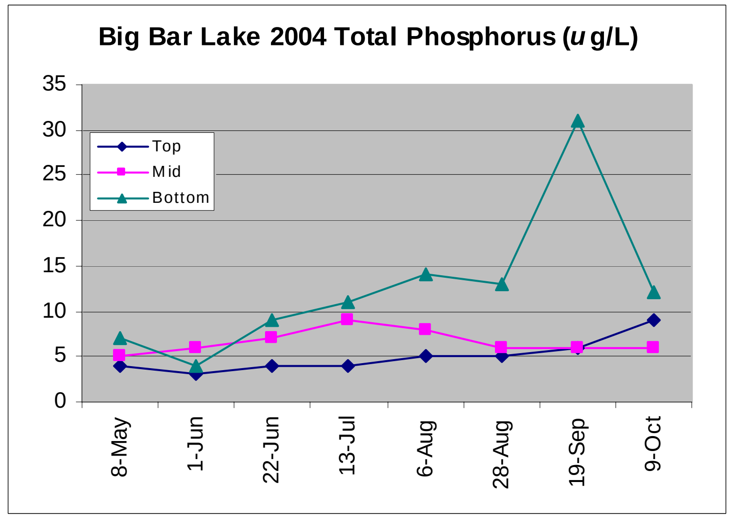
Phosphorus

As mentioned previously, productivity can also be determined by measuring nutrient (i.e. phosphorus) levels and chlorophyll. 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. In some lakes, marl precipitation events in the early summer help move phosphorus into the lake sediments maintaining relatively high water clarity. Marl lakes are discussed on the following page.

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.

The following diagram displays 2004 phosphorus cycling in Big Bar Lake. Low TP levels were observed in all three sample depths throughout most of the summer. The noticeable increase of TP in the lake bottom in September (31 *u*g/L) is likely due to a release of nutrients from the bottom sediments where anoxic conditions were present. The water sample had an odour of sulphur, indicating the presence of hydrogen sulphide caused by low dissolved oxygen levels. The concentration of TP at all levels approach uniformity on October 9th, indicating that fall overturn had begun.

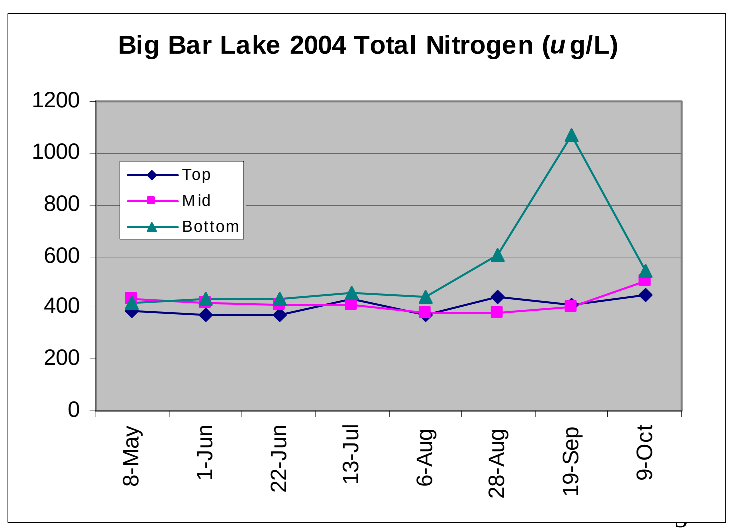
The 2004 Big Bar average TP surface concentration was 5 *u*g/L, compared to 6.2 *u*g/L in 2001. Total phosphorus data for 2003 was incomplete. The 2001 and 2004 TP values indicate oligotrophic conditions for Big Bar Lake.



Nitrogen

Nitrogen is the second most important nutrient involved in lake productivity. In BC lakes, nitrogen is rarely the limiting nutrient for algae growth. In most lakes, the ratio of nitrogen to phosphorus is well over 15:1, meaning excess nitrogen is present. In lakes where the 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.

As shown in the following graph, total nitrogen concentrations were relatively constant and similar at all depths over most of the sampling period. Near bottom nitrogen was slightly greater than in the surface or mid-depth water for most of the season, an expected trend considering the isola-



tion of the deeper water as a result of thermal stratification and the release of nitrogen from the bottom sediments. Near-bottom nitrogen levels vary from 370 *u*g/L to a noticeable peak of 1070 *u*g/L in September. This peak coincides with that of the total phosphorus.

The 2004 N:P ratio at spring overturn is approximately 78:1 which means that the lake is a phosphorus-limited system for the growth of algae. Therefore, an increase in nitrogen should not increase algal biomass, although the species could change, possibly to a less desirable species. Nevertheless, this high concentration of nitrogen would mean any increase in phosphorus concentrations would result in increased algae biomass and the many problems associated with it. The phosphorus, therefore, should be closely monitored.

Marl Lakes

The climate, hydrology, and basin geology within a watershed help to determine the chemistry of a lake. The chemical composition of the water helps to determine the types of species that can survive there and the water's recreational and drinking water value. Human activity within the watershed can also have an impact on the chemical composition of a lake. Some lakes, such as hardwater lakes, have a natural way of combating problems such as acidification.

Hardwater lakes have a high pH level, which causes calcium carbonate to precipitate and remove phosphorus from the water column by adsorption of phosphorus to the calcium carbonate. One type of hardwater lake is a marl lake. Marl lakes are generally saturated with calcium and carbonate ions. The sediment of these lakes consist of marl, a soft-textured mixture of clay, sand, and limestone. When the calcium carbonate in these lakes begins to precipitate, phosphorus is effectively removed as a co-precipitate. Therefore, these lakes can reduce the impact of phosphorus loading from sources such as septic systems, livestock, domestic gardening, car washing, and agriculture. In other words, marl lakes are more resistant to eutrophication.

But how do we decide if a lake is a marl lake or not? There are a few qualities that we can use to determine this. The first is a visible shift from dark blue/green to extreme turquoise colour during periods of warmer temperatures. Tiny particles remain suspended in the water, refracting light and causing the lake to turn a light aquamarine (lake whitening). Another quality of a marl lake is high calcium concentrations in the sediment, especially in the shallower areas. These sediments are often lighter in colour due to the increased amount of limestone (calcium carbonate).

Since phosphate precipitates with calcium, marl lakes generally have low phosphorus levels and good water clarity. Calcium carbonate precipitate can be observed on vegetation and along the lake's edge. The presence of *Chara* species also indicates the possibility of a marl lake. Charophytes are a type of large, structurally complex green algae that attach to substrates. The rhizoids that enable this attachment play an important role in the absorption of nutrients and extraction of calcium carbonate.

Many hardwater lakes in the interior dry belt of British Columbia can be classified as marl lakes, including Big Bar Lake.

Should Further Monitoring Be Done on Big Bar Lake?

The data collected on Big Bar Lake indicates that the water has remained relatively stable in terms of Secchi depth and nitrogen and phosphorus concentrations over the last few years. The available data suggests that the lake water quality has shown improvement over the 2001 results. As a marl lake, Big Bar Lake has the ability to limit the amount of available phosphorus. This helps protect it against algal blooms and other problems associated with high levels of phosphorus. However, all residents and land developers within the watershed are advised to continue to practice good land management so that nutrient migration to the lake and its tributaries is minimized.

It may be worthwhile to continue monitoring Secchi depth, temperature, and phosphorus in order to have three consecutive years of data. It is also recommended that spring overturn data be collected. This would add to the current data set and help establish a good baseline that can be used in future years to compare to and determine potential changes in water quality. In addition to continued monitoring, freeze-up and break-up of ice should be recorded for climate change studies. Another lake specific document, summarizing the three years of data, will be produced after the 2005 sampling season.

Tips to Keep Big Bar 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 because 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 Styrofoam 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

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FishWizard