

Osoyoos Lake Sediment Coring Project

Pre-Settlement Water Quality Conditions of Osoyoos Lake



Osoyoos Lake Sediment Coring Project

Statement of Problem

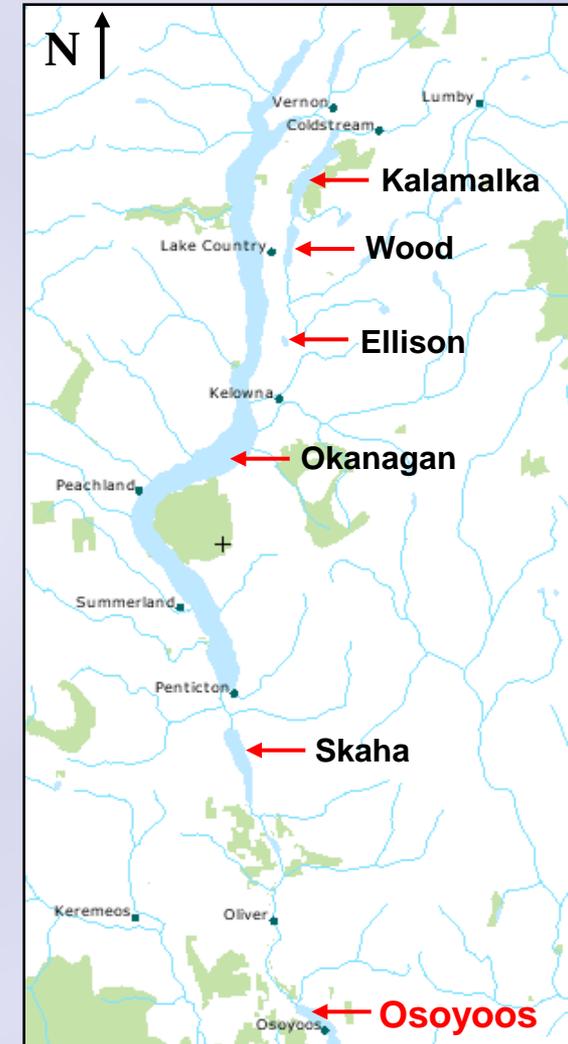
- Without an understanding of pre-settlement water quality conditions, reasonable management expectations for Osoyoos Lake water quality are difficult to establish.
- Existing water quality data for Osoyoos Lake does not extend to the pre-settlement period. Accordingly, it is not known to what extent settlement, sewage disposal and other changes in the Okanagan basin and Osoyoos Lake specifically have changed Osoyoos Lake water quality.

Project Goals

- To establish an estimate of **water quality conditions in Osoyoos Lake early in the settlement period** using paleolimnological techniques.
- To establish an estimate of **water column phosphorus for the past ~200 years**. From this estimate, the present spring phosphorus water quality objective of 15 ppb for Osoyoos Lake can be re-evaluated. This information will be instrumental in guiding waste management and phosphorus management efforts within the Osoyoos Lake basin and areas upstream.

Okanagan River Basin

- The Okanagan River Basin drains through a chain of lakes in the Southern Interior of BC before crossing the US/Canada border and flowing into the Columbia River (Ellison, Wood, Kalamalka, Okanagan, Skaha, and Osoyoos lakes).
- These lakes provide important habitat for aquatic life, community drinking water, irrigation water to orchards and vineyards, and provide a variety of tourism and recreational opportunities.
- Osoyoos Lake is the southernmost lake in the Okanagan River Basin.



Okanagan Basin Lake	Surface Area (HA)	Volume (DAM ³)	Mean Depth (m)	Maximum Depth (m)	Watershed Area (km ²)	Theoretical Flushing Time (yrs)
Ellison Lake	210	5400	2.5	5	138	1.2
Wood Lake	930	199,500	22	34	151	22
Kalamalka Lake	2,590	1,520,000	59	142	572	51
Okanagan Lake	35,100	24,644,000	76	230	6,061	52.8
Skaha Lake	2,000	588,000	26	55	6,890	1.2
Osoyoos Lake	2,300	397,000	14	63	8,280	0.7

Osoyoos Lake

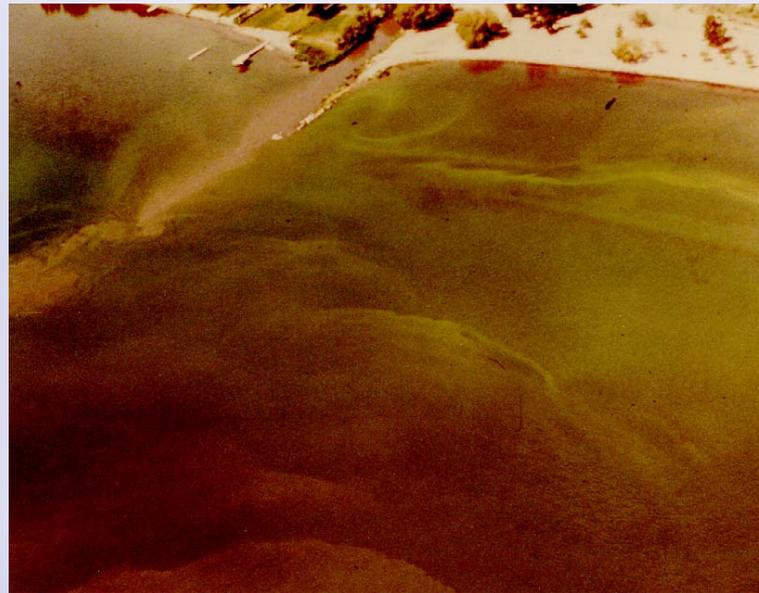
- Consists of three distinct basins separated by shallow sand bars.
- US/Canada border bisects the south basin.
- The Okanagan River flows south for 35 km from Skaha Lake via Vaseux Lake, eventually draining into the north basin of Osoyoos Lake.
- Located at the Town of Osoyoos and surrounded by a unique desert ecosystem.
- Primary uses include recreation, irrigation and domestic water supply.
- Treated effluent from the Town of Osoyoos is spray irrigated above the town and does not directly enter the lake.
- Since Osoyoos Lake is the last lake in the Okanagan basin drainage system, it receives nutrient inputs from numerous upstream non-point sources.



Modified from Google Earth image

Historic Water Quality

- Large algal blooms were not uncommon in Osoyoos Lake and other Okanagan basin lakes during the 1950's and 1960's. These were of great concern to the public and local governments.
- Secondary sewage was being discharged into these water bodies, leading to increased nutrient enrichment.
- Phosphorus plays a major role in biological metabolism and is the least abundant primary nutrient. As a result, it is commonly the first element to limit biological productivity in freshwaters.
- In 1970, a federal-provincial study called the Okanagan Basin Study recommended phosphorus reductions set to a target of 90%, and phosphorus control was initiated shortly thereafter.

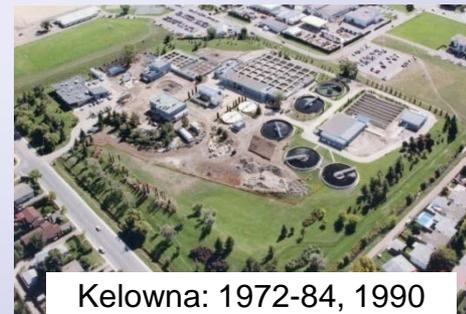


Historic Water Quality

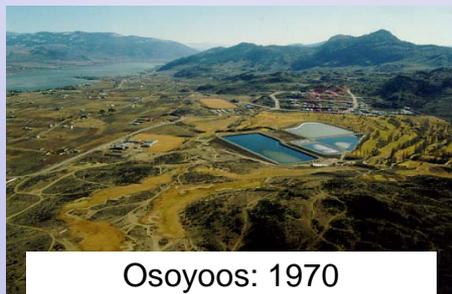
- Tertiary sewage treatment was implemented in various stages using chemical and eventually biological nutrient removal or Bardenpho technology in 4 of 7 Okanagan basin communities (Kelowna, Westbank, Summerland and Penticton).
- 3 of 7 communities chose to implement effluent storage and spray irrigation systems (Vernon, Oliver and Osoyoos). However, total phosphorus concentrations in groundwater in these spray irrigation areas are not comparable to tertiary effluent, but the net loading is thought to be reduced by ~ 95%.
- When phosphorus concentrations in Okanagan basin lakes did not decline in the 1980's, the entire basin was declared an Environmentally Sensitive Area and there was further investment under the Okanagan Water Control Project which set a reduction target of 95% and set water quality objectives targets for the main lakes.



Penticton: 1972-81, 1994



Kelowna: 1972-84, 1990



Osoyoos: 1970



Vernon: 1977



Oliver: 1984

Historic Water Quality

- Although many point sources of pollution have decreased over the past 30 to 40 years, efforts are still needed to reduce non-point sources from storm water, septic systems, agriculture and logging activities to protect water quality in these lakes.
- Non-point source phosphorus control efforts that have been implemented include:
 - *Agriculture Code*
 - aerial surveillance for problem areas
 - Manure storage
 - Relocation of feedlots and run-off
 - *Forest Range Practices Act*
 - stream protection set backs
 - *Liquid Waste Management Planning*
 - reduce septic tank problem areas
 - storm-water planning
- While knowledge of absolute loads from these sectors is limited, efforts to reduce nutrient loading through application of best management practices has been moderately successful particularly in terms of animal waste loading and reduced impact from septic tanks.

Water Quality Monitoring

- Okanagan basin lake water quality data is gathered by Ministry of Environment staff, sampling the lakes twice a year. The first sampling occurs in the early spring before nutrient uptake by plankton and before heating and stratification of the water column occurs. The second occurs in the fall when much of the nutrients in the surface waters have been used by plankton and decomposition of sinking organic matter begins to reduce dissolved oxygen in the bottom waters of the lakes.
- Many of these monitoring sites, including Osoyoos Lake, have been sampled for over 30 years.



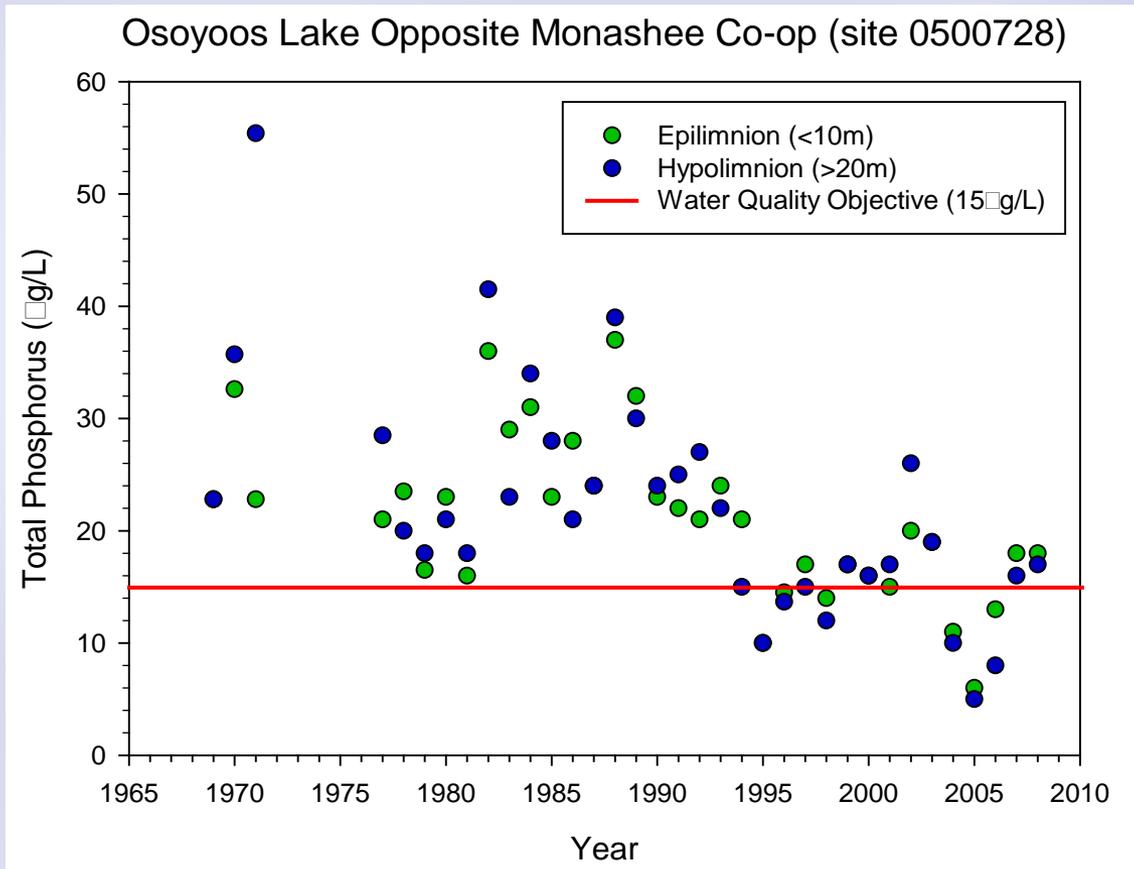
Water samples are collected using a Van Dorn water sampler at a variety of depths.

- The objectives of this monitoring program are to:
 - determine whether water quality at sampling sites exceed established water quality objectives.
 - provide analytical water quality information that describes present conditions and changes (trends) in key parameters such as nutrients, water clarity and dissolved oxygen.
 - provide timely and high-quality data for other users.
 - assess the status of water quality in lakes of the Okanagan in response to watershed and climate change, pollution control and fisheries management actions.

Water Quality Monitoring

Osoyoos Lake: Spring Total Phosphorus

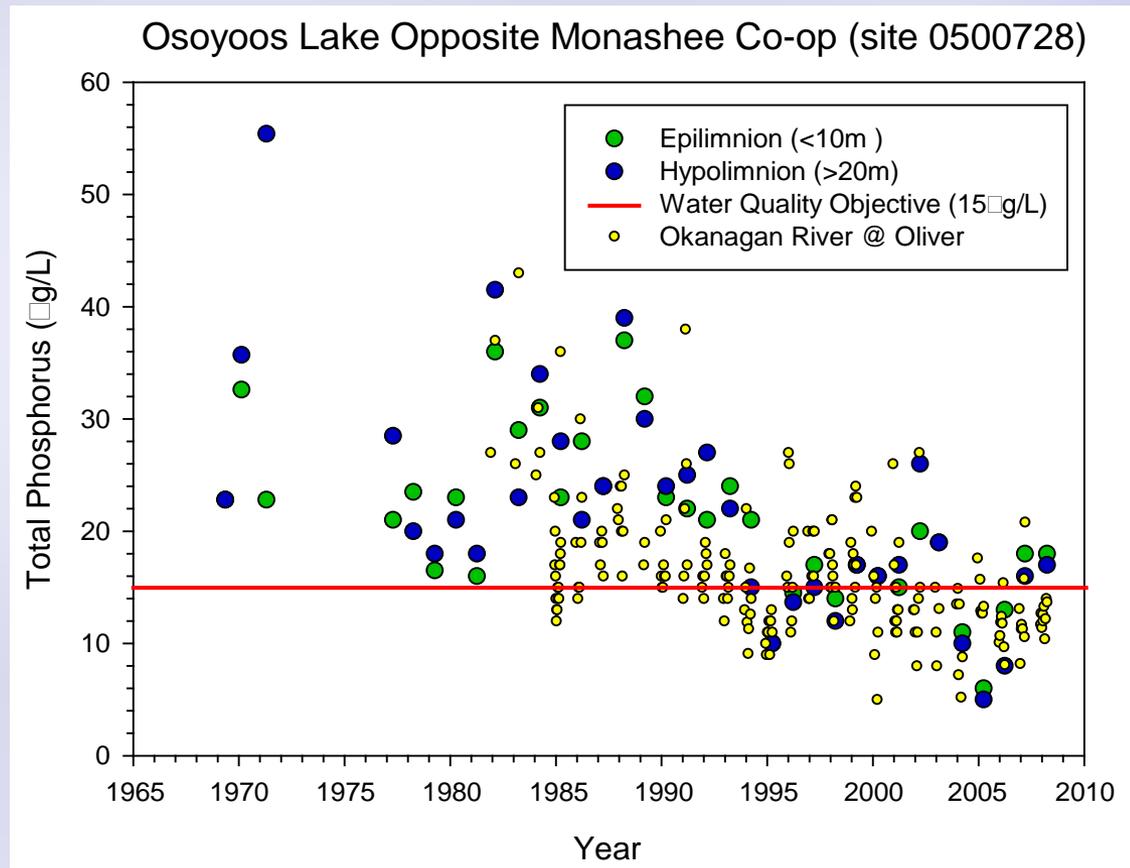
- Although spring total phosphorus in the north basin of Osoyoos Lake has been quite variable over the past 40 years, concentrations have generally been declining since the late-1980's.
- This decreasing trend is primarily due to the reduction of sewage inputs from the Penticton wastewater treatment plant in the 1980's to the early-1990's and the diversion of the Oliver sewage treatment plant discharge to land disposal in 1983.
- Despite the reductions in point-source phosphorus loading, concentrations still remain high and frequently exceed the guideline level of 15 ug/L.



Water Quality Monitoring

Osoyoos Lake and the Okanagan River: Spring Total Phosphorus

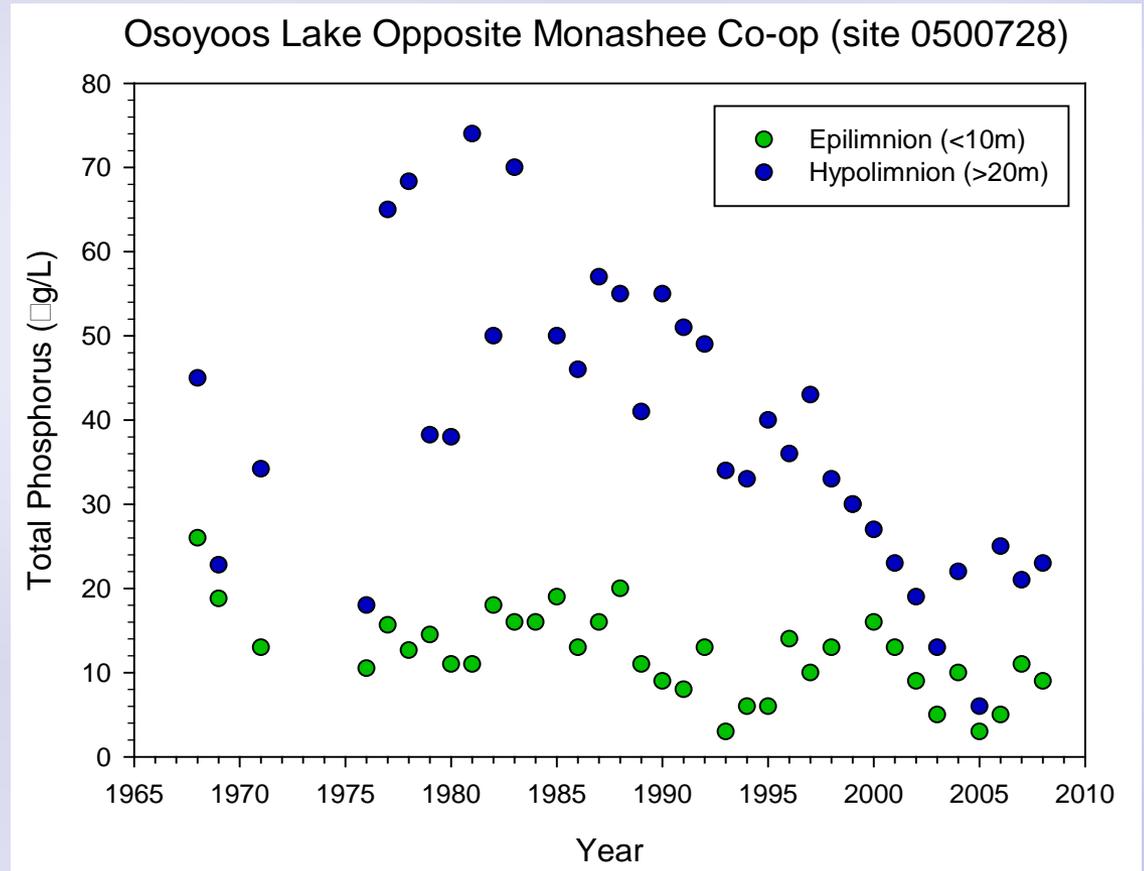
- A federal-provincial water quality monitoring station is located on the Okanagan River (south of Oliver at the No. 18 road bridge) and is sampled bi-weekly for a variety of parameters including total phosphorus.
- The Okanagan River is the primary inflow to Osoyoos Lake and appears to be the major source of phosphorus loading to the lake.
- Despite variable conditions in the Okanagan River, concentrations of spring total phosphorus in Osoyoos lake follow those in the river (Dec. - Mar.) reasonably well.
- Although the total phosphorus concentrations in the river have declined due to reduced point source inputs, multiple diffuse nutrient sources (e.g. septic fields and agricultural activities) continue to negatively impact Osoyoos Lake water quality.



Water Quality Monitoring

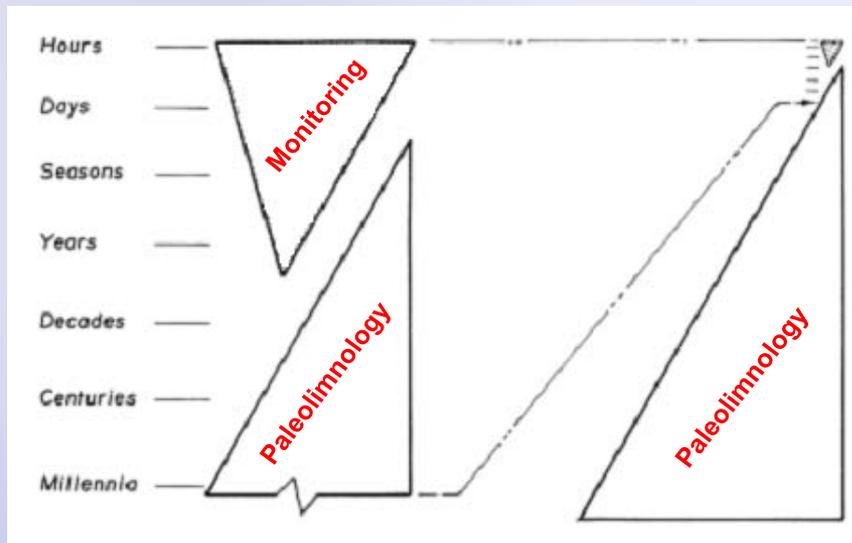
Osoyoos Lake: Fall Total Phosphorus

- Concentrations of fall total phosphorous in the hypolimnion has been steadily declining since the early-1980's to levels approaching that of the epilimnion.
- As with spring phosphorus, this can be attributed to decreased inputs from Penticton and Oliver nutrient point sources.



Paleolimnology: Time Scales

- Ministry of Environment monitoring data can provide useful information on Osoyoos Lake water quality for the past 40 years, but there are very few direct measurements taken before the late 1960's. In the absence of direct water quality records, we must rely on paleolimnological proxy-data to quantify past conditions and the variability within an ecosystem.
- Paleolimnology is the multidisciplinary science that uses physical, chemical and biological information preserved in the sediments of aquatic systems to reconstruct past environmental conditions.
- Most environmental monitoring studies are usually short term, often only seasonal, a few years, or less. However, paleolimnological studies can extend these approaches further back in time.

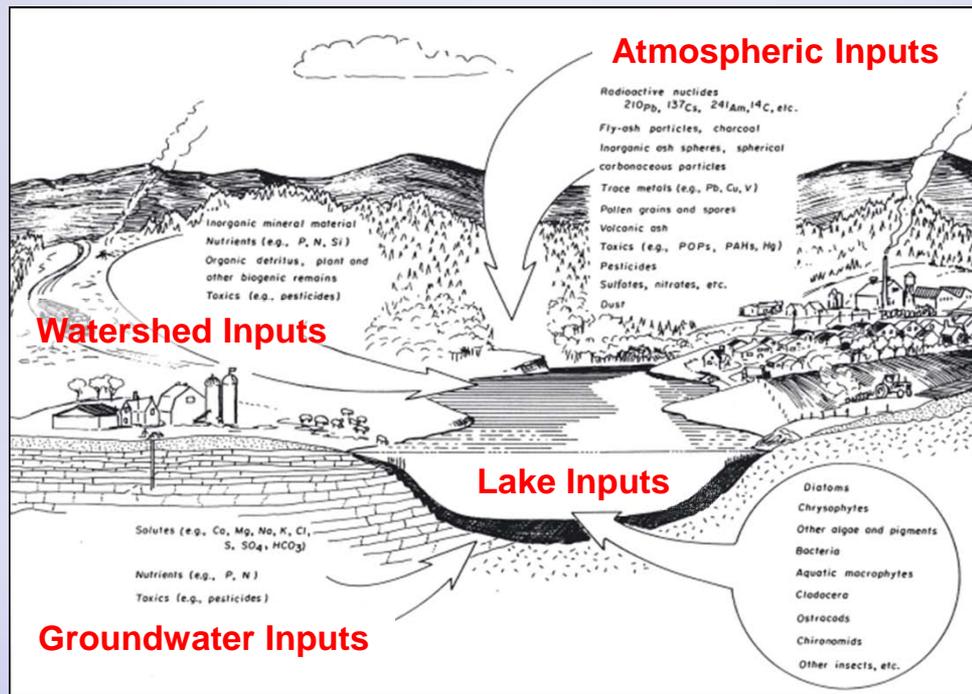


Modified from Smol, 2008

- The time scales shown on the left side of the following figure are on a logarithmic scale, but the right side shows a more realistic representation of the relative amount of information potentially available from sedimentary deposits in lakes.

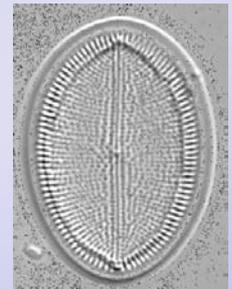
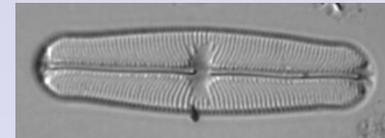
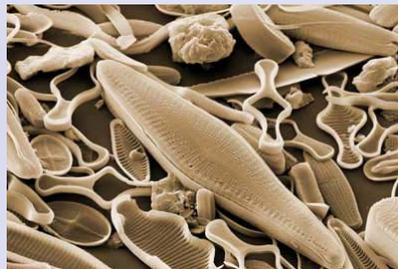
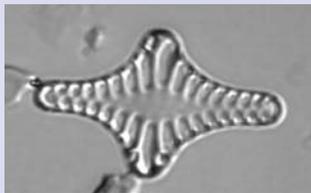
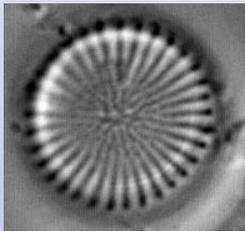
Paleolimnology: Lake Sediments

- Lakes function as natural sediment traps, and are composed of material from a large variety of sources. These include sources from outside of the lake (from the catchment or airshed) and from inside the lake itself.
- Sediments cores are collected from the bottoms of lakes and allow for the reconstruction of past lake communities, lake biogeochemistry and lake development.
- Paleolimnological perspectives can assess whether environmental change is occurring, as well as the direction, magnitude, and rate of change. It can also help to identify and understand the mechanisms and driving forces of change and variability (natural and/or human-induced).



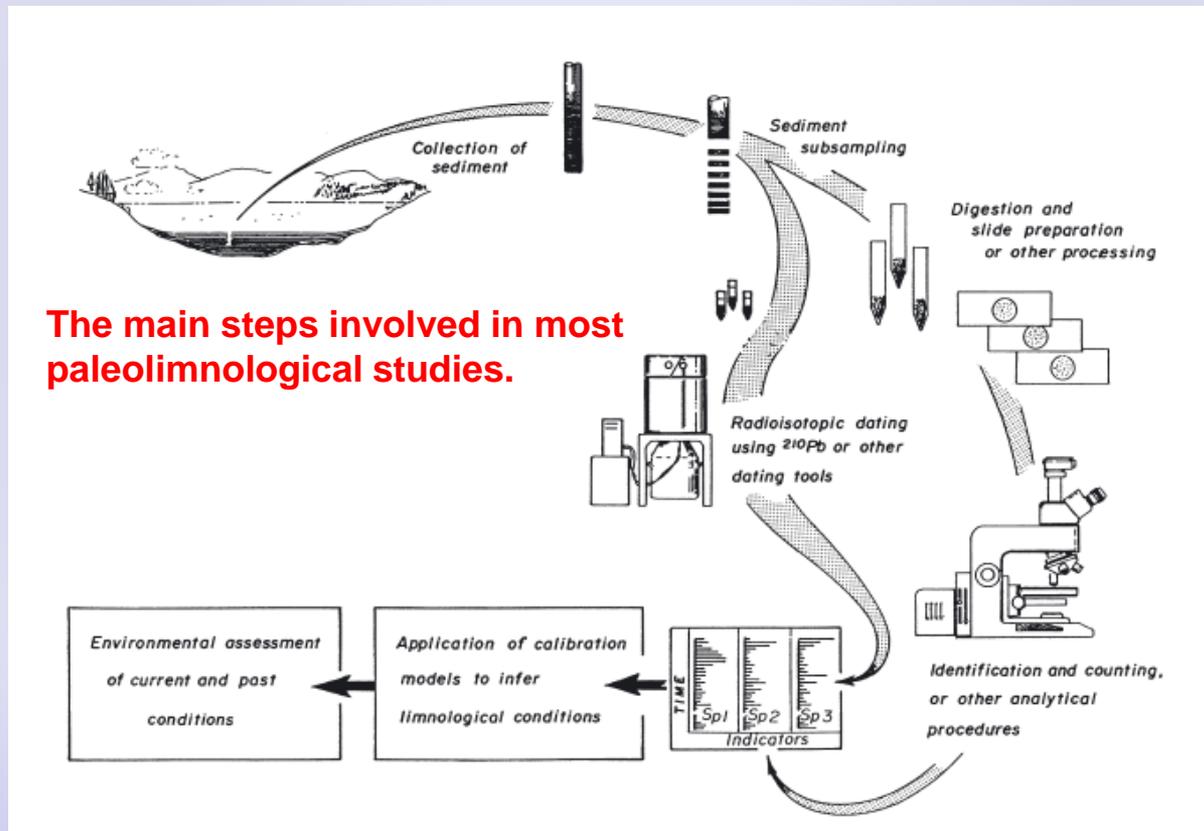
Paleolimnology: Diatoms

- There are numerous paleolimnological analyses used today, including geochemistry, pollen grains, algal microfossils, fossil pigments, plant macrofossils and animal remains. Of these, diatoms are one of the most sensitive environmental indicators and provide an excellent tool for monitoring changes in aquatic systems.
- Diatoms are a diverse group of unicellular microscopic algae that are prevalent in most aquatic environments.
- They are very useful in paleolimnological studies because diatoms have a cell wall made of silica, which preserves well in most aquatic sediments and is used in taxonomic identification.
- A core sample of lake sediment, allows for the recognition of changes in the distribution and abundance of individual species with sediment depth, or age of the sample.
- Most individual diatom species have specific ecological requirements and, therefore, information on past ecological conditions can be interpreted from a careful analysis of diatom assemblages (e.g. changes in total phosphorus concentration over time)



Paleolimnology: Methods

- Once a location has been selected for sediment core collection, a variety of steps are needed to conduct an environmental assessment of past lake conditions.

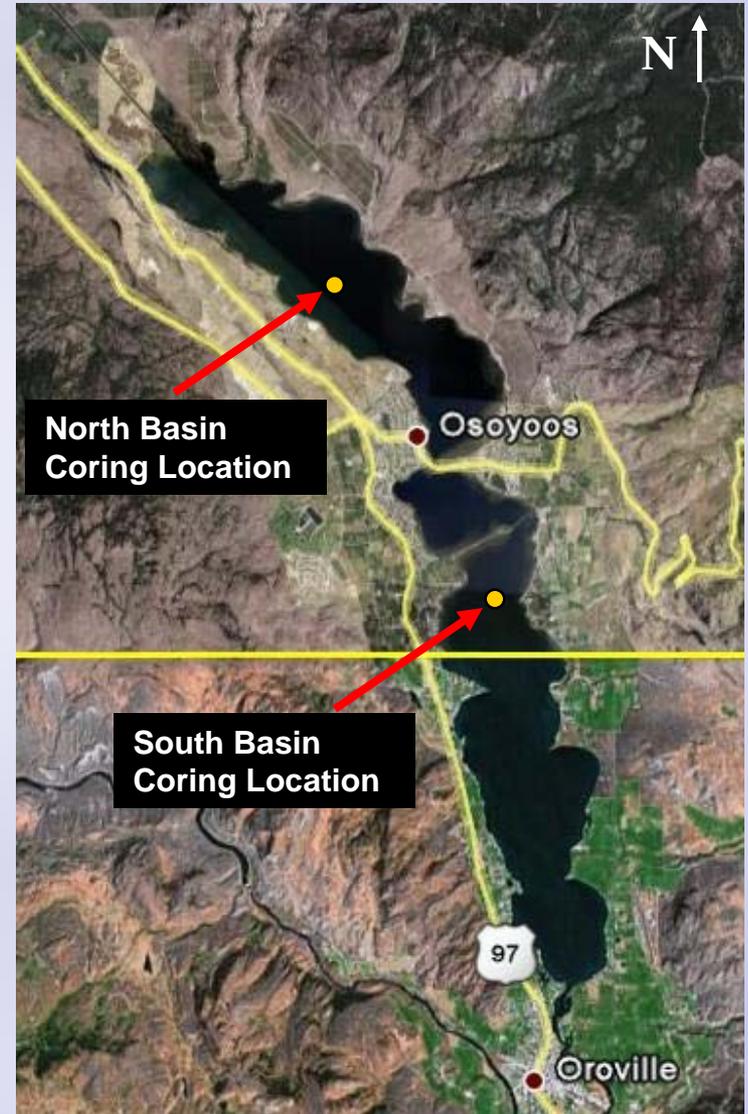


Paleolimnology and Osoyoos Lake

- **What were baseline (pre-impact) conditions, prior to human disturbances?**
 - Without knowing what a lake was like before a disturbance occurred, how can we attempt to gauge the extent of a problem?
 - We need to know what our restoration targets should be to set realistic mitigation goals.
- **What is the range of natural variability?**
 - We need to determine whether any trends that are evident in monitoring programs have any significance. The data archived in lake sediments can often provide that missing information.
- **At what points in time and at what level of disturbance did negative impacts become apparent?**
 - Ecosystems are under constant stress from a variety of sources, both natural and those caused by humans. For example, we need to know the level of stress that a system can be subjected to before algal blooms develop.

Fieldwork

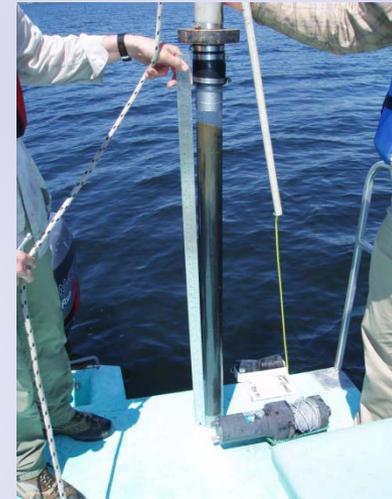
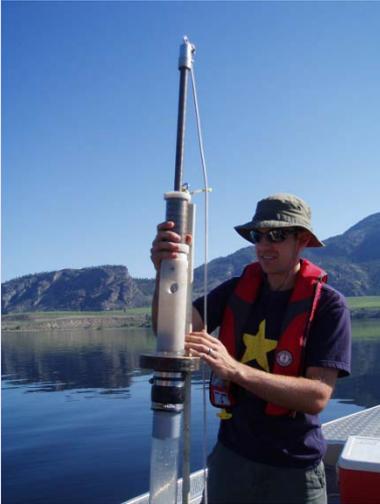
- Sediment coring sites were selected in the deepest parts of the north (63 m) and south (25 m) basins of Osoyoos Lake.
- 90 cm and 99 cm sediment cores were collected from a pontoon boat on June 17th and 18th, 2008 from the north and south basins, respectively.
- The sediment cores were subsequently sectioned into 0.5 cm intervals and shipped for laboratory analyses.



Modified from Google Earth image

Fieldwork

- Sediment core collection and sectioning.



Laboratory Methods

Radioisotopic Dating:

- 21 sediment intervals from the north basin and 22 samples from the south basin core were prepared for ^{210}Pb and ^{137}Cs analysis and counted using gamma spectroscopy to determine the age of the cores.

Diatoms:

- 32 intervals were subsampled for diatoms from each Osoyoos Lake sediment core, every 2 cm from 1 to 29 cm, then every 4 cm down to the bottom of the cores.
- For each sample, diatoms were identified and enumerated

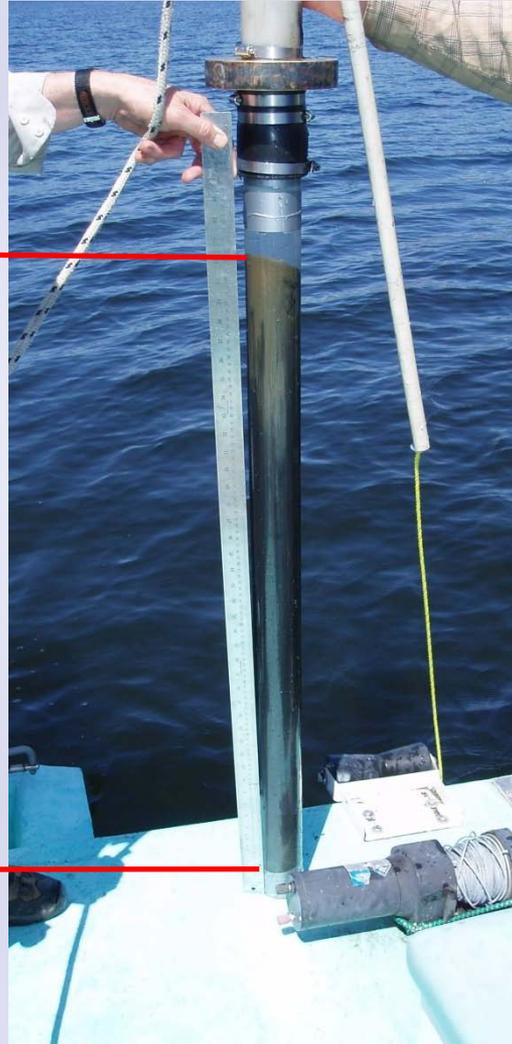
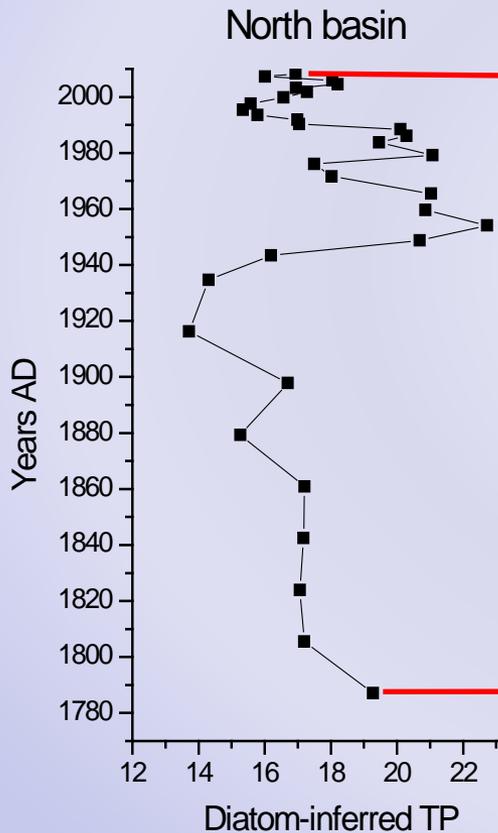
Diatom-based Reconstructions of Total Phosphorus:

- Inferences of total phosphorus from the diatom assemblages in the cores are based on a phosphorus model developed from 268 freshwater lakes from several regions of British Columbia.
- This model is based on estimates of the total phosphorus optima of diatom taxa .

Pigments:

- 32 intervals were subsampled for fossil pigments from the sediment core in the North basin, every 2 cm from 1 to 29 cm, then every 4 cm down to the bottom of the core.
- Fossil algal pigments were extracted from the sediments and analyzed using High Performance Liquid Chromatography (HPLC).

Results

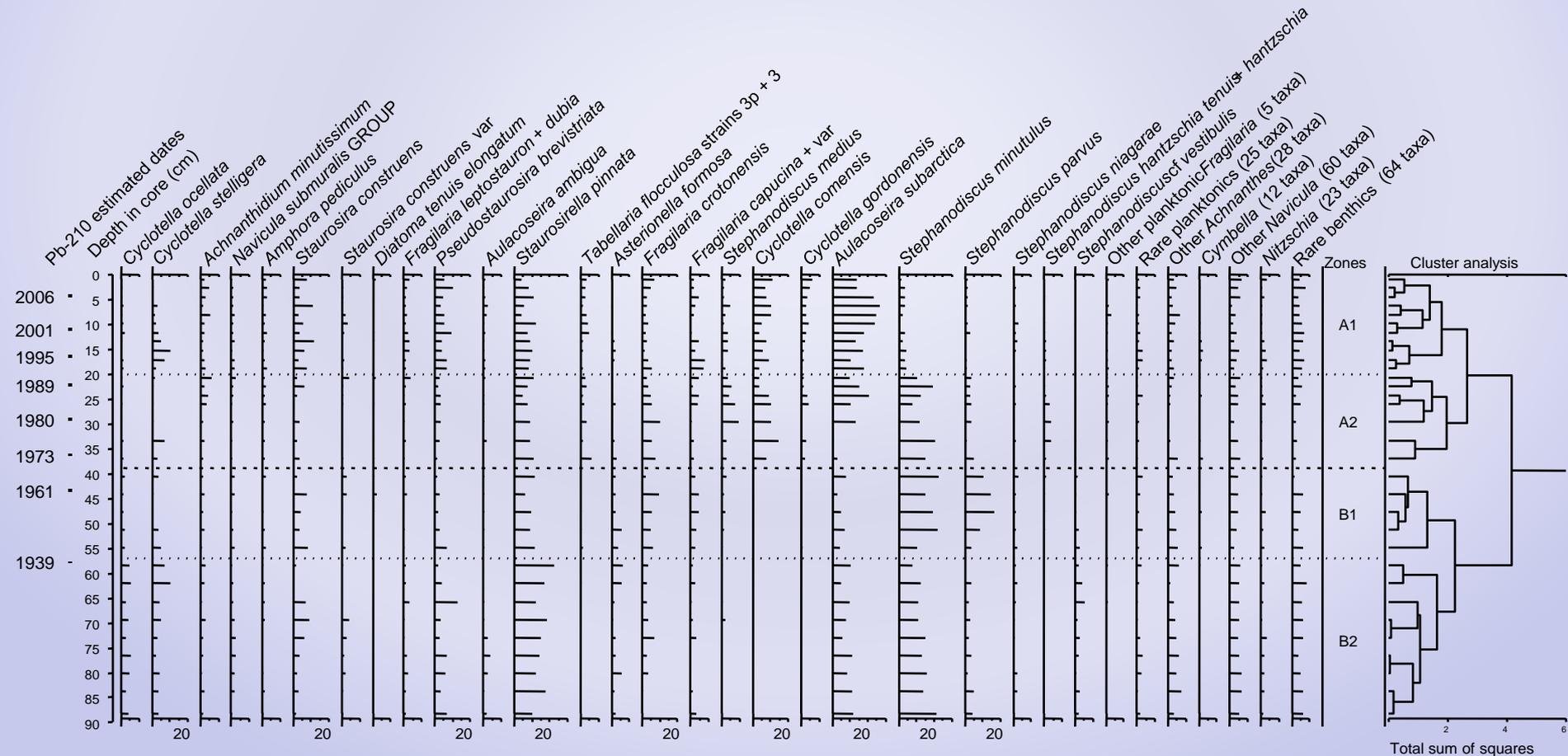


- The sediment core from the north basin (90 cm) was dated and is approximately **220 years old**, with a basal date of AD 1787.
- The core from the south basin (99 cm) is approximately **200 years old**, with a basal date of AD 1807.
- Both basins are composed of highly inorganic sediment with high sedimentation rates throughout most of the core length.

Results: Diatoms

North Basin Diatom Data (% abundance)

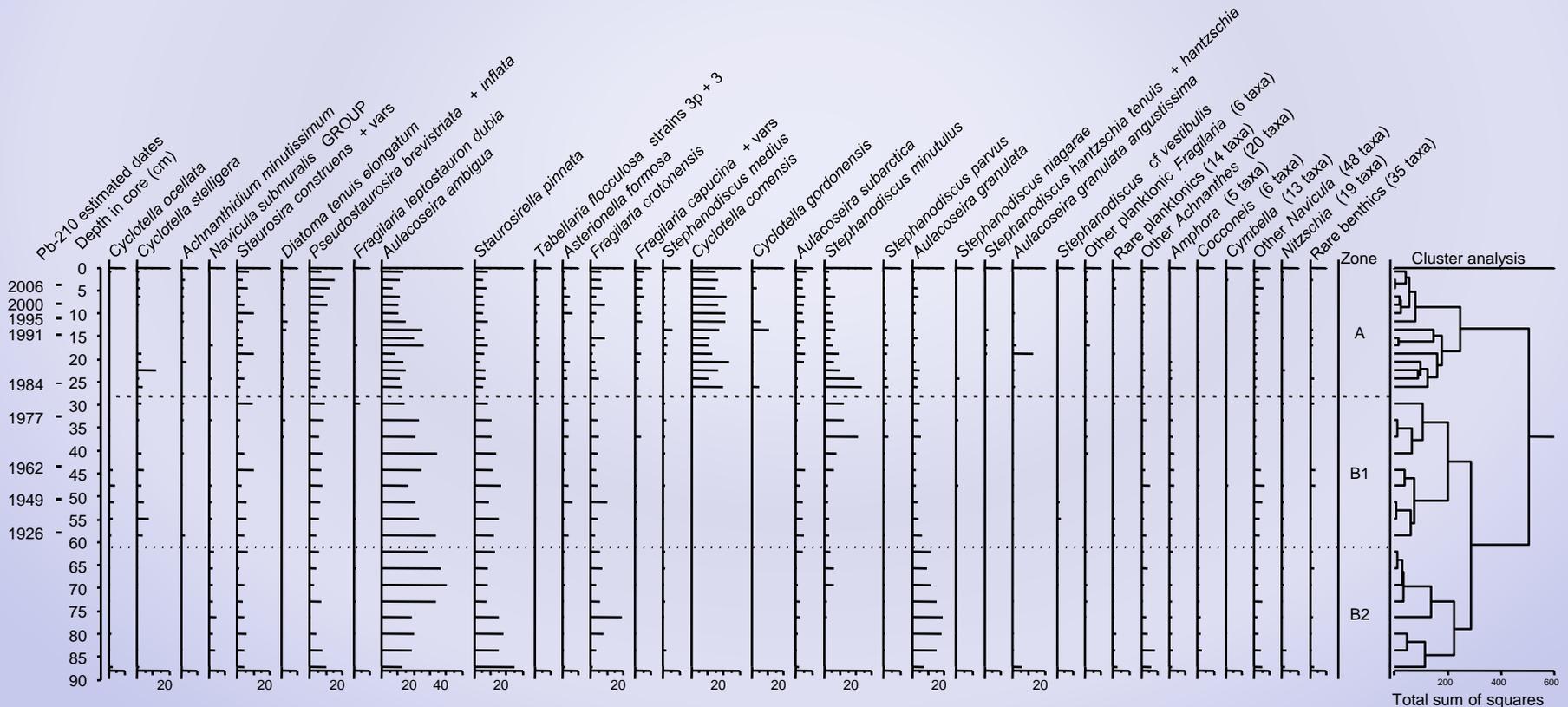
- Diatom analyses indicate 3 zones in the sedimentary record (**Zone B2: prior to ~1940, Zone B1: ~1940 to ~1967, Zone A2: ~1967 to 1991, and Zone A1: ~1991 to 2008**)
- Diatom assemblages are composed primarily of mesotrophic/eutrophic planktonic and benthic taxa.



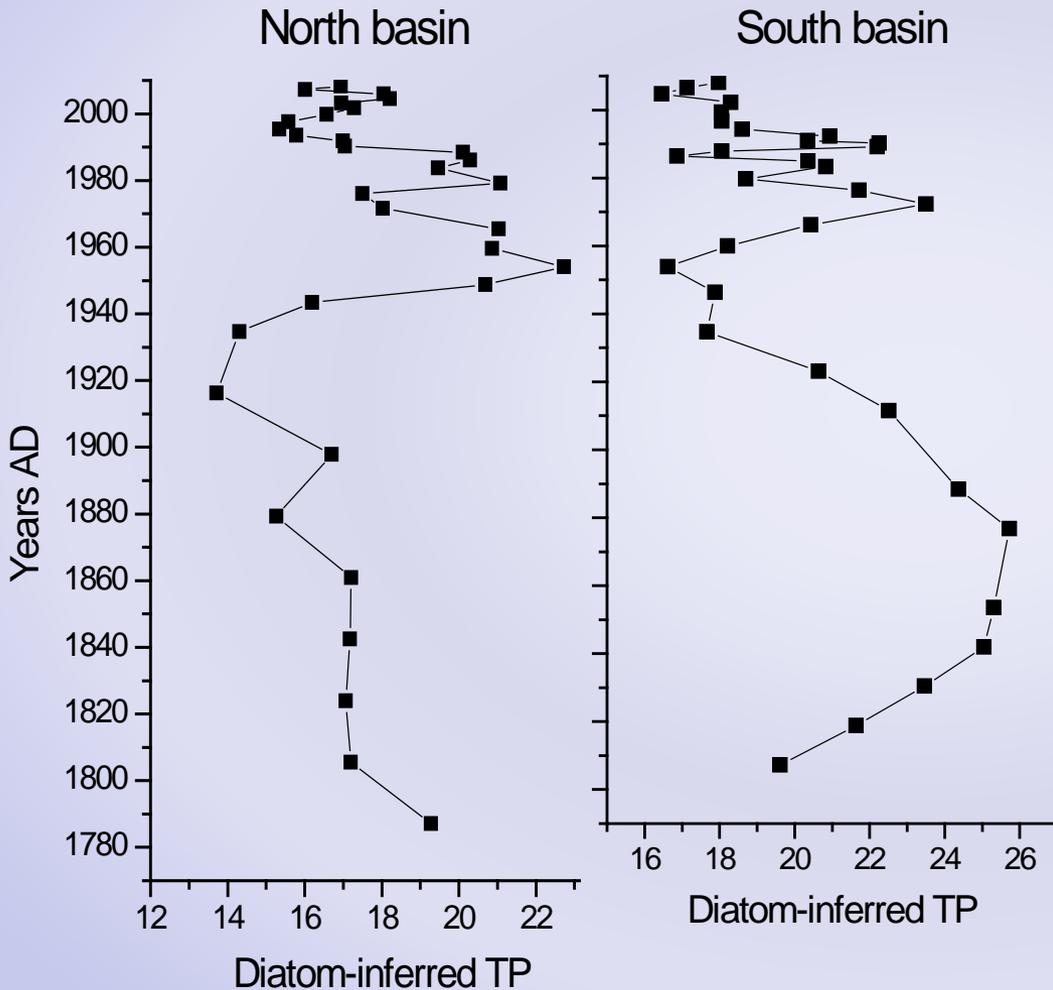
Results: Diatoms

South Basin Diatom Data (% abundance)

- Diatom analyses indicate 3 zones in the sedimentary record (**Zone B2: prior to ~1920, Zone B1: ~1920 to ~1982, and Zone A: ~1982 to 2008**)
- Diatom assemblages are composed primarily of mesotrophic/eutrophic planktonic and benthic taxa.



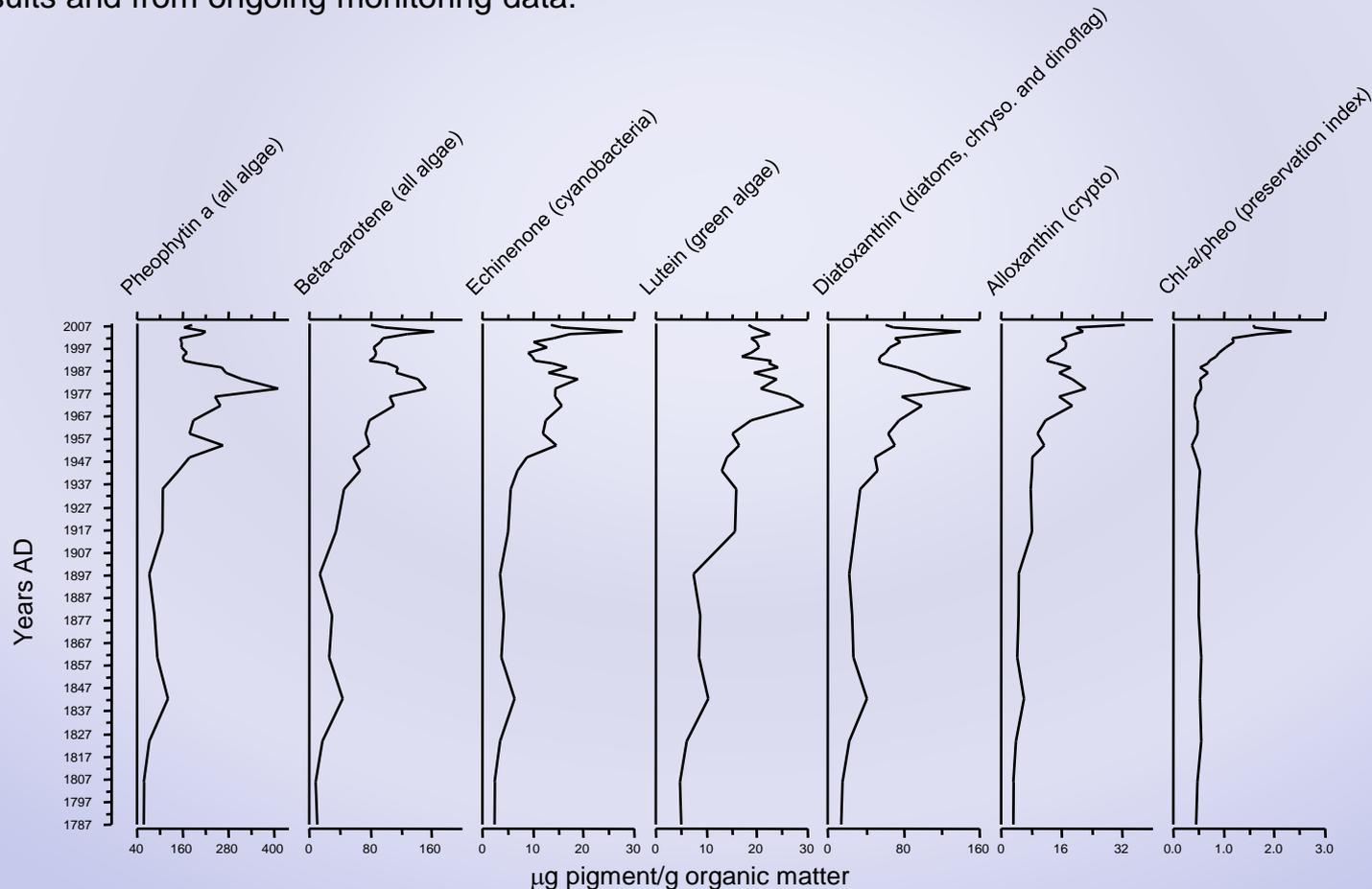
Results: Diatom-Inferred TP



- Past ~200 years of diatom-inferred TP concentrations are within the range of modern TP samples collected in lake.
- Generally mesotrophic conditions
- Large increases in TP begin in the late-1940's for the North basin and around 1960 for the South basin
- Highest TP levels between ~1950-1990 in the North basin and ~1960-1993 in the South basin
- Slightly higher TP in South basin compared to the North basin and the South basin lags behind North basin by ~10-15 years
- Post-1990 TP concentrations decrease; similar to findings in measured TP levels
- Large TP increase in South Basin in 1800's is inconclusive and may be related to localized nutrient inputs or geomorphic change.

Results: Pigments (North Basin)

- There is a general trend of increasing pigment abundance over time, which is consistent with the diatom data and a history of nutrient enrichment from point and non-point sources in the Osoyoos Lake watershed.
- There are large increases in pigments in the late-1940's that peak in the mid-1970's.
- Declining pigment concentrations from 1977-2000 accurately track the TP trend evident in monitoring data.
- Secondary peaks post-2000 may be preservation artefacts as no parallel changes are seen in the diatom results and from ongoing monitoring data.



Conclusions

- **What were baseline (pre-impact) conditions, prior to human disturbances?**
 - Likely mesotrophic for past ~200 years (moderate levels of TP)
 - Pre-European conditions were relatively stable (little fluctuation)
- **What is the range of natural variability?**
 - Current TP concentrations are similar to pre-settlement levels, however, there is still room for improved lake water clarity, decreased frequency of algal blooms, and *possibly* decreased spring TP levels
 - Marked increase in TP and decreasing water quality trend beginning in the 1940's-1950's is outside the range of natural variability – significant human-induced change
- **At what points in time and at what level of disturbance did negative impacts become apparent?**
 - Increased settlement and agricultural activities in the Okanagan during the 1940's-1950's likely led to increased productivity and decreased water quality in Osoyoos Lake
 - Further urban development sustained high TP levels that exceeded background conditions
 - In the 1980's, upstream management of wastewater led to decreased TP loads entering the lake and slowly increased water quality

Future Monitoring

- Although many point sources of pollution have decreased over the past 30 to 40 years, efforts are still needed to reduce non-point sources from storm water, septic systems, agriculture and logging activities to protect water quality in Okanagan basin lakes.
- Emerging issues such as pharmaceuticals and other organic chemicals need to be examined to determine the potential risks of these compounds to the Okanagan Basin water supply and aquatic ecosystems.
- Trend monitoring studies in the Okanagan basin can increasingly benefit from collaboration with senior and local governments, academic institutions and stewardship groups.
- Continued monitoring of Osoyoos Lake is important to understand current and changing conditions as well as determining long-term climatic variability and its effects on lake water quality.



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Media Release | June 10, 2008

OSOYOOS LAKEBED STUDY TO EXAMINE IMPACT OF SETTLEMENT

There's a lot of environmental history at the bottom of Osoyoos Lake. Starting June 16, researchers from UBC Okanagan and the B.C. Ministry of Environment will begin to reconstruct that history by sampling and analyzing sediments from the deepest parts of the lake.

They'll be looking for chemical and biological clues about how human settlement in that part of the South Okanagan has impacted the environment during the past century and a half.

"Lakes are continually accumulating layers of sediment, and preserved in those sediments we have a variety of chemical substances," says paleo-ecologist Ian Walker, Professor of Biology and Earth and Environmental Sciences at UBC Okanagan. "Sediment analysis will indicate the level of nutrient enrichment of the lake before European settlement of the area, and early in that settlement period."

The research is a collaboration between the Okanagan Basin Water Board which provided primary funding, the B.C. Ministry of Environment, Okanagan Nation Alliance, UBC Okanagan, and the Osoyoos Lake Water Quality Society.

"Our intention is to reconstruct historic nutrient concentrations as well as look at the levels of contaminants entering Osoyoos Lake back to the late-1800s," says Michael Sokal, Impact Assessment Biologist with the B.C. Ministry of Environment's Environmental Protection Division in Penticton. "From this information, more accurate and supportable nutrient targets, particularly for phosphorus, may be set for Osoyoos Lake."

The project will involve collecting sediment cores from two locations in Osoyoos Lake, and examining the sediment for the presence of specific toxins and other chemicals -- for example, phosphates, nitrates, the pesticide DDT, PCBs, lead and arsenic -- and algal remains which can indicate, for example, total phosphorus concentrations in the lake during the past.

Walker notes that if the results are similar to recent

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studies of sediments from Wood Lake in the Central Okanagan and Skaha Lake south of Penticton, the upper half-metre of sediments from Osoyoos Lake could reveal evidence of human activities such as fertilizing crops (adding phosphorus and nitrogen), spraying pesticides (historically a contributor of arsenic), and even driving cars with leaded gasoline (causing elevated lead levels).

-- 30 --

[to top](#)

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UBC Okanagan Spring Convocation sees 668 students graduate
UBC degrees were conferred upon 668 graduates during the Spring Convocation ceremonies on Friday, June 6.

"I hope that already, only a few days or weeks after the end of your degree, you are beginning to sense the freedom that a university education provides," UBC President **Stephen Toope** told graduates. "When I talk to our UBC alumni, which I do all the time and all around the world, so many tell me that they realize that university changed the world for them."

In a morning ceremony, 309 graduates from the Barber School of Arts and Sciences received their degrees. Graduates from the faculties of Creative and Critical Studies (96 grads), Education (115 grads), and Health and Social Development (148 grads) received their degrees in an afternoon ceremony.

[Read more...](#)

Strong demand for engineering co-op students
"Co-op programs can significantly boost employment opportunities after graduation," says **Erika Annala**, Engineering Co-op Program Coordinator. "The

June 18, 2008

Osoyoos lakebed study to examine impact of human settlement

There's a lot of environmental history at the bottom of Osoyoos Lake. On June 16, researchers from UBC Okanagan and the B.C. Ministry of Environment began reconstructing that history by sampling and analyzing sediments from the deepest parts of the lake.

They're looking for chemical and biological clues about how human settlement in that part of the South Okanagan has impacted the environment during the past century and a half.

"Lakes are continually accumulating layers of sediment, and preserved in those sediments we have a variety of chemical substances," says paleo-ecologist **Ian Walker**, Professor of Biology and Earth and Environmental Sciences. "Sediment analysis will indicate the level of nutrient enrichment of the lake before European settlement of the area, and early in that settlement period."

[Read more...](#)

Co-op education program booming
UBC Okanagan is getting a serious boost in profile thanks to a growing number of co-op students working in the community this

Media Reports

Scientists dig deep into history of Osoyoos Lake

By Tracy Clark - Penticton Western News - June 17, 2008



Tracy Clark/Western News

Impact assessment biologist Michael Sokal and Danny St. Hilaire with the Environmental Protection Branch remove the plug on the base of a core sampling tube near Osoyoos Lake.

The sediment at the bottom of Osoyoos Lake has a story to tell.

At least that is what a group of scientists are hoping, as they spent the early part of this week capturing a little of the lake's story in a coring tube Monday and Tuesday morning as part of the Osoyoos Lake bed study.

Researchers from UBC Okanagan and the B.C. Ministry of Environment will use the 80-millimetre samples taken from the deepest portions of lake's north and south basin — which are dated using a technique similar to carbon dating — to reconstruct the history of the lake.

"Lakes are continually accumulating layers of sediment and preserved in those sediments we have a variety of chemical substances," said Ian Walker, a paleo-ecologist and professor of biology, earth and environmental sciences at UBCO.

The scientists will primarily be looking for biological and chemical information in the sediment — such as phosphates, nitrates, the pesticide DDT, PSBs, lead and arsenic — that will help to determine the impact of human settlement on the lake's environment over the past 150 years.

"Our intention is to reconstruct historic nutrient concentrations as well as look at the levels of contaminants entering Osoyoos Lake back to the late-1800s," said Michael Sokal, impact assessment biologist with the ministry's environmental protection division in Penticton. Similar studies on other Okanagan lakes, including Skaha Lake and Wood Lake, have shown that human settlement has had a major impact. In these studies, researchers found that activities such as fertilizing crops, spraying pesticides and even driving vehicles near lakes have increased the level of harmful substances in the lake, including lead and arsenic.

The study's researchers expect the picture may be similar for Osoyoos Lake.

While Osoyoos Lake is not a major drinking water source for the community, Sokal said determining historical nutrient levels, past fish populations and human impacts in the lake may be vital for supporting aquatic life and the sustaining ecological health in the lake into the future.

"From this information, more accurate and supportable nutrient targets, particularly for phosphorus, may be set for Osoyoos Lake," explained Sokal.

High nutrient levels, for example, could reduce the oxygen levels at the bottom of the lake where larger fish, like salmon, have historically resided. Knowing the past levels could provide scientists with the information to improve conditions that will assist with the restoration of salmon populations in the lake.

The \$16,000 study, which is also being supported by the Okanagan Basin Water Board and Osoyoos Lake Water Quality Society and Okanagan Nation Alliance, is the result of the Osoyoos Lake Water Science Forum, where a group of scientists, researchers, First Nations and political leaders met last year to discuss the current condition of the lake and its future.

Find this article at:

http://www.bclocalnews.com/okanagan_similkameen/pentictonwesternnews/news/20139554.html

Osoyoos Lake Sediment Coring Project

Partners (funding, fieldwork and logistical support):

- Okanagan Basin Water Board (www.obwb.ca)
- Dr. Ian R. Walker – UBC Okanagan (www.paleolab.ca/iwalker)
- Ministry of Environment, Environmental Protection Division (www.env.gov.bc.ca/epd)
- Denis Potter, Gwen Monteith, Lionel Dallas - Osoyoos Lake Water Quality Society (www.olwqs.org)
- Alfred Snow - Okanagan Nation Alliance (www.sylx.org)

Laboratory Analyses & Report Preparation:

- Dr. Brian Cumming & Dr. Kathleen Laird – Queens University, Kingston Ontario
- Dr. Irene Gregory-Eaves – McGill University, Montreal Quebec

Questions or Comments?

- Contact Ian Walker (ian.walker@ubc.ca) or Michael Sokal (mike.sokal@gov.bc.ca)

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