"THE RIPPLE EFFECT: CONNECTING COMMUNITIES"

Education Workshop, August 22-23, 2005, Gavin Lake, BC

(Community Partners Edition)

TABLE OF CONTENTS

Attendees

Education Coordinators

Bev Bowler (North Vancouver, LF)
Cathy Solmonson (Prince George, BCI)
Chrissy MacInness (Smithers, NC)
Dianne Sanford (Roberts Creek, SC)
Don Lowen (Victoria, SC)
Jackie Hildering (Port McNeill, CC)
Joanne Nicklas (Kamloops, MF)
Josina Davis (Tlell, NC)
Neil Brookes (Enderby, MF)
Patti Lazorko (Port Alberni, SC)
Rob Dams (Terrace, NC)
Sarah Casley (Port Alberni, SC)
Shelee Hamilton (Nanaimo, SC)
Shirley Willson (Bella Coola, CC)

Community Advisors

Barry Peters (Campbell River, CC)
Christina Engel (Queen Charlotte City, NC)
Dave Davies (Comox, SC)
Mark Johnson (Mission, LF)
Roy Argue (Williams Lake, BCI)
Sandie Hollick-Kenyon (North Vancouver, LF)

Regional and Area Staff

Elizabeth Leboe (Community Liaison, RHQ)
Jeff Jung (A/Chief, Stewardship and Community Involvement Unit, RHQ)
Joanne Day (Information Officer, RHQ)
Theresa Southam (Education Coordinator, Nelson)
Jason Hwang (OHEB Area Chief, BCI)
Gary Taccogna (OHEB Area Chief, CC)

Community Partners

Cathy Koot, (UBC Alex Fraser Research Forest)
Karla van Diest (Gavin Lake Rainbow Trout Education Program)
Beth Collingwood (Baker Creek Enhancement Society)
Nicola Focht (The Exploration Place, Fraser-Fort George Regional Museum)
ZoAnn Morten (Pacific Streamkeepers)
James Stoltz, Hatchery Manager (Community Economic Development Program-Penny Project)

Guest Speakers

Pille Bunnell, systems ecologist (LifeWorks Environmental Consulting)
Jean Williams, Elder (Cariboo-Chilcotin First Nation)
Ken Ashley, Limnologist (BC MOE)
Rob Dolighan, Large Lakes Biologist (BC MOE)
Rick Nordin, Professor of Biology (UVIC)

Regrets (ECs):

Barry Drees (Prince Rupert, NC)
Dave Chitty (Port Alberni, SC)
Lorraine Landry (Port MacNeill, CC)
Kelly Aitken (Campbell River, CC)
Lisa Helmer (Pemberton, LF)
Trix Tanner (Whitehorse, YT)

Abbreviations and Acronyms used in this document:

BCI: BC Interior Area
C: Carbon
CA: Community Advisor
CC: Central Coast Area
DFO: Fisheries and Oceans Canada
DIN: Dissolved Inorganic Nitrogen
EC: Education Coordinator
ESWG: Evaluation and Strategy Working Group
IRP: (BC Ministry of Education's) Integrated Resource Package
ISBN: International Standard Book Number
LF: Lower Fraser Area
LRWG: Learning Resources and Marketing Working Group
Ma: Million years ago
MDN: Marine-derived Nutrients
MOE: BC Ministry of Environment
N: Nitrogen
NC: North Coast Area
OHEB: Oceans, Habitat and Enhancement Branch
P: Phosphorous
PPB: Part Per Billion (ppb)
PSS: Pacific Stewardship Strategy
RHQ: (DFO Pacific Region) Regional Headquarters
SARA: Species at Risk Act
SC: South Coast Area
SRP: Soluble Reactive Phosphorous
TDP: Total Dissolved Phosphorous
TSWG: Training and Support Working Group
UVIC: University of Victoria
YT: Yukon and Transboundary Area

Monday, August 22

Gavin Lake Ground-Truth: Where Are We?

Cathy Koot (Research Coordinator, UBC Alex Fraser Research Forest) lives in the Cariboo, and welcomed us to the area with a slide show presentation on the biogeoclimatic zones[1], we would encounter if we traveled east from low to high elevations in the Gavin Lake area[2]. Cathy's presentation was followed by an outdoor scavenger hunt to familiarize participants with the local plants, animals, and geography. All the biogeoclimatic zones we learned about drain to the Fraser River, which in turn flows to the ocean - one fine example of how inland watersheds are linked to the marine environment.

Interior Douglas Fir Zone

Located at low- to mid-elevations in the southern part of the Chilcotin and Cariboo on the Interior Plateau, this zone intergrades with grasslands near the Fraser River, and lies in the rain shadow of the Coast mountains. The summers are short, warm, and dry, and winters are cool and dry. Forests are dominated by Douglas-fir, with a sometimes grassy understory adapted to dry conditions. The natural clumping nature of the forest means much variety within the ecosystem, which suits wildlife (e.g. mule deer).

Prior to fire suppression activities beginning about 100 years ago, regular low intensity fires burned every 10-20 years, which promoted growth, reduced fuel build-up, resulted in a patchwork of young and old stands of trees, and kept forests from encroaching on grasslands. In the past 100 years, forests have become denser, and competition for nutrients and water has resulted in slow growth.

This biogeoclimatic zone has been traditionally used for grazing leases, one of the Cariboo's oldest industries, and is home to much of the Province's forest industry.

Subboreal Spruce Zone

Gavin Lake is situated in this mid-elevation zone of rolling terrain with lakes and wetlands in the Interior Plateau. The climate is continental with short, warm and moist summers, and extremely cold winters with

snow laying on the ground from November to March. Coniferous forests are dominated by lodgepole pine, Douglas-fir, hybrid spruce, and subalpine fir. Black cottonwood, trembling aspen, and paper birch are common deciduous trees in moister sites. The understory is more varied than at lower elevations with many berry shrubs. Lungwort, a lichen that is very sensitive to pollution, thrives here. The only known American white pelican colony in British Columbia occurs in the neighbouring Sub-boreal Pine Spruce Zone. They are often seen in the vicinity of Williams Lake during spring and summer.

Sweeping forest fires (often resulting from lightning in summer) result in a mosaic of forest stands of varying ages and types. The mountain pine beetle is killing much of the pine in this zone.

This zone is productive for the forest industry in this region of BC. Copper mining, limited agriculture and grazing also take place here.

Interior Cedar Hemlock Zone

The Gavin Lake Block of the UBC Alex Fraser Research Forest is at a transition zone into the Interior Cedar-Hemlock zone, which extends east to the Quesnel Highlands. Western red cedar and western hemlock are common trees in this zone's forests which contain more tree species, including deciduous trees, than any other biogeoclimatic zone in the Province. This zone is generally more moist than those lower down and further west due to the interior mountains; moisture-laden clouds, recharged after their passage east across the Chilcotin Plateau into the more moist Cariboo Region, are induced to unleash their moisture onto the windward (western) slopes. Because of these higher levels of precipitation, forest fires are less frequent, and trees may grow to much larger sizes - in some cases rivaling those on the BC coast. The understory of these forests is rich with living and decaying plants, providing habitat to many plants and animals adapted to warm summers and cool wet winters.

The forest industry is also active in this zone, but terrain is relatively difficult to operate in. More commonly, this zone is less developed by people and is used by wilderness-requiring wildlife like mountain caribou, grizzly bears and wolves.

Englemann Spruce - Subalpine Fir and Alpine Tundra Zones

As one crosses into higher elevations, one enters the Engelmann Spruce Subalpine Fir zone (the highest forested zone in BC) and then the alpine tundra zone, a rugged, treeless ecosystem with short cool summers and long, windy, snowy winters. Vegetation is scarce except near the timberline, and this zone is home to only the hardiest of organisms.

These zones' major industries are (near timberline) timber harvesting and recreational, but it also provides a small portion of rangeland for ranchers' animals cattle and sheep. Many of the Province's parks are located in these two zones.

Welcome

Jeff welcomed all participants to the Cariboo and "The Ripple Effect: Connecting Communities" workshop.

Jean William, an elder of the Secwepemc First Nation[3], welcomed workshop participants to the traditional territory of the Secwepemc - a vast territory in the south-central interior of BC that is home to almost 20 bands. Jean told stories about the culture and traditions of her people, including how children learned of the connections in and their connections to nature by intense observation and immersion in the outdoors with the help and guidance of their older relatives.

Introductions

Don Lowen led participants in an activity after dinner that introduced everyone. We formed a large circle, and in turn, each person answered the question "what are two non-material things that you wouldn't give up in this changing world?" A piece of basalt rock was passed around from person to person to indicate their turn to speak.

Basalt: a hard, black extrusive igneous rock found across the southern and central interior of the Province. This lava had erupted from a fissure, or vent, and spread out over the land surface, filling in lower areas and accumulating to great thicknesses, constructing the Interior Plateau.

The Spirit of Sustainability: Pille Bunnell

Theresa introduced Pille Bunnell, a biologist and systems ecologist whose work over the years has led her to notice that peoples' experiences in nature and spiritual experiences are often related. Pille has prepared a presentation that puts science and spirituality into the perspective of human evolution, and that provides some insight on how to become a sustainable species. Much of the following summary is gleaned from "Becoming a Sustainable Species"[4], a published article by Pille Bunnell and Nicholas Sonntag.

The Biology of Living Systems

Living systems are composed of simple cells which interact together in complex systems or networks. These living systems cannot be understood independent of their environment as they are units of interaction; they exist in two domains which cannot be separated:

- physiological (its structural and biological components): autopoesis
- behavioural (connection with and adaptation to its medium): structural coupling

Autopoiesis

Autopoiesis is the process by which an organism continuously reorganizes its own structure. An autopoietic system responds to and absorbs stimulus from its environment while maintaining its relationship to its environment and holding constant its identity (organization).

Structural Coupling

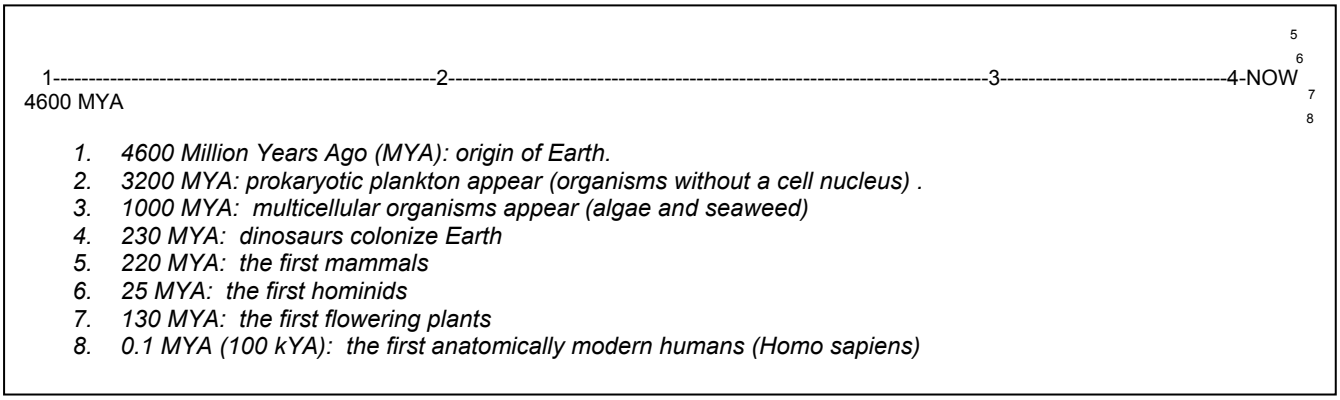
Structural coupling arises from the autopoietic processes by which living systems change in conjunction with their surrounding media. By this constant interaction, adaptation and reciprocally-triggered changes, our ecosystems and living things within them have co-evolved as we now know them. Structurally coupled systems have an interlocked history of transformations selected by and determining each other's trajectories. All living systems are interrelated in some way.

The Deep History of Evolution

Humans live in a niche usually dominated by relations with other people, but we do also have a relationship with the rest of the world (the biosphere) due to our long, deep history of evolution. We are very good at dropping our awareness of the natural world even though that natural world supports us. We sense but do not fully acknowledge our connection to the biosphere, but our link between spirituality and nature is derived from this long evolutionary relationship.

The Long String of Co-Evolution

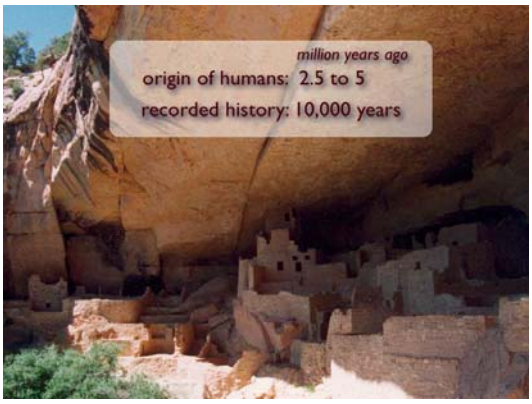
How long have the ecosystems we now know been co-evolving? Pille used a long string (460') on a spool to demonstrate the length of time during which co-evolution has taken place, creating the deep connection we humans have to our biosphere. Each foot of the string represented 10 million years. Marked on the string at the appropriate interval were events of significance in the evolution of Earth's biosphere:



1. *4600 Million Years Ago (MYA): origin of Earth.*
2. *3200 MYA: prokaryotic plankton appear (organisms without a cell nucleus) .*
3. *1000 MYA: multicellular organisms appear (algae and seaweed)*
4. *230 MYA: dinosaurs colonize Earth*
5. *220 MYA: the first mammals*
6. *25 MYA: the first hominids*
7. *130 MYA: the first flowering plants*
8. *0.1 MYA (100 kYA): the first anatomically modern humans (Homo sapiens)*

While we passed the end of the string from person to person, one person held onto and unrolled the spool, calling out each evolutionary event as the flags marking them were uncovered. After much unrolling, we finally arrived at humans, just moments before the roll of string was completely unwound.

The Steps of Human Evolution



How long have humans had a history on Earth? And how long have we been like we are now? Pille asked Jeff to start walking across the room, counting out loud his steps where each step represented 10,000 years. After only 25 steps, Jeff ended up at the far end of the room; he would have had to walk 10 times further (250 steps) to represent the entire history of humans! Common culture today believes that "how we are now is how we always have been"; we have very little conscious history of our origins and how we have been constantly co-evolving with our biosphere. In reality the we're just a blip in time, and as inevitably as humans have co-evolved with the biosphere in the past, we will continue to do so in the future.

The Biology of Cognition

Cognition is knowledge (or that which comes to be known) through perception, reasoning, or intuition. The "Biology of Cognition" is a concept founded by Humberto Maturana, a Chilean biologist and philosopher. The cognition of an organism is defined by its interactions with the environment. In many ways the organism operates in a predictive manner, assuming that "what happened once will occur again"; thus, the biology of an organism reflects regularities in the environment.

> *"The Biology of Cognition is an explanatory proposition that attempts to show how human cognitive processes arise from the operation of human beings as living systems. As such, The Biology of Cognition entails reflections oriented to understand living systems, their evolutionary history, language as a biological phenomenon, the nature of explanations, and the origin of humanness."*
>
> *Humberto Maturana*

From childhood, we ask questions seeking explanations for what we see around us. For an explanation to be acceptable to us, it must fit with the world we experience; we arbitrarily decide what constitutes an acceptable answer or explanation based on what is congruent with what we already understand. In this way, both the science of refereed journals and the science of First Nations are both valid explanations based on observation.

Epigenesis is where one development leads to the next, precluding other options. This happens all the time in life and can result in very different explanations for similar things in different cultures. Those explanations that are not familiar to us we call "myths", although to the society in which this other explanation was derived it makes perfect sense. We often hear things in our own context, which may not be what the speaker meant, which can result in frustration, incomprehension, and lack of compassion.

Becoming What We Conserve

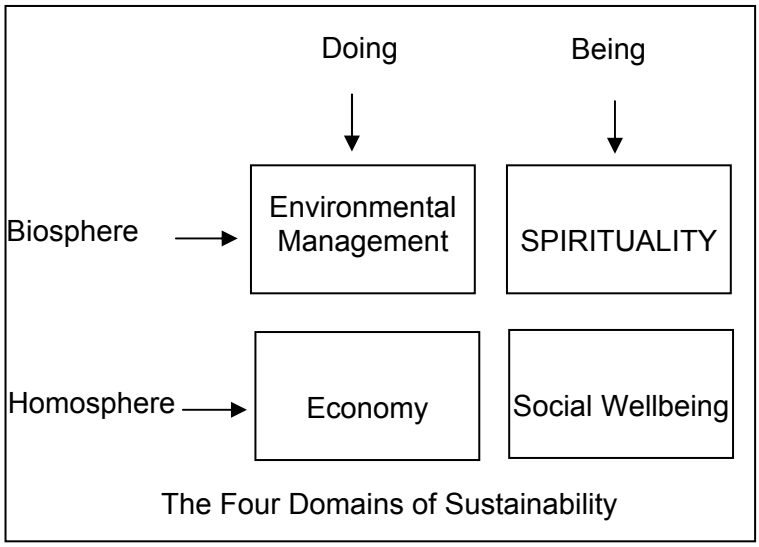
The characteristics of living systems are defined by what is conserved by the individuals making up the system. Although constant change requires constant adaptation, individuals in a system consistently try to conserve that which is deemed most important to them, e.g., although we may change our job or our home, we may choose to conserve our proximity and love for our family.

Individual choices of what to conserve are often based on the "explanations" accepted in a culture. These accepted explanations influence what we see and how we act; from these cumulative actions, a sort of world arises which validates the original explanations which influenced us in the first place, leading us back to the familiar. We are very good at stretching our beliefs despite observations to maintain that which we expect or that is familiar.

Although in our society it is hard for us to imagine something "just happening" for no cause or reason, it is important to conserve an acceptance of mystery, and an acceptance of others' explanations.

The Four Domains of Sustainability

A theory has been developed to explain the essential elements of sustainability based on an understanding of how our current culture is divided: the generally accepted "three pillars" of sustainability are economic, social, and environmental.



The Four Domains of Sustainability

Pille proposed a different theory that would be more inclusive of the human need for spirituality because of our deep evolutionary ties to the natural world. By viewing the various combinations of "being" and "doing", "homosphere" (the realm of all things related to humans) and "biosphere", the three "pillars" as we know them are represented, but there is now a fourth domain that explicitly provides a place for spirituality to exist when contemplating nature ("being" in the "biosphere").

Becoming a Sustainable Species

We humans as a species behave according to the widely-held societal belief that evolution has stopped at "us" and that we are restricted to the cultural systems that we are currently experiencing. Based on how we act and on the ideas we are currently conserving, we may be described as *Homo sapiens "aggressans"* (aggressively placing footprints all over Earth) or *Homo sapiens "arrogans"* (arrogantly believing that we are the culmination of all evolution and ignoring the consequences of our actions). However, the evolution of the biosphere (of which we are a part) will continue.

Although we cannot predict the evolution of the biosphere, we can direct our path - moment by moment - by controlling how we humans choose to behave and what concepts and material things we choose to conserve. We could choose to adapt to change in a manner that respects all other life in the biosphere, thus recreating our species as H*omo sapiens "amans"* (from the Latin root for love - wisely accepting the legitimacy of other beings in coexistence with us). By choosing to become what we wish to conserve and by adapting in congruence with the whole planet, we can evolve to become a sustainable species.

Tuesday, August 23

Setting Our Course

Theresa introduced the agenda: it included a training component (marine-derived nutrients in freshwater ecosystems); a strategy component (decisions we would make throughout the workshop to provide guidance to the Regional Steering Committee and Working Groups for the coming year) and a social component (free time, camp activities, icebreakers and evening presentations).

Regional Steering Committee - Heads Together: Jeff Jung

Background

For many years, Salmonids in the Classroom programs were strong under the Salmonid Enhancement Program (SEP). However, once the Oceans Act was adopted in 1997, we needed to incorporate oceans and develop a more holistic education program to reflect the Department of Fisheries and Oceans (DFO) and the Oceans, Habitat and Enhancement Branch's (OHEB's) priorities.

In 1998, Mark (then Chief of Community Involvement Division) and Theresa (Southam Consulting) wrote a K-12 education strategy, but it was poorly received. A process was then undertaken to obtain input from all interested ECs and CAs, and "Stream to Sea: Strategy for an Ecosystem Approach to Education" was written and adopted in June 2003. To implement the strategy, a Regional Steering Committee and three working

groups - Evaluation and Strategy (ESWG), Learning Resources and Marketing (LRWG), Training and Support(TSWG) - were formed.

The Steering Committee has three roles: to oversee the implementation of the Stream to Sea strategy; to oversee OHEB education in the Region; and to provide functional guidance to the three working groups. The committee members are:

- Jeff Jung: Regional Chief, Stewardship and Community Involvement Unit
- Elizabeth Leboe, Community Liaison Biologist, Stewardship and Community Involvement Unit
- Cheryl Lynch, Data Management Coordinator, Oceans and Watershed Planning Unit
- Theresa Southam: contracted Regional Stream to Sea Education Coordinator
- Gary Taccogna: OHEB Area Chief, Central Coast

The annual Regional budget for OHEB K-12 education is $12k for the workshop, $5k for each working group, and $50k for Theresa's contract.

Past steering committee work has included: raising and maintaining the profile of the Stream to Sea program within the Department; letting Managers know about the stewardship component of the program that can be linked to the Pacific Stewardship Strategy (PSS); and a mid-strategy report that identified the status of the strategy and Regional changes to education programs that have occurred since 2002.

Steering Committee Decision Points

Our mid-strategy report showed that we are making progress in adopting a more integrated approach to education; however, we can no longer ask people to do more with the status quo resources available. The Steering Committee presented two ideas that could potentially increase our ability to help students become aquatic stewards: the first is to spend some time seeking additional Regional partnerships or funding that could augment Stream to Sea resources (e.g., SARA funding for LRWG); the second is to move toward supporting volunteer groups that do parallel K-12 work (e.g., strategic presentation at bi-annual volunteer workshops; invitation to annual education workshop).

"I was meant to go to work today
But a butterfly flitted by
A brown bird sang in a tree
The grass was blowing to and fro
And all the trees were swaying so
All I could do was laugh and go!"

- On a lakeside bench at Gavin Lake.

Success of Internal Communications?	Sue Farlinger was a big proponent of the Stream to Sea Strategy. Now, James Boland (champion of the Pacific Stewardship Strategy) accepts the Stream to Sea Strategy. This confirms that the Stream to Sea work is important and is on the radar Regionally.
Education Budget Hit Bottom?	It would seem so, and there is hope. There is a lot of retirement within the department on the horizon, and there is a lot of energy to find ways to keep valuable programs going - using different ways despite the lack of new resources.
Regulation vs. Stewardship?	There has already been acceptance that education and stewardship are required to complement regulatory work to have a complete program. However, the Department's resources don't reflect that balance. We need to figure out how best to make our program work within this unbalanced budget.
SARA Creating Change in DFO?	The Department will have to change, its *modus operandi* to do recovery plans, but change will be very slow. Education will not be just for the K-12 audience; other audiences will also have to be engaged. It is uncertain what kind of "teeth" the Species at Risk Act will have. The associated integrated planning processes will require all stakeholders to compromise and make thoughtful decisions.
RHQ Time Available?	Currently, RHQ dedicates between 1.7 and 2.3 full-time equivalents (FTEs) to K-12 education amongst 5 people. Jeff juggles this project with other Branch projects and gets pressure that his unit is spending too much time on K-12 at the expense of other initiatives. This pressure is not on Area Stream to Sea education staff and contractors to expand into other areas (Stream to Sea is still K-12); however, Jeff is responsible for stewardship in OHEB, and there is branch-wide pressure to address the gaps of adult and industry education and outreach. These activities would be outside Stream to Sea, and may be addressed by the PSS.

Following a question and answer session, participants broke into small groups or pairs to discuss the pros and cons of each idea, and then individually wrote their responses down and handed them in

anonymously. Many people chose to wait until the ESWG made their presentation about the volunteer survey results before answering question #2. Results below include feedback from non-attendees who chose to submit their "2¢ worth".

Q? Would you like the Regional Steering Committee to seek funds or partnerships to build the capacity of Stream to Sea? Are there opportunities that you know of that we should pursue?

Yes	Depends	No
19	3	0

Internal awareness important	The Regional Steering Committee should focus its efforts on increasing awareness within DFO Pacific Region, making links to Regional initiatives like the PSS and CEDP, and informing employees so they can help promote the Program.
Focus on regional partnerships	The Regional Steering Committee should seek partnerships that are Regional, with other government organizations.
Use IRPs to forge links	Many organizations are attempting to raise environmental aquatic awareness on the basis of BC Curriculum's IRPs. It makes good sense to partner to be able to offer more lesson plans on the new website.
Don't compete	Pursue external funds without directly competing with non-government organizations.
Watch your time	Pursue other funding or partnership avenues so long as we don't risk losing the Regional support we currently have.
Be cautious	Don't make too many changes before we determine if the present strategy is working. Ensure core programs are fully supported before taking on more duties. Don't decrease funding from DFO budget if additional short-term funds are identified.
Suggestions	• Environmental NGOs: World Wildlife Federation, Pacific Salmon Foundation, Sierra Club • Bamfield Marine Sciences Centre • Vancouver Aquarium • Insurance Corporation of BC (agency with a surplus) • Federal and Provincial departments or initiatives: Natural Resources Canada, SARA, Kyoto Accord, Environment Canada, Human Resources Development Canada, Aboriginal Fisheries Strategy, Northern Development Initiative Trust • BC Teachers Federation • Olympic 2010: Olympic Legacy groups, Community Federation of Whistler

Q? Do you think the Regional Steering Committee should move toward providing additional support to volunteer groups doing K-12 education in parallel with the Stream to Sea program?

Yes	Depends	No
16	1	5

Combine efforts	It would be best if our respective programs were coordinated so that we could increase momentum and reduce redundancy while supporting each other.
DFO buy-in	We need greater departmental buy-in before providing support outside our ranks.
Support needed	In addition to financial support, volunteer groups could use support in the form of teaching resources and equipment. Also, additional EC time could be hired.

Be cautious — We don't want to overload already taxed volunteers, nor do we wish to dilute our efforts. We would also need to establish criteria for forging worthy partnerships. We already feel we don't have enough ECs to go around.

Suggestions

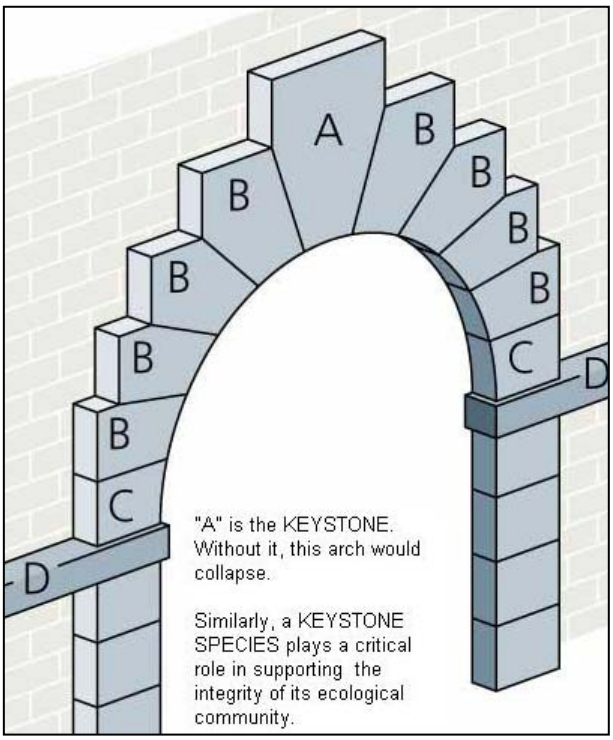
- Presentations at bi-annual volunteer workshop
- Communications with volunteer groups through CAs
- Funding through CAs to volunteer groups for education
- Invite partners to annual Education Workshops
- Have an EC from the workshop Area join the Steering Committee for the year.

Linking Oceans and Interior Watersheds - The Role of Marine Derived Nutrients: Ken Ashley

Ken Ashley is a limnologist with the BC Ministry of Environment specializing in the consequences of nutrient loss and low productivity on ecosystem biodiversity and fish production. Ken prepared a presentation that puts the "anadromous nutrient pump" into perspective, discusses how salmon are keystone species in our Region's ecosystems, and that explains some of the reasons responsible for declining oceanic productivity.

The role of marine derived nutrients (MDN) in Pacific Northwest ecosystems

The nutrients essential to sustain healthy and productive aquatic and terrestrial ecosystems are nitrogen (N), and phosphorous (P). Granitic rock, such as underlies much of the Pacific Northwest, does not contain many of these important nutrients. A cursory study of the region's geography and climate would suggest that the rainy Pacific Northwest could not possibly be home to biologically productive ecosystems; i.e., the small geological inputs of macronutrients N and P would be limiting factors. However, geology and climate do not take into account the keystone species that plays an integral role in ecosystem productivity, bringing MDN to inland watersheds and back again out to sea: this keystone species is salmon.



A keystone species is an organism in an ecosystem that many other species depend upon for continued survival and support. Just as removing the keystone from an arch causes the arch to fail, if you pull the keystone species out of an ecosystem, the whole ecosystem collapses or unravels to a fragment of what it used to be. Salmon are the keystone species in the Pacific Northwest's ecosystems because their carcasses supply energy and nutrients which are cycled throughout the ecosystem again and again. The effect of MDN is stronger in BC, Washington and Oregon than anywhere else in the world.

Nutrients and Nutrient Limitations

Although other macro- and micronutrients can be limiting to productivity in some circumstances, the primary limiting macronutrients are P and N.

Measuring total P in a system is usually done by adding the particulate (soluble reactive - SRP) and total dissolved (TDP) concentrations of P in a system. P is usually a limiting factor to productivity in streams and lakes when the concentration of SRP is less than 1 µg/L, and the TDP is < 2-3 µg/L.

Total dissolved inorganic nitrogen (DIN) is usually used as an adequate proxy for total N. DIN is the sum of nitrite (NO_2), nitrate (NO_3), and ammonia (NH_3). In streams, N is limiting to productivity when DIN concentration is below 20 µg/L. In lakes and reservoirs, N is limiting at concentrations less than 30 µg/L.

These concentrations are very low, but ecosystems are very efficient at taking advantage of tiny amounts of these nutrients, recycling N and P again and again.

Stable Isotopes

An atom consists of protons and neutrons. The number of protons determines the element and is equivalent to its atomic number. As seen in a periodic table[5], an atom with atomic number 6 (or that has 6 protons) is carbon (C), one with 7 protons is N, and with 15 is P. The number of neutrons in an atom may vary, resulting in different isotopes of the same atom with different atomic weights and physical characteristics. Most elements have both radioactive isotopes (which decay according to a half-life) and stable isotopes (which remain the same over time). Stable isotopes may be used as tracer elements because they show no tendency to undergo radioactive breakdown over time.

1 µg/L is the same as 1 ppb.

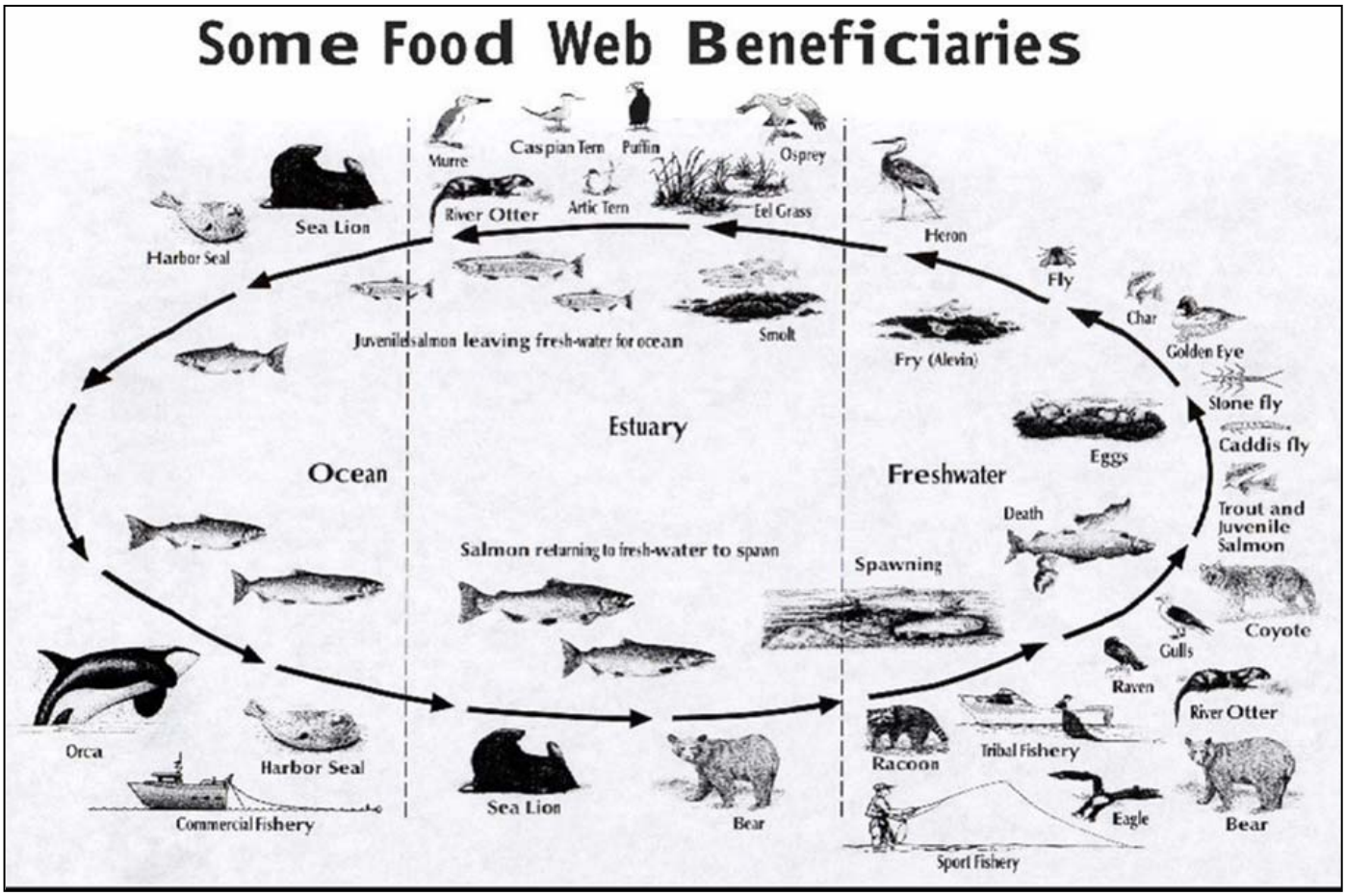
1 part per billion (ppb) is the same as 1 second every 32 years.

Tracking Food Webs with Stable Isotopes

The stable isotope ^{15}N (N with 7 protons and 8 neutrons) is so stable that it has not changed since it originated from ^{15}O β-decay in stars[6], 5 billion years ago. This isotope is often used as a tracer in agricultural and medical research. ^{13}C is the stable carbon isotope used as a tracer; it makes up about 1% of all naturally-occurring carbon on earth. P, however, has no stable isotopes that can be used for tracing in the food web. Isotopic ratios are measured in the laboratory by a mass spectrometer especially calibrated to work for low-weight atoms. Universities first began to obtain these stable isotope machines in the mid-1980s, and when these machines became more affordable in the 1990s, more stable isotope studies were done.

"A bear is just a salmon with claws and fur"
- Ken Ashley

The study and recognition of the salmon-nutrient link was just coming into the world of science in the 1960s when the University of British Columbia had the world's best ecology school. The use of stable isotopes were used to confirm that salmon concentrate N, and P in their bodies (a salmon is 0.3% P and 3% N), and these nutrients can be traced through the food web kilometers into forests from the stream. Tom Riemchen[7], at the University of Victoria has tracked marine-derived N and C in plants and animals and has correlated tree ring thicknesses with annual salmon escapements. Jeff Cederholm[8][9], at the Washington Department of Natural Resources has been fastidiously examining the coho carcass' role in the ecology of headwater streams.



The cycling of MDN from the sea to freshwater watersheds by salmon was termed the "anadromous nutrient pump" by Stockner and MacIsaac [10] in 1996. Ironically, the First Nations have always had this knowledge, and did not require mass spectrometers to confirm it.

Nutrient Loading

The nutrient loading effect of salmon carcass additions to a river lasts about a year. If artificially seeded, the addition of carcasses should be timed to coincide with the timing of former natural nutrient loading. Artificial nutrient addition through carcasses or nutrient pellets (as at the Keogh River) may be enough to let the watershed recover to higher nutrient levels. Of course, if a dam is present on the river, artificial nutrient loading will need to continue until the dam is removed or fish passage is restored.

Evidence of nutrient loss

In the past, over 50 million salmon have returned in a single year to the Fraser and Columbia Rivers, including the so-called giant Chinook "June bulldogs". In 1905, so many salmon were caught that canneries could not process all the fish, and salmon were dumped in the lower Fraser. At that time, it was cheaper in Britain to buy imported canned salmon than it was to buy locally-grown beef!

Since then, commercial landings of salmon have declined on the Fraser and Columbia, and we have created impoundments impassable to salmon on some of our major rivers. Urbanization and deleterious forest-harvesting practices have resulted in habitat loss at ever-increasing rates. Hydroelectric developments to meet our increasing demand for power have contributed to a weakening of the anadromous nutrient pump.

We now have 5-7% of historical pre-European marine-derived nutrients reaching Pacific Northwest freshwater ecosystems. Although agricultural fertilizers and effluent may be contributing P and N to freshwater systems, all these nutrients end up downstream, and none upstream or in forests.

Effect of Nutrient Loss on Ecosystems

Aquatic effects

Decreased salmon returns reduce aquatic productivity due to lowered N and P concentrations. In streams, this results in even lower salmon populations. In lakes and reservoirs, this results in collapse of kokanee stocks and of predator and scavenger populations (e.g., sturgeon). This negative feedback loop has been occurring over many decades.

Terrestrial effects

Decreased quantities of nitrogen and phosphorous returning to land via salmon carcasses results in decreased productivity of forest ecosystems. This results in fewer predators and scavengers (eagles, grizzly bears, mink), and less healthy inland watershed ecosystems.

Ocean Survival of Salmonids

Oceanic productivity declines when ocean temperatures increase. Warm sea surface water prevents nutrients from welling up from below; the lack of turn-over in the ocean blocks the fuelling of productivity. There are three known events driving oceanic temperature changes: El Niño, the Pacific Decadal Oscillation, and climate change.

El Niño/Southern Oscillation (ENSO)

The El Niño/Southern Oscillation is the name given to a warming of the ocean surface off the western coast of South America that occurs every 4 to 12 years when upwelling of cold, nutrient-rich water does not occur. It causes die-offs of plankton and fish and affects Pacific jet stream winds, altering storm tracks and creating unusual weather patterns in various parts of the world.

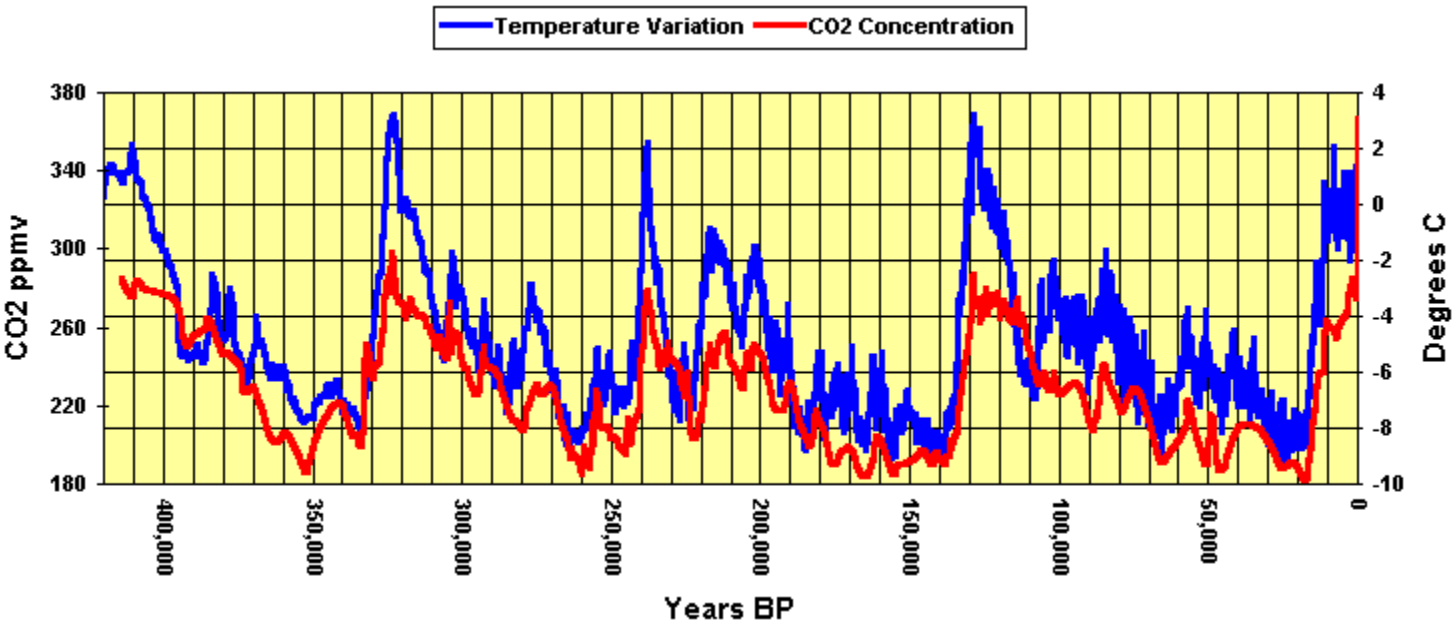
Pacific Decadal Oscillation (PDO)

The Pacific Decadal Oscillation is a pattern of sea surface temperature changes in the Pacific Ocean that occurs on decadal (20 to 30 year) time scales. The positive (warm) phase of the PDO is characterized by cooler than average sea surface temperatures and air pressure near the Aleutian Islands and warmer than average sea surface temperatures near the California coast.

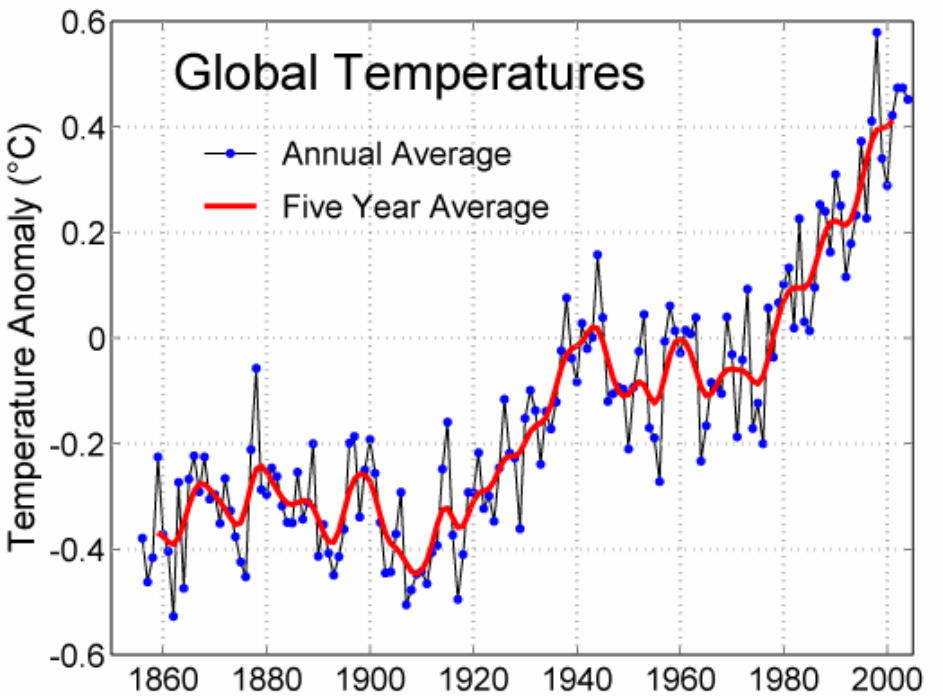
The PDO and ENSO can interact so that one may be reinforced or weakened by the other, i.e., a positive (warm) PDO reinforces the magnitude of an El Niño event. The PDO last "flipped" in 1990 from a warm regime to a cool one (resulting in warmer sea surface temperatures off the BC coast).

Greenhouse effect and the Hydrocarbon Age

Carbon dioxide (CO_2) and methane (CH_4) are two of the "greenhouse gases" known to cause atmospheric warming. CO_2 levels have been correlated with atmospheric temperatures. Using CO_2 levels measured from gas bubbles in Antarctic ice cores, atmospheric temperatures have been extrapolated back 420,000 years. Over geological time, the maximum natural CO_2 levels were at 270 parts per million (ppm).



In 1760 (the start of the industrial revolution) CO_2 levels dramatically increased with increased use of hydrocarbon fuels. Carbon dioxide levels are now at 370 ppm, and predictions indicate that in 20-50 years, levels could rise to between 800-and 1000 ppm. The issue of "Peak Oil"[11] (the point at which the Earth's endowment of oil has been 50 percent depleted and the rate of oil production begins to go down while cost begins to go up) will have unknown effects on global atmospheric CO_2 levels. Warmer atmospheric temperatures result in warmer sea surface temperatures.



Ocean Productivity and Salmon

Scientists used to think salmon went right offshore when leaving estuaries as smolts or juveniles, but it is now known that all juveniles swim first up the continental shelf to the Aleutians, then go offshore. Oceans now are the warmest they have been since the 1950s, and there is comparatively little food for salmon; they starve to death *en route* to their food due to the lack of upwelling along the continental shelf.

There is evidence that salmon populations have responded to climatic variations[12], over the past 2200 years, prior to the effect of humans on atmospheric (and therefore sea surface) temperatures. Despite

very reduced numbers of returning salmon at various points in the distant past, populations have survived and even thrived. Humans have control indirectly over only one of the three causes of increased sea surface temperatures: climate change. Through our actions, we can reduce the production of greenhouse gases which are heating up our planet.

Conclusion

The Pacific Northwest and the North Pacific Rim are unique in the world, and they require the "anadromous nutrient pump" to maintain their terrestrial and freshwater productivity. Salmon are the keystone species that link the marine environment to inland watersheds and inland watersheds back to marine environments. In part due to natural cycles, and in large part due to increasing human population pressures, the fresh and saltwater habitats that salmon require to live are no longer supporting this important species upon which many other plant and animal species depend. The only real solutions humans can undertake are to stop over-fishing salmon stocks, stop or reverse habitat degradation, and stop warming up the planet.

Student Activity: The Dream Bucket

Theresa and Don led two groups in an outdoor activity called "The Dream Bucket". The objectives of the activity were to:

- identify why we love or value water bodies
- experience a sense of loss for something we value
- inspire cooperative problem-solving
- discuss ways we can conserve water bodies

Materials (per station)

- a bag with a closure (i.e., about 50 cm^2 is ideal)
- a 20 L bucket
- 4 or more 4.5 meter ropes
- rope to make a 2 m diameter circle (6 m long) and a 6 m diameter circle (20 m long)
- slips of paper or index cards (one for each participant)
- packing tape
- writing instruments
- a bicycle tube

Method

This activity works best with groups of 4-8 people (otherwise many are left out of the problem-solving process). Provide each participant a slip of paper. Have them write their "dreams": the name of a water body they know and why it is important to them. Then, have participants collect a small, non-living natural item that symbolizes this place and tape it to the piece of paper. Collect up all papers and objects in to the zippered bag (some may already be reluctant to part with the symbol of their dream place).

Place the short rope on the ground forming a circle and place the upturned bucket at the centre. Place the bag on top of the upturned bucket. With the longer rope, create a concentric circle around the bucket; have participants stand outside of the large circle. The space between the small and large circles is the "Field of Despair". The participants must rescue the bag containing their dreams from the top of the bucket without touching the Field of Despair with their bodies. Using the remaining tools (4 or more 4.5 m pieces of rope, inner tube), participants brainstorm a way to "bring back their dreams" from the bucket. Once the "dreams" have been retrieved, lead a discussion on how we can conserve aquatic ecosystems.

Options

- Have students brainstorm threats to their identified water bodies prior to the problem-solving activity "What's keeping you from your dreams?". Locate items representing these threats and place them within the rope circle;
- Discuss the importance of identified water bodies within the "big picture" (ecosystem);
- For younger students, provide a "word bank" in advance of the activity to identify words and concepts you will be using or teaching (ecosystem, estuary, habitat, etc.)
- Conduct this activity as part of a field trip, and have all students think about the same water body;
- Use terminology from Lord of the Rings (Mordor, etc.) to name the parts of the circle.

Valuing the Nutrient Link - the Quesnel Lake Story: Rob Dolighan

Rob Dolighan is a large lakes biologist with the BC Ministry of Environment. He provided a talk on the situation at Quesnel Lake, where economic and social desires for trout sport fishing are in competition with the ecosystem's environmental requirement for healthy sockeye runs providing marine-derived nutrients.

Physical Characteristics of Quesnel Lake

Quesnel Lake is one of the deepest lakes in the world; at its maximum (610m) it is deeper than the Empire State building is tall. Because water needs to get to 4ºC before it will upwell and overturn, it is difficult for primary production to get going in this deep lake. Quesnel Lake is fed by the Horsefly River which flows into the southwest portion, and the lake's waters drain to the ocean via the Quesnel and Fraser Rivers.

The three fish species in Quesnel Lake of relevance to this story are anadromous (sea-going) sockeye salmon, resident rainbow trout, and non-anadromous kokanee salmon.

- The Quesnel Lake sockeye population is one of the largest in the province (Shuswap Lake is the other one): millions of sockeye return annually to the Horsefly River and shoals in Quesnel Lake to spawn. The sockeye compete with kokanee (plankton-feeding fish) for food. These sockeye salmon provide the majority of marine-derived nutrients to the Quesnel Lake ecosystem. Analysis of core samples taken in Quesnel Lake suggest that historic sockeye runs may have exceeded 15 million fish. Recent peak runs have been around 6 million fish (which is equivalent to 89 tonnes of P and 274 tonnes of N!). This year's run was anticipated to be 12 million, but was in fact only 1 million fish. The estimated carrying capacity of the lake was 1.5 million female sockeye.
- Rainbow trout in this lake migrate into streams in summer and fall to feed on bugs, sockeye eggs and kokanee fry. One two-year old kokanee is equivalent in food energy to about 150 sockeye fry; these kokanee are the preferred food of the trout, which preferentially expend their energy to catch and consume this larger prey. Following a dominant year of sockeye returns, there is greater invertebrate production which results in better rainbow trout fishing. The rainbow trout population has been supporting an escalating sport fishery and related commercial interests; currently, Quesnel Lake and tributaries support about 20,000 angler days per year.
- Kokanee are resident in the lake; they compete with sockeye for food (plankton). They provide a valuable food source to the trout. Although salmonids, they do not migrate to the ocean and back, and thus do not provide a source of added nutrients. There is strong evidence in other lakes (Kootenay) that if kokanee stocks collapse, the trout population also collapses.

Disaster at Hell's Gate: A Salmon Fishery in Ruins

1913 was a peak cycle for sockeye salmon, and canneries tinned as much fish as they could - over 2.3 million cases! Despite this enormous catch, the river was still full of fish. However, as summer approached and water levels dropped, it became apparent that blasting debris dumped into the Fraser from the construction of the Great Canadian Northern Railway was increasing the current to furious torrents and creating new obstacles for the migrating salmon. For the battered, bleeding fish that managed to leap past the tumbled rocks and gigantic boulders, there was little shelter in the debris-filled upper pools that had once offered respite for the continuing journey. Thousands of sockeye died without spawning, their rotting carcasses drifting downstream along the bars and banks of the lower river.

On the night of February 23, 1914, the weakened Fraser River sockeye fishery collapsed completely and dramatically when a massive rock slide crashed into the Fraser at Hell's Gate, instantly narrowing the canyon to the size of a creek. Water poured in a mad, constricted torrent through the small opening of what was now no more than a stream that drained the accumulated waters of almost 80,000 square miles.

Despite immediate and often heroic efforts on the part of federal fisheries officers to dredge the canyon, build box flumes and even transfer individual fish with the help of aboriginal dip nets, the Fraser River sockeye run had been virtually destroyed. By 1921, the recorded catch had fallen to only 6% of its 1913 peak. Not until 1945, when the Hell's Gate Fishways were opened, did the Fraser River once again become a salmon river.

(www.greatcanadianrivers.com)

History of Quesnel Lake

Various human endeavours over the last century have had notable effects on Quesnel Lake and its associated ecosystem, and have had almost completely detrimental effects on the sockeye population.

- 1898: placer miners built a dam across the Quesnel River at Likely that blocked all salmon access to Quesnel Lake. Kokanee proliferated. This resulted in increased population of rainbow trout, spurring the sport fishing industry.

- 1913: railway construction in the Fraser Canyon narrowed and then entirely blocked fish passage for spawners. Once the debris dam was removed, only a few sockeye could get up the Fraser, bringing marine-derived nutrients to Quesnel Lake.
- 1937: in what should have been a dominant year, only 200 sockeye spawners returned.
- 1945: Fishways at Hell's Gate were built, permitting the Fraser to once again allow sockeye to pass through to the north, bringing much needed nutrients with them.
- 1980 - 1990: the Province didn't want to see enhanced sockeye production (through construction of a spawning channel) in the Horsefly watershed because of their competition with kokanee and rainbow trout.
- 1987: numbers of returning sockeye had built up so much that they were consuming all available phytoplankton in Quesnel Lake, causing kokanee numbers to drop.
- 1989 - 1998: increased settlement and commercial fishing along the Fraser resulted in a dramatic decline in the size of returning sockeye, which reduced their reproductive potential and decreased lake carrying capacity. This caused a dramatic collapse of the kokanee population in Quesnel Lake, also causing declines in the trout population.

Currently, sockeye populations are rebuilding in the Quesnel Lake watershed.

Since 2004, limnological research has shown that the lake's primary productivity has at least doubled with the increased numbers of returning sockeye. Although it is currently unknown where all the added nutrients are ending up within the ecosystem, the increased quantities of phytoplankton being produced due to increased nutrient loading are better able to sustain all three fish populations.

Ecosystem Management and Studies

Numerous studies have been conducted and various management options tried out over the years:

- A review of the extensive water temperature data that has been recorded on the Horsefly River since 1950 shows that there has been a 2.3ºC rise between 1950 and now;
- Concerned that Kokanee were out-competing Sockeye, the Pacific Salmon Foundation conducted studies in the 1950s. The BC Ministry of Environment and DFO have conducted and continue lake-wide hydroacoustic studies to estimate populations; since 2000, not a single Kokanee has been spotted in important local streams;
- The BC Ministry of Environment has adjusted their catch and release regulations over the years to prevent a decline in rainbow trout numbers; they made the unpopular decision in 2000 to eliminate catch over 50 cm;
- BC Ministry of Environment (Fish and Wildlife) is trying to maintain recreational fishing for British Columbians by capping guided fishing for out-of-province residents.

Balancing Human Values and Ecosystem Requirements

When Sockeye return in larger numbers and exceed the lake carrying capacity (i.e., they eat all the available phytoplankton), they out-compete kokanee. The resulting decrease in kokanee numbers cause a decline in rainbow trout populations, the basis of the sport fishery. When sockeye numbers decrease, kokanee and rainbow trout populations rebound for a while due to lack of competition, but eventually the lack of marine-derived nutrients added annually to the Quesnel Lake ecosystem lowers productivity and populations begin to decline again.

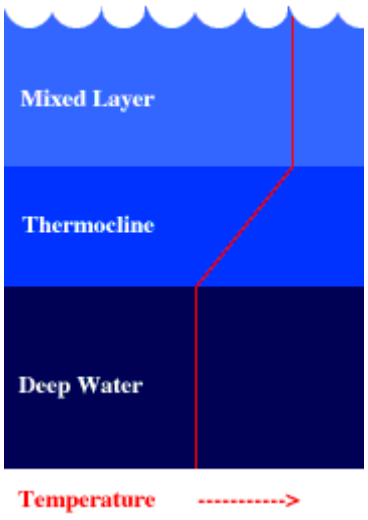
The challenge that the community and that BC Ministry of Environment (Fish and Wildlife) face is trying to find the balance to re-establish big rainbow trout (which support the recreational fishing industry) while maintaining a productive system for sockeye. The BC Ministry of Environment has opened communications with partners[13], and has begun a project to collect the fish population data required to figure out management options for the future.

Ultimately, if higher numbers of returning sockeye (unfairly termed "overescapements" in socio-political jargon) are seen in this watershed, lake productivity will increase, resulting in enough food to support sockeye and kokanee and trout. With so many fish being supported, there would be increased numbers of fish available for all fisheries in the lake, on the rivers, and on the coast.

Professional Development Field Trip – Limnology, Tools of the Trade: Rick Nordin

Due to the inclement weather, last minute changes were made to the field trip to ensure safer boating; the fry sampling portion of the afternoon was cancelled. All participants drove out to Cedar Point, a park on Quesnel Lake in a chartered bus where we met two boats that had been arranged by Roy Argue, Community Advisor and provided by West Fraser Timber Co. Ltd. and University of Northern BC's Quesnel River Research Centre. One half of the group at a time went out on the boats with Rick Nordin, professor of biology at University of Victoria and his assistant Chris Swan (BC Ministry of Environment). Rick is involved in the LakeKeepers[14] organization through the BC Lake Stewardship Society. Many of the sampling devices demonstrated during the field trip are used by LakeKeepers to conduct their studies.

Limnology Basics



The scientific study of lakes is called limnology; this science evolved into a science distinct from oceanography in the past two centuries when improvements in microscopes, the invention of the silk plankton net, and improvements in the thermometer combined to show that lakes are complex ecological systems with distinct structures. Water on the Web[15] is a website that has a complete primer on lake ecology for those who wish to learn more.

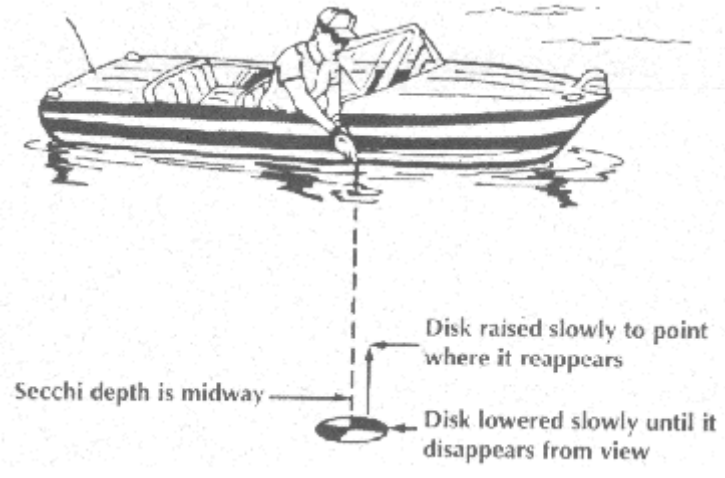
Lakes can be characterized by many physical, biological, and chemical attributes, all of which play a role in determining the productivity and health of a lake ecosystem. This field trip was intended to demonstrate or show some of the tools that can be used to measure these attributes.

Nutrient cycling (whereby nutrients are brought up from the deep by upwelling) in a lake can be restricted by the presence of a thermocline, a transition layer in which the temperature decreases rapidly from the mixed layer above to the much colder deep water layer below. The presence of a pronounced thermocline results in a strongly stratified lake in which the physical, chemical and biological characteristics of water at depth may be vastly different in deep water than compared to the surface. Strongly stratified lakes may also behave in strange and dangerous[16] ways if their permanent stratification is disturbed.

Secchi Disk

In 1865, an Italian scientific advisor to the Pope used a dinner plate on a string to measure the clarity of water in the Mediterranean Sea. Today, the eponymous disk is more generally an 8" metal disk painted with alternating black and white quadrants, but one can easily be constructed for use on a field trip with an ice cream pail lid, a metal washer, and a string marked in one metre intervals attached via the washer to the centre of the lid.

Sampling is generally done at the deepest spot in the lake as determined from a bathymetric map (you can obtain bathymetric maps of BC lakes from the FishWizard[17] website). The Secchi disk is slowly lowered by a person without sunglasses (not like in the cartoon!) on a measuring tape straight down from the shady side of a boat between 10:00 and 14:00 until it disappears from view. Once it disappears, a depth measurement is taken. The disk is slowly pulled back up until it reappears and another depth measurement is taken. The Secchi depth is the average of the two measurements.



Water clarity is indicative of the productivity of fresh water, and is affected by the suspended quantity of phytoplankton (microscopic plants and bacteria), zooplankton (microscopic animals) and sediment (from logging, agriculture and glaciers). Changes in Secchi depths occur over the course of the year due to changes in nutrient levels; as nutrients levels increase, algae blooms will occur, and the Secchi depth decreases.

Secchi depth measurements are repeatable, and can thus be used to compare lake productivity over time or between lakes. A eutrophic lake (one with high productivity) would have a Secchi depth of only 3-4 m. An oligotrophic lake (one with very low productivity) could (in very clear lakes) have a Secchi depth of up to 20 m, and Quesnel Lake's Secchi depth varies from between 8 and 10 m depending on the time of year.

Because this sampling device is inexpensive to make or buy, simple to use, and results in repeatable results, LakeKeepers use Secchi depth measurement as part of their monitoring work. The Great North American Secchi Dip In[18] is a North American event that has LakeKeepers and other volunteers record Secchi depths in North America all at the same time, and provide their data to Kent State University for compiling into maps and charts illustrating changes from region to region or over time.

Zooplankton Net Tow

The zooplankton net tow is like a mesh wind-sock that is used to collect zooplankton, which in turn is used to determine secondary productivity (the rate at which primary (plant and organisms) material is synthesized into animal tissue per unit area in a given time period). A net can inexpensively be made by attaching a pantyhose leg or cone-shaped mesh fabric to a hoop; secure a small glass jar with an elastic into the toe of the mesh "sock". The book "Once Upon a Seashore" also contains instructions for making a plankton net[19].

The zooplankton net is lowered down to a depth of 50 m, and then pulled straight back up, straining all the water in this narrow column.

Zooplankton in lakes usually measure 3-4 mm and live for a 2-3 week cycle. They swim down the water column to seek darkness during the day to avoid being eaten. Common zooplankton include: Daphnia and other cladocerans (can be grown in an aquarium), copepods, and rotifers. *Mysis relicta* (an introduced freshwater shrimp-like animal) competes with small salmonids for zooplankton.

Water Sampler

The water sampler is a bottle open at one end that can be lowered down through the water column to a predetermined depth, and then closed via a "messenger" (a weight that slides down the lowering cable), trapping water from that depth inside the bottle. This trapped water can be brought back up to the surface uncontaminated by water from other depths and used for lab analysis: dissolved O_2, temperature, salinity, conductivity, coliform counts, pH, etc.

A handmade water sampler[20] for community group or student use can be created following the diagram at right or the instructions below. Take an empty champagne or other heavy bottle, its cork and some rope (yes, you must drain the bottle of champagne!). Attach a long string to the cork, which is then inserted into the bottle end. Tie a separate string marked in

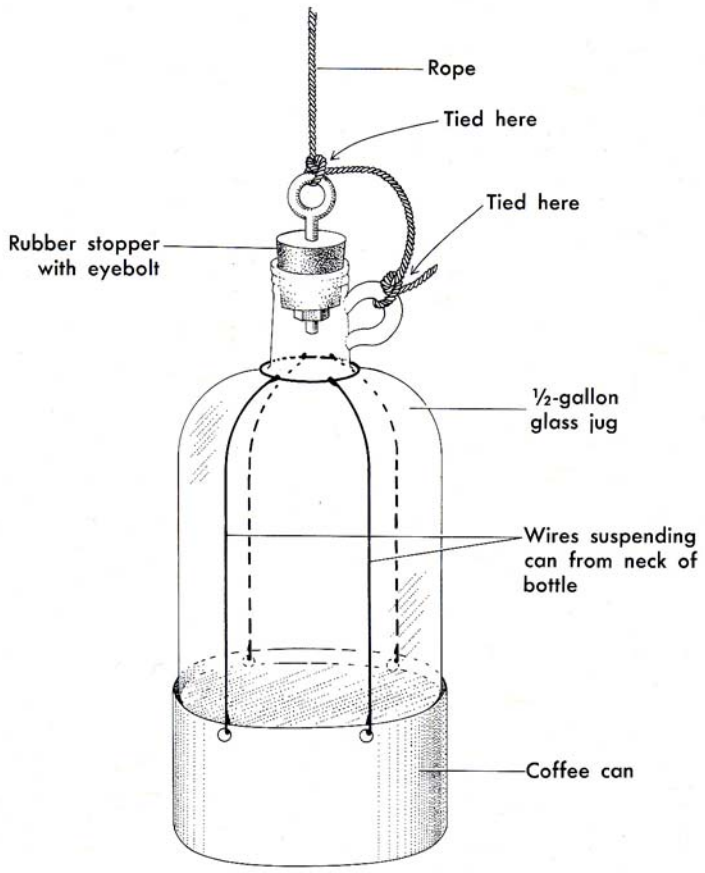


Fig. 9. A simple water sampler of the Meyer type is easily constructed from a weighted bottle. This type of sampler is not suitable for collection of subsurface water for dissolved gas analysis.

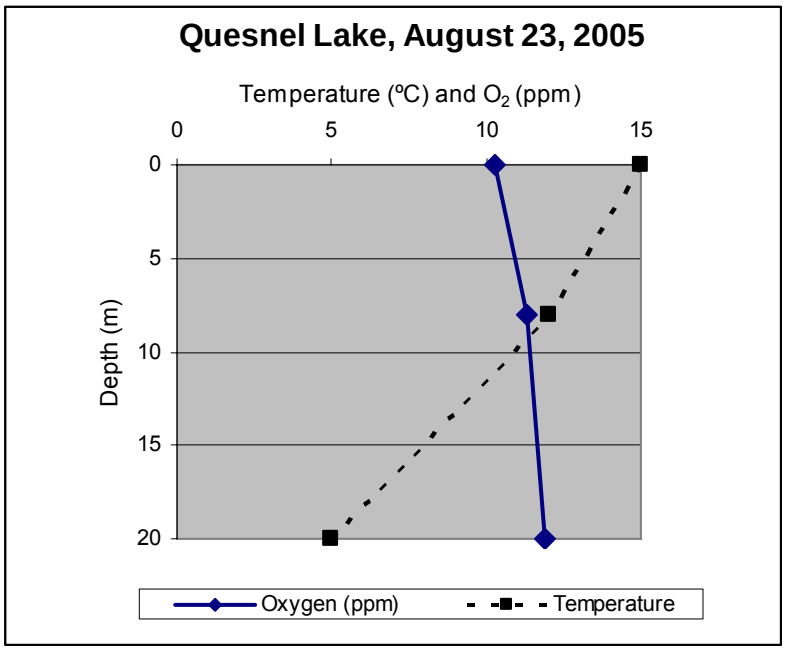
metre intervals around the bottle's neck; you will use this string to lower the bottle, dragging the cork-string with it. Hold the ends of both strings in your hands! Once the bottle is at the required depth (not greater than 25 m), yank on the cork string to release the cork from the bottle, which will then fill with water. Pull the bottle back up to the surface. The water contained within the bottle will be that collected at depth, and will not have intermingled with waters from different depths on the way up.

Multi-parameter Probe

The multi-parameter Probe exhibited during the field trip was made by Hydolab. It can measure dissolved oxygen (O_2), turbidity, temperature, pH, and the electrical conductivity of water at various depths in a water body, identifying stratification based on various characteristics of a lake.

The probe was lowered into the water on a calibrated cable to take various readings at the surface, at 8 m depth, and 20 m depth.

Although the percentage of O_2 in air is 20%, or 200,000 ppm, O_2 concentrations in water are 14 ppm at best. Cold water can hold more O_2. In productive lakes with much oxygen-using bacteria, the bottom layers can be anaerobic.



Corer

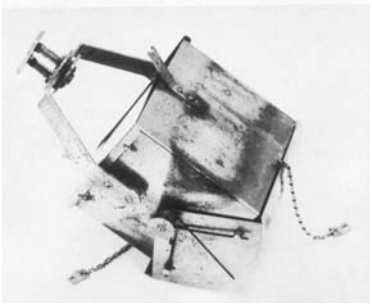
The corer is a long tube that can retrieve a column of lake bottom sediments. A 50cm column may contain a record of 200 years, laid down in annual laminations. By slicing these cores into layers, and analyzing such things as pollen, diatoms, stable isotopes, and chemistry, carbon particles (forest fire indicator) the history of the lake can be reconstructed.

Various isotopes and geological markers may be used to date sediments:

- Cesium-137 (^{137}Cs) is a radioactive isotope produced when uranium and plutonium absorb neutrons and undergo fission; its presence is directly related to the atmospheric testing of nuclear devices during the latter half of the 1950s and early 1960s. Highest concentrations indicate 1962-65.
- Mount Mazama ash is a white volcanic ash (pumice) deposit widely distributed in the northwestern United States and southwestern Canada, released by the eruption of Mount Mazama, the event that produced Crater Lake in Oregon. The eruption is dated at about 6,600 years ago.
- Lead-210 (^{210}Pb) a radioactive isotope created by the radioactive decay of uranium-238 (^{238}U) in sediments and rocks and in the atmosphere. ^{210}Pb takes 7 half-lives or 150 years for to reach near-zero radioactivity. It is the most common way of measuring the age of recent sediments

The bottom of Quesnel Lake in blanketed by about 10 m of sediment; this sediment accumulated at the rate of about 1 mm/year for the last 10,000 years (since glaciers retreated).

Eckman Sampler



The Eckman sampler is a bottom dredge used to grab the soft mud, silt, or sand sediments in lakes or other relatively still bodies of water. It is lowered to the bottom of the water body to collect a sample of the top few centimeters of sediment and whatever bugs may be contained within. The Eckman sampler is set by pulling back each of two spring-loaded scoops on the bottom of the sampler and locking these in the open position. The sampler is lowered on a cable until it rests on the lake floor, then a messenger (or weight) is sent down to cable. This weight releases

the spring-loaded scoops which spring shut, trapping a small sample of sediment. The sampler is then pulled to the surface, and the sample collected into a bucket or sample bag.

The sediment at the bottom of a productive lake may contain thousands of bugs per sample; it is these bugs emerging from the mud that provide food for fish.

Creating a Lesson Plan Linking Marine and Freshwater Environments

While one half of the group was out on the boats, the other half remained on shore at Cedar Point Park to work on creating lesson plan concepts that would exemplify the nutrient cycling knowledge we had learned during the morning. Theresa had previously identified the strongest IRP links between Ken Ashley and Rob Dolighan's topics, and the group set to putting some lesson plan ideas down on paper.

This work has been summarized by Theresa, and will be handed to the LRWG for review and next steps.

Walking the Decision Trail: Mike Tudor

Mike took interested participants on a walk around "The Decision Trail", one of several interpretive trails on the Gavin Lake camp site. During the school year, this trail is generally used by Grade 6 students in groups of 10 who use role playing and discussion to make "decisions" on various forestry-related issues.

Incredible Invertebrates: Shirley Willson

Shirley Willson of Bella Coola and photographer Mike Wigle[21], worked together to create a PowerPoint presentation titled, "Aquatic Insects of Streams and Ponds". Shirley showed this presentation, and put out some of Mike's beautiful posters. Aquatic invertebrates provide a good indication of stream health (in formal monitoring programs, the Benthic Index of Biotic Integrity is used).

The presentation included information on the biology and habitat of Category One (pollution-sensitive), Category Two (somewhat pollution tolerant), and Category Three taxa (pollution-tolerant organisms found in any quality of water). Further information about how to use aquatic invertebrates in your stream studies can be found in StreamKeepers Module 4[22].

Wednesday, August 24

Salt Water Tank in the Cariboo: Beth Collingwood

Beth Collingwood, Education Programmer at the Baker Creek Enhancement Society[23], in Quesnel provided an overview of the saltwater tank they have been operating in the Cariboo.

The Baker Creek Enhancement Society (BCES) is a non-profit organization dedicated to watershed restoration and public environmental education which operates the Nature Education and Resource Centre in Quesnel. Their saltwater tank was acquired through a joint funding proposal to the Pacific Salmon Foundation with Scout Island Nature Centre[24], (Williams Lake) and Spruce City Wildlife Association[25], (Prince George), with matching funds from DFO. The tank is an excellent addition to these programs; it strengthens the link between the Fraser and Quesnel Rivers and the ocean, and helps emphasize the global importance of environmental stewardship.

Students and community groups (Scouts, Guides, Big Brothers/Sisters), preschools, day camps, and drop-in visitors all have opportunities to view and learn from the tank. The saltwater tank is used to provide experience-based learning within the BC school curriculum that teachers would not be able to provide on their own, such as:

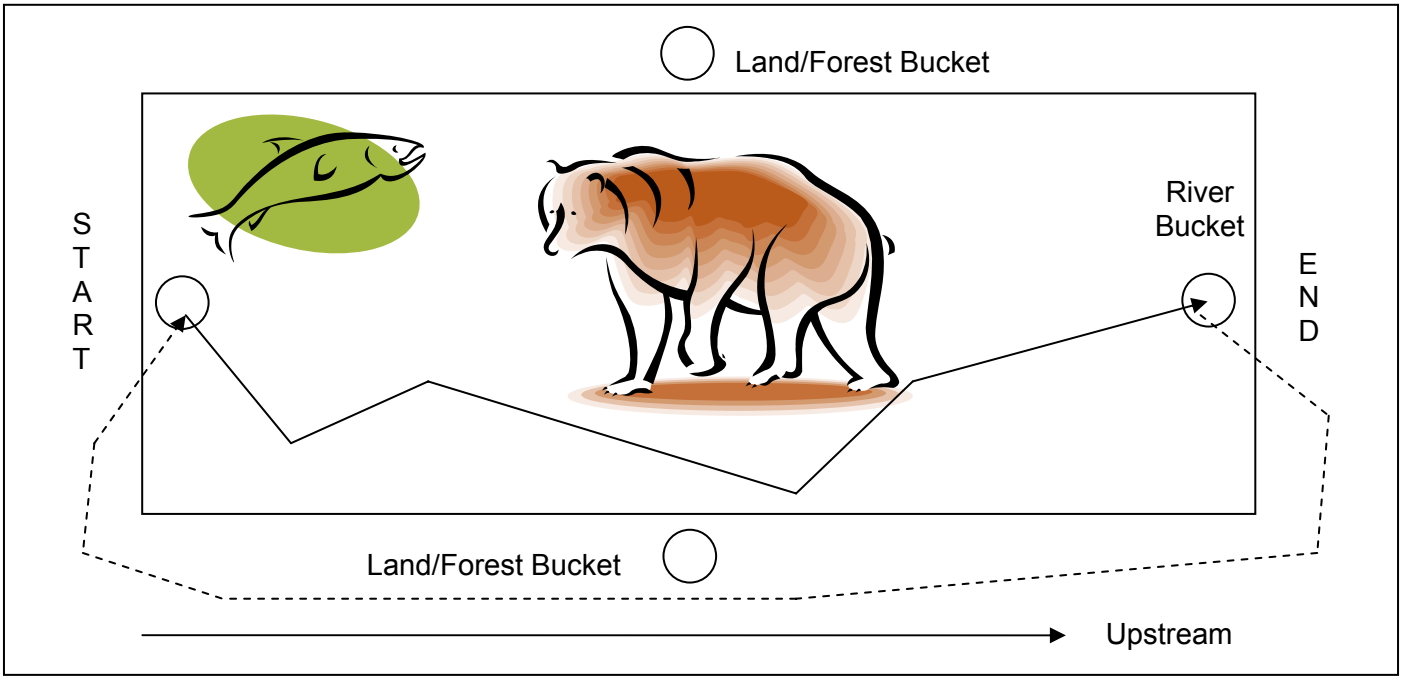
- comparing saltwater and freshwater ecosystems,
- adaptations of organisms,
- classification of organisms (from primary to secondary classes),
- watershed connections, water cycle, salmon migration.

Participants learn about marine organisms and their habitat by using these activities and resources:

- touching, feeding and observing the creatures and making comparisons to a freshwater tank,
- field guides, CD slide show of creatures in tank, vocabulary cards
- BCTF Stream to Sea lesson aids (Once Upon a Seashore, Ocean Animals Clue Cards…)
- Incredible Invertebrates[26], box that travels with tank (items, cards, worksheets) created by Jackie Hildering. Refer to Jackie's database of marine mammal links[27].
- Project WILD freshwater-ocean connections activities
- Bowie Seamount pilot Marine Protected Area[28], resources (CD, movies, posters, brochures, draft management plan)
- Picture books, sand box and matching cards are used by younger kids.

Student Activity: The Salmon Bear Forest Game

Josina Davis led the group in an energizing outdoor activity that allows participants to burn off steam while learning where spawning salmons' nutrients end up in the ecosystem. This activity was adapted from the game developed by Julie Towers and Josina Davis for the "Watershed and Fisheries Grade 4-7 Curriculum Package" by the Haida Gwaii Marine Resources Group Association. This resource will be posted on the SMRFA[29] website. An excellent book for learning more on this topic is: Salmon Forest,[30] By David Suzuki and Sarah Ellis



Materials

- Two 50 metre ropes or flagging tape: river boundaries
- 50-100 small objects (poker chips, stones, bottle caps, etc.): energy/nutrient tokens
- Four buckets: energy/nutrient token receptacles

Set-up

Set out "river" using flagging tape or rope creating a rectangular space about 50m long and 10-20m wide; the space between the ropes will be water; the sidelines will be terrestrial habitat, or forest. Place a bucket

containing the collection of small objects at one end of the rectangle, and an empty bucket at the other end. Place one empty bucket on each side of the rectangle ("on land"). Select 2 to 4 students to be "bears"; these bears will place themselves in the "river". The remaining students will be "salmon".

Play

The object of the game is to see how many salmon can transfer their nutrient/energy tokens upstream, while the bears try to obtain nutrient/energy tokens for themselves and the forest.

The salmon each pick up one energy token and "swim" (run) up the river to place their energy token in the container at the opposite end. Meanwhile, the bears try to tag the swimming salmon; once a salmon is tagged, the bear takes its energy token and places it in one of the containers on land. Once a salmon either relinquishes its token to a bear, or deposits its token at the upstream end of the river, the salmon returns back to the start (outside the river boundaries to avoid collisions) to try again with another token. Only one token can be taken at a time, but a salmon can "swim upstream" as many times as it is able until all the downstream tokens are used up.

Conclusion

Count up the tokens in each bucket at the end: were there more tokens in the river or on the land? Who wins? (Everyone. If the token stays in the river it becomes food for salmon larvae and for aquatic insects. If the token moves into the forest it becomes food for birds, terrestrial insects and trees.) Have a discussion after the game: Introduce the concepts of Nitrogen and Phosphorous, the nutrient cycle and food webs. What is a simulation game? Why did we play it? Where do most of the nutrients and energy from salmon end up? What other animals (including people) want to use the salmons' nutrients and energy? What happens if there are not enough salmon? What happens if there are more predators?

Adjourn

The community partners departed after breakfast on Tuesday August 23, 2005.

Suggested Reading And References

This section contains a list of all the books, web sites, educational tools, wacky facts, and organizations that were referenced during the Workshop.

---

[1] **Biogeoclimatic zones and Trees of British Columbia** www.for.gov.bc.ca/hfd/library/documents/treebook

The BC Ministry of Forests and Range provides an online map of the BC biogeoclimatic zones with information on the ecology of each one. The Ministry also offers for download or for sale ($6) the "Tree Book: Learning to Recognize Trees of British Columbia".

[2] **Interactive Cross-Section of Interior Plateau Biogeoclimatic Zones** www.selkirk.ca/rr/bec/zones/xsections.html

This interactive tool from Selkirk College allows you to test your new knowledge of the biogeoclimatic zones from Williams Lake up and east to the Cariboo Mountains.

[3] **Secwepemc First Nation** www.secwepemc.org www.landoftheshuswap.com

These two websites of the Secwepemc (also known as Shuswap) First Nation has information about its 17 bands and their traditional territory, culture, languages, legends, and history, as well as current education and language-documentation initiatives.

[4] **"Becoming a Sustainable Species"** (2000), Pille Bunnell and Nicholas Sonntag. Reflections: Journal of the Society for Organizational Learning. 1(4): 66-70. www.solonline.org

[5] **Periodic Table** www.chemicalelements.com

A user-friendly web-based periodic table created and maintained by a high school student.

[6] **Coming of Age of the Milky Way**, Timothy Ferris (2003), Harper Perennial.
ISBN: 0060535954

"How the human species slowly awakened to the vast reaches of space and time is the story absorbingly told by popular science writer Ferris. His narrative humanizes the scientific enterprise. Although it covers well-trod ground,

this remarkable synthesis makes broad areas of science accessible to the layperson, from Darwin's and Lyell's investigations of the age of the earth to modern physicists' quest for a perfectly symmetrical, hyperdimensional universe." (1988 Reed Business Information, Inc.)

[7] **Tom Reimchen Salmon Forest Project** http://web.uvic.ca/~reimlab/salmonforest.html

This research group has observed that black bears and grizzly bears throughout the British Columbia coast transfer large quantities of salmon carcasses from rivers into forests and these nutrients are incorporated into a broad diversity of plant and animal taxa. They are using N and C isotopes to quantify the uptake of salmon-derived nutrients by mosses, herbs, shrubs, trees, insects, songbirds, bears and wolves.

[8] **"Pacific Salmon and Wildlife: Ecological Contexts, Relationships, and Implications for Management"**. C. Jeff Cederholm, Washington Department of Fish and Wildlife, Habitat Program, 2000. Special Edition Technical Report. Downloadable as a .PDF document from wdfw.wa.gov/hab/salmonwild/

This updated Technical Report integrates information on the ecology and management of species in terrestrial, freshwater, and marine environs, and synthesizes fundamental information linking salmon with wildlife species and the broader aquatic and terrestrial realms. This scientifically-robust report greatly strengthens our collective understanding of the role that salmon play in the populations of Pacific Northwest wildlife species, the ecology of freshwater ecosystems, and how management activities such as hatcheries and harvest can impact these aspects. This document contains "Figure 5", reproduced in this workshop summary.

[9] **Pacific Salmon Bring it All Back Home**, Sharon Levy (1997). BioScience 47(10), pp. 657 - 660.

This popular science article summarizes the work of Jeff Cederholm and his associates. It is available in hard copy by contacting Elizabeth Leboe (604) 666-8515.

[10] **The British Columbia Lake fertilization program: overview after two decades of salmon enhancement**, Stockner, J.G., and E.A. MacIsaac. 1996. Regulated Rivers: Research and Management. 12: 344-356.

An article entitled "Salmon Nutrients: Closing the Cycle" by J. Stockner and Ken Ashley (American Fisheries Society Symposium 34: 3-15, 2003) is available in hard copy from Elizabeth Leboe (604) 666-8515.

[11] **Peak Oil** www.peakoil.net www.peakoil.org www.peakoil.com

All of these web sites discuss the concept of peak oil, and links to personal and political action that you can take to plan for a world of declining oil production and availability.

[12] **Fisheries productivity in the northeast Pacific Ocean over the past 2200 years**, Bruce Finney et al. (2002) Nature 416(6882): 729-733. www.nature.com

This article was published in the April 18, 2002 issue of Nature, and summarized in the April 18, 2002 edition of the Vancouver Sun. "Historical catch records suggest that climatic variability has had basin-wide effects on the northern Pacific and its fish populations, such as salmon, sardines and anchovies. However, these records are too short to define the nature and frequency of patterns. We reconstructed ~2,200-year records of sockeye salmon abundance from sediment cores obtained from salmon nursery lakes on Kodiak island, Alaska. Large shifts in abundance, which far exceed the decadal-scale variability recorded during the past 300 years, occurred over the past two millennia. A marked, multi-centennial decline in Alaskan sockeye salmon was apparent from ~100 BC to AD 800, but salmon were consistently more abundant from AD 1200 to 1900. The coherent patterns observed across large regions demonstrate the strong role of climatic forcing in regulating northeastern Pacific fish stocks."

[13] **Quesnel Lake Fish Interaction Workshop, September 28-29, 2004**

This interagency workshop was designed to discuss fish issues on Quesnel Lake, reviewing status of kokanee, rainbow trout, lake char, and sockeye salmon populations, and impacts that changing stock statuses may have on other species. A summary report of this workshop was authored by H. Andrusak and R. Dolighan (Fisheries Project Report No. RD 110 2004), and a limited number is available upon request from Elizabeth Leboe (604) 666-8515.

[14] **"LakeKeepers" and the BC Lake stewardship Society** www.bclss.org/lakekeepers.html

The LakeKeepers manual is a guide to the stewardship and monitoring of lakes, and is available for sale. It is useful and informative for for anyone concerned or curious about BC lakes. The manual provides insight to the fascinating nature of lakes, and helps readers understand basic lake function. This is especially important for individuals who wish to play an active role in managing the health of those lakes in which they are interested.

[15] **Water on the Web** http://watersontheweb.org/under/lakeecology/index.html

WOW. 2004. Water on the Web - Monitoring Minnesota Lakes on the Internet and Training Water Science Technicians for the Future - A National On-line Curriculum using Advanced Technologies and Real-Time Data,

supported by University of Minnesota Duluth and Lake Superior College. The primary goal of Water on the Web is to train high school and first year college students to understand and solve real-world environmental problems using two sets of curricula (Basic Science and Water Science). This web site contains lucid explanations of the physical, biological, and chemical aspects of lakes.

[16] **Limnic Eruptions (or Exploding Lakes)**

If water at depth contains high concentrations of dissolved carbon dioxide (CO_2) like soda pop in a can, a strange and potentially catastrophic event called a limnic eruption can occur should the lake waters turn over due to volcanic or landslide activity. A cloud of released CO_2 can smother all lakeside life.

Only two known and observed limnic eruptions have been identified with certainty: in 1984, Lake Monoun in Cameroon overturned, killing 37 people; and more catastrophically in 1986, nearby Lake Nyos. At Lake Nyos, over 80 million cubic meters of CO_2 was released from the lake depths into the atmosphere, killing between 1700 and 1800 people, as well as wildlife and livestock.

Through scientific investigations, Lake Kivu, on the border of the Democratic Republic of Congo and Rwanda, is suspected of periodic massive biological extinction about every 1,000 years or so. The trigger for lake overturns in Lake Kivu's case is unknown but this lake contains dissolved methane (CH_4) and CO_2 at depth and is permanently stratified. Volcanic activitiy can heat water at depth, forcing CH_4 out of the water, sparking an explosion, and triggering a near-simultaneous release of CO_2. The results of a Lake Kivu overturn would be catastrophic since approximately 2 million people live in the lake basin. Creatively, the Bralirwa brewery near Goma is siphoning methane out of the lake to power their plant; the quanitities of CH_4 remain mainly untapped and potentially dangerous.

[17] **Fish Wizard** www.fishwizard.com

You can use the Fish Wizard web site to create maps, view reports and find the most recent information about British Columbia's lakes, rivers and streams.

[18] **The Great North American Secchi Dip-In** dipin.kent.edu/index.htm

The Dip-In is a demonstration of the potential of volunteer monitors to gather environmentally important information on our lakes, rivers and estuaries. On one day during the weeks surrounding Canada Day and July Fourth, individuals in volunteer freshwater monitoring programs take a transparency measurement. These transparency values are used to assess the transparency of volunteer-monitored lakes in the United States and Canada. The goal of the Dip-In is to increase the number and interest of volunteers in environmental monitoring, and to provide a national perspective of water quality, both regionally and over time.

[19] **Once Upon a Seashore**, Gloria Sniveley, 2001, Kingfisher Press
ISBN: 0-9687811-0-1

“Once Upon a Seashore: a curriculum for Grades K-6” is by Gloria Snively, and is available through the BCTF lesson aids catalogue www.bctf.ca/LessonAids in the Salmonids go the Ocean section (catalogue number S65). Instructions for making a plankton net are on page 302.

[20] **Handbook of Common Methods in Limnology**, Owen T Lind, 2nd edition 1979, CV Mosby Co.
ISBN 0-8016-3019-3

This handbook is the source of the “home-made water sampler” diagram.

[21] **Mike Wigle’s Jumping Mouse Studio** www.jumpingmousestudio.com

Mike Wigle created the PowerPoint presentation that Shirley showed, as well as the beautiful posters of aquatic invertebrates. He can be contacted by email at jumpingmouse@belco.bc.ca or by phone at (250) 982-2463.

[22] **StreamKeepers Modules** http://www.pskf.ca/publications/download.html

The Streamkeepers Handbook and Modules is designed as an easy to use resource for getting actively involved in your local stream and, is part of the Stewardship Series. It will help you discover and monitor the health of your stream, undertake restoration projects, and includes information about: Streamkeeper Programs; Project Modules for Streams; Watershed Ecology; Home Tips for Clean Streams.

[23] **Baker Creek Enhancement Society**

410 Kinchant Street Quesnel, B.C. V2J 7J5 (250) 992-5833 Fax: (250) 992-5010 bces@telus.net Contact: Beth Collingwood or Tracey Bond.

[24] **Scout Island Nature Centre**

The Scout Island Nature Centre's vision is to: conserve the Nature Centre's wildlife habitat, vegetation and other natural values; offer nature education and interpretation; and provide a relatively secluded, natural place for wildlife and plant viewing, facilitated by a system of walking trails. 1305A Borland Road, Williams Lake BC V2G 5K5 (250) 398-8532 Contact: Sue Hemphill.

[25] **Spruce City Wildlife Association** www.scwa.bc.ca

The Spruce City Wildlife Association (SCWA) is a local non-profit organization that is made up of families, individuals, and corporations in Prince George who are especially concerned about public involvement in local environment and conservation matters. Phone (250)-563-5437 Contact: Cathy Solmonson.

[26] **Incredible Invertebrates Treasure Box**

The "Incredible Invertebrates Treasure Box" is aimed at inspiring interest, wonder and respect for marine invertebrates, their adaptations and their role within the aquatic ecosystem. This Treasure Box is a hands-on resource that uses 20 marine invertebrate artefacts and question cards to guide students through reflection on food chain dynamics, classification, harvesting, cultural uses, evolution, the impact of introduced species and the perfection of design. Artefacts include a crab moult, octopus beak, bull kelp holdfast and a wide variety of shells. Two resource books are included. Cost is $550 + GST & shipping and handling. Contact Jackie Hildering for more information or to order by email at earthlingenterprises@telus.net or by phone at (250) 956-3525.

[27] **Database of marine mammal links** www3.telus.net/public/a6h4z2/schools%20page.htm

This web page, compiled by Jackie Hildering, contains links to more information about marine mammal species interactive marine-themed web pages.

[28] **Bowie Seamount Marine Protected Area** www.pac.dfo-mpo.gc.ca/oceans/mpa/bowie_e.htm

The Minister of Fisheries and Oceans Canada announced Bowie Seamount as a Pilot Marine Protected Area in December, 1998. Information and links on this topic can be found on the DFO website.

[29] **South Moresby Forest Replacement Account** www.smfra.ca

The South Moresby Forest Replacement Account (SMFRA) was created in 1988 following the creation of Gwaii Haanas National Park Reserve and Haida Heritage Site. The Account mitigates the impacts of loss in timber supply and forest-based employment resulting from the creation of Gwaii Haanas by developing employment opportunities in sustainable forest management, research, education and training.

[30] **Salmon Forest**, David Suzuki and Sarah Ellis, 2003 Greystone Books.
ISBN: 1550549375

In clear, kid-friendly language, this book discusses how the salmon and the forest ecosystem form an intricate web of dependency. This book evokes the spirit and mystery of the West Coast rain forest. Suitable for early-elementary science units.