Adapting to Climate Change in the Coastal Pacific Northwest:

Challenges for Ecosystems, Communities, Industries and Institutions

Victoria Conference Centre
Victoria, BC

May 23, 2003

Sponsored by:
Air & Waste Management Association

in co-operation with:

Capital Regional District of Victoria (CRD)

BC Ministry of Water, Land and Air Protection

Canadian Climate Impacts & Adaptation Research Network (C-IARN)

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Introduction

The May 2003 Conference, **"ADAPTING TO CLIMATE CHANGE IN THE COASTAL PACIFIC NORTHWEST: Challenges for ecosystems, communities, industries, and institutions"** was sponsored by the following four organizations.

The **Air & Waste Management Association** (A&WMA) is a nonprofit, nonpartisan professional organization that provides training, information, and networking opportunities to more than 9000 environmental professionals in 65 countries. The Association's goals are to strengthen the environmental profession, expand scientific and technological responses to environmental concerns, and assist professionals in critical environmental decision making to benefit society. The Pacific Northwest International Section of the A&WMA acts as a catalyst for environmental leadership by providing a neutral forum for discussion, education, and networking on technical issues relating to environmental management in the U.S. Pacific Northwest and Western Canada. For more information see: http://www.pnwis.org.

The **BC Ministry of Water, Land and Air Protection**, through the Water, Air and Climate Change Branch, has a mandate to develop and implement – in partnership with other provincial agencies – a climate change action plan for British Columbia that includes both measures to reduce greenhouse gas emissions, and measures to support effective adaptation. For more information see: http://wlapwww.gov.bc.ca/air/climate/index.html.

The **Canadian Climate Impacts and Adaptation Research Network** (**C-CIARN**) is a national network that facilitates the generation of new climate change knowledge by bringing researchers together with decision-makers from industry, government, and non-government organizations to address key issues. C-CIARN regions and sectors work together to increase their understanding of climate change, impacts and adaptation, identify knowledge gaps, and define research priorities. Adaptation options are needed to help predict and manage for changes that are expected during the 21st century across many regions, communities and ecosystems. C-CIARN is a critical component of Canada's national climate change strategy. C-CIARN provides a collective voice for this community to:

- improve our knowledge of Canada's vulnerabilities to climate change;
- identify ways to minimize the negative effects of future impacts; and
- explore opportunities that take advantage of any positive impacts.

For more information see: http://www.fishclimate.ca , http://britishcolumbia.c-ciarn.ca/ and http://www.c-ciarn.ca

Capital Regional District (CRD), Environmental Services is responsible for administering waste management, air quality management, building inspection, environmental education and communications services for the region. Services include sewage, septage and solid waste disposal, waste reduction and recycling and environmental education. The department also provides, under contract to CRD Water, bulk water to the Saanich Peninsula and provides sewage collection, treatment and disposal, and water treatment and supply for Port Renfrew and some communities on Salt Spring Island and in the Southern Gulf Islands. For more information see: http://www.crd.bc.ca/es.

These organizations came together with a common goal to help initiate discussion and planning on impact and adaptation responses of resources and sectors to climate change in the Pacific NW.

Climate change has recently gained world wide attention from the related impacts of storms, drought, fires and other climate extremes. Our science supports the hypothesis that the accelerated rate of climate variation and change and the frequency of climate extremes are associated with anthropogenic activities producing accumulated greenhouse gases (IPCC 2001). Human industrial development, resource and land use have modified the earth's surface and led to increased concentrations of atmospheric greenhouse gases such that global surface temperatures have increased on average 0.6 ± 0.2°C within the last century. Global Climate Models predict that global surface air temperature will increase on average by 1.3 to 5.8°C to 2100 relative to 1990 and that sea level will rise 0.09 to 0.88m.

Many countries have adopted the Kyoto Protocol to mitigate and reduce greenhouse gas emissions. While mitigation will be important, it can only slow the rate of greenhouse gases accumulation, but will not alter impacts on the most sensitive portions of ecosystems including species biodiversity and species at risk. Social adaptation through landscape and ecosystem based management can be used to help ameliorate the affects of climate change. Adaptation science and research will help identify anticipatory approaches for sustainable use and development of ecosystems and their component species and habitats. Recognizing the need to improve our knowledge of climate change impacts and adaptation, the workshop on "**Adapting to Climate Change in the Coastal Pacific Northwest:** Challenges for Ecosystems, Communities, Industries and Institutions" has been developed to provide a balance of existing and future research on the issues of climate change.

The May 23, 2003 conference ***"Adapting to Climate Change in the Coastal Pacific Northwest: Challenges for ecosystems, communities, industries, and institutions"*** was designed to address the past and projected future impacts of climate change, and the ways in which coastal communities and resource managers can prepare and adapt.

ADAPTING TO CLIMATE CHANGE IN THE COASTAL PACIFIC NORTHWEST:

Challenges for ecosystems, communities, industries, and institutions

Victoria, B.C.
Friday, May 23, 2003

8h30	**Welcome and Opening Remarks** Judy Brownoff, Chair, Capital Regional District
8h45	**Climate Change in the Pacific Northwest** Climate Trends in BC, Canada, and the World *Bill Taylor, Environment Canada* Impacts of Climate Change in the Pacific Northwest *Philip Mote, Climate Impacts Group, University of Washington*
10h00	**Break**
10h30	**Impacts and Adaptation – Approaches and Case Studies** Adapting to Climate Change: An Overview *Jenny Fraser, BC Ministry of Water, Land and Air Protection* Climate Change and Forest Ecosystems in Coastal BC *Dave Spittlehouse, BC Ministry of Forests* Case Study: The Somass River Fishery *Kim Hyatt, Canadian Climate Impacts and Adaptation Research Network – Fisheries Sector*
12h00	**Lunch – Saanich Room**
Session A – Oak Bay Room 1 Marine Ecosystems and Fisheries	Ocean Temperature and Sea Level Changes in Coastal British Columbia *- Bill Crawford, Fisheries and Oceans Canada* Climate Variability and Salmon Production *- Nathan Mantua, Climate Impacts Group, University of Washington* Adaptation to Climate Change in Coastal Fisheries *- Mark Johannes, C-CIARN Fisheries Sector*
Session B – Oak Bay Room 2 Communities and Infrastructure	Climate Change Adaptation and Regional Planning: Experience from the GVRD *- Jennie Moore, Greater Vancouver Regional District* Impacts of Sea Level Rise on Coastal Communities: A Collaborative Approach *- David Mate, Geological Survey of Canada* Challenges in Sustaining Quantity and Quality of Drinking Water Under Extreme Climate Variability: Sooke Watershed as a Case Study *- Asit Mazumder, University of Victoria*
Session C – Esquimalt Room Economic and Social Issues	Adaptive Responses to Climate Change in Communities and Institutions *- Erik Karlsen, CIP, Professional Planner* Social Issues and Challenges in Resource-Based Communities *- Holly Dolan, University of Victoria* Coastal Forest Industry Perspectives on Climate Change *- Shannon Janzen, Western Forest Products Ltd.*

Welcome and Opening Remarks

Judy Brownoff
Chair, Capital Regional District

Good morning and welcome to the conference.

At the forefront of both this conference and the mandate of local governments, is the issue of climate change. We are here today as individuals, government and industry to challenge and develop adaptation measures to evoke positive change.

We see the early impacts climate change is having on our physical and biological systems. We see that these changes will challenge how we do business, live, and prepare for generations to come.

We see there is a lot of work to be done.

Consider these figures:

- In the Capital Regional District, we spend millions of dollars each year managing our solid and liquid waste

- Yet when it comes to addressing climate change issues we have approximately $100,000 for air quality monitoring and NO budget for the management of air quality or green house gas emissions.

This is where we at the CRD can make a difference.

In June it is being recommended to our Environment Committee, that the CRD take on a coordinating role for Green House Gas issues in our region. I hope to obtain approval to establish a Green House Gas inventory, establish reduction targets, and work with municipal governments for progressive change in an uncertain future.

Up to half of Canada's green house gas emissions are under control or influence of municipal governments. This is why the CRD recognizes that governments at a municipal level have the ability to contribute significantly to the reduction of green house gases.

In addition to this proposal to further reduce green house gases in the Capital Region, the CRD has hired an Energy Manager, in partnership with BC Hydro. The manager will coordinate energy audits of CRD and local municipal government buildings. This will prove integral in developing a model municipal energy reduction program.

The CRD has also recently introduced a first-rate gas collection and flaring system at Hartland Landfill to generate electricity from landfill gas.

BUT we can do more.

I am very pleased to see you all here today, to engage yourself in making a difference. This forum encourages communication, idea sharing and hopefully will culminate in recommending the actions that are required to make a change.

When participating in the three excellent sessions this afternoon, I ask you to find measures we can introduce to benefit our local organizations, communities and environment. I don't expect a global solution to climate change to come from these sessions, but I do hope that collaborative ideas and recommendations will come from them -- ideas that we at the CRD, and our member municipalities, can act on.

I propose that those ideas and recommendations be forwarded to our CRD Environment Committee for further discussion and consideration.

The Board, the Environmental Services staff, and I are committed to protecting human health and environment for our residents. Your being here today shows your commitment.

Together, I am confident we can develop a plan to Adapt to Climate Change in our beautiful Coastal communities of the Pacific Northwest.

Thank you.

Climate Change in the Pacific Northwest

Climate Trends in BC, Canada, and the World

Bill Taylor
Environment Canada

Global climate is changing, and changing very rapidly. While the reasons for that are complex, most scientists agree that the accumulation of greenhouse gases in the atmosphere over the last 150 years or so has contributed in a significant way to that warming and that humans are partially responsible for that.

The material used in this presentation comes largely from the *Third Assessment Report*, published in 2001 by the Intergovernmental Panel on Climate Change (IPCC), an international panel of experts formed under the auspices of the United Nations and the World Meteorological Organization to reach consensus on the science of climate change. The IPCC is recognized as the most credible source for scientific information on climate change.

Evidence of climate change: Is the climate changing?

Accurate global temperature records from thermometers are available for about the past 140 years comprising what is known as the instrumental record. To get an idea of a longer temperature record, proxy data from ice cores, coral, and tree rings are used.

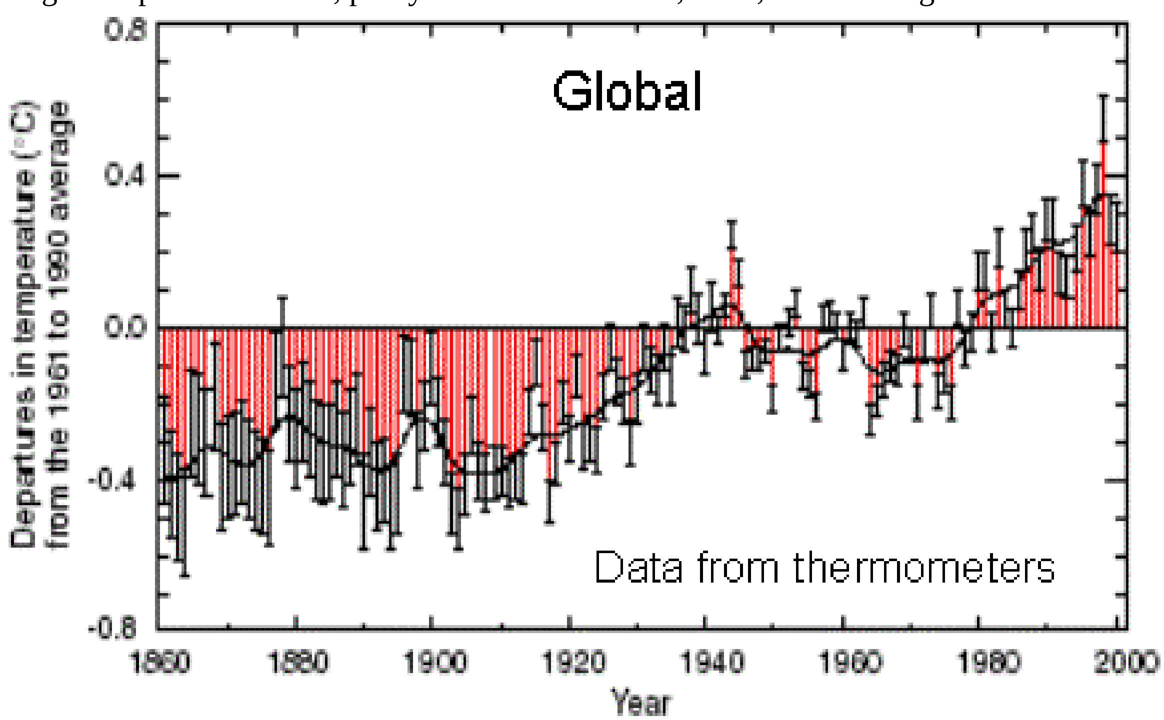


Figure 1 Variation in the Earth's Surface Temperature for the Past 140 Years

Source: Intergovernmental Panel on Climate Change, Third Assessment Report, 2001

These proxy data have in common an annual layer of growth dependent on climate (e.g., tree rings) that allows researchers to deduce temperatures.
The chart shown above (see Figure 1) shows annual temperature departures from the 1961-90 reference period for the past 140 years. While there is considerable year to year variability, there is also evidence of a gradual warming trend. The 1990s were the warmest decade on record and 1998 is the warmest year. The amount of warming, a 0.6°C rise during the 20th century, may seem like a very small amount but nonetheless it is quite significant in terms of the rate of warming. For example, a recent Stanford University study detailed the kind of impacts that a small change in temperature can have in such things as the timing of blooming dates, egg laying, nesting behaviour, and also a change in the range of many species. Scientists have termed these impacts on the natural environment the "fingerprint of climate change," and the study shows that warming has had a very large impact already. The warming also has not been uniform. There were two periods of warming from 1910 to 1940 and from 1975 to 2000, and there appears to be a slight cooling trend between 1940 and 1975.

The question we're trying to answer is "Is 20th century warming unusual?" To determine that, we have to go back and look at some longer time periods, and this is where the proxy data comes into play. A graph of temperatures for the past 1,000 years (see figure 2) was reconstructed from proxy data from tree rings, ice cores, and coral. The graph shows that temperatures became gradually cooler over the 900-year period from 1000-1900 AD, while 20th century temperatures rose dramatically and are a clear departure from that trend. This graph has often been described as a hockey stick for obvious reasons.

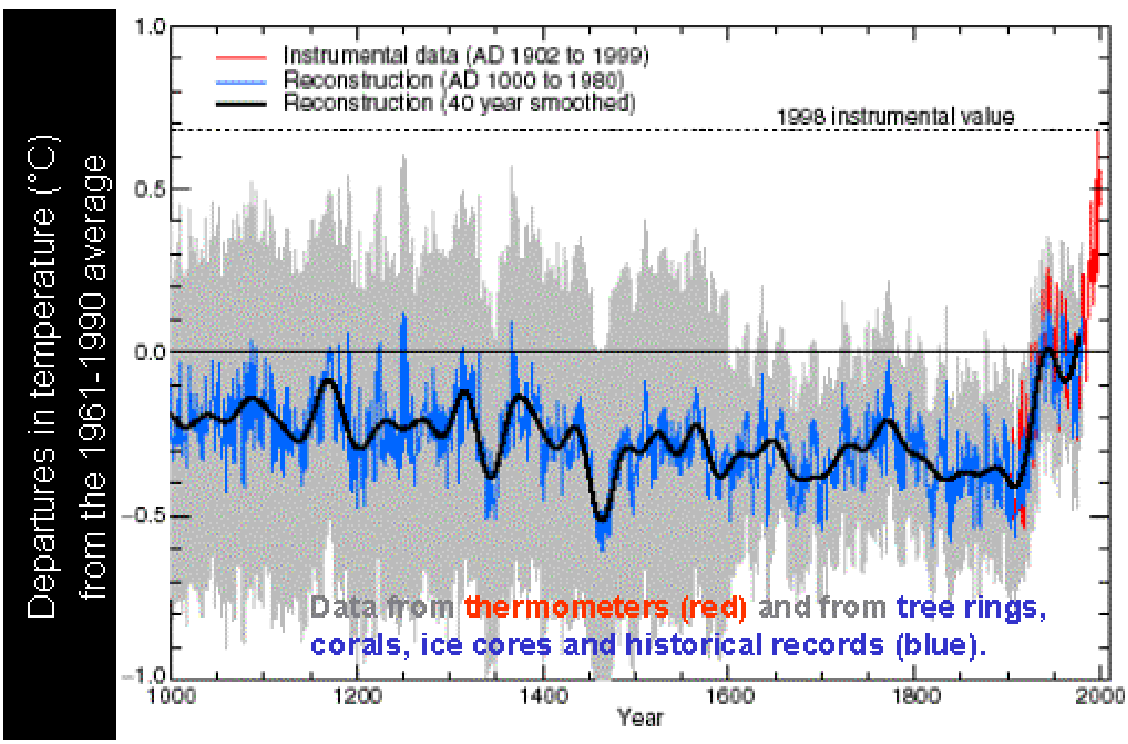
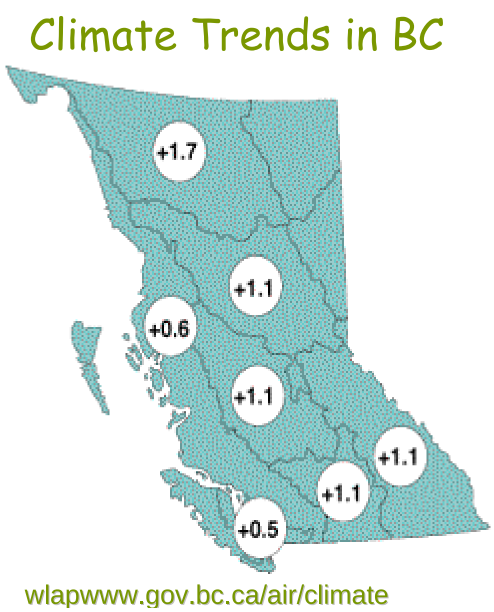


Figure 2: Variations in the Earth's surface temperature for the past 1000 years (N. Hemisphere)
Source: Intergovernmental Panel on Climate Change, Third Assessment Report, 2001

Temperature trends in Canada are similar but it has warmed quite a bit more in Canada than globally. A chart of Southern Canadian temperatures since 1900 is similar to the global trend with two periods of warming separated by a period of slight cooling. Southern Canada is separated from the whole of Canada because a climate observation network did not exist in the North until the 1940s. Southern Canada has warmed 0.9°C versus a global warming of 0.6°C over the past century.

Looking at regional temperatures from 1950-1998 (actually a very short period), the whole of Western Canada shows quite significant warming— it is more than 2°C warmer in BC and the Yukon— but in North-eastern Canada (Labrador Sea) there has been significant cooling. This regional pattern is consistent with hemispheric-scale changes in the circulation of the ocean and the atmosphere that have occurred over the same period.

Looking at trends in daily minimum temperatures, the greatest warming over the past 50 years has been in the winter and spring (about 3°C). There is also a slight warming in summer, and for a large part of the country fall has seen a cooling trend. When we talk about warming, it is not happening uniformly over the globe and it is not happening uniformly in time. There are both regional and seasonal differences in the temperature trends.



Temperature trends in BC reveal that the interior of BC warmed 1.1°C during the 20th century, with warming more modest on the coast (0.5°C) because of the moderating influence of the oceans, and greater (1.7°C) in the far north of BC. The other interesting aspect of these trends is that the nighttime minimum temperatures are rising faster than daytime maximum temperatures. For most of BC there is no significant trend in daytime maximum temperatures, whereas all parts of BC show a significant increase in nighttime minimum temperatures ranging from 0.9°C along the coast to 2.1°C in the north.

Figure 3: Climate trends in BC: Change in temperature over 20th century

Source: BC Ministry of Water, Land and Air Protection – Environmental Trends, 2000

If we want to look for evidence of climate change in the environment to corroborate the temperature record, there's probably no better example than what is happening with glaciers. Wedgemont Glacier in south-western BC has lost a huge amount of mass in the past 20 years. This is very consistent with an IPCC chart showing glacier loss in other parts of the world. There are some places in the world, including some places in BC, where glaciers are actually increasing but generally speaking there is a loss or retreat.

In summary, the world has warmed by 0.6°C, while Canada has warmed by 0.9°C over the 20th century. Canada is generally "less cold" since temperature increases are mainly in winter and spring, and also because nighttime minimum temperatures are rising faster than daytime maximum temperatures. Canada also is wetter, and there have been changes in the "snowfraction," with a higher percentage of precipitation falling as rain in spring. There are also large regional and large seasonal differences in the rate of climate change.

Attribution: Why is the climate changing?

Over very large time scales, the climate responds in a very profound way to changes in the Earth's orbit, but those changes really aren't evident over the short term. We can divide the causes of 20th century climate change into two categories:

- natural forcing factors, including variations in the sun's output, volcanic eruptions, and internal variability (El Niño – Southern Oscillation, the Pacific Decadal Oscillation, etc.);
- human factors including greenhouse gases, aerosols (air pollution that actually has a cooling effect), ozone depletion (ozone is a greenhouse gas), and land use change.

These factors are all affecting climate change, often at the same time. That is why it is difficult to point to a single cause or provide a simple explanation for changes in the temperature record.

In the atmospheric energy budget, about 31% of incoming solar radiation (short wave) is reflected back into space and the rest goes into heating the earth and driving ocean currents and atmospheric circulation. Earth itself radiates its own form of energy at longer wavelengths than the incoming solar radiation. In the end, the amount of radiation going out has to equal that coming in; otherwise the temperature of the Earth would rise continuously. It just so happens that greenhouse gases are very efficient at absorbing the long wave radiation the Earth emits. On its way out to space, some of the long wave radiation gets trapped by greenhouse gases and radiated back to the surface, and the surface warms up as a result. This is actually a very good thing, because without greenhouse gases Earth would be about -18°C, or 33°C cooler than it is at present. The greenhouse effect is necessary to support life on earth.

The three most abundant greenhouse gases are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). These three, along with three other greenhouse gases, are being targeted for reduction under the Kyoto Protocol. Despite their low concentration, less than 0.1% in the atmosphere, these greenhouse gases play a significant role in the Earth's energy budget. The one that gets the most attention is CO_2, because it is the most abundant. Recent increases in CO_2 are due to burning fossil fuels, a primary source of energy for the world.

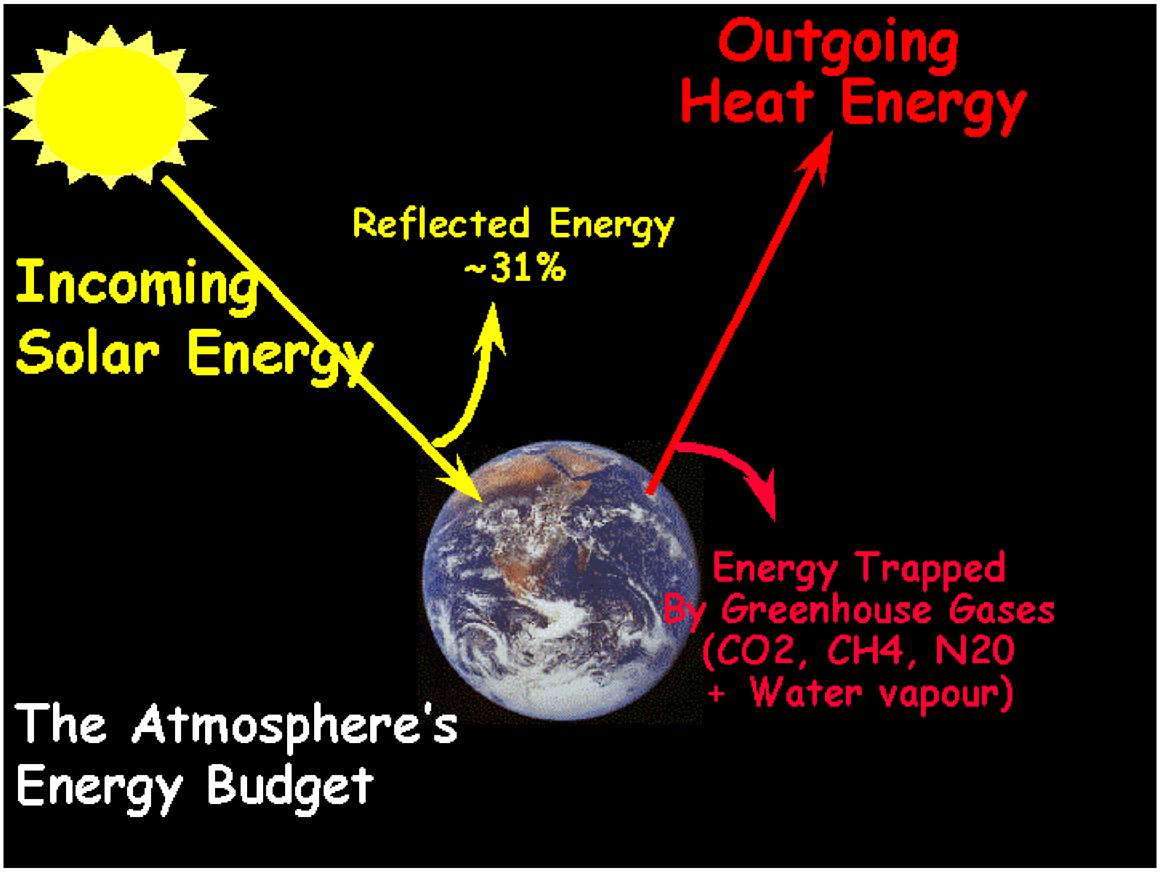


Figure 4: The Atmosphere's Energy Budget

When the natural sources of carbon (fires, decomposition, and animal respiration) are equal to natural removal processes, or what we call "sinks" (photosynthesis, dissolution in ocean water), there is no net increase in carbon to the atmosphere. However, when fossil fuel production and consumption are added in, there is an imbalance in the carbon cycle because the emissions of gases are larger than the processes that remove them, thus carbon builds up in the atmosphere. In the 1990s, sources of carbon included 6.4 gigatons per year from fossil fuels plus 1.6 gigatons per year from deforestation, while the uptake of carbon was 3.1 gigatons per year on land and 1.7 gigatons per year in the ocean (a gigaton is one billion tons). This imbalance resulted in 3.2 gigatons per year of carbon being added to the atmosphere. Over the past 1,100 years, concentrations of CO_2 in the atmosphere have gone from 280 parts per million by volume (ppmv) to nearly 360 ppmv, with most of the increase in the 20^{th} century. The CO_2 trend somewhat resembles the "hockey stick" of the temperature trend chart.

The IPCC concluded in 2001 that "there is new and stronger evidence that most of the warming of the last 50 years is attributable to human activities."

Discussion:

Q: What are the remaining uncertainties? What don't we know yet?
A: Challenges for climate modeling include increasing resolution so that we can create models of the scale that can show local impact, incorporating the impact of clouds which can block incoming radiation and prevent outgoing, and capturing water vapour feedbacks which currently have only been crudely modeled.
A: Another uncertainty is our ability to project the use of fossil fuels and energy choices. For example, if we had asked this question around 1900, what prediction could we have made at that time?

Q: Most data regarding changes in temperature focuses on the land surface – what about the ocean?
A: Evidence shows that ocean temperatures increase more slowly than air temperatures. Ocean temperatures will continue to increase long after we reach stabilization of greenhouse gas (GHG) emission.

Q: Rising temperatures will affect ocean currents and oscillations. Is this built into models?
A: IPCC experiments are based on coupled atmosphere-ocean models. There are feedbacks and interactions represented within coupled models that show how a rise in temperature can affect ocean circulation and vice versa.

Q: You mentioned some periods of cooling – what caused that variation in the overall trend?
A: Cooling trends evident during the last 100 years (in particular after the second world war) can be attributed to the increased use of aerosols, creating a form of pollution that blocked sunlight. But the trend didn't last, as greenhouse gases were also rising, mitigating the effects of aerosols. Also, global concentrations of aerosols declined in the second half of the 20th Century due to improvements in air quality.

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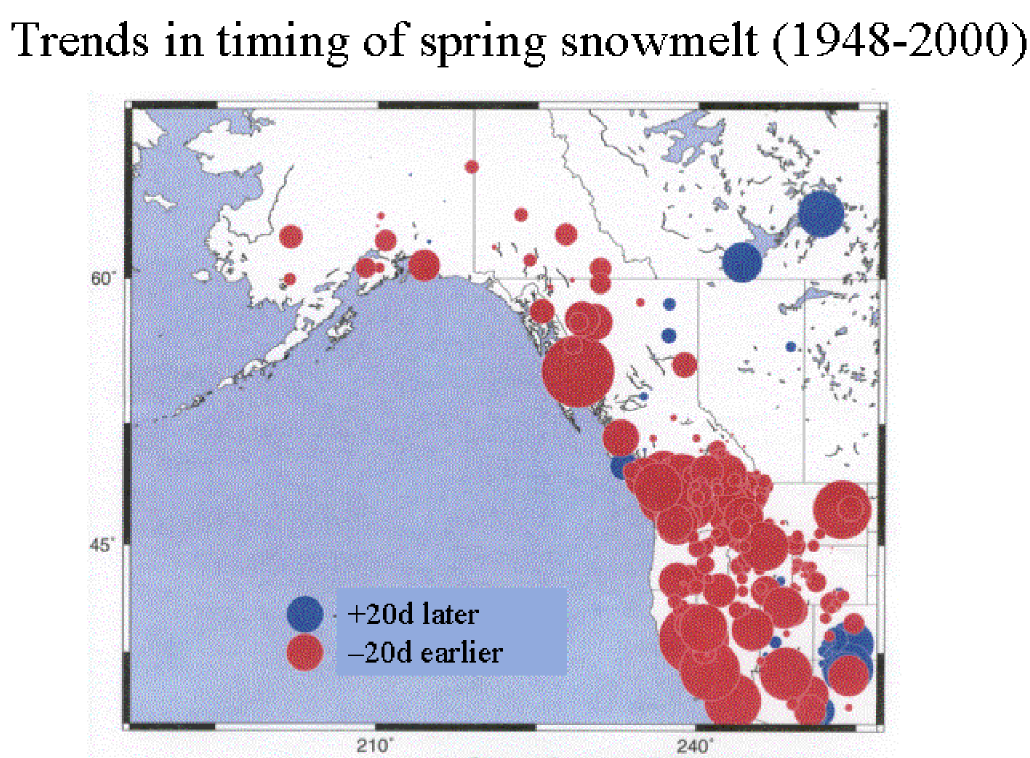
Impacts of Climate Change in the Pacific Northwest

Philip Mote
Climate Impacts Group, University of Washington

The climate is already changing; this is not just an issue for the future. Climate warming is real and there are already consequences. Unfortunately political and public response to climate change risks and uncertainties is determined by how we are personally affected; we do not tend to think globally. Yet the things we can say with most certainty are things that almost no one cares about, such as changes in the global average temperature.

The Climate Impacts Group at the University of Washington is funded by NOAA (National Oceanic and Atmospheric Administration) Office of Global Programs. The goal of this group is to help the Pacific Northwest region, encompassing parts of BC, Washington, Idaho, Montana, Wyoming, Oregon, and Nevada, become more resilient to climate variations and climate change. The areas of focus for climate change research include; water, salmon, forests and coastal zone issues.

Research on snow water equivalent trends provides evidence that climate change is occurring in the Pacific Northwest. Data was collected from 260 snow course collection



Courtesy of Mike Dettinger, Iris Stewart, Dan Cayan

Figure 5: Trends in Timing of Spring Snowmelt (1948-2000)

sites within the region. The majority of these stations showed a decline in snow water equivalent in the spring. This trend was most pronounced at lower elevations in the

Cascades and Olympics, implicating a warming of average temperatures within the region.

Further evidence of warming within the region is the dramatic glacial retreats in the Cascade Mountains. Photographs from 1928 and 2000 of the South Cascade glacier were compared and showed significant retreat of the glacier. Glacial retreat worldwide illustrates the effects of climate change that are being experienced globally.

Another trend occurring within the region is the change in the timing of spring snow melts. In western North America, the monitoring of spring snow melts between 1948-2000 have illustrated a warming trend. Spring snow melts on average have been occurring earlier than previously experienced and this has been associated with higher average spring temperatures.

There are significant risks that may result from climate change, but these are very difficult to quantify at the regional level. Current global climate models are limited in their ability to show regional climate projections. The level of uncertainty increases as the scale for discussion becomes more focused upon a particular region. We need to develop a model that can discuss regional level impacts.

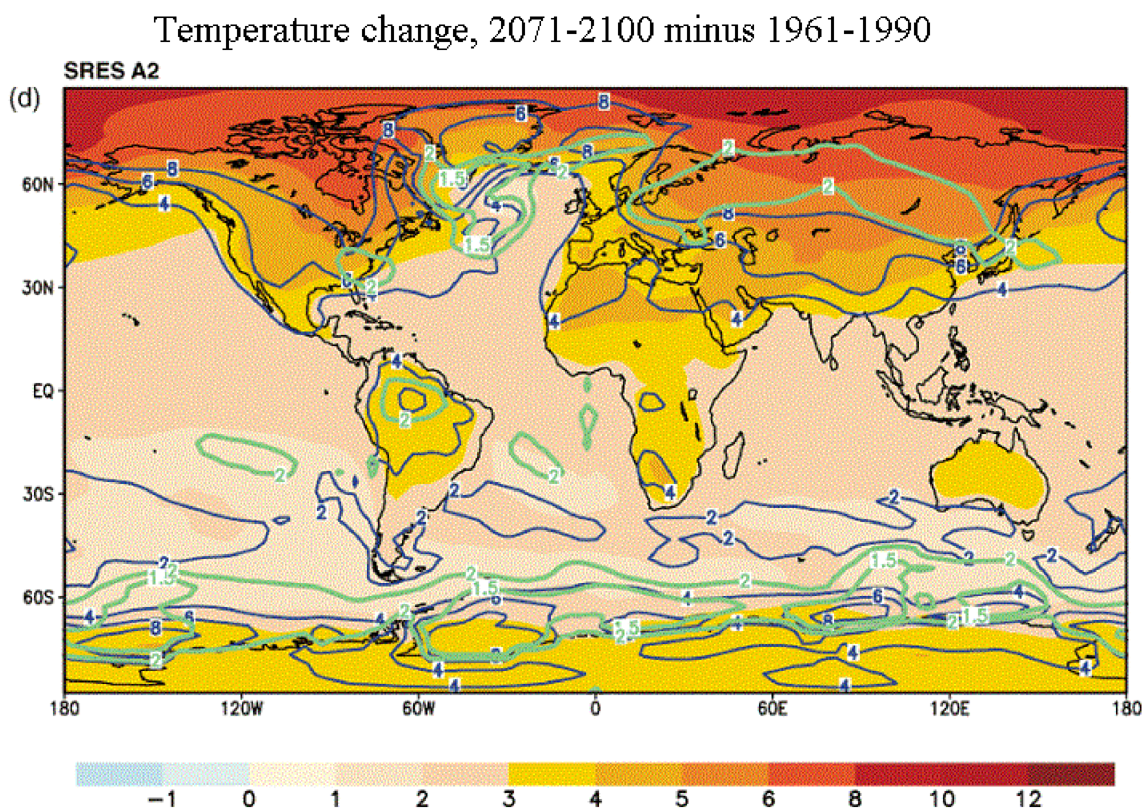


Figure 6: Temperature Change, 2071-2100 minus 1961-1990

A starting point is to look at temperature change patterns. Global temperature change has been modelled and shows significant warming in the northern latitudes. The continents will have the largest change in temperature while the ocean temperature change will be less significant. The most pronounced warming is expected to be in the Arctic where temperature changes could be as high as +8 C over the next 100 years. Within the next 20 years, the Pacific Northwest region is expected to have a mean temperature change of +1.5 C, and by 2040 a change of +2.3 C. Precipitation amounts are also projected to rise in the Pacific Northwest and by 2020 an increase of +6.9 % is expected and by 2040 an increase of +7%. Climate change is projected to bring warmer, wetter winters and warmer summers to the Pacific Northwest.

What are the impacts for water resources? The main impact, which we can predict with confidence, is that there will be less snow, and it will melt earlier. Warmer winter temperatures will produce more rain than snow, resulting in higher winter flows, and less precipitation in the summer causing droughts. The impact on flood risk is harder to predict because there are many variables, however it is likely that high winter flows will contribute to increased winter flood risk in warmer basins. However, since winter snow packs are expected to be significantly less over the next century peak water flows in cooler basins will be lower than current averages and will come earlier producing a longer dry season and less water. Summer flows will be significantly less, water temperatures will increase dramatically and there will also be a decrease in the amount of dissolved oxygen in the water. We can speculate that water quality may be also affected: there may be increased salt-water intrusion in coastal areas, changes to water pH and increased summer water temperature may impact fecal coliform levels.

The impacts on salmon populations as a result of climate change are significant. Salmon could be affected by climate change at all of their life stages. Impacts resulting from climate change that may negatively influence salmon include lower summer flows, higher average water temperatures during the summer, lower amounts of dissolved oxygen in the water, flooding which risks damaging eggs, and changes to water quality.

Impacts on forest ecosystems, as a result of climate change, are also expected in the Pacific Northwest. The seasonality of precipitation is expected to change and the effect this may have on forest ecosystems is not entirely known. Summer droughts may not affect trees that are deeply rooted, but the chances for the disturbance of seedlings are quite high. More extensive forest fires and the chance for higher disturbances from pests may result due to increased summer drought, which increases the forests level of vulnerability.

One of the impacts on coastal zones may be an increased risk of landslides. Increased winter rains, causing the saturation of slopes, may have the potential to produce landslides, which could affect properties along the coastline. Sea level rise will increase the reach that waves have onto the shore and this wave action may begin to undercut slopes along the coast also contributing to landslides. Changes to storm intensity from climate change will again impact coastal slopes as wave activity increases and further undermines slopes. Wave activity has been increasing in the North Pacific since 1948 (Graham and Diaz, 2001). The resulting impacts to the coastal environment will include; increased coastal erosion as a result of rising sea levels and changing wave activity, increased risk of landslides as rainfall increases and also increased flooding and inundation of sea water as sea level rises and there is increased winter stream flows.

We have already made a commitment to global warming. Through our actions, we have set a process in motion that will continue for a long time. Regardless of what steps we take now to address global warming, we will also have to adapt to climate changes.

Climate Wise Planning

"Climate-wise planning" needs to be developed for the Pacific Northwest. As we look to the future, we need to consider how climate statistics may or may not be useful to us. In particular, we need to be wary about assumptions about the extent to which the future may look like the past.

In terms of water supplies we need to increase supply, decrease demand and increase management flexibility. For example, we can look at the current management of dams, which sets July 1 as the fill date for dams. Recognizing the earlier spring melt, we also need to move this date. Salmon populations would benefit from promoting biodiversity and biocomplexity by increasing healthy and connected habitats. Forest ecosystems need to have a full range of their biodiversity maintained and protected. We need to recognize that different trees may perform better as the climate continues to change, and to take this into account when areas are being reforested. Within the coastal environment, the possibility of increased risks need to incorporated into land-use planning in order to minimize the impacts to private property.

In summary, the main impacts of climate change for the Pacific Northwest include less snow, flood risks, water quality, impacts on salmon, impacts on forests, landslide risks, and coastal erosion. Looking to the future we must develop a "climate-wise" approach to land-use and resource planning, remembering that we can no longer base plans on the assumption that the future will look like the past. Dr. Mote's goal is to help the region become more resilient to climate variations and climate change thus minimizing the economic and social consequences.

Discussion:

Q: If there were an exhibit on climate change at a museum, how would we make climate change real to people? We would need to find a way to talk about risk and likelihood. The challenge for all of us is finding an effective way to communicate the risk. For example, people understand the risk of floods, and will agree to put money into addressing a flood that might happen once in 50 or 100 years. In contrast, it is hard to get money committed to deal with climate change, which poses a much bigger risk.

A: In the past scientists have not wanted to talk about low probability / high impact outcomes of climate change because of a concern of losing credibility. There is a tension between what can be said with confidence and what people care about: scientists tend to err on the side of bland or safe projections. But for planning, we must look at low risk / high impact. We need to be willing to talk about the risks and economic realities. We need money to prepare adaptation strategies, in the same way as money has been made available for flooding risk, something that people understand.

Q: In your presentation you talked about projected changes in 2020 and 2040. What are these changes in relation to?
A: The projected increases in temperature in the 21st century are measured from 1990.

Q: Is there any good news? Will climate change have any benefits?
A: Give up skiing and take up golf! There will be a mix of both bad and good. Climate Change will make some areas more livable – for example, you have to ask, is warming such a bad thing in Canada? A risk management approach is most effective. We need to consider how we are going to manage the changes.

Q: Will climate change create a challenge for global supply of food? How will agriculture be affected?
A: The IPCC looked at this issue and reached some conclusions. Modest rates of warming will bring benefits such as extended growing seasons in the north, but there will be adverse effects in tropical climates. With higher rates of warming, the benefits decline, for example the extended growing season is offset by droughts. As well, increases in CO2 preferentially benefit weeds.

Q: The message is that we have to prepare for change whether it's good or bad. As a scientific community, we need to get away from saying "we are uncertain" if we want to increase funding. We also need to move away from a focus on defining all the aspects of climate change to a focus on creating models of ecological and social processes that will help us to understand the impacts of climate change.

Impacts and Adaptation – Approaches and Case Studies

Adapting to Climate Change: An Overview

Jenny Fraser
BC Ministry of Water, Land and Air Protection

Ms. Fraser began with a "primer on adaptation": key concepts to keep in mind when considering the issues.

"Climate change" includes long-term change in average climate, for example changes in average temperature and precipitation, as well as change in climate variability, or the frequency and severity of climate extremes. Adapting to climate change, means adapting both to the longer-term changes and to increased variability, for example climate extremes that are more severe and/or more frequent.
Long-term climate change includes atmospheric warming, and the effects of such warming on other parts of the climate system, including precipitation, cloud cover, ocean currents, and the hydrological cycle. These changes will affect physical systems, such as the timing and volume of river flows and biological systems, such as the timing of

flowering and the growth of pests. The climate and the bio-physical systems will also affect socio-economic systems in ways that may be positive or negative. For example, warmer temperatures may lead to a longer growing season, a positive for farmers. At the same time, these changes may mean that farmers have to cope with new pests.

Analysis of historical data suggests that already many parts of BC are starting to experience the impacts of climate change. The MWLAP report, *Indicators of Climate Change for British Columbia 2002*, documents trends in climate and related variables during the past century. The document is available on the MWLAP website: http://wlapwww.gov.bc.ca/air/climate/indicat/.

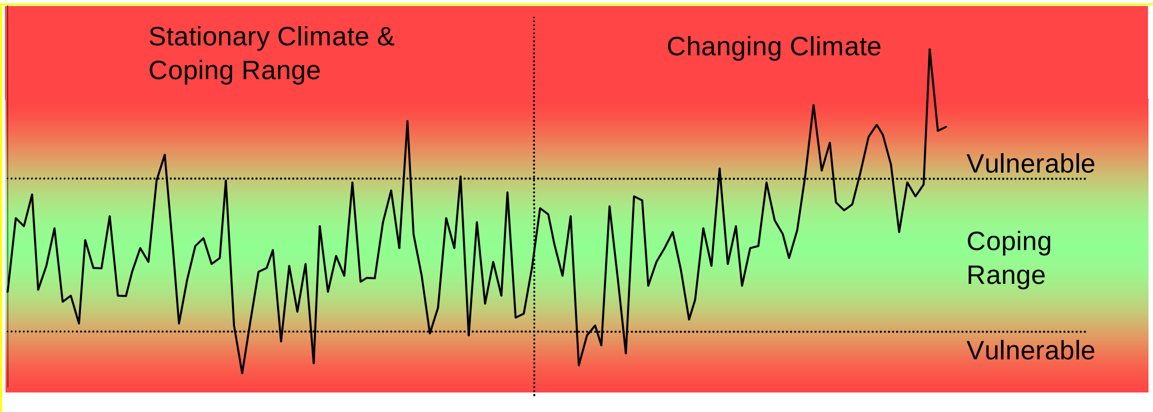


Figure 7: Climate Variability and Change

The impacts of climate change will likely vary from one part of BC to another. For example, during the past century the coast of BC experienced less warming than the interior of the province. The impacts will therefore vary from one community to another, and because of this, adaptation strategies will also need to vary.

Climate impacts also vary over time. Some of this variability reflects natural cycles, and some reflects changes in atmospheric greenhouse gas composition over time.

Adaptation

The IPCC (2001) defines adaptation as "adjustments in ecological, social or economic systems in response to actual or expected climatic stimuli and their effects or impacts." Both natural and human systems can and do adapt. Natural systems respond autonomously, while changes in human systems reflect conscious decision-making with the goal of decreasing harmful impacts and maximizing potential benefits. Adaptation can be responsive (initiated after climate change occurs) or anticipatory (initiated in advance of change). The climatic stimuli which adaptation strategies address include long-term change in 'average' climate, and changes in variability including extreme climate events that are more frequent and/or more severe than we've seen in the past. Adaptation is also time- and place- specific.

This workshop is primarily interested in the anticipatory kind of adaptation, which can position communities and businesses to take advantage of potential benefits and minimize negative impacts. Adaptation doesn't get the same amount of attention as mitigation (that is, reducing greenhouse gas emissions) right now, but it is nevertheless an important part of our response to climate change.

There are both short term and long term adaptations that are needed in order to deal with climate change. A series of short-term adjustments may allow our systems to be less vulnerable to the impacts of climate change. For example, farmers take climate and other conditions into account each year before deciding which crops to produce. Over time these adjustments may create significant changes, for example leading to new crops. Adaptation can also reflect a long-term vision, and large changes. For example, when planning new infrastructure, with a long-life, it is important to consider future impacts of climate change. An example is the Confederation Bridge to PEI, which was built one metre higher in order to accommodate predicted rise in the sea level. Charlottetown, PEI has also done significant work on the impacts of sea level rise, including mapping elevation of the entire downtown core, and is looking at using this information to make changes to land use regulations. Toronto has a program in place to address heat waves. Measures include providing air-conditioned shelters for people who do not have access to cool places.

Some adaptation measures are designed to protect past investments, such as breakwaters that are built to protect shoreline and low-lying coastal infrastructure from storm surges and sea level rise. Other measures focus on preparing for a different future, for example a park in Winnipeg that was designed with regular flooding in mind.

Another way to consider adaptation is to ask, “adapting to what?” There are two standard approaches to thinking about adaptation. The first focuses on the potential climate **hazard** that a community, agency, or sector faces, and the question “what will the future bring?” The hazard approach looks at trends and models, considers potential impacts, how big these impacts will be and when they will arrive. It assesses the probability of certain outcomes and looks at how the manage that risk. Adaptation strategies arising from this approach are designed to manage the specific hazard.

The second approach focuses on the **vulnerability** of the community, agency, or sector in question and the question “how can we be better prepared”? Vulnerability is a factor of the hazards to which the community or system is exposed combined with their capacity to respond to those hazards. For example, if you compare Richmond and Burnaby, Richmond is more sensitive to flooding although both cities have a similar capacity to respond. By contrast both Florida and Bangladesh are low-lying and exposed to flooding, but Florida has more capacity to respond and is therefore less vulnerable. This approach looks at the way that a community or sector has been affected by climate in the past, how effectively they responded to these impacts, whether climate change will increase or decrease risks, and how well-equipped the community is to deal with increased risks. Adaptation strategies are designed to increase “adaptive capacity”.

An Ontario study gives some idea of what is meant by adaptive capacity. This study found that municipalities were better able to deal with water quality issues if the staff were specially trained, dedicated to dealing with water quality, had access to appropriate data and knew how to interpret it. Other factors were whether the community had invested resources in water management, government roles and responsibilities were clearly defined and the public was well-informed and engaged.

The path forward is to assess what the hazards from climate change may be, assess our capacity to deal with these hazards and then identify what our information needs are. What research can be done to help us understand climate change better?

In summary, there are two aspects to our changing environment: climate variability or the changes that occur from year to year and the overall change to our climate that is better viewed on the larger scale of decades or centuries. Adaptation is needed in order to deal with climate change, reduce the risks and impacts to physical, biological and socio-economic systems and take advantage of any benefits. Conscious adjustments are needed in the short term and the long term in order to address the hazards created by climate change, and assess our current capacity to deal with and mitigate them.

Discussion:

Q: What progress is local government making on the issue of climate change?
A: The Federation of Canadian Municipalities (FCM) has a climate change program, with one or two people looking at the impacts. FCM supported the development of six case studies in different parts of Canada, to identify some of the effects of climate change. FCM may also ask communities that apply for green infrastructure funding to assess likely climate change impacts. Charlottetown, PEI has done significant work on the impacts of sea level rise, including mapping elevation of the entire downtown core, and is considering using this information to make changes to land use regulations. Toronto has a program in place to address heat waves, including providing air-conditioned shelters for people who do not have access to cool places during the day.

Q: Some forms of adaptation may contribute to the problem, such as increased use of air conditioning in Toronto. The longer-term solution is to make changes in building designs in order to improve air flow (as is done in tropical countries).
A: I suppose you could say that Toronto's solution does address this to some extent – using fewer air conditioners to cool more people, i.e. one air conditioner for 100 people, but you're right, this isn't a really sustainable adaptation. As an alternative, Municipalities could develop and promote better designs for air flow within and outside buildings, so they don't need air conditioning at all – as in many tropical countries.

Q: Are there any examples of water flow/supply problems connected with climate change?
A: BC Hydro recognizes that there are still lessons to be learned balancing low water issues with fish and recreation. As well, corporate culture needs to adjust to thinking about extremes.
A: Climate-related water supply problems are already evident in some parts of Canada. Montreal faces the challenge of out takes in shallow lakes and will need to deal with the problem

Q: There was a study in the Ottawa Valley re the response of the water table to warming temperatures. Many rural people depend on wells and the study found that there is a drop in the water table, with the result that wells are drying up in summer.

Climate Change and Forest Ecosystems in Coastal BC

Dave Spittlehouse
BC Ministry of Forests

Dave began by asking the question "What can you do in terms of adaptation to climate change?" Current climate models do not have good resolution and this causes problems when trying to determine the potential impacts from climate change. It therefore makes it difficult to identify adaptation measures to employ in specific locations to reduce the potential impacts.

How will climate change affect forest ecosystems in BC? The factors controlling how the forest may respond to climate change are important in understanding the potential impacts.

Factors controlling forest response to climate change include:

- rate and amount of climate change
- species vulnerability— factors affecting this include distribution (where are they on the landscape, are they able to move anywhere, are they isolated); climate tolerance (can they handle a wide range of climate and still survive or are they sensitive to small changes); habitat needs (climate change will change habitat quantity and quality, not just for animals like deer and elk but also the quality and quantity of material that insects eat); fecundity (how fast and how well do they breed); and life span (species with a short lifespan will keep breeding and adjusting, for example, squirrels in the Yukon are now breeding earlier to take advantage of an earlier food supply).
- Frequency and size of disturbance— fire, disease, insects.
- Regenerating versus established stands— these may respond differently
- Barriers to movement— as things change, if the environment elsewhere is better, can specie move or are there barriers?

We have already observed some biological responses to climate change, including an earlier start to the growing season, earlier arrival of migratory birds, increased productivity in the boreal forest, changes in animal ranges and genetic adaptation in resident species. However, in BC we don't have the kind of monitoring needed to actually measure these changes, so they will be difficult to quantify.

So what does the future hold?

Climate change scenarios

	Winter		Summer	
	Temp.C	Precip.%	Temp.C	Precip.%
2020	+1 to 2	0 to +5	+1 to 2	-10 to +5
2080	+3 to 5	+5 to 20	+3 to 5	-10 to +5

Range from 8 GCMS - http://www.cics.uvic.ca/scenarios/index.cgi?Scenarios

Figure 8: Climate Change Scenarios

There are several possible responses to climate change in BC's forest ecosystems. There could be an increase in the potential for fire occurrence and intensity, especially more and earlier spring fires.

Species will respond differently to a changing climate and there will be changes in the species composition of ecosystems. It's the rate of climate change that is important—whether it is a step change or a slow drift. Once established, forests are quite resilient, so it will be disturbances 30 or 50 or 70 years in the future when the "shock to the system" occurs and we will find out then whether forests can adjust or not.

Alpine ecosystems may experience a shorter winter season and shallower snowpacks. However, lack of soils will limit tree encroachment into alpine areas. Slow regeneration and growth rates will limit the speed of encroachment of trees into alpine parklands.

In coastal forests, there will likely be no net gains in growth, although there may be reduced productivity at low elevations and increased growth at mid-elevations. It rains a lot, so an increase in winter precipitation won't make much difference to tree growth, although there would be an increase in winter stream flow. There will be an increase in summer moisture stress if predicted reductions in summer precipitation occur. Hemlock grows over a very wide range so some warming can be tolerated. The Mountain Hemlock Zone will experience a longer growing season with less snow, but more precipitation as rain. The Coastal Western Hemlock Zone may experience increased growth with warmer summer temperatures, but low nitrogen levels in the soil will limit the ability of trees to respond.. The Coastal Douglas Fir Zone, which is drought sensitive, is already water stressed during our summers and further stress may affect growth rates.

Wetlands are affected by the timing of moisture availability (i.e., earlier spring melts, evaporation timing) — so you would have to look at a specific system and see what's really driving the water supply of that system in trying to determine how much of a change there might be.

Overall, a 1997 study suggests that birds and ungulates are likely to gain habitat, while fish are likely to lose habitat. However, there are losers as well as winners within each group.

Forest operations are an integral part of forests and forest communities. If we're getting less snow, and it is warmer in the winter, this will restrict winter logging. There may or may not be some productivity increase. More disturbances may lead to earlier harvests, smaller logs to mill, and also more salvage logs.

There is also a concern about the effect of more fires on communities. We are already at the limit of our ability to deal with fires, so any increase will make it worse. We'll have to target our resources, and where we fight fires. Maintenance of haul roads and other infrastructure may also be affected. If there is more rain there may be more slides or more sediment runoff, and companies may have to consider improved stabilization of road surfaces.

So what do we do about it? Forests are going to adapt to whatever climatic conditions eventually occur— called "autonomous adaptation" in the technical literature on adaptation. Society will have to adapt to or accept what comes— in terms of forestry this means society would be dealing with whatever forests we have for our timber supply and recreation. In some situations society may be able to influence the direction and timing of adaptation— so-called "planned adaptation." Planned adaptation will mostly apply to commercial tree species or commercially interesting wildlife— for example, after harvesting you might replant a different species or change the provenance to a more appropriate variety. But change is going to happen over the whole land base, so a lot of the adaptation will be autonomous.

Planned adaptation includes strategies and plans to address future problems— this is a risk management issue and we need to think of it as that. Many of the necessary adaptive actions are already part of sustainable forest management. For example, provenance trials to evaluate the capabilities of species from different climatic regimes need to continue so that we can select provenances appropriate for the new climate of an area. Designing fire smart landscapes— landscapes that are less susceptible to large fires through interspersing less and more flammable material over the landscape— will be important. We could also address stand management through sanitation thinning.

Maintaining biodiversity and parks and conservation are areas where we will have difficulty doing intervention. We will have to reassess our approach to conservation. Values and attributes that a park or wilderness area is designed to protect may not exist in

50 to 100 years. For example, we may have to find other ways to preserve the Vancouver Island marmot— perhaps in special refugia or an artificial environment.

All of this requires a reassessment of sustainable forest management. Adapting to climate change in forestry involves putting a climate change adaptation focus into management plans. Because the timber harvesting land base is extensive we will likely focus much of our effort on the intensively managed areas.

In conclusion, over the next 50 years, moisture availability will be the critical factor. We will likely see disturbance increases— fire, insects, and disease. The forests in BC are generally getting older so the trees are naturally becoming more susceptible to disturbance. When warming and moisture stresses are added, the potential for disturbance is greater. There is likely to be an increase in forest productivity in some areas though this will coincide with a predicted increase in the global timber supply. Other changes are likely to be responses of species at the edges of their ranges, changes in community composition, and an earlier start to the snowmelt season.

<u>Discussion:</u>

Q: We have glossed over the potential change on the coast. A different view shows that if Southern Vancouver Island climatic conditions change, if it gets warmer and summers get drier, then in the medium term we will lose coastal Western Hemlock, and it will be replaced by coastal Douglas Fir.

A: In the next 20 –50 years we do not expect major changes as forest changes do not occur rapidly. We have seen that after a disturbance, coastal Douglas Fir moves in. Will coastal Western Hemlock return? It is not likely in the undergrowth.

Q: Is there adequate monitoring being done for the changes that are taking place to Western Red Cedar? Western Red Cedar, dry zone vs. wet zone, 'are getting beat on' on the east side of Vancouver Island. One of the challenges is that we don't have any red flag warnings from 50 years ago. We should be monitoring tree rings but that stopped in 1996 in the Cowichan Valley.

A: Yes.

Q: To protect vulnerable species, such as the Vancouver Island Marmot, we need to know more about ecological processes and dynamics -- it is not as simplistic as the models would suggest. The marmot requires open habitats. In drier areas with warming climates we would expect trees to move up the slope into alpine areas, but in the southern interior the forests have disappeared instead of moving up, and the lower grasslands have extended, thus increasing the habitat for marmots.

A: We need to understand ecological processes better in order to avoid making simplistic, and wrong, decisions. Risk management needs to look at the range of potential outcomes and how we will react to each of those possibilities.

Q: What could be the potential impacts of increased windstorms, especially to the Interior?

A: Although it is thought that windstorms should increase with warming, the, global climate models have not shown this. The question is 'how will we deal with this when/if it happens'.

Case Study: The Somass River Fishery

Dr. Kim Hyatt,
Research Scientist, Fisheries and Oceans Canada
Manager, Canadian Climate Impacts and Adaptation Research Network – Fisheries Sector

Climate change poses potentially large risks, but we can't quantify those risks with any certainty. Therefore we face the question of whether we should allocate funds to address these risks? Should we devote resources to understanding the potential impacts, and exploring issues of vulnerability and adaptation? In this presentation, Dr. Hyatt used a microscale snapshot of the impact on fisheries to explore these general concepts of vulnerability and adaptation.

The Somass watershed on Vancouver Island contains a complex array of natural resources (e.g. water, timber, fish) and "built" environment assets (e.g. dams, fishways, hatcheries, aquaculture facilities, a pulp mill, fishing fleets, power generation plants). It provides social, cultural, economic, and environmental benefits worth more than $60 million annually, including:

- wild and cultured salmon fisheries (Great Central Lake and Robertson Creek) -- $4-9 million
- power generation (BC Hydro, Summit)-- $10.2 million
- paper manufacture (Norske Canada) -- $40 million
- Timber (Weyerhauser, Timber West) – $3 million
- Municipal water supply
- Aquaculture
- Agriculture

Water flows are regulated at several locations in the Somass system to meet the needs of fish, industry and urban populations. The Great Central Lake – Stamp River watershed within the Somass system is managed primarily to:

- provide adequate flows for migratory passage by salmon at multiple fishways through summer and fall.
- maintain water levels and flow requirements for seasonal spawning and egg incubation needs of salmon.
- provide adequate flows for power generation

Great Central Lake supports wild sockeye and coho spawning in late summer and early fall. The Stamp River, which flows out of the southeast corner of the lake, supports wild coho migration and river spawning Chinook and steelhead salmon. Fisheries stakeholders include the Nuu-chah-nulth First Nation, commercial and sports fishers, Pacific National Aquaculture (PNA) and DFO. Both PNA and DFO maintain separate salmon culture facilities near the outlet of the lake.

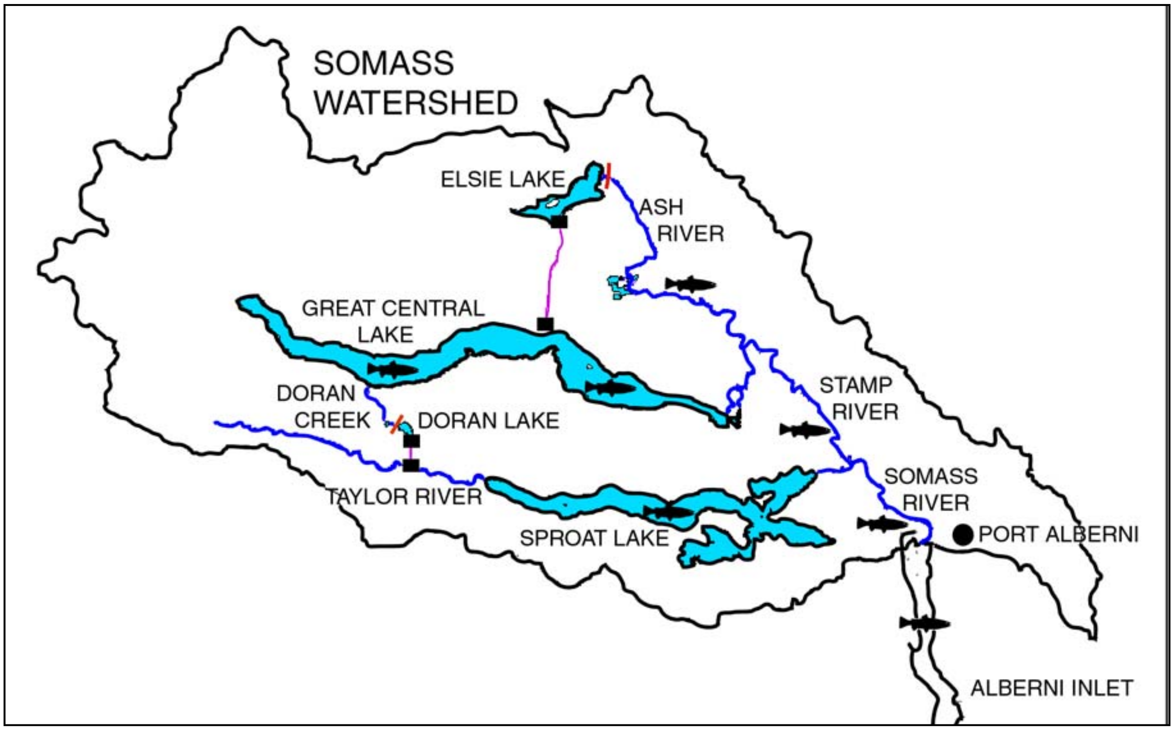


Figure 9: Map of Somas River

Great Central Lake water supplies are also influenced by dams that permit water diversions both into and out of Great Central Lake from a BC Hydro Elsie Lake-Ash River facility and a Summit Power Doran Creek facility located on the north and south shores of the lake respectively. In addition, Norske Canada operates a water storage dam at the east end of Great Central Lake as it exits through the Stamp River.

The standard management approach during drier-than-usual summers is to maintain lake levels high for as long as possible, while maintaining adequate flows in the Stamp River for Chinook and steelhead salmon migration and spawning. Maintenance of higher lake levels also ensures the availability of water supplies for the two fish culture facilities near the east end of the lake. Minimum flow levels are established by a "rule curve" that is based on historic rainfall, river flow patterns, maintenance of Alberni Inlet water quality and fish culture water supply requirements.

The 2002 Drought

During 2002, southern British Columbia experienced a significant (more than one in fifty year) drought event. Precipitation was average to below average for much of the late summer and moved towards drought conditions during the fall and early winter. By fall, levels in Great Central Lake and discharge rates to the Stamp River were well below normal.

Water level and river flow have a direct impact on salmon reproductive success. For example, lake level fluctuations of as little as a meter between the time of spawning in fall and the time of fry emergence in April place 10-30% of wild sockeye salmon redds and eggs at risk of displacement or dessication in Great Central lake. The value of potential fisheries losses from a single drought event in the Somass system has been estimated at $1- 2.5 million or more.

In 2002, sockeye initiated spawning in the lake during the extended fall drought interval when lake levels were declining. As the drought continued into the fall water managers in DFO and WLAP faced a critical decision. If they maintained normal seasonal flow rates into Great Central Lake from hydropower facilities and also in the Stamp River to meet downstream requirements of chinook and steelhead salmon then fish culture facilities upstream of the Great Central Lake Dam would run out of water within one week and Great Central Lake levels would drop such that major losses of both cultured (chinook, coho and Atlantic salmon) and wild salmon (sockeye) would occur. By contrast reductions of water releases to extend the period during which minimum flows would be available to fish culture facilities would place downstream wild river-spawning Chinook and steelhead, and migrating wild coho at risk? The problem that water and fisheries managers faced was one of choosing the lesser among several “evils” where no choice would simultaneously satisfy the water supply needs of cultured fish, wild fish, hydroelectric generation and other users.

On November 1st, managers decided to reduce the discharge from Great Central Lake in order to provide Robertson Creek Hatchery with minimally adequate flow until November 29th. On November 4th, it finally rained, averting a potential crisis for wild salmon.

Implications for Climate Change & Adaptation

From a management perspective, an event like the 2002 drought is considered an anomaly, and represents management of a crisis situation. Similar drought events, however, have occurred a few times in the past decades. Climate models project increasing climate variability in decades to come, with extreme events such as drought occurring more frequently. Although it is too early to establish a definite, climate-related trend on southern coastal BC rivers, there is anecdotal evidence that such drought events are more frequent than in the past. In addition, the 2002 drought increased water use conflicts and challenged resource managers in many salmon-bearing water systems across southern British Columbia, including the Cowichan, Nanaimo, Sooke, and Coquitlam rivers. Wild salmon populations as well as water dependent urban and industrial activities were at risk and subject to crisis management in all of these locations. If late summer drought occurs more often, crisis management may not be the best management approach. It requires significant resources, time and attention. It is more difficult to achieve consensus under time pressure between multiple parties with competing interests. Indecision or poor decisions made under pressure increase the likelihood of conflict and demands for litigation or compensation.

A more effective alternative might be to consider late summer drought as a “normal” occurrence, and to plan for it as part of the regular management regime. Possible planned adaptation options include:

- Negotiate arrangements in advance with power producers (Summit Power and/or BC Hydro) to secure more water for fish production in late summer during drought years.

- Negotiate arrangements in advance with Norske Canada to identify an "optimal water release strategy" that provides the best mixture of benefits for upstream and downstream water users (i.e. hydrolectric, fish culture facilities, wild fish populations) during drought years
- License any available (unused) water storage rights in other parts of the Somass system to provide relief during drought years
- Develop informed and anticipatory "standing order responses" to future extreme climate events

Such options would introduce more flexibility into the water management system, making it more able to respond effectively to extreme drought events.
Effective introduction of these and other potential adaptation options will require further research into:

- the economic costs and benefits of potential tradeoffs in drought years between using stored water for hydroelectric generation, cultured fish or wild fish production.
- "built environment" constraints on the use of Great Central Lake "live storage" e.g. examine cost-benefit of altering water supply limits on fish hatchery intakes

It will also require greater interaction between stakeholders, and processes to support orderly and informed negotiation of tradeoffs between multiple assets (e.g. wild fish production, fish culture, power generation) and of conditions under which a specific adaptation option would routinely be applied.

Using the experience of the Somass River Fishery as an example, it has been demonstrated that there is a need for interdisciplinary research that takes all stakeholders into account, and the need for impact and vulnerability studies to be done in advance of the need to respond to climate change consequences and impacts. Fisheries is an important sector of the BC economy that has already been negatively affected by climatic change. During the 2002 drought event on Vancouver Island, a minimum estimate of 1–2 million-dollar loss to fisheries was averted using established data and guides. In a field of complex interactions, and at a time when science cannot quantify risk with high certainty, provincial and federal resource managers were almost overwhelmed in their attempts to mitigate a resource disaster that could have been extensive.

Discussion:

Q: The allocation of scarce resources is particularly difficult with centralized planning. One approach in the US has been to establish water markets, for example in Idaho. They bought water from farmers who had extra, and reallocated it where it was needed. There would be challenges applying this approach to some of the issues raised: for example it would be difficult to value wild fish. But markets are very responsive, and is it possible that they could play a role?

A: We do not have a good model for using markets in this way. In BC water licenses once granted tend to become 'water rights' and we have not seen much movement to buy back licenses. It is a critical issue in the southern Interior where water is scarce and water and fish conflicts do happen. Water and fish conflicts will also happen on eastern Vancouver Island. Conflicts over related resources will become common and we do need new ways to balance competing issues. Perhaps markets are one tool.

Q: In developing strategies to adapt to the impacts of climate change, we will need to consider and address the rights of First Nations. The CRD experienced this when dealing with water supply in Victoria. Their decision would impact on First Nations interests in relation to fish in the Sooke River. How much have these issues come into play in your experience?

A: Salmon harvest is a constitutionally guaranteed right for First Nations. However, neither the *Fisheries Act* nor the Constitution have taken climate change into account. In changing the *Act* to accommodate the impacts of climate change, the constitutional rights of First Nations could be affected. If Aboriginal rights are not considered, there is the potential to end up in the courts. We will also have to wrestle with socio-economic impacts of climate change and adaptation strategies. We need to ensure the right balance of staff to work with these diverse and complex issues (e.g. fisheries need people who can deal with the socio-economic side of issues, not just the biology).

Q: Going back to the question of markets, we may be able to look at our “natural capital”, such as a forest, and value that. But how do we determine the value of an ecosystem in totality? What are the costs associated with a catastrophic collapse of a whole ecosystem?

A: To begin to answer this we can think about the socio-economic impact of the collapse of the cod fishery on the east coast. Some say that area picked up more in crab and lobster than was lost in cod. But there were losers as well as winners, and the losers are still reeling from the change. There has been a massive social impact. How can we plan for changes such as this so that we mitigate the impacts? We need to bring different people, different skills into our scientific research institutions in order to address issues like this.

Afternoon Breakout Sessions

In the afternoon conference participants were invited to participate in one of three concurrent sessions. These sessions provided the opportunity for more detailed discussion among participants on impacts and adaptation issues in three key areas:

A) Marine Ecosystems and Fisheries
B) Communities and Infrastructure
C) Economic and Social Issues

Each session began with short presentations from experts and stakeholders in order to provide a context for the discussion, followed by questions and answers. After the presentations, participants broke into small groups to explore issues and share information. A series of questions were provided to guide the discussion. The sessions ended with a report back from each of the small groups.

Session A: Marine Ecosystems and Fisheries

Temperature and Sea Level Changes in Coastal BC

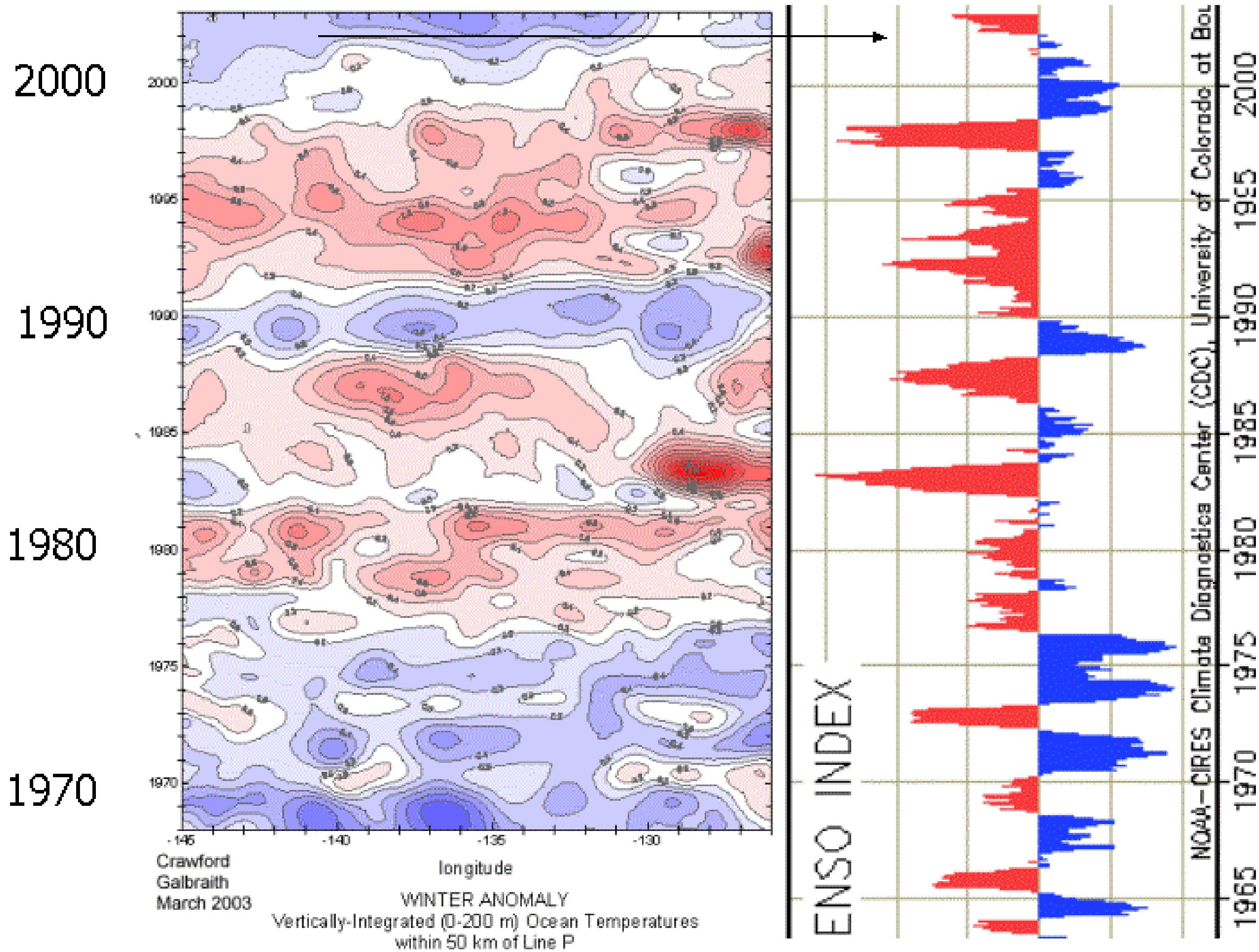
Dr. Bill Crawford
Institute of Ocean Sciences – DFO

Profiles of ocean temperature to a depth of 400m have been taken from numerous points in BC waters. Measurements of ocean temperatures have also been taken along “Line P” which runs from the mouth of the Juan de Fuca Strait to Ocean Station Papa at 145°W. I have averaged the temperatures in the top 200 metres of the ocean along Line-P from all observations since 1966, and the results are shown in Figure 1. Colder-than-average waters are in blue, warmer in red. The graph at the right shows a time series of El-Niño – Southern Oscillation (ENSO) variability. El Niño years are shown in red, La Niña periods in blue.

The graph in figure 10 clearly shows there is a tendency for warm ocean temperatures along Line-P in El Niño years, and cold ocean temperatures in La Niña years. Much of the warming in the ocean west of British Columbia is associated with warmer currents flowing from the south, due to winter storms and warmer waters stored south of our region, both part of the global El Nino response.

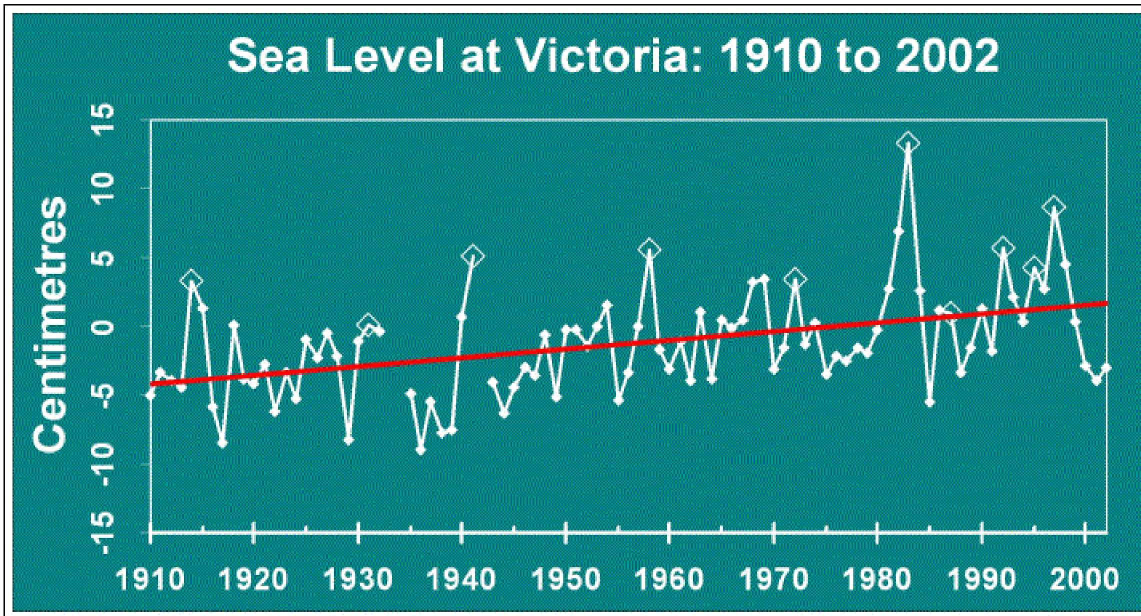
During warmer oceanic temperature regimes, sea levels rise in response to this warmer water. These currents, which come from the south, cause ocean waters to be highest near the coast, thus causing a rise in average sea levels. Flooding and the risk of erosion both increase with higher sea levels and increased storm activity. In fact, six out of eight flood events occur during El Nino years. There are three ways that El Niño raises sea levels: a warm coastal wave which arrives from the south, a strong Aleution low pressure system in winter, and a boost of water coming from the south due to storms passing south of British Columbia pushing warmer waters north.

Figure 10: ESNO Index



Fluctuating oceanic temperatures during El Nino and La Nina years appear to impact the West Coast fishing industry. In the summer of 2002, colder average ocean temperatures were found at 100m of depth on the BC coast. The cooler waters had more nutrients so there was a resulting benefit to the fishing industry.

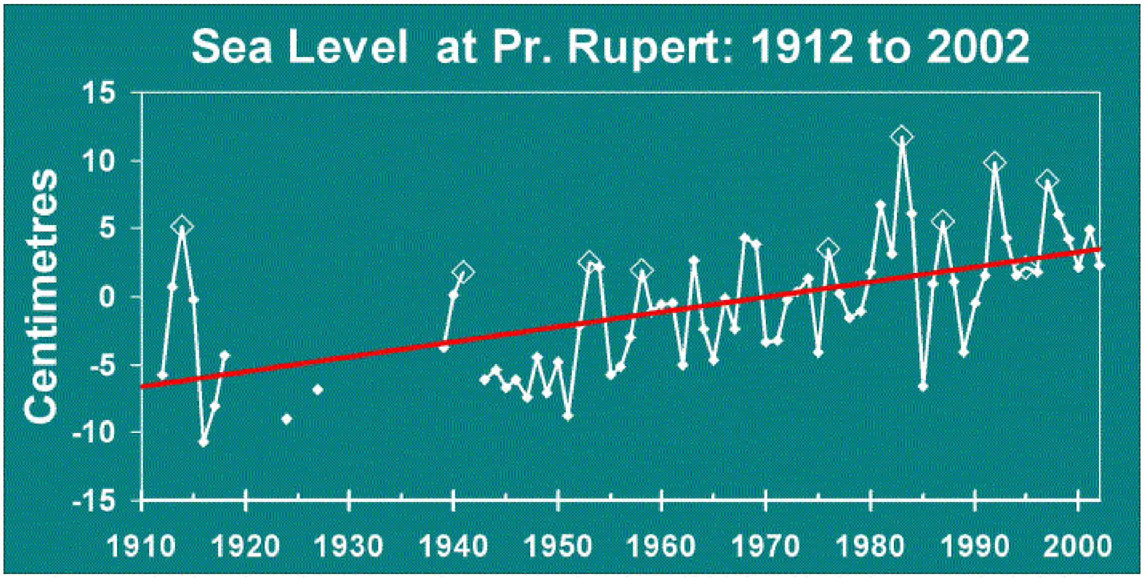
Sea level rise will vary along the BC Coast as some communities may see an average rise of sea level while other areas could experience a decrease in average ocean levels. Sea level changes at three British Columbia ports are displayed in Figures 2 to 4. Figure 2 displays trends in sea level at Victoria. Years in this graph indicated by diamonds are El Nino years with higher than average sea level. In Prince Rupert (Fig. 3), the average rate of sea level rise is +11mm/year which would amount to +11cm/century. In Tofino (Fig 4), the average rate of sea level change is –14mm/year, amounting to –14cm/century. During an earthquake in BC it is believed that the West Coast of Vancouver Island could drop by up to 1 metre. The impacts from changing sea levels will vary from place to place along the BC coastline as significant variations in ocean level changes occurs.



Average rate of rise: +8 mm/year = +8 cm/century

Global rate: between 10 and 20 cm/century

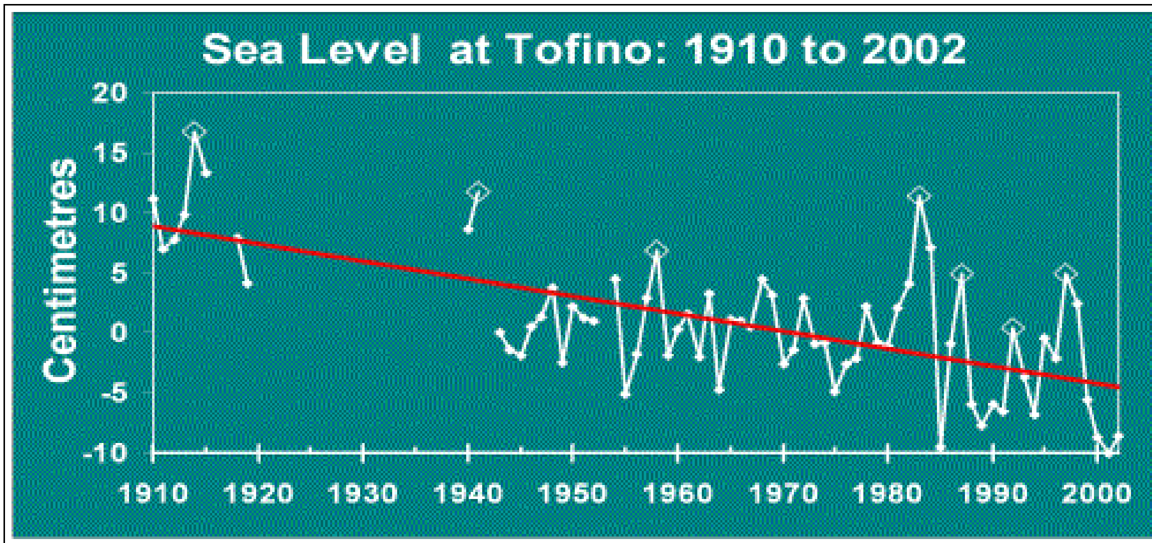
Figure 11: Sea level at Victoria



Average rate of rise: +11 mm/year = +11 cm/century

Projected global rate: up by 9 to 90 cm by the year 2100, and continuing rise after 2100.

Figure 12: Sea Level at Prince Rupert



Average rate of rise: -14 mm/year = -14 cm/century

Figure 13: Sea Level at Tofino

Changes to both ocean temperature and average sea levels will affect the coastal Pacific Northwest. The specific impacts will vary along the BC coastline as changes to sea levels will be dependent upon geographic location. The fluctuations to average ocean temperatures and average sea levels will vary from year to year with the ocean currents El Nino and La Nina playing a large role in determining these changes.

Climate Change and Pacific Marine Ecosystems

Dr. Nathan Mantua
University of Washington, Climate Impacts Group

There are direct links between climate and marine ecosystems. The direct impacts of increased ocean temperature include habitat suitability changes, such as thermal stress for certain species which could cause population declines, as well as distribution changes that may expand the range of some warm water species. The indirect impacts of ocean warming include both "top down" changes such as alterations to the predator field within the food web as well as "bottom up" changes such as habitat changes causing adjustments in the food web production.

Ocean temperatures, upper ocean stratification, and phytoplankton production are closely connected. Colder ocean waters tend to be less stratified and contain more nutrients, which results in higher amounts of phytoplankton production. Phytoplankton form the base of the marine food web and are therefore a very crucial element in the marine ecosystem. Phytoplankton abundance within the ocean can then influence the biodiversity of marine species at any given time. A study conducted at Pavlov Bay Alaska showed a significant change in the biodiversity of the most abundant marine species as changing ocean temperatures were experienced with variations in ocean currents, wind and weather patterns. A bottom trawl with small mesh netting was used to survey the marine species in Pavlov Bay over a 40-year period. During the 1960's and early 1970s shrimp and capelin were found to be in great abundance in comparison with other marine species. In the late 1970's large pisciverous fish (like cod, halibut and pollock) began appearing in the catches, though shrimp and capelin were still abundant. The 1980's saw the most pronounced shift in marine species as Pacific cod, pollock and halibut were the most abundant species, and shrimp and capelin were very scarce. Trawls in the past few years find that shrimp and capelin have appeared in slightly greater numbers than they did in the 1980's through late 1990's.

Climate change, resulting in the possible warming of ocean temperatures, could have significant impacts on salmon abundance in BC coastal waters. Welch et al. 1998 hypothesized that the marine distribution of sockeye and steelhead are determined by thermal limits. They speculate that salmon are surface oriented while at sea and metabolically constrained by surface ocean temperatures. If this hypothesis is correct, a warming of surface ocean temperatures may force sockeye and steelhead out of the Pacific and into colder northern ocean areas during the warmest months of the year. Other studies have highlighted timing changes in the life cycle of some zooplankton species in the NE Pacific and Georgia Strait. With warming temperatures in the 1980's and 1990's, some zooplankton have advanced their annual emergence from the deep to the surface ocean by several weeks. With this kind of climate-related change in zooplankton behaviour, a timing mis-match between juvenile salmon and zooplankton, a key food source, could develop. Ocean temperature changes could also produce altered wind and current patterns causing possible variations in nutrients, zooplankton, and larval fish transports. Salmon may migrate to follow these food sources, which may take them to less desirable locations in terms of the fishing industry. These potential impacts to salmon abundance could have significant impacts upon the fishing industry in BC as salmon populations migrate to follow their prey and ideal ocean conditions.

Changing ocean temperatures will both directly and indirectly affect marine species in the Pacific Northwest. The potential impacts on the fishing industry in BC could be quite significant as salmon abundance could be affected by changing ocean conditions (for instance: temperatures, stratification, upwelling, and current patterns).

Adaptation to Climate Change in Coastal Fisheries and Communities

Dr. Mark Johannes
Pacific Biological Station, Nanaimo, BC
C-CIARN Fisheries Sector, National Coordinator

Climate variation and change is here! It’s not getting hotter, it’s getting less cold. Storms are not getting bigger, they are getting more frequent.

Climate change has recently gained worldwide attention from the related impacts of storms, drought, fires and other climate extremes. It is well supported in the scientific literature that the accelerated rate of climate variation and change and the frequency of climate extremes are associated with anthropogenic activities (IPCC 2001). Human industrial development, resource and land use have modified the earth's surface and led to increased concentrations of atmospheric greenhouse gases such that global surface temperatures have increased on average 0.6 ± 0.2°C within the last century. The Third Assessment Report of the Intergovernmental Panel on Climate Change (Working Group 1, IPCC 2001) stated "in light of new evidence and taking into account the remaining uncertainties, most of the observed warming over the last 50 years is likely to have been due to the increase in greenhouse gas concentrations." Global Climate Models predict that global surface air temperature will increase on average by 1.3 to 5.8°C to 2100 relative to 1990 and that sea level will rise 0.09 to 0.88m.

Canada has adopted the Kyoto Protocol to mitigate and reduce greenhouse gas emissions. While mitigation will be important, it can only slow the rate of accumulation of greenhouse gases but will not alter the accumulated impacts on the most sensitive portions of ecosystems including species biodiversity and indicators of change like species at risk, fisheries stock abundance and productivity. Social adaptation through management, awareness, communication and research and development can be used to help ameliorate the affects of climate change. Adaptation science and research will help identify anticipatory approaches for sustainable use and development of ecosystems and their component species and habitats.

Present approaches of single fisheries species management, protected areas, and management area boundaries may not provide appropriate levels of conservation and protection to potentially vulnerable fisheries, species at risk, and socio-economic systems of coastal communities, given the predictions of future impact responses of climate variation and change.

Early adaptation is needed to reduce the risks and vulnerability to climate change within Canada's coastal fisheries and communities. Climate variation and change has and will have dramatic impact on the physical environment including: variations in ocean temperature and salinity patterns; wind and ocean circulation; rising sea levels; reduced permanent ice; reduced snow packs; increased coastal erosion; frequency of extreme weather and storm events; and changes in freshwater supply and flow. Climate change will have an impact on freshwater and marine fish productivity including: altered fish growth, physiology, reproduction and spatial distribution; changed species composition and productivity within ecosystems; altered optimal habitat characteristics; changed production in important commercial and sport fisheries; increased toxic algae blooms and parasite infestations; and enhanced risk of disease particularly in aquaculture farms.

The impacts to coastal fisheries could be quite dramatic and significant to both natural marine and freshwater fish species, and the coastal communities who depend on these resources. Natural ecosystems and communities will be exposed to a greater level of variation in resource productivity. There is also sensitivity and concern about the vulnerability and threats to traditional lives of those living in fishing communities.

Adaptation is intended to adjust practices or processes in response to variation and change in physical and biological systems. Early adaptation to reduce the risks of climate variation and change could prove to be less costly in the long run, but will require immediate consideration and effort. Anticipatory adaptations are needed within the fishing industry, coastal communities, fisheries and aquatic management and decision-making structure to minimize the negative impacts of climate change. Early adaptation could potentially provide cost advantages to industry and communities. Sustainable fisheries management in the future could involve modifications in the timing of harvests, locations of harvests, methods used for harvesting, and also the species that will be harvested. It is crucial that communities, industry and socio-economic and management structures adapt to climate variation change in order to adjust to changing marine ecosystems and conditions.

Success in adapting to climate change will depend on effective research and development, innovative approaches to adapt to change, and an ability to create awareness and communicate to stakeholders and communities in order to motivate action for future prosperity.

Discussion:

- Participants strongly agreed on the need for a stronger collaboration and linkage between harvesters, processors, and those who are decision makers of species catch and dependent fisheries. All stakeholders need to be involved in any discussions related to marine ecosystem management that affect them.
- Effective communication and education for all stakeholders are crucial for effective decision-making. We also need to be able to localize the issues in terms of that specific place or community. Better information and communication will empower decision makers and increase community trust for any plans that are developed.
- The best method to communicate the issues surrounding climate change is to draw connections between what is going on and the economics of the situation. Using real life events occurring worldwide and including the effect they have on the economy of the local community will make the public realize how real climate change is.
- Both the public and decision makers need "translators" of the science behind climate change research. We need to develop the capacity of the scientific institutions where this research takes place. Specialists are needed to research specific aspects of climate change, but there must also be a bridge between these differing fields. We need individuals with multi-disciplinary expertise who can bring together all of the different research within climate change and an ability to assemble teams of scientists to look at specific problems. We also need individuals who can serve as a communicator to the public.
- The diversification of the fishing industry, as well as its basis of operation, is needed in order to adapt to climate change.
- The inclusion of climate change within the curriculum of our school system is needed as well as researching new ways to educate the general public on this subject.

Small Group Discussions:

To assist resource mangers to adapt to climate change, what are the key information needs? (e.g. Natural cycles, anthropogenic influence, ecosystem response, future scenarios …)

- More collaboration linkage between harvesters, processors, and those who are decision makers of species catch and dependent fisheries with the desired result of improved decisions in harvesting towards localized issues.
- We also need to be asking 'what are the questions scientists should be trying to answer'.

Are these needs being addressed now? Is there research capacity and coordination to fill these information needs? What is needed? (e.g. Institutions, expertise, funding, collaboration …)

- Adapting to climate change requires a team approach, multi-disciplinary, broad expertise, pulling together specialists as needed. The opportunity of involving 'retired' scientist and other experts should be examined. We need to educate and train multi-disciplinarians who could serve the role of communication with the general public and assemble teams of specialists.

- There exists a challenge with institutional capacity within scientific organizations. Present collaboration and communication tends to be 'vertical' with insufficient exchange between experts.

What methods should be a priority for guiding resource managers in adapting to climate change: future ocean regime scenarios, downscaling from GCMs, developing climate analogues.

- Resource managers and policy makers need to know the potential financial and social costs, of the risks associated with climate change impacts. They need to be able to take real life scenarios that the public can relate to and quantify the impacts in terms of dollars and cents.

Is the current knowledge and implications of ocean and climate dynamics accessible to resource managers and decision makers? What improvements are needed?

- There is a need to learn to communicate the science of climate change and potential consequences in a language that resource managers and decision makers can understand. A focus on impacts rather than a definition of climate change is needed. (e.g. GVRD water use/person/day, change in habits imposed by legislation to use less water – new toilets)

How do we involve, inspire and educate community stakeholders?

- There is a need to improve communication with community stakeholders and decision makers. Budgets need to be identified for activities such as a doomsday clock counting down the days for specific species extinction rates.
- It is important to remember that the public is not interested in high uncertainty. The information that they need to be receiving is related to actual impacts being experienced by communities in North America (e.g. Quebec ice storms, Somass drought etc.).
- The importance of targeting education to youth and taking a generation approach to public awareness was highlighted. We need to provide information and education that will support habit changes as well as establishing rules and bylaws.

<u>Key Points Summary:</u>

- Improved collaboration is necessary between stakeholders, the scientific community and decision makers. Information being disseminated needs to be 'reader friendly', quantifiable and address the impacts of climate change in a manner that facilitates change in policies and behaviours.
- Adaptations to climate change can only be successfully achieved with a multi-disciplinary approach involving all stakeholders.
- The engagement of the public/stakeholders when plans are being developed is crucial, as local ownership of these plans will improve their effectiveness.

Session B: Communities and Infrastructure

Climate Change Adaptation and Regional Planning: Experience from GVRD

Jennie Moore for Robert Hicks
Greater Vancouver Regional District

The GVRD includes 21 municipalities, 1 electoral district and a population base of approximately 2 million people. Services include water supply, sewerage collection, treatment and disposal, air quality management and other regional services.

In 2000, Environment Canada provided the GVRD with regional scenarios for climate change so that it could begin to understand potential impacts. The Vancouver scenario explained that a 3.5 ºC rise in summer and winter average temperatures could occur by 2101, there is the potential for a 10-30% increase in fall and winter precipitation by the 2080's and a 10-30% decrease in late spring-early summer precipitation by the 2080's. The Kyoto Protocol will not likely influence these scenarios.
The GVRD climate change efforts include green-house gas management as part of their air quality mandate, and adaptation strategies focusing on planning and design for water, sewer and stormwater systems. Climate change is not part of planning at the day-to-day decision level.

Barriers to effective long-term planning include short-term budget and political timelines versus long-term infrastructure lifecycle and planning horizons. Climate change is considered to impact municipalities into the future, 50 –100 years, while land use plans and infrastructure plans are generally no longer than 10 – 50 years. To accommodate this disparity, their focus is on planning and asset management resiliency. For example, major infrastructure is planned on a 50-year asset life cycle, and stormwater management plans are adopting a 50-year watershed vision. Municipal "Strategic Road-maps" are needed for long-term planning as they could provide guidance and vision for 50-75 years into the future.

There is a need to build adaptive capacity within our municipalities. Integrating climate change scenarios as part of routine planning requires, political and staff support, financial commitments for impact studies, research and scenario development, and financial and political commitment to implement responses to analyses. There needs to be acceptance from municipalities that climate change is now part of the usual planning process and this will enable them to build adaptive capacity and resiliency appropriate to their context and needs. There is also professional responsibility for engineers and planners that are providing services to municipalities to fulfil their ethical responsibility of due-diligence by addressing climate change risks in their analyses and plans.

Discussion:

- Discussed variety of water systems – Vancouver relies on snow pack whereas Victoria has storage capacity. Other communities use wells.
- Topic of Fisheries Act and Safe Drinking Water Act came up (Fisheries Act overrides Safe Drinking Water Act).

Impacts of Sea Level Rise on Coastal Communities: A Collaborative Approach

Dr. Phil Hill and David Mate
Geological Survey of Canada, Natural Resources Canada

The Geological Survey of Canada is currently undertaking case study research on sea level change on the intertidal zone of the Fraser River Delta, specifically the Roberts Bank tidal flats. The physical, natural, and socio-economic impacts of a rise in the sea level at Roberts Bank is the focus of this research. This work is one of 5 case studies that are part of a national project looking at the impacts of climate change on planning in Canadian municipalities.

It is predicted that the global sea level will rise by 0.09 to 0.88m by 2100. During the 20th century, the sea level rise experienced in Vancouver was +0.04m. Climate change is expected to bring stronger storms to our coast, compounding impacts of sea level rise in low-lying areas such as the Roberts Bank tidal flats. Possible climate change impacts affecting Roberts Bank include inundation of upper tidal flats, increase in height of storm surges, and significant increases in the area's exposure to wave energy. This translates into increased erosional attack on the tidal flats and the critical infrastructure that it supports (i.e. dykes, and causeways), erosion of surface layers and reduction of biota in sediments and biofilm, and degradation of salmon and bird habitat.

The Roberts Bank case study involves physical research of the tidal flats, a biological investigation of plant and animal habitat, and socio-economic research to identify stakeholders and determine how rising sea level will affect them. . Community partners include the Corporation of Delta, Tsawwassen First Nations and GVRD. Stakeholders are Vancouver and Fraser River Port Authorities, BC Ferries, Fisheries and Oceans Canada, Environment Canada and NGOs facilitated by the Fraser Basin Council.
The climate change impacts from all five of the case studies will be documented and potential adaptation strategies identified. The planned outcome is to have municipalities incorporate scientific climate change information into their planning processes.

Discussion:

One member recommended the Coasts under Stress Program, which has a website: www.coastsunderstress.ca/home.html

Challenges in Sustaining Quantity and Quality of Drinking Water Under Extreme Climate Variability: Sooke Watershed as a Case Study

Dr. Asit Mazumder
University of Victoria, BC

Dr. Mazumder is involved with research being done at the University of Victoria in support of ensuring a continued source of quality water originating from the Sooke Watershed and several other watersheds in BC. Presently there are 30 –35 people involved in the project at UVIC. The group is looking at:

- Watershed processes
- Aquatic processes
- Ecology and source tracking of pathogens
- Production of carcinogenic byproducts
- Development of GIS and remote sensing based models
- Modeling waterborne diseases
- Reconstruction of historic climate conditions, land/water use and food web changes

The downstream quality and quantity of water, conflicts between consumers and fisheries and varying land uses found within a watershed are all issues affecting our drinking water. Dr. Mazumder referred to the fact that the *Fisheries Act* overrides the *Safe Drinking Water Act*. Water quantity is an issue due to high consumption rates and population growth within urban areas.

The effects of climate change on our water supply include substantial inter-annual variations, which may be linked to variable climate conditions, resulting in years of low precipitation. Excess demand would need to be curtailed by imposing water restrictions within the municipality, such as in the summer of 2001 in Victoria. Low rainfall and high demand caused severe drawdown and changes to water quality as the high concentrations of nutrients and sediment were released from deeper water and shoreline erosion. Adaptation strategies are needed in order to deal with water quantity issues. The challenge is to sustain the quality of drinking water under conflicting land use practices and under variable climatic conditions. The development of best adaptation strategies for sustainable water resources is a necessary tool to deal with our changing climate and increases to municipal populations. To do this we must have better integration of science at the level of the community watershed, stronger interaction of sectors (e.g. Fisheries, Water Management) and more effective knowledge transfer to communities and managers. Some examples of adaptation strategies in the CRD include imposing severe water restrictions, which have significant aesthetic and economic implications, compensating consumers who upgrade to efficient infrastructure in their homes, and media promotion to conserve water.

Discussion:

- Raising the Sooke dam doesn't solve the problem if water doesn't come; water usage increase is the issue and water conservation could be the answer.
- Population growth – sustainable growth is not sustainable. Conflict in thinking – the municipalities are focused on growth.
- Building Codes / public policy has got to be modified to meet present day needs – reduced use fixtures, gray water use.

Small Group Discussions:

What are the potential impacts of climate change that are of the most concern in your community?

- The impact of immediate concern to most communities is the issue of water supply. Anticipated challenges include water supply deficiency, localized flooding, storm water management due to precipitation increase and the resulting infrastructure stress, aquifer recharging and impacts on vegetation. It is anticipated that the future will hold an increase in conflict between human and sectoral demands on this resource. (e.g. fisheries, agriculture)
- Also of concern are air quality, shoreline erosion resulting from sea level change, an increase in pest infestations affecting agriculture and forestry, and the effect of the snow pack decline and 'death of beauty' on the recreational/tourism sector.

How have you adapted to climate impacts in the past? What works now? What new approaches might be needed?

- Municipalities in the past have been more reactive than proactive in their adaptation plans.
- Responses to water supply issues include watering restrictions, recycled water use, development of water efficiency fixtures (e.g. drip irrigation, toilets), improved water conservation strategies and water metering. It has also been necessary for municipal planners to respond to flooding challenges with the rebuilding of banks and raising dams.
- Air quality issues have been addressed through outdoor burning bans, car emission testing stations and through developing and promoting the use of mass transit (Transportation Demand Management - TDM).
- Many of these approaches may have an influence on what we define as a higher standard of living and many activities 'indirectly' responded to climate change but were more directed to managing land use and other pressures.
- Proactive strategies have included emergency contingency plans, education of stakeholders through explicit statements of benefits and co-benefits, and the collection of impact feedback such as water consumption graphs.
- An example of an engineering plan reflecting the impacts of climate change is demonstrated in the comparison of construction of the Vancouver and Victoria seawalls. The Vancouver seawall is wider and stepped, the Victoria seawalls are concave in shape with additional gravel and rock extensions to slow down the power of the waves.

What additional information or resources would your community need in order to adapt to climate change?

- The establishment of a ‘best practices guide’ detailing an overall environmental management plan that could be used by all communities was discussed. Incorporated in this management plan would be adaptation strategies targeted at addressing climate change.
- The issue of community and stakeholder education was again highlighted. The need was identified to educate the general public, explaining that ‘they are part of the problem *and* part of the solution’. The experiences and solutions of other countries and regions of Canada were identified as a valuable resource of information that should be captured. (e.g. Spain dealing with 15" of rain annually) Moving this information into the school system and targeting youth was sited as a priority. Teaching resources could be made available to teachers through the BC Climate Exchange (http://bcclimateexchange.ca/index.php), CRD and local boards. The need to relate the issues of climate change to a personal level was seen as an effective method to gain the attention of youth. (e.g. summer smog and health)

What should local governments be doing to address change impacts and adaptation?

- Several potential initiatives of local governments were identified as catalysts to addressing change impacts. These included municipalities establishing baseline audits, incorporating climate change scenarios in planning and capital budgeting, introducing economic incentives, enacting climate change bylaws and regulations and encouraging densification. ‘Green’ bylaws were suggested as the best practices for policy alignment and land use flexibility. The need exists to identify the ‘goal’ and determine how far and how fast.
- In order to get the public support for policy changes it is important to translate climate change into a quantifiable impact on communities (e.g. what impact will a climate change of 2° have?) to demonstrate the necessity of such changes. The need exists to educate politicians that there is a need for huge federal dollars to be invested to ensure grass roots knowledge in municipalities to empower or second those knowledgeable to local government.
- Education opportunities exist using the scenario model building software – Q.U.E.S.T. (e.g. shifting precipitation/season – impact on supply/demand management) and the use of the GVRD web-based GHG Action Guide.
- While encouraging personal responsibility we must ensure that as community leaders we are leading by example. Practice what we preach.

<u>Key Points Summary:</u>

- Start introducing “climate change” into day-to-day correspondence / reports – institutionalize it.
- Leverage resources – e.g. Policy working group. Free up resources. A lot of the ideas for adaptive strategies are available from the people working with it day to day, but they do not have the time to share / formalize the information. The ideas are not getting to those who set the policy and manage the budgets.

Session C: Economic and Social Issues

Adaptive Responses to Climate Change in Communities and Institutions

Erik Karlsen, MCIP
Professional Planner

Mr. Karlsen spoke from the perspective of a community and regional planner. The focus of his presentation was to provide checklists and tools that can help communities and institutions to respond effectively to the impacts of climate change.

Effective community planning requires a comprehensive view. Communities can be considered from many levels – from a global perspective down to specific places or sites. Regardless which level of community or order of government you are working at, you need to consider what is happening at other levels.

There is also a range of influences to be considered – ignore these at your peril! All influences will have a bearing, regardless of the level you are working at. If you do not consider what is happening at other levels or do not take all influences into account, your plan will not make sense and you will not be able to deliver on your objectives.

To put things in context for our discussion, most land-use planning happens at the regional and community levels.

There are three approaches to adaptation and planning, each of which involve social, economic and political choices:
"Decline and depart." Watch things happen and leave. Ghost towns are created this way.
"Respond and recover." Attempt to intervene in response to occurrences. One example is when government tries to intervene after the decline of an industry, by providing funds, supporting new enterprises, etc.
"Anticipate and adapt." Are we prepared to anticipate changes and adapt in order to keep moving forward?

Looking at the third option in more depth, what are the abilities that help us to adapt?

- Can we predict the harmful outcome? Can we estimate the level of harm?
- Are we capable of avoiding, mitigating or compensating for this outcome?
- Are we institutionally prepared to take action and to be accountable?

Another perspective on our ability to adapt is to look at institutional evolution and the extent to which our institutions have shifted to a new paradigm. The old paradigm for responding to change was based on sector specific priorities and order of government specific programs. Work was done in a hierarchical and disaggregated fashion. The approach to change was ad hoc and arbitrary. This paradigm still exists, in particular in resource industries and to a lesser extent in regional and community planning.

A new paradigm that will be more effective in adapting to change recognizes broader priorities, but looks at change from a place-based perspective. The focus is on planning, stewardship and anticipatory adaptation.
How can we align the various mandates and interests of different stakeholders in a place to identify and focus on the future well-being of the people and the place? We need to start by understanding the roles various "institutions" can play. We need to understand and, if necessary, enhance their capacity to participate in preparing and implementing adaptive strategies.

Mr Karlsen developed the "P10" checklist to help assess and focus attention on strengthening an institution's capacity in its own right and in relation to collaboration with others . These are the attributes an institution (or any organization) needs in order to adapt and to support effective collaboration. As an organization goes down the list it will find gaps, areas that aren't well developed, and that is where it will be vulnerable.

Figure 14: P10 – Instituational Capacity

The "What Matters Dialogue?" checklist is another tool that can assist groups to develop effective partnerships and build collaborative working relationships. By talking through the different points on the checklist potential partners will be able to quickly establish the basis for collaboration. They will learn about each other from the outset, and set aside misunderstandings that lead to poor communication and un-met or un-reasonable expectations.

Figure 15: What Matters Dialogue

Using the Georgia Basin-Puget Sound Region as an example, Mr. Karlsen demonstrated that adapting to climate change is part of a broader set of issues and changes to be addressed. There are nearly 7 million people living in this region now, and there will be 9 million in an increasingly urbanized environment by 2020. The type of changes that we need to think about in relation to the GB-PS Region include hydrological shifts, natural hazards, ecosystem shifts and resource shifts.

The approach to land-use planning for this area needs to be both place-based and place-making:

A) Getting started. Identify the planning areas. Take a watershed approach and work from the bottom up – from the geology and hydrology of the region. Identify priorities and the policy context.
B) Area assessments. Points assessed include: protected areas, natural hazards, sensitive ecosystems, water supply areas, storm water management, resource management areas, settlement pattern, cultural perspectives. Climate change is one more factor to be addressed, but it needs to be put in the context of all the other issues.
C) Align place and policies. Designate any areas that need particular policies based on conditions (for example, areas prone to flooding). Identify external or community-based policies and standards.

D) Draft plan and strategy. Apply design principles. Identify ways and means and build these into the plan – something we do not do well.
E) Implementation: Enacting the plans and policies, developing necessary agreements, putting finances in place, monitoring outcomes, reporting and reviewing and revising plans are all needed elements to achieve the intended results or revise outcomes and strategies as needed.

The GVRD has developed the following risk-based / adaptive management model for liquid waste management:

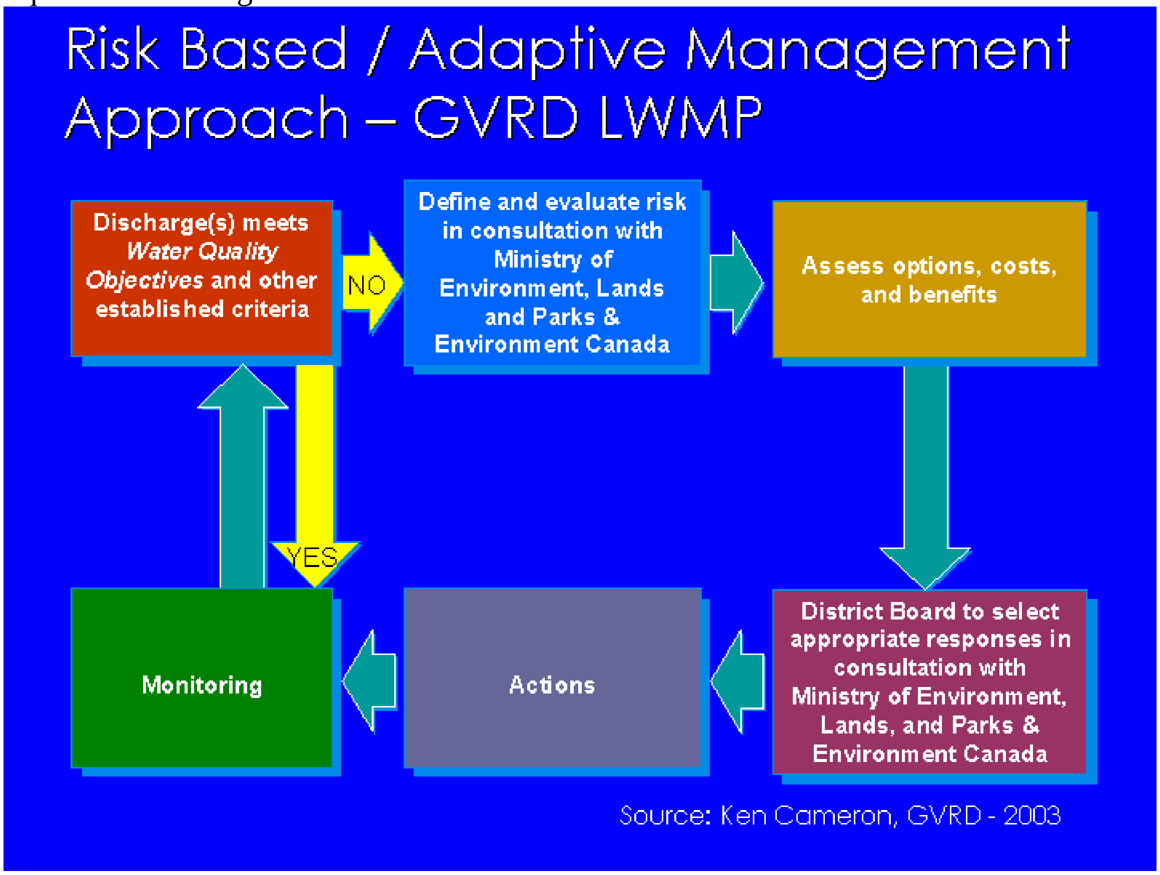


Figure 16: Risk-based / Adaptive Management

BC Hydro has identified three bottom lines: environmental, social and economic. Managing the impacts of climate change is integrated into each bottom line.

"Smart Growth on the Ground" is a statement of principles for planning more sustainable and affordable communities:

- Each community is complete (with all services residents need)
- Pedestrians come first
- Work with natural systems, not against them
- Buildings, roads and services are greener, smarter, cheaper
- Housing is safe and equitable
- Good jobs are close to home
- The spirit of the place is protected

- Everyone has a voice.

Climate change could be addressed within these principles.

By using these principles to prepare a neighbourhood concept plan for East Clayton in Surrey this 550-acre area will provide a full range of services to 13,000 residents who will generate 40% fewer car trips and 90% less run-off than typical suburban developments.

In summary, adapting to climate change is part of a broader perspective to community planning:
- Focus on "adapt abilities"
- Build institutional capacity
- Engage in dialogue
- Make your strategies place-based (in context)
- Be sustainable and adaptive

Discussion:

Q: Which institutional capacities are most important when it comes to responding to climate change?

A: All of the capacities listed in P10 are important. For example, you can take an institution and introduce the principle that we will adapt to climate change. But is adapting to climate change given any priority? If not, you can't go any further. Is the need to adapt to climate change integrated into policy? How is it translated into regulations or standards? You need to look at all 10 capacities in order to assess whether this organization will be effective on this topic.

Social Issues and Challenges in Resource-based Communities

Dr. Holly Dolan
University of Victoria

Dr. Dolan stressed that we know that climate change is of concern in B.C. We have projections and we know that some impacts are already occurring.

Projected changes include:
- potential average annual temperature increase of 1 - 4 °C
- potential average annual precipitation increase 10-20%
- sea level rise by up to 88 cm along parts BC coast
- retreat & potential disappearance small glaciers
- decreased river discharge in summer & early fall
- salmon migration patterns & success of spawning likely to change
- mountain pine beetle may expand into new regions

Resource-based communities are by nature dependent on the environment for their economic well-being and community health. Climate change will affect them. However, many resource-based communities are already in crisis as a result of environmental degradation, changes in their industrial base and social and political changes. For example, resource-based communities in BC have experienced sawmill closures, reduced access to natural resources (such as fish), school and hospital closures and reduced access to social support. Community and individual health is affected by the socio-economic conditions, social cohesion, whether or not people have a voice and many other factors. As a result, we are also seeing degradation in health status.

Climate change is only one risk among the multitude of risks facing resource-based communities and it must be considered in that context.

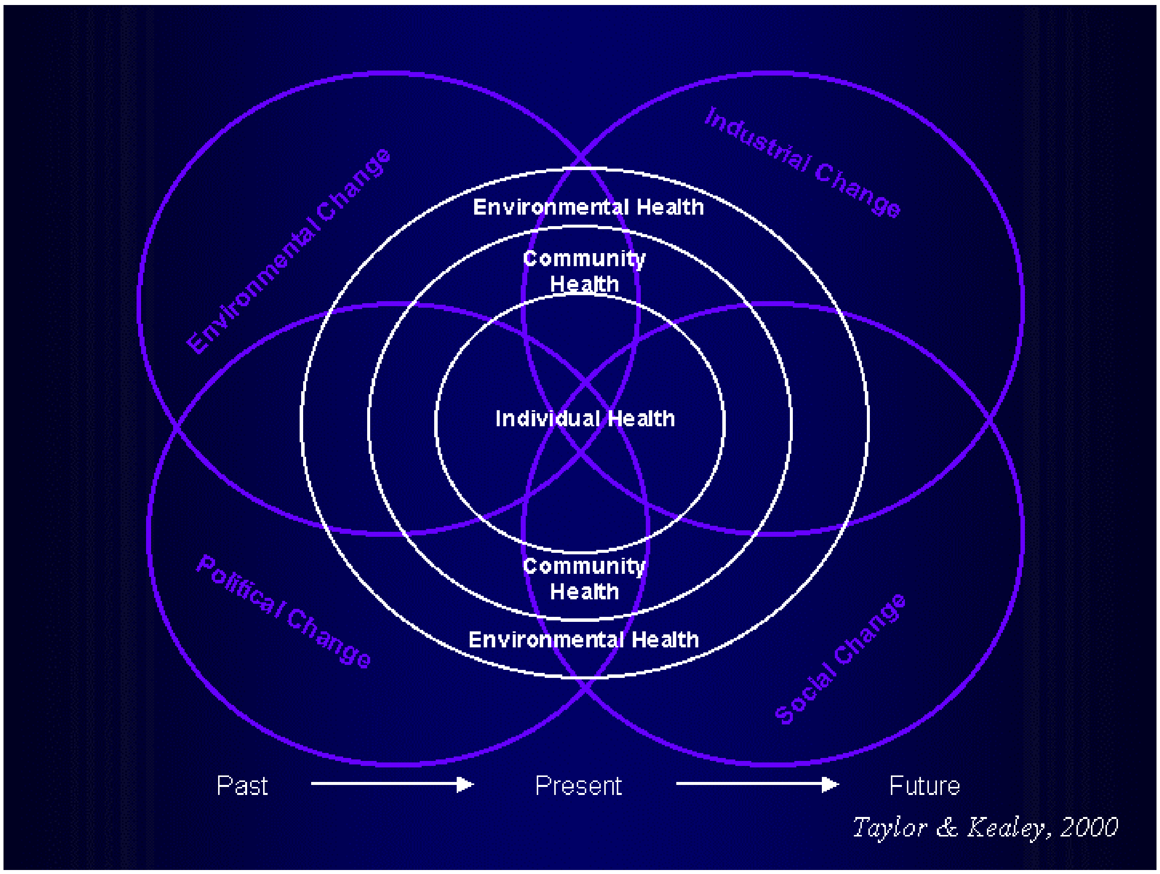


Figure 17: Context for Resource-based Communities

Adaptation to Climate Change

Many earlier impact assessments assumed autonomous adaptation in response to a stimulus. Climate change was perceived as driving the system.
Adaptation can be defined as adjustments in ecological, social & economic systems in response to actual or expected climatic stimuli & their effects or impacts *(Smit & Pilifosova, 2002)*. The fundamental role of adaptation is to moderate impacts of climate-related changes.

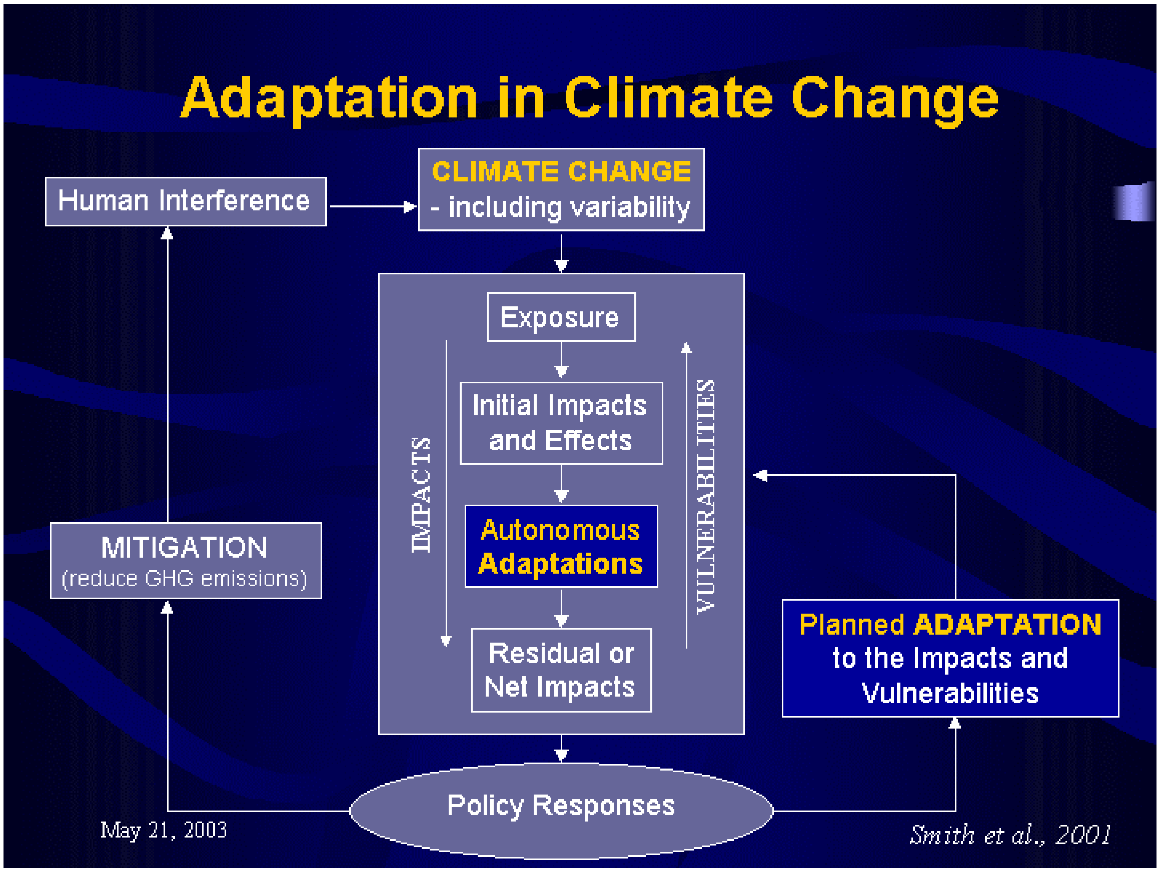


Figure 18: Adaptation in Climate Change

The **adaptation approach** considers the impact of climate change on systems, and what adaptation is needed in response. The starting point is the stimulus. Key questions for the adaptation approach include:

- What is likelihood of adaptation?
- What is key determinant of adaptation?
- What adaptation options are superior given specific circumstances?

All these questions assume adaptation to a particular risk, in this case climate change, and the focus is on identifying appropriate adaptation measures

There are a number of limitations to this approach *(Smit & Pilifosova, 2002)*

- Adaptation measures in any particular case are numerous. It may be impractical to identify all the potential impacts, the many possible adaptations, and evaluate the merit of each.
- Adaptation measures are very location- and situation-specific, so assessing them requires detailed knowledge of the community or system.
- Adaptation measures are not unlikely to be implemented if they are not consistent with or integrated into broader management decision-making processes. Climate-related risks will be managed with other risks and within established risk management processes, legal frameworks & decision processes.

These limitations suggest that it may be more effective to focus on enhancing **adaptive capacity** overall instead of focusing on a particular adaptation measure

The **vulnerability approach** does that. The vulnerability approach is the inverse of the adaptation approach. The starting point is the system itself – the community, region or sector – and an examination of the characteristics that may make that system vulnerable to climate change (or other changes). From this perspective, the focus is on building the adaptive capacity of the community, region or sector.

Key questions related to the vulnerability approach include:
- Who/what is vulnerable?
- To what is the who/what vulnerable?
- Where is vulnerability spatially & temporally distributed?
- Why are the who/what vulnerable?

Building adaptive capacity:

The IPCC identified the following determinants of adaptive capacity:

A) Range of available technological options for adaptation
B) Availability of resources & their distribution across the pop.
C) Structure of critical institutions, derivative allocation of decision-making authority & decision criteria employed
D) Stock of human capital including education & personal security
E) Stock of social capital including definition of property rights
F) System's access to risk spreading processes (for example, insurance)
G) Ability of decision-makers to manage information, processes by which decision-makers determine which information is credible, and the credibility of decision-makers themselves
H) Public's perceived attribution of the source of stress & significance of exposure to its local manifestations

The remainder of the presentation described research that has begun in the Queen Charlotte Islands.

The project focuses on coastal vulnerability to climate change and sea level rise on Graham Island in Haida Gwaii (Queen Charlotte Islands). The project targets physical and socio-economic impacts of climate change on north-eastern Graham Island. The Geological Survey of Canada has identified this area as one of BC's most sensitive coasts to sea-level rise impacts (Shaw et al. 1998). Macrotidal range, erodible sediments, frequent extreme storms and strong winds, and an energetic wave climate produce a dynamic environment that experiences ongoing coastal erosion of 1-3 metres per year *(Harper 1980, Clague et al. 1982, Barrie & Conway 1996)*. The coastline is highly vulnerable to the projected sea-level rise of 0.15 metres per century. As well, dramatic retreats occur during extreme climate events. For example, in 1997-98 El Niño caused up to 0.4 metre of sea-level rise and 12 metres of coastline erosion *(Barrie & Conway 2002)*.

The research objectives are:

A) examine historical and contemporary coastline changes in the area by measuring and mapping recent morphological changes in the coastline
B) assess coastline sensitivity to extreme climate variability and change impacts in the area by mapping coastal sensitivity using the sensitivity index of Shaw et al. (1998)
C) evaluate sea-level rise impacts & vulnerabilities by assessing & mapping projected impacts – system exposure (e.g., inundation and tidal encroachment zones, areas of enhanced erosion, sea water intrusion) and;
D) 'community-relevant' vulnerable regions/activities (e.g., forest/habitat damage or change, fishing grounds, susceptible land/property/infrastructure, extreme storm damage and wave breaching) and determinants of adaptive capacity

Dr. Dolan is the only social scientist (the rest of the team are focused on the natural environment). She will be working with local communities and stakeholders to identify their exposure to risks, assess the importance of the various risks, and identify their adaptive capacity.

Update (December 2003):

Since this presentation, a graduate student has joined the research team to work on the social science side of the vulnerability assessment. Dr. Dolan and the graduate student spent some time up in Haida Gwaii this summer and have established links with the Council of Haida Nations and other groups within the communities on Graham Island. The research project is now working closely with community groups to identify important and relevant questions regarding environmental changes in the region. Dr. Dolan is looking for an additional masters level student to work on the project.

<u>Discussion:</u>

Q: In terms of the community research, were local people involved in the project design? If not, will this affect their willingness to be involved?
A: No. The project was conceived by the researcher, but there is support from the Haida Nation and the research team will spend time getting to know local people, community issues and dynamics.

Q: How relevant is climate change is to local communities in the Queen Charlotte Islands, given many other priorities (for example, treaty negotiations)?
A: One strength of the vulnerability approach is that the focus on vulnerabilities and enhancing adaptive capacity and resilience can help a community to deal with many issues in addition to climate change.

Coastal Forest Industry Perspectives on Climate Change

Shannon Janzen
Western Forest Products Ltd.

The coastal region includes a great deal of climatic variation. The magnitude of potential environmental impacts and economic consequences resulting from changes in precipitation levels, wind patterns and atmospheric temperature varies by location.

Precipitation

A 2001 publication by the Intergovernmental Panel on Climate Change found that, on average, precipitation on the coast has increased 2% per decade since 1929. Seasonal increases in precipitation are expected to continue. This publication also suggests that there is a strong potential for an increase in the frequency of extreme events.

Precipitation levels vary significantly along the coast, as does the degree of saturation that can be reached before landslides occur. For example, WFP's geotechnical assessments show that the potential for landslides increases dramatically after 100mm of rain is received within 24 hours in the wetter regions and 55mm in drier locations. Rainfall is monitored by forest operations and when in excess of these limits no work is permitted within potentially unstable terrain. Employees are not permitted to return to work until the water balance is within acceptable limits. This can be several days in severe rain events.

The likely increase in the frequency of extreme rainfall events will curtail production, due to unsafe conditions, and reduce the productive capacity of soils where landslides occur.

As precipitation and the frequency of extreme events are likely to increase with climate change, past events may not reflect future trends. This results in risk to infrastructure designed according to current standards. For example, bridges built for 3 to 15 years of use are based on 50-year climate patterns. An increase in the frequency and/or severity of extreme events may make this standard inadequate.

Wind

Unlike the interior, where fire dominants the landscape, windthrow is the primary disturbance within the majority of coastal landscapes. Increases in extreme wind events pose a substantial risk to the forest resource as thy may result in large volume losses and reductions in wood quality.

Temperature Variation

The trend towards increasing atmospheric temperatures is expected to continue. As a result, climate change may have both positive and negative impacts on timber supply.

Positive Benefits

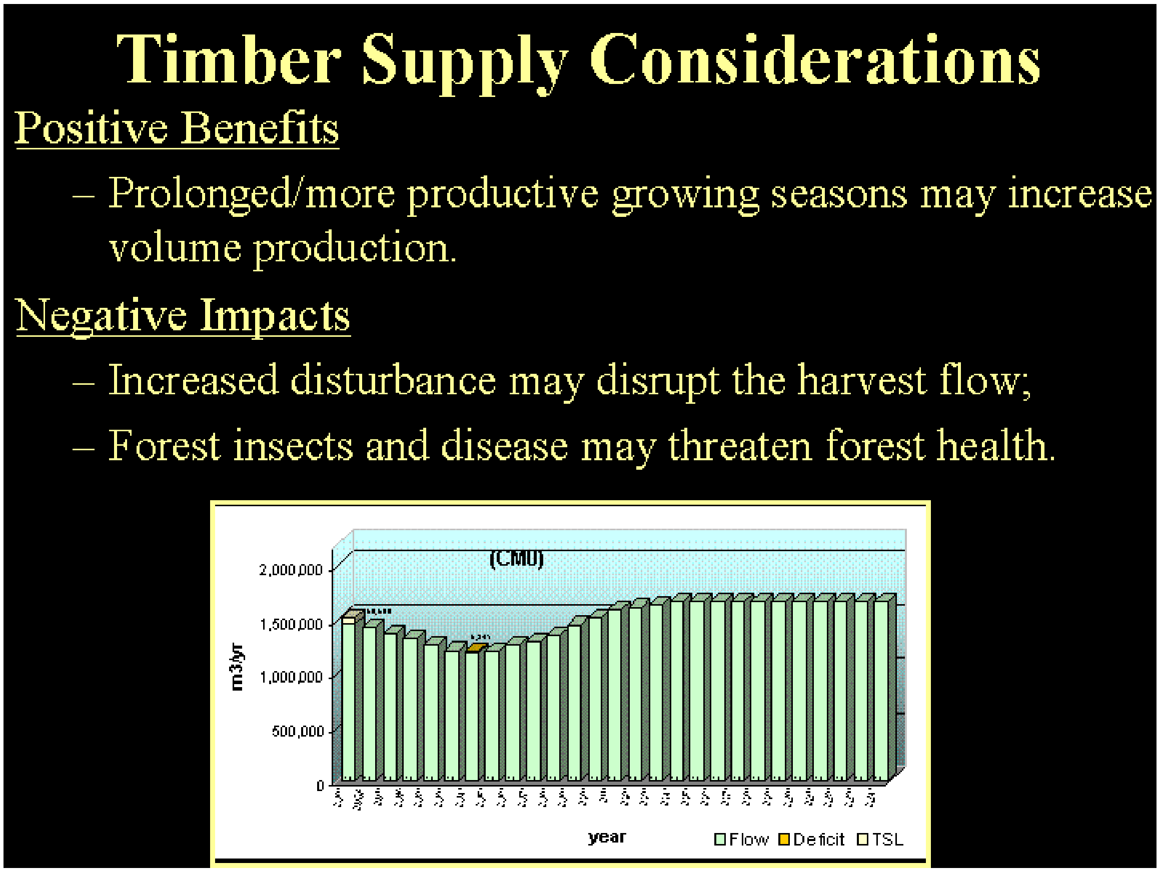


Figure 19: Timber Supply Considerations

This graph shows a sustainable harvest flow for TFL 6 (northern Vancouver Island) and is based on current site productivity and growth rates. Climate change could have a net positive benefit on long-term harvest levels by increasing the growth potential of forests. However, the potential magnitude of this benefit is questionable as elements such as the suitability of commercial species within future ecosystems can greatly influence productivity.

Negative Impacts

Continual harvest flow through time is essential for sustainable management. Certain pests, previously controlled by minimum temperatures, can force large increases in short-term harvest levels. This is currently reflected in the mountain pine beetle dilemma of the interior.
Another excellent example of a pest dependant on climate is spruce leader weevil. Climate has been a barrier to this pest in the past. Forest management techniques address leader weevil where historic climatic conditions enabled its survival. However, in areas historically not impacted by this insect, plantations may become susceptible with increasing temperatures.

The Challenge of Adaptive Management

In order to maximise the positive benefits associated with climate change and minimise potential negative impacts, an adaptive management approach to resource management must be implemented.

In many circumstances applying this approach will not be complicated nor will it involve a huge financial investment. For example, planting weevil resistant spruce in areas historically beyond the weevil's northern range is operationally feasible once sufficient resources are available. However, the implementation of many potentially viable management techniques is much more complicated. For example, progeny trials, which move trees adapted to southern climates north, are extensive for commercial tree species; however, commercial application will be a challenge due to various uncertainties and legislative constraints.

With climate change, ecosystems will likely change as opposed to move in unison. Given that, is moving the trees enough to maintain productivity? As ecosystems change, the suitability of even southern progeny may be questionable.

As ecosystems adapt to climate change their function will also change. This leads to uncertainly in the structure of parks and protected areas. Through landscape level planning, protected Old Growth Management Areas are currently being delineated within the province. Among the considerations for establishment are rare old-growth ecosystems and specific wildlife habitats. With climate change, will these ecosystems still be represented? Will the wildlife habitat they protect continue to be sufficient?

Incorporating Climate Change into Management Decisions

Forest certification systems such as Canadian Standards Association incorporate a requirement for a public advisory group. Members represent diverse local interests and work toward the development of long-term economic, social and environmental goals for a Defined Forest Area. This forest certification includes criteria addressing global ecological cycles and basic carbon accounting. Discussions pertaining to these criterion increases awareness about climate change and help incorporate potential impacts into strategies to meet long-term goals.

Along with adaptive management and continual improvement, forecasting future forest conditions is an integral component of CSA certification. These requirements are in recognition that, like human values, forest ecosystems are not stagnant. How climate change impacts are incorporated into such forecasts is not clearly defined. However, new standards are expected to place more emphasis on forecasting, monitoring and measurement.

Community Adaptive Capacity

Many small coastal communities depend almost exclusively on the forest industry and diversification is difficult to achieve. Therefore, the ability of these communities to adapt to negative pressures on timber supply resulting from climate change will be far less than in regions with a more diversified economy. Addressing the risks and enhancing positive benefits can decrease the long-term vulnerability for these communities.

In Conclusion

The forest industry is beginning to consider climate change in managing the forests. However, much of the current legislative and planning framework continues to be based on current forest conditions and previous climatic events. Climate change is only one of the many issues affecting forestry, and the extent to which the industry can plan adaptation specific to climate change is limited by the complexity of the issue and the uncertainty about impacts.

Discussion:

Q: American companies either do not seem to see climate change as relevant at all, or they see the focus on climate change as part of a plot to overthrow the industry! What is different in Canada?

A: Not all Canadian companies recognize the problem yet, however sheer economics do encourage taking climate change into consideration. For example, a company may spend $240,000 to build a bridge that may be washed out unless higher spring stream flows are considered. As well, Canadian Standards Association certification, to which many companies have subscribed, incorporates elements which address climate change issues.

Q: It was noted that many communities will be affected by changes in forestry, and suggested that Port Hardy is 100% vulnerable to changes in the forest industry. Why is this?

A: These estimates were made by Statistics Canada, and it reflects their assessment that all jobs in the community are directly or indirectly (e.g. the service industry) dependent on forestry. Even if tourism jobs might increase as forestry jobs decrease, those jobs do not pay enough to support families and maintain the community. Statistics Canada estimates that it takes 6 to 8 tourism jobs to equal one job in forestry. That's because a forestry job pays higher wages, resulting in more spin offs such as greater investment in the community (i.e. housing starts etc)

Q: Why isn't climate change taken as seriously as earthquakes, or as Y2K – a lot of money has been spent addressing those possible problems but not related to climate change.

A: We know more about earthquakes, and have a more concrete sense of the damage that can result. For Y2K there was a deadline. Climate change is more complex, less tangible, and there is no set deadline.

Small Group Discussions:

What are the potential impacts of climate variability and change that are of the most concern in your community? To your industry?

- Small, resource dependent communities will be most vulnerable. Anticipated effects will include: coastal erosion, water supply and management, forestry impacts due to fire, pests and wind throw. All of these have potential impacts on quality of life.

- There will be ongoing challenges in planning due to inability to quantify risks/impacts (e.g. unpredictability of precipitation). These impacts may be mitigated through encouraging changes in the behaviour of community members and corporations (e.g. reduction in water consumption).

How have you adapted to climate impacts in the past? What works now? What needs to be improved?

- Many organizations are already adapting or adjusting, but what about other organizations or communities that may lack capacity to adapt?
- In the agricultural sector crop insurance, other hazard insurance, and federal bail outs have been accessed to alleviate the impacts of climate change. There is a need for alternatives to public funding for risk response.
- Continued improvements in knowledge and technology have assisted municipal engineering responses to experienced and/or anticipated climate change impacts.
- Decision makers who are better informed about current ecosystems and improved monitoring of impacts will help to alleviate the challenges of climate change in resource extraction. We need to do vulnerability analyses and we need models which can be applied to local areas with more precision.
- Better (more relevant) evidence of climate change, communicated in a way that is relevant and appropriate for public information, will facilitate the integration of climate change and variation into planning processes, strategies and action plans.
- Consider incentives to encourage small and medium enterprises to make take action.
- Improvements will result from educating the community members and working with stakeholders at the community level.

What additional information or resources would your community and industry leaders need in order to better respond to climate variability and change?

- There is an immediate need to raise the awareness of climate change impacts and the need for mitigation and adaptation at both the leadership level and with the general public. Information and incentives together can encourage change.
- Working in partnerships and developing ‘a sense of community’ is key to adaptation and sustainability.
- Information that is specific to the needs of decision-makers in government and industry and tools that help them to develop responses to the defined risks.

Key Points Summary:

We must take a public interest perspective. We need to inform the public of the challenges and ramifications of climate change in a way that encourages them to respond and provides them with the means to participate.

Appendix A: Speaker Biographies

Plenary Session 1
Climate Change in the Pacific Northwest

Bill Taylor

Bill Taylor is a climatologist with Environment Canada.

His work involves analyzing trends and variations in the climate record, and constructing climate scenarios for use in climate change impacts work.

Bill was a co-editor of Responding to Global Climate Change in British Columbia and Yukon, published in 1997, as part of the Canada Country Study. He was also the project leader on the Temperature Rising poster that has been widely distributed to schools throughout southern BC.

Bill is currently involved in a study of climate change impacts on the Okanagan basin water supply and its potential effect on the region's agricultural sector.

Philip Mote

Dr Philip Mote is a research scientist at the University of Washington, in the Climate Impacts Group (CIG), and an Affiliate Professor in the Department of Atmospheric Sciences. He has a BA in physics from Harvard (1987) and a PhD in atmospheric sciences from the University of Washington (1994). Between college and graduate school, Dr. Mote taught math and physics at Monte Vista Christian School in Watsonville, Calif. After completing his PhD, he was a Visiting Fellow in the Department of Meteorology at the University of Edinburgh in Scotland for 2 years. He joined CIG in 1998 and was lead author of a 110-page report "Impacts of Climate Variability and Change: Pacific Northwest" in 1999. He has written about 30 scientific articles and also edited a book on climate modeling, published in 2000 by Kluwer Academic Press. In March 2003 he became the Washington State Climatologist.

Plenary Session 2
Impacts and Adaptation – Approaches and Case Studies

Jenny Fraser

Jenny Fraser works full time on climate change impacts and adaptation for the BC Ministry of Water, Land and Air Protection. Her overall task is to help develop an integrated science, impacts and adaptation strategy for the BC government. She chairs the C-CIARN BC Advisory Committee, and represents BC on the national intergovernmental Impacts and Adaptation Working Group.

Dave Spittlehouse

Dave Spittlehouse is a scientist in the Research Branch, BC Ministry of Forests, Victoria. He is working on climate change issues - impacts of climate change on forests and adaptation in forest management. He is also involved in work evaluating BC's forest carbon balance. He has represented the Ministry of Forest at the provincial and national level on committees related to climate change and greenhouse gases and was a member of the National Greenhouse Gas Sinks Table. Dave is also currently a member of C-CIARN Forest Sector Advisory Committee.

Kim Hyatt

Dr. Hyatt is a Research Scientist with Fisheries and Oceans Canada’s Science Branch at the Pacific Biological Station in Nanaimo. He directs the Salmon in Regional Ecosystems Program in the Stock Assessment Division and he serves as a manager and science advisor for the Fisheries Sector of the Canadian Climate Impacts and Adaptation Research Network (C-CIARN Fisheries). Dr. Hyatt holds adjunct faculty positions at the University of British Columbia in the Institute of Resources and Ecology as well as at the University of New Brunswick in the Department of Biological Sciences. His current research interests include: (i) the status of salmon populations in Canada’s Pacific Region, (ii) the role of climate variations in controlling production and recruitment variations of salmon populations in freshwater and marine ecosystems and (iii) the development of information systems and decision tools to improve the delivery of applied research results to fisheries managers.

Concurrent Session A
Marine Ecosystems and Fisheries

Bill Crawford

Bill Crawford has been employed as a research scientist at the Institute of Ocean Sciences since 1977, studying most aspects of physical oceanography. He is also an adjunct professor of oceanography at the University of Victoria. (“Adjunct” means he receives all benefits of a university prof except money.) His most recent studies are of predictability of storm surges in BC, oceanographic aspects of hydrocarbon exploration in northern BC, flow through Bering Strait as measured by satellite, tsunami impacts in BC, and the two programs you will hear during this presentation.

Nathan Mantua

Nathan Mantua received his B.S. degree from the University of California at Davis in 1988 and his Ph.D. from the University of Washington's Department of Atmospheric Sciences in 1994. He spent one year as a post-doctoral fellow at the Scripps Institute for Oceanography where he work on climate prediction issues. Since 1995 he has worked as a research scientist with the University of Washington's Climate Impacts Group.

Most of his current research focuses on the regional impacts of climate on the water cycle and Pacific marine ecosystems, and how climate is or isn't being used in resource management decisions.

Mark Johannes

Mark Johannes is the Fisheries Sector, National Coordinator of the Canadian Climate Impacts and Adaptation Research Network (C-CIARN www.fishclimate.ca). Mark is also senior fisheries research scientist at University of Victoria, Biology-Watershed Lab. (www.uvic.ca/water) and teaches at UVIC and Royal Roads University. Mark is an active Director with the Northwest Ecosystem Institute, a research based NGO based in the Pacific Northwest (www.ecosystems.bc.ca). He completed his Ph.D. in Ontario and was a NSERC postdoctoral fellow at Simon Fraser University and Pacific Biological Station. Mark is a fisheries biologist / ecologist with >15 years of experience across North America working on watersheds and ecosystems in freshwater lakes, rivers, marine estuaries and oceans habitats.

Concurrent Session B
Communities and Infrastructure

Jennie Moore

Jennie Moore is an Air Quality planner with the Greater Vancouver Regional District. Her work focuses on building local capacity to implement actions for sustainable communities. She assisted the BC Greenhouse Gas Forum in developing BC's negotiating position on emission reduction targets and preferred policy measures leading up to the 1997 Kyoto Protocol. She developed the Greater Vancouver Regional District Employee Trip Reduction Program which received an Eco-Action award of recognition from the Federal Government in 1998, and the Regional and Local Government Working Group on Climate Change which has been recognized as a best practice by the Canadian National Climate Change Secretariat. In 2001 she was invited by the International Council of Local Environmental Initiatives to participate in the U.S. and Canadian Municipal Leaders Rio+10 Preparatory Meeting for the United Nations World Summit on Sustainable Development. Recently she developed the Greater Vancouver Regional District, Corporate Energy Policy and is currently working in the Sustainable Region Initiative to review the District's plans from a sustainability perspective.

David Mate

David is a Quaternary geologist by training who has mapped glacial deposits in southern Ontario and central British Columbia. This work has been applicable for groundwater issues, landslide hazards, and mineral exploration. Besides having a keen interest in applied science, David is also passionate about communicating science to the general public. Presently, his role with Natural Resources Canada is to communicate the department's science to the public.

Asit Mazumder

After finishing Ph.D. in aquatic ecology from the University of Waterloo in 1989, Dr. Asit Mazumder joined Université de Montréal, where he served as a faculty member for 10 years and as the Director of Laurentian Biological Station for five years. During the last 10-12 years, he has published over 40 peer-reviewed papers in international journals, made 100 invited, plenary and conference presentations, served as associate editors of several international journals, as committee members for provincial and national granting agencies and as advisory members in several drinking water related committees. His major areas of research expertise are water quality/quantity, nutrient-foodweb dynamics, microbial ecology, ecotoxicology and salmon ecology. In 1999, he joined University of Victoria as the NSERC-Industry Senior Research Chair in Environmental Management of Drinking Water. The major focus of this Research Chair Program is to develop the understanding, models and techniques linking ecosystem and watershed process with the quality of water at the source and their relationships with the chemical and biological quality of drinking water at the tap. The long-term goal of Mazumder's research is to develop the strategies for the management of ecosystems and watersheds for sustainable water and fisheries resources under variable land-use, climate variability and population growth.

Concurrent Session C
Economic and Social Issues

Erik Karlsen

Erik Karlsen -- as a professional planner with 35 years experience, Erik has worked at the federal, provincial, regional and local levels of government and in the private sector. Throughout his career, he has focused on forging intergovernmental and civil society partnerships to achieve sustainable project, community and regional development. Since leaving the British Columbia Provincial Government in 2002, Erik continues to pursue these interests as a consultant, speaker, facilitator, and educator. He has served as an Associate Faculty member in the Masters of Environment and Management program at Royal Roads University and is the Chair of the Smart Growth on the Ground Advisory Committee.

Holly Dolan

Holly has a PhD in Geography (Resource Assessment) from the University of Guelph, where she worked with Barry Smit on adaptation research and evaluation methodologies in agriculture. Holly was also the coordinator for the Canadian Climate Impacts and Adaptation Research Network (BC) for C-CIARN's first year of operation. Holly is currently working on a join NSERC/SSHRC collaborative research project exploring the impacts of social and environmental change on environmental, community and population health. She has also just began work with Dr. Ian Walker on a Climate Change Action Fund-supported research project in Graham Island, Haida Gwaii (Queen Charlotte Islands) BC to explore coastal vulnerability to climate change

Shannon Janzen

Shannon is a registered Professional Forester employed by Western Forest Products Limited. In addition to operational forestry, Shannon is involved with WFP's International Standards Association and Canadian Standards Association certification. She graduated with a Bachelor of Science in forestry from the University of Northern British Columbia and has worked in various locations of the province, including Revelstoke, Port Alberni and Smithers. Her current position allows her to live in the small logging community of Holberg, population 120, on the northern tip of Vancouver Island.

Appendix B: List of Participants

Mr Peter J Ballin	Vancouver Community College
Mr Christopher T Bell	Landsdowne Junior Secondary School
Ms Lynne Bonner	Ministry of Water, Land and Air Protection
Mr Glen Brown	Ministry of Community, Aboriginal and Women's Services
Ms Michele d'Eon	Environment Canada
Mr John D Dewis	BC Ferries
Mr Peter D Dixon	Veins of Life Watershed Society
Mr Colin P Doyle	Municipality of Saanich
Ms Giselle M Duhamel	Meteorological Service of Canada
Mr Allen S Eade	Enkon Environmental
Mr. David Fishwick	Ministry of Health Planning
Mr Rod A Fowler	Kwantlen University College
Ms Kelly L Goody	Transport Canada
Mr Dale M Green	Capital Regional District
Mr Sigi J Gudavicius	Capital Regional District
Dr John TM Hardy	Western Washington University
Dr David E Harper	Westland Resource Group
Ms Helen P Harvey	Johns, Southward, Glazier, Walton & Margetts
Dr Richard J Hebda	Royal BC Museum
Mr Jack Hull	Capital Regional District
Dr Robert (Bob) G Humphries	Levelton Engineering
Ms Lynn D Husted	Ministry of Water, Land and Air Protection
Dr James R Irvine	Fisheries and Oceans Canada
Mr Lorne James	BC Hydro
Mr Curtis R Johnston	Western Economic Diversification Canada
Mr Robert (Bob) A Lawrence	City of Nanaimo
Mr Rick J. Lee	Canadian Institute for Climate Studies
Mr Paul Lingl	David Suzuki Foundation
Mr Chris J Lowe	Capital Regional District
Mrs Kathleen E MacDonald-Date	BC Ministry of Agriculture and Fisheries, Food and Fisheries
Mr Byron Mah	Western Economic Diversification Canada
Mr Aaron Maxwell	Wild BC
Mr Carey McIver	Regional District of Nanaimo
Mr. Allister R. McLean	BC Hydro
Mr Trevor A Murdock	Canadian Institute for Climate Studies
Ms Carol L Murray	ESSA Technologies Ltd
Mr. C. P. Newcombe	Ministry of Water, Land and Air Protection
Mrs Michael-Anne Noble	Royal Roads University
Mr Joe Pashak	District of Port Hardy
Mr Mike Pawlicki	Lafarge Canada Inc.
Mr Robert W Penrose	BC Hydro
Mr Dean A Rebneris	Cottage Grove/ Thousand Summers
Mr Kevin Rieberger	BC Ministry of Water, Land and Air Protection
Mr Michael Roth	District of Cambell River

Ms Maureen R Sager	West Coast of Vancouver Island Aquatic Management Branch
Mr Russ Simonson	Lafarge North America
Dr Gordon S Smith	Center for Global Studies-University of Victoria
Mr Forrest R Smith	Eco Sol Consulting
Ms Margot M Stockwell	Fisheries & Oceans Canada
Mr Craig E Sutherland	UMA Engineering Ltd
Mr Andy Telfer	Coast Waste Management
Ms Sheree L Walter	Ministry of Community, Aboriginal and Women's Services
Mr Gilles Wendling	EBA Engineering Consultants
Dr Paul R West	University of Victoria
Mr Ken L Whitcroft	Quadra Cedar Hill Community Association
Mr Michael Williams	Capital Regional District
Dr Vivienne R Wilson	Royal Roads University

Speakers, Conference Organizers and Support Staff

Mr Warren Bell	Raincoast Resources Inc.
Mr Chris Robins	Capital Regional District
Ms Catherine Yen	
Ms Cindy Bertram	Geospatial International Inc./ SALASAN Operating Division
Ms Sally Bertram	Geospatial International Inc./ SALASAN Operating Division
Ms Kris Dartnell	Geospatial International Inc./ SALASAN Operating Division
Ms Chris Hunter	Geospatial International Inc./ SALASAN Operating Division
Ms Andrea Mercer	Capital Regional District
Ms Judy Brownoff	Capital Regional District
Mr Bill Crawford	Fisheries and Oceans Canada
Ms Holly Dolan	University of Victoria
Ms Jenny Fraser	BC Ministry of Water Land and Air Protection
Mr Kim Hyatt	Climate Change Impacts and Adaptation Research Network – Fisheries
Ms Shannon Janzen	Western Forest Products
Dr Mark RS Johannes	C-CIARNS Fisheries Sector
Mr Erik Karlsen	Planning Consultant
Mr Nathan Mantua	Climate Impacts Group, University of Washington
Mr David Mate	Geological Survey of Canada
Mr Asit Mazunder	University of Victoria
Mr Jennie Moore	Greater Vancouver Regional District
Dr Philip Mote	JISAO/SMA Climate Impacts Group
Mr Dave Spittlehouse	Resarch Branch, BC Ministry of Forests
Mr Bill Taylor	Environment Canada
Ms Julia James	C-CIARNS BC
Mr Ben J Kangasniemi	Ministry of Water, Land and Air Protection
Mr Ted W Sheldon	Ministry of Water, Land and Air Protection
Ms Josie L Cleland	C-CIARNS Fisheries Sector