weathering change

newsletter of **the northern climate exchange** summer - fall 2003

Troubled waters: How climate change may affect northern water resources

BANO MEHDI, C-CIARN WATER RESOURCES

It is often stated that water is the basis of all life. This holds particularly true in northern regions, where water is present in the most variable—and in the most myriad—of states, forms and colours.

Ecosystems and communities have come to rely on the rhythmic, almost predictable, patterns of precipitation, snowmelt, spring peak flows, and ice melts for sustaining their livelihoods, their needs, and their well-being.

Recent global climate change scenarios predict increasing temperatures and variations in the intensity and occurrences of precipitation in the North.

Recent global climate change scenarios predict increasing temperatures[1] and variations in the intensity and occurrences of precipitation in the North. Although climate forecasts may seem harsh compared to current conditions, humans are able to adapt by incorporating future climate change scenarios into their planning strategies. While ecosystems are denied the luxury of planned adaptation, humans—when made aware of some of the changes that may occur under future climate change scenarios—possess the capability of effectively safeguarding environments most at risk.

Warmer air temperatures have been speculated to bring a number of changes to northern regions, some of which include the melting of permafrost, drying of some marshes and deltas, less ice formation in winter, and warming lake temperatures. These changes will influence water as a habitat for many species of wildlife.

In Sachs Harbour, no ice floes have been observed in the bay for the past few years. Ringed seals, which use the ice as a platform, no longer drift past regions populated by humans, who depend on the seals for sustaining their livelihood. Walruses and polar bears also rely on the ice to extend their habitat ranges. In a warmer climate, sea ice for the most part is predicted to become thinner and less extensive. Inland ice will also be affected. However, the lack of ice cover in the upper reaches of the Peace River encourages animals that require open water, such as the beaver, and also can provide habitat for some fish species.

River ice is an integral part of ecosystems in the North. The spring flooding of ice-jammed north-flowing rivers, such as the Mackenzie River, replenishes the water supply of lakes in delta regions and provides habitat for aquatic organisms. As a result of increased air temperatures, ice jam dynamics have changed. A recent spell of warmer winter temperatures in December 2002 caused a mid-winter break-up of ice on the Klondike River, contributing to ice floating downriver only to pile up for three kilometres further downstream. When temperatures plunged, the ice refroze. At the end of April, the inevitable flooding took place when a rapid spring thaw flushed the meltwater downstream.

continued on page 2 . . .

[1] During this century, the temperature of western Arctic and sub-Arctic regions is expected to increase by an average of 5 to 7˚C. An increase of 1.5˚C has already been observed. Some northern regions (Labrador Sea, eastern Nunavut, and Baffin Island) have experienced a cooling, consistent with predictions. *IPCC (WGII) 2001: Impacts, Adaptation and Vulnerability.*

contents

A note from the editor

2003 has been designated the International Year of Freshwater. To celebrate the theme, this issue of *Weathering Change* explores various topics relating to water.

Globally, water is an essential part of our everyday lives. To emphasize this fact, the theme of this year's International Environment Day (June 6) was "Water: Two Billion People are Dying for It!" A quick glance at a map of Canada's North reveals how extensively freshwater covers the three northern territories and the extent of our Arctic coastline.

In this issue, we have articles from the Canadian Climate Impacts and Adaptation Research Network (C-CIARN) Water Resources office examining the impacts of climate change on northern waters, as well as an article from the C-CIARN Coastal Zones office touching on the impacts on coastal areas. Aynslie Ogden looks at the need to develop adaptation strategies to cope with climate change impacts, while Jody Mackenzie-Grieve looks at the possible climate change impacts on a shallow Yukon lake and its fish population. Finally, Al von Finster looks at the importance of groundwater to northern ecosystems.

In the "Exchanging Views" column, Stewart Cohen and Gerry Whitley examine the need for communities to become educated on the impacts of climate change on the water that surrounds them and to be involved in adaptation planning.

We hope that this issue provides an enlightening and informative read.

Bob Van Dyke

continued from page 1 . . .

In other northern areas, however, ice jams are no longer a common occurrence. Major flooding of the Peace-Athabasca Delta has failed to occur for 29 years, since the last major ice-jam event took place. Residents of this delta have observed how wetland meadows and marshy areas are being replaced with more dry-tolerant vegetation. Consequently, the Peace-Athabasca Delta has seen a decrease in the number of semi-aquatic animals and waterfowl. However, the resulting increase in the number of willows presents a more suitable habitat for moose.

Wetlands that have a permafrost base are in peril of being lost. Almost half of North America's wetlands are located in Alaska, NWT, and the Yukon. Permafrost located near the surface plays a major role in supplying water to lakes and wetlands since it often maintains them above an impermeable frozen water table. The Old Crow Flats, located 73 kilometres north of the Arctic Circle, is Yukon's most valuable wetland area, providing breeding habitats for several species of waterfowl, as well as shore and song birds. Temperature increases in the region could lead to the drying of many lakes, which would lead to changes in limnology and fish and bird species characteristics. While the permafrost melting will cause more ponding of water in some areas, peat lands may dry out because of increased evaporation and plant transpiration (together, these are known as evapotranspiration).

The take-home message is that although climate variation will bring about shifts in the natural system, the final outcome is not certain. The North is particularly sensitive to escalating air temperatures, since the extent of the vast snow and ice cover will decrease, accelerating the hydrological cycle. Every ecosystem relies on the presence of water. Since humans are the only species that has the capacity to undertake planned adaptation, we must ensure the availability and quality of this precious resource for all future generations.

Selected references and websites for further reading:

"Effects of climate change on the freshwaters of arctic and subarctic North America," Wayne et. al., *Hydrological Processes*, Vol. 11, 1997, pp. 873-902.

Climate Change 2001: Impacts, Adaptation and Vulnerability. IPCC, TAR Working Group II. Chapter 15 on North America and Chapter 16 on Arctic and Antarctic. http://www.grida.no/climate/ipcc_tar/wg2/index.htm.

Mackenzie Basin Impacts Study (MBIS), S. Cohen (ed.), Environment Canada, 1997. Available on CD from Dr. Stewart Cohen: scohen@sdri.ubc.ca (604) 822-1635.

Northern River Basins Study Final Report, www3.gov.ab.ca/env/water/nrbs/sect3/sect35.html.

www.greenpeace.org

weathering change

Volume 2 Number 1

A quarterly newsletter published by the Northern Climate ExChange, Whitehorse, Yukon, Canada

ISSN 1703-4256 (Print)
ISSN 1703-4264 (Online)

Design by Walker LeBrun Creative Services Ltd.

MAILING ADDRESS
Northern Research Institute
c/o Yukon College
Box 2799, 500 College Drive
Whitehorse, Yukon, Canada Y1A 5K4

PHONE: 867-668-8735
FAX: 867-668-8734
EMAIL: aogden@yukoncollege.yk.ca
WEBSITE: www.taiga.net/nce

The Northern Climate ExChange is funded by Government of Canada, Government of Yukon, and Yukon College.

YukonCollege

Yukon Government

Canada

Lake trout: Can fish adapt to climate change?

JODIE MACKENZIE-GRIEVE, M.SC. STUDENT, UNIVERSITY OF CALGARY

Current climate warming models predict air temperature will increase with increasing latitude. While the most pronounced warming will occur over land, aquatic systems will not escape the influence of climate warming. Increases in air temperature will translate into changes in the vertical temperature distribution and thermocline position in lakes—factors that govern how aquatic organisms exploit their environment. These changes will affect all aquatic life, including fish.

The lake trout, an important subsistence and sport fish in the North, has often been suggested as an "indicator species" of climate change due to the species' requirement for cold, well-oxygenated water. As climate warming becomes increasingly apparent, geographical range contractions and expansions for the species are expected as habitats become too warm to be exploitable (southern or shallow lakes), or habitats become increasingly exploitable due to warming of the water column (northern or deep, cold lakes).

Researchers have identified a strong relationship between lake trout production (kg/yr) and the volume of thermal habitat within the preferred temperature range for lake trout of 8 to 12˚C; production increases as thermal habitat volume increases. If climate warming affects the volume of water in lakes within this preferred range, we can expect production of lake trout to be impacted as well. Depending on the intensity of the impact on production, adjustments to our current management strategies may be required to reflect the sensitivity of this species to availability of adequate thermal habitat.

J. MACKENZIE-GRIEVE

Tagged lake trout

Negative impacts of climate warming on lake trout populations should initially be most apparent in lakes that are shallow and can warm considerably in summer months. For example, in Dezadeash Lake, a large, shallow lake located in southwest Yukon, the lake trout population displays an uncommon behaviour whereby it congregates at cold-water creek plumes along one side of the lake. These creeks are very cold since they are the result of glacial/snowpack melt in the surrounding mountains. Trout congregate in these cold-water refugia presumably to decrease energetic costs associated with living in a warmer habitat, in an effort to remain closer to their preferred temperature range. It is generally agreed that the year-round snowpack in the region is disappearing. With it, the runoff that provides cold-water refugia for these lake trout will also disappear. Should the refugia disappear, there would be no thermal habitat in Dezadeash Lake throughout much of the summer, perhaps leading to the loss of lake trout from this lake. This form of behavioural thermoregulation may become more common in lakes of similar morphologies as environmental temperatures continue to rise, provided these thermal refugia exist. In deeper lakes, lake trout will move into deeper, colder water, providing adequate supplies of oxygen exist, as lake temperatures rise.

It is clear that climate warming will affect our freshwater resources in years to come, including our fisheries resources. We need to identify uncommon situations, as seen in Dezadeash Lake, where little in the way of thermal refugia exists, so that we can adjust our current management strategies in an effort to reduce additional stress on these sensitive populations.

Reading list:

Michael J. Bradford, Jeff A.Grout and Sue Moodie, "Ecology of juvenile chinook salmon in a small non-natal stream of the Yukon River drainage and the role of ice conditions on their distribution and survival," *Canadian Journal of Zoology*, Vol. 79, 2001, pp. 2043-2054.

R. J. Beamish (ed.), "Climate Change & Northern Fish Populations," Canadian Special Publication of Fisheries and Aquatic Sciences, 121, National Research Council of Canada, Ottawa.

Dezadeash Lake

YUKON GOVERNMENT PHOTO

Canada's arctic shores: The impacts and implications of climate change

With the longest coastline in the world, bounding three oceans and the world's largest freshwater lake system, Canada's coastal zone supports diverse ecosystems as well as cultural, recreational, and economic needs. Anyone who has visited or lived in one or more arctic communities knows well the diversity and splendor of this coastline. Climate change in the Arctic is regionally variable, which creates wide-ranging impacts on humans and biophysical systems. This diversity is recognized by the Coastal Zone sector of the Canadian Climate Impacts and Adaptation Research Network (C-CIARN) in its initiative to identify key climate change impacts and knowledge gaps, and to develop adaptation strategies within the coastal zone. C-CIARN Coastal Zone's efforts are designed to reinforce and complement those of C-CIARN North, which must deal with all regional climate change impacts in the North. Using a network of researchers, C-CIARN Coastal Zone can provide the expertise to examine coastal issues identified by northern residents more thoroughly and include them in national priorities for further investigation or action by government.

WWW.1000PICTURES.COM

Glacial meltwater

Preliminary climate change impacts for the Arctic Coastal Zone have been identified through discussions with northerners and researchers and through extensive literature reviews. The accompanying table (page 5) presents an overview of those issues organized under broad physical categories and the associated impacts on biophysical and human systems. It quickly becomes apparent that there are many interrelated factors; change in one process will affect another process or human activity. For example, the loss of a large, semi-permanent snow patch along a particular coastline can impact shoreline stability, biological habitat, hunting, and remove a navigational marker for people traveling along the coast in poor weather. It is important to understand how a coastal system responds naturally to the potential impacts of climate change. With an increasing demand for use, access, development, and protection of the coast, a thorough understanding is needed to prepare for and adapt to change.

What can you do to assist us in our endeavour? C-CIARN Coastal Zone needs more input from residents and people working or studying in the North. We welcome your observations of changes along the coasts and examples of adaptation you have witnessed or

continued on page 5 . . .

2003: The International Year of Freshwater

BOB VAN DIJKEN, NORTHERN CLIMATE EXCHANGE EDUCATION AND OUTREACH PROGRAMS

The United Nations named 2003 the International Year of Freshwater. A full calendar of public and scientific events has been scheduled for the year. These events include a number of workshops that include sessions on water and climate change. While none of these events focus specifically on northern issues, many are of interest. Some of these events are highlighted here:

The 3rd World Water Forum, held in Japan in March, included a session on water and climate. Information on this forum and the session on climate and water is available at http://www.world.water-forum3.com.

In July, a conference, Rational Use and Conservation of Water Resources in a Changing Environment, was held in Armenia. One of the topics addressed was new approaches to evaluating and forecasting changes in water resources under conditions of global warming. Information is available at http://water-sustainability.ph.unito.it/ye03_ann.html.

In September, the 8th International Living Lakes Conference will be held in England. Conference topics include possible impacts of climate change on biodiversity, water levels, and water quality as well as on human livelihood in lake and wetland regions. Information is available at: http://www.globalnature.org/8.LLC.

In October, the International Freshwater Conference will be held in Malaysia. One of the topics up for discussion is Managing Risks (floods, droughts, climatic change). Further information is available at http://www.emang.net/sdiform/freshwater/main_freshwater.htm.

November brings the Banff Mountain Summit 2003: Mountains as Water Towers. Mountains as Water Towers will focus on the worldwide importance of mountain watersheds. Conference topics include mountain water ecosystems, water ownership, effects of climate change, and mountain watershed management. Information on the summit is available at http://www.banffcentre.ca/mountainculture/festivals/summit/.

Many more workshops and forums on water are happening throughout the remainder of 2003. A complete calendar of these events is available at http://www.wateryear2003.org/en/ev.php@URL_ID=1664&URL_DO=DO_TOPIC&URL_SECTION=201.html.

contributors this issue

Stewart J. Cohen
Jaime Dawson
Jody Mackenzie-Grieve
Bano Mehdi
Aynslie Ogden
Al von Finster
Gerry Whitley

instigated. Most important to the success of C-CIARN is the continued growth of our network, which allows us to share information, questions, and concerns among researchers and others interested in the impacts of climate change. You can join C-CIARN Coastal Zone by visiting www.c-ciarn.ca or by contacting the Coastal Zone Coordinator at 902-426-8988 or jdawson@nrcan.gc.ca. It is our goal to have a workshop in cooperation with other C-CIARN regions and sectors in 2004 focusing on sea ice and community issues.

Jaime Dawson
C-CIARN Coastal Zone Coordinator
Bedford Institute of Oceanography
P.O. Box 1006
Dartmouth, Nova Scotia B2Y 4A2
(902) 426-8988
jdawson@nrcan.gc.ca

Table 1: Impacts and implications of climate change on the Arctic Coastal Zone

PHYSICAL PROCESSES AFFECTED BY CLIMATE CHANGE	BIOPHYSICAL SYSTEMS IMPACTED	HUMAN SYSTEMS IMPACTED
Oceanographic Conditions	• Distribution and productivity of polynyas • Marine life	• Traditional lifestyles and activities
Sea Level	• Tidal spectrum, wave climate, coastal circulation, and sediment redistribution • Storm surge and flood events • Stability of coastline and ecosystems	• Human health and safety, emergency preparedness, insurance or construction, maintenance and repair • Property ownership, legal boundaries and jurisdictional issues • Coastal communities and infrastructure
Weather Conditions	• Wave climate, coastal circulation, and sediment redistribution • Sea ice and shorefast ice formation, and iceberg calving • Distribution and productivity of polynyas • Storm surge and flood events • Stability of coastline, ground thaw, spring melt and freeze-up	• Human health and safety, emergency preparedness, insurance or construction, maintenance and repair • Traditional lifestyles and activities • Coastal communities and infrastructure
Sea Ice Conditions	• Wave climate, coastal circulation, and sediment redistribution • Sea ice and shorefast ice, shore ice ride-up and piling • Distribution and productivity of polynyas • Stability of coastline and ecosystems	• Traditional lifestyles and activities • Canadian defence and sovereignty issues • Marine transportation and navigation

C-CIARN Water Resources

C-CIARN Water Resources is a sector of the Canadian Climate Impacts and Adaptation Research Network (C-CIARN). Set up in January 2002, and housed at the Brace Centre for Water Resources Management at McGill University, the Water Resources Sector works towards facilitating impacts and adaptation measures by hosting workshops and conference sessions, and by presenting at various venues. In doing so, the network hopes to increase researcher and stakeholder participation in climate change research in order to identify research priorities to better adapt our water resources to the changing climate.

The largest workshop to date was held in Montreal on September 9 – 10, 2002, and entitled "Water Resources at Risk due to Climate Change." The workshop identified impacts climate change would have on Canadian water resources and identified possible adaptation strategies. Furthermore, research priority issues were determined, based on knowledge gaps existing in the water resources sector. Six themes were tackled: ecosystems and the environment, transportation and navigation, communities and municipalities, hydropower and energy, and agriculture and natural resources. Approximately 70 participants attended the workshop.

Participants included representatives from universities, utility sectors, transportation, municipalities; consultants; all levels of government; policy divisions of several government ministries; funding agencies; and students. The final workshop report is available on the website.

Plans to collaborate with C-CIARN North in identifying impacts, adaptations, and knowledge gaps are foreseen. There are also plans to participate in the Northern Margins symposium on February 24 – 29, 2004, in Churchill, Manitoba.

For more information, please visit the website www.waterresources.c-ciarn.ca.

Can we modify current water resource management practices to adapt to climate change?

AYNSLIE OGDEN M.SC., R.P.F., R.P.BIO.,P.AG. NORTHERN CLIMATE EXCHANGE COORDINATOR

It is vitally important to understand the vulnerability of water resources to climate change in northern Canada. Northern Canadians depend on water and ice for a number of goods and services, including drinking water, food, energy, industry, transportation, recreation, and ecosystem health.

We can reduce the risks associated with the impacts of climate change on water resources by developing adaptation strategies. Adaptation is defined as actions that are taken to reduce vulnerability to the adverse consequences of climate change. Although there is some uncertainty as to the nature and extent of climate change impacts on water resources, a number of adaptation options are available. The best options to consider are those that provide benefits other than reducing vulnerability to climate change, also called 'no-regret' options.

Much of the climate change effort in the Canadian North is devoted to improving understanding of the impacts of climate change and to reducing greenhouse gas emissions. Little is being done to develop and test adaptation strategies to increase our resiliency to global change.

However, a number of recent developments in the North make this an opportune time to assess future vulnerabilities and implement and test adaptation strategies to build resilience to climate change and other forces of change in the region.

For example, a pipeline is likely to be constructed in the Mackenzie Valley to transport natural gas from fields in the Mackenzie Delta near Inuvik, Northwest Territories (NWT), to markets in northern Alberta. This proposed development project will soon be subject to regulatory approval processes, including environmental impact studies that will consider adaptation options.

Water resource managers in the Mackenzie Valley have many resources available to them to support adaptation decision-making, thanks to the Mackenzie Basin Impact Study (MBIS) (Cohen, 1997), a major climate change impacts study that took place in the Basin between 1990 and 1996. This six-year cooperative study applied a scientist-stakeholder approach and was one of the first attempts at an integrated regional assessment of climate change. Integrated assessments attempt to understand the current and future vulnerabilities of a region to climate change by examining the diversity of impacts of climate change, and by placing these impacts within the context of other forces of change in a region.

MBIS resulted in a number of recommendations for actions that can be taken to adapt to climate change by governments (e.g., include climate change in natural resource management agreements and support community-based monitoring programs), communities (e.g., participate in monitoring programs and support training on adapting to climate change), private sector industries (e.g., include climate change in research, planning, and design of projects), and researchers (e.g., use traditional knowledge, use regional institutions for coordinating monitoring, provide reports in plain English, and consider scenarios beyond the doubling of greenhouse gas concentrations). Many of these recommendations have been implemented, but not as part of a comprehensive adaptation strategy. Nevertheless, these recommendations are still relevant to facilitate, implement, and monitor the effectiveness of a strategy to build resilience in this region to the impacts of climate change.

COMMONLY RECOMMENDED ADAPTATION OPTIONS

Some of the most frequently recommended adaptation options for the water-resources sector are:

- Water conservation measures;
- Improved planning and preparedness for droughts and severe floods;
- Improved water-quality protection;
- Enhanced research and monitoring efforts to better assess the risks and benefits posed by climate change and to build the foundation upon which appropriate decisions on adaptation can be made; and
- Improved procedures to allocate water equitably among different user-groups.

Source: Lemmen, 2003

Reading list:

Don Lemmen (ed.), "Water Resources," Climate Change Impacts and Adaptation: A Canadian Perspective, Climate Change Impacts and Adaptation Directorate, Natural Resources Canada, Ottawa, 2002.

J. Bruce, I. Burton, H. Martin, B. Mills, and L. Mortsh, Water Sector: Vulnerability and Adaptation to Climate Change, Final Report, Canada Climate Change Action Fund, 2000.

S. J. Cohen, (ed.), Mackenzie Basin Impact Study, Environment Canada, 1997.

Water underfoot is vulnerable to climate

The Yukon is blessed with such an abundance of surface waters that we have tended not to think about the water below our feet. Many of the plants and animals that we value depend directly or indirectly on ground water. Ground water is part of the hydrological cycle. The cycle is a reflection of climate. As the climate changes, there will be effects on certain types of ground water and on the ecosystems to which they contribute.

Ground water is important to living organisms. Most ground water discharges in the glaciated portions of the Yukon have short underground flow paths. They flow through aquifers in the gravels and sands deposited by the retreating glaciers. This water tends to be high quality. In the summer, the discharge areas, commonly called springs, support rich and diverse plant and animal communities. In the winter, they provide refuge areas for plants and aquatic insects that are intolerant of freezing. Chum salmon spawn in some locations where the discharging water is of very high quality.

Ground-water-fed springs directly or indirectly provide most of the winter flows in Yukon streams. Without this discharging water, many and perhaps most lake outlets and streams would freeze solidly. Springs are also valuable during the summer. Ground water tends to be much cooler than the surface waters, providing habitat for species of invertebrates and fish that are intolerant of warm temperatures.

Ground water in the glaciated area of the Yukon will be affected, perhaps profoundly, by increasing summer temperatures related to climate change. Rising temperatures result in increased evapotranspiration (evaporation from the Earth's surface and transpiration from plants). As more water returns to the atmosphere, less water will enter or recharge the aquifers.

Less water entering the aquifers will result in less water discharging from them. In time, springs will become smaller. Some, which may have flowed throughout the year, will become intermittent. If the current temperature trends continue, they will dry up altogether. The rich plant and animal communities that depend on them will become less diverse. Eventually, the site where the spring once flowed may become indistinguishable from the surrounding land.

Since winter stream flows and summer low flows depend on discharging ground water, reductions in flow will also affect aquatic ecosystems. In some instances, the streams will no longer be deep enough to allow fish to migrate to spawning grounds. Portions of streams will dry in mid-summer, trapping fish in pools. Streams will become warmer and no longer suitable for cool-water fish species.

During the winter, there will be a reduction in the amount of overwintering habitat for stream-dwelling fish such as juvenile chinook salmon. Individual fish in streams or sections of streams that no longer have spring-fed winter flows will die. Only invertebrate species that are able to survive freezing will remain, resulting in less diverse communities.

It is probable that the low water in many southwestern Yukon streams this year is related to climate change. The chinook salmon are returning to spawn. How much longer will the smaller, groundwater-fed streams have enough water for them to do so?

Al von Finster is with the Habitat and Enhancement Branch of the Department of Fisheries and Oceans Canada (DFO), and works on the restoration of salmon and freshwater fish stocks and their habitats.

C. EAMER PHOTO

Monitoring groundwater recharge, McIntrye Creek

Climate Change. Are you doing your bit?

***Tip**: Walking to do an errand, get to work or go shopping is a great idea for a number of reasons. In addition to the health benefits of regular exercise, you also save money and reduce air pollution by leaving your vehicle at home.*

For more tips from the NCE's Bob and Dog Mackenzie go to www.taiga.net/nce/doyourbit.html

ExChanging VIEWS

Expanding the dialogue on climate change and water management

STEWART J. COHEN, RESEARCH SCIENTIST, ADAPTATION AND IMPACTS RESEARCH GROUP, ENVIRONMENT CANADA; ADJUNCT PROFESSOR, INSTITUTE FOR RESOURCES, ENVIRONMENT & SUSTAINABILITY, UNIVERSITY OF BRITISH COLUMBIA

Climate change is projected to alter the hydrologic cycles of watersheds around the world. In the North, this would include changes in glaciers, lake and river ice, precipitation, snow accumulation and snowmelt, growing season length, and evapotranspiration. This would lead to changes in runoff, stream flow, and lake levels, with subsequent effects on ecosystems and communities. These effects could also extend to the Arctic Ocean, since any changes in freshwater runoff could change ocean salinity and sea ice.

This scenario has now become a familiar one. But while researchers continue to explore these issues, what are the next steps in expanding the dialogue from research to practice? How can information from uncertain climate change scenarios be used to assess implications for water management? What are the potential impacts for small communities? What difference would these scenarios make for the management of large watersheds in order to meet various goals, including protection of fish, wetlands, and drinking water; production of hydroelectricity; maintaining summer and winter transportation routes; and protecting communities from floods? Would climate change affect the achievement of these goals?

These are questions about how communities and institutions use information to make decisions about the stewardship of resources. Climate change is a different kind of challenge to consider. Its causes are global. Its effects are regional and local, and can vary from one watershed to another. It not only creates new uncertainties, but it also challenges our confidence in applying lessons from the past to plans for the future. In other words, climate change is an additional source of surprise.

The ongoing work of the Arctic Climate Impact Assessment should yield an important inventory on what is known about these effects, and on the nature of remaining uncertainties. The announcement of funding for the new research network "ArcticNet" ought to be a launching point for an expanded dialogue on adaptation to the direct and indirect effects of future climate change in northern waters.

What water planning?

GERRY WHITLEY, RETIRED WATER QUALITY SCIENTIST AND FORMER DIRECTOR OF THE YUKON RIVER BASIN STUDY

The governments of Yukon, British Columbia, and Canada completed the Yukon River Basin Study in 1984 and found that "Water is the one essential natural resource in the Yukon River Basin. The survival of every other renewable natural resource in the Basin depends on the availability of specified quantities of water with established quality."

The study committee recommended that a coordinating committee of agencies with water management responsibilities be established to complete the development of a framework for water resource planning and to coordinate ongoing planning and management activities.

The study began when pipeline planning and mining activities were at a peak. In the intervening 20 years, many water quantity stations have been closed and every water quality station eliminated. The planning tools such as flow and quality models have disappeared. Water management has devolved to the Yukon government. First Nations are just beginning to manage their resources. The economy has stagnated.

Opportunities for joint and cooperative activities should not be left to chance. Climate change will increase competition between water users. Efficient development of fisheries and hydroelectric, forestry, and mineral resources will require coordination of data collection.

It is time to get organized and have a water forum where data collectors, water users, developers, scientists, and the public can share plans and results. The planning and coordination will then occur naturally.