NWT ENVIRONMENTAL MONITORING ANNUAL RESULTS WORKSHOP

2012/2013 ABSTRACTS

Workshop held in Yellowknife, Northwest Territories, January 21-23, 2013, in partnership with Aboriginal Affairs and Northern Development Canada, Fisheries and Oceans Canada, Environment Canada and the Government of the Northwest Territories.

Aboriginal Affairs and Northern Development Canada
Affaires autochtones et Développement du Nord Canada

Fisheries and Oceans Canada
Pêches et Océans Canada

Environment Canada
Environnement Canada

Northwest Territories Environment and Natural Resources

Prepared by:

NWT CIMP
Northwest Territories Cumulative Impact Monitoring Program

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CUMULATIVE IMPACT MONITORING IN THE NWT

Update on cumulative impact monitoring in the Northwest Territories

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The importance of cumulative impact monitoring for resource decision-making was recently highlighted during the environmental impact review of the Gahcho Kue Diamond Mine, potentially the fourth diamond mine in the Northwest Territories (NWT). The review also underscored the lack of a framework or a coordinated effort for monitoring and managing cumulative impacts in the NWT. Cumulative impact monitoring is a multi-disciplinary endeavor that requires the coordination and efforts of all groups involved in the monitoring and management of natural resources. In the Northwest Territories, the Cumulative Impact Monitoring Program (CIMP) has a mandate to support, facilitate and coordinate cumulative impact monitoring; with the goal of supporting sustainable development. CIMP is positioning itself to be a central source and repository for cumulative impact monitoring information; however, CIMP cannot act alone. Partnerships at multiple levels, from between programs to within individual projects, are critical to success. Though CIMP is a lead agency, cumulative impacts are really everyone's responsibility. In particular, other government departments are also responsible under the Mackenzie Valley Resource Management Act. Since most groups are mandated to conduct monitoring and management in their own particular program area, CIMP's unique strength is its focus on cumulative impacts. We encourage groups to leverage our mandate and work with us to address cumulative impact monitoring in the NWT.

In collaboration with our partners, CIMP has conducted work in a number of key areas in 2012-13:

Coordination

- CIMP is conducting a review of regional cumulative effects monitoring frameworks that could be used to align project-specific monitoring with regional monitoring.
- In collaboration with the Government of the Northwest Territories (GNWT), CIMP is conducting a review of modeling tools available for cumulative effects assessment in the NWT.
- CIMP is initiating the development of metadata standards for water quality, which would make regulatory data more amenable to analysis beyond site compliance.

Guidance

- Through the Pathways approach developed by CIMP, community input is being sought, in partnership with the Aurora Research Institute, to develop guidance on how researchers can better interact with communities.
- CIMP staff have provided leadership by conducting exemplary scientific projects demonstrating strong study design, links to cumulative impacts, collaboration, and engagement with decision-makers and communities.

Accessibility

- NWT decision makers have indicated that disparate sources of environmental data need to be accessible in one location. CIMP has developed the NWT Discovery Portal http://nwtdiscoveryportal.enr.gov.nt.ca , an environmental monitoring data library, in collaboration with

the NWT Centre for Geomatics. Further refinements are planned with a spatial user interface that will draw data layers from multiple sources.

Information gaps

- CIMP has provided targeted funding for priority information gaps that include baseline data, and address cumulative impacts. Funding will become more targeted as CIMP works with its partners to develop cumulative impact monitoring frameworks and blueprints.
- CIMP is engaging partners to develop a Landscape Change Inventory which will document the location and extent of past development and natural disturbance, data that is currently unavailable.

Communication

- CIMP co-hosts an annual results workshop with monitoring partners, distributes an abstract volume, and communicates with decision makers and communities directly.
- CIMP, in collaboration with the GNWT and Natural Resources Canada, is developing a Decision-makers Atlas which compiles raw monitoring information and analyzed results in an online application. A pilot program is being launched in the Inuvialuit Settlement Region.

CARIBOU

Boreal caribou monitoring in the Dehcho

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Succession and regeneration response on seismic lines with respect to ecology, disturbance factors and time

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The goal of this study is to collect and analyze data on the vegetation, forest and soil conditions on seismic lines in the NWT with the aim of defining ecological and physical parameters that will assist in determining the long term recovery pathways of oil and gas disturbances.

Very little work has been done in the Northwest Territories to quantify and qualify the recovery and regeneration of seismic lines. We know that many lines that are decades old are visible from the air and the ground, but there is no information on the status of regeneration.

Understanding the natural processes involved in recovery of seismic lines provides a foundation for improving best management practices to minimize the impacts of seismic activities and ensure regeneration. Since many of the recovery processes evident on seismic disturbances are common to other types of disturbance, understanding the ecology of recovery processes allows other disturbances to be developed in such a way that recovery is enhanced.

Oil and gas disturbances, and particularly seismic lines have been identified as a primary concern for boreal caribou because of fragmenting the landscape and increased ability for predators to travel throughout the range. There is no empirical information to quantify the recovery of these sites and therefore predict the long term impact to boreal caribou habitat.

Work underway for 2012/13 will deliver a methodology and analysis methods based on extensive work that has been done in the Yukon related to regeneration on seismic lines and development of best practices for oil and gas industry.

In 2013/14, the intent is to begin collecting field data on seismic line regeneration at various sites in the Dehcho and Sahtu. An initial location for field data collection is around the Arrowhead River, a tributary of the Liard River. This site was selected for data collection because there are various ages of seismic lines, many of the lines are several decades old (from the 1970's and 80's), and there is also a substantial amount of caribou collar location data that can be used to further study caribou response to varied seismic regeneration.

Wolf abundance and predation on caribou

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Wolf predation on migratory barren-ground caribou is poorly understood, yet an important factor in shaping caribou populations across the Northwest Territories. Estimating the number of wolves and how they influence adult caribou survival and calf recruitment is critical to understanding their impact. This study will estimate the number of wolves associated with caribou on the Bathurst winter range. Wolves are counted using an aerial survey conducted in late winter. Wolves are collared a few weeks prior to the survey. During the abundance survey, the ratio of collared versus uncollared wolves sighted each day is used to estimate abundance. The survey is repeated for 4-5 days to improve the estimate.

Having wolves with Global Positioning System (GPS) collars allows their movements to be tracked with great precision and frequency. Clusters of locations will be observed and many of them will be predation sites because wolves spend time at kill sites of large prey. However, site investigations of these cluster locations are required to distinguish them from resting sites. With this “ground-truthing” conducted for many packs, a signature of a predation site from GPS locations is anticipated, and wolf predation rates can then be estimated for the entire winter.

Currently, the Department of conducts wolf den site surveys to estimate trends in wolf numbers. As caribou numbers declined, the number of wolf pups observed at dens has also declined, but so has the number of dens remaining active in August. It is unknown if this decline in dens in late summer is because of total litter loss or dens have simply moved. Tracking collared wolves during this time will resolve this and provide useful feedback on the effectiveness of late summer wolf den surveys during caribou lows.

Remotely sensed summer range Forage anomalies and their cumulative impacts on Bathurst caribou productivity from 1985-2011

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In this study we tackle two common challenges in assessing cumulative impacts on a target (e.g., caribou productivity): the lack of data about factors that might affect the target (e.g., habitat, harvest, predators,

diseases/parasites, extreme weather, climate change, industrial development, and pollution), and the lack of methods for separating impacts of one factor from that of others when data for many of other factors are not available.
As a part of the NWT Cumulative Impacts Monitoring Program (CIMP), We filled the data gap on the Bathurst caribou summer range forage availability and quality using remotely sensed leaf biomass and phenology products from 1985-2011. NOAA AVHRR data provide daily coverage since early 1980's, and thus could be a useful tool for detecting leaf biomass and phenology changes on the summer range, after several longstanding problems being resolved. These problems include high noise level caused by significant residue cloud contamination and aerosol variations, uncertainties introduced by various subjectively selected smoothing and fitting methods for dealing with the high level noise, and arbitrariness in defining the start/end of growing season (SOS/EOS). We solved these problems by applying and refining an un-biased and objective method for constructing seasonal profiles of AVHRR simple ratio vegetation index (SRVI) and defining SOS/EOS for a land cover class within the Bathurst caribou summer range. The value of summer range mean anomaly (SRMA) was then calculated as the average of anomalies in leaf biomass during late spring-early summer, mid-summer, late summer-fall, the two periods in between, in SOS and EOS, and in leaf nitrogen content at peak leaf biomass.

We also developed an algorithm that enables us to quantify the impacts of one factor (i.e., summer range conditions) without having to have data of other factors, by applying the principle of limiting factors and the upper envelope method.

Our results indicated good correspondences between the minimum of SRMA among the 3 broad land cover classes within the Bathurst caribou summer range and calf:cow ratios, all of which showed an increase during late 1980's, remained high during 1990's, decreased sharply in early 2000's, and then returned to high values during late 2000's. From 1985-2011, SRMA in previous 2 years can explain 54% of the variation in late-winter calf:cow ratio, a measure of caribou net productivity (with sample size n = 19 and p-value < 0.01); while previous year's SOS of the lichen low vegetation class, which dominates the calving ground, can explain 66% of the variation in the start date of peak calving (n = 17, p-value < 0.01).

Impacts of climate on summer range conditions were complex and non-linear. A large fraction of the variation in summer range anomalies cannot be explained by climate variables alone, indicating the need of direct monitoring of summer range conditions through remote sensing and field observation.

Using passive microwave radiation to quantify the spatial and temporal distribution of snowpack water equivalent in the northern boreal subarctic/low arctic tundra and implications for caribou

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The annual circumpolar snowpack plays a significant role in global climate, and in an equally significant way to arctic/subarctic terrestrial and aquatic ecology and watershed hydrology. Quantifying the spatial and temporal distribution of the annual subarctic/low arctic snowpack, except at small scale, without

remote sensing tools is more or less impossible. Recent developments in the use of interpreting passive microwave radiation emission from snowpacks using satellite data has resulted in formulation of algorithms that enable reasonably accurate assessments of snowpack water equivalent (SWE) in both arctic tundra and subarctic boreal forest landscapes. In recent years the caribou herd populations in northern Canada have suffered significant decline (GNWT-ENR 2011). Though anthropogenic and natural predation have been linked to this alarming reduction issues related to climate change, including changes to the annual snowpack, have also been mentioned as contributing factors. As one of the main sources of caribou food lies underneath the snowpack, its' changing characteristics (depth and density) may pose challenges to caribou survival if the energy requirements to obtain food exceed the benefits. Global Circulation Models indicate elevated snowfall for much of northern Canada over the next few decades with warming conditions. Our data collected between 2000 and 2010 at Daring Lake in the low arctic tundra indicate short periods of thaw when ice lenses formed (3 years out of the 11 year period) in the snowpack. These changing snowpack conditions can pose challenges to caribou survival. There are three objectives of this research: 1. To monitor changing snow conditions in the northern boreal forest near Wekweeti in order to verify/adjust the passive microwave emission-SWE algorithm relationship established by Derksen et al (2005); 2. Initiate discussions with hunters/elders in Wekweeti to gain some understanding of how they see caribou interactions with changing snowpack characteristics, and 3. Work with ungulate biologists at Environment and Natural Resources (GNWT) to relate changes in snow conditions vis-à-vis winter migratory patterns of caribou.

ECOSYSTEM and COMMUNITY-BASED RESEARCH

Arctic Borderlands Ecological Knowledge Co-op: Contributions to ecological and cumulative impacts monitoring

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The Arctic Borderlands Ecological Knowledge Co-op coordinates Community Based Ecological Monitoring in the range of the Porcupine Caribou herd, and adjacent coastal communities. With communities as active partners the Co-op creates the framework for community based ecological monitoring data to be collected and turning the data into meaningful information. The ability to provide comprehensive community based information as soon as possible combined with relevant explanatory measures is key to addressing opportunities and limitations facing decision makers and data users.

Numerous environmental valued components and indicators are reflected in the Co-op's community based survey/ questionnaire, including: population and trends of moose, caribou, furbearers, muskoxen, predators and other animals. Populations and health of fish, the timing of their runs and harvests are documented. In addition, monitors inquire about harvest details, animal health, observations about habitats, are also dealt with. Human activities such as development, research, snow machine use, and hunting are also documented.

Recent successful efforts to analyze and improve application and use of data have resulted in increased linkages for co-management boards and government reporting/ monitoring requirements. Of note, Co-op indictors of status and trends related to wildlife health have sometimes been some of the few indicators for resource managers to consider. For example 2011-2012 results presented in Inuvik at the Co-op's annual data validation/ Gathering in Inuvik indicated continued strong caribou body condition/ health indicators and reflected several months before aerial surveys were cancelled due to herd aggregation challenges.

The Co-op is a result of multiple partners coming together to better understand and monitor the ecological changes in a meaningful manner to inform both cumulative impacts frameworks and decision points within the region. What has transpired since it's initiation in 1996 has now evolved to a world class model demonstrating how collaborative programs can be effective and productive in the north.

Trophic network assessment of Mackenzie Great Lakes using Ecopath modeling: A path to ecosystem based management approach

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Climate change and fishing activities could impact aquatic ecosystems structure and functioning by modifying their features and affecting the interactions between their biological components. Ecological modeling is an important tool to improve our knowledge of ecosystem functioning and to explore the ecological consequences of fishing. Ecopath with Ecosim (EwE) is useful tool that has been widely used to explore interactions and impacts of fishing in aquatic ecosystems. We have developed preliminary Ecopath models for the Great Bear Lake and Great Slave Lake ecosystems to evaluate the utility of this approach in these lakes. Input information for these models was generated from published and unpublished reports and data sets. Local traditional fisheries knowledge studies were conducted in the communities around these ecosystems to gather local fisheries knowledge and observe changing fisheries and climate scenarios. During the traditional knowledge survey, communities identified climate change and related ice duration changes impacting these ecosystems and fisheries, though commercial fishermen observed these changes positively impacting the fisheries activities while for the subsistence fishers, impact was negative. Communities also observed increase in population of pike in Great Bear Lake and of lake trout and inconnu in Great Slave Lake during last twenty years.

These ecosystem models assessed the trophic relationship, energy flow and interactions between ecological groups. We used trophic network analysis to quantify ecosystem functions through analysis of food web transfers. Both grazing and detritus pathways were found having an important role in these ecosystems. Lake Trout and Pike were found to be the keystone species in Great Bear Lake and Great Slave Lake respectively while in both lakes; benthic fauna had an important role in total relative impact. Primary production requirement per unit catch of whitefish was very much lower in Great Slave Lake explaining its success and sustainability in fisheries. Average trophic level of fish catch was 3.53 and 3.24 in Great Bear Lake and Great Slave Lake, respectively. Percentage of primary production required for harvest was 0.85% in Great Bear Lake and 3.11% in Great Slave Lake showing that overall fisheries were within sustainable range.

Many holistic indicators in Ecopath models integrate the ecosystem process and can be useful in quantification of ecosystem state, maturity, development, and health by comparing across different modelled systems. We compared coefficients of flows and nutrient cycling indexes of the Great Bear Lake and Great Slave Lake including biomass/primary production, biomass/throughput, flow diversity, cycling index and path length with results from previous research on Laurentian Great Lakes. Analysis of these ecosystem functioning metrics shows that Mackenzie basin great lakes ecosystems especially Great Bear Lake is still in comparatively healthier and pristine stage. The models developed during the project are helpful in identifying critical gaps in knowledge and data, and can be used as vehicles for developing an enhanced understanding of ecosystems functioning of these great lakes. Further modelling on basis of ongoing monitoring data and sub models for management areas are recommended for management simulations.

Understanding shallow-water Sahba (Lake Trout) morphotypes through traditional knowledge and science: Dialogue toward new knowledge?

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Stock assessment research has been conducted on the Lake Trout of Great Bear Lake, Arctic Canada, by Fisheries and Oceans, the Sahtu Renewable Resources Board and the Deline Renewable Resource Council since 2000. This research has been complemented more recently with investigations on the occurrence of multiple shallow-water forms of lake trout in collaboration with University of Alberta. Nevertheless, many questions remain (e.g., origin and maintenance of polymorphism). Increasingly, conservation biologists, resource managers, and local communities have recognized the importance of interdisciplinary participation in addressing many such unanswered questions.

Because Lake Trout has been an important component in the diet of local community members for many generations, significant time and effort are put into capturing the species throughout the year. Consequently, community members have been able to observe Lake Trout over an extensive time period. This provides an ideal case to incorporate both Aboriginal Traditional and scientific knowledge into our study on shallow-water morphotypes of lake trout in Great Bear Lake and thereby improve interdisciplinary participation.

We organized a focus group of key members of the community having active, long-term fishing experience and expert knowledge of lake trout to discuss intraspecific diversity in Great Bear Lake. Individual interviews with the most knowledgeable individuals followed to allow for more in-depth exploration of their traditional knowledge. The interviews were semi-structured, based on key themes identified during the focus group. Standardized questions on habitat, movements, diet, and morphology of lake trout in Great Bear Lake were asked. This project combined a number of different kinds of documentation, including mapping, stories, and Dene terminology related to the lake area, fish nomenclature, morphology, and diet. Although traditional knowledge has a more qualitative nature than scientific knowledge, characteristics of the Lake Trout population were identified, which contribute to our studies on polymorphism in Great Bear Lake.

Investigating the cumulative impacts of environmental change and human activity in the Tathlina watershed

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The Tathlina Lake area is a culturally and economically significant area for the Ka'a'gee Tu First Nation, as Band members and their ancestors have lived, hunted, trapped and fished in the Tathlina Lake area for thousands of years. The lake itself supports a small commercial fishery, which employs KTFN members and contributes significantly to the economy of the community. The area is also downstream of one of the only producing oil and gas fields in the NWT, in the Cameron Hills. Environmental change and multiple resource pressures in the region have led the KTFN to question the cumulative impacts of these influences on the current and future health of the aquatic system of the Tathlina watershed.

This is a multidisciplinary research project coordinated by the Ka'a'gee Tu First Nation and CIMP, involving communities, universities, and government. The primary goal of this program is to understand the current health of the aquatic system in the Tathlina watershed and to understand how this system has changed over time. A key component of the project is developing an understanding of the potential drivers of change in the aquatic system. This requires the determination of individual influences on the system, including the effect of climate change, upstream development, fire history and commercial fishing.

A variety of techniques are being used to assess the current health of the aquatic system, including broad scale water quality and macroinvertebrate sampling using Environment Canada's CABIN protocol, and detailed fish health studies, including recording physiological parameters and testing for contaminants in muscle tissue. Lake sediment cores are being used to address specific research questions regarding historic contamination from upstream development and tracking environmental change in the region. In this presentation we will present some preliminary results from the first year of the program.

Community and scientific monitoring of the Great Slave Lake ecosystem

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Community-based monitoring provides numerous opportunities for an improved understanding of ecosystem health, capacity building through training, and for the advancement of scientific understanding. Despite its importance locally, nationally and internationally, there are few monitoring programs on Great Slave Lake with the majority of studies focussing on contaminant trend monitoring in fish in the lake and water quality trend monitoring in the Slave River. Trends of mercury increase are being observed in fish but, in the absence of other monitoring, including water quality, it is difficult to determine what is causing these changes. Warming trends and changes in wind speed and precipitation also are occurring which could affect water quality. Increased development in the Peace, Athabasca and Slave Rivers may also impact water quality if such developments release chemicals into these waters. Clearly, there is the need for improved monitoring of Great Slave Lake, particularly at Fort Resolution, near the Slave River inflow.

Here we report on highlights of studies conducted in 2012.

In 2012, we focussed our collaborations on exploring the utility of the water intake at Fort Resolution to serve as a year-round, fully-accessible monitoring site. Water intake monitoring has been used for decades on the Great Lakes to assess trends in nutrients, major ions, algal populations, etc. and could be adapted for use on the Great Slave Lake. As part of the ongoing operation of the water treatment plant, water temperature, turbidity, pH, and water color are measured every 2-3 days throughout the year and iron and manganese measured several times a month on the intake side of the plant, i.e., before the water is treated. Data going back to 2005 were abstracted from log sheets and entered into Excel files by a high school student working on the project. Next, data were graphed and error checking conducted with potential sources of error identified and corrected. The resulting data were examined to explore relationships between heating and cooling cycles for the air (from daily climate records for the same periods) and water; turbidity with ice cover and wind activity; turbidity and water color relationships; turbidity and iron and manganese relationships; and pH. Differences between years and the effects of events such as storms on water quality were explored. Overall data were viewed as being of high quality and an enhanced monitoring program began in September with weekly samples being collected for total phosphorus and chlorophyll and monthly samples for major ions, dissolved organic carbon, major ions, metals and algal composition. Such collections will allow for investigations of phytoplankton productivity cycles in Resolution Bay and comparisons of water quality with that being measured in the Slave River. Highlights of these findings will be presented.

We also will discuss the training in limnological sampling techniques that was provided in August 2012 with delegates from Lutsel K'e, Fort Smith and Yellowknife attending; this training should help form the basis for enhanced monitoring in 2013. Finally, we will discuss the highlights of the trip the high school student and water treatment plant operator made to Saskatoon where they learned data management techniques, investigated educational opportunities, and toured the Saskatoon water treatment plant.

COMMUNITY-BASED MONITORING IN THE ISR

Community coastal based monitoring: A regional approach for the Inuvialuit Settlement Region (ISR)

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Many fish and marine mammal coastal monitoring programs have taken place throughout the Inuvialuit Settlement Region (ISR) to address questions raised by both science and communities. These programs are often carried out as partnership programs between Fisheries and Oceans Canada, the Fisheries Joint Management Committee and local communities. Programs are designed to address key questions or issues, many monitor key indicators of ecosystem structure, function and health, and thus provide a baseline of system functioning. Long term research and monitoring are essential in characterizing the ecosystem and understandings its natural variability. Timely factors such as: a) the rise in oil and gas interests and need for knowledge for regulatory decision making, b) changes in the physical environment (e.g. loss of sea ice) in response to climate change ; and c) the start of an offshore fish project (DFO/ BREA) in 2012, together have provided the impetus to take a regional approach to coastal monitoring in the ISR. Thus in 2012, a co-ordinated approach to monitoring key valued ecosystem components (VECs; e.g., fish, beluga) was implemented. It included the tailoring of already established programs (e.g. Hendrickson Island, ACES) and establishing new ones (e.g. Paulatuk beluga and fish project). While the field and laboratory analytical aspects of the program are underway and supported (i.e. FJMC, DFO, BREA) we recognized the need to complete a framework for a coastal regional monitoring program, synthesizing existing indicator data for the region, testing the robustness of some of these indicators to ensure the indicators currently being used are ideal for continued long term monitoring (specifically cumulative impact monitoring) and lastly providing community perspectives on indicators and monitoring programs in general.

Given the size of this program we summarize milestones here. Several components of the framework were completed in concert with our field activities while others are currently underway. A database has been completed summarizing all coastal aquatic monitoring activities that have taken place in the ISR since the 1970s, and a partnered FJMC database of monitoring activities is underway. Concurrent with our monitoring programs, beluga and fish monitors provided feedback on how to improve the monitoring programs and better represent community perspectives. Outcomes from a TEK program and ISR community workshop also gave guidance on incorporating local indicators into monitoring programs. Currently, we are conducting a sensitivity analysis based on a Beaufort Sea Ecosim with Ecopath model to better understand the power of our indicators in context with a broader ecosystem perspective. Finally we are analyzing several biochemical indicators (e.g. stable isotopes, vitamin A) to define baselines, variability and suitability as indicators. Year two will focus on continued testing of indicators, initiating community indicators (along side science indicators) and completing the coastal monitoring framework.

Tracking and understanding vegetation change in the northern Mackenzie basin

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The Northern Mackenzie Basin is an area of ecological and cultural significance that includes the Mackenzie Delta, lower Mackenzie River, and adjacent uplands. Recent research indicates that warming air temperatures and more frequent disturbances (natural and human-caused) are driving significant changes in regional vegetation. Since vegetation structure and composition directly and indirectly impact most valued ecosystem components (VCs), research on the patterns and rates of change is vital to the assessment of regional cumulative impacts. Over the past several years, our project team has been working at multiple scales to understand the rate and causes of vegetation change in the Northern Mackenzie Basin. This presentation reviews recent progress of several project initiatives. To monitor vegetation change over time we developed a sampling protocol intended for use by participants with varying levels of technical training. To examine the ability of this protocol to detect change over time we used data from 35 undisturbed sites to parameterize simulation models. These models examined the influence of user error and sample size on the statistical power of our sampling design. Results suggest that repeated sampling following our protocol can be used to detect modest changes in plant functional group abundance. To characterize the impact of several types of anthropogenic disturbance we established monitoring sites on historical seismic lines, abandoned quarries, drilling mud sumps, and alongside all-weather roads. Comparing biotic and abiotic conditions at these sites with the range of variability at undisturbed sites will allow us to evaluate the relative impacts of different forms of disturbance. Preliminary analysis of this data shows that disturbances have a significant influence on vegetation structure, composition, and the abundance of edible berries. To quantify landscape scale impacts, ongoing work combines field work, remote sensing analysis, and regional disturbance mapping. Changes in vegetation indices derived from LANDSAT imagery (1985-2012) will be used to assess the magnitude and extent of regional vegetation change. By comparing plot sampling and disturbance maps with these vegetation indices we also seek to characterize the landscape-scale impact of different forms of disturbance. These data will be of interest to a range of users, but are especially relevant to organizations interested in understanding and managing the effects of landscape change on wildlife.

COMMUNITY-BASED MONITORING (cont'd)

CIMP implementation using remote sensing

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The aim of the Northwest Territories (NWT) Cumulative Impact Monitoring Program (CIMP) Cumulative Implementation using Remote Sensing (CIRS) project is to assess the potential for remote sensing technologies to address the Value Components (VCs) identified by the NWT-CIMP needs assessment process. The study will identify where remote sensing capabilities (with an initial focus on Earth Observation (EO) satellites) can monitor VCs and what types of benefits or limitations should be expected. This assessment will provide a tool for the CIMP program in evaluating how remote sensing may be used to cost effectively expand the areas being monitored.
The study reviews the work done to date on the development of the VC Statement of Knowledge documents, implements an interview process to define information gaps related to the VCs that can be easily translated into remote sensing requirements, and recommends remote sensing approaches that address the information gaps. The initial focus is on the priority VCs (water, caribou, fish), but will also include the other CIMP identified VCs where remote sensing has as strong potential to contribute.

In addition to the current status of the project, the presentation will cover a similar initiative in the oil and gas and mining sectors, look for areas where common approaches can be cost effectively promoted, and discuss the current LOOKNorth Call for Expressions of Interest.

PATHWAYS APPROACH

Creation of a PATHWAY Framework Guidance Document

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The PATHWAY is a step-by-step process that can help plan and implement research or monitoring programs that address issues of importance and concern to northern communities, and engage northern partners more effectively in the research process. As northern monitoring and research partners have valuable insights on how to best accomplish the various steps of the PATHWAY, we're speaking with a broad group of these partners to obtain input for developing a guidance document. The guidance document will assist groups that are interested in establishing or continuing monitoring and research projects in the NWT. Our main objectives are:

A. To obtain input from monitoring and research partners on keys to success and challenges in northern monitoring and research, how to overcome these challenges and how to improve northern and community engagement in monitoring and research; and
B. To organize the diversity of input using the PATHWAY Framework to produce a guidance document promoting better northern monitoring and research.

The guidance document will not be prescriptive but instead will offer a range of experiences, recommendations and advice to promote meaningful research relationships and encourage partnerships between those who use the land and are most familiar it, those in charge of managing it, and those who study it. The PATHWAY Framework was developed by the Cumulative Impact Monitoring Program, which is also supporting the creation of the guidance document in partnership with the Aurora Research Institute.

FISH ECOLOGY

Results of a multi-year study of movement patterns of Lake Trout in Chitty Lake, NT

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Lake trout is a species that is relied upon by many residents in the Northwest Territories (NT). It is harvested for subsistence and recreation, and provides valuable economic benefits through tourism and the commercial harvest on Great Slave Lake. Lake trout is widely distributed in the NT, typically inhabiting clear and deep lakes. While the diet of lake trout can vary, they are typically piscivorous and are apex predators in Arctic lacustrine habitats. Because they are sensitive to habitat conditions such as water temperature, dissolved oxygen, and water clarity, it is important to improve our understanding of their movements and habitat use in the Arctic to better predict impacts from development and climate change.

A study was conducted between September 2004 and April 2007 to examine the movements of adult lake trout in Chitty Lake, NT using acoustic technology. Chitty Lake is a small (305 ha) lake located approximately 28.5 km northeast of Yellowknife. The lake consists of two deep basins (a northern one with a maximum depth of 20 m and a southern one with a maximum depth of 15 m) connected by a shallower basin (maximum 7.5 m). Of the sixteen lake trout implanted with acoustic tags, nine of these transmitted temperature and or depth information. The majority of the tagged lake trout were captured from the two deep basins of the lake. All surgeries and releases took place at the same location in the southern basin. Eleven receivers were positioned throughout the lake. Movement data was collected continuously over time except when receivers were removed in late April (2005 and 2006) prior to the spring thaw and placed back in the summer. The type of tag used permitted the study of coarse-scale horizontal and fine scale vertical (depth) (0.1 m) movements.

The majority of lake trout captured from the northern basin returned to the basin within three days of release. Lake trout remained in their basin of capture for most of the time during the study. The average depth of lake trout during the summer (July and August 2005 and 2006) was between 8 and 14 m, where the average water temperature was between 7 and 9°C. Summer habitat was restricted to the deep basins and closely associated with the thermocline depth which was approximately 8 m. Presumed spawning activity was observed in late August/ early September when lake trout moved abruptly from deep to shallow depths (~2 m) and remained at these depths for approximately 20 days. During winter months when data were logged (November to April), the average depth of most lake trout was approximately 5 meters. Individual lake trout did not occupy the entire water column in the deep basins during the winter when, unlike summer, there was no restriction in habitat due to water temperature. Diel patterns in vertical movement were evident during the summer and winter months (excluding presumed spawning activity). Greater variation in vertical movements occurred during the day (after sunrise) while they were either absent or more restricted after sunset.

A watershed-scale sampling protocol for accurate distribution and trend assessments of stream salmonids in the Northwest Territories

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Stream salmonids, which include chars, grayling, and whitefishes, are key species in subsistence fisheries across the Northwest Territories. These species occupy upper trophic levels and are integral components of aquatic ecosystems, yet are sensitive to impacts, making them good indicators of the general health of aquatic ecosystems. Traditional monitoring based on site level abundance is not well suited for these indicator species because they naturally occur at low densities and use spatially disjunct habitats over large home ranges. Alternative monitoring strategies based on spatial and temporal patterns of species occurrence have recently been developed that require less intense sampling at individual sites, yet provide powerful and accurate trend detection across broad areas.

A pilot study was developed to explore application of distributional monitoring techniques to streams in the Northwest Territories. The study was based on the following assumptions: juvenile salmonids spend some period after emergence in natal spawning streams; therefore, occupancy in streams can be used to identify rearing habitat and also as a proxy for spawning habitat being nearby. In addition, high occupancy of juveniles in streams across a watershed can be used as a surrogate for the presence of healthy salmonid populations.

Streams that possessed suitable rearing and spawning habitat for Bull Trout were identified in the Prairie Creek watershed. Of the 64 streams identified, 19 were randomly selected and surveyed in July 2012. Approximately 10-15 sites were electrofished in each stream to quantify the occupancy of juvenile Bull Trout. Sampling sites extended beyond predicted suitable habitat boundaries to determine if our criteria for delineating these habitats were appropriate. Juvenile Bull Trout were detected in 11 streams and occurred at 10% to 90% of sites within streams.

In 2013 suitable habitats will be re-sampled in Prairie Creek to validate results and improve estimates of capture efficiency and false absence rates. This stream-sampling protocol will also be tested in other watersheds within the Nahanni Region to refine detection rates for Bull Trout, improve criteria for delineating suitable habitat, and assess the transferability of this method to other stream salmonids, such as Arctic Grayling. In subsequent years this protocol will be tested in other watersheds across the region to assess the broad-scale applicability of this method.

Habitat use of predatory fish species in a northern boreal lake

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Northern Canada is experiencing a number of changes, including rapid climate change and increased industrial exploitation, threatening its pristine freshwater ecosystems. However, there is little information describing the habitat use by top predatory fishes in these systems, making it difficult to monitor and predict potential effects of climate and human induced disturbances on fish populations. We initiated a whole-lake assessment of habitat use of three predatory fish species; lake trout (*Salvelinus namaycush*), northern pike (*Esox lucius*) and burbot (*Lota lota*) in a northern lake using passive acoustic telemetry. Alexie Lake, located ~30km north-east of Yellowknife, Northwest Territories (NWT) is 420 ha, with maximum depth of 32 m, has food web structure typical of many northern lakes, and is closed to fishing, making results of this study transferable to other northern systems. We deployed an acoustic telemetry positioning system consisting of 72 receivers, and surgically implanted pressure sensitive acoustic tags into 30 lake trout, 10 pike, and 4 burbot. This system provides near full lake coverage of the movements of tagged fish. Detailed bathymetric mapping was conducted to relate fish movements with habitat use. Here we introduced the project rationale, objective, methods and present preliminary results (June-September 2012) describing fish behaviour in relation to habitat conditions and relate potential habitat overlap of predatory fish species to feeding overlap inferred from stable isotope analysis.

The influence of climate change on the carbon cycle and its impact on fish in freshwater lakes

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A recent study from the Sahtu region (Carrie et al., Env. Sci. Tech. 2010) has shown that climate change is having long-term impacts on mercury biogeochemical cycling. Increasing aquatic primary productivity due to a longer, warmer ice-free season is leading to more mercury being scavenged from the water column by algae. These increasing trends are mirrored in the increasing mercury concentrations seen in Fort Good Hope burbot over more than 25 years. Our CIMP-funded research is examining whether these trends hold up elsewhere in the Sahtu and Dehcho regions (Kelly Lake and Trout Lake, respectively), by comparing mercury and organic matter in dated sediment cores with annual fish collections. Sediment cores from both lakes show increasing amounts of mercury near the surface, indicating that more mercury is reaching the sediments over time. Two to three years of fish mercury data show that mercury concentrations in fish are indeed increasing at these sites over time, coincident with the increases observed in the sediment cores. However, the statistical significant of these sparse data remains weak, and will improve substantially with continued annual fish collections with the assistance of local communities, similar to our work at Fort Good Hope.

Quantifying baseline PAC levels and changes since onset of Alberta oil sands development: A sediment core study from the Slave River Delta

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The potential for delivery of polycyclic aromatic compounds (PACs) from the Athabasca oil sands to the Slave River Delta (SRD) via the Slave River has caused concern for residents of Fort Resolution. Concerns have arisen because the SRD is a dynamic freshwater landscape that provides habitat for a diverse array of wildlife and is important for residents of Fort Resolution who utilize resources in the delta for traditional lifestyle activities. A key unknown is the relative contributions of oil-sands-related contaminants from natural riverbank erosion and from oil sands mining operations. This project, which was identified as a priority by the Slave River and Delta Partnership, addresses community concerns that contaminants may be increasing in the Slave River. Because long-term records of measurements of river water are not available, sediments deposited by floods into lakes of the SRD provide one of the best and only sources of information to track changes in water quality of the Slave River over time.

In this study, we utilized prior knowledge (Brock et al. 2010; *Canadian Water Resources Journal*) of a sediment-based flood history of a lake (SD2) in the SRD that is susceptible to periodic flooding from the Slave River during the spring ice break-up. We analyzed contaminants in a new 48-cm-long sediment core retrieved from lake SD2 in September 2011 to: (1) determine baseline concentrations of contaminants of concern (PACs, metals) before oil sands development began; and (2) assess if the levels of the contaminants have changed since development of the Athabasca oil sands.

Reconstruction of the lake's flood history, using the organic carbon-to-nitrogen weight ratio, identified periods of frequent flooding that included one before (1932, 1936-1951) and one after (1987-1994, 2000) oil sands development began in 1967. We compared PAC concentrations and proportions between these two periods. Results showed no significant changes in concentrations or proportions of river-transported bitumen-associated indicator PACs (as defined by Hall et al. 2012; *PLoS ONE*) between these two periods. These results indicate that organic contaminants characteristic of the Athabasca oil sands have not increased or changed in sediments of lake SD2 deposited by Slave River floodwaters between the 1940s and the 1990s. Additionally, the concentration of river-transported bitumen-associated indicator PACs in SD2 are about 55% of values in the sediments of a flood-prone lake in the Athabasca Delta during the interval 1987-1994. This suggests that contaminants from the oil sands that are carried by the Athabasca River are retained in the Athabasca Delta and Lake Athabasca, and may be also diluted by 'cleaner' sediments carried by the Peace River farther downstream. Additional studies in the SRD are required to capture PAC depositional patterns and trends during the past decade.

FISH ECOLOGY; CUMULATIVE IMPACTS AND FISH

Sound production by *Lota lota*

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Sound is central to the reproductive ecology of many animals, particularly when conditions prevent use of visual mating cues. Some codfishes have muscles attached to their swim bladders that enable sound production for mate selection. The burbot (*Lota lota*) are a freshwater codfish that spawn in a light-limited under-ice environment. Both sexes possess swim bladder muscles, suggesting that both sexes may engage in vocalization. We monitored sound production by burbot within an experimental enclosure. Burbot do vocalize and their calls are coincident with their spawning period. Further research is required to determine if winter-based resource development activities that generate under-ice noise are disruptive to reproduction of gadoid fishes.

Monitoring salmon in the Canadian Arctic to assess and adapt to change

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Arctic ecosystems are changing due to climate warming, and biological indicators such as migratory fishes (e.g., Pacific salmon) may be responding by both shifting distributions and also altering abundances in the Canadian Arctic. Although captures of all species of Pacific salmon in the Canadian Arctic appear to have increased in recent years, natal Chum and vagrant Pink salmon are the most frequent salmon species caught in subsistence fisheries. Chum Salmon have suspected spawning locations on the Liard and Slave rivers, but appear to have been historically present only in low abundances. Recently they have been captured in additional locations throughout the Mackenzie River watershed suggesting increased abundances and perhaps the use of additional spawning locations. In this study, salmon are provided from the subsistence fishery, gathered on a community basis by local organizations, and sent to Fisheries and Oceans Canada for further analyses. This passive collection program was started in 2000, expanded in 2011, and continued in 2012 with effort similar to that in 2011. A total of 263 salmon were collected between 2000 and 2010; 229 were collected in 2011; and 23 were collected in 2012. Biological data (e.g., length, weight, sex, maturity level) are being analyzed by catch location to assess population structure of Chum Salmon in the Mackenzie River.
Vagrant Pacific salmon that colonize or natal Chum Salmon that expand existing ranges increase the potential for interaction with local native salmonids such as Dolly Varden and Bull Trout. However, Pacific

salmon co-exist with these and other native salmonids elsewhere in their range. An extensive literature review suggests that species-specific groundwater temperature may allow for resource partitioning of limited spawning habitat, thus reducing the potential for competition among native salmonids and Pacific salmon. Future research will monitor groundwater temperature at known Dolly Varden and suspected Bull Trout spawning locations to assess risk of colonizing Pacific salmon on native salmonids in the Arctic. Greater understanding regarding the presence, persistence, and changes with respect to Pacific salmon in the Arctic will provide insight into adaptation of fisheries to ongoing Arctic change and also contribute to ecosystem-based fisheries management.

Understanding adaptive mechanisms of fishery productivity and fish community diversity corresponding to environmental and cumulative impacts on Great Slave Lake ecosystems

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Following feasibility study and sampling protocol in 2011-2012, we employed a depth-stratified random sampling strategy to work in 42 pre-selected grids during July 2-August 17, 2012. A set of strata-specific environmental variables, depth, temperature, DO, pH, turbidity, and chlorophyll a, were measured by YSI. Of 66 gillnet sets, 10 gillnet sets, inappropriately set or longer than 30 soak hours, were discarded, leading to 26 pelagic, 33 benthic, and 2 mid-water gillnet settings at 38 effective grids. Our pursues strategically targeted to 1) development of community-based ecomonitoring framework, 2) evaluation of species-specific abundance, biomass, and production versus mesh-sized gillnet selectivity, 3) evaluation of age estimate structures of Lake Whitefish, 4) association of fish community with indicators of environmental and cumulative impacts, and 5) spatial distribution of Inconnu.

Hydrological environment parameters displayed pronounced spatial and bathymetric variation, characterized by a thermal stratification where grid depth was over 10m deep. The thickness of the thermal structure can be clearly discerned at the 5-12 m below the surface and turbidity started to be stable in the hypolimnon regime. Eighteen fish were identified, belonging to 9 orders, 10 families, and 13 genera. IRI indicated that a group of Cisco comprising Lake Herring, Least Cisco, and Shortjaw Cisco, predominated in NPUE, BPUE, and occurrence frequency, followed by Lake Whitefish, Longnose Sucker, and Burbot. Combined with these dominants, %N, %W, and %IRI were summed to 92%, 82%, and 96%, respectively. The overall NPUE and BPUE were 0.57 individuals/m^2 and 81.47 g/m^2 in pelagic, and 0.43 individual/m^2 and 134.64 g/m^2 in benthic gillnets, respectively. More than 31% abundance appeared in pelagic environment while 65% biomass was found from benthic gillnets. Group Cisco took up >84% in pelagic abundance and Lake Whitefish dominated benthic biomass (26%).

Among ten mesh-sized panels, more than 57% individuals were captured by 1-inch panel pelagic nets. Lake Whitefish and Longnose Sucker appeared throughout a full mesh size range of panels; the arithmetic means and kurtosis of fork length increased while the standard deviation decreased. No conspicuous trends in arithmetic mean, standard deviation, kurtosis, and skewness were found for Burbot and Inconnu due to the limit of sample sizes.

Since commence of commercial fisheries, Lake Whitefish has been monitored through a series of fish plant sampling programs. When implementing these programs, the scales have been used as a primary structure for age estimates of Lake Whitefish whilst, meanwhile, some researchers documented that the discrepancies between scales, otolith, and fin rays increased linearly after ages 4 or 5. We collected scales, otoliths, and pectoral fin rays of 283 Lake Whitefish in Fort Resolution area to examine which is the most reliable ageing structure and what differs in the ageing precision and uncertainty among these

structures. The most age classes (23 ages) and greatest mean age (10.59 years) were confirmed by otolith readings, compared with 19 age classes and 9.31 years by sectioned pectoral fin rays and 19 age classes and 9.99 years by scale readings. Moreover, age differences, precision, and uncertainties varied with ageing structures and specific age classes.

The spatiotemporal patterns of lacustrine fish community largely reflect the integral information on species richness, food linkages, and habitat-related environmental associations. Integrated with eight environmental variables, we applied canonical correspondence analysis (CCA) to examine the variation of NPUE and BPUE along GSL environmental gradients. It was found that grid depth functioned as the first forcing vector principally dictated the majority of fish community NPUE into shallow and deep water environment while pH imposed the second influential vector to impact the spatial distribution of Ciscoes except Shortjaw Cisco. In terms of species-specific BPUE, the first CCA axis represented by grid depth and temperature together separated the southern GSL into shallow warm and depth cold microhabitat regimes; the second CCA axis of turbidity divided the surveyed areas into clean and turbid waters. According to those spatial divisions of environmental variables, four fish assemblages have been identified: Lake Whitefish, Burbot, and Shortjaw Cisco preferred to a deep, cold, and turbid environment whilst Lake Trout, Lake Herring, Least Cisco, Longnose Sucker, and Inconnu tended to congregate in the clean-water environment. The third assemblage included Northern Pike, Walleye, Round Whitefish, White Sucker, and Ninespine Stickleback in shallow and warm habitat. The fourth assemblage comprising rare and small-sized species Goldeye, Lake Chub, Spoonhead Sculpin, Spottail Shiner and Troutperch in shallow, warm, and turbidity habitat. In particular, the BPUE distribution of Inconnu displayed significant spatial preference to covariate variables of turbidity and biomass of Ciscoes. As a typical visual predator, clean water is beneficial for Inconnu to search for the prey resource; positive correlation between Inconnu and Ciscoes indicated an evident prey-predator relationship. Use of these surrogate monitoring endpoints can greatly help understand how the changes of environmental and cumulative impacts can interact on dynamics of fisheries production, fish community, and aquatic ecosystems as well as how the multivariate factors can be integrated into a precautionary decision framework for sustainable development of the northern fisheries productivity.

WATER AND CUMULATIVE IMPACTS

Implementation of the NWT Water Strategy

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The NWT Water Stewardship Strategy (the Strategy), released in 2010, was developed to respond to concerns expressed by northerners about their water, which they use for transportation, subsistence, spiritual, cultural and economic purposes. It identifies a common vision for water stewardship and management in the NWT, and sets out goals that include: assuring that waters flowing into, within or through the NWT are substantially unaltered in quality, quantity and rates of flow; residents have access to safe, clean and plentiful drinking water at all times; aquatic ecosystems are healthy and diverse; and, residents are involved and knowledgeable about water stewardship. The Strategy stresses the need for water partners to work together and share ideas and knowledge to make sound decisions about responsible water use. The Plan for Action was released in 2011, and identifies specific actions that contribute to meeting the goals and vision of the Strategy ('Keys to Success'), with deliverable dates and identified lead agencies.

The purpose of this presentation is to provide an overview of activities outlined in the Plan for Action that have been implemented to date, as well as to highlight successes and outline next steps for the Strategy's implementation. Specifically, this presentation will address community-based monitoring programs underway, source water protection planning, transboundary water management agreement negotiations updates, water monitoring inventory development, and communication and engagement of NWT water partners in water stewardship.

Implementing an NWT approach to collaborative monitoring that addresses the needs of water partners, including community concerns and cumulative impacts

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The purpose of this presentation is to outline the development of a flexible Northwest Territories approach to community-based monitoring. An NWT approach to community based monitoring is one that addresses community concerns, incorporates analysis of past and current related monitoring and research, links western science with traditional and local knowledge, and builds community capacity through training opportunities. Communities and scientists work together to develop monitoring priorities and design programs to decrease duplication thereby increasing cost-effectiveness. The approach was developed and then validated through the testing of the Cumulative Impacts Monitoring Program's (CIMP) Pathway

Approach and participation in various community-based monitoring programs. The approach is consistent with CIMP's Valued Components and allows for integration across programs.

This presentation will highlight the three main phases of the NWT approach. In the first phase community concerns regarding water and aquatic ecosystems are identified. Past and current water monitoring and research are also identified. The level of community participation is determined and relevant external partnerships are identified to support the community. The second phase includes synthesizing available information, including western science, traditional knowledge and local knowledge, regarding the different ecosystem components. Information is put together into a State of the Knowledge Report. The next step is to identify information gaps and potential vulnerabilities through a Vulnerability Assessment, and to prioritize questions from a community and scientific perspective. While this work is being completed, a community-driven research project occurs to begin to answer questions and develop the partnership and capacity. Phase one and phase two provide a foundation for monitoring and research activities, with priority work undertaken in the third phase. This phase also includes maintaining the different parts of the partnership, and finding funding to support implementation. The results of these activities feed into future State of the knowledge reports and support ongoing prioritization of monitoring and research needs.

Finally, this presentation will highlight how the NWT approach to community based monitoring is being utilized across the NWT, including monitoring activities on the Slave, Mackenzie, Peel and Hay Rivers, and collaborative program development with the Slave River and Delta Partnership, and with Sambaa K'e and Fort Good Hope.

Cumulative Effects Monitoring in the Slave River and Delta

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The purpose of this presentation is to outline ongoing community-based monitoring conducted by the Slave River and Delta Partnership ('SRDP') in the Slave River and Delta ('SR + D') , and to highlight development of a community-based cumulative effects monitoring framework for the SR + D being developed collaboratively by the Partnership with the Canadian Water Network (CWN). The Partnership was formed in 2010 in response to community concerns over fish health, water quality and water quantity. The goal of the SRDP is to address community driven questions about changes to the SR + D, including cumulative effects associated with upstream development, and undertake research and monitoring activities to address such questions. The first step toward developing the SRDP was a series of conference calls during October and November 2010. These involved community members, Aboriginal governments and organizations, territorial and federal governments, ENGOs and researchers. The purpose of these call was to identify what work has been done before, what work was currently underway, who was doing what, what activities communities wanted to participate in and opportunities for partners to work together. The second step of the process was an aquatic ecosystem health indicators workshop, where participants identified concerns about upstream development and identified key questions and indicators.

The third step, a CIMP-funded project, was the development of a State of the Knowledge Report and Vulnerability Assessment, and a prioritization of key indicators and community concerns for research and monitoring activities. The SRDP conducted a series of research and monitoring projects throughout this

process, in partnership with territorial and federal government agencies and southern universities, including: sediment core sampling in the delta; a fish health study and community fishing days; a DFO health study; and, a furbearer population and contaminants study.

The partnership is currently collaborating with the CWN to develop a cumulative effects monitoring framework for the SR + D. The program focuses on community concerns, is collaborative, inclusive and participatory and incorporates both traditional and local knowledge and western science. The goal of the framework is a community-based cumulative effects monitoring program that is cost-effective and designed for long-term community monitoring, and can be adapted and implemented NWT-wide if communities are interested. Information gathered through this process will contribute to decision-making at multiple levels, and will complement existing water monitoring and research programs throughout the NWT. The field component of this project is scheduled to begin in April 2013.

Health Status and Biomarker Responses in Fish from the Athabasca and Slave Rivers in Relation to Potential Exposure to Contaminants from Oilsands operations.

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A large segment of the Alberta oilsand open-pit mining activities are adjacent to the Athabasca River. Aerial emissions and oil sands process-affected waters contain many different chemicals including polycyclic aromatic hydrocarbons (PAHs) naphthenic acids and metals, some of which are persistent, toxic, mutagenic and potentially carcinogenic. Concerns have been expressed about the potential environmental and human health effects of emissions by communities in the Athabasca River basin as well as by communities in the downstream Slave and Mackenzie river basins. These concerns have been exacerbated by uncertainties concerning the origin of these contaminants. The aim of this research was to describe the current status of fish health on the Athabasca and Slave rivers in relation to concentrations of metals and PAHs measured in fish tissues. Target sample size for the project was 30 individuals of 5 species (Gold Eye - Hiodon alosoides, Whitefish - Coregonus clupeaformis, Northern Pike - Esox lucius, Walleye - Sander vitreus, Burbot - Lota lota) at three location on the Athabasca river and two locations on the Slave River. Fish were sampled in summer, fall and winter of 2011, A total of 834 fish were collected. At the time of collection all fish were subjected to a standardized and detailed health assessment including both external and internal examinations. Tissues were preserved for chemical analyses and for histological and biochemical and molecular biological markers. External and internal matrices of fish health showed no significant differences related to proximity to oilsands operations of location on the river system. These results will be discussed with reference to the observed concentrations of PAHs and metals measured in the fish and the biochemical markers analysed. While

chemical residue data indicates exposure of fish to contaminants there appears at this time to be little or no impact on fish health I the Athabasca/Slave river system.

Bile PAH profiles were determined by synchronous fluorescence spectroscopy followed by quantitative LC/MS/MS and GC/MS to determine individual parent and alkylated PAHs. Fish sampled from upstream Athabasca River locations close to operational sites have a greater exposure to PAHs than fish from the Slave River. Bile PAH profiles also suggest different sources of PAHs on the Slave and Athabasca rivers. At the Slave River sites lower molecular weight PAHs represent a greater proportion of the total bile PAHs compared to the Athabasca River sites.

Concentrations of 20 metals were measured in fish tissues by ICP-MS. While most of the metals analysed showed little or no location associated variability vanadium and thallium showed increased concentrations in fish collected downstream of oilsands operations. The latter two metals have been previously associated with discharges from petroleum based activities. Statistically significant ($p<0.05$) increases in vanadium were observed at Fort Resolution and Fort Smith on the Slave River compared to sites on the Athabasca River. A steady increase in the concentration of thallium in fish muscle was noted at sites proceeding down the Athabasca/Slave system.

Furbearer contaminants, population and harvest on the Slave River and Slave River Delta: historical and current conditions

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The transboundary (NWT-AB) Slave River and the Slave River Delta are culturally and spiritually significant, support northern subsistence harvesting and lifestyles, are a direct source of drinking water, and provide habitat for a range of wildlife species including fish and furbearers. There are several potential sources of cumulative impacts to the Slave River and the Delta including hydroelectric development, historic transport of uranium and hydrocarbons, upstream development (oil sands, pulp mills, agriculture, etc.) and climate change. Through ongoing work as part of the Slave River and Delta Partnership (SRDP), community members identified semi-aquatic furbearers as a critical focus for examination of cumulative effects associated with upstream development, which precipitated this study. Local hunters, trappers and land users have noted that changing winter flows/water levels have affected muskrat and bank beaver populations, and concerns have been raised about contaminant levels in a number of species.

The purpose of this study is to address community-driven questions about the health of and changes to semi-aquatic furbearers in the Slave River and Slave River Delta. Species of focus for the study include muskrat, beaver, mink and hare. There are three main objectives associated with this research: 1) Examine levels of metals and contaminants in mink and several prey species (muskrat and hare) along the Slave River and compare to levels documented in the same area in the 1990s; 2) observe and identify active locations of bank beaver and muskrat houses (push-ups) along the Slave River and Slave River Delta; and observe potential impacts to beaver and muskrat activity (survival/mortality rates) after winter flooding; and, 3) assess the historical trapping and harvest records (pre-regulation vs. post-regulation) for south Slave region communities including Fort Smith, Fort Resolution and Fort Fitzgerald.

For objective 1, 30 specimens of mink, beaver, muskrat and hair will be collected and analyzed for the following: sex, weight and body condition; stomach contents (mink only); tooth cementum; trophic relationship in the food web via stable via stable isotope analysis; and, analysis of liver, kidney and fat samples for persistent organic pollutants (POPs), mercury and 34 other elements. For objective 2, field work conducted by local hunters and trappers working with a community coordinator will locate and document muskrat and beaver houses along the Slave River and Delta, focusing on areas susceptible to winter flooding. This portion of the research will focus specifically on identifying house activity through presence of breathing holes (beaver houses) or plunge holes (muskrat push-ups), and assessment of presence of flooding (to assess double layer of ice) via ice depth analysis and trail cameras monitoring snow conditions at 2 sites. This portion of the study will also include a population and mortality assessment of muskrat and beaver populations. Finally, for objective 3, historical trapping records will be assessed to identify trends and changes in harvest rates both pre- and post-regulation of the Peace River via the W.A.C. Bennett dam, and will include analyses of multiple species, multiple communities, and number of trappers will be included to attempt to reduce potential bias (i.e. less trapping because of change to wage economy, etc.).

Work on this study is currently ongoing. Data collected will be compared with available information on water quality, water quantity and fish health to assess contaminant trends and changes to rates of flow over time for the Slave River and Slave River Delta.

Monitoring heavy metals in the Mackenzie River basin

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Trace metals exist in a variety of inorganic and organic forms in aquatic systems, ranging from simple ionic molecules to large organic complexes. The biological availability, and hence toxicity, of metals in aquatic systems is strongly dependent on the concentration and nature of the metal species present. Accordingly, determining the chemical form, or speciation, of metals in the environment is fundamental to predicting impacts to aquatic biota.

In speciation studies, sampling and storage of samples can irreversibly change the speciation of metals, resulting in erroneous information about the system. The application of in situ techniques using passive samplers can considerably reduce this problem. One of the most promising is the diffusive gradient in thin-film gels or DGT.

In this study, a suite of surface water samples were collected in the Mackenzie River Basin between July and October 2012. DGT units for trace metals, vanadium and methylmercury were deployed at 19 sites. Preliminary results showed that Canada's water guidelines for the protection of aquatic life were not exceeded for study metals (Al, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Mo, Cd, Tl, Pb, Hg) despite some spatial variability. Temporal and spatial variations in metal concentration and speciation will be discussed.

Changes to taiga shield water chemistry regimes with enhanced winter streamflow

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Enhanced winter streamflow is the primary characteristic of a shift around 1995 from a nival streamflow regime to a combined nival/pluvial streamflow regime in small watersheds in the Taiga Shield. This study is attempting to 1) evaluate the associated impacts of this shift on aquatic chemistry and 2) determine if this change is historically distinct or part of longer term cycles. A year with enhanced winter streamflow in Baker Creek was associated with lower average annual chemical concentrations, but higher annual fluxes because of higher concentrations during winter. Winter chemical fluxes were several orders of magnitude larger during enhanced flow conditions than typical winter low flow. This was most pronounced with metals and nutrients. It remains unclear the runoff pathways along which these solutes reach the stream during these winter events. The larger Cameron River, with a catchment that contains several large lakes, too experienced much larger winter fluxes during enhanced winter flow, but exhibited similar annual fluxes independent of winter flow conditions. Furthermore, the larger Cameron was consistently less efficient in producing chemical flux than Baker Creek. It is expected that the large lakes in systems like the Cameron act as a buffer, and a solute sink. This suggests that aquatic chemistry regimes of smaller streams may be less resilient and more vulnerable to the cumulative impacts of both development and environmental change. To place these results in a longer historical context, three lake sediment cores were collected from the Baker Creek watershed in March 2012. Cores were collected using a freeze coring technique that will enable high-resolution (sub-decadal temporal scale) chemical, physical, and biological analyses of sediments that will provide insight on water depth, hydrology, nutrient loading, and metal flux to lake sediments over past centuries to millennia. Comparison to modern lake sediment chemistry and assemblages of testate amoebae from over 100 lakes in the central NWT will enable quantitative reconstruction of past environmental conditions at these sites. These results improve understanding of "baseline" conditions in this landscape and could be used to inform regulatory decision making.

Landscape flooding in the Mackenzie Bison Sanctuary

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In recent decades, lakes have rapidly expanded across portions of the Mackenzie Bison Sanctuary (MBS) in the southwest corner of the Northwest Territories. Using Landsat imagery, we found that some lakes expanded in areal extent by as much as 66% over a single year. The cause(s) of these rapid expansions remain unclear; however, the expanding lakes are encroaching on wood bison (*Bison bison athabascae*) habitat, encouraging the bison to migrate out of the core area of the MBS. The MBS herd is one of the largest free-ranging and disease-free bison herds in Canada, other regionally-significant populations are infected with bovine brucellosis (*Brucella abortus*) and tuberculosis (*Mycobacterium bovis*). Interaction between the MBS herd and infected herds could introduce widespread infection into the MBS herd, which are already impacted by other acute stressors such as periodic anthrax (*Bacillus anthracis*) outbreaks. Therefore, from a management perspective, it is important to understand why these lakes are expanding and causing the bison to migrate from the core of the MBS. Furthermore, lake expansion and movement of the MBS wood bison are occurring in the traditional territory of Deh Gah Gotie Dene Band in Fort Providence, and have implications for local land users.

To better understand the potential drivers as well as the consequences of recent lake expansion, we are conducting a detailed study that combines a variety of complementary approaches. This includes remote sensing to detect the timing and extent of recent lake expansion, and the analysis of lake sediments and tree rings to investigate long-term changes in a variety of meteorological, terrestrial and limnological conditions in the regionthat may coincide with, and provide insights into the potential mechanisms driving lake expansion. Lake sediment records are also being utilized to track changes in sedimentary mercury in expanding lakes, since there is considerable concern regarding the potential for flooded terrestrial vegetation to release significant concentrations of mercury into lakes as it decomposes. Our research also relies heavily on community engagement, and traditional knowledge interviews are being undertaken with local community members. Based on preliminary data available for tree-rings, as well as traditional knowledge, we will present some initial insights into the climatic setting in which recent lake expansion have taken place. We will also present our early findings on mercury concentrations in lake sediments, and set the context for ongoing research into this ecologically significant phenomenon.

A watershed approach to monitoring cumulative impacts of landscape change.

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Monitoring the cumulative impacts of anthropogenic and natural disturbance on northern water resources requires collaborative and multidisciplinary approaches. The relevance of northern monitoring and research projects is enhanced by the involvement of northern communities and through input by co-management boards and regulators.

In this presentation, we report results of a multidisciplinary project investigating the remarkable changes impacting the landscape and rivers of the Peel Plateau in northwestern NWT. This region is of cultural and traditional importance to the Gwich'in and Inuvialuit, and it is of ecological and infrastructure significance. The Peel Plateau extends along the eastern slopes of the Richardson and Mackenzie Mountains and represents one of the most rapidly changing landscapes in Canada. A collaborative program amongst governments, academic researchers and the Tetlit Gwich'in was initiated in response to community concerns and scientific interest related to the discovery of massive areas of landscape collapse termed "mega slumps". These disturbances have created crater like scars up to 50 ha in area and debris flows up to several km in length, which have infilled numerous stream valleys. Terrain mapping indicates that hundreds of streams are impacted by these disturbances which are anticipated to increase in size and abundance with climate warming. These disturbances have major impacts on stream water quality and invertebrate habitat. Preliminary results show the significant impacts of mega slumps on the ecology of streams, far outweigh those impacts resulting from local anthropogenic activities. Forty years of Peel River water quality data shows that the chemistry of this major river has been significantly altered as a result of thawing permafrost. Sediment cores from impacted lakes have been collected to determine how the impacted conditions that we are seeing today compare to conditions in the past. These field studies provide context for laboratory experiments investigating the effects of these water quality changes on the physiology of Char, and the water quality thresholds associated with deleterious effects to fish. In addition, researchers are monitoring the growth of these large disturbances and assessing permafrost conditions and terrestrial ecology at both natural and anthropogenically disturbed sites.

Remote sensing is being used to monitor and map the distribution of mega slumps and other landscape disturbances. The delineation of stream networks and watersheds throughout the region provides a platform upon which to synthesize and display the intensity of disturbance and ecological change. This watershed approach provides a framework to portray other data relevant to the monitoring of cumulative impacts and the modeling of sensitive or fish bearing streams.

The multidisciplinary approach implemented here has helped our team to better track the impacts of disturbance, understand the relative importance of different stressors and evaluate their biological consequences. By working closely with the community, local observers have provided real time observations of environmental change, a longer-term perspective on regional environmental conditions and important guidance on the design and implementation of field studies. Linkages between the project team and local priority setting initiatives, infrastructure planners and regulators has allowed the project team to fine-tune project details to continue to ask the "right" questions and it has improved the flow of information between project partners.

POSTERS

Sympatric polymorphism in Lake Trout: the coexistence of multiple shallow-water morphotypes in Great Bear Lake

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Polymorphism in northern fishes is common but the extent to which polymorphism occurs in lake trout, a species generally associated with a low intraspecific variation, is not well known. Although morphological variation can sometime be subtle, on other occasions, differences are dramatic enough to have caused misidentification of morphs as distinct species. Typically, cases of sympatric polymorphism involve a resource-based variation in a fish population, where significant differences in morphology, life-history, and behaviour are associated with differences in diet and habitat use. This study examined the polymorphism of lake trout inhabiting the shallow-water zones (≤30 m) of Great Bear Lake, NT.

We combined classical morphometric/meristic measures with shape analysis (geometric morphometrics) to quantify morphological differences among adult and juvenile shallow-water Lake Trout from Great Bear Lake. A UPGMA cluster analysis of 558 Lake Trout distinguished three different morphs that co-exist in the shallow waters of Great Bear Lake, NT. A fourth, albeit rarer, morph was supported by a MANOVA that indicated significant differences in head and fin characteristics among the four groups. The most important differences among adult morphotypes are associated with variation in head and fin measurements, whereas body shape variation is less distinctive. These patterns are consistent with many evolutionary adaptations in fish that involve traits associated with feeding and swimming. However, no consistent patterns of variation were found among juveniles, suggesting that divergence develops at later stages Due to the large size and complex morphometry of Great Bear Lake, we also examined patterns across different regions of the lake. Within a single morphotype, morphological variation, including body shape differences, was found to vary among lake areas.

This unusual endemic diversity challenges prevailing ideas that Lake Trout forms are segregated primarily by depth and have a low degree of phenotypic variation compared to their congeneric relatives, especially Arctic Char. Although the deep-water regions of Great Bear Lake have not been well studied, additional morphotypes may exist in these habitats.

Understanding shallow-water *Sahba* (lake trout) morphotypes through traditional knowledge and science: Dialogue toward new knowledge?

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Stock assessment research has been conducted on the Lake Trout of Great Bear Lake, Arctic Canada, by Fisheries and Oceans, the Sahtu Renewable Resources Board and the Deline Renewable Resource Council since 2000. This research has been complemented more recently with investigations on the occurrence of multiple shallow-water forms of lake trout in collaboration with University of Alberta. Nevertheless, many questions remain (e.g., origin and maintenance of polymorphism). Increasingly, conservation biologists, resource managers, and local communities have recognized the importance of interdisciplinary participation in addressing many such unanswered questions.

Because Lake Trout has been an important component in the diet of local community members for many generations, significant time and effort are put into capturing the species throughout the year. Consequently, community members have been able to observe Lake Trout over an extensive time period. This provides an ideal case to incorporate both Aboriginal Traditional and scientific knowledge into our study on shallow-water morphotypes of lake trout in Great Bear Lake and thereby improve interdisciplinary participation.

We organized a focus group of key members of the community having active, long-term fishing experience and expert knowledge of lake trout to discuss intraspecific diversity in Great Bear Lake. Individual interviews with the most knowledgeable individuals followed to allow for more in-depth exploration of their traditional knowledge. The interviews were semi-structured, based on key themes identified during the focus group. Standardized questions on habitat, movements, diet, and morphology of lake trout in Great Bear Lake were asked. This project combined a number of different kinds of documentation, including mapping, stories, and Dene terminology related to the lake area, fish nomenclature, morphology, and diet. Although traditional knowledge has a more qualitative nature than scientific knowledge, characteristics of the Lake Trout population were identified, which contribute to our studies on polymorphism in Great Bear Lake.

Mapping landscape-scale disturbances in the Northern Mackenzie Basin, NWT using a 25-year landsat satellite image archive

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The Northern Mackenzie Basin in north-western Canada has ecological, cultural, and economic significance. This landscape is changing rapidly in response to natural and anthropogenic disturbances, as well as recent temperatures changes. To improve environmental monitoring and better inform

decision making within NWT, the Cumulative Impacts Monitoring Program (CIMP) was established by Aboriginal Affairs and Northern Development Canada in partnership with a joint Aboriginal, territorial, and federal working group. Under the CIMP initiative, we are analyzing a 25-year archive (145 scenes) of 30 m resolution Landsat satellite imagery in an effort to scale-up previous CIMP disturbance mapping activities to an area covering 194,000 km^2 within the northern Mackenzie Basin. Change detection techniques will be used to determine the location, extent, and timing of vegetation disturbances caused by thaw slumping, draining lakes, storm surges, wildfires, infrastructure, and hydrocarbon and mineral exploration activities. The dense time series of images will also allow investigation of long-term, gradual vegetation changes resulting from warming temperatures in the region. Satellite change detection products (for the southern portion of the study region) will be analyzed and reported using a watershed framework, which will provide flexibility by using a hierarchy of nested watershed scales based on stream order. The geospatial products will be made available through the NWT Spatial Data Warehouse to assist planners and decision makers in better understanding large-area disturbance impacts on water quality, fish habitat, and caribou forage.

Depth and habitat related variation among cisco populations in Great Bear Lake.

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Adaptive radiation and the development of high levels of intraspecific phenotypic diversity are common features of fishes, particularly salmonids in recently deglaciated areas and is thought to be related to high intraspecific competition and niche availability in these regions. Ciscoes in particular are characterized by exceptional intraspecific variability across their range with respect to morphology, life history and ecology resulting in a high degree of taxonomic uncertainty within this group.

Great Bear Lake has been highlighted as a location where there is a need for more information on the cisco diversity to help inform decisions by COSEWIC, however to date there has been very little research examining the diversity of cisco in this system. Great Bear Lake is the only Great Lake within North America that has not been commercially fished or ecologically altered through other mechanisms such as non-indigenous species introductions. It therefore provides an ideal system for studying patterns and mechanisms of intraspecific diversification and speciation in a natural setting. More recent research activities by DFO, largely focused on lake trout assessment, have provided an opportunity for the complementary collection of depth stratified cisco samples thus allowing for a more in depth examination of the taxonomy and ecology of this species within Great Bear Lake.

Historical reports indicate that more than one form of cisco may occur in Great Bear Lake; these include lake cisco and possibly least cisco. Recent sampling of cisco concurs with earlier studies and includes what may be two or more forms or species. Based on preliminary results, cisco captured in deeper waters of Great Bear Lake showed characteristics that are consistent with those described for shortjaw cisco (*C. zenithicus*) including shorter, fewer and more widely spaced gillrakers, lighter paired fins and a diet consisting mainly of *Mysis relicta*. Other characteristics such as longer paired fins and greater body depth were not consistent with shortjaw cisco, but are often associated with adaptation to vertically migrating in deeper water and have been noted in other deepwater coreginids such as *Coregonus kiyi*. Deepwater cisco were found to differ in their life history traits, being smaller, later maturing and slower growing than their shallow water counterparts. In addition to variation by depth, we also observed consistent variation among geographically separated populations within deep and shallow water types, suggesting reproductive isolation and parallel evolution of these morphotypes within individual lake arms. With the

exception of Great Bear Lake, shortjaw cisco or a shortjaw-like form of cisco has been reported from most of the remnant proglacial Great Lakes in North America running from the Laurentian Great Lakes northwest to Great Slave Lake. Thus our findings may represent a northern range extension for this particular form or species and certainly represents the first comprehensive account of distinct cisco morphotypes within Great Bear Lake

Evaluating fish habitat compensation at Diavik Diamond Mines, NWT

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In fall 2011, Diavik Diamond Mines Inc. undertook a fish habitat compensation project to offset habitat losses due to mining in the Barrenlands region, Northwest Territories. The compensation site features three small, headwater lakes ("M-Lakes") with connecting streams that were impassable to fish. One choke-and-pool and two gabion-weir fishpasses were built to increase inter-lake connectivity and improve access to these lakes from the larger Lac de Gras, to increase the productive capacity of this pristine system. The objectives of our study are to (1) evaluate the efficacy of the fishpasses using a combination of abiotic and biotic criteria, and (2) determine if such habitat manipulations enhance the productive capacity of the M-Lakes system. Our evaluation process includes three years of before-construction baseline data, and integrates ecological and hydraulics criteria. The choke-and-pool fishpass increased duration of flows suitable for fish passage, and Arctic Grayling were observed using the structure. Gabion-weir style fishpasses were ineffective at providing flows suitable for fish passage, and few if any fish used these fishpasses. Habitat, invertebrates, and ecosystem processes are still being monitored to assess productive capacity. Our preliminary results were used in fall 2012 in an adaptive management approach to improve the M-Lakes gabion-weir fishpasses, and guide design and construction of another stream compensation project in the area. We recommend against using gabion-weir style fishpasses in Arctic headwater lake-stream systems, characterized by limited and highly seasonal flows, uncertainties associated with predicting flows, and limitations in aligning "as-built" structures with design specifications in remote, wilderness settings.