# Investigating the Effects of Environmental Change on Arctic Char (*Salvelinus alpinus*) Growth Using Scientific and Inuit Traditional Knowledge

*by Jennie A. Knopp*

For centuries, and still today, fishing and hunting of local natural resources have been a source of food and a part of the culture of the Inuvialuit of the Western Arctic region (Fig. 1) (Alunik et al., 2003; Inuvik Community Corporation et al., 2006). The Inuvialuit have attained an intimate and detailed understanding of their surroundings through their own experiences as well as from nearly a thousand years of accumulated observations passed on by their ancestors. This understanding of the local environment, known as traditional knowledge (TK), can provide expert information for the study of climate change effects on northern species (Riedlinger and Berkes, 2001; Furgal et al., 2006; Laidler, 2006) and is being increasingly recognized by the scientific community as a valuable way to understand our environment (Huntington et al., 2004; Hinkel et al., 2007).

The direct effects of climate change observed through scientific studies in Canada's Arctic regions include increasing annual temperatures, unprecedented changes in sea-ice conditions, melting permafrost, and increasing storm events (ACIA, 2004). It is hypothesized that these climate changes will lead to indirect secondary effects on Arctic freshwater and anadromous fishes, resulting in changes to body condition and growth, changes in anadromous behaviours, and losses of local biodiversity due to alterations to habitat (Reist et al., 2006a). The people in the local communities will have to adapt to the potential outcomes of these secondary effects.

However, there is a general lack of long-term environmental and faunal data for many of the northern regions of Canada, including the Inuvialuit Settlement Region (ISR) (Reist et al., 2006a), and therefore, a lack of understanding of how the changing climate will ultimately affect northern species. The Inuvialuit of Sachs Harbour and Ulukhaktok (formerly known as Holman), the two northernmost and only permanent island communities in the ISR (Fig. 2), have been noticing unprecedented changes in their environment and local fauna since the mid 1990s and have expressed concern about the impacts of these changes. They have reported that the weather has become "unpredictable" and have observed a suite of rapid environmental changes, which include thinning and melting sea ice, melting permafrost, changes to the seasons, new species occurrences near their communities, and changes in the quality of the Arctic char (*Salvelinus alpinus*) on which they rely as a source of country food (Riedlinger and Berkes, 2001; Nichols et al., 2004; Barber et al., 2008; Pearce et al., 2009; Sachs Harbour community residents, pers. comm. 2009; Ulukhaktok community residents, pers. comm. 2010).

Arctic char is an important biological indicator of climate change in the Arctic because it is the only freshwater fish that has a circumpolar distribution and uses a wide variety of aquatic habitats, including marine, river, and lake environments (Reist et al., 2006b). As the chars are a vital traditional subsistence and economic resource to the Inuit of Canada (Usher, 2002), we need to understand how climate change might affect their condition and populations in Canada's North. The current importance of Arctic char to Inuvialuit communities and the impending effects of a changing environment necessitate effective long-term community-based monitoring (CBM) plans. CBM supports opportunities for both local study and the collection of scientific data to inform the ongoing inquiry into how environmental stressors affect northern fish species.

*FIG. 1. Margaret Kanayok, a resident of Ulukhaktok, Northwest Territories, holds up two Arctic char she caught while angling. The fish meat will be air-dried (called* piffi *in the Kangiryuarmiut dialect) and eaten by people in the community (Photo: Jennie Knopp).*

The purpose of my PhD research is to anticipate and demonstrate the secondary effects of climate variability on Arctic char and provide understanding of these effects to

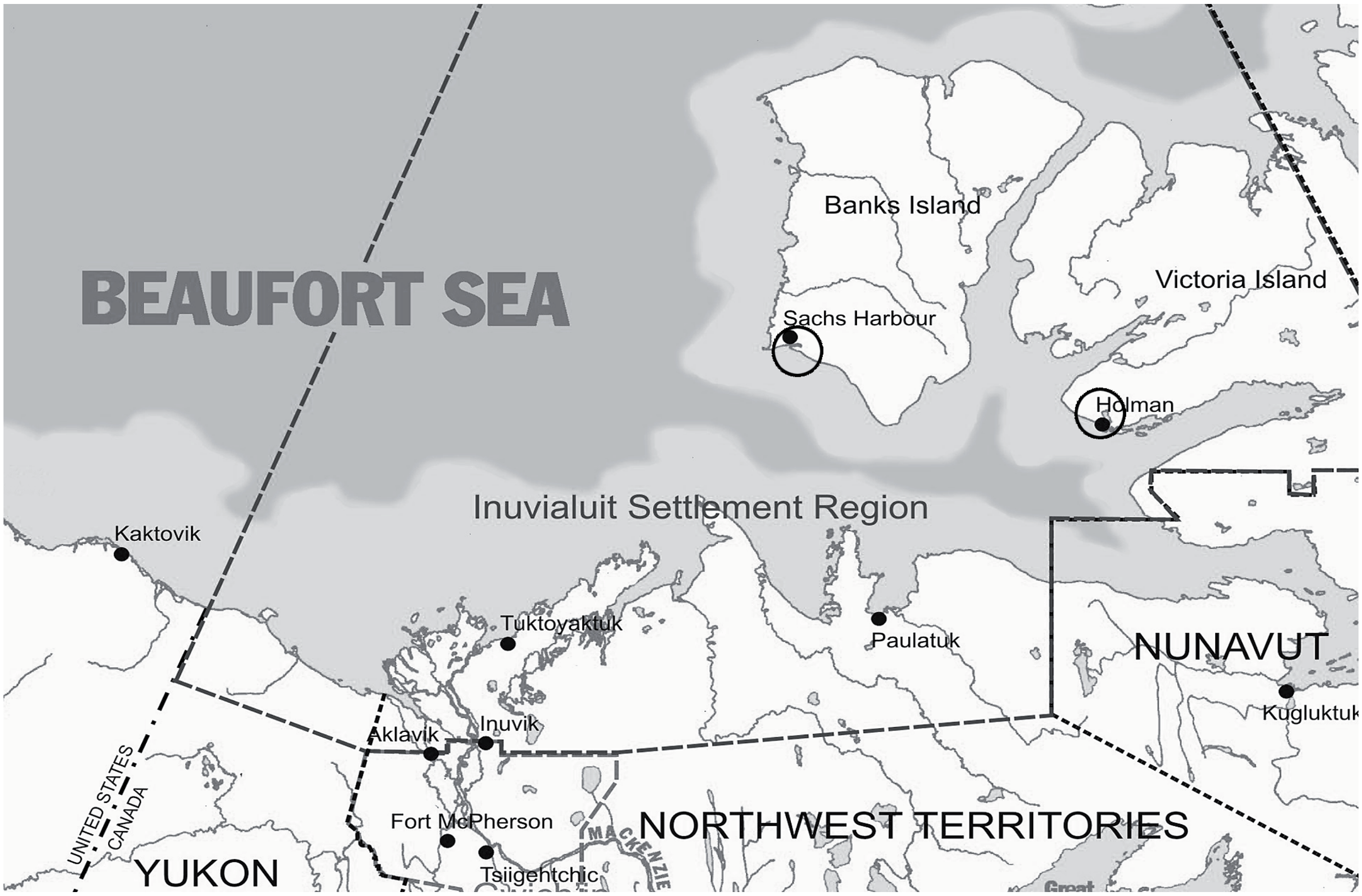


*FIG. 2. Map of the Inuvialuit Settlement Region located in the northern portions of the Northwest Territories and Yukon. The communities involved in the research project, Sachs Harbour (Ikaahuk) and Ulukhaktok (formerly Holman), Northwest Territories, are highlighted with circles. (Map courtesy of John Babaluk, Fisheries and Oceans Canada.)*

the local resource users, allowing them to make informed choices about adapting to upcoming changes. I am examining key environmental and biological indicators of climate change effects on the growth of Arctic char in Sachs Harbour (Ikaahuk) and Ulukhaktok, two ISR communities in the Northwest Territories, and using them to forecast upcoming changes. These forecasts can then be used in community-based monitoring and fishing plans. My research provides the opportunity to exchange information and concepts of Western science and Inuit traditional knowledge and to assist directly with the monitoring and management of local fish resources (Berkes et al., 2007).

## METHODS

### *Interdisciplinary Mixed-Methods Approach*

I am employing an interdisciplinary mixed-methods approach to my research, using scientific methods concurrently with insights from local TK to obtain a robust picture of Arctic environments and northern fish ecology. TK is analyzed to help identify candidate variables for study, in recognition that standard scientific approaches and literature may miss local indicators of environmental change, especially for my little-studied research locations. Using a “concurrent triangulation” approach to the mixed research methods, I am collecting both quantitative (scientific) and qualitative (TK) data (Creswell, 2007, 2009) to determine whether there are complements, corroborations, or contradictions between the two knowledge bases (Huntington et al., 2004; Creswell, 2007, 2009; Carmack and Macdonald, 2008). This approach uses the separate qualitative and quantitative methods as a means to build on the strengths of both knowledge bases. The influence of environmental variables (such as mean annual temperature, mean seasonal precipitation, and annual area of sea-ice coverage) on land-locked and anadromous char growth is examined by comparing the values of these variables and the local TK found at six study locations near Sachs Harbour on Banks Island. Previously documented TK reviewed for the project revealed different primary and secondary effects of climate change in other ISR communities. Therefore, two study locations near Ulukhaktok on Victoria Island were added to determine whether similar or differing climate variation effects are occurring in the two regions.

### Field Work

I conducted field sampling in 2008, 2009, and 2010 on six lakes and one nearshore ocean location to obtain data on the current status of both the char and the aquatic habitat. Fish were sampled for a variety of morphological parameters, including length, weight, sex, maturity, parasite load, and stomach contents, in order to catalogue their current condition. Otoliths (fish "earbones") were also collected to determine age and growth histories of the Arctic char. The field sampling protocol was designed to complement historical Fisheries and Oceans Canada (DFO) sampling efforts completed in the same waterbodies in 1993–94, 1996, and 2009. I tested water quality and conducted aquatic habitat sampling to check for the presence of thermoclines and to assess the current conditions of the lake environment. The study sites were chosen on the basis of existing historical data, as well as for their historical and current use as traditional fishing locations, where a rich and detailed body of TK would be available. All local field assistants were trained in scientific sampling methods so that monitoring of the resource can continue after the project is complete (Fig. 3).

*FIG. 3. Jennie (on left) teaching Catherine Kuptana, a resident of Sachs Harbour, how to remove the otoliths from a lake trout. (Photo: Tracey Loewen.)*

### Traditional Knowledge Interviews and Analysis

A grounded theory approach is used for the qualitative methods in this research. "Grounded theory" is a method of examining knowledge in which the researcher derives general theories about study topics grounded in the perspectives of the interviewees (Creswell, 2009). Scoping sessions and semi-directed TK interviews with local fish and environment experts (Davis and Wagner, 2003) conducted in Sachs Harbour and Ulukhaktok provided insight into past climate variability and fish condition (Riedlinger and Berkes, 2001), and these data will be used to build a comprehensive understanding of climate-change effects on char in the region (Huntington, 2000; Davis and Wagner, 2003).

### Data Analysis

Previous studies (Power et al., 2000; Chavarie, 2008), including studies using otolith back-calculation (e.g., Kristensen et al., 2006), show a direct correlation between variation in the environment and variation in annual char growth. Otolith back-calculation techniques measure the radii of annuli from transverse otolith sections and calculate the ratio of each to the total otolith radius (Kristoffersen and Klemetsen, 1991). These ratios are used to assess the age-specific annual growth of each individual Arctic char (Kristensen et al., 2006; Høie et al., 2008). With the two time series of otoliths from the historical DFO samples and the current samples collected, approximately three decades of char annual growth rates are available, as otoliths from char approximately 15 years of age obtained from DFO would have been alive in 1979. Local meteorological data and satellite imagery of mean annual ice cover will be used to examine environmental variation in the area over the same time period. Arctic char growth can then be examined in relation to local annual and seasonal environmental conditions (Kristensen et al., 2006).

## PRELIMINARY RESULTS

The preliminary results demonstrate that the Arctic char in the lakes in the Sachs Harbour area: a) fit expected patterns of fish growth; b) have different maximum sizes; and c) reach their maximum size at different ages in different lakes. In one study lake on Banks Island, fish across a variety of age classes experienced a growth spurt around 1999. The preliminary results from my research show concordance with the local traditional knowledge and recent community observations.

## SIGNIFICANCE OF THE RESEARCH

Arctic char and their natural habitat are sensitive to perturbations in the environment and offer an excellent system for studying the effects of climate change on northern fish species. This research demonstrates the importance of linking two knowledge bases, which is necessary for local monitoring of northern species and for their conservation in light of climate change effects. Examining the ways in which TK and science interact provides a deeper understanding of the Arctic environment and its biota (when the two knowledge bases complement or corroborate each other) or suggests areas where further research is required (when they contradict each other) (Huntington et al., 2004; Furgal et al., 2006). Furthermore, it is anticipated that the interdisciplinary approach of this research project will facilitate a process of collaboration between practitioners of the two knowledge bases, enhancing our understanding of our changing northern environment. Finally, this project will identify local indicators of change in northern ecosystems and will result in the development of community-specific monitoring plans with appropriate training for the management of an important Inuvialuit resource. The dissemination of this research enhances local capacity, incorporates local input into the research and provides northern residents with important information for local fish management and monitoring. This project should provide the people of Sachs Harbour, Ulukhaktok, and other communities in the ISR with the knowledge and capabilities they need to monitor and manage their resources for generations to come.

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