Labrador Inuit Knowledge: Literature Review

Pardy, G., Dale, A., Snook, J., and J. Whalen

Torngat Wildlife, Plants and Fisheries Secretariat,
217 Hamilton River Rd., P.O. Box 2050 Stn. B
Happy Valley-Goose Bay, NL A0P 1E0

2011

Torngat Joint Fisheries Board
Torngat Wildlife, Plants & Fisheries Secretariat Series 2011/05

Torngat Wildlife, Plants and Fisheries Secretariat

The primary responsibilities of the Torngat Wildlife and Plants Co-management Board and the Torngat Joint Fisheries Board are to establish total allowable harvests for non-migratory species of wildlife and for plants, recommend conservation and management measures for wildlife, plants, and habitat in the Labrador Inuit Settlement Area (LISA) and to make recommendations in relation to the conservation of species, stocks of fish, aquatic plants, fish habitat, and the management of fisheries in the Labrador Inuit Settlement Area.

The Secretariat is the implementation agent of the Torngat Joint Fisheries Board and the Torngat Wildlife and Plants Co-Management Board. The Secretariat is a team of professionals based in Happy Valley-Goose Bay that provide financial management, logistical, project management and analytical support to both boards.

Torngat Omajunik, Piguttunik Oganniaganillu Suliangit

Suliagigumajangit Torngat Omajunik, Piguttunillu AulatsiKatigengita AngajukKauKatigengit ammalu Torngat Ikajuttiget Oganniatuligijingita AngajukKauKatigengit sakKititsigiamut pijaugunnatunik katillugit aullaigatsatagiamut nokataKattangitunik omajunik ammalu piguttunik, uKautjigiajut asikKitailigiamut ammalu aulatsigiamut omajunik, piguttunik, ammalu inigiKattajanginnik Labradorimi Inuit Satusasimajanginni Nunani (LISA) ammalu uKautjigiagutinik ilingajunik asikKitailigiamut omajunik, oganniaganik, piguttunik, oganik, ammalu aulatsigiamut oganniaganik Labradorimi Inuit Satusasimajanginni Nunani.

SuliaKattet atuliaKititsigumajut kiggatuttinganik Torngat Ikajuttiget Oganniatuligijingita AngajukKauKatigenginnik ammalu Torngat Omajuligijinginnik Piguttunillu AulatsiKattajut AngajukKauKatigenginnik, sunatuinnanik, suliatsanik aulatsigiamut ammalu ikajutsitaullutik tamâginnut angajukKauKatigenut.

Torngat Wildlife, Plants & Fisheries Secretariat Series

2011

Labrador Inuit Knowledge: Literature Review

Pardy, G.,[1] Dale, A.,[2] Snook, J.,[2] and J. Whalen[2]

[1]Integral Geomatics,
98 Carmichael Dr, Sydney, NS, B1S 3J4

Torngat Wildlife Plants and Fisheries Secretariat
217 Hamilton River Rd, P.O. Box 2050 Station B
Happy Valley-Goose bay, NL
A0P 1E0

Published by:
Torngat Wildlife, Plants and Fisheries Secretariat
217 Hamilton River Rd., P.O. Box 2050 Stn. B
Happy Valley-Goose bay, NL
A0P 1E0

Correct citation for this publication:
Pardy, G., Dale, A., Snook, J., and J. Whalen (2011).Labrador Inuit knowledge: Literature review. *Torngat Wildlife, Plants and Fisheries Secretariat Ser.* 2011/05 + 17 p

Table of Contents

List of Tables

Introduction

The health of the world's oceans is in a precarious state despite, or because of, the rapid technological advancements of the last 50 years. Human population on the planet has been continuously increasing since the 1400s but particularly since the industrial revolution and is now an estimated 6.9 billion, with two-thirds of the world's population – 4.6 billion people - living within 400 kilometers of a seacoast (Hinrichsin, 2010). As a result of coastal migration, urbanization, resource exploitation and tourism, ecosystems such as coral reefs, wetlands, mangroves, estuaries, marches, seagrass beds, barrier islands, swamps and dunes are being degraded and destroyed. With the loss of biodiversity and habitat, many critical ecosystem goods, services and functions we depend on are also disappearing or losing value (Costanza, et al., 1998).

Unsustainable and unregulated development in coastal zones is a global concern due to human dependency on marine resources. Marine ecosystems provide economic and social services generating billions of dollars annually through fisheries, aquaculture, tourism, and ocean transport. Coastal ecosystems also provide environmental and cultural services, such as, protecting vulnerable coastal communities from the onslaught of natural disasters, providing daily sustenance, recreation and spiritual traditions. For the above reasons we see human health and wellbeing to be irrevocably connected to coastal and ocean health. Conservation and the sustainable development of coastal ecosystems is therefore one of the greatest challenges of our time.

Fisheries management has existed in Canada for hundreds of years, predating European settlement, formal Canadian government, and the application of Western scientific knowledge (WSK) as the authoritative voice in fisheries resource management. As Federal and Provincial governments took root, the knowledge systems and institutions of Canada's indigenous peoples were undermined, and in many cases destroyed (King, 2004). Under the prevailing management systems, the fisheries have experienced a decline up to the present day as industrial scale fishing has grown to meet the demands of the global economy.

The marine environment and its resources have faced issues such as stock depletion, user conflicts, and pollution for decades. More recently, globalization has led the additional threats of marine invasive species, overfishing of shared stocks in regional seas, trans-boundary pollution, and loss of remaining habitat (Chua, 2006). The Food and Agriculture Organization of the United Nations (FAO) estimates that the maximum wild capture fisheries potential from the world's oceans has probably been reached. Overall, 80% of the world's fish stocks for which assessment information is available are reported as fully exploited or overexploited and, thus, require effective and precautionary management (Food and Agricultural Organization, 2008).

One way in which the Canadian government is attempting to create more effective, ecosystem-based management is by incorporating knowledge other than WSK. This has led to the creation of co-management institutions and institutional arrangements that increase dialogue and interaction between harvesters, scientists, and decision makers in government agencies, as well as distributing responsibility and control among these groups (Olsson, Folke, & Berkes, 2004), (Armitage, et al., 2009) (Berkes, 2009) (Plummer, 2009). Co-management is viewed as a shared process of knowledge co-production comprised of: (1) knowledge gathering, (2) knowledge sharing, (3) knowledge integration, (4) knowledge interpretation, and (5) knowledge application (Dale, 2011). It is expected to facilitate vertical and horizontal linkages between institutions and provide local communities with a role in decision-making (Berkes, 2009). These linkages provide a means for otherwise distant decision makers and resource users to communicate, build trust, tighten feedback loops, and ultimately increase adaptive capacity in resource management (Berkes, 2010).

The objective of co-management is to bridge cultural differences between local users and fisheries managers in order to provide more effective management. This is achieved through combining Traditional Ecological Knowledge (TEK) and the experience and observations of resource users, both indigenous and non-indigenous, with western scientific research and management techniques (Fisheries and Oceans Canada, 2010). Co-management is still evolving and, while challenges exist in translating TEK into a management or scientific framework, literature supports a positive trend toward adaptive comanagement strategies.

Non-science based knowledge in the context of co-management has been called Traditional Ecological Knowledge (TEK), Local Ecological Knowledge (LEK), Aboriginal Knowledge (AK), Inuit Knowledge (IK), Fishers' Knowledge (FK), among others. Roepstorff (2000) comments that any catchy first word and "knowledge" will suffice in this context.

The most overarching term would be Traditional Knowledge, as not all Traditional Knowledge is related to ecosystems. We can define Traditional Knowledge as "a cumulative body of knowledge, practice and belief, evolving by adaptive processes and handed down through generations by cultural transmission". This definition encompasses both Inuit and Fishers' knowledge in general, as both are culture-specific bodies of knowledge. However, the term does not account for the specific qualities that make them discrete from one another.

In this literature review, we will examine Inuit Knowledge and Fishers' Knowledge. We will explore how these knowledge types are alike, how they are discrete from one another, and how this knowledge is being incorporated into research and management in Canada and abroad.

Nature of Inuit/aboriginal knowledge

Every society has its own understanding of the natural world, skills, and customs through which members of a society construct their livelihoods. As a collection of knowledge, practices and belief, indigenous knowledge includes close observation and interaction with the natural world, as well as institutions that dictate how to interact with the environment and interpret observations. This perspective shapes the world-view of a society and its people, informing people of what knowledge is legitimate, relevant and what social sanctions exist in hunting practices. Indigenous knowledge is engrained in the people's way of life and is a basis of creating a livelihood.

The involvement of indigenous knowledge in the day-to-day life of a people offers an explicit social context to knowledge within the culture. This is not always the case of western science. As institutions, both indigenous knowledge and science involve processes, or systems of creating knowledge based on observations. Quantifiable factors, evidence, and repeatability are all essential to the western scientific process. Quantification in particular is greatly emphasized, as it provides a basis of objectivity and the means to perform statistical analyses from which scientists draw conclusions. Conversely, many indigenous knowledge systems place little or no value on quantification, but rely on an understanding of the environment and the ability to interpret signals from the environment, and the relationships within it.

Holistic views of the environment is one characteristic of indigenous knowledge. In the arctic, O'Neil et al. (1991) documented how the Inuit of the Hudson Bay region recognized signs of ecosystem contamination by its effects on seals. The Inuit had a sense of how a normal, healthy seal looked and behaved. The diagnosis of a sick animal was based on indicators like lumps, discoloured bones, abnormal liver, bumps and blueish spots in the intestines, and how skinny the animal was. The Inuit also made behavioral observations, noting characteristics associated with feeding, swimming and responding to predators. The Inuit in the region developed a unique set of indicators to monitor seal health as a result of the continuous nature of these qualitative observations made over long periods of time.

The emergence of Inuit knowledge as a distinct body of knowledge gained visibility during the formation of the Nunavut territorial government. As an Inuit territory, the stance of incorporating Inuit culture and values into Nunavut's governance was made clear during a conference on traditional knowledge in Igloolik in March, 1998. Nunavut's Interim Commissioner, J. Anawak, stated that, "Our commitment must be strong to Inuit ways and the traditional values of our society. We must use our own way of thinking when creating a new government." (Nunavut Social Development Council, 1998). The final report of this conference included an outline of the concept of *Inuit Qaujimajatuqangit* (IQ) – the central philosophical tenet of the Nunavut Government, which includes all aspects of traditional Inuit culture including values, world-view, language, life skills, perceptions and expectations.

Nature of Fishers' Knowledge

It is widely recognized that fishery users are an important source of information on the ecology of their resources. Fishery users develop detailed knowledge of their resources, their environments, and their fishing practices (Neis, et al., 1999). Local ecological knowledge, in this context, is a cumulative body of knowledge, passed down through generations of fishers in a geographic region. FK offers a fine-scale understanding of local changes in stock abundance and distribution, accounting for dynamic ecosystem changes over time. This knowledge is derived from fishers' experiences and observations collected over years of interaction with a resource and its environment (Hill, Michael, Frazer, & Leslie, 2010). The importance of fishers' knowledge is evident when contrasted with the short-term, system-wide nature of scientific assessments. Each generation of fishermen has developed an understanding of the stock characteristics of their locality. The culmination of generations of practice offer insights into historical periods of the fishery, providing datasets over a large time-scale. This is particularly important in data-poor fisheries, as fishermen are often the only available source of local, historical, place-based fisheries information.

Although its value has long been recognized, FK has primarily been used by fisheries scientists as background knowledge (Smith, 1994) (Hutchings, Neis, & Ripley, 1997), gathered in highly structured telephone surveys or logbook programmes. Knowledge gathering programs often suffer from inconsistent participation and a lack of systematic methodology (Berkes, 1993) (Pinkerton, 1994). The geographic range of information from fishers is limited, and unevenly distributed among fishers, with a greater concentration of knowledge held by older fishers and skippers. Because fishers' knowledge is passed down orally, rather than in written form, FK is subject to the effects memory loss (Neis, Felt, Haedrich, & Schneider, 1999).

Inuit vs. Fishers' knowledge

Inuit Knowledge and Fishers' Knowledge both represent cumulative bodies of knowledge, derived from generations of experience tied to a people's culture, livelihood, and geographic region. Both IK and FK differ from western scientific knowledge as conclusions are drawn intuitively from observations and the application of personal experience, rather than by objective, experimental investigation. Both are largely passed on by word of mouth, rather than in written form. They are practical and behavior-oriented, focusing on important resource types and species (Ruddle, 2000). The knowledge is a result of extensive interaction with the environment, where an applied understanding of its resources is essential for success.

The two begin to differ when we account for their integration into research and management. IK does not place much value on quantification of knowledge, but does assign relative value or rank order to observations (ex. a seal may be "fat" or "skinny"). FK, on the other hand, may assign quantitative value as it relates specifically to a fishery. For example, a fisherman would value and in some cases make record of the number of fish caught, fish length, weight, quantity of gear, vessel capacity and vessel power.

Inuit knowledge incorporates the Inuit world-view and ethical principles. It includes factual knowledge about the environment derived from individual experiences, knowledge about past and current use of the environment, culturally based value systems about appropriate behavior concerning animals and the environment, and culturally based cosmology that organizes and serves as a framework for the other categories. IK provides a specific moral and sociological context to the use of knowledge. For example, the emphasis on subsistence practices that minimize waste and impacts on sustainability is a common theme in IQ and other indigenous knowledge-practice-belief systems.

Modern Inuit have occupied Northern Canada for approximately 1000 years (Indian and Northern Affairs Canada, 2006), long before European settlement or large-scale commercial fisheries. Generations of connection with the environment is part of the cultural identity of the Inuit, and likely contributes to the worldview and ethical components of IK.

Fishers' knowledge relates to generations of resource users for whom fishing is their livelihood. It is viewed that fishers work within and add to a local "system of knowledge", and that achieving livelihood success is contingent on users' ability to apply this knowledge in accessing and extracting resources.

When this knowledge and information matches scientific assessments, uncertainty is reduced and assessments become more convincing to resource users (Neis, et al., 1999). The fine-scale information held by fishers provides valuable insights into seasonality and migration of fish, stock structure, spawning grounds, and juvenile habitat, and on resource abundance (Hutchings, Spatial and temporal variation in the density of northern cod and a review of hypotheses for the stock's collapse, 1996).

These are structured forms of knowledge, which are at least somewhat compatible with Western concepts in ecosystem research, in that there is a clear awareness of ecological links and notions of resource conservation. Unlike Western scientific knowledge, conclusions drawn by IK and FK are based on inductive logic, with conclusions based on many prior observations.

Incorporating Inuit Knowledge in Research and Management

Examples in Canada

In Nunavut and the Northwest Territories, DFO delivers fisheries management programs through the area offices of its Central and Arctic region, which is by far the Department's largest administrative region. The region encompasses 71% of Canada's coastline, 67% of its freshwater and 65% of Canada's marine waters. North of 60, more than 300 stocks of fish and more than 50 stocks of marine mammals are harvested. In the region of the Beaufort Sea, there are 51 marine fish species, 49 of which live in freshwater for at least part of their life-cycle. The Inuit make up the majority of the marine resource users and inhabitants of this region. It is, therefore, essential that Inuit knowledge and values be incorporated in order for communities to participate fully in management strategies (Fisheries and Oceans Canada, 2010).

As in other regions of Canada, Fisheries and Oceans is mandated under the *Fisheries Act* to conserve and protect fish and marine mammal populations in the North, supporting subsistence needs, as well as regulating commercial, domestic and recreational fisheries. Under the *Oceans Act*, the Minister of Fisheries and Oceans is also charged with leading oceans management. Where land claim agreements are in place, Inuit representation has been made possible through co-management arrangements for wildlife and habitat management, research, environmental impact screening and review, land use and conservation planning and environmental monitoring, through representatives of Aboriginal organizations and federal and territorial governments. Co-management ranges from large-scale, multi-stakeholder projects between government authorities and Aboriginal organizations, to small-scale community-based projects (Fisheries and Oceans Canada, 2010).

Much of the literature regarding traditional knowledge use in research and management has been generated in Arctic Canada, where its inclusion is mandated by the Government of Nunavut under its land claims agreements. In this region, the concept of TK and methods of documentation and assessment are researched extensively, while challenges remain in its specific application in management contexts. Inclusion of TK is presumed to lead to more effective and equitable decision making, but the process of effective information exchange is often overlooked (Huntington, et al., 2002). Despite these challenges, it is clear that knowledge co-production is essential to collaboration, and provides an important foundation for learning and adaptive capacity (Dale & Armitage, 2011).

The benefits of IK to data-poor fisheries assessment are clear. The community of Arctic Bay, Nunavut is heavily dependent on subsistence hunting of marine mammals such as narwhal and ringed seal. The narwhal hunt is culturally and economically important to the community, but faces changes in management due to stock uncertainty. Biological parameters used in creating population models for the narwhal of Baffin Bay/Davis Strait are all uncertain, and the statistical power to detect trends is low. In 1999, under the management rights defined by the Nunavut Final Agreement, the Nunavut Wildlife Management Board (NWMB) implemented an experimental community-based narwhal management (CBM) program.

In the first year of this experimental CBM system, there was a great deal of concern over the sustainability of the hunt by DFO, NWMB and several environmental groups. The reaction was in part due to the largely arbitrary number of harvestable animals determined by DFO that did not meet the needs of communities who depended on the hunt. As well, narwhal mortality remained uncertain as struck/lost reporting and sampling information from hunters was inconsistent. The results of the first year of the CBM project led to a closure period in which the parties involved identified sources of management conflict, and the mechanisms necessary to resolve those conflicts (Diduck, Bankes, Clark, & Armitage, 2005).

It was clear that a diversified knowledge base was required to effectively manage the narwhal fishery. DFO had stated that population estimates were determined only from aerial surveys with several sources of error. For example, only narwhals at the surface could be counted and, depending upon ice conditions, not all animals were visible. Hunters believed that the stock abundance was greater than DFO had assumed. Certain decision-making powers have been given to the community level, where the local Hunters' and Trappers' Organization is responsible for regulating and enforcing quotas, implementing reporting systems, and training young hunters. The quotas are still determined by DFO, with advice from the NWMB. The current system allows for a transfer of community quota from year to year. This flexible system is intended to reduce incentives to harvest as quickly as possible, and to allow hunters to take advantage of favourable hunting conditions (Dale & Armitage, 2011).

Another example of the increasing use of Traditional Ecological Knowledge in Nunavut is found in Ferguson et al (2012), regarding the behavioural ecology of the killer whale and its consequences on the commercial fishery of eastern Nunavut. In this study, Inuit observations on killer whales and their prey items were collected in a series of 105 semi-directed interviews. The interviews were conducted in 11 communities from 2007 to 2010. By interviewing Inuit hunters and elders, researchers were able to compile extensive baseline knowledge of Arctic killer whales. The questions included information on prey items, hunting techniques, prey avoidance behavior, and consumption patterns. Participants also provided information on killer whale abundance, distribution, and movements. Interviewees also provided spatial information (hunting and traveling locations, outpost camps, sightings, migration routes, etc.), recorded on maps.

The sound background knowledge provided by Inuit hunters in this study provided an example of the potential for meaningful integration in short term projects, supporting scientific assessments and actively involves TEK-holders in science development. The researchers see this as a necessary step in developing long-term knowledge integration between scientists and hunters as the Arctic marine ecosystem structure changes in response to warming and loss of sea ice.

Examples Abroad

A 2002 publication by Frank Sejersen investigates the political and ecological dimensions of indigenous use of beluga whales. In Greenland, Inuit hunters of beluga whales rely heavily on the resource for social and economic subsistence. Their management interests are based on maximizing accessibility of the resource. The beluga hunt is strongly tied to their sense of identity, with many stating that they hold rights to hunting beluga as part of their cultural heritage. This has led to conflicts with non-local Greenlandic hunters who demand access to the limited resource. Local hunters have raised concerns regarding shrimp trawlers scaring away belugas, making beluga whaling from small skiffs a less reliable hunting activity. Requests that shrimp trawling outside Sisimiut during the night be banned were turned down by municipal council. The Danish government has also taken measures to impose quotas and reduce the number of whales hunted. Local hunters argued that quotas would be unnecessary if only subsistence hunting for traditional use took place.

Upon recommendations made by local hunters to government, management changes were made in order to maximize accessibility to belugas for local subsistence hunters. Hunters suggested that subsistence hunting should be given priority, whereas hunting for commercial gain should be discouraged through limiting the allowed hunting practices, equipment and vessels used. These measures increased the sustainability of the hunt without excluding specific groups of Greenlandic hunters.

A 2007 article by Carter and Hill examines the involvement of indigenous knowledge in the data-poor Sandfish fishery of Northern Australia, and issues of knowledge exploitation by commercial interests. The commercial sea cucumber species known as Sandfish was the subject of a 4 year community based fisheries research project with Aboriginal Australians, intended to assess the viability of indigenous Australians' involvement in the wild-stock fishery. The research involved extensive and intensive indigenous participation including field surveys and habitat mapping to complement commercial catch data modeling. The program revealed new commercially viable areas in waters adjacent to Aboriginal lands, which were later expanded into by non-aboriginal commercial fishers. Because the project did not have the desired outcome to establish a community based fishery for the indigenous population, a great deal of interest was gained in the area of developing a framework for fair and equitable community based fisheries initiatives. Researchers concluded that while community based management strategies can be developed, these strategies must be recognized, supported, and enforced by public authorities, as community groups with insufficient capital cannot afford to enforce their regulations and protect their resources from outside interests.

Defending indigenous rights to fishing and accessibility to resources is a global concern, also affecting indigenous groups in Scandinavia as addressed in a report by the United Nations General Assembly (2011). Norway's indigenous people, the Sami, have been subject to mismanagement by non-Sami actors, impacting their fishery off the northern coast of Norway. Increased industrialization of fishing has eroded local control over marine resources, and decisions regarding these resources are determined at a national level, without local participation or inclusion of local knowledge. In order to bring accessibility concerns to the national level, the Sami Parliament formed the Coastal Fishing Committee, which has entered into consultations with the Norwegian Ministry of Fisheries and Coastal Affairs. Legal backing to support Sami claims in Sweden is difficult to obtain. In order to prove traditional rights, Swedish courts require that claimants document a minimum of 90 consecutive years of use in an area. This especially difficult to prove by the Sami, as their tradition is to leave no physical marks and the high burden of proof requirements are costly. Solutions to these issues are being sought after, through clarifying and legally protecting Sami fishing rights in Norway, as well as revising the high burden of proof required in Swedish court and providing legal aid to Sami pursuing land claims.

Incorporating Fishers' Knowledge in Research and Management

Examples in Canada

Research conducted by Neis et al (1999) concluded that fishers have detailed knowledge of their resources, their environment, and their fishing practices, although this knowledge is rarely systematically collected. In a study of fishers' knowledge in coastal Newfoundland, researchers sought to identify the range of information available, to see if knowledge could be quantified, and to explore its potential for reconstructing trends within fisheries. Researchers interviewed career cod fishers approximately two years following the moratorium.

The research was based on two types of personal interviews, conducted in the summers of 1994 and 1995, and follow-up telephone interviews conducted in December 1995 and 1996. Random sampling was not possible, as a list of licensed fishers was not available and such sampling is not recommended for this type of research. Instead, snowball sampling was used to identify local “experts”, generally the older, retired fishers distributed throughout the study area who were recommended by interview participants.

Interviews were carried out by a team of at least two researchers from the social and natural sciences, in which one researcher conducted the interview while the second helped the fisher record spatial information and monitored the interview schedule, to ensure key subject areas were covered. Interviews were semi structured and lasted between 1.5 and 4 hours.
Trends were detectable across the three generations of fishers. For example, third-generation fishers began and ended up with higher levels of effort than previous generations. Trends in categories such as engine power, vessel capacity and number of nets and traps were also detected.

It was found that fisheries knowledge can be assembled in forms usable in quantitative stock assessments. There is a mismatch of spatial scale between local, small scale understanding of fishers and the larger scale approach of scientific management, however, fishers’ knowledge is found to aid scientific assessments in interpreting spatial and temporal variation in catch data.

Rather than compartmentalizing fishers as a source of knowledge or data, some researchers have designed their studies to utilize fishers’ knowledge in proposing research questions, designing and conducting experiments, and interpreting the results. In an acoustic study of widow rockfish in British Columbia by Stanley et al (2000), fishers collaborated with fisheries scientists conduct a biomass assessment of the species. Accurate assessments were difficult as the rockfish tend to inhabit untrawlable bottom, and acoustic signals are difficult to interpret due to the fish’s proximity to the bottom and the many co-habiting species.

A captain serving as an industry advisor on groundfish management was aware of a shoal of widow rockfish which formed regularly each winter. The shoal was predominantly inhabited by rockfish which swam off the bottom at dusk, making it an ideal site for acoustic estimation. Subsequently, the shoal was studied in early February of 1998 and 1999. The timing and location were based on fishers’ knowledge.
While no change in quota appeared necessary, the study had a number of research benefits outside its defined objectives. The study had confirmed a method of biomass assessment using acoustic sensors, which in turn were calibrated to commercial vessels for future rockfish shoal estimation, educated fishers in acoustic sensing, and educated acoustic staff in interpreting echograms of near-bottom species. In addition, this alleviated fishers’ skepticism of quota determinations and built trust between fishers and fisheries scientists.

Examples Abroad

Reinforcing the concept that fisheries science is less involved in the study of local-level phenomena regarding stock structure and behavior, a UNESCO publication by Ames (2006) emphasizes the historical information on fine-scale changes possessed by cod fishers in the Gulf of Maine.

After the collapse of the inshore cod fishery, the Maine Gillnetters association and Main Fisherman's Coop petitioned the Maine State Legislature to for a groundfish hatchery commission to study the feasibility of establishing one or more groundfish hatcheries. The premise was that if hatchery production could increase the number of active spawning sites in abandoned inshore grounds, the time needed for the depleted stocks to recover would be greatly reduced. The commission recommended that juvenile cod and haddock be released near former nursery areas and productive spawning grounds. Unfortunately, the locations of these inshore grounds, fished out decades before, were not known by current fishers and could not be determined by fisheries scientists as the existing stocks had collapsed.

A study was then funded to locate and interview the few remaining fishers with knowledge of the former coastal spawning and nursery areas of cod and haddock. Older fishers were interviewed and the locations of the spawning grounds were mapped. From having little to no knowledge of historic groundfish spawning areas, the study had soon identified more than 2800 km^2 of spawning grounds. In a follow-up study in which side-scan sonar determined substrates and depth, the spawning areas identified in the fisher interviews proved to be exceptionally accurate (Barnhardt, Belknap, Kelly, Kelly, & Dickson, 1996).

In a study by Zukowski et al (2011) focusing on crayfish size and sex ratios in the River Murray, Australia, recreational fishers' knowledge is found to produce reliable scientific data. The study defies criticisms of including fishers' knowledge in science based assessments, as both scientific surveys and fishers' observations drew the same conclusions on the stock structure of the River Murray crayfish.

The study compares the independent outputs of scientific surveys, and LEK gathered by in-person, semi-directed interviews and catch card data in testing two hypotheses related to crayfish sex and size ratios – one, that the catch is dominated by crayfish <90 mm occipital carapace length (OCL); and two, that there is a skew in the sex ratios of larger crayfish (>90 mm OCL) towards females.

Scientific field surveys were carried out at three river sites on three consecutive days using a standardized sampling protocol, setting nets to catch crayfish. The recorded net data included date, position, flow, depth, distance from bank, time set, time retrieved and habitat characteristics. The catch data recorded included the number of crayfish, OCL, sex, maturity of adult females, and whether or not females were berried.
30 fishers were interviewed, selected during site visits. Interviews focused on six key interview points – fisher values, biological knowledge, knowledge and views on fishing regulations, perceived compliance rates, sustainability of the fishery, and future management of the fishery.

30 single-trip catch cards were issued to another 30 fishers. The cards were explained to fishers prior to their fishing trip and contained detailed information on how to identify the species. The data included the size, sex and number of crayfish caught and the date, time and location of the single fishing trip.

Upon analysis, all three datasets revealed the same conclusion regarding the hypotheses – the majority of crayfish were below the legal limit of 90 mm, and the majority of large crayfish (>90 mm) were female. Researchers discuss that fisher LEK could be a reliable data generating source that could improve fisheries management by detecting population changes at an early stage to enable proactive and efficient management measures.

Discussion

Based on the literature reviewed, it becomes clear that there are best practices for designing and implementing studies pertaining to gathering and integrating aboriginal and fishers' knowledge into science based assessments. A commonly used method to gather local knowledge is the use of semi-directed interviews. For Zukowski et al. (2011) this method enabled one-off interviews to be undertaken over a period of time and added depth and richness to the information obtained. The interview duration ranged between 20 and 70 minutes, with questions designed around six key points of interest. The points of interest and specific questions under these key points are illustrated in the table below. The interviews were undertaken in a general conversation manner. The interviewer attempted to gently guide the conversation to incorporate key questions, and where necessary, used the probes outlined in Table 1 to verify interpretations of responses provided by interviewees.

Table 1: Summary of the fisher interview schedule

Key points for fishery interview schedule	Probes
Fisher Values	Why do you fish? What do you like about fishing? Views on fishing for future generations? Preferences for fishing? Where and how often do you fish?
Biological knowledge of Murray crayfish	Where found? Habitat and environmental preferences? Growth rates?
Knowledge and views on fishing regulations	What are current regulations? History of regulations? Views on current regulations?
Perceived compliance rates	Current compliance rates? Changes in compliance rates?
Future management of crayfish fishery	Role of different stakeholders in management? Changes required? If yes, then detail?

In the cod fishery study by Neis et al. (1999) semi-structured interviews were used to gather fishers input and included a mapping component. The interviews were conducted by a team of

2 or more researchers in which one researcher would help the fisher record spatial information and monitor the interview schedule, while the other administered the questions. The interviews lasted between 1.5 and 4 hours. In this study, rather than randomly selecting fishers, snowball sampling was used to identify local "experts". The interviews were focused on the career-history of the participants. Interviews began with basic demographics and information on training. Data collected included all of the licenses held and vessels owned, when they were owned, as well as descriptions of engines, gear, and equipment used on each vessel. Fishers were asked to describe a typical fishing season – species fished, timing, place, gear fished, landings – at the beginning of their careers, at one or two points of change during their careers, and at the end of their careers or just prior to the moratorium. The interview transcripts provided several kinds of information relevant to understanding stock structure: information on seasonal locations of cod, the direction and timing of movement, and spawning.

An example of the semi-directed interview used in gathering Inuit knowledge is the killer whale study conducted by Ferguson et al (2012). The researchers used this interview format to document spatial and textual information on killer whales ecology and prey interactions. This method was chosen as it avoids the rigidity of questionnaires and provides flexibility in collecting TEK. The questions were predetermined, but left open for interview participants to talk about matters that were important to them. A mix of qualitative and quantitative survey data on killer whales was collected and analyzed, in particular information related to predation. Qualitative data were analyzed using an interpretive approach to create data categories from content. In total, 105 interviews were conducted between July 2007 and March 2010 in 11 Nunavut communities.

On the international stage, Canada's approach to decentralized management of resources by indigenous groups is considered to be at the forefront of indigenous self-government. Sejersen (2002) quotes that "Greenland lacks behind 20 or 30 years of Canada in terms of the elaboration of decentralized management regimes." and that "Native peoples in Canada and Alaska manage their restricted rights in a decentralized fashion giving more space for different regional (and ethnic) input." The article by Carter and Hill, and the report by the UN General Assembly emphasize the lack of legal and political backing in Northern Australia and Scandinavia, respectively, to protect aboriginal access to fisheries resources. Decision making in these countries is made at a national level without input from local resource users. Conversely, aboriginal access to marine resources is being guaranteed in Canada through co-management arrangements and legislature which mandates the inclusion of LEK in management.

Co-management arrangements between governments and local resource users are based on the integration of traditional knowledge -whether Inuit Knowledge or Fishers' Knowledge. The collection of TK is based largely on social science methodology and the semi-directed interview format has had a great deal of documented success. Literature supports that TK can be applied to science-based quantitative stock assessment research. Both forms of knowledge can provide accurate historical data to fisheries, as knowledge holders have developed a comprehensive understanding of the environment and resources that their cultures and livelihoods depend on.

Co-management is a process through which government institutions, communities, and local resource users work to achieve the desired outcome of sustainability – meeting the economic and cultural needs of the present without compromising those of future generations.

Canada is leading the way for many countries when it comes to including and partnering with aboriginal and user groups in undertaking fisheries research and developing best management practices. This is highlighted in Diduck et al (2005), in which a strictly western science based assessment of the narwhal population resulted in a quota based on inadequate information, leaving communities with a quota too small to support their subsistence needs and practices. In order to reconcile the problem, government departments, community groups, and resource users were able to adapt management structures to include recommendations from a local management board. Sejersen (2002) document a similar case where adaptive management measures were taken in Greenland to ensure aboriginal access to subsistence hunting of beluga whales. At a time when subsistence fishing was threatened by non-aboriginal commercial interests, the Danish government tightened commercial fishing regulations in favour of supporting small-scale aboriginal fisheries. The Sandfish fishery example by Carter and Hill (2007) identifies that although the inclusion of aboriginal knowledge can be beneficial in identifying locations of commercial stocks, there are ethical considerations regarding the use of this knowledge so that aboriginal access is protected. Sufficient legal protection must be provided so that commercial interests cannot simply use local knowledge to exploit the traditional resources of indigenous groups. The study by Neis et al (1999) demonstrates how fishers' knowledge of local, small scale fisheries can be collected and integrated into scientific management frameworks, aiding researchers in interpreting spatial and temporal variations in large scale commercial stock assessments. Fishers' knowledge is often the only source of local historical information on fished species. This is highlighted in two examples – Stanley et al (2000) and Ames (2006) -where fisheries management efforts relied upon the knowledge of local users who were able to provide a window into the past and current state of their marine resources. In Ames' study, local fishermen provided researchers with the locations of previously unknown cod spawning grounds, ideal locations for the reintroduction of juvenile groundfish in hopes of reducing the time to replenish the stocks. Without the information from the older generations of fishermen, these locations may have never been discovered. In Stanley's study, researchers were directed by fishers' recommendations to perform acoustic studies at a specific time and place where widow rockfish would shoal. This fine scale knowledge was essential to performing accurate biomass assessments of the widow rockfish.

Upon reviewing these examples, the benefits of incorporating FK and IK into fisheries management and research are clear. Co-management is essential if governments and users are to interpret changes in stock abundance, set responsible catch limits, identify critical habitat, and protect traditional users rights to access resources.

References

Ames, T. (2006). Putting fishers' knowledge to work: Reconstructing the Gulf of Maine cod spawning grounds on the basis of local ecological knowledge. In UNESCO, *Fishers' knowledge in fisheries science and management* (pp. 351-361).

Armitage, D. R. (2005). Community-based narwhal management in Nunavut, Canada: change, uncertainty, and adaptation. *Society and Natural Resources*, 715-731.

Armitage, D., Plummer, R., Berkes, F., Arthur, R., Charles, A., Davidson-Hunt, I., . . . Wollenberg. (2009). Adaptive co-management for social-ecological complexity. *Frontiers in Ecology and the Environment*, 95-102.

Barnhardt, W. A., Belknap, D. F., Kelly, A. R., Kelly, J. T., & Dickson, S. M. (1996). *Surficial geology of the inner continental shelf of the northwestern Gulf of Maine.* Maine Geological Survey.

Berkes, F. (1993). Traditional ecological knowledge in perspective. In J. T. Inglis, *Traditional ecological knowledge: concepts and cases* (pp. 1-10). Ottawa, Ontario: International Development Research Centre.

Berkes, F. (2009). Evolution of co-management: role of knowledge generation, bridging organizations and social learning. *Journal of Environmental Management*, 1692-1702.

Berkes, F., & Armitage, D. (2010). Co-management institutions knowledge and learning: adapting to change in the Arctic. *Etudes/Inuit/Studies*, 109-131.

Carter, J., & Hill, G. (2007). Indigenous community-based fisheries in Australia. *Journal of Environmental Management*, 866-875.

Chua, T. (2006). *The Dynamics of Integrated Coastal Management: Practical Applications in the Sustainable Coastal Development in East Asia.* Quezon City, Philippines: PEMSEA.

Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., . . . van den Belt, M. (1998). The value of ecosystem services: putting the issues in perspective. *Ecological Economics*, 67-72.

Dale, A., & Armitage, D. (2011). Marine mammal co-management in Canada's Arctic: Knowledge coproduction for learning and adaptive capacity. *Marine Policy*, 440-449.

Diduck, A., Bankes, N., Clark, D., & Armitage, D. (2005). Unpacking social learning in social-ecological systems: Case studies of polar bear and narwhal management in northern

Canada. In F. Berkes,
R. Huebert, H. Fast, M. Manseau, & A. Diduck, *Breaking ice: renewable resource and ocean management in the Canadian north* (pp. 269-290). Calgary, Alberta: University of Calgary Press.

Ferguson, S. H., Higdon, J. W., & Westdal, K. H. (2012). Prey items and predation behaviour of killer whales (Orcinus orca) in Nunavut, Canada based on Inuit hunter interviews. Retrieved from http://www.aquaticbiosystems.org/content/8/1/3

Fisheries and Oceans Canada. (2010). *The Management of Fisheries and Oceans in Canada's Western Arctic.*

Food and Agricultural Organization. (2008). *The State of World Fisheries and Aquaculture.*

Hill, N., Michael, K. P., Frazer, A., & Leslie, S. (2010). The utility and risk of local ecological knowledge in developing stakeholder driven fisheries management: The Foveaux Strait dredge oyster fishery, New Zealand. *Ocean and Coastal Management*, 659-668.

Hinrichsin, D. (2010). *People and the Planet* . Retrieved 05 10, 2011, from http://www.peopleandplanet.net/?lid=26188&section=35&topic =44

Huntington, H., Brown-Schwalenberg, P., Frost, K., Fernandez-Gimenez, M., Norton, D., & Rosenberg, D. (2002). Observations on the workshop as a means of improving communication between holders of traditional and scientific knowledge. *Environmental Management*, 778-792.

Hutchings, J. A. (1996). Spatial and temporal variation in the density of northern cod and a review of hypotheses for the stock's collapse. *Can. J. Fish. Aquat. Sci.*, 943-962.

Hutchings, J. A., Neis, B., & Ripley, P. (1997). The "nature of cod": perceptions of stock structure and cod behaviour by fishermen, "experts" and scientists from the nineteenth century to the present. In
D. Vickers, *Marine resources and human societies in the North Atlantic since 1500* (pp. 123-188). St. John's, Newfoundland: ISER books.

Indian and Northern Affairs Canada. (2006). *Canada's relationship with Inuit: A history of policy and program development.* Ottawa, Ontario: Indian and Northern Affairs Canada.

King, L. (2004). Competing Knowledge Systems in the Management of Fish and Forests in the Pacific Northwest. *International Environmental Agreements: Politics, Law and Economics*, 161-177.

Neis, B., Felt, L., Haedrich, R. L., & Schneider, D. C. (1999). An interdiciplinary methodology for collecting and integrating fishers' ecological knowledge into resource management. In D. Newell, & R. Ommer, *Fishing places, fishing people: issues and traditions in Canadian small-scale fisheries* (pp. 217-238). Toronto, Ontario: University of Toronto Press.

Neis, B., Schneider, D. C., Felt, L., Haedrich, R. L., Fischer, J., & Hutchings, J. A. (1999). Fisheries assessment: what can be learned from interviewing resource users? *Can. J. Fish. Aquat. Sci.*, 1949-1963.

Nunavut Social Development Council. (1998). *Report of the Nunavut Traditional Knowledge Conference, Igloolik, March 20-24.* Iqaluit: Nunavut Social Development Council.

Olsson, P., Folke, C., & Berkes, F. (2004). Adaptive co-management for building resilience in social-ecological systems. *Environmental Management*, 75-90.

O'Neil, J. D., Elias, B., & Yassi, A. (1991). Poisoned food: cultural resistance to the contaminants discource in Nunavik. *Arctic Anthropology*, 29-40.

Pinkerton, E. (1994). Local fisheries co-management: a review of international experiences and their implications for salmon management in British Columbia. *Can. J. Fish. Aquat. Sci.*, 1-17.

Plummer, R. (2009). *The adaptive co-management process: an initial synthesis of representative models and influential variables.* Retrieved from http://www.ecologyandsociety.org/vol14/iss2/art24

Roepstorff, A. (2000). The double interface of environmental knowledge. Fishing for Greenland Halibut. In B. a. Neis, *Finding Our Sea Legs. Linking Fishery People And Their Knowledge With Science And Management* (pp. 165-188). St. John's, Newfoundland: ISER books.

Ruddle, K. (2000). Systems of knowledge: dialogue, relationships and process. *Environment, Development and Sustainability*, 277-304.

Sejersen, F. (2002). *Local knowledge, sustainability, and visionscapes in Greenland.* Copenhagen: University of Copenhagen Amager.

Smith, T. D. (1994). *Scaling fisheries: the science of measuring hte effects of fishing, 1855-1955.* New York: Cambridge University Press.

Stanley, R. D., & Rice, J. (2003). Fisher Knowledge? Why not add their scientific skills to the mix while you're at it? *Putting Fishers' Knowledge to Work.* Vancouver, British Columbia.

Stanley, R. D., Kieser, R., Cooke, K., Surry, A. M., & Mose, B. (2000). Estimation of a widow rockfish (Sebestes entomelas) shoal off British Columbia, Canada as a joint exercise between assessment staff and the fishing industry. *ICES Journal of Marine Science*, 1035-1049.

United Nations Human Rights Council. (2011). *The situation of the Sami people in the Sapmi region of Norway, Sweden and Finland.* United Nations.

Zukowski, S., Curtis, A., & Watts, R. J. (2011). Using fisher local ecological knowledge to improve management: The Murray crayfish in Australia. *Fisheries Research*, 120-127.