CHAPTER 4

ECOSYSTEM-BASED MANAGEMENT & MARINE ENVIRONMENTAL QUALITY IN NORTHERN CANADA

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INTRODUCTION

Consistent with the provisions of the *Oceans Act* is a commitment to the integrated management (IM) of ocean resources and activities. Integrated management brings together the environmental, economic, and social considerations by planning for sustainable use. As such, there is ongoing interest in selecting ecosystem-based management objectives that ensure the health of the marine environment. Indicators are needed to assess progress toward meeting these ecosystem-based management objectives. Although the Department of Fisheries and Oceans (DFO) has made some progress in the development of a framework for the environmental objectives and indicators, the social and cultural dimensions of these objectives and indicators have not, to any extent, been incorporated into the discussion, and very little of the existing science takes into account local and traditional knowledge. This is not surprising, considering that in fact MEQ (marine environmental quality), and even ecosystem-based management in Canada's coastal waters, are relatively new. Hence, the timing is good to initiate discussion on how to bring together MEQ-related science and local/traditional knowledge. This chapter attempts to provide a starting point for that.

The integration of social and cultural considerations into long-term research in marine ecosystems is a priority. Since humans are part of the ecosystem and human resource use impacts ecosystems, social and cultural dimensions of marine resource use have to be addressed. However, there is relatively little capacity and experience in this area in the DFO, and there has been little research to address questions such as: Do northern peoples have views that are similar to or different from those of scientists regarding MEQ and ecosystem-based management? Is there relevant local and traditional knowledge? Are there ways to develop community-based monitoring approaches for MEQ? What would these monitoring systems look like, and how would they work?

We explore some possible approaches to take into account indigenous knowledge, both for MEQ and, in the broader context, for ecosystem-based management undertaken to manage human activities that may impact ecosystems (and not to manage the ecosystem itself). The objective of the chapter is to examine some of the challenges and opportunities in establishing MEQ indicators in Canada's northern coastal areas and the appropriateness of considering traditional ecological knowledge along with science.

OCEANS ACT, ECOSYSTEM-BASED MANAGEMENT AND MARINE ENVIRONMENTAL QUALITY

Canada's *Oceans Act* (Canada 1997) provided the Minister of Fisheries and Oceans (DFO) the mandate to lead and facilitate in the development of a national oceans strategy. Canada's Oceans Strategy (DFO 2002a) provides the overall strategic framework for Canada's oceans-related programs and policies. The strategy is based on the principles of sustainable development, integrated management (IM), and the precautionary approach. The overarching program to deliver on the *Oceans Act* is the Integrated Management Program. The Policy and Operational Framework for Integrated Management (DFO 2002b) specifies an objectives-based approach to management through the establishment of social, cultural, economic, and environmental objectives in IM plans. Within the context of the IM framework, tools such as Marine Protected Areas (MPA) and Marine Environmental Quality (MEQ) programs attempt to provide a means to achieve and assess the effectiveness of IM plans. In order to achieve ecosystem-based management, those components or functions of the ecosystem which should not be compromised with various ocean uses will be established at a broad, or Large Ocean Management Area (LOMA), scale (*e.g.*, Beaufort Sea). Embedded within, and transferred from ecosystem objectives from the LOMA scale, are MEQ objectives for coastal management (*e.g.*, western Hudson Bay), which are then applied to IM or MPA planning. Integrated management aims at participation by coastal communities and stakeholders, while respecting land claims agreements. Integrated management planning in this context would offer a means to gather scientific and traditional knowledge, set MEQ objectives in a collaborative way, select indicators, monitor, assess, and report. The challenge is how to achieve these objectives in Canada's diverse coastal areas, and particularly in northern Canada with its unique environmental and social setting.

To assist IM planners tasked with implementing ecosystem-based management, DFO held a workshop to develop a framework for ecosystem objectives to be applied at the LOMA scale, and MEQ objectives for use in IM or MPA planning at the local coastal management scale (Jamieson *et al.* 2001). Conservation of species and habitats (the environmental dimension) and the sustainability of human uses (economic and socio-cultural dimensions) were the two overarching objectives

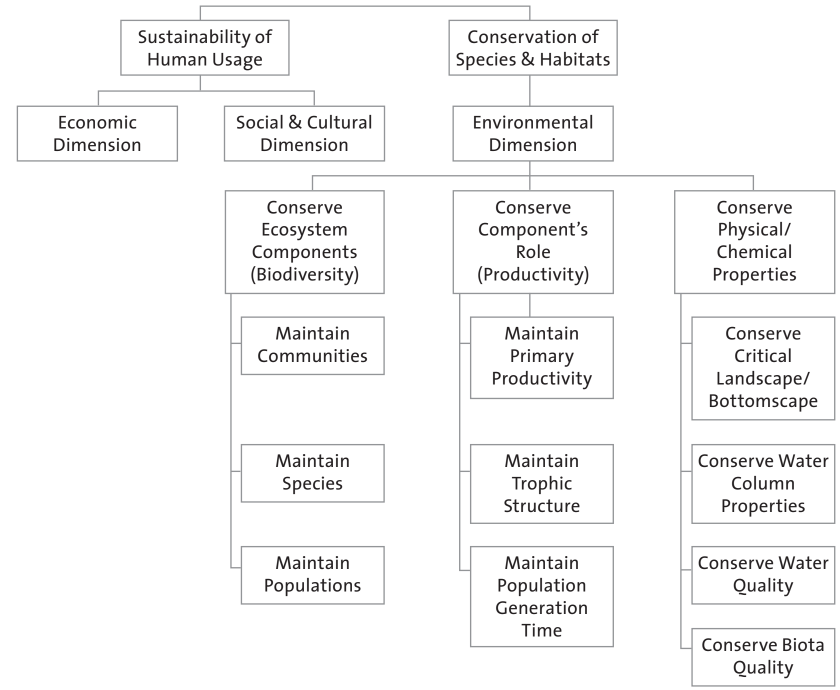

Figure 4.1 Ecosystem objectives from DFO and Oceans Workshop. (Jamieson *et al.* 2001)

(Figure 4.1). Since this was a science-driven process, workshop participants discussed only the environmental component, and focused on a scientific approach to "unpacking" broad ecosystem objectives into MEQ objectives, targets, and indicators. They did, however, recognize that within IM plans, the other components can be as important. As a result of input from this workshop, the subsequent Policy and Operational Framework for Integrated Management (DFO 2002b) contains characteristics of ecosystems that could be used as a guide to setting ecosystem objectives for a LOMA. Vandermeulen and Cobb (2004) expanded on this list to develop a more complete set of overarching objectives (Table 4.1). They concluded that more work remains to define ecosystem-based management objectives at national and regional scales.

The MEQ program is recognized in s. 32 of the *Oceans Act*, which states that the Minister "may establish marine environmental quality guidelines, objectives and criteria respecting estuaries, coastal waters and marine waters" (Canada 1997). Although the concept of MEQ and associated objectives is contained within the *Oceans Act* as a tool for IM and MPA planning, the Act does not elaborate upon the nature of MEQ, and the intent of the *Oceans Act* regarding MEQ must be interpreted to provide policy and operational direction. The evolution of MEQ over several decades is fully described in Vandermeulen and Cobb (2004). Of particular relevance to our discussion is the broadening of the definition

Table 4.1
A HIGH LEVEL TAXONOMY OF ECOSYSTEM OBJECTIVES
(FROM VANDERMEULEN AND COBB, 2004)

a) ***Maintain enough components*** (e.g., ***communities, species, populations***) ***to ensure natural resilience of ecosystems;***
   - maintain communities within bounds of natural variability
   - maintain species within bounds of natural variability
   - maintain populations (genetic diversity) within bounds of natural variability.

b) ***Maintain function of each component of ecosystem to allow it to play natural role in food web*** (i.e., ***not cause any component of ecosystem to be altered such that it ceases to play its natural role***);
   - maintain primary production within the bounds of natural variability
   - maintain trophic structure so that individual species/stages can play their natural role in the food web
   - maintain mean generation times of populations such that population resiliency is assured.

c) ***Maintain physical and chemical properties of ecosystem;***
   - conserve critical landscape/bottomscape features and water column properties
   - conserve water, sediment and biota quality.

of MEQ. Early federal activity related to MEQ was led by Environment Canada during the 1980s, where it mainly had a pollution focus. In the early 1990s, interdepartmental (DFO and DOE) efforts attempted to broaden the view of MEQ to focus on ecosystem-based management. There was the recognition of a need for consultation and collaboration with stakeholders, and many elements of these efforts are reflected in the DFO IM framework. The concept of MEQ now encompasses ecosystem structure and function and includes such factors as population viability, contaminant and nutrient loading, biodiversity, disease, and physical disturbance. This broadening of the meaning of MEQ is significant, and would make it a valuable tool in setting ecosystem objectives and more specific MEQ objectives within an IM or MPA plan. MEQ objectives are designed to direct management action on environmental issues specific to a particular marine area. MEQ objectives lead to the development of MEQ indicators, with reference points (limits and targets) for management action.

DFO has also an interest in developing a suite of national MEQ indicators in order to address sustainable development issues. Vandermeulen and Cobb (2004) discuss problems and approaches to the development of indicators for use in integrated management. The need for socio-economic and environmental indicators has now become a priority for DFO (Rice 2003). DFO recognizes the need for a more integrative approach to assessing marine environmental quality. For northern indigenous peoples, the use of holistic approaches to environmental change is not a novel one. The use of multi-level, multi-year observing is central to traditional knowledge. Thus the development of indicators and approaches may in fact gain strength from both the integrative approaches

being attempted in Western science and the holistic traditional knowledge of northern indigenous peoples.

So although DFO's approach to MEQ has an environmental focus, the selection of MEQ objectives, indicators and reference points should be accomplished with contributions from both scientists and stakeholders involved in the IM planning process. Local and traditional knowledge has an invaluable contribution to make to the setting of MEQ objectives in the north, as northern indigenous people's concept of the ecosystem is a broad one. Traditional knowledge has been successfully applied to understanding environmental change (McDonald *et al.* 1997) and assessing environmental impacts of development (Sadler and Boothroyd 1994), and these will be further explored in the following sections. Moreover, local coastal communities should be involved in the development and delivery of monitoring programs. There are opportunities to work collaboratively with scientists through participatory environmental monitoring and research, and these programs are discussed in this chapter and others in the book.

NORTHERN VIEWS ON CULTURE AND ENVIRONMENT

There are a number of different views of environment and culture among northern indigenous peoples, and these views share some common elements. Indigenous languages have words that usually get translated into English as "land" but carry other meanings as well. To them, land is more than a physical landscape; it encompasses the living environment, including humans (Berkes *et al.* 1998). For example, the term used by the Dene groups, such as the Dogrib, ndé (ndeh), is usually translated as "land." But its meaning is closer to "ecosystem" because it conveys a sense of relations of living and non-living things on the land. However, ndé differs from the scientific concept of ecosystem in that it is based on the idea that everything in the environment has life and spirit (Legat *et al.* 1995). Similarly, the Cree of the James Bay area use the word "aschkii" (askii), which is often translated as "land." However, it is a comprehensive concept of the environment because it refers to plants, animals, and humans as well as the physical environment. The Western James Bay Cree consider that "the Indians go with the land" as part of "land's dressing" in the sense that it is the presence of humans that makes the land complete (Preston *et al.* 1995).

The environment has always been the source of livelihood and basis of culture for northern indigenous peoples. In the contemporary world, it continues to be crucially important in the mixed economy of northern communities in sustaining social relationships and distinctive cultural characteristics of a group. The environment helps maintain social identity and provides a source of social values, such as sharing. Traditional knowledge, ethics and values, and cultural identity are transferred to succeeding generations through the annual, cyclical repetition of activities on the land, from berry gathering to whaling (Freeman 1993). Any loss of resources, or the health of the environment, has the potential to damage indigenous cultures through the loss of social relations of production, socialization of children, land stewardship ethics, and traditional knowledge.

Traditional community feast in Rankin Inlet, Nunavut. Photo by Steve Newton, 2002.

Traditional knowledge or traditional ecological knowledge is a body of knowledge built up by a group of people through generations of living in close contact with nature. The working definition we have used for traditional ecological knowledge is "a cumulative body of knowledge, practice and belief, evolving by adaptive processes and handed down through generations by cultural transmission" (Berkes 1999: 8). We use the term indigenous knowledge and traditional knowledge in the broader sense to mean knowledge specific to an area or culture, and traditional ecological knowledge when the knowledge is of ecological nature (not all traditional knowledge is). These are dry definitions compared to what Aboriginal people themselves have to say about traditional knowledge. For example, when native participants in a conference in Inuvik were asked to describe traditional knowledge, there was consensus on the following meanings: practical common sense; teachings and experience passed through generations; knowing the country; rooted in spiritual health; a way of life; an authority system of rules for resource use; respect; obligation to share; wisdom in using knowledge; using heart and head together.

Traditional knowledge, as a "way of life," has been part of indigenous culture for millennia. But it has become part of a shared northern culture and politics only relatively recently. The Government of Northwest Territories (GNWT) policy recognizes that "aboriginal traditional knowledge is a valid and essential source of information about the natural environment and its resources, the use of natural resources, and the relationship of people to the land and to each other" (GNWT 1993). The policy may be seen as a way of implementing self-government: "… the GNWT has adopted what is probably the first formal traditional knowledge policy in Canada, in an attempt to improve democratic representation in the North by moving the policies and practices of territorial government closer to reflecting the values and needs of all northern residents" (Abele 1997).

Traditional knowledge has a place in the *Oceans Act* through Canada's Oceans Strategy (COS). The strategy addresses the integrated management of activities in coastal, marine, and estuarine waters of Canada, and contains language that provides for the inclusion of "bodies established under land claims agreements" and other stakeholders, specifically mentioning "affected aboriginal organizations, coastal communities and other persons." In the Arctic region, this means that the operational frameworks for *Oceans Act* implementation must be consistent with land claims agreements, providing for co-management with land claims organizations and for the incorporation of traditional ecological knowledge into decision making.

The land claims agreements bring traditional ecological knowledge into the forefront for environmental management in the North. Traditional knowledge may be seen as a key mechanism for participatory approaches in environmental research and policy. This is true for fisheries and marine mammal co-management under such bodies as the Fisheries Joint Management Committee (*e.g.*, Beaufort Sea Beluga Management Plan) and the Beaufort Sea Integrated Management Planning Initiative (Fast *et al.* 2001, and Berkes and Fast chapter, this volume). Environmental change, detected through local observations and traditional knowledge, has been shown to enrich the understanding, for example, of Arctic climate change (Riedlinger and Berkes 2001). Hence, traditional knowledge has become a key mechanism for implementing participatory management in a number of areas of resource and environmental management, including monitoring (Berkes *et al.* 2001).

There are two areas in which northern views of culture and environment are particularly important for our thinking about MEQ and ecosystem-based management. The first is that local observations and place-based research are important for understanding ecosystems for ecosystem-based management purposes because ecosystems are complex and information is needed at multiple scales. Scientific models dominate the discussion of MEQ and ecosystem-based management in general. But can these models provide the whole answer? One may argue that scientific models, without local observations of change, are limited in their explanatory power. As well, models do not directly address the major human and ecological impact of environmental change, which is not so much about mean change but about the local impact of environmental quality changes on such factors as food, nutrition, and culture. The shortcomings of global and regional models can be seen, for example, in the case of climate change research in which local observations and understanding are needed to supplement these models (Krupnik and Jolly 2002).

Second, dealing with indicators based on traditional knowledge requires a major shift in thinking. Land claims agreements in the Arctic have produced a new model of governance in which communities, regional organizations, and governments share power. Hence, community-based research is significant in bringing community objectives to the forefront. However, working with indigenous peoples and dealing with local and traditional environmental knowledge is not always easy to do. Developing new models of community-based research that do justice to local observations and facilitate sharing of knowledge is a challenge. For example, community-based participatory research and monitoring to better understand near-shore sea ice was a key recommendation from a workshop on sea ice variability and change (Barber *et al.* in press), where local hunters and trappers from the Inuvialuit Settlement Region and sea ice scientists gathered to share the two ways of knowing about sea ice. Such an approach marks a shift away from expert-knows-best science and toward acceptance of traditional knowledge (and civil science in general) as a source of legitimate knowledge (Berkes 1999). We explore such challenges further, after a consideration of how science and traditional knowledge can be used together in the area of contaminants research.

CONTAMINANTS: SCIENCE AND TRADITIONAL KNOWLEDGE

Indicators as Used in Science

A great deal of work has been done in the past twenty years regarding northern contaminants, their chemistry, biology, and human health implications, as documented in the two massive Canadian Arctic Contaminants Assessment Reports (Jensen *et al.* 1997; NCP 2003; see also Myers *et al.* chapter, this volume). The Northern Contaminants Program is the main source of this large database. The Program has had direct input from northern indigenous groups since 1989, when its technical committee was expanded to include five Aboriginal parties (see chapter by Myers *et al.* for more detail). The inclusion of northern voices helped establish a participatory process for setting objectives, and oriented the program to address northern concerns. However, integrating Aboriginal views and approaches into contaminants research has been slow. In this section, we explore how science and local knowledge can be used together in searching for indicators of environmental quality.

We use the area of contaminants as an illustration of possible approaches for bringing together the two kinds of knowledge. Our discussion is exploratory, acknowledging that the two kinds of knowledge are in fact different. Indicators provided by science and traditional knowledge are different in the way they have been arrived at, but are similar in showing the state of well-being of the environment. Hence, we look at the use of scientific and local ecological indicators: What are they? How similar or different are they? How or when can they be brought together? To do this, first we consider the use of indicators in toxicology. Second, we investigate how northern indigenous peoples consider environmental signs and signals, and the kinds of indicators that may be identified by them.

In the broadest sense, indicator is a general term that is used to denote a relatively simple signal of complex trends and conditions or states, often

Inuvialuk woman harpooning a beluga whale near East Whitefish Station in the Mackenzie Delta. Photo by Fisheries Joint Management Committee, 1998.

obtained from various sources (Meadows 1998). The most common use of indicators is to document signs of change and to monitor trends of change. Various environmental conditions, such as pollution, express their effect on biological systems in a variety of ways. Biomarkers are indicators that signal some kind of change in an organism or system in response to a stressor. A biomarker can be a change in the amount or production of a particular chemical, such as an amino acid, a protein, or an enzyme. If the biomarker is a gene, then the term genetic marker is used. Biomarkers are detected by specific tests and techniques.

Biomarkers are generally measured at the biochemical level in tissue extracts or at the cellular level by examining change in cells. For example, the heavy metal exposure biomarker for fish, metallothionein, normally occurs in tissues in trace amounts; metallothionein is widely distributed in the animal kingdom. Exposure to heavy metals induces metallothionein production in fish. Heavy metals are not the only chemicals that have the ability to induce metallothionein, but this effect is much greater in the case of heavy metals (20–50 fold increases) than for other chemicals that induce metallothionein production (for example, for glucocorticoids that cause a 2–4 fold increase). Hence, metallothionein is a good biomarker. Its levels in fish tissues are measured with spectrophotometers of high sensitivity, and evaluations are made about the level of heavy metal exposure (Klaverkamp *et al.* 2002).

For broader responses at the level of organism to the same stressor, the term biomarker is not used. Instead, one refers to clinical signs and pathology. These may include parameters such as changes in body weight, external changes in skin, body, fur, eyes, mucus membranes; changes in respiratory, circulatory, or nervous systems; and changes in activity and behaviour patterns. Such changes may be expressions of multiple causes rather than changes specific to a stressor. Hence, they are not as valuable as biomarkers for diagnostic purposes. Biomarkers are called biological indicators (bioindicators) when they are causally linked to ecologically relevant end points. Bioindicators typically reflect cumulative effects of stressors at individual, population, and community levels. As such, they do not indicate clear-cut cause-and-effect relationships to specific contaminant exposure (ESD 2003).

The term "bioindicator" is commonly used in pollution research and biological effect monitoring. In recent studies, the trend is toward the use of a number of broader and less specific biological or ecological indicators (Wrona and Cash 1996). In fact, the larger the system under consideration, the less specific (but the more inclusive) are the indicators. There is a difference between the reductionistic approaches of analytical sciences using chemical and cytological methods commonly employed in toxicology, on the one hand, and the holistic approaches of ecosystem monitoring studies, on the other (Suter 2001).

The toxicological approach focuses on identifying and quantifying a specific effect: What amount of a certain toxicant produces what level of undesirable effect? By contrast, ecosystem monitoring studies focus on documenting effects without necessarily identifying or quantifying the precise nature of causality. One could argue that the holistic approach to ecosystem monitoring is on a continuum, partway between the reductionistic approach of toxicology and the holistic approach of traditional ecological knowledge. Further, one can make the argument that current multi-level, multi-year ecosystem health or ecosystem integrity studies are in some ways more similar to the Aboriginal way of observing and understanding of the world than are toxicological studies.

Indicators in Traditional Ecological Knowledge

What is the nature of the "indicators" used in traditional ecological knowledge? The term and concept of environmental quality indicators have no direct translation in most northern indigenous languages. However, many indigenous people who are knowledgeable about the land do recognize and monitor various environmental signs and signals. These may be related to changing seasons, the timing of harvesting activities, abundance of animals, health of animals, and unusual patterns and deviations from the norm (Table 4.2). Such "indicators" may be chosen on the basis of shared culture, values, and issues important for that community, and reflect the knowledge and experience of current and previous generations. This accumulated experience with the environment may be used to detect trends, for example, in fish catches. Indigenous fishers are experts in keeping mental track of the catch per unit of effort and judging trends, after allowing for year-to-year variations (Berkes 1999, Chapter 7). If, year after year, fewer fish are caught per unit of effort, fishing at the same locations with similar nets, then this is an indication of declining productivity or some kind

Table 4.2
ENVIRONMENTAL SIGNS AND SIGNALS USED BY SOME NORTHERN INDIGENOUS HUNTERS

Signs and signals	*Description*	*Reference*
Changing seasons	Noting changes in sea ice, winds, snow cover, temperature, etc. for reading the weather and predicting hunts	Krupnik and Jolly (2002)
Signs and signals for harvesting	Environmental cues for harvesting, *e.g.*, whitefish are spawning when tundra changes colour (Chisasibi, James Bay)	Berkes, unpublished field notes
Catch per unit of effort to track abundance	Monitoring harvest success, usually per unit of time, *e.g.*, catch per net per day	Berkes (1999)
Monitoring health of animals by noting body condition	Observation of fat in certain parts of the body to judge health of big game, small game, birds, fish	Kofinas *et al.* (2002); Berkes (1982)
Noting unusual patterns in distribution and abundance	Unusual occurrences of species in an area, *e.g.*, unfamiliar species, strange distributions, breeding failure	Jolly *et al.* (2002)
Monitoring biophysical change by noting extremes	Detecting change by noting, not averages, but extremes and major deviations from the norm, *e.g.*, in sea-ice cover and thickness	Nichols *et al.* (2004); Jolly *et al.* (2002)
Noting changes in environmental quality	Detecting change through taste of fish and game, observations of pathological conditions	(see Table 4.3)

of environmental change. Evaluation of indicators over time allows users to receive feedback from the ecosystem, enabling them to assess various aspects of the system. For example, a catch of burbot with shrivelled, discoloured livers may mean that something in the environment is causing this or something in the water may have changed (Lockhart *et al.* 1987).

Table 4.3 provides a sample of local indigenous observations on environmental quality changes, including the burbot example noted above. The table is compiled from examples recorded in the Canadian Arctic Contaminants Assessment Report (Jensen *et al.* 1997). Note that local observations may be useful not only in detecting abnormal body conditions (liver, body deformity, small eggs) but also abnormal taste and consistency, parasitism, poor condition (lower body fat content), and abnormal behaviour, as in the example of altered spawning behaviour. Locally used indicators can be quite specific. For example, the mesentery fat content of fish caught in nets would mean the fish are in poor condition, hence not suitable for consumption in James Bay. When the reservoir of the LG 2 dam was being built, Cree fishers were checking the

Table 4.3
EXAMPLES OF COMMUNITY OBSERVATIONS REGARDING CONTAMINANTS AND OTHER SUSPECTED NEGATIVE ENVIRONMENTAL QUALITY CHANGES

Observation	*Community and/or area*
Decrease in the quantity and size of whitefish and trout eggs	Yukon First Nations
Changes in texture and consistency of fish flesh	Yukon First Nations
Altered migratory behaviour in spawning salmon, upstream travel distance reduced	Yukon First Nations
Changes in fish flesh quality and fish numbers	Dene Nation
Fish (burbot, *Lota lota*) with spotted, shrivelled or discoloured livers	Dene, Mackenzie River area
Increases in deformities of fish and other animals	Dene Nation
Thinner marine fish, reduced firmness of flesh	Tuktoyaktuk area
Pacific herring (*Clupea harengus*) with white spots in flesh and altered taste	Tuktoyaktuk area
Trichinosis in walrus associated with suspected negative environmental influences	Sanikiluaq, Hudson Bay
Sores on the insides (*i.e.,* body cavity) of seals	Avativut report, Nunavik and Labrador

condition of the *Coregonus* species in the estuary of the La Grande River to monitor the health of the fish (Berkes 1982; Olsson *et al.* 2004). Some indicators show an understanding of ecological interactions and effects of key variables acting together (*e.g.*, sea ice and wind). For example, the observation of skinny ringed seal pups was connected to lack of sea ice south of Sachs Harbour (Nichols *et al.* 2004).

In the case of contaminants as well, the Inuit do not appear to make linear, cause-and-effect connections as usually made in Western science. Rather, they see environmental change and observations such as those in Table 4.3 as empirically connected (O'Neil *et al.* 1997). Among the Inuit and in many other northern cultures, systematic generalizations regarding cause-and-effect relationships are in general regarded negatively. According to the Inuit worldview, making simplifications and generalizations of complex phenomena is "childish" and without sense (without *ihuma*) (Omura 2002). As pointed out in the chapter by Myers *et al.*, these considerations suggest that the problem in communicating contaminants information to the Inuit is not exclusively a translation problem. The poor communication is not only due to lack of suitable Inuktitut (Inuit language) terminology. It is in part due to differences between the Inuit worldview and the Western one which emphasizes cause-and-effect relationships.

Similarly, the Inuit concept of wellness and sickness is holistic, as the following Inuit quotations from Nunavik (northern Quebec) taken from O'Neil *et al.* (1997, 32, 33) illustrate: "We just keep finding again and again that everything is interlocked. Everything is intertwined. Everything is not neat [like] with [scientific] classification. The world does not work like that to Inuit people. Do your labelling but we see this whole. So let us cherish this [Inuit] knowledge."

The diagnosis of a sick animal is also holistic: "The Inuit know what animals are sick or when they are not sick because they know it even without samples because they have been hunting it for years and years" (O'Neil *et al.* 1997, 32). Nevertheless, Inuit hunters do make reference to specific signs that tells them that an animal is not well and should not be eaten. The following refer mainly to seals: animals with *manimiq* (lumps), skinny animals, discoloured bones, abnormal liver, bumps, and blue-coloured spots in the intestines. The problem may be with the meat, the behaviour of the animal, or its outward appearance. The health of the animal would be in doubt if "it did not look normal" (O'Neil *et al.* 1997). Assessing the "wellness" of an animal by appearance and behaviour is rather similar to a medical doctor assessing the wellness of a person by looking at clinical signs, such as weight, skin colour, eyes, breath, and so on. In the case of the Inuit, the signs of wellness are read continuously and cumulatively, and that is perhaps why an experienced hunter has a good sense about the state of health of an animal. The Inuit hunter's logic is similar to some integrated scientific approaches to stressors in which anomalies are noted and quantified as a percentage and used as a component of an index of biological integrity (Tong 2001).

We have argued that the Inuit (and other northern indigenous) views of contaminants and health are holistic. However, there are specific signs and signals of environmental quality that native hunters monitor within a context of holistic understanding. Returning to the question of the kinds of indicators that may be identified by the two ways of looking at the world, Table 4.4 provides a listing of contaminant-related indicators as used in toxicology and as may be used by indigenous observers. The table is exploratory and is not meant to imply that the two kinds of knowledge systems make similar observations using similar methodologies. They do not. The cultural context of the observations are obviously also different. Rather, our point is that each set of indicators, as used by the two knowledge systems, assesses environmental conditions and wellness in its own way.

At the chemical, biochemical, and cellular levels, toxicology uses many indicators. Local observations and traditional knowledge are generally not very useful at this scale – except that some northern indigenous people are apparently able to taste and smell some contaminants, or effects of contaminants, in animal tissues. At the organismic, population, and community levels, however, local observations can provide a great deal of information. There are some effects, such as physiological changes, that would not be observable to hunters. How-

Table 4.4
Examples of indicators of contaminant-related effects, as may be identified by Western science and by traditional knowledge

	Scientific knowledge	Traditional knowledge
Chemical/biochemical level		
Metallothionein levels (*e.g.,* Cd, Pb, Hg)	+	–
Inhibition of enzyme and protein synthesis in liver, kidney, brain (*e.g.,* Hg)	+	–
Contaminants in tissues, sediments, water	+	–?
Cellular level		
Adenomas, nuclear, mitochondrial, cytological changes in	+	–
Structural changes in cells	+	–
Organismic level		
Structural alteration in fish epidermal mucous	+	+
Tumours	+	+
Lesions related to parasites	+	+
Parasitic infestation	+	+
Reduction in sperm viability	+	–
Changes in survival of larvae and fry	+	–
Growth rate by size (from catch data)	+	+
Growth rate by age (*e.g.,* otolith data)	+	–
Body condition	+	+
Muscle firmness, mesentery fat	–	+
Physiological changes (*e.g.,* osmoregulation)	+	–
Visible neurophysiological changes (*e.g.,* swimming)	+	+
Other behavioural changes	–	+
Population and community level		
Abundance (numbers, biomass)	+	+
Fecundity; sex ratio in catches	+	+
Reproductive life span	+	–?
Age at maturity	+	–?
Genetic diversity	+	–
Community change	+	+

Sources: Compiled from various sources, Attrill and Depledge (1997), Lockhart *et al.* (1992) and Muir *et al.* (1992) for scientific knowledge; Jensen *et al.* (1997), O'Neil *et al.* (1997) and McDonald *et al.* (1997) for traditional knowledge. See also Tables 4.2, 4.3, 4.5, and 4.6.

ever, such physiological effects may express themselves as behavioural effects, and the Inuit are experts on reading those. There are other indicators that may be noted by indigenous observers and not normally studied by science. These include the use of mesentery fat of fish as an indicator of health (Berkes 1982) and observations of a range of animal behaviours.

The implication of Aboriginal worldviews for the question of environmental quality and health indicators is that a high degree of indicator specificity is not a sought-after characteristic on its own. A holistic worldview favours a large number of less specific (and probably multicausal) indicators used simultaneously as a suite, giving the community feedback on many aspects of the environment. At the same time, it gives them a more complete and holistic picture of the environment. Unlike common scientific indicators, local indicators do not produce formalized generalizations. This gives community-based indicators built-in adaptability, that is, they would be readily modified with changing conditions and thus be flexible.

The approach of using a broad suite of simpler indicators, instead of a few detailed and costly ones, is finding favour in Western science as well (Wrona and Cash 1996; Kislalioglu *et al.* 1996). It is increasingly recognized that the use of a few indicators, no matter how well chosen and researched, may be inadequate in reflecting complexity.

LESSONS FROM SOME INDIGENOUS KNOWLEDGE SYSTEMS

The use of traditional knowledge for MEQ and ecosystem-based management is relatively new. However, the potential contribution of traditional knowledge is considerable, given local environmental expertise guided by generations of experience. The knowledge held by indigenous experts enables local scale understandings of impacts and changes in environmental quality, and can be used as a guide for research and application. Documenting this knowledge is only the first step. Recognizing and including local expertise requires building relationships between scientists and communities – those who are studying change and those who are experiencing it. Table 4.5 provides some examples of community observations regarding environmental change and ecosystem-based management in the Arctic. Many of these examples are climate-related but illustrate the nature of ecosystem changes that are being observed by communities and are therefore relevant for community-based monitoring.

A number of community-based monitoring projects have been or are currently being conducted in the North (see chapters by Manseau *et al.* and by Parlee *et al.*). Some are directly related to marine environmental quality, while others are related to other components of the environment. Valuable lessons can be learned from these projects regarding the application of traditional and scientific knowledge to environmental quality. One of these projects is the Tariuq (Ocean) community-based monitoring program in Aklavik and Tuktoyaktuk, NT, carried out since 2000 (Cobb *et al.* 2003). Its objective is to understand the health

Table 4.5
EXAMPLES OF COMMUNITY OBSERVATIONS REGARDING ENVIRONMENTAL CHANGE AND ECOLOGICAL LINKAGES AS MAY BE RELEVANT TO THE BROADER DEFINITION OF MEQ

Observation	*Community/area*	*Reference*
Warming trends affecting fish populations, Arctic char looking unhealthy, smaller size	Rankin Inlet, NWT	1
Earlier spring arrival, shallower rivers, poorer Arctic char flesh quality	Rankin Inlet, NWT	1
More polar bears on land and near communities perhaps because of thinning of ice on floe edge	Whale Cove, Arviat, others	1
Occurrence of fish species not normally known in the area (*e.g.,* salmon in Beaufort Sea), related to climate change	Tuktoyaktuk; Sachs Harbour	2, 4
Lack of ringed seals because of absence of sea ice habitat	Sachs Harbour; Whale Cove	4,1
Coastal erosion increasing because of more wave action due to longer ice-free seasons	Tuktoyaktuk; Sachs Harbour	3, 4
Changes in wind direction affecting Pacific herring harvesting	Tuktoyaktuk Harbour	5

Sources: (1) DFO (2001); (2) Chiperzak and Cockney (2000a); (3) Chiperzak and Cockney (2000b); (4) Jolly *et al.* (2002) ; (5) A. Kristofferson, DFO, pers. comm.

of the marine ecosystem, using community-selected indicators and monitors. The strength of the program results from the working group, which consists of elders, youth, and experienced hunter and trapper members. The DFO sits on the working group and provides a conduit to input from other agencies and scientists on a required basis. This arrangement allows community concerns to be expressed through the selection of indicators and having teams of monitors consisting of youth and an experienced (and often an elder) hunter and trapper. Monitors use scientific methods to carry out sampling, and tissues samples are analyzed for a variety of contaminants. Marine environmental quality objectives are established through workshops. The scientific objectives are to conserve populations and species and quality of water and biota. The social and cultural objectives were established as the use of traditional knowledge; sharing of knowledge and awareness; training and capacity-building; and providing information for decision-making.

A second example is the traditional knowledge project of the Lutsel K'e Dene First Nation (Parlee *et al.* 2001). The Lutsel K'e Dene notion of healthy fish involves observations regarding five points: (1) size and shape: visual assessment of the length/weight ratio, with attention to deformities; (2) population and diversity: whether the species that are supposed to be present in a place are present there; (3) fatness of fish: fat around the internal organs is a sign of good fish health and good water quality; (4) cleanliness and healthy organs: infections, parasites, and deformities are signs of poor health; and (5) colour and texture of the flesh: firm texture and appropriate colour, for example, darker red meat in the case of lake trout (Parlee *et al.* 2001, p. 33). The Lutsel K'e Dene traditional knowledge project covers indigenous concepts of the health of the environment and the health of the community, which are considered to be interrelated. Hence the overall social objective of a healthy Dene way of life encompasses indicators of healthy fish and other animals, such as caribou. The results regarding fish are interesting because the five-point list, completely produced by Dene hunters and elders, is concise but comprehensive. It suggests a range of indicators that can actually be used for monitoring change.

A third example is the Inuit Bowhead Knowledge Study, carried out under the provisions of the *Nunavut Land Claims Agreement*. The Inuit concept of a healthy ecosystem is clearly articulated in the report: animals "remain healthy and abundant only if they were harvested and treated with respect" (Hay *et al.* 2000). The social and cultural objectives were to follow traditional rules of respect; to share food and never to waste it; and to renew traditions of bowhead whale hunting. The traditional knowledge study was based on Inuit monitoring, and the main sources of information were (1) the frequency of sightings, (2) trends in bowhead group size, and (3) observations of cows with calves (Hay *et al.* 2000). These indicators of a healthy and recovering bowhead population are likely to be considered suitable by scientists as well. Inuit hunters are assessing changes by mentally tracking changes in these indicators over the years. The indicators can be made consistent with science by quantifying them. However, there is a notable discrepancy in objectives. While the scientific objectives were about conserving populations and species, the Inuit objectives were about Inuit-bowhead relationships and access to the resource. The two sets of objectives may be reconciled by aiming for the long-term sustainability of the resource.

A fourth example is *Voices from the Bay*, a report on the traditional environmental knowledge of Inuit and Cree in the Hudson Bay region (McDonald *et al.* 1997). The primary objective of the study was to assess region-wide environmental change related to cumulative impacts of hydroelectric development. It was a remarkable project, initiated and carried out by indigenous people themselves, documenting what communities said about changes occurring in their environment, combining these local observations into a regional whole, and using this information as a baseline in the face of additional hydroelectric development. The report makes a holistic assessment of observed changes, including those related to contaminants and climate change, as well as to hydro development impacts. Table 4.6 is an attempt to capture the Cree and Inuit notions of respect as a starting point, followed by concepts of healthy human-environment relations and signs and signals of problems.

Table 4.6
CREE AND INUIT VIEWS FROM THE HUDSON BAY AREA RELATED TO A HEALTHY ENVIRONMENT. SELECTION OF ITEMS COMPILED FROM MCDONALD *ET AL.* (1997)

***Concept of respect** (pp. 1, 4, 5)*

- Knowledge of the land from ancestors
- Co-existence with the environment
- Respect for the land tied to a healthy environment

Concept of healthy human-environment relations

- Knowledge of seasonal cycles (p. 25)
- Ability to anticipate change by watching animals (p. 25)
- Knowledge of long-term population cycles, *e.g.*, walrus (p. 42), beaver (p. 43), beluga (p. 87)

***Wellness indicators** (p. 43)*

- Seasonal fat thickness
- Condition of the liver
- Meat colour
- Fur condition
- Behaviour of the animal

Signs and signals of problems

- Changes in sea-ice (pp. 30, 31 and throughout)
- Polynyas (open-water areas) freezing over (pp. 30–31)
- Changes in currents (pp. 30, 31 and throughout)
- Changes in weather (p. 28)
- People cannot predict weather and seasons anymore (p. 29)
- Taste of snow and rainwater has changed (p. 30)
- Changes in colour, composition and taste of snow (p. 27)
- Taste of land animals and plants changing (p. 27)
- Changes in animal migrations, *e.g.*, flyways of geese shifted east in James Bay (pp. 46, 84, 86)
- Behaviour of animals changing, *e.g.*, polar bears lost fear of humans and dogs (p. 91)
- Species disappearing, *e.g.*, Rankin Inlet area, fish and ringed seals (p. 27)
- Change in fish condition, *e.g.*, Deception Bay, northern Quebec
- Change in fish size, *e.g.*, Great Whale area, Arctic char and trout (p. 26)
- Change in fish meat quality, *e.g.*, James Bay, Harrikanaw River sturgeon (p. 83)

The indigenous expertise leading to Voices was built stepwise, starting with the La Grande hydro development of the 1970s. The hydro project produced unexpected impacts in the La Grande estuary, and the Cree learned to use scientific styles of monitoring (*e.g.*, coring for ice thickness), in addition to their own traditional monitoring (*e.g.*, judging safety of ice by colour and the sound of tapping stick) (Berkes 1988). The Cree and Inuit used their own knowledge of sea ice, currents, and animal and plant distributions to assess regional-scale change. They used signs and signals (*e.g.*, changes in sea ice and currents) as well as their knowledge of ecological relations to produce a comprehensive evaluation. For example, the Cree observed that changes in the freshwater-saltwater balance not only affected fish distributions but also marine grasses that, in turn, affected the distributions of geese feeding on them. The Inuit of Sanikiluaq reported winterkills of eider ducks and reduction in polynyas (open-water habitat for wintering eider) associated with post-1970 changes in currents and sea ice. Subsequently, Robertson and Gilchrist (1998) provided scientific follow-up and cross-verification of these observations.

CONCLUSIONS

The framework for ecosystem and MEQ objectives and indicators developed at the DFO workshop (Jamieson *et al.* 2001) (Figure 4.1) was an important step for moving forward with the implementation of IM and MPA activities under Canada's Oceans Strategy. The environmental objectives remain to be further defined as objectives, targets, and indicators. As part of the IM node within the Oceans Management Research Network, we have begun to examine the framework and its implementation in northern Canada. Our intent was not to redesign the current framework, rather to examine how the social dimension inherent in northern societies can contribute to and enhance the present framework, and subsequent work on MEQ objectives and indicators.

A number of factors led us to conclude that there is likely to be overlap and interaction between indicators of the environmental and social components of ecosystem and MEQ objectives in their application to IM planning in northern Canada. We conclude this because northern indigenous peoples have a unique perspective on their environment, based on societal, cultural, and spiritual ties to the land. Moreover, the use of traditional knowledge, which has been transferred from generation to generation through time-honoured use of the land, is integrated into all aspects of society, community conservation plans, and land claims resource co-management arrangements. Northern indigenous peoples have their own perceptions about what constitutes a healthy marine ecosystem, and they have a holistic approach to understanding environmental change.

Based on the four examples of recent and ongoing monitoring studies provided in this chapter, we conclude that northern indigenous peoples have criteria as to what constitute suitable indicators (signs and signals) of environmental change. This comes from many generations of observing seasonal patterns of flora and fauna used for subsistence foods, and travelling across the land and sea ice. These indigenous criteria should be examined and attempts made to validate the observations. The Arctic Borderlands Ecological Co-op has attempted to consolidate several years of community observations gathered by interviewing community members (Kofinas *et al.* 2002).

There are several examples of the use of the two kinds of combined knowledge to improve resource and environmental management (Berkes 1999). For example, in the Inuit Observations of Climate Change project, Riedlinger and Berkes (2001) developed a conceptual framework for linking science-based research with local knowledge. The framework was articulated through five interrelated convergence areas; that is, research areas that could facilitate collaboration and communication between scientists and local experts. These convergence areas were the use of traditional knowledge (i) as local scale expertise; (ii) as a source of climate history and baseline data; (iii) in formulating research questions and hypotheses; (iv) as insight into impacts and adaptation in Arctic communities; and (v) for long-term, community-based monitoring.

The five areas highlight the ability of local experts to address the complexities of Arctic environmental research at spatial and temporal scales often underrepresented in Western science. All five areas are applicable to environmental quality indicators. For example, indigenous hunters can and do note changes in the environment and deviations from the normal, as in the abnormal burbot liver example (Lockhart *et al.* 1987) and in the northern Quebec seal examples (O'Neil *et al.* 1997). Animals that "do not look normal" is an expression typical of the results of continuous indigenous monitoring of the environment, or continuous visual "sampling" as scientists might put it, and the use of mental reference points to make an assessment of whether an animal is sick or not. The logic is similar to the scientific one, but the observation is holistic and the discourse does not fit well with scientific discourse.

What are the implications for these explorations for MEQ indicators? We conclude that probably no single approach to setting ecosystem and MEQ objectives, or selecting and monitoring indicators will be suitable in the North. The vast territory, harsh environment, and high costs of research make long-term monitoring programs a challenge. We suggest that the judicious use of traditional ecological knowledge and community monitoring provides the most effective way of moving forward. The concept of mutual learning rather than attempting to "integrate" local knowledge into science might provide a "weight of evidence" approach to environmental change. Collaborative or participatory approaches to setting ecosystem objectives, selecting indicators, and monitoring are likely to provide the best path forward. More research is needed in order to develop the most effective models to bring scientists and those with ecological knowledge together to move along this path. Each land claim settlement region has its own structure, and facilitating the adequate engagement within each region is important and challenging.

The strengths contained within community-based monitoring seem to indicate that this is the best way of overcoming this challenge. The various approaches of ongoing community-based monitoring programs are examined elsewhere in this book (Parlee *et al.*, this volume). Each has its strength and weakness, but common to all are the challenges of sustaining long-term monitoring. Sustaining long-term funding, maintaining interest and relevance in the programs, maintaining capacity within both the communities and scientific agencies to dedicate the time needed to accomplish community-based monitoring, shifting policies, etc., are all challenges that must be overcome in order to make a successful monitoring program. More research is required to further develop and refine this approach for use both locally and throughout the North in the implementation of Integrated Management, and more specifically in helping to "unpack" ecosystem and MEQ objectives. Is it possible to develop a common suite of indicators for use in different regions of the Arctic, or will they have to be tailored to suit the individual settlement regions?

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