CHAPTER 12

ADAPTIVE CO-MANAGEMENT OF ARCTIC CHAR IN NUNAVUT TERRITORY

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INTRODUCTION

The Inuit of Canada's new Territory of Nunavut are descendents of the people who made a living by following the resources of the land and the sea from one season to the next. Their continued existence is proof that their traditional management methods were indeed successful. The twentieth century has led to an end to this nomadic lifestyle. The contemporary Inuit are primarily located in settlements and live in a mixed economy that consists of wage employment, transfer payments, and subsistence resource harvests (Berkes and Fast 1996). Resource harvesting remains an important activity for economic, cultural, and nutritional reasons (Myers *et al.,* this volume).

Harvesting of fish, in particular Arctic char, near coastal communities, is still actively pursued. In addition to subsistence fisheries, small-scale commercial and recreational fisheries exist in various parts of Nunavut where resources permit. In some communities, such as Cambridge Bay on the south shore of Victoria Island (Figure 12.1), there exists an abundance of char beyond that needed to satisfy subsistence needs. This resulted in the development of a small commercial fishery in the early 1960s. With the development of this fishery came government regulation required by the laws of the land. Harvest levels were assigned on the basis of limited scientific data, but proved to be less than effective, as evidenced by declines. Recent research has led to a better understanding of sea run Arctic char populations in the area and the complexity of their stock structures. What is needed now is a more effective approach to the management of this important resource.

The Inuit of Cambridge Bay have developed a working relationship with Department of Fisheries and Oceans (DFO) managers, a relationship that has evolved over a number of years and led to the establishment of an informal co-

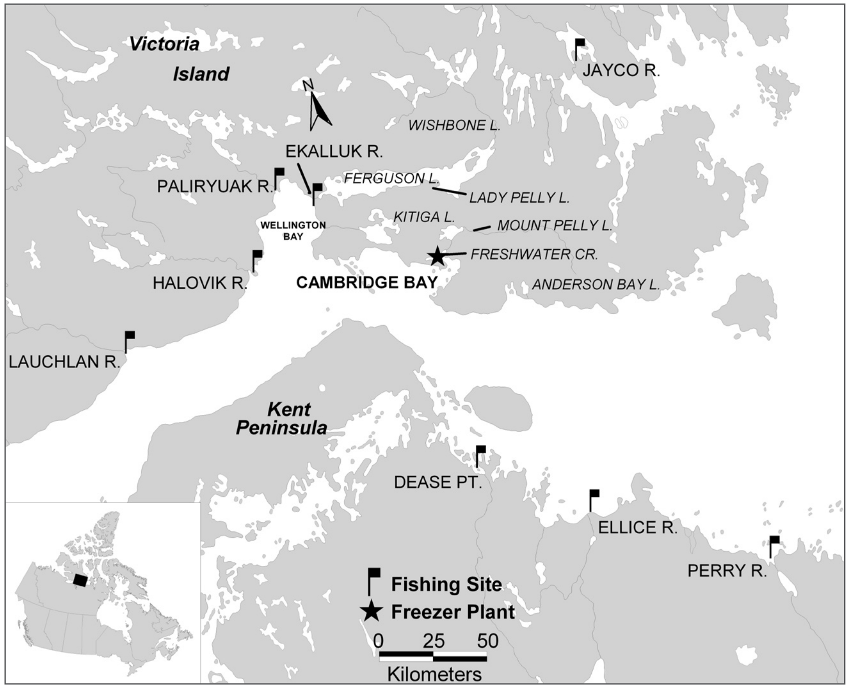


Figure 12.1 Fishing locations for sea run Arctic char.

management approach. Since then, under the Nunavut Land Claims Agreement of 1993, legislated co-management has been instituted in Nunavut Territory. This provides an opportunity to build upon past co-operative management experience.

In this chapter, we make the argument that adaptive co-management is the next step in the evolution of resource management with Arctic char and perhaps other species. Adaptive co-management systems are flexible community-based systems of resource management, tailored to specific places and situations and supported by, and working with, various organizations at different levels. Folke and others (2002, 20) define adaptive co-management as a process by which institutional arrangements and ecological knowledge are tested and revised in a dynamic, ongoing, self-organized process of learning-by-doing. Adaptive co-management is typically carried out by networks of actors sharing management power and responsibility (Olsson *et al.* 2004). It combines the *dynamic learning* characteristic of adaptive management (*e.g.,* Holling 1978; Walters 1986) with the *linkage* characteristic of co-operative management (*e.g.,* Pinkerton 1989).

We explore adaptive co-management as a practical method of dealing with the biological complexities of Arctic char stocks in a collaborative, learning-by-doing management approach that incorporates both traditional knowledge and scientific information. The objective of this chapter is to illustrate how such an adaptive co-management system can work. Further, this approach is not unique

to the case study area but can probably be applied to the management of other Arctic char stocks in Nunavut.

The Arctic Char Resource

The Arctic char has a circumpolar distribution. In Canada it is found in Newfoundland and Labrador, north along the Ungava Peninsula to Hudson Bay, throughout the islands of the Arctic Archipelago and west to the Mackenzie River (McPhail and Lindsey 1970; Scott and Crossman 1973). It occurs as both a migratory (sea run) form and a nonmigratory form resident in lakes throughout the species range (Johnson 1980), and is widespread in Nunavut Territory.

The Arctic char spawns in fresh water in fall. The eggs incubate over winter and hatch in spring. The young then spend the first stage of their life entirely in fresh water. When they reach a size of about 150–200 mm, those that become sea run make their first migration to the sea, returning in fall to escape freezing. Generally, this pattern is repeated each year until they reach sexual maturity (Johnson 1980). Spawners appear to home to natal spawning grounds with a high degree of fidelity, resulting in the establishment of discrete stocks both between and within river systems (Kristofferson 2002). Spawning does not appear to take place in consecutive years, and there is evidence that Arctic char may not return to their home stream during nonspawning years.

The Arctic char is highly valued by the Inuit and is an excellent food source. In many places, there are competing demands for the species. On the one hand, populations are increasing and so is the general demand for more Arctic char to meet subsistence needs, even though demand for fish as dog food has declined since the 1970s (Usher 2002). On the other hand, economic opportunities are limited in Nunavut, and Arctic char fisheries, both commercial and sport, offer the promise of economic gain if they can be developed. These factors are contributing to an increased demand on Arctic char. However, the Arctic char cannot sustain heavy exploitation because of its relatively slow growth, low fecundity, and infrequent spawning and must be managed very carefully (Scott and Crossman 1973; Johnson 1980).

Management approaches that have been applied to Arctic char fisheries in Nunavut include the traditional one employed by the Inuit prior to government management and the conventional fishery management approach employed by government for northern commercial fisheries. Neither of these approaches deals successfully with the challenges of contemporary Nunavut, given the increase in the Inuit population, the need to develop a cash economy, and the biological complexity of the Arctic char resource itself. Thus, there is a need to develop and implement a new approach that can accommodate the new circumstances and provide sustainability over the long term. A short discussion of the previous management approaches is useful to provide a framework for the development of such a new management approach. The focus is on the Arctic char fishery in the Cambridge Bay area.

The Arctic ecosystem is characterized by long cold winters, short cool summers, low annual biological production, and a general paucity of food resources. Human inhabitants had to utilize adaptive processes and survival strategies to ensure their existence over the long term (Balikci 1968). For example, the Inuit of Pelly Bay, formerly called the Netsilik Eskimos, followed an annual migration cycle. In winter they relied on seals out on the sea ice. In summer they moved inland, harvesting seals along shore and occasionally hunting caribou. In early autumn they fished for Arctic char using the stone weir or *saputit*. In late autumn the Netsilik fished for char through the thin river ice. In winter, they moved again onto the sea ice to pursue the seal (Balikci 1968). The Arctic char was a very important food source, and most harvesting took place during the autumn upstream migrations. In areas where Arctic char were abundant, starvation was rare (Balikci 1980).

The Inuit of the Cambridge Bay area, formerly called Copper Eskimos, had a seasonal economic cycle similar to that of the Netsilik (Damas 1968), using a mix of fish, marine mammals, and terrestrial mammals. Survival required that critical decisions be made to relocate if food sources went into decline in any particular area. The Inuit had accumulated a great deal of ecological and environmental expertise on a local level that provided them with a basis for this decision making (Riedlinger and Berkes 2001).

There are few studies on the traditional fishery management techniques of the Inuit of Nunavut Territory. Perhaps the most detailed study of subsistence fisheries in northern Canada comes from the James Bay area. Berkes (1999) summarizes a traditional fishery management approach employed by the Chisasibi Cree fishers of James Bay, for lake whitefish (*Coregonus clupeaformis*) and cisco (*C. artedi*), studied over a period of some fifteen years and reported through a series of research papers. The management strategy had three essential components. The first was to concentrate fishing effort on aggregations of fish, the second was to pulse fish intensively for a burst of time and then move on, and the third was to use methods that resulted in the harvest of a wide range of fish sizes. All three strategies were driven by the fishers' ability to detect declines in catch per unit of effort, and using this as an indicator of when to move on.

These strategies allowed Cree fishers to maximize their catch per unit of effort, making the best possible use of their time, selecting from among a range of possible resources. But at the same time, by moving on to other areas, to other fish stocks, and perhaps to other resources, they were able to conserve the existing stocks. Indeed, the distribution of the harvesting effort in space and time is not only used by the Cree and the Inuit but is one of the most commonly used traditional management practices throughout the world. Often, this practice takes the form of rotational use of fishing areas, harvesting one area intensively for a time but then lifting the fishing pressure completely, allowing the resource to replenish itself (Berkes 1999). There is strong evidence from the work of Johnson (1976) that the Inuit of the Central Arctic rotated their Arctic char fishing areas.

The third fishing strategy employed by the Cree (they use methods that result in the harvest of a range of fish sizes) produces another important ecological effect. Catching a range of sizes of fish instead of concentrating on the large (reproductive) ones would allow escapement of some of the spawners, thus ensuring the perpetuation of the stock. Modelling studies showed that the thinning of populations by the use of a mix of gill net mesh sizes (as the Cree fishers use) conserves population resilience, as compared to the wholesale removal of the older age groups by single large mesh size. The use of a mix of mesh sizes appears to be more compatible with the natural population structure than the use of a single large mesh size alone. Using a traditional Cree fishing strategy, models showed many reproductive year-classes remaining in the population. At the same time, the reduction of the overall population density likely increases productivity by stimulating growth rates and earlier maturation in the remaining fish, and helps the population renew itself (Berkes 1999, 125).

The Inuit of the Central Arctic seem to have practised management methods similar to those of the Cree fishers discussed above. By fishing for Arctic char at the *saputit* during the autumn upstream migration, they maximized their return for effort because Arctic char were present in great abundance in the upstream migration and were very vulnerable to capture in the shallow Arctic rivers. The char were also in prime condition after a summer of feeding in the sea and thus presented an ideal energy-rich food source. Arctic char of a variety of sizes were captured (Balikci 1980), thus allowing escapement of some of the potential spawners. By detecting declines in resource abundance, they would relocate to other systems, allowing the area to recover so that it could be fished again. This management approach of rotating fishing areas ensured the survival of both the Inuit and the fish.

Traditional management systems, such as the James Bay Cree fishery (Berkes 1999), tend to be adapted to the local area, and resource users themselves are the "managers." Allocation decisions are not made individually, and compliance is by social sanctions. These systems tend to have a large moral and ethical context, and there is no separation between nature and culture. Knowledge is primarily qualitative and data are diachronic in nature, that is, a long time-series of local information.

The Inuit of the Cambridge Bay area lived the traditional way of life until about 1946–47, following food sources through the seasons. The construction of the LORAN navigation beacon station at Cambridge Bay at that time served to create a wage economy which led to a concentration of Inuit in the settlement and a significant change from the traditional way of life. This event coincided with a decline in fox fur market, and the relatives of those employed drifted into Cambridge Bay for extended visits. This led to a further concentration of people in the community, ending their traditional lifestyle of living off the land by moving with the seasons (Abrahamson 1964).

Table 12.1

DISTINGUISHING CHARACTERISTICS OF INUIT TRADITIONAL MANAGEMENT PRACTICE FOR ARCTIC CHAR VS. CONVENTIONAL SCIENTIFIC MANAGEMENT PRACTICE

The two sets of characteristics may be read as opposites, or they may be read as potential complementarities.

Inuit traditional management practice	*Conventional management practice*
Local knowledge of fish biology, *e.g.*, spawning areas, migration times	Universal knowledge of char biology applied locally
Diachronic information	Synchronic data
Qualitative observations related to management decision-making, *e.g.*, monitoring of catch per unit of effort, relative strength of spawning runs, fat content of fish	Quantitative data on population size by use of counting weir, age-specific growth rates, spawning sizes and frequencies, tagging to determine migrations
Indirect management by rotating fishing areas and spreading out fishing effort in space and time	Management by annual harvest quotas on assumed discrete stocks
Social enforcement of accepted, proper Inuit practice	Tools: quotas, gillnet mesh sizes, closed seasons
Sharing by social agreement and convention	Allocation decisions made by distant authorities
Enforcement by social mechanisms and, under the 1993 Nunavut Land Claims Agreement, through co-management mechanisms	Enforcement by the laws of the land, Federal Government fishery-related acts and regulations

Conventional Management

Conventional management, in contrast to traditional management, is based almost exclusively on scientific information and methods, using primarily quantitative data. These data are often synchronic in nature. That is, they are simultaneously observed, with little time depth. Conventional management takes a reductionist approach to the resource, and ecological complexities and uncertainties are often ignored. Resource managers are not the users themselves, and allocation decisions are made at a distance from the community. Such an approach leads managers in the direction of tighter government controls over fisheries. Such top-down management, over time, may become unworkable (Holling and Meffe 1996).

The conventional management approach was applied in the development of the commercial fishery for Arctic char in the Cambridge Bay area. Government established fishing areas, a harvest limit or quota, fishing seasons and, ultimately, a minimum mesh size limit (139 mm) for gillnets used in the commercial fishery (Barlishen and Webber 1973; Kristofferson and Carder 1980; Kristofferson *et al.* 1984). There were no regulations limiting the subsistence harvest. Table 12.1 summarizes some of the major features of the two kinds of approach to fishery management.

The Arctic char resource in nearby Freshwater Creek (Figure 12.1) was once abundant, which was why Inuit gathered seasonally at this "fair fishing place." However, the concentration of Inuit in the settlement of Cambridge Bay also meant increased concentration of fishing pressure in the area near the community, rather than rotational use over a wider geographic area. In 1961, the fishing co-operative was formed to begin the commercial exploitation of Arctic char in the area, and the first commercial fishery took place at nearby Freshwater Creek. However, the Freshwater Creek Arctic char fishery was showing signs of depletion (Barlishen and Webber 1973) because it was already supporting a large subsistence fishery as well as a non-native recreational fishery. Angling for Arctic char provided community residents with a much-needed pastime after a long cold winter. Therefore, the commercial fishery was relocated to the Ekalluk River in 1962 (Abrahamson 1964).

At the outset, an annual quota of 18,000 kg was allocated to the Ekalluk River commercial fishery (Barlishen and Webber 1973). This river-specific quota remained in effect until 1967, when area fishers petitioned the federal government for an area quota for Wellington Bay. The intention was to allow commercial fishing to take place at the Lauchlan, Halovik, and Paliryuak rivers that flow into Wellington Bay, as well at the Ekalluk River. An area quota of 46,000 kg was subsequently allocated to Wellington Bay. In 1967, the fishery reported sales of $28,904 and a net operating loss of $3,112. Fishers received $9,324 for their fish, while labour for processing earned $1,321 (Barlishen and Webber 1973).

The economic constraints of developing a commercial fishery in this area were severe. Float-equipped aircraft were used to transport the catch from the fishing sites to Cambridge Bay, and the frozen product was flown to markets in the South. In order to make a profit, fishers had to maximize the harvest and minimize the overhead. This led to a concentration of fishing effort at the Ekalluk River from 1967 to 1969. The result was a serious decline in the average size of Arctic char in the catch at Ekalluk River by 1969. The average weight of Arctic char taken in the Ekalluk River commercial fishery in 1963 was 3.9 kg. This had dropped to 1.4 kg by 1969. Consequently, the commercial fishery at the Ekalluk River was closed in 1970.

Following the closure of the Ekalluk River commercial fishery, river-specific quotas were put in effect and remain so to the present. This was based on the assumption that each river supported a discrete stock of Arctic char (Kristofferson *et al.* 1984). Gillnets, with a minimum mesh size of 139 mm, still predominate in the fishery, but a weir, now adopted for commercial harvesting purposes, has been used periodically at three sites (Jayco, Ekalluk, and Halovik rivers). This is a traditional-style weir but made of modern material (conduit pipe). There is no minimum size limit for Arctic char taken in the weir, although experience has shown that the larger char are selected. These river fisheries appear to have been sustained over the years. In 2003, Kitikmeot Foods Ltd., which runs the fishery, reported a harvest of 42,000 kg of Arctic char with sales of $450,000.

A total of twenty-four fishers received $140,000 for their efforts. The processing plant employed another sixteen people, who earned a total of $130,000 that year (C. Schindel, pers. comm.). However, in light of subsequent studies, the Arctic char resource, on a stock-by-stock basis, might well have been utilized in a less-than-effective manner.

Managing Arctic Char with Complex Stocks

Conventional fishery management, as used in the Canadian North and elsewhere, assumes that harvest quotas can be assigned on discrete stocks, whether for Atlantic cod or for Arctic char. There are a number of shortcomings of this approach, as criticized over the years (Charles 2001). It does not take into account ecosystem interactions such as predator-prey and competition relations; it does not take into account the year-to-year environmental variability; and it does not take into account complexities in stocks. Does the "discrete stock" assumption of conventional management hold in the Cambridge Bay fishery?

The study by Kristofferson (2002), which has revealed that multiple stocks of Arctic char spawn and overwinter within individual river systems, has complicated the management challenge. Significant differences in morphology (Figure 12.2) and trace elements (strontium) in otoliths (Figure 12.3) were found among aggregations of spawners both within and between river systems. This information supports the current river-specific harvest limits. However, the trace element data (Figure 12.3) indicate that fall upstream migrations are comprised of an admixture of Arctic char from the different resident stocks, as well as itinerant Arctic char from other river systems that migrate in only for overwintering purposes.

Such complexities pose a challenge to the conventional management approach, which is based on the assumption that the fishery is targeting a homogeneous stock at each fall fishing site. Random samples are taken each year from the commercial harvest that is carried out on these upstream migrations. Length and age data gathered over successive years are examined annually to determine the response of the stock to certain harvest levels. These random samples likely have no biological meaning because the harvest is comprised of Arctic char from more than one stock and the proportional contribution of each stock to the fishery is unknown. Such data would not be sensitive to a decline of smaller, more vulnerable stocks, and larger stocks could be harvested at less than optimal levels. Thus, utilizing these data for monitoring and modelling purposes is likely to give spurious results. Clearly, there is a need to manage these Arctic char fisheries as mixed-stock fisheries, and to develop appropriate techniques to do so.

A number of techniques have been used to estimate stock composition in the conventional management of mixed-stock fisheries. Examples of these techniques utilize stock differences based on morphology (Messinger and Bilton 1974; Cook 1982; Fournier *et al.* 1984; Friedland and Reddin 1994), enzyme electrophoresis (Utter and Ryman 1993), mitochondrial DNA (Bermingham *et al.* 1991) and nuclear DNA (Galvin *et al.* 1995). These and other techniques should be investigated in

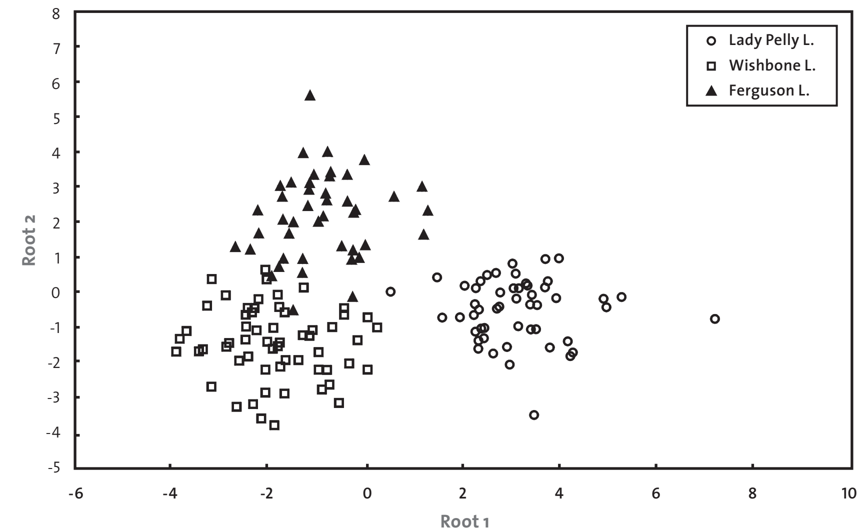


Figure 12.2a

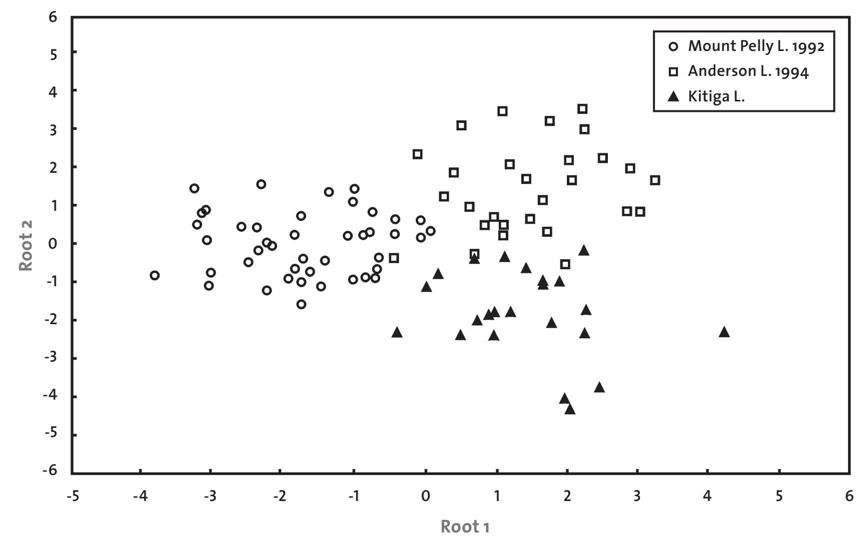


Figure 12.2b

Delineation of three discrete stocks of Arctic char based on morphology (Discriminant Function Analysis) (a) within the Ekalluk River system and (b) among three different river systems (from Kristofferson 2002).

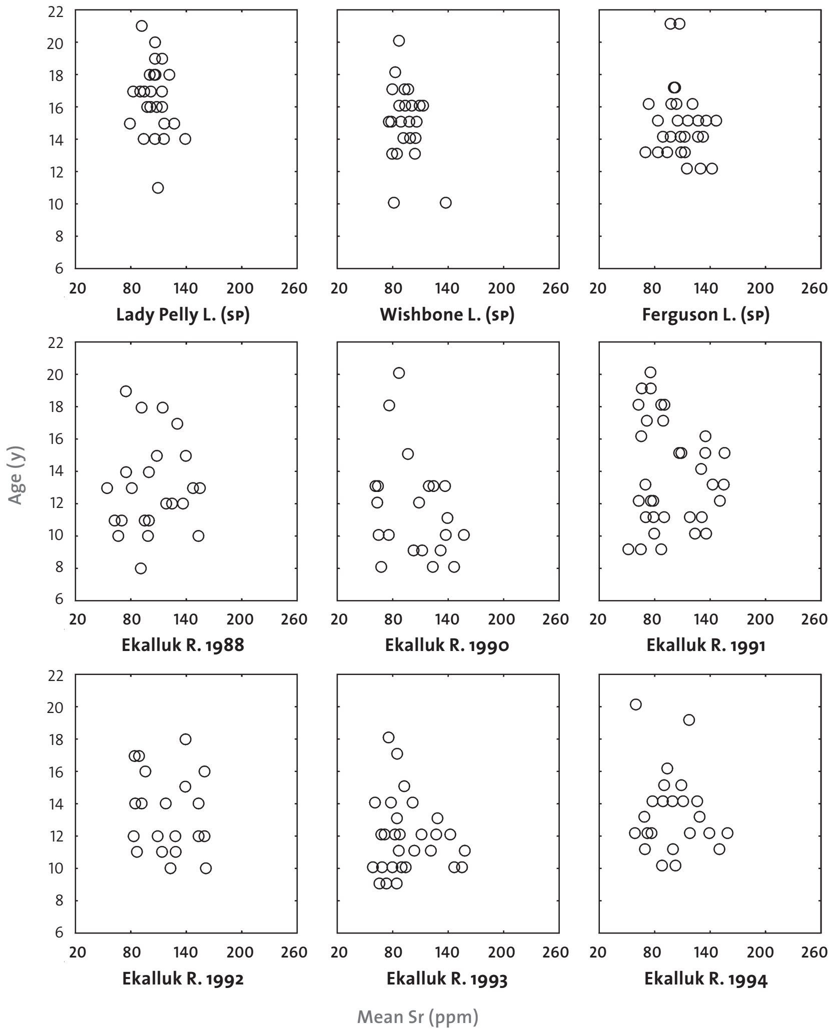


Figure 12.3 Mean strontium concentration in otoliths of three groups of spawners (upper row) compared with those from six upstream runs (below). The greater variation in samples from upstream runs is indicative of mixed stocks. (from Kristofferson 2002).

terms of their usefulness for managing mixed-stock Arctic char fisheries in the study area. However, even when this is done, the current conventional management strategy alone will likely not deal adequately with stock complexity and environmental uncertainty.

Evolution of Co-management in the Cambridge Bay Fishery

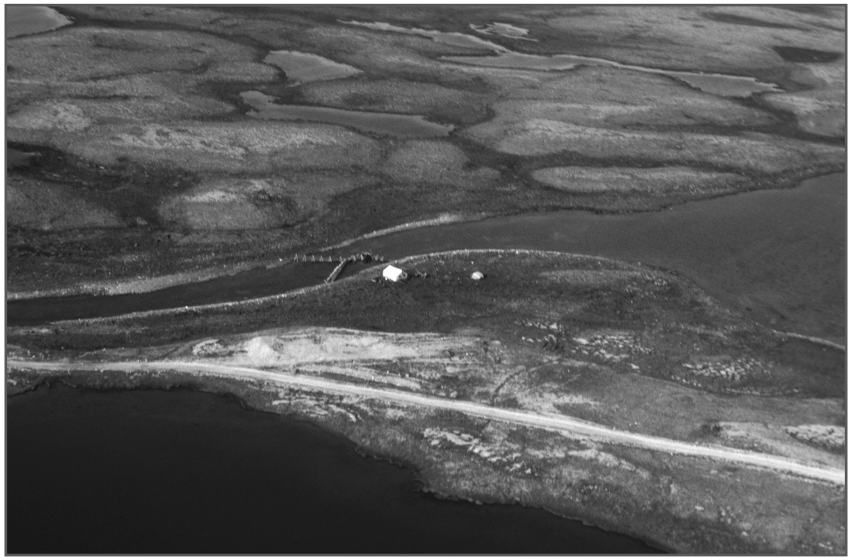
In many cases, fisheries need to be managed on a small ecological scale, taking into account local ecological factors such as habitat and local populations that

The community of Cambridge Bay, Nunavut, located on the south coast of Victoria Island. Photo by D.K. McGowan, Department of Fisheries and Oceans.

are central to the health of the whole ecosystem. Fisheries management needs to be designed to fit this smaller scale by allowing resource users to take more responsibility for management and by utilizing their local knowledge of the resource (Berkes *et al.* 2001a). This can be accomplished through co-management, defined as a sharing of power and responsibility between the state and resource users in the management of natural resources (Pinkerton 1989).

Co-management as a process is flexible and participatory, and provides a forum for rule making, conflict management, power sharing, leadership, dialogue, decision making, negotiation, knowledge generation and sharing, learning, and development among resource users, stakeholders, and government (Berkes *et al.* 2001a). Co-management allows passing of responsibilities to resource users who then become accountable for their decisions. It can use fishers' own local knowledge, so that they become active participants in the development of management plans.

In Canada, almost all of the Arctic char resource is found in areas under land claims agreements: the Nunavut Territory, the Inuvialuit Settlement Region of the Northwest Territories, the Ungava region (which is under the *James Bay and Northern Quebec Agreement*), and the Labrador coast (where a land claims agreement is nearly finalized). The settlement of land claims in these areas has formalized resource co-management (Berkes *et al.* 2001b), and almost all Arctic char stocks are under joint jurisdiction. The details of sharing of jurisdiction for fisheries management can be found in specific sections of the *Nunavut Land Claims Agreement* (1993), the *Inuvialuit Final Agreement* (1984), and the other agreements.



The counting weir located upstream on Freshwater Creek.
Photo by D.K. McGowan, Department of Fisheries and Oceans.

Well before the *Nunavut Land Claims Agreement* came into effect in 1993, a form of co-management had developed between the Government of Canada, Department of Fisheries and Oceans (DFO), and the residents of Cambridge Bay. Initially, the local participation in management was limited to the employment of Inuit as technicians in management work.

During the late 1970s and early 1980s, DFO staff used a weir to enumerate the upstream migration of Arctic char at various commercial fishing sites in the Cambridge Bay area. Local Inuit were hired to assist in these projects and became familiar with this counting technique. Presentations of the results of these projects to community members contributed to a better understanding of what could be accomplished with this technique. Community members were well aware of the dwindling Arctic char resource in the nearby Freshwater Creek. Through the local *Ekaluktutiak Hunters and Trappers Association* (now called *Hunters and Trappers Organization*), they approached DFO with a request to enumerate the upstream migration of Arctic char in Freshwater Creek as a first step toward rehabilitation of the stock. DFO complied with this request and the upstream migration was enumerated by weir in 1982. This included a tagging program to determine the level of exploitation, harvest by fishery (recreational, subsistence), and the seasonal distribution of the Arctic char of Freshwater Creek.

The 1982 weir project counted 9,961 Arctic char in the upstream migration (McGowan and Low 1992), and 1983 returns on the 808 Arctic char tagged in 1982 revealed an exploitation rate in excess of 12 per cent. A study at nearby Nauyuk Lake (Johnson 1980) indicated that this was excessive for Arctic char stocks in the area. The estimated total harvest in 1983 was just under 2,000 Arctic char. A creel census taken in 1983 (Carder 1991), combined with tag returns from the various fisheries, revealed that about 46 per cent of the harvest was taken by the recreational fishery, 50 per cent by the subsistence fishery, and 4 per cent by the commercial fishery. In the following years, 86 per cent of all tag recoveries (N = 163) were made in Freshwater Creek, the sea near Cambridge Bay, or nearby Greiner Lake. The small number of Arctic char counted in the 1982 assessment convinced the residents of Cambridge Bay to develop a recovery plan for the Freshwater Creek Arctic char stock. Although it took time to implement, it appears to have been somewhat successful.

The evolution of the informal co-management in this fishery did not occur in a planned way. It occurred through the mutual recognition of a problem. The results of the tagging study revealed that both the recreational and subsistence fisheries were targeting the Freshwater Creek Arctic char stock. This provided information to the community and government that there was a need to reduce the harvest of both fisheries. The government responded by reducing the catch and possession limit for non-native sport fishers, and the community implemented a ban on its own subsistence gillnet fishing.

The locations where tagged char were captured provided the information needed to delineate the area where fishing pressure had to be reduced. The periodic counts of the upstream migration and the increase in migrant char observed in these counts provided information to community residents that their recovery program appeared to be successful. The periodic monitoring of the harvest provided evidence of compliance with the fishing restrictions. In essence, government and the community discovered through experience that each had critical information necessary to address the problem.

They found that by working together, they were able to accomplish what has been interpreted as a recovery of the Freshwater Creek Arctic char stock. In terms of power sharing, government had the authority to reduce daily catch and possession limits for non-native fishers, and they did so, from four Arctic char per day and seven in possession, to one per day. Government has no regulation on the subsistence fishery, but the community put a moratorium on subsistence gillnetting into effect, and ensured compliance through community sanctions. The informal co-management at Cambridge Bay is summarized in Table 12.2. As a footnote, although the number of Arctic char counted in the 1994 upstream migration was less still than that counted in 1991, the average size of char in the run had increased by 1994, as had the proportion of char of reproductive size.

Legislated Co-management under the Nunavut Agreement

Clearly, the sharing of management power is not a new concept to the residents of Cambridge Bay. But in any case, joint management has been instituted across the North through land claims agreements (Berkes and Fast, this volume). The legislated co-management put in effect in 1993 by the *Nunavut Land Claims*

Table 12.2

A SUMMARY OF INFORMATION-SHARING AND DECISION-MAKING BETWEEN DFO AND THE COMMUNITY OF CAMBRIDGE BAY THAT REPRESENTS AN INFORMAL CO-MANAGEMENT APPROACH TO THE ARCTIC CHAR FISHERY AT FRESHWATER CREEK

Government	*Community*
Weir count 1982 (9 961)	Community participation in creel census
Tagging program 1982 (N=808)	Moratorium on subsistence gillnets (1988)
Creel census 1983	Community monitoring to comply with moratorium on gillnets
Weir count 1988 (36 933)	Door-to-door harvest survey (1992, 93,94)
Reduce recreational limit (1 char daily) 1991	Continue dialogue with DFO
Weir count 1991 (39 559)	Continue dialogue with DFO
Weir count 1994 (26 150)	Concern by community on lower count

Agreement (NLCA) has provided the Inuit with the legal arrangements necessary to establish rights over natural resources, including fisheries. International experience suggests that a legal arrangement is necessary if co-management is to be durable and successful (Pomeroy and Berkes 1997; Berkes *et al.* 2001a).

Under Nunavut agreement, *Article 5, Wildlife*, the Principles (5.1.2 NLCA) recognize, among other things, that "there is a need for an effective system of wildlife management that complements Inuit harvesting rights and priorities, and recognizes Inuit systems of wildlife management that contribute to the conservation of wildlife and protection of wildlife habitat." The Principles also recognize the "need for an effective role for Inuit in all aspects of wildlife, including research," and that "Government retains the ultimate responsibility for wildlife management." The *Objectives* (5.1.3 NLCA) recognize, among other things, the creation of a wildlife management system that "fully acknowledges and reflects the primary role of Inuit in wildlife harvesting," and "invites public participation and promotes public confidence, particularly amongst Inuit."

The Nunavut Wildlife Management Board (NWMB) was established as the main instrument of wildlife management in the Nunavut Settlement Area (5.2.1 NLCA). It is a nine-member board with four Inuit representatives, four government representatives, and a chairperson nominated by the NWMB. While it recognizes that Government has the ultimate responsibility for wildlife management (5.2.33 NLCA), the NWMB functions in a variety of different ways. It participates in research, conducts the Nunavut Wildlife Harvest Study, rebuts presumptions as to need, establishes, modifies, or removes levels of total allowable harvest, ascertains and adjusts basic needs level, allocates resources to other residents and existing operations. It also deals with priority applications, makes recommendations as to allocation of remaining surplus, establishes, modifies or removes non-quota limitations, sets trophy fees, and any other function required by the agreement.

Recognizing the ability and the right of the Government of Canada to carry out its research function, the NWMB also has a role to play in research as outlined in 5.2.37 of the NLCA. This includes identifying research requirements and deficiencies pertinent to wildlife management, identifying relevant persons and agencies to undertake wildlife research, and promoting the employment of Inuit and Inuit organizations in research.

The Department of Fisheries and Oceans is charged with the development of Integrated Fisheries Management Plans (IFMP) with resource users across Canada. The mandate for the development of IFMPs also holds in areas where settled land claims exist. These IFMPs are based on the principles of co-management. Inuit traditional knowledge or *Inuit Qaujimajatuqangit* (IQ) has traditionally been a part of Inuit systems of fisheries management. The DFO recognizes the role of IQ in all aspects of fisheries management, including research, and the need to incorporate it into IFMPs wherever possible.

DISCUSSION AND CONCLUSIONS

Adaptive management is a relatively new management approach that has developed out of concern with uncertainty in fishery and wildlife management (Holling 1978). It advocates learning from management successes and failures, and relies on systematic feedback learning. It utilizes common-sense logic that emphasizes learning-by-doing and it eliminates the barrier between research and management. Adaptive management can be viewed as a rediscovery of traditional systems of knowledge and management. Although there are differences between the two, adaptive management is, in a sense, the scientific analog of traditional ecological knowledge because it integrates uncertainty into management strategies and it emphasizes practices that confer resilience (Berkes *et al.* 2000).

Adaptive and conventional resource management differ primarily in approach and scientific methodology (McDonald 1988). Conventional resource managers attempt to simplify complex relationships in harvesting systems, accumulating large quantities of data that form the basis of conservative harvesting policies until a better biological understanding can be achieved. Adaptive managers, on the other hand, acknowledge uncertainty and attempt to identify key relationships in an ecosystem that can provide a measure of how the resource responds to various management practices. While both management approaches recognize the need for management, they differ in their perception of the role of biological uncertainty (McDonald 1988). The conventional approach assumes that biological uncertainties can be resolved through research and modelling. The adaptive management approach recognizes the inherent uncertainty of ecological systems and emphasizes the need to learn from experience and experimentation to deal effectively with uncertainty (Walters 1986).

Co-management is adaptive because it is based on learning through information sharing among stakeholders, leading to problem solving in a stepwise matter and to iterative improvements in management (Berkes *et al.* 2001a). This is indeed what has happened through experience at Freshwater Creek in Cambridge Bay. The case study also indicates another key element of co-management.

An essential ingredient for successful co-management seems to be the establishment of a level of trust among all involved. Government fisheries personnel spent a number of years in Cambridge Bay working on river systems other than Freshwater Creek and involved residents in the field studies, and residents began to see the value of this work. Community meetings were held explaining the results of the studies as they became available. People got to know one another as individuals and knowledge was shared freely. Because co-management is adaptive, allowing participants to adjust their activities based on results obtained and lessons learned, modifications to the recovery plan took place as new data became available.

Community members understand their own situations better than outsiders do, and can devise and administer regulatory mechanisms that are often more appropriate than those imposed by external regulations. While government could, and did, restrict the harvest of char by non-native anglers in Freshwater Creek through changes in regulations, no such mechanism existed to limit the subsistence harvest. This was accomplished through community sanctions. Community involvement may give fishers a sense of ownership that often translates into greater compliance with management measures over the long term. This apparently happened in the Cambridge Bay experience.

Legislative change under the *Nunavut Land Claims Agreement* now sets the stage for formalizing this informal arrangement and building on it. Can the collaborative management that evolved in Cambridge Bay be characterized as adaptive co-management in the sense used by Folke *et al.* (2002) and Olsson *et al.* (2004)? The informal arrangement certainly has some of the elements of adaptive co-management. But the arrangement can be improved through more effective collaboration (as now legally required) and more systematic adaptive management that incorporates active learning into the management design (Walters 1986). An outline for an adaptive co-management process for the Arctic char resource in the Cambridge Bay area is presented in Table 12.3. It follows the three cyclical phases in the adaptive management process presented by Walters (1986), which includes identifying a range of management alternatives, developing key management indicators, and the design and implementation of effective monitoring systems. While there is no single "correct" method of implementing adaptive management (Holling 1978), it is necessary to develop a plan that is specific to the system, and then to implement it. Success may be achieved over time, essentially by learning-by-doing.

The study by Kristofferson (2002) provided information that has revealed a level of complexity in stock structuring of sea run Arctic char that was previously suspected but not proven. Currently, there is no way to manage Arctic char in the Cambridge Bay area on a stock-by-stock basis. Even if stock admixtures can be taken into account, the cost of the data needed would be prohibitive.

Table 12.3

STEPS TO IMPLEMENT AN ADAPTIVE CO-MANAGEMENT PLAN FOR ARCTIC CHAR IN THE CAMBRIDGE BAY AREA

Headings follow McDonald (1988).

Phase	***Implementation Action***
Dialogue	Conduct a community presentation to outline the study results and the problem. Include a discussion of conventional management, identification of management goals and the need for an alternative approach. Develop a shared understanding of the management problem to be solved. Document Inuit understanding of the problem and how they perceive the resource. Discuss commonalities and differences
Field Study and Analysis	Identify the need to collect and analyze additional information to provide a better understanding of the biological relationships within the ecological system that relate to key questions posed by management goals. Incorporate traditional ecological knowledge such as identification of additional spawning grounds within river systems. Develop methods to determine the relative contributions of different stocks to a mixed fishery.
Design of Alternative Management Actions	Explore alternative management options jointly such as pulse fishing, use of different gillnet mesh sizes, weirs, timing of fishery, that can be tested within the range of predictive outcomes.
Monitoring and Assessment of Management Actions	Analyze management actions in relation to outcomes predicted by ecological theory. Identify key indicators in the system (index netting of spawning aggregations) to ensure the quality of the monitoring system. Maintain continuous dialogue with fishers to assess their "gut feelings" of responses of stocks to each management action.
Evaluation	Determine likely impacts of alternative management options (modelling) in view of the different approaches taken. Jointly identify key questions posed by the management options which initiates subsequent rounds of the adaptive management process.

The conventional management approach, as it has been applied to this fishery, has proven to be less than effective in light of this additional complexity. An adaptive approach can utilize different methods such as rotational pulse fishing, removing a range of sizes of Arctic char with variable mesh size gillnets or weirs, and fishing over the duration of upstream runs to spread effort over as many stocks as possible, if there is temporal segregation of returning stocks. As many spawning sites as possible need to be identified in each river system fished, and this can often be accomplished using traditional ecological knowledge (Inuit IQ). Periodic monitoring of these spawning assemblages can be used to assess the effects of a particular management method on individual stocks. Changes in the management plan can then be implemented if data indicate a decline in any particular stock.

An adaptive co-management approach, implemented under current legislation in effect throughout most of the distribution area of Arctic char in Canada, offers a potentially effective way to manage the Arctic char resource, while simultaneously providing optimum socio-economic benefits to resource users. It may provide an opportunity to combine traditional ecological knowledge with the scientific research that will ultimately lead to a better understanding of biological complexities and ways of dealing with ecological uncertainties. It will also provide users with the incentive to utilize the resource in the best manner possible because of their partnership in management, ultimately contributing to more effective resource management in the Cambridge Bay area and elsewhere throughout the Territory of Nunavut.

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