Towards an improved understanding of community-based monitoring:

A case study of the Wemindji Community Fisheries Program

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Abstract

Community-based monitoring (CBM) is widely recognised as a cost-effective alternative to conventional externally-driven, professionally executed monitoring. It has the potential to improve understanding of wildlife and ecosystems, enhance local authority and capacity, and contribute to the inter-generational transmission and cross-cultural exchange of knowledge. CBM can take a variety of governance approaches, including three categories of CBM involving indigenous communities: contributory monitoring (limited to local inputs); collaborative monitoring (roughly equal partnerships); and community-led (local control over all aspects). Unfortunately, few assessments of local indigenous perspectives are available within the field of CBM. This thesis addresses this gap by drawing upon the experience of a James Bay Cree First Nations community with one of the longest running subsistence fisheries monitoring programs ever conducted in the Canadian north. Specifically, we identify the benefits and challenges experienced as a result of twenty-three years of the Wemindji Coastal Fisheries Monitoring Program. The study uses semi-structured interviews and participant-based observations to facilitate the identification of program components, with a strong emphasis on the perspectives of local Cree program participants and administrators. It is hoped that my findings can contribute to the design and implementation of locally meaningful, and culturally appropriate, CBM programs that simultaneously maximize knowledge and labour inputs from local indigenous resource users.

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List of Abbreviations

ABC: Arctic Borderlands Ecological Knowledge Co-op

CBC: Community-Based Conservation

CBD: Convention on Biological Diversity

CBM: Community-Based Monitoring

CBMP: Circumpolar Biodiversity Monitoring Program

CBNRM: Community-Based Natural Resource Management

CMMP: Community Moose Monitoring Project

CPUE: Catch-Per-Unit-Effort

CTA: Cree Trappers Association

GIS: Geographical Information System

GPS: Global Positioning System

ICDP: Integrated Conservation and Development Project

ILO: International Labour Organization

JBNQA: James Bay and Northern Quebec Agreement

MPA: Marine Protected Area

NMCA: National Marine Conservation Area

NSTP: Northern Scientific Training Program

PA: Protected Area

PNAP: Plan Nord Action Plan

QCBS: Québec Centre for Biodiversity Science

SAR: Search and Rescue

UNDRIP: United Nations Declaration on the Rights of Indigenous People

WCFP: Wemindji Community Fisheries Program

WCFMP: Wemindji Community Fisheries Monitoring Program

Chapter 1: Introduction

In recent decades the contributions of local indigenous communities to conservation and natural resource management strategies have been increasingly acknowledged (Nadasdy, 1999; Kimmerer, 2002; Nadasdy, 2003; Houde, 2007). This recognition has been informed by developments at the international level. The first major call for action towards an improved understanding of human-environment interactions came from the 1972 United Nations Conference on the Human Environment (Stockholm Conference). In 1987, Our Common Future, the report released by the Brundtland Commission, highlighted the connection between indigenous peoples and the earth's sustainability because of their unique knowledge and stewardship practices. In Canada, the contributions of indigenous peoples are demonstrated through their ongoing commitments as stewards of their traditional territories. This is strengthened by Section 35 of the Constitution Act of 1982 which recognizes the rights of indigenous peoples within Canada, including their right to hunt, fish and trap for subsistence purposes.

International efforts to recognize the contributions of indigenous peoples include article 8(j) of the 1992 Convention on Biological Diversity (CBD) which supports the protection of indigenous knowledge and the International Labour Organization (ILO) which promotes respect for the social and cultural values of indigenous peoples (The Indigenous and Tribal Populations Convention of 1957; The Indigenous and Tribal Peoples Convention of 1989). More recently, the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP) affirmed indigenous peoples' rights and recognized the significance of their knowledge, culture and traditional practices. Canada adopted the UNDRIP in 2010, following its initial refusal to sign in 2007.

Efforts, particularly at the international level, to recognize the rights and interests of indigenous peoples have been paralleled by the rise of neoliberalism and its attendant support for free trade, open markets and deregulation (Mulrennan et al., 2012), whereby the interests of private industries and economic development agendas and goals are prioritized over those of local peoples and their livelihoods.

This makes it increasingly difficult for indigenous peoples to pursue traditional lifestyles resulting from the loss of communal social values in favor of individuality and private industry. Neoliberal policies are transforming the manner in which local and indigenous communities are represented and consulted within governmental decision-making, including offering opportunities for local communities to assume greater roles and responsibilities in managing their affairs (Nadasdy, 2003).

The shift from command and control approaches was also supported by a paradigm shift in the environmental sciences that acknowledged nature as an inherently disordered complex system associated with unpredictable changes and interactions. A spectrum of participatory governance arrangements emerged, extending from degrees of shared decision-making power to self-management. In Canada, co-management arrangements were embraced as the centerpiece of comprehensive land claims settlements, including protected areas contexts, but this maybe shifting as more indigenous groups insist on and achieve conditions that support enhanced indigenous autonomy, including in some instances self-management regimes. The proliferation of co-management boards in northern Canada, involving degrees of shared decision-making power between communities and government, was widely regarded as an opportunity for knowledge integration (Plummer & Fitzgibbon, 2004).

The conservation community also called for collective action, and the inclusion of multiple forms of knowledge and perspectives (Berkes, 2007) given the unpredictability of natural ecosystems (Holling, 1973). In Canada, examples of successful community-based conservation projects and initiatives have been documented in the academic literature. In speaking to co-management, Mabee and Hoeberg (2006) have described its benefits in the context of forest management in Clayoquot Sound, British Columbia. Freeman and Wenzel (2006) have suggested that community-based polar bear management has resulted in improved wildlife management and economic development opportunities in the Canadian Arctic. While both rely on principles of self-governance, co-management arrangements allow for increased opportunities for external collaboration from interested stakeholders. Castleden et al. (2012) and Koster et al. (2012) suggest that community-based participatory research can enhance the authority of local and indigenous communities in relation to their stewardship of their traditional territories.

Community-based monitoring (CBM) is recognized as a potentially valuable contributor to such forms of governance, providing opportunities for local knowledge inputs, while offering a cost-effective alternative to conventional top-down monitoring programs (Carr, 2004; Dyck, 2007). Moreover, increasing interest, and requirements by regional governments, in adaptive co-management and collaborative partnerships has further supported a growth in CBM.

The outcome of these various theoretical and policy shifts has been the increased adoption of community-based management and monitoring. The approaches adopted to accommodate these shifts have been the focus of an expanding literature in the field of community-based management (Holling & Meffe, 1996; Brosius et al., 1998; Forgie et al., 2001; Natcher & Hickey, 2002; Berkes, 2004) and the subject, particularly in the highly contested field of protected area development, of much controversy (Redford & Sanderson, 2000; Terborgh, 2000; Redford et al., 2003).

Community-based approaches that primarily include locally-driven and self-organized efforts, have been advocated and applied in numerous sectors within Canada, including fisheries management (Graham et al., 2006), forestry management (Mabee & Hoeberg, 2006) and protected areas management (Ban et al., 2008) in order to support local resource users that are actively engaged in the harvesting and management of local natural resources. While Canada has an established history of community-based initiatives, including those involving indigenous peoples, our understanding of their contribution is generally lacking. More specifically, there is a gap in the academic literature describing the benefits and challenge of CBM approaches in indigenous contexts. This research aspires to fill that gap.

1.2 Research Objectives

Within the scope of my research, the aforementioned developments over the past three decades, have contributed to a growing recognition of indigenous communities at international and domestic levels as well as within conservation science and management. The primary objective of my research is to contribute to this recognition by identifying best practices in the field of community-based monitoring and conservation that will facilitate enhanced roles and responsibilities for indigenous peoples with respect to their stewardship of their traditional lands, seas and resources.

To achieve this, I have conducted an assessment of an established subsistence fisheries monitoring program. My secondary objectives, which reflect the interests of indigenous partners with whom this research was co-designed, are:

1. To assess the extent to which monitoring has been used to inform decision-making;
2. To gain insights into the dynamics of local resource monitoring through the introduction of two innovations to the program;
3. To make recommendations for improvements to the program; and
4. To identify trends in subsistence fisheries harvesting over time.

1.3 Context of the research

This thesis examines the Wemindji Coastal Fisheries Program (WCFMP), a monitoring program that involved the James Bay Cree community of Wemindji in relation to its coastal subsistence fisheries. My motivation in conducting this research was to document the experience of local subsistence fishers and fishing families in relation to the program, and to explore implications for improving current and future subsistence-based monitoring programs in the region. The WCFMP, which ran from 1989 to 1996 and from 2003 to 2011, was established under the broader Wemindji Coastal Fisheries Program (WCFP), a mitigation program with the purported objective of providing the community of Wemindji with fresh, uncontaminated fish, in response to the mercury contamination. The WCFP was one of numerous programs designed to support traditional hunting, trapping and fishing in the Eeyou Istchee. The WCFP included two components: support for and promotion of traditional coastal fishing activities through seasonal income support; and "monitoring of fish catches in order to ensure the long-term availability of fish for future generations" (Hydro-Québec, 1990) through the Wemindji Coastal Fisheries Monitoring Program (WCFMP).

My research is part of a larger program of research on traditional ecological knowledge, community-based conservation and protected area development, including the proposed creation of a Tawich National Marine Conservation Area (NMCA) in the Wemindji offshore (Mulrennan et al. 2009). As such, the implications of my study go beyond fine-tuning an existing local monitoring program. Understanding how and why local resource users have provided input into this local scale-monitoring program may be useful when designing monitoring programs at larger spatial scales, such as is anticipated for marine and terrestrial protected areas in the region.

1.4. Organization of the thesis

The thesis follows a manuscript-based format and is comprised of seven chapters and an appendix. Given the format, both manuscripts (Chapters 4 and 5) borrow from other chapters within the thesis; some repetition can be expected. Chapter 2 provides a literature review examining community-based conservation, traditional ecological knowledge, community-based monitoring and its historical context, and some context on subsistence-based fisheries. The methodologies used to address the research objectives are presented in Chapter 3, followed by a description of the study area. The first of two manuscripts is then presented in Chapter 4, focused on an account of the WCFMP and is intended for publication in the Journal of Ocean and Coastal Management. The second manuscript is presented in Chapter 5 where I attempt to present a typology of CBM projects according to the type and extent of indigenous participation and will be submitted to the Journal of Marine Policy for review. Finally, Chapter 6 provides a concluding discussion to the thesis.

Chapter 2. Literature Review

2.1 Community-based conservation

Various forms and cases of community-based conservation (CBC) have been documented. The academic literature is dominated by a focus on integrated conservation and development projects (ICDPs), which are generally limited to the developing world (Brandon & Wells, 1992; Wainwright & Wehrmeyer, 1998; Brown, 2002; Campbell & Vainio-Mattila, 2003; Garnett et al., 2007; Haque et al., 2009;), and co-management initiatives (Pomeroy & Berkes, 1997; Castro & Nielsen, 2001; Bradshaw, 2003; Nadasdy, 2003; Mabee & Hoeberg, 2006; Dyck, 2007; Freeman & Wenzel, 2006; Plummer & Armitage, 2007; Ban et al., 2008) in indigenous-settler states, including Canada, Australia, New Zealand and the United States of America.

In principle, the definition of CBC, as defined by Western and Wright (1994), "includes natural resources or biodiversity protection by, for, and with the local community" (as quoted in Berkes, 2007, p. 15189). Borrini-Feyerabend et al. (2000) defined co-management as "a situation in which two or more social actors negotiate, define, and guarantee amongst themselves an equitable sharing of the management functions, entitlements, and responsibilities for a given territory or set of natural resources" (as cited in Castro & Nielsen, 2001, p. 230). Strictly speaking co-management is not a form of community-based conservation, rather it has been observed by Pomeroy and Berkes (1997, p. 467) to be "a middle course between pure state property and pure communal property regimes".

In a review of the CBC field in the developing world, Campbell and Vainio-Mattila (2003) suggest that community-involvement should not be a "mechanism" for achieving conservation; communities must be recognized as the backbone of conservation efforts. They also identified three trends within the conservation field: (i) conservation and development agendas are converging; (ii) development agendas and organizations are increasingly funding conservation projects; and (iii) the field of CBC was not learning from past conservation and development failures.

In an attempt to create a framework for the analysis of ICDPs, Garnett et al. (2007) found that priority was given to the conservation of natural resources rather than the livelihoods of the people living within the region. In order to balance conservation and development more effectively, an improved understanding of natural, human, social, built, and financial assets within the region is needed. In instances where a certain level of environmental protection already existed (e.g. protected areas (PA)), Brandon and Wells (1992, p. 557) found that the "cooperation and support of local people" was required for the success of the protected area because of the reliance of people living in and around protected areas upon the primary resources available within that area. The inclusion of communities within conservation areas has led to heated debates within the literature polarized between two different views of humans in relation to conservation where: (i) human inhabitants should be included in the biodiversity of the landscape (Chicchón, 2000; Colchester, 2000; Schwartzman et al., 2000a; 2000b); and (ii) human inhabitants must be excluded from the biodiversity of the landscape (Redford & Sanderson, 2000; Terborgh, 2000).

Agrawal and Gibson (1990) identified the oversimplification of local communities as a major obstacle to CBC, often resulting in the erroneous perception that local communities are an obstacle to achieving conservation goals. Numerous studies support their assessment of a lack of understanding of the concept of "community" (Brown, 2002, Mulrennan, 2008; Mulrennan et al., 2012).

Notwithstanding heated debates and controversies surrounding CBC, many successes have been documented within the field (Jones, 1999; Lobe & Berkes, 2004; Mabee & Hoeberg, 2006; Freeman & Wenzel, 2006; Dyck, 2007; Ban et al., 2008). Jones (1999) described the success of a community-based initiative facilitating wildlife management within the Kunene Region in Namibia. Lobe and Berkes (2004) described how the use of a traditional lottery system in Kerala, Tamil Nadu and Sri Lanka allows for rotational access to coastal resources, all the while increasing community resilience.

In Canada, Section 35 of the Constitution Act of 1982 recognizes the rights of indigenous peoples to hunt, trap, and fish for subsistence purposes. The Beaufort Sea Integrated Ocean Management Plan is one successful example of how indigenous identity, participation, and recognition of traditional land rights were maintained through constitutional recognition (Beaufort Sea Partnership, 2009). Ban et al. (2008) described how such an arrangement has allowed for the traditional harvesting of beluga by Inuvialuit peoples within a marine protected area (MPA). Freeman and Wenzel (2006) have observed that community-based wildlife management, through a co-management framework, of polar bears resulted in increased community development in the Canadian Arctic. Cooperation between local hunters, government and university scientists led to community allocated hunting quotas, resulting in increased levels of community responsibility and involvement. Local hunters have been placed at the forefront of wildlife management and conservation as they are the ones gathering and sharing biological data with wildlife managers (Freeman & Wenzel, 2006).

Mabee and Hoeberg (2006) described the benefits that co-management has played in Clayoquot Sound's forest management. They found that that co-management arrangements resulted in improved relationships between indigenous and government stakeholders. However, the participants did not consider the co-management arrangement in Clayoquot Sound as an "equal partnership" and members of the Nuu-chah-nulth First Nation expressed dissatisfaction with the arrangement (Mabee & Hoeberg, 2006, p. 884).

The literature also refers to unsuccessful attempts at CBC. Pomeroy and Berkes (1997) and Bradshaw (2003) found a lack of trust displayed by decision-making bodies towards local resources users, in relation to their ability to manage local natural resources, as a primary reason for the failure of CBC. Plummer and Armitage (2007, p.7) claim that "the unwillingness and inflexibility of the state and resource managers to share power" results in inefficient natural resource management. They called for increased levels of responsibility and power sharing with local communities in order to move towards more effective and efficient natural resource management. Nadasdy (2003) goes further, suggesting that complete devolution of decision-making powers in favor of local communities (i.e. First Nation residents) is required.

Greater attention is also being given to collaborations and partnerships between researchers and indigenous communities. Koster et al. (2012, p.195), highlight the importance of a change "from research on, to research with and for indigenous communities". Their findings indicate that it is primarily western science that benefits from research carried out "on" indigenous peoples, whereas research conducted "with and for" indigenous peoples, results in indigenous communities and external researchers benefiting from research outcomes. In order to achieve mutually beneficial and respectful collaborative research, Koster et al. (2012) advocate for frameworks that actively encourage and support open communication and respect.

Mulrennan et al. (2012) propose once such framework; using participatory research as a way to revamp community-based conservation. Through "community-defined research agenda[s]" (p. 250), "collaborative research process[es]" (p. 251), and "meaningful research outcomes" (p. 253), participatory research aims to strengthen local community capacity and institutions through a process of "co-learning" (Mulrennan et al., 2012, p. 256). In a Canadian indigenous community context, such an approach is favored by Koster et al. (2012) as it encourages an atmosphere of mutual respect between all involved parties, whilst favoring local community-driven priorities.

2.2 Traditional Ecological Knowledge

Traditional ecological knowledge (TEK) is defined by Berkes et al. (2000, p. 1252) as the "cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment". In his review of TEK, Houde (2007) elaborated on the definition by stating that "this type of knowledge is also about understanding the interrelationships that occur among species, the connections within the biophysical environment, and the spatial distributions and historical trends of spatial and population patterns, allowing for the monitoring of ecosystem health indicators and the measurement of ecological changes, including climate" (Houde, 2007, p. 4).

Huntington (2000) observed that the understanding of TEK is facilitated by its practitioners, not the natural resource being harvested or managed. The documentation of TEK involves semi-structured interviews, questionnaires, analytical workshops, and collaborative field work. Particular challenges in applying TEK arises when western-scientific (abstract) and traditional (historical) practices are simultaneously used (Nadasdy 1999, 2003; Berkes et al., 2000; Houde, 2007). Houde (2007) suggested that the use of the word "traditional" by indigenous communities differentiated the management systems utilized within co-management arrangements. The latter have been perceived as western science dominated. Although Kimmer (2002) and Drew (2005) noted that the IUCN supported the utilization of TEK alongside western science in order to provide a more comprehensive form of knowledge, "factual TEK is open to being misinterpreted or discarded when it does not serve the particular interests of the state or private interests represented by the state" (Houde, 2007, p.5). Houde (2007) observed that TEK supported local subsistence. TEK is used in the management of natural resources within the practitioner's local environment (Olsson & Folke, 2001). It is temporal in nature, reflecting the knowledge of the changing environment and its present uses (Drew, 2005). Observations made by Houde (2007) showed that the characteristics and social structure surrounding TEK differed from the manner in which management regimes were accustomed to working; the challenge was the incorporation of TEK within these management contexts.

Nadasdy (1999, 2003) suggests that TEK is often utilized as a "new" dataset within a project, making it difficult for western scientists to grasp and appreciate. TEK tends to be viewed as "qualitative, intuitive, holistic, and oral", while "science is seen as quantitative, analytical, reductionist, and literate" (Nadasdy, 1999, p. 2). According to Kimmerer (2002), western-science is more likely to "marginalize" forms of traditional ecological knowledge. Similarly, Nadasdy (1999) indicated that many indigenous communities are not satisfied with the way in which TEK has been utilized within management frameworks. Nadasdy (1999) suggests the major problem with the utilization of TEK is the manner in which it gets translated into information for natural resource managers and decision-makers. During the translation process, the value and context of TEK is reduced, and "compartmentalization" of the knowledge occurs, altering its context and intended application. A further challenge in the incorporation of TEK as described by Nadasdy (1999) is that researchers and natural resource managers simply pay "lip-service" to the inclusion of traditional knowledge and indigenous involvement. Too often natural resource scientists and managers fail to recognise TEK as a legitimate source of knowledge. Instead, political correctness is used as a means to gain community support (Nadasdy, 1999).

Nadasdy (2003) suggests that the same challenges exist when biologists are faced with the integration of TEK into biological sciences. TEK is deliberately downplayed in order to secure the role of biologists and western science systems within natural resource management frameworks.

Despite many challenges, the integration of TEK in western science is found to have contributed towards an improvement in northern wildlife management, often providing Northern aboriginal residents with increased authority in land and resource management decisions (Nadasdy 2003). Similar observations made by Houde (2007, p.5) indicate that traditional forms of knowledge were "able to somewhat increase the participation of First Nations in decision-making processes by helping to identify, for instance, unforeseen and undesirable consequences of development projects. It provides First Nations with the opportunity to influence the direction of resource management actions". Kendrick and Manseau (2008) described how GIS information was supplemented through narratives provided by elders resulting in greater comprehension of the spatial information representing hunting patterns of caribou. They indicated that the value of information was diminished if the knowledge of elders could not be applied within the management framework on an annual basis (Kendrick & Manseau, 2008). Peloquin and

Berkes (2009) observed that the forms of traditional knowledge utilized by the James Bay Cree were based on observations of complex environmental systems that are shared and applied in a communal setting over various temporal scales. The James Bay Cree did not simplify natural observations. They identified environmental changes through their appropriate relationships and adapted their hunting and gathering strategies accordingly. The common use of traditional practices within communities, for the purpose of natural resource harvesting, has been shown to support communal social relationships and construct social norms under which The James Bay Cree operate (Berkes, 1977).

2.3 Community-based monitoring

Community-based monitoring is widely acclaimed as a way to facilitate increased participation of local communities in the conservation and management of natural resources (Whitelaw et al., 2004; Wiber et al., 2004; Pollock and Whitelaw, 2005). Whitelaw et al. (2003, p. 410) define CBM as a "process where concerned citizens, government agencies, industry, academia, community groups and local institutions collaborate to monitor, track and respond to issues of common community concern". CBM is informed by the guiding principles of decentralized management frameworks, including co-management (Wiber et al, 2004, 2009) and participatory research and development (Pollock and Whitelaw, 2005; Castleden et al., 2012; Koster et al., 2012). A shift from top-down to bottom-up governance is usually inferred (see Chapter 6 for details), associated with greater levels of participation and responsibility by local communities (Pollock and Whitelaw, 2005; Hermann et al., 2014).

In Canada, the aspirations of local communities to expand their civic engagement in the scientific study and management of natural resources has led to increased adoption of CBM (Conrad and Hilchey, 2011; Hermann et al., 2014; Sharpe and Conrad, 2006; Whitelaw et al., 2003). According to Whitelaw et al. (2003) this increase can also be attributed to: reductions in government funding, the inability of current government monitoring programs to satisfy the expectations and needs of decision-making bodies (e.g.

rapid delivery, usability, and relevancy), and increased opportunities for communities to involve themselves in management and planning processes. Moreover, according to Garcia and Lescuyer (2008, p. 1304), CBM programs that emphasize decentralized management and governance have the potential to: "(i) increase the well-being of rural populations; (ii) better preserve the [natural] resources and the biodiversity which depend on the knowledge and the know-how of native communities; and (iii) improve local governance by empowering communities and enabling them to democratically control resource management".

Studies examining primarily non-indigenous Canadian communities have suggested that CBM initiatives benefit from the willingness of communities to increase their levels of participation in environmental conservation planning and management (Conrad and Hilchey, 2011; Kearney et al., 2007; Sharpe and Conrad, 2006). Sharpe and Conrad (2006) and Conrad and Hilchey (2011) have suggested that community involvement in environmental decision-making increased through participation in CBM and led to increased levels of scientific literacy; that is, more comprehensive levels of understanding of changes affecting the natural environment are fostered through their engagement in CBM. Kearney et al. (2007) similarly observed that when communities, especially those with significant levels of dependency on their local environment, increased their participation in environmental monitoring efforts, their management, governance, and resilience capacity also increased. In other words, the ability of local communities to self-manage, self-govern, and allocate the necessary time, energy, and financial resources, towards resource harvesting increased in the context of CBM. Moreover, providing the space for communities to engage in monitoring, as an aspect of decision-making and management processes, can potentially serve to "bring management closer to those most affected by the decisions made" (Kearney et al., 2007, p. 90).

Within the literature, successful CBM projects involving First Nations communities have been characterized by their ability to: (1) recognize, and prioritize, traditional ecological knowledge (TEK) within the monitoring framework (Berkes, 2004; 2007; Carr, 2004; Golfman, 2010); (2) design, build, and maintain working relationships with both internal and external community partners through participatory (Mulrennan et al., 2012; McLachlan, 2014;), and co-management (Berkes, 2007; Golfman, 2010), arrangements in order to avail of local and external expertise; and (3) communicate monitoring results through locally appropriate methods, including word of mouth, formal reports (Berkes, 2004; Golfman, 2010), and multimedia (McLachlan, 2014).

Unfortunately, CBM projects prioritizing First Nations communities' involvement, particularly assessments of long-term CBM projects, are scarce, resulting in knowledge gaps in the design and implementation of environmental monitoring programs within cross-cultural contexts. Furthermore, much of the current literature tends to privilege the views of outside experts, with limited attention to community perspectives (Mulrennan et al., 2012). According to Hermann et al. (2014), lack of funding, stakeholder conflicts, non-standardized data collection protocols and sensitivity concerning data ownership can present significant logistical obstacles to CBM implementation in indigenous communities.

2.4 Historical context of community-based monitoring

Community-based monitoring has been influenced by two theoretical shifts (Berkes et al., 2000). The first involved a fundamental rethinking within the natural sciences of our understanding of ecosystem scales and complexities. In the past, natural systems were assumed to be predictable, capable of being quantitatively simplified and subject to command and control approaches to environmental management and resource regulation, with local communities and resource users often viewed as obstacles to environmental protection (Agrawal & Gibson, 1999).

Holling's (1973) study underscored the unpredictability of natural ecosystems and the importance of disturbances in shaping their temporal and spatial character and paved a way for the field of "new ecology" (McIntosh, 1987; Botkin, 1990; Zimmerer, 1990; Scoones, 1999), where ecological theory could be viewed through the lenses of "ecological anthropology, political ecology, [and] environmental and ecological economics" (Scoones, 1999, p. 479). These developments broadened the ecological discourse, whereby indigenous understandings of the environment, informed by alternative forms of knowledge and local resource use practices (Berkes et al., 2000), gained traction at the international level and, with traditional knowledge systems, have been recognized for their valuable contributions to conservation and natural resource management (see article 8(j) of the 1992 Convention on Biological Diversity).

The second theoretical shift involved participatory democracy theory and the related principle of subsidiarity, which suggests that decisions should be taken at the lowest possible level and that governments should be limited to performing only those tasks that cannot be performed effectively at a more immediate or local level (Berkes, 2004; Plummer & Fitzgibbon, 2004). These shifts encouraged moving away from conventional top down, regulatory frameworks, towards community-based management and monitoring arrangements to include local resource user participation and their associated knowledge (Bryant & Wilson, 1998; Berkes, 2004; Wiber et al., 2004).

CBM borrows from the guiding principles of decentralized management frameworks, including co-management (Ribot, 2004; Wiber et al., 2004, 2009) and participatory research and development (Pollock and Whitelaw, 2005; Castleden et al., 2012; Koster et al., 2012); a shift from a top-down to a bottom-up approach is emphasized, encouraging greater levels of responsibility and decision-making by local communities (Ribot, 2004; Pollock and Whitelaw, 2005). CBM is recognized as a potentially valuable form of involvement for indigenous peoples and supports increased levels of decentralized governance favoring local control and management of resources. It has been suggested that CBM can provide opportunities for local knowledge inputs, a cost-effective alternative to conventional top-down monitoring programs (Carr, 2004; Dyck, 2007), and alternative sources of income for indigenous peoples. Moreover, the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP) has affirmed indigenous peoples' rights and recognized the significance of their knowledge, culture, and traditional practices (United Nations, 2008; Mulrennan, 2013).

Efforts, particularly at the international level, to recognize the rights and interests of indigenous peoples have been paralleled by the wider discourses surrounding human rights, indigenous peoples' invested time, energy, agency, and the rise of neoliberalism and its attendant support for free trade, open markets and deregulation (Mulrennan et al., 2012; Langdon, 2015). These movements are transforming the manner in which local and indigenous communities are represented and consulted within governmental decision-making at the same time as providing opportunities for local communities to assume greater roles and responsibilities in managing their affairs (Nadasdy, 2003).

2.5 Subsistence fishing

Subsistence fishing is defined as a form of labour intensive fishing, excluding sport fishing, practiced in proximity to local shorelines serving the primary purpose of feeding families, relatives and community members. Such forms of fishing do not require large financial investment nor result in significant financial profits (Belhabib et al., 2015; World Fisheries Trust, 2008). In various parts of the world, subsistence fishing is associated with a lifestyle choice that is linked to forms of small-scale agriculture requiring little to no management, influenced by local traditional norms and beliefs (Belhabib et al., 2015), and recognized as an important dimension of indigenous cultures (The World Fisheries Trust, 2008).

2.5.1 Subsistence fishing in a Canadian context

Davis and Jentoft (2001) indicated that subsistence harvesting, including fishing, was of great importance to Canadian First Nations, such that "the [United Nations] has asked Canada to ensure that

First Nations have an adequate resource base to support [their] own means of subsistence and to provide for [their] self-sufficiency. It has also warned that extinguishments or conversion of [their] aboriginal rights are a violation of international law (Matthew Coon Come as cited in Davis & Jentoft, 2001, p. 223).

The most significant contributions to the field of Northern Canadian subsistence fisheries, including detailed studies of the fishing practices of the James Bay Cree, and the importance that the Cree people attribute to subsistence fishing, were made by Berkes and Mackenzie (1978), Berkes (1977; 1979; 1982; 1990), Berkes et al. (1995), and Peloquin and Berkes (2009). In studying the subsistence fishery of the Crees of Fort George (now known as Chisasibi), Berkes (1977) indicated that whitefish and cisco represented an important source of "wild food", second only to Canada geese; the total 1977 estimated catch levels were between 85,700 and 106,500 for whitefish and cisco, respectively. This catch was sufficient to support the entire community at the time.

Berkes (1977) observed that Cree people not only attributed great importance to fishing for personal subsistence, the continued practice of this traditional fishery was of equal cultural importance. The majority of the catch at the time was landed by the use of traditional cotton gillnets, modern nylon filament gillnets, and motorized vessels; it is noteworthy that all materials, methods, technologies and gear that were used were considered traditional by the Cree fishers (Berkes 1977). Harvesting of other food sources was hypothesized by Berkes (1977) to be the reason the fishery resulted in stable fish stocks that were ideal for indigenous subsistence fishing at the time. Moreover, Berkes (1977; p. 306) observed that even with the basic technologies employed at the time, the Cree people retained the ability to affect fish abundance within the area, but "social practices regulating the fishing intensity, locations, and the minimum mesh size provided a control against the overfishing of stocks".

Berkes (1990) suggested that annual variations in fish landings in Fort George could be attributed to changes in employment opportunities within the region. Berkes (1979) also noted that a social and financial dependence upon the technologies used to harvest fish was created. While subsistence fishing was not classified as a commercial activity (Berkes, 1977), it was unclear at the time if personal financial security was a prerequisite for participation in subsistence fishing activities along the James Bay coast. That is, there was no evidence to suggest that the Cree engaged in fishing activities for financial gain. Given that more than thirty-five years have passed since Berkes' (1977) study, it is logical to assume that the socio-economic reality of the James Bay Cree has changed.

2.6 Conclusion

The above literature review provided an overview of the various focus areas that must be considered when engaging in collaborative community-based monitoring activities involving indigenous peoples. Individually, the thematic areas described are demonstrably complex in theory as well as in practice. Second, it is evident that a strong understanding of traditional ecological knowledge and subsistence practices, in the context of community-based conservation, is important to better understand the continued ties indigenous peoples have to their lands and seas. Nevertheless, it is equally important for us to understand modern governance frameworks and models that may best accommodate the needs and aspirations of indigenous peoples. This includes the desire to increase levels of participation in the monitoring and protection of their territories, while engaging in subsistence-based activities. The subsequent chapters in this thesis are informed by the literature that was presented in this chapter.

Chapter 3. Methodology

This chapter provides an account of my desktop-based research and data collection efforts in Montreal from 2011 to 2015 as well as a description of field-work conducted in the Cree Nation of Wemindji from July 30th to August 20th, 2012. The chapter begins with a description of my efforts to find, collect, and examine twenty-three years of fisheries harvesting data from the WCFMP. This is followed by an account of my time spent in the Cree Nation of Wemindji where I conducted my field work in collaboration with Cree fishermen, program administrators and community members. By working collaboratively with Cree fishing families that have been involved in the fisheries program over the past three decades, I tried to incorporate local observations and insights about the program and fisheries with my analysis of the monitoring record. Local assessments of the benefits and limitations of this long-standing community-based monitoring program were also important in identifying if and how the program might be amended.

3.1 The examination of long-term fisheries harvesting data (1989 to 2012)

WCFMP annual reports were obtained from various sources and include reports for the years of 1989 to 1996 and 2003 to 2011. Attempts to obtain a complete collection of these reports proved challenging, as the Hydro-Québec Documentation Centre did not have copies of all annual reports. As a result, reports were obtained from various sources: (1) the Hydro-Québec Documentation Center, through Concordia University's Inter-Library Loan service (1989, 1991 - 1996, 2003 - 2004, 2006, 2008, and 2009); (2) Niskamoon Corporation (1990, 2005, 2007 and 2010); and (3) Wemindji Cree Trappers Association (2011).

Time series of annual summer coastal fish catches for lake whitefish (*Coregonus clupeaformis*), brook trout (*Salvelinus fontinalis*), and cisco (*Coregonus artedii*) in each coastal fishing camp (see Chapter 4 for more information) were created using the annual report data (Figures 5 to 13). The time series were used as an interview tool during the semi-structured interviews, supporting discussions on inter-annual variations in fishing activities.

3.2 Semi-structured interviews and participant-based observation (July – August 2012)

A three-week field visit was conducted to Wemindji from July 30th to August 20th, 2012. Semi-structured interviews were carried out in order to gain insights into program administration and local resource users' perspectives on the program and its benefits. Research participants included Cree fishermen and program administrators involved with the program. Cree fishermen were interviewed about the realities and dynamics of coastal fish camp operations, subsistence harvesting, and monitoring. Program administrators informed us about the administrative and financial realities of managing the program. Interview questions were structured around the following themes: funding and program development; collection and analysis of available data; feedback received from program administrators throughout the program lifecycle; program contributions benefitting local fishing families and the community; presentation and feedback of monitoring results; and levels of influence over coastal fisheries decision-making (Table 1). These themes were selected in order to engage in discussions related to the social, cultural and local economic aspects of fisheries monitoring. Participant-based observations were conducted in order to gain an understanding of local fishing methods and realties. This included time spent fishing, working, cooking, and eating with fishermen, program administrators, and community members as an invited guest.

3.3 Study Area

The Cree Nation of Wemindji is one of ten communities that comprise the Cree Nation of Eeyou Istchee. The village of Wemindji is located on the central east coast of James Bay (Figures 1, 2) and inhabited by approximately 1,400 residents (Statistics Canada, 2011). A mix of traditional and contemporary livelihoods and activities are carried out by community members, with certain individuals and families engaged in fishing, hunting, and trapping throughout the year, while others alternate between wage-labor employment and retaining connections to land-based activities during weekends and free time (Scott, 1988, 1996; Sayles and Mulrennan, 2010).

The maintenance of traditional land-based activities is recognised as vital to intergenerational knowledge transfer, cultural sharing, and the identity and well-being of the Cree people (Grand Council of the Crees, 2012). Senior family "hunting bosses" (referred to locally as "tallymen" or "Uchimaau") provide oversight and stewardship of their respective family hunting territories (Sayles and Mulrennan, 2010), several of which extend beyond the shoreline to include nearby offshore islands where fishing camps have been established.

The Cree Nation of Wemindji has been subject, over recent decades, to numerous social and environmental changes related to hydroelectric development, mining, and regional infrastructure expansion. The James Bay Project ("Project de la Baie-James") was one of the earliest and largest development projects in the region. The first construction phase began in the 1970s and resulted in major hydrological changes to the La Grande River catchment area (north of Wemindji but affecting a significant inland portion of Wemindji territory). This resulted in the flooding of hunting lands and ancestral burial grounds from the impounding of approximately 11,500km^2 of land in order to create artificial reservoirs and nine hydroelectric power stations (Chevalier et al., 1998). The Eastmain, Opinaca and Rupert rivers, located to the south of Wemindji, were diverted into the La Grande catchment area resulting in reduced flow rates in the Eastmain River and a sharp increase in the La Grande River to the north (Mulrennan et al., 2009). Environmental and social impacts resulting from the James Bay project have been extensively documented (Berkes, 1977; 1979; 1982; Roebuck, 1999; Tanner, 1999; Warner, 1999; Woodward, 1999; Young, 1999) and numerous scientific studies commissioned.

Environmental impact assessments of the affected area, carried out by Hydro-Québec in 1980s and 1990s, indicated a significant increase in mercury levels present in the estuarine ecosystem as a result of increased dissolved organic matter associated with the creation of hydroelectric reservoirs. The increased presence of mercury in the ecosystem negatively affected fish stocks in the region (Dumont et al., 1998), prompting an advisory by the Cree Board of Health and Social Services of James Bay to limit the consumption of piscivorous fishes in the region (Chevalier et al., 1998). Delormier and Kuhnlein (1999) found that the ensuing reduction in fish consumption presented a major challenge to the maintenance of a traditional diet for the Cree, particularly given that traditional fish species accounted for 54% of total food intake (in the summer months) of Cree women in Wemindji and were, and continue to be, considered a readily available source of healthy dietary fat.

The results from environmental impact assessments conducted by Hydro- Québec, in parallel to mounting pressure from the Grand Council of the Crees, acknowledged that the James Bay Project led to ecosystem-wide mercury contamination, negatively impacting upon human health. Moreover, the cultural and dietary importance of fish to the Cree people was acknowledged by Hydro- Québec. As a result, the Mercury Agreement of 1986 was signed, and later amended in 2001, between the Grand Council of the Crees, the Cree Regional Authority, the Cree Bands, the Government of Québec, Hydro-Québec and the Société d'énergie de la Baie James (Grand Council of the Crees, 2001). As part of the agreements, "Mercury funds" (*Namess*[1] *Fund, EM 1 Mercury Fund, and Eastmain 1A / Rupert Mercury Fund*) were established to support environmental monitoring, research, fisheries restoration and development projects (Grand Council of the Crees, 2001). From 1986 to 2001, the funds were administered and managed by Hydro-Québec. In 2002, the administration and management of program funds (for more details, see chapter 5) were delegated to the Niskamoon Corporation. This is a not-for-profit organization that was established following the signing of the "Agreement Concerning the Administration of the Cree-Hydro-Quebec Agreements and the Niskamoon Agreement" (commonly

[1] Meaning "fish" in the Cree language.

referred to as "the Niskamoon Agreement") (Niskamoon Corporation, 2012). The Niskamoon Corporation is comprised of various committees responsible for the oversight and administration of funds and community programs (for a visual representation of events, see Figure 21).

The region currently faces mounting pressure from regional resource developments, particularly mining, which is recognized as the largest development activity affecting the Cree Nation, including "Le Plan Nord" ("The Northern Plan", in English) which in its current proposed development plan, has the potential to impact 1.2 million km^2 of land and waterways in northern Quebec (Grand Council of the Crees, 2011).

Goldcorp Incorporated currently operates a gold mine as part of the Eleonore Gold Project, located south east of the community of Wemindji, within a catchment area. There is environmental concern surrounding the potential for the tailing ponds to leak into waterways. In response to newly encroaching development, a multitude of local conservation strategies and projects have been initiated. Examples of this at the regional level include the Cree Regional Conservation Strategy and the Wemindji Protected Areas Project. The first, was established in order to ensure the protection and conservation of the local bio-cultural landscape and resources (Cree Nation Government, 2014). The second, the Wemindji Protected Areas Project, a collaborative participatory research project involving researchers from McGill, Concordia and the University of Manitoba, was initiated by the Cree Nation of Wemindji. This project has resulted in the establishment of a terrestrial biodiversity reserve, and a proposed marine conservation area (Mulrennan et al., 2009)

Chapter 4. Manuscript 1[2]

Culturally appropriate community-based monitoring? Local Cree perspectives on the Wemindji Coastal Fisheries Monitoring Program (1989 - 2011)

Abstract

Community-based monitoring (CBM) is promoted as a cost-effective alternative to conventional externally-driven, professionally executed monitoring with the potential to improve understanding of wildlife and ecosystems, enhance local authority and capacity, and contribute to improved management decisions. Additional benefits, particularly in indigenous contexts, are said to include enhanced local authority and capacity as well as support for the inter-generational transmission and cross-cultural exchange of knowledge. However, few assessments have been made of the extent to which CBM delivers on this potential and to our knowledge none address local indigenous perspectives on their direct experience of CBM programs. We address this gap by drawing upon the experiences of community members from the James Bay Cree Nation of Wemindji's Coastal Fisheries Program (WCFP), a twenty-two year CBM program of subsistence fishing activities. Our findings indicate that Cree fishermen strongly engaged with the WCFP because it: (1) supports enhanced access to traditional coastal fishing activities; (2) provides a source of seasonal income; and (3) is integrated into a traditional subsistence harvesting activity that provides an important food source for the community. However, benefits from the Wemindji Coastal Fisheries Monitoring Program (WCFMP) were assessed to be limited because: (1) fishermen's input is restricted to data collection; (2) the monitoring data is limited in its value whereby seasonal fishing snapshots are documented over time rather than a comprehensive biological assessment of the fisheries and associated stock; and (3) limited feedback is provided to program participants or community members on the findings or significance of monitoring. Based on this assessment of the WCFMP, several recommendations are presented that we hope will contribute to the improved design

[2] This chapter has been formatted to follow the Journal of Ocean and Coastal Management submission guidelines

and implementation of locally meaningful, and culturally appropriate, CBM programs, where collaboration between stakeholders is prioritized.

Keywords*:* Community-based monitoring; First Nations; indigenous peoples; fisheries; subsistence; knowledge.

1. Introduction

Community-based monitoring (CBM) is widely acclaimed as a way to facilitate increased participation of local communities in the conservation and management of natural resources (Whitelaw et al., 2004; Wiber et al., 2004; Pollock and Whitelaw, 2005). Whitelaw et al. (2003, p. 410) define CBM as a "process where concerned citizens, government agencies, industry, academia, community groups and local institutions collaborate to monitor, track and respond to issues of common community concern". CBM is informed by the guiding principles of decentralized management frameworks, including co-management (Wiber et al., 2004, 2009) and participatory research and development (Pollock and Whitelaw, 2005; Castleden et al., 2012; Koster et al., 2012). A shift from top-down to bottom-up governance is usually inferred (see Chapter 6 for details), associated with greater levels of participation and responsibility by local communities (Pollock and Whitelaw, 2005; Hermann et al., 2014).

In Canada, the aspirations of local communities to expand their civic engagement in the scientific study and management of natural resources has led to increased adoption of CBM (Conrad and Hilchey, 2011; Hermann et al., 2014; Sharpe and Conrad, 2006; Whitelaw et al., 2003). According to Whitelaw et al. (2003) this increase can also be attributed to: reductions in government funding, the inability of current government monitoring programs to satisfy the expectations and needs of decision-making bodies (e.g. rapid delivery, usability, and relevancy), and increased opportunities for communities to involve themselves in management and planning processes. Moreover, according to Garcia and Lescuyer (2008, p. 1304), CBM programs that emphasize decentralized management and governance have the potential to: "(i) increase the well-being of rural populations; (ii) better preserve the [natural] resources and the biodiversity which depend on the knowledge and the know-how of native communities; and (iii) improve local governance by empowering communities and enabling them to democratically control resource management".

Studies of non-indigenous Canadian communities have suggested that CBM initiatives benefit from the willingness of communities to increase their levels of participation in environmental conservation planning and management (Conrad and Hilchey, 2011; Kearney et al., 2007; Sharpe and Conrad, 2006). Sharpe and Conrad (2006) and Conrad and Hilchey (2011) have suggested that community involvement in environmental decision-making increased through participation in CBM and led to increased levels of scientific literacy; that is, more comprehensive levels of understanding of changes affecting the natural environment are fostered through their engagement in CBM. Kearney et al. (2007) similarly observed that when communities, especially those with significant levels of dependency on their local environment, increased their participation in environmental monitoring efforts, their management, governance, and resilience capacity also increased. In other words, their ability to self-manage, self-govern, and allocate the necessary time, energy, and financial resources to resource harvesting increased. Moreover, providing the space for communities to engage in monitoring, as an aspect of decision-making and management processes, can potentially serve to "bring management closer to those most affected by the decisions made" (Kearney et al., 2007, p. 90).

Within the literature, successful CBM projects involving indigenous communities have been characterized by their ability to: (1) recognize, and prioritize, traditional ecological knowledge (TEK) within the monitoring framework (Berkes, 2004; 2007; Carr, 2004; Golfman, 2010); (2) design, build, and maintain working relationships with both internal and external community partners through participatory (Mulrennan et al., 2012; McLachlan, 2014;), and co-management (Berkes, 2007; Golfman, 2010), arrangements in order to avail of local and external expertise; and (3) communicate monitoring results through locally appropriate methods, including word of mouth, formal reports (Berkes, 2004; Golfman, 2010), and multimedia (McLachlan, 2014).

Unfortunately, studies documenting long-term CBM projects that include indigenous communities are scarce, resulting in knowledge gaps in the design and implementation of environmental monitoring programs within cross-cultural contexts. Furthermore, much of the current literature tends to privilege the views of outside experts, with limited attention to community perspectives (Mulrennan et al., 2012). According to Hermann et al. (2014), lack of funding, stakeholder conflicts, non-standardized data collection protocols and sensitivity concerning data ownership can present significant logistical obstacles to CBM implementation in indigenous communities.

This study aims to address the lack of local indigenous perspectives in the CBM literature by reporting on the experience of the Cree Nation of Wemindji, located on the eastern shores of James Bay, with more than two decades of subsistence fisheries monitoring. The perspectives of local program participants, administrators, and other community members were gathered using semi-structured interviews, supported by participant-based observation. We hope this study can contribute to current CBM discourses by identifying program components that facilitate the design and implementation of locally meaningful and culturally appropriate CBM programs.

We begin with a description of the study area, including an account of the customary land and sea territories and activities of members of the Cree Nation of Wemindji as well as the large-scale development and resource extraction activities that have taken place in the region since the 1970s. The methods used in the study, including semi-structured interviews and participant-based observation, are then described. An account of the Wemindji Coastal Fisheries Monitoring Program (WCFMP) follows which includes a description of the political, logistical, and financial aspects of this subsistence-based fisheries monitoring program. From there, the perspectives of local program participants and administrators, and community members are summarized. Successes and weaknesses of the program are identified in the subsequent section, including key program components that aided in its establishment. Following a discussion of the findings in relation to the literature, recommendations for the adoption of critical program components in emergent and future CBM programs are proposed.

2. Study area: The Cree Nation of Wemindji

The Cree Nation of Wemindji is one of ten Cree communities that comprise the Cree Nation of Eeyou Istchee. The village of Wemindji is located on the central east coast of James Bay (Figures 1, 2) and inhabited by approximately 1,400 residents (Statistics Canada, 2011). A mix of traditional and contemporary livelihoods and activities are carried out by community members, with certain individuals and families engaged in fishing, hunting, and trapping throughout the year, while others alternate between wage-labor employment and retaining connections to land-based activities during weekends and free time (Scott, 1988, 1996; Sayles and Mulrennan, 2010).

The maintenance of traditional land-based activities is recognised as vital to intergenerational knowledge transfer, cultural sharing, and the identity and well-being of the Cree people (Grand Council of the Crees, 2012). Senior family "hunting bosses" (referred to locally as "tallymen" and "Uchimaau") provide oversight and stewardship of their respective family hunting territories (Sayles and Mulrennan, 2010), several of which extend beyond the coast to include nearby islands where fishing camps have been established .

The Cree Nation of Wemindji has been subject, over recent decades, to numerous social and environmental changes related to hydroelectric development, mining, and regional infrastructure expansion. The James Bay Project ("Project de la Baie-James") was one of the earliest and largest development projects in the region. The first construction phase began in the 1970s and resulted in major hydrological changes to the La Grande River catchment area (north of Wemindji but affecting a significant inland portion of Wemindji territory). This resulted in the flooding of hunting lands and ancestral burial grounds from the impounding of approximately 11,500km^2 of land in order to create artificial reservoirs and nine hydroelectric power stations (Chevalier et al., 1998). The Eastmain, Opinaca and Rupert rivers, located to the south of Wemindji, were diverted into the La Grande catchment area resulting in reduced flow rates in the Eastmain River and a sharp increase in the La Grande River to the north (Mulrennan et al., 2009). Environmental and social impacts resulting from the James Bay project have been extensively documented (Berkes, 1977; 1979; 1982; Roebuck, 1999; Tanner, 1999; Warner, 1999; Woodward, 1999; Young, 1999) and numerous scientific studies commissioned.

Environmental impact assessments of the affected area, carried out by Hydro-Québec in 1980s and 1990s, indicated a significant increase in mercury levels present in the estuarine ecosystem as a result of increased dissolved organic matter associated with the creation of hydroelectric reservoirs. The increased presence of mercury in the ecosystem negatively affected fish stocks in the region (Dumont et al., 1998), prompting an advisory by the Cree Board of Health and Social Services of James Bay to limit the consumption of piscivorous fishes in the region (Chevalier et al., 1998). Delormier and Kuhnlein (1999) found that the ensuing reduction in fish consumption presented a major challenge to the maintenance of a traditional diet for the Cree, particularly given that traditional fish species accounted for 54% of total food intake (in the summer months) of Cree women in Wemindji and were, and continue to be, considered a readily available source of healthy dietary fat.

Results from the environmental impact assessments conducted by Hydro-Québec, in parallel to mounting pressure from the Grand Council of the Crees, acknowledged that the James Bay Project led to ecosystem-wide mercury contamination, negatively impacting human health. Moreover, the cultural and dietary importance of fish to the Cree people was acknowledged by Hydro-Québec. As a result, the Mercury Agreement of 1986 was signed, and subsequently amended in 2001, between the Grand Council of the Crees, the Cree Regional Authority, Cree Band Councils, the Government of Québec, Hydro-Québec and the Société d'énergie de la Baie James (Grand Council of the Crees, 2001). As part of the agreements, "Mercury Funds" (*Namess*[3] *Fund, EM 1 Mercury Fund, and Eastmain 1A / Rupert Mercury Fund*) were established to support environmental monitoring, research, fisheries restoration and development projects (Grand Council of the Crees, 2001).

In more recent years, the region has seen a rapid rise in regional resource developments, particularly mining which is the largest development activity affecting the Cree Nation of Wemindji. The Eleonore Gold Project, located south east of the community of Wemindji is operated by Goldcorp Incorporated and a source of some local and regional level Cree concerns about the potential for the tailing ponds to leak toxic metals, including arsenic and mercury, into waterways.

Further expansion of industrial scale development linked in part to Quebec's Plan Nord, has triggered a multitude of regional and local conservation initiatives. For example, the Cree Regional Conservation Strategy was established to support the protection and conservation of the local bio-cultural landscape and resources (Cree Nation Government, 2014). At the local level, the Wemindji Protected Areas Project, a collaborative participatory research project involving researchers from McGill, Concordia and the University of Manitoba, was initiated by the Cree Nation of Wemindji. This project includes a terrestrial biodiversity reserve, and a proposed marine conservation area. The proposed Tawich National Marine Conservation Area aims to protect 20 000km^2 of the eastern James Bay coastline, and offshore, along the Cree Nation of Eeyou Istchee (Mulrennan et al., 2009; 2012).

3. Methods

3.1 The examination of long-term fisheries harvesting data

The WCFMP annual reports were obtained from various sources and include reports for the years

[3] Meaning "fish" in the Cree language.

of 1989 to 1996 and 2003 to 2011. Annual reports included catch-per-unit-effort (CPUE) and total annual fish harvest numbers. Reports were distributed to the Cree Nation of Wemindji while a second set were intended for archiving at the Hydro-Québec Documentation Centre in Montreal, Quebec.

Attempts to obtain a complete collection of reports proved challenging. Local CTA employees expressed uncertainty surrounding the reports' whereabouts and indicated that report archiving was not a priority. More importantly, the Hydro-Québec Documentation Centre did not have copies of all annual reports. As a result, reports were obtained from various sources: (1) the Hydro-Québec Documentation Center, through Concordia University's Inter-Library Loan service (1989, 1991 - 1996, 2003 - 2004, 2006, 2008, and 2009); (2) Niskamoon Corporation (1990, 2005, 2007 and 2010); and (3) Wemindji Cree Trappers Association (2011).

Time series of annual summer coastal fish catches for lake whitefish (*Coregonus clupeaformis*), brook trout (*Salvelinus fontinalis*), and cisco (*Coregonus artedii*) in each coastal fishing camp were created using the annual report data (Figures 5 to 13). These time series were used as an interview tool during the semi-structured interviews, supporting discussions on inter-annual variations in fishing activities.

3.2 Semi-structured interviews and participant-based observation

A field visit was conducted in Wemindji from July 30th to August 20th, 2012. Semi-structured interviews were carried out in order to gain insights into program administration and local resource users' perspectives on the program and its benefits. Research participants included Cree fishermen and program administrators. Cree fishermen were interviewed to gain an understanding of the realities and dynamics of coastal fish camp operations, subsistence harvesting, and monitoring. Program administrators provided details about the administrative and financial realities of managing the program. Two sets of interview questions were developed for this study. The first set targeted program administrators and band council employees and focused on the following: funding and program development; collection and analysis of available data; community benefits in program participation; and influence in regional fisheries decision-making. The second set of questions was developed for community members and program participants and targeted: feedback received from program administrators throughout the program lifecycle; program contributions benefitting local fishing families and the community; presentation and feedback of monitoring results; and levels of influence over coastal fisheries decision-making (Table 1). These themes were selected in order to initiate discussions about the social, cultural and local economic aspects of fisheries monitoring, which were not reported or captured in the WCFMP reports. Participant-based observations were conducted in order to gain an understanding of local fishing methods and realties. This included time spent fishing, working, cooking, and eating with fishermen, program administrators, and community members as an invited guest.

4. Wemindji Coastal Fisheries Monitoring Program

The Wemindji Coastal Fisheries Program (WCFP) was established as a mitigation program to provide the community of Wemindji with "fish of acceptable quality" (Hydro-Quebec, 1990) in response to the mercury contamination, and was designed to support traditional fishing in the Eeyou Istchee. The WCFP included two components: 1) support for and promotion of traditional coastal fishing activities through seasonal income support; and 2) "monitoring of fish catches in order to ensure the long-term availability of fish for future generations" (Hydro-Québec, 1990) through the Wemindji Coastal Fisheries Monitoring Program (WCFMP).

Between 1989 and 1996, Hydro-Québec provided direct seasonal program funding to the WCFMP through the Wemindji Band Council. When political tensions escalated between the Cree Nation of Eeyou Istchee and Hydro-Québec in the 1990s in relation to the Great Whale hydroelectric project, programs such as the WCFMP were temporarily suspended. Following the abandonment in 1994 by

Hydro-Québec and the Québec Government of the Great Whale Project, no funding was allocated to the WCFMP by Hydro-Québec from 1997 to 2002. Funding was reallocated after the signing of the *Agreement Respecting a New Relationship Between the Cree Nation and the Government of Québec* in 2002 (commonly referred to as "La Paix des Braves") between the Grand Council of the Crees and the Québec Government (personal communications with The Niskamoon Corporation, 2014).

This second phase of WCFMP funding commenced under a new administrative arrangement. Hydro-Québec allocated a total of $30 million CAD (in 2002 dollars) to the "Mercury Funds", to be administered by the Niskamoon Corporation, a not-for-profit organization established following the signing of the "Agreement Concerning the Administration of the Cree- Hydro-Québec Agreements and the Niskamoon Agreement" (commonly referred to as "the Niskamoon Agreement") (Niskamoon Corporation, 2012). The Niskamoon Corporation is comprised of various committees responsible for the oversight and administration of funds and community programs. The Fisheries and Health Committee aims to "enhance Cree fisheries with initiatives that respond to Cree needs and aspirations" and "support public health authorities in developing and delivering services as part of risk-management programs relative to human exposure to mercury" (Niskamoon Corporation, 2012, p. 47). In practical terms, the Niskamoon Agreement provides support for projects and initiatives that prioritize the wellbeing of the Cree peoples and their connection to their lands. From 2002 to 2011, annual project proposals to support the WCFMP were prepared by the Wemindji Cree Trappers Association[4](CTA) and submitted to the Niskamoon Corporation for funding approval.

The WCFMP consisted of coastal and inland lake fisheries harvesting and monitoring during the summer months and occasional ice fishing during the winter months. The monitoring component of the program was externally designed in consultation with a fisheries biologist responsible for creation of the

[4] The Cree Trappers Association was established following the signing of the James Bay Northern Quebec Agreement in 1975. The organization represents the interests of James Bay Cree trappers, hunters, and fishers across the Cree Nation of Eeyou Istchee. The head office is located in Eastmain, Quebec and operates local offices in each of the Cree communities.

data collection protocol, data aggregation, seasonal catch assessments, and report compilation. No feedback from Wemindji residents was utilized during the design and implementation of the monitoring program prior to its commencement in 1989. Local Cree fishermen were seasonally employed to carry out the fishing and monitoring activities related to the program.

While feedback from Wemindji residents was non-existent, the WCFMP was designed by Hydro-Québec to be implemented, on the ground, under the authority of the local hunting bosses. Most years the program supported the activities of five coastal fishing camps (Figure 2): Goose Island, Moar Bay, Old Factory, Rabbit's Ridge, and Shephard Island, with occasional involvement by the Black Stone Bay, Sculpin Island, Paint Hills Bay, and Paint Hills Island camps. The Wemindji CTA coordinated the program by providing administrative, logistical, and technical support to the hunting bosses and program participants. Administrative support involved workshops and meetings with hunting bosses which provided them assistance in writing individual funding proposals. These proposals were used to generate annual seasonal funding proposal prepared by the Wemindji CTA and submitted to the Niskamoon Corporation. Communications between the Wemindji CTA and the Niskamoon Corporation were coordinated through local on-the-ground Niskamoon program coordinators that worked from Wemindji.

Hunting bosses were responsible for the hiring of program participants for each fishing camp, and were expected to contribute to a prescribed daily workflow (Figure 3). Annual employment numbers in the camps fluctuated over the years between three to ten employees per camp. The duration of the program was largely determined by the amount of seasonal funding secured by the Wemindji CTA, which in turn was allocated based on the previous year's level of participation by community members and the CTA's ability to successfully apply for all funding requests. The Wemindji CTA director at the time stated that "we do the best with what we receive from [the Niskamoon Corporation] [...] our goal is to make sure we spend the most time fishing". The WCFP provided funds to support the purchase and use of: gill nets, canoes and outboard motors (Figure 4), sleds, skidoos, gasoline-powered generators, freezers, tents, and kitchen equipment. Lake whitefish, brook trout, and cisco were harvested during the summer coastal portion of the program. Walleye (*Sander vitreus*), lake sturgeon (*Acipenser fulvescens*), northern pike (*Esox lucius*), and suckerfish (*Catostomuscatostomus* and *Catostomus commersoni*) were harvested as part of the summer inland portion of the program (Niskamoon Corporation, 2010).

The WCFP was designed to provide a supply of fresh fish to community members through traditional food sharing practices. Cree fishermen communicated with the Wemindji CTA by means of radio to arrange fish drop-offs along the Wemindji riverbank. Fish were picked up from the canoes and transported by Wemindji CTA employees using all-terrain vehicles. Fish were distributed to community elders, families, and any community feasts or festivals. The Wemindji CTA maintained an allocation list in order to ensure that community members received a fair distribution of the harvested fish catch. While the distribution of catch was sometimes sporadic, a CTA administrator in 2012 indicated that the CTA tried to ensure that the distribution was fair, with community elders prioritized. Referring to the distribution of fish, one program participant stated that "we tried to bring out fish in town every second day when they are still fresh. We burn a lot of gas. The program was running smooth. When the fish [was] caught, I [called] in the driver and I [tried] to meet them at the river bank so I can give them the fish there, and usually they go around right away house to house while [the fish] are still fresh. Before we used to go to the mini-mall and put them there and people would come and take what they need".

During my field work in 2012, the then CTA administrator indicated that in order to secure annual WCFMP funding, the Niskamoon Corporation required program participants to record daily fish catch information. Program participants followed data collection guidelines and collection sheets (Figures 22 and 23) developed by a contractually employed biologist that was employed since the beginning of the program in 1989. Fish camp name, date (day and month), fish species, total length (inches) and geographical location of gill net placement were recorded by Cree fishermen on data collection sheets (see supplementary information). The collection guidelines and sheets were designed to ensure that quantitative data would be consistent throughout the program. Fisheries monitoring training was offered to program participants. This consisted of a workshop organized in collaboration with the Wemindji CTA at the start of the fishing season when data recording guidelines for daily catches were explained to program participants. The Wemindji CTA director in 2012 explained that "a lot of the fisherman already had [the fishing] experience. What is important is that the camps were provided [with] monitoring sheets to record the fish information. Most of them will have [the fishing] experience and will know what to do. They have been working on that a long time". Similarly, a fisherman stated: “the CTA never gave me training for fishing, but only on the paperwork.”

At the end of each program period, completed data collection sheets were submitted to the CTA. This information facilitated the preparation of the WCFMP annual reports by the contractually employed biologist. At the local level, fisheries data collection efforts were sustained in the presence of two local community champions: Wemindji hunting bosses and their representative local organization, the Wemindji CTA. External support was provided through a partnership between a privately contracted biologist and the CTA, facilitating the division of responsibilities. Through this arrangement, the CTA coordinated and assisted the hunting bosses and program participants with the recording of fish catch information, local logistics, and management. The submission of annual catch data represented the mechanism by which funding could be allocated in order to ensure continued access to fishing (as explained by the CTA administrator and through personal communications with the Niskamoon Corporation). Monitoring data and seasonal reports were not made publically available and were exclusively distributed to Hydro-Québec, the Niskamoon Corporation, and the Wemindji CTA.

5. The Wemindji Coastal Fisheries Monitoring Program: local program perspectives

In speaking to research participants and community members, it was made clear that the WCFMP played an important role in Wemindji and was a program that generated some excitement and community engagement. The CTA administrator in 2012 described the WCFMP as "our most popular program […] tallymen would come and see me and ask when is the program starting?" At the program's peak in 1993, the WCFMP was reporting 4,770 fish catches on a seasonal basis (Figure 19). One community member observed that "[e]lders always come back with smiles on their face and their skin refreshed and rejuvenated from the time they spend on the land. There is a very good balance offered in the community". Another community member stated that "the women and kids that don't go out fishing get involved by organizing festivals, feasts, and cooking competitions when the fish come in […] families get to share their best recipes and everyone gets to taste and judge. At the end, we give a prize for the best dish".

In speaking to the continued attachment to the WCFP, a fisherman stated that "the fisheries is part of my life and I have spent a lot of time in the bush. If you work you get paid, I do not want to slack off. I do not mind doing it, it is part of the enjoyment of the fishing and it feels like going back to school". On the other hand, in speaking to the monitoring aspect of the fisheries program, one fisherman stated that "we measure the fish at the camp, and then clean them. Everyone loves going out fishing. I enjoy the fishing more than the monitoring and I enjoy being out at my fishing camp", while another expressed that "we measure the fish because we are told to. I do not care about the [monitoring] program anymore, I am concerned about the other fisherman that depend on the income from the program".

Program administrators in 2012 suggested that funding allocated by the Niskamoon Corporation played an important role in ensuring sustained fishing capacity. In one interview, it was stated that "we live in the real world, there is no guarantee of funding for the tallymen. If the funding is cut, we will be able to carry out less projects, the activities and the organization will not stop, we will continue to work with what we have. I would like to ensure that the funding is steady and we can carry out the projects on a regular basis".

Multiple program participants described a decrease in both fishing activity and fish abundance as a contributing factor to the observed decline in fish catch over time (see Table 3, Figure 19, and supplementary results in Appendix). One hunting boss stated that "there are less fish and fishermen out in the bay, sometimes I do not catch any fish. We realize that whatever we are harvesting, we will get larger and smaller than expected, [and] we have to accept that." Similarly, a program administrator indicated that "there are also less people that are fishing out in the bay". From an administrative perspective, the Wemindji CTA stated that these observations should not be interpreted as a loss of interest in fishing activities in the community (see tables 3 and 5 and supplementary results in Appendix).

Even though program participants observed declining fish numbers over the years, none of the interviewed program participants believed that they were facing a decline in fish abundance that would result in critical shortages in the future. Interviewed hunting bosses attributed annual variations (e.g. maximum fishing effort and seasonality) as contributing factors to reduced catch numbers. Personal commitments and family responsibilities, including wage employment, resulted in a lack of physical labor (i.e. workers capable of performing strenuous physical tasks within the camp) that in turn reduced fishing effort. One program participant stated that "if there were no jobs, there would be a lot more [fishing]. Now that there are jobs, there are less people [fishing]. So it balances it out."

In speaking to fishing capacity, elderly fishermen and fisherwomen involved in the program described the demands of running a fish camp and the needs for assistance with particular tasks. One hunting boss indicated that "when the weather is difficult, it becomes difficult to check the net. When someone is checking the net, another person needs to steer and stabilize the boat". Interviews revealed that when younger Cree family members were not available to assist in supporting functions (e.g. cutting of firewood, setting and checking gill nets), it became increasingly difficult for elders to fish at their desired capacity.

6. Discussion

This study found that although the broader WCFP was successful on several fronts, including support of traditional subsistence harvesting and continued local involvement in the coastal fisheries through traditional income support mechanisms, the WCFMP's purported intention of "monitoring of fish catches in order to ensure the long-term availability of fish for future generations" (Hydro-Québec, 1990), was never clearly articulated. While the annual WCFMP reports did make use of the collected data and provided recommendations to the Wemindji CTA as to whether to continue with seasonal fishing activities in subsequent years, the reports missed an important opportunity to include local perspectives in the seasonal monitoring and reporting.

The reported monitoring data was limited in its utility given that the WCFMP only reported seasonal fish catches as part of the WCFMP and did not have a mechanism in place to account for the fish caught outside of the monitoring program (i.e. by Cree fishermen who decided to go out fishing on their own time). Second, the catch data used to prepare the annual WCFMP reports was inconsistent throughout the years; only data representing total number of fish caught, number of mature fish caught, proportion of mature fish caught (%), and mean total length (inches) were consistently included from 1989 to 1996 and 2003 to 2011. Moreover, maximum fishing effort (represented in the maximum number of days fished during the season) was only reported from 2003 to 2011; fishing success (represented in number of fish caught, per day, per camp) was only reported from 2005 to 2011; and catch-per-unit-effort (CPUE; represented in number of fish, per 100m of net, per day) was only reported in three years (2008, 2010, and 2011). By the second-half of the WCFMP (i.e. from 2003 to 2011), the Niskamoon Corporation began reporting on fishing success rates and CPUE. While neither of these metrics were consistently reported on an annual basis, efforts were made to share the status of the fishery with the Wemindji CTA and Wemindji fishermen.

While varying levels of enthusiasm were expressed in relation to the monitoring and data collection required as part of the program, apart from the CTA staff, none of the individuals interviewed for this study claimed to have understood the value-added dimension of collecting fisheries catch data. More importantly, none of these individuals knew whether Wemindji fishermen understood how the data was to be used, or where it would end up. In one interview, a community member stated “I have witnessed the program at Goose Island and saw them measure and identify the fish. I always wondered where the reports went, but after that I have no idea”. While local fishermen were disconnected from the final monitoring reports, this did not prevent them from continually engaging in seasonal fishing outside of the WCFMP (e.g. through traditional income support programs and personal means). The WCFMP monitoring protocols were incorporated into an existing organizational structure involving the Wemindji hunting bosses and the CTA. This allowed for the local management and control of fishing operations and logistics, leaving the monitoring data assessment and report creation to external program partners.

The WCFMP was intended to support seasonal fish consumption for the Wemindji Cree while simultaneously ensuring local fish stock sustainability. Inconsistencies in the metrics applied to monitoring over the years by the Niskamoon Corporation and Hydro-Québe suggest that the collection of monitoring data may have been driven by bureaucratic concerns around accountability than best practices for fisheries monitoring. This observation was confirmed by board members of the Niskamoon Corporation, at a Fisheries and Health Committee board meeting where this research was presented (Dewan and Mulrennan, 2014), who clarified that the compilation and production of annual reports served as a mechanism through which program funding could be channeled to provide additional income support to program participants in return for data collection (personal communication between board members, 2014).

Based on my interview data, the intended purpose and value of the monitoring component within the WCFP was not understood by the program participants. Cree fishermen considered the monitoring component of the program a casual labour opportunity and a supplementary source of income which they willingly undertook while fishing. None of the interviewed program participants indicated that the collected seasonal monitoring data had any value to them. One fisherman simply described the data collection and reporting as "paperwork". In speaking to these findings, a Niskamoon Corporation employee, who wished to remain anonymous, indicated in 2014 that Niskamoon Corporation's goal was not to micromanage the program. Instead, they decided to employ a local-level strategy though which community communications would be coordinated through local CTA offices and on-the-ground Niskamoon program coordinators. By doing so, it was revealed that fishermen were more interested in undertaking traditional fishing, without the extra "paperwork". That is, Cree fisherman did not consider the data collection aspect of the WCFMP to be integrated within the program. Instead, they believed it was an additional task that needed to be performed in order to continue fishing. This sentiment was observed both at the local level in Wemindji, and higher up at the Niskamoon Corporation, where the submission of annual catch data represented the mechanism by which funding could be allocated in order to ensure continued access to fishing. Thus, the largest motivational driver for continued monitoring was financial, for all parties. Monitoring data and seasonal reports were not made publically available and were exclusively distributed to Hydro-Québec, the Niskamoon Corporation, and the Wemindji CTA. Finally, the value and potential contribution of the actual monitoring data collected by the WCFMP was undermined by: (1) annual variations in the start and end dates for each fishing season; (2) inconsistency in metrics that were applied as part of the program over the years; and (3) limited feedback from local program participants in the monitoring process.

While the social and political realities of communities engaged in CBM vary and are case-specific, this study echoes the observation made by Rist et al. (2010, p. 497) where it was observed that "[for] any monitoring scheme that [utilized financial compensation] to be sustainable in the longer term, the incentives for participation must be based on more than short-term financial motivation. For a locally based monitoring scheme to work in practice, the benefits of monitoring (e.g., improved future harvests), must be greater than the costs for the individuals and communities concerned, both of monitoring and implementing management interventions". Failing to effectively communicate the value of collected monitoring data and providing feedback to local program participants reflects ineffective management and incomplete implementation of a CBM program based on Pollock and Whitelaw's (2005, p. 224) criteria whereby CBM programs should "deliver timely, usable, accessible, and relevant information and feedback to decision-makers".

Incorporating the monitoring requirements of the WCFMP within an existing organizational structure, while leaving the analysis and catch data and the creation of monitoring reports to external program partners, allowed the community to take ownership of aspects of the program which mattered most to them. This approach aligned itself with Pollock and Whitelaw's (2005, p. 213) understanding of participatory-based approaches where "the central goal is improved quality of life, and the approach is adaptive, decentralized, and supported by internal and external partnerships". Hockley et al. (2005, p. 2797) suggested that the willingness of a community to engage in monitoring and management of local resources is directly dependent on whether "cultural, nutritional or financial" benefits can be derived from those resources. The monitoring component of the WCFMP allowed limited levels of local community input and involvement, while supporting local fishermen's ability to harvest a traditionally important food source.

Nasuchon and Charles (2010, p.168) found that in order for community-based initiatives to be successful, "consultation and collaboration" between involved actors was required. In the context of this study, local and regional actors were involved in the WCFMP. Unfortunately, the levels of collaboration between actors was low. One research participant indicated that there is a lack of transparency from the Niskamoon Corporation in actively disclosing all funding sources that can be accessed by the Cree Nation communities in order to support subsistence harvesting activities. While the Wemindji CTA now hosts a full-time Niskamoon Coordinator in the local office to aid with project proposals, Wemindji hunting bosses felt that communication and clarity surrounding traditional fishing, trapping, and hunting support services could be improved, especially when the disclosure of available funding sources was concerned. In speaking to funding sources, one hunting boss expressed his frustration by stating that regional funds remain "difficult to access".

We conclude by identifying program components that aided in the establishment of the WCFMP and provide recommendations (Table 2) as to how they can benefit current and future CBM programs that seek to support knowledge and labour inputs from local indigenous resource users. This study, in-line with the literature, suggests that CBM programs should continue to aim for long-term consistent monitoring methods that are simple to implement for all involved actors, especially local program participants (Andrianandrasana et al., 2005; Pollock and Whitelaw, 2005; Conrad and Daoust, 2008; Rist et al., 2010). Moreover, monitoring programs should continue to work towards gaining a deeper understanding of local realities (Agrawal and Gibson, 1999; Danielsen et al., 2008) and motivational factors driving local resources users (Rist et al., 2010; Nielsen and Lund, 2012), and serve to benefit conservation science and management and not be seen or utilized as a "stand-alone activity" (Nichols and Williams, 2006, p. 668).

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Chapter 5. Manuscript 2[5]

Community-based monitoring and indigenous peoples: from contributory monitoring to collaborative monitoring to community-led monitoring

Abstract

Community-based monitoring (CBM) is widely recognized as a way to facilitate the increased participation of local communities in conservation and environmental management, while supporting increased levels of decentralized governance. CBM can take a variety of governance approaches, including government-led or "top-down" monitoring, interpretive or educational monitoring, advocacy or "bottom-up" monitoring, and collaborative or multi-party monitoring. Few comparative assessments of the experience of indigenous communities with CBM exist, in spite of CBM increasingly being adopted in Canadian indigenous contexts. We address this by presenting an assessment of the challenges and benefits of CBM based on a review of the academic literature. Second, an account of four Canadian CBM programs where indigenous participation was prioritized is presented in order to highlight the type and extent of indigenous participation, and their respective program components. Three categories of CBM involving indigenous communities are identified: contributory monitoring (limited to local inputs), collaborative monitoring (roughly equal partnerships), and community-led (local control over all aspects). The benefits and challenges of CBM are then discussed, particularly as they relate to different levels of indigenous participation. For this we draw on the broader literature, as well as interviews and participant observation data from a case study of a twenty-three year CBM program of indigenous subsistence fishing in the Canadian sub-arctic.

Keywords: Community-based monitoring; indigenous peoples; fisheries; local communities; conservation.

[5] This chapter has been formatted to follow the Journal of Marine Policy submission guidelines

1. Introduction

Community-based monitoring (CBM) is widely claimed as a way to facilitate increased participation of local communities in the conservation and management of natural resources (see Chapter 4). According to Whitelaw et al. (2003, p. 410) CBM is a "process where concerned citizens, government agencies, industry, academia, community groups and local institutions collaborate to monitor, track and respond to issues of common community concern". Various terminologies appear within the literature as variants of CBM: "participatory monitoring", "locally-based monitoring", "hunter self-monitoring" and "ranger-based monitoring" (Rist et al., 2010, p. 490). Four approaches to CBM design and implementation dominate the literature, reflecting different levels and types of stakeholder involvement (for a detailed review see Pollock and Whitelaw, 2005 and Figure 17):

1. Government-led CBM refers to a top-down approach where national, regional or local governments assume the responsibility to organize monitoring efforts "designed to provide early detection of ecosystem changes" (Pollock and Whitelaw, 2005, p. 214).
2. Interpretive CBM is led by government or local organizations emphasizing citizen and community outreach, and local environmental education (Pollock and Whitelaw, 2005; Conrad and Daoust, 2008).
3. Advocacy monitoring (also referred to as bottom-up monitoring) involves initiatives of citizen and advocacy groups intended to impact the decision-making process and spur action surrounding local environmental issues (Pollock and Whitelaw, 2005).
4. Multiparty monitoring includes ''all interested stakeholders, private landowners, individual citizens, representatives of civil society organizations, businesses, government, and others committed to the community'' (Whitelaw et al., 2003, p.411).

Given the range in terminologies used to describe various forms of CBM in the literature, and the lack of clarity surrounding indigenous peoples' involvement in CBM approaches, this paper presents an assessment of the challenges and benefits of CBM based on a review of the academic literature. Second, we present an account of four Canadian CBM programs where indigenous participation was prioritized. CBM programs, especially those involving indigenous peoples, are fluid and flexible in nature, whereby the number of external partners and levels of local autonomy regularly fluctuate and data sharing practices and local compensation mechanisms vary on a case-by-case basis in order to address local realities and program requirements.

2. Methodology

2.1 Assessment of Canadian CBM programs prioritizing indigenous participation

Five criteria were utilized to highlight CBM components. They are:

1. Governance and management arrangement;
2. Process for selection program participants;
3. Funding sources;
4. Data sharing and feedback; and
5. Local community compensation.

These criteria were selected in order to represent a simplified understanding of the requirements and processes that allow indigenous peoples' participation in CBM programs. While they are not based on any theoretical framework, these criteria are informed by the authors' field experiences and the necessity to articulate complex local realities to a wide range of audiences, including natural resource decision-makers.

These five criteria were used to highlight four Canadian CBM programs that represent varying forms of indigenous participation. These four programs include: (1) the Arctic Borderlands Ecological

Knowledge Co-op (ABC), a program that is co-managed by six First Nations communities; (2) the Community Moose Monitoring Project (CMMP), a joint monitoring collaboration between the local fish and wildlife office and the Nacho Nyak Dun First Nations community; (3) the Mikisew Cree and Chipewyan First Nations Athabasca Oil Sands CBM program in Northern Alberta, a self-governed monitoring program initiated by the Mikisew Cree and Athabasca Chipewyan First Nations communities; and (4) the Cree Nation of Wemindji's Coastal Fisheries Monitoring Program, an externally administered subsistence fisheries monitoring program in the Cree Nation of Wemindji. The first two programs are initiatives of the Circumpolar Biodiversity Monitoring Programme of the Conservation of the Arctic Flora and Fauna Working Group of the Arctic Council (Gofman, 2010). The third program is the Mikisew Cree and Athabasca Chipewyan First Nations Athabasca oil sands monitoring program, located in Northern Alberta (McLachlan, 2014). The fourth initiative is a locally executed fisheries monitoring program supporting access to coastal subsistence fishing within the Cree Nation of Wemindji, located along the central East coast of James Bay. The first three programs are based on a review of the literature, while the fourth is from original research involving semi-structured interviews and participant observation. The programs were selected in order to illustrate a range of management and governance arrangements, data sharing practices, and local compensation mechanisms that reflect diversity of CBM possibilities. Moreover, these four CBM programs reflect some of the ecological diversity of Canada, including Arctic, temperate, and aquatic environments.

2.2 Wemindji Coastal Fisheries Monitoring Program

A three-week field visit was conducted to Wemindji from July 30th to August 20th, 2012. Semi-structured interviews were carried out in order to gain insights into program administration and local resource users' perspectives on the program and its benefits. Research participants included Cree fishermen and program administrators involved with the program. Cree fishermen were interviewed about the realities and dynamics of coastal fish camp operations, subsistence harvesting, and monitoring. Program administrators informed us about the administrative and financial realities of managing the program. Interview questions were structured around the following themes: funding and program development; collection and analysis of available data; feedback received from program administrators throughout the program lifecycle; program contributions benefitting local fishing families and the community; presentation and feedback of monitoring results; and levels of influence over coastal fisheries decision-making (Table 1). These themes were selected in order to engage in discussions related to the social, cultural and local economic aspects of fisheries monitoring. Participant-based observations were conducted in order to gain an understanding of local fishing methods and realties. This included time spent fishing, working, cooking, and eating with fishermen, program administrators, and community members as an invited guest.

3. Community-based monitoring benefits and challenges

3.1 Community-based monitoring challenges

In reference to numerous shortcomings of CBM (e.g. methodological flaws, inability of decision makers to acknowledge traditional ecological knowledge, lack of financial support towards communities) acknowledged within the literature (Table 6), Nielsen and Lund (2012) called for a more critical assessment of CBM challenges and outcomes, with greater attention paid to the local context where they are implemented. They suggested that CBM must be evaluated more critically to take account of local contexts and should not be considered by management and government authorities as an "end all solution" in environmental monitoring. That is, given community needs, local realities and available resources, other forms of environmental monitoring, other than CBM, may be more appropriate. Conrad and Daoust (2008) noted that CBM projects often fail to implement standardized monitoring protocols for program participants, resulting in poor data collection and undermining the understanding of change over time.

Pollock and Whitelaw's (2005) framework for the creation and assessment of CBM projects in Canada has been a significant contribution to our understanding of CBM in practice. The framework was applied in the implementation of thirty-one CBM pilot projects across a range of Canadian communities, which varied in population sizes from 300 to 400,000+ residents and included both urban and rural communities. Unfortunately, only three First Nations' CBM pilot projects were considered, despite an urgent need to encourage and support such CBM initiatives. Moreover, it was not made clear how existing and established CBM projects and communities might incorporate the framework to suit their purposes. Furthermore, implementing the framework would pose challenges for communities with limited management capacity.

Conrad and Daoust (2008) subsequently expanded upon Pollock and Whitelaw's (2005) framework by integrating feedback and comments from program participants involved in eleven CBM projects in Nova Scotia, Canada. This feedback resulted in the creation of a "functional CBM framework" that attempted to address a lack of standardized monitoring and reporting procedures by communities engaged in CBM (Conrad and Daoust, 2008, p. 364). This expanded framework presented a simplified overview of all program components that have been deemed essential to effective CBM, with a description of the processes required to effectively implement them. A shortcoming of this revised framework is that while it works well for designing and implementing new CBM projects, communities with established CBM projects may have difficulty modifying their existing program structure to accommodate missing or ineffective program components. Conrad and Daoust (2008) also failed to mention if any First Nations or Aboriginal communities were consulted as part of the study, thereby omitting an opportunity to address design and implementation issues in cross-cultural contexts. To our knowledge, no comprehensive survey or analysis of indigenous peoples' involvement within the field of CBM exists. This is compounded by the lack of clarity surrounding Conrad and Daoust's (2008) inclusion of First Nations communities and the wide, often inconsistent, use of terminologies and approaches applied in the implementation of CBM within the wider literature.

CBM projects prioritizing First Nations communities' involvement, particularly assessments of long-term CBM projects, are scarce, resulting in knowledge gaps in the design and implementation of environmental monitoring programs within cross-cultural contexts. Furthermore, much of the current literature tends to privilege the views of outside experts, with limited attention to community perspectives (Mulrennan et al., 2012). According to Hermann et al. (2014), lack of funding, stakeholder conflicts, non-standardized data collection protocols and sensitivity concerning data ownership can present significant logistical obstacles to CBM implementation in indigenous communities.

3.2 Benefits of community-based monitoring

Studies examining primarily non-indigenous Canadian communities have suggested that CBM initiatives benefit (Table 7) from the willingness of communities to increase their levels of participation in environmental conservation planning and management (Conrad and Hilchey, 2011; Kearney et al., 2007; Sharpe and Conrad, 2006). Sharpe and Conrad (2006) and Conrad and Hilchey (2011) have suggested that community involvement in environmental decision-making increased through participation in CBM and led to increased levels of scientific literacy; that is, more comprehensive levels of understanding of changes affecting the natural environment are fostered through their engagement in CBM. Kearney et al. (2007) similarly observed that when communities, especially those with significant levels of dependency on their local environment, increased their participation in environmental monitoring efforts, their management, governance, and resilience capacity also increased. In other words, the ability of local communities to self-manage, self-govern, and allocate the necessary time, energy, and financial resources, towards resource harvesting increased in the context of CBM. Moreover, providing the space for communities to engage in monitoring, as an aspect of decision-making and management processes, can potentially serve to "bring management closer to those most affected by the decisions made" (Kearney et al., 2007, p. 90).

In Canada, the aspirations of local communities to expand their civic engagement in the science and management of natural resources has led to increased adoption of CBM (Conrad and Hilchey, 2011; Hermann et al., 2014; Sharpe and Conrad, 2006; Whitelaw et al., 2003). According to Whitelaw et al. (2003) this increase can be further attributed to: (1) reductions in government funding; (2) the inability of current government monitoring programs to satisfy the expectations and needs of decision-making bodies (e.g. rapid delivery, usability, and relevancy); and (3) increased opportunities and space for communities to involve themselves in management and planning processes. Moreover, according to Garcia and Lescuyer (2008, p. 1304), CBM programs that emphasize decentralized management and governance have the potential to "(i) increase the well-being of rural populations; (ii) better preserve the [natural] resources and the biodiversity which depend on the knowledge and the know-how of native communities; and (iii) improve local governance by empowering communities and enabling them to democratically control resource management".

Within the literature, successful CBM projects involving First Nations communities have been characterized by their ability to: (1) recognize, and prioritize, traditional ecological knowledge (TEK) within the monitoring framework (Berkes, 2004; 2007; Carr, 2004; Golfman, 2010); (2) design, build, and maintain working relationships with both internal and external community partners through participatory (Mulrennan et al., 2012; McLachlan, 2014;), and co-management (Berkes, 2007; Golfman, 2010), arrangements in order to avail of local and external expertise; and (3) communicate monitoring results through locally appropriate methods, including word of mouth, formal reports (Berkes, 2004; Golfman, 2010), and multimedia (McLachlan, 2014).

4. Indigenous participation within CBM in Canada

4.1 Circumpolar biodiversity monitoring programme

The Conservation of the Arctic Flora and Fauna Working Group of the Arctic Council oversees the multidisciplinary Circumpolar Biodiversity Monitoring Program (CBMP) which operates across nine countries (Norway, Canada, Denmark, Finland, Iceland, Greenland, Russia, Sweden, and the United States of America) with the goal to "improve detection, understanding, reporting and response to significant trends in Arctic biodiversity" (Gofman, 2010, p. 3). The CBMP relies upon various data sets collected, and maintained, in collaboration with indigenous communities and other partners. Two established Canadian CBM initiatives within the program include the ABC, and the CMMP.

The Arctic Borderlands Ecological Knowledge Co-op was established in 1996 and consists of a collaborative arrangement between six First Nation communities (Old Crow, Aklavik, Fort McPherson, Tsiigehtchic, Inuvik, and Tuktoyaktuk), two Native American villages (Kaktovik and Arctic Village), and a government department (Environment Canada). According to Gofman (2010, p. 17), ABC seeks to identify "local and traditional knowledge about the ecosystem within the range of the Porcupine Caribou Herd and adjacent marine/coastal areas with the focus on contaminants, climate change and development". The second initiative, the CMMP, is a collaborative project established in 2001 between the local fish and wildlife office of the Mayo region and the Nacho Nyak Dun First Nation community in the Yukon. The CMMP aims to continuously monitor the size and health of local moose herds within the region. The initiative was spearheaded by residents of the Nacho Nyak Dun community and is technically and logistically supported by the Mayo Fish and Wildlife Office, whereby continual training and logistical support is provided and overseen by a locally established co-management board.

In both initiatives, local indigenous involvement in CBM was prioritized through several mechanisms. Firstly, the expertise of traditional land users is formally recognized (Tables 8 and 9). Second, local participation within both CBM initiatives is self-selected, meaning that local residents inform project administrators of their desire to participate in the monitoring program every year. Third, both CBM initiatives ensure that locally collected monitoring data is distributed to all local community residents and external stakeholders by means of formal hard copy reports (CMMP) and online distribution (ABC). In line with the goals of the CBMP, as outlined by Huntington (2008), both the ABC and CMMP demonstrate the ability to: undertake monitoring activities, interpret, and report Arctic biodiversity trends; make use of local and external expertise to carry out CBM initiatives; and share the outcomes, experiences, and methodologies of undertaken monitoring by means of summary reports and external communications.

4.2 Mikisew Cree and Athabasca Chipewyan First Nations Athabasca oil sands monitoring program

The Department of Government Industry Relations of the Mikisew Cree First Nation (MCFN) and the Athabasca Chipewyan First Nation (ACFN) Industry Relations Corporation initiated the Mikisew Cree and Athabasca Chipewyan First Nations Athabasca oil sands community-based participatory research (CBPR) project. The program ran from June 2012 to September 2013 in collaboration with researchers from the University of Manitoba. According to McLachlan (2014) the CBPR program was established in response to concerns surrounding the potential impact to local flora, fauna, and human health resulting from increased bitumen extraction from the Athabasca Oil Sands in Alberta. Both MCFN and ACFN communities logistically supported and "established the research priorities reflected in [the project]" (McLachlan, 2014, p. 22). The National First Nations Environmental Contaminants Program, Health Canada, Social Sciences and Humanities Research Council of Canada, the MCFN, and ACFN financially supported the project.

Initially, the program prioritized the participation of community Elders, hunters and trappers to avail of their expertise in trapping traditionally harvested fauna, required to determine levels of environmental contamination. The study expanded to include the human health dimension and began incorporating the participation of community members through semi-structured and open interviews and the continued hunting and trapping of fauna (McLachlan, 2014). Attempts made to hire local community members to harvest selected animal species proved unsuccessful. McLachlan (2014) indicated that efforts to collect animals for sampling proved to be successful only when they were integrated into traditional family harvesting activities that did not distract, or remove community members from their regular hunting and trapping activities. McLachlan (2014, p. 25) explained that "community members hunt in familial areas, and seemed to be willing to sample animals as long as it did not interfere with their primary purpose of being on the land. While we attempted to hire land users to harvest select species in other specified (and polluted) areas, this was also largely unsuccessful."

According to McLachlan (2014), the research objectives, process, and output were designed to be open and accessible to the wider community (Table 10). This was achieved by addressing local needs and concerns in the research design phase, and the use of simplified language in combination with a variety of media formats to publicize the research. "It was always the intent of these organizations and the outsider researchers to make this research as open to community input and as responsive to community needs as possible. This has been reflected in our approach to interacting with the grassroots, incorporating community priorities at all stages of the project, supporting capacity throughout the work, and employing a wide diversity of media and plain languages to communicate research results." (McLachlan, 2014, p. 22)

4.3 Wemindji Coastal Fisheries Monitoring Program

The Wemindji Coastal Fisheries Program (WCFP) was established as a mitigation program designed to support traditional fishing and to provide the community of Wemindji with "fish of acceptable quality" (Hydro-Quebec, 1990) in response to mercury contamination. As such, the WCFP included two components: support for and promotion of traditional coastal fishing activities through seasonal income support; and a program of "monitoring of fish catches in order to ensure the long-term availability of fish for future generations" (Hydro-Québec, 1990)

(Table 11).

The WCFMP was implemented on the ground, under the authority of the local hunting boss (acting stewards of their family hunting territories and coastal lands). Local Cree fishermen were seasonally employed to carry out the fishing and monitoring activities related to the program. The Wemindji CTA, a regional organization with local community offices established to represent the interests of Cree hunters, trappers, and fishermen, coordinated the program by providing administrative, logistical, and technical support to the hunting bosses and program participants. Program participants followed data collection guidelines and collection sheets developed by a contractually employed biologist that was employed throughout the duration the program. Fisheries monitoring training was offered to program participants. This consisted of a workshop organized in collaboration with the Wemindji CTA at the start of the fishing season when data recording guidelines for daily catches were explained to program participants.

Over the course of twenty-three years, the WCFP evolved to be locally recognized as a program that logistically and financially supported access to traditional fishing camps. This gradually occurred through two major shifts. The first shift began at the local level whereby local hunting bosses and the Wemindji CTA increased their levels of involvement in administrative and management activities (e.g. board meetings, local task forces, and voicing of local concerns through the CTA) and assumed responsibility and local ownership of the WCFP. The second shift occurred at the funding and program administrative level, whereby the Niskamoon Corporation hired Niskamoon representatives and staffed them in local CTA offices, including Wemindji. This allowed for increased communication between the Niskamoon Corporation and the needs and requirements of local hunting bosses, through the CTA.

5. Discussion: Can we move from community-based to community-led monitoring?

This paper attempted to present an assessment of the challenges and benefits of CBM based on a comparative examination of four Canadian CBM programs involving indigenous communities. The programs were selected to reflect varying levels of governance arrangements: co-managed; collaborative; self-initiated and governed; and externally administrated.

Our study found that the terminologies used to describe CBM approaches are inconsistently applied in the theoretical literature. Moreover, there is a lack of clarity surrounding of indigenous peoples' involvement in CBM. In attempting to identify levels of indigenous peoples' participation in CBM, it is not sufficient to categorize forms of participation and involvement into existing CBM approaches (Figure 17) tailored to encompass monitoring protocols and community initiatives that are not specific to indigenous peoples' realities. Indigenous peoples' involvement in CBM programs are fluid and flexible in nature, whereby the number of external partners and levels of local autonomy regularly fluctuate and data sharing practices and local compensation mechanisms vary on a case-by-case basis in order to address local realities and program requirements. This was demonstrated through the presentation of four CBM programs highlighting: governance and management arrangement; process for selection program participants; funding sources; data sharing and feedback; and local community compensation.

CBM efforts should support the processes of community engagement, local capacity building, and allow for indigenous peoples to decide the best course of action, based on current governance arrangements, regardless of what that arrangement is. In order for this to be achieved, CBM frameworks must be redefined in scope and definition in order to better describe the varying levels of involvement of indigenous peoples (Figure 18) and the varying capacities and program components that reflect levels of involvement (Figure 19). Given the range of governance arrangements reflected in the four environmental monitoring programs examined in this chapter, CBM appears to be an approach that can cater to varying local and regional realities. That is, CBM is not limited to one particular type of governance model. Rather, it can provide an opportunity for local communities and governments to address mutual interests in conservation monitoring and management (Pollock and Whitelaw, 2005; Conrad and Daoust, 2008; Nielsen and Lund, 2012), while simultaneously facilitating, and supporting, the decentralized management of natural resource management (Wiber et al., 2004; Garcia and Lescuyer, 2008).

Kearney et al. (2007) observed that when communities, especially those with significant levels of dependency on their local environment, increased their participation in environmental monitoring efforts, their management, governance, and resilience capacity also increased. In other words, their ability to self-manage, self-govern, and allocate the necessary time, energy, and financial resources, towards resource harvesting increased. Moreover, providing the space for communities to engage in monitoring, as an aspect of decision-making and management processes, can potentially serve to "bring management closer to those most affected by the decisions made" (Kearney et al., 2007, p. 90).

The place and space in which local communities are involved in the data collection carry little to no significance in the literature. That is, the physical and cultural environments in which data collection is undertaken appears to have no theoretical significance in the reviewed literature. This needs to change. Culturally appropriate conservation methodologies that are relevant, and directly benefit indigenous communities should be prioritized (Walter and Hamilton, 2014). Greater attention needs to be paid to the local contexts in which CBM programs are implemented (Nielsen and Lund, 2012). To support this, the current theoretical paradigm needs to change so that the perspectives of communities are taken into consideration when planning CBM programs. Unfortunately, despite lip-service to this recognition, meaningful levels of participation are rarely applied in practice. Research protocols and methodologies that fail to address indigenous participation and empowerment, achieve little more than the extraction of local environmental information by external agents to satisfy third-party research goals (Adams et al., 2015). Decision-makers gain little insight to the context of local monitoring and management, resulting in inappropriately designed programs (Yoccoz et al., 2001; Nasuchon and Charles, 2010; Nielsen and Lund, 2012) which fail to benefit local communities and program participants (Pollock and Whitelaw, 2005; Katsanevakis et al., 2012).

We conclude by cautioning against the broad use of CBM programs that fail to appropriately define indigenous peoples' involvement in the monitoring of their lands and seas. The concept of CBM needs to be applied more critically and with greater sensitivity to the type and extent of local participation in each program component of CBM, especially in relation to indigenous participation.

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Chapter 6. Conclusion

The primary objective of this thesis was to address the limited consideration of local indigenous perspectives in the field of CBM by highlighting the experiences of fishermen from the Cree Nation of Wemindji, a First Nations community located on the eastern shores of James Bay, in undertaking a long-term monitoring program in the Canadian sub-arctic. Second, we attempted to identify the benefits and challenges of CBM, particularly as they relate to different levels of indigenous participation. To achieve this, experience gained from twenty-three years of subsistence fisheries monitoring in the Wemindji Coastal Fisheries Monitoring Program was documented. This supported the following research objectives:

1. To assess the extent to which monitoring has been used to inform decision-making in fisheries management;
2. To gain insights into the dynamics of local resource monitoring through the introduction of two innovations to the program;
3. To make recommendations for improvements to the program; and
4. To identify trends in subsistence fisheries harvesting over time;

This study found that although the WCFP was successful on several fronts, including support of subsistence harvesting and continued local involvement towards data collection and reporting over the years, the WCFMP missed an opportunity to:

1. Engage program participants and community members in broader decision-making;
2. Communicate the status of coastal fish stocks to community members;
3. Broaden regional understanding of the contribution of subsistence fisheries to local community food security; and
4. Utilize the WCFMP as an avenue for intergenerational knowledge transmission.

While the annual WCFMP reports did make use of the collected data and provide recommendations to the Wemindji CTA as to whether to continue with seasonal fishing activities in subsequent years, the reports failed to include local perspectives and embrace opportunities for meaningful engagement with local knowledge. This limited the utility of the reports by failing to provide context to empirically collected monitoring data. There was varying levels of enthusiasm in relation to the monitoring and data collection required as part of the WCFMP, apart from the CTA staff, none of the interviews revealed that fishermen understood the value-added dimension of collecting fisheries catch data. More importantly, none of the interviews revealed whether Wemindji fishermen understood how the data was to be used, or where it would end up.

While the social and political realities of communities engaged in CBM vary and are case-specific, this study echoes the observation made by Rist et al. (2010, p. 497) where it was observed that "[for] any monitoring scheme that [utilized financial compensation] to be sustainable in the longer term, the incentives for participation must be based on more than short-term financial motivation. For a locally based monitoring scheme to work in practice, the benefits of monitoring (e.g., improved future harvests), must be greater than the costs for the individuals and communities concerned, both of monitoring and implementing management interventions". Failing to effectively communicate the value of collected monitoring data and providing feedback to local program participants reflects ineffective management and an incomplete implementation of a CBM program based on Pollock and Whitelaw's (2005, p. 224) criteria whereby CBM programs should "deliver timely, usable, accessible, and relevant information and feedback to decision-makers". Moreover, monitoring programs should continue to work towards gaining a deeper understanding of local realities (Agrawal and Gibson, 1999; Danielsen et al., 2008) and motivational factors driving local resources users (Rist et al., 2010; Nielsen and Lund, 2012), and serve to benefit conservation science and management and not be seen or utilized as a "stand-alone activity" (Nichols and Williams, 2006, p. 668).

Second, this research found that CBM approaches detailing indigenous peoples' participation are limited within the academic literature. In attempting to identify levels of indigenous peoples' participation in CBM, it is not sufficient to categorize forms of participation and involvement into existing CBM approaches tailored to encompass monitoring protocols and community initiatives that are not specific to indigenous peoples' realities. CBM programs involving indigenous peoples, like all other CBM programs, are fluid and flexible in nature, whereby the number of external partners and levels of local autonomy regularly fluctuate and data sharing practices and local compensation mechanisms vary on a case-by-case basis in order to address local realities and program requirements.

CBM is not limited in application to one particular type of governance model. Instead, it provide an opportunity for local communities and governments to address mutual interests in conservation monitoring and management (Pollock and Whitelaw, 2005; Conrad and Daoust, 2008; Nielsen and Lund, 2012), while simultaneously facilitating, and supporting, the decentralized management of natural resource management (Wiber et al., 2004; Garcia and Lescuyer, 2008). Our findings suggest that the potential of CBM programs can only be fully realized when indigenous communities are meaningful participants in the monitoring of their lands and seas. More attention to CBM program design and implementation is therefore needed in indigenous community contexts.

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Appendix

Tables

Table 1. Semi-structured interview themes and sample questions

Administration oriented	*Local resource user oriented*
Question Themes	
1. Funding and program development 2. Collection and analysis of data 3. Feedback and contribution to local fishing families and community 4. Presentation of results 5. Influence on fisheries decision-making	1. Personal level of involvement within monitoring 2. Community level involvement within monitoring 3. Usefulness of collected data 4. Fisheries, children, and other community members 5. Suggested improvements in monitoring
Sample interview questions	
1. What role does (organization) have in the coastal fisheries monitoring program? 2. Why is fishing important to the community? 3. How successful has the overall fisheries program been? 4. Have there been any changes made to the program since it was started? What are they? 5. What are some of the costs and benefits to running the fisheries program? 6. Do you think there would be a significant decline in summer fishing activity if the fisheries program was discontinued? 7. How valuable has the monitoring aspect of the program been? 8. Do you believe the community understands the reasons why monitoring data is collected annually? 9. Do you believe that the data is useful 10. Has the monitoring data ever been examined by the community or (organization)? 11. What feedback on the monitoring program has been provided to (organization) or the community? 12. Do you ever consult or use the annual fisheries reports? If so for what purpose? 13. What do you think works well about the monitoring program? What do you think could be improved? 14. Do you think the fisheries program, particularly the monitoring aspect, contributes to maintaining fishing activities and the knowledge associated with them? 15. What responsibilities, if any, do children have in the fishing program? 16. What roles and responsibilities do women have?	1. How important is fishing to you, your family, and your community? 2. How long have you been a participant in the fisheries program? 3. Why are you participating in the fisheries program? 4. What do you think works well about the program; what don't you like? What could be better? 5. *(If respondent has children)* what tasks or responsibilities do your children have in the fish camp? 6. What do you think about the monitoring aspect of fishing? 7. What are you required to do for the monitoring aspect of the program? Did you receive any training to do this? How long does each step take? 8. What are you monitoring and why? 9. Have you ever seen the monitoring data come back to you? 10. Do you think the monitoring is useful? 11. Do you believe the monitoring program can be improved? If so, how? 12. Has anyone ever thanked you for all the work you do? 13. Have you noticed any changes in the fish throughout the years? 14. Do you believe there was one really good fishing year?

Table 2. Key program components that aided in the establishment of the WCFMP along with recommendations for their integration in other CBM program

Program Components	Recommendations
1. Integration of data collection protocols within an existing traditional subsistence fishery that is actively practiced, culturally significant, and provides a valuable source of food for the community.	1. CBM programs that seek to be culturally appropriate should aim to integrate environmental monitoring within existing local harvesting programs; 2. Programs should be developed and managed in accordance with local institutions of authority and management; 3. Programs should build in flexibility and sensitivity to local community, institutional, and local government needs, without compromising rigours of scientific methodology and environmental monitoring requirements.
2. Decentralized management structure which allowed for the Wemindji CTA and hunting bosses to assume responsibility and ownership of fishing efforts and program logistics.	1. CBM programs that seek to be culturally appropriate should aim to recognize and prioritize local expertise, knowledge, and labour efforts in program design and implementation.
3. Annual program proposals submitted by the Wemindji CTA to the	1. CBM programs that seek to be culturally appropriate should provide adequate, and

Niskamoon Corporation, and previously Hydro-Québec, provided funding for the WCFP. This allowed for seasonal income to program participants and provided funds to support the purchase and use of: gill nets, canoes and outboard motors, sleds, skidoos, gasoline-powered generators, freezers, tents, and kitchen equipment	appropriate, incentives for local participation; 2. Incentives should be culturally appropriate. That is: (1) in conformity with local and social norms; (2) sufficient to support local lifestyles; (3) in conformity with local, regional, and/or national legislation; 3. Ideally, CBM programs should aim to provide all logistical program materials to local participants (e.g. monitoring tools, transportation to field/monitoring sites). Otherwise, adequate incentives compensating for these services should be provided to local participants; 4. Beyond financial and logistical incentives, CBM programs should seek to build local capacity, training, and infrastructure with the goal of ensuring local long-term monitoring capabilities beyond the intended scope of the original program.
4. Division of program responsibilities and tasks through local institutions and external partnerships: local capacity was supported by the hunting bosses,	1. CBM programs that seek to be culturally appropriate should seek to establish and maintain collaborative partnerships that aid in the overall implementation and

Wemindji CTA and Band Council in collaboration with external partnerships with a contractually employed biologist and support from the Niskamoon Corporation	management of the program; 2. Outside of stipulated program requirements and guidelines, CBM programs should seek external expertise solely when it benefits the overall efficiency of the program; 3. When local expertise does not exist in a given domain, the priority should be to build the required expertise, or create participatory relationships which seek to build local expertise and capacity in a specified domain.

Table 3. Number of summer fishing camps, individuals employed per camp, and program start and end dates from 1989 - 1996 and 2003 - 2011

Date	Number of fishing camps	Number of fisherman per camp	Start of fishing program	End of fishing program
1989	3	n.d. [6]	End June[1]	Mid-September[1]
1990	n.d.[2]	n.d. [2]	n.d. [2]	n.d. [2]
1991	3	n.d. [6]	1991-06-17	1991-09-17
1992	3	n.d. [6]	1992-07-16	1992-09-14
1993	3	n.d. [6]	1993-06-14	1993-09-04
1994	n.d. [2]	n.d. [2]	n.d. [2]	n.d. [2]
1995	3	5	1995-07-04	1995-08-16
1996	3	5	1996-07-08	1996-08-14
2003	5	5	2003-07-07	2003-08-22
2004	5	5	2004-08-18	2004-10-02
2005	4	5 to 7[3]	2004-07-06	2004-08-15
2006	3	5	2006-07-24	2006-08-19
2007	5	5 to 10[4]	2007-07-10	2007-08-24
2008	4	5	2008-07-17	2008-08-30
2009	5	5	2009-07-01	2009-09-09
2010	5	5	2010-07-15	2010-09-07
2011	5	5 to 6[5]	2011-07-21	2011-09-11

n.d. No data

1. Specific start and end dates were not provided in the 1989 report.

2. For the years of 1990 and 1994, no data beyond the catch numbers were available from annual reports. The 1989-1996 summary report was used to gather catch data but did not include logistical data.

3. In 2005, the Shephard's Island coastal camp employed seven fishermen. Moar Bay, Old Factory, and Rabits Ride camps each employed five fishermen.

4. In 2007, the Black Stone Bay coastal camp employed ten fishermen. The Goose Island Camp employed seven fishermen. The Shephard's Island camp employed six fishermen. The Moar Bay and Old Factory camps each employed five fishermen.

5. In 2011, the Moar Bay coastal camp employed five summer fishermen as part of the monitoring

program. Goose Island, Old Factory, Sculpin Island, and Shephard Island each employed six fishermen.

6. The number of fishermen employed in each camp was not indicated in the 1989, 1991, 1992, and 1993 reports.

Table 4. Results from linear regression output for total fish catches per year for each coastal fishing camp participating in the Wemindji Community Fisheries Monitoring Program

Fish camp name		Fish species		
		Cisco	Brook trout	Lake whitefish
Moar Bay	R^2	0.5696	0.4308	0.7108
	P-value	0.00046	0.0042	0.00002
Old Factory	R^2	0.6541	0.6942	0.6793
	P-value	0.00008	0.0003	0.00005
Black Stone Bay	R^2	n.d.	n.d.	n.d.
	P-value	n.d.	n.d.	n.d.
Goose Island	R^2	0.5263	0.583	0.2628
	P-value	0.007813	0.0039	0.0884
Paint Hills Bay	R^2	n.d.	n.d.	n.d.
	P-value	n.d.	n.d.	n.d.
Rabbits Ridge	R^2	0.2794	0.895	0.006
	P-value	0.4715	0.05398	0.9217
Sculpin Island	R^2	n.d.	n.d.	n.d.
	P-value	n.d.	n.d.	n.d.
Shephard Island	R^2	0.6203	0.1929	0.3417
	P-value	0.01173	0.2369	0.0983

n.d. No data

Table 5. Annual maximum fishing effort in days

Year	Maximum fishing effort (in days)
1989	n.d.
1990	n.d.
1991	92
1992	60
1993	82
1994	n.d.
1995	43
1996	37
2003	46
2004	45
2005	38
2006	26
2007	31
2008	44
2009	70
2010	22
2011	52
R^2 = 0.162331872	***P-value*** = 0.172244606

n.d. No data

Table 6. Challenges of community-based monitoring

Challenges	Study context	Source
Local communities can introduce monitoring bias	CBM assessment	Danielsen et al. (2007)
Potential for local monitors to misreport information if they believe that the collected data will be used to restrict, reduce or limit catch numbers or effort as a management outcome (i.e. failure to understand local motivation)	NRM using CBM	Rist et al. (2010)
External stakeholders can attempt to block monitoring efforts to maintain power	NRM using CBM	Garcia and Lescuyer (2008)
Initial CBM start up phases can be prohibitively costly to underfinanced communities and groups	NRM using CBM	Garcia and Lescuyer (2008)
Maintaining a consistent monitoring effort can prove challenging for local community members	NRM using CBM	Garcia and Lescuyer (2008); Wiber at al. (2009)
Local communities can lose interest in monitoring	CBM assessment; NRM using CBM	Conrad and Daoust (2008); Garcia and Lescuyer (2008)
Collected monitoring data may no longer be relevant to decision-makers	CBM assessment; NRM using CBM	Pollock and Whitelaw (2005); Garcia and Lescuyer (2008)
Potential dependence on funding agencies to ensure continued monitoring	NRM using CBM	Garcia and Lescuyer (2008)
Decision-making may be dependent on power and authority and may not consider collected data	NRM using CBM	Garcia and Lescuyer (2008)
Data collected may be less accurate than professionally collected data	CBM assessment; CBM assessment; NRM using CBM	Pollock and Whitelaw (2005); Conrad and Daoust (2008); Uychiaoco et al. (2010)
Government budget cuts can result in unexpected termination of CBM programs	CBM assessment	Conrad and Daoust (2008)
Can be disorganized and result in confusion	CBM assessment	Conrad and Daoust (2008)
Inconsistent funding can result in data fragmentation	CBM assessment	Pollock and Whitelaw (2005)
Can be plagued by methodological flaws	CBM assessment	Pollock and Whitelaw (2005)
Difficulties in translating and explaining scientific monitoring protocols to native local languages and dialects	CBM assessment	Pollock and Whitelaw (2005)
Decision-makers may fail to understand specific context and design inappropriate programs	Monitoring assessment; NRM using CBM; CBM assessment	Yoccoz et al. (2001); Nasuchon and Charles (2010); Nielsen and Lund (2012)
Lack of linkages between design objectives and decision-making frameworks	Monitoring assessment	Lyons et al. (2008)
May only serve scientific objectives and fail to benefit local communities and program participants	CBM assessment; monitoring assessment	Pollock and Whitelaw (2005); Katsanevakis et al. (2012)
Local communities may be left to absorb associated costs	CBM assessment	Pollock and Whitelaw (2005); Danielsen et al. (2007)
Methodologies may lack scientific rigor	NRM using CBM	Rist et al. (2010)
Methodologies may be overly complex and inconsistent	NRM using CBM; CBM assessment	Andrianandrasana et al. (2005); Pollock and Whitelaw (2005)
Local monitoring efforts and achievements may not be recognized and communicated	CBM assessment	Pollock and Whitelaw (2005)
May be perceived as the end all solution	CBM assessment	Nielsen and Lund (2012)
Local communities may fail to understand the importance and value of CBM data	CBM assessment	Pollock and Whitelaw (2005)

Table 7. Benefits of community-based monitoring

Benefits	Study context	Source
Opportunity for local communities and governments to address mutual interests towards conservation monitoring and management	CBM assessment	Pollock and Whitelaw (2005); Conrad and Daoust, (2008); Nielsen and Lund (2012)
Can increase the level of engagement and interaction between all involved stakeholders	NRM using CBM; CBM assessment; NRM using CBM; CBM assessment	Andrianandrasana et al. (2005); Pollock and Whitelaw (2005); Uychiaoco et al. (2005); Conrad and Daoust, (2008)
Can support, facilitate, and promote decentralized and participatory NRM	NRM using CBM	Wiber et al. (2004); Garcia and Lescuyer (2008)
Can enhance our knowledge of ecosystem functionality		Conrad and Hilchey (2011)
Can potentially increase local capacity	CBM assessment	Danielsen et al. (2009)
More cost-effective than conventional top-down monitoring	NRM using CBM; CBM assessment; NRM using CBM	Garcia and Lescuyer (2008); Danielsen et al. (2009); Rist et al. (2010)
Can be as accurate as professionally collected data	NRM using CBM	Rist et al. (2010)
Inclusion of local environmental perceptions, priorities, and knowledge	CBM assessment	Pollock and Whitelaw (2005); Conrad and Daoust, (2008); Danielsen et al. (2009)
Potential for more management interventions than with conventional monitoring approaches	CBM assessment	Danielsen et al. (2009)
Can enhance the decision-making process by including local knowledge	NRM using CBM	Andrianandrasana et al. (2005); Nasuchon and Charles (2010)
Encouragement and support of transparent and efficient governance	NRM using CBM	Andrianandrasana et al. (2005)

Table 8. The Arctic Borderlands Ecological Knowledge Co-op

Governance and management arrangement	Co-management arrangement with Canadian First Nation communities through Native land claim settlements
Process for selecting program participants	All participating indigenous communities were self-selected, and volunteered to join the project. Both formal and semi-structured questionnaires and interviews were conducted with local community experts that have varying levels of connection to their traditional lands.
Funding sources	Environment Canada administers the project while funding is secured annually through a variety of sources including: "Competitive grants, Territorial Governments, United States Fish and Wildlife Service, Parks Canada, Environment Canada and other sources"
Data sharing and feedback	Data is shared at the community level and online through the project website
Local community compensation	Annual program participants are compensated for their work through fuel vouchers

Table 9. Community Moose Monitoring Project

Governance and management arrangement	Locally initiated monitoring program supported by local fish and wildlife office and overseen by a co-management board.
Process for selecting program participants	Program participants are all from the local community and are self-selected and are all traditional hunters and community residents with extensive time spent on their lands
Funding sources	Funding is provided by the Yukon Government
Data sharing and feedback	Initially, for the first five years of the project, annual one-page monitoring reports were provided to each community household. At present, the collected monitoring data is compiled into an annual report by the local fish and wildlife office and presented at the local Mayo Area Renewable Resources Council. A multi-year report is being prepared for the Yukon Government, at their request. A shorter version of the same report will be summarized and provided to all local community members.
Local community compensation	Program participants are provided free coffee mugs which change in design each year. Moreover, each year, five CDN $100 vouchers are drawn from a lottery of the twenty program participants. The vouchers can be used towards food and fuel purchases.

Table 10. Mikisew Cree and Athabasca Chipewyan First Nations

Governance and management arrangement	Community-based participatory research project initiated by the Mikisew Cree First Nation Government Industry Relations and the Athabasca Chipewyan First Nation Industry Relations Corporation.
Process for selecting program participants	Initially, the program prioritized the participation of community Elders and hunters and trappers in order to utilize their expertise in trapping traditionally harvested fauna, in order to determine levels of environmental contamination. Subsequently, the study expanded to include the human health dimension and began incorporating the participation of community members through semi-structured and open interviews, and continual hunting and trapping.
Funding sources	National First Nations Environmental Contaminants Program, Health Canada, Social Sciences and Humanities Research Council of Canada, Mikisew Cree First Nation, and Athabasca Chipewyan First Nation
Data sharing and feedback	According to McLachlan (2014, p.22), the research objectives, process, and output were designed to be open and accessible to the wider community. This was achieved by addressing local needs and concerns in the research design phase, and the use of simplified language in combination with a variety of media formats to publicize the research.
Local community compensation	Attempts made to hire local community members to harvest selected animal species proved unsuccessful. McLachlan (2014) indicated that efforts to collect animals for sampling proved to be successful when integrated into traditional family harvesting activities that did not distract, or remove community members from their regular hunting and trapping activities.

Table 11. Wemindji Coastal Fisheries Monitoring Program

Governance and management arrangement	Administered by Hydro-Québec and the Wemindji Band Council from 1989 to 2001 and between the Niskamoon Corporation and the Wemindji Cree Trapper's Association from 2002 to 2011. The WCFP was implemented on the ground, under the authority of the local hunting boss. The Wemindji CTA coordinated the program by providing administrative, logistical, and technical support to the hunting bosses and program participants
Process for selecting program participants	Through the Wemindji CTA, local hunting bosses were responsible for the identification and hiring of seasonal program participants
Funding sources	Hydro-Québec (1989 to 2001) Niskamoon Corporation (2002 to 2011)
Data sharing and feedback	Copies of annual monitoring reports are provided to the Wemindji CTA and stored in the Hydro-Québec Documentation Centre, a private library owned and operated by Hydro-Québec.[6]
Local community compensation	The program provides funds to support the purchase and use of: gill nets, canoes and outboard motors, sleds, skidoos, gasoline-powered generators, freezers, tents, and kitchen equipment. Program participants are financially compensated for their work.

[6] Poor data archiving

Figures

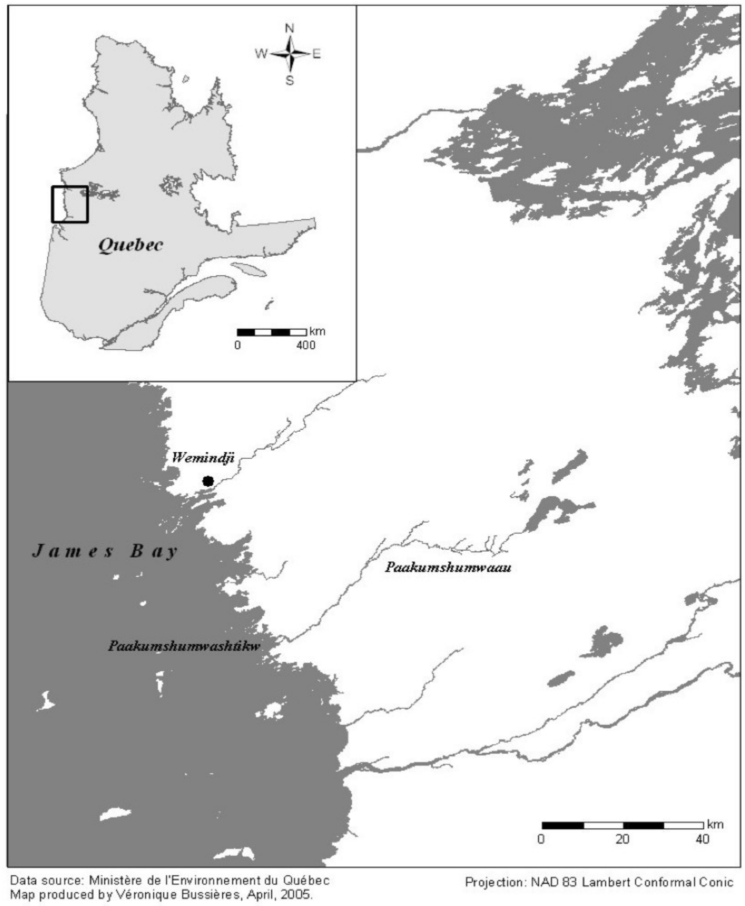


Figure 1. Wemindji located within the province of Quebec (Bussières, 2005)

Figure 2. Coastal fishing camps participating in the Wemindji Coastal Fisheries Program (Martin Lessard Inc.)

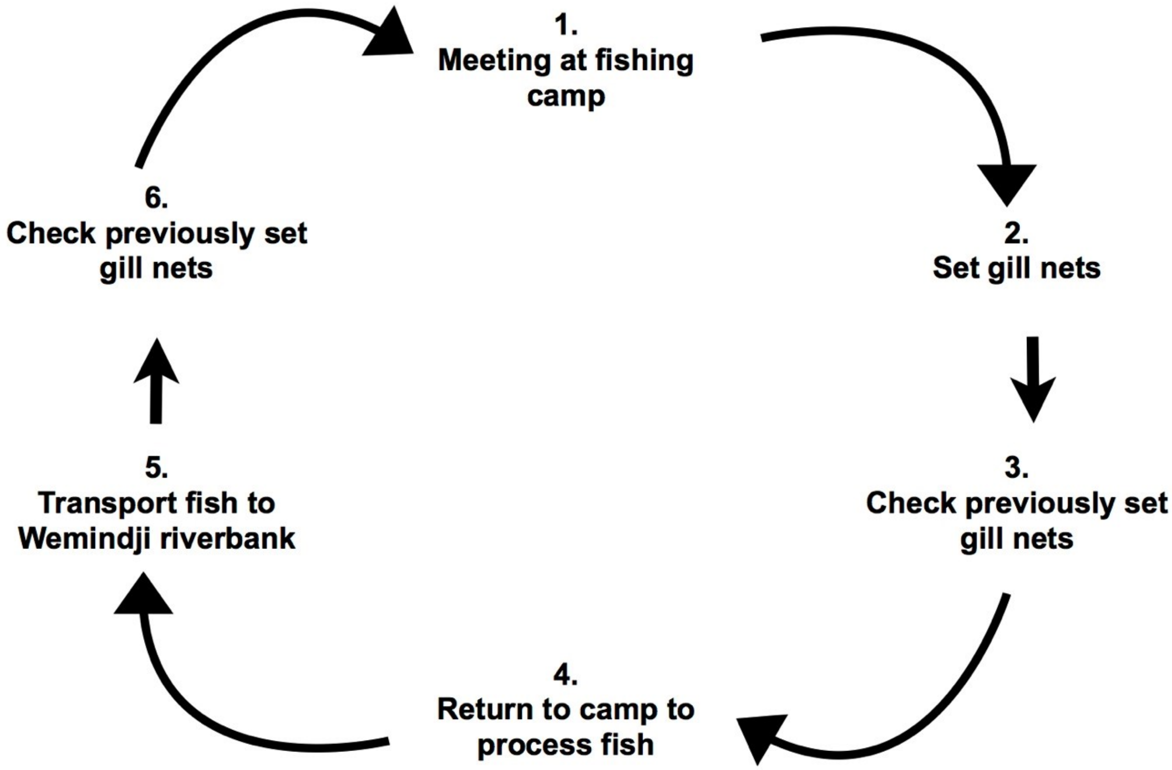


Figure 3. Daily WCFMP workflow

Figure 4. Freighter canoe with gasoline powered outboard motor

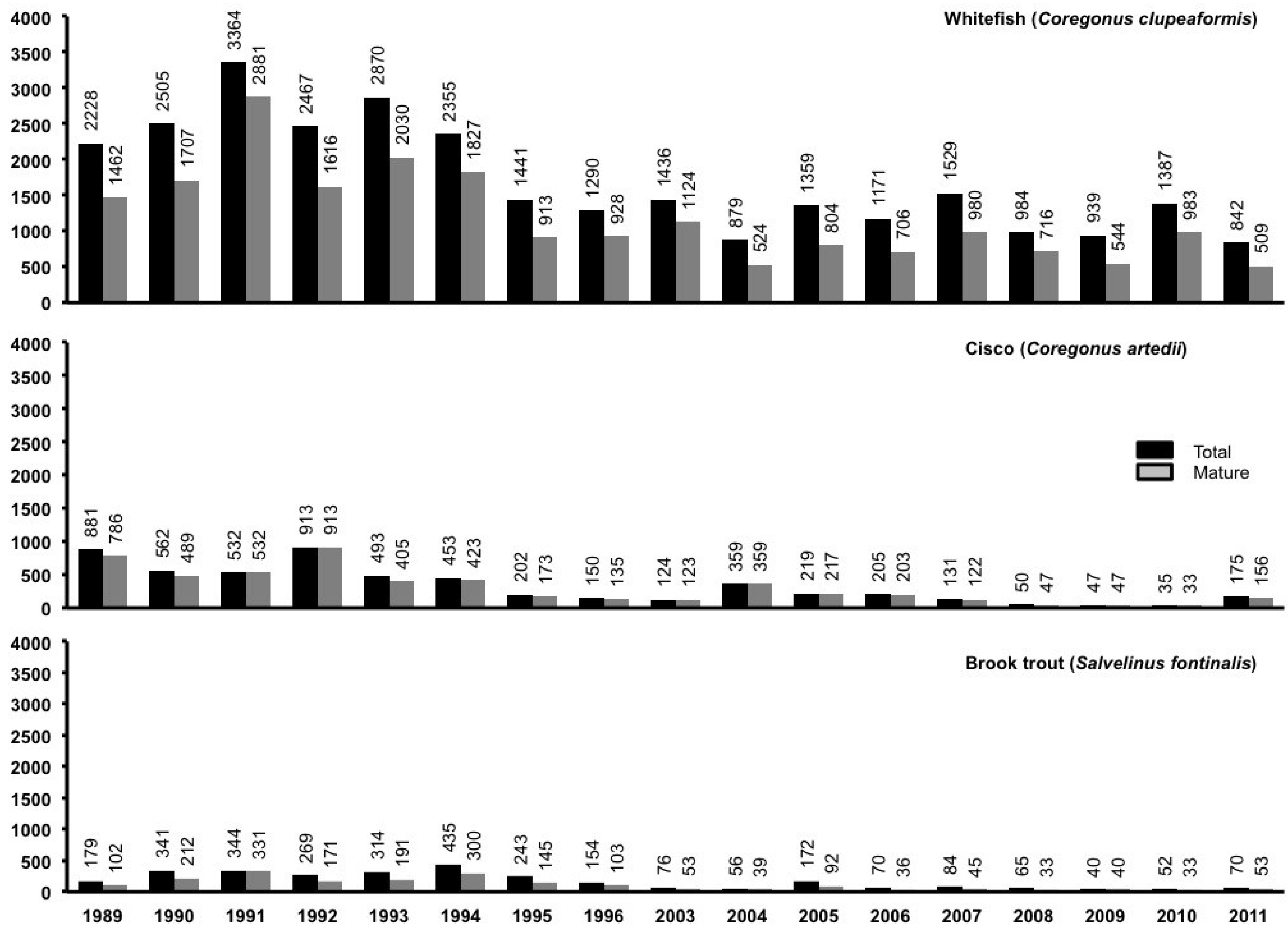


Figure 5. WCFMP harvesting data for whitefish, cisco, and brook trout at Old Factory from 1989 - 1996 and 2002 – 2011

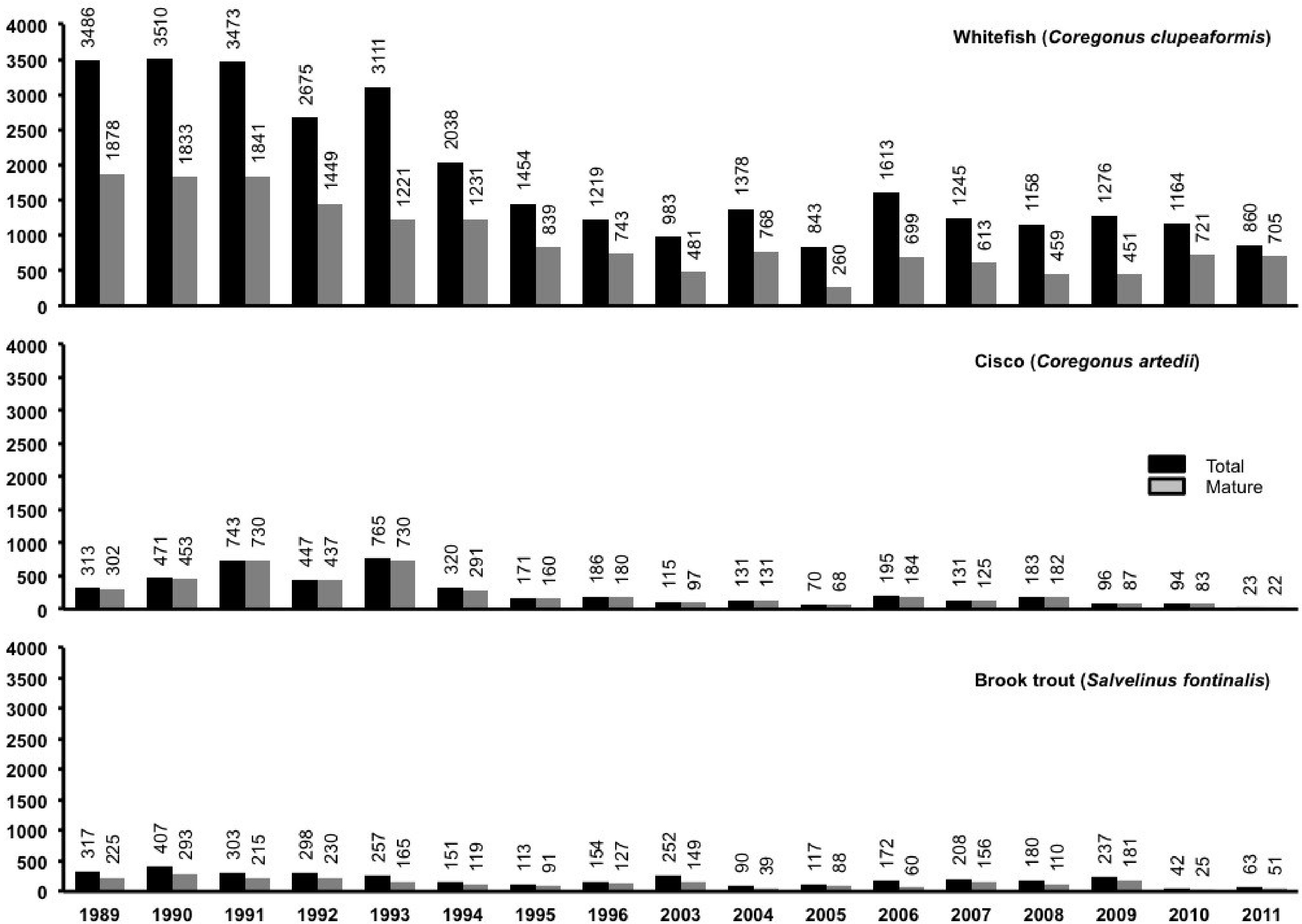


Figure 6. WCFMP harvesting data for whitefish, cisco, and brook trout at Moar Bay from 1989 - 1996 and 2002 - 2011

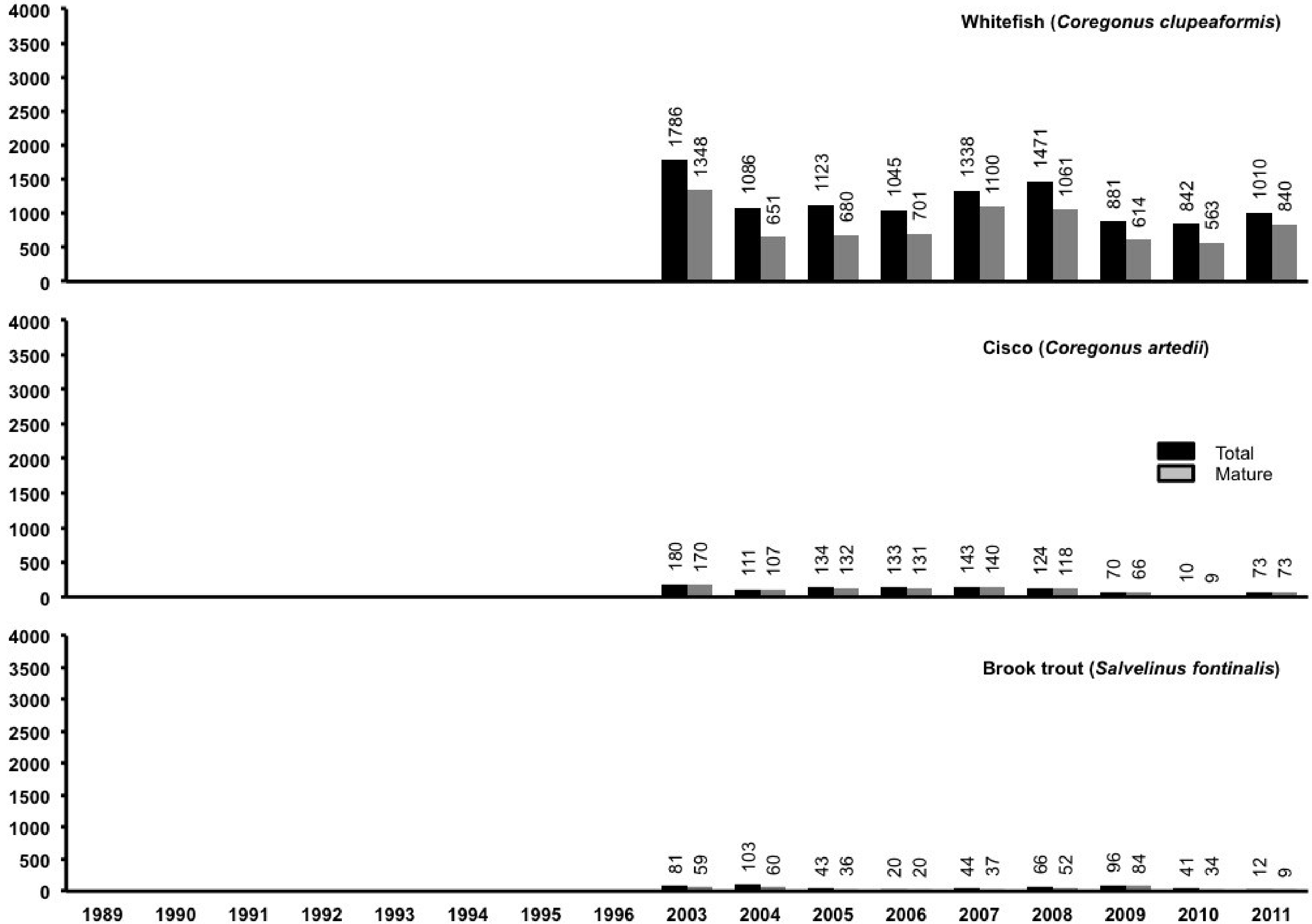


Figure 7. WCFMP harvesting data for whitefish, cisco, and brook trout at Shephard Island from 2003 – 2011

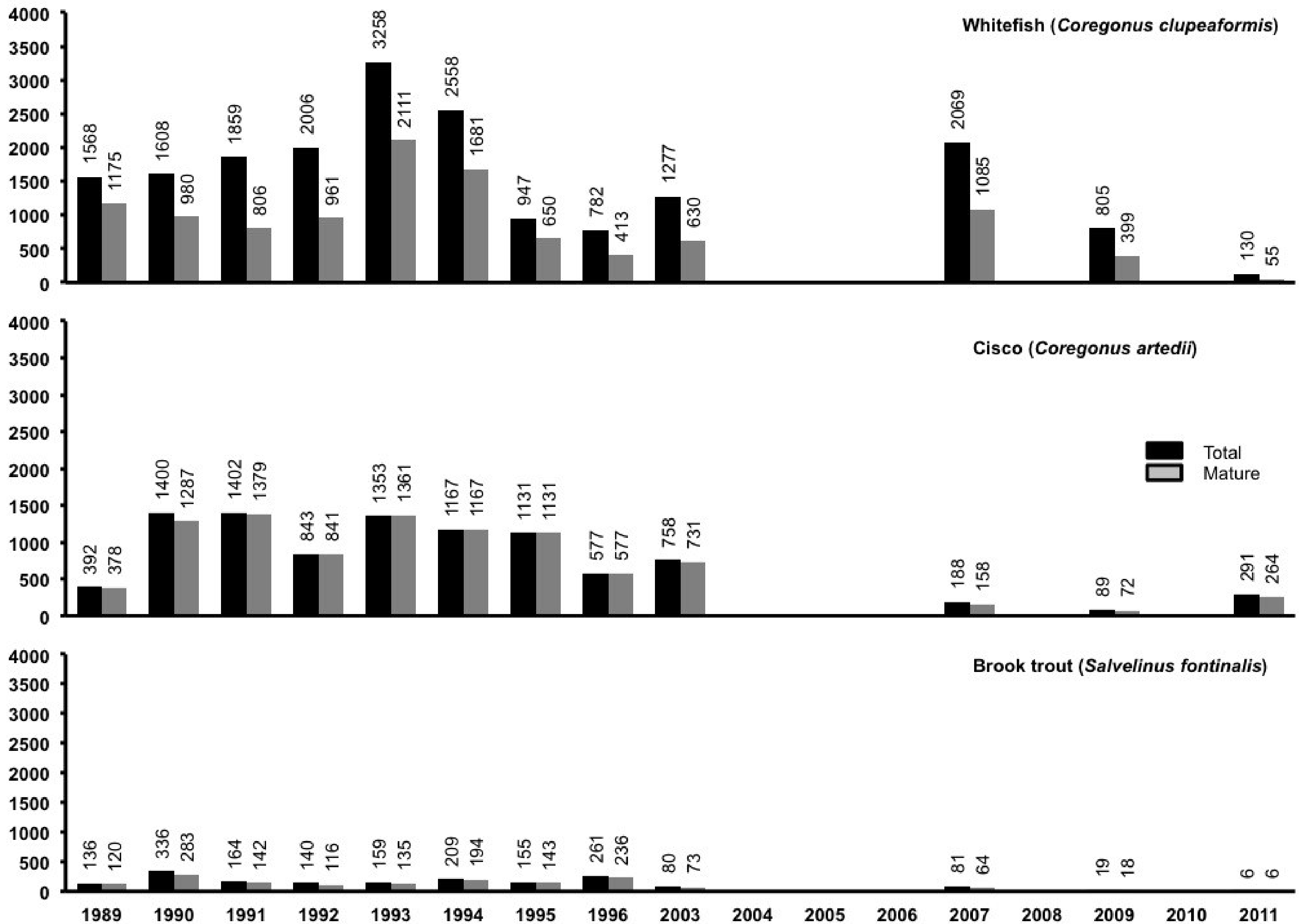


Figure 8. WCFMP harvesting data for whitefish, cisco, and brook trout at Goose Island from 1989 - 1996, 2003, 2007, 2009, and 2011

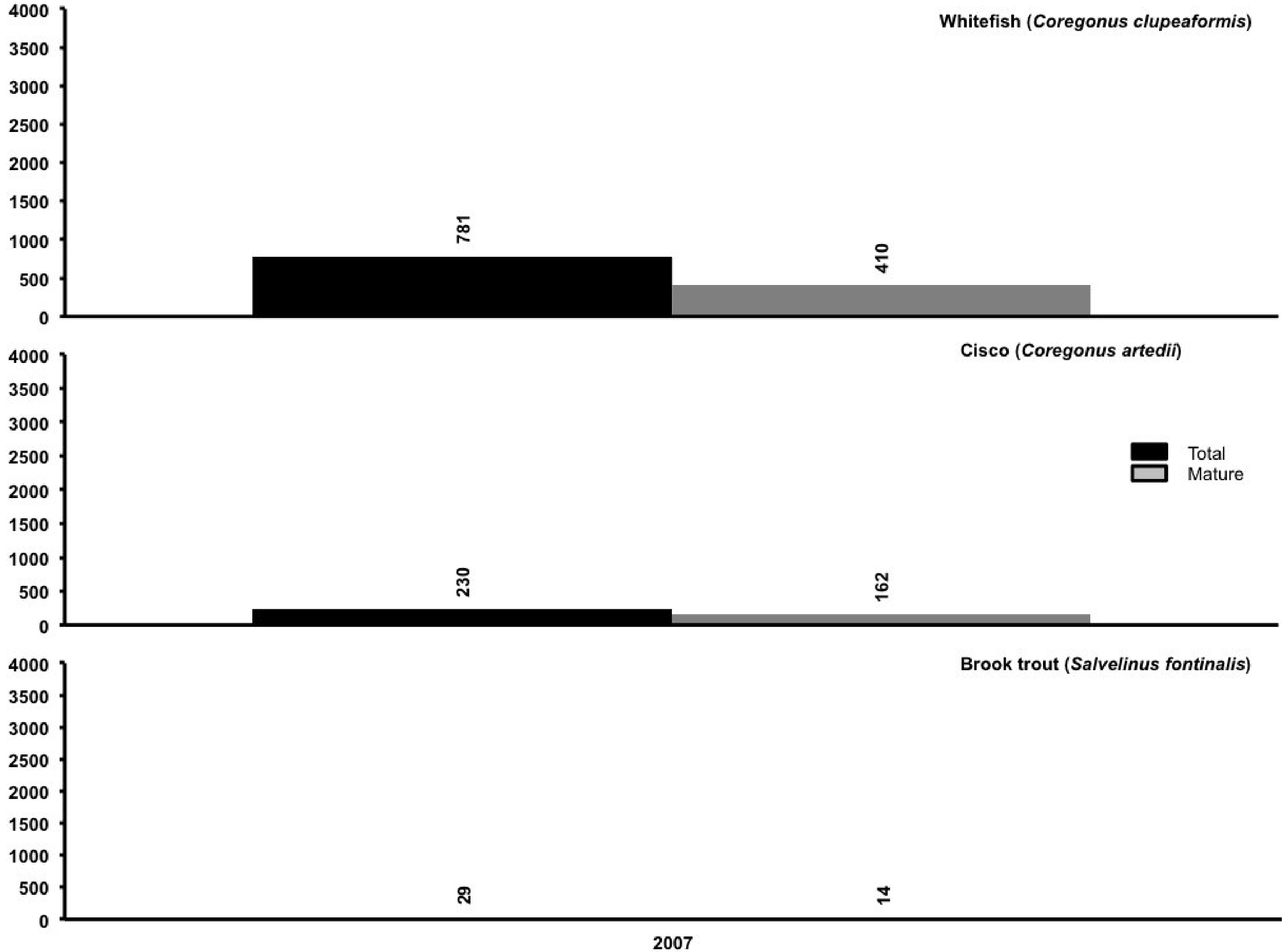


Figure 9. WCFMP harvesting data for whitefish, cisco, and brook trout at Black Stone Bay from 2007

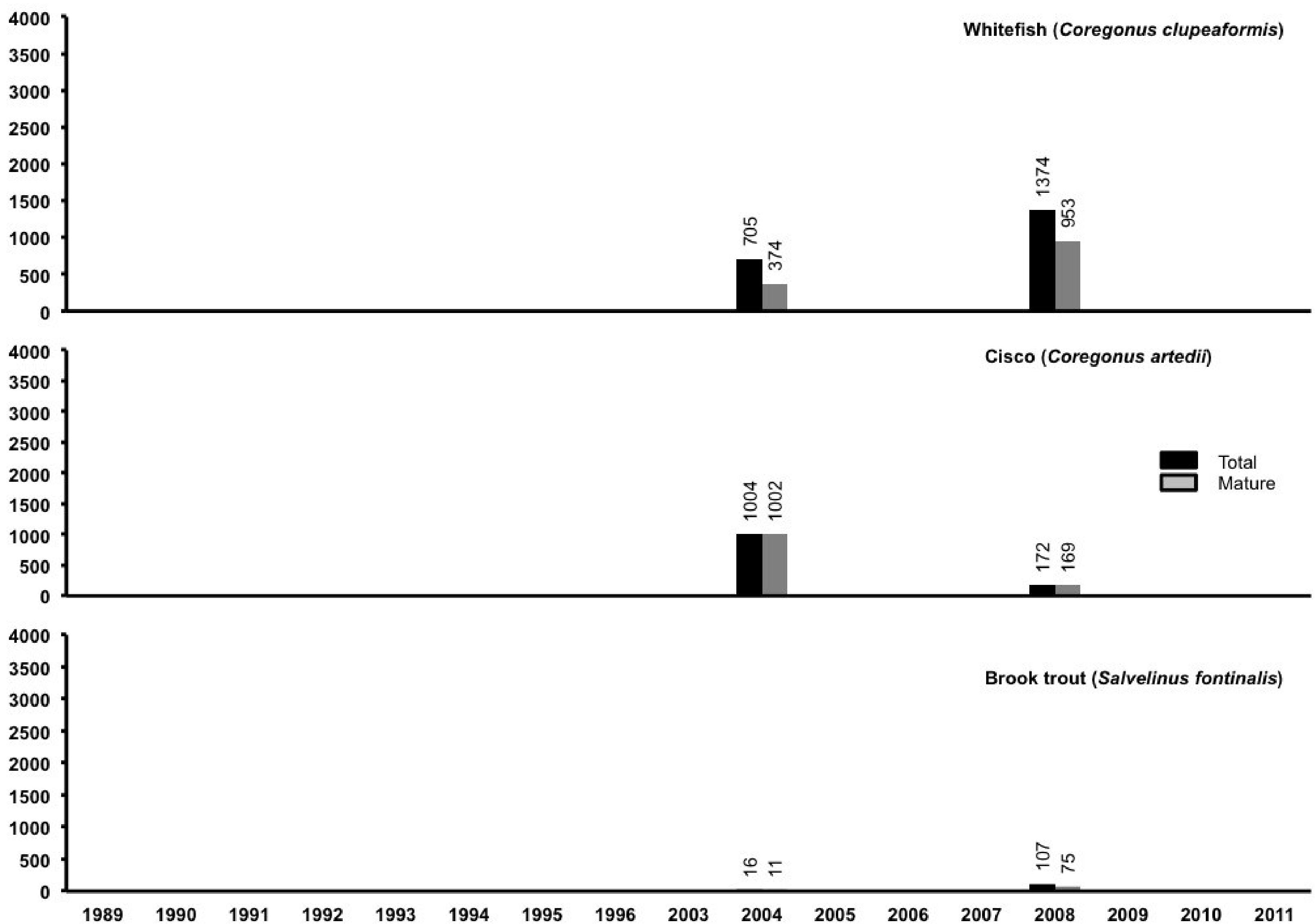


Figure 10. WCFMP harvesting data for whitefish, cisco, and brook trout at Paint Hills Bay from 2004 and 2008

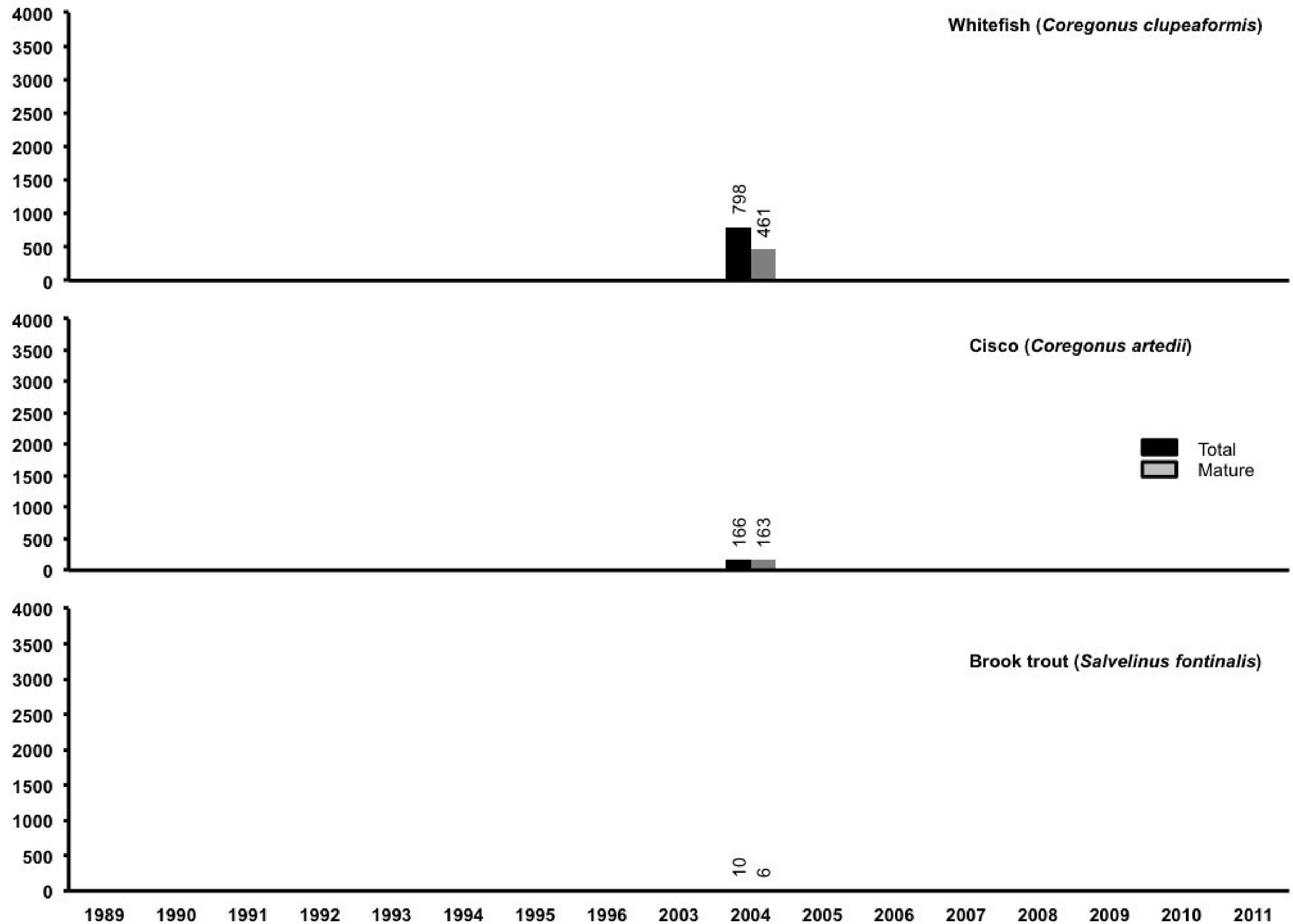


Figure 11. WCFMP harvesting data for whitefish, cisco, and brook trout at Paint Hills Island from 1989 - 1996 and 2002 – 2011

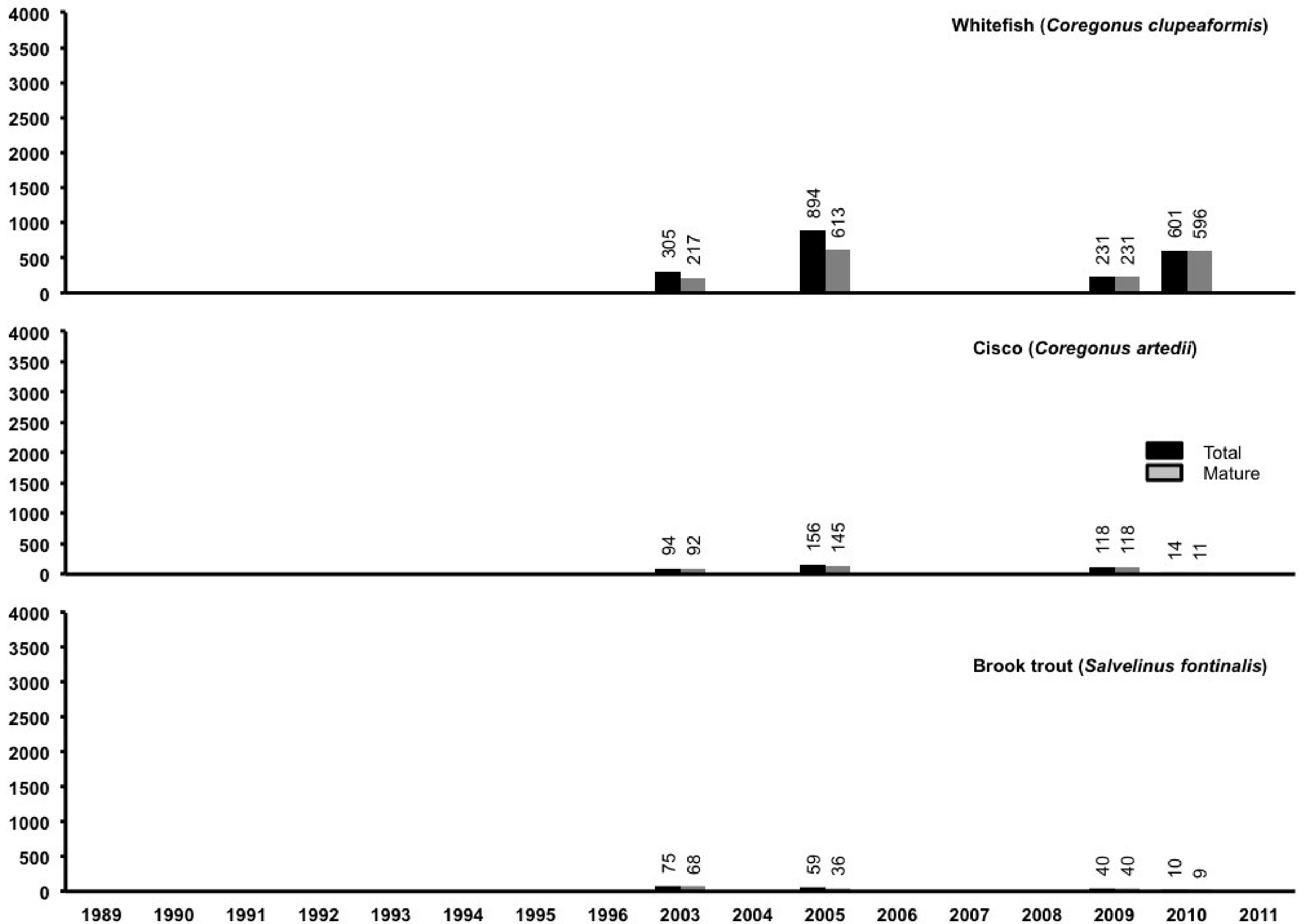


Figure 12. WCFMP harvesting data for whitefish, cisco, and brook trout at Rabbit Ridge from 2003, 2005, and 2009 – 2010

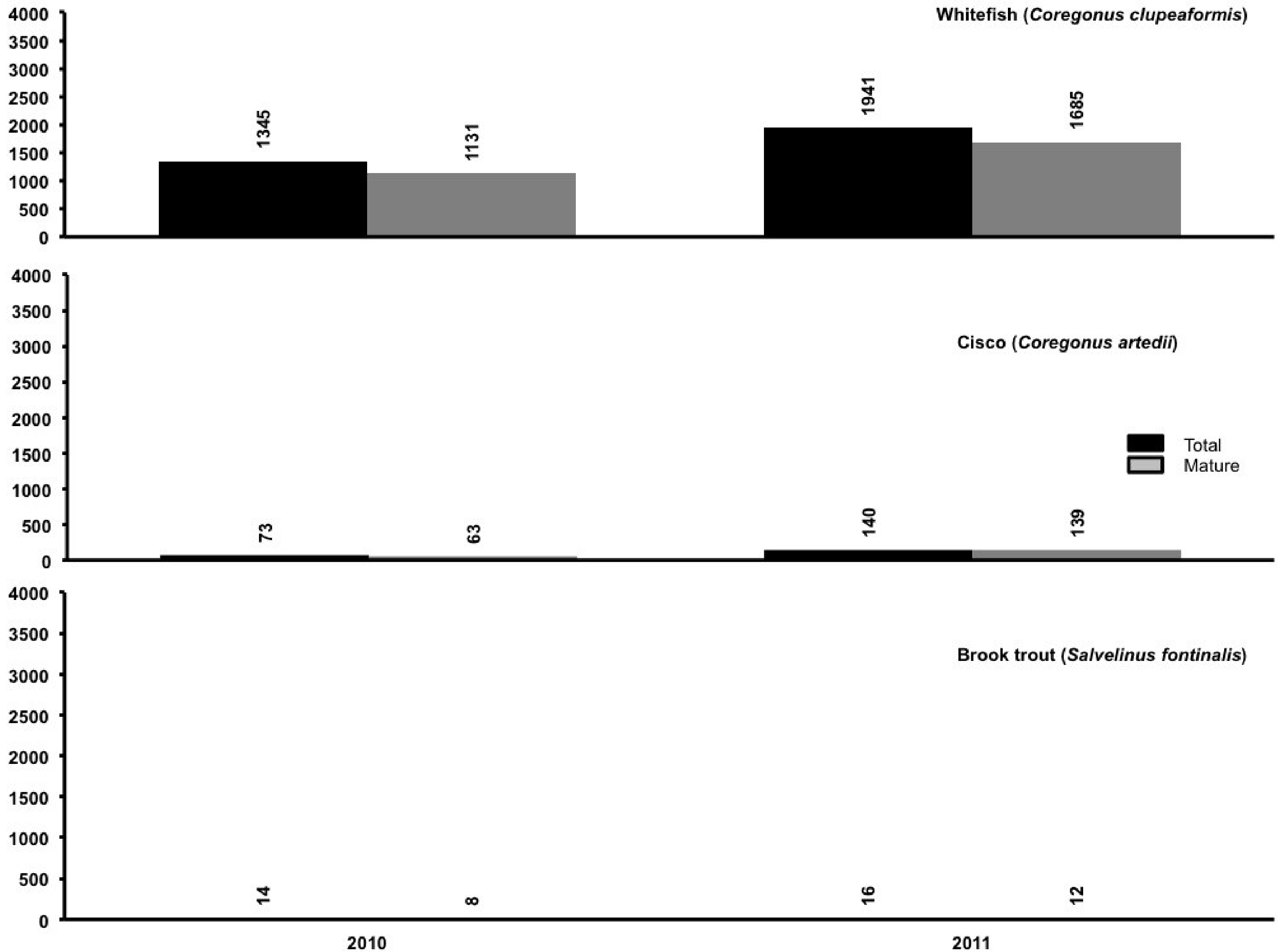


Figure 13. WCFMP harvesting data for whitefish, cisco, and brook trout at Sculpin Island from 2010 – 2011

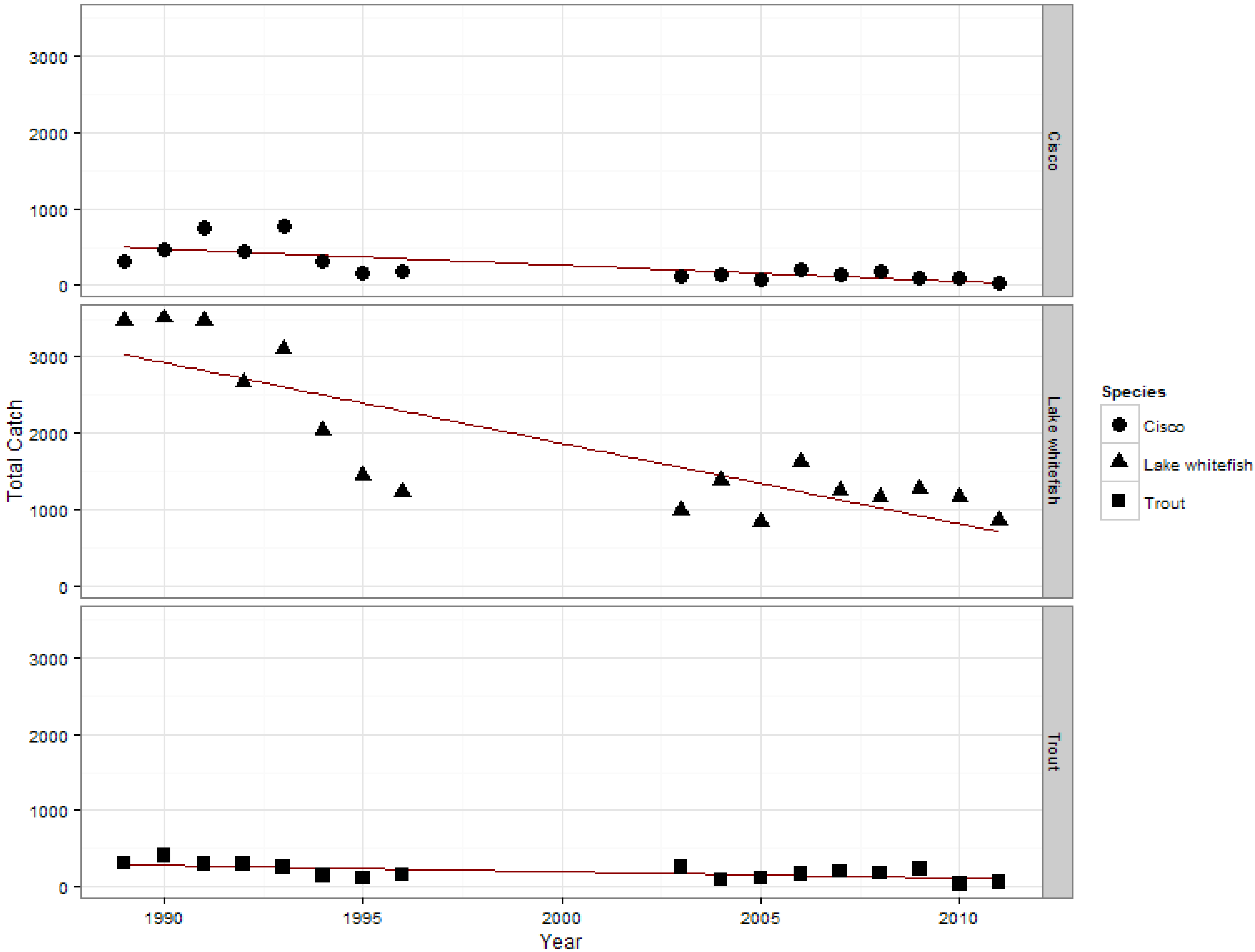


Figure 14. WCFMP total annual catches for cisco, lake whitefish, and brook trout at Moar Bay from 1989 to 2011

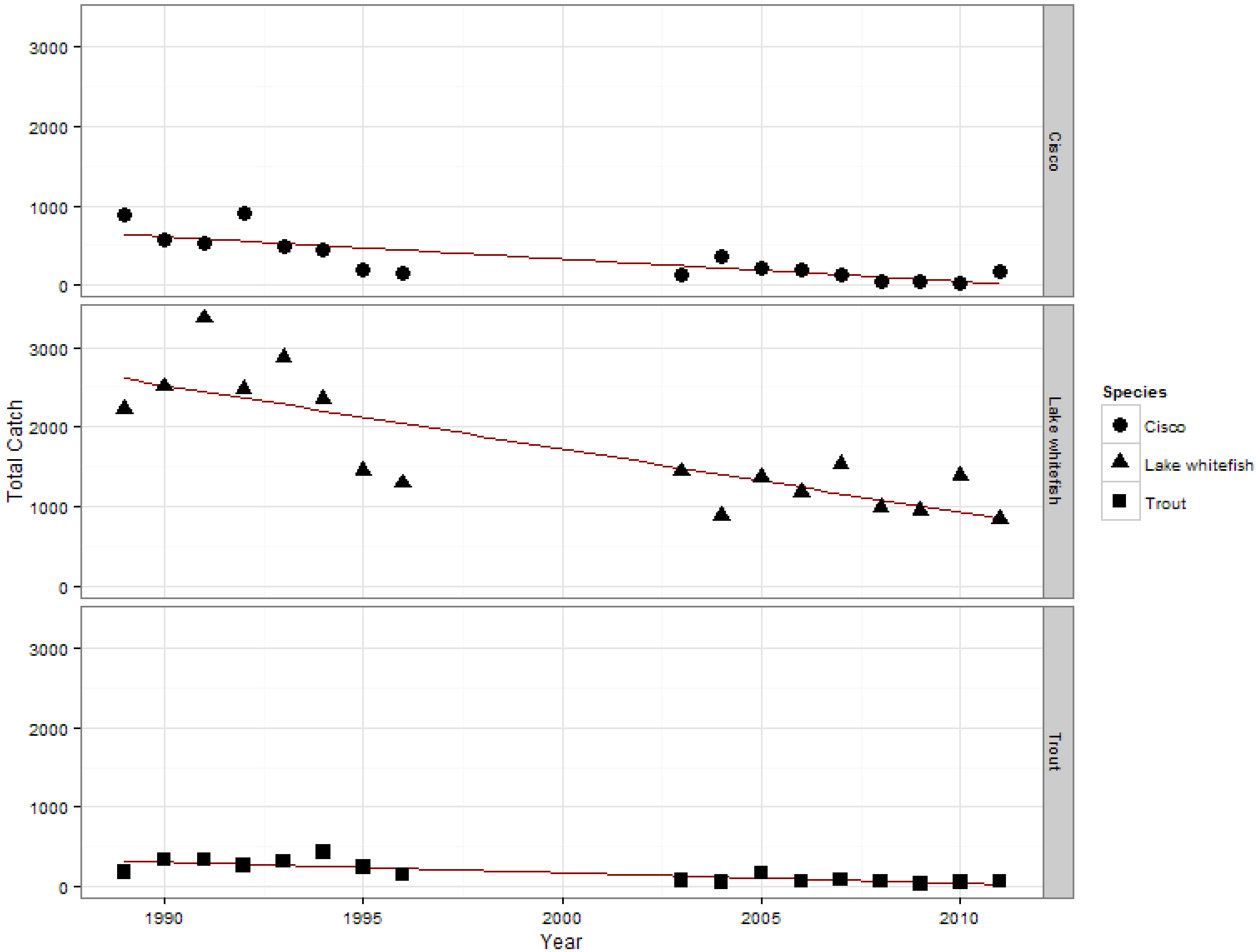


Figure 15. WCFMP total annual catches for cisco, lake whitefish, and brook trout at Old from 1989 to 2011

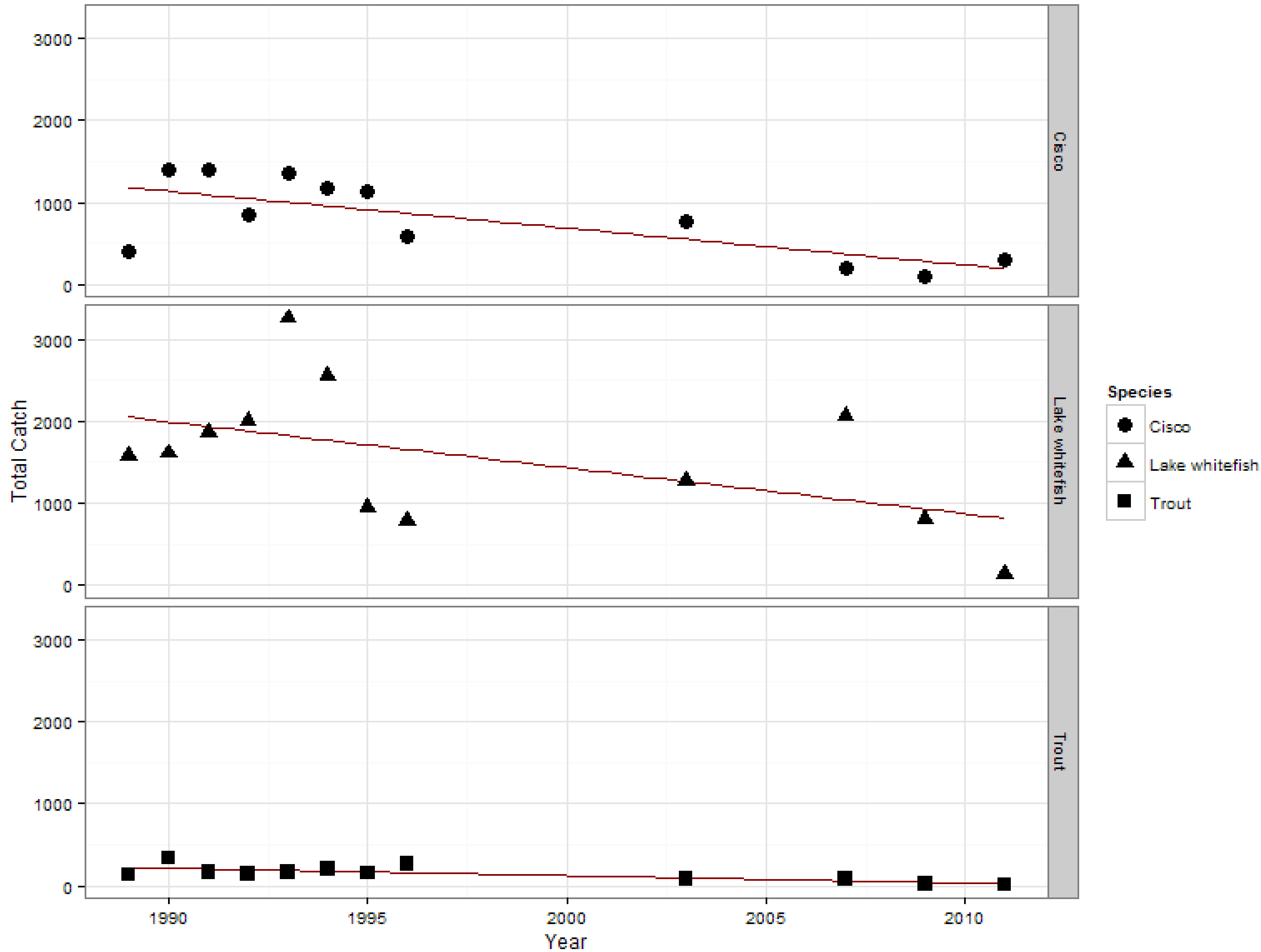


Figure 16. WCFMP total annual catches for cisco, lake whitefish, and brook trout Goose Island from 1989 to 2011

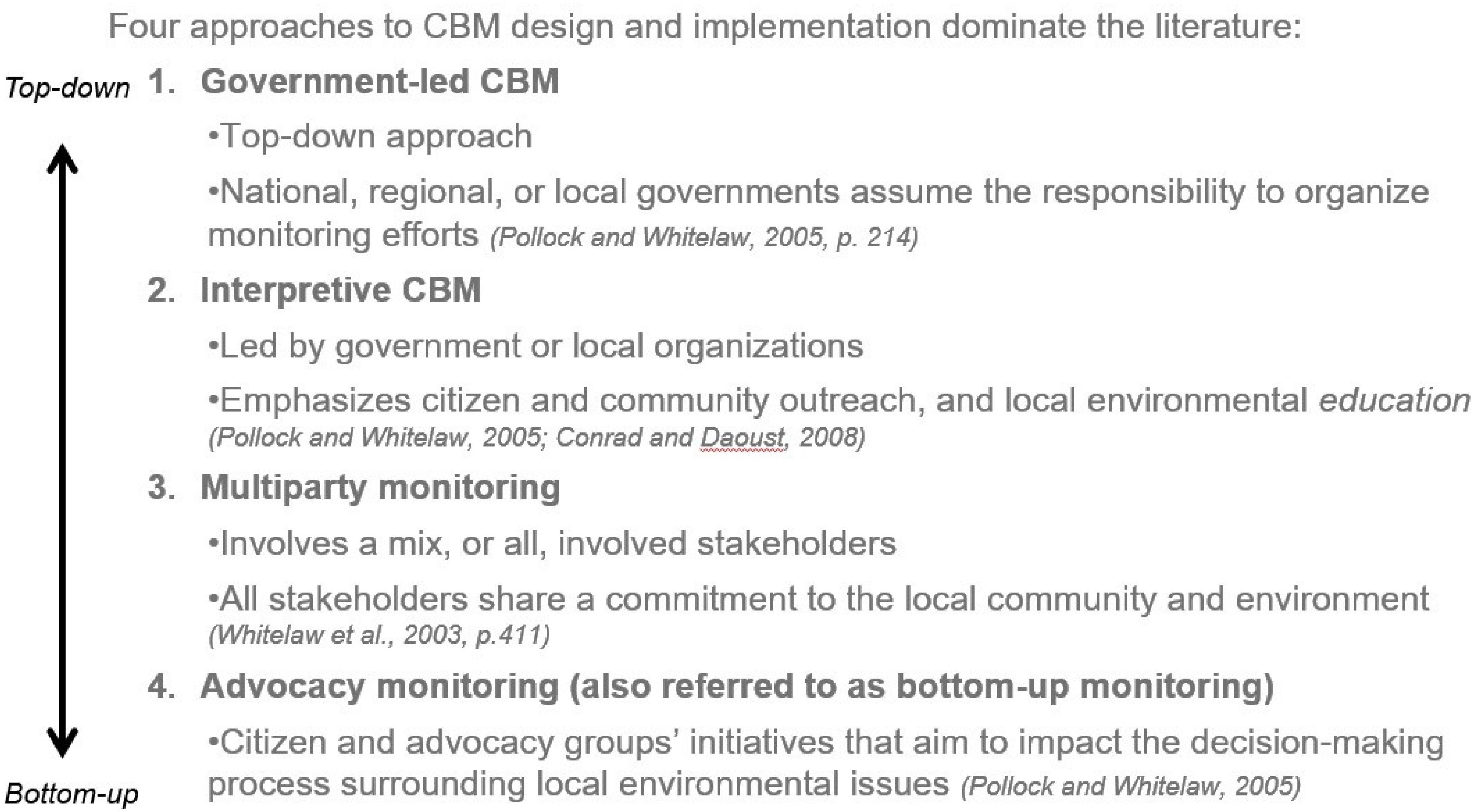


Figure 17. Four approaches to CBM design and implementation that that dominate the academic literature

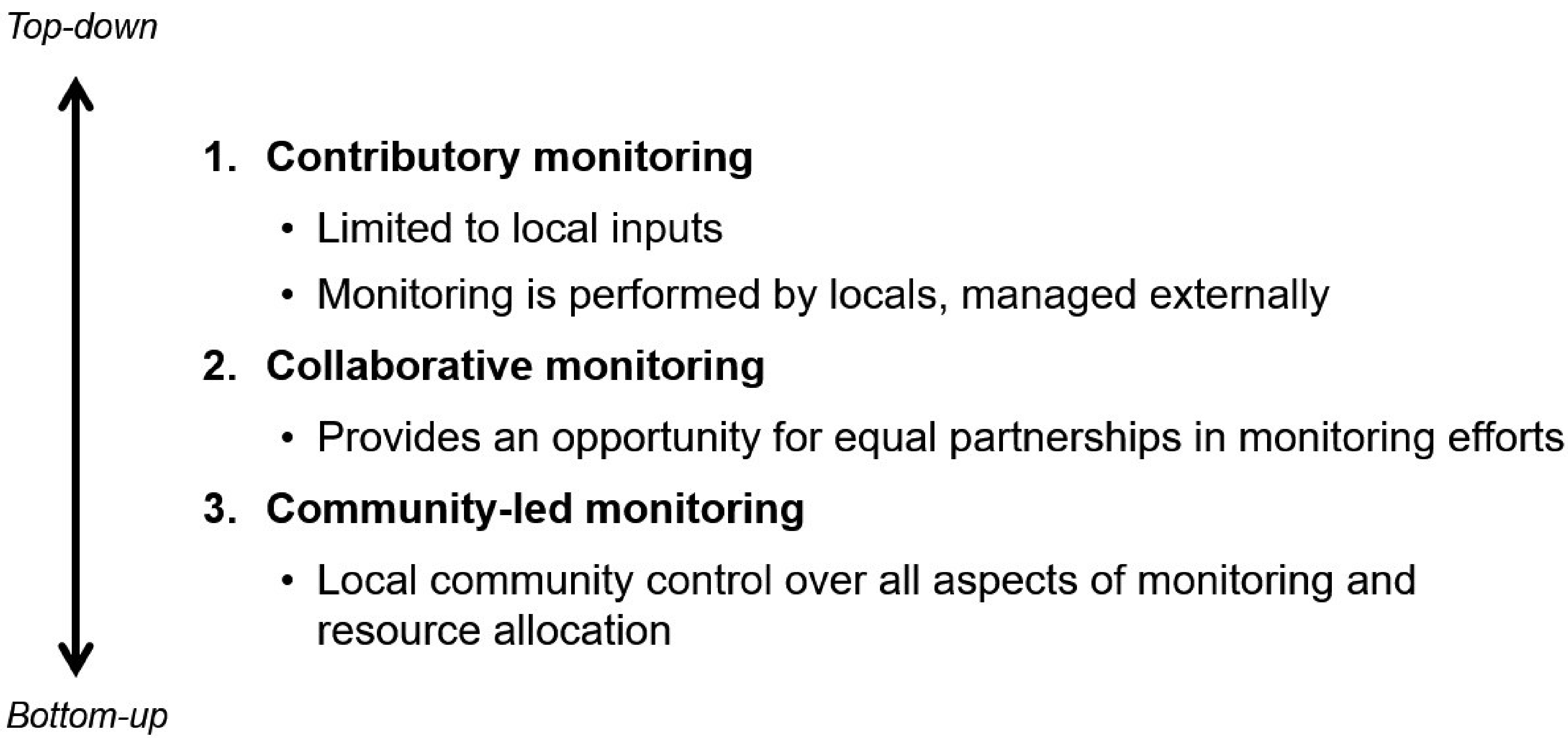


Figure 18. Proposed CBM terminologies used to described varying levels of indigenous peoples' participation and involvement

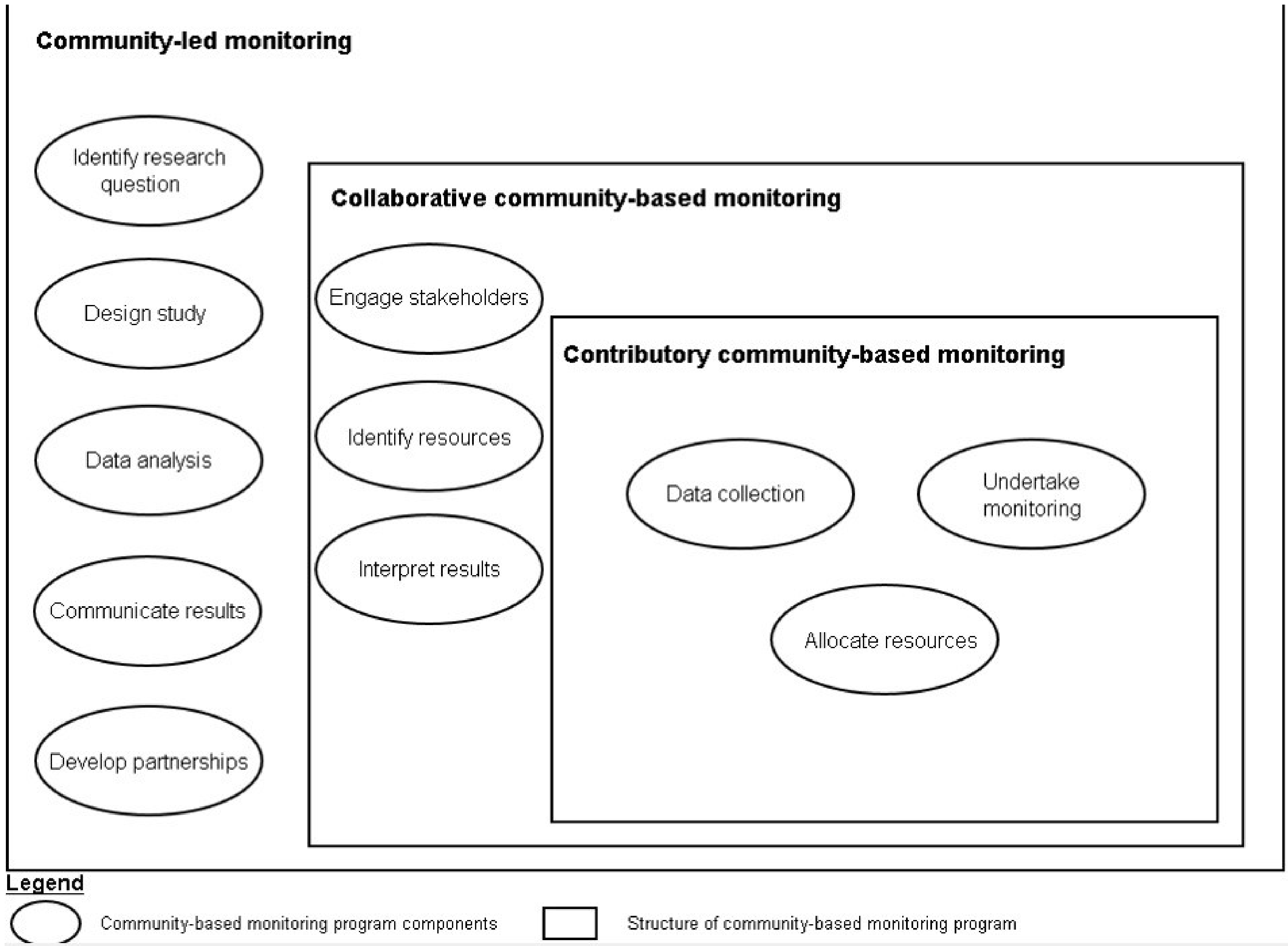


Figure 19. Proposed CBM terminologies used to described varying levels of indigenous peoples' participation and involvement and their specific program components and structures

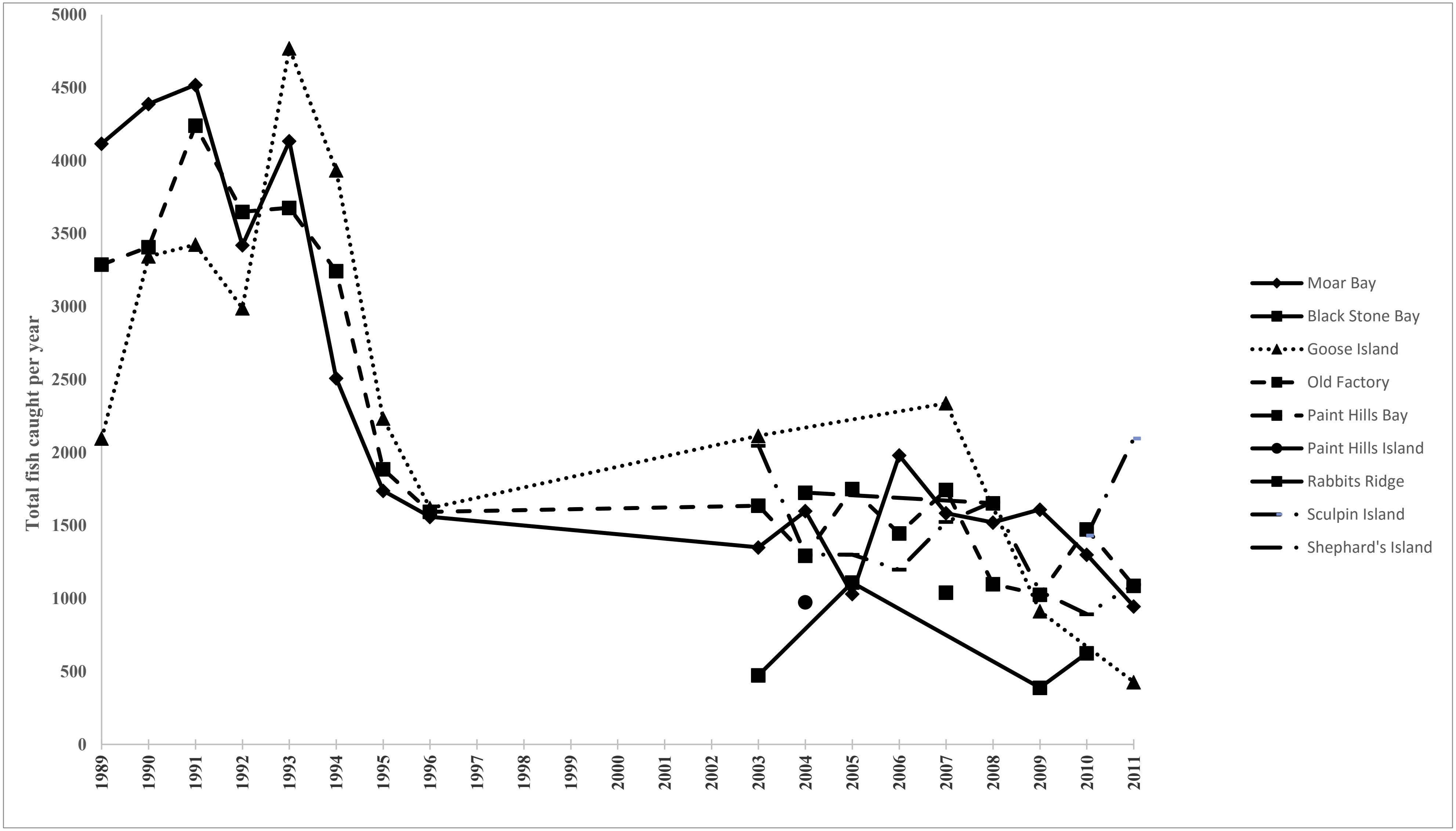


Figure 20. WCFMP total fish catches for all fishing camps involved in program from 1989 to 2011

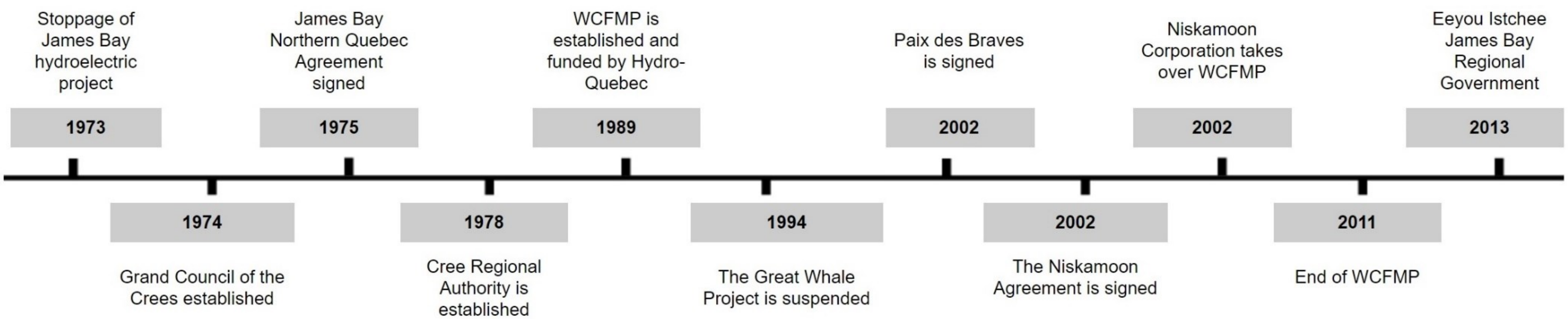


Figure 21. Timeline of major developments and activities impacting the Cree Nation of Eeyou Istchee and the WCFMP

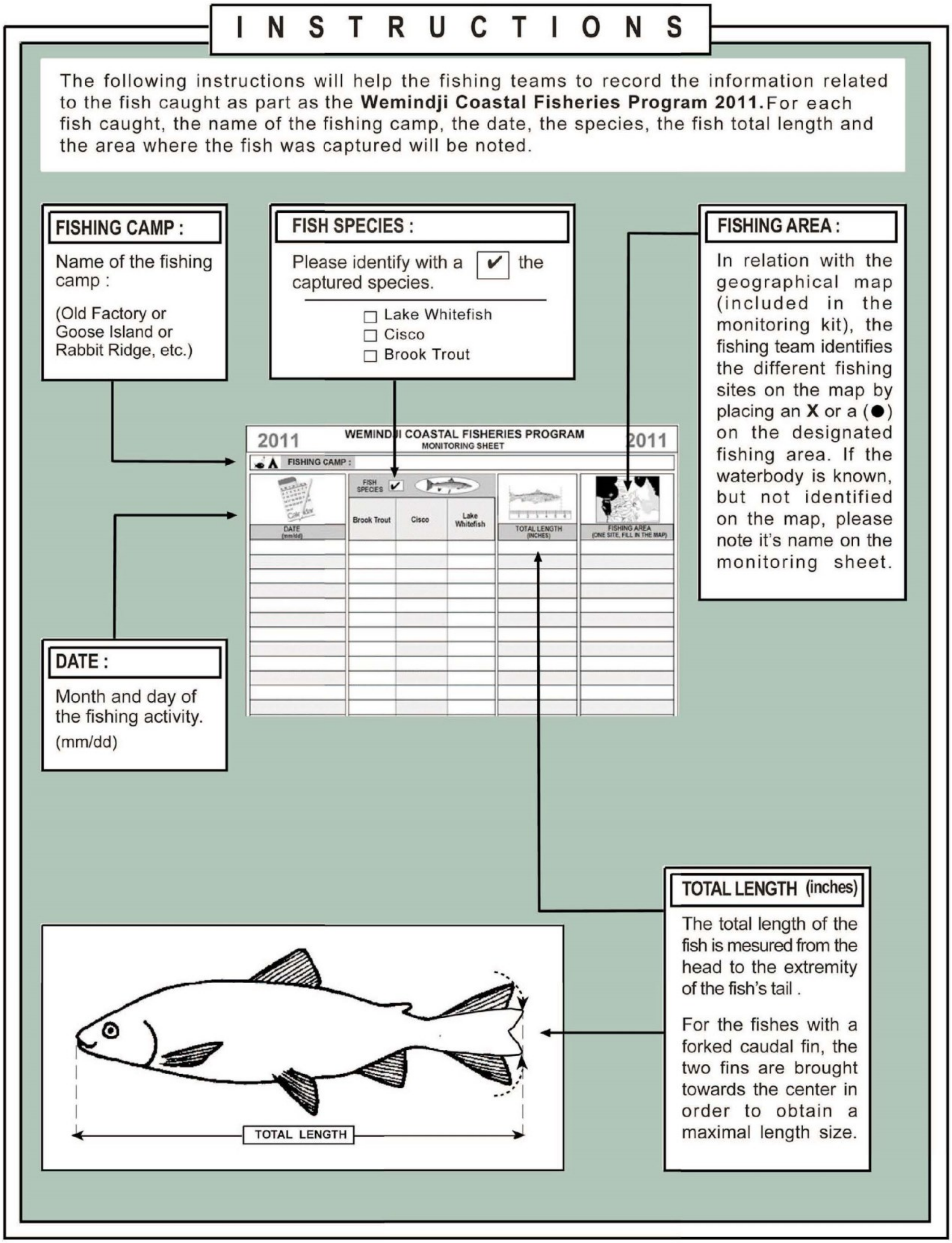
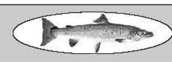


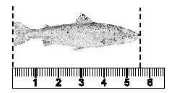
Figure 22. WCFMP data recording instruction sheet for program participants

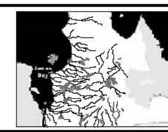
2011 **WEMINDJI COASTAL FISHERIES PROGRAM** 2011

MONITORING SHEET

FISHING CAMP :







	FISH SPECIES ✔				
DATE (mm/dd)	Brook Trout	Cisco	Lake Whitefish	TOTAL LENGTH (INCHES)	FISHING AREA (ONE SITE, FILL IN THE MAP)

Figure 23. WCFMP data recording sheet for brook trout, cisco, and lake whitefish

```
library(ggplot2)
WCFMP <- read.csv("WCFMP_Data.csv", header = T)
MoarBay <- subset(WCFMP, Fish_Camp == "Moar Bay")
BlackStoneBay <- subset(WCFMP, Fish_Camp == "Black Stone Bay")
GooseIsland <- subset(WCFMP, Fish_Camp == "Goose Island")
OldFactory <- subset(WCFMP, Fish_Camp == "Old Factory")
PaintHillsBay <- subset(WCFMP, Fish_Camp == "Paint Hills Bay")
RabbitsRidge <- subset(WCFMP, Fish_Camp == "Rabbits Ridge")
SculpinIsland <- subset(WCFMP, Fish_Camp == "Sculpin Island")
ShephardsIsland <- subset(WCFMP, Fish_Camp == "Shephard's Island")
########################################################################
############################ Moar Bay ################################
########################################################################
# Create the plot object based on the following ggplot2 parameters
# X-axis data = Year
MoarBayTotalCatchPlot <- qplot(Year, Catch, data = MoarBay, shape = Species, color = Species,
facets = Species~., size = I(3), xlab = "Year", ylab = "Total Catch")
MoarBayTotalCatchPlot + geom_smooth(method = lm, se = FALSE, aes(group =1)) +
theme_bw()
# Plot for PPTs
#MoarBayTotalCatchPlot + geom_smooth(method = lm, colour = "darkred", size = 0.5, se =
FALSE, aes(group =1)) + theme_bw() + geom_point(size = 4, colour = "black")
# Create subset datafrom for Moar Bay cisco, trout, and whitefish
MoarBay_Cisco <- subset(MoarBay, Species == "Cisco")
MoarBay_Trout <- subset(MoarBay, Species == "Trout")
MoarBay_Whitefish <- subset(MoarBay, Species == "Lake whitefish")
#Create regression output for Moar Bay cisco, trout, and whitefish
# lm(y ~ x, data = dataframe_source)
MoarBay_Cisco_Regression <- lm(Catch ~ Year, data = MoarBay_Cisco)
MoarBay_Trout_Regression <- lm(Catch ~ Year, data = MoarBay_Trout)
MoarBay_Whitefish_Regression <- lm(Catch ~ Year, data = MoarBay_Whitefish)
#Display regression summary for Moar Bay cisco, trout, and whitefish
summary(MoarBay_Cisco_Regression)
summary(MoarBay_Trout_Regression)
summary(MoarBay_Whitefish_Regression)
########################################################################
########################### Old Factory ###########################
########################################################################
# Create the plot object based on the following ggplot2 parameters
# X-axis data = Year
OldFactoryTotalCatchPlot <- qplot(Year, Catch, data = OldFactory, shape = Species, color =
Species, facets = Species~., size = I(3), xlab = "Year", ylab = "Total Catch")
OldFactoryTotalCatchPlot + geom_smooth(method = lm, se = FALSE, aes(group =1)) +
theme_bw()
# Plot for PPTs
#OldFactoryTotalCatchPlot + geom_smooth(method = lm, colour = "darkred", size = 0.5, se =
```

```
FALSE, aes(group =1)) + theme_bw() + geom_point(size = 4, colour = "black")
# Create subset datafrom for Old Factory cisco, trout, and whitefish
OldFactory_Cisco <- subset(OldFactory, Species == "Cisco")
OldFactory_Trout <- subset(OldFactory, Species == "Trout")
OldFactory_Whitefish <- subset(OldFactory, Species == "Lake whitefish")
#Create regression output for Old Factory cisco, trout, and whitefish
# lm(y ~ x, data = dataframe_source)
OldFactory_Cisco_Regression <- lm(Catch ~ Year, data = OldFactory_Cisco)
OldFactory_Trout_Regression <- lm(Catch ~ Year, data = OldFactory_Trout)
OldFactory_Whitefish_Regression <- lm(Catch ~ Year, data = OldFactory_Whitefish)
#Display regression summary for Old Factory cisco, trout, and whitefish
summary(OldFactory_Cisco_Regression)
summary(OldFactory_Trout_Regression)
summary(OldFactory_Whitefish_Regression)
######################################################################
########################### Black Stone Bay #######################
######################################################################
# Create the plot object based on the following ggplot2 parameters
# X-axis data = Year
BlackStoneBayTotalCatchPlot <- qplot(Year, Catch, data = BlackStoneBay, shape = Species,
color = Species, facets = Species~., size = I(3), xlab = "Year", ylab = "Total Catch")
BlackStoneBayTotalCatchPlot + geom_smooth(method = lm, se = FALSE, aes(group =1)) +
theme_bw()
# Plot for PPTs
#BlackStoneBayTotalCatchPlot + geom_smooth(method = lm, colour = "darkred", size = 0.5, se
= FALSE, aes(group =1)) + theme_bw() + geom_point(size = 4, colour = "black")
# Create subset datafrom for Black Stone Bay cisco, trout, and whitefish
BlackStoneBay_Cisco <- subset(BlackStoneBay, Species == "Cisco")
BlackStoneBay_Trout <- subset(BlackStoneBay, Species == "Trout")
BlackStoneBay_Whitefish <- subset(BlackStoneBay, Species == "Lake whitefish")
#Create regression output for Black Stone Bay cisco, trout, and whitefish
# lm(y ~ x, data = dataframe_source)
BlackStoneBay_Cisco_Regression <- lm(Catch ~ Year, data = BlackStoneBay_Cisco)
BlackStoneBay_Trout_Regression <- lm(Catch ~ Year, data = BlackStoneBay_Trout)
BlackStoneBay_Whitefish_Regression <- lm(Catch ~ Year, data = BlackStoneBay_Whitefish)
#Display regression summary for Black Stone Bay cisco, trout, and whitefish
summary(BlackStoneBay_Cisco_Regression)
summary(BlackStoneBay_Trout_Regression)
summary(BlackStoneBay_Whitefish_Regression)
######################################################################
########################### Goose Island ##########################
######################################################################
# Create the plot object based on the following ggplot2 parameters
# X-axis data = Year
GooseIslandTotalCatchPlot <- qplot(Year, Catch, data = GooseIsland, shape = Species, color =
Species, facets = Species~., size = I(3), xlab = "Year", ylab = "Total Catch")
```

```
GooseIslandTotalCatchPlot + geom_smooth(method = lm, se = FALSE, aes(group =1)) +
theme_bw()
# Plot for PPTs
#GooseIslandTotalCatchPlot + geom_smooth(method = lm, colour = "darkred", size = 0.5, se =
FALSE, aes(group =1)) + theme_bw() + geom_point(size = 4, colour = "black")
# Create subset datafrom for Goose Island cisco, trout, and whitefish
GooseIsland_Cisco <- subset(GooseIsland, Species == "Cisco")
GooseIsland_Trout <- subset(GooseIsland, Species == "Trout")
GooseIsland_Whitefish <- subset(GooseIsland, Species == "Lake whitefish")
#Create regression output for Goose Island cisco, trout, and whitefish
# lm(y ~ x, data = dataframe_source)
GooseIsland_Cisco_Regression <- lm(Catch ~ Year, data = GooseIsland_Cisco)
GooseIsland_Trout_Regression <- lm(Catch ~ Year, data = GooseIsland_Trout)
GooseIsland_Whitefish_Regression <- lm(Catch ~ Year, data = GooseIsland_Whitefish)
#Display regression summary for Goose Island cisco, trout, and whitefish
summary(GooseIsland_Cisco_Regression)
summary(GooseIsland_Trout_Regression)
summary(GooseIsland_Whitefish_Regression)
########################################################################
############################# Paint Hills Bay #########################
########################################################################
# Create the plot object based on the following ggplot2 parameters
# X-axis data = Year
PaintHillsBayTotalCatchPlot <- qplot(Year, Catch, data = PaintHillsBay, shape = Species, color
= Species, facets = Species~., size = I(3), xlab = "Year", ylab = "Total Catch")
PaintHillsBayTotalCatchPlot + geom_smooth(method = lm, se = FALSE, aes(group =1)) +
theme_bw()
# Plot for PPTs
#PaintHillsBayTotalCatchPlot + geom_smooth(method = lm, colour = "darkred", size = 0.5, se =
FALSE, aes(group =1)) + theme_bw() + geom_point(size = 4, colour = "black")
# Create subset datafrom for Paint Hills Bay cisco, trout, and whitefish
PaintHillsBay_Cisco <- subset(PaintHillsBay, Species == "Cisco")
PaintHillsBay_Trout <- subset(PaintHillsBay, Species == "Trout")
PaintHillsBay_Whitefish <- subset(PaintHillsBay, Species == "Lake whitefish")
#Create regression output for Paint Hills Bay cisco, trout, and whitefish
# lm(y ~ x, data = dataframe_source)
PaintHillsBay_Cisco_Regression <- lm(Catch ~ Year, data = PaintHillsBay_Cisco)
PaintHillsBay_Trout_Regression <- lm(Catch ~ Year, data = PaintHillsBay_Trout)
PaintHillsBay_Whitefish_Regression <- lm(Catch ~ Year, data = PaintHillsBay_Whitefish)
#Display regression summary for Paint Hills Bay cisco, trout, and whitefish
summary(PaintHillsBay_Cisco_Regression)
summary(PaintHillsBay_Trout_Regression)
summary(PaintHillsBay_Whitefish_Regression)
########################################################################
############################# Rabbits Ridge ##########################
########################################################################
```

```
# Create the plot object based on the following ggplot2 parameters
# X-axis data = Year
RabbitsRidgeTotalCatchPlot <- qplot(Year, Catch, data = RabbitsRidge, shape = Species, color =
Species, facets = Species~., size = I(3), xlab = "Year", ylab = "Total Catch")
RabbitsRidgeTotalCatchPlot + geom_smooth(method = lm, se = FALSE, aes(group =1)) +
theme_bw()
# Plot for PPTs
#RabbitsRidgeTotalCatchPlot + geom_smooth(method = lm, colour = "darkred", size = 0.5, se =
FALSE, aes(group =1)) + theme_bw() + geom_point(size = 4, colour = "black")
# Create subset datafrom for Rabbits Ridge cisco, trout, and whitefish
RabbitsRidge_Cisco <- subset(RabbitsRidge, Species == "Cisco")
RabbitsRidge_Trout <- subset(RabbitsRidge, Species == "Trout")
RabbitsRidge_Whitefish <- subset(RabbitsRidge, Species == "Lake whitefish")
#Create regression output for Rabbits Ridge cisco, trout, and whitefish
# lm(y ~ x, data = dataframe_source)
RabbitsRidge_Cisco_Regression <- lm(Catch ~ Year, data = RabbitsRidge_Cisco)
RabbitsRidge_Trout_Regression <- lm(Catch ~ Year, data = RabbitsRidge_Trout)
RabbitsRidge_Whitefish_Regression <- lm(Catch ~ Year, data = RabbitsRidge_Whitefish)
#Display regression summary for Rabbits Ridge cisco, trout, and whitefish
summary(RabbitsRidge_Cisco_Regression)
summary(RabbitsRidge_Trout_Regression)
summary(RabbitsRidge_Whitefish_Regression)
######################################################################
############################ Sculpin Island ########################
######################################################################
# Create the plot object based on the following ggplot2 parameters
# X-axis data = Year
SculpinIslandTotalCatchPlot <- qplot(Year, Catch, data = SculpinIsland, shape = Species, color =
Species, facets = Species~., size = I(3), xlab = "Year", ylab = "Total Catch")
SculpinIslandTotalCatchPlot + geom_smooth(method = lm, se = FALSE, aes(group =1)) +
theme_bw()
# Plot for PPTs
#SculpinIslandTotalCatchPlot + geom_smooth(method = lm, colour = "darkred", size = 0.5, se =
FALSE, aes(group =1)) + theme_bw() + geom_point(size = 4, colour = "black")
# Create subset datafrom for Sculpin Island cisco, trout, and whitefish
SculpinIsland_Cisco <- subset(SculpinIsland, Species == "Cisco")
SculpinIsland_Trout <- subset(SculpinIsland, Species == "Trout")
SculpinIsland_Whitefish <- subset(SculpinIsland, Species == "Lake whitefish")
#Create regression output for Sculpin Island cisco, trout, and whitefish
# lm(y ~ x, data = dataframe_source)
SculpinIsland_Cisco_Regression <- lm(Catch ~ Year, data = SculpinIsland_Cisco)
SculpinIsland_Trout_Regression <- lm(Catch ~ Year, data = SculpinIsland_Trout)
SculpinIsland_Whitefish_Regression <- lm(Catch ~ Year, data = SculpinIsland_Whitefish)
#Display regression summary for Sculpin Island cisco, trout, and whitefish
summary(SculpinIsland_Cisco_Regression)
summary(SculpinIsland_Trout_Regression)
```

```
summary(SculpinIsland_Whitefish_Regression)
########################################################################
############################# Shephards Island ########################
########################################################################
# Create the plot object based on the following ggplot2 parameters
# X-axis data = Year
ShephardsIslandTotalCatchPlot <- qplot(Year, Catch, data = ShephardsIsland, shape = Species,
color = Species, facets = Species~., size = I(3), xlab = "Year", ylab = "Total Catch")
ShephardsIslandTotalCatchPlot + geom_smooth(method = lm, se = FALSE, aes(group =1)) +
theme_bw()
# Plot for PPTs
#ShephardsIslandTotalCatchPlot + geom_smooth(method = lm, colour = "darkred", size = 0.5, se
= FALSE, aes(group =1)) + theme_bw() + geom_point(size = 4, colour = "black")
# Create subset datafrom for Shephards Island cisco, trout, and whitefish
ShephardsIsland_Cisco <- subset(ShephardsIsland, Species == "Cisco")
ShephardsIsland_Trout <- subset(ShephardsIsland, Species == "Trout")
ShephardsIsland_Whitefish <- subset(ShephardsIsland, Species == "Lake whitefish")
#Create regression output for Shephards Island cisco, trout, and whitefish
# lm(y ~ x, data = dataframe_source)
ShephardsIsland_Cisco_Regression <- lm(Catch ~ Year, data = ShephardsIsland_Cisco)
ShephardsIsland_Trout_Regression <- lm(Catch ~ Year, data = ShephardsIsland_Trout)
ShephardsIsland_Whitefish_Regression <- lm(Catch ~ Year, data = ShephardsIsland_Whitefish)
#Display regression summary for Shephards Island cisco, trout, and whitefish
summary(ShephardsIsland_Cisco_Regression)
summary(ShephardsIsland_Trout_Regression)
summary(ShephardsIsland_Whitefish_Regression)
```

Supplementary results: analysis of fisheries catch data

Using R, individual data subsets (using the subset() function) were created for each coastal fishing camp to account for total annual catches for lake whitefish, brook trout, and cisco. A linear regression analysis (using the lm() function) was performed for each data subset against an annual timescale in order to determine whether there was a statistically significant decrease in annual fish catches over the course of the program (the WCFMP data and RCode used to perform this analysis is included in pp. 117-121 in the Appendix).

Program participants indicated a decline in fish catches since 1989 for all fishing camp locations involved in the WCFMP. The linear regression model output supports observations made by certain WCFMP program participants. The linear regression analysis undertaken in this study suggests a statistically significant decline in annual fish catches in eight cases: (1) cisco caught in Moar Bay ($R2 = 0.5696$, $p < 0.05$); (2) brook trout caught in Moar Bay ($R2 = 0.4308$, $p < 0.05$); (3) lake white fish caught in Moar Bay ($R2 = 0.7108$, $p < 0.05$) (Figure 14); (4) cisco caught in Old Factory ($R2 = 0.6541$, $p < 0.05$); (5) brook trout caught in Old Factory ($R2 = 0.6942$, $p < 0.05$); (6) lake whitefish caught in Old Factory ($R2 = 0.6793$, $p < 0.05$) (Figure 15); (7) cisco caught in Goose Island ($R2 = 0.5263$, $p < 0.05$); and (8) brook trout caught in Goose Island ($R2 = 0.583$, $p < 0.05$) (Figure 16; see Table 3). There was insufficient continual annual catch data for Black Stone Bay, Paint Hills Bay, and Sculpin Island, resulting in no statistical summary output from R. Nevertheless, there was no statistically observable decrease in maximum fishing effort ($R2 = 0.1623$, $p > 0.05$; see Table 4).

The catch data was used to prepare the annual WCFMP reports was inconsistent throughout the years; only data representing total number of fish caught, number of mature fish caught, proportion of mature fish caught (%), and mean total length (inches) were consistently included from 1989 to 1996 and 2003 to 2011. Maximum fishing effort (represented in maximum number of days fished during the season) was reported from 2003 to 2011; fishing success (represented in number of fish caught, per day, per camp) was reported from 2005 to 2011; and catch-per-unit-effort (CPUE; represented in number of fish, per 100m of net, per day) was only reported in three years (2008, 2010, and 2011).

By the second-half of the WCFMP (i.e. from 2003 to 2011), the Niskamoon Corporation began reporting on fishing success rates and CPUE. While both metrics were not consistently reported on an annual basis, efforts were made to share the status of the fishery with the Wemindji CTA, and Wemindji fishermen.

Technical report 1

The use of a digital tool in a community-based monitoring program: the potential for CyberTracker software in the Wemindji Community Fisheries Monitoring Program

Executive Summary

This report outlines the potential for the use of a digital monitoring tool in a community-based monitoring program in the Cree Nation of Wemindji. I present the practica and technical advantages, and disadvantages, from the use of the CyberTracker suite of software. The objective of this study was to determine whether data collection within the Wemindji Community Fisheries Monitoring Program could be facilitated and enhanced through the use of the CyberTracker software by Cree fishermen. Based on field trials and fishermen feedback, the use of a digital monitoring tool is not recommended in the Wemindji Community Fisheries Monitoring Program. Socially, the use of a digital monitoring tool requires a large time investment in order to operate, removing fishermen from their regular fishing activities. From a technical standpoint, current hardware specifications, and limitations, restrict the utilization of this platform in aquatic environments. Second, lengthy GPS satellite acquisition times in open waters require numerous hardware troubleshooting sessions in order to utilize all software features. Until field appropriate hardware can be sourced, the use of a digital monitoring tool may better be suited to terrestrial based hunting, trapping, and tracking activities in the Cree Nation of Wemindji. I recommend that a digital monitoring tool be trialed with the newly established Wemindji Cree Trappers' Association Task Force, in order to assess the potential for broader ecosystem based monitoring.

1. Introduction

The Wemindji Community Fisheries Monitoring Program (WCFMP) was established in 1989 with the goal of providing the community of Wemindji with “fish of acceptable quality” (Hydro-Québec, 1990). Fisheries monitoring is conducted as part of the program in order to provide a means for ensuring that fish stocks are not depleted. The WCFMP is implemented on the ground, under the authority of the local tallyman (also referred to as the “hunting boss”). The program is coordinated by the local Cree Trappers’ Association (CTA), which in turn is overseen and funded by the Cree Nation of Wemindji, the regional CTA, and The Niskamoon Corporation.

The WCFMP provides funds to support the purchase and use of sleds, skidoos, and motorboats. Gasoline-powered generators, freezers, tents, and various kitchen equipment are also provided to fishing camps through the program. Most years the program has supported the activities of five coastal fishing camps (Goose Island, Moar Bay, Old Factory, Rabbits Ridge, and Shephard’s Island) (Niskamoon Corporation, 2010). Whitefish, brook trout, and cisco fish species are netted as part of the WCFMP (Niskamoon Corporation, 2011).

While the theoretical uses of CyberTracker software are numerous within the context of the WCFMP, my time spent with Cree fisherman in the field and interviews indicate contrasting social and technical findings.

2. Objectives

The objective of this report is to present the findings from the initial trial of the CyberTracker software by Cree fishermen, community members, tallymen, and a graduate researcher within the context of the WCFMP. Findings are separated by the practical and technical advantages and disadvantages. I attempt to identify best practices in the field of community-based conservation and monitoring that will potentially facilitate enhanced roles and responsibilities for indigenous peoples towards the management of their traditional lands and resources.

Following the research objectives outlined by Brammer et al. (2011), I was interested in determining whether data collection within the WCFMP could be facilitated and enhanced through the use of CyberTracker. My objectives were to determine:

1. How CyberTracker could be used for fisheries monitoring?
2. What are the practical and technical advantages of using CyberTracker software for fisheries monitoring?
3. What are the practical and technical disadvantages of using CyberTracker software for fisheries monitoring?

3. Methods

Semi-structured interviews and participant observation of Cree fishermen were used in examining the WCFMP. During the interviews with Cree fishermen, a demonstration of the CyberTracker software was performed. Cree fishermen were asked: "how the monitoring program and data collection could be improved through the use of CyberTracker software".

The participant observation portion of the study involved canoe trips to deploy, check, and clean fish gill nets, as well as time spent at coastal family fishing camps assisting Cree fishermen and family members with cleaning, cooking, and performing basic camp maintenance. Prior to the start of my fieldwork, the CyberTracker software was loaded onto a Champion Scepter II Geographical Information System Data Collector.

4. Results

4.1 Potential for CyberTracker in fisheries monitoring

At present, fisheries monitoring data is manually recorded onto computer generated data sheets (see Appendix) that are printed and provided to Cree fishermen by the Wemindji CTA. The use of CyberTracker has the potential to eliminate all paper-based data sheets by: 1) enabling the fishermen to quickly record the species of fish through a pre-generated list; 2) providing a numeric keypad to facilitate the entry of individual fish length measurements; and 3) geographically "tagging" individual fish records through an internal hardware GPS receiver accessed by the CyberTracker software.

4.2 Practical advantages

Cree youth and younger generation Cree hunters and trappers in Wemindji have readily adopted mobile devices and "smart phones". A digital monitoring tool such as CyberTracker has the potential to appeal to the younger demographic that practice traditional fishing, hunting, and trapping, and potentially attract others that are not as involved; involvement of Cree youth within the WCFMP, and other traditional hunting and trapping activities has been identified as a priority area by the Wemindji Band Council and Wemindji Cree Trappers' Association.

4.3 Technical advantages

Using a digital monitoring tool allows for the geographical location of a fishing net to be recorded (commonly referred to as "geotagging"), potentially improving the quality of the recorded data by facilitating the creation of maps through geographical information systems. Second, the ability to "geotag" data is beneficial in tracking and hunting, and provides the ability to mark historical and culturally significant sites on the land without the need to refer to paper-based maps and reference points.

One particular advantage to the CyberTracker suite of software is the ease in which input screens can be designed through the desktop-based software. Whilst the desktop-based software requires the user to be familiar with the Microsoft Windows operating system, the design interface itself does not require the use, or prior understanding, of any specific computer programing or design language. Moreover, CyberTracker input screens can be modified to display numerous languages, other than English and French.

4.4 Practical disadvantages

Cree fisherman expressed their concern with CyberTracker's geotagging feature. Fishermen felt that the ability for anyone to record the geographical placement of gillnets and traditional fishing locations removed the "traditional" and "social" element of fishing. That is, discussions surrounding daily fishing activities would be unnecessary if information could instead be digitally retrieved and shared. Second, fishermen expressed privacy concerns surrounding the ability to collect location specific information. Interviews revealed that fishermen are concerned with traditional fishing locations being fished by "southerners" (sports fishermen travelling to Wemindji for recreational fishing activities). Furthermore, fishermen suggested that through the collection of geographical information, trust is violated, as it is the fishermen that are being monitored, and not the fish.

The largest drawback from the use of a digital monitoring tool while fishing is the extra time commitment required to operate the device. Cree fishermen suggested that this would remove the deep connection between the Cree and the land and sea. Introducing a digital monitoring tool might take away from that connection, defeating the reason why traditional fishing and hunting are practiced in the first place. Lastly, Cree elders did not feel comfortable using a digital monitoring tool, expressing their concerns surrounding steep learning curves associated with new technologies unfamiliar to them.

4.5 Technical disadvantages

The maneuverability of an individual in a canoe is limited and would require the digital monitoring tool to be next to the individual removing the fish from a gill net. If speed and time are of the essence when checking and retrieving gillnets (e.g. due to unfavorable weather conditions), a second individual would be required to input the necessary data.

The mobile handheld device, upon which the CyberTracker software operates, is not entirely waterproof and had exposed connection ports that would easily take on water if dropped. Whilst the device had a “superficial” appearance of being a “rugged outdoors” mobile handheld device, the device is prone to surface scratches does not float, reducing its potential in aquatic environments. Second, the touch screen interface fails to register inputs once fingers, and hands, begin accumulating fish blood, guts, and scales. It is my recommendation that one person on board the canoe be dedicated to data recording and collection in order to facilitate and simplify the process.

GPS satellite signal acquisition times were unexplainably long. It is recommended that the device be turned on and CyberTracker be allowed to acquire satellite signals well before the data collection begins. Lastly, as the majority of the fishing activity takes place in the early morning and evenings, screen visibility is greatly reduced from lack of natural lighting. It is recommended that a portable flashlight or headlamp be worn in order to read and interact with the touch screen interface if data collection is to be performed in the canoe during dusk and dawn.

5. Conclusion and recommendations

CyberTracker is a simple tool for researchers to setup and use in and around the Wemindji coastline. Unfortunately, due to specific technical drawbacks (i.e. not waterproof, lengthy satellite acquisition times) and social constraints (i.e. steep learning curves for Cree hunters and fishers, distraction from actual hunting and fishing activities), it is my recommendation that CyberTracker, or any digital monitoring, tool not be utilized in the Wemindji Community Fisheries Monitoring Program. I recommend that the WCFMP continue to use the computer generated data sheets in order to record fish species, measurements, and catch location.

Whilst the WCFMP does not present itself as an ideal program for the use of a digital monitoring tool, the newly established Wemindji Cree Trappers' Association task force might benefit from the use of a digital tool to record all hunting activity on the land. I recommend that CyberTracker be trialed with the cooperation of the task force and Cree hunters in order to determine the potential for broader ecosystem based monitoring and reporting. Lastly, beyond CyberTracker, semi-structured interviews with Cree fishermen and administrative staff of the Cree Trappers' Association revealed their interest in utilizing a multi-purpose GPS enabled device capable of:

1. Search and rescue (SAR) notification;
2. Land and sea navigation; and
3. Identifying areas of interest and concern on a map (identification of illegal hunting, fishing, and historical sites.