Protecting marine biodiversity in Canada: Adaptation options in the face of climate change

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Abstract. Climate change adds a significant stress to biodiversity in Canada, compounding the effects of continuing habitat loss and over-exploitation of natural resources. These cumulative threats to flora and fauna heighten the need for conservation strategies. Policy in the climate change area has focused on greenhouse gas mitigation, but the complementary response of adaptation must also be addressed as changing climate will have effects on biodiversity even if global emission targets are met. It is internationally recognized that protected area networks support the ability of ecosystems to cope with climate change. Natural ecosystems have greater resilience in the face of climate change impacts when additional stresses from industrial and commercial exploitation are reduced, and when species migrating to more suitable locations are facilitated through protected areas. Conservation as part of an adaptation policy is good insurance against the risk of species extinctions due to climate change. In Canada's biodiversity and conservation policies there is little evidence to date of explicit recognition of, or action on, climate change adaptation, especially in the oceans. In Canada's oceans, there is an urgent need to create comprehensive networks of large protected areas to assist in buffering the effects of climate change. While some marine protected areas have been established in Canada, their sufficiency and their ability to facilitate connections between them needs to be examined in light of climate change. Marine ecosystems are vulnerable to the impacts of climate change and this is compounded by the many stresses they already face from overharvesting, habitat destruction, alien species, and pollution. Minimizing these chronic stresses and employing ecosystem based management approaches are key strategies to reducing the impact of climate change on marine ecosystems in Canada.

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INTRODUCTION

Canada is the steward of a large proportion of global "natural capital", including 20 % of the world's freshwater, and over one-third of the world's remaining original forests in the boreal forest (Lee *et al.* 2003). Together with the longest coastline in the world bordering on three of the world's oceans, and an ocean estate of 7.1 million square kilometers (Fisheries and Oceans Canada 2008) –the second largest in the world, Canada is home to a diversity of species and ecosystems on land and in the sea. This natural capital in turn has provided the basis for a prosperous society (NRTEE 2004).

According to the most recent assessment by the Intergovernmental Panel on Climate Change there is no doubt that the earth's climate is warming, affecting both terrestrial and marine natural systems (Fischlin *et al.* 2007). Climate change is now considered one of the key stressors leading to biodiversity loss (Millenium Ecosystem Assessment 2005). Some ecosystems and species are especially vulnerable to climate change (Secretariat of the CBD 2003), and there is now considerable evidence that many are already being affected by climate change and some are seriously threatened (Fischlin *et al.* 2007). Canada, has experienced and is projected to continue to experience greater rates of warming than most other regions of the world over this century, although variations are expected across the country (Lemmen *et al.* 2008).

Efforts to manage and conserve living marine and terrestrial systems in the face of climate change will require adaptation responses. Even with greenhouse gas mitigation measures in place, there is an immediate need to plan and implement adaptation measures to deal with existing and projected changes in climate (Burton 2007), requiring new conservation priorities and approaches (Peters and Darling 1985; Peters and Lovejoy 1992; Lovejoy 2005; Gitay *et al.* 2002). A variety of anticipatory or proactive adaptation options could improve the capacity of ecosystems to cope with climate change (Fischlin *et al.* 2007).

In this paper we review the international literature on the implications of climate change for marine biodiversity and on the adaptation measures that have been proposed to address them. We consider the implications of climate change for Canada's marine ecosystems and the adequacy of Canada's existing programs and policies for the protection of marine biodiversity. Our focus is on the management of ocean ecosystems and the establishment of marine protected areas in Canada in order to prepare for climate change. We draw upon our experience as NGO practitioners involved in marine conservation processes in Canada. We review the extent to which existing marine conservation policies and programs are incorporating proposed adaptation measures and identify the opportunities for improving Canada's approach to marine conservation in the face of climate change.

IMPACTS OF CLIMATE CHANGE ON BIODIVERSITY

According to the IPCC (2007) climate change is unequivocal and already evident. Eleven of the last twelve years ranked among the warmest years since recording began in 1850 and an additional increase of approximately 0.4°C is expected over the next two decades. The Millennium Ecosystem Assessment (2005) warns that climate change is likely to become the dominant direct driver of biodiversity loss by the end of the century. Climate change is already having an impact on biodiversity through shifting habitat, changing life cycles, the development of new physical traits or species die-offs and extinctions (Root *et al.* 2003; Parmesan and Yohe 2003; Parmesan 2006).

According to the IPCC (Fischlin *et al.* 2007) if global average temperatures increase more than 2 to 3 degrees C above pre-industrial levels, the result will be major changes in ecosystem structure and function, ecological interactions between species and shifting geographical ranges for many species. Further, the resilience of many ecosystems (their ability to adapt naturally) will likely be exceeded by the year 2100 and on a global basis, 20-30% of species assessed so far will likely be at an increased risk of extinction if global warming continues. Ecosystems projected to be especially affected by climate change include tundra, boreal forest and mountain regions, coastal salt marshes, coral reefs and the sea-ice biome.

Globally, marine ecosystems are undergoing a variety of physical and chemical changes as a result of climate change (Harley *et al.* 2006). Ocean temperature increases are now being observed to depths of 3000 metres (Fischlin *et al.* 2007), resulting in thermal expansion of ocean waters which together with melting glacier and Arctic ice, is leading to sea level rise. This sea level rise is predicted to lead to the loss of 13-25% of the world's coastal wetlands (Fischlin *et al.* 2007). Species compositions are changing in the oceans with increased temperatures, and increased rainfall and fresh water runoff are leading to localized changes in salinity and turbidity, and altering species habitats (Harley *et al.* 2006; Hoffman 2003).

In their exploration of the coping response and adaptive capacities of marine ecosystems around the world, Perry *et al.* (2008) found that responses of the natural marine sub-system at shorter scales include altered migration and distribution patterns, changes in species composition, and changes in available prey. At longer time scales, adaptive responses include changes in size composition within species and increased turn-over rates, changes in abundance, and changes in food web dynamics and structure.

Oceans are becoming more acidic due to increasing carbon dioxide. Much of the extra CO_2 released by burning fossil fuels is absorbed by the oceans, increasing the dissolved inorganic carbon concentration, resulting in an increase in acidity and a decrease in pH. The decrease in pH threatens sea life like corals and shellfish that produce calcite and aragonite shells or structures (Gitay *et al.* 2002; Harley *et al.* 2006; Zeebe *et al.* 2008).

Marine species as varied as corals, birds and polar bears are facing great challenges due to climate change. Tropical coral reefs are subject to bleaching as temperatures rise and both tropical and cold water corals will be impacted by ocean acidification, which affects their ability to grow. Polar bears, which are dependent on sea ice to hunt ice-breeding seals, face possible extinction as the sea ice declines (Fischlin *et al.* 2007). Migratory species, including birds, are facing serious declines with the change in timing of biological events, leading to disconnects between migratory timing and availability of food (Butler and Taylor 2005; Price and Root 2005).

Climate change is one of many human-induced stressors on marine ecosystems and biodiversity . Other stressors include destruction and fragmentation of habitat, pollution, overexploitation, and invasive species. Recent research has demonstrated the staggering extent of multiple stressors on oceans with 40% of the world's oceans already heavily impacted by human activities, and no area of the global oceans left unaffected by human influence (Halpern *et al.* 2008). Harley *et al.* (2006) note that "…marine ecological responses to climate change will hinge on human fishing pressure". Fishing impacts marine ecosystems through overfishing, destruction of habitat and bycatch (Jackson *et al.* 2001; Pauly *et al.*1998; Thrush and Dayton 2002; Watling and Norse 1998; Worm *et al.* 2006). Combined, these stressors affect the resilience of ecosystems, thereby increasing their vulnerability to climate change.

Ecosystems can recover from many kinds of disturbances. However, there is often a threshold beyond which an altered ecosystem may not return to its previous state. The tipping points for these irreversible changes may be impossible to predict, yet they are known to exist, as demonstrated by the decline of Atlantic cod. Thus, a precautionary approach is prudent as ecosystems are pushed further from pre-existing states (McLeod *et al.* 2005). The cumulative and synergistic effect of climate change with these stressors will require new conservation strategies and adaptation measures (Peters and Darling 1985; Peters and Lovejoy 1992; Lovejoy 2005).

CANADIAN BIODIVERSITY UNDER THREAT

Every region of Canada is experiencing the effects of a changing climate. The most recent national assessment of impacts and adaptation to climate change has clearly identified unequivocal impacts on physical and biological systems (Lemmen *et al.* 2008). Canada's average temperature has increased twice the global average. Significant changes in environmental conditions are expected with climate change. There is already considerable evidence of changes in temperature, precipitation and moisture regimes, extent and nature of glaciers and sea ice, and in the frequency and intensity of extreme events (Lemmen *et al.* 2008).

Climate change will have profound effects on Canada's species and ecosystems. Biodiversity - the variability of life forms within a given ecosystem - will inevitably be affected. With warming temperatures, species and habitat will shift northward, move to higher elevations and even disappear (Lemmen *et al.* 2008). Already 521 species in Canada are in various risk categories, (212 endangered, 136 threatened, 151 Special Concern) (COSEWIC 2007). Worldwide species extinctions are expected by the IPCC (Fischlin *et al.* 2007) if global warming continues. Species with limited climatic ranges and/or restricted habitat requirements will be most vulnerable to extinction (Gitay *et al.* 2002; Parmesan 2006).

Canada's marine ecosystems are already experiencing the effects of climate change and are expected to exhibit additional changes in the future. On the Atlantic coast, possible changes in the Labrador current, due to increased glacial melting in Greenland, will bring colder water south and lead to local fish kills. Of particular concern for marine food webs is the impact on capelin stocks, a key prey species for cod and seabirds (Vasseur and Catto 2008). Projected reductions in Great Lakes outflow will affect the flood regime along the

St. Lawrence River, leading to declines in Northern Pike, as well as marshland birds and waterfowl (Bourque and Simonet 2008). On the Pacific coast, wild salmon stocks are particularly vulnerable to climate change impacts, as warming affects both habitats on which they are dependent – the open ocean of the eastern North Pacific and the streams and rivers in which they spawn (Lemmen and Warren 2004). With continued warming of the eastern North Pacific, the population distribution of Sockeye Salmon is predicted to retreat to the colder waters of the Bering Sea (Welch *et al*. 1998; Bruce and Haites 2007). North Pacific Ocean waters are now the most acidic in the global ocean (DFO 2008), with possible severe consequences for cold water corals on the coast.

In Canada's north, marine fish communities in Hudson's Bay changed from Arctic to sub Arctic in 1997 as a result of warming waters and the reduction in summer ice cover (Chiotti and Lavender 2008). These changes in northern waters are also affecting Ringed Seals and Polar Bears that rely on ice platforms which are now melting 2-3 weeks earlier than 20-30 years ago. This is affecting reproductive success and overall body condition of Polar Bears (Chiotti and Lavender 2008). At Wapusk National Park, established to protect denning Polar Bears, deteriorating sea ice conditions may lead to their extirpation (Scott *et al*. 2002).The warming experienced in the Arctic over the past 50 years is leading to shifts in the distribution and migratory behaviour of wildlife, including birds and whales, and to potential restructuring of marine ecosystems as southern species, like Pacific and Atlantic Salmon move north (Furgal and Prowse 2008).

ADAPTATION FOR BIODIVERSITY CONSERVATION

While much of the current focus for climate change policy makers in Canada is on mitigation strategies to reduce the emissions of carbon into the atmosphere, the United Nations Framework Convention on Climate Change (UNFCC) also requires countries to address adaptation to climate change. The Ultimate Objective of the UNFCCC explicitly states the need "to allow ecosystems to adapt naturally to climate change", and Article 4.1 commits Parties, including Canada, to "formulate, implement, publish and regularly update national and, where appropriate, regional programmes containing … measures to facilitate adequate adaptation to climate change".

Adaptation is necessary not only for the projected future changes in climate but also because climate change is already affecting ecosystems around the world, and will continue to do so for decades and possibly centuries to come (Lemmen *et al.* 2008; Burton 2007). Anticipatory and strategic approaches to adaptation are needed to address this ongoing process of change and to build the capacity and flexibility to cope with whatever comes with the future evolving climate (Burton 2008). However, it must also be recognized that biodiversity adaptation measures will likely only be successful if future climate change remains.

Progress has been made on understanding the nature and processes of adaptation (Smit *et al.* 2001; Burton *et al.* 2002). However, adaptation to climate change has been dominated by considerations of the adjustments that society will have to make to deal with the consequences of climate change. As noted by Smit and Wandel (2006), the concept of adaptation has its origins in the natural sciences and refers to the development of characteristics that enable organisms or biological systems to cope with and survive environmental changes. In this paper we focus on the proactive adaptation policies that governments should implement to help species and ecosystems best adapt to climate change within their natural limits.

The Commissioner of the Environment and Sustainable Development (2006) reviewed Canada's response to climate change and concluded that the federal government has not adequately addressed adaptation issues: "Despite commitments to take action going back to 1992, there is no federal strategy to specify how the effects of a changing climate would be managed." The constraints on the implementation of adaptation strategies generally can be attributed to a number of political, social and institutional factors, (IPCC 2007) and may include fundamental misunderstandings and misinformation about the urgency and nature of adaptation (Dickinson 2007).

The recent Canadian assessment of impacts and adaptation (Lemmen *et al.* 2008) provides many examples of climate change vulnerabilities and adaptation initiatives to address impacts on human communities and economic sectors. While ecosystem impacts are identified for every region of the country (Lemmen *et al.* 2008) few formal adaptation programs or policies to address the conservation of biodiversity are identified. Among protected area agencies, only Ontario Parks and Parks Canada are developing adaptation strategies for their systems (Lemieux *et al*. 2007; Chiotti and Lavender 2008; Suffling and Scott 2005; Parks Canada 2008). In British Columbia, Walker and Sydneysmith (2008) note that climate change impacts on sea-surface temperatures, species migrations and diversity, and ocean productivity have received little consideration in the planning and management of marine protected areas.

Clearly there is a need for comprehensive adaptation initiatives to maintain Canada's distinct natural resources and to honour Canada's obligations under the UNFCCC and under the Convention on Biological Diversity to protect biodiversity.

ADAPTATION OPTIONS FOR CONSERVATION

A consistent finding in the field of adaptation relates to "mainstreaming" (Smit and Wandel 2006), by which climate change risks are incorporated into existing policies, programs and decision making processes related to resource management, coastal and oceans management, and sustainable development. Mainstreaming is necessary for effective adaptation implementation, helping to ensure that the risks and opportunities associated with climate change (and other environmental changes) are addressed in decision making. Given that most adaptive actions will not be taken in light of climate change alone, we explore this key approach to biodiversity conservation below.

Various adaptation options to address biodiversity conservation in the face of climate change have been identified in the literature, and the authors of the recent IPCC report (Fischlin *et al.* 2007) note that this is a rapidly developing field. These adaptation options are focused on enhancing ecosystem resilience to climate change to allow ecosystems to respond to climate change within the limits of natural variability (Gitay *et al.* 2002; Hannah *et al.* 2005; Fischlin *et al.* 2007; Julius *et al.* 2008; Keller *et al.* 2008; Smith *et al.* 2006; Parmesan and Galbraith 2004). Hannah and others (2002 and 2005) have coined the phrase "climate change-integrated conservation strategies", that respond to the speed, magnitude and range shifts due to climate change. While the specifics of these measures vary from author to author, there is a considerable degree of overlap, and we summarize the consistent elements below.

REDUCE AND MANAGE MULTIPLE ANTHROPOGENIC STRESSORS

Reduction and management of other anthropogenic stressors on biodiversity arising from habitat destruction, over-harvesting, pollution, and alien species invasions constitute critical climate change adaptation measures, which will promote resilience in any situation (Fischlin et al 2007; Julius *et al.* 2008). For example, the FAO (2006) recommends that fishing efforts should be reduced, as lightly fished stocks are likely more resilient to climate change impacts than heavily fished ones.

ESTABLISH NETWORKS OF PROTECTED AREAS

A network approach to protected areas on land and in the sea has been advocated for more than two decades (Noss and Harris 1986; Soule and Terborg 1999) in order to stem the tide of biodiversity loss by maintaining connectivity between individual protected areas. Studies of marine protected areas around the world demonstrate their contribution to maintaining, enhancing and restoring biodiversity (Halpern *et al* 2003) leading many fisheries scientists to call for their establishment as a key conservation mechanism (Worm *et al* 2006; Pauly *et al.* 2002;Roberts 2007). Marine protected area networks can provide significant ecological and social benefits that cannot be attained through individual MPAs (Smith *et al* 2006).

Networks of protected areas should be established and explicitly designed to represent the diversity of habitats across the landscape or seascape (Keller *et al.* 2008; Roberts et al 2001) and to account for projected changes in climate. Incorporating these elements into the design of protected area networks, the movement of species to new geographical locations will be facilitated and be increasingly necessary as climate shifts (Gitay *et al* 2002; Keller *et al.* 2008; Taylor and Figgis 2007; Hoffman 2003). Replication of habitats in the reserve system is a vital form of insurance and central to the representativeness goal of protected area networks. Conserving ecotones/transitional zones as repositories of genetic diversity may assist with future rehabilitation of adjacent ecoclimatic regions. This approach also ensures that areas throughout a species range are included in the network (Hoffman 2003;Hannah *et al.* 2007).

Some scientists have proposed a conservation matrix model that would see protected areas as the foundation for all other management, with invasive activities strictly contained and areas of no protection constituting only a small portion of the land or sea (Roberts 2007; Schmiegelow *et al.* 2006). Recent scientific studies have identified science-based targets for the optimal extent of protected area networks. For terrestrial protected area networks these have generally ranged between 32 and 70% of the land base, and for marine protected areas (specifically reserves with no fishing) the range is between 20 to 50% (Price *et al* 2007; Schmiegelow *et al.* 2006; Sarkar *et al.* 2006; Fahrig 2001; Wiersma and Nudds 2006; Allsopp *et al* 2007; Vierros 2004; Schubert *et al.* 2006) These targets far exceed those that have generally been achieved by governments to date.

THROUGH INTEGRATED PLANNING, SITUATE PROTECTED AREAS WITHIN A MOSAIC OF OTHER CONSERVATION MEASURES ACROSS LANDSCAPES AND SEASCAPES

Under the Convention for Biological Diversity (2004), countries have committed, by 2015, to "integrate protected areas into broader land- and seascapes and sectors so as to maintain ecological structure and function".

Situating the network within a broader mosaic of buffer zones and other conservation measures and uses ensures connectivity around and between protected areas. The establishment of biological and migration corridors between protected areas helps to counter habitat fragmentation (Gitay *et al* 2002; Welch 2005; Fischlin *et al.* 2007; NRTEE 2003). These strategies require implementation over larger regions, possibly across national borders, and over longer time periods, but are critical to effectively functioning protected area systems (Dudley *et al.* 2005).

Hannah and Hansen (2005) stress the importance of making climate change an explicit consideration in connectivity design and provide specific steps for designing dynamic landscape or seascape plans. By taking into account projected changes in climate and reducing other pressures on biodiversity, natural systems will be less vulnerable to climate change (Gitay *et al.* 2002).

MAINTAIN VIABLE POPULATIONS TO ENABLE ADAPTATION

Maintaining viable, connected and genetically diverse populations appears to increase their long-term persistence (Fischlin *et al.* 2007). Conservation of genotypes, species and functional types, along with the reduction of habitat loss, fragmentation and degradation, may promote the long term persistence of ecosystems and the provision of ecosystem goods and services (Schmiegelow *et al.* 2006; Hannah *et al* 2007).

DESIGN AND MANAGE PROTECTED AREAS AS REFUGIA FOR SPECIES

Identify and protect climate refugia as places where favourable habitat will persist or develop as the climate changes and as sources of "seed" for recovery. As the changing climate renders areas outside refugia inhospitable to certain species, these species will only continue to exist in the refugia (Taylor and Figgis 2007; Julius *et al.* 2008; Marshall 2006; Harley *et al.* 2006).

DEVELOP ARRANGEMENTS FOR GREATER COLLABORATION AND COOPERATION IN ADAPTIVE MANAGEMENT

In order to support the network and matrix approach across the landscape/seascape, institutional mechanisms for coordination and collaboration will be required to effectively achieve these approaches (Hannah *et al.* 2005;Lovejoy 2005;Welch 2005). In fact Lovejoy (2005) notes that "Institutional coordination, always vital, will be required as never before." The success of landscape and seascape management will depend on coordination between all levels of government, together public and stakeholder support and understanding of the important ecological services provided by nature. Public support and endorsement of management actions is critical to gaining political support. Future management and planning of protected areas hinges on public and political agreement on the ultimate goal - to protect current ecological communities or to facilitate ecosystem adaptation (Scott 2005).

Climate change strengthens the call for an adaptive management approach (Hoffman 2003;Welch 2005) that focuses on transparency and learning (IUCN 2003). Adaptive management is a structured process of "learning by doing" (Walters 1997). Conservation agencies must move from managing on the basis of models based on climatic and biogeographic stability, and begin to incorporate measures to address the changes that are likely to arise in the face of climate change (Scott 2005; IUCN 2003;Hannah et al 2007).

MONITORING TO DETERMINE EFFECTIVENESS

Determining the effectiveness of the management strategies and changing management regimes based on this information, is key to further adaptation success (Welch 2005; Da Fonseca *et al.*2005). Since climate change impacts are uncertain, monitoring provides important information on which to base future management decisions.

Tools to assist with this process include the IUCN/WWF (Pomeroy *et al.* 2004) guidebook on assessing management effectiveness of marine protected areas based on a series of biophysical, socioeconomic and governance indicators.

Taken together, these measures comprise an ecosystem based approach aimed at maintaining an ecosystem in a healthy, productive and resilient condition by considering both the cumulative impacts of all user sectors and the needs of humans (Arkema *et al.* 2006; Fischlin *et al.* 2007; McLeod *et al.* 2005; Cicin-Sain and Belfiore 2003; Hoffman 2003;Dudley *et al.* 2005). Even aside from the climate change context, they are considered an important basis for the conservation of biological diversity (Lovejoy 2005). As such they represent win-win or no-regrets adaptation options, based on the precautionary principle, that will provide benefits for biodiversity conservation regardless of the existence of climate change (Fischlin *et al.* 2007; Dickinson 2007).

MARINE CONSERVATION IN CANADA – POLICY CONTEXT AND CURRENT STATUS

Biodiversity conservation in Canada is a shared responsibility between federal and provincial governments, as well as First Nations and local governments (NRTEE 2003). Across Canada there are a variety of approaches to conservation that include comprehensive, integrated oceans and land use management combined with protecting key habitats and species, promoting sustainable use of plant and animal species, and mechanisms for public education, awareness and action.

Canada has made international commitments to complete protected area networks on the land and in the sea. Under the Convention on Biological Diversity, Canada along with other signatories agreed in 2004 to establish by 2010 for terrestrial and 2012 for marine areas, "comprehensive, effectively managed and ecologically representative national and regional systems of protected areas…to reduce the current rate of biodiversity loss" (CBD 2004). Similar commitments were made at the World Summit on Sustainable Development (United Nations 2002) and the World Parks Congress (IUCN 2003). In the latter case, this included specific targets of at least 20-30% of each habitat in the marine environment.

However, despite these commitments, as of 2005 Canada had protected only 9.9% of the total land area in Canada. The share of total land protected varies with jurisdictions across the country - ranging from 2.8% in Prince Edward Island to 13.1% in British Columbia (Government of Canada 2007). Protection in Canada's oceans falls far short of the progress made on land so far, with less than 0.5% protected and an even smaller fraction is closed to all industrial activities, including fishing.

The remainder of this paper will focus on Canada's efforts to protect biodiversity in the oceans by examining the extent to which the adaptation options noted above have been implemented through current management and decision making processes.

MARINE CONSERVATION INITIATIVES AND CLIMATE CHANGE IN CANADA

Marine ecosystems are vulnerable to the impacts of climate change due to the myriad stresses they already face from overharvesting, habitat destruction, alien species, and pollution. Minimizing these chronic stresses and employing ecosystem based management approaches are key strategies to reducing the impact of climate change and addressing the management of other human activities in the marine environment. Canada has the legislative tools that could constitute both a "no regrets" approach to marine conservation and achieve climate change adaptation goals. Two key mechanisms considered here are integrated oceans management and marine protected areas.

INTEGRATED OCEANS MANAGEMENT

Canada was one of the first countries in the world to legislate an ecosystem based management approach for its oceans territory when it passed the *Oceans Act* in 1997. Fisheries and Oceans Canada (2002) has responsibility under the act to develop integrated management plans through a process that will inclusively and comprehensively plan and manage human activities to minimize conflict among users, using a transparent planning process and guided by the principles of ecosystem-based management, sustainable development, the precautionary approach, and conservation.

Integrated oceans management is supported by research conducted by departmental scientists across the country, including ecosystem overviews and identification of ecologically and biologically significant areas (EBSAs). The department has been active in climate change science since 1979 (Minns and Wilson 2005), and it has recently revamped its science agenda (Fisheries and Oceans Canada's 2007c) which outlines a five year set of nine research priorities that includes climate change. However, Fisheries and Oceans Canada has to date not implemented a comprehensive national program to address climate change impacts and adaptation as recommended by staff at a national workshop in 2000 (Minns and Wilson 2005). The report also notes that many of the attributes that scientists say need to be better understood to predict the impacts of climate change on marine resources and sectors, are the same as those needed to move from a single –species to an ecosystem-based management approach.

The 2004 Oceans Action Plan (OAP) (Fisheries and Oceans Canada 2005) sets out a comprehensive approach to management of Canada's vast ocean territory. The Plan notes that the health and quality of the marine environment is declining in Canada due to a number of factors, including "shifts in major oceanographic drivers due to climate change" and identified five large scale ocean management areas where integrated management planning is now proceeding: Eastern Scotian Shelf, Gulf of St. Lawrence, Placentia Bay/ Grand Banks, Beaufort Sea and Pacific North Coast (Figure 1). Eventually the intent is to complete large scale oceans management planning throughout Canada's ocean territory. Progress and structure of the integrated oceans planning initiatives varies considerably among these five planning regions, but is slow overall. The two most advanced processes, the Eastern Scotian Shelf and the Beaufort Sea are reviewed further below.

EASTERN SCOTIAN SHELF INTEGRATED MANAGEMENT PROCESS (ESSIM)

The Eastern Scotian Shelf (ESSIM) project covers 325,000 sq km of offshore area that is heavily used by a variety of activities including fishing, oil and gas development, shipping, maritime defence operations, submarine cables, scientific research, and recreation and tourism. The multi stakeholder and multi government process has been underway since 1998 and is the most advanced of all the integrated oceans planning processes in Canada. Last year, a strategic level plan (Fisheries and Oceans Canada 2007b) was submitted to the Minister of Fisheries and Oceans by the stakeholder and government committees and is awaiting approval.

The Eastern Scotian Shelf ecosystem has been subjected to large and rapid changes as a consequence of human actions and environmental variability. Trophic level shifts, introduced invasive species, and shifting species range distributions are characteristics of this changed marine ecosystem structure. According to a recent scientific report, the ecosystem has undergone a complex reorganization as a result of changes in biodiversity (Zwanenburg *et al.* 2006). Pelagic and invertebrate species are proliferating on the Eastern Scotian Shelf, while groundfish (cod) which were overfished and collapsed in the 1980s are not rebuilding as quickly as expected (Zwanenburg *et al*. 2006; Fisheries and Oceans 2007b). Reduced cod stocks are more sensitive to climate change and recovery will be determined by changes in forage and prey species, which themselves are influenced by climate changes (Bruce and Haites 2008). Other changes include earlier spring phytoplankton blooms and increased abundance of grey seals (Zwanenburg *et al.* 2006).

Some stakeholders participating in the ESSIM process are concerned that conservation options are being foreclosed by the rapid pace of offshore oil and gas development, (NRTEE 2003; Guenette and Alder 2007). To date, only two protection measures have been implemented: the designation in 1994 of The Gully marine protected area, which supports a rich diversity of marine life, including the Northern Bottlenose Whale and cold water corals, and fishing closures for two areas of high concentration and rare cold-water corals – Northeast Channel and Lophelia coral conservation areas (Fisheries and Oceans Canada 2007a).

The combination of major ecosystem changes already observed resulting from overexploitation, industrial use and climate change suggests an urgent need to implement more comprehensive conservation measures, including planning for MPA networks and more explicit consideration of climate change adaptation options. Scientists studying this marine region have identified the need for ecosystem level targets for use in management of fisheries in order to better account for the collateral impacts of fishing and changing environmental conditions (Zwanenburg *et al.* 2006).

The strategic management plan highlights the collaborative nature of the process among stakeholders and a coordinated approach among government agencies, both important attributes in integrated planning at a seascape level. The plan includes objectives and strategies for the conservation of biodiversity, including through a network of MPAs and addressing the impacts of current activities, such as fishing and noise (Fisheries and Oceans Canada 2007a). However, explicit mention of adaptation strategies to address the impacts of climate change are absent.

BEAUFORT SEA INTEGRATED MANAGEMENT PLANNING

Centred on the Inuvialuit Settlement Region, the Beaufort Sea planning process in the western Arctic began in 1999 in response to the resurgence of oil and gas industry activities in the Mackenzie River Delta and the potential threat posed to the Beluga and their habitat in the region. As a result, the initial focus of the planning process was on the urgent need to provide long-term protection to the Beluga, by the designation of Tarium Niryutait marine protected area (Berkes *et al.* 2007; Elliott and Spek 2004). Extensive local consultation and involvement in the management process occurred among the Inuvialuit, the federal government and industry. A regulatory package is currently being completed for this MPA (Gardner 2008), and the steering committee and working groups are now turning their attention to developing longer term plans for more comprehensive oceans planning,

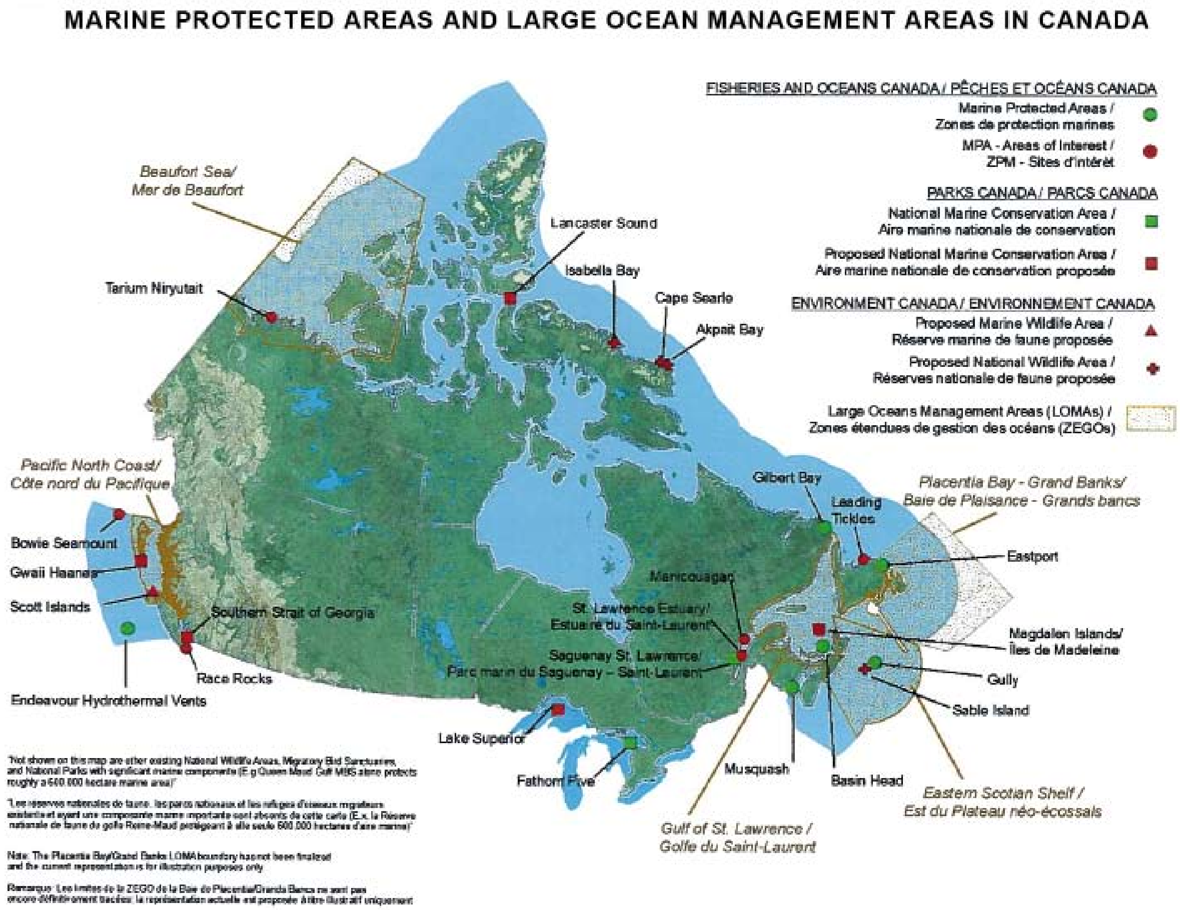

Figure 1.
MPAs and LOMAs in Canada
Note. An announcement was made on Aug 22nd, 2008 of the formation of three new national wildlife areas on Baffin Island.

Figure 2.
Ecologically and biologically significant areas (EBSAs) in the Beaufort Sea LOMA region. These areas of high ecological or biological significance were identified by scientific and local communities in accordance with Fisheries and Oceans Canada's national evaluation framework. The identification of these areas as EBSAs requires that management activities focus on greater risk aversion. The Oceans Act authorizes the department to provide these areas with enhanced protection. In some cases this may include marine protected area designation (map courtesy of Fisheries and Oceans Canada 2007).

Table 1: Number and area of federal marine areas protected in Canada

Administrator	Type of MPA	No. of Marine Areas	Approximate MPA size (ha)
Parks Canada	National Marine Conservation Area	1	11,500
Parks Canada	National Park (Marine Portion)	15	716,305
Joint Parks Canada/ Québec	Saguenay - St. Lawrence Marine Park	1	113,800
Environment Canada	National Wildlife Area (Marine Portion)	13	152,317
Environment Canada	Migratory Bird Sanctuary (Marine Portion)	51	1,417,145
Fisheries and Oceans	Marine Protected Area	6	255,160
Totals		87	2,666,227

Source: (Gardner *et al.* 2008).

with a first task being the development of objectives (Beaufort Sea Partnership 2008).

The risks posed by climate change were identified as one of two primary concerns facing communities in the western Arctic in 2000 (Ford and Smit 2004). Climate change was not addressed through the initial phase of integrated marine planning process for the Beaufort Sea. Given the anticipated impacts of future climate change in the polar regions, it is expected that this will become an issue of high priority for marine planning. In community consultations held over the last two years, residents identified a variety of climate change related issues, including; observations of changes in wildlife movements and distributions, physical impacts like coastal erosion, changing ice conditions and more open water and general concerns about the effects of climate change (pers. comm. J. Paulic, 11 April 2008). These issues are being considered in the current development of conservation objectives for the next phase of the planning process.

The ecosystem overview report for the region (Cobb *et al.* 2008) identifies ecologically and biologically significant areas, together with a suite of stressors in the Beaufort Sea region (see figure 2). The stressors include: coastal infrastructure, watershed activities and long-range transport of pollutants, impacts of seismic, exploratory and ultimately exploitation activities related to oil and gas and mineral and granular resource extraction. Marine transport impacts include those that occur with the passage of ships and barges, discharge of ballast water, and unplanned spills and discharges. Subsistence hunting and fishing and limited recreational and tourism activities are thought to have only minor impacts on the region.

Climate change is considered one of the most important environmental and socioeconomic issues facing the Beaufort Sea region and one of the biggest challenges facing the people, institutions and processes in the region (Cobb *et al.* 2008). The authors note that the goal of ecosystem based management (EBM) is to preserve the ability of ecosystems to adapt to climate change, (i.e. preserve their natural resilience). However, their view is that "coastal residents will have to rely on their capacity for resilience and adaptation to cope with a changing and uncertain environment. It is hoped that, by working together, additional resources and intelligence will be brought to bear on these questions." Surely far more can be done than is suggested here to address the climate change challenge in the Beaufort Sea. There is now considerable understanding of the sensitivities and adaptive capacity of northern communities (Ford and Smit 2004). What is suggested by Cobb and others is hardly an effective adaptation strategy given that the risks of climate change are well known. The integrated planning process affords an opportunity to bring an explicit, coordinated and strategic approach to addressing the climate change issue, that should go beyond "hoping" that residents will somehow 'figure it out'.

MARINE PROTECTED AREA NETWORKS

Canada has also made commitments to establish a national network of marine protected areas. In addition to the international commitments already noted, these include national commitments under the Canada's Oceans Strategy (2002), Oceans Action Plan (2004) and through federal budgets (2004, 2005, 2007). Despite these commitments, as noted above, Canada has made negligible progress in establishing marine protected areas, with less than 1% of the oceans territory currently protected. And at a recent conference, federal officials estimated that by 2012, less than one third of Canada's MPA system would be complete (Gardner *et al.* 2008).

The Canadian Parks and Wilderness Society recently released a comprehensive study examining the opportunities and challenges to achieving a national network of MPAs in Canada by 2012 (Gardner *et al.* 2008; CPAWS 2008). On the basis of extensive interviews of MPA practitioners across the country, with a focus on government officials in the three federal agencies with MPA responsibilities, a number of issues were identified that are contributing to the lack of progress on MPAs in Canada. A lack of leadership and capacity, ineffective federal coordination, together with the absence of a clear plan to achieve the 2012 commitment, were identified as significant challenges impeding Canada's progress.

A network approach to the planning of MPAs in Canada remains in its infancy. The current approach to the establishment of MPAs in Canada is largely *ad hoc* and proceeds on a site-by-site basis, with as yet, no consideration for potential linkages between sites and no explicit network planning, either within any of the integrated management planning process, or anywhere else in Canada's oceans for that matter (Gardner *et al.* 2008; Smith *et al.* 2006; Guenette and Alder 2007). As a result of the current *ad hoc* approach, it can take between 6 and 20 years for marine protected area candidates to achieve final legal protection (Gardner *et al.* 2008).

In 2005, the three federal agencies with responsibilities for marine protected areas, Parks Canada, Environment Canada and Fisheries and Oceans Canada, released a federal Marine Protected Areas Strategy (Fisheries and Oceans Canada 2005). The strategy acknowledges the need for a more systematic and coordinated approach to the establishment of MPAs. It commits the agencies to establish an MPA network within the integrated oceans management framework. Through the integrated planning processes, baseline scientific information is compiled, including the analysis and identification of ecologically and biologically significant areas (EBSAs) (Fisheries and Oceans Canada 2004) which help to guide the location of future MPAs. While there is only a passing reference to climate change, the strategy acknowledges the drawbacks of the current *ad hoc* approach and the benefits of a network approach.

Canada's federal agencies with marine protected area responsibilities can learn from international experience on establishing MPA networks (Smith *et al.* 2006). A recent workshop (Fisheries and Oceans Canada and World Wildlife Canada 2007) explored the experience of other countries with a network approach to MPAs and distilled some best practice advice for future steps in Canada, with a focus on identifying ecological criteria for sound MPA networks. Principles for incorporating climate change adaptation into site and system planning are also available (Hoffman 2003; Hannah and Hansen 2005; Dudley 2005). Spatial analysis tools using Geographical Information Systems (GIS) are becoming increasingly sophisticated and able to address connectivity and protected area network design with climate change in mind (Hannah and Hansen 2005).

Of the three agencies with MPA responsibilities, only Parks Canada (2008) has developed a climate change adaptation strategy, *albeit* still in draft form, to guide its approach to incorporating climate change adaptation measures into its planning for and management of national parks and national marine conservation areas. This strategy was preceded by a series of comprehensive reports commissioned by Parks Canada relating to climate change and the national parks system. They included scenarios for 41 national parks, three NMCAs and six proposed national parks (Scott 2003; Suffling and Scott 2000; Jones *et al.* 2003; Scott *et al.* 2002), as well as the ecological impacts likely to occur at each park, adaptation options available to park managers, and Canadian biome changes that could occur under climate change. Across the 44 parks and NMCAs, Parks Canada has 45 distinct monitoring programs that track hydrological or ecological responses to climate. Nearly two thirds of the parks and NMCAs address climate change in their management planning, and indicators of climate change are being selected as part of Parks Canada's ecological-integrity-monitoring framework (Scott 2003).

Overall, observing the integrated management planning processes and the implementation of MPA networks, it would appear that the urgency to address the current and future impacts of climate change on marine ecosystems is not matched by a similar urgency to achieve tangible results through these initiatives. Long delays in realizing substantive progress in Canada's oceans through these two initiatives and the lack of explicit adaptation strategies is leaving marine biodiversity at great threat from the multiple stressors of climate change, overfishing, habitat destruction and industrial developments. The work being done by Parks Canada on adaptation strategies for national parks and national marine conservation areas could serve as a model for the other agencies like Fisheries and Oceans to emulate. However, all federal agencies, together with their provincial counterparts need to step up efforts to establish MPA networks on each of Canada's coasts.

Accelerating work on integrated management planning for Canada's oceans and incorporating MPA network planning as a key outcome could have significant benefits for biodiversity conservation in Canada's oceans, and help to ensure more resilient marine ecosystems that can withstand the impacts of climate change. However, political support, federal coordination and adequate funding are among the obstacles that must be overcome in order to achieve this outcome (Gardner *et al.* 2008).

CONCLUSIONS

Canada's ocean ecosystems and biodiversity are at risk as a result of the stresses of climate change. Canada has obligations under the Convention on Biological Diversity and the UN Framework Convention on Climate Change to initiate measures that will facilitate adaptation strategies to protect ecosystems and biodiversity.

Notwithstanding progress on some fronts, most of Canada's marine environment is still threatened by the combined impacts of climate change and other stressors such as overfishing and habitat destruction. The need remains urgent to address the changes that are already occurring in Canada's ecosystems and to prepare for future changes.

The adaptation options presented in this paper, if properly implemented, could help to protect biodiversity in the face of climate change and other anthropogenic stressors. Canadian policy makers have identified the requisite elements on paper but Canada's progress is inadequate on both the integrated management planning and MPA network front, and deliberate planning for climate change in these processes is not well advanced.

Other experience warns that societal responses to large environmental challenges tend to be incremental and *ad hoc* rather than strategic and planned. This combines with an inclination to "muddle through" and to postpone action until a catalyst dramatically indicates the seriousness of the threat (Smit and Pilifosova 2001). The Canadian experience, unfortunately, is consistent with these tendencies. If Canada does not proceed to implement forward-thinking policies and to integrate climate change planning into ocean management processes, biodiversity in this country will suffer serious, avoidable, losses.

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