Fall | 08

State of the Ocean in the Pacific North Coast Integrated Management Area (PNCIMA)

David Suzuki Foundation
SOLUTIONS ARE IN OUR NATURE

Sierra Club BC

Living Oceans Society
Healthy Oceans, Healthy Communities

CPAWS
Canadian Parks and Wilderness Society
British Columbia Chapter

State of the Ocean in the Pacific North Coast Integrated Management Area (PNCIMA)

ISBN 978-1-897375-18-1

Citation

Hall, A. 2008. State of the Ocean in the Pacific North Coast Integrated Management Area (PNCIMA). David Suzuki Foundation. 159pp.

PREPARED BY

Anna Hall, MSc.

EDITED BY

Bill Wareham, Senior Marine Conservation Specialist, David Suzuki Foundation.

ON BEHALF OF

The David Suzuki Foundation - www.davidsuzuki.org
Living Oceans Society - www.livingoceans.org
Sierra Club of BC - www.sierraclub.bc.ca
The Canadian Parks and Wilderness Society - www.cpawsbc.org

ACKNOWLEDGEMENTS

Gratitude is extended to the Gordon and Betty Moore Foundation for the financial support and to the David Suzuki Foundation for the administrative support for this report. The David Suzuki Foundation, the Living Oceans Society, Sierra Club of BC, and the Canadian Parks and Wilderness Society provided advice and support on the project steering committee throughout the report-writing process. Appreciation is extended to Jodi Stark for research assistance in the early stages of preparing this report, and to Bill Wareham, Kate Willis-Ladell, and Eva Riccius for their guidance and input. Sincere thanks are offered to Heather Deal, Scott Wallace, and Jacqueline Booth for their expert review and editorial comments, to Bill Wareham for editing, and Ian Hanington for his final copyediting. Finally, sincere thanks are extended to Chris Hall for the use of his photographs, which capture so many aspects of the marine environment, and to Judi Fitzgerald for her assistance in reviewing the final draft.

COVER PHOTO Peggy White

David Suzuki Foundation

State of the Ocean in the Pacific North Coast Integrated Management Area (PNCIMA)

Prepared by
Anna Hall, MSc

June 3, 2008

Citation

Hall, A. 2008. State of the Ocean in the Pacific North Coast Integrated Management Area (PNCIMA). David Suzuki Foundation. 148pp.

Table of Contents

Table of Figures

Table of Tables

Acknowledgements

Gratitude is extended to the Gordon and Betty Moore Foundation and to the David Suzuki Foundation for the financial and administrative support, respectively. The David Suzuki Foundation, the Living Oceans Society, and the Canadian Parks and Wilderness Society provided advice and support on the project steering committee throughout the report-writing process. Appreciation is extended to Jodi Stark for research assistance in the early stages of preparing this report, and to Bill Wareham, Kate Willis-Ladell, and Eva Riccius for their guidance and input. Sincere thanks are offered to Heather Deal, Scott Wallace, and Jacqueline Booth for their expert review and editorial comments, to Bill Wareham for editing, and Ian Hanington for his final copyediting. Finally, sincere thanks are extended to Chris Hall for the use of his photographs, which capture so many aspects of the marine environment, and to Judi Fitzgerald for her assistance in reviewing the final draft.

Executive Summary

The purpose of this report is to consolidate some of the most relevant information on the state of the marine environment within the Pacific North Coast Integrated Management Area (PNCIMA) to help inform the Integrated Management Plan (IMP) process and identify gaps in information that will need to be filled to inform decision-making on marine-resource use issues. This report contains information on the status and trends of specific species and ecosystem elements.

The PNCIMA is one of five Large Ocean Management Areas (LOMAs) defined by the Department of Fisheries and Oceans Canada (DFO) under the federal government's Oceans Action Plan. The 88,000-square-kilometre PNCIMA designation was based on oceanographic, physiographic, and ecological characteristics. An IMP initiative led by DFO is proposed for the PNCIMA. More than 45,000 square kilometres of this area have been identified by the DFO as Ecologically and Biologically Significant Areas (EBSAs).

The PNCIMA IMP is intended to be a collaborative process involving federal, provincial, and First Nations authorities; stakeholders from a full range of sectors; and local community members. The planning process is intended to develop an ecosystem-based management plan aimed at reducing resource-use conflict and protecting the integrity of ecosystems and natural processes in this marine environment. Important social and economic considerations within the PNCIMA include commercial fisheries, recreational fisheries, aboriginal fisheries, aquaculture development, tourism, transportation, and offshore energy development.

The marine biodiversity within the PNCIMA ranges from the locally common to the rarely seen species. In this report, we explore the full range of biological values. The abundance and diversity of life in the PNCIMA is dependent on the basis for all marine life: plankton. Many unique ecosystem components, like kelp forests and eelgrass beds, provide important structural architecture to the PNCIMA ecosystem. The region supports some spectacular life forms, such as glass sponge reefs, which collectively cover an estimated 1000 square

kilometres of the PNCIMA seafloor. A diversity of cold-water corals, which provide habitat for many species, is also found here. Physical damage and sedimentation from commercial activities threaten the survival of these unique sponge and coral ecosystems. Within PNCIMA, spatially explicit recommendations have been made to protect sponges, and Fisheries and Oceans Canada has implemented area closures to mitigate damage.

Thirty three species within the PNCIMA are listed as Endangered, Threatened, and Special Concern by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), the expert body that reviews the status of wild plants and animals in Canada. Some of these species, such as the northern abalone (Endangered) and the harbour porpoise (Special Concern) are year-round residents. Others, such as chinook salmon (Endangered) and the short-tailed albatross (Threatened) are seasonal visitors. Not all species designated by COSEWIC are recognized under the federal Species at Risk Act (SARA).

The PNCIMA provides an economic base for many northern British Columbia communities. Commercial fisheries are highly varied with regard to fishing areas, gear, target species, season, and catch rates. Each fishery faces specific challenges and collectively they result in a range of environmental effects. Bottom-trawl fisheries can result in destruction of sensitive bottom habitat. This gear can be indiscriminant in its catch and can damage the very habitat that supports commercially desired species. The collective effects of fisheries on the ecosystem should be addressed in a systematic and scientific manner in order to realize an ecosystem-based approach to ocean management in PNCIMA. This should include evaluation of bycatch, habitat destruction, pollution, and illegal fishing (i.e., poaching).

Aquaculture in the PNCIMA has economic and ecological implications that should also be considered in the development of an ecosystem-based plan for this region. The current state of aquaculture within the PNCIMA is addressed with potential environmental threats evaluated. The contentious sea-lice issue is evaluated with federal and independent research results. Recommendations from several sources are suggested to help mitigate current issues associated with the salmon and shellfish aquaculture industries in B.C.

Marine and coastal industrial development is central to the social and economic well-being of many B.C. communities that rely on forestry, transportation, fishing, tourism, and shipping. The three main ports of the PNCIMA include Kitimat, Prince Rupert, and Stewart. Over the next 15 years, container volumes are expected to increase some 300 per cent, bulk cargo shipments 25 per cent, and cruise-ship traffic 20 to 25 per cent. The observed increase in cruise-ship traffic is noted for provincial waters.

The oil and gas industry in B.C. presents several challenges for marine ecosystems. *The BC Energy Plan: A Vision for Clean Energy Leadership* sees B.C. at the forefront of environmental and economic leadership in energy policies. The plan affirms a commitment to promoting competitiveness to attract oil and gas development while working with the federal government, communities, and First Nations to advance offshore development in a scientifically sound and environmentally responsible way. The prospect of offshore oil and gas development and the escalation of oil-tanker traffic in this region require a serious assessment of ecosystem risks that should be incorporated into an IMP for the PNCIMA.

Marine pollution in PNCIMA includes chemical and urban sewage contamination, plastic debris, and discarded fishing gear. An IMP for this region could serve to reduce the incidence of pollution through recommendations for tighter regulation and enforcement.

The governance structure for ocean management in PNCIMA presents challenges for an IMP. A more integrated approach to management will be required to realize an ecosystem-based plan. Governance in PNCIMA is complicated by mixed government authorities, jurisdiction, and regulations. This complexity is further challenged by international treaty and convention obligations intended to protect marine ecosystems. The overarching goal of sustainable management could be partially addressed within the framework of the existing laws and management structures; however, to achieve the desired long-term goals of maintaining ecosystem health and ecosystem-based management, an IMP would be useful in confirming and/or restructuring government, First Nations, and industry responsibilities. For this process to be fully effective, tools are required to enforce mandated conservation requirements of laws such as the Fisheries Act and Oceans Act. Additional scientific capacity will be required to fulfill the conservation and management mandate prescribed by an IMP. The scientific capacity exists within British Columbia; scientists, researchers, technicians, and graduate students simply need the support of their government representatives and agencies in long-term vision and funding.

The current state of the PNCIMA is of interest to many British Columbians, and this report is intended to serve as an overview of the biological and ecological diversity, along with a profile of commercial industries that operate within and rely on the PNCIMA. Major threats to the sustainability of the PNCIMA species or ecosystems are reviewed. This report also highlights the Canadian governance complexities as related to ecosystem-based ocean management and the scientific capacity available in British Columbia and finishes with a summary of social attitudes toward the integrated management of the PNCIMA.

Canadians are interested in ocean-related issues, but more effort is needed to increase the level of ocean literacy in this country. An IMP that aims to engage an ecosystem-based management approach to ocean resources using the best available science and local knowledge from residents, community groups, and stakeholders in the region would develop a comprehensive and successful plan, a plan that would reduce the risks to ocean ecosystem health in the PNCIMA well into the future.

1.0 INTRODUCTION

Coastal ecosystems are complex in nature, having both marine and terrestrial components that involve the integration of biotic and abiotic factors. The sea-land boundary changes hourly, daily, seasonally, inter-annually, and on geologic time scales. The process of defining specific ecosystems is complicated by this dynamic and the fluid nature of the oceans. Rarely are system boundaries clearly delineated. There is a need in PNCIMA for an ecosystem-based management approach that allows for multi-species management and holistic approaches to the management of natural resources. The magnitude and importance of this undertaking should not be underestimated.

Many layers of human interaction with the ocean in the form of recreation and economic and cultural activities create layers of complexity to the management of coastal species and their habitats. These human factors interwoven with the natural intricacy of ocean systems require an IMP approach to maximize the probability of sustainable economic use that is consistent with contemporary conservation and social values.

Coastal ecosystems have formed the basis for human survival over millennia, and it is well known that our historic and contemporary actions have the potential to severely impact diversity, abundance, and resilience at the species, community, and ecosystem levels. To best ensure the longevity of coastal ecosystems, ocean management must integrate the spatial and temporal ecosystem complexities with socio-economics and conservation principles.

1.1 PNCIMA AND LOMA DEFINED

The Pacific North Coast Integrated Management Area (PNCIMA) is one of five pilot Integrated Management Planning initiatives being led by Fisheries and Oceans Canada (DFO). It is the only initiative of its kind on the Pacific Coast of Canada. The four others are in the Beaufort Sea, Gulf of St. Lawrence (GOSLIM), Eastern Scotian Shelf (ESSIM), and Placentia Bay/Grand Banks (PBGB) (DFO 2007d). These five areas were designated as

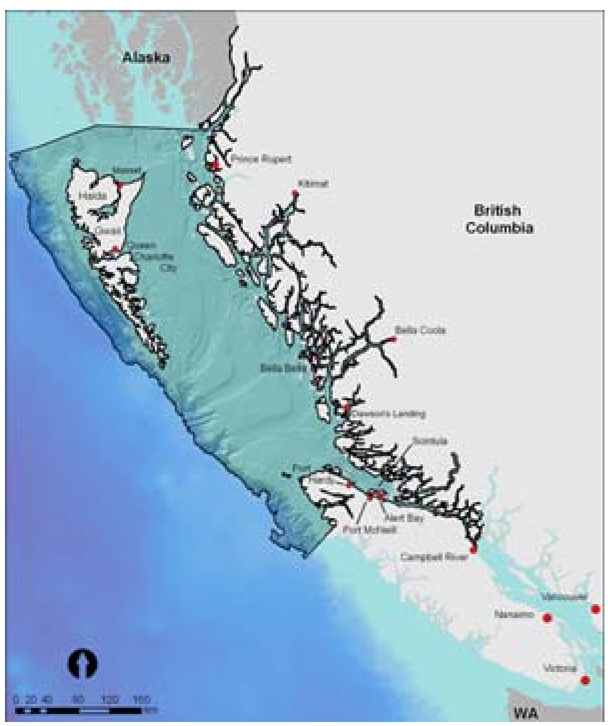
Large Ocean Management Area (LOMA) initiatives under the Oceans Action Plan (DFO 2007d).

The PNCIMA designation was based on ecological characteristics including oceanographic currents and physiographic features (Hillier and Gueret 2007) in order to frame a relatively intact and functioning ecosystem.

1.2 GRAPHICAL REPRESENTATION OF THE PNCIMA

The PNCIMA is located on the west coast of central and northern British Columbia (Figure 1), and encompasses approximately 88,000 square kilometres, encompassing the waters from the Canada-Alaska border to Brooks peninsula on Northwest Vancouver Island, and Quadra Island and Bute Inlet to the south (Hillier and Gueret 2007). Known locally as the Queen Charlotte Basin, the PNCIMA accounts for approximately 22 per cent of the total sea area within Canada's exclusive economic zone on the West Coast (total sea area ~400,000 km^2 - DSF 2007).

Figure 1. The Pacific North Coast Integrated Management Area (PNCIMA)



(From: www.pncimawatch.ca)

The PNCIMA encompasses all waters from the continental slope to the headwaters of coastal watersheds, although terrestrial and freshwater components are not included in the proposed marine planning process (Hillier and Gueret 2007). Important social and economic issues within the PNCIMA relate to biodiversity, fisheries, aquaculture, tourism, transportation, offshore energy development, pollution, governance, and scientific capacity.

1.3 PNCIMA PROCESS OBJECTIVES

The PNCIMA is of ecological, biological, social, and economic significance to coastal residents. Several communities, including Prince Rupert and Queen Charlotte City, rely on the natural resources of the Queen Charlotte Basin. The government intention in PNCIMA is to develop a framework to address issues related to the multiple use of marine areas, sustainability, and conservation, and the creation of governance mechanisms that foster involvement by those who are most affected by management decisions (Hillier and Gueret 2007).

According to the DFO, an IMP process in PNCIMA will be open to any interested Canadians, and is to involve federal, provincial, community, First Nations, and stakeholder community members. First Nations are expected to be part of a government-to-government decision authority and to have significant involvement in the planning and use of marine resources (Hillier and Gueret 2007). To reduce conflict over resource use and access, four key objectives have been identified:

1. To promote ocean-management decisions based on shared understanding and appreciation of the ecological, cultural, and socio-economic characteristics of the PNCIMA.

2. Design an integrated decision-making framework for management across sectors.

3. Develop institutional arrangements that bring together governments, First Nations, user groups, and other interests, resource management, conservation, and economic development and enter into agreements on oceans management with specific responsibilities, powers, and obligations.

4. Contribute to social, cultural, and economic well-being for coastal communities and stakeholders (Hillier and Gueret 2007).

Resource-management plans that integrate both biological and anthropogenic factors offer the greatest hope for long-term survival of the PNCIMA's natural resources. Any IMP for this region would benefit by being grounded firmly in science, making use of the best available information.

1.4 POTENTIAL IMPACTS OF HUMAN ACTIVITY IN THE PNCIMA

Human activities have the potential to disrupt natural ecosystems through destruction, disturbance, and occupation. Ecological stress can result from single actions or from the cumulative effect of multiple actions. Stressors can also act in synergy. Ecosystem-based management may mitigate some factors by addressing ecological sensitivities. Human activities that contribute to the degradation of the PNCIMA environment include but are not limited to:

1) Terrestrial resource extraction (e.g., mining and logging) can lead to increased sedimentation of estuarine regions.
2) Marine resource extraction (e.g., mining, fishing, petrochemical exploration and acquisition) can lead to increased noise levels and the loss of habitat through the installation of physical structures and removal of biomass from the ecosystem.
3) Marine aquaculture (e.g., fish and invertebrates) can lead to habitat loss and degradation and contamination of surrounding waters, sea beds, and inter-tidal areas.

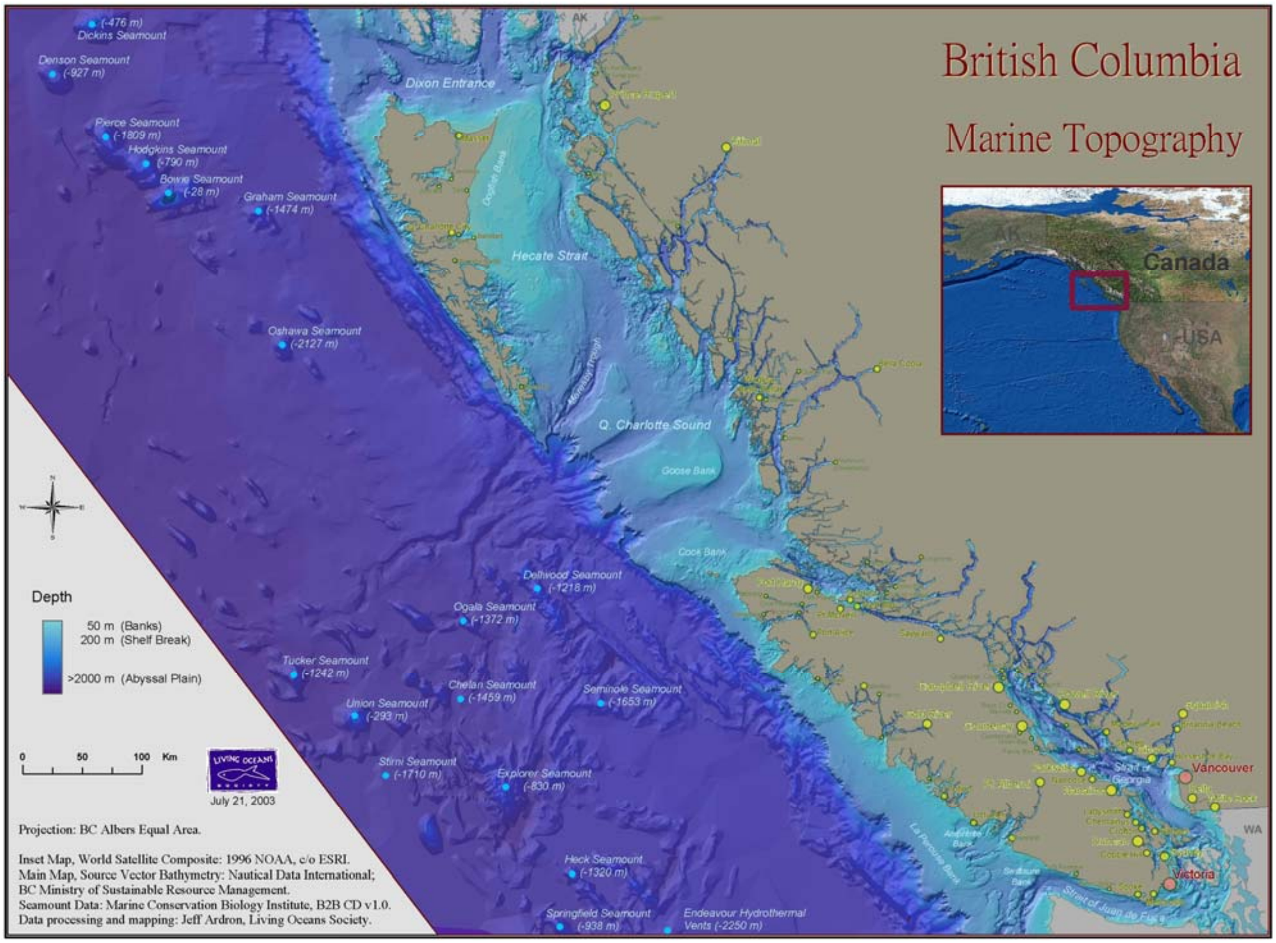
4) Transportation (e.g., cargo and passenger), communication (e.g., cable laying and installation of radio and cell-phone towers), and coastal development (e.g., marinas, ferry terminals, breakwaters, docks) can lead to physical displacement of wildlife and increased acoustic impact.
5) Recreation and ecotourism (e.g., power and sail boats, and kayaks) can lead to marine-animal disturbance through physical presence, seafloor-habitat disturbance by anchorage, and acoustic disturbance.
6) National defence (e.g., vessels, sonar, weapons firing and detonations) can disturb marine animals through physical presence and acoustic impact, as well as habitat disturbance.

Steps can be taken within ecosystem-based management models to mitigate potential problems of the day-to-day coastal activities, and to develop action plans to counteract unforeseen catastrophic events that may affect the incredible biodiversity and natural resources of the PNCIMA.

2.0 PNCIMA COASTAL AND MARINE ECOSYSTEMS

This coastal marine ecosystem is characterized by a broken shoreline of islands, deep fjords, and shallow banks and bays that provide habitats for an incredible diversity of species. The major landmasses of the Queen Charlotte Islands are Graham Island to the north and Moresby Island to the south. The major water bodies are Queen Charlotte Sound, Hecate Strait, and Dixon Entrance (Figure 2).

Figure 2. The British Columbia Coast



(Image from: www.livingoceans.org/maps/gen_topo_bc_3c.jpg)

2.1 PHYSICAL OCEANOGRAPHY

Oceanographically, the PNCIMA is considered to be a complicated region with offshore oceanic waters being modified by the estuarine processes of the coastal waters (Thompson 1981). Bathymetrically, the seafloor descends to greater than 2,000 metres westward of Graham and Moresby Islands.

To the north, Dixon Entrance, at the B.C. – Alaska border, has two east-west channels that extend to 400 metres on the seaward side (Thompson 1981). To the south, Queen Charlotte Sound has three submarine channels, also extending to 400 metres, which are oriented across the continental shelf in an east-west direction (Thompson 1981). Hecate Strait lies in a north-south orientation and is the shallowest of the three major channels, rising to about 50 metres at the northern end (Thompson 1981). A broad platform of glacial sands and gravels less than 100 metres deep lies east of Graham Island in Hecate Strait (Thompson 1981).

Provincially, the PNCIMA contains two management areas: the Continental Slope Ecoregion (west of Graham and Moresby islands, and Queen Charlotte Sound) and the Hecate Continental Shelf Ecoregion (south of Alaska Panhandle to north of Vancouver Island, containing much of the Queen Charlotte Islands) (MOE 2007).

The tidal pattern of the area is mixed, predominantly semidiurnal with a tidal range of 2.4 to 3.7 metres (Thompson 1981). Sea surface temperatures range from about three to 20°C, with the coldest waters found to the north (Thompson 1981). Inter-annual variation is driven by large-scale processes such as the Pacific Decadal Oscillation (Mantua et al. 1997) and the more recently recognized Victoria Mode (Bond et al. 2003, King 2005, DFO 2006b). Seasonal weather patterns are driven by the Aleutian Low (winter) and the North Pacific High (summer) pressure systems, similar to the rest of coastal B.C.

One of the major shifts anticipated with global climate change is an intensification of the Aleutian Low Pressure system (a semi-permanent North Pacific weather feature) during the winter months (DFO 2006b). The extent to which this and other expected alterations such as increased surface-water stratification and a decrease of hypoxic depths may affect the flora and fauna found within the PNCIMA remains unknown.

2.2 ECOLOGICALLY AND BIOLOGICALLY SIGNIFICANT AREAS (EBSAs)

Marine areas can be considered significant based on the life-history functions they serve in the ecosystem or because of the structural properties they posses (DFO 2004a). Ecologically and Biologically Significant Areas (EBSAs) are regions selected by DFO to be worthy of enhanced management or risk aversion through an evaluation process that involves the identification and ranking of biologically and physically Important Areas (IAs) for species or habitat features (Clarke and Jamieson 2006a).

Regional scientific experts were consulted for their opinions on where IAs existed within the PNCIMA for anadromous fish, bird, marine mammals, elasmobranches, groundfish, sponges, corals, kelp and eelgrass beds, pelagic fish, invertebrates (i.e., without a backbone), turtles, and oceanographic features (Clarke and Jamieson 2006a). Provincial eco-units and Parks Canada areas of interest were also included. Using a ranking system of low to high importance, and spatial analyses, EBSAs were identified (Clarke and Jamieson 2006a). Evaluation criteria included the uniqueness of the area (Uniqueness), spatial and temporal reliance on the area by species or groups of species (Aggregation), importance of the area to the fitness of a species or population (Fitness Consequences), resilience of the area for recovery from disruption (Resilience), and the degree to which the area can be considered pristine (Naturalness) (Clarke and Jamieson 2006a).

The analyses of Clarke and Jamieson (2006b) resulted in 45,182 square kilometres (44 per cent of the total area) of the PNCIMA being acknowledged as ecologically and biologically significant. The identified areas include:

- The Hecate Strait front,
- McIntyre Bay,
- Dogfish Bank,

- ◊ Learmouth Bank,
- ◊ Brooks Peninsula,
- ◊ Cape St. James,
- ◊ Continental Shelf break,
- ◊ Scott Islands,
- ◊ North Island Straits,
- ◊ Sponge reefs,
- ◊ Chatham Sound,
- ◊ Caamano Sound,
- ◊ River mouths and estuaries.

2.3 PNCIMA ECOSYSTEM CONCLUSIONS AND RECOMMENDATIONS

As dependence on and demand for coastal resources increases, the need for integrated ecosystem-based management will become progressively more critical for maintenance of a long-term balance between ecosystem health, conservation, and coastal community economic and cultural survival. An IMP that serves to reduce the risks to the abundance and diversity of life in the marine environments in PNCIMA is especially relevant to the PNCIMA residents, many of whom are intricately linked to the region's biodiversity.

3.0 MARINE BIODIVERSITY

The PNCIMA has diverse and unique ecosystems that stretch from the continental slope across the continental shelf to the shores of the northeast Pacific archipelago of northern British Columbia. Marine biodiversity within the PNCIMA ranges from the locally common to the cryptic and obscure. Some of the more familiar creatures include tide pool anemones, harbour seals, majestic bald eagles, and powerful killer whales. However, the PNCIMA is also home to many species that are less familiar. Some, such as the harbour porpoise, are found within the PNCIMA waters year-round yet are rarely seen by most coastal residents. Others such as the hexactinellid sponge reefs are completely unknown to most residents as they are almost completely inaccessible. It is hoped that the Biodiversity section of the report will serve to provide an informative overview of the PNCIMA's variety of life.

3.1 PLANKTON

Plankton are the tiny drifting plants (phytoplankton), animals (zooplankton), and bacteria (bacterioplankton) that exist in the sunlit regions of the ocean. Plankton form the foundation for the marine web of life. Though these species are often microscopic, they have preferred habitats and conditions that determine species abundance, composition, and distribution. Plankton are influenced by oceanographic conditions on both intra- and inter-annual scales, and if environmental conditions change, either due to natural processes or anthropogenic activities, repercussions can reverberate from the sea surface to the sea floor.

The enormous diversity of life found within the plankton is often not readily apparent to the casual observer; however, these life forms are critically important for life in marine and terrestrial ecosystems. The bacterioplankton are primarily decomposers that function to release organic matter from dead organisms back into the marine environment. As with most plants, the phytoplankton respond physiologically to the increasing light levels of the spring, when they proliferate. In response to this newly available food supply, the herbivorous zooplankton populations thrive. With the increased abundance of herbivorous zooplankton, the carnivorous zooplankton flourishes. The entire marine food web is subject to change based on the repercussions of the seasonal abundance fluctuations of phyto- and zooplankton.

Data indicate that the spring phytoplankton bloom occurs first in the northeast Hecate Strait in March, followed two months later by blooms in eastern Hecate Strait and Queen Charlotte Sound (Lucas et al. 2007). The continental shelf area of the PNCIMA is measurably but variably productive March through September (Lucas et al. 2007). Lucas et al. (2007) provide an overview of the oceanographic and atmospheric processes, which lend to this temporal and spatial variability.

There has been limited examination of the species-specific distribution of plankton within the PNCIMA waters; however, the euphausiid species (*Thysanoessa* spp. and *Euphausia pacifica*) and copepods (*Neocalanus* spp., *Pseudocalanus* spp., *Ointhona* spp., and *Acartia* spp.) often dominate in the spring (Beattie 2001, Ainsworth et al. 2002, Mackas et al. 2007). Many species, such as the copepod *Neocalanus plumchrus*, are considered to be "interzonal migrants" that exhibit seasonal bathymetric shifts to the shallow sunlit waters for the spring and summer months, then return to deep waters for the remainder of the year (Mackas et al. 1998).

Euphausiid concentrations are expected to be highest along the margins of the continental shelf and the deep-water regions of Queen Charlotte Sound (Fargo et al. 2007, Lucas et al. 2007). In Hecate Strait, these small shrimp-like creatures have been found to account for up to 90 per cent of the plankton biomass (Beattie 2001).

Higher trophic levels are dependent on the diversity and abundance of phyto- and zooplankton, and changes in species composition and abundance can have significant consequences throughout the marine food web and coastal economies. Overall, a single copepod species, *Neocalanus plumchrus*, makes up much of the zooplankton biomass in subarctic waters of the Pacific and is important in the diets of many fish, including juvenile salmon, as well as seabirds and marine mammals (Mackas et al. 1998). Commercially important fish species in the PNCIMA that prey upon on zooplankton include Pacific herring (*Clupea pallasi*), coho salmon (*Oncorhynchus kisutch*), sockeye salmon (*O. nerka*), and chum salmon (*O. keta*) (Freiwald et al. 2004, DFO 2006b, Jamieson et al. 2006).

Significant changes can have devastating economic impacts for communities that rely on the resources of the sea. A strong correlation has been determined on the West Coast of North America between annual average phytoplankton biomass and commercial catch of resident fish stocks (Ware and Thomson 2005). Though plankton are critically important to the coastal marine food web, no plankton species are currently recognized by the COSEWIC as at-risk species.

3.1.1 IMPORTANT AREAS

Oceanographically the PNCIMA contains features that serve to enhance marine productivity and recruitment. Key oceanographic zones or attributes were identified where phyto- and zooplankton aggregate, plankton and nutrient transporting eddies form, significant tidal mixing occurs, and invertebrate juvenile-phase rearing grounds are known. These oceanographic Important Areas were identified at Queen Charlotte Sound upper continental shelf and canyons/troughs, the tip of Cape St. James, Scott Islands, Dogfish Bank, McIntyre Bay, Learmouth Bank, Hecate Strait tidal front, Brooks Peninsula, Coastal waters of Prince Rupert, and the northwestern waters of Aristazabal Island (Clarke and Jamieson 2006a).

3.1.2 POTENTIAL THREATS TO PLANKTON

The threats to plankton include increased nutrient loading, chemical pollution, fine plastic debris (see Section 6.3.3), and possibly large-scale climate-change impacts. Ozone depletion may negatively affect plankton by increasing the ultraviolet radiation they are exposed to (UNEP 2008). Sea-surface temperature fluctuations and changes to the amount of deep-ocean nutrients that are brought to the surface waters through upwelling can affect plankton communities. These potential threats are difficult to quantify.

3.2 AQUATIC PLANTS

The term *aquatic plant* includes the microscopic phytoplankton presented in Section 3.1 and the larger species referred to as macroalgae and aquatic angiosperms. In British Columbia, more than 500 species of macroalgae have been recognized, making up about 4.5 per cent of the world's total marine algal species (Tunnicliffe 1993). Many macroalgae are well known to coastal residents as seaweed.

The macroalgal groups found within the PNCIMA include species of brown (Division Ochrophyta), green (Division Chlorophyta), and red algae (Division Rhodophyta). All three types of macroalgae are found within the intertidal and subtidal zones; however, different species have different preferred habitats, and the brown algae make up the bulk of the algal biomass (Bates 2008). The red algae are the most diverse group and stretch from the intertidal zone to the deepest parts of the sunlit waters (Bates 2008).

Common green algae include *Ulva* spp., also known as sea lettuce. Common brown algae include the kelps and rockweeds, also known as *Fucus* spp. Common red algae include *Chondracanthus exasperatus*, which is also known as "Turkish Towel" because small sheets of this bumpy algae are often found on beaches after a storm (Bates 2008).

Surfgrasses and eelgrass are also common in the PNCIMA. These are not macroalgae but rather marine angiosperms (flowering plants). Three species of surfgrasses have been recorded in the PNCIMA: *Phyllospadix scouleri*, *P. serrulatus*, and *P. torreyi* (Pojar and MacKinnon 1994). Eelgrasses prefer the more protected stretches of shoreline, whereas the surfgrasses flourish on exposed, surf-beaten shores with strong wave action (Pojar and MacKinnon 1994).

Of all the aquatic plants found within the PNCIMA, two functional groups stand out: The kelp forests and eelgrass beds.

Kelp forests and eelgrass beds serve considerable ecosystem functions as they provide important residence, foraging, breeding, and nursery habitats for many marine invertebrates, fishes, seabirds, and some mammals. These architecturally important systems also contribute to sediment stability, which is important for nutrient cycling (Fargo et al. 2007).

The kelp forests are composed mainly of four species in British Columbia: the giant kelp (*Macrocystis integripholia*), bull kelp (*Nereocystis luetkeana*), walking kelp (*Pterygophora californica*), and laminaria (*Laminaria setchellii*), whereas the eelgrass beds are composed mainly of one species (*Zostera marina*) (Fargo et al. 2007). Commercially important fish species, such as Pacific herring, are reproductively reliant on the presence of intertidal and subtidal plants, as this is where they spawn (deposit and fertilize eggs). Eelgrass and kelp beds have been identified as major habitats integral to the overall health of the marine ecosystem in British Columbia (CIT 2003).

3.2.1 IMPORTANT AREAS

An analysis of Important Areas for aquatic plants could not be conducted due to data gaps. However, with improved data coverage such an analysis may be possible in the future (Clarke and Jamieson 2006a).

3.2.2 POTENTIAL THREATS TO AQUATIC PLANTS

All aquatic plants are potentially threatened by various anthropogenic and biological activities including:

- ◊ Contamination from vessel discharge, oil spills, and run-off from land.
- ◊ Sedimentation.
- ◊ Over-harvesting.
- ◊ Physical removal.
- ◊ Marine herbivores (e.g., sea urchins).
- ◊ Estuarine development through habitat loss by shoreline alteration and constructions.
- ◊ Ships' wakes and propellers.
- ◊ Severe winter storms.
- ◊ Industrial log dumping and storage.
- ◊ Shading by coastal constructions such as docks and float homes.

No marine plants are listed by the Committee on the Status of Endangered Wildlife in Canada, nor are any designated under the Species at Risk Act (SARA).

3.3 BENTHOS

The benthic or sea-floor community is made up of a diverse array of largely invertebrate species that live hidden beneath the sea. Some of the most common members of the invertebrate benthos include sea stars, barnacles, clams, snails, urchins, chitons, sea cucumbers, crabs, and nudibranchs.

3.3.1 BENTHIC INVERTEBRATE COSEWIC STATUS

The COSEWIC has only two benthic invertebrates listed as a Species at Risk in Canada (Table 1). Both are recognized under the SARA; however, a recovery strategy exists for only the abalone (SARA 2008).

Table 1. Invertebrate Species at Risk

Species	COSEWIC Status	SARA Status	Population Trend	Threats
Northern abalone	Threatened	Threatened	Declining	Poaching, Population fragmentation, Sea otters
Olympia oyster	Special Concern	Special Concern	Stable	Aquaculture, Harvesting, Introduction of exotic species

3.3.2 POTENTIAL THREATS TO BENTHOS

The potential threats to benthic creatures include:

- ◊ Poaching and over-harvesting.
- ◊ Population fragmentation.
- ◊ Predation.
- ◊ Contamination.
- ◊ Competition from invasive species.
- ◊ Habitat degradation and loss.

3.4 REEF SYSTEMS

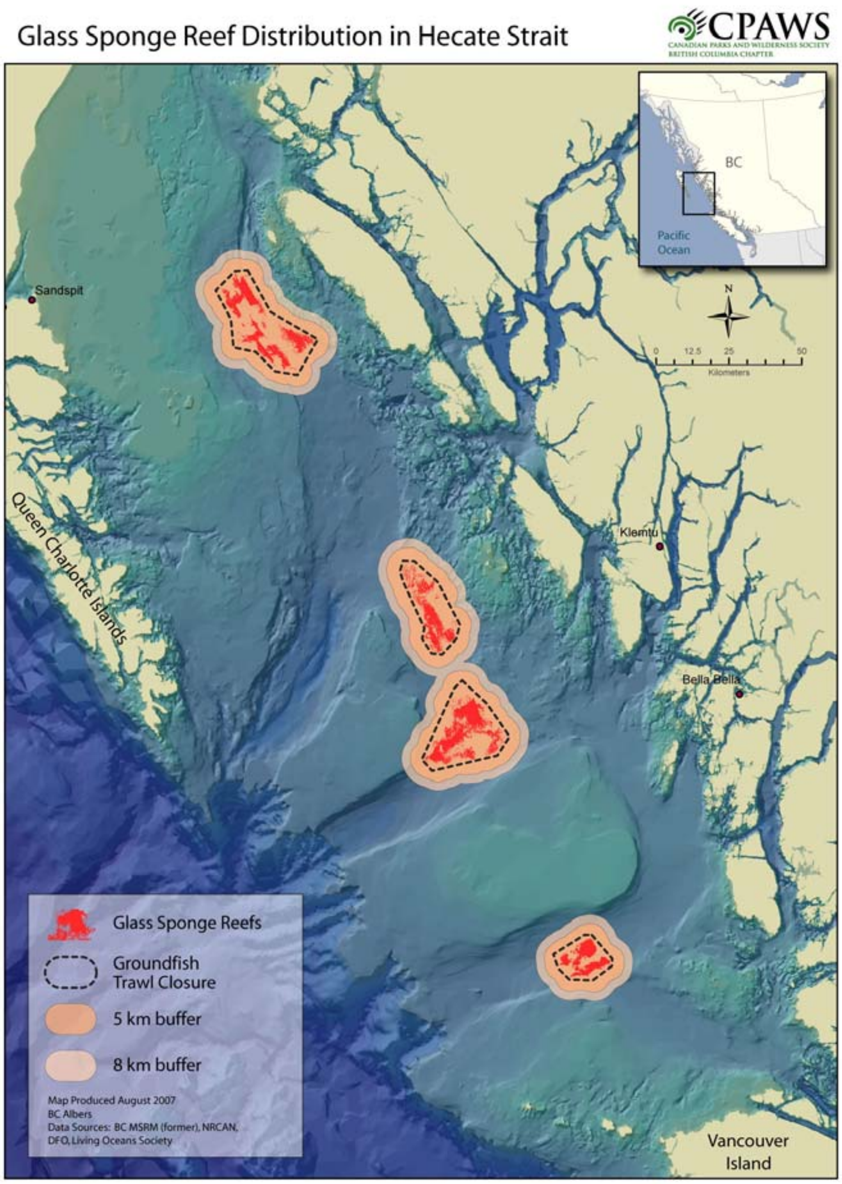
Biological reefs are solid structures usually composed of either calcium carbonate or silica that are built by colonies of marine organisms. These ecosystems have existed in the Earth's oceans for more than 400 million years (Stearn and Carroll 1989). Although the most familiar reefs today are the tropical corals, reef systems are found in both nearshore and the deep-sea environments, and are not limited to the warm low-latitude waters.

HEXACTINELLID SPONGE REEFS

British Columbia's marine environment contains some of the only siliceous sponge reefs in the world. These are known as hexactinellid or glass sponge reefs (Thompson 1981, Prescott-Allen 2005). Hexactinellid sponge reefs can be considered living fossils, as they were thought to be extinct until 1987, when they were discovered alive in northern British Columbia waters (Conway 1999). Further investigation revealed that these glass sponge reefs have existed since the end of the most recent period of glaciation (approximately 9,000 years ago) (Prescott-Allen 2005). Individual glass sponges live between 100 and 200 years (Prescott-Allen 2005).

The glass sponge reef systems of the PNCIMA are found in Hecate Strait and Queen Charlotte Sound (Figure 3) and collectively cover an estimated 1,000 square kilometres (Fargo et al. 2007). These expansive systems can extend 18 metres in height from the sea floor, and cover up to 227 square kilometres (Prescott-Allen 2005). Essentially, the glass sponge reefs are composed of three species: *Chonelasma calyx*, *Aphrocallistes vastus*, and *Farrea occa* (Fargo et al. 2007), which in turn provide habitat for a variety of species including rockfish, spider and king crabs, shrimps, prawns, euphausiids, annelid worms, bryozoans, bivalves, gastropods, sea stars, and urchins (LOS 2007b).

Figure 3. Glass Sponge Reef Distribution in Hecate Strait and Queen Charlotte Sound



(Courtesy of the Canadian Parks and Wilderness Society.)

COLD-WATER CORALS

Cold-water corals are found around the world. British Columbia has a diverse range, with at least 61 recognized species (Jamieson et al. 2006). Corals belong to the same taxonomic group as jellyfish and sea anemones, known as Cnidaria. These ancient invertebrate animals have been recorded from the world's ocean fossils dating back over 600 million years (Stearn and Carroll 1989). Today there are many different forms of coral, some externally hard (e.g., Gorgonian coral), others soft (e.g., sea whips). Jamieson et al. (2006) provide a comprehensive overview of taxonomy and zoogeography of the cold-water corals in the explored areas of the B.C. coast. A brief description of some of the different types of coral found in B.C. waters is presented in the following sections.

Gorgonian corals

The deep-sea Gorgonian corals are composed of a calcareous skeleton and grow in clusters or groves, thus resembling a forest. These Gorgonian forests are a critically important component of the marine ecosystem as they provide habitats for deep-sea fish and invertebrates. In Alaska, rockfish (*Sebastes* spp.), Atka mackerel (*Pleurogrammus monopterygius*), shortspine thornyhead (*Sebastolobus alascanus*), juvenile Pacific halibut (*Hippoglossus stenolepis*), rock sole (*Lepidopsetta spp*), juvenile red king crab (*Paralithodes camtschaticus*), and shrimp species use these forests for foraging, nursery areas, and refugia from predators. The exact species composition of the deep-sea coral reefs of the PNCIMA remains uncertain.

Stony corals

Stony corals are the most familiar type of coral, as they can be found in shallow waters and deep-water habitats. These colonial animals have a hard skeleton made of calcium carbonate that can result in the formation of expansive reef systems.

Sea pens

Sea pens are known as soft corals because the calcium carbonate forms an interior stalk to which the soft polyps adhere. As with other corals, sea pens are made up of colonial polyps. These feathery-looking animals are so named because they resemble an antique quill pen.

Corals provide a three-dimensional structure to the sea floor, which provides feeding, residence, refugia, and nursery habitats to a variety of different marine species.

3.4.1 IMPORTANT AREAS

The following areas within the PNCIMA have been identified as having high coral and sponge bycatch: Learmouth Bank (Gorgonian Corals), Mid-Moreseby Trough (Gorgonian and Stony Corals), South Moreseby Gully (Gorgonian Corals and Sea Pens), and Bell Passage (Sea Pens) (Ardron and Jamieson 2006). These, in addition to Hecate Strait and Queen Charlotte Sound, were identified by Clarke and Jamieson (2006a) as Important Areas for glass sponge and coral reef systems.

3.4.2 POTENTIAL THREATS TO SPONGES AND CORALS

The PNCIMA glass sponge reefs have existed for millennia, but now in some regions they are threatened by commercial bottom-trawling fishing gear. Researchers estimate that approximately 295 tonnes of cold-water corals and sponges were taken as incidental catch in B.C. waters in the groundfish trawl fishery (1996 – 2002) (DFO 2006a). Unfortunately, this figure may be an underestimate of the total damage as it is likely that not all the fragmented pieces made it to the decks of fishing vessels, and that some remained unaccounted for on the sea bottom.

Furthermore, bottom trawling can impair sponge reef growth rates by increasing the benthic water turbidity, requiring increased energy expenditure by the sponges to clear the resulting sedimentation. This reallocation of energy is expected to slow reproductive rates (Henry and Hart 2005), such that regions with higher levels of disturbance are expected to have lower regeneration rates. Recovery is estimated to take between 50 and 200 years (Conway 1999, DFO 2006a), as the rate of recovery for damaged hexactinellid sponges reefs may be as little as zero to seven centimetres per year (LOS 2007b).

Physical destruction is considered to be the greatest threat to the survival of these cold-water reef ecosystems (Conway 1999, Jamieson and Chew 2002, Ardron and Jamieson 2006). In 2002, Fisheries and Oceans Canada imposed closures to bottom trawling in some regions of the PNCIMA to protect the rare glass sponge reefs. Though the closure boundaries were readjusted in 2006, concern still exists that the buffer zones around the reefs may need to be extended (Jamieson et al. 2006).

Industries that have the potential to damage the cold-water coral reefs of B.C. include commercial fishing with bottom trawls, traps, and long lines; cable or pipe laying; oil and gas exploration and extraction; research; and any industry that involves the dumping of materials (Freiwald et al. 2004, Jamieson et al. 2006). However, it is important to note that levels of actual damage are highly variable depending on the activity, proximity to the sponge or reef ecosystem, and implemented mitigative actions.

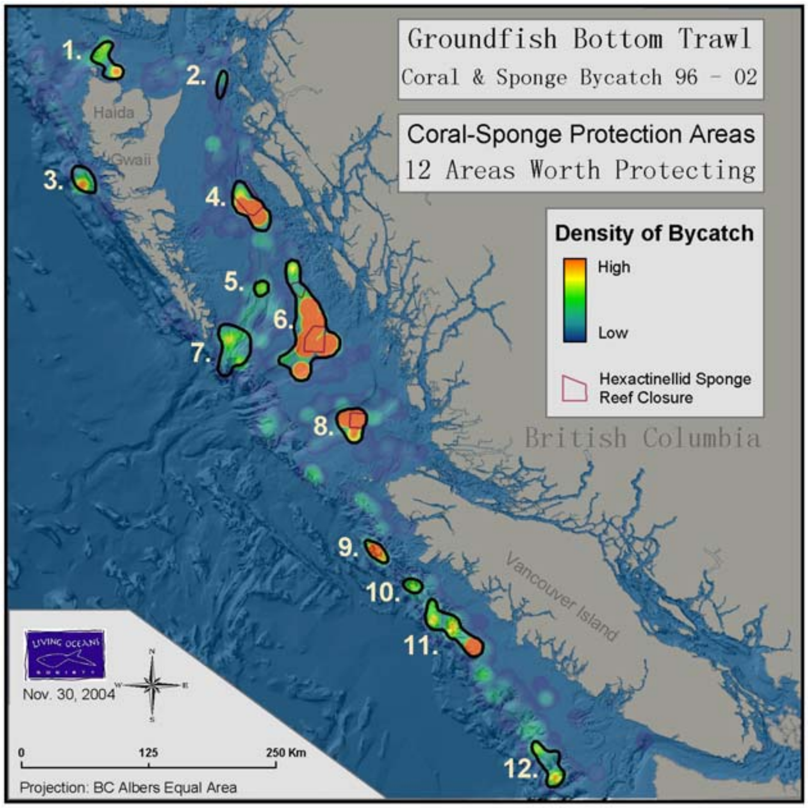
3.4.2.1 PROTECTIVE MEASURES

Australia, the European Union, New Zealand, Norway, Iceland, Scotland, and the USA have all enacted closures to protect corals and sponges in their national waters (DFO 2006a). Enacting a biologically and ecologically useful closure requires detailed knowledge of species distribution, diversity, and abundance. Furthermore, it requires participation and commitment from all sectors.

On Canada's East Coast, fisheries closures and marine protected areas have been enacted to protect corals. Though some areas have been closed to trawling, no legislated protection for coral species or coral habitats exists in British Columbia (Jamieson et al. 2006). An experimental groundfish trawl closure for the protection of thornyheads extends to 182 metres, which may inadvertently protect some corals (Jamieson et al. 2006). However, this closure only pertains to a small area of the continental slope.

However, the proposed Gwaii Haanas National Marine Conservation Area (NMCA), which would encompass approximately 3,400 square kilometres, would likely include some deep-water regions potentially up to 1,000 metres (Jamieson et al. 2006), and thus may have some protective function if prohibitions or limitations on damaging activities are implemented. It should be noted that the human activities to be permitted within an NMCA (e.g., Gwaii Haanas) are not yet identified. The Living Oceans Society has prepared a map detailing suggested trawl closures to protect the deep-sea corals and sponges of the PNCIMA (Figure 4).

Figure 4. LOS-Suggested Bottom Trawl Closures



A Diversity of Corals & Sponges...

1. **Learmonth Bank** (Gorgonian Corals)
2. **Bell Passage** (Sea Pens)
3. **Kindakun** (Sponges)
4. **McHarg Bank** (Sponges, Hex. Reef)
5. **Mid-Moresby Trough** (Gorgonian, Stony Corals)
6. **Mitchell's Trough** (Stony Corals, Soft Corals, Calcareous Corals, Sponges, Glass Sponges, 2 Hex. Reefs)
7. **S. Moresby Gully** (Gorgonian Corals, Sea Pens)
8. **Goose Trough** (Sponges, Hex. Reef)
9. **Kwakiutl Canyon** (Sponges, Sea Pens)
10. **Crowther Canyon** (Gorgonian Corals, Sponges, Sea Pens)
11. **Esperanza Canyon** (Sponges, Glass Sponges, Calcareous Corals)
12. **Barkley Canyon** (Sponges, Glass Sponges)

Trawl Data: DFO Observer, 1996-2002. Closure Data: DFO Groundfish Trawl Management Plan, 2003 / 2004.
Mapping and Analysis: J. Ardron, Living Oceans Society. Density Analysis: 10 Km Kernel (decay).

Much remains to be discovered about the glass sponge and cold-water coral communities of the PNCIMA, and the unique biodiversity of these potentially rare ecosystems should not be discounted. Comprehensive ecosystem-based management should acknowledge both the inherent biological value as well as data gaps while operating under a precautionary framework to ensure these systems are not destroyed or lost before they are scientifically described and understood.

3.5 MARINE FISH

The marine fish of the PNCIMA are diverse. This region is critically important for hundreds of species that range from the locally abundant to the exceptionally rare. The diversity of species and the range of occupied niches reflect the importance of this area. Some have significant contemporary economic value, others were valued historically and subsequently over-harvested, some were historically demonized and eradication programs enacted, while others have quietly escaped the detrimental effects of humans – so far.

The inshore, continental shelf, and slope habitats are occupied by numerous bony and cartilaginous fish whose habitats range from the sea floor to the rocky reef crevices to the sunlit surface waters. Pelagic fish inhabit the water column, with some having a seasonal habitat shift to the intertidal regions for reproduction and/or predator avoidance. Pelagic fish include herring, sand lance (*Ammodytes hexapterus*), surfperch, smelts, and deep sea smelts. Of these, the herring are considered the most ecologically important (Schweigert et al. 2007).

Long-lived rockfish also make use of inshore regions, as well as the continental shelf and the slope. Roundfish and flatfish occupy niches that often include areas with muddy or sandy sea floors, including some commercially important species such as Pacific cod, halibut, and sole (Lucas et al. 2007). PNCIMA is home to all six salmon species that seasonally occupy habitats from the open ocean to the coastal estuaries and rivers. There is also an array of cartilaginous fishes, skates, and rays, including the deep-water bluntnose sixgill shark (*Hexanchus griseus*), the sandpaper skate (*Bathyraja interrupta*), and the Pacific electric ray (Torpedo californica). The latter has a diverse niche occupying habitats that include sandy bottoms, rocky reefs, and kelp forests (MBA 2008). A discussion of some of the commercially important fish species is presented in Section 4.0.

3.5.1 IMPORTANT AREAS

The waters from Johnstone to Queen Charlotte straits, including the Broughton Archipelago, have been identified as Important Areas for sockeye, steelhead, and coho, as have all salmon rivers in the PNCIMA (Clarke and Jamieson 2006a). The area west of Brooks Peninsula was identified as an IA for green sturgeon and sablefish, while areas within Hecate Strait and Dixon Entrance were identified as IAs for eulachon (*Thaleichthys pacificus*), Pacific cod, walleye pollock, lingcod, sablefish, halibut, sole, flounder, rockfish, Pacific hake, and Pacific herring (Clarke and Jamieson 2006a). Areas on the west coast of the Queen Charlotte Islands were identified as IAs for halibut, sole, flounder, rockfish, and Pacific hake (Clarke and Jamieson 2006a). Marine fish IAs include both open-water areas as well as coastal and fjord regions. Though considerable variability exists in the size, rank, and locations of each species-identified Important Area, many have overlapping borders; therefore, considerable conservation benefits may be achieved through comprehensive and strategic protective measures. It should be noted that there are many marine fish species for which Important Areas are completely unknown. However, protective measures for the PNCIMA marine fish species at risk may inadvertently offer a conservation advantage to those that can currently be considered data-deficient.

3.5.2 MARINE FISH SPECIES AT RISK

The number of marine fish species within the PNCIMA whose distribution, abundance, and life history are affected by human activities is greater than the number that has been assessed by the COSEWIC. However, as is often the case, data are more available for those with economic value, or those that are socially favourable. Those species identified by the COSEWIC as having a conservation risk are summarized in Table 2.

Table 2. Marine Fish Species at Risk

Species	COSEWIC Status	SARA Status	Population Trend	Threats
Coho salmon -Interior Fraser	Endangered (May 2002)	No Status - Denied	Decreasing	Habitat deterioration/loss, Overexploitation, Poor survivorship
Sockeye salmon - Cultus	Endangered (May 2003)	No Status - Denied	Decreasing	Habitat deterioration/loss, Overexploitation, Incidental mortality, Poor survivorship

Species	COSEWIC Status	SARA Status	Population Trend	Threats
Sockeye salmon - Sakinaw	Endangered (April 2006)	No Status - Denied	Decreasing	Habitat deterioration/loss, Overexploitation, Incidental mortality, Poor survivorship
Basking shark	Endangered (April 2007)	No Status	Decreasing	Historic exploitation and eradication program, Incidental mortality, Low fecundity, Vessel collision
Bocaccio	Threatened (November 2002)	No Status – Returned to COSEWIC	Decreasing	Exploitation, Low fecundity
Chinook salmon -Okanagan	Threatened (April 2006)	No Status	Decreasing	Habitat loss, Historic exploitation, Introduced species predation and competition
Canary rockfish	Threatened (November 2007)	No Status	Uncertain	Overexploitation, Low fecundity
Rougheye rockfish type I	Special Concern (April 2007)	No Status	Unknown	Increasing mortality, Species identification complicated by sympatric species, Exploitation
Rougheye rockfish type II	Special Concern (April 2007)	No Status	Unknown	Increasing mortality, Species identification complicated by sympatric species, Exploitation
Longspine thornyhead	Special Concern (April 2007)	No Status	Decreasing	Exploitation
Bluntnose sixgill shark	Special Concern (April 2007)	No Status	Unknown	Exploitation, Incidental mortality
Tope (soupfin shark)	Special Concern (April 2007)	No Status	Unknown	Low fecundity, Historic exploitation, Incidental mortality

An alarming trend illustrated in Table 2 is the lack of federal SARA status for all of the species recognized by the expert panel COSEWIC. However, perhaps the most shocking aspect of the data in Table 2 is that three of the endangered marine fish have been reviewed by the federal government and been denied a listing.

The Interior Fraser River coho salmon were denied a federal endangered status as “The GIC [Governor in Council], on the recommendation of the Minister of Environment, on the advice of the Minister of Fisheries and Oceans, is not listing Coho Salmon (Interior Fraser Population) based on uncertainties associated with changes in the marine environment and potential future socio-economic impacts on users associated with the uncertainty. Not listing provides future management flexibility related to uncertainty about marine survival and possible difficulties in recovery if marine survival worsens” (Canada 2006).

With regard to the Cultus and Sakinaw sockeye salmon populations, the Canada Gazette states “the COSEWIC assessments for the Cultus and Sakinaw populations make it clear that those populations are at very low levels and are at risk of biological extinction, adding them to the List as ‘endangered’ would lead to severe consequences for the south coast British Columbia (BC) sockeye salmon fishing sector and for the coastal communities, including first nations, who depend on salmon fishing” (Canada 2005).

On review of the Species at Risk Public Registry (SARA 2008), the remainder of the species listed in Table 2 are still awaiting a decision as to whether they will be listed under the Species at Risk Act, with the exception of bocaccio, which was reviewed and returned to COSEWIC. Announcements of the Response to the COSEWIC listing date from:

- ◊ November 29, 2006 (Chinook Salmon – Okanagan).
- ◊ December 4, 2007 (Basking Shark, Rougheye Rockfish Type I & II, Longspine Thornyhead, Bluntnose Sixgill Shark, and Tope) (SARA 2008).

Consultation documents were found for:

- ◊ Chinook salmon – Okanagan - Submission date by 28 February 2007.

Accordingly, there are no recovery strategies for any of these marine fish.

The COSEWIC is considered to be the expert scientific body in Canada, and these marine fish are facing immediate conservation risks, yet the Government of Canada denies them protection under our Species at Risk Act. These decisions may directly contribute to the extinction of species.

3.5.3 POTENTIAL THREATS TO MARINE FISH

One of the most significant threats to marine fish is exploitation, whether historical, present, or future. Harvest practices can greatly influence the age structure, overall biomass, and reproductive potential of fish populations. Coupled with this is the threat that exists from fisheries to non-target species, which are incidentally caught and often discarded. Some threats to marine fish survival, such as low reproductive rates, are natural; however, the effect on populations is exaggerated when coupled with harvest practices or ocean climate fluctuations that can further reduce the reproductive potential. Loss or damage to reproductively important habitats can be a significant threat. This is especially relevant for species with an inshore or coastal-waters life-history component, where the influence of human activity is often greatest. Lastly, of potential threat to marine fish is the approach to conservation taken by the federal government for the coho and sockeye salmon populations (Table 2) presented in the last section.

3.6 SEABIRDS

Sites within the PNCIMA are regionally and internationally important for seabird foraging, nesting, breeding, migrating, and staging, and encompasses several important colonies (Scott Islands, Queen Charlotte Islands, northern mainland B.C.). Marine birds can be used as indicators species for the state of the ocean as their breeding and foraging is often wholly dependent upon the presence, abundance, and seasonal availability of specific zooplankton species (see Section 3.6.3).

The reliability of undisturbed seabird nesting grounds with productive foraging areas is critical for population survival. The Canadian Wildlife Service recognizes the importance of seabird habitat within the PNCIMA and as such maintains long-term monitoring programs on the Queen Charlotte Islands and on Triangle Island.

3.6.1 IMPORTANT AREAS

Scientists estimate that more than five million seabirds use the B.C. coast as breeding habitat (Rodway 1991), including Cassin's auklet (*Ptychoramphus aleuticus*), storm-petrels (*Oceanodroma furcata* and *O. leucorhoa*), rhinoceros auklet (*Cerorhinca monocerata*), and ancient murrelets (*Synthliboramphus antiquus*) (Gaston 2008).

Important Areas for seabirds within the PNCIMA region have been determined at 16 localities, including the Scott Islands, which have been determined to be the most important breeding grounds for seabirds in the province of British Columbia (Clarke and Jamieson 2006a). These islands provide habitat for Cassin's auklet, rhinoceros auklet, tufted puffin (*Fratercula cirrhata*), common murre (*Uria aalge*), Brandt's cormorant (*Phalacrocorax penicillatus*), pelagic cormorant (*Phalacrocorax pelagicus)*, pigeon guillemot (*Cepphus columba*, glaucous-winged gull (*Larus glaucenscens*), Leach's storm-petrel (*Oceanodroma leucorhoa*) and fork-tailed storm-petrel (*Oeanodroma furcata*), black-footed albatross (*Phoebastria nigripes*), northern fulmar (*Fulmarus glacialis*), sooty shearwater (*Puffinus griseus*), and herring and Thayer's gulls (*Larus argentatus* and *L thayeri*). A more detailed discussion of the importance of the Scott Islands is presented in Section 7.4.1.

Important Areas were also designated at the Storm Islands, Reid Islets, Tree Islets, Pine Island, and the Buckle Group, as they are considered the most important breeding colonies in B.C. for storm-petrels and rhinoceros auklet (Rodway and Lemon 1991) and host significant proportions of fork-tailed storm-petrels and Leach's storm-petrels (Clarke and Jamieson 2006a).

Two banks were identified as IAs. Dogfish Bank was identified as an IA for sheerwaters, phalaropes, herring gulls, and ancient murrelets, while Learmouth Bank was noted for its high concentrations of alcids and other marine birds (Clarke and Jamieson 2006a).

Other identified Important Areas include McIntyre Bay for its high concentrations of seabirds, geese, and ducks; the head of the Nass River and the Prince Rupert area for black- and white-winged scoters; the area around Brooks Peninsula as phalaropes, common murre, tufted puffin, sooty shearwater, glaucous-winged gull, rhinoceros auklet and black-legged kittiwake (*Rissa tridactyla*) use the area for foraging and migrating; the Goose Island Bank as black-footed albatross, northern fulmar, sooty shearwater, Leach's and fork-tailed storm-petrels, Cassin's and rhinoceros auklets, and herring and Thayer's gulls use this productive area for feeding; and a number of islands and bays (Langara Island, Frederick Island, Hippa Island, Englefield Bay, Anthony Island, and Marble Island) on the east coast of the Queen Charlotte Islands as they support large seabird breeding colonies (Clarke and Jamieson 2006a).

3.6.2 SEABIRD SPECIES AT RISK

Several of the PNCIMA seabirds deserve special attention due to their precarious conservation status. Five seabird species have been recognized by the COSEWIC as being at risk: Three are threatened, and two are special concern (Table 3).

Table 3. Seabird Species at Risk

Species	COSEWIC Status	SARA Status	Population Trend	Threats
Marbled murrelet	Threatened (November 2000)	Threatened	Uncertain	Habitat loss due to logging, Incidental mortality, Pollution, Low reproductive rate
Pink-footed shearwater	Threatened (May 2004)	Threatened	Decreasing	Incidental mortality, Pollution
Short-tailed albatross	Threatened (November 2003)	Threatened	Increasing	Incidental mortality, Pollution
Ancient murrelet	Special Concern (November 2004)	Special Concern	Decreasing	Increased mortality from introduced predators (e.g., rats, raccoons), Human disturbance, Pollution
Black-footed albatross	Special Concern (April 2007)	No Status	Uncertain	Incidental mortality, Ingestion of plastics, Pollution

Unlike the marine fish, nearly all of the seabirds listed by the COSEWIC have been recognized by the federal government and are protected by the Species at Risk Act, with the exception of the black-footed albatross. According to the Species at Risk Public Registry, the Minister of the Environment was to have forwarded the COSEWIC report to the Governor in Council within three months of December 4, 2007 (SARA 2008). The government is still consulting as to whether to list this albatross under the SARA.

All of the species in Table 3, except the ancient murrelet, have a Recovery Team with a Recovery Strategy either completed or in draft (SARA 2008).

3.6.3 SEABIRDS AS INDICATORS

Seabirds have the distinct disadvantage of being susceptible to environmental fluctuations both on land and at sea. Whether the environmental change is human or naturally induced, the effects can be catastrophic.

The seabirds at Triangle Island have had variable breeding success with fluctuating environmental conditions. In 2005, the breeding success of all species of seabirds was poor (Hipfner 2005). As an example, only eight per cent of the Cassin's auklets pairs that laid an egg fledged a chick, and these fledglings were severely underweight (Hipfner 2005). The poor recruitment and condition of young was linked to diets low in the putative preferred food, which was linked to unfavourably warm sea conditions (Hipfner 2005). Furthermore, warm sea-surface temperatures and tufted puffin breeding success have been linked both inter- and intra-annually, indicating these seabirds are highly vulnerable to climate change (Gjerdrum et al. 2003). Survival rates of rhinoceros auklet indicate a similar link to large-scale oceanographic processes

Cassin's auklets, tufted puffins, and rhinoceros auklet populations may serve as barometers of environmental change in the PNCIMA (Bertram et al. 2000, Hedd et al. 2002, Bertram et al. 2005).

3.6.4 POTENTIAL THREATS TO SEABIRDS

Oil spills threaten all birds. If a bird encounters an oil spill, the oil can interfere with the insulating and buoyancy properties of the birds' feathers. This can result in hypothermia and/or a compromised ability to dive and capture prey. Ingesting the oil or breathing its vapours can poison seabirds, the consequences of which range from short-term illness to death. Seabirds can suffer and die if they are not treated by humans.

However, there are other more insidious threats. Human activities that pose a potential risk to the survival of the PNCIMA seabirds include:

- ◊ Vessel traffic and discharge of oily waste or petrochemical spills,

- ◊ Oil and gas exploration or extraction through spills, leaks, and physical and acoustic disturbance,
- ◊ Chemical pollution including endocrine (hormone) disrupting persistent organic pollutants, heavy metals that can alter physiological processes and behaviour, and poisoning or obstruction by ingestion of plastic materials (see Section 6.3),
- ◊ Increased mortality due to introduced species on colonies – especially important for ground-nesting birds,
- ◊ Competition with commercial fisheries and loss of available prey,
- ◊ Incidental mortality by entanglement in commercial fishing gear,
- ◊ Marine tourism and recreation that can lead to disruption or destruction of breeding/nesting habitats.

Some actions have already been taken to mitigate some potential threats. An example of this comes from the commercial vessels operating in the Pacific groundfish fishery, which must use mandatory seabird-avoidance measures and devices to avoid the incidental mortality of seabirds (DFO 2007g).

3.7 PNCIMA MARINE MAMMALS

The north Pacific coast of British Columbia has provided seasonal and year-round habitats for dozens of marine mammal species for millennia. The PNCIMA marine mammals can be divided into two groups: partially aquatic and fully aquatic. The partially aquatic mammals include the seals, sea lions, and otters, whereas the fully aquatic marine mammals include the whales, dolphins, and porpoises.

Many of PNCIMA's marine mammals have suffered tremendous population losses due to historical human economic interests and social attitudes. Fortunately, dramatic changes have occurred over the past half-century. Commercial whaling and sealing in the PNCIMA have ceased, and some populations are beginning to recover. There are no longer federally paid bounties on "nuisance" species, and the public is generally supportive of marine-mammal conservation.

Protection of marine mammals under the Fisheries Act (see Section7.5) has resulted in the recovery of some species. Harbour seals (*Phoca vitulina*), which were once killed in B.C. for a federal bounty, appear to have recovered and are now a familiar sight on the B.C. coast. However, for others the federal protection may not have come in time. The North Pacific right whale (*Eubalaena japonica*) was hunted to near extinction by the 1920s (Goddard 1997) and remains one of Canada's most endangered mammals. Today social attitudes are more conservationist in nature; however, the marine mammals of the PNCIMA still face many threats to their survival even though the bounties and harpoons have been laid to rest.

3.7.1 MARINE MAMMAL IMPORTANT AREAS

Identification of IAs for cetaceans is complicated by a deficiency of data with regard to knowledge of calving grounds and social understanding for many species. For historically commercially important species, habitat-use knowledge often stems from whaling statistics or sightings networks for which the effort remains unknown. Our understanding of habitat use for pinnipeds is often related to haul-out sites. This only accounts for a portion of the life cycle and does not include foraging sites. Further contributing to the difficulty of identifying Important Areas are the expansive annual ranges of some marine mammals. However, Clarke and Jamieson (2006a) were able to identify some IAs for some cetaceans (e.g., whales, dolphins, and porpoises), pinnipeds (e.g., seals and sea lions), and sea otters. However, IAs were not identified for harbour porpoise (*Phocoena phocoena*), Dall's porpoise (*Phocoenoides dalli*), transient killer whales (*Orcinus orca*), offshore killer whales, Pacific white-sided dolphins (*Lagenorhynchus obliquidens*), or harbour seals.

CETACEANS

Coastal mainland areas from Johnstone Strait to the Alaska border, as well as the northern waters of the Queen Charlotte Islands, were identified as IAs for resident killer whales, whereas the PNCIMA western margin at the continental shelf break was identified for sperm whales (*Physeter macrocephalus*) (Clarke and Jamieson 2006a).

Important Areas for humpback whales (*Megaptera novaeangliae*) were identified from Port Hardy to Bella Coola and Sandspit, as well as in the Prince Rupert area and the northern waters of the Queen Charlotte Islands (Clarke and Jamieson 2006a).

The IAs for grey whales overlapped with those identified for sperm whales and humpback whales, with Skidegate Inlet being highlighted as an IA for grey whales due to observed feeding aggregations. Cape Caution at the northern end of Vancouver Island was identified as an IA for resident grey whales.

Blue and sei whales (*Balaenoptera musculus* and *B. borealis*) are still quite rare in the post-whaling PNCIMA. However, IAs were identified at the shelf break and offshore and extended along the western and northern most boundaries of the PNCIMA (Clarke and Jamieson 2006a). The same was found for fin whales (*Balaenoptera physalus*), though a more coastal component was included around the southern end of the Queen Charlotte Islands to the Estevan Group area (Clarke and Jamieson 2006a).

PINNIPEDS AND OTTERS

Though the population of Steller sea lions (*Eumetopias jubatus*) is increasing, only three breeding sites exist in B.C.: the Scott Islands (off the northwestern tip of Vancouver Island), Cape St. James (southern Queen Charlotte Islands), and offshore from the Banks Islands (in the northern portion of the continental coast) (DFO 2007j). These three rookeries, with 20-kilometre radial zones, were identified as Important Areas (Clarke and Jamieson 2006a). Additionally, 16 haul-out sites within the PNCIMA were also classed as IAs (Clarke and Jamieson 2006a). Steller sea lion IAs are found in almost all coastal regions of the PNCIMA.

Two northern fur seal (*Callorhinus ursinus*) feeding areas are in Hecate Strait and Queen Charlotte Sound. Both were identified as IAs (Clarke and Jamieson 2006a). Two IAs were also identified for sea otters (*Enhydra lutris*). One extends coastally from Nigei Island to the southwestern PNCIMA boundary along the coast of northern Vancouver Island, while the other is in the vicinity of Bella Bella (Clarke and Jamieson 2006a).

3.7.2 MARINE MAMMAL SPECIES AT RISK

Of the 13 marine mammals listed by COSEWIC, 62 per cent (8/13) are endangered or threatened. The consultation period for the only PNCIMA marine mammal with a COSEWIC status but without a SARA status (northern fur seal) closed in February 2007.

Table 4. Marine Mammals Species at Risk

Species	COSEWIC Status	SARA Status	Population Trend	Potential Threats
North Pacific right whale	Endangered (November 2004)	Endangered	Unknown	Extremely low population size, Entanglement in fishing gear
Blue whale	Endangered (May 2002)	Endangered	Unknown	Low population size, Entanglement in fishing gear
Sei whale	Endangered (May 2003)	Endangered	Unknown	Low population size
Humpback whale	Threatened (May 2003)	Threatened	Increasing	Entanglement in fishing gear
Fin whale	Threatened (May 2005)	Threatened	Increasing	Low population size, Entanglement in fishing gear, Ship strikes.
Northern fur seals	Threatened (April 2006)	No Status	Decreasing	Entanglement in fishing nets and marine debris, Disturbance, Pollution, Oil spill, and Environmental changes
Northern resident killer whale	Threatened (November 2001)	Threatened	Increasing	Prey availability, Low rate of increase, Vessel disturbance, Pollution, Oil spill
Transient killer whale	Threatened (November 2001)	Threatened	Uncertain	Low population size, Low rate of increase, Pollution, Vessel disturbance, Oil spill
Grey whale	Special Concern (May 2004)	Special Concern	Decreasing	Entanglement in fishing gear, Collisions with boats, Habitat loss
Harbour porpoise	Special Concern (November 2003)	Special Concern	Unknown	Incidental mortality in fishing gear, Pollution, Habitat loss, Oil spill
Offshore killer whale	Special Concern (November 2001)	Special Concern	Uncertain	Low population size, Low rate of increase, Pollution, Vessel disturbance
Steller sea lion	Special Concern (November 2003)	Special Concern	Increasing	Disturbance, Oil Spills, Large-scale environmental fluctuations
Sea otter	Special Concern (April 2007)	Threatened	Increasing	Food limitation, Hunting, Conflicts with fisheries, Incidental mortality in fishing nets, Pollution, Oil spill

The public comment period for the northern fur seal closed on February 28, 2007 (SARA 2008), yet there is still no SARA status for this species.

3.8 PNCIMA REPTILES

Though much remains to be discovered about the natural history of leatherback sea turtles (*Dermochelys coriacea*) in British Columbia, sightings have been reported from throughout the PNCIMA where the animals are likely feeding on cold-water jellyfish. Fisheries and Oceans Canada considers the shelf and slope areas of the PNCIMA to contain leatherback sea turtle foraging habitats (Fargo et al. 2007). A large IA within the PNCIMA was suggested for this species based on sightings along the western boundary of the PNCIMA including the southeastern coastal portion of the Moresby Island. Significant knowledge gaps were acknowledged, indicating other IAs may exist (Clarke and Jamieson 2006a). Both the COSEWIC and the SARA have this species classified as endangered.

3.9 POTENTIAL THREATS TO MARINE MAMMALS AND REPTILES

A single summary of potential threats is provided for PNCIMA marine mammals and reptiles, as they face comparable threats due to the similarities in their pelagic existence. For some, the human damage began over a century ago, and today a low population size may be one of the greatest threats to continued survival. Anthropogenic threats that all B.C. marine mammals and reptiles face include:

- ◊ Entanglement in fishing gear.
- ◊ Ship strikes.
- ◊ Vessel disturbance.
- ◊ Ingestion of pollution.
- ◊ Chemical pollution, including oil spills.
- ◊ For some, illegal shooting.

The latter is likely not a threat for the whales, dolphins, porpoises, and turtles but remains an issue for seals, sea lions, and sea otters, especially because in some areas of the coast sea otters are viewed as competitors for harvestable shellfish resources (see Section 3.11.1).

3.10 MARINE BIODIVERSITY CONCLUSIONS AND RECOMMENDATIONS

The PNCIMA region is sufficiently large and ecologically varied that it maintains a diversity and abundance of life. These ecosystems range from common to globally unique, with some species whose life spans far exceed our own. Increased human pressures will likely compromise the PNCIMA ecosystems' resilience and recovery from past and present damage.

Aquatic plants form the basis of the marine ecosystem and contribute to its architecture. Without the kelp and eelgrass beds, many species would be unable to carry out their fundamental life functions. For some, such as the glass sponge reefs, the structure and function are only just being understood. However, the consequences of the physical destruction to these reef ecosystems are well known. Furthermore, coral and sponge distributions and species diversity may be greater than that which is currently known. These living fossils have survived millennia; how long they continue into the future is largely under our control.

Immediate actions should be taken to aid in the conservation and recovery of those species classified by COSEWIC as endangered, threatened, or special concern. Thirty-three such species are identified in this report; however, only 19 (58 per cent) are listed under the Species at Risk Act. Recovery Strategies appear to be being drafted for most marine mammals and seabirds; however, due to the lack of SARA status for marine fish, no recovery strategies in process are listed on the SARA Public Registry.

The research and conservation communities should not ignore special concern species. It is rare that a solution is found by avoiding the issues; however, if we disregard the special concern species, they may just go away – permanently.

Actions to protect single species will likely have multi-species benefits. For example, efforts to protect the marbled murrelet, northern resident killer whale, and Olympia oyster will undoubtedly have indirect positive consequences for other seabirds, mammals, fish, and invertebrates that occupy similar niches within the PNCIMA, as many threats transcend phylogenetic boundaries.

Recommendations:

1. Evaluate the efficacy of trawl-fishery closures to protect sponge and coral reef systems.
2. Fund non-destructive research to increase the scientific knowledge of B.C. corals and sponges.
3. Assess the population trends for data-deficient species such as the Olympia oyster.
4. Expedite the SARA status process for COSEWIC-listed species and initiate Recovery Teams and Strategies.
5. Protect kelp and eelgrass beds from destructive human activities and work to restore damaged areas.
6. Use a multi-species approach to fisheries management that includes the biological dependence of one species upon another. For example, resident killer whales depend seasonally on chinook salmon, yet no proportion of this resource is specifically allocated to them in management policy.
7. Provide incentives for industries that operate in COSEWIC- and SARA-listed species habitats to operate under a best-practices regime, based on the best available science.
8. Continue to monitor PNCIMA's seabird population trends as related to environmental fluctuations.
9. Engage the community in species protection and recovery (e.g., northern abalone; see Section 3.11.1).

3.11 OVERVIEW OF SOME NON-COMMERCIAL COSEWIC/SARA SPECIES

3.11.1 NORTHERN ABALONE

The northern or pinto abalone (*Haliotis kamtschatkana*) is considered by COSEWIC and SARA to be threatened (Table 1). This beautiful species, identifiable by its red or green shell with white or blue mottled areas, continues to decline (COSEWIC 2007b). As a conservation measure, the British Columbia northern abalone fishery has been closed since 1990 (COSEWIC 2007b).

Habitat for this species is located throughout all coastal regions of the PNCIMA, from the lower intertidal zone to about a 100-metre depth on firm substrate, most often rocky surfaces (CWS 2004). The two main threats to the survival of this species are:

1) Illegal poaching.
2) Reduced reproductive rate due to population fragmentation.

According to the Canadian Wildlife Service, mature northern abalone tend to accumulate in shallow waters, making them readily accessible to poachers (CWS 2004). Furthermore, there is evidence that poaching occurred prior to the closure of the fishery as individuals smaller than the 100 millimetres minimum size were harvested illegally (CWS 2004). Compounding the pressures of illegal harvest is the inherently slow reproductive rate due to a long maturation period, sedentary nature, and sporadic recruitment (CWS 2004). Based on the seriously reduced population size, the concern is that although reproductively capable adults are present, the population may be so fragmented that chances of producing a next generation are significantly reduced (CWS 2004).

Northern abalone are a food source for sea otters. Consumption of northern abalone by sea otters raises difficult questions with regard to Species at Risk management in Canada. Both have the SARA status, and the conservation of the sea otter and the northern abalone are equal. Furthermore, the latter is the only invertebrate species for which there is an entire ban on harvest under the Fisheries Act (CWS 2004). This then leads to the question: What do we do when one species at risk consumes another?

This is not easily answered, but it is one that Canadians must face. How we manage conflicts (either between multiple species at risk, or between humans and species at risk) is a significant challenge that is likely to increase as wild habitats shrink and human encroachment advances into the marine wilderness.

The northern abalone has been decreasing in British Columbia since at least 1978. By 1984 the provincial population had declined by an estimated 75 per cent (CWS 2004). It appears that past efforts to protect the northern abalone were insufficient, as the total density declined by 43.8 per cent between the 1993 and 1997 surveys (CWS 2004). Recovery planning began in 2000 with emphasis on research and stewardship with the overall goal of rebuilding the northern abalone population through monitoring and recovery planning. Included in this are population-abundance surveys to be conducted at five-year intervals, and the development of genetic markers aimed at the identification of illegally harvested abalone to assist fisheries officers in successful convictions of poachers (CWS 2004).

Coastal residents initiated the "Coast Watch" program to improve the level of local monitoring and participation in conservation efforts. Within the PNCIMA, significant efforts to protect northern abalone have been developed through two stewardship areas within Queen Charlotte Islands and the Kitasoo/Xaixais territory on the mainland. Mature northern abalone have been aggregated within these regions to try to improve the reproductive success by reducing the level of fragmentation within the population (CWS 2004). Though no IAs have been identified for this species in British Columbia, Clarke and Jamieson (2006a) highlight that all coastal marine habitats within the PNCIMA that are less than 10 metres in depth are potential important northern abalone habitat.

The conservation urgency that exists for northern abalone in British Columbia cannot be understated. The efforts underway to protect and enhance this species need to be supported and enhanced. Illegal harvesting, or poaching, of this protected species should not be tolerated anywhere along British Columbia's extensive coastline.

3.11.2 BASKING SHARK

For some, historic exploitation was so destructive that the viability of the current population is questionable. The basking shark (*Cetorhinus maximus*) has been subject to such significant human pressure that the species may not be part of British Columbia's future without concerted conservation efforts and a bit of biological good luck. Only six sightings have been confirmed in B.C. since 1996 (DFO 2007b). Historically, the basking shark was valued for its liver oil, and between 1941 and 1947 a directed fishery occurred. Following the era of commercial shark fishing, an eradication program commenced until 1970 (DFO 2007b). No clear figure exists for the total number of basking sharks killed between the 1940s and 1970, but it is estimated to be as high as several thousand (DFO 2007b). Today it is nearly extinct in B.C. waters.

3.11.3 SHORT-TAILED AND BLACK- FOOTED ALBATROSS

Two species of albatross are found seasonally within the PNCIMA. The short-tailed albatross was once considered abundant in British Columbia but was designated as threatened by the COSEWIC due to a near extinction in the early 20th century (COSEWIC 2003). The population once numbered in the millions; however, due to significant exploitation, the global population is now about 1,600 birds (COSEWIC 2003). This species prefers the shallow nutrient-rich waters associated with areas of upwelling and increased productivity.

The black-footed albatross is designated as special concern by the COSEWIC, as significant numbers feed off the British Columbia coast during the summer months and this species is highly susceptible to incidental mortality in long-line fishing gear, suffers from ingestion of plastic debris, and accumulates high levels of pollutants (COSEWIC 2007a). Estimates show that thousands of black-footed albatross are killed annually in the North Pacific Ocean in commercial fisheries’ long lines (Kaufman 1996). Even though the long-line related mortality occurs outside the PNCIMA border, it is of potential consequence to the albatross that feed within the PNCIMA and should be incorporated into any relevant ecosystem-based management plans.

3.11.4 NORTH PACIFIC RIGHT WHALE

The North Pacific right whale is the most endangered whale (along with the North Atlantic right whale) in the world and likely the most endangered species in the PNCIMA. Historically, the North Pacific right whales used PNCIMA waters, and with any luck still do today. However, the occurrence of this species in British Columbia is infrequent at best.

Said to be the "right one to hunt" these whales were virtually depleted by the 1850s, only 20 years after commercial "discovery" (Goddard 1997). A few more were discovered in the PNCIMA between 1905 and 1967, but they too were harpooned and killed (Goddard 1997). Today, the entire population may be as low as 20 animals, and none have been observed in Canadian waters in the past 50 years (DFO 2007f). However, in 2002, a mother and calf were sighted in Alaskan waters, providing a glimmer of hope that extinction may be staved off.

3.11.5 HARBOUR PORPOISE

Harbour porpoises are the smallest cetacean (usually less than 200 centimetres) that may be present year-round in the PNCIMA (Anna Hall, unpub. data). They are one of the least understood with regard to their sociality, population dynamics, natural history, abundance, and distribution. The harbour porpoise is susceptible to mortality in commercial salmon gillnets in some areas of the PNCIMA (Hall et al. 2002); however, the extent to which this affects the population(s) of harbour porpoise within the PNCIMA is currently unknown.

Figure 5. Harbour Porpoise

3.11.6 STELLER SEA LION

Like the harbour porpoise, the Steller sea lion population of British Columbia is considered to be a special concern species.

The Steller sea lion is sensitive to human activities while on land, and oil spills are also damaging to the population (COSEWIC 2007c). Some individuals may spend significant time within the PNCIMA waters, especially females, who remain at the breeding rookeries year-round. Steller sea lions have a diverse prey base, but they have learned that aquaculture facilities provide easy access to a dense food source. This interaction can be fatal if the sea lion is shot or becomes entangled in the anti-predator nets (CP 2007).

3.11.7 SEA OTTER

Sea otters are considered by COSEWIC to be a special concern species in B.C. Current sea otter distribution is reduced from historical North Coast habitats, and today this species is limited to only the northern end of Vancouver Island and from the Goose Island Group to Milbanke Sound (Nichol et al. 2005).

Historically, this species was hunted extensively for its fur and was extirpated from British Columbia. Today's sea otters are a result of successful reintroductions between 1969 and 1972 (CWS 2007b). Though the population is growing, the sea otter remains threatened in some areas by malicious shooting. Oil spills are also a significant threat to sea otters throughout their range. The introduction of exotic shellfish to the expanding aquaculture industry in B.C. may pose a threat to the survival of sea otters if these non-native species out-compete or displace native shellfish critical for the survival of the otters. The effects of the introduction of non-native shellfish to the sea otter are not understood.

4.0 COMMERCIAL FISHERIES

Commercial fisheries in B.C. are highly varied with regard to the areas fished, gear, species targeted, season, total removal, bycatch, and effect on the ecosystem. There are eight main ways in which fisheries can negatively influence ecosystem processes: 1) the capture and removal of targeted species, 2) the capture and discarding of bycatch either dead or injured, 3) altered food-web dynamics resulting from unbalanced biomass removal, 4) damage to the benthos and sea floor by fishing gear, 5) entanglement in discarded gear and potential injury or death of marine species, 6) ingestion of discarded gear by marine species, 7) acoustic disturbance, and 8) vessel pollution.

As fisheries transition toward ecosystem-based management, consideration of these in commercial fisheries will become increasingly important. It is also relevant to consider the commercial ecosystem impacts of other marine industries, including recreational and aboriginal fishing. Each fishery faces its own challenges as well as collective ecosystem effects. However, bottom-trawl fisheries are generally regarded to be one of the most destructive fishing practices in Canadian waters, as they potentially damage the habitat that supports the commercially desired species.

However, no human activity acts in isolation, and for effective conservation planning, it is not just isolated events that need to be addressed, but rather the potential cumulative effects of biotic, abiotic, and anthropogenic stressors. The collateral damage to the ecosystem from fisheries needs to be addressed in a systematic and scientific manner. This includes evaluation of bycatch impacts, biomass-removal consequences, habitat destruction, pollution, and action to cease illegal fishing operations (i.e., poaching). In general, as more scientifically collected information becomes available, managers will become better-equipped to administer individual fisheries.

Though the present approach is still largely a single-stock management regime, in recent years several new independent fisheries-research surveys have been implemented to help track the abundance of both commercial and non-commercial groundfish species impacted by commercial fisheries. As long as these surveys are conducted regularly, after a decade or so they should start providing managers with a tool for indexing the abundance of several species (S. Wallace, pers. comm.).

The following section provides an overview of the main commercial fisheries relevant to the PNCIMA. Fish and invertebrate species are grouped, as they are collectively managed by DFO: pelagics, salmon, groundfish, and shellfish.

4.1 PELAGICS

Pelagic fish are those that spend most of their adult life near the surface or in the water column (Schweigert et al. 2007). In the PNCIMA, there are both shallow- and deep-water pelagics, with some being resident while others are seasonal visitors. Twenty-four pelagic or forage-fish species are known to use PNCIMA waters (Schweigert et al. 2007). Of these, only the Pacific herring is a significant PNCIMA commercial fishery.

The pelagic fish species covered in the following sections include Pacific herring for its economic importance, sandlance for its ecological importance, and eulachon due to its social importance. Perch are also briefly presented, as they are a by-caught species in the PNCIMA shrimp fishery.

4.1.1 PACIFIC HERRING

Pacific herring are abundant within the PNCIMA (Fargo et al. 2007). As many British Columbians are aware, Pacific herring spawn in inshore regions in the late winter and spring. Pacific herring are harvested mainly for their roe and spawn-on-kelp, and also as food and bait (DSF 2006, DFO 2007b). Pacific herring play an important ecosystem role and therefore the proper management of this species is critical for not only the harvest but also for maintaining ecosystem structure and integrity.

The PNCIMA has three main management districts: the Central Coast, Prince Rupert District, and the Queen Charlotte Islands (DFO 2007b). There are other minor herring populations but only those stocks on the west coast of the Queen Charlotte Islands and those spawning in Quatsino Sound (northwest Vancouver Island) are managed individually (Schweigert et al. 2007). Thirteen sites are identified as major herring-spawning sites throughout the PNCIMA (Schweigert et al. 2007). Four fisheries currently target Pacific herring: roe, spawn-on-kelp, special use, and food and bait (Rusch et al. 2003). In total, the mature biomass of herring in the PNCIMA area averages about 100,000 metric tones; however, there is significant inter-annual variation in stock abundance (Schweigert et al. 2007).

Concerns about declines around the Queen Charlotte Islands and the Central Coast (DSF 2006) are relevant to the PNCIMA. The Queen Charlotte herring-roe fishery has been closed for the past six years, and in 2008 the Central Coast fishery will be closed for the first time in 25 years. Pacific herring are economically, socially, and nutritionally important to many coastal communities and are an integral component of the coastal marine food web. Species such as chinook salmon, humpback whales, and harbour porpoise seasonally rely on Pacific herring.

4.1.2 SAND LANCE

Sand lance are considered to be relatively widespread and prevalent in most inshore waters of B.C. with sand-gravel substrates, but a lack of stock-assessment data impede analysis of stock trends (Schweigert et al. 2007). Contributing to the lack of data is the fact that sand lance is a difficult fish to sample with traditional sampling gear. They are, however, often found in trawl bycatch (Schweigert et al. 2007). There are no commercial fisheries for this pelagic in B.C.; however, dietary studies of fish, seabirds, and marine mammals (Hall 2004, Pearsall and Fargo 2007, Schweigert et al. 2007) indicate that this species plays an integral role in the marine ecosystem food web.

4.1.3 EULACHON

Eulachon are considered a pelagic species as they generally inhabit the upper sunlit waters in the open ocean away from coastal regions (DFO 2007b), but they do rely on the river systems of the PNCIMA for spawning (Prescott-Allen 2005). B.C. has 15 recognized eulachon spawning rivers, with the Nass and Skeena being major PNCIMA rivers (DFO 2007b). Eulachon have experienced a range-wide decline over the past 10 or 15 years (Beacham et al. 2005) with the cause(s) of such an geographically extensive collapse unknown. However, changes in the ocean climate combined with habitat changes are suspected (DFO 2007b). The PNCIMA encompasses 88 per cent (n=30) of the known eulachon spawning rivers in British Columbia (Schweigert et al. 2007).

Eulachon are an important part of the marine food web and provide a seasonal but significant prey base for many marine fish, mammals, and seabirds due to their high oil content. Some of British Columbia's aboriginal communities also consume eulachon. The high oil content and anadromous (i.e., live in saltwater but return to freshwater to spawn) nature of eulachon makes them an ideal candidate as an ecosystem indicator species, as many persistent organic pollutants (POPs) are lipophilic in nature and bind to fat molecules within organisms.

No commercial harvest of eulachon occurs in North Coast waters, though historically a commercial fishery existed on the Nass River (Stoffels 2001). A food harvest of this anadromous fish species has been a seasonal event in several First Nations communities throughout the PNCIMA region for centuries. Since 2000, several eulachon runs in the PNCIMA region (Kitimat River, Bella Coola River, Kimsquit/Dean Rivers, Chuckwalla/Kilbella, and Wannock/Oweekeno Rivers) have been declared insufficient to support food, social, and ceremonial fisheries (Schweigert et al. 2007).

The Skeena and Nass river systems are critical for the survival of North Coast eulachon. The Nisga'a annual harvest from the Nass River is not insignificant and regularly measures in the hundreds of tons of biomass removal (Stoffels 2001). A lesser volume is removed from the Skeena River system (Stoffels 2001). Eulachon catch limits have been imposed on the shrimp trawl fleet. Eulachon are another pelagic fish that appear to be fundamental to the coastal ecosystem as they are a food source for many fish, seabirds, and marine mammals.

4.1.4 PERCH

Four perch species are found in the PNCIMA region: pile perch (*Rhacochilus vacca)*, shiner perch (*Cymatogaster aggregate*), striped seaperch (*Embiotoca lateralis)*, and kelp perch (*Brachyistius frenatus)*(Schweigert et al. 2007). There are currently no major fisheries for perch in the PNCIMA region, although some recreational angling from docks and wharves occurs. However, shiner perch are often caught as bycatch in the shrimp trawl fishery, including the Prince Rupert District fishery, but catch rates are considerably lower in other areas such as the Strait of Georgia (Hay et al. 1999).

4.2 PACIFIC SALMON

Of all fish species on the B.C. coast, perhaps none is more iconic than salmon. The marine ecosystem of the PNCIMA, in association with the adjacent river systems, provides residence and breeding habitats for seven Pacific salmon species, with the Nass and Skeena rivers being critically important (Prescott-Allen 2005). The numerically dominant PNCIMA salmon species are pink, chum, and sockeye (Hyatt et al. 2007). The other three species include coho, chinook (*Oncorhynchus tshawytscha*), steelhead (*Oncorhynchus mykiss)*, and cutthroat (*Oncorhynchus clarki*). The PNCIMA ecosystem provides important migration, rearing, and staging areas for Pacific salmon.

Salmon are critical to the social and economic identities of many North Coast communities through commercial and aboriginal fisheries. Substantial recreational fishing also occurs, drawing anglers from around the world to some of the PNCIMA's most famous fishing regions: Rennel and Cartwright Sound, Langara Island, Chatham Sound, and Douglas Channel.

For all species, there are concerns over the inter-annual fluctuations in stock abundance, condition of spawning habitats, ability of salmon to survive large-scale environmental changes (whether anthropogenic or natural), allocation of quotas between various fishing sectors, and the timing and placement of fishing closures.

Pink salmon are widely distributed throughout the PNCIMA as the most numerically dominant species (Fargo et al. 2007). However, the majority of pink salmon production is associated with a few large populations (>250,000 spawners) returning to major river systems such as the Bella Coola-Atnarko, Kitimat, Yakoun, and Skeena (Fargo et al. 2007). More than 130 streams and rivers on the B.C. central coast support pink salmon, and total returns since 1960 have been generally more abundant on even years than odd (DFO 2007c).

Historically, the B.C. Central Coast has been an important area for commercial catches of pink salmon, with a record high catch of 13.5 million fish in 1962 (DFO 2007c). Of all species, pink salmon have been evaluated to be the most sustainable fishery, although stocks in the Queen Charlotte Islands region and the Broughton Archipelago have declined in recent years (DSF 2006).

Chum is the second-most abundant salmon species in the PNCIMA, with local populations commonly exceeding 25,000 adults. Sockeye salmon populations are the third-most abundant, with greater than 90 per cent of average annual abundance originating from a few large lakes in the Nass (Meziadin and Bowser lakes), Skeena (Babine Lake), Nimpkish (Nimpkish and Woss lakes), and Rivers Inlet (Owikeno and Long lakes) (Fargo et al. 2007). Coho are widely distributed in small spawning populations (<5000 spawners) throughout the PNCIMA. In general, coho production within the PNCIMA has been declining since the 1960s (Hyatt et al. 2007). Chinook salmon have the lowest overall abundance (Fargo et al. 2007).

For chinook and chum salmon, significant biological concern exists over the availability of this resource to the endangered northern resident killer whales, which seasonally visit the PNCIMA region.

On average, between 25 and 30 million adult salmon return to the PNCIMA watersheds, although the annual fluctuations are significant and in the range of 12 to 48 million (Hyatt et al. 2007). During the past decade (1997 to 2006), returns have fallen well below the all-year average (Hyatt et al. 2007). Two major run collapses have occurred for sockeye salmon in the PNCIMA: Owikeno Lake (Rivers Inlet) and Long Lake (Smith Inlet) (Hyatt et al. 2007).

According to a recent analysis of escapement, catch and harvest rates, or trends in smolt and adult runs, and survival, there are six salmon runs in the PNCIMA that have significantly declined and require immediate conservation actions (English et al. 2008). These are as follows:

1. Lakelse Lake – Lower Skeena (sockeye)
2. Long Lake – Smith Inlet (sockeye)

3. Nimpkish – Johnstone Strait (sockeye)
4. Nimpkish – Johnstone Strait (chinook)
5. Viner Sound Creek – Johnstone Strait (chum)
6. Keogh River – Queen Charlotte Sound (steelhead)

Due to the highly mobile nature of salmon, comprehensive conservation efforts will likely have to be exerted both within and beyond the PNCIMA borders.

4.3 GROUNDFISH

Significant groundfish habitats exist in the PNCIMA, including the Goose Island Trough, near Cape St. James, the southeastern regions of Dixon Entrance, Goose Island, North Bank, and the northern end of the Moresby Trough (Fargo et al. 2007).

A variety of species of groundfish are harvested within the PNCIMA. The 2007 harvest in tonnes is itemized by species (or species group) and fishery in Table 5.

Table 5. 2007 Groundfish Harvest Levels

Species	Trawl TAC (tonnes)	Hook and Line Rockfish TAC (tonnes)	Halibut TAC (tonnes)
Yellowtail rockfish	4471		
Widow rockfish	2658		
Canary rockfish	1193	140	6
Silvergray rockfish	1433	157	9
Pacific ocean perch	6148		
Yellowmouth rockfish	2444	62	19
Rougheye rockfish	1140	469	35

Species	Trawl TAC (tonnes)	Hook and Line Rockfish TAC (tonnes)	Halibut TAC (tonnes)
Shortraker rockfish	240	105	9
Redstripe rockfish	1564		
Shortspine thornyheads	771	18	18
Longspine thornyheads	425	10	10
Yelloweye rockfish	284	183	94
Quillback, Copper, China and Tiger rockfish combined	220	192	22
Pacific cod	1690		
Dover sole	3073		
Rock sole	1650		
Lemon sole	730		
Petrale sole	600		
Lingcod	3450		
Dogfish	15 000		
Sablefish	3745		
Pollock	4225		
Gulf hake	10 000		
Offshore hake	95 128		

Species	Trawl TAC (tonnes)	Hook and Line Rockfish TAC (tonnes)	Halibut TAC (tonnes)
Halibut (see note below)	5730		
Big skate	567		
Longnose skate	47		
Arrowtooth flounder	15 000		

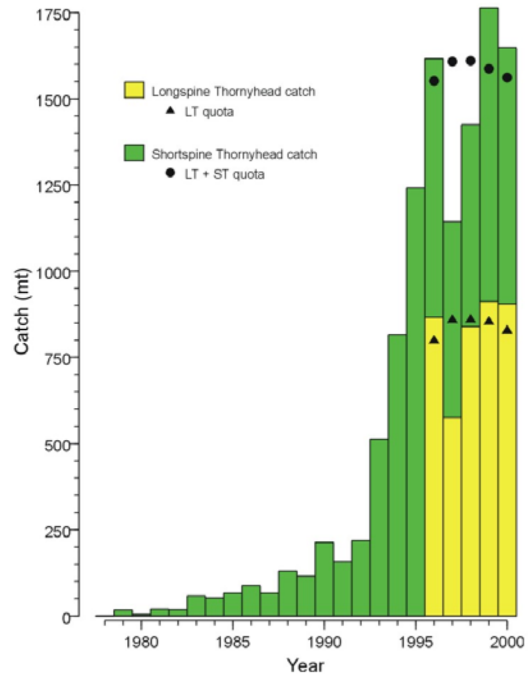
(This table is adapted from Tables 13.10 and 13.10.1 in DFO 2007g.)

Note: The groundfish trawl fishery has a bycatch mortality cap of 454 tonnes that is not part of the commercial TAC (DFO 2007g).

There are seven commercial groundfish fisheries in British Columbia’s Pacific waters: groundfish trawl and hook-and-line fisheries for halibut, sablefish (which can also use traps), rockfish, lingcod, and dogfish (DFO 2007g). The estimated area greater than 500 metres fished by the groundfish fishery increased from an estimated 3,100 square kilometres in 1996 to 7,300 square kilometres by 2005 (Sinclair 2007). During this time, a corresponding coast-wide decline in the fishing effort in the waters 0 to 500 metres was observed (Sinclair 2007).

The largest deep-water (>500 m) expansion of the groundfish trawl fishery occurred during the development of the longspine thornyhead fishery (1996 to 2005) (Sinclair 2007). In 2000, the fishery explored the more northern regions of the province, including the waters of the Queen Charlotte Islands. A graphical representation of the increased catch of thornyheads in metric tonnes over time is displayed in Figure 5.

Figure 5. History of Thornyhead Landings (Metric Tonnes) on the B.C. Coast



From 1978 to 1995, thornyheads were recorded as an aggregate. In 1996, longspines (lower light bars) were separated from shortspines (upper dark bars), and each had a separate quota (triangles for longspines). The combined quota is denoted by circle symbols. This image and associated explanation were obtained at www.pac.dfo-mpo.gc.ca/sci/sa-mfpd/slope_rockfish/thorn_fishery.htm.

In 2006, a two-year research survey began to index groundfish populations in all areas of the B.C. coast. Beginning in April of that year, all groundfish licence types became integrated under a three-year pilot management regime that included 100 per cent observer coverage of all fleets through electronic monitoring (i.e., video surveillance), transferable quotas between licence types, and fisheries logbooks audited against video surveillance. Under the reformed system, DFO has much better capacity to manage the groundfish fishery, most of which occurs in the PNCIMA.

Groundfish is now the most valuable commercial fishing sector in B.C. ($145 million of the $390 million landed value for all species in 2004) and involves approximately 500 vessels, most of which operate in the PNCIMA (DFO 2007g).

4.3.1 PACIFIC HAKE

Pacific hake is the largest fishery in British Columbia by landings. Pacific hake, also called Pacific whiting, are caught in mid-water trawls, and though a valuable fishery to British Columbia, most of the historic catch is outside the boundary of the PNCIMA waters off the west coast of Vancouver Island (DFO 2003d, 2007i). However, in the past few years an increasing proportion (~20 per cent) of the catch has been taken from within the PNCIMA boundary. The Pacific hake stock is jointly managed between Canada and the United States (see Section 8.6).

4.3.2 ROCKFISH

Thirty-seven species of rockfish are known to occur in British Columbia. They are generally slow-growing, long-lived fish that often maintain fairly restricted residence areas (Fargo et al. 2007). Due to declines in rockfish abundance in inshore areas, Rockfish Conservation Areas (RCAs) have been implemented in British Columbia, including some areas of the PNCIMA. In total, 2,338 square kilometres (Fargo et al. 2007) are designated RCA protected waters (Figure 5).

Figure 6. Rockfish Conservation Areas (RCAs)

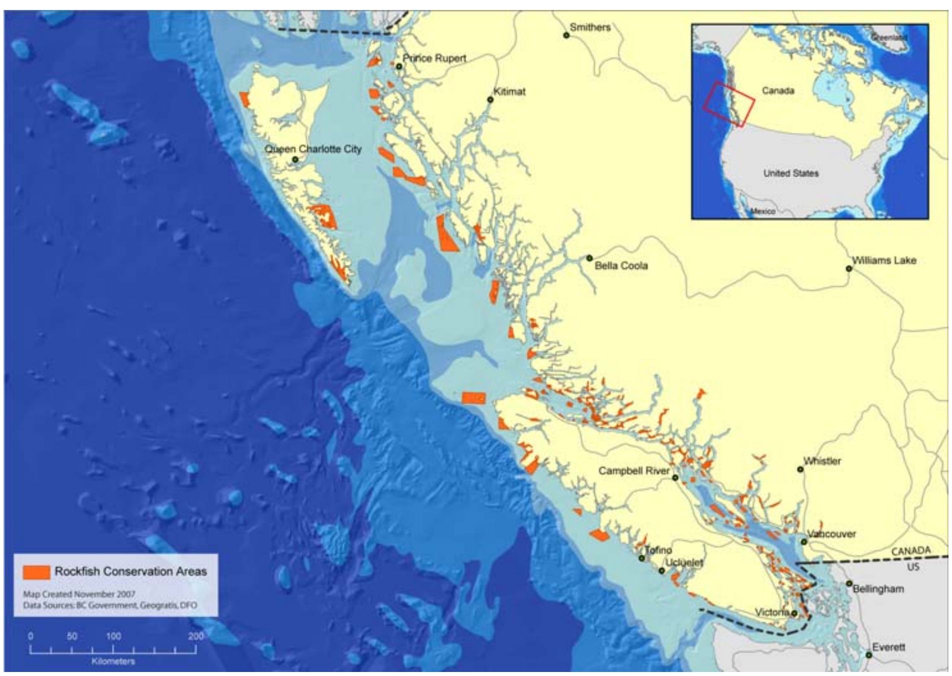


Image courtesy of the Canadian Parks and Wilderness Society.

The status of most rockfish species in PNCIMA waters is not encouraging. In the recent ecosystem overview prepared by Lucas et al. (2007), of the 16 rockfish species evaluated six (37.5 per cent) were listed as declining, nine (56.3 per cent) as uncertain, and one (6.3 per cent) as not expected to increase in the near future (Table 6).

Table 6. Groundfish Stock Status Trend Summaries

Rockfish Species	Stock Status Trend	Non- Rockfish	Stock Status Trend
Yelloweye (*Sebastes ruberrimus*)	Declining	Pacific cod	Low abundance (increasing trend)
Quillback (*S. maliger*)	Declining	Dover sole	Stable
Copper (*S. caurinus*)	Uncertain	Rock sole	Stable
China (*S. nebulosus*)	Uncertain	Lemon sole	Increasing population
Black (*S. melanops*)	Uncertain	Petrale sole	Stable
Tiger (*S. nigrocinctus*)	Uncertain	Lingcod	Stable
Widow (*S. entomelas*)	Uncertain	Dogfish	Unknown (likely stable)
Silvergray (*S. brevispinis*)	Uncertain	Sablefish	Stable but variable
Canary (*S. pinniger*)	Low abundance	Pollock	Stable but highly variable
Yellowtail (*S. flavidus*)	Declining	Offshore hake	Low abundance
Yellowmouth (*S. reedi*)	Expected to decline until next major recruitment	Halibut	High abundance (declining trend)
Rougheye (*S. aleutianus*)	Uncertain, but thought to remain low for some time	Big skate	Average abundance (stable)
Shortraker (*S. borealis*)	Not expected to increase in the near future.	Longnose skate	Average abundance (stable)
Redstripe rockfish (*S. proriger*)	Declining	Arrowtooth flounder	Stable
Shortspine thornyheads (*Sebastolobus alascanus*)	Uncertain		

Rockfish Species	Stock Status Trend	Non- Rockfish	Stock Status Trend
Pacific ocean perch (*S. alutus*)	Declining		
Longspine thornyhead (*S. altivelis)*	Rapid decline, low abundance		

(Table 6 - Rockfish species adapted from (Lucas et al. 2007), and non-rockfish species, S. Wallace, pers. comm.)

Some of these species exist in low abundances naturally. Therefore, exploitation has the potential to further limit the possibility of long-term survival for species in which low fecundity is already a limiting factor.

While several rockfish populations are depleted due to poor historic management, several initiatives implemented over the past five years should improve the long-term sustainability of these fisheries. Changes include increased survey effort (both trawl and long-line surveys), better catch data, closed areas, and reduced quotas for several species.

4.3.3 PACIFIC HALIBUT

The Pacific halibut fishery is generally a well-managed fishery in British Columbia, but concerns exist with regard to bycatch of rockfish, seabirds (e.g., black-footed albatross), and skates (DSF 2006). Since 1991, this fishery has been using an Individual Vessel Quota (IVQ) system that eliminated the problems associated with the “race” to catch fish. Based on annual standardized research surveys and stock assessments, the overall status of Pacific halibut is considered healthy (DFO 2007g).

Pacific halibut is currently allocated between the commercial and recreational fishery at an 88:12 per cent split. A substantial recreational fishery for halibut within the PNCIMA has proven to be poorly monitored and enforced, resulting in catches well above 12 per cent of the TAC derived by the International Pacific Halibut Commission. The DFO is working on establishing a mechanism to transfer quota (not a change in allocation) from commercial to recreational fisheries. The aboriginal fishery is overseen through a communal licensing program.

4.3.4 SABLEFISH

Sablefish, also known as black cod, are a deep-water, black-skinned fish, harvested on the West Coast of Canada. In Canada, most of this fishery uses live traps, though a small portion of the harvest is caught using long-lines. On average approximately 4,000 tonnes are harvested annually (CSA 2007). This fishery has occurred for over 40 years, but it is only recently that the market has included Canadian and U.S. consumers. Historically, this fish was harvested for export to Japan.

In 1981, the DFO took steps to limit entry to the sablefish fishery, resulting in 48 sablefish "K" licences issued annually (CSA 2007). Fewer than 30 vessels are currently operating in this fishery. The fishery operates using a Total Allowable Catch (TAC) with specified openings and closings. This fishery is now co-managed by the Canadian Sablefish Association and the DFO.

Dedicated sablefish surveys have been conducted since 1998 to collect catch rate and biological data (DFO 2007g). Surveys from 1990 to 2006 show catch rates have declined approximately 38 per cent since 2003, with the averages from 2006 and 2003 being about the same (DFO 2007g).

4.4 SHELLFISH AND OTHER INVERTEBRATES

Approximately 8,000 invertebrate species have been identified in B.C. waters, with commercial and recreational harvests currently occurring for just over 40 (DFO 2007b). On the North Coast, the DFO shellfish management team is responsible for managing 25 different invertebrate species, including clams, shrimp, prawns, geoducks, sea cucumbers, crabs, krill, octopus, scallops, squid, and sea urchins.

4.4.1 GREEN AND RED SEA URCHINS

The green sea urchin (*Strongylocentrus droebachiensis*) stocks appear to be rebuilding and are healthy after extensive historical harvest. This is a dive fishery, and within the PNCIMA waters harvest is restricted to Queen Charlotte Strait (DSF 2006). Most of the catch is exported to Asian markets, so there is little economic gain to coastal B.C. economies (DSF 2006). There are concerns over the occurrence of associated abalone poaching, and sea otter predation may affect this species in the coming years. Interestingly, the green sea urchin may live 20 to 25 years (DFO 2007a).

The red sea urchin (*Strongylocentrus franciscanus*) is the largest sea urchin species in B.C. waters, and it is also harvested within the PNCIMA waters. Red sea urchins are harvested by divers and delivered fresh to processing plants where the roe is extracted, treated, and sold in Japan and North American markets as uni (DFO 2007b). Concerns exist over predation by sea otters, as their population expands in this region. According to the David Suzuki Foundation (2006), this fishery is being effectively managed, although there are concerns that poaching of abalone may exist within this fishery, and if predation by sea otters increases, that may put the species at risk.

Hand rakes are permitted for red sea urchin harvesting, but the green urchin fishery is limited to hand picking (MacConnachie et al. 2007).

Clarke and Jamieson (2006a) identified Important Areas for the green sea urchin in the Queen Charlotte and Johnstone Straits, but no IAs were identified for the red sea urchin within the PNCIMA region.

4.4.2 GIANT PACIFIC OCTOPUS

The giant Pacific octopus (*Octopus dofleini*) stocks appear to be healthy, and current catch rates are relatively low (DSF 2006). This dive fishery is typically not a food fishery, but rather most of the catch is used as bait in other fisheries. This fishery participates in the collection of biological information related to the catch, which is managed through a minimum size limit rather than quota (DSF 2006). There is an increasing catch in northern B.C. waters (DFO 2007c). Fisheries and Oceans Canada is concerned with the use of chlorine bleach and chlorine bleach derivatives by divers in the octopus dive fishery (DFO 2007c). These irritants were used as agents to force the octopus from their dens, enabling divers to catch them (DFO 2003e).

As of 2000, divers must sign a letter agreeing not use these chemicals in the harvest of octopus and to provide a list of the agents they may use during harvesting activities (DFO 2007c). There are also concerns over the lack of a maximum annual catch limit and a lack of protection for brooding females (DSF 2006).

4.4.3 CLAMS (MANILA, VARNISH, RAZOR, GEODUCK)

In general, the B.C. clam fishery appears to be sustainable (DSF 2006). However, caution must always be exercised as harmful algal blooms such as red tide occur in many locations along the coast and each year more beaches are lost to increasing pollution (DSF 2006). Lucas et al. (2007) provide a comprehensive summary overview of the current clam habitats in British Columbia by species, including distribution, growth rates, spawning times, and food sources.

MANILA CLAMS

The manila clams are an invasive species that were accidentally introduced to B.C. waters in the 1930s, and are currently being farmed, thereby increasing local densities (DFO 2007b).

VARNISH CLAMS

There is some interest in pursuing aquaculture of varnish clams, which are another introduced species (DSF 2006, DFO 2007b). This is an inter-tidal beach fishery that occurs only on low tides. Concerns exist regarding the degradation of natural clam habitats and the potential for ecological imbalance through a minimum size harvest (DSF 2006). Pollution is an issue that may affect the longevity of this fishery, as clams are susceptible to ingesting toxic algae, such as those responsible for paralytic shellfish poisoning (commonly referred to as “red tide” on the B.C. coast), and also bacteria from sewage waste.

In 1993, the Heiltsuk Tribal Council (HTC) and Fisheries and Oceans Canada established a joint management plan within their Fisheries Agreement for the clam fishery. The Heiltsuk clam fishery is to set an annual total allowable catch (TAC) with a minimum size limit, rather than the South Coast's spatial and temporal closure schemes that also involve minimum size limits (DFO 2007e).

RAZOR CLAMS

Beaches near Masset, Haida Gwaii, have significant populations of razor clams that have supported a commercial fishery since 1922 and an important non-commercial fishery (DFO 2007e). Co-management of this fishery occurs between the Council of Haida Nation (CHN) and Fisheries and Oceans Canada. The Haida fishery is managed through a communal licence and all participants receive authorization from the CHN (DFO 2007e). Under the communal licence, the CHN is responsible for collecting and compiling fish-slip data and for collecting toxicological monitoring samples (DFO 2007e). Clarke and Jamieson (2006a) identified Important Areas for this species around the northeast coast of Graham Island.

GEODUCK CLAMS

The geoduck fishery began in North Coast waters in 1980. Geoducks are one of the longest-lived shellfish in the world, with growth-ring analysis indicating many individuals live more than 100 years (DFO 2007b). This is one of the most valuable fisheries on the B.C. coast, and new beds are still being discovered on the North Coast (DFO 2007b). This dive fishery uses compressed air to extract the geoducks. Concern exists about the environmental sensitivity of this practice. Commercial harvesters have to provide bed data to Fisheries and Oceans Canada as a condition of their licence (DFO 2007b). The David Suzuki Foundation rates this fishery with caution due to concerns about habitat damage and the accuracy of annual quotas (DSF 2006). Clarke and Jamieson (2006a) identified Important Areas for this species in the waters west of Bella Bella.

4.4.4 DUNGENESS AND TANNER CRAB

The Dungeness (*Cancer magister*) fishery is one of the oldest commercial invertebrate fisheries on the North Coast, with the first crab cannery in Canada opening in Naden Harbour when the crab fishery began there in 1920 (DFO 2007b). According to Fisheries and Oceans Canada, North Coast Dungeness crab stocks are probably composed of two or more non-isolated populations in Dixon Entrance (Naden Harbour, Virago Sound, and

McIntyre Bay) and Hecate Strait. This North Coast region has supported the major crab fishery in B.C. since 1993.

Crab abundance fluctuates in this region on an inter-annual scale with periods of low abundance interspersed with relatively short periods of extremely high abundance (DFO 2007b). The David Suzuki Foundation recognizes the B.C. Dungeness fishery as a well-managed and sustainable fishery but has some concerns about illegal harvest of juvenile or undersize female and soft-shelled crab (DSF 2006).

The fishery is managed primarily by season, sex, and size. Beginning in 2006, 100 per cent electronic monitoring equipment was made mandatory on crab vessels to monitor overall individual trap hauls; fishing activity; and fishing location, date, and time while the vessel is fishing.

Dogfish Bank in Hecate Strait and Prince Rupert Harbour have both been recognized as Important Areas for this species in the PNCIMA (Clarke and Jamieson 2006a).

Two species of tanner crab are also harvested within the PNCIMA waters (*Chionoecetes tanneri*, and *C. bairdi*) but to a far lesser extent as this fishery is still in an exploratory phase (Clarke and Jamieson 2006a). As such, there is still much to be learned of these species' biology, ecology, and conservation concerns. Nevertheless, the entire continental shelf break was identified as an Important Area for this species within the PNCIMA (Clarke and Jamieson 2006a).

4.4.5 PRAWNS AND SHRIMP

SPOT PRAWN

The trap prawn fishery within the PNCIMA occurs mostly in the waters off Prince Rupert in Chatham Sound. This fishery appears to be sustainable, though some concerns exist regarding sponge-habitat damage and enforcement of the recreational fishery (DFO 2000). The target species is usually the spot prawn (*Pandalus platyceros*) due to its large size. The two main markets for B.C. prawns are frozen at sea (FAS) for export to Asia, and fresh live for local markets. Economically, there is a strong dependence on the Asian market (DFO 2007b). Concern exists with regard to the growing recreational fishery, which in some areas may exceed the commercial harvest, and may be illegally operating in areas closed to commercial harvest for conservation purposes (DFO 2007b). Further concern exists regarding the local abundance of the spot prawn stocks (DSF 2006).

PINK AND HUMPBACK SHRIMP

Other shrimp are targeted in North Coast waters, including the pink shrimp (*Pandalus borealis*) and the humpback shrimp (*Pandalus hypsinotus*). A directed commercial fishery for humpback shrimp occurs in Masset Inlet as well as near Prince Rupert Harbour, and a commercial fishery for pink shrimp occurs in the Prince Rupert area.

Clarke and Jamieson (2006a) identified three Important PNCIMA Areas for shrimp in Prince Rupert/Chatham Sound, Queen Sound/Calvert Island, and Queen Charlotte Strait.

4.4.6 GIANT RED SEA CUCUMBER

The commercial fishery for the giant red sea cucumber (*Parastichopus californicus*) was opened to North Coast waters in 1986 (DFO 2007b). The B.C. dive fishery for sea cucumbers is considered to be sustainable as it has the ability to be highly selective; however, some concern exists over localized depletions (DSF 2006). Management of this fishery has been proactive in enacting closures, and only 50 per cent of the coast is available for harvest, with only 25 per cent available for commercial harvest (DSF 2006).

Robust province-wide abundance estimates are lacking, which raises concern over the health of sea cucumber stock. Additional concerns relate to the social equity of this fishery. As with other shellfish fisheries, there are strong ties to the Asian market (DSF 2006). Clarke and Jamieson (2006a) identified two Important Areas (IAs) for the giant red sea cucumber within the PNCIMA coastal regions. It is likely that other IAs exist because the locations of commercial production harvest beds remain confidential (Clarke and Jamieson 2006a).

4.4.7 OPAL SQUID

The opal squid fishery within the PNCIMA varies inter-annually and accounts for a low proportion of the total catch in B.C. (MacConnachie et al. 2007). These squid are often caught using seine nets and are used as bait in other more lucrative fisheries such as sablefish, crab, and halibut (MacConnachie et al. 2007). There is also a recreational fishery for opal squid.

4.5 SUSTAINABLE SEAFOOD CHOICES

The David Suzuki Foundation evaluated the sustainability of British Columbia's harvested fish and shellfish stocks. According to this review (DSF 2006), consumer choices as they relate to the PNCIMA are presented in Table 5.

Table 5. Seafood Consumer Choices Based on a David Suzuki Foundation Analysis

Most Sustainable	To be consumed in moderation	To be avoided
Green sea urchin	Chum salmon	Pacific cod
Giant Pacific octopus	Geoduck clam	Dover sole
Red sea urchin	Lingcod (caught by hook and line only)	English sole
Pacific hake	Chinook salmon	Lingcod (trawl-caught only)
Clams (Preferred species native species: razor, butter, littleneck)	Pacific halibut	Rock sole
Dungeness crab	Coho salmon	Petrale sole
Pacific herring	Shrimp (trawl-caught)	Rockfish
Spot prawn (trap-caught)	Sockeye salmon	Northern abalone
Giant red sea cucumber		
Pink salmon (highest rating of all salmon species)		
Opal squid (ensure B.C. caught)		
Sablefish (black cod) (ensure B.C. caught)		

However, other consumer guides are available including SeaChoice and the International Seafood Guide. They are available on-line at www.seachoice.org and www.seafoodguide.org respectively. SeaChoice is specific for Canadian consumers, whereas the International Seafood Guide provides consumer information for 17 countries, including Canada.

As each is an independent effort with unique criteria, some discrepancies can be found between the three ranking systems. Only the David Suzuki Foundation list covers B.C. specific species such as green urchin, giant Pacific octopus, red sea urchin, giant red sea cucumber, and northern abalone.

The International Seafood Guide lists urchins (or uni as they are commercially known) as safe to eat based on their sustainability criteria, but consumers are cautioned against purchasing hake. The other two lists classify Pacific hake as sustainable.

Geoducks are listed as safe by the International Seafood Guide, but the David Suzuki Foundation cautions consumers. The same apparent inconsistency arises for halibut, Pacific cod, and sole. It is likely that the sometimes contradictory consumer ratings stem from the differing scales for which these guides were developed.

Nevertheless, the message is relatively unified with regard to clams, Dungeness crab, Pacific herring, prawns, wild salmon, farmed salmon, squid, sablefish, lingcod, and rockfish, though each list has its own specific advice.

B.C. residents should support fisheries that operate in a sustainable manner. Fisheries with unsustainable practices should be encouraged to follow the lead of the other members of the fishing or managerial communities, depending on the source of the unsustainable practices.

> **“Sustainable seafood options of exist. And it’s up to all of us to ensure our fisheries are managed in a way that maintains this incredible natural resource of the future.”**
>
> *David T. Suzuki (DSF 2006)*

4.6 COMMERCIAL FISHERIES AND FISH STOCKS CONCLUSIONS AND RECOMMENDATIONS

Commercial fisheries are fundamental to the socio-economic basis of many coastal communities. The very fabric of coastal life is integral to, and dependent on, healthy ecosystems and sustainable commercial fisheries. The commercial fisheries of the PNCIMA are as diverse as their target catches. Gear types and sustainable practices are highly varied, as are the annual catch rates. Although the commercial sector is often targeted as the cause of resource depletion in some areas, the impact of personal or recreational fishing can exceed that of the commercial extraction (DSF 2007). In some cases, like northern abalone, poaching exceeds all legal extraction, as there is a total ban on northern abalone harvest in the province.

The management of PNCIMA commercial fisheries is an ideal mechanism with which to implement ecosystem-based management practices. Individual species need to be addressed in an integrated ecosystem framework. For example, Pacific herring are a core species upon which an entire web of ecosystem interactions and species survival depend. Ecosystem-based management may help incorporate the relationships between other marine fish, seabirds, marine mammals, and herring into an integrated management framework. Action, rather than more reports, is required for commercial fisheries and fish-stock management.

Recommendations:

1. Conduct stock assessments for data-deficient species such as sand lance.
2. Provide public access on the Internet to a comprehensive account of the full cost (ecologic and economic) of all fisheries (commercial, recreational, and aboriginal).
3. Support and encourage the development and implementation of selective gear, and incorporate the efficacy of new gear into management plans.
4. Evaluate the significance of derelict or discarded commercial fishing gear to the PNCIMA’s marine biodiversity.
5. Provide economic incentives for selective fishing techniques.
6. Legislate protection for endangered stocks.

7. Achieve transparency in the location of shellfish beds for management between DFO and harvesters.
8. Provide financial incentives for individuals that currently operate in a sustainable manner, or for those willing to switch gear or practices.
9. Carefully select marine reserves that encompass spawning or rearing grounds for commercially important species at risk.
10. Apply species-conservation measures equally to all sectors, including recreational, commercial, and aboriginal fisheries.
11. Support local sustainable fisheries.

5.0 MARINE AQUACULTURE

Marine aquaculture is the cultivation of marine organisms for human consumption. B.C. has two main types of aquaculture, finfish and shellfish, each with its own unique challenges and solutions. Aquaculture is a significant industry on the B.C. coast and is regulated through the 1988 federal-provincial Memorandum of Understanding, which delineates governmental responsibilities (Peterson et al. 2005). Since 1995, the DFO has maintained the lead agency status.

This section will provide an overview of aquaculture industry with emphasis on the issues relevant to the PNCIMA and ecosystem-based management.

5.1 SHELLFISH AQUACULTURE

There are more than 400 shellfish leases on the B.C. coast, with significant interest in expanding, especially on the Central and North coasts (Deal 2005). However, only a few sites are now operating in the PNCIMA. The most common shellfish farmed in B.C. include the Pacific oyster (*Crassostreea gigas*), Manila clam (*Venerupis philipparum*), and Japanese scallop (*Patinopecten yessoensis*), with oysters and clams accounting for most of the wholesale value (MacConnachie et al. 2007).

Present and future shellfish aquaculture sites should be environmentally sensitive, taking into account the inter-tidal ecosystem, the surrounding terrestrial environment, and the visiting avian species in order to minimize damaging environmental consequences. Deal (2005) cautions that the negative environmental consequences that may result from the shellfish aquaculture industry include:

- ◊ Anti-predator netting on avian species.
- ◊ Predator exclusion.
- ◊ Landscape alteration through fencing and substrate rows.
- ◊ Increased human and vehicular traffic.
- ◊ Disease and larval transport to adjacent areas.
- ◊ Changes in ratios in species abundance and diversity due to high density single species.
- ◊ Biotic and abiotic ecological alterations.
- ◊ Increased night activity.

Nocturnal disruption from increased night activity may lead to ecosystem-level alterations and behavioural changes in terrestrial, avian, and aquatic organisms.

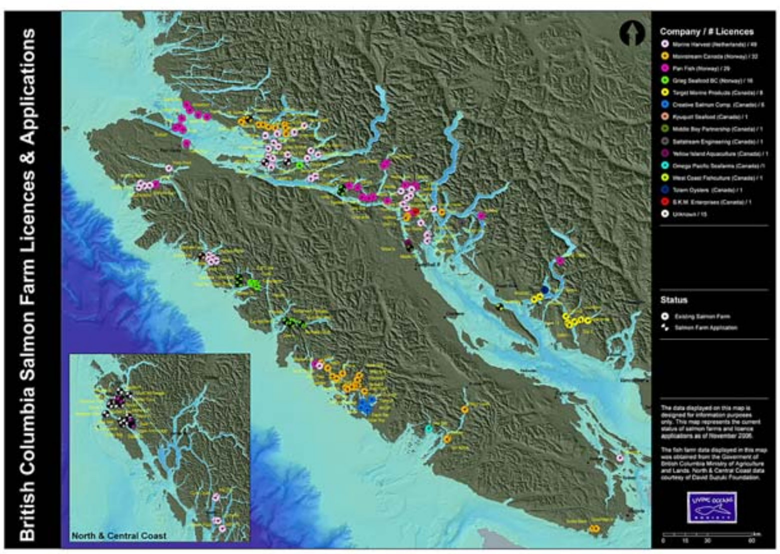
The David Suzuki Foundation has presented a comprehensive overview of recommendations to reduce the environmental impact of shellfish aquaculture in British Columbia. The recommendations are specific to various types of aquaculture and include a number of techniques to reduce vehicular damage, non-native species introduction to the surrounding environment, structural modifications for rafts and long lines used in deep-water cultures, abiotic and biotic negative effects such as substrate disruption and anti-predator techniques, and physical-structures use, and to increase the success of low-impact beach cultures (Deal 2005).

5.2 FISH AQUACULTURE

Salmon have been farmed in coastal British Columbia for the past four decades (MacConnachie et al. 2007). Within the PNCIMA, most existing farms and applications for future farms are within Queen Charlotte Strait, and most of these are salmon-producing facilities (LOS 2007a). Most of the finfish farms of B.C. are in the PNCIMA (MacConnachie et al. 2007). The salmon farms are a series of floating cages, with nets made from synthetic material. Farming salmon in this type of net is highly controversial as the net cages act like sieves and attempt to contain the fish while allowing their waste and excess feed to fall directly into the ocean beneath the operation (LOS 2007a). An average farm contains between six and 14 net cages, each measuring 30 by 30 meters (322 by 322 square feet) and containing up to 80,000 fish (LOS 2007a).

In recent years, conservationists, fishermen, First Nations, and scientists have voiced concern over the nature of the B.C. salmon-farming industry due to the risk associated with the escape of farmed salmon into the wild, disease transfer from farms to wild salmon, pollution from fish waste, threats to human health from the antibiotics and artificial colourants given to farmed fish, and the economic impacts of industrial salmon farming on wild salmon fisheries (LOS 2007a). One of the key issues associated with salmon farming along the B.C. coast is that the species farmed is Atlantic salmon (*Salmo salmar*), which is not native to this region or even this ocean basin. Current locations of farm licences and applications are presented in Figure 6.

Figure 7. Province-wide Salmon-farm Licences and Applications, Including the PNCIMA



(Courtesy of the Living Oceans Society.)

5.3 SALMON FARMING MORATORIUM

In 1995, the provincial and federal governments enacted a salmon-farming moratorium, limiting the number of farm licences to 121 (LOS 2007a). In September 2002, the government lifted the seven-year moratorium on new licences, thereby allowing an expansion of salmon farms into PNCIMA (LOS 2007a).

In response to the impending expansion, a coalition of environmental groups and First Nations joined together to create the Coastal Alliance for Aquaculture Reform (CAAR). Their unified goals are to protect wild salmon, coastal ecosystems, cultural traditions, and human health from destructive salmon-farming practices. CAAR believes that salmon farming is possible on the B.C. coast, but only if the impact on the environment is significantly reduced (CAAR 2007).

5.4 POTENTIAL RISKS AND MITIGATIVE APPROACHES

The marine environment of PNCIMA is at potential risk if open-net fish farming continues. These risks include increasing the incidence of naturally occurring diseases such as infectious haematopoietic necrosis (IHN) virus due to the high density of fish within the net pens; transfer of the parasitic sea lice to wild salmon; impact of non-native species (e.g., Atlantic salmon) from escapes on endemic flora and fauna; over-loading of nutrients from accumulated waste products; introduction of antibiotics and other non-natural products; and shooting of marine mammals considered predators of the farmed fish (LOS 2007a).

Significant avoidance behaviour of killer whales (Morton and Symonds 2002) and harbour porpoise (Olesiuk et al. 2002) has been observed in the vicinity of fish farms actively using acoustic deterrent devices on the B.C. coast. Due to the significant impact on marine mammals, the use of these devices is now prohibited on the B.C. coast. This ban should continue.

The risk to wild salmon from commercial salmon-farm operations has been hotly debated in British Columbia. The pink salmon runs that pass through the Broughton Archipelago have precipitously declined in recent years. According to Fisheries and Oceans Canada, it is probable that a sea-lice infestation was the cause (DSF 2006). However, recent research from outside Fisheries and Oceans Canada points to more serious survival risk for wild salmon from sea lice than the DFO originally indicated.

Sea Lice and Salmon

Krkošek et al. (2006) conducted a comprehensive review of the spread and impact of farm-originated parasites on the survival of wild salmon in British Columbia. They computed that sea lice from farms produced mortality rates ranging from nine to 95 per cent for several wild juvenile pink and chum salmon that shared habitat with salmon-farms.

There is still much to be learned of the risk posed by infectious diseases on the marine ecosystem. However, current data are compelling and the ecosystem-level effects of such human-induced changes stand to be significant as the importance of salmon transcends the B.C. coast. Salmon are economically and culturally significant to many coastal communities. Perhaps most significant is the dietary dependence of resident killer whales on wild coastal salmon runs.

5.5 MARINE AQUACULTURE CONCLUSIONS AND RECOMMENDATIONS

Ecosystem-based management is appropriate for both fish and shellfish aquaculture development in this province, as these farms can significantly affect the surrounding ecosystem and species composition.

Recommendations:

1. Prohibit the development of new open-net facilities until the current problems have been successfully mitigated.
2. Maintain moratorium on the use of acoustic deterrent devices.
3. Uphold Fisheries Act.
4. Base management decisions on unbiased scientific evaluations.
5. Support and encourage those facilities that are operating sustainably.

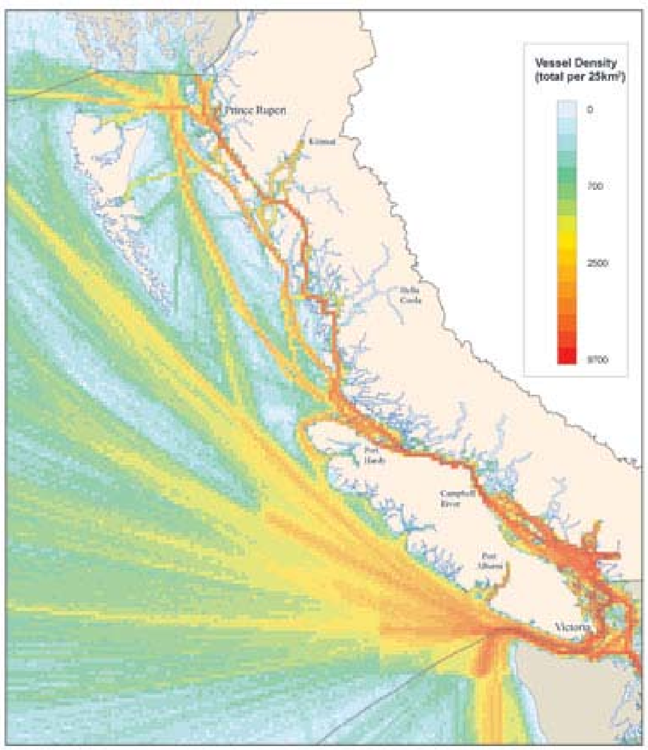
6.0 MARINE AND COASTAL DEVELOPMENT

The three industries that present the greatest risk to the ocean environment of British Columbia are (in no particular order) fisheries, aquaculture, and shipping (DSF 2007). However, other industries also pose a risk to the marine environment as they occur near the ocean. Examples of such industries include upland development, forestry, and shoreline tenures (DSF 2007).

6.1 SHIPPING

Vessel traffic has become part of the marine ecosystem in British Columbia, though by far the greatest concentration is in southern B.C. Figure 7 shows a snapshot of vessel traffic density in 2003; however, shipping along the North Coast is expected to increase in the near future. This image was produced by the Ministry of Environment and is available at www.env.gov.bc.ca/soe/bcce/01_population_economic/marine_traffic.html.

Figure 8. Density of B.C. Marine Traffic in 2003



6.1.1 COMMERCIAL GOODS TRANSPORT

The PNCIMA waters include three major ports: the rapidly expanding industrial port of Kitimat, the large commercial port of Prince Rupert, and adjacent to the Alaska border, the port of Stewart. Kitimat is deeper and wider than the other North Coast ports (COS 2007). The Port of Prince Rupert is the deepest natural harbour in North America, and is ice-free throughout the year (COS 2007), which makes it increasingly important to the North Coast.

Present and future shipping traffic will shape the acoustic environment of marine ecosystems. This statement not only applies to the PNCIMA but to the world's oceans ubiquitously. Increasing the levels of ocean noise can be disruptive to wildlife, especially marine mammals that rely on acoustics for navigation, hunting, social communication, and group cohesiveness. It is accepted that the noisier the environment, the more difficult these tasks can become for marine mammals. There is also evidence that exposure to extreme noise levels can result in behaviours that have lethal consequences for some whales (Rossiter 2006).

The acoustic impact of vessel traffic is not the only consideration, as vessel traffic has the potential to physically alter habitats found within anchorages and traffic schemes, and to displace mobile animals from specific areas. Ship traffic is currently the primary source of acoustic disturbance within PNCIMA (Demarchi et al. 2006), but other industries such as fishing, oil and gas exploration (or future extraction), aquaculture, or scientific exploration should not be discounted. Vessel traffic is known to also be a source of mortality for marine mammals through ship strike (Douglas et al. 2008).

6.1.2 CRUISE SHIPS

Cruise ships are increasingly part of the B.C. coastal environment. In 1995, 283 cruise ships visited the three main ports in B.C. (Vancouver, Victoria, and Prince Rupert). In 2004, this number had reached 381(BCCMEP 2006). Cruise ships to visit the PNCIMA include both large and small vessels, the latter locally referred to as "pocket cruisers". Not all vessels stop in PNCIMA ports as many travel directly to other ports such as Alaska or Vancouver. For example, in 2005, of the 300 large cruise vessels transiting the PNCIMA region, only 49 stopped at the port of Prince Rupert (MacConnachie et al. 2007). Other ports of call for the pocket cruisers include Bella Coola, Port Hardy, and Alert Bay (MacConnachie et al. 2007).

It has been estimated that a cruise ship carrying 3,000 people for one week can produce 7.3 tonnes of garbage, 3.8 million litres of wastewater, 800,000 litres of sewage, and 95,000 litres of oil-contaminated water (DSF 2007). Little information is available on the impacts of the cruise industry on the B.C. marine environment, and specifically the PNCIMA.

The cruise industry is estimated to be worth $500 million to the B.C. economy (MacConnachie et al. 2007).

6.1.3 TANKERS

There is an industry Code of Practice that has established a voluntary tanker exclusion zone of 50 nautical miles from the coast, which results in most traffic carrying liquid gas, petroleum products, and vegetable oils transiting outside the PNCIMA (MacConnachie et al. 2007). Those that are bound for the ports of Prince Rupert or Kitimat use maritime Traffic Separation Scheme in Hecate Strait.

6.1.4 SHIPPING AND TRANSPORT POTENTIAL RISKS

Perhaps the one of the most widespread concerns over marine shipping is that of an oil or other harmful substance spill occurring near to land or in highly valued habitat. This risk not only increases with the amount of ship traffic, but also with the type of vessel. Over the next 15 years, container volumes are expected to increase some 300 per cent, bulk cargo shipments 25 per cent, and cruise ship traffic 20 to 25 per cent (DSF 2007). British Columbia will also allow single-hulled oil tankers to operate in coastal waters until 2015 (DSF 2007). This raises serious concerns over the probability of a catastrophic spill of harmful materials.

Passenger ferries that operate between the mainland and numerous island destinations throughout the province are also a significant concern. Based on the current ferry schedules and routes, this risk is considerably lower within the PNCIMA than other areas in the province.

The waterways of British Columbia are highways of commerce (Figure 8) and transportation for the residents of this province. We must ensure that these marine highways remain safe and clean for all coastal residents – human and otherwise.

Figure 9. Shipping Traffic in Inshore B.C.

6.2 OIL AND GAS EXPLORATION

The pursuit of oil and gas in B.C.'s offshore waters is highly controversial. Federal and provincial moratoria on offshore oil and gas exploration have been in place since 1972. In February 2007, the province of British Columbia released its *BC Energy Plan: A Vision for Clean Energy Leadership*, announcing that the province was to be at the forefront of environmental and economic leadership in energy policies. The highlights of the plan affirm the commitment to promoting competitiveness to attract oil and gas development while working with the federal government, communities, and First Nations to scientifically and responsibly advance offshore development (MEMPR 2007b).

6.2.1 BC ENERGY PLAN

The *BC Energy Plan* was aimed at enhancing the 2004 Oil and Gas Environmental Stewardship Program by improving existing efforts to manage waste and preserve habitats. It is also aimed at removing the moratorium in light of the improved technology of recent decades, with conservation, energy efficiency, and environmental and socially responsible management as key components (MEMPR 2007a). A number of non-governmental organizations, including the Living Oceans Society and the David Suzuki Foundation, question whether the potential environmental costs outweigh the potential economic benefits.

According to the *BC Energy Plan*, British Columbia's oil and gas sector has grown to become a major force in the provincial economy, employing tens of thousands people (MEMPR 2007a). In 2005, investment in the oil and gas sector was $4.6 billion, with provincial economic gains of approximately $1.95 billion annually or seven per cent of the province's annual revenues (MEMPR 2007a).

The *BC Energy Plan* identifies key objectives for the development of offshore oil and gas projects as:

- ◊ Continue to work to lift the federal moratorium on offshore exploration and development and reiterate the intention to simultaneously lift the provincial moratorium.
- ◊ Work with the federal government to ensure that offshore oil and gas resources are developed in a scientifically sound and environmentally responsible way.
- ◊ Participate in marine and environmental planning to effectively manage marine areas and offshore oil and gas basins.
- ◊ Develop and implement a comprehensive community engagement program to establish a framework for a benefits-sharing agreement resulting from offshore oil and gas development for communities, including First Nations (MEMPR 2007a).

The *BC Energy Plan* also has objectives to establish baseline data and develop risk-mitigation plans for environmentally sensitive areas. It is anticipated that this will build on the work of the Oil and Gas Environmental Stewardship Program as that had two components: the Environmental Policy Program and the Environmental Resource

Information Project. The former was aimed at identifying and mitigating environmental issues in the petroleum sector focusing on policy development in environmental waste management, habitat enhancement, planning initiatives, wildlife studies for oil and gas priority areas, and government best-management practices (MEMPR 2007a), whereas the latter was aimed at collecting the baseline environmental data (MEMPR 2007a).

6.2.2 HYDROCARBON DEPOSITS

Hydrocarbons are organic, naturally occurring chemical compounds composed of hydrogen and carbon that are used as fuel. Petroleum is a familiar hydrocarbon. Interest in the hydrocarbon potential of the PNCIMA dates back several decades, with the first wells drilled in 1913 (MacConnachie et al. 2007) and Shell Oil Ltd. and Chevron conducting extensive seismic surveys in the 1960s and 1970s (RSC 2004).

The largest hydrocarbon deposits in British Columbia are believed to be beneath the seafloor of Queen Charlotte Basin (MacGillivray 2007). The Geological Survey of Canada estimates the Queen Charlotte Basin could contain 25.9 trillion cubic feet of natural gas and 9.8 billion barrels of oil (Phelan 2007). In 2004, these resources were valued at $110 billion by the Royal Society of Canada Expert Panel in *Report on Science Issues Related to Oil and Gas Activities, Offshore British Columbia* (Phelan 2007).

This clearly has the potential for a significant impact on the economy of the PNCIMA. However, the development of hydrocarbon resource extraction also has the significant potential for serious disruption or destruction of the marine environment both within PNCIMA and beyond its borders in the event of a major spill. Any future extraction of hydrocarbon resources from the B.C. coast must be carried out within an ecosystem-based integrative framework that mitigates negative consequences such as increased noise levels from ships, sonar and seismic activity, physical disturbance related to increased ship traffic, and habitat destruction from seafloor installations and drilling.

NATURAL GAS HYDRATES

Considerable work has been done globally, and in Canada's Arctic and West coasts, on the presence and abundance of natural gas hydrates as a potentially clean energy source that occurs in very large reserves (Hyndman and Dallimore 2001). Natural gas hydrates are composed of a chemical known as clathrite and can be considered a modified ice structure enclosing methane and other hydrocarbons (Dutch 2003).

Extensive natural gas hydrate is found beneath some continental slopes at all latitudes, and presence of the hydrate was confirmed by a bottom-trawl fishing vessel off the west coast of Vancouver Island that inadvertently dredged several tonnes of hydrate to its deck (Hyndman and Dallimore 2001).

The largest reserves of natural gas hydrate appear to be outside the boundary of PNCIMA, but this issue should remain pertinent to the management of the region if new reserves are located, or transport and/or refinement of the gas within PNCIMA becomes a viable future option.

6.2.3 POTENTIAL RISKS AND MITIGATIVE APPROACHES

Little is known about the specific behavioural, social, and physiological effects on marine wildlife within the PNCIMA with regard to the activities associated with oil and gas exploration. To begin to address this issue, the University of Victoria, BC Offshore Oil and Gas Team, and JASCO Research Ltd. co-sponsored a thesis project for predicting air-gun survey sound levels in the marine environment, and specifically applied the findings to the Queen Charlotte Basin (MacGillivray 2006). Based on the results of the sound-transmission modelling, received levels of underwater sound are expected to vary with location of survey vessel, water depth, geoacoustic environment, water profile, season, and azimuthal direction (MacGillivray 2006, 2007).

The environmental implications of seismic surveys have been studied in various localities around the world. A comprehensive study with sea trials conducted in Australian waters found a range of responses of marine wildlife (McCauley et al. 2000). For example, humpback whales maneuvered to keep the seismic vessel from passing within three to 12 kilometres, depending on sex, behaviour, and habitat type. Interestingly, not all behaviour was avoidance, as male humpbacks were attracted to a single air-gun signal (McCauley et al. 2000). Studies of sea turtles, fish, and squid in captivity indicated an avoidance or alarm response at distances of two to five kilometres (McCauley et al. 2000).

Adherence to the principles of ecosystem-based management is likely to reduce the potential for negative consequences from oil and gas exploration and extraction. According to Phelan (2007), the Ministry of Energy, Mines and Petroleum Resources is evaluating other jurisdictions to determine appropriate development protocols for the Canada's West Coast. The Offshore Oil and Gas Branch is weighing the risks and benefits of such developments while developing comprehensive fiscal and regulatory regimes, and pursuing the advancement of scientific knowledge (Phelan 2007). The Nisga'a Nation signed a Protocol Agreement with the province in 2005 to honour a collaborative approach to development in the area.

6.2.4 CANADA'S STATEMENT OF PRACTICE

In Canada, a Statement of Practice with regard to mitigation of environmental noise generated by seismic activities in the marine environment was developed based on scientific findings. An impact-evaluation framework was developed for marine fish, invertebrates, zooplankton, eggs, fish and invertebrate larvae, turtles, and marine mammals (DFO 2004b). The Statement of Practice recognizes that the biological and ecological effects of marine seismic are expected to be low, unknown, or not understood with regard to fish, invertebrates, and marine mammals with the following exceptions:

a) If a behavioural response dispersed spawning aggregations or caused a lasting deflection from migratory paths.
b) If marine mammals were displaced from feeding areas, with no available alternatives.
c) If marine mammals were displaced from breeding or nursery areas.

d) If marine mammals were diverted from migratory paths with no available alternatives or if substantially greater physical costs arose from the diversion (DFO 2004b).

Furthermore, data are generally insufficient to evaluate the potential damage to eggs and larvae; however, modelling exercises indicate that the magnitude of egg or larvae mortality would be below that which would have a population-level effect, and it is unlikely that marine turtles are more sensitive to seismic sound than cetaceans or some fish (DFO 2004b). The scientific information for which the Statement of Practice was based recognizes that the spectrum of potential consequences is extremely broad and that general risks are often poorly quantified or even known (DFO 2004d).

6.2.4.1 GOVERNMENT RESPONSIBILITY

In British Columbia, the Ministry of Energy, Mines and Petroleum Resources is responsible for developing environmentally and socially responsible oil and gas management plans, as well as creating policy and fiscal frameworks for oil and gas development.

The Oil and Gas Commission (OGC) is a Crown agency that regulates oil and gas exploration and development, ensures responsible provincial standards, ensures compliance through inspection, and responds to complaints and emergencies. The Ministry of Environment regulates the discharges from oil and gas facilities through permits, and regulates the management of hazardous wastes. Finally, the Environmental Assessment Office (EAO) is the neutral provincial agency that coordinates the impacts of major development proposals; considers the environmental, economic, social, heritage, and health effects; and grants Environmental Assessment certificates (MEMPR 2007c).

The many agencies, offices, and commissions that oversee the nuances of oil and gas in British Columbia epitomize the need for a management framework based on a cooperative working regime if future exploration and exploitation becomes a reality. Defining and understanding the associated responsibilities will help ensure accountability for actions in the future. If spills occur within the PNCIMA, they could have serious deleterious consequences to most marine wildlife, including plankton, benthos, fish (both commercially and non-commercially important), seabirds, and marine mammals.

6.3 POLLUTION

Coastal development also generates spin-off impacts to the environment. Under the Constitution Act of 1867, the federal government is responsible for the oceans, including pollution that originates at sea (Peterson et al. 2005). However, pollution that originates on land is primarily the responsibility of the provinces (Peterson et al. 2005). All industries generate some level of pollution. This is another example of how ecosystem-based management that incorporates integration of responsible agencies, concerned citizens, and stakeholders may lead to effective strategies to battle a growing problem.

6.3.1 PLASTIC DEBRIS

Perhaps the most visible form of marine pollution is discarded plastic debris (Figure 9), due in part to its widespread use, industrially selected longevity, and buoyant characteristics. Most of the global marine litter is composed of plastic, and pollution by plastic debris constitutes a major threat to marine life (Derraik 2002). Proportionately, plastics make up between 60 and 80 per cent of the total marine debris (Gregory and Ryan 1997).

Sources include coastal municipality outfalls, land-based industrial areas, aquaculture facilities, commercial shipping vessels, merchant ships, recreational vessels, fishing vessels, rivers, and careless beach-goers (Horseman 1985, Pruter 1987, Wilber 1987, Cawthorn 1989, Williams 1989, Derraik 2002).

Figure 10. Plastic Fishing Debris on a Cobble Beach

Image copyright: Chris Hall

Current measures to reduce plastic debris pollution must include reducing and eliminating new sources, but also removing the historically vast amounts of plastic pollution dumped into the world's oceans. Horseman (1985) estimated that merchant ships alone were responsible for the daily dumping of 639,000 plastic containers in the world's oceans.

6.3.2 GHOST FISHING

Modern fishing nets and lines are often made of strong, durable, flexible plastic materials that persist in the environment (Figure 9). Lost or abandoned derelict gear continues to fish, regardless of whether it is manned, floating in the water column, or resting on the sea floor. Since plastics are designed to last, the fishing gear can effectively fish for long periods of time. Once the caught, deceased animals decompose and are scavenged, the gear continues to "fish". This "ghost fishing" continues around the world, and though no studies have been directly related to the PNCIMA area, it is likely that this is a real factor for the seabirds, fish, marine mammals, and turtles that utilize North Coast waters.

6.3.3 PLASTIC PELLETS

Another source of plastic pollution that is much less visible are the small plastic pellets or granules used in the plastics production, which range from two to six millimetres in size (Derraik 2002). Plastic "scrubbers" are another source of non-visible plastic pollution. These are derived from hand cleaners, cosmetics, and cleaning products (Derraik 2002). These "scrubbers" are tiny plastic abrasives that have replaced more natural abrasive products such as ground shells or pumice.

6.3.4 THREATS ASSOCIATED WITH PLASTIC POLLUTION

No marine wildlife are immune to the deleterious effects of plastic pollution. Plankton, fish, seabirds, turtles, and marine mammals can suffer the consequences of ingestion (Figure 10) or entanglement. Fish have been found to ingest plastic cups (Anon 1975). Blight and Burger (1997) found plastic particles in the stomachs of eight of 11 seabird species by-caught in the North Pacific Ocean. In British Columbia, a dead juvenile harbour porpoise was found to have ingested plastic debris (Baird and Hooker 2000).

Ingestion of plastic materials can lead to a myriad of negative consequences, including internal injury, blockage of gastric enzyme secretions, diminished feeding stimulus, intestinal blockages, lowered steroid hormone levels, delayed ovulation, reproductive failure, and death (Azzarello and Van-Vleet 1987, Derraik 2002). Plastics can also serve as a vehicle for the ingestion of other toxic chemicals such as polychlorinated biphenyl ethers (PCBs) (Ryan et al. 1988, Bjorndal et al. 1994). Such contaminants can disrupt natural hormonal processes.

Animals entangled in plastic debris can suffer injury and infection as the animal grows into the material. Entanglement can lead to impaired swimming or prey-acquisition abilities, increased susceptibility to predation, infection, and death. Ironically, as the longevity of plastic often exceeds that of the animal, once the animal dies and decomposes, the plastic is available to entangle another victim (Mattlin and Cawthorn 1986, Derraik 2002).

Globally, at least 267 species have been recognized to suffer the deleterious effects of marine debris, and this number is thought to be an underestimate as the effects to benthos through ingestion, habitat alteration, habitat loss, and altered gas exchange between sea water and sea floor sediments are less well understood (Laist 1997).

Furthermore, plastic debris can serve as a vehicle for the introduction of alien or invasive species (Derraik 2002) as the floating material becomes a floating substrate or shade.

Figure 11. Anthropogenic Mortality of an Eel Having Ingested Derelict Fishing Gear

Image copyright: Chris Hall

6.3.5 CHEMICAL CONTAMINANTS

Toxic pollutants or contaminants affect all marine life to various extents, but killer whales and other long-lived marine mammals are considered especially vulnerable to accumulating chemicals known as persistent organic pollutants (POPs). Polychlorinated biphenyls (PCBs) and dichlorodiphenyltrichloroethane (DDT) have been found in measurable quantities in B.C. killer whales. High levels of PCBs have been observed in resident killer whales, with those in the south having the highest concentrations (Grant and Ross 2002). Other chemical pollutants that have been measured from the tissues of B.C. killer whales include dioxins, furans, polybrominated diphenyl ethers (PBDEs), and polycyclic hydrocarbons (PAHs). Both point and non-point sources exist in British Columbia for the dispersion of toxic pollutants; however, atmospheric transport of contaminants has been found to be of great importance for POPs, which can enter the atmosphere through burning fossil fuels, municipal and industrial incineration, and through volatilization from water surfaces (Grant and Ross 2002). Exposure to PCBs and POPs has been linked to a variety of health disorders in marine mammals, including endocrine disruption, reproductive impairment, immunotoxicity, and skeletal malformations (Grant and Ross 2002).

6.4 MARINE AND COASTAL DEVELOPMENT CONCLUSIONS AND RECOMMENDATIONS

A long-term vision for the PNCIMA region would help guide mitigative strategies, including exploration of alternative energy sources. As shipping increases in PNCIMA waters, the effects and consequences will become more significant. Vessel traffic is likely to increase, the potential for oil and gas exploration is plausible, and the levels of pollution and contamination will increase as well. Plastics have been integrated into all aspects of human society and consequently have become a ubiquitous feature of the marine environment. A reduction strategy is appropriate. Levels of mortality due to anthropogenic marine plastic debris within the PNCIMA (or the rest of British Columbia) are not known, but this injury or mortality is entirely avoidable.

The plastic debris found within the PNCIMA has both domestic and non-domestic sources. Regardless of the origin, efforts to reduce current levels of marine plastic debris are imperative as these objects pose a lethal threat to marine wildlife. We cannot keep polluting the ocean.

Recommendations:

1. Provide funding for a comprehensive analysis of vessel impacts, including the expanding cruise industry.
2. Explore the viability of alternative energy sources.

3. Develop an integrative ecosystem-based management approach for oil and gas exploration.
4. Develop a coast-wide clean-up plan that includes beaches, waterways, and sea floors.
5. Expand coastal recycling capabilities.
6. Encourage the development of biodegradable or photodegradable products.
7. Challenge chemical manufacturers to develop marine-animal-friendly compounds.

7.0 LEGISLATIVE COMPONENTS

7.1 THE CONSTITUTION ACT

Canada's national system of governance is legislated as the Constitution Act (1867, 1982), which defines the roles of federal and provincial governments and provides direction for the general governance of the country. The Constitution Act outlines the delineation of power of the government with respect to all matters pertaining to Canada and its citizens. Section 91 of the Constitution Act pertains to the management of the PNCIMA, as it articulates federal jurisdiction of 29 subjects that includes naval service and defence, navigation and aids to navigation, shipping, sea coast, and inland fisheries.

Section 92 is also relevant because it pertains to the allowable legislative powers held by provincial authorities, including intra-provincial shipping, international shipping, and all matters that are purely provincial in nature (1867, 1982). Section 92A outlines the provincial authority to create legislation pertaining to non-renewable resources that includes:

a) Exploration for non-renewable natural resources.
b) Development, conservation, and management of non-renewable natural resources and forestry resources in the province, including laws in relation to the rate of primary production from these resources.
c) Development, conservation, and management of sites and facilities in the province for the generation and production of electrical energy (1867, 1982).

Section 92A also pertains to the provincial export and system of taxation of non-renewable resources or electricity within Canada (1867, 1982).

7.2 OCEANS ACT

Ocean governance in Canada is driven by the Oceans Act, enacted in 1996, which requires consideration of all human activities that may impact or threaten the ocean. The Oceans Act and the Fisheries Act have been described as the guiding legislation for the DFO (Hearn 2007). These articles charge the Minister of Fisheries and Oceans with leading oceans management, including the management of fisheries, habitat, and aquaculture; and providing coast guard and hydrographic services on behalf of the Government of Canada.

The Oceans Act (1996) preamble recognizes that

a) The three oceans, the Arctic, the Pacific, and the Atlantic, are the common heritage of all Canadians.
b) Parliament wishes to reaffirm Canada's role as a world leader in oceans and marine-resource management.
c) Canada promotes the understanding of oceans, ocean processes, marine resources, and marine ecosystems to foster the sustainable development of the oceans and their resources.
d) Canada holds that conservation, based on an ecosystem approach, is of fundamental importance to maintaining biological diversity and productivity in the marine environment.
e) Canada promotes the wide application of the precautionary approach to the conservation, management, and exploitation of marine resources in order to protect these resources and preserve the marine environment.
f) Canada promotes the integrated management of oceans and marine resources.

The Oceans Act clearly identifies the Minister of Fisheries and Oceans as the person responsible for collaborating with other ministers, boards, and agencies of the Government of Canada; provincial and territorial governments; affected aboriginal organizations; coastal communities; and other people and bodies, including those established under land-claims agreements.

The Oceans Act is partitioned in three sections. Part I identifies Canada's maritime zones, and identifies the waters over which Canada has sovereignty, including the Exclusive Economic Zone. Part II pertains to ocean management and Section 30 highlights that a national strategy will be based on principles of sustainable development, integrated management, and the precautionary principal. Part III outlines the powers, duties, and functions of the minister, including coast guard services and marine science (1996).

Section 14 of Part I articulates Canada's rights to explore and exploit and conserve and manage natural resources (living or non-living) of the waters superjacent to the seabed and of the seabed and its subsoil (1996). Section 14 also identifies Canada's rights to marine scientific research and protection and preservation of the marine environment (1996). Sections 17 and 18 pertain to Canada's sovereign rights to the continental shelf through physical identification and delineation, and for the exploration and exploitation of mineral and other non-living natural resources, as well as sedentary living resources (1996). Court jurisdictions and regulations are also found in Part I of Canada's Oceans Act.

Marine Protected Area definitions, criteria, and regulations are laid out in Part II, Sections 35 and 36. Subsequent sections of Part II articulate the procedures, fines, and enforcement authority if the Oceans Act is contravened.

The Oceans Act is based upon three principles:

1. Sustainable development of ocean resources.
2. Precautionary approach as part of all operations.
3. Integrated management of ocean resources and activities (DFO 2002).

The Minister of Fisheries and Oceans is responsible for developing and implementing a national strategy for the management of estuarine, coastal, and marine ecosystems (1996).

In July 2002, Canada's Oceans Strategy was released as the national policy for implementing the Oceans Act.

7.2.1 OCEANS STRATEGY AND ACTION PLAN

As part of the Oceans Strategy, the government announced the development of the Oceans Action Plan (OAP) in 2004. The February 2005 budget included $28 million dollars over two years for this initiative. The Oceans Action Plan has four main components:

1. International leadership, sovereignty, and security.
2. Integrated oceans management for sustainable development.
3. Health of the oceans.
4. Ocean science and technology.

The OAP also highlights the need for integrated management for sustainable development of marine resources. The OAP in part led to the development of the PNCIMA, and identification of EBSAs.

On September 18, 2004, Minister of Fisheries and Oceans Geoff Regan (DFO) and British Columbia Minister of Agriculture, Food and Fisheries John van Dongen signed the Canada-B.C. *Memorandum of Understanding (MOU) Respecting the Implementation of Canada's Oceans Strategy on the Pacific Coast*, which included a framework for the joint development of sub-agreements on implementation measures for:

- ◊ A marine protected areas framework.
- ◊ Coastal planning and integrated oceans management planning.
- ◊ An integrated ocean information management system.
- ◊ Indicators for oceans management and state of the environment reporting.
- ◊ Streamlining and harmonizing regulatory decision-making for aquaculture.
- ◊ Sharing of information related to offshore oil and gas resources (DFO 2004c).

The Oceans Strategy commits to the use of ecosystem-based management, but some questions remain regarding the managerial implementation of this approach with regard to specific maritime activities such as shellfish aquaculture (Deal 2005).

7.2.1.1 INTEGRATED MANAGEMENT

Many challenges exist regarding the promises outlined in the Oceans Strategy for ecosystem-based management. However, a collaborative approach focusing on what needs to be accomplished rather than what was not upheld in the past is more likely to expedite realization of those goals.

The integrated management approach to be used in the PNCIMA is to:

1. Identify ocean resources and economic and other opportunities through an ecosystem overview and marine-use analysis.

2. Identify the interests and priorities of community, First Nation's, industry, and economic development of the region.

3. Assess ecosystems to determine current and emerging threats to ecosystem health and determine a broad system of ecosystem and socio-economic objectives for planning and management in response to those threats.

4. Identify the requirements and priorities for monitoring and research in support of the Integrated Management Plan.

5. Identify priorities and strategies for conservation (Hillier and Gueret 2007).

Adherence to the principles of integrated management in the PNCIMA will provide greater assurances that both resources and local communities will live long and prosper. Furthermore, several key pieces of legislation in Canada are designed to protect and manage natural resources.

7.3 SPECIES AT RISK ACT

The Species at Risk Act became law in 2003 and is aimed at providing federal tools to prevent wildlife from becoming extinct, and in the case of at risk species to provide a recovery framework. This act was intended to provide protection to both plant and animal species that are considered at risk anywhere in Canada. The goal of the Act is to prevent Canadian indigenous species, subspecies, and distinct populations from becoming extirpated or extinct, to provide for the recovery of endangered or threatened species, and to encourage the management of other species to prevent them from being considered at risk (2003). This act resulted from the Canadian Biodiversity Strategy, developed in response to the United Nations Convention on Biological Diversity. Because of the Species at Risk Act's broad nature, DFO shares responsibility with Environment Canada and Parks Canada.

The process to get listed under the SARA is initiated through wildlife monitoring. Every five years the federal government is to produce an overview of Canadian wildlife in a report called *The Wild Species*. This was created under the auspices of the Accord for the Protection of Species at Risk, which was established in 1996 by provincial, territorial, and federal ministers responsible for wildlife, with the goal of preventing species in Canada from becoming extinct or extirpated because of human impact (CWS 2006). General status assessments are used to classify species into 10 categories: extinct, extirpated, at risk, may be at risk, sensitive, secure, undetermined, not assessed, exotic, and accidental (CWS 2006). As the total number of species in Canada is estimated at 70,000 (CWS 2006), considerable work must be done to fulfill these wildlife protection goals. According to the 2005 *Wild Species* report, the major threats affecting Canadian marine wildlife include over-fishing, pollution, climate change, interactions between wild and farmed species (including competition for food and habitat, interbreeding, and introduction of disease and parasites), habitat degradation, and destruction and loss.

For species considered potentially at risk, a species status report is prepared. COSEWIC experts assess each species review to assign a conservation status. For SARA-listed species, a recovery plan and subsequent action plan must be developed with the goal of stopping or reversing the factors contributing to the conservation concern. The goal is to provide the means for recovery for species at risk due to human activity, and to ensure through sound management that species of special concern do not become endangered or threatened (2003). Prohibitions under SARA include killing, harming, harassing, capturing, or taking species at risk, and destroying their critical habitats (2003). As of June 3, 2008, the SARA registry reported that for Canada:

- One recovery strategy was under a 30-day comment period.
- 145 recovery strategies were delayed.
- 66 were final.
- Six delayed in the finalization.

Of the finalized recovery strategies, seven pertain to the waters of the PNCIMA (blue, fin, and sei whales; leatherback turtles; northern abalone, northern and southern resident killer whales, sea otters, and transient killer whales) (SARA 2007).

Other legislation designed to protect Canadian marine species from human activity that threatens their survival includes the National Marine Conservation Areas Act (2002), Canada Wildlife Act (1994), and the Fisheries Act (1985).

7.4 NATIONAL MARINE CONSERVATION AREA ACT

According to the Canada National Marine Conservation Areas Act, a lack of scientific certainty is not reason enough to postpone preventive measures where there are threats of environmental damage (2002). This is encouraging, as many species have yet to begin the process for SARA protection through assessment by the COSEWIC.

7.4.1 SCOTT ISLANDS MARINE WILDLIFE AREA

The Canadian Wildlife Service (CWS) of Environment Canada is leading an initiative to establish a Marine Wildlife Area (MWA) in the waters of the Scott Islands (CWS 2007a). This remote archipelago is composed of five islands, including Triangle Island, located in southern PNCIMA waters.

The goal is to federally protect the critical foraging area used by the seabirds that occupy the Scott Islands (CWS 2007a). This area is provincially recognized as an Ecological Reserve. These islands, extending in a line westward from 10 to 46 kilometres offshore of Cape Scott, sustain over two million breeding seabirds – the largest concentration of breeding seabirds in the eastern North Pacific south of Alaska, and the most important colony in British Columbia (CWS 2007a). This area supports the world's largest breeding population of Cassin's auklet (1.1 million), and significant breeding populations of rhinoceros auklet (82,000), tufted puffins (52,000), and common murres (8,200) (Rodway 1991).

The Scott Islands area has already been identified as a globally Important Bird Area (IBA) by Birdlife International (Clarke and Jamieson 2006a). The MWA Study Area also supports significant seasonal populations of pelagic bird species such as the black-footed albatross, an internationally listed species at risk.

The proposed Scott Islands Marine Wildlife Area will be the first marine area designated under the Canada Wildlife Act. It covers approximately 2,700,000 hectares of deep water west of the Pacific continental shelf and slope (CWS 2007a). The formation of this protected area would serve to safeguard seabird foraging habitats for species such as Cassin's auklet, rhinoceros auklet, and tufted puffin, as well as the breeding habitats for an estimated 2.2 million seabirds (CWS 2007a). This area also provides habitat for nationally significant populations of Brandt's cormorant, pelagic cormorant, pigeon guillemot, glaucous-winged gull, leach's storm petrel, and fork-tailed storm petrel (Clarke and Jamieson 2006a).

Furthermore, the protection of this region may have conservation consequences for a variety of other marine species recognized by the COSEWIC, including:

- ◊ Marbled murrelet (threatened)
- ◊ Ancient murrelet (special concern)
- ◊ Blue whale (endangered)

- ◊ Sei whale (endangered)
- ◊ Fin whale (special concern)
- ◊ Offshore killer whales (special concern)
- ◊ Transient killer whales (threatened)
- ◊ Northern resident killer whales (threatened)
- ◊ Sea otter (threatened)
- ◊ Short-tailed albatross (threatened)
- ◊ Pink-footed shearwater (threatened) (CWS 2007a)

This initiative supports Environment Canada's responsibilities under the Migratory Birds Convention, Species at Risk Act, Canadian Conservation of Biodiversity Strategy, North American Bird Conservation Initiative, Important Bird Areas Initiative, draft B.C. Marine Protected Areas Strategy, national and regional seabird plans, and the Pacific Marine Heritage Legacy Program (CWS 2007a). This initiative also lends to supporting an ecosystem-based management integrative approach as a large number of species would likely benefit from such a designation and cooperation among agencies would be required to oversee the implementation of a Marine Wildlife Area.

7.5 FISHERIES ACT

The Fisheries Act (1985) provides for the management and protection of harvestable fish and shellfish stocks, and affords the enactment of spatial and temporal fishing closures if conservation risks are determined. The Fisheries Act also protects marine plants. This legislation delineates gear types, habitat protection, pollution prevention, prohibitions, and penalties for the contravention of the Act (1985). Commercial, recreational, and aboriginal fishing in British Columbia is governed through this act and is administered by Fisheries and Oceans Canada. The Pacific Fishery Regulations (DFO 1993) regulate fisheries within Pacific waters and apply only to commercial fisheries, fishing for tuna from Canadian vessels on the high seas, and harvesting marine plants from Canadian fisheries waters outside of the geographical limit of the province. Recreational fishing, aquaculture, whaling, sealing, or fishing from a foreign fishing vessel are not covered.

The marine and freshwater recreational fishery is regulated through B.C. Sport Fishing Regulations (1996) (DFO 2007k). These regulations do not cover fishing within National Parks, and freshwater fishing is also subject to provincial regulations under the Wildlife Act (DFO 2007k). The killing of whales and seals is managed through the Marine Mammal Regulations within the Fisheries Act.

The DFO manages fishing of saltwater salmon, freshwater salmon, finfish, invertebrates, and shellfish through the Fisheries Act and imposes regional species, area, and time-specific fishery regulations. Additionally, temporary and permanent closures are enacted when deemed necessary for species protection or for coastal resident protection if contamination exceeds threshold limits. Annual licences must be purchased from the federal government for legal fishing in Canada. Regional DFO offices and their respective fisheries officers are responsible for enforcement in B.C.

7.5.1 FISHERIES ACT ENFORCEMENT SUCCESS

In February 2006, fisheries officers led the largest poaching-related arrest in Canada's history. Three men were arrested in British Columbia with an estimated 11,000 dying abalone (1,120 kilograms) and received record penalties for their crimes, including house arrest, monetary fines totalling $30,000, forfeiture of equipment totalling $183,000, and a scuba-diving ban (DFO 2007h).

In 2005, three northern abalone cases led to convictions for all involved. Recent fines have been $25,000 and $35,000 (2002, CWS 2004). These fines reflect the serious extinction risk for northern abalone in British Columbia waters.

7.6 CANADA SHIPPING ACT

The Canada Shipping Act regulates all aspects of maritime vessel traffic. Some of the objectives of the Canada Shipping Act are:

- ◊ Protect the health and well-being of individuals, including the crews of vessels, who participate in marine transportation and commerce.

- ◊ Promote safety in marine transportation and recreational boating.
- ◊ Protect the marine environment from damage due to navigation and shipping activities.
- ◊ Ensure that Canada can meet its international obligations under bilateral and multilateral agreements with respect to navigation and shipping.
- ◊ Establish an effective inspection and enforcement program (2001).

Fisheries and Oceans Canada and Transport Canada are the governmental bodies that enforce this legislation.

7.7 NAVIGABLE WATERS PROTECTION ACT

This act (Canada 1985) protects the public right of navigation by a vessel (motorized and non-motorized) in Canadian waters and regulates the construction of structures that may impede or complicate navigation. Transport Canada, DFO, and the Coast Guard are all involved in the implementation of this act.

7.8 CONSOLIDATED ACTS AND REGULATIONS

In British Columbia, the following Consolidated Acts and Regulations govern provincial parks and protected areas:

- ◊ Land Act
- ◊ Wildlife Act
- ◊ Protected Areas of British Columbia Act
- ◊ Environmental Assessment Act
- ◊ Park Act and Park and Recreation Area Regulations
- ◊ Ecological Reserve Act
- ◊ Islands Trust Act
- ◊ Drinking Water Protected Act and Drinking Water Protection Regulations

- ◊ Water Act
- ◊ Waste Management Act
- ◊ Bill 15 - Miscellaneous Statutes Amendment Act, 2006 (See section 31, Protected Areas of British Columbia Act)
- ◊ Bill 28 - Park (Conservancy Enabling) Amendment Act, 2006 (BCParks 2007)

It is clear that many statutes pertain to the protection of wildlife and regulation and management of human activity as it may affect the lives and habitats of particular species. However, because of the apparent complexity associated with protecting species and their habitats, it is no surprise that B.C. has few marine protected areas. In 1998, the commitment of Fisheries and Oceans Canada, Parks Canada, Environment Canada, and the Province of British Columbia to develop a network of Marine Protected Areas on Canada's Pacific coast was outlined in *A Marine Protected Areas Strategy for Canada's Pacific Coast*. On December 8, 1998, the Minister of Fisheries and Oceans announced that Bowie Seamount in the PNCIMA region would be a pilot Marine Protected Area. The Bowie Seamount was designated an MPA on April 19, 2008.

Many coastal residents are concerned about Canada's ability to protect the marine environment while enabling local communities that rely on the sea. Peterson et al. (2005) evaluated the effectiveness of the DFO in meeting its conservation mandate in the Pacific region. Their assessment both commends and criticizes the ability of Pacific region DFO to achieve its mandate with its 2,200 staff and budget of approximately $290 million. Peterson et al. (2005) found increasing proportions of the budget committed to salaries, leaving fewer dollars available for fieldwork and enforcement. On a positive note, they observed that the DFO has made some significant paradigm shifts toward effective conservation, including public accountability (instead of to Parliament), increased openness, and sustainable management (instead of extractive) (Peterson et al. 2005). Eight possible challenges to meeting the conservation mandate were identified: 1) inadequate scientific information, especially for fisheries and habitat management, and enhancement and restoration; 2) lack of transparency and accountability with regard to individual fisheries and the public; 3) budgetary issues including decreasing allocations for conservation programs, lack of continuity, short-term surges; 4) political influence; 5) external relations and shared responsibilities; 6) bureaucratic complexity; 7) conflicting, changing, and expanding mandates and direction; 8) weakness of enforcement (Peterson et al. 2005).

7.9 LEGISLATIVE CONCLUSIONS AND RECOMMENDATIONS

Canada has developed and implemented a broad range of national and provincial legislation designed to protect natural resources while still providing for energy production, transport, commerce, and recreation. Additionally, numerous international treaties and conventions are designed to internationally uphold the values of Canadians. In many cases, whether the apparent good intentions from Ottawa have transcended to coastal British Columbia as concrete actions remains uncertain. The shared and overlapping responsibilities among and within international, federal, provincial, and aboriginal governments has resulted in a complicated and multi-faceted system that requires an expert legal team to fully unravel the ownership of official obligations. In urban areas, another layer of lawmaking complexity is added with municipal governments.

Because of the apparent myriad of contemporary marine problems and challenges, it’s plausible that the system intended to protect and conserve natural resources may have become so unwieldy that its mechanisms run counter to the intended goals and objectives.

Recommendations:

1. Allocate federal funding in a way that reflects the increasing difficulties associated with marine conservation while allowing for significant long-term studies to be completed.
2. Align conservation mandates across federal, provincial, municipal, and aboriginal agencies where shared responsibility or common interest exists.
3. Provide enforcement divisions with the tools/funding required to effectively achieve their goals as related to the conservation mandate, and when shared responsibility exists encourage the responsible agency to adequately fund its

enforcement branch so that DFO officers are not hindered by jurisdictional or political boundaries.

4. Enforce existing legislation.

8.0 INTERNATIONAL OBLIGATIONS

Canada has a long-standing international commitment to the oceans resources. Historically, the emphasis was on ensuring Canada's share of the harvest, whereas more contemporary agreements have language directed at conservation and preservation of natural resources and biodiversity of the marine environment. Nevertheless, contemporary agreements are rarely purely altruistic and have consumptive resource use as the driving force.

8.1 INTERNATIONAL CONVENTION FOR THE REGULATION OF WHALING

International politics can greatly complicate the success of international agreements, especially in cases of trans-boundary species. An acute example of this comes from the 20th-century international whaling industry. In 1946, 15 nations, including Canada, signed the International Convention for the Regulation of Whaling to promote and maintain whale stocks. The signatory nations were aware of the potential for stock destruction and recognized that:

> " …Considering that the history of whaling has seen over-fishing of one area after another and of one species of whale after another to such a degree that it is essential to protect all species of whales from further over-fishing…" (ICRW 1946).

However, during the 1961-1962 whaling season, the highest global catches were reported, with the International Whaling Commission registering 66,900 large whales killed (Stoett 1997). This was 15 years after the ICRW was signed, which in its opening statements emphasized the potential for resource overexploitation. It was not for another nearly 20 years that the global moratorium on whaling was signed in 1986 by the member nations of the International Whaling Commission (IWC) (Stoett 1997). Though Canada was an original member nation in 1946, it withdrew its IWC membership in 1982. Thus, Canada did not participate in the implementation of the global moratorium. It was not successful resource management that initiated the global moratorium; it was a near complete eradication of the species targeted by this consumptive industry.

Fortunately, this example is an extreme case, but international politics certainly can influence the overall success of multinational agreements. International conventions that may affect the management of the PNCIMA include the following:

- ◊ Convention of the Prevention of Marine Pollution by Dumping Wastes and Other Matter
- ◊ Protocol to the International Convention for the Prevention of Pollution from Ships (MARPOL)
- ◊ International Convention for the Safety of Life at Sea
- ◊ International Convention for High Seas Fisheries of the North Pacific Ocean
- ◊ The United Nations Agreement for the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks
- ◊ Pacific Salmon Treaty
- ◊ Convention on Biological Diversity

8.2 INTERNATIONAL MARITIME ORGANIZATION

Canada joined the International Maritime Organizations (IMO) in 1948. The main task of the IMO is to develop and maintain a comprehensive regulatory framework for shipping. It includes safety, environmental concerns, legal matters, technical co-operation, maritime security, and the efficiency of shipping (IMO 2007).

8.2.1 INTERNATIONAL CONVENTION FOR HIGH SEAS FISHERIES OF THE NORTH PACIFIC OCEAN

In 1953, Canada ratified the International Convention for High Seas Fisheries of the North Pacific Ocean. This convention was signed by the three nations actively fishing the North Pacific: Japan, the United States, and Canada, and initiated the International North Pacific Fisheries Commission. This Convention was to promote and coordinate scientific studies related to fisheries resources of the North Pacific and to aid in their conservation (INPFC 1952).

8.2.2 INTERNATIONAL CONVENTION OF THE PREVENTION OF MARINE POLLUTION BY DUMPING WASTES AND OTHER MATTER

In 1972, the IMO tackled ocean pollution with the International Convention of the Prevention of Marine Pollution by Dumping Wastes and Other Matter (the London Dumping Convention or LDC) by delineating what types of pollution could and could not be dumped in various regions of the ocean. It covers accidental and operational oil pollution as well as pollution by chemicals, goods in packaged form, sewage, garbage, and air pollution (IMO 2007). The Protocol of 1978 relating to the 1973 Convention was adopted at a Conference on Tanker Safety and Pollution Prevention in February 1978 held in response to a number of tanker accidents in 1976-1977. The 1972 and 1978 Conventions were merged to create the MARPOL Convention (IMO 2007). The MARPOL Convention is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes (IMO 2007). MARPOL contains six authorative sections:

- Annex I Regulations for the Prevention of Pollution by Oil
- Annex II Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk
- Annex III Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form
- Annex IV Prevention of Pollution by Sewage from Ships
- Annex V Prevention of Pollution by Garbage from Ships
- Annex VI Prevention of Air Pollution from Ships (IMO 2007)

Annex V of MARPOL is the key international authority for controlling ship sources of marine debris and came into effect in 1988 (Ninaber 1997). It restricts at-sea discards of garbage and bans at-sea disposal of plastics and other synthetic materials such as ropes, fishing nets, and plastic garbage bags with limited exceptions (Pearce 1992). Annex V applies to all watercraft, including recreational vessels (Nee 1990).

These conventions are dynamic in nature and undergo periodic revisions in order to reflect current conditions and social attitudes. In 1996, a much more restrictive protocol was adopted to replace the 1972 convention. For the first time, the precautionary approach was introduced. The protocol also required that:

> "Appropriate preventative measures are taken when there is reason to believe that wastes or other matter introduced into the marine environment are likely to cause harm even when there is no conclusive evidence to prove a causal relation between inputs and their effects."

In 2006, amendments pertaining to carbon dioxide (CO_2) sequestration were made to the IMO 1996 Protocol (IMO 2007). The IMO's Intervention Convention affirms the right of a coastal state to take measures on the high seas to prevent, mitigate, or eliminate danger to its coastline from a maritime casualty, and the 1990 International Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC) provides a global framework for international co-operation in combating major incidents or threats of marine pollution (IMO 2007).

8.2.3 INTERNATIONAL CONVENTION FOR THE SAFETY OF LIFE AT SEA

Other IMO conventions include the International Convention for the Safety of Life at Sea, which is generally regarded as the most important of all international treaties concerning the safety of merchant ships. The first version was adopted in 1914, in response to the *Titanic* disaster (IMO 2007). This convention has been revised many times to keep current with new technologies.

8.3 CONVENTION ON INTERNATIONAL TRADE IN ENDANGERED SPECIES OF WILD FAUNA AND FLORA

On April 10, 1975, Canada ratified the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), an international agreement aimed at ensuring that the international trade in wild animals and plants does not threaten their survival. There are currently 172 parties to CITES (CITES 2007). Trade in wildlife is diverse, ranging from live specimens to a diversity of wildlife products, including food products, exotic leather goods, wooden musical instruments, timber, tourist curios, and medicines (CITES 2007). CITES affords protection to more than 30,000 species of animals and plants globally (CITES 2007). This convention may be increasingly relevant to the management of the PNCIMA region if exploitation of resources is not conducted in a sustainable manner. This convention is currently relevant to many of the whale, dolphin, porpoise, seal, bird, turtle, fish, and invertebrate species found within the PNCIMA.

8.4 UNITED NATIONS CONVENTION ON THE LAW OF THE SEA

Canada signed the United Nations Convention on the Law of the Sea in 1982 but did not ratify it until November 7, 2003. This convention articulates a comprehensive operating regime for order in all the world's oceans and seas, and for the use of ocean resources. The convention is a fairly encompassing document detailing the rights and responsibilities for territorial seas, innocent and transit passage, merchant and commercial vessels, warships and government vessels, archipelagic states, exclusive economic zones, continental shelf, high seas, conservation and management of living resources of the high seas, as well as many other legal aspects of maintaining order in the international oceans (UN 1982).

The United Nations Agreement for the Implementation of the Provisions of the Law of the Sea relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks sets out principles for the conservation and management of fish stocks and establishes that management must be based on the precautionary approach and the best available scientific information (UN 2007b). The agreement was adopted on August 4, 1995.

8.5 PACIFIC SALMON TREATY

The Pacific Salmon Commission negotiated the Pacific Salmon Treaty between Canada and the United States in 1985. The Commission aims to achieve two main goals:

- ◊ To conserve Pacific salmon in order to achieve optimum production.

- ◊ To divide the harvests so that each country reaps the benefits of its investment in salmon management (PSC 2007).

This treaty came into being because of the belief that U.S. fishermen were catching salmon that the Canadian fishermen believed belonged to them and vice versa. The treaty provided a framework for national equality with regard to the salmon resources, and bi-national cooperation for research and cooperation. Considering the plight of salmon stocks in Canada and the U.S. since this treaty was signed, its efficacy is questionable.

In 1997, Canada and British Columbia signed a Memorandum of Understanding. The Canada-B.C. Agreement on the Management of Pacific Salmon Fishery Issues is intended to manage the overlapping jurisdictional interest in this resource.

8.6 PACIFIC HAKE TREATY

The Pacific Hake Treaty was signed on November 21, 2003, by Canada and the United States for joint management of the trans-boundary Pacific hake stocks. The treaty outlines the portion of the Total Allowable Catch that each country is allowed. Under this international agreement, Canada is allowed 26.12 per cent, while the U.S. receives the remaining 73.88 per cent (DFO 2003c).

The purpose of this treaty is to manage sustainably the Pacific hake commercial harvest through the establishment of cooperative working agreements for the joint stewardship of trans-boundary stocks (DFO 2003c). The Pacific Hake Treaty establishes that resource management is based on the peer-review process and stock assessments. A five-member Joint Technical Committee (JTC) is charged with the latter task, which is then reviewed by a six-member Scientific Review Group (SRG)(DFO 2003c). This treaty outlines that the governments of both signatory nations are to receive management advice from an eight-member Joint Management Committee (JMC), which receives its scientific information from the SRG and JTC, as well as further input from an Advisory Panel (DFO 2003c). This treaty only applies to offshore hake stocks and does not include the inshore waters of the Georgia Basin or Puget Sound (DFO 2003a).

This international fishery makes use of mostly mid-water trawls in the offshore waters from April to November, and is worth an estimated $12 to $15 million to the Canadian economy (DFO 2003b). In 2002, Canada adopted a management plan that requires the entire Canadian harvest to be processed in on-shore processing plants (DFO 2003b). Most consumers in British Columbia are more familiar with the product, surimi or imitation crab, which results from the harvest and process of hake, rather than the fish itself.

8.7 CONVENTION FOR THE PRESERVATION OF THE HALIBUT FISHERY

This fishing industry treaty dates to March 2, 1923, and is significant to Canada as it was the first treaty signed independently from Britain (Smith 1926). As with other international management of exploited resources, this treaty was drafted and signed in response to declining commercially valuable stocks. The Convention for the Preservation of the Halibut Fishery was replaced by the Convention for the Preservation of the Halibut Fishery of the North Pacific Ocean and Bering Sea on March 2, 1953. The main objective of both conventions is the preservation of halibut stocks so that the fishery could operate under a management regime of maximum sustainable yield (IPHC 2007). The International Pacific Halibut Commission (IPHC) was originally established by Canada and the USA in 1923 as the International Fisheries Commission to research and manage the halibut stocks covered by the 1923 convention (IPHC 2007). The IPHC is federally funded by both member countries and conducts research and management activities from California to the Aleutian Islands, including British Columbia (IPHC 2007).

8.8 UNITED NATIONS CONVENTIONS

In 1992, the United Nations hosted an unprecedented conference in Rio de Janeiro, Brazil, known as the Earth Summit. The United Nations Framework Convention on Climate Change and the Convention on Biological Diversity were opened for signature at the summit. These conventions were aimed at preventing global climate change and the eradication of the diversity of biological species. The Convention on Biological Diversity stated that biodiversity must be maintained at three levels: 1) communities, 2) species, and 3) genetic composition (UNEP 1992). Canada ratified this convention on June 11, 1992.

On May 15, 1981, the Convention on Wetlands of International Importance (Ramsar Convention 1971) came into force in Canada. Environment Canada is the lead for ensuring Canada upholds its responsibilities. According to the convention, Environment Canada must:

- ◊ Facilitate policies and principles for wise use of wetlands in Canada.
- ◊ Facilitate management of a network of protected wetland sites.
- ◊ Work within the convention to build international co-operation on wetlands conservation.
- ◊ Make financial contributions to the Convention (UN 2007a).

This is likely of lesser importance to the PNCIMA management, as according to the *Atlas of Canada* only two per cent of the nation's wetlands exist in British Columbia (NRC 2007).

8.9 MIGRATORY BIRD CONVENTION ACT

In Canada, most migratory birds are protected under the 1994 Migratory Birds Convention Act (MBCA), which dates to the original legislation passed in 1917. This Act is administered by the Wildlife Enforcement Division of Environment Canada in cooperation with provincial and territorial governments (E.C. 2007). Interestingly, not all birds are covered by this convention as those birds that were considered pests in the early 20th century, such as pelicans, hawks, owls, and cormorants, were excluded (E.C. 2007).

The goal of this legislation is to protect migratory birds, their eggs, and their nests through regulating hunting, prohibiting trafficking, and issuing permits. Enforcement of the act and regulations is the responsibility of the Canadian Wildlife Service, the Royal Canadian Mounted Police, and provincial or territorial law-enforcement authorities (E.C. 2007). This legislation protects waterfowl, cranes, rails, shorebirds, pigeons, insectivorous birds, and some seabirds such as auklets, puffins, guillemots, and murres.

8.10 INTERNATIONAL OBLIGATIONS CONCLUSIONS AND RECOMMENDATIONS

Due to the historical nature of ocean-resource exploitation and extraction, the scope and breadth of international agreements and treaties is extensive. In some cases, international agreements no longer reflect the current social climate in British Columbia (e.g., International Convention for the Regulation of Whaling). With reference to the sustainable management of the PNCIMA, it seems prudent to work within the framework of those conventions, and their signatory nations, to achieve the desired long-term goals.

Recommendations:

1. Within an ecosystem-based management approach, clarify government authority and roles with regard to natural resources.
2. Promote provincial and federal cooperation to achieve international obligations.
3. Work within the existing legislation and agreements to achieve Canada's conservation objectives.
4. PNCIMA conservation objectives should be developed with community input.

9.0 SCIENTIFIC CAPACITY

Scientific and technical capacity within Canada provides an analytical basis for ecosystem-based management, and B.C. has significant human and infrastructure resources. There is no shortage of scientific interest in the PNCIMA due to the diversity of life, complex oceanography, multifaceted socio-economics, and potential for discovery.

Fisheries and Oceans Canada research facilities in British Columbia include the Institute of Ocean Sciences in Sidney, the Pacific Biological Station in Nanaimo, the Centre for Aquaculture and Environmental Research in West Vancouver, and the Cultus Lake Laboratory at Cultus Lake. Other locations for Pacific Region science include Pacific Region Headquarters (Vancouver), Simon Fraser University (Burnaby), New Westminster, Kamloops, and Prince Rupert.

The Institute of Ocean Sciences (IOS) and the Pacific Biological Station (PBS), both on Vancouver Island, are the main science centres on the West Coast. Research at the IOS is focused on the coastal waters of British Columbia, the Northeast Pacific Ocean, the Western Arctic, and navigable waters east to the Manitoba-Saskatchewan border. It is one of nine federal DFO scientific facilities in Canada. Research at the IOS is aimed at evaluating the variability and fluctuations in oceanic conditions and the resulting effects on marine ecosystems and the global climate system. Two science divisions exist at the IOS, including the Canadian Hydrographic Service, and Ocean Sciences. Additionally, the Geological Survey of Canada, Canadian Wildlife Service, Canadian Coast Guard, and the North Pacific Marine Science Organization (PICES) are also located at the IOS in Sidney, British Columbia.

The Pacific Biological Station was founded in 1908 and is still the primary site for fisheries research on Vancouver Island. Research at PBS is focused on stock assessment, aquaculture, marine environment, habitat science, ocean science, and productivity. PBS is also the federal centre for marine mammal work in British Columbia. PBS conducts regional work but also participates in international research efforts such as the Structure of Population, Levels of Abundance, and Status of Humpback Whales (SPLASH) project. For main departmental contacts please see Appendix 1.

The provincial government of British Columbia facilitates various aspects of research. B.C. Archives houses a research-based archival collection with a strong emphasis on the province’s social and political history. The Royal B.C. Museum houses biological and anthropological collections. The Ministry of Advanced Education is now responsible for research and innovation under the new BC Research and Innovation Strategy. There are many other research interests and departments within the provincial government (please see Appendix 1).

In addition to the federal and provincial research facilities, the six major B.C. universities (University of British Columbia, University of Victoria, Simon Fraser University, University of Northern British Columbia, Vancouver Island University, University of the

Fraser Valley) have many academic departments that devote countless hours and resources to understanding various aspects of the pure and social sciences. For main departmental contacts please see Appendix 1.

In January 2002, the Coast Information Team (CIT) was formed to provide independent information and analyses for the development and implementation of ecosystem-based management in the North and Central coastal region of B.C. (CIT 2007). This multidisciplinary team incorporated the provincial and federal governments, First Nations governments, the forestry sector, environmental groups, and communities, and operated under a joint Memorandum of Understanding (CIT 2007). Though primarily involved in terrestrial issues, the team outlined operative ecosystem-based management frameworks and provided guidebooks to facilitate appropriate analyses and operational considerations (Prescott-Allen 2004a, c, b). These may prove useful for the PNCIMA as steps are taken toward ecosystem-based management.

It is clear that the scientific capacity exists within British Columbia to meet the conservation goals of the Oceans Act and Ocean Action Plan. In order to determine whether active steps are being taken to realize the OAP objectives, a series of interviews was conducted with scientists and interested members of the public. Several themes from these interviews became readily apparent:

1. Respondents requested anonymity.
2. Respondents shared similar views that federal funding was insufficient to meet OAP scientific goals.
3. Scientific respondents believed that the will and the capacity to achieve OAP goals exist in the B.C. science community.
4. Science respondents were concerned about the lack of incorporation of socio-economists and social scientists in DFO Pacific Region.
5. Scientific respondents shared the view that OAP scientific goals do not appear to be a priority at the ministerial level.

6. All respondents believed that ecosystem-based management is a useful approach to direct resource-related actions within the PNCIMA.
7. Public respondents believe that marine resources are valuable and should be used in a sustainable manner.
8. All public respondents believed that fisheries resources were depleted and need immediate conservation action.

It was interesting that all discussions with members of the B.C. scientific community were only open once anonymity was assured. Members of the public, however, did not feel the same need for anonymity. The similarity of concerns between federal scientists and members of the public was striking, especially with regard to research funding levels and sources. Further, it was expressed that the standard for ocean priorities needs to be set and articulated by the Minister of Fisheries and Oceans. Some of these sentiments have already been described in Rice (2003).

9.1 SCIENTIFIC CAPACITY CONCLUSIONS AND RECOMMENDATIONS

There is no shortage of scientific capacity in British Columbia. Nor is there a shortage of scientists or scientific facilities. There is a desire to have social scientists and socio-economists integrated into the EBM process for the PNCIMA. The thresholds at which resources are to be maintained must be determined. There is also a desire to see the will and priority for ocean science and ecosystem-based management start at the highest levels of government. Further, there is a desire to see objective funding allocation that allows long-term, quality research. It appears that all sectors want to see action by the government to uphold the OAP and Oceans Act.

Recommendations:

The recommendations here are presented as summaries of discussions with respondents.

1. Define specific research goals that will contribute to integrated management within the PNCIMA.
2. Fund research that will directly contribute to ecosystem-based management.
3. Integrate socio-economics into Pacific Region.

4. Minister of Fisheries and Oceans needs to set standards so that scientists can achieve the goals and objectives outlined in the OAP.
5. Make resources available to allow the realization of the OAP.
6. Initiate an independent funding body that allows federal and non-federal scientists the freedom to pursue long-term research programs.
7. Define and implement Marine Protected Areas on the B.C. coast.
8. A champion of ocean science is required within the political avenues of the Canadian government.
9. Make use of the best available resources to understand the consequences of human activity with regard to the PNCIMA, including strengthening the working relationships between governmental and non-governmental interests.

10.0 FINANCIAL COMPONENTS

The 2007-2008 Report on Plans and Priorities (RPP) (Hearn 2007) identifies three key outcomes: safe and accessible waterways, sustainable fisheries and aquaculture, and healthy and productive aquatic ecosystems. To help achieve these outcomes, DFO is to focus on a number of priorities for 2007-2008 (outlined in the RPP). The federally stated priorities relevant to the PNCIMA include:

- ◊ Updating the Fisheries Act to better reflect current fisheries.
- ◊ Strengthen international fisheries governance.
- ◊ Further assist aboriginal commercial fisheries.
- ◊ Improve fisheries science in Canada.
- ◊ Rejuvenating the Coast Guard.
- ◊ Implement Canada's Oceans Action Plan.
- ◊ Promote aquaculture.
- ◊ Improve the regulatory processes (Hearn 2007).

The following table was adapted from the 2007-2008 RPP (Hearn 2007).

Table 6. Federal Planned Spending and Budget in Millions of Dollars

	2007 – 2008 Planned Spending	2008 – 2009 Planned Spending	2009 – 2010 Planned Spending
Canadian Coast Guard	718.1	755.3	753.8
Small Craft Harbours	109.2	104.4	104.3
Science (Safe and Accessible Waterways)	48.0	47.5	47.1
Fisheries Management	350.5	344.1	340.6
Aquaculture	5.0	5.0	5.0
Science (Sustainable Fisheries and Aquaculture)	191.0	188.6	184.5
Oceans Management	21.2	21.0	21.0
Habitat Management	79.8	78.6	73.3
Science (Healthy and Productive Aquatic Environments	74.0	77.8	74.8
Total	1596.8	1622.3	1604.4

Table 7. Percent of DFO Expected Spending 2007 – 2010

	2007 – 2008 Allocation, %	2008 – 2009 Allocation, %	2009 – 2010 Allocation, %
Canadian Coast Guard	44.9	46.6	47.0
Small Craft Harbours	6.8	6.4	6.5
Science (Safe and Accessible Waterways)	3.0	2.9	2.9
Fisheries Management	22.0	21.2	21.2
Aquaculture	0.3	0.3	0.3
Science (Sustainable Fisheries and Aquaculture)	12.0	11.6	11.5
Oceans Management	1.3	1.3	1.3
Habitat Management	5.0	4.8	4.6
Science (Healthy and Productive Aquatic Environments)	4.6	4.8	4.7

Table 6 presents the categorical expected spending for the next three years across the national responsibility of DFO. From Table 7, it is evident that very little change is anticipated within the department in terms of percent of total funds allocated between 2007 and 2010. In terms of science, slight decreases are observed in Fisheries Management (net decrease 0.8 per cent) and Sustainable Fisheries and Aquaculture (net decrease 0.4 per cent), and a slight increase is observed in Healthy and Productive Aquatic Environments (net increase 0.1 per cent). The latter receives less than five per cent of the overall budget.

10.1 FINANCIAL CONCLUSIONS AND RECOMMENDATIONS

On a positive note, the DFO is not reducing its anticipated commitments with regard to ocean science and management, but the converse is true as well – substantial increases are not expected. Considering this is the national allocation, the Pacific Region will only receive a portion of the total available funds. With this in mind, it does not seem realistic that the research and management changes required to facilitate ecosystem-based management will be achieved in all industrial and research sectors.

Recommendations:

1. Increase funding allocation for ocean science, including healthy and productive ecosystems.
2. Raise the international profile of Canadian science to further governmental and public interest in long-term funding commitments.
3. Challenge the DFO to forecast commitments on a broader temporal scale, as few research programs can be completed in one- to three-year intervals.
4. Encourage federal support for long-term research programs.
5. Reduce the discrepancy between political and scientific timelines such that research goals remain consistent with changing political climates.

11.0 SOCIAL COMPONENTS

Public awareness and knowledge of issues related to the marine environment is highly variable; however, the public desire to learn more about the ocean, marine wildlife, and how human activity influences aquatic ecosystem appears to be increasing.

In Canada, a formal network has been initiated with more than 500 Canadian researchers, managers, community leaders, and agencies to form the Ocean Management Research Network (OMRN). Though based at the University of Ottawa, the OMRN functions at the national level to reach out to those seeking an improved understanding of oceans challenges and a positive framework for addressing them in order to advance strategies and policies for a shift toward a new vision of oceans management (OMRN 2008). This network functions through partnerships that promote and share leading-edge interdisciplinary research and management practices on a wide range of oceans-related issues (OMRN 2008). The primary focus is to translate knowledge into action, and research into policy while exploring Canada's oceans from the broadest possible perspective (OMRN 2008).

In addition to the OMRN, numerous government agencies, conservation groups, and ecotourism companies work throughout the year to improve public understanding of the natural world. A number of DFO initiatives have been aimed at increasing ocean knowledge in Canadian schools. These include the Marine and Aquatic Educators Resource Guide, the classroom incubation program, and the development of specialized curricula for the B.C. school system. Curricula have been developed to educate British Columbia’s school children about killer whales, salmonids, and harbour porpoise (all available free of charge at www-heb.pac.dfo-mpo.gc.ca/community/education).

Additional resources, such as beach exploration guides and storm-drain marking programs, have also been developed and are available from the DFO at either no or nominal cost.

A general assessment of ocean literacy and education campaigns identified a lack of a core consensus by which the various avenues for public education operate as a national shortcoming (R. Searle, pers. comm.). Furthermore, the laudable efforts that are currently underway in Canada are generally independent rather than part of an organized education campaign. This results in a patchwork of ocean education across the country. The criteria for what is required to transform Canadians into ocean-literate citizens have not been articulated (R. Searle, pers. comm.).

Currently, there appears to be a high level of interest with regard to three aspects of ocean education:

1) The health of the ocean as it relates to consumer fish products.
2) Marine mammals, especially whales and dolphins.
3) The effects of climate change on coastal storms.

One Vancouver Island resident recently commented:

> “Ecosystem-based management is simply common sense; there is no other alternative. Let the ocean recover from past mismanagements, and employ

> protections such as Marine Protected Areas – they work! The oceans are in trouble; we and our government must act now. ” (N. Gregory, pers. comm..).

About 70 per cent of the surface of Earth is water, and of that approximately 97 per cent is made up of the saltwater of our oceans. Though many residents of British Columbia get their ocean knowledge from media headlines and television, they have an appetite for information. Considering the magnitude of the Canadian and British Columbian coastlines – 243,042 kilometres and 25,725 kilometres, respectively – the lack of any comprehensive national or provincial ocean-literacy program is remarkable. A coordinated national initiative for all Canadians would likely be successful if implemented in interesting and innovative ways.

11.1 SOCIAL COMPONENT CONCLUSIONS AND RECOMMENDATIONS

Although the level of societal knowledge of the oceans and ocean health is highly variable among Canadians, many Canadians would like to learn more about ocean resources and conservation. As a maritime nation, we should collectively strive to improve social awareness of the ocean and related issues in Canada.

Recommendations:

1) Define the criteria for what ocean literacy means to Canadians.
2) Develop a comprehensive framework and timeline for achieving an internationally recognizable level of ocean literacy.
3) Link the OMRN with whale-watch naturalists and other marine-ecotourism guides to help disseminate newly available relevant scientific information to interested members of the public (and visitors to Canada).
4) Develop an integrated network across Canada linking all groups that have ocean education programs.
5) Implement a cooperative, community-based ocean literacy action network in British Columbia.

12.0 SUMMARY

An ecosystem-based approach that makes use of the best available science, coupled with local knowledge from residents, community groups, and stakeholders in the region, will provide a comprehensive plan for the future. Ecosystem-based management allows resource consumption but at a rate and in a manner that is consistent with long-term survival of the resource and the integral natural systems. It is imperative that the intricate links between multiple species and trophic (i.e., place in food web) levels be recognized within an ecosystem-based framework to provide management guidance for the single species known as *Homo sapiens*. We need to shift our collective thinking from the management of resources to the management of our collective actions within a natural framework that maintains the biological and ecological diversity of the Pacific North Coast Integrated Management Area, because, for better or worse, we are a significant part of the coastal ecosystem.

LITERATURE CITED

1867, 1982. The Constitution Act. *in*. http://laws.justice.gc.ca/en/const/c1867_e.html#pre, Statutes of Canada.

1985. Fisheries Act. *in*. http://laws.justice.gc.ca/en/showdoc/cs/F-14/bo-ga:s_1//en#anchorbo-ga:s_1, R.S., c. F-14, s.1.

1994. Canada Wildlife Act. *in*. http://laws.justice.gc.ca/en/ShowFullDoc/cs/W-9///en, R.S., 1985, c. W-9, s.1; 1994, c.23, s. 2(F).

1996. Oceans Act. *in*. http://laws.justice.gc.ca/en/showdoc/cs/O-2.4///en?page=1, 2.4.

2001. Canada Shipping Act. *in*. http://laws.justice.gc.ca/en/showdoc/cs/C-10.15///en?page=1, c. 26. C-10.15.

2002. Canada National Marine Conservation Areas Act. *in*. http://laws.justice.gc.ca/en/showdoc/cs/C-7.3///en?page=1, c.18.

2003. SARA. Pages 104, *in* Species At Risk Act. http://www.sararegistry.gc.ca/default_e.cfm, Canada Gazette Part III.

Ainsworth, C., J. J. Heymans, T. J. Pitcher, and M. Vasconcellos. 2002. Ecosystem models of northern British Columbia for the time periods 2000, 1950, 1900 and 1750. University of British Columbia, Vancouver, BC.

Anon. 1975. Plastic cups found in fish. Marine Pollution Bulletin **6**:148.

Ardron, J. A., and G. S. Jamieson. 2006. Reducing bycatch of corals and sponges in British Columbia's groundfish trawl fishery through trawl fishery closures. Canadian Science Advisory Secretariat **Research Document**.

Azzarello, M. Y., and E. S. Van-Vleet. 1987. Marine birds and plastic pollution. Marine Ecology Progress Series **37**:295-303.

Baird, R. W., and S. K. Hooker. 2000. Ingestion of plastic and unusual prey by a juvenile harbour porpoise. Marine Pollution Bulletin **40**:719-720.

Bates, C. 2008. An Introduction to the Seaweeds of British Columbia. University of British Columbia.

BCCMEP. 2006. British Columbia Coast and Marine Environment Project 2006: Population and Economic Activity. *in*. Ministry of Environment, http://www.env.gov.bc.ca/soe/bcce/#.

BC Parks. 2007. Provincial parks and protected areas legislation website. *in*. http://www.env.gov.bc.ca/bcparks/info/legis.html.

Beacham, T. D., D. E. Hay, and K. D. Le. 2005. Population structure and stock identification of eulachon (*Thaleichthys pacificus*), an anadromous smelt, in the Pacific Northwest. Marine Biotechnology **7**:363-372.

Beattie, A. I. 2001. A new model for evaluating the optimal size, placement and configuration of marine protected areas. Unpublished Master's thesis. University of British Columbia, Vancouver.

Bertram, D. F., A. Harfenist, and B. D. Smith. 2005. Ocean climate and El Nino impacts on survival of Cassin's Auklets from upwelling and downwelling domains of British Columbia. Canadian Journal of Fisheries and Aquatic Science **62**:2841-2853.

Bertram, D. F., I. L. Jones, E. G. Cooch, H. A. Knechtel, and F. Cooke. 2000. Survival rates of Cassin's and rhinoceros auklets at Triangle Island, British Columbia. The Condor **102**:155-162.

Bjorndal, K. A., A. B. Bolten, and C. J. Lagueux. 1994. Ingestion of marine debris by juvenile sea turtles in coastal Florida habitats. Marine Pollution Bulletin **28**:154-158.

Blight, L. K., and A. E. Burger. 1997. Occurrence of plastic particles in seabirds from the eastern North Pacific. Marine Pollution Bulletin **34**:323-325.

Bond, N. A., J. E. Overland, M. Spillane, and P. Stabeno. 2003. Recent shifts in the state of the North Pacific. Geophysical Research Letters **30**:2183-2186.

CAAR. 2007. Farmed and Dangerous website. *in*. http://www.farmedanddangerous.org/, Coastal Alliance for Aquaculture Reform.

Canada. 1985. Navigable Waters Protection Act. *in*, http://laws.justice.gc.ca/en/showdoc/cs/N-22///en?page=1.

Canada. 2005. Order giving notice of decisions not to add certain species to the list of endangered species. Canada Gazette Part 2 (Final Version) Order Giving Notice of Decisions **139**:SI/2005-2002 January 2026, 2005.

Canada. 2006. Order Giving Notice of Decisions not to add Certain Species to the List of Endangered Species. Canada Gazette Part 2 (Final Version) Order Giving Notice of Decisions **140**:http://www.sararegistry.gc.ca/document/dspHTML_e.cfm?ocid=4458.

Cawthorn, M. 1989. Impacts of marine debris on wildlife in New Zealand coastal waters. Pages 5-6 *in* Dept. of Conservation - Proceedings of Marine Debris in New Zealand's Coastal Waters Workshop, Wellington, New Zealand.

CIT. 2003. Draft: An Ecosystem Spatial Analysis for Haida Gwaii, Central Coast, and North Coast British Columbia.

CIT. 2007. Coast Information Team website. *in*. www.citbc.org.

CITES. 2007. Convention on International Trade in Endangered Species of Wild Fauna and Flora website. *in* http://www.cites.org, Geneva, Switzerland.

Clarke, C. L., and G. S. Jamieson. 2006a. Identification of ecologically and biologically significant areas in the Pacific North Coast Integrated Management Area: Phase I - Identification of important areas. Canadian Technical Report of Fisheries and Aquatic Sciences **2678**:97.

Clarke, C. L., and G. S. Jamieson. 2006b. Identification of ecologically and biologically significant areas in the Pacific North Coast Integrated Management Area: Phase II - Final Report. Can. Tech. Rep. Fish. Aquat. Sci. 2686.

Conway, K. W. 1999. Hexactinellid sponge reefs on the British Columbia continental shelf: geological and biological structure with a perspective on their role in the shelf ecosystem. Canadian Stock Assessment Secretariat **Research Document.**

COS. 2007. BC North Coast Ports. *in*. Chamber of Shipping, http://www.chamber-of-shipping.com/index/portsnorth.

COSEWIC. 2003. COSEWIC assessment and status report on the Short-tailed Albatross *Phoebastria albatrus* in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa.

COSEWIC. 2007a. Black-footed Albatross species search. *in* Committee on the Status of Endangered Wildlife in Canada, http://www.cosewic.gc.ca/eng/sct1/searchdetail_e.cfm?id=991&StartRow=1&boxStatus=All&boxTaxonomic=2&location=18&change=All&board=All&commonName=&scienceName=&returnFlag=0&Page=1.

COSEWIC. 2007b. Northern abalone species search. *in* Committee on the Status of Endangered Wildlife in Canada. http://www.cosewic.gc.ca/eng/sct1/searchdetail_e.cfm?id=603&StartRow=1&boxStatus=All&boxTaxonomic=All&location=All&change=All&board=All&commonName=abalone&scienceName=&returnFlag=0&Page=1.

COSEWIC. 2007c. Steller Sea Lion species search. *in* Committee on the Status of Endangered Wildlife in Canada. http://www.cosewic.gc.ca/eng/sct1/searchdetail_e.cfm?id=606&StartRow=1&boxStatus=All&boxTaxonomic=All&location=All&change=All&board=All&commonName=killer%20whale&scienceName=&returnFlag=0&Page=1.

CP. 2007. Fish-farm nets snare, drown 51 sea lions off Vancouver Island. *in* C. Press, editor. West Coast Aquatic, http://www.westcoastaquatic.ca/article_sealions_fishfarms0407.htm.

CSA. 2007. Canadian Sablefish Association. *in*, http://www.canadiansablefish.com/index.htm.

CWS. 2004. Northern Abalone. *in* C. W. Service, editor., http://www.speciesatrisk.gc.ca/search/speciesDetails_e.cfm?SpeciesID=603.

CWS. 2006. Wild Species 2005. pp. 141.

CWS. 2007a. Establishment of the Scott Islands Marine Wildlife Area (MWA). *in*. Environment Canada.

CWS. 2007b. Species At Risk - Sea Otters. *in*. Environment Canada, Canadian Wildlife Service.

Deal, H. 2005. Sustainable Shellfish. pp. 34, David Suzuki Foundation.

Demarchi, M. W., R. C. Bocking, S. K. Meier, M. Holst, S. Humble, B. Baxter, W. J. Richardson, J. Diebold, R. Racca, and A. McGillivray. 2006. Environmental assessment of the marine BATHOLITHS seismic survey, inland waterways and near-offshore central coast of British Columbia. LGL Report TA2822-32.

Derraik, J. G. B. 2002. The pollution of the marine environment by plastic debris: a review. Marine Pollution Bulletin **44**:842-852.

DFO. 1993. Pacific Fishery Regulations. *in*. Fisheries and Oceans Canada, http://www.dfo-mpo.gc.ca/communic/policy/dnload_e.htm.

DFO. 2000. Backgrounder - Victoria Marine Communications and Traffic Services Centre. http://www-comm.pac.dfo-mpo.gc.ca/pages/release/bckgrnd/2000/bg0005_e.htm.

DFO. 2002. Canada's Oceans Strategy. Fisheries and Oceans Canada, http://www.dfo-mpo.gc.ca/oceans-habitat/oceans/ri-rs/cos-soc/index_e.asp.

DFO. 2003a. Agreement between the government of Canada and the government of the United States of America on Pacific Hake/Whiting. http://www-comm.pac.dfo-mpo.gc.ca/pages/release/bckgrnd/2003/HakeAgreement_e.htm.

DFO. 2003b. Backgrounder - Pacific Hake. http://www-comm.pac.dfo-mpo.gc.ca/pages/release/bckgrnd/2003/bg017_e.htm.

DFO. 2003c. Canada and the United States sign treaty to improve stewardship of Pacific Hake. http://www-comm.pac.dfo-mpo.gc.ca/pages/release/p-releas/2003/nr066_e.htm, NR-PR-03-066e.

DFO. 2003d. Pacific hake (offshore). Canada Science Advisory Secretariat, Stock Status Report.

DFO. 2003e. Pacific Region Experimental Harvest Guidelines Octopus. Pages 23 *in*. Fisheries and Oceans Canada, http://www.dfo-mpo.gc.ca/Library/315447.pdf.

DFO. 2004a. Identification of Ecologically and Biologically Significant Areas. CSAS Ecosystem Status Report 2004/006.

DFO. 2004b. Mitigation of seismic noise in the marine environment - Statement of Canadian Practice. http://www.dfo-mpo.gc.ca/oceans-habitat/oceans/im-gi/seismic-sismique/pdf/statement-enonce_e.pdf.

DFO. 2004c. News Release - Canada and British Columbia Join Forces to Implement Canada's Oceans Strategy. *in*. http://www-comm.pac.dfo-mpo.gc.ca/pages/release/p-releas/2004/nr053_e.htm.

DFO. 2004d. Review of scientific information on impacts of seismic sound on fish, invertebrates, marine turtles and marine mammals. DFO Can. Sci. Advis. Sec. Habitat Status Report:2004-2002.

DFO. 2006a. Proceedings of the PSARC meeting on Deep Sea Corals, April 26, 2006. Canadian Science Advisory Secretariat Proceedings Series:19.

DFO. 2006b. State of the Pacific Ocean 2005. Ocean Status Report. 2006/001, DFO Science.

DFO. 2007a. Fact Sheet: Sea Urchins. *in*. Fisheries and Oceans Canada. http://www-comm.pac.dfo-mpo.gc.ca/publications/factsheets/species/urchins_e.htm.

DFO. 2007b. Fish Stocks of the Pacific Coast. *in*. Fisheries and Oceans Canada.

DFO. 2007c. Fish Stocks of the Pacific Coast: Online Book. *in* M. Stocker and A. Mentzelopoulos, editors. http://www-comm.pac.dfo-mpo.gc.ca/publications/speciesbook/introduction/default.html, Fisheries and Oceans Canada.

DFO. 2007d. Guidance Document on Identifying Conservation Priorities and Phrasing Conservation Objectives for Large Ocean Management Areas. www.dfo-mpo.gc.ca/csas/Csas/status/2007/SAR-AS2007_010_E.pdf.

DFO. 2007e. North Coast - Shellfish. *in*. http://www.pac.dfo-mpo.gc.ca/northcoast/shellfish.htm, Fisheries and Oceans Canada.

DFO. 2007f. North Pacific Right Whale. *in*. http://www.dfo-mpo.gc.ca/species-especes/species/species_rightWhale_north_pacific_e.asp, Fisheries and Oceans Canada.

DFO. 2007g. Pacific Region Integrated Fisheries Management Plan Groundfish. Pages 134 *in*. Fisheries and Oceans Canada, http://www-ops2.pac.dfo-mpo.gc.ca/xnet/content/mplans/mplans.htm?#Groundfish.

DFO. 2007h. Record penalties for abalone poachers. *in* Aquaculture Reports and Publications. http://www.dfo-mpo.gc.ca/aquaculture/ref/oceans_01_e.htm, Fisheries and Oceans Canada.

DFO. 2007i. Sector Catch Summary 2007/2008 Groundfish Trawl. Pages 2 *in*, http://www.pac.dfo-mpo.gc.ca/ops/fm/Groundfish/default_e.htm.

DFO. 2007j. Steller Sea Lion. *in*. http://www.dfo-mpo.gc.ca/species-especes/species/species_stellersealion_e.asp.

DFO. 2007k. Welcome to Recreational Fishing in the Pacific Region. *in*. Fisheries and Oceans Canada, http://www.pac.dfo-mpo.gc.ca/recfish/default_e.htm.

Douglas, A. B., J. Calambokidis, S. Raverty, S. J. Jefferies, D. Lamborn, and S. Norman. 2008. Incidence of ship strikes of large whales in Washington State. Journal of the Marine Biological Association of the United Kingdom:1121-1132.

DSF. 2006. State of the Catch. David Suzuki Foundation, Vancouver, BC.

DSF. 2007. Impacts Report - Draft. Pages 68 *in*. David Suzuki Foundation, Vancouver, BC.

Dutch, S. 2003. Natural Gas Hydrates: Overview. *in*, http://www.uwgb.edu/DutchS/PETROLGY/Clathrate-0.HTM.

E.C. 2007. The Migratory Birds Convention Act and Regulations. *in*. Environment Canada, http://www.mb.ec.gc.ca/nature/migratorybirds/dc00s06.en.html#0.

English, K. K., G. J. Glova, and A. C. Blakley. 2008. An Upstream Battle: Declines in 10 Pacific salmon stocks and solutions for their survival. Pages 46 *in*. David Suzuki Foundation.

Fargo, J., L. MacDougall, and I. Pearsall. 2007. Ecosystem overview: Pacific North Coast Integrated Management Area (PNCIMA): Appendix G: Groundfish.

Freiwald, A., J. H. Fossa, A. Grehan, T. Koslow, and J. M. Roberts. 2004. Cold-water coral reefs. Cambridge, UK.

Gaston, A. J. 2008. Seabirds. *in*. http://www.ecoinfo.ec.gc.ca/env_ind/region/seabird/seabird_e.cfm, Environment Canada.

Gjerdrum, C., A. M. Vallee, C. C. St. Clair, D. F. Bertram, J. L. Ryder, and G. S. Blackburn. 2003. Tufted puffin reproduction reveals ocean climate variability. Proceedings of the National Academy of Science **100**:9377-9382.

Goddard, J. 1997. A window on whaling in British Columbia. Desktop Publishing, Victoria.

Grant, S. C. H., and P. S. Ross. 2002. Southern resident killer whales at risk: Toxic chemicals in the British Columbia and Washington environment. Canadian Technical Report of Fisheries and Aquatic Sciences **2412**:xii+111.

Gregory, M. R., and P. G. Ryan. 1997. Pelagic plastics and other seaborne persistent synthetic debris: a review of Southern Hemisphere perspectives. Pages 49-66 *in* J.

M. Coe and D. B. Rogers, editors. Marine Debris-Sources, Impacts and Solutions. Springer-Verlag, New York.

Hall, A. 2004. Seasonal abundance, distribution and prey species of harbour porpoise (*Phocoena phocoena*) in southern Vancouver Island waters. M.Sc. University of British Columbia, Vancouver.

Hall, A., G. Ellis, and A. W. Trites. 2002. Harbour Porpoise Interactions with the 2001 Selective Salmon Fisheries in Southern British Columbia and License Holder Reported Small Cetacean By-Catch. Selective Salmon Fisheries Science Program, Fisheries and Oceans Canada, Victoria, BC.

Hay, D. E., R. Harbo, K. Southey, J. R. Clarke, G. Parker, and P. B. McCarter. 1999. Catch composition of British Columbia shrimp trawls and preliminary estiamtes of by-catch - with emphasis on eulachons. Canadian Stock Assessment Secretariat **Research Document. 99/26**.

Hearn, L. 2007. Report on Plans and Priorities. *in* F. a. O. Canada, editor. Treasury Board of Canada Secretariat, http://www.tbs-sct.gc.ca/rpp/0708/fo-po/fo-po01_e.asp#Alignment.

Hedd, A., J. L. Ryder, L. L. Cowen, and D. F. Bertram. 2002. Inter-annual variation in the diet, provisioning and growth of Cassin's auklet at Triangle Island, British Columbia: responses to variation in ocean climate. Marine Ecology Progress Series **229**:221-232.

Henry, L., and M. Hart. 2005. Regeneration from injury and resource allocation in sponges and corals - a review. International Reviews in Hydrobiologica **90**:125-158.

Hillier, J., and D. Gueret. 2007. The Pacific Coast Integrated Management Area: Moving Towards Modern Ocean Management. Canadian Society of Exploration Geophysicists Recorder **32**:31-32.

Hipfner, M. 2005. Seabirds on Triangle Island in 2005: All species experienced a very poor breeding season. State of the Pacific Ocean 2005:70.

Horseman, P. V. 1985. The amount of garbage pollution from merchant ships. Marine Pollution Bulletin **13**:167-169.

Hyatt, K., M. S. Johannes, and M. Stockwell. 2007. Appendix I: Pacific Salmon. In Ecosystem overview: Pacific North Coast Integrated Management Area (PNCIMA).

Hyndman, R. D., and S. R. Dallimore. 2001. Natural gas hydrate studies in Canada. Canadian Society of Exploration Geophysicists Recorder **26**:11-20.

ICRW. 1946. International Convention for the Regulation of Whaling. *in*. International Whaling Commission, http://www.iwcoffice.org/commission/convention.htm#convsigs.

IMO. 2007. International Maritime Organization. Pages website *in*, http://www.imo.org/.

INPFC. 1952. International Convention for the High Seas Fisheries of the North Pacific Ocean. International North Pacific Fisheries Commission, Tokyo.

IPHC. 2007. International Pacific Halibut Commission. *in*. http://www.iphc.washington.edu/halcom/, Seattle, Washington.

Jamieson, G. S., and L. Chew. 2002. Hexactinellid sponge reefs: areas of interest as Marine Protected Areas in the North and Central Coast. Canadian Science Advisory Secretariat **Research Document**:77.

Jamieson, G. S., N. Pellegrin, and S. Jessen. 2006. Taxonomy and zoogeography of cold water corals in explored areas of coastal British Columbia. Canadian Science Advisory Secretariat **Research Document**:49.

Kaufman, K. 1996. Lives of North American Birds, New York.

King, J. R. 2005. Report of the Study Group on Fisheries and Ecosystem Responses to Recent Regime Shifts.

Krkosek, M., M. A. Lewis, A. B. Morton, L. N. Frazer, and J. P. Volpe. 2006. Epizootics of wild fish induced by farm fish. Proceedings of the National Academy of Science **103**:15506 - 15510.

Laist, D. W. 1997. Impacts of marine debris: entanglement of marine life in marine debris including a comprehensive list of species with entanglement and ingestion records. Pages 99-139 *in* J. M. Coe and D. B. Rogers, editors. Marine Debris - Sources, Impacts and Solutions. Springer-Verlag, New York.

LOS. 2007a. Living Oceans Society Salmon Farming and the Environment. *in*. Living Oceans Society, www.livingoceans.org/fishfarms/impacts.shtml.

LOS. 2007b. Sustainable Fisheries. *in*. Living Oceans Society, http://www.livingoceans.org/programs/sustainable_fisheries/fishing-bc.html.

Lucas, B. G., S. Verrin, and R. Brown, editors. 2007. Ecosystem overview: Pacific North Coast Integrated Management Area (PNCIMA).

MacConnachie, S., J. Hillier, and S. Butterfield. 2007. Marine use analysis of the Pacific North Coast Integrated Management Area. Canadian Technical Report of Fisheries and Aquatic Sciences **2677**:188.

MacGillivray, A. O. 2006. An acoustic modeling study of seismic airgun noise in Queen Charlotte Basin. M.Sc. University of Victoria, Victoria, BC.

MacGillivray, A. O. 2007. Summary of a recent study of seismic airgun survey noise propagation in Queen Charlotte Basin. Canadian Society of Exploration Geophysicists Recorder **32**:28-29.

Mackas, D., R. Goldblatt, and A. G. Lewis. 1998. Interdecadal variation in developmental timing of Neocalanus plumchrus populations at Ocean Station P in the subarctic North Pacific. Canadian Journal of Fisheries and Aquatic Science **55**:1878-1893.

Mackas, D., A. Pena, D. Johannessen, R. Birch, K. Borg, and D. Fissel. 2007. Appendix D: Plankton. Pages 34 *in* Ecosystem Overview: Pacific North Coast Integrated Management Area (PNCIMA). Canadian Technical Report of Fisheries and Aquatic Sciences, Ottawa, ON.

Mantua, N. J., S. R. Hare, Y. Zhang, J. M. Wallace, and R. C. Francis. 1997. A Pacific interdecadal climate oscillation with impacts on salmon production. Bulletin of the American Meterological Society **78**:1069-1079.

Mattlin, R. H., and M. Cawthorn. 1986. Marine debris-an international problem. New Zealand Environment **51**:3-6.

MBA. 2008. Pacific Electric Ray. *in*. Monterey Bay Aquarium, http://www.montereybayaquarium.org/efc/living_species/default.asp?hOri=1&inhab=510.

McCauley, R. D., J. Fewtrell, A. J. Duncan, C. Jenner, M.-N. Jenner, J. D. Penrose, R. I. T. Prince, A. Adhitya, J. Murdoch, and K. McCabe. 2000. Marine Seismic Surveys-A study of environmental implications. Australian Petroleum Production and Exploration Association:692-709.

MEMPR. 2007a. The BC Energy Plan. *in* M. a. P. R. Ministry of Energy, editor. http://www.energyplan.gov.bc.ca.

MEMPR. 2007b. Oil and Gas Backgrounder. *in*. Ministry of Energy, Mines and Petroleum Resources, http://www.energyplan.gov.bc.ca/backgrounder/backgrounder4.htm.

MEMPR. 2007c. Who's Who in Oil and Gas. *in* M. a. P. R. Ministry of Energy, editor., British Columbia.

MOE. 2007. Ecoregions of British Columbia. *in* Ecoregion Unit Descriptors. Ministry of the Environment, Victoria, BC.

Morton, A. B., and H. K. Symonds. 2002. Displacement of *Orcinus orca* (L.) by high amplitude sound in British Columbia, Canada. ICES Journal of Marine Science **59**:71-80.

Nee, J. 1990. What do you do when the nearest trashcan is 2000 miles away? Seafarer **39**:8-9.

Nichol, L. M., J. C. Watson, G. E. Ellis, and J. K. B. Ford. 2005. An assessment of abundance and growth of the sea otter (*Enhydra lutris*) population in British Columbia.

Ninaber, E. 1997. MARPOL Annex V, commercial ships, and port reception facilities: making it work. Pages 239-243 *in* J. M. Coe and D. B. Rogers, editors. Marine Debris - Sources, Impacts and Solutions. Springer-Verlag, New York.

NRC. 2007. The Atlas of Canada. *in* N. R. Canada, editor. Natural Resources Canada, http://atlas.nrcan.gc.ca/site/english/dataservices/free_data.html.

Olesiuk, P. F., L. M. Nichol, M. J. Sowden, and J. K. B. Ford. 2002. Effect of the sound generated by an acoustic harassment device on the relative abundance and distribution of harbour porpoises (*Phocoena phocoena*) in Retreat Passage, British Columbia. Marine Mammal Science **18**:843-862.

OMRN. 2008. Ocean Management Research Network. *in*. website, http://www.omrn-rrgo.ca.

Pearce, J. B. 1992. Marine vessel debris: a North American perspective. Marine Pollution Bulletin **24**:586-592.

Pearsall, I. A., and J. Fargo. 2007. Diet compostion and habitat fidelity for groundfish assemblages in Hecate Strait, British Columbia. Canadian Technical Report of Fisheries and Aquatic Sciences **2692:vi + 142p**.

Peterson, D. L., A. Wood, and J. Gardner. 2005. An assessment of Fisheries and Oceans Canada Pacific Region's effectiveness in meeting its conservation mandate. David Suzuki Foundation, Vancouver, BC.

Phelan, B. 2007. Offshore BC - Current Status. Canadian Society of Exploration Geophysicists Recorder **32**:26-27.

Pojar, J., and A. MacKinnon, editors. 1994. Plants of Coastal British Columbia. Ministry of Forests and Lone Pine Publishing.

Prescott-Allen, R. 2004a. CIT Ecosystem-based management framework. Cortex Consultants Inc., Victoria, BC.

Prescott-Allen, R. 2004b. CIT Ecosystem-Based Management Planning Handbook. Cortex Consultants Inc, Victoria, BC.

Prescott-Allen, R. 2004c. CIT Scientific Basis of Ecosystem-Based Management. Cortex Consultants Inc., Victoria, BC.

Prescott-Allen, R. 2005. Coast Information Team Review Report. Cortex Consultants Inc.

Pruter, A. T. 1987. Sources, quantities and distribution of persistent plastics in the marine environment. Marine Pollution Bulletin **18**:305-310.

PSC. 2007. Pacific Salmon Commission. *in*. http://www.psc.org/index.htm.

Rice, J. 2003. The Future of Aquatic Science in Canada (Oceans Emphasis). Can. Tech. Rep. Fish. Aquat. Sci. **2474**.

Rodway, M. S. 1991. Status and conservation of breeding seabirds in British Columbia. Pages 43-102 *in* J. P. Croxall, editor. Seabird Status and Conservation: a Supplement, ICBP, Cambridge.

Rodway, M. S., and M. J. F. Lemon. 1991. British Columbia seabird colony inventory: Report # 8 - Queen Charlotte Strait and Johnstone Strait. Technical Report Series **123**:82.

Rossiter, W. 2006. Noise in the Oceans: Military Sonar. Whales Alive **XV**.

RSC. 2004. Report of the expert panel on science issues related to oil and gas activities, offshore British Columbia. Royal Society of Canada, Ottawa, ON.

Rusch, B., S. MacConnachie, and L. Hamer. 2003. A review of 2002/2003 British Columbia Herring Fisheries. Canadian Industry Report of Fisheries and Aquatic Sciences **273**:63.

Ryan, P. G., A. D. Connell, and B. D. Gardner. 1988. Plastic ingestion and PCBs in seabirds: is there a relationship? Marine Pollution Bulletin **19**:174-176.

SARA. 2007. Species At Risk Act Public Registry. *in*, http://www.sararegistry.gc.ca/plans/timelines_e.cfm#5.

SARA. 2008. Species At Risk Public Registry. *in*. http://www.sararegistry.gc.ca.

Schweigert, J., B. MCCarter, T. Therriault, L. Flostrand, C. Hrabok, P. Winchell, and D. Johannessen. 2007. Ecosystem Overview: Pacific North Coast Integrated Management Area (PNCIMA) Appendix H: Pelagic Fishes. Pages 39 *in* B. G. Lucas, S. Verrin, and R. Brown, editors. Can. Tech. Rep. Fish. Aquat. Sci.

Sinclair, A. 2007. Trends in Groundfish Bottom Trawl Fishing Activity in BC. Canada Science Advisory Secretariat:26.

Smith, H. A. 1926. Canadian Diplomacy and Responsibility. Pages 53-66 *in* T. E. C. o. C. S. 1926, editor., http://www.empireclubfoundation.com/details.asp?SpeechID=607.

Stearn, C., and R. Carroll. 1989. Paleontology. John Wiley & Sons, Inc.

Stoett, P. J. 1997. The International Politics of Whaling. UBC Press, Vancouver, BC.

Stoffels, D. 2001. Eulachon in the North Coast. Province of British Columbia.

Thompson, R. E. 1981. Oceanography of the British Columbia coast. Canadian Special Publications of Fisheries and Aquatic Sciences **56**:291.

UN. 1982. United Nations Convention on the Law of the Sea. Pages 202 *in* U. Nations, editor. United Nations, http://www.un.org/Depts/los/convention_agreements/convention_overview_convention.htm.

UN. 2007a. Multilateral Environmental Agreements. *in* U. Nations, editor., http://www.ec.gc.ca/international/multilat/wet_e.htm.

UN. 2007b. Oceans and Law of the Sea. *in* U. Nations, editor. United Nations, http://www.un.org/Depts/los/convention_agreements/convention_overview_fish_stocks.htm.

UNEP. 1992. The Convention on Biological Diversity. *in* S. o. t. C. o. B. Diversity, editor., http://www.cbd.int/convention/default.shtml.

UNEP. 2008. Biodiversity and Climate Change 2000 - Plankton. *in*. United Nations Environment Programme.

Ware, D. M., and R. E. Thomson. 2005. Bottom-uo ecosystem trophic dynamics determine fish production in the northeast Pacific. Science **308**:1280-1284.

Wilber, R. J. 1987. Plastic in the North Atlantic. Oceanus **30**:61-68.

Williams, G. L. 1989. Coastal/Estuarine fish habitat description and assessment manual. Part I; Species/habitat outlines. Prepared for: Unsolicited Proposals Program, Supply and Services Canada.

Personal Communications

Rick Searle, University of Victoria, Victoria, BC, 250-598-0199

Scott Wallace, David Suzuki Foundation, Vancouver, BC, 604-732-4228

Neil Gregory, Marine Conservationist, Victoria, BC, 250-881-8551

Appendix 1

British Columbia Governmental Science Contacts
Institute of Ocean Sciences
9860 West Saanich Road
P.O. Box 6000
Sidney, British Columbia, V8L 4B2
Phone: (250) 363 6517

Pacific Biological Station
3190 Hammond Bay Road
Nanaimo, BC V9T 6N7
Phone: (250) 756 7000

Parks Canada – Gwaii Haanas NMCA Reserve
Contact: Doug Burles, Research Coordinator:
Gwaii Haanas National Marine Conservation Area Reserve
Queen Charlotte City, BC, V0T 1S0
Tel: (250) 637-2351
Doug.Burles@pc.gc.ca

Environment Canada – Canadian Wildlife Service
Pacific Wildlife Research Centre
RRI, 5421 Robertson Road
Delta, BC
V4K 3N2
(604) 940-4700

Natural Resources Canada – Geological Survey of Canada
Contact: Dr. Vaughn Barrie, Project leader:
Natural Resources Canada
9860 West Saanich Road
PO Box 6000, Room. 4716
Sidney, BC V8L 4B2
Telephone: (250) 363-6424
E-mail: vbarrie@nrcan-rncan.gc.ca\\

Non-Governmental Science Contacts in British Columbia
David Suzuki Foundation
Contact: Scott Wallace - Sustainable Fisheries Analyst,
Suite 219, 2211 West 4th Avenue
Vancouver, BC, V6K 4S2
Phone: (604) 732-4228
swallace@davidsuzuki.org

Living Oceans Society
Contact: Kate Willis-Ladell - PNCIMA Planning Specialist
207 W. Hasting Street, Suite 1405
Vancouver, BC, V6B 1H7
Phone: (604) 696-5044
kwillis@livingoceans.org

Nature Conservancy Canada – BC.
Contact: Dave Nicolson Manager, Conservation Information & GIS Services
1205 Broad Street, Suite 300
Victoria, BC V8W 2A4
Tel.: (250) 479-3191
Toll-free: 1-888-404-8428 (in BC)
Dave.Nicolson@natureconservancy.ca

Canadian Parks and Wilderness Society – BC Chapter.
Contact: Sarah Patton , Marine Science Coordinator.
410 - 698 Seymour St.
Vancouver, BC V6B 3K6
Telephone: (604) 685-7445
sarah@cpawsbc.org

Sierra Club of Canada, BC Chapter
Contact: Colin Campbell, Science Advisor
302-733 Johnson Street
Victoria, BC V8W 3C7
phone: (250) 386-5255
colin@sierraclub.bc.ca

World Wildlife Fund of Canada
Contact: Michele Patterson, director, Pacific Conservation Program
409 Granville Street, Suite 1588
Vancouver, BC, V6C 1T2
Phone: (604) 678-5152 Ext. 2
mpatterson@wwfcanada.org

Pacific Marine Analysis and Research Association (PacMARA)
Contact: Michele Paterson (WWF)
c/o #512B - 409 Granville Street
Vancouver, BC, V6C 1T2
Tel: 604-678-5152
info@pacmara.org

Academic Institutions With Marine Science In British Columbia

University of British Columbia

Marine Mammal Research Unit http://www.marinemammal.org/MMRU/

Fisheries Centre http://www.fisheries.ubc.ca/

Aboriginal Fisherieshttp://www.fisheries.ubc.ca/aborig_new/index.htm

Sea Around Us http://www.seaaroundus.org/

Fisheries Economics Research Unit http://www.feru.org/

University of the Fraser Valley
(Formerly University College of the Fraser Valley)
http://www.ucfv.ca/home.htm

Vancouver Island University
(Formerly Malaspina University College)
www.mala.ca/

Simon Fraser University
School of Resource and Environmental Management, Fisheries Science and Management Research Group http://www.rem.sfu.ca/fishgrp/

Department of Biological Sciences, Centre for Wildlife Ecology
http://www.sfu.ca/biology/wildberg/

Centre for Coastal Studies http://www.sfu.ca/coastalstudies/

University of Victoria
Marine Protected Areas Research Group
http://www.geog.uvic.ca/MPARG/index.htm\

School of Earth and Ocean Science
Venus: http://www.venus.uvic.ca
Neptune: http://www.neptunecanada.ca/index.html

Bamfield Marine Sciences Centre http://www.bms.bc.ca/research/