Benefits of Marine Planning: An Assessment of Economic and Environmental Values

Marine Planning Research Report No. 4

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Executive Summary

1. This report examines economic and environmental values of the PNCIMA and the benefits of integrated marine planning as a means of protecting and enhancing economic and environment values.

2. The economy of the PNCIMA relies on the public sector, transfer payments, natural resources, and tourism. Compared to the province as a whole, a much higher proportion of employment in the PNCIMA is associated with the production of goods, primarily based on natural resource extraction and manufacturing. Unemployment is higher in the PNCIMA compared with the provincial average and employment has declined in much of the region over the last decade.

3. Across BC, economic activity that relies on the marine environment contributes $11 billion to provincial GDP and 168,000 person-years of employment, amounting to 7-8% of the provincial economy. The most important components of the ocean-based industries in order of importance are: recreation (e.g., boating, cruise ship tourism, ferry travellers, whale watching, etc.; 33%), transport (29%), and seafood (12%).

4. The PNCIMA also provides significant environmental values. The PNCIMA is home to: ancient sponge reefs; globally-significant bird populations; a wide range of whales, dolphins, porpoises, and pinnepeds; and hundreds of fish species. Many of these species and their associated ecological communities are at risk. The PNCIMA also provides many ecological services, such as nutrient regulation, water treatment, nursery functions, and recreation opportunities. Altogether, the marine environment provides for many commercial, cultural, and ecological benefits.

5. Placing economic values on the ecological services provided by the PNCIMA requires detailed economic valuation that to date has not been done. However, a very rough order of magnitude calculation of the economic value of ecological services can be made by using the data from a major study of the ecological services of the world's major ecosystems completed by Costanza et al. (1997). Based on the data in this study, the value of ecological services provided by the PNCIMA is $92 billion per year.

6. Another indicator of the economic value of the PNCIMA is provided by estimates of the economic value of damages caused by the 1989 *Exxon Valdez* oil spill. The studies used in determining the value of damages examined a variety of impacts, from market impacts of lost fishing opportunities, to non-use values held by households across the US. After a protracted legal battle, the courts settled on an award of $507.5 million which was said to reflect damages. However, studies and claims made by affected parties suggest that damages more realistically amounted to upwards of $10 billion.

7. The PNCIMA is expected to experience significant growth over the coming decade. Based upon a variety of government and industry information, there are about 25 proposed projects constituting about $37 billion in potential investment and roughly

15,000 short-term construction jobs and 2,000 long-term operational jobs being considered for the PNCIMA. While there is considerable uncertainty over how much development will actually proceed, it is clear that there will be major investment in the PNCIMA in the coming years. The consequences of new and existing industrial activities in the PNCIMA are likely to be very significant. Most types of development entail economic, environmental, and social impacts, in some cases of very significant natures.

8. The current management regime is based on project-by-project approvals and sector-by-sector strategies that do not provide integrated management. The problem with this current approach is that it does not adequately manage conflicts among competing uses that negatively impact each other. This problem will intensify with the significant increase in competing activities forecast to occur in the region over the coming decades. Lack of integrated planning will jeopardize the environmental health of the region and inhibit sustainable development of the economy.

9. Integrated marine planning brings together stakeholders to plan and manage the region by face-to-face interaction to seek consensus on management strategies. Marine planning involves jointly agreeing on goals and objectives and developing and implementing plans to achieve these mutually agreed-upon goals in a manner that meets the interests of all stakeholders. The elements of a marine plan normally include assessment of the needs of current and future activities, resource assessment of the marine environment, use allocation by way of zoning that specifies what activities can occur where, and regulations of activities to minimize negative inter-sectoral impacts.

10. Research into marine protection areas highlights the many benefits provided by marine environments. Marine protected areas provide benefits such as: preservation of ecosystem components, conservation of economic opportunities, creation of new economic opportunities, enhancement of recreational opportunities, and preservation of cultural values and scientific opportunities. Costs of marine protected areas include loss of economic opportunities and recreation opportunities, and management costs. A wide variety of studies highlight these benefits and costs.

11. Integrated planning is essential to achieve sustainable development that meets environmental, social, and economic objectives. The benefits of marine planning can be discussed under three themes: environmental protection, sustainable economic development, and social capital. The benefits of marine planning are summarized in table ES-1.

12. A key mechanism by which marine planning can protect environmental values and contribute to sustainable development is designation of marine protected areas. Marine protected areas can provide protection to areas that have important environmental values by prohibiting and/or regulating potentially damaging activities as well assist sustainable development by increasing certainty for investors by designating areas in which development is prohibited early in the process.

Table ES-1. Benefits of integrated marine planning.

Type of Benefit	Components of Benefit	Value Protected*
Environmental Protection	Zoning (marine protected areas) Regulations	$97 billion in annual ecological services
Sustainable Economic Development	Increased certainty Reduced conflict Mitigation of impacts Reservation of areas to accommodate highest and best uses	$37 billion in new investment and $11 billion in annual ocean dependent GDP
Social Capital	Improved stakeholder relations Improved stakeholder knowledge and skills Reduced conflict	Civil society

Note: * These values should be viewed as very rough order of magnitude estimates.

Acronyms

BC EAO	BC Environmental Assessment Office
BC MTTED	BC Ministry of Technology, Trade and Economic Development
CAD	Canadian dollars
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
DFO	Department of Fisheries and Oceans
DR	Development region
GDP	Gross domestic product
GNP	Gross national product
LNG	Liquefied natural gas
MPA	Marine protected area
MW	Megawatt
PNCIMA	Pacific North Coast Integrated Management Area
PY	Person-years
ROE	Renewable ocean energy
TEV	Total economic value
USD	US dollars
WTA	Willingness to accept
WTP	Willingness to pay

1 Rationale

This report is part of a series of four reports completed by researchers in the School of Resource and Environmental Management at Simon Fraser University assessing issues and benefits of integrated marine planning for the Pacific North Coast Integrated Management Area.

The four reports in the series include:

Report 1: Benefits of Marine Planning: Assessment of the Experiences of other Jurisdictions

Report 2: Benefits of Marine Planning: Evaluation of Marine Planning in Canada

Report 3: Benefits of Marine Planning: A Survey of Stakeholders

Report 4: Benefits of Marine Planning: An Assessment of Environmental and Economic Benefits

2 Introduction

Integrated marine planning can generate significant economic benefits by providing for prudent management of industrial activities, protection of environmental values, and reduction of uncertainty of investment. In this report we examine the variety of economic and environmental values of the PNCIMA and explore them through the concept of total economic value. As will be shown, the PNCIMA provides for a wide range of values, many of which are not generally recognized in markets. Maximization of value through integrated marine planning requires both awareness and inclusion of all types of values.

This report is structured as follows. First we review the concept of total economic value and relate it to the marine environment. In the second section we explore economic activities in the PNCIMA and we review a variety of statistics on the PNCIMA economy. Third we discuss environmental values of the PNCIMA, and then examine several means in which these environmental values can be compared to other economic values of the PNCIMA. In the fourth section we provide an overview of planned future industrial activities and provide an overview of their expected economic, environmental, and social impacts. In the final section we describe the economic benefits of integrated marine planning.

3 Total Economic Value

Total economic value (TEV) is economists' attempt to aggregate all values into a single framework of evaluation and is a useful concept for understanding the many values provided by the marine environment. TEV is based on several tenets of the economic theory (Philcox 2007). First, economic value is based on the contribution that goods or services provide for people's well-being. Second, individuals are in the best position to judge what contributes to their own well-being. Third, individuals' valuations of goods and services can be summed to give society's valuation. Fourth, values are best approximated by individuals' willingness to pay (WTP) for a gain or willingness to accept (WTA) compensation for a loss.
TEV is typically broken down into several types of value (table 1). Value can further be distinguished as market or non-market. Market values are those associated with goods and services traded in markets, such as fish and accommodation services. Non-market values are associated with goods and services that are not traded in markets, such as the recreation opportunities provided by wilderness marine areas.

Standard measures of economic activity such as gross domestic product focus on market values such as fish landings and hotel and restaurant sales. In most cases these market values are of the use value type; only rarely do standard measures of economic activity capture non-use values as these types of values are rarely traded in markets. However, as will be discussed further below, non-market values and non-use values can be quite large. Ecosystem services, for example, are extremely valuable as will be discussed later in this report.

Table 1. Components of Total Economic Value (Adapted from Boardman et al. (2006), Philcox (2007), and Hussen (2000).

Value Type	Value Category	Definition	Example
Use Value	Rivalrous	Benefits from use of a resource but where others' benefits are affected	Salmon fishing
	Non-rivalrous direct	Benefits from direct use of a resource but where others' benefits are not affected	Sea kayaking
	Non-rivalrous indirect	Benefits from indirect use of a resource but where others' benefits are not affected	Watching a film about whales
Non-use (passive use)	Option	Benefits from the option to use a resource in the future	Possibility of visiting a marine park in future
	Pure existence (intrinsic value)	Benefits from knowing that something exists; value from satisfaction of preservation	Perceived value of natural order
	Altruism	Benefits from giving something to someone else	Preservation of a marine park for friend's use
	Bequest	Benefits from being able to pass something on to future generations	Preservation of a marine park for grandchildren's use

While decision-making tends to focus on market values, it is obviously important to consider all types of values if they exist. Only by considering all types of values in decision-making can net benefits to society be maximized.

4 Economic Activities in the PNCIMA

The PNCIMA generates a wide variety of values stemming from a diversity of economic activities that are currently taking place. In this section we provide an overview of economic activities taking place in the PNCIMA, and examine these activities in terms of their economic impacts.

4.1 Overview of Economic Activities

The marine environment supports many activities in the PNCIMA. One of the key contributions is ocean-based transportation. Ports, for example, provide transit points, supply stations, and building and repair facilities. Of the many large and small ports and harbours in the PNCIMA, perhaps the most important are the ports of Prince Rupert and Kitimat. The Port of Prince Rupert is the deepest natural harbour in all of North America, is ice-free throughout the year, is the closest North American port to Shanghai, China, and is well-connected by rail to key North American markets (MacConnachie et al. 2007; Stark 2008). The Port of Prince Rupert is currently expanding to further boost its capabilities and market attractiveness. Kitimat is also an important port and may become a key transit point for oil and gas imports and exports between Alberta and the US and Asian markets.

Ship traffic to and from the ports of Prince Rupert and Kitimat as well as the many other ports and harbours in the PNCIMA ranges from cruise ships to container ships to oil tankers to fishing vessels to recreational craft. In 2003, about 3,000 commercial vessels passed through the PNCIMA (MacConnachie et al. 2007).[1] Stark (2008) reports that over the next 15 years the volume of containers shipped through the PNCIMA will increase 300% and the volume of bulk cargo ships will increase 25%. With increased traffic and the planned commencement of the transport of liquefied natural gas (LNG) and other petroleum products via the ports of Prince Rupert and Kitimat, marine planning will be essential to address the economic impacts that port development promises as well as the potential conflicts they present for other values of the PNCIMA.

The fishing industry is another major economic activity in the PNCIMA. Activities include commercial, recreational, and subsistence fishing, finfish and shellfish aquaculture, as well as processing, marketing, and distribution of seafood products. Stark (2008) reports that the PNCIMA supports:

- 85% of BC's trawl catch (excluding hake);
- 90% of BC's hook-and-line catch;
- 85-90% of BC's sablefish catch;

[1] More accurately, in 2003 there were 3,000 "vessel equivalents" signifying that vessels may travel the route more than once.

- 85% of BC's salmon catch;
- 60% of BC's geoduck catch;
- 95% of BC's Dungeness crab catch;
- 45% of BC's prawn catch;
- almost the entire red and green urchin and sea cucumber catch; and
- 55% of BC's finfish aquaculture sites.

While the future outlook for fishing in the PNCIMA is mixed depending upon the fishery, global market conditions and many characteristics of BC coast favour the growth of aquaculture (MacConnachie et al. 2007).

Tourism is another activity that has a substantial economic impact in the PNCIMA. Tourist activities include cruise and ferry trips, boating, sailing, fishing, kayaking, wildlife viewing, cultural tourism, and guided recreation. The cruise ship industry is an important component of tourism in the PNCIMA. In 2007, the Port of Prince Rupert hosted 100,000 passengers and 60 large cruise ships (Stark 2008). The Prince Rupert Port Authority expects annual revenues from cruise ship passengers to grow from $4 million in 2006 to between $24 and 36 million by 2016 (MacConnachie et al. 2007). The Canadian Coast Guard forecasts cruise passengers visiting Prince Rupert to grow from 40,000 in 2001 to over 200,000 by 2011 (MacConnachie et al. 2007). Cruise ships large and small venture throughout the PNCIMA and many smaller communities are working hard to capture some of the growing market. Analysts expect that the PNCIMA will experience growth in both large cruise ship and "pocket cruise" tourism as tourists repeatedly express their interest in experiencing the scenery, wildlife, and small communities of the BC coast (MacConnachie et al. 2007).

Recreation among tourists and residents of the BC coast is also a significant activity in economic terms. EPG (2003), in a study of the economic impacts of outdoor recreation on BC's central and north coasts and Queen Charlotte Islands, identified a wide range of marine-based activities with economic footprints including: boating, saltwater and freshwater fishing, kayaking, hunting, diving, nature study, hiking, and river sports. They estimated that this activity contributed about $55 million annually to the regional economy.

In many cases tourists and locals alike take advantage of parks and protected areas. Within the borders of the PNCIMA there are ten types of federally- and provincially-managed protected areas (MacConnachie et al. 2007). Federal protected areas include a proposed Marine Wildlife Area, a proposed National Marine Conservation Area, a National Park, and several Rockfish Conservation Areas. Provincial protected areas include Ecological Reserves, Provincial Parks, Conservancies, Protected Areas, Wildlife Management Areas, and Wildlife Reserves. Obviously, while these protected areas provide benefits, such as recreational experiences, they can also constrain other activities, such as fishing. Marine planning must consider both the benefits and costs of existing and proposed protected areas.

As discussed further below, a great deal of economic activity in the PNCIMA stems from the activity of both the provincial and federal governments. Provincial agencies active in the PNCIMA include the Ministry of Agriculture and Lands, the Offshore Oil and Gas

Branch in the Ministry of Energy, Minerals, and Petroleum Resources, and BC Parks. Federal agencies active in the PNCIMA include the Department of Fisheries and Oceans, Transport Canada, National Defence, Parks Canada, Natural Resources Canada, and research supported by federal agencies such as NSERC. These government agencies and the activities that they support provide for many jobs and influxes of revenue to citizens, firms, institutions, and local governments throughout the PNCIMA.

Finally, there is economic activity associated with potential energy development in the PNCIMA. While renewable energy development has only begun, there are many plans for its growth as well as a potential for development of offshore oil and gas resources. Currently onshore and offshore wind energy is under development, and a few tidal energy sites are being investigated. A moratorium is in place blocking the development of offshore oil and gas resources that are believed to lie underneath the waters of the PNCIMA, but interest exists among some stakeholders to lift the moratorium and commence exploration.

Altogether we can see that the PNCIMA is host to many economic activities. These activities provide many benefits (values) but also present management challenges due to conflicts among these competing uses. In the next section we investigate the economic values of the PNCIMA by examining economic indicators.

4.2 Employment in the PNCIMA

A useful indicator of the structure of the PNCIMA economy, and thus the nature of economic values provided by the PNCIMA, is employment by sector. Employment data gathered by BC Statistics is summarized in table 2 for BC, and two regions which overlap the PNCIMA. While BC Statistics data is not geographically-disaggregated in line with the boundaries of the PNCIMA, data for the Victoria Census Metropolitan Area can be subtracted from that for the Vancouver Island/Coast Development Region (DR) to more closely approximate employment in the Vancouver Island portion of the PNCIMA, and data from the combined North Coast and Nechako region can be used to approximate employment in the rest of the PNCIMA.

Several patterns are visible in the data. First, a much higher proportion of employment in the PNCIMA is associated with goods production compared to the province as a whole. In 2007, 24% of employment in the Vancouver Island/Coast (without Victoria) and 33% of employment in the North Coast and Nechako regions were in goods production compared to 22% across the province. Much of the goods production is based on natural resource extraction and manufacturing of goods from natural resources. The second major pattern that is visible in the data is that while total employment grew by 25% across the province between 1996 and 2007, it grew much less in the PNCIMA. In the Vancouver Island/Coast (without Victoria) region, employment grew by 17%, but in the North Coast and Nechako region, total employment declined by 19%.

Table 2. Employment (thousands of jobs) by sector (BC Statistics Undated).

Economic Activity	British Columbia				Vancouver Island/Coast (without Victoria)				North Coast and Nechako			
	1996	*% of total*	2007	*% of total*	1996	*% of total*	2007	*% of total*	1996	*% of total*	2007	*% of total*
Total employed, all industries	1816	*100*	2266	*100*	166	*100*	195	*100*	52	*100*	42	*100*
Goods-producing sector	408	*22*	496	*22*	49	*30*	46	*24*	15	*29*	14	*33*
Agriculture	31	*2*	36	*2*	5	*3*	4	*2*	-		-	
Forestry, fishing, mining, oil and gas	55	*3*	47	*2*	13	*8*	10	*5*	3	*6*	3	*7*
Utilities	10	*1*	10	*0*	2	*1*	2	*1*	-		-	
Construction	119	*7*	197	*9*	12	*7*	21	*11*	2	*4*	2	*5*
Manufacturing	193	*11*	205	*9*	18	*11*	12	*6*	9	*17*	7	*17*
Services -producing sector	1408	*78*	1771	*78*	117	*70*	150	*77*	37	*71*	28	*67*

The decline in employment in the North Coast and Nechako region is evident in unemployment data (table 3). While across the province unemployment has declined from 8.4% in 1990 to 4.2% in 2007, unemployment in the North Coast and Nechako region has remained about the same over the last decade at 8%, almost double the provincial rate.

Table 3. Unemployment (%) by Development Region (BC Statistics Undated).

Development Region	1990 (1995)	2000	2007
North Coast & Nechako	(8.1)	10.2	8
Vancouver Island/Coast	(9.3)	7.8	4.3
British Columbia	8.4	7.1	4.2

4.3 Sources of Basic Income in the PNCIMA

Another way of examining the economic values of the PNCIMA is by examining sources of basic income. Basic income is money that flows into a region from the exports of goods and services, including sales to visiting tourists, jobs in the provincial and federal governments, and transfer payments (e.g., employment insurance) (Horne 2004). Therefore, basic income can be said to be the basis of the regional economy. Basic sectors include forestry, mining, fishing, trapping, agriculture and export-based manufacturing, tourism, high technology, the public sector, construction, and a variety of miscellaneous export activities. Non-basic sectors are those that exist to supply basic sectors – they are the goods and service sectors that are supported through re-spending within a region. Non-basic sectors therefore depend on basic sectors for their existence.

Basic and non-basic income data is only available for larger incorporated areas (called "local areas") in the PNCIMA. The data in table 4 indicate that the public sector and

transfer payments are major sources of basic income in the PNCIMA, followed by forestry, fishing, mining, and tourism. The relative importance of these different basic sectors varies considerably among communities though it can be seen that the PNCIMA relies heavily on a limited number of resource-based activities.

Table 4. Percent income dependencies (after tax incomes, 2001). Data from Horne (2004).

Local Area	Forestry	Mining & Mineral Processing	Fishing	Agriculture & Food	Tourism	Public Sector	Construction	Other	Transfer Payments	Other non-employment
Campbell River										
2001	29	4	2	2	7	20	5	2	16	11
1996	36	6	3	1	7	17	-	-	13	7
Alert Bay										
2001	8	0	15	1	8	32	4	1	24	6
1996	18	0	19	0	3	31	-	-	12	8
Port Hardy										
2001	49	1	4	2	8	19	1	0	10	5
1996	51	5	5	1	7	16	-	-	7	3
Central Coast										
2001	13	0	7	1	6	39	5	1	22	5
1996	26	0	8	1	9	38	-	-	9	4
Queen Charlotte Island										
2001	33	0	4	1	7	30	5	4	11	6
1996	34	0	6	0	8	32	-	-	9	6
Prince Rupert										
2001	23	0	11	0	6	30	3	3	18	5
1996	22	0	15	0	8	28	-	-	13	5
Kitimat-Terrace										
2001	19	20	0	0	5	26	6	4	13	7
1996	24	17	0	1	5	22	-	-	11	5

Notes: High Technology and Film Production are not shown as they provide only negligible contributions. "-" signifies data not available.

4.4 Economic Contribution of the Ocean Sector

A third window into the economic values of the PNCIMA is GSGislason & Associates Ltd et al.'s (2007) recent study of the economic contribution of the "ocean sector" in BC. The study was intended to fill an information gap on the economic impacts of oceans-related industry, government, and non-government activity. They defined the ocean sector as "the private industries, research and education organizations, and various levels of government that depend on the ocean environment as a medium for transportation, operation, innovation, or recreation, or as a source of extractable resources" (7). GSGislason et al. determined that the ocean sector was comprised of seven private subsectors, two public subsectors, a non-government subsector, and two potential energy subsectors (Box 1). Each subsector was examined in terms of contributions to gross output, gross domestic product, labour income, and employment, and in terms of direct, indirect, and induced impacts.

In total, GSGislason et al. estimated that the ocean sector contributed $11 billion to provincial GDP and 168,000 person-years of employment, amounting to 7-8% of the provincial economy. Table 5 presents a summary of their estimates of the ocean sector's employment impacts in 2005. The ocean recreation subsector – boating, cruise ship tourism, ferry travellers, whale watching, etc. – was the largest contributor, followed closely by transport and then by seafood.

Box 1. Economic Activities on the BC Coast

Existing Private Subsectors
1. Seafood
2. Forestry – Marine Component
3. Marine Construction
4. Ship & Boat
5. High Technology
6. Ocean Recreation
7. Ocean Transport

Existing Public Subsectors
1. Federal Government
2. Provincial Government

Existing Non-government Subsectors
1. University / R&D
2. Environmental NGOs

Potential Energy Subsectors
1. Offshore Oil and Gas
2. Offshore Wind

The data are not broken down by region. However, table 6 shows ocean employment as a proportion of BC employment and as a proportion of the employment for the three regions where ocean employment is located. The proportion of BC employment dependent on the ocean sector is 8.1% and the proportion of the North Coast, Vancouver Island, and Vancouver regions dependent on the ocean sector is 10.8%.

Table 5. Economic contribution of ocean sector on BC Coast in 2005 (Person-years employment including direct, indirect, and induced).

Subsector		BC Coast			
		GDP (million $)	% of Ocean Sector	Employment (PYs)	% of Ocean Sector
Private	Seafood	1,300	12%	21,570	13%
	Forestry	262	2%	3,030	2%
	Ship & Boat Building	340	3%	4,600	3%
	Construction	205	2%	3,060	2%
	High Technology	1,055	9%	13,320	8%
	Recreation	3,600	33%	60,200	36%
	Transport	3,210	29%	47,200	28%
Public	Federal Gov't	936	8%	12,700	7%
	Provincial Gov't	53	1%	760	1%
Non-Gov't	Universities and Research	65	1%	755	0.4%
	Environmental NGOs	31	0.3%	610	0.4%
	Total Marine Sector	11,057	100%	167,805	100%

Notes: All economic impact data are sums of direct, indirect, and induced impacts. PYs = person-years. GDP = gross domestic product.

Overall, GSGislason et al. concluded that the ocean sector "makes a very important contribution to the economy of British Columbia" and that "the economic contribution of the ocean to the BC economy is larger and is more broad-based than previously

estimated" (58). The importance of the ocean sector to the economy of the coastal regions is even more significant. Furthermore, as "the influence of the ocean on the lives and livelihoods of British Columbians is more pervasive than indicated by ... market-based economic contributions" and "the ocean is integral no just to the economy, but also to our culture, way of life, and collective identity" and "provides key ecosystem services", they acknowledged that any assessment of the economic significance of the marine environment requires assessment of non-market values.

Table 6. Marine Sector Employment (GSGislason & Associates Ltd. et al. 2007).

Employment Category	As % of British Columbia Employment	As % of North Coast, Vancouver Island, and Metro Vancouver Employment
Direct Employment	4.0%	5.4%
Total Employment	8.1%	10.8%

4.5 Summary of Economic Values of the PNCIMA

From the above discussion we can see that the PNCIMA provides for a variety of economic values. Economic impacts stem from a diverse array of activities. The region's economy is heavily reliant on natural resources, tourism, marine transportation, as well as government activity. The contributions as well as the potential conflicts that this diversity of economic activity can create must all be considered in marine planning to maximize net benefits to society.

5 Environmental Values in the PNCIMA

The PNCIMA provides important environmental values. The PNCIMA provides habitat for economically- and culturally-important species, and provides ecological services that humans depend on. Most of these values are not traded in markets and are thus non-market goods and services. In this section we provide an overview of the environmental values of the PNCIMA and then discuss several means with which the environmental values of marine environments can be considered in planning. In this discussion we describe attempts to place monetary values on non-market goods and services. Valuation of non-market goods and services is an imperfect and evolving discipline. Therefore, the specific dollar value estimates should be viewed with some caution.

5.1 Overview of the Environmental Values of the PNCIMA

The PNCIMA is home to numerous and in some cases very rare species and communities (Hall 2008; Stark 2008). In Hecate Strait, sponge reefs made out of glass and thought to be extinct since the Cretaceous period were discovered in 1987. These living reefs are 9,000 years old and are the largest specimens known. The PNCIMA is also globally-significant habitat for birds. One hundred and eight species of marine birds inhabit the PNCIMA during all or part of their life cycle. Eighty percent of the global breeding population of Cassin's auklets is found in the PNCIMA, as well as 56% of the global breeding population of rhinoceros auklets and 74% of the global breeding population of

ancient murrelets. The Scott Islands, a small group of islands off the northern tip of Vancouver Island, is one of the most important seabird breeding areas in the world. Twelve species of seabirds inhabit the islands in globally or nationally significant numbers. The PNCIMA is home to a wide range of whale and marine mammal species. Twenty-seven different species of whales, dolphins, porpoises, and pinnepeds inhabit the PNCIMA, including huge whales like blues and humpbacks. Finally, the PNCIMA is the home to hundreds of fish species. In the PNCIMA there are schools of herring that stretch several kilometres in length, and rockfish older than 200 years. Of all of the species that inhabit the PNCIMA, 33 are listed as Endangered, Threatened, or of Special Concern by the federal Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

The marine ecosystem within the PNCIMA is home to a complex web of interactions. One example is this is the relationship between salmon and forests. In recent years it has become apparent that salmon act as a nutrient pathway for forests. Nitrogen is taken up by salmon in the ocean, and then as salmon return to rivers and streams of the coast to spawn, predators such as bears consume the salmon, spread salmon carcasses along the riverbank, and deposit nitrogen throughout the forest in their scat.

These complex dynamics among species highlight how change to any one element can have dramatic implications on others. The relationship between sea otters and other marine species is a good example of this. The rebound of the sea otter has brought about changes in entire marine ecological communities (Hsu Undated). Sea otters eat sea urchins, which in turn eat kelp. As sea otters have rebounded, a diverse marine community has emerged composed of sea otters, kelp, fish of various sizes and types, seals, whales, and of course – but in relatively lower densities – sea urchins.

Some of the most important ecological features of the PNCIMA to humans may be the natural systems and processes that occur via the many living and non-living components of the region. Beyond the provision of "goods" such as fish, the PNCIMA provides many ecological services. According to the Millennium Ecosystem Assessment (UNEP 2006), there are three types of services that ecosystems can provide in addition to the provision of goods: (1) regulating services such as regulation of climate, wastes, and disease, (2) cultural services, such as the provision of recreational and spiritual benefits, and (3) supporting services, such as soil formation and nutrient cycling. In a review of ecosystem benefits of marine environments, Wilson et al. (2005 in Philcox 2007) identified 19 ecosystem services and five types of goods. These benefits are provided by estuaries, beaches, mud flats, reefs, and other biomes within marine environments. For example, estuaries provide water and nutrient regulation, water treatment, a nursery function, recreation opportunities, food, and ornamental resources. Seagrass, on the other hand, provides gas regulation, disturbance prevention, aesthetic value, and science and education opportunities.

5.2 Valuation of Ecosystem Services

To date there has been little economic valuation conducted towards most of the ecological components of marine environments. Within the PNCIMA, only a very small number economic valuation studies have been conducted of ecosystem benefits, and most valuation research has been focused on ecosystem benefits associated with fishing

(Philcox 2007). To get an order of magnitude estimate of the economic value of ecosystem benefits of the PNCIMA, we can utilize the findings on the economic value of the world's ecosystems by Costanza et al. (1997).

Costanza et al. gathered economic valuation studies on the ecosystem benefits provided by ecosystems around the world, and then multiplied these monetary values by the surface area of each type of ecosystem. While acknowledging many sources of uncertainty, Costanza et al. estimated an annual value for the world's ecosystems of $33 trillion 1994 US dollars and an annual value of services from marine areas of $21 trillion. At the time, global gross national product (GNP) was $18 trillion per year.[2] The authors stressed that their values are likely minimums and that actual values may be much higher.

Before exploring what Costanza et al.'s results might mean for the PNCIMA, it is important to acknowledge criticisms of the study presented by Ayres (1998), Bockstael et al. (2000), and others. Perhaps the greatest criticism stems from Costanza et al.'s estimation of the value of global ecosystem services by multiplying the area of ecosystems by marginal values of each ecosystem. In economic valuation, value is estimated by determining the values of marginal changes in some flow of goods or services, i.e., the WTP or WTA for a small change from an existing level of ecosystem service provision. Costanza et al.'s application of marginal values to each unit of entire ecosystems assumes that marginal values accurately represent the values that people place on any level of ecosystem services. In a later paper, Costanza et al. (1998) acknowledged the limitation of their method but argued that other forms of capital, like labour, also have steeply-sloped demand curves, and that their method of aggregating values of ecosystem services compares with how GNP is calculated using market prices.

The second common criticism of the Costanza et al. study is that the total estimated value of global ecosystem services amounts to a value greater than the value of the global economy. Critics argue that there is a logical inconsistency when WTP exceeds ability to pay. Costanza et al. (1998) countered this by arguing that GNP is a faulty measure because it ignores non-market values and market prices don't reflect "true" prices that address externalities and other price distortions and therefore comparing their result with global GNP is like comparing apples and oranges.

Despite many critiques of their work, Costanza et al. (1998) argue that their estimate of the value of global ecosystem services is simply a "first approximation" to illustrate the economic significance of nature. They acknowledged the limits of economic valuation, but noted it is a way to communicate to people, and that it is just one way to examine the topic. They concluded:

Our Nature paper was a synthesis study. It was an attempt to synthesize existing information to address a new and important question, and to stimulate additional research and debate. We think we succeeded in that goal, and that both the importance

[2] In a later paper Costanza et al. (1998) acknowledged a calculation error and that global GNP was actually $25 trillion a year.

of the question and the limitations of our initial stab at it have been well recognized. Now it is time to take the next steps (72).

Mixed opinion remains among the economics community of the study, and thus anyone following in Costanza et al.'s footsteps must go forth acknowledging the limits of the method.

With this in mind, it seems useful to apply Costanza et al.'s estimates of the economic value of marine ecosystem services to the PNCIMA to provide a rough order of magnitude of the value of ecosystem services provided by this marine region. Marine biomes and Costanza et al.'s estimates of their annual value are summarized in table 7. They found that estuaries and seagrass and algae beds are among the most valuable ecosystems in terms of service provision per hectare. As Costanza (1999) noted, coastal environments are of "disproportionately high value" covering but 6% of the world's surface but are responsible for an estimated 43% of the value of the world's ecosystem services.

Results for the PNCIMA are in the right-hand column of table 7. The PNCIMA is 88,000 km^2 and the federal Department of Fisheries and Oceans (DFO) considers 45,000 km^2 of this area as ecologically and biologically significant due to uniqueness, usage patterns and importance of the habitat to species, the benefits that the area can provide ecosystems in terms of resilience from disruption, and the degree to which the area can be considered pristine (Hall 2008). In the PNCIMA, such areas include the Scott Islands, river mouths and estuaries, Dogfish Bank, and the sponge reefs, among others.

Applying Costanza et al.'s value for open ocean to the "non-ecologically significant" portion of the PNCIMA gives a value of $1.9 billion 2008 CAD. [3] Applying the average of the coastal value estimates to the "ecologically significant" area gives a value of $90.2 billion. Without detailed breakdowns of the different biomes present in the PNCIMA it seemed reasonable to average coastal value estimates and apply this to the portion of the PNCIMA that the DFO has termed ecologically significant. In total, therefore, the PNCIMA could provide in the order of $92 billion in annual ecosystem benefits. To put this value in context, all industries in BC generated $150 billion in GDP in 2007 (BC Statistics 2008). Forestry generated $2.9 billion and mining, oil and gas extraction generated $4.6 billion. Although these estimates are solely rough order of magnitude calculations, they show that ecosystem benefits of the marine environment are substantial.

[3] **Non-ecologically significant areas:** 43,000 km^2 is equal to 4,300,000 ha. 4,300,000 ha multiplied by the value estimate for open ocean of $252 equals $ 1,083,600,000 1994 USD. To convert to 2008 USD, we used an inflation rate of 44.38% which corresponds to CPI January 1994 to CPI January 2008 (http://inflationdata.com/Inflation/Inflation_Calculators/Inflation_Rate_Calculator.asp#results) which gives $1,564,501,680 2008 USD. To convert to Canadian dollars, we multiplied by 1.2082 which is the conversion factor on November 11, 2008 (http://www.xe.com/ucc/convert.cgi) to arrive at $1,890,230,930 2008 CDN. **Ecologically significant areas:** 45,000 km^2 is equal to 4,500,000 ha. 4,500,000 ha multiplied by the average of the value estimates for Coastal, Estuaries, Seagrass / Algae Beds, Shelf, and Tidal Marsh / Mangroves ($11,498) equals $51, 739,200,000 1994 USD. Converting to 2008 USD gives $74,701,056,960 2008 USD. In Canadian dollars, this equals $ 90,253,817,019 2008 CDN.

Table 7. Economic values of marine biomes and PNCIMA.		
Biome	**Costanza et al.'s Estimate of Annual Value/Hectare ($ 1994 USD)**	**Annual Value for PNCIMA ($ 2008 CAD)**
Open Ocean	252	1.9 billion
Coastal	4,052	
Estuaries	22,832	
Seagrass / Algae Beds	19,004	
Shelf	1,610	
Tidal Marsh / Mangroves	9,990	
Average of Coastal and Coastal sub-categories	11,498	90.2 billion
Total		92.1 billion

5.3 Compensation for Damages and the Exxon Valdez

Another way of estimating the economic value of the marine environment is by looking at the results of valuation case studies of specific marine environments. One of most comprehensively studied marine areas is the Alaska coastline where the *Exxon Valdez* oil spill occurred in 1989. After the oil spill, legal proceedings led to numerous studies attempting to estimate the magnitude of damages. The area where the spill occurred is very similar ecologically to much of the BC coast. The studies examined a variety of impacts, from market impacts of lost fishing opportunities, to non-use values held by households across the US.

After a protracted legal battle between those affected by the spill and Exxon, the courts awarded plaintiffs $507.5 million in damages. This award was punitive in nature, i.e., a punishment as opposed to providing compensation. However this amount was awarded based upon the notion of a 1:1 ratio with damages. According to a brief by one of the law firms involved, this amount equalled "the trial court's calculation of appropriate compensatory damages" (Lieff Cabraser Undated).

However, studies and claims made by affected parties suggest that more realistic damages amounted to much more. Affected parties including commercial fishermen, Alaska natives (whose subsistence foods had been affected), landowners, and other Alaskan parties made claims or were assessed with damages amounting to $2 billion (Duffield 1997; Lieff Cabraser Undated). Commercial fishermen, for example, claimed $895 million in damages from lost fishing and lost value due to "tainting" (itself valued at $419 million) (Duffield 1997). In a study of US households affected by lost non-use value, Carson et al. (2003) determined that a minimum loss amounted to between $2.8 and $7.2 billion.

These studies show that damages to a marine area providing both use and non-use values and market and non-market values can be significant. The oil spill damages occurred in one of the world's prime locations for fishing and tourism and where many people hold

substantial attachment to place. Based upon the valuation studies that occurred to support the legal process, the economic value for damages caused by the *Exxon Valdez* oil spill amounts to somewhere between $500 million and $10 billion. Although the methods used in such valuations are controversial, and the completeness of the legal process in terms of covering the full range of values is questionable, the damage valuations represent state-of-the-art efforts to estimate the economic value of a small portion of the Alaska marine environment. This study has applicability to valuing the PNCIMA by virtue of comparable environments, economic activities, and attachment to place by citizens across Canada, including especially First Nations.

5.4 Summary of Environmental Values of the PNCIMA

The foregoing discussion highlights the many environmental values of marine environments and the PNCIMA in particular. Marine environments provide for many of the constituent components of TEV including food, ecosystem services, recreational opportunities, and wilderness. A variety of research has uncovered the range of values and has also attempted to translate these values into monetary terms. While accurate measures of the economic values of marine environments are difficult to determine with any degree of precision, it is clear that marine environments provide substantial benefits. An appreciation of these benefits is necessary when considering what activities should and should not take place in the PNCIMA.

6 Future Activities in the PNCIMA

Before considering how one might tally up the many economic and environmental values of the PNCIMA for marine planning purposes, it is essential to have an appreciation for the scale of human activity planned for the PNCIMA in the coming years. In this section we review several studies and sources of information that highlight the appreciable level of growth planned in the PNCIMA by industry and government.

In their report on the economic contribution of the oceans sector the BC economy, GSGislason et al. (2007) forecasted economic impacts from future offshore oil and gas and renewable energy development on the BC coast. For offshore oil and gas they estimated an annualized stream of $5.3 billion in GDP and 10,265 person-years in employment impacts.[4] These estimates include direct, indirect, and induced impacts. They noted that the majority of economic impacts would occur during operations[5], the

[4] Key assumptions include: 1,615 million barrels of oil production, 6,060 billion cubic feet of gas production, both worth $109 billion US ($50 US per barrel of oil, $6 US per thousand cubic feet of gas); construction costs of $15.4 billion US; lifetime operating and transportation costs of $15 billion US; 24 years construction and operations for oil facilities; and 31 years construction and operations for gas facilities.

[5] Note that it can only be said that the majority of impacts occur during the operations phase when one aggregates the economic impacts of the total time of operations (GSGislason et al. assumed 24 years in the case of oil, 31 years in the case of gas). On a year-to-year basis, employment impacts are much greater during construction compared to during operations.

majority of direct impacts would stem from industry activity, but the majority of employment impacts would stem from indirect and induced consumer/retail spending. They cautioned that the estimated impacts of offshore development are highly speculative as they are based on a variety of assumptions about key parameters, including whether or not the current moratorium on oil and gas development will be lifted and whether there are economically accessible oil and gas reserves.

In terms of potential future offshore wind energy development, GSGislason et al. estimated that offshore wind would generate $12,590 million in GDP and 42,645 person-years in employment over the lifetime of the projects, or an annualized stream of $600 million in GDP and 2,030 person-years in employment. Their estimates are based upon an assumption that 1,500 MW of capacity would be constructed. GSGislason et al. concluded that it is too early to tell what the economic impacts from future tide and wave energy development would be.

The proportion of the new energy investment that will be based in the PNCIMA is uncertain. It is likely that much of the actual offshore oil and gas development will take place within the boundaries of the PNCIMA (figure 1), however much of the economic activity will occur non-locally (e.g., engineering studies, environmental impact consulting services, government services, rig manufacturing, etc.) in Vancouver or elsewhere outside of the PNCIMA (Gunton et al. 2004). Similarly, offshore wind energy development is planned for locations within the boundaries of the PNCIMA, but similarly, a large portion of the economic impacts – perhaps the majority – would occur non-locally outside of the PNCIMA in large urban centres and outside of BC (Joseph and Gunton 2008). As with offshore oil and gas, much of the economic activity of offshore wind development is composed of studies, government activity, and manufacturing, most of which would be expected to be completed by firms and agencies located in large urban centres and in some cases outside BC altogether. Only a fraction of tidal energy development is being contemplated in the PNCIMA (in the Campbell River area) and no wave energy development is being contemplated in the region (Joseph and Gunton 2008).

Other estimates of future investment intentions are available from the BC *Major Projects Inventory* which is a list of proposed projects with capital costs of over $15 million. According to the most recent data (BC MTTED 2008), there are 19 projects totalling $16.4 billion in potential investment proposed in the PNCIMA.[6] Of the 19 projects, 15 are energy-related, three are mining-related, and one is a port development.

Additional information on planned industrial development is available from the BC Environmental Assessment Office's (BC EAO) on-line database of projects as well as

[6] Note that others may find some variation to our numbers as it is somewhat arbitrary to distinguish which industrial projects planned for the geographical boundaries of the PNCIMA are actually relevant for marine planning purposes. For example, are all hydroelectric projects in the geographical area generally consistent with the PNCIMA boundary relevant to the PNCIMA planning process, or are only those much more proximal to the ocean relevant? Similarly, are mines such as the Mount Klappan coal mine which will transport coal by slurry pipeline to the coast for eventual marine transport relevant? In constructing our estimate we considered all projects that occurred at least in part within the marine environment as relevant to PNCIMA planning.

consultants' reports and company websites. Table 8 presents a list of planned industrial development for the PNCIMA. The list includes 25 energy projects, three port developments, two mineral-related developments, and the prospect of growth in the aquaculture industry. Available data indicates that the 25 proposed projects constitute about $37 billion in potential investment.

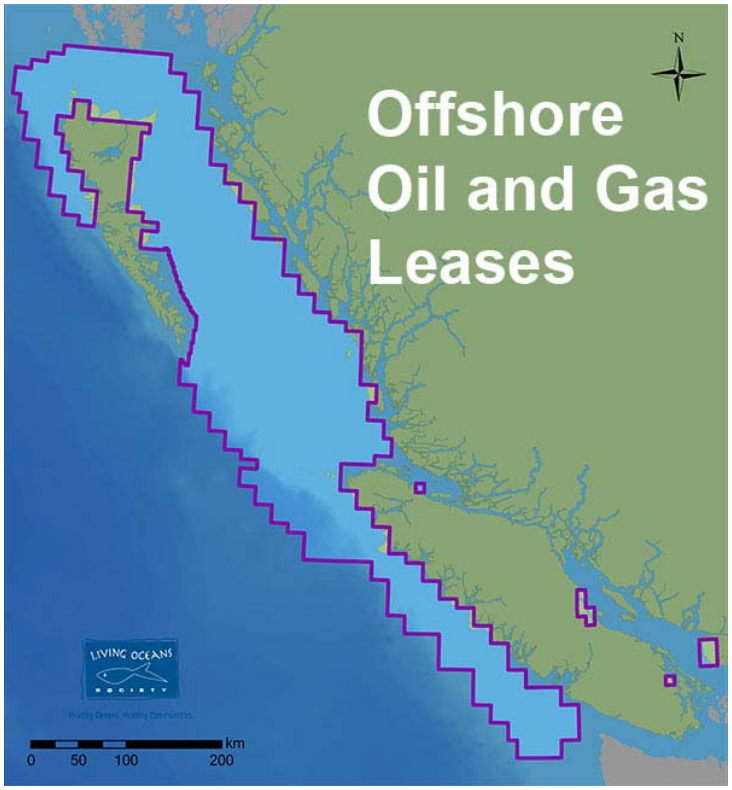

Figure 1. Offshore oil and gas leases on the BC coast (Living Oceans Society 2008).

Employment data is available for many projects planned for the PNCIMA, though it is difficult to develop an order-of-magnitude estimate of employment impact. Employment impact data is provided by BC MTTED's *Major Projects Inventory*, on BC EAO's website for projects undergoing environmental assessment, and in a variety of other documentation. However, in most cases employment data is not clearly described in terms of its scope (i.e., direct, or a total of direct, indirect, and induced) or is reported using differing units of measurement. Regardless, information on employment impacts for many of the projects listed in table 9 is available. As such, if all projects go ahead there will be something in the range of 15,000 short-term construction jobs and 2,000 long-term operational jobs. Depending upon the pace of development, construction jobs may arise over a relatively short period of time, providing for a boom, or be spread out over time and thus provide for more sustained employment.

It should be cautioned that there is considerable uncertainty regarding forecasts of future economic activity. However, despite these uncertainties, the data indicates that there will likely be major new investments in the PNCIMA over the next several decades.

Table 8. Industrial development planned for the PNCIMA.

Name	Location	Phase	Timing	Cap Cost ($ million)	Notes
Aristazabal Island Offshore Wind Farm	North Coast	Pre-construction	Uncertain	*206*	110 MW
Banks Island Wind Farm (Banks Island Wind Farm Ltd.)	Banks Island, North Coast	Pre-construction	Near-term	*413*	90-350 MW
Banks Island Wind Farm (North Coast Wind Energy Corp.)	Banks Island, North Coast	Proposed	Near-term	1,400	700 MW, expansion to 3,000 MW
Kitimat Break-Bulk Port Facility	Kitimat	Proposed	Uncertain	500	
Cape Sutil Offshore Wind Farm	Vancouver Island/Coast	Pre-construction	Uncertain	*608*	310-340 MW
Enbridge Gateway Pipeline and Terminal	Kitimat	Proposed /On hold	Uncertain	4,400	condensate import & oil export; includes tanker traffic
Europa Creek Hydroelectric Development	Kitimat	Proposed	Uncertain	180	67-83 MW
Harmony Gold Mine	Queen Charlottes	Proposed	Uncertain	50	
Kennedy Island Wind Farm	North Coast	Pre-construction	Uncertain	*187*	100 MW
Kinder Morgan TMX (Spirit) Pipeline and Terminal	Kitimat	Pre-construction	Uncertain	2,500	condensate import & oil export; includes tankers
Pembina Pipelines Pipeline and Terminal	Kitimat	Proposed	Near-term	700-1,200	condensate import; includes tankers
Pacific Trails / KSL / PNG Pipeline	Kitimat	Proposed	Near-term	1,100	gas pipeline for Kitimat LNG Terminal
Kitimat LNG Terminal Project	Kitimat	Proposed	uncertain	500-700	Environmental assessment approved in 2006; includes tankers
Klinaklini Hydroelectric Project	Knight Inlet	Pre-construction	Near-term	560	280 MW
Kokish River Hydroelectric Project	Port McNeill, Vancouver Island	Pre-construction	Uncertain	130	55 MW
Malcolm Island Wind Farm	Port McNeill, Vancouver Island	Pre-construction	Uncertain	*346*	90-280 MW
McCauley Island Wind Farm	North Coast	Pre-construction	Uncertain	*468*	250 MW
Mount Hays Wind Farm	Kaien Island near Prince Rupert	Proposed	Near-term	50	25.2-30 MW

Mount Klappan Coal Mine	Stewart or Prince Rupert	Proposed	Uncertain	274-414	port activity and marine transportation
Naikun Offshore Wind Farm	Western Hecate Strait	At "pre-app" stage in EA process	Near-term	1,600	initially 320 MW, expansion to 1,750 MW
Offshore oil and gas development	Throughout PNCIMA	Pre-proposal	Uncertain	1,257	includes ship traffic
Porcher Island Offshore Wind Farm	North Coast	Pre-construction	Uncertain	*16,905*	9,040 MW
Porcher Island Wind Farm	North Coast	Pre-construction	Uncertain	*1,833*	980 MW
Price Island Wind Farm	North Coast	Pre-construction	Uncertain	*187*	100 MW
Prince Rupert Potash Terminal Expansion	Prince Rupert	Proposed	Uncertain	300	
Songhees Creek Hydro Project	Port Hardy, Vancouver Island	Pre-construction	Near-term	30	15 MW
Stewart Bulk Cargo Expansion	Stewart	Pre-construction	Near-term	6	includes ship traffic
Tidal energy development	Campbell River area	Pre-construction	Uncertain		at least 1 tidal project under consideration for PNCIMA
Trutch and Barnard Islands Wind Farm	North Coast	Pre-construction	Uncertain	*168*	90 MW
Victoria Lake Hydro Project	Port Alice, Vancouver Island	Pre-construction	uncertain	18	9.5 MW
Aquaculture development	Coastlines of PNCIMA	Proposed	uncertain		
				≥36,874	

Notes: Re timing: "near-term" signifies expectation to complete in next 3-5 years; "uncertain" signifies a range of possible dates or no established timeline. "Cap cost" signifies expected capital investment; cap cost values in italics are estimated by authors based upon similar projects' costs.
Sources: BC EAO (BC EAO Undated), BC MTTED (2008), CAPP (2007), Enbridge (2008), Gunton et al. (2005), Joseph and Gunton (2008), Parker (2008), and Pembina Institute (2006).

The consequences of new and existing industrial activities in the PNCIMA are likely to be very significant. In tables 9, 10, and 11 summaries are presented from previous studies of environmental and socio-economic impacts of oil and gas development, port, pipeline, and tanker development, and renewable energy development on the BC coast. As these tables demonstrate, there are likely to be significant impacts from industrial development and therefore careful assessment of impacts and planning is necessary to minimize impacts and to maintain the economic and environmental values of the PNCIMA.

Table 9. Summary of environmental impacts offshore oil and gas development on the BC coast (after Gunton et al. (2004)).

Source Impact	Known Impacts	Key Uncertainties	Relevant Characteristics of Queen Charlotte Basin	Duration of Impact
Exploration				
Geophysical surveying; marine and air traffic	limited lethal impacts, but sublethal impacts, including behavioural effects	species' sensitivity; impact of chronic noise and low levels of noise; nature of sublethal impacts; ecological, and long term impacts; impacts of some technologies	data gaps regarding wind and wave regimes, water depth, geological and geomorphological hazards, species habitat usage, and ecosystem sensitivity	months to years
Exploratory drilling; drilling discharges	water quality degradation; physical changes; lethal and sublethal impacts in the vicinity of drilling sites; long-term ecological change in vicinity of drilling sites	toxicity of some discharges; degree of dispersal and spatiality of impacts; cumulative nature	rapid dilution/dispersal in water column; data gaps regarding ecosystem sensitivity	years to decades
Exploratory drilling; flare gasing and air pollution	relatively small air pollution contributions	none specifically noted	none specifically noted	days to ?
Blowouts	See Spills (below)	See Spills (below)	inadequate subsea geological data	years to decades
Development and Production				
Noise during drilling, production, and other activities	potential avoidance responses from marine mammals and other species	impact of chronic noise	data gaps regarding sound transmission characteristics of QCB; species distribution/ habitat usage	decades
Physical changes at offshore sites	local lethal, sublethal, and ecological impacts from habitat alteration above and below sea surface; disruption of biota movement/migration patterns	impact on bird populations, including migration and movement	vigorous currents, oceanic scouring and depositional processes; large bird populations	years to ?

Discharges during production and transportation	water quality degradation; local lethal, sublethal, and ecological impacts from pollution; chronic pollution; ecological impacts of species introductions; also see Spills (below)	dispersal and impacts of produced water; nature of impacts of species introductions; duration of impacts; also see Spills (below)	rapid dilution/dispersal in water column; data gaps regarding ecosystem sensitivity	months to decades
Air pollution	local air quality degradation; atmospheric fallout; greenhouse gas emissions	none specifically noted	none specifically noted	weeks to ?
Onshore impacts	local pollution and habitat change leading to local impacts	magnitude of impacts	none specifically noted	likely permanent2
Spills				
Small spills (<1,000 barrels)	water and air quality degradation; local lethal and sublethal impacts	none specifically noted	none specifically noted	days to months
Large spills (>1,000 barrels)	water and air quality degradation; lethal and sublethal impacts to exposed species; long-term persistence in certain shoreline sediments; population- and ecosystem-level impacts that may be long term	size of spill (because a chance event); nature of impacts, including time length, scale, and ecological aspects; impact of methanol on marine life; models of spill trajectories; models of spill impacts	models of spill trajectories indicate spills will strike coast (unless prevented by countermeasures); shorelines would absorb and retain substantial volumes of hydrocarbons; large numbers of biota inhabit QCB	decades
Clean-up activities	population- and ecosystem-level impacts at spill sites	impact of clean-up on marine life; proper use of clean-up strategies; recovery	many shorelines are moderately to highly susceptible to hydrocarbon infiltration and retention	months to years
Decommissioning				
Noise, activity, possibly including explosions	local lethal and sublethal impacts	none specifically noted	none specifically noted	days to months

Remnants at site	legacy of chemical contamination, providing lethal, sublethal, and local ecological impacts; legacy of habitat change if artificial reef abandoned, resulting in unnatural local community	duration of chemical contamination	none specifically noted	decades or longer
Disposal of used equipment	chemical and radioactive pollution on or offshore, resulting in local impacts	none specifically noted	none specifically noted	decades or longer
Combined Impacts				
Incremental impacts	ecological change at offshore sites; ecological change in chronically polluted waters	significance of impacts of chronic pollution	none specifically noted	?
Cumulative impacts	mixed data, though evidence in Alaska	capacity of impacts to accumulate; magnitude that cumulative impacts would constitute	QCB currently under stress and demonstrating change	?

Table 10. Overview of socio-economic impacts of ROE development and key uncertainties (from Joseph and Gunton (2008)).

Impact Receptor	Description of Impact	Key Uncertainties
Coastal Defence	Reduction in damage to coastal features	Extent of effect
Cultural Resources	Damage to historical and/or archaeological resources	
Economic – Employment	Direct and multiplier employment impacts	Extent of impacts (inexperience, novelty of technology, how many projects will proceed)
Economic – Revenue	Earnings to governments, communities and First Nations through taxes, fees, leases, and partnerships	Extent of impacts (inexperience, novelty of technology, how many projects will proceed)
Economic – Boom and Bust Phenomena	Mostly negative effects due to rapid rise/drop-off in economic activity and worker population	
Economic – Aviation	Hazard to low-flying aircraft from wind energy installations	
Economic – Aquaculture Industry	Possible conflict over marine space	
Economic – Communication Industry	Interference with radio, radar, VHF, etc.	Effect on certain technologies and overall effect
Economic – Fisheries Industry	- Negative impacts on fish from noise, activity, vibrations, etc. - Exclusion of fishers from fishing grounds - Positive effects of artificial reefs and no-take zones	Overall effect on fish and fisheries
Economic – Forestry Industry	Exclusion and/or obstruction of forestry activities	
Economic – Marine Navigation and Ports	- Exclusion and/or obstruction of shipping and other marine travel - Collision risk / - Enhancement of marine safety - Increases in business of marine industries and at ports	Overall effect on marine users and ports
Economic – Mining Industry	Exclusion and/or obstruction of mining activities	
Economic – Offshore Oil and Gas Industry	- Conflict over existing leases - Exclusion and/or obstruction of activities	- Effect of leases held by oil companies on ROE development - Extent that future oil and gas activities would be excluded or obstructed
Economic – Property Values	Effect on values	Extent of effect
Economic – Tourism Industry	- Aesthetic (visual and noise) impacts - Degradation of tourist's recreational experiences - Attraction of tourists	Overall effect on tourism
Energy Supply	Potential to improve the energy supply of the BC coast in terms of cost, quantity, reliability, etc.	Degree to which the improved energy supply will stimulate economic growth
Health Benefits	- Reduction in air pollution and noise - Emotional benefits from association with green power	
Recreation	Degradation/improvement in recreational experiences	Overall effect on recreation
Rural Demographics and Migration	Possible reduction in rural-to-urban migration pattern	Extent of population loss from rural areas
Traditional Activities and Interests	- Infringement of Aboriginal Rights and Title - Obstruction of Traditional activities and culture	Extent to which the land claims process will affect the growth of the ROE industry

Table 11. Potential environmental impacts of pipelines, ports, and tanker projects (from Gunton et al. (2005)).

Project Component	Impact Category	Potential Impacts
Pipeline Construction and Operation	Physiography and Soils	- Loss of soil capability - Soil compaction, pulverization, rutting, and reduced percolation rate - Erosion and increased sediment load - Decreased terrain stability - Direct topsoil and subsoil loss
	Surface and Groundwater	- Changes in groundwater recharge and discharge rates and flow obstruction - Decreased water quality and quantity - Contamination from solid, industrial, and liquid wastes
	Air Quality	- Increased emissions due to burning of slash and debris, construction and operation of pump stations, and vehicle use - Increased dust from construction and maintenance vehicles
	Noise	- Negative effects on nearby residents, hunters, recreational users, and indigenous wildlife
	Vegetation	- Direct loss and alteration of vegetation - Changes to physical site conditions due to introduction of nonnative and invasive species - Disturbance of rare plants and traditional collecting sites
	Wildlife	- Direct habitat loss, alteration, or fragmentation leading to species loss - Disturbances on feeding, nesting, denning, or breeding patterns - Alteration of seasonal and daily movements of wildlife - Increased mortality due to greater human access to wildlife areas
	Fish and Fish Habitat	- Direct species loss due to increased sedimentation, turbidity, flow disruption, trenching, or dredging in watercourses - Indirect species loss due to increased water use and access to fishing areas
	Oil Spills and Accidents	- Detrimental impacts on soils, water, and vegetation - Destruction of bird nests and feather contamination in waterfowl - Direct loss of wildlife due to contaminated food intake, reduced respiratory functions, or ingestion of oily water - Direct loss of water birds, livestock, fish, fish eggs, and larvae
Port Construction and Operation	Air Pollution	- Negative human health effects - Destruction of upper-atmosphere ozone - Generation of acid rain - Increased global warming

		- Destruction of agricultural resources, forest, and plant communities
	Water and Contaminant Discharges	- Direct and indirect loss of marine biodiversity and fishery resources - Ocean floor contamination and loss of benthic organisms
	Dredged Material and Contaminated Sediment Disposal	- Negative effects on plant and animal communities - Decreased water quality - Contamination of ocean sediments leading to species loss
	Ship and Port Generated Solid Waste	- Direct loss of marine mammals, sea turtles, seabirds, and fish due to entanglement or ingestion of marine debris - Reduced capacity of animals to forage, digest food, and absorb nutrients
	Oil Spills and Accidents	- Direct loss of vegetation communities, bird and mammal populations, threatened and endangered species, fish populations, and benthic communities
Tanker Operations	Air Pollution	- Detrimental human health effects - Destruction of upper-atmosphere ozone - Increased acid rain - Increased global warming - Destruction of agricultural resources, forest, and plant communities
	Ballast Water Discharge	- Introduction of alien species - Increase mortality in marine birds - Generation of beach tar
	Accidents and Oil Spill Risks	- Direct loss of marine and terrestrial mammals, birds, and other species - Direct loss and/or decreased survival capacity in fish and fish larvae - Decreased water quality by chronic toxicity levels - Contamination of shorelines - Other negative effects due to oil spill clean-up techniques

7 Benefits of Marine Planning

The current management regime for the PNCIMA is evaluated in Report No. 2 of this series. The evaluation indicates that the current management regime is based on project-by-project approvals and sector-by-sector strategies that do not provide integrated management. The problem with this current approach is that it does not adequately manage conflicts among competing uses that negatively impact each other. This problem will intensify with the significant increase in competing activities forecast to occur in the region over the coming decades. Lack of integrated planning will jeopardize the environmental health of the region and inhibit sustainable development of the economy

The components of integrated marine planning are described in detail in Report No. 1 in this series. In brief, integrated marine planning brings together stakeholders to plan and manage the region by face-to-face interaction to seek consensus on management strategies. Marine planning involves jointly agreeing on goals and objectives and developing and implementing plans to achieve these mutually agreed upon goals in a manner that meets the interests of all stakeholders. The elements of a marine plan normally include assessment of the needs of current and future activities, resource assessment of the marine environment, use allocation by way of zoning that specifies what activities can occur where, and regulations of activities to minimize negative inter-sectoral impacts. This type of integrated planning is essential to achieve sustainable development that meets environmental, social, and economic objectives. The benefits of marine planning can be discussed under three themes: environmental protection, sustainable economic development, and social capital, and are presented in table 12.

Table 12. Benefits of integrated marine planning.

Type of Benefit	Components of Benefit	Value Protected*
Environmental Protection	• Zoning (marine protected areas) • Regulations	$97 billion in annual ecological services
Sustainable Economic Development	• Increased certainty • Reduced conflict • Mitigation of impacts • Reservation of areas to accommodate highest and best uses	$37 billion in new investment and $11 billion in annual ocean dependent GDP
Social Capital	• Improved stakeholder relations • Improved stakeholder knowledge and skills • Reduced conflict	Civil society

Note: * These values should be viewed as very rough order of magnitude estimates.

7.1 Environmental Protection

The importance of protecting and enhancing the ecological health of the PNCIMA cannot be overstated. Although it is not possible to provide a specific estimate without more

detailed analysis, a rough order of magnitude estimate based on other studies suggests the value of ecological services provided by PNCIMA could be in the order of $92 billion per year. Studies of the economic cost of environment damage caused by the *Exxon Valdez* on only a small component of the marine environment range as high as $10 billion. Further, economic analysis of the regional economy shows a high degree of dependence on a healthy marine environment. Clearly the costs of damaging the environment are substantial.

Integrated marine planning is essential for protecting the environmental health of the region. A key mechanism for providing this protection is to identify areas of the PNCIMA that have significant environmental values and designate them as marine protected areas where activities that could damage the environment are prohibited and/or regulated in a manner to prevent environmental damage.

A substantial literature has developed examining the environmental values of marine protected areas (MPAs). A summary of costs and benefits of marine protected area designation is provided in table 13.

Table 13. Benefits and Costs of MPAs.

Benefits	Costs
Preservation of ecosystem components	Loss of economic opportunities
Conservation of economic opportunities	Loss of recreation opportunities
Creation of new economic opportunities	Management costs
Enhancement of recreational opportunities	
Preservation of cultural values	
Preservation of scientific opportunities	

One of the main benefits of MPAs is their ability to preserve ecosystems. MPAs, particularly those that impose strong limits to human activity, are useful in terms of protecting ecosystem components such as key habitat, threatened species, communities, and areas of high biological activity (Pendleton 1995; Reeves 2000; Sumaila et al. 2000). Fish, marine mammals, and other species tend to exhibit improved viability in MPAs compared to unprotected areas. MPAs thus provide a buffer or "insurance" against human pressures (e.g., overfishing), uncertainty (which affects management decisions), and natural disturbances (Murray et al. 1999; Reeves 2000; Sumaila et al. 2000; Pitchford et al. 2007; Sumaila et al. 2007).

The ecological value of MPAs provides an economic benefit for fisheries. Several studies have shown that MPAs boost fish stocks in terms of biomass, egg production, and other indicators (Murray et al. 1999; Sumaila et al. 2000; Cucherousset et al. 2007; Tetreault and Ambrose 2007). MPAs thus serve as a means to conserving fishing opportunities by way of conserving and enhancing fish stocks. Studies of the relative costs of MPAs on fisheries on both small (i.e., local) and large (i.e., global) scales have concluded that MPAs are a cost-effective means to conserving fishing opportunities (Cucherousset et al. 2007; Pitchford et al. 2007; Sumaila et al. 2007; White et al. 2008).

The ecological value of MPAs also contributes to the conservation and/or creation of cultural, recreational, and scientific opportunities. MPAs preserve the sense of wilderness

(a non-use value), but also provide for the preservation of values held by indigenous and other cultural groups (Reeves 2000). First Nations in BC, for example, receive spiritual as well as subsistence value from undisturbed marine environments. As with the impacts of the *Exxon Valdez* oil spill in Alaska, non-use values may constitute the greatest component of TEV. In a study of the value of an MPA in Greece, Togridou et al. (2006) found that non-use values, particularly bequest values, were associated with the highest WTP amounts elicited from respondents.

Many studies have linked MPAs with recreational benefits – numerous studies have established high levels of economic value of MPAs to SCUBA divers, beach walkers, surfers, and other recreationalists (e.g., Arin and Kramer 2002; Hall et al. 2002; Green and Donnelly 2003; Asafu-Adjaye and Tapsuwan 2008). Green and Donnelly (2003), for example, found that the majority of SCUBA dive operators in the Caribbean were located within 20 km of at least one MPA and 46% conduct at least 80% of their diving within a MPA. Green and Donnelly concluded that substantial revenue could be generated by charging divers for access. The establishment of MPAs thus provide benefits for recreationalists and can generate new tourism opportunities (Murray et al. 1999; Sumaila et al. 2000).

Finally, MPAs provide opportunities for research and education to the benefit of government, academia, and educational institutions. MPAs provide places to gather baseline information, monitor environmental change, evaluate the effectiveness of policy (e.g., protected areas strategies), and conduct research (Murray et al. 1999; Reeves 2000).

The literature documents few negative impacts of MPAs. Nonetheless, there is concern among existing marine stakeholders that MPAs may reduce or prohibit opportunities. The fishing, offshore oil and gas, renewable energy (wind, tidal, wave), and shipping industries are obviously at risk of impediment when MPAs are considered.[7] The offsetting benefit of MPAs for these stakeholders is that they can reduce uncertainty by indicating early in the assessment process locations that should not be considered for future resource investment. Also, as discussed above, the literature concludes that the fishing industry is better off with MPAs than without because of their capacity to fortify fish stocks. The only other negative impact is the cost of administering MPAs, including enforcement of rules, etc. Cook and Heinen (2005) found that the costs of managing a MPA in Florida were relatively minor.

7.2 Sustainable Economic Development

A large segment of the PNCIMA economy is dependent on the marine environment. The health of this ocean-dependent economy relies on many factors. Several factors relate directly to the planning framework used to manage the PNCIMA region. These include: location and management of activities so that they do not negatively impact on each other, and clarity in regulations and approval processes to reduce uncertainty pertaining to future investment.

[7] See Joseph and Gunton (2008) for a review of stakeholder conflicts over loss of marine space in an offshore renewable energy development context.

The current management regime based on project-by-project assessment does adequately meet these needs. The survey of industry in Report No. 3 in this series shows that about two-thirds of industry respondents expressed concern over the uncertainty created by the lack of a marine plan. One-third of respondents indicated the lack of a marine plan has affected their industry, and one-quarter indicated that projects were either delayed or cancelled. The cost of this uncertainty can be high. As discussed in this report, currently there are about $37 billion in proposed investment for the PNCIMA comprised of over 25 projects. Applying the one-quarter impact ratio based on survey respondents, the number of projects impacted by uncertainty could be in the range of 6-7 projects representing $9 billion in potential investment. The actual impact may be greater or less than this because the survey results on which the impact ratio of one-quarter is based are not specific to the projects.

Another way of estimating the cost of uncertainty is by applying a risk premium to investment. One study attempted to estimate the economic costs of uncertainty associated with land claims in BC by surveying investors (Price Waterhouse 1990). The study concluded that uncertainty generated a risk premium for some major investors in the range of 1% of the value of the project and delays and cancellation of projects. Although estimating a risk premium is challenging and unique to each case, a 1% risk premium applied to planned investment in the PNCIMA would be equivalent to a cost of $370 million based on the $37 billion in investment.

Another major economic cost is impairment of existing activities caused by negative impacts of other activities. Industrial activities can, for example, negatively impact tourist activities if they are located close to each other. Estimating the costs of impairment caused by the interaction of incompatible activities is a challenging task unique to the specifics of each case that is beyond the parameters of this report. Nonetheless, as the impact assessment tables show (tables 9, 10, and 11) the costs are likely to be substantial, especially with the development of new projects in the region.

An integrated marine plan can mitigate these costs by increasing certainty through identification of appropriate locations for proposed activities by consensus agreement among stakeholders based on suitability analysis of the region. As discussed earlier, the setting aside of marine protected areas is a way of increasing certainty by identifying zones where certain activities are prohibited and where certain activities may be allowed. An integrated marine plan can also identify and reserve areas with high suitability for certain activities and reduce impairment by ensuring that conflicting uses are not located too close to each other.

7.3 Social Capital

Previous studies (e.g., Frame et al. 2004) show that stakeholder-led planning processes can build what can be termed social capital, which is defined as improved stakeholder knowledge and skills and improved stakeholder relationships and networks. Social capital generates significant benefits by reducing conflict among stakeholders and increasing the ability of stakeholders to manage their activities to improve the public good. Studies of stakeholder planning processes show that generation of social capital is one of the most important benefits of planning, with over three-quarters of stakeholders reporting social

capital gains as a result of participation in planning. The preparation of an integrated marine plan could be expected to generate similar social capital gains.

8 Conclusion

The PNCIMA is a multi-facetted region characterized by diverse and conflicting activities and generating significant environmental and economic values. Conflicts in the region can be expected to escalate over the next decade due to anticipated expansion of potentially conflicting activities. As such, the unique and important assets of the region will increasingly be in jeopardy. The current management regime based on project-by-project assessment and sectorally-specific strategies is not equipped to handle the management challenges in the region. What is required is preparation of an integrated marine plan using a consensus-based stakeholder process that identifies goals, identifies interests of different stakeholders, analyzes the resource base, and develops and implements a marine plan that allocates activities to suitable areas within the PNCIMA and regulates activities to minimize negative impacts. An integrated marine planning process will protect environmental values, promote sustainable economic development, and build social capital among stakeholders.

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