CLEANING UP OUR OCEAN

A report on pollution from shipping-related sources in the Pacific North Coast Integrated Management Area (Pncima) on the British Columbia Coast

Living Oceans Society
Healthy Oceans. Healthy Communities.

Sierra Club BC

David Suzuki Foundation
SOLUTIONS ARE IN OUR NATURE

Produced by the David Suzuki Foundation in collaboration with the Living Oceans Society and the Sierra Club of B.C.

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The David Suzuki Foundation
209 – 221 West 4th Ave.
Vancouver, BC, Canada
V6K 4S2
Ph. 604-732-4228
www.davidsuzuki.org

Living Oceans Society
207 W. Hastings St., Suite 1405
Vancouver, BC, Canada
Ph. 604-696-5044
www.livingoceans.org

Sierra Club of BC
302-733 Johnson St.
Victoria, BC, Canada
Ph. 250-386-5255
www.sierraclub.bc.ca

For more information on Pncima and to find our how you can help clean up our oceans, visit the websites of the organizations listed above or go to:

www.pncimamatters.ca or www.healthyoceans.ca

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Introduction

For more than 5,000 years the Pacific Northwest has been a corridor for the marine transportation of goods, services, and people. Today it remains key to industries operating in the region. However, human growth and its associated industrial activity have wide-ranging effects on the marine environment. Pollution of ocean waters can range from small but consistent events to large catastrophic events like oil spills. Regardless of the size and frequency of the polluting source, the effects of ocean pollution are cumulative. As the degree and type of human activity in our oceans increases we must find ways to reduce the accumulation of pollutants and to clean up our oceans as much as possible.

The known list of contaminants released into the ocean from human sources ranges from heavy metals, organic compounds, chemicals, polycyclic aromatic hydrocarbons (PAHs), and pentachlorophenols (PCPs) to persistent organic pollutants (POPs). Sources of these pollutants include urban runoff; fossil-fuel use; industrial emissions; sewage; agricultural activities; shipping and transportation; activities associated with ports, harbours, and marinas; tourism sources; and oil spills (Stewart and White, 2001).

With the launch of Canada's Ocean Strategy in 2002, the federal government formally recognized the unique values present in the waters off the North Pacific coast. The policy document outlined requirements to develop an integrated management plan for this region, designated as a large ocean management area (LOMA) called the Pacific North Coast Integrated Management Area (Pncima). The guiding theory of resource management underlying this policy is ecosystem-based management (EBM), an adaptive approach to managing human activities that seeks to ensure the coexistence of healthy, fully functioning ecosystems and human communities. This theory supports the adoption of area-based management (ABM), which involves spatially allocating the marine environment for a variety of compatible and/or specific uses while accounting for the many stressors on the ecosystem.

Since its original commitment in 2005 under Canada's Ocean Action Plan to develop a comprehensive management plan for Pncima, the federal government has been slow to implement the process. It has, however, established a Marine Transportation Working Group (MTWG), which will contribute to the planning process in the region. The government has proposed that the MTWG will provide input and advice with respect to the issues of cargo shipping, tanker traffic, cruise ships, and other marine-transportation interests. This report aims to assist this process by assessing the pollution impacts of the shipping sector. In addition to examining the range of effects that shipping has on the marine environment, it offers area-based management recommendations as a contribution to the discussion of integrated management of the region.

Healthy oceans will only be realized if we take action to reverse current trends. The proposed integrated management planning process for the Pncima on the B.C. coast presents an opportunity to engage all those involved in ocean-related activities to make reforms to current commercial and industrial practices and decrease the threat of pollution in our ocean.

Pncima

The Pncima region covers 88,000 square kilometres, from the Canada-Alaska border to the northern tip of Vancouver Island, including the islands of Haida Gwaii (see Figure 1). Steep mountains, fjords, islands, estuaries, rivers, and inlets dissect and carve the entire coast. Located in a transition zone south of the Alaska Coastal Current downwelling and north of the California Current upwelling, Pncima is unlike other areas of the North American west coast (Lucas et al., 2007). The waters here are home to a great diversity of ecosystems, habitats, and marine organisms. Glass sponge reefs once thought extinct, forests of kelp, 27 different types of whales and dolphins, and more than 400 species of fish all reside or migrate through Pncima. It's important to protect this diversity and ideally increase the health and abundance of these animals while we still have the opportunity.

FIGURE 1: MAP OF PNCIMA

Source: Living Oceans Society

Approximately 34,500 people live in 25 communities throughout Pncima. Many have historically relied on the resources provided by the ocean and coastal environment. Today, signs of stress are emerging from existing industrial activities. If environmental and economic health is desired in the long term, an integrated, holistic approach to marine management must be implemented in a way that reduces these stresses.

Report Outline

Section 1 presents the major sectors of the shipping industry and provides an overview of their associated operations, key sources of marine pollution, and industry trends.

Section 2 reviews the top sources of marine pollution arising from the shipping sector. The impacts on marine ecosystems and their associated processes, as well as marine life and human life, are discussed.

Section 3 offers recommendations for operational reforms and sustainable development of the shipping sector.

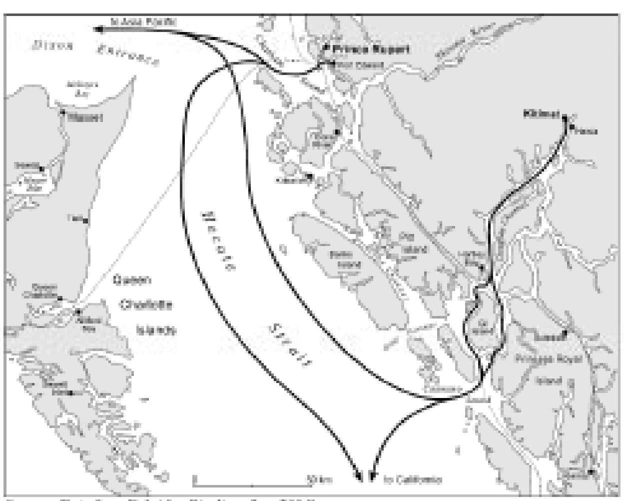
1. Shipping Sectors

1.1 Ports, Harbours, and Marinas

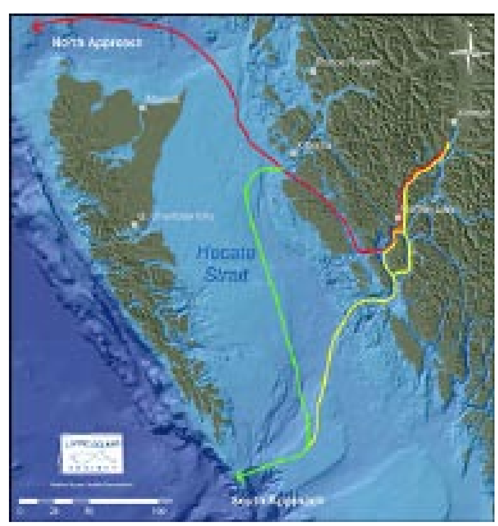
Construction and operation of a port may create serious environmental damage if proper mitigation measures are not implemented. Operational-related activities carried out in major ports include the maintenance of the port facility and equipment. The most common activities include building and ground maintenance; chemical storage and handling; air emissions and liquid discharges from ships; solid-waste generation and disposal; ship and vehicle cargo handling; ship and vehicle fuelling; vessel repair and maintenance; and painting and paint stripping (Van Hinte, 2005).

As a result, ports, harbours, and marinas are a source of numerous contaminants, such as wood preservatives and antisapstains, antifouling paints, PAHs and PCPs, bilge and grey water from vessels, oil spills and chronic oiling (Johannessen et al., 2007). Prince Rupert, Kitimat, and Stewart (adjacent to the Alaska border) are the three major ports within Pncima. Although most large tankers avoid the Pncima area due to an industry Code of Practice that has established a Voluntary Tanker Exclusion Zone (VTEZ) extending 50 nautical miles off the coast, many tankers enter the area en route to Prince Rupert and Kitimat. Figure 2 represents proposed oil tanker routes to Kitimat, and current routes used since 2006 by tankers carrying condensate (used in the tar sands) to Kitimat. The condensate is classified as a dangerous good by the federal government and has been documented to kill marine life on contact (Living Oceans Society, 2007a).

FIGURE 2: PROPOSED OIL TANKER APPROACH TO KITIMAT AND PRINCE RUPERT



Source: Data from Enbridge Pipelines Inc. 2004b



Data from Living Oceans Society

Prince Rupert

The port of Prince Rupert is the largest and busiest port within Pncima. A new cruise ship dock was completed in 2004, bringing with it record numbers of cruise ships (Johannessen et al., 2007) and making 2008 its best season ever with 63 ships and a record 103,635 passengers (Prince Rupert Port Authority, 2008a). In 2005, the Fairview terminal was demolished and the new $170 million 500,000 TEU (20-foot equivalent) Fairview container terminal was completed in the fall of 2007 with the support of the federal and provincial governments (Prince Rupert Port Authority, 2008b). The terminal is one of the first dedicated intermodal terminals in North America, essentially eliminating truck activity, as cargo is unloaded directly onto trains.

With an expected increase in container traffic by 2020, the port of Prince Rupert has further plans to expand its capacity (Prince Rupert Port Authority, 2008b). Phase 2 will see the port quadruple capacity to two million TEUs by 2012, while a second terminal will add another two million TEUs once completed by 2020 (Prince Rupert Port Authority, 2008b). Other expansion plans include a 1,000-acre industrial park with deep-water access, ideal for bulk and liquid terminals. Because of the proximity of Prince Rupert to most Asian ports (three days closer than other North American ports), the port's sheltered and deep nature, and the ability for expansion of services provided, it appears that shipping traffic within the Pncima area will only increase through to 2020 and beyond.

Not only has the significant expansion of the port of Prince Rupert greatly increased the amount of treated/preserved wood and other construction materials in the marine environment, but it will also likely result in a huge increase in shipping traffic on the North Coast (Johannessen et al., 2007). Growth at the port of Prince Rupert will result in a greater probability of oil spills and chronic oiling and an increased input of TBT, CCA, antisaptains, PAHs, air pollution, and noise pollution at the port and along shipping routes – all of which will cause harm to the marine environment.

Kitimat Port

Kitimat Port has two sections: the industrial port and a small-craft harbour (Johannessen et al., 2007). The industrial port serves the Alcan aluminum smelter, the Eurocan paper mill, and the Methanex methanol plant, which is currently closed. Encana also imports condensate by tanker to Kitimat and transports it by train to Alberta. Condensate is a highly flammable hydrocarbon that is classified as a dangerous good by the federal government. It is considered to be so toxic that it kills marine life on contact (Living Oceans Society, 2007b). Future plans include the Enbridge Northern Gateway Project, a new twin pipeline system running from Edmonton to a new marine terminal in Kitimat (Figure 3) (Enbridge Inc., 2008). The pipeline is currently going through an intense review process. Once operational, it would carry 400,000 barrels of petroleum to the coast for export, while importing 150,000 barrels of condensate per day (Living Oceans Society, 2007b).

FIGURE 3: PROPOSED ENBRIDGE PIPELINE

Source: Living Oceans Society, 2007b

Operated by Enbridge Inc., the new port would include two ship berths with 11 petroleum and two condensate storage tanks. Kitimat LNG, a subsidiary of Galveston LNG Inc., also plans to construct a liquefied natural gas (LNG) receiving, regasification, and send-out terminal in Bish Cove, 15 kilometres from Kitimat (Kitimat LNG, 2008). Construction is expected to commence in 2009 with operations beginning by 2013. The facility will include two 210,000-cubic-metre LNG storage tanks (with potential future expansion to three) with four to five anticipated shipments per month. The company decided to build the port some distance from Kitimat because of opposition to LNG ports, which have historically been banned from the United States due to the risk of explosions associated with their operation (Johannessen et al., 2007).

The transportation of crude oil, LNG, and condensate within Pncima poses a significant threat to marine life due to the potential for oil spills, chronic oiling, and other forms of pollution associated with shipping traffic and marine ports. In 1977, the Canadian Coast Guard reviewed the environmental and navigation issues associated with the Kitimat port and concluded that oil spills would be an inevitable result of an oil terminal operation and spill effects could be serious (especially for marine birds). It also concluded that tanker traffic to Kitimat has high potential for adverse impacts on fisheries and fish populations in the North Coast region (Transport Canada, 1977).

Small-Craft Harbours

The North Coast has a total of 19 small-craft harbours, and the Central Coast has 28 (of which at least 10 have fuel docks) (Haggarty et al., 2003; Johannessen et al., 2007). Many of these harbours house recreational and small commercial vessels, including much of the fishing fleet on the B.C. coast. Harbours and marinas should be seen as small-scale hotspots for many contaminants, particularly organic wastes, hydrocarbons, and persistent chemicals such as PCPs, TBT, and PAHs, which can be found in concentrations 260 times higher than in non-harbour sites (Haggarty et al., 2003). Contamination from toxic metals including mercury, copper, cadmium, lead, silver, nickel, and arsenic are also of concern in harbours, where most metal contamination on the Central Coast occurs.

One of the major sources of contaminants in the marine environment here includes boat-repair sites or boat grids for hull repair, where most of the waste goes directly into the water. DFO is actively discouraging the use of grids and suggests that work be carried out in boatyards where proper disposal methods for spilled or excess chemicals are employed in order to keep waste out of the marine environment (Johannessen et al., 2007). DFO is also encouraging the use of floating concrete in dock structures to reduce the use of creosote or CCA treated woods.

Also of concern in most small craft harbours is organic waste, as many small recreational vessels do not have sewage-treatment systems or holding tanks. There are now only four pumping stations in the Central Coast, and consequently many vessels with holding tanks release raw sewage or treated effluent directly into the marine environment as they are unable to properly dispose of the waste (Haggarty et al., 2007). Furthermore, there are no regulated "no-dumping" zones in the Central Coast, and while most marinas and harbours have no-dumping policies, wastes are often still released. While the impact of recreational vessel sewage and wastes (including pharmaceuticals and cleaning products) is likely diluted within Pncima, the cumulative impacts of wastes from all boat use do lead to a significant amount of pollution to the marine environment (Haggarty et al., 2007).

Small crafts are also significant users of fuel oils and lubricants. Although it is rare for large spills of outboard fuels to occur, it is likely that hydrocarbons lost during refuelling and fuel-transfer activities will end up in the ocean (GESAMP, 2007). Furthermore, the over-priming or choking of outboard engines can cause fuel from carburetors and lubricating oil to leak into marine waters (GESAMP, 2007). These losses often occur in harbours and marinas where vessel operators not only tend to refuel and add oil to their engines, but also where they regularly start their engines cold, thus requiring the engine to be primed or choked.

Although individually the amount of pollution associated with outboard motors is minor, the cumulative effect associated with large numbers of outboard engines within Pncima could be significant. Current estimates suggest that 1.12 million tonnes of hydrocarbons are released every year into the air and water in the U.S. by two-stroke engines, while 187,000 tonnes are released by inboard four-stroke engines (GESAMP, 2007). As such, it is believed that 53,000 tonnes of oil per year are input to the world's oceans by small leisure craft (GESAMP, 2007). While regulations in the U.S. required all manufacturers to lower their engines' emissions by 75 per cent by 2006, the release of hydrocarbons into the marine environment by small pleasure craft remains significant as many vessels have not upgraded to newer, cleaner-burning engines.

1.2 Bulk Carriers

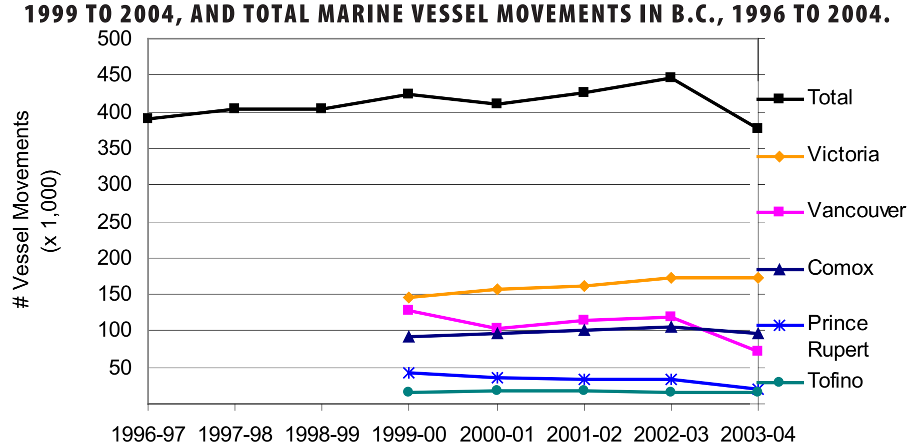
Marine traffic is a source of disturbance and pollutants to the marine ecosystem. Bulk carriers are defined as vessels utilized for the carriage of bulk cargoes (e.g., grain, iron ore, and coal), containerized cargo, and general cargo that is not containerized (e.g., farm machinery, market goods, automobiles) (Haggarty et al., 2003). Some bulk carriers may also change their category within a zone so that they may carry one cargo inbound but convert to a tanker role and carry petroleum outbound. Pollutants discharged into the ocean by the routine operations of bulk carriers include air pollution, noise pollution, sewage, petroleum hydrocarbons from engine exhausts, and ballast waste, which is a vector for transporting invasive species (DFO, 2004; Cordell and Morrison, 1996). Vessel-related pollution may also occur as a result of accidental oil spills, chronic oiling, and solid-waste disposals, while disturbances may include ship strikes of marine mammals.

Trends in Density of Bulk Carrier Traffic

The Coast Guard's Marine Communications and Traffic Services (MCTS) collects ship-movement data through Vessel Traffic Services (VTS). Vessel traffic movement by zone decreased between 1999 and 2004 (Figure 4), including movement entering, exiting, or travelling through the Prince Rupert VTS zone (MoE, 2006). Since the construction of the new Fairview port, however, vessel traffic has risen within the Prince Rupert VTS and subsequently within the coastal waters of Pncima.

Over the next 15 years, the volume of containers being shipped through these waters is expected to increase 300 per cent, bulk cargo ships are expected to increase by 25 per cent, and cruse-ship traffic is expected to increase 20 to 25 per cent (Hall, 2008).

FIGURE 4: VESSEL MOVEMENTS BY VESSEL TRAFFIC SERVICE (VTS) ZONE IN B.C., 1999 TO 2004, AND TOTAL MARINE VESSEL MOVEMENTS IN B.C., 1996 TO 2004.



Source: MCTS, Canadian Coast Guard, 1997–2004.

Notes: a. Values for 2003/04 for Vancouver may be low due to a tugboat strike at the Port of Vancouver. b. Before 1999/2000 the Vancouver VTS zone included Victoria and Comox. For clarity, data before that year were not included in this graph for the separate VTS zones

Average annual vessel movements for the various vessels operating off the coast of B.C. between 1996 and 2004 indicate that passenger vessels (including cruise ships and ferries) accounted for 56 per cent of marine traffic, while tugs (towing or propelling barges) accounted for 29 per cent (MoE, 2006). Bulk cargo carriers were the third-most abundant vessel type at seven per cent, representing an average of 29,253 vessels per year (MoE, 2006).

The number and type of ships in transit varies with seasons, such that shipping traffic is greater in the summer than winter. However, the distribution of bulk carrier, cargo, and tanker traffic does not show much season variation off the coast of B.C. (MoE, 2006).

1.3 B.C. Ferries

Ferry traffic accounts for the most vessel activity on the North Coast (Johannessen et al., 2007). Two major B.C. Ferries routes serving the North Coast pass through Pncima, while other small routes exist between Vancouver Island and smaller island communities (e.g., routes between Port McNeill, Alert Bay, and Sointula). Wastes produced by ferries include sewage, grey water, oil pollution, air pollution, and those associated with vessel coating (Johannessen et al., 2007). While their passenger volume is much less than that of most cruise ships, ferries prompt similar pollution concerns as those raised by the cruise-ship industry (see section 1.4 below).

1.4 Cruise Ships

The cruise-ship industry in the Pncima comprises two key segments: large vessels that travel up the coast and sometimes make port-of-call stops in Prince Rupert, and smaller ships that make up the pocket cruise industry, which can carry anywhere from fewer than a dozen to hundreds of passengers, frequently making stops at various ports throughout Pncima (e.g., Port Hardy, Bella Bella, Ocean Falls, McLoughin Bay, Shearwater, and Klemtu) (MacConnachie et al., 2007). The impacts of the pocket cruise industry are similar to those experienced in small-craft harbours (see section 1.1).

Large-vessel cruise ships can accommodate up to 5,000 people, prompting many to compare them to floating cities. Spanning up to 300 metres in length and often weighing more than 100,000 gross register tons (GRT), these vessels feature onboard facilities that include theatres, dining halls, swimming pools, cinemas, shopping malls, photo-processing shops, laundry and dry cleaning, and many others. All of these activities generate hundreds of tonnes of waste, part of which is released into the ocean. An average-size cruise ship carrying 2,000 to 3,000 passengers has been estimated to generate approximately 1,000 tonnes of waste per day (Oceana, 2008). Broken down, this translates into:

- 500,000-800,000 litres of grey water
- 100,000-115,000 litres of black water
- 13,500-26,000 litres of oily bilge water
- 7,000-10,500 kilos of garbage and solid waste
- 60-130 kilos of toxic waste

In addition, the cruise industry is responsible for discharging oil pollution, ballast water, air pollution, and greenhouse gases (primarily CO2), and for anthropogenic noise pollution and endangerment of species through ship strikes. If these vessels were land-based towns or coastal resorts, national and international treaties, agreements, and legislation regulating these emissions and effects would be considerably stricter.

Trends in Cruise-Ship Traffic

Canada's Pacific Coast is recognized as a leading destination for cruising (Pearce, 2005). A recent survey conducted in Vancouver and Seattle in 2005 found that approximately 50 per cent of the target market is "very interested" or "quite interested" in taking a B.C. cruise (Wirtz, 2005). B.C. port authorities are focusing on developing cruise options within B.C. that promote the province's history, First Nations' culture, and scenic marine environments (MacConnachie et al., 2007), while the communities of Port Hardy and Sointula are actively working to attract more pocket cruise ships (ibid.). The development of additional cruise options will add to the growth of cruise-ship traffic in Pncima, which is projected to increase by up to 25 per cent over the next 15 years (Hall, 2008).

1.5 Oil and Gas Exploration

The federal government legislated an oil and gas moratorium along B.C.'s coast in 1972 that remains in effect today. Government and industry stakeholders, however, have recently expressed an interest in lifting this restriction on the premise that oil and gas development will help stimulate the local and provincial economies. The Queen Charlotte Basin (QCB), which lies squarely within Pncima, is a key site for potential development, and thus the pollution impacts of oil and gas exploration in this area are included in this report.

Oil and gas exploration emits oil, air, and noise pollution as well as contaminants such as PAHs. Each phase of exploration results in a unique set of impacts whose effects cumulate as development proceeds.

The environmental impacts discussed below depend on a number of factors, including: (Dale 2005; Joseph et al., 2005)

- Choice of technology (e.g., drilling muds)
- The regulatory framework (e.g., protected areas)
- The scale of the project (in size and duration)
- Location and timing of production
- Accident rates
- Cumulative effects
- Environmental characteristics of the region

Seismic Testing:

Oil reserves are located using a technique called seismic testing. This process requires shooting high-pressure sound waves into the ocean toward the seabed that then bounce back at varying speeds and intensities. This process provides information about rock formations, indicating where oil is most likely located. This process can also damage marine life, resulting in everything from behavioural effects to serious physical harm or mortality.

Behavioural effects: Behavioural effects occur at distances of several kilometres and more. Of greatest concern is the disruption to traditional migratory paths of marine mammals and fish (e.g., salmon, herring, and whales), which may prompt some species to leave the area entirely (GESAMP, 2007). This could have substantial impacts for species currently listed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as threatened or endangered (i.e., killer whale, North Pacific right whale, humpback whale, sei whale, blue whale, and sea otter, as well as coho, sockeye, and chinook salmon).

Serious harm/Mortality: Serious physical harm occurs at air-gun ranges of a few metres and includes damage to hearing, which may reduce a species' ability to fend off predatory attacks, and loss of reproductive capacity (Royal Society of Canada, 2004). Mortality is observed at ranges of about one metre. For a model array of 12,700 cubic centimetres, with three strings of seven guns each, all fish within 300 cubic metres would be killed with each shot. While the impact on eggs and larvae are seen as minimal (five per cent mortality rate), this number could be significant when compounded at spawning areas, particularly for species of special concern (ibid).

Exploration:

Seismic surveys reveal possible hydrocarbon traps but do not usually give direct indications of hydrocarbons. Drilling is the only sure way of testing geological structures for oil and gas. Mobile offshore drilling rigs are used for exploration of potential underwater sites.

Discharges of cuttings and mud: Large amounts of waste are produced during drilling operations. Patin (1999) quotes the following figures for discharges from a single exploration well during exploration activities:

Discharges	Amounts (tonnes)
Drilling mud:	150 - 400 (cumulative)
Cuttings (dry mass):	200 -1,000
Base oil on cuttings:	30 - 120

The environmental impact of fluid and cuttings discharges arises from the toxicity of drilling-fluid components, as well as the smothering of benthic communities by large volumes of small particulate material from cuttings (Royal Society of Canada, 2004). Biological impacts of the cuttings plume are usually assessed by changes in species abundance and diversity in benthic communities. Multivariate statistical methods reveal that impacts have been inferred beyond a five-kilometre radius from some North Sea drilling rigs, although this is based on multi-well production drilling in the pre-SBM era (Gray et al., 1990; Olsgard and Gray, 1995).

There is usually a trend in the severity of impact, with major reductions in both species abundance and diversity occurring close to a drilling rig (i.e., within a few hundred metres) and with community characteristics approaching those in non-impacted environments as distance from the rig increases (Royal Society of Canada, 2004).

Produced water: During exploration and production, large amounts of produced water are recovered with the hydrocarbons. This is cleaned and some of it is re-injected to maintain reservoir pressure; however, most is discharged into the sea (Royal Society of Canada, 2004). From the 1960s to 2002, Cook Inlet released over 162 litres of toxic "produced water" byproduct into the sea – or 10 billion litres/platform (Living Oceans Society, 2007). Some studies show that impacts range from a half kilometres to two kilometres away from the discharge point (Kenchington, 1997; GESAMP, 1993), while other research suggests effects occur at even further points (Lee, 2003; Kingston, 1992).

The main concern with produced water lies with oil content. While the argument has been made that oil concentrations remain low even as discharge volumes are high, discharge of produced water continues at a steady rate as oil is produced and tends to increase as production ages (Royal Society of Canada, 2004). In a remote and sparsely populated area such as Queen Charlotte Sound or Hecate Strait, discharges of produced water into the sea may represent a larger-than-usual fraction of hydrocarbons introduced to the environment (ibid.).

Development and Construction:

Rig construction: Rig construction results in loss of sea-floor habitat in two ways. Construction will initially alter the benthic habitat and marine life that relies upon it. Subsequently, as rigs attract coral and fish, pollutants from cuttings will ultimately denigrate this new habitat as well (Energy B.C., 2004).

Production:

Flaring: Flaring is a common practice used to burn off gas to test a well's potential and to deal with a malfunction of the well, or to separate gas from oil deposits. Flared gas yields almost 30 per cent of the total world production of gaseous hydrocarbons and is one of the world's biggest sources of atmospheric emissions (Putin, 1999). The emissions released from a single flaring contain more then 250 toxic compounds including:

- Sulphur dioxide (a lung and heart irritant)
- Benzene (a known carcinogen)
- Nitrogen oxide (an asthma trigger)
- Toluene (a toxin associated with reproductive problems)

In addition to their impact on those at the drilling site, these pollutants can affect people and animals as far as 300 kilometres downwind from their source location.

Oil spills: The biological impact of an oil spill or blowout will depend on several factors, including:

(a) The nature of the hydrocarbon spilled (i.e., heavier vs. lighter oil)
(b) Climate, weather, and sea-state at the time of the spill and afterwards
(c) The physical nature of the "receiving" environment (where the spill happens)
(d) The sensitivity or vulnerability of biological systems

Over the past two decades the probability of major spills or blowouts has been declining, yet such an event may still occur in the QCB. If one were to occur, the semi-enclosed basin would likely direct the oil into the internal circulation eddies, until it reaches the shore, which would likely occur within a few days (Royal Society of Canada, 2004). Once ashore any oil spill can be expected to have a number of biological effects, ranging from subtle biochemical changes to death, depending on species and exposure.

Decommissioning:

Cutting piles: Even if oil installations are completely removed, cutting piles left behind may spread and impact local marine life for 20 years or more after their discharge. There is currently no technology to remove cutting piles, whose effects on ecosystems may extend in a radius of up to five kilometres from the point of discharge. It is estimated that oil production in the North Sea cutting piles may contain up to 40,000 tonnes of contaminated sediment (Royal Society of Canada, 2004).

2. Impacts of Pollutants

2.1 Antifouling Compounds

Antifouling paints contain organotin compounds (Haggarty et al., 2003), the most common of which is tributyltin (TBT), which has been used internationally as a biocide on vessel hulls since the 1970s. TBT has been described as "the most toxic substance ever deliberately introduced into natural waters" (Stewart and Thompson, 1994) and has serious effects on marine ecosystems. TBT has been documented to cause imposex in mollusks, a condition that includes irreversible imposition of male sexual characteristics, particularly a penis and vas deferens, on female neogastropod mollusks (Tester et al., 1996). This condition can lead to inhibited reproduction, resulting in rapid population declines or even extirpation of the affected species from the contaminated site (Haggarty et al., 2003). TBT can also cause damage to organisms higher up in the marine food web. Butyltin has been detected in the blubber of porpoises, dolphins, and whales in the Indian and North Pacific oceans (Stewart and Thompson, 1997), while some evidence suggests that TBT can cause hearing loss in killer whales, destroying their ability to communicate and locate prey (DFO, 2008).

Canada is among several countries that imposed a ban on the use of antifouling paints containing TBT in 1989, largely due to concerns over its environmental impacts. The regulations, however, only prohibit the use of TBT-based paints on vessels shorter than 25 metres in length, and permit the use of low-release formulations on larger vessels and aluminum surfaces (Stewart and Thompson, 2004). The continued use of TBT-based paints on large vessels and the illegal use of these paints on pleasure craft, coupled with the fact that many developing countries do not restrict the use of TBT in antifouling paints, has led to the continued presence of TBT in B.C.'s marine environment.

Significant quantities of TBT have been found in open waters up to 200 kilometres offshore in the North Sea (Stewart and Thompson, 1994), indicating that contamination is not restricted to ports, harbours, marinas, or coastal waters. In studies conducted by Stewart and Thompson (1994), samples obtained from remote coastlines, as well as benthic sediment cores collected at a depth of greater than 350 metres approximately 25 kilometres offshore from Vancouver harbour, showed traces of TBT. These findings bolster the argument that the extent and scope of biological damage attributed to TBT pollution is a long-term, global problem and not an isolated, short-term one (Ellis and Pattisina, 1990).

Ferries, cruise ships, and Canadian Navy vessels are now using copper-based antifouling paints rather than TBT-based paints (Haggarty et al., 2003). The use of copper-based antifouling paints, however, may lead to the bioaccumulation of copper in aquatic biota, and may lead to decreased benthic community diversity, reduced organism abundance, increased mortality, lowered reproductive success, and behavioural changes (Table A1, Haggarty et al., 2003).

2.2 Wood Preservatives and Antisapstains

Many ports utilize products such as creosote and chromated copper arsenate (CCA) to increase the lifespan and structural integrity of wooden structures in the ocean. Creosote and CCA, which are also considered pesticides (Johannessen et al., 2007), are often applied to pilings, piers, and docks. Although mainly used in ports, harbours, and marinas, these products are also applied to wooden structures associated with aquaculture, log booms, and private docks (Haggarty et al., 2003).

Creosote was the most commonly used wood preservative in B.C. in 1999 (see Figure 5); however, none was sold or used in the North Coast region in 1999 (Johannessen et al., 2007). Here, creosote was replaced with CCA, a chemical that is considered to have a negative effect on the environment greater than the sum of its parts (copper, chromium, and arsenic), which are all toxic heavy metals (Cox, 1991 in: Johannessen et al., 2007).

The most widely used wood preservative active ingredient in 2003 was creosote (2,163,142 kilograms used in B.C. wood-treatment plants that year alone). Previously, wood preservatives such as pentachlorophenol were applied extensively as a wood-protection agent, but were found to have large amounts of dioxins that are extremely toxic. In 2003, wood preservation accounted for the majority of pesticides used in British Columbia (West Coast Environmental Law, 2007).

FIGURE 5: WOOD PRESERVATIVES USED IN B.C. IN 1991, 1995, AND 1999

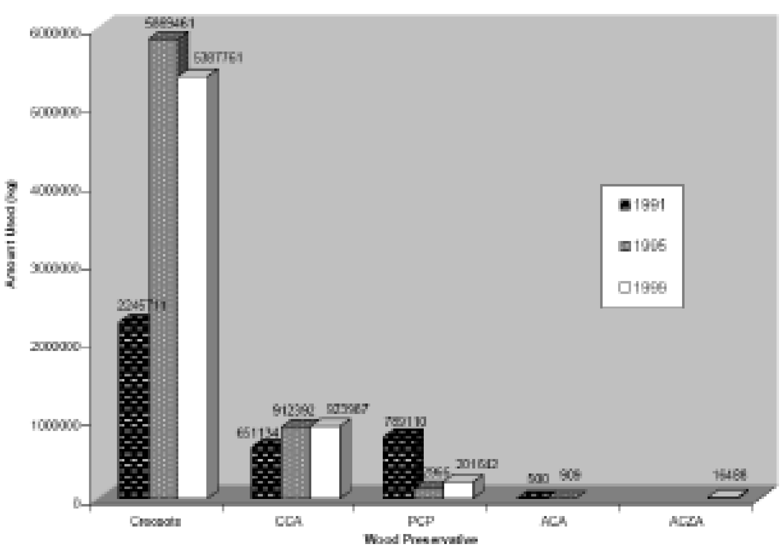


Figure from Haggarty et al., 2003.

The overall use of PCP appears to be declining; however, it is still used as a wood preservative in the marine environment. PCPs can be transported through the atmosphere, are persistent, have high lipid solubility, and have been observed to bioaccumulate up to 139,000 times in biota (Grant and Ross, 2002). Point sources of PCP in the marine environment are difficult to identify; however, Yunker et al. (2002; in Haggarty et al., 2003) found PCPs present in many harbours off the B.C. coast, including Campbell River, and in remote locations such as Clayoquot Sound and the Queen Charlotte Islands.

Another form of preservative, antisapstains, are applied to freshly cut wood by lumber mills to protect the wood from fungal growth (Johannessen et al., 2007). Reports by the Fraser River Action Plan (1998) show these chemicals to be highly toxic to fish; however, improvements in the storage of treated lumber has helped prevent the runoff of these chemicals into the ocean.

2.3 Polycyclic Aromatic Hydrocarbons

Most PAHs enter the marine environment from airborne emissions, waterborne effluents, and surface runoff (Eickhoff et al., 2003). They can be introduced to the environment through many sources, both anthropogenic (e.g., oil spills and chronic oiling, smelter emissions, and coal-based energy) and natural (e.g., forest fires and volcanic activity) (Cordell et al., 1996; Stevenson, 2003). In the marine environment, PAHs are associated with particulate materials (e.g., soot) and are not only resistant to degradation and desorption, but are also found to be bioavailable to marine organisms such as crabs (Eickhoff et al., 2003).

PAHs of low molecular weight have been shown to be acutely and chronically toxic and can impair survival and growth by causing abnormal reproduction and development (Cordell et al., 1996). In contrast, high molecular weight PAHs can be carcinogenic and mutagenic to higher-level organisms such as fish, seabirds, and sea otters (Haggarty et al., 2003). For example, exposure to high molecular weight PAHs has resulted in carcinogenesis and immunotoxicity in flat fish from polluted harbours in Puget Sound, Washington (Myers et al., 1999). Some bottom-dwelling fish caught in PAH-contaminated waters have also been found to display tumours in their mouths, livers, and on their skin (Eickhoff et al., 2003). Bioaccumulation of PAHs by invertebrates such as mollusks can occur since they are not capable of excreting or metabolizing them. Adding to concerns related to the impacts of this carcinogen on sediment-dwelling organisms is the potential for public health risks related to the ingestion of some marine organisms (e.g., crab).

Ports, marinas, and harbours have been found to exhibit high levels of pollutants such as PAHs and PCPs, especially those with fuel docks (Haggarty et al., 2003). Kay (1989, in Haggarty et al., 2003) found PAH levels up to 260 times higher at harbour sites than at non-harbour sites. Increased levels of dioxins and furans from nearby industrial activities or wood-treatment facilities may also be detected in harbour locations, including Campbell River, Prince Rupert, and Kitimat.

2.4 Air Quality

The impacts of air pollution include depletion of upper-atmosphere ozone, acid rain, changes in soil chemistry, and damage to agriculture and forestry resources (Van Hinte, 2005; Mitchell, 2001). Adverse impacts on regional air quality are caused by ship and port-related vehicle emissions, vessel painting, and cleaning, and other activities (Van Hinte, 2005). In many regions, emissions from vehicles and vessels make up 80 per cent of air pollution. The negative consequences resulting from introducing these products into the environment include human health effects, acid rain, and global warming, to name a few.

Studies completed by the Greater Vancouver Regional District (GVRD) suggest that marine vessels are a major source of air pollution, with the amount of emissions from ships being forecasted to increase over the next 20 years due to sustained growth in freight movement in the Vancouver region and along the coast (MoE, 2006). By 2010 it is expected that marine vessels will exceed on-road motor vehicles as the largest source of air pollutants contributing to smog in the GVRD region (MoE, 2006; Van Hinte, 2005).

Similar studies conducted by Environment Canada and the U.S. Environmental Protection Agency (EPA) have looked at both natural and anthropogenic sources of air pollution in the Georgia Basin/Puget Sound air shed. Results suggest that marine vessels emit 33 per cent of the area's sulphur dioxide emissions, making them the largest single source in the air shed (Van Hinte, 2005). Twenty-two per cent of nitrogen oxide emissions have been identified to originate from marine vessels in the Georgia Basin/Puget Sound. The predicted growth of the Prince Rupert port is expected to result in similar increases in air pollution within the vicinity and along shipping corridors.

Bulk carriers and tankers contribute to air pollution mainly through the use of diesel combustion engines while in transit or at port. Diesel engines are known to contribute nitrogen oxide and sulphur dioxide emissions into the atmosphere as well as diesel particulate matter (Van Hinte, 2005). While ship emissions currently constitute only a small fraction of total global emissions, they could have important environmental and health effects on coastal areas near ports with predicted heavy ship traffic, as shown in studies of regions in Europe, Asia, and North America (Vutukuru and Dabdub, 2008). Many of the impacts presented above have been observed in and around major ports (Mitchell, 2001; Vutukuru and Dabdub, 2008) and may provide an evidence-based foreshadowing of the impact a predicted future increase in shipping traffic would have on Pncima.

Environmental impacts associated with marine traffic also affect human health. Impacts on human health resulting from marine vessel pollution, specifically the release of ozone and nitrogen oxide, include damage to lung tissue resulting in inflammation; lung damage and reduced lung function; increased respiratory illness; and an aggravation of breathing problems, coughs, chest pain, and asthma (Mitchell, 2001). The increased release of sulphur dioxide by marine traffic into the environment can have both short- and long-term health effects, including bronchitis and a suppressed immune system (Mitchell, 2001). Studies also indicate that diesel and heavy fuel oils trapped in the atmosphere as particulate matter can lead to increased incidence of cancer and the onset of cardiopulmonary disease (Mitchell, 2001).

2.5 Ship-Generated Solid Waste

Debris and solid waste disposal by ships and ports can have severe environmental consequences (Van Hinte, 2005). In the United States alone, ships account for over 111,000 tonnes of garbage each year (Van Hinte, 2005), including waste such as glass, metals, paper, cloth, food, wood, rubber, and packing materials (Van Hinte, 2005).

Most of these materials are allowed to be discharged overboard at a prescribed distance from shore under various marine conventions (Van Hinte, 2005). Nonetheless, waste and debris pose a serious risk to marine animals including fish, marine mammals, sea turtles, and seabirds. Entanglement is a threat to at least 143 marine species around the globe, including nearly all the world's sea turtles (Environment Canada, 2003), while at least 162 marine species have reportedly ingested plastics and other debris, including most seabirds.

Entanglement presents more than just a conundrum for animals that find themselves tied up; many remain permanently entangled or injure themselves and become vulnerable to infection. Once tangled, they may lose their ability to catch food or avoid predators and can even die (Environment Canada, 2003; Van Hinte, 2005).
Marine debris can also look deceivingly similar to prey for many marine animals. Sea turtles, dolphins, and some species of fish are known to ingest plastic bags floating in the ocean, as they resemble jellyfish (BCCSN, 2008). Ingestion of marine garbage may result in choking, damage to the stomach lining or intestinal blockage, inability to forage, inability to digest food, reduced absorption of nutrients, and other physiological effects from the absorption of toxins (Van Hinte, 2005). Plastic also eventually reduces to micron-size particles that are ingested by plankton near the base of the food chain, resulting in negative effects on the nutritive content of the food chain.

2.6 Sewage (Black Water) and Grey Water

Raw sewage, also referred to as black water, is often more concentrated than municipal sewage as it is less diluted by water. Regulations governing the disposal of sewage into the marine environment differ depending on whether the black water has been disinfected. Disinfected sewage discharge is permitted at a distance of three nautical miles from land, while non-disinfected sewage discharge must occur 12 nautical miles from shore (Johannessen et al., 2007). There are currently zero no-discharge zones along the North Coast of British Columbia. As well as the danger posed by the release of organic compounds from sewage into the marine environment, the possibility that black water may contain pharmaceuticals is also cause for concern, especially as we have limited information about their impact (Johannessen et al., 2007).

Grey water consists of wastewater from sinks, showers, and galleys. It is not usually treated and may contain organics, petroleum hydrocarbons, oils, greases, metals, suspended solids, nutrients, coliform bacteria, and personal-care products (Johannessen et al., 2007). Of major concern regarding grey-water disposal is its proximity to shellfish beds, shorelines, or within protected bays with low tidal exchanges (Johannessen et al., 2007). Transport Canada regulations state that grey-water disposal should take place only when the ship is travelling at least six knots, is not in port, and is at least four nautical miles from shore (Johannessen et al., 2007).

BC Ferries is in the process of upgrading its sewage system to the Hydroxyl CleanSea Oxidation® advanced wastewater purification system, which uses bio-oxidation to deal with wastewater (Johannessen et al., 2007). The CleanSea Oxidation® shipboard water process technology, put in place March 2008, effectively processes and treats black and grey water generated by the 2,100-passenger Spirit of British Columbia, 1,340-passenger Queen of New Westminster, and the 600-passenger Northern Adventure vessels (Hydroxyl, 2008). While only the latter is scheduled to travel through Pncima, several other BC Ferries ships have already been upgraded to the Hydroxyl system. All of the new coastal-class vessels are fitted with Transport Canada–approved sewage-treatment plants.

2.7 Ballast Water

Ballast water is typically water that is used to help with vessel stability. It is routinely discharged into the ocean. Ballast water continues to be a source of oil pollution in the marine environment, despite Canadian regulations requiring that ballast water be cleaned of oil (Van Hinte, 2005). Ballast water collected in one area and discharged in another can also serve as a vector for the introduction of alien and invasive species into the marine environment (Van Hinte, 2005; DFO, 2004; Cordell and Morrison, 1996). It has been estimated that ships around the world may be carrying up to 3,000 species of animals and plants a day in their ballast water (DFO, 2004).

Ships travelling the world carry entire faunal assemblages, and once released to the environment these invasive species have the capacity to become established in their new environment, resulting in changes to native assemblages of marine species (Cordell and Morrison, 1996). Some studies have documented the introduction of European green crab to San Francisco Bay through ballast water, and the subsequent migration of this alien species up the West Coast – threatening indigenous crab populations (Van Hinte, 2005). Through the disruption of the native ecology, invasive species may have an affect on economic activities such as fisheries, and may cause disease in humans (DFO, 2004).

The discharge of ballast water may also lead to increased mortality in marine birds and may cause production of beach tar (Van Hinte, 2005). The release of oil, hydrocarbons, lead, and other contaminants in ballast water may contribute to chronic pollution, which will concentrate at the sea surface and accumulate in seabed sediments (Van Hinte, 2005), having a negative impact on marine species occupying those areas.

A system has been developed whereby the ballast water in a vessel is continuously exchanged so that the contained water at any time is local water – overcoming the faunal-transport issue. Not all vessels travelling through Pncima are equipped with the system at this time, however.

2.8 Acute and Chronic Oil Pollution

Chronic sources that impact areas such as harbours, marinas, ports, high-use areas, and shipping routes represent the most imminent threat of oil pollution on the Central Coast. Chronic oiling, mostly from dirty bilge water and exhaust, is believed to contribute more oil to the environment than acute spills and is thought to have a greater effect on bird populations (Johannessen et al., 2007). More information about the effects of chronic oil pollution is needed.

Oil spills and accidents associated with port operations have the potential to generate adverse effects on the marine environment by way of chronic oiling (Van Hinte, 2005). Oils spills and oil discharges from ports may occur in several different ways, including leaking or ruptured storage tanks used to temporarily store oil from pipelines prior to tanker loading, loading and offloading, tank washing and wastewater discharging by ships, and draining bilge water into the environment (Van Hinte, 2005). Bilge water usually contains the greases and oils from leaky engines, machinery, and equipment, as well as engine drippings, and is one of the main sources of chronic oiling in small harbours and marinas.

Many ports are not equipped to properly dispose of oil wastes and often wastes generated in ports get illegally mixed in with ballast water from ships (Van Hinte, 2005). However, ballast-water treatment plants are not designed to handle such wastes, making the disposal of wastes in most ports a major problem.

Catastrophic tanker oil spills may also occur while ships are in transit, within the harbour, or at port. Both water and land-based spills have the potential to occur in ports, harbours, and marinas. A land spill might affect the vegetative communities and the terrestrial bird and mammal populations, and may cause effects similar to a water-based spill if not contained.

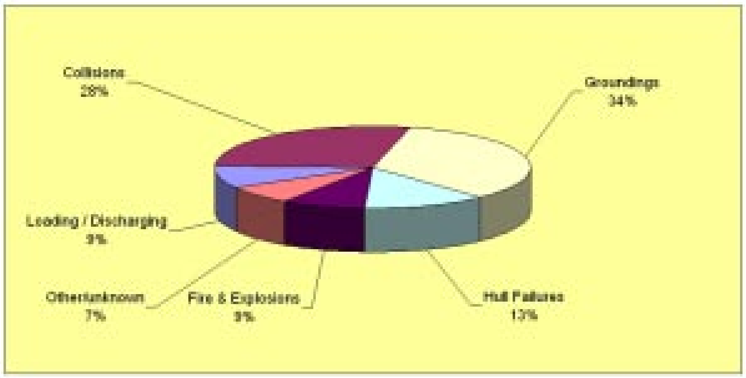
Oil pollution attributed to ferries is associated with bilge water, oil residue from vehicles on deck, and wastes from engines and machinery. Transport Canada requires that bilge water be processed and that filtering devices be fitted with a stop-discharge mechanism when the oil contents exceed 15ppm (Johannessen et al., 2007). Furthermore, BC Ferries has equipped the new coastal ferries with a means of collecting water runoff from vehicles on the car deck, which may contain oil residue (BC Ferries, 2008). Water collected is processed to reduce environmental impact following disposal.

While air pollution and runoff from urban and industrial sources, as well as boat operations and bilges, contribute more oil to the environment than spills, oil spills contribute much more oil on a local, short-term scale (Haggarty et al., 2003). The most significant environmental concern associated with shipping is the risk of acute oil spills from bulk carrier or tanker accidents (Van Hinte, 2005). Worldwide, oil and other chemical spills from ships have caused major devastation of marine wildlife and coastal ecosystems (MoE, 2006).

Oil spills from shipping vessels occur through collisions, groundings, hull failures, fires and explosions, striking floating objects, or impacts with fixed objects (Van

Hinte, 2005) (Figure 6). Spills of greater than 51 barrels occurring between 1974 and 2003 have resulted in the loss of over 39 million barrels of oil (Van Hinte, 2005).

FIGURE 6: CAUSES OF OIL SPILLS FROM SHIPPING VESSELS



Source: Van Hinte, 2005

A study conducted in 2002 by the Pacific States/British Columbia Oil Spill Task Force, made a number of conclusions with respect to the risk of oil spills on the West Coast as a result of vessel traffic. The study (Pacific States/British Columbia Oil Spill Task Force, 2002) stated that a higher concentration of spills was reported near major ports such as Prince Rupert's, and that this was likely due to higher traffic density in these areas. Furthermore, the report found that cracks and fractures in vessel cargo tanks were the most common type of structural failure off the Pacific coast. Finally, the risk of grounding and collisions increased as a vessel got closer to shore, resulting in higher risk oil spill areas that extend 25 nautical miles from the West Coast, except in northwest British Columbia where the higher risk areas extend 100 nautical miles offshore (Pacific States/British Columbia Oil Spill Task Force, 2002). Thus, the areas surrounding the new port of Prince Rupert and Kitimat appear to be highly vulnerable to acute oil spills due to the increased vessel traffic expected in the region.

Acute

Acute oil spills often lead to acute effects, including the death of organisms that come into contact with the oil. For example, the Exxon Valdez oil spill in 1989 resulted in the death of about 2,800 sea otters, a population decrease of 28 per cent (Haggarty et al., 2003), 250,000 seabirds, 1.9 million salmon, and 12.9 billion herring (OOGRG, 2004), with numerous other impacts on the marine environment where the spill occurred. Oiled sea otters exhibited tissue lesions, pulmonary emphysema, gastric erosion, and damage to the liver and kidneys (Haggarty et al., 2003). Furthermore, chronic or sublethal effects were reported in sea otters up to five years after the spill (Haggarty et al., 2003) and included continued exposure to oil from the consumption of prey (e.g., mussels). Of the killer whales exposed to the spill from the AB Matriline, the first seven that went missing were expected to have succumbed to immediate stress from toxic vapours, while six others may have suffered complications from mucous membrane damage, including damage to airways (Haggarty et al., 2003).

The Nestucca, a fuel barge that collided with its tender off Grays Harbour in Washington, released 875,000 litres of oil into the environment (Haggarty et al., 2003). Oil from the spill was transported up the B.C. coast as far north as Bella Bella and along the west coast of Vancouver Island. Approximately 1,000 of the total oiled and dead birds were collected from Vancouver Island and one sea otter was known to have died as a result of oil exposure (Haggarty et al., 2003). It is estimated that 30,000 to 40,000 seabirds also died as a result of the spill (Rodway et al., 1990). The crab fishery in Clayoquot Sound was also closed for several weeks, as the crabs were deemed unmarketable due to oil spots on their claws. It is believed that the crabs were eating or coming into contact with dead oiled birds on the bottom (Haggarty et al., 2003).

A summary of the immediate and harmful impacts oil spills can have on marine communities is listed in Figure 7.

FIGURE 7: SUMMARY OF IMPACTS OF SPILLS ON MARINE LIFE

LIFE TYPE	SPECIFIC IMPACTS NOTED
Microbes	Increase in abundance of some species
Intertidal communities, including invertebrates and vegetation	***General:*** lethal and sublethal effects ***Invertebrates:*** Lethal and sublethal effects, including premature egg release, reduced mating, reduced brood size, effects on success and timing of moulting, increased oxygen consumption, reduced feeding, reduced growth rate, narcotization, impaired movement ***Vegetation:*** Lethal and sublethal effects, including smothering, poisoning, habitat destruction, growth due to herbivore decline
Fish	Lethal and sublethal effects, including coating of gills, inhibited or modified feeding behaviour, long-term physiological and behavioral impacts, reproductive and immune system effects, behavioral abnormalities, genetic damage, reduced growth, decreased larval production, population-level and potentially ecosystem-level impacts
Birds	Lethal and sublethal effects, including loss of waterproofing, hypothermia, drowning, stress, altered immune function, altered metabolic function, breeding success, chick success, potentially indirect reproductive failure due to nest and chick abandonment by parents Oil in slick form contaminates seabird plumage, leading to ingestion via preening (toxic effects), and interferes with water-resistant characteristics of the plumage, leading to hypothermia and the loss of buoyancy.
Marine mammals	Lethal and sublethal effects, including loss in waterproofing and thermoregulatory capability, drowning, hypothermia, starvation due to the increased energy needs to compensate for heat loss, stress responses, reduced ability for parents to recognize young when young are oiled, increased exposure from contaminated haul-out sites, possible exposure to greater predation rates, external oiling, fouling of baleen, avoidance and behavioural effects, sublethal poisoning, reduced diversity in prey, reduced diving ability, increased oxygen consumption
Terrestrial animals	Lethal and sublethal effects, including poisoning through ingestion of contaminated food sources and/or ingestion from cleaning activities, and absorption through skin; loss of shoreline habitat

Source: OOGRG, 2004

Sensitive species expected to be affected on the Central Coast include sea otters, seabirds, intertidal communities, marine mammals such as harbour seals and killer whales, and fish populations including salmon and herring (Haggarty et al., 2003). Organisms that live at the sea surface, in intertidal zones, and in coastal habitats, including seabirds, juvenile salmon, and larvae, are most at risk from oil spills within Pncima (OOGRG, 2004). Also vulnerable to the impact of oil spills are those species that are immobile, such as much of our benthic infauna (e.g., mollusks), those species that cannot detect pollution (e.g., Dungeness crab larvae), and early life stages in marine life (OOGRG, 2004).

Studies suggest that the impacts of a 1,500-barrel spill would have the following effects:

- Water quality in the vicinity of the spill would be at chronic toxicity levels for up to 30 days.
- Up to 38 kilometres of shoreline would be contaminated for up to a decade.
- Local intertidal and subtidal organisms would be affected for up to a year.
- Mortalities of some adults and millions of young fish would occur, and recovery could require multiple generations.
- Fish may also become tainted, resulting in closure of some or all of the affected fishery.
- Impacts to fish habitat would last for more than a decade due to resident oil.
- Tens of thousands of birds would be killed and recovery could take up to a few generations.
- Small numbers of resident marine mammals would be killed and recovery would be expected within five years.
- Similarly, a small number of terrestrial mammals would be killed with recovery within three years expected.

OOGRG, 2004

The duration of environmental impacts from oil spills is now believed to last much longer than initial studies suggested. It was believed that species would recover in less than five years following the Exxon Valdez spill; however, recent research by Peterson et al. (2003, in OOGRG 2004) shows that some species are still exhibiting signs of serious impacts from the spill 14 years after its occurrence (OOGRG, 2004). The end result is the potential for a long period of toxic contamination in the marine ecosystems of Pncima.

Clean-up efforts remain generally inefficient. Removing between five to 15 per cent of the oil released is an accepted target (OOGRG, 2004), which often results in the injury of wildlife. Studies indicate that while the cleaning of oiled seabirds helps deal with the impacts of oil spills on the short term, the "cleaned" birds rarely resume breeding and have low survival rates (OOGRG, 2004). Dispersants (e.g., dish soap) often applied to spilled oil can increase the toxic impacts on young fish and eggs and destroy water-repellency and insulating capacities of fur- or feather-bearing animals (OOGRG, 2004). Furthermore, dispersed oil is believed to penetrate sediment to a greater extent (OOGRG, 2004). Clean-up efforts can often lead to longer-term contamination and, in some cases, can prolong recovery (OOGRG, 2004).

Chronic

Worldwide, operational discharge from ships released into the marine environment is estimated to amount to 189,000 tonnes /year (GESAMP, 2007), with 186,120 tonnes being fuel oil, 1,880 tonnes being bilge oil, and 907 tonnes being oily ballast from fuel tanks (Figure 8).

FIGURE 8: AMOUNT OF FUEL RELEASED BY MARINE VESSELS (2007)

Ship Type	Total Oil Consumed for Vessel Type	Sludge Generation	Legal Discharge 15 ppm	100% compliance, tonnes discharged
Bulk Carriers	43,901,183	351,210	5.27	3,517
Combination Carriers	1,878,610	15,029	0.23	151
Container Vessels	29,184,295	233,474	3.50	2,338
Dry Cargo Vessels	15,009,051	120,073	1.80	1,203
Miscellaneous	14,263,099	114,105	1.71	1,143
Offshore Vessels	11,864,184	94,913	1.42	951
Ferries/Passenger Vls	22,935,349	183,483	2.75	1,838
Reefer Vessels	7,647,164	61,177	0.92	613
RoRo Vessels	15,300,591	122,405	1.84	1,226
Tankers - All cat.	62,135,997	497,088	7.46	475
Total	224,119,523	1,792,956	26.89	13,453

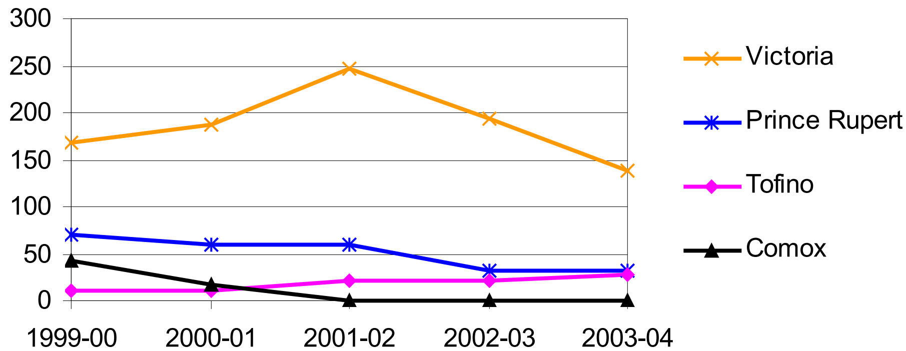
GESAMP, 2007

Anthropogenic sources of marine oil pollution range from intentional releases from ships, air pollution, natural seepages, bilge water, bilge cleaning, and land-based urban and industrial runoff. Oil may be released through accidental spills or leakage or may be released intentionally. Intentional releases may occur through dumping of oily bilge water and through tank washings, although this is legally required to take place offshore.

In Canada, it is a federal offence to accidentally or willfully discharge oil, garbage, sewage, or other pollutants into Canadian waters (MoE, 2006). Under law, polluters are supposed to report any oil spills to the Canadian Coast Guard, and the Marine

Communication and Traffic Service (MCTS) compiles pollution reports in relation to pollution originating from oil-handling facilities or vessels using the Vessel Traffic Service (VTS) (MoE, 2006). Pollution reports between 1999 and 2004 arranged by VTS zone are presented in Figure 9 (MoE, 2006).

FIGURE 9: POLLUTION INCIDENT REPORTS PER YEAR FROM SHIPPING BY VTS ZONE, 1999-2004



Source: MCTS, Canadian Coast Guard.

Pollution reports for the Prince Rupert VTS zone were on the decline with an average of 61 over five years (MoE, 2006); however, this trend is expected to shift upwards with the expansion of the Prince Rupert port and increased shipping pressure within the region. Furthermore, as pollution events are detected by chance and not all occurrences are reported, the data represent a minimum estimate of actual events.

About half (52 per cent) of the nation's reported spills occur on the B.C. coast, which is where half of all vessel movements in Canada occur (MoE, 2006). While chronic spills are less visible than major spills (e.g., Exxon Valdez spill), they have persistent, cumulative impacts on marine organisms (MoE, 2006). Chronic impacts can include decreased health, growth, or reproduction, as well as genetic effects (Haggarty et al., 2003). Chronic oil pollution from marine traffic contributes more oil to the marine environment than do acute spills (Haggarty et al., 2003), and is thought to have greater effects on seabird populations. Research conducted between 1998 and 2000 in Atlantic Canada indicates that approximately 300,000 seabirds died annually as a result of chronic oiling (Johannessen et al., 2007; Wiese and Robertson, 2004; MoE, 2006). Similar estimates are not available for the Pacific Coast; however, the National Aerial Surveillance Program has found a higher rate of oil spills off the West Coast than the East Coast. It is therefore believed that a similar proportion of marine birds are killed off the West Coast of Canada due to ship-derived oil pollution (Johannessen et al., 2007; MoE, 2006). Up to half of the dead seabirds found along the west coast of Vancouver Island were oiled (MoE, 2006).

The effects of chronic oiling are concentrated in harbours, marinas, and high-use areas such as shipping routes (Haggarty et al., 2003). The West Coast of British Columbia is characterized by dense aggregations of seabirds (many of which are considered species at risk), high biodiversity, and important foraging areas, and many of these areas overlap with shipping lanes (Johannessen et al., 2007). With predicted increases in tanker and cruise-ship traffic as a result of upgrades to the Prince Rupert port and industrial activity at the Kitimat port, chronic oiling can be expected to increase in the near future and pose a greater risk in terms of environmental contamination (Johannessen et al., 2007; MoE, 2006). Certain areas, such as the Triangle Islands, are breeding territory for large numbers of several seabird species, and any impact would be disproportionately severe for them. In addition, the opening of the Northwest Passage may result in a further increase in shipping and cruise-ship traffic within the Pncima area, resulting in the potential for an even greater increase in chronic oiling.

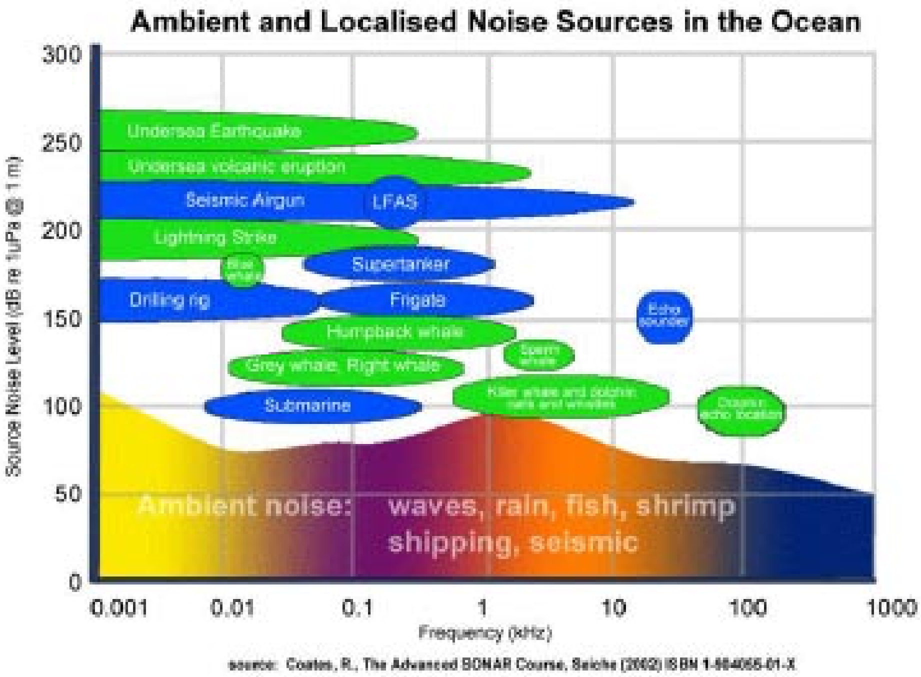
2.9 Anthropogenic Noise Pollution

Increases in ocean shipping have prompted parallel growths in ocean noise. Between 1948 and 1998, the global marine shipping fleet has increased from 85 million tonnes worth of ship weight to 550 million tones, resulting in an increase of 15 decibels of background noise in the world's oceans. For most cetaceans whose visibility under water can be limited, sound is as important as light. These organisms have adapted to take advantage of the physics of sound under water (BCCSN, 2008), using it for communication among individuals, reproduction (finding a mate), navigation, and locating food (BCCSN, 2008).

Today, propellers produce some of the loudest continuous sounds in the ocean. Large ships such as tankers and bulk carriers can produce sounds levels over 170 dB and even small, fast-travelling pleasure boats produce noise of 145 to 160 dB. Seismic surveys and navy sonar emit levels of noise pollution over 240 dB (BCCSN, 2008). In many cases, navy sonar and seismic testing have resulted in trauma, death, and mass strandings of some species of cetaceans.

Research has shown that killer whales react strongly to a received level of 135 dB, which is their pain threshold (Figure 10), while quieter noises can impair their ability to detect other whale calls and to locate their prey (BCCSN, 2008). Currently, the Killer Whale Recovery Team has identified a portion of the Pncima as critical habitat for threatened northern resident killer whales (DFO, 2008), but it is not yet clear if the recent legal protection of this habitat includes prohibitions on noise pollution. Furthermore, the recovery team has identified disturbance, including anthropogenic noise, as one of the current threats facing the recovery of the northern resident population. As such, the threat of increased noise pollution off the B.C. coast will have a negative impact on a species at risk whose habitat overlaps with Pncima.

FIGURE 10: NATURAL AND ANTHROPOGENIC NOISE LEVELS IN THE OCEAN



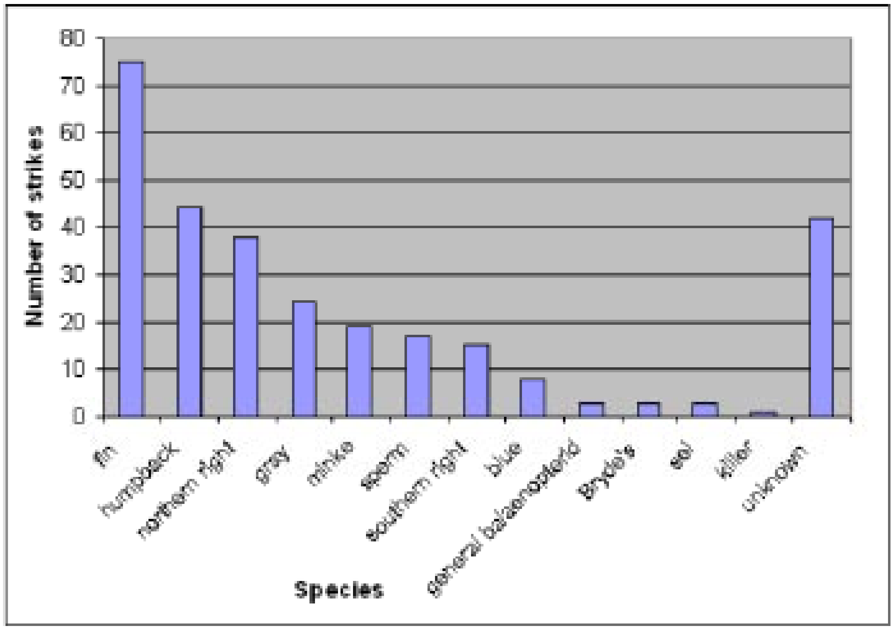
source: BCCSN, 2008

Further noise pollution in Pncima may occur as a result of industrial activities such as dredging, drilling, and underwater construction associated with port activities (DFO, 2008).

2.10 Ship Strike

Fatal collisions with ships have become a leading threat to whale survival. Increased vessel traffic and the number of high-speed vessels, coupled with the gradual growth in the populations of several whale species off the coast of British Columbia, have increased the incidence of whale strikes off the West Coast of Canada (BCCSN, 2008). Increased underwater noise levels, which inhibit the ability of whales to hear approaching vessels, may also contribute to ship strikes. Jensen and Silber (2003) report that fin whales are the most commonly struck large whale at almost twice the rate as the next most commonly struck species, humpback whales (BCCSN, 2008) (Figure 11). Injury and death as a result of ship strikes are significant threats to recovering cetacean populations (Jensen and Silber, 2003) and have the potential to damage smaller vessels and cause injury to passengers (BCCSN, 2008).

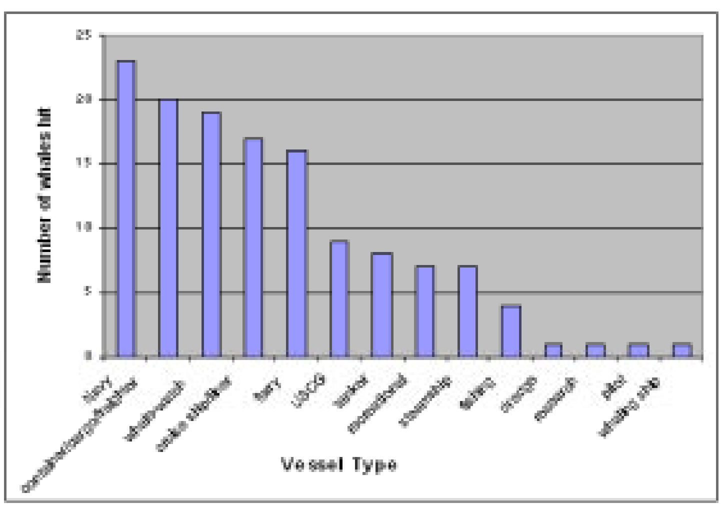
FIGURE 11: THE NUMBER OF SHIP STRIKES BY SPECIES OF CETACEAN



Jensen and Silber, 2003.

Container ships, cargo ships, and freighters make up the second-highest contributor to large whale ship strikes, second only to the U.S. Navy and Coast Guard (Figure 11). It is believed that the high numbers attributed to the navy and coast guard ships is a result of strict government regulations requiring them to report any incidents involving ship strike. Many of the reports attributed to the shipping-industry result directly from occasions where the whale carcass was carried into port (Figure 12).

FIGURE 12: NUMBER OF WHALES HIT BY VESSEL TYPE



Note: The high occurrence of Navy reports may reflect military and government reporting practice rather than an actual higher frequency of collisions relative to other ship types. Reporting struck or dead whales to NOAA Fisheries is now a part of standard operating practices for Navy and USCG.

The vast majority of ship strikes, however, are not reported as they may occur undetected or in remote areas, while the whales themselves may drift out to sea (Jensen and Silber, 2003). Thus, the actual number of strikes is undoubtedly much greater than what is known (Jensen and Silber, 2003).

3. Recommendations

The following recommendations are based on the foregoing analysis and are intended to motivate discussion of area-based management and conservation plans for Pncima. These pertain to current activities in Pncima.

1. Establish additional pumping stations at ports in Pncima to allow marine vessels with holding tanks to release raw sewage or treated effluent.

   Currently, there are only four pumping stations in the Central Coast. Consequently, many vessels with holding tanks release raw sewage or treated effluent directly into the marine environment.

2. Equip Ports throughout Pncima with facilities to properly dispose of oil wastes.

   The Canadian Shipping Act (CSA 2001) does not require that all docks provide adequate and proper waste-disposal facilities. In contrast, international agreements such as MARPOL, Annex V, do require such facilities. While most large ports have disposal facilities, numerous smaller ports, small-craft harbours, and private marinas do not. If Canada is to become a signatory to Annex V, the infrastructure and enforcement capabilities must be in place at all harbours and marinas to allow for adequate control of vessel waste.

3. Establish regulated "no-dumping" zones within four nautical miles (nm) of the nearest 20-metre depth contour or designated areas of high ecological significance, while travelling at a speed of no less than six knots.

   CSA 2001 contains no explicit regulatory exclusion for zero discharge within or near National Marine Conservation Areas, marine ecological reserves, and other marine protected areas, placing the marine habitat and species of these areas at risk of undue harm. Furthermore, amendments to the Shipping Act are less stringent with respect to the discharge of garbage, reducing the distance from four to three nm from shore.

Current regulations use distance from shore as an indicator of where discharges are allowable. Four nautical miles corresponds with the results of GIS analysis of discharge patterns and international best practices. The impact on the open ocean environment of discharged waste is minimized at a vessel speed of six knots or greater (ICCL, 2006).

Modelling exercises have found that the intense mixing zone immediately behind a ship is limited to a depth of approximately 20 metres (ibid.). As shallow water may extend some distance from the shore, the 20-metre depth contour should be considered the "shoreline" wherever possible.

4. Designate no-discharge zones for bilge water within four nm of protected areas and/or areas of high ecological significance throughout Pncima.

   The CSA 2001 contains no explicit regulatory exclusion for zero discharge within or near National Marine Conservation Areas, marine ecological reserves, and other marine protected areas, placing the marine habitat and species of these areas at risk of undue harm.

   Current regulations use distance from shore as an indicator of where discharges are allowable. Four nautical miles corresponds with the results of GIS analysis of discharge patterns, while the impact on the open ocean environment of discharged waste is minimized at a vessel speed of six knots or greater (ICCL, 2006).

5. Impose a ban on grey-water disposal within four nm of shellfish beds and shorelines or within protected bays with low tidal exchanges throughout Pncima.

   Grey water (from sinks, showers, pools, kitchens, etc.) is not regulated by the CSA 2001. The recommendation to ban grey-water disposal in shallow waters is due to concerns about the impact of chlorinated brominated compounds, nutrients, viruses, and other chemical constituents, many of which are not fully understood. The recommendation to ban disposal near shellfish-growing areas is because shellfish tend to concentrate pathogenic microorganisms and contaminants in the process of filtering water.

6. Enhance the inspection requirements for cracks and fractures in vessel cargo tanks for all large marine vessels travelling through Pncima.

Amendments to the CSA in 2001 included substantial increases in pollution penalties. Whereas Transport Canada is assigned primary responsibility for ship inspection to verify compliance with CSA 2001 and is responsible for ensuring foreign ships comply with international conventions, Environment Canada is responsible for ship inspections under the Canadian Environmental Protection Act. Under this structure, either could be deemed responsible for inspecting vessel cargo tanks under the premise of pollution prevention or wildlife protection, creating the situation in which neither is clear of its inspection requirements.

7. Increase emergency planning and preparedness capacity to address the impacts of potential oil spills.

   Transport Canada, Environment Canada, Fisheries and Oceans Canada, BC Ministry of Environment, and the BC Chamber of Shipping should establish a task force to address all consequences of a major vessel casualty, including risk mitigation and response preparedness, financial and institutional roles and responsibilities, and technical gaps.

8. Establish seasonal ship transport closures and/or speed limits along known large whale migration routes.

   An explicit management strategy is needed in Canada to address whale mortality due to ship strikes. Wherever possible, a predictive, synchronized, and monitored management system, which statistically determines the best route for vessels travelling close to whale migration routes and advises operators accordingly, is recommended. An alternative would be to implement required speed limits along whale migration routes.

   Laist et al. (2001) found that whales sustain severe or fatal wounds if hit by vessels travelling at speeds of 14 knots or more, indicating that the acuteness of injury is directly proportional to vessel speed. Based on the successful duplication of these findings, the National Oceanic & Atmospheric Administration (NOAA) proposed a speed limit of 10 knots for vessels travelling in areas (and at times) where they are likely to encounter a whale. It has been estimated that such measures would increase total vessel operating costs by less than 0.5 per cent (Kite-Powell and Hoagland, 2002).

9. Improve boat-repair sites or boat grids for hull repair by locating these services in boatyards where proper disposal methods for spilled or excess chemicals are employed in order to keep waste

out of the marine environment.

Environment Canada and Fisheries and Oceans Canada are actively discouraging the use of grids to mitigate the amount of waste going into the water. Currently, such best management practices (BMP) are voluntary. The David Suzuki Foundation recommends BMP related to boat-repair sites be mandated through regulations.

10. Adjust shipping lanes to avoid shipping conflicts with other values that would be compromised by shipping activity in protected areas or other areas of high ecological significance.

CSA 2001 contains no overall principles, objectives, or goals that refer to protecting public health or the environment. Only minimum requirements are stated with no consideration of cumulative impacts. Nonetheless, the Oceans Act implies such considerations should be carried out in the pursuit of sustainable development.

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