B.C. NORTHERN SHELF BIOREGION SPEED AND DISCHARGE ANALYSIS

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ACRONYMS AND INITIALISMS

AIS	Automatic identification system
B.C.	British Columbia
CH	Critical habitat
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
DFO	Department of Fisheries and Oceans
EEZ	Exclusive economic zone
GDP	Gross domestic product
GT	Gross tonnage
HFO	Heavy fuel oil
HRA	High-risk area
IH	Important habitat
IMO	International Maritime Organization
KFS	Kitimat Fjord System
KT	Knots
LNG	Liquid natural gas
LNG-C	LNG Canada Development Inc.
LPG	Liquid petroleum gas
MaPP	Marine Plan Partnership for the North Pacific Coast
MPA	Marine protected area
NGO	Non-governmental organization
NM	Nautical mile
NSB	Northern Shelf Bioregion
PAH	Polycyclic aromatic hydrocarbon
PoPR	Port of Prince Rupert
RO-RO	Roll-on/roll-off cargo vessels
SARA	Species at Risk Act
TEU	Twenty-foot equivalent unit
TSS	Traffic separation scheme
VPZ	Voluntary protection zone

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EXECUTIVE SUMMARY

Canada's Northern Shelf Bioregion (NSB) encompasses two thirds of coastal British Columbia (B.C.) and features cold, nutrient-rich waters that support high productivity and marine biodiversity, including several endemic, at-risk cetacean populations.

The NSB is not only biologically distinct but has also sustained coastal First Nations since time immemorial. Numerous remote coastal communities in the NSB rely on these coastal waters as a way of life.

The impacts of shipping in the NSB have been overlooked as most of the human population and shipping activity have been centralized in southern B.C. However, global trade demands are on the rise, and rapid port expansion plans are currently underway in Kitimat, Prince Rupert and Stewart. In light of these changes, this analysis aims to understand vessel speeds and operational discharge volumes within the NSB's four subregions, as determined by the Marine Plan Partnership for the North Pacific Coast (MaPP).[1]

Intensified shipping in these waters can result in more noise and contamination, and high speeds can elevate the risk of ship strikes. Cumulative effects to cetaceans from these activities include physiological stress, adverse behavioural modifications and inability to communicate. [9-15, 20-31, 33-35, 37-40]

This analysis identifies a number of high-risk areas (HRAs) in all four NSB subregions where both high vessel speed and operational discharge values overlap with at-risk cetacean habitat. The analysis provides recommendations to mitigate shipping impacts in HRAs, including vessel speed reductions, re-routing ships away from HRAs, enhancing operational discharge restrictions and banning the use of exhaust gas cleaning systems (scrubbers).

These recommendations should be advanced through co-management with NSB coastal First Nations and ongoing collaboration between government, non-governmental organizations (NGOs), coastal communities and maritime stakeholders to effectively uphold Canada's marine conservation commitments in the NSB.

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INTRODUCTION

B.C.'S NORTHERN SHELF BIOREGION

B.C.'s Northern Shelf Bioregion (NSB) is one of Canada's 13 distinct ecological bioregions, encompassing approximately 102,000 square kilometres (km²).[1] The NSB is divided into four subregions: North Vancouver Island, Central Coast, North Coast and Haida Gwaii (Figure 1).[1]

These distinct subregions feature unique bathymetry, ocean currents and geographic features such as narrow glacial fjords and vast intertidal zones that support a rich abundance of marine life and provide vital ecological, cultural and socioeconomic value to B.C.[1]

The rugged NSB boasts the highest coastal biodiversity in North America. This bioregion is home to numerous keystone species that rely on the nutrient-rich waters of the NSB to survive, including Pacific herring, Pacific salmon, cold-water corals, coastal sea wolves, sea otters, spirit bears, grizzly bears, killer whales, humpbacks, fin whales and blue whales. These keystone species, some of which are endemic to coastal B.C., play a disproportionately large role in balancing ecosystem health, productivity and resiliency.[2, 3, 4]

The health and resiliency of the NSB is not only vital to support such abundant biodiversity but has also been a critical lifeline for Indigenous populations since time immemorial. These traditional territories remain home to dozens of coastal First Nations who rely on the NSB to uphold traditional knowledge, beliefs and practices. The NSB is a critical transportation corridor for remote coastal communities and sustains coastal Nations by providing valuable seasonal resources and economic self-sufficiency.[5]

As a region that is rich in biodiversity and provides highly valuable marine resources through fisheries, aquaculture and ecotourism, the NSB has rapidly evolved as a central component of B.C.'s economy and global trade in recent decades. The NSB also hosts some of the busiest ports in Canada and is positioned as a critical trans-Pacific gateway for international trade.[6]

Figure 1. Overview of the four Northern Shelf Bioregion subregions within the Marine Plan Partnership for the North Pacific Coast (MaPP). Note there is an area of overlap between the north and central coast boundaries.

CETACEANS OF THE NORTHERN SHELF BIOREGION

At-risk species in Canada are protected under the federal *Species at Risk Act* (SARA). Fisheries and Oceans Canada (DFO) is mandated to develop management plans for listed marine species.[7] Several initiatives under Canada's Oceans Protection Plan (OPP) also aim to advance conservation and protection efforts for coastal ecosystems that are affected by human activities, including harmful shipping impacts to whales and whale habitat.[8]

Several at-risk cetacean species can be found throughout the NSB subregions seasonally and year-round (Table 2, Figure 2). Blue whales, grey whales, humpback whales and fin whales migrate between equatorial waters to the cold coastal waters within the NSB to forage on thousands of pounds of krill, herring and other small forage fish daily. Resident killer whales rely on migrating Pacific salmon returning to the coast to survive, while Bigg's killer whales travel up and down the coast year-round in search of diverse marine mammal prey. Cetacean abundance and diversity are generally high between the months of March and October due to seasonal coastal upwelling of cold, nutrient-rich water that provides essential foraging opportunities. However, as monitoring efforts throughout the NSB improve, visual and acoustic sightings are more frequently reported year-round.[9, 10]

As cetaceans have complex communication abilities and rely on acoustic information to communicate and sense their environment, they are especially vulnerable to cumulative effects from ship-radiated noise, including acoustic masking, increased stress, reduced foraging and communication abilities, and increased risk of ship strikes.[11] Due to their long lifespans and high caloric intake, cetaceans are also susceptible to bioaccumulation of harmful contaminants discharged by ships, including heavy metals and polycyclic aromatic hydrocarbons (PAHs).[12]

Fin whales are documented as the species most frequently struck by vessels globally.[13, 14] The B.C. population of fin whales is currently under reassessment by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) to be downgraded from "threatened" to "special concern" under Canada's SARA, due to an increase in offshore Pacific stock numbers. However, recent research confirms North Coast fin whales display unique site fidelity to the north coast Kitimat Fjord System (KFS) and are disproportionately vulnerable to increasing shipping risks along North Coast B.C. and Hecate Strait, which is a known corridor.[15]

Humpbacks are the most frequently encountered baleen whale in B.C., and the number of reported ship strike events with humpbacks in the NSB has increased in recent years. As liquified tanker presence is expected to increase upon the completion of the Kitimat LNG terminal, ship strike mortalities are projected to increase 2.3 times for fin whales and 3.9 times for humpbacks in the KFS.[13]

Table 1. Cetaceans in the Northern Shelf Bioregion listed under Canada's Species at Risk Act (SARA).

Species	SARA Listing
Southern resident killer whale	Endangered
Northern resident killer whale	Threatened
Bigg's (transient) killer whale	Threatened
Offshore killer whale	Threatened
Blue whale	Endangered
Sei whale	Endangered
North Pacific right whale	Endangered
Fin whale	Threatened
Grey whale (eastern North Pacific population)	Special Concern
Humpback whale	Special Concern
Harbour porpoise	Special Concern

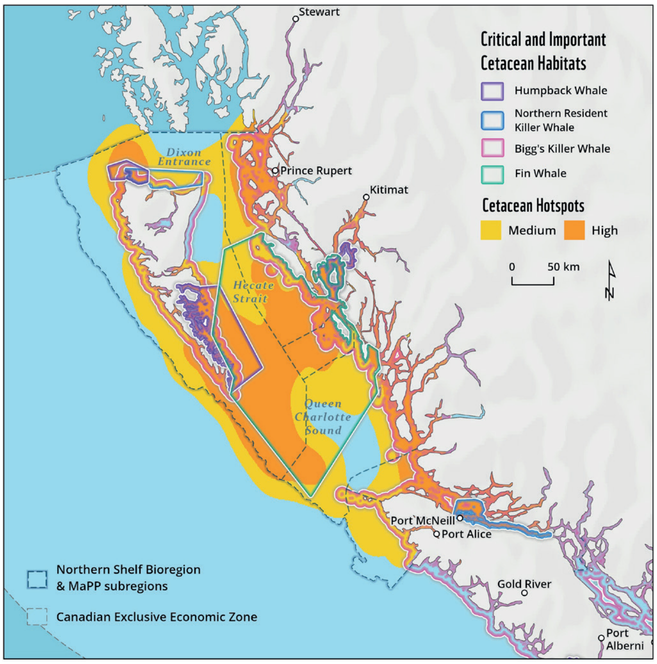

Figure 2. Critical and important cetacean habitat as designated by Canada's Species at Risk Act. Cetacean hotspots determined using Ocean Wise's Sightings Network database for humpback, fin, resident and Bigg's public sightings reports. Sightings data supplied by the B.C. Cetacean Sightings Network. Sightings are opportunistic and not corrected for effort.

Canada has committed to conserving 25 per cent of its marine and coastal areas by 2025 and 30 per cent by 2030.[16] However, the extent to which static protected areas can effectively protect cetacean seasonal habitat and migratory routes, which are known to adapt over space and time, is limited.

B.C.'S SHIPPING AND MARITIME TRANSPORTATION INDUSTRY

B.C.'s marine sectors contribute an estimated $5 billion annually towards provincial gross domestic product (GDP), with the marine transport sector being the highest GDP contributor, followed by cruise lines.[17] As a result of increasing economic demands, port and terminal activity and supporting infrastructure are expected to expand along the Pacific coastline to support a rapidly growing shipping industry.

On average, 4,000 large vessels (>260 metres [m] in length) transit through Canadian Pacific waters annually, primarily to load and offload cargo.[6] The most common large vessels transiting to Canadian ports are cargo ships and tankers, followed by bulk carriers and container ships. Container and cruise ship traffic has increased 200 per cent in B.C. ports since the 1980s.[6, 17]

The coastal channels within the NSB are also frequently travelled by tugs, barges, yachts and ferries.[6] The narrow Inside Passage along the coastal NSB is heavily transited year-round, as it acts as a sheltered route for many vessels of all sizes.[6, 18] Close proximity to the shoreline is also desirable for passenger vessels, including ferries and cruise ships, to provide passengers with spectacular views while taking advantage of more sheltered waters.

PORTS IN THE NORTHERN SHELF BIOREGION

There are four small ports and one large port within the NSB, collectively handling thousands of port calls annually within the bioregion (Figure 1 and Table 1).[6] The Port of Prince Rupert (PoPR) is the third-largest seaport in Canada and the second-largest port for cargo and container volume in B.C. In 2022, the PoPR reported a 22 per cent increase in liquified petroleum gas (LPG) exports, a 67 per cent increase in thermal coal exports and a 230 per cent increase in cruise ship passenger volumes compared to 2019; it is currently in the process of doubling its container terminal capacity to 1.8 million 20-foot equivalent units (TEU) to meet growing demand.[6, 19] Additional expansion plans are currently being assessed.

The District of Kitimat is constructing a new terminal for exporting liquified natural gas (LNG), which will result in a drastic increase in bulk carrier traffic through the KFS. Once the LNG Canada (LNG-C) terminal is fully operational by 2030, 700 additional transits will be completed annually by LNG carriers.[13] The federal government approved funding for infrastructure expansion in Stewart in 2019 to support increased bulk facility capacity for mineral, forestry and grain exports.

Table 2. List of major and small ports located within the Northern Shelf Bioregion.

Port	Main exports
Port of Prince Rupert	Containers, coal, liquid petroleum, petroleum coke, forestry products, raw lumber, grains
Kitimat	Aluminum, bulk products, petroleum, LNG (upon completion)
Port of Stewart	Raw lumber, forestry products, mineral ore
Port McNeill	Sand and gravel cargo
Port Alice	Forestry products

IMPACTS OF SHIPPING ON CETACEANS

As the shipping sector continues to expand to support global trade demands, increasing ship traffic poses a significant risk to several vulnerable cetacean populations that rely on coastal corridors in the NSB.

This report analyzes two critical shipping pressures that threaten the well-being of cetacean populations in the NSB: vessel speeds and operational waste discharges.

VESSEL SPEED

Vessel traffic density and speed are directly correlated to underwater noise pollution in marine soundscapes. Larger vessels (>100m in length) and faster-moving vessels (>10 knots [kt]) tend to produce more noise, often at low frequencies that mask whale vocalizations.[20] As the number of large commercial vessels continues to grow to keep pace with demand, prolonged exposure to commercial vessels operating at high average speeds will increasingly impact cetaceans' ability to communicate, forage, navigate safely, avoid threats and engage in social interactions.[13, 20-25]

Speed is also directly correlated with increased risk of a lethal ship strike for both baleen and toothed whales. Vessel speeds between 9kt and 20kt increase the probability of a strike being lethal from 20 per cent to 100 per cent.[26, 27] The likelihood of a strike being lethal increases most rapidly as speed increases from 10kt to 14kt.[26, 27] Ship strikes have been found to be a significant cause of mortality for humpbacks, fin, sei, blue and killer whales.[27-29]

Mortality rates for marine mammals are higher where seasonal habitat ranges overlap with shipping lanes that connect to major ports.[18] This poses a significant threat to populations in major shipping lanes where vessel traffic is already high and/or increasing.[30] Several reported and suspected ship strikes occurred in 2023 within the NSB; however, the total number of ship strikes, particularly to baleen whales, is largely unknown because the majority of ship strikes are unobserved or unreported.[31]

This analysis identifies high-risk areas where cetacean habitats are exposed to high vessel speeds.

A previous analysis on ship speed impacts in B.C., including the NSB, can be found in WWF-Canada's report [Shipping Traffic and Speed in Cetacean Habitats on Canada's Pacific Coast](#).

OPERATIONAL DISCHARGES

Operational wastes including sewage (body wastes from humans and live animals, drainage from toilets, medical facilities and live animal enclosures, and other wastes and forms of drainage that are mixed with the aforementioned types of waste), greywater (drainage from sinks, laundry machines, dishwashers, tubs, shower stalls and some floor drains), scrubber washwater (a mixture of seawater and water-soluble components of exhaust gas including dissolved metals, organic compounds and acids), and oily bilge water (a mixture of substances often including oily fluids, lubricants, grease, surfactants and other substances) are produced as a result of normal vessel operations. WWF-Canada's recent *National Vessel Dumping Assessment* estimates that 147 billion litres (L) of ship waste are generated in Canadian waters annually, roughly 10 per cent of which is generated in federally designated marine protected and conserved areas.[32]

Routine exposure of cetaceans to contaminants, including those found in operational discharges, can lead to chronic health problems and other adverse physiological effects, including decreased fertility, endocrine disruption, increased prevalence of cancer at the population level and mortality.[32-34] Long-lived apex predators such as killer whales are particularly at risk of accumulating harmful substances through chronic exposure. According to the United States Environmental Protection Agency, southern resident killer whales are among the most contaminated animals in the world.[35] A 2019 study found that 3.5 million tonnes of scrubber washwater were discharged into resident killer whale critical habitat in 2017 by 30 vessels, which were predominantly cruise and container ships.[12] Since 2017, the number of ships fitted with scrubbers globally has increased by 1,500 per cent.[32]

In Canada, operational discharges from ships are authorized and regulated under national maritime and environmental statutes. The *Canada Shipping Act, 2001* is the principal statute addressing pollution from ships and regulates discharges through its *Vessel Pollution and Dangerous Chemical Regulations*. Canada's authority to regulate international shipping is greatest within internal waters (<0 nautical miles [nm]), followed by the territorial sea, which extends out to 12nm seaward of the baseline (0–12nm). Canada's regulatory authority over international shipping is limited within the exclusive economic zone (EEZ) (12–200nm). Canada does, however, have the authority to regulate Canadian-flagged ships at any distance from the baseline.

In 2023, the Government of Canada announced two additional tools to reduce the impacts of operational discharges in Canadian waters that are relevant for the NSB: the Marine Protected Areas (MPA) Protection Standard and new mandatory environmental measures for cruise ships. The MPA Protection Standard includes proposed enhanced vessel discharge restrictions for sewage, greywater, bilge water, and scrubber washwater in federally designated MPAs (marine protected areas).[36] These restrictions have the potential to significantly reduce pollution from ships in protected areas; however, these restrictions are yet to be operationalized, thus making it impossible to assess their strength, and the timeline for implementation is currently unknown. The new mandatory environmental measures for cruise ships strengthen discharge requirements for sewage and greywater by strengthening treatment requirements and minimum setback distances and by doing so bring Canadian requirements for these waste streams more closely in line with those of Alaska.

Treating operational wastes prior to discharge is the primary means used by ships to mitigate the adverse impacts of disposal at sea. However, treating waste reduces but does not eliminate the potential for harm, and there remains much room for regulatory improvements as well as for better monitoring and enforcement of existing requirements. Aside from improving on existing national and international regulations, solutions for mitigating the adverse impacts of operational wastes on the marine environment include adopting operational and technological measures to reduce waste production at source; fitting vessels with better treatment technologies that are capable of exceeding minimum treatment standards; offloading waste to shore reception facilities instead of discharging it at sea; not investing in highly polluting technologies like scrubbers; and avoiding making discharges in environmentally, ecologically and culturally important waters, including those set aside for conservation and those used for harvesting activities.

A detailed analysis of vessel discharges in B.C. waters can be found in WWF-Canada's [National Vessel Dumping Assessment: Quantifying the Threat of Ship Waste to Canada's Marine Protected Areas].

METHODS

VESSEL AND CETACEAN DATA

This analysis used automatic identification system (AIS) point data from Spire Maritime throughout the year 2022 to analyze ship traffic and speed. For this analysis, the following ship types were selected and categorized:

Table 3. Reclassification of vessel types into ship class. Passenger ship classes (purple) include cruise ships, ferries and yachts.

Ship class	Vessel type	Ship class	Vessel type
Bulk carrier	Bulk carrier	**Naval ship**	Aircraft carrier
	Bulk/oil carrier		Destroyer
	Cement carrier		Frigate
	Chip carrier		Icebreaker AGB
	Covered bulk cargo barge		Patrol vessel
	Forest product carrier		Patrol vessel, naval
	Gypsum carrier		Research vessel, naval auxiliary
	Open hatch carrier		Submarine salvage vessel
	Ore carrier		Training ship, naval auxiliary
	Salt carrier	**Offshore**	Accommodation vessel
	Slurry carrier		Cable layer (fibre optic)
Chemical tanker	Chemical and oil carrier		Cable, umbilicals and FP/flowline lay
Container	Fully cellular container		Crew boat
Cruise	Cruise ship		Geophysical survey
Ferry pax only	Passenger vessel		Hydrographic survey
Ferry ro-pax	Passenger/cargo catamaran vessel		Maintenance
	Passenger/cargo ferry		Multi-purpose support
	Passenger/cargo vessel		Oceanographic survey
	Passenger/ro-ro (inland)		Oilfield pollution control
	Ro-ro freight/passenger		ROV/submersible support
Fishing	Factory stern trawler		Research vessel
	Fish factory ship		Seismic support
	Fishery patrol vessel		Seismic survey
	Fishery research vessel		Semi-submersible heavy lift
	Fishery support vessel		Transport (heavy lift)
	Fishing vessel		Utility/workboat
	Live fish carrier (well-boat)	**Oil tanker**	Oil bunkering tanker
	Stern trawler		Shuttle tanker
	Trawler		Tanker

Ship class	Vessel type	Ship class	Vessel type
General cargo	Aggregates carrier	**Other liquid tankers**	Asphalt and bitumen carrier
	Barge carrier		Methanol carrier
	Cement carrier		Product carrier
	General cargo		Replenishment tanker
	Heavy lift cargo vessel	**Refrigerated**	Reefer
	Landing craft		Reefer fish carrier
	Livestock carrier	**Ro-ro**	Logistics vessel (naval ro-ro cargo)
	Multi-purpose		Pure car carrier
	Multi-purpose/heavy lift cargo		Ro-ro
	Replenishment dry cargo vessel		Ro-ro/container
Liquefied gas tanker	Ethylene/LPG		Ro-ro/lo-lo
	LNG carrier	**Service other**	Backhoe/dipper/grab dredger
	LNG/ethylene/LPG		Dredgers (stone dumping, fallpipe)
	LNG/regasification		Trailing suction hopper dredger
	LPG carrier	**Tug/towing**	Anchor handling tug
Miscellaneous	Anti-pollution vessel		Anchor handling tug/supply
	Buoy/lighthouse tender		Crew/fast supply vessel
	FPSO		Fire-fighting tug
	Icebreaker		Ocean-going tug
	Jack-up drilling rig		Platform supply
	Jack-up production unit		Supply
	Marine research		Towing/pushing (inland)
	Pilot vessel		Tug
	Salvage vessel		Tug, anchor hoy
	Semi-submersible drilling rig		Tug, naval auxiliary
	Supply tender	**Yacht**	Motor yacht
	Training ship		Sailing vessel
	Work/repair vessel		Yacht (sailing)

Table 4. Ship classes included or excluded in the analysis.

Included ship classes	
Bulk carrier	Liquified gas tanker
Chemical tanker	Oil tanker
Container	Other liquid tankers
Cruise	Refrigerated
Ferry pax only	Ro-ro
Ferry ro-pax	Tug/towing
Fishing	Yacht
General cargo	
Non-included ship classes	
Miscellaneous	Offshore
Naval ship	Service other

The cetacean dataset includes both scientific and opportunistic data. SARA CH and IH were acquired from DFO. Opportunistic data were acquired from Ocean Wise BC Cetacean Sightings Network and vectorized using an Iso Cluster classifier based on the original relative abundance colour ramp legend. Data obtained from the B.C. Cetacean Sightings Network were collected opportunistically with limited knowledge of the temporal or spatial distribution of observer effort. As a result, absence of sightings at any location should not be interpreted as absence of cetaceans or sea turtles.

For detailed methodology regarding the processing and analysis of these datasets, please refer to WWF-Canada's document *Shipping Traffic and Speed in Cetacean Habitats on Canada's Pacific Coast*.

For this analysis, HRAs are defined as geographical boundaries where at-risk cetacean habitat intersects with moderate-to-high average vessel speeds and moderate-to-high vessel discharge volumes. HRAs identified in this analysis are areas that pose significant risk to the survival and recovery of identified at-risk cetacean species without mitigation measures.

VESSEL DISCHARGE MODELLING

This study used 2022 vessel attribute data acquired from Clarkson's Research in conjunction with a 2022 AIS dataset from Spire. For detailed methodology regarding the processing and analysis of vessel discharges, please refer to WWF-Canada's *National Vessel Dumping Assessment*.

IDENTIFYING HIGH-RISK AREAS

To identify HRAs in this analysis, the NSB was divided using a regular 100 km^2 hexbin grid. For each hexbin, the maximum speed of vessels and total amount of all discharge types was calculated. Values for maximum speed and total discharge were separated into three equal quantiles representing relatively low, medium and high values within the possible range within the area of interest. Quantiles were visualized using a bivariate colour scheme, and hexbins that belonged to the highest quantile ("High") were determined to be high-risk areas. The bivariate risk map was then overlayed with habitat data to locate areas of particular risk for cetacean species.

KEY FINDINGS

NORTHERN SHELF BIOREGION 2022 SHIPPING STATISTICS

In 2022, 794 individual vessels with IMO numbers transited through the NSB, covering a total distance of 3 million kilometres (km) and corresponding to 367,000 operational hours (Appendix A, Table A1). While bulk carriers make up the largest proportion of ships, with 299 vessels (Figure 3), cruise ships and tugs maintain the highest percentage total distance travelled within the NSB, at 24 per cent and 27 per cent, respectively (Figure 3; Appendix A, Table A1).

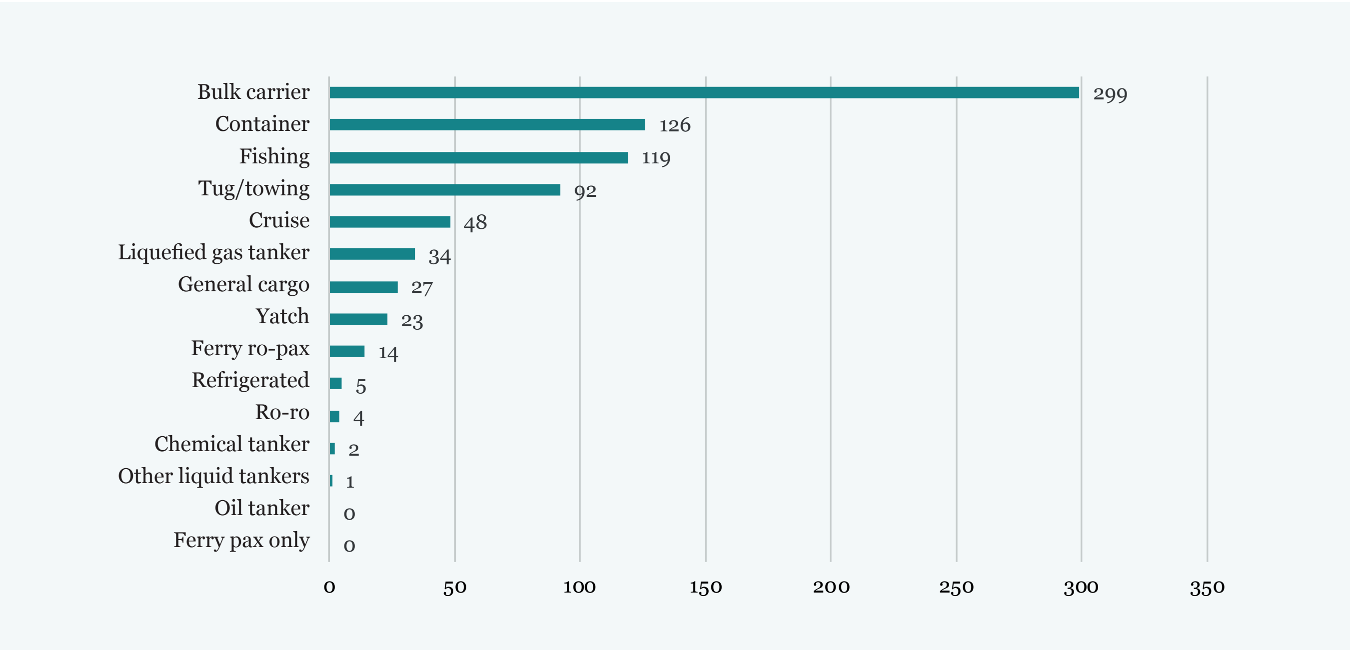

Figure 3. Total number of ships per type transiting through the Northern Shelf Bioregion MaPP boundary throughout 2022.

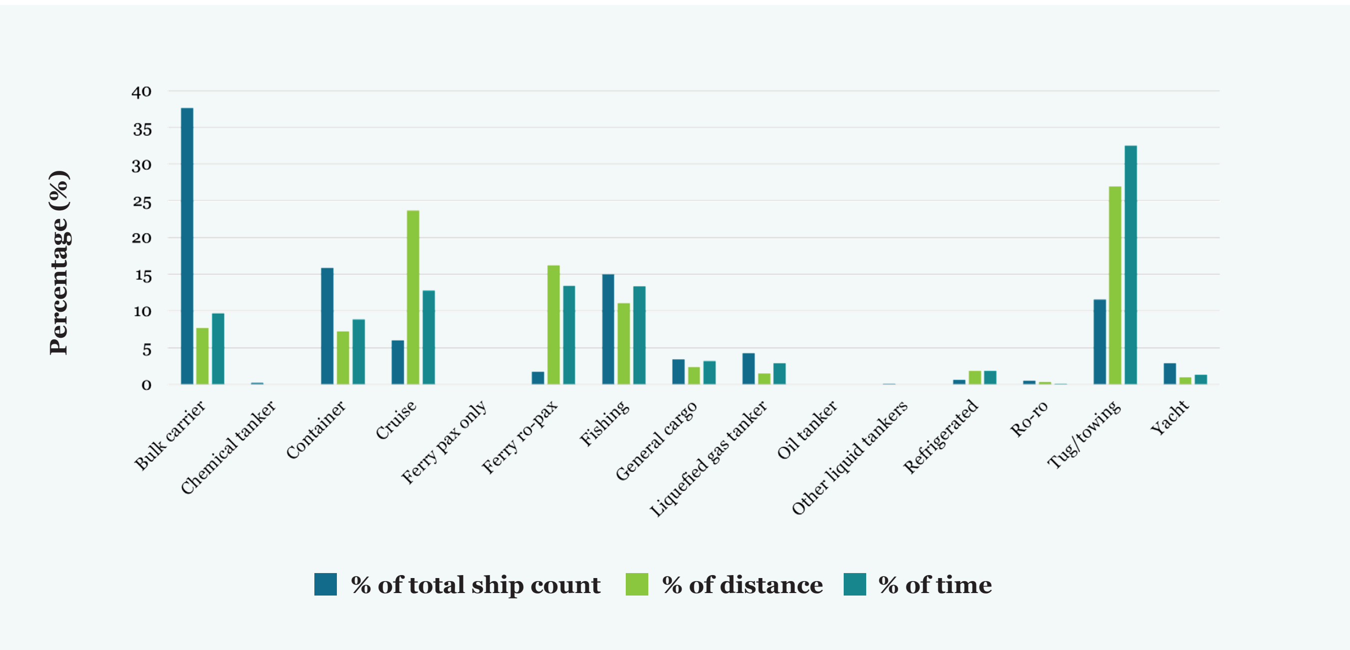

Figure 4. Summary of percentages of total ship count per type, total distance travelled and total time spent within the MaPP Northern Shelf Bioregion boundary throughout 2022.

VESSEL SPEED

Average ship speeds in 2022 for all classes are shown in Figure 5. Speed maps for unique vessel types are listed in Appendix B. Notably, cruise ships, roll-on/roll-off (ro-ro) cargo ships and ferries were transiting at the highest average speeds (>16kt) through NSB waters (Appendix B, Figures B1–B5).

Out of 794 total vessels that travelled through the NSB in 2022, 713 transited through CH/IH boundaries (Appendix B, Table B1). Of these 713 vessels, 697, or 97.8 per cent of vessels, were travelling at average speeds greater than or equal to 11kt (Appendix B, Table B1).

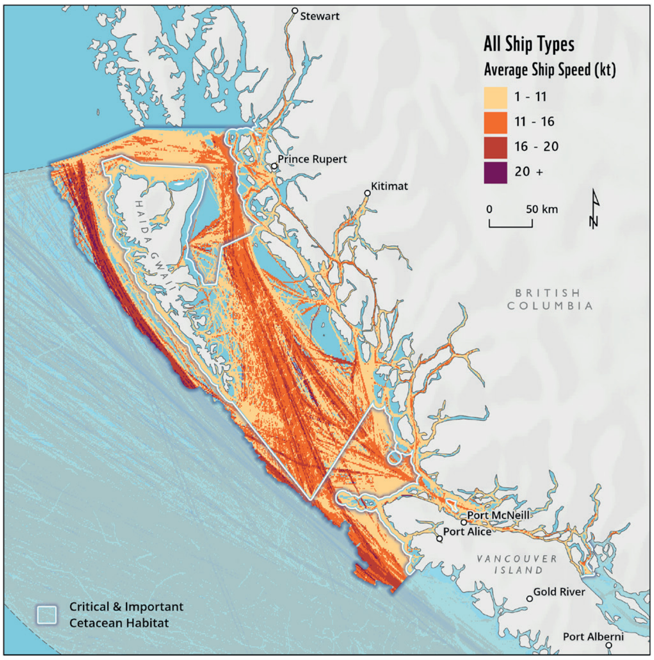

Figure 5. Average ship speed (kt) for all ship types within Northern Shelf Bioregion waters in 2022, determined using the AIS dataset provided by Spire.

OPERATIONAL VESSEL DISCHARGE

An estimated 56 billion litres of waste were produced in the NSB in 2022. This includes 29 billion litres of scrubber washwater, 161 million litres of sewage, 1 billion litres of greywater and 11 million litres of oily bilge water (Appendix C, Table C1),

Out of 794 total vessels, 173 vessels were fitted with exhaust gas cleaning systems (scrubbers), compared to 112 out of 788 in 2019 (Appendix C, Figure C2). The greatest uptake in scrubbers between 2019 and 2022 was by liquified gas tankers, general cargo ships and container ships, with increases of 600 per cent, 800 per cent and 133 per cent, respectively (Appendix C, Table C2). Of the vessels fitted with scrubbers, 71 per cent were equipped with open-loop systems (a 45 per cent increase since 2019), 24 per cent had hybrid systems and 1 per cent had closed-loop systems. Four per cent were unspecified, but for the purpose of this analysis were presumed to be open-loop systems (Appendix C, Table C3).

Cruise ships produced more waste than any other vessel type and are by far the greatest contributor to vessel discharge volumes in each of the NSB subregions (Appendix C, Table 8). The volume of scrubber washwater is also overwhelmingly produced and discharged by cruise ships (Appendix C, Table C4, Figure C3).

Sixty per cent of the total volume of waste produced by vessels in 2022 was within cetacean CH/IH (Appendix C, Table C5). Figures illustrating waste production for all ship types can be found in Appendix C, Figures C1–C4.

IDENTIFIED HIGH-RISK AREAS

The total distance travelled by all ship classes in CH/IH throughout 2022 was over 2.06 million km, contributing to both significant speeds and operational discharge in sensitive waters (Appendix B, Table B1).

Of the 2.06 million km, 952,000 km or 46 per cent of the distance travelled by all ship classes within these CH/IH was at a speed of 11kt or greater; 94 per cent of the distance travelled by ro-ro ships was at 11kt or faster, followed by 93 per cent of cruise ship travel, 89 per cent of liquid tanker travel and 73 per cent of passenger ferry travel (Appendix B, Table B1).

HRAs in this analysis were identified where both speed and discharge overlapped with CH/IH. The HRAs identified for the NSB are categorized where high values for both vessel speed and operational discharge values intersect, and are visualized as purple cells in Figure 6.

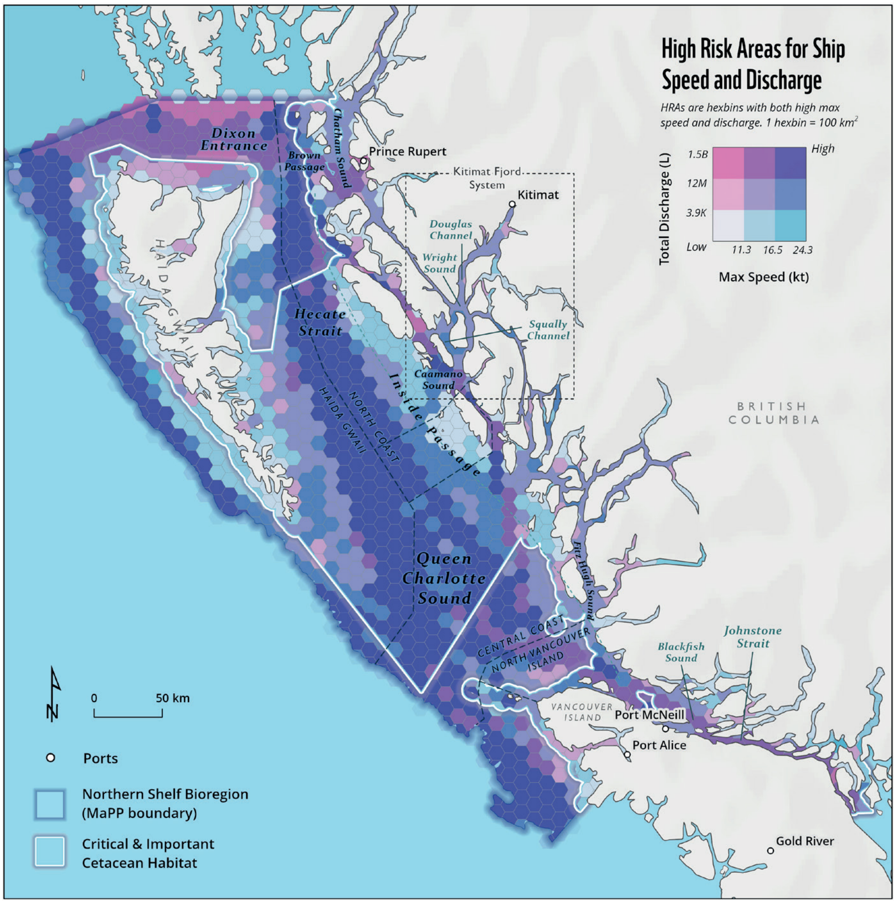

Figure 6. Identified high-risk areas in the Northern Shelf Bioregion. Legend depicts maximum speed and the total discharge in 100km² grid cells. Purple displays zones that are in the highest quantile for both speed and discharge, pink displays zones with high discharge values but low max speed, and blue displays high speeds but low discharge values.

RECOMMENDATIONS

REDUCING RISKS TO CETACEANS IN THE NORTHERN SHELF BIOREGION

The following recommendations and best practices are technical in nature and aim to mitigate impacts of both vessel speed and vessel discharge on at-risk cetaceans in HRAs within the NSB.

These recommendations should be advanced through co-management with NSB coastal First Nations and ongoing and adaptive collaboration between government, NGOs, coastal communities and maritime stakeholders.

SLOW VESSELS DOWN IN HIGH-RISK AREAS

Reducing vessel speeds in HRAs identified in this analysis, including the Dixon Entrance, Hecate Strait, Inside Passage and the KFS, is a highly effective measure to reduce shipping impacts effectively and imminently to at-risk cetaceans. Modest regional speed reductions have the potential to address multiple shipping mitigation efforts simultaneously, including reduced GHG and underwater noise pollution, reduced lethal ship strikes and increased navigational safety.[37, 38] Voluntary seasonal vessel speed restrictions in southern B.C. have been successful in reducing both underwater noise levels and presumably ship strike risks in killer whale CH by vessels maintaining speeds of 8–10kt.[39, 40] Speed reductions for deep-sea vessels >300 gross tonnage (GT) could reduce lethal ship strikes by 22 to 26 per cent if compliance can reach 95 per cent.[41] Further NSB analyses support restricting large commercial vessel speeds to under 10kt as the most effective immediate action to reduce mortality risks to cetaceans.[13]

WWF-Canada recommends implementing vessel speed management measures in all identified HRAs when the presence of whales seasonally increases, particularly in nearshore coastal waters where re-routing ships around HRAs is not possible. Speed restrictions of 10kt or less should be monitored in heavily trafficked shipping routes and port entry/exits, such as the Dixon Entrance, KFS and Inside Passage, to effectively assess and reduce shipping impacts to at-risk cetaceans in these key corridors.

MOVE VESSELS AWAY FROM HIGH-RISK AREAS

Vessel avoidance measures in HRAs is highly effective in mitigating shipping impacts to cetaceans, including for its reduction of collision risks during periods where seasonal abundance and distribution of species along aggregation areas increases. Re-routing ships away from cetaceans may be applied through a variety of methods including traffic separation schemes (TSS), seasonal exclusion zones and other tools which have been effective mitigation measures globally.[42] Re-routing and avoidance measures have been successful in Canada, as seen in the Bay of Fundy's TSS to reduce strike risks to North Atlantic right whales for vessels >300GT, as well as within the NSB, where 94 per cent of vessels >500GT remained outside of the voluntary protection zone (VPZ) offshore Haida Gwaii in 2022.[42, 43]

WWF-Canada recommends collaborative efforts between regulators and maritime stakeholders to identify and expand vessel avoidance and re-routing measures within the NSB, where safe and feasible, through regulatory or non-regulatory measures that reduce the risk of adverse shipping impacts in identified HRAs.

STRENGTHEN OPERATIONAL DISCHARGE REGULATIONS AND PRACTICES

a. **Operationalize and implement enhanced vessel discharge restrictions.** Enhanced vessel discharge restrictions for sewage, greywater, scrubber washwater, oily engine bilge and food waste were announced as part of Canada's MPA Protection Standard but have yet to be operationalized or implemented, leaving federally designated protected areas within the NSB vulnerable. These measures should be introduced as soon as possible.

b. **Ban scrubbers.** Scrubber washwater is the most voluminous waste stream produced by ships after ballast water, despite only a minority of ships being fitted with scrubbers. Scrubbers are a regulatory compliance loophole whose sole purpose is to enable the continued use of heavy fuel oil (HFO). Canada should ban the use of all scrubbers in Canadian waters and support measures to ban their use internationally.

c. **Define treatment standards for greywater.** Greywater is produced at five to eight times the rate of sewage, and untreated greywater can be as environmentally damaging as raw domestic sewage. Yet, unlike sewage, Canada has not defined treatment standard for greywater. We call on Canada to define a robust standard for greywater and to support measures to regulate greywater internationally.

d. **Expand on new environmental measures for cruise ships.** Canada recently introduced by ministerial order new measures for cruise ships discharging sewage and greywater into Canadian waters. These measures should be expanded to include other polluting waste streams such as scrubber washwater and other vessel types.

e. **Operators can help.** In the absence of stronger regulations, the cruise and shipping industries can adopt voluntary measures to reduce the impacts of polluting discharges. These measures could include treating waste to the highest possible standard prior to discharging it regardless of distance from shore; refraining from discharging treated waste in the territorial sea (12nm); offloading waste to shore reception facilities when feasible; installing vacuum toilets and low-flow fixtures; and complying with the global sulfur cap by using <0.1 per cent sulfur fuel instead of using scrubbers.

WWF recommends that the Government of Canada operationalize the MPA Protection Standard's enhanced vessel discharge restrictions and implement them within all existing and future designated protected areas; ban scrubbers in Canadian waters; define treatment standards for greywater; expand the enhanced measures for cruise ships to include additional wastes such as scrubber washwater and other vessel types; and increase regulation and incentivization for the shipping industry to transition towards alternative clean fuels and green shipping technologies in Canadian waters.

CONCLUSION

To ensure Canada prioritizes protecting marine biodiversity and meeting our 30 per cent ocean protection targets by 2030, Canada must adopt an evolving protection strategy that adapts with increasing cumulative shipping impacts and increasing knowledge of marine ecosystems within the NSB. The intent of this analysis is to guide further discussions and encourage collaborative stakeholder involvement in the development of stronger protection measures for at-risk cetaceans in the NSB.

The HRAs identified in this analysis face significant cumulative impacts to at-risk whale populations as commercial shipping activity continues to increase over the next decade. High priority should be placed on implementing immediate and robust shipping mitigation measures in HRAs including the Dixon Entrance, Hecate Strait, the Inside Passage and the KFS.

Adaptive mitigation measures such as speed restrictions, vessel rerouting and enhanced discharge regulations result in effective and immediate reduced shipping impacts to cetaceans. Prioritizing increasing knowledge and co-management of coastal marine ecosystems and resources through identified HRAs for at-risk cetaceans is vital to the long-term preservation and protection of the NSB's health and biodiversity.

For more information, including WWF-Canada publications related to this analysis, visit **wwf.ca/report/**

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APPENDICES

APPENDIX A: VESSEL TRAFFIC SUMMARY DATA

Table A1. Summary of ships per ship class, total distance travelled and operational hours in the Northern Shelf Bioregion.

Ship type	Count	Distance (km)	Operational hours	% total ship count	% total distance	% total time
Bulk carrier	299	230,473.81	35,501.80	37.66	7.69	9.67
Chemical tanker	2	342.21	15.80	0.25	0.01	0.00
Container	126	217,091.60	32,432.53	15.87	7.24	8.83
Cruise	48	710,337.75	47,067.50	6.05	23.70	12.82
Ferry ro-pax	14	485,068.76	49,254.72	1.76	16.19	13.41
Fishing	119	331,692.42	49,099.00	14.99	11.07	13.37
General cargo	27	71,500.46	11,782.56	3.40	2.39	3.21
Liquefied gas tanker	34	44,681.86	10,592.70	4.28	1.49	2.88
Other liquid tankers	1	849.57	87.54	0.13	0.03	0.02
Refrigerated	5	55,717.91	6,803.37	0.63	1.86	1.85
Ro-ro	4	10,956.19	353.04	0.50	0.37	0.10
Tug/towing	92	809,388.85	119,426.22	11.59	27.01	32.52
Yacht	23	28,924.05	4,801.21	2.90	0.97	1.31
Total	**794**	**2,997,025.46**	**367,217.996**	**100**	**100**	**100**

APPENDIX B: VESSEL SPEED TABLES AND FIGURES

Table B1. Summary speed data per ship type travelling through Northern Shelf Bioregion critical and important habitat. Values include total distance travelled, percentage of individual ships transiting at average speeds greater than or equal to 11 knots, distance travelled through critical or important habitat at average speeds greater than or equal to 11 knots, and per cent of vessels per ship type transiting at average speeds greater than or equal to 11 knots.

Ship type	Count	Distance in CH/IH (km)	# of vessels avg speed >=11kt	Distance travelled >= 11kt (km)	% high speed distance
Ro-ro	3	1,758.94	3	1,645.54	93.55
Cruise	48	342,050.46	48	317,569.09	92.84
Other liquid tankers	1	483.72	1	428.21	88.52
Ferry ro-pax	14	445,724.66	14	320,635.47	71.94
Yacht	23	22,782.76	23	15,015.26	65.91
Bulk carrier	270	116,205.36	264	66,555.15	57.27
Container	111	103,823.57	109	57,292.52	55.18
Liquefied gas tanker	34	13,201.02	34	6,330.28	47.95
Refrigerated	5	46,439.03	5	18,799.08	40.48
General cargo	27	57,996.72	27	21,791.24	37.57
Fishing	85	216,643.21	80	35,225.22	16.26
Chemical tanker	1	45.38	1	6.52	14.36
Tug/towing	91	696,993.25	88	90,981.28	13.05
Total	**713**	**2,064,148.10**	**697**	**952,274.86**	**46.13**

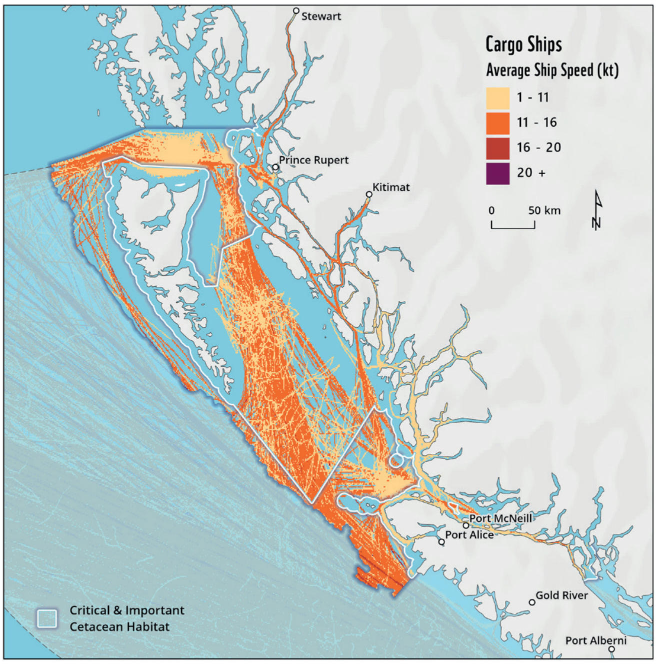

Figure B1. Average speed of cargo ships travelling through the Northern Shelf Bioregion.

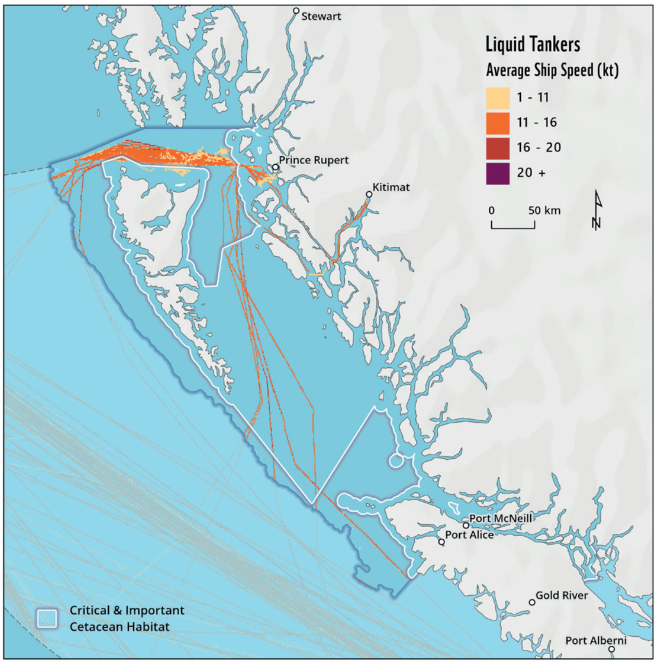

Figure B2. Average speed of liquid tankers travelling through the Northern Shelf Bioregion.

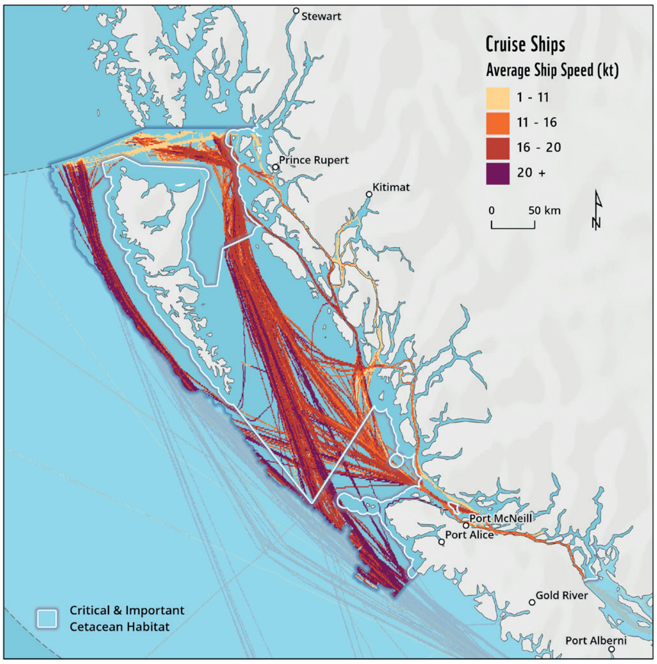

Figure B3. Average speed of cruise ships travelling through the Northern Shelf Bioregion.

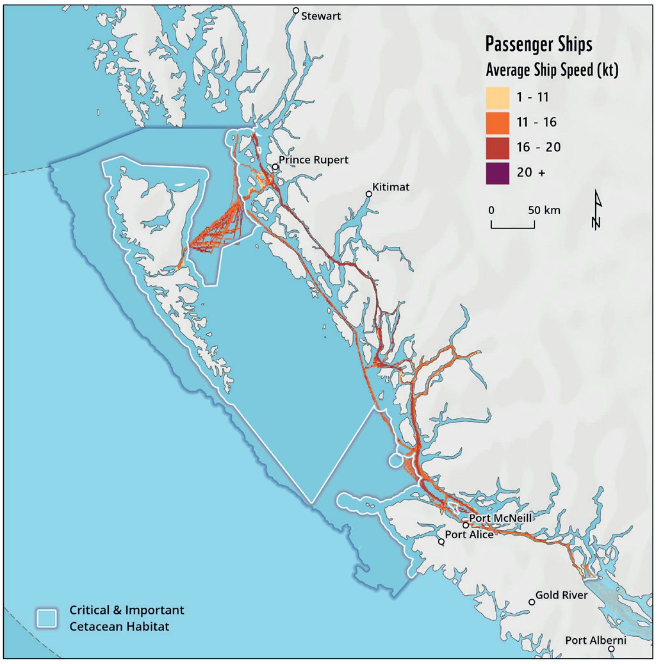

Figure B4. Average speed of passenger ships (ferries) travelling through the Northern Shelf Bioregion.

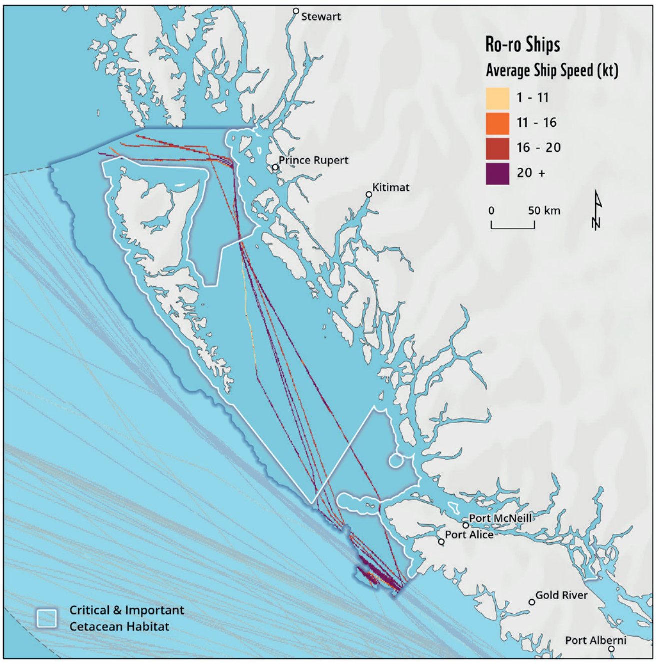

Figure B5. Average speed of ro-ro ships travelling through the Northern Shelf Bioregion.

APPENDIX C: VESSEL DISCHARGE TABLES AND FIGURES

Table C1. Total estimated vessel operational discharge produced in each Northern Shelf Bioregion subregion in 2022. Note: Subregions do not align with the MaPP boundary and have overlapping areas; discharge volumes for the four subregions will therefore not add up to the MaPP boundary total.

Subregion	Area (km²)	Greywater (L)	Sewage (L)	Bilge (L)	Scrubber (L)
Central Coast	23,750.32	120,697,270.01	16,341,973.11	1,543,380.88	6,522,713,366.51
North Vancouver Island	8,002.89	155,419,196.05	21,081,905.85	2,172,894.11	6,017,541,753.82
North Coast	21,033.20	319,640,245.04	43,472,496.52	5,014,662.70	12,533,362,287.87
Haida Gwaii	46,057.26	1,197,988,714.38	161,292,719.11	10,894,357.38	28,585,452,046.14
Total MaPP boundary	**101,524.34**	**1,835,976,148.02**	**247,898,984.63**	**20,038,676.27**	**56,650,415,924.30**

Table C2. Summary of vessels outfitted with engine scrubbers in 2019 vs 2022.

Ship type	2019	2022	Change in scrubbers	% change in scrubbers
Bulk carrier	55	63	8.00	14.55
Chemical tanker	2	2	-	-
Container	24	56	32.00	133.33
Cruise	27	28	1.00	3.70
Ferry pax only	0	0	-	-
Ferry ro-pax	0	0	-	-
Fishing	0	0	-	-
General cargo	1	9	8.00	800.00
Liquefied gas tanker	2	14	12.00	600.00
Oil tanker	0	0	-	-
Other liquid tankers	1	1	-	-
Refrigerated	0	0	-	-
Ro-ro	0	0	-	-
Tug/towing	0	0	-	-
Yacht	0	0	-	-
Total	**112**	**173**	**61.00**	**54.46**

Table C3. Summary of engine scrubber types in 2019 vs 2022.

	2019 Scrubber Types				2022 Scrubber Types			
Ship type	**Open loop**	**Closed loop**	**Hybrid**	**TBC**	**Open loop**	**Closed loop**	**Hybrid**	**TBC**
Bulk carrier	49	0	0	6	62	0	0	1
Chemical tanker	0	0	2	0	1	0	1	0
Container	15	0	6	3	25	0	24	7
Cruise	18	1	8	0	16	1	11	0
Ferry pax only	0	0	0	0	0	0	0	0
Ferry ro-pax	0	0	0	0	0	0	0	0
Fishing	0	0	0	0	0	0	0	0
General cargo	1	0	0	0	9	0	0	0
Liquefied gas tanker	1	0	1	0	9	0	5	0
Oil tanker	0	0	0	0	0	0	0	0
Other liquid tankers	1	0	0	0	1	0	0	0
Refrigerated	0	0	0	0	0	0	0	0
Ro-ro	0	0	0	0	0	0	0	0
Tug/towing	0	0	0	0	0	0	0	0
Yacht	0	0	0	0	0	0	0	0
Total	**85**	**1**	**17**	**9**	**123**	**1**	**41**	**8**
% Change in scrubbers between 2019 and 2022					**44.71**	**0.00**	**141.18**	**-11.11**

Table C4. Ship operational discharge volume (L) per ship type within the entire MaPP Northern Shelf Bioregion.

Ship type	Greywater (L)	Sewage (L)	Bilge (L)	Scrubber (L)
Bulk carrier	4,166,547.72	833,309.54	482,058.50	705,294,236.52
Chemical tanker	1,768.34	353.67	229.21	3,835,175.08
Container	4,656,509.88	931,301.98	2,024,043.15	3,050,061,093.89
Cruise	1,739,576,939.91	233,777,138.17	14,488,282.86	52,542,007,485.27
Ferry pax only	0.00	0.00	0.00	0.00
Ferry ro-pax	78,165,203.51	10,504,414.70	1,408,532.01	0.00
Fishing	2,131,641.44	426,328.29	357,598.48	0.00
General cargo	1,233,783.19	246,756.64	79,438.98	106,567,159.96
Liquefied gas tanker	1,009,346.68	201,869.34	125,227.46	234,905,038.66
Oil tanker	0.00	0.00	0.00	0.00
Other liquid tankers	9,037.93	1,807.59	941.43	7,745,734.92
Refrigerated	659,018.94	131,803.79	49,403.67	0.00
Ro-ro	69,710.45	13,942.09	16,751.70	0.00
Tug/towing	3,849,025.77	769,805.15	891,105.44	0.00
Yacht	447,614.26	60,153.70	115,063.37	0.00
Total	**1,835,976,148.02**	**247,898,984.63**	**20,038,676.27**	**56,650,415,924.30**

Table C5. Total estimated vessel operational discharge produced within critical and important habitat in the Northern Shelf Bioregion.

Habitat Zone	Area (km^2)	Greywater (L)	Sewage (L)	Bilge (L)	Scrubber (L)
Total	60,466.61	424,348,549.00	57,880,969.63	7,277,905.42	20,459,290,751.00
Per cent in NSB CH/IH	**59.56**	**23.11**	**23.35**	**36.32**	**36.11**

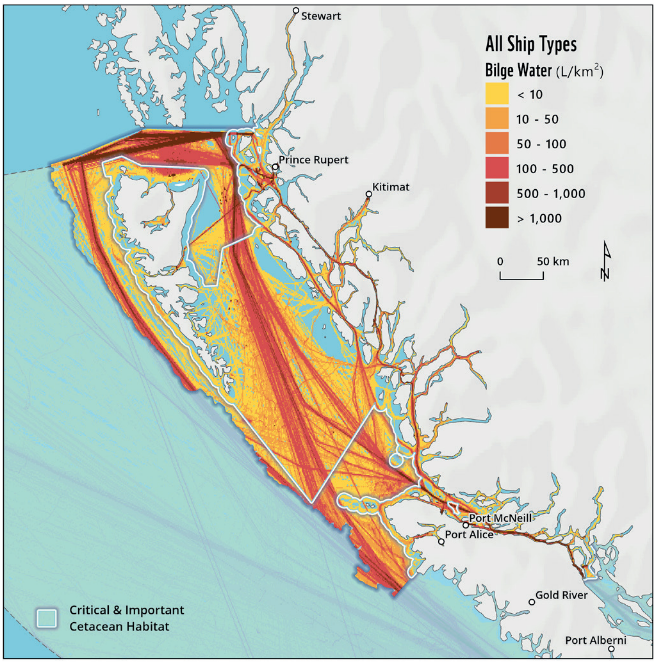

Figure C1. Modelled bilge water (L/km^2) generated in the Northern Shelf Bioregion.

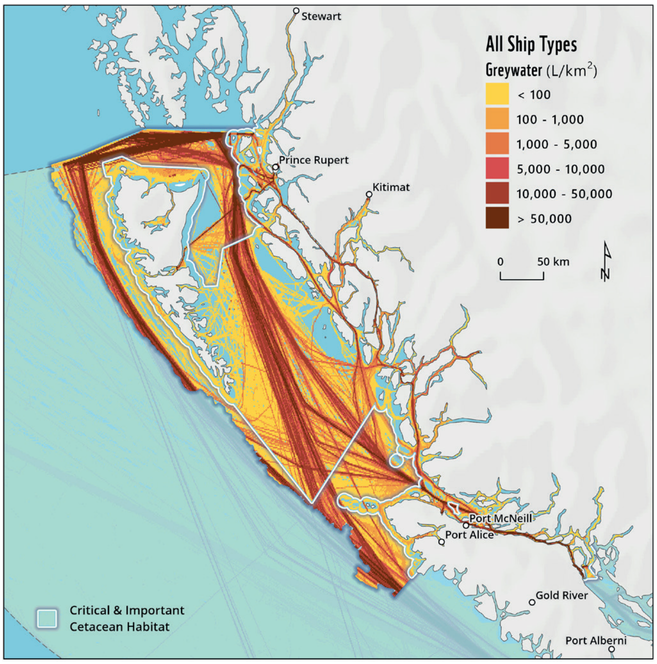

Figure C2. Modelled greywater (L/km^2) generated in the Northern Shelf Bioregion.

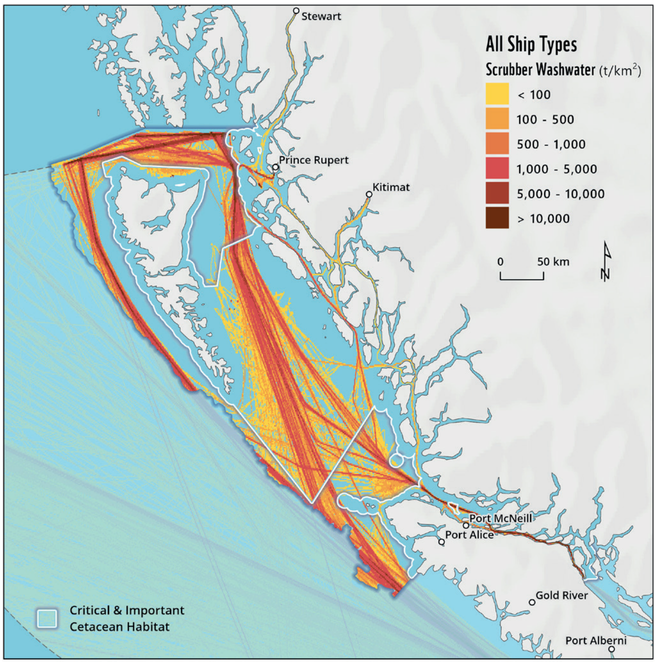

Figure C3. Modelled scrubber washwater (L/km^2) generated in the Northern Shelf Bioregion.

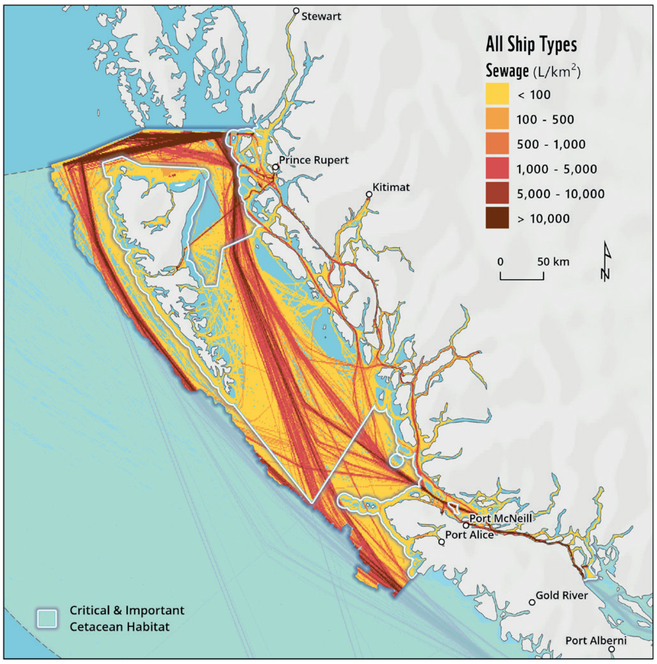

Figure C4. Modelled sewage water (L/km^2) generated in the Northern Shelf Bioregion.

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