Biophysical and Ecological Overview of the Caamaño Sound and Douglas Fjord System Network Zones

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by

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ACRONYMS

AIS	Automatic Identification System
ASP	Aerial Surveillance Program
AVHRR	Advanced Very High Resolution Radiometer satellite instrument
BC	British Columbia
BCCM	British Columbia Continental Margin Model
BCMCA	British Columbia Marine Conservation Analysis
BHM	Benthic Habitat Mapping survey
BKW	Bigg's Killer Whales
BNF	Bubble net feeding
CBD	Convention on Biological Diversity
CCIRA	Central Coast Indigenous Resource Alliance
Chl-a	Chlorophyll-a
CITES	Convention on International Trade of Endangered Species of Wild Fauna
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CP	Conservation Priority
C-CP	Cultural Conservation Priority
CPUE	Catch per unit effort
CSAS	Canadian Science Advisory Secretariat
CU	Conservation Unit
DFO	Fisheries and Oceans Canada
E-CP	Ecological Conservation Priority
EBSA	Ecologically and Biologically Significant Area
ENSO	El Niño Southern Oscillation
ESS	Ecologically Significant Species
EEZ	Exclusive Economic Zone
ECCC-CWS	Environment and Climate Change Canada, Canadian Wildlife Service
iREC	DFO's Internet Recreational Effort and Catch database
IUCN	International Union for the Conservation of Nature
LNG	Liquid Natural Gas
MaPP	Marine Plan Partnership
MODISA	MODerate Resolution Imaging Spectroradiometer on Aqua satellite
MPATT	Marine Protected Area Technical Team
MPA	Marine Protected Area
NCCS	North Coast Cetacean Society
NEP36-CanOE	Northeastern Pacific Canadian Ocean Ecosystem Model
NRKW	Northern Resident Killer Whale
NSB	Northern Shelf Bioregion
OMZ	Oxygen Minimum Zone
OLI	Operational Land Imager instrument
PAM	Passive Acoustic Monitoring
PECP	Pacific Estuary Conservation Program
PDO	Pacific Decadal Oscillation
PFMA	Pacific Fishery Management Areas
PMECS	Pacific Marine Ecological Classification System
PMZ	Protection Management Zone
PNCIMA	Pacific North Coast Integrated Management Area
PWSD	Pacific White-Sided Dolphins
RFA	Reconciliation Framework Agreement
RCP	Representative Concentration Pathway
SST	Sea Surface Temperature
Station P	Ocean Station Papa
TIRS	Thermal InfraRed Sensor on Landsat-8
TIRS-2	Thermal InfraRed Sensor-2 on Landsat-9
UAV	Unmanned Aerial Vehicle
VME	Vulnerable Marine Ecosystem
VCI	Vulnerable Composite Index
VRN	Vessel Registration Number

ABSTRACT

Liu, A.D., Bannar-Martin, K., Bluteau, C.E., Hilborn, A., Clifton, K., Burke, L., Wright, B., Wray, J., Keen, E., Baer, G., Pilkington, J., Nichol, L., Denley, D., Stacey, C.D., Herbert, J., Vanderjagt, A., Robb, C., and Rubidge, E. 2026. Biophysical and Ecological Overview of the Caamaño Sound and Douglas Fjord System Network Zones. Can. Tech. Rep. Fish. Aquat. Sci. 3664: xviii + 374 p. https://doi.org/10.60825/nctj-n651

The Caamaño Sound and Douglas Fjord System Network Zones were identified as areas of ecological and cultural significance as part of the Northern Shelf Bioregion Marine Protected Area Network planning process (led by the governments of Canada, British Columbia, and 15 First Nations). These Network Zones are situated in the nearshore North Coast region in the traditional territories of the Gitga'at, Gitxaała, Haisla, and Kitasoo Xai'xais Nations. This Biophysical and Ecological Overview report compiles available knowledge and data on the physical and biological oceanography, climate change projections, human uses, and ecological diversity that is present within the seven Network Zones. Network-level Ecological and Cultural Conservation Priorities are highlighted throughout the report. Data presented in this report incorporate information gathered in the data compilation step of the Northern Shelf Bioregion Marine Protected Area Network planning process, in addition to regionally-specific data and knowledge and projections of two climate change scenarios. Knowledge gaps, recommendations, and the sensitivities and resiliencies of ecological features and taxonomic groups are detailed. The Network Zones have a well-established estuarine circulation supported by large freshwater inputs from rain and snowmelt. Unlike many fjord systems, deep waters are not hypoxic due to annual renewals every spring and summer. Although this remote area has comparatively less commercial and recreational fishery activity compared to other parts of the province, a substantial amount of vessel traffic passes through several zones – the most noticeable route being the Inside Passage. The distribution of biogenic habitats and species is variable throughout the Network Zones from the transition of the outer continental shelf to fjord systems. Key ecosystem features include kelp forests, **gadza k'aw**/eelgrass and surfgrass beds, estuaries, and areas of high rugosity. The many nearshore habitats provide shelter for the growth of juvenile fishes and invertebrates and spawning habitats for forage fishes and salmonids. Notably, the Network Zones encompass important habitats for Killer, Fin, and Humpback whales and other marine mammals. Many culturally and spiritually significant areas are also present, including contemporary harvesting sites, historical settlements, and the community of **Txałgiu**/Hartley Bay, home of the Gitga'at Nation. Connectivity within the Network Zones, between existing protected areas, and within the Northern Shelf Bioregion is described. This report is intended to inform research, monitoring, policy, management, and subsequent steps in developing a potential Marine Protected Area under Canada's *Oceans Act*.

RÉSUMÉ

Liu, A.D., Bannar-Martin, K., Bluteau, C.E., Hilborn, A., Clifton, K., Burke, L., Wright, B., Wray, J., Keen, E., Baer, G., Pilkington, J., Nichol, L., Denley, D., Stacey, C.D., Herbert, J., Vanderjagt, A., Robb, C., and Rubidge, E. 2026. Biophysical and Ecological Overview of the Caamaño Sound and Douglas Fjord System Network Zones. Can. Tech. Rep. Fish. Aquat. Sci. 3664: xviii + 374 p. https://doi.org/10.60825/nctj-n651

Dans le cadre du processus de planification du réseau d'aires marines protégées (AMP) de la biorégion du plateau Nord (dirigé par les gouvernements du Canada et de la Colombie-Britannique, ainsi que par 15 Premières Nations), on a déterminé que les zones de l'entrée Caamaño et du chenal Douglas, qui font partie d'un système de fjords, sont des zones d'importance écologique et culturelle. Ces zones du réseau d'AMP sont situées dans les eaux côtières de la région de la côte nord, au sein des territoires traditionnels des Nations Gitga'at, Gitxaała, Haisla et Kitasoo Xai'xais. Dans le présent rapport sommaire sur les aspects biophysiques et écologiques, on compile les connaissances et les données disponibles sur l'océanographie physique et biologique, les projections des changements climatiques, les activités humaines et la diversité écologique au sein des sept zones du réseau d'AMP. Les priorités en matière de conservation écologique et culturelle à l'échelle du réseau d'AMP sont mises en lumière tout au long de ce rapport. Les données présentées dans le rapport intègrent les renseignements recueillis à l'étape de la compilation de données du processus de planification du réseau d'AMP de la biorégion du plateau Nord, des données et des connaissances régionales, ainsi que des projections issues de deux scénarios de changements climatiques. Les lacunes dans les connaissances, les recommandations, ainsi que la sensibilité et la résilience des caractéristiques écologiques et des groupes taxonomiques sont présentées de façon détaillée. Les zones du réseau d'AMP sont caractérisées par une circulation estuarienne bien établie, qui est soutenue par d'importants apports d'eau douce provenant de la pluie et de la fonte des neiges. Contrairement à de nombreux autres systèmes de fjords, les eaux profondes des zones en question ne sont pas hypoxiques en raison du renouvellement annuel des eaux au printemps et en été. Même si cette région éloignée fait l'objet de moins d'activités de pêche commerciale et récréative que d'autres régions de la province, une quantité importante de navires passe par plusieurs zones; la route la plus connue est le Passage de l'Intérieur. La répartition des habitats et des espèces biogéniques varie dans l'ensemble des zones du réseau d'AMP, depuis la partie extérieure du plateau continental jusqu'au système de fjords. Les principales caractéristiques de l'écosystème comprennent des forêts de laminaires, des **gadza k'aw**/herbiers de zostère et de phyllospadix serrulé, des estuaires et des zones rocheuses à rugosité élevée. Les nombreux habitats côtiers offrent un abri pour la croissance des poissons et des invertébrés juvéniles, et sont utilisés à titre de frayères par les poissons-fourrages et les salmonidés. Plus particulièrement, les zones du réseau d'AMP englobent des habitats importants pour l'épaulard, le rorqual commun et le rorqual à bosse, ainsi que d'autres mammifères marins. De nombreuses zones importantes sur les plans culturel et spirituel sont également présentes, y compris des sites de pêche contemporains, des villages historiques et la communauté de **Txałgiu**/Hartley Bay, où vit la Nation Gitga'at. Le rapport décrit la connectivité au sein des zones du réseau d'AMP, entre les aires protégées existantes et à l'échelle de la biorégion du plateau Nord. De plus, il vise à orienter la recherche, la surveillance, les politiques, la gestion et les étapes subséquentes pour l'élaboration d'une possible zone de protection marine en vertu de la *Loi sur les océans* du Canada.

1 PREFACE AND CONTRIBUTORS

The Marine Protected Area (MPA) Network Action Plan (Marine Protected Area Technical Team, 2022) previously referred to these Network Zones as the Caamaño Sound Network Zones. A discussion took place between co-authors to change the name to reflect the two different physical, oceanographic, and ecological areas that these Network Zones encompass, which includes the important Douglas Fjord System features. Thus, it was decided the name Caamaño Sound and Douglas Fjord System Network Zones would be a more accurate biophysical descriptor for the purposes of this report. The general area that details both within and outside of the Network Zones is referred to as the Caamaño-Douglas area. The name change in this report does not indicate a permanent name change in the other documents and proceedings in the *Oceans Act* MPA designation process. Therefore, the name "Caamaño Sound Network Zones" may still appear in this report (e.g., in figures) and other documents while referring to the same spatial area. The authors recognize that the name may change again in subsequent stages.

This document contains geographic names and species names in Indigenous languages that are spoken by First Nations whose traditional territories overlap with the Caamaño Sound and Douglas Fjord Network Zones. The **Sm'algyax** language spoken by the Gitga'at and Gitxaała Nations is highlighted in **green text**. The **Haisla** language (part of the Wakashan language family and spoken by the Haisla Nation) is highlighted in **blue text**. The **Sgüüx̲s** dialect of the Tsimshian language (one of the traditional languages of the Kitasoo Xai'xais) is highlighted in **purple** text. The first time these words are used in a new section that contains a bolded heading, the words will be highlighted in **Sm'algyax**, **Haisla**, **Sgüüx̲s**, and English (if all languages have a translation). In the following paragraphs, they will be referred to in Indigenous languages similar to the format in the Biophysical and Ecological Overview of the Offshore Haida Gwaii Network Zones Report (Bannar-Martin et al. 2025). Indigenous words referenced in this report and their sources are listed in **Appendix A**. Indigenous languages and sources. The lack of a word in the Indigenous languages should not be interpreted to mean that the respective word does not exist. This document is not meant to be an Indigenous language reference. Incorporation of traditional languages in this document is ongoing and flexible to change.

Traditional knowledge presented in this report should not be considered complete and only represents some of extent of knowledge that has been anecdotally shared, reported, or published with permission from knowledge holders. It is important to recognize that this report in no way represents the totality of knowledge regarding the marine environment from the Gitga'at Nation, the Gitxaała Nation, the Haisla Nation, or the Kitasoo Xai'xais Nation.

In addition to the author list, many contributors have provided writing, editing, data, or expert review of particular report sections. Contributors are listed in **Table 1**.

Table 1. *Name and Affiliation of Report Contributors. The listed contributors provided datasets, figures or expert reviews on a specific section(s) of the report. DFO = Fisheries and Oceans Canada. ECCC = Environment and Climate Change Canada.*

Name	Affiliation	Topic of contribution
Sheena Majewski	DFO, Aquatic Ecosystem & Marine Mammal Science	Pinnipeds
Chad Nordstrom	DFO, Aquatic Ecosystem & Marine Mammal Science	Pinnipeds
Strahan Tucker	DFO, Aquatic Ecosystem & Marine Mammal Science	Pinnipeds
Josephine Iacarella	DFO, Freshwater Ecosystems	Vessel traffic and Fisheries and Subsistence Activities
Danielle Perron	DFO, Economic Analysis	Commercial Fishery
Evan Damkjar	DFO, Economic Analysis	Commercial Fishery
Sarah Dudas	DFO, Marine Spatial Ecology and Analysis	Invertebrates
Anna Podhorodeski	DFO, Marine Spatial Ecology and Analysis	Ecological settings and human activities
Sophia Johannessen	DFO, Ocean Ecology and Biogeochemistry	Geology and sediments
Melissa Hennekes	DFO, Ocean Ecology and Biogeochemistry	Phytoplankton
Akash Sastri	DFO, Ocean Ecology and Biogeochemistry	Zooplankton
Lu Guan	DFO, Ocean Modelling and Predictions	Oceanographic setting
Hauke Blanken	DFO, Ocean Modelling and Predictions	Oceanographic setting
Charles Hannah	DFO, State of the Ocean	Oceanographic setting
Erika Lok	ECCC, Canadian Wildlife Service	Marine birds
Bruce Watkinson	North Coast-Skeena First Nations Stewardship Society (Formerly Gitxaała Nation)	Ecological and cultural knowledge
Mike Jacobs	Haisla Nation, Haisla Harbour Authority and Fisheries Manager	Ecological and cultural knowledge
Ken Cripps	Kitasoo Xai'xais Nation, Marine Planning & Fisheries Advisor	Ecological and cultural knowledge

Name	Affiliation	Topic of contribution
Evan Loveless	Kitasoo Xai'xais Nation, Stewardship Advisor	Ecological and cultural knowledge
Chris McDougall	Parks Canada Agency	Regional context

2 REGIONAL CONTEXT

2.1 History of Marine Planning in the Caamaño Sound and Douglas Fjord System area and the Northern Shelf Bioregion

The Sm'algyax word **Gitga'ata** translates to "People of the cane" and refers to people of the Gitga'at Nation contemporarily based in **Txałgiu** (Hartley Bay). **Gitga'ata** have resided in the heart of the Caamaño Sound and Douglas Fjord System area since time immemorial. The traditional territories of neighbouring First Nations, the Gitxaała, Haisla, and Kitasoo Xai'xais, overlap with the Gitga'at Nation in this area. Physically, the Caamaño-Douglas area is located in the North Coast regional district of mainland British Columbia (BC) in the Pacific Region of Canada. All four Nations have provided and continue to provide stewardship for the sustainability and long-term resource use of their terrestrial and marine environment.

The Nations of the Caamaño-Douglas area have been and are currently involved in many marine planning processes in the broader region of coastal BC. This work includes the local community-based marine planning that led to the development of each Nation's Marine Use Plans, which guide the management and usage of natural marine resources in ancestral territories. As signatories of the Reconciliation Framework Agreement (RFA) for Bioregional Oceans Management and Protection (RFA)[1], the Gitga'at Nation, Gitxaała Nation, and Kitasoo Xai'xais Nation and the Government of Canada, "...wish to advance a collaborative, coordinated and efficient approach to the governance, management, restoration and protection of oceans in the Pacific North Coast, including marine ecosystems, marine resources and marine use activities" (RFA 2018). As a signatory of the Convention on Biological Diversity (CBD)[2], Canada has committed to safeguarding biodiversity through "…equitably managed, ecologically representative and well-connected systems of protected areas…" (CBD 2011), and planning processes are underway in five priority bioregions.

The Northern Shelf Bioregion (NSB), located off the coast of BC, has been the focus of multiple marine planning initiatives over the past several years. The NSB is one of five priority bioregions identified to develop MPA networks. The NSB is the largest bioregion in BC, extending from the northern end of Vancouver Island, including an area of 102,000 km^2, from Quadra Island and Bute Inlet, northward to the border of Alaska, United States. Planning initiatives in the NSB include the Pacific North Coast Integrated Management Area (PNCIMA) Plan (2017), the Marine Plan Partnership (MaPP – North Coast Marine Plan, 2015), and most recently, the MPA Network planning process[3] (MPA Network BC Northern Shelf Initiative 2023). The NSB MPA Network planning process has a tripartite governance structure, co-led with 15 partner First Nations, the Government of Canada, and/or the Province of BC. The following section describes the region's past and ongoing planning processes and the participating members.

---

[1] Reconciliation Framework Agreement for Bioregional Oceans Management and Protection

[2] Convention on Biological Diversity (CBD). 2011. Strategic plan for biodiversity 2011-2020. IUNEP/CBD/COP/10/INF/12/Rev.1.

[3] MPA Network – Network Action Plan

The NSB shares boundaries with the PNCIMA, one of the five national Large Ocean Management Areas in Canada's 2005 Oceans Action Plan. The need for an integrated management plan to tackle challenges in the marine environment led to the development of the PNCIMA plan through the collaboration between several First Nation governments, federal and provincial governments, and a wide range of stakeholders and other interested parties. The high-level multiyear plan presented an ecosystem-based management framework to inform, guide, and manage marine activities and resources in the NSB (PNCIMA 2017). A main priority was the planning and development of MPAs. The PNCIMA plan was officially endorsed by their planning partners (Fisheries and Oceans Canada, Canadian Coast Guard, BC's Forests, Lands, and Natural Resource Operations, Coastal First Nations, North Coast Skeena First Nations Stewardship Society) in 2017.

Building on the previous work, the MaPP process was launched in 2011. This partnership involves 15 First Nations members, represented by three First Nations organizations (the Coastal First Nations Great Bear Initiative, the North Coast – Skeena First Nations Stewardship Society, and the Nanwakolas Council) and the BC provincial government. This partnership led to the development of one regional action framework and four sub-regional marine plans (Haida Gwaii, North Coast, Central Coast, and Vancouver Island) for the NSB. The North Coast subregion stretches from the Southern border of Alaska to Hecate Strait (**Figure 1**). It encompasses many unique ecosystems and oceanographic features of the NSB, from significant upwelling and tidal mixing areas to estuaries and fjord inlets and overlaps the Caamaño-Douglas area. The North Coast Marine Plan (2015) resulted from a collaboration between six First Nations represented by the North Coast – Skeena First Nations Stewardship Society and the Government of BC. The plan provides a framework for marine resource management, usage, decision-making, and identifying activities and spatial planning for environmental conservation, restoration, and economic activity, among many other goals. Areas allocated for conservation purposes or objectives and local values were identified as Protection Management Zones (PMZ) and will inform subsequent MPA Network planning processes. These areas differ from designated MPAs because they do not provide recommendations for marine use and activities outside First Nations and provincial regulatory authorities. Spatial boundaries, protection purposes, recommended uses and activities were evaluated for each PMZ. A total of 12.76% of the North Coast subregion was recommended to be PMZs. They were grouped according to the International Union for Conservation of Nature (IUCN) Protected Areas Management Categories as high protection (IUCN Ib and II) or medium protection (IUCN IV), or existing protection (North Coast Marine Plan 2015).

Building on the information in the PNCIMA and MaPP plans, 15 First Nations governments, the Federal Government of Canada, and the Provincial Government of BC formed a partnership and a technical team (MPA Network Technical Team, MPATT) to develop the NSB MPA Network. The BC MPA Network Strategy (Canada and BC 2014) and the National Framework for Canada's Network of MPAs (Canada, 2011) guided the network planning process which began in 2015 (**Figure 2**). The planning process included reviewing the contribution of existing protected areas in the NSB and identifying potential new areas that meet network conservation objectives while balancing cultural, economic, and recreational opportunities. These proposed MPA Network areas were identified based on the MPA Network goals and objectives, ecologically important species, habitats, and features (Gale et al. 2019), cultural conservation

priorities[4], spatial conservation targets and ecological design strategies (Martone et al. 2021), site selection analyses, and partner discussions (MPA Network BC Northern Shelf Initiative 2023). Information used to inform the resulting network scenario, timeline for implementation, and recommendations for the potential policy tool for implementing each Network Zone, are summarized in the Network Action Plan (MPA Network BC Northern Shelf Initiative 2023). The draft MPA Network footprint is 30,493 km^2 (around 30% of the NSB), of which 38% are the new potential MPAs, and the remaining 62% is made up of existing MPAs and PMZs. Altogether, the MPA Network aims to preserve ecological species, habitats, and cultural areas of importance, build resilience against climate change, provide access to social activities, and sustainably provide and manage economic opportunities. On February 5th, 2023, 15 First Nations, the federal, and provincial governments officially endorsed the Network Action Plan for the NSB.

In the Network Action Plan (2023), MPATT identified and proposed three aggregates of Network Zones to be designated as MPAs under the *Oceans Act*. The first aggregate is the Offshore Haida Gwaii Network Zones, the second is the Caamaño Sound and Douglas Fjord System Network Zones, and the third is the Kitkatla Inlet Network Zones (**Figure 1**). All three aggregates are Category 1 Zones, also identified in the Network Action Plan (MPATT 2023), and aim to become MPAs by 2025. There are five general steps to establishing and managing an *Oceans Act* MPA: 1) pre-planning, 2) feasibility assessment and policy development, 3) regulatory development, 4) MPA management, and 5) ongoing monitoring and management[5]. This Biophysical Overview Report is part of the second step, feasibility assessment and policy development, and provides a foundation for subsequent planning (see section 2.4 Report Organization and Contents for details). In November 2022, the Offshore Haida Gwaii Network Zones Biophysical Overview Canadian Science Advisory Secretariat (CSAS) Regional Peer Review Meeting occurred. Species and habitat information, spatial datasets, and area descriptions from the Haida Gwaii report informed the structure and content of this report.

Biophysical Overview Reports for the Network Zones differ from standard Biophysical Overview reports for single MPAs because most of the work at the network level has already occurred. Generally, Biophysical Overview Reports for *Oceans Act* MPAs are written to support the development of conservation objectives, select conservation priorities, and highlight potential activities of concern for individual areas of interest (**Figure 2**). Because the Network Zones discussed here result from the NSB regional network planning process described in section 2.1, these Zones have already been integrated into a Network Plan (MPA Network BC Northern Shelf Initiative 2023). Therefore, conservation objectives, ecological conservation priorities (E-CPs), cultural conservation priorities (C-CPs[2]), and activities of concern have already been identified (MPA Network BC Northern Shelf Initiative 2023). This existing work allows the overview reports to focus more specifically on the contribution of these areas to the overall MPA Network while also highlighting locally important ecological, cultural, and physical components. The report for the Caamaño Sound and Douglas Fjord System Network Zones will provide information that may assist in identifying and/or refining conservation objectives and help inform

[4] Butler, C., McDougall, C., Cripps, K., Clarkson, M., Heidt, A., Rigg, C., McGee, G., Diggon, S. and Jones, R. (2023). First Nations Cultural Conservation Priorities: Integrating Indigenous Values into Marine Protected Area Network Planning. [Manuscript in preparation].

[5] Establishing new Marine Protected Areas (dfo-mpo.gc.ca)

the development of a management plan and subsequent advice on monitoring, regardless of the marine conservation tool ultimately employed for the area.

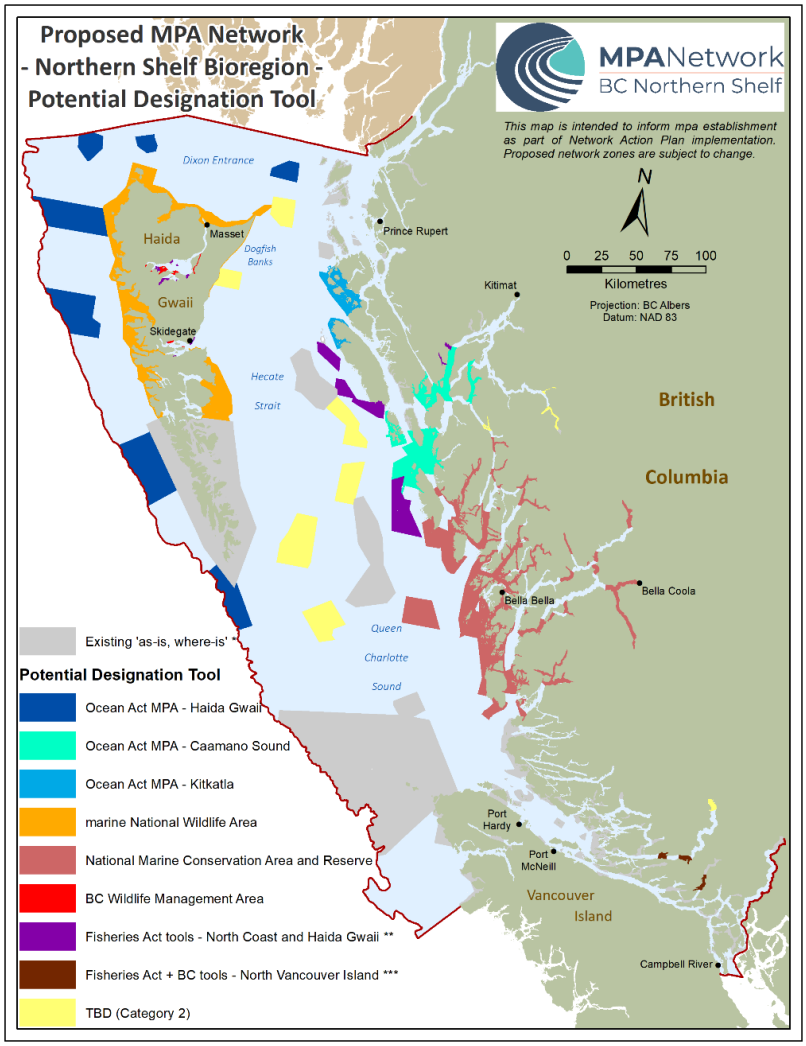

Figure 1*. The potential Marine Protected Area Network of Zones in the Northern Shelf Bioregion (red outline). The seven polygons that comprise the "Caamaño-Douglas area" Network Zones are shown in cyan colour and have potential to become Oceans Act MPAs.*

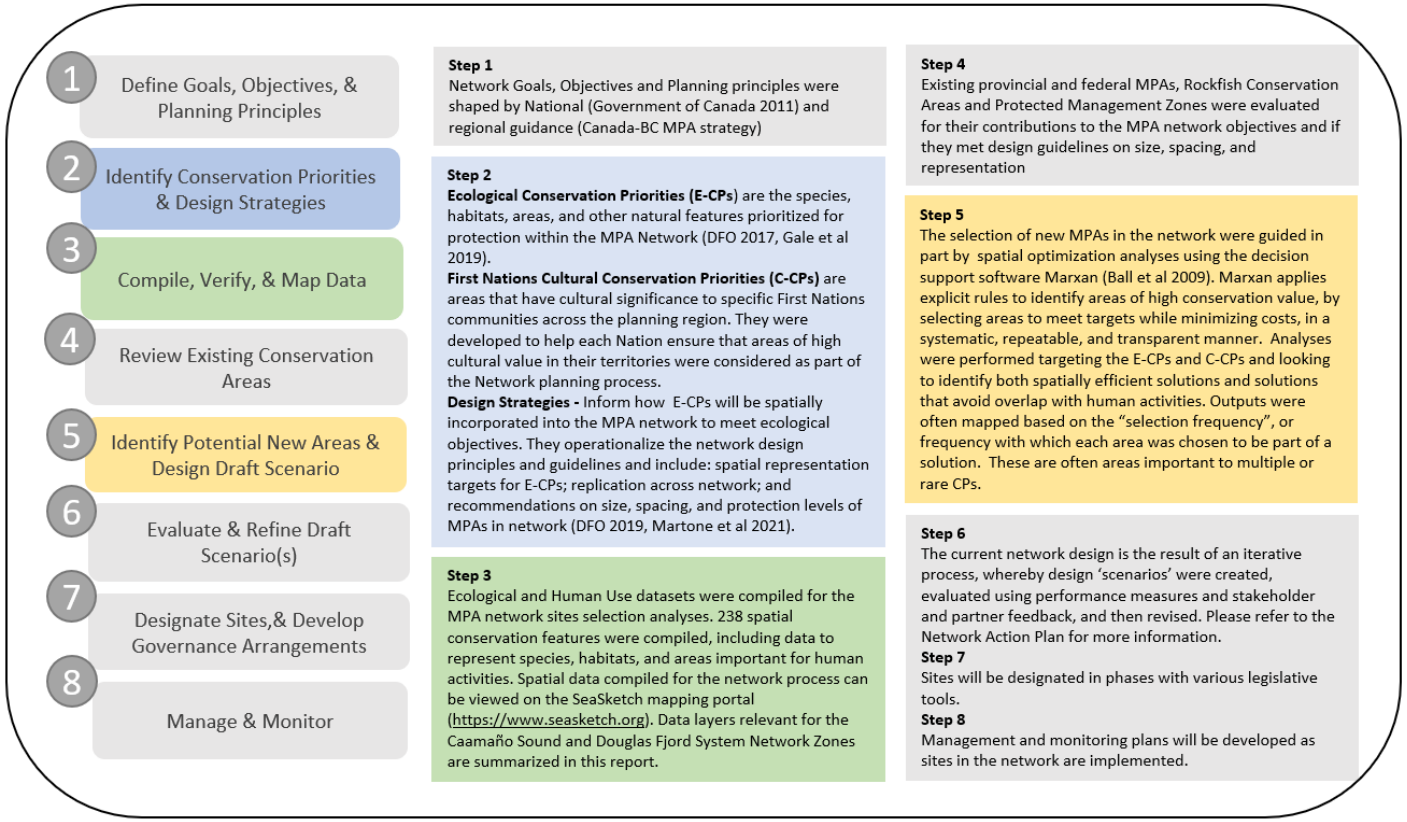

***Figure 2**. Summary of steps in the Northern Shelf Bioregion (NSB) Marine Protected Area (MPA) Network planning process. Coloured boxes are particularly relevant for this report, including defining key terminology of the network process. For more information on each step refer to publications within the NSB MPA Network website. Edited from Figure 2 of Bannar-Martin et al. 2025.*

2.2 Caamaño Sound and Douglas Fjord System Network Zones

The Caamaño Sound and Douglas Fjord System Network Zones (previously referred to as the Caamaño Sound Network Zones, MPA Network BC Northern Shelf Initiative 2023) are one of three NSB MPA aggregate network areas have potential for implementation under the federal *Oceans Act*. The region is represented as seven Zones (numbered 310 through 316, **Figure 3**) that contribute to the overall ecological, cultural, social, and economic objectives of the entire MPA Network (**Figure 1**). Potential Network Zones, including the Caamaño-Douglas area sites in the North Coast subregion, were identified by the Marine Protected Area Technical Team (MPATT) as part of the draft MPA Network scenario during the summer of 2021. **Table 2** provides high-level descriptions of the rationale behind the current boundaries for each Zone.

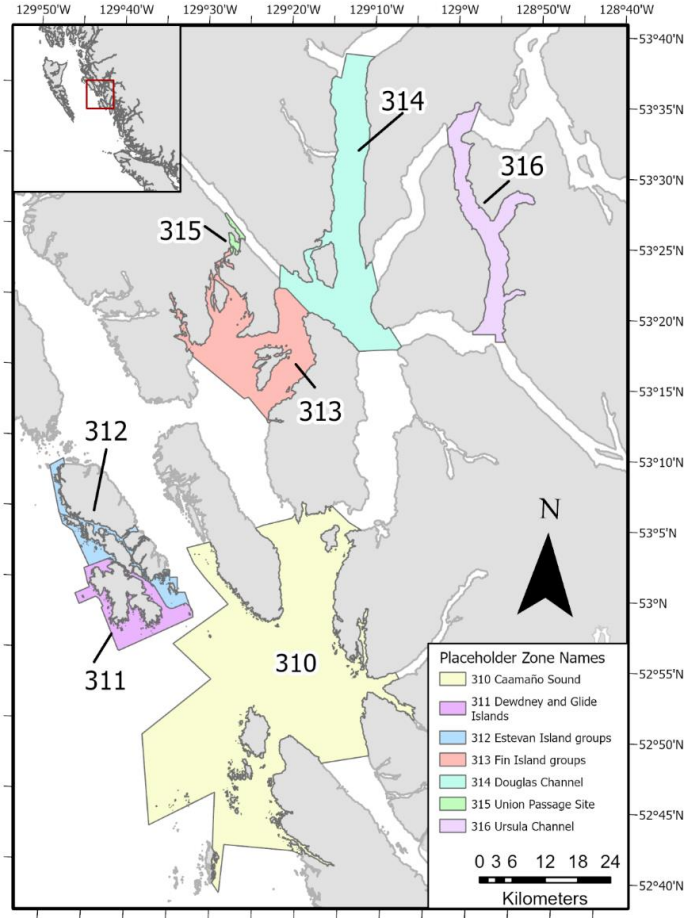

***Figure 3**. The seven Caamaño Sound and Douglas Fjord System Network Zones (coloured polygons with black outline). The inset map shows the area in the North Coast subregion in the Northern Shelf Bioregion, British Columbia. Please note that Zone numbers and names are described for this report and are subject to change in later discussions of the potential marine protected area process.*

***Table 2**. Caamaño Sound and Douglas Fjord System Network Zones and area (km^2) listed according to the Network Action Plan designated Network Zone numbers. Overlapping geographic features (see **Figure 5**) and existing protected areas (see **Figure 6** and **Figure 7**) correspond to each of the seven Network Zones. The list of geographic features is not meant to be exhaustive. Please note that Zone numbers and names are described for this report and are subject to change in later discussions of the potential marine protected area process.*

Zone Number	Total Zone Area (km^2)	Zone Name	Overlap with geographic features	Overlap with existing protected areas
310	743.78	Caamaño Sound	Caamaño Sound, Rennison Island, Aristazabal Island, Moore Islands, **Lax Ka'gaas**/Campania Island (Southern), **K'nabiyaaxl**/Ashdown Island, **K'ts'ats'aas**/Gil Island	**Lax Ka'gaas**/Campania marine Conservancy. Western Aristazabal Island Rockfish Conservation Area. Moore/McKenney/Whitmore Islands Ecological Reserve.
311	52.06	Dewdney and Glide Islands	Dewdney Island, Pemberton Bay	Dewdney and Glide Islands Ecological Reserve
312	40.97	Estevan Island groups	Trutch Island, Prior Island, Lotbiniere Island, Barnard Island, Estevan Group, Hickey Islands	Ethelda Bay – Tennant Island Conservancy
313	151.70	**Lax Kwil Dziidz**/ Fin Island groups	**Lax Kwil Dziist**/Fin Island, Farrant Island, **K'duwaadz**/Tuwartz Inlet, Cherry Islets, **Maxtaktsm'aa**/Union Passage	**K'distsausk**/Turtle Point and Monckton Nii Luutiksm Conservancies. **Lax Kwil Dziidz**/Fin and **Maxtaktsm'aa**/Union Passage Conservancies **Ktisgaidz**/MacDonald Bay Conservancy
314	209.72	Douglas Channel	Douglas Channel, Wright Sound, **Txałgiu**/Hartley Bay, Promise Island	**K'distsausk**/Turtle Point Conservancy
315	4.28	**Maxtaktsm'aa**/ Union Passage Site	**Maxtaktsm'aa**/Union Passage	**Maxtaktsm'aa**/Union Passage Marine Provincial Park
316	88.66	Ursula Channel	Ursula Channel, Bishop Bay, Goat Harbour	Bishop Bay – Monkey Beach marine Conservancy

The Caamaño Sound and Douglas Fjord System Network Zones are located along the coastline of mainland BC, along the eastern margin of Hecate Strait (**Figure 3**). These seven Zones are divided into two marine boundary classifications known as “ecosections” and “upper ocean sub-regions”. Ecosections were classified by the Province of BC according to physical, oceanographic, and biological characteristics (BC Marine Ecological Classification, 2002), whereas upper ocean sub-regions were defined by Parks Canada and BC Marine Conservation Analysis (hereafter BCMCA) according to expert knowledge, primary literature, satellite imagery, and oceanographic modelling (BCMCA, 2013).

Three Outer Coast Zones (310, 311, 312) and four Inner Fjord Zones (313, 314, 315, 316) are divided similarly between the two classifications (**Figure 4**). The Outer Coast Zones are on the boundary between classifications in both systems, and the Inner Fjord Zones are neatly categorized as fjord systems. Ursula Channel (316) also has several oceanographic and cultural use differences compared to the other Inner Fjord Zones. Ecological data are less definitive in separating Ursula Channel and the Inner Fjord Zones because of either 1) lack of sampling in the Inner Fjord Zones, or 2) where there are data, showing no clear differences in species and habitat patterns.

Consequently, these distinctions inform three general groups for the seven Network Zones: the Outer Coast Zones (310, 311, 312), Inner Fjord Zones (313, 314, 315) and Ursula Channel (316). The Outer Coast Zones border Caamaño Sound and Hecate Strait and contains significant kelp and **ła’ask**/**lhlaˈq̓s**/**ɬa̱'a̱sk**/seaweed, along with **bilhaa**/**g̃elhg̃enaiq**/abalone, giant mussel, geoduck, **aswit**/**ʾemdém**/**a̱ws**/sea urchins, in addition to important spring and summer **łbuun**/**g̃ʷey̓ém**/**łpuun**/whale habitat. The Inner Fjord Zones near Wright Sound has important areas for **hoon**/**qeqapela** salmon, **gyenti**/**’éllas**/sea cucumber, and important areas for shellfish harvest. Ursula Channel supplies harvest for fall **hoon**/**qeqapela** and winter shellfish, and important fall/winter **łbuun**/**g̃ʷey̓ém**/**łpuun** habitats. Details of the unique oceanographic, ecological, and cultural features within each Network Zones are expanded upon in later sections of this report.

The boundaries of the three southern and western-most Zones include Northern Aristazabal Island, Moore Island, and the Rennison Island groups in Caamaño Sound and **Lax Ka'gaas**/Campania Sound (Zone 310), Dewdney and Glide Islands (Zone 311), and the Estevan Island groups on the opposite side of Estevan Sound up to Otter Passage (Zone 312). The four northern and eastern-most Zones are further inland and encompass **Lax Kwil Dziist**/ Fin Island and the northwestern side of **K'ts'ats'aas**/Gil Island to Cherry Inlet and Wright Sound (Zone 313), Douglas Channel from outside of Kitkatla Inlet down to Wright Sound (Zone 314), **Maxtaktsm’aa**/Union Passage Site (Zone 315), and Ursula Channel (316). For terrestrial and marine geographic feature locations and names in the Caamaño-Douglas area, please refer to **Figure 5**.

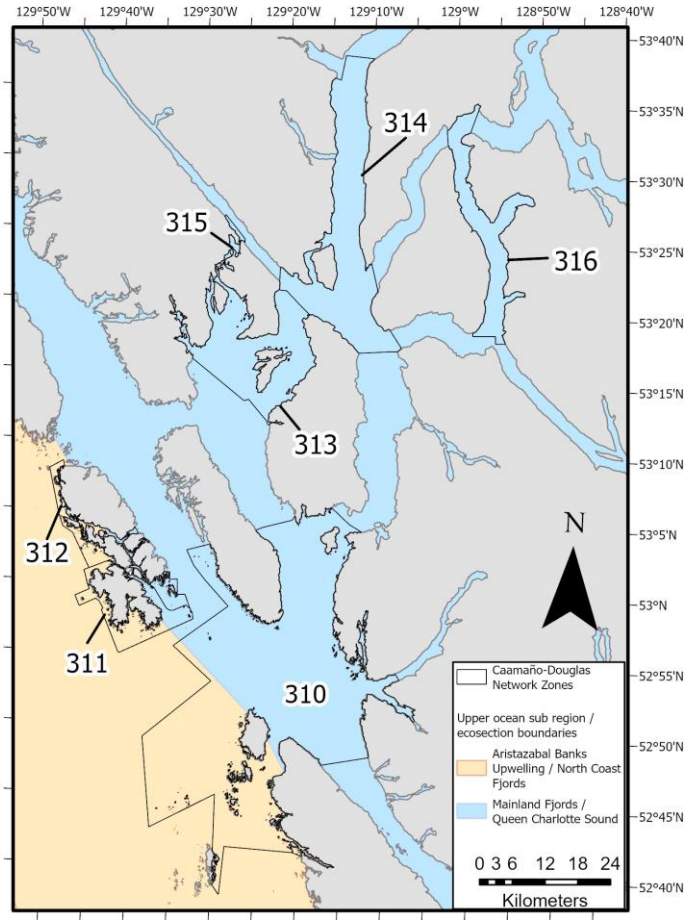

Figure 4. *Upper ocean subregion / ecosection boundaries classified by Parks Canada and Province of BC respectively in the Caamaño-Douglas area, North Coast subregion of British Columbia.*

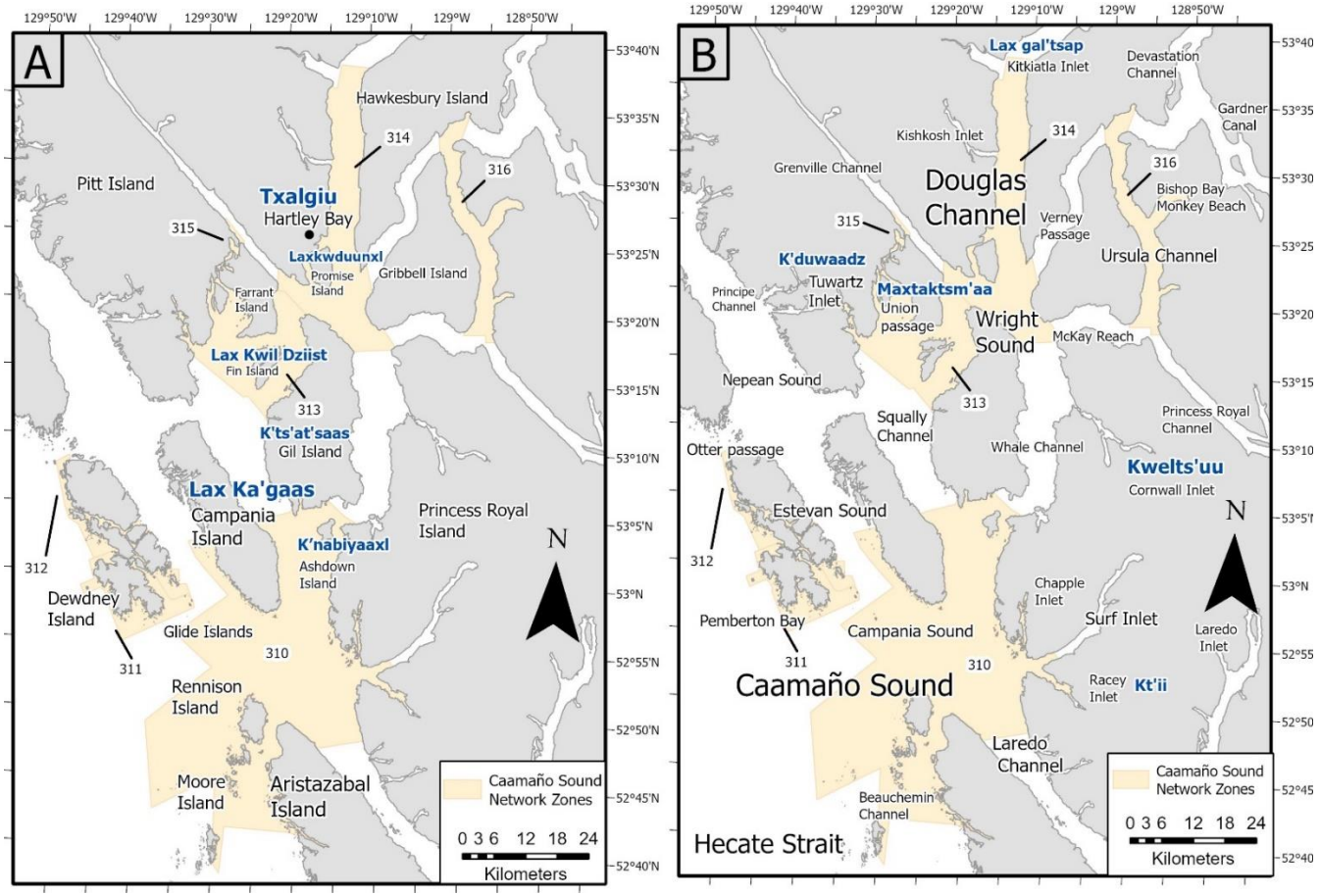

Figure 5. *Name reference of A) terrestrial and B) marine features of the nearshore Caamaño-Douglas area in the North Coast subregion of British Columbia. Names in* ***Sm'algyax*** *are bolded in blue, with the English name in black.*

Increased productivity from coastal upwelling and tidal mixing in these seven Network Zones drives the natural diversity of fish, invertebrates, and marine mammals. There are a variety of habitats, including tidal channels, protected bays, sandy beaches, rocky intertidal areas, estuaries, salt marshes, **gadza k'aw**/eelgrass meadows, and kelp beds. The Caamaño-Douglas area supports many species of conservation concern and species with at-risk status. Notably, waterways in this area are of high importance to marine mammals, especially cetaceans such as humpback, fin, and **'naaxł** /**hélx̄'inix̄ʷ**/**niixł**/killer whales, Dall's porpoises, and Pacific white-sided dolphins.

This area is also critically important to local First Nations culturally and spiritually (MPA Network BC Northern Shelf Initiative 2023). These Zones are used as waterways to access terrestrial sites of cultural and spiritual significance, fishing camps, and archaeological sites, and also for the harvest and usage of marine resources, including seabirds. The nearshore location invites many recreational activities, including fishing, wildlife viewing, scuba diving, kayaking, and ecotourism. Other human uses, such as sheltered anchorages, harbours, and log handling tenures, are intermittently present. Commercial fisheries for groundfish, shellfish, **hoon**/**qeqapela**, and tuna are found within the Zones. Douglas Channel is used as a shipping lane and ferry passageway to and from the port of Kitimat to Hecate Strait, traversing several Zones. The Inside Passage, a popular waterway for cargo ships, ferries, and cruise ships through coastal BC, also crosses through Wright Sound and Zone 316. BC Whales, also known as North Coast Cetacean Society (NCCS), operates the Fin Island Research station on the southwestern shore of **Lax Kwil Dziidz**/Fin Island. The Fin Island Research station was established in 2017 in direct partnership with the Gitga'at First Nation and World Wildlife Fund-Canada, though research with NCCS in this area dates back to 2002.

The boundaries of the Caamaño Sound and Douglas Fjord System Network Zones were in part chosen because of other nearby conservation areas that have also been identified in the MPA Network (for full details, refer to **Appendix B**. Caamaño-Douglas Network Zones Boundaries). The three Outer Coast Zones (310, 311, 312) overlap with the Central Mainland Ecologically and Biologically Significant Area (EBSAs; Clarke and Jamieson 2006; Rubidge et al. 2020) and West Aristazabal Island Rockfish Conservation Area (RCA) and are close to the Hecate Strait Glass Sponge Reefs EBSAs and two RCAs (Otter Passage RCA and North Danger Rocks RCA), as well as the northern two sections of the Hecate Strait/Queen Charlotte Sound Glass Sponge Reefs MPA (**Figure 6**). The Network Zones are also near, or overlapping, the boundaries of provincial conservancies, ecological reserves, and parks established in collaboration with the **Gitga'ata** (**Figure 7**).

MPA Network Zones have been proposed for all three RCAs and Kitkiata and Kishkosh Inlets, bordering Zone 316 and Douglas Channel (**Figure 1**). The Network Action Plan (MPATT 2023) describes the proposal to connect the existing RCAs into the Banks Aristazabal Network Zones from five smaller Zones using various designation tools suited for each Zone. Kitkiata and Kishkosh Inlets have potential to become separate Network Zones through provincial Wildlife Management Area and federal *Fisheries Act* designation tools.

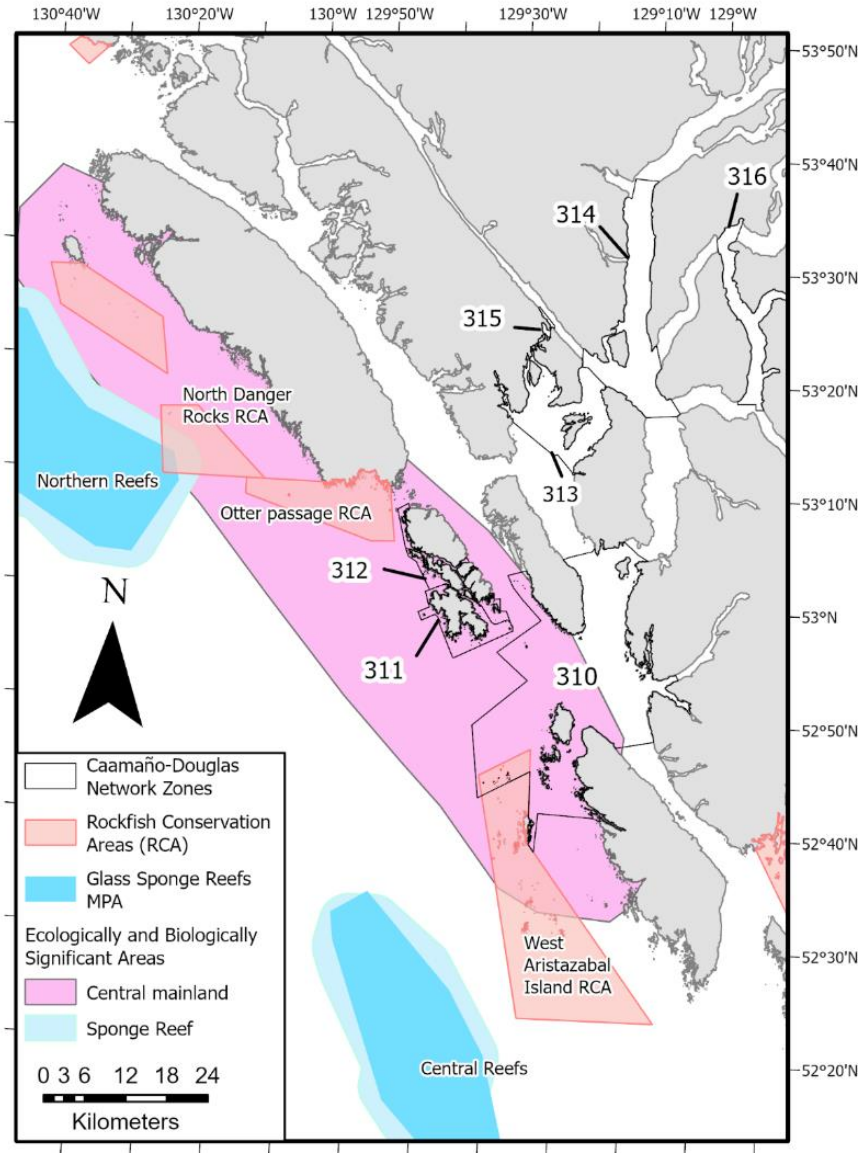

***Figure 6**. Nearby and overlapping important marine features with the Caamaño Sound and Douglas Fjord System Network Zones. The Central mainland Ecologically and Biologically Significant Area (EBSA) is shown in pink, two of the three Glass Sponge Marine Protected Areas (MPA) and the sponge reef EBSA/MPA are shown in blue, and nearby **Ts'mhoon**/Rockfish Conservation Areas are shown in red.*

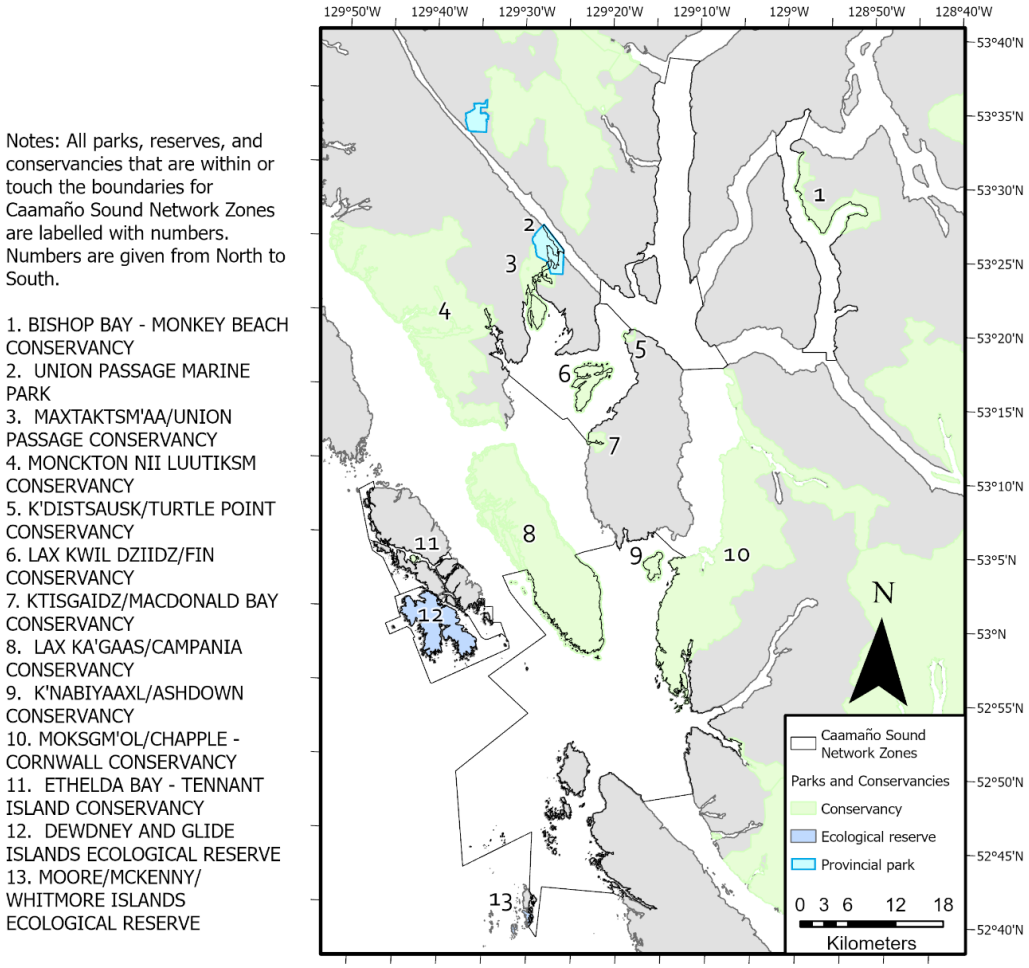

***Figure 7**. Conservancies, Ecological Reserves, and Parks established by the Province of BC near or overlapping the Caamaño Sound and Douglas Fjord System Network Zones. Each are labelled with numbers from North to South, and names are listed to the left. For details of these boundaries that overlap with Network Zones, please refer to **Table 2** and **Appendix B**. Caamaño-Douglas Network Zones Boundaries.*

2.3 Conservation Significance

This section describes the conservation significance of the Caamaño-Douglas area using Network-level categories of Cultural Conservation Priorities (section 2.3.1) and Ecological Conservation priorities (section 2.3.2) within each of the Zones. Because the Caamaño-Douglas Zones are located close to shore, the Network Zones are more exposed to human activities and impacts. Since this area is notable for its populations of **łbuun**/**ḡʷeẏém**/**łpuun**/whales, various human disturbances including potential impacts from increased vessel traffic is detailed in Section 6.2.5. Anthropogenic stressors and threats to the Network Zones are described in later sections of this report in several ways: 1) Specific stressors and sensitivities of some habitats and species are detailed in “Ecological Setting” section; (2) Human use and potential anthropogenic activities pose are detailed in the “Human Uses of Area” section; and (3) The

ramifications of two different climate change scenarios on fish communities are described in the "Climate Change" Section.

Below, a suite of ecological and cultural conservation priorities are presented for the seven Network Zones and summarized by zones in the bullets below. Please refer to **Table 2** and **Figure 7** for overlap of each Zone with existing protected areas, **Table 3** for details of cultural conservation priorities, and **Table 4** for details of ecological conservation priorities.

Caamaño Sound (Zone 310)

- Overlaps with the Central mainland EBSA, West Aristazabal Island RCA, and the marine component of the internationally recognized Moore and Byers Islands and Banks Important Bird Area.
- Overlaps with areas of critical and very high cultural conservation priorities.
- Representation of multiple commercially, ecologically and important shellfish and groundfish species (including multiple **ts'mhoon**/rockfish species) as well as invertebrate biomass and diversity hotspots.
- Representation of biogenic habitats including corals and sponges, canopy-forming kelps, macroalgae, **gadza k'aw**/eelgrass meadows, salt marshes and estuaries.
- Representation of areas of high rugosity (habitat complexity) and all geomorphic units of the continental shelf and continental shelf (fjords) classifications.
- Includes important habitats for **łbuun**/**ḡʷey̓ém**/**łpuun**/whales and other marine mammal use.

Dewdney and Glide Islands (Zone 311)

- Overlaps with the Central mainland EBSA.
- Overlaps with areas of very high cultural conservation priorities.
- Representation of multiple commercially, ecologically and important shellfish and groundfish species as well as invertebrate biomass and diversity hotspots.
- Representation of biogenic habitats including canopy-forming kelps, macroalgae, **gadza k'aw**/eelgrass meadows, and salt marshes.
- Representation of several geomorphic units of the continental shelf and continental shelf (fjords) classifications.
- Includes known breeding colonies for marine birds.

Estevan Island groups (Zone 312)

- Overlaps with the Central mainland EBSA.
- Overlaps with areas of very high cultural conservation priorities.
- Representation of multiple commercially, ecologically and important shellfish and groundfish species as well as invertebrate biomass and diversity hotspots.
- Representation of biogenic habitats including canopy-forming kelps, macroalgae, **gadza k'aw**/eelgrass meadows, and salt marshes.
- Representation of areas of several geomorphic units of the continental shelf and continental shelf (fjords) classifications.
- Includes known breeding colonies for marine birds.

Lax Kwil Dziidz / Fin Island groups (Zone 313)

- Overlaps with areas of critical cultural conservation priorities.
- Representation of multiple commercially, ecologically and important shellfish and groundfish species as well as invertebrate biomass and diversity hotspots.
- Representation of biogenic habitats including canopy-forming kelps, macroalgae, **gadza k'aw**/eelgrass meadows, and salt marshes.
- Representation of areas of high rugosity (habitat complexity) and all geomorphic units of the continental shelf (fjords) classifications.
- Includes important habitats for **łbuun**/**ḡʷey̓ém**/**łpuun**/whales and other marine mammal use.

Douglas Channel (Zone 314)

- Overlaps with areas of critical cultural conservation priorities.
- Representation of multiple commercially, ecologically and important shellfish and groundfish species as well as invertebrate biomass and diversity hotspots.
- Representation of biogenic habitats including canopy-forming kelps, macroalgae, **gadza k'aw**/eelgrass meadows, salt marshes and estuaries.
- Representation of areas of high rugosity (habitat complexity) and all geomorphic units of the continental shelf (fjords) classifications.
- Includes important habitats for **łbuun**/**ḡʷey̓ém**/**łpuun**/whales and other marine mammal use.

Maxtaktsm'aa/Union Passage Site (Zone 315)

- The smallest of the Caamaño-Douglas Network Zones, and therefore includes many data gaps.
- Overlaps with areas of critical cultural conservation priorities.

- Representation of biogenic habitats including canopy-forming kelps, macroalgae, **gadza k'aw**/eelgrass meadows, and salt marshes.
- Representation of areas of high rugosity (habitat complexity) and several geomorphic units of the continental shelf (fjords) classifications.

Ursula Channel (Zone 316)

- Overlaps with areas of very high and critical cultural conservation priorities.
- Representation of multiple commercially, ecologically and important shellfish and groundfish species as well as invertebrate biomass and diversity hotspots.
- Representation of biogenic habitats including canopy-forming kelps, macroalgae, and **gadza k'aw**/eelgrass meadows, and estuaries.
- Representation of areas of high rugosity (habitat complexity) and all geomorphic units of the continental shelf (fjords) classifications.
- Includes important habitats for **łbuun**/**g̱ʷey̓ém**/**łpuun**/whales and other marine mammal use.

2.3.1 Network Cultural Conservation Priorities

Partner First Nations are involved with collaboration efforts and co-governance in designing the MPA Network. This process has helped identify areas within the NSB of high cultural and spiritual significance called cultural conservation priorities (C-CPs; MPA Network BC Northern Shelf Initiative 2023). Representation of C-CPs are ensured within the potential Network Zones. These C-CPs include harvesting areas, knowledge transference sites, areas containing species of cultural significance, places of recreational use, archaeological sites, and abandoned or contemporary villages sites. The importance of C-CPs was informed by First Nations partners during the network planning process. The C-CPs identified in the planning process and their importance encompass the territories of specific partner First Nations within specific Network Zones areas; they do not capture the interests of all First Nations communities in the NSB[4].

The Caamaño-Douglas area is abundant with culturally and spiritually significant sites of local First Nations. The Gitga'at Marine Use Plan (Hartley Bay Council 2012) identifies the cultural, social, and intellectual values entwined with the marine resources of their territories. These values include community and social development through interacting with the environment. For example, children participating in shellfish harvesting not only presents an opportunity for knowledge transfer from elders to youths, but also provides a sense of unity in providing for one's community (Satterfield et al. 2012). Aesthetic, artistic, and spiritual inspiration is another value tied to the land and ocean, as reflected through cultural legends and depictions of species in family crests (Hartley Bay Council 2012). Preservation of these cultural components can ensure the resources and environment tied to cultural and spiritual wellbeing are abundant for generations.

Caamaño Sound and Douglas Fjord System Network Zones that overlap with C-CPs evaluated as 'high', 'very high' and 'critical' are summarized in **Table 3**. Aristazabal and the islands around it (e.g., Moore and Rennison) in Zone 310 are the ancestral home of several local First Nations,

and therefore the location of significant cultural sites, origin stories, and harvesting activities (North Coast Marine Plan, 2015). **Lax Ka'gaas**/Campania Sound (Zone 310) and Whale Channel contain important harvesting sites such as Surf Inlet and Chapple Inlet. Dewdney (Zone 311) and Trutch Islands (Zone 312) are important for recreational use. **K'distsauk**/Turtle point on **Lax Kwil Dziist**/Fin Island (Zone 313) has both harvesting and culturally significant sites. **K'duwaadz**/Tuwartz Inlet and Cherry Islets (Zone 313), and **Maxtaktsm'aa**/Union Passage (Zone 315) contains scenic beaches, and areas of safe anchorages, along with ancient village sites, sacred areas, and historical commercial fishing camps (North Coast Marine Plan, 2015). Notably, Zone 314 surrounds the community of **Txałgiu**/Hartley Bay, and the boundaries are adjacent to Kishkosh Inlet, an important area for harvesting, and Kitkiata Inlet, where **Laxgal'tsap**/Old Town is located. Ursula Channel (Zone 316) is incredibly important to the Haisla for **gyenti/'éllas**/sea cucumber harvest (M. Jacobs, pers. comm 2023). Bishop Bay and Monkey Beach (Zone 316) contain regularly used boat anchorage sites and one of the most popular marine hot springs in the area. For overlaps with existing protected areas please refer to **Table 2**.

Table 3. *Summary results for individual cultural conservation priorities (C-CPs) in the Caamaño Sound and Douglas Fjord System Network Zones. The area is the surface area coverage of each C-CP for the Network Zones.*

Zone overlap	C-CP (rating)	C-CP Area (km^2)
310	Aristazabal Island North (Critical)	270.30
	Moore Islands (Very high)	508.74
	Lax Ka'gaas/Campania Sound & Whale Channel (Critical)	196.62
	Squally Channel* (Very high)	241.99
311 and 312	Dewdney Island (Very high)	48.89
	Trutch Island (Very high)	35.10
313	**Lax Kwil Dziidz** Fin Island & **Ktisgaidz**/MacDonald Bay (Critical)	63.11
	Maxtaktsm'aa/Union Passage & **K'duwaadz**/Tuwartz Inlet (Critical)**	39.58
314	Squally Channel* (Very high)	241.99
	Wright Sound & Lower Douglas Channel (Critical)	149.60
315	**Maxtaktsm'aa**/Union Passage & **K'duwaadz**/Tuwartz Inlet (Critical)**	39.58
316	Ursula Channel (Critical)	74.13

**Squally Channel overlaps both Zone 310 and 313.*
*** **Maxtaktsm'aa**/Union Passage overlaps with Zone 313 and 315, whereas **K'duwaadz**/Tuwartz Inlet is located in Zone 313.*

2.3.2 Network Ecological Conservation Priorities

The Caamaño Sound and Douglas Fjord System Network Zones are individual sites within the NSB MPA network. Through the MPA Network planning process, sites (also referred to as zones) were identified for protection based on various factors, including their contribution to representation of the network's ecological conservation priorities (E-CPs; Gale et al. 2019). E-CPs for the MPA Network include species considered vulnerable, ecologically important, or of conservation concern, as well as areas of climate resilience, degraded areas, representative habitats, and EBSAs. The design strategies for the MPA Network process also include ecological conservation targets, which are quantitative estimates of how much of each spatial feature representing an E-CP should be included in the network (e.g., 20 - 40% of **mo'ox**/**wáudi**/**moox**/Bull Kelp biobands; Gale et al. 2019). Consequently, the relative proportion

of conservation priorities that each polygon contributes to the Caamaño Sound and Douglas Fjord System Network Zones can be examined and compared to the overall ecological conservation targets for the entire network.

The coverage of the relevant E-CPs in the Caamaño Sound and Douglas Fjord System Network Zones are summarized in **Table 4**. The proportions provided represent the proportional amount of each feature found within the MPA Network scenario footprint that is contained in the Caamaño Sound and Douglas Fjord System Network Zones, without considering the potential consequence of human activities. For this analysis, only those spatial features with at least 5% total coverage are included (**Table 4**). It is important to note that this summary is based on available data and is likely to underestimate zone specific conservation contributions due to patchy spatial data on conservation features. Furthermore, the NSB MPA Network planning process predominantly used regional-scale spatial data for characterizing ecological features across the NSB, as a result local variations in species or habitat distributions are missing from the E-CP summaries. Zone 310 includes the highest proportional value of E-CPs for both species and habitat features. The highest total species feature proportions (> 10%) occurred for Ochre Sea star locations, Resident **ʻnaaxɬ/hélx̄ʼinix̄ʷ/niixɬ**/Killer Whale potential critical habitat, and **mo'ox/wáudi/moox**/bull kelp beds. The highest habitat feature total proportions (> 10%) occurred for Mainland Fjords Upper Ocean Region, North Coast Fjords Ecosection, Fjord Floor Depression Geomorphic Unit, Fjord Crest Geomorphic Unit, and Central Mainland EBSA. Zone 310 stands out in the E-CP coverage as being the only zone with species and habitat features that make up five or more percent of the coverage of E-CPs in the NSB MPA network, including **t'iibn**/Steller Sea Lion winter haul-outs, Canary Rockfish populations, Rhinoceros Auklet colonies, Quillback Rockfish populations, **loon/g̃ʷénceg̃awi/lo'on**/Horse Clam locations, Purple-hinged Rock Scallop locations, Resident **ʻnaaxɬ/hélx̄ʼinix̄ʷ/niixɬ** potential critical habitat, and Ochre Sea star locations, Fjord Depression geomorphic unit, Central Mainland EBSA (**Table 4**). Zone 315 has very low E-CP coverage, which corresponds to this zone's small size and limited coverage by research surveys.

***Table 4**. Summary results for individual ecological conservation priorities (E-CPs) in the Caamaño Sound and Douglas Fjord System Network Zones. The total proportion (total prop.) is the sum of the proportions of each E-CP in the network scenario footprint found in the Caamaño Sound and Douglas Fjord System Network Zones, without considering the potential consequence of human activities within the Zone. Only those features for which there is at least 5% coverage in the Network Zones are included. Sum of proportions is provided in increasing order for the feature type. Bolded values indicate the highest sum of proportions for each feature type. Data sources and descriptions of E-CP features are provided in **Appendix G: E-CP data sources**. Dash indicates no data or percent coverage < 0.0%. CCIRA stands for Central Coast Indigenous Resource Alliance.*

E-CP Feature Name	Total Prop.	Zone 310	Zone 311	Zone 312	Zone 313	Zone 314	Zone 315	Zone 316
Species Features								
Steller Sea Lion Winter Haul-outs	5.3%	5.3%	-	-	-	-	-	-
Geoduck Locations	5.3%	4.2%	0.2%	0.6%	0.2%	-	-	-
Canary Rockfish (CCIRA Surveys*)	5.5%	5.5%	-	-	-	-	-	-
General Kelp Polygons	5.8%	2.8%	1.3%	1.7%	0.1%	-	-	-
Marbled Murrelet Density	6.0%	3.4%	0.2%	-	0.6%	0.1%	-	1.7%
Sa'mx/**ḵux^{w}**/Butter Clam Locations	6.1%	2.2%	0.2%	1.0%	2.1%	0.6%	-	-
Rhinoceros Auklet Colonies	6.2%	6.0%	0.2%	-	-	-	-	-
Quillback Rockfish (CCIRA Surveys*)	6.4%	6.4%	-	-	-	-	-	-
Humpback Whale Critical Habitat	6.7%	2.1%	-	-	1.9%	1.3%	-	1.3%
gyoós/**q̓áq̓elḭis**/Giant Kelp Biobands	6.8%	1.9%	1.1%	3.6%	-	0.2%	-	-
Harbour Seal Haul-outs	7.1%	4.3%	0.6%	0.9%	1.1%	0.1%	-	0.1%
ts'akwe'ats/Red Urchin Locations	7.2%	4.9%	1.0%	0.9%	0.3%	-	-	0.1%
mo'ox/**wáudi**/**moox** /Bull Kelp Biobands	7.3%	4.0%	1.1%	0.9%	0.7%	0.7%	-	-
Surfgrass Biobands	7.4%	4.2%	1.9%	1.2%	0.0%	-	-	-
loon/**g̃^{w}énceg̃awi**/**lo'on**/ Horse Clam Locations	7.8%	5.2%	0.1%	0.7%	0.9%	0.5%	-	0.4%
Purple-hinged Rock Scallop Locations	9.7%	6.6%	1.5%	0.5%	1.0%		-	-
mo'ox/**wáudi**/**moox**/Bull Kelp Beds	12.7%	4.5%	3.3%	5.0%			-	-
Resident **'naaxł**/**hélx̃'inix̃^{w}**/ **niixł**/Killer Whale Potential Critical Habitat	12.9%	8.6%	0.3%	0.2%	2.7%	1.1%	-	-
Ochre Sea Star Locations	14.7%	6.0%	0.8%	1.2%	4.5%	0.5%	-	1.7%
Habitat Features								
Rock Platform Coastal Class	5.3%	3.3%	0.8%	0.6%	0.2%	0.3%	-	-

E-CP Feature Name	Total Prop.	Zone 310	Zone 311	Zone 312	Zone 313	Zone 314	Zone 315	Zone 316
Aristazabal Banks Upwelling Upper Ocean Region	5.9%	4.8%	0.6%	0.4%	-	-	-	-
Fjord Mound Geomorphic Unit	6.3%	4.0%	0.5%	0.8%	0.2%	0.3%	-	0.5%
Rock Ramp Coastal Class	6.5%	2.6%	0.6%	1.2%	0.8%	0.7%	-	0.6%
Fjord Steep Wall Geomorphic Unit	7.3%	3.2%	-	-	1.0%	2.1%	-	1.0%
Fjord Depression Geomorphic Unit	7.7%	5.5%	0.2%	0.2%	0.4%	1.2%	-	0.1%
Channel Coastal Class	7.8%	3.2%	-	-	4.6%	-	-	-
Sandflat Coastal Class	8.1%	0.9%	2.8%	2.9%	1.0%	0.5%	-	0.2%
Mainland Fjords Upper Ocean Region	10.0%	4.9%	0.2%	0.2%	1.6%	2.2%	-	0.9%
North Coast Fjords Ecosection	10.2%	4.8%	0.2%	0.3%	1.6%	2.2%	-	0.9%
Fjord Floor Depression Geomorphic Unit	11.1%	1.8%	-	-	4.1%	3.6%	-	1.7%
Fjord Crest Geomorphic Unit	11.4%	3.4%	-	-	3.5%	3.4%	-	1.1%
Central Mainland EBSA	15.7%	13.2%	1.4%	1.1%	-	-	-	-

*Central Coast Indigenous Resource Alliance (CCIRA)

2.4 Report Organization and Content Considerations

The three biophysical overview reports for the NSB MPA Network Zones share many components, topics, methodologies, and authors in common. Instead of repeatedly referring to the first report written for the Offshore Haida Gwaii Network Zones (Bannar-Martin et al. 2025), we have reproduced sections here to ensure each report stands alone with permission from the primary authors of the Offshore Haida Gwaii Network Zones report (Bannar-Martin et al. 2025). As such, certain overlapping sections may have duplicate or similar descriptions, data, and figures.

The following objectives of this biophysical overview technical report are to:

1. Describe the contribution of the Caamaño Sound and Douglas Fjord System Network Zones to bioregional MPA network design/planning, i.e., relative to NSB MPA network objectives.
2. Evaluate, describe and map, where possible, the identified conservation priorities and other key biophysical and ecological features of the study area, including:
    - predominant and/or unique physical and biological oceanographic characteristics.
    - predominant, unique, and/or sensitive habitat features; and
    - ecologically, socially/culturally significant species; depleted species; and marine mammals and birds
3. Where appropriate, identify relevance of the study area to the life histories of species of interest, species distribution and abundance (and status and trends where available),

and the local abiotic and biotic factors influencing these.

4. Identify and describe for species and habitats of interest: known Vulnerabilities and Recoverability (where knowledge is available).

5. Identify key uncertainties and knowledge gaps as it pertains to the current understanding of the existing environment and species of interest within the study area, and recommend measures to address these gaps, where possible.

Following these objectives, this biophysical report includes five sections focusing on the Caamaño Sound and Douglas Fjord System Network Zones and surrounding Caamaño-Douglas area. The first describes the Network Zones' oceanographic setting, focusing on the physical and biological systems and geological structure. The second section details current and anticipated climate change impacts and the effects on specific habitats and taxonomic groups. The third section details the human activities in the region, including active and potential threats to key physical and biological features. The fourth section describes the ecological setting and cultural relationships, focusing on unique ecosystems, biodiversity patterns, and species and habitats identified for their ecological importance. Finally, the fifth section summarizes the conservation significance and contribution of the Network Zones to the NSB MPA Network as a whole. Information gaps and data limitations, where applicable, are highlighted throughout.

3 OCEANOGRAPHIC SETTING

The open ocean of the northeast Pacific forms the western boundary of the NSB. The water over the upper continental slope is the source of the bottom water in the deep troughs and inlets of the northern BC coast. The oceanography of the Northeast Pacific and the Caamaño-Douglas area is described, with some repetitions from the previous biophysical review of Haida Gwaii (Bannar-Martin et al. 2025). For a more comprehensive overview of the marine environment of the northern coast of BC, please see Burd et al. (2019).

3.1 NORTHEAST PACIFIC

3.1.1 Large-scale circulation, currents and climate

BC is at the eastern end of the large-scale circulation pattern of the North Pacific Ocean, where both the subpolar gyre and subtropical gyre transport water from west to east via the Subarctic Current and the North Pacific Current, respectively (**Figure 8**). These currents are products of two large-scale atmospheric systems: the Aleutian Low in the Gulf of Alaska and the subtropical North Pacific High further south in the northeast pacific. The resulting gyres generate two persistent currents. One is the Subarctic Current, which turns north and becomes the Alaska Current. The other one is the North Pacific Current, which turns south and becomes the California Current. These large-scale currents do not directly impinge on the continental shelf of BC, but they brought tsunami debris across the Pacific for several years after the 2011 Fukushima tsunami. The atmospheric systems that generated them also impact the prevailing nearshore wind patterns and, thus, currents. The divergence, or bifurcation, in the currents

coming across the North Pacific, leads to the oceanic region offshore of the BC shelf being a region with 'Variable Currents" (**Figure 8**).

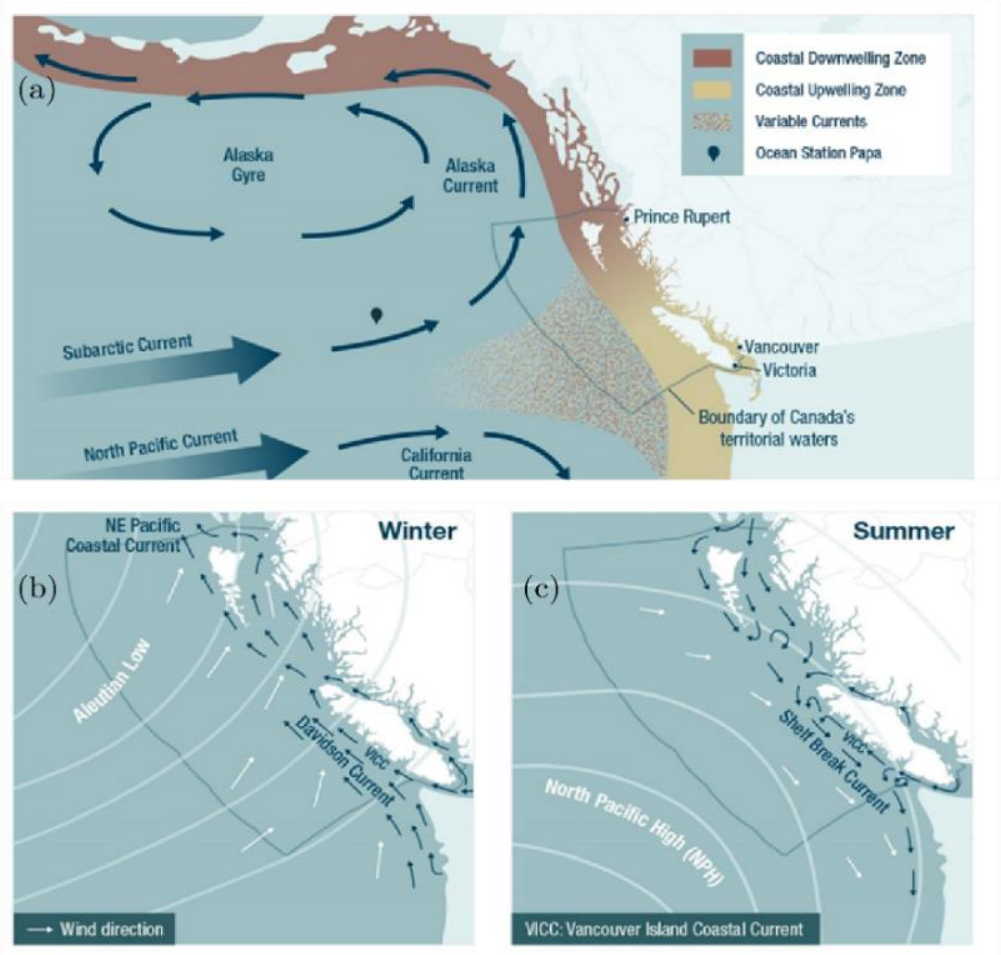

Figure 8. *The Northeast Pacific regional current systems (used with permission; DFO 2021a). (a) Large scale current systems in Canada's Northeast; (b) Winter season currents and wind direction within Canada's territorial waters; (c) Summer season current and wind direction within Canada's territorial waters. The grey bounding box denotes Canada's territorial waters. The dark blue arrows represent the current direction, and the white arrows represent the wind direction.*

The seasonal variability in the Northeast Pacific is driven primarily by changes in large-scale atmospheric weather patterns. The Aleutian Low dominates winter, whereas the North Pacific High dominates summer (Thomson 1981). These seasonal changes result in different mean wind patterns (**Figure 9**). In the winter, the winds generally blow towards the northeast (or north) along the coast. But in the summer, winds along the BC south coast are usually from the northwest, while mean winds along the North Coast are weaker and generally from the west. The southern region, with northwesterly summer winds, typically corresponds to the 'Coastal Upwelling Zone' (**Figure 8**a). The sea surface temperature (SST) patterns vary among seasons because of the change in air temperatures, solar radiation, and local winds. In winter, the SST ranges from 8-9°C at the Entrance to Queen Charlotte Sound to 6-7°C further north at Dixon Entrance (**Figure 10**a). In summer, the SST ranges from 13-14°C at the mouth of Queen

Charlotte Sound, with cooler water (10-11°C) in some coastal regions with upwelling-favourable winds (**Figure 10**b).

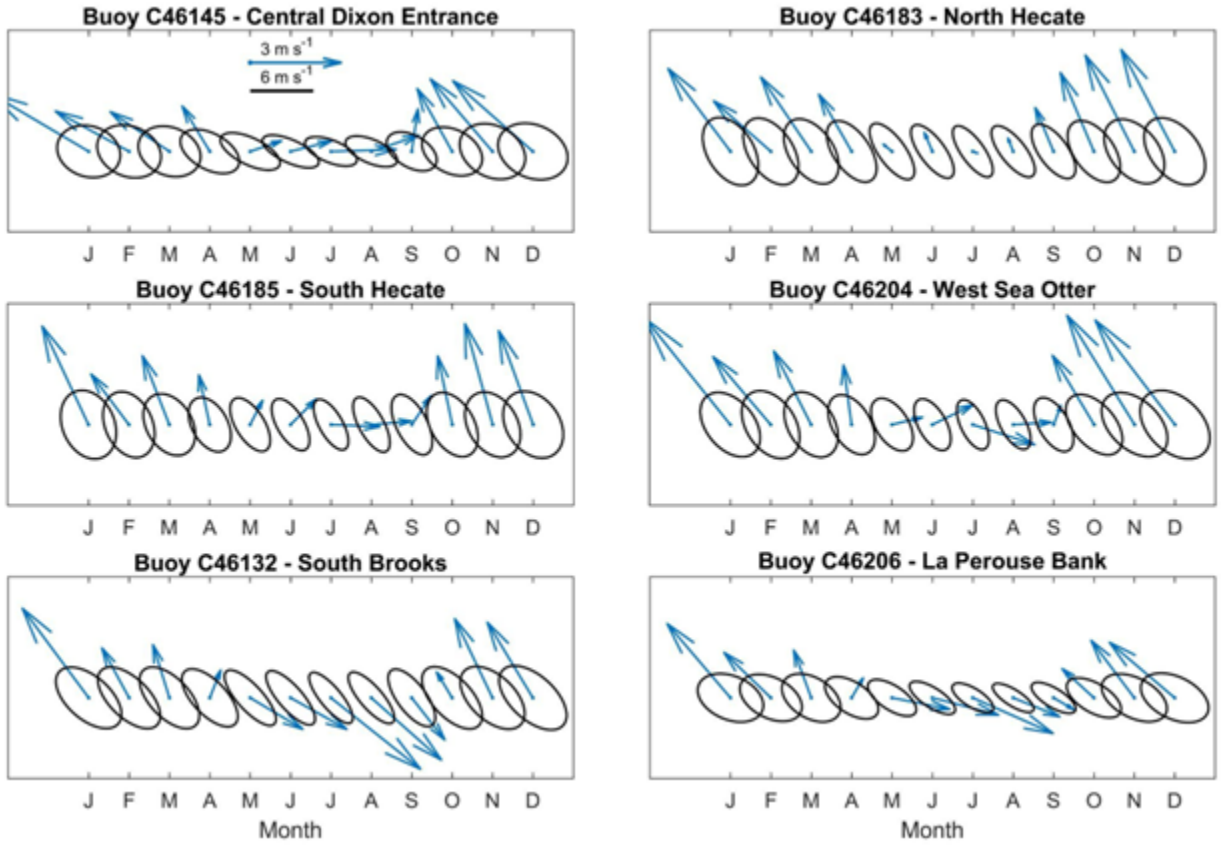

Figure 9. *The monthly mean wind vectors and the standard deviation ellipses at marine weather buoys along the BC coast. The panels are organized from Dixon Entrance in the upper left to the southern Vancouver Island Shelf in the lower right.*

El Niño Southern Oscillation (ENSO) is caused by atmosphere-ocean coupling variations in the tropical Pacific. ENSO plays an important role in the Northeast Pacific on times scales of about 2 to 7 years. During the warm ENSO phase, the Aleutian Low strengthens and moves southwards, while storm tracks extend east (Jiménez-Esteve and Domeisen 2019). The overall impact on the BC coast is warming surface waters during late winter (Crawford et al. 2011). The opposite occurs during the La Nina years. The Aleutian Low weakens and moves northwards, making surface waters colder. The ENSO index has been negative (La Niña) since 2020, as has the Pacific Decadal Oscillation index (PDO; Newman et al. 2016). The PDO amalgamates the effects of many physical processes and provides an indicator of the Northeast Pacific climate on decadal time scale. This index is the leading mode of monthly SST variability in the North Pacific (20-70^{o}N, Newman et al. 2016) and is primarily dictated by the Aleutian Low variations. A positive PDO is associated with anomalously warm waters along the North American coast (eastern North Pacific) and below-average SSTs in the western Pacific Ocean. The opposite occurs during years of negative PDO.

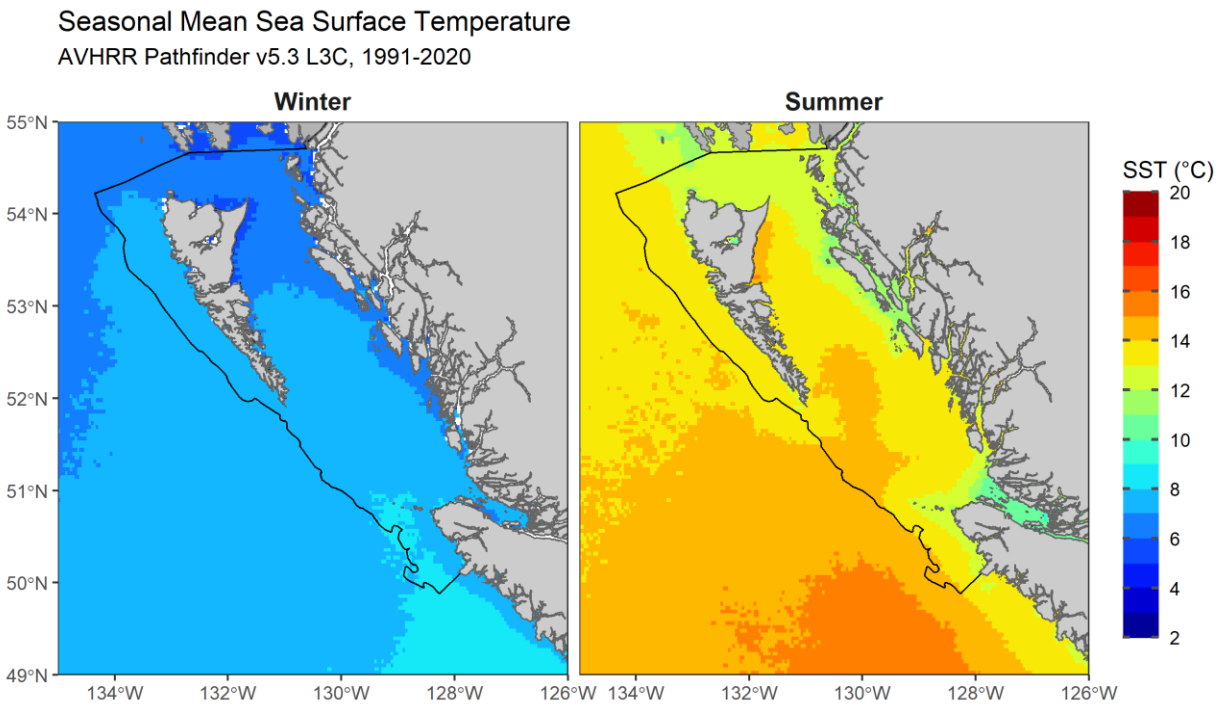

***Figure 10**. Sea surface temperature (SST) averaged by season over the period 1991-2020, showing A) winter (the months January, February, and March) b) and summer (July, August, and September). The black line indicates the NSB boundary. These maps were calculated from night-time AVHRR SST at 4 km spatial resolution with colours shown in 1-degree intervals.*

Hecate Strait connects Dixon Entrance to the north with Queen Charlotte Sound to the south, separating Haida Gwaii from the mainland. Dixon Entrance is a roughly 50 km wide strait that supports a complex circulation driven by topography, tidal rectification, freshwater input, and inflows from the continental slope (Crawford and Greisman 1987). The freshwater from the Skeena and Nass Rivers is transported through Dixon Entrance to the ocean. The shallow Rose Spit Sill and the relatively shallow connection by the northern end of Hecate Strait (20 m) limit deep water exchanges between Hecate Strait and Dixon Entrance.

Queen Charlotte Sound is at the southern extent of Hecate Strait. Around this area, currents are primarily wind-driven (Crawford et al. 1985, 1988; Hannah et al. 1991). In the winter, the prevailing winds are from the south, and the flow is almost always northward through the Queen Charlotte Sound and Hecate Strait (Thomson 1989; see **Figure 8b**). This flow transports relatively warm water northwards through Hecate Strait and offshore of Haida Gwaii (**Figure 8b**). In summer, the flow tends to follow the variable winds and may flow persistently towards the south in Hecate Strait (**Figure 8c**). In addition to the wind-driven flow, the topography, freshwater inflows, and tidal mixing generate complex flow patterns in this area (Crawford et al. 1995). For example, a clockwise gyre has been observed around Goose Bank (Crawford et al. 1985), and there is a recirculation pattern at the southern end of Hecate Strait (Crawford et al. 1988, 1990). At the south end of Haida Gwaii, around Cape St. James, Haida Eddies are formed each winter (Crawford et al. 2002; Di Lorenzo et al. 2005), which advect nutrient-rich coastal water into the open waters of the Gulf of Alaska (Whitney and Robert 2002; Crawford

et al. 2005). The Haida Eddies bring iron, a vital micronutrient, offshore from the shelf into the iron-deficient North Pacific (Whitney et al. 2005; Ladd et al. 2009).

3.1.2 Water properties and exchanges

Along the continental slope of BC and Alaska, eddies dominate the ocean circulation (Thomson and Gower 1998; Crawford et al. 2002; Ladd et al. 2009). The water properties (temperature, salinity, dissolved oxygen, nutrients) between the continental shelf and the deep ocean gyres result from a complicated mixture of water from the shelf, the California Undercurrent, and the subtropical and subpolar gyres represented by the Subarctic Current and the North Pacific Current, respectively (Whitney et al. 2005). Water properties along the continental slope do not just reflect the properties in the gyres. For example, Crawford and Peña (2016) showed that oxygen concentrations between about 200 – 400 m over the upper slope were closely related to those measured off California rather than those observed offshore at Ocean Station Papa (**Figure 8**; hereafter "Station P") in the subpolar gyre. This connection is the signature of the California Undercurrent.

The California Undercurrent and its extension north to Alaska delivers relatively warm, high salinity, nutrient-rich, low oxygen water from the equatorial Pacific to Alaska along the upper continental slope (Thomson and Krassovski 2010; Crawford and Peña 2016). Over the BC continental slope, the California Undercurrent extension flows poleward between 150 and 400 m depth (Thomson and Krassovski 2010). At the southern end of the mouth of Queen Charlotte Sound, about 30-40% of the water between 100 m and 300 m depth is Pacific Equatorial Water (between density surfaces of 26 and 26.75 kg m^{-3}; Thomson and Krassovski 2010). Further north, at the mouth of Dixon Entrance, this water mass had shoaled to between 100 and 200 m depth and comprised 25-35% Pacific Equatorial Water. Over several decades of measurements, Crawford and Peña (2016) showed that dissolved oxygen was low in the 1950s and higher in the 1970-80s before declining until 2012, when their analysis ended. Since then, oxygen levels have increased (Cummins and Ross 2020). This California Undercurrent water is the source for most of the bottom water in the NSB. The likely route for this water to reach Caamaño Sound is via Moresby Trough, which starts just south of Cape St. James (Haida Gwaii) and cuts across the shelf to the eastern side of Hecate Strait before turning north.

Deeper in the Northeast Pacific, an oxygen minimum zone (OMZ) impacts the water properties. It exhibits hypoxic conditions between approximately 480 m and 1700 m (Whitney et al. 2007; Cummins and Ross 2020; Ross et al. 2020). The OMZ's bottom boundary has been deepening by 3 m yearly, whereas the calcite saturation horizon has been moving upwards at about 1.7 m annually since the 1980s (Ross et al. 2020). The water at the OMZ's shallowest edge likely gets onto the shelf and deep troughs such as the Moresby Trough beneath the layer of California Current water.

3.2 LOCAL CONDITIONS

3.2.1 Bathymetry

From an ocean circulation point of view, two sills separate the deep waters of Hecate Strait from the Caamaño Sound and Douglas Network Zones:

- The first sill is a broad and wide 140 m deep sill at the entrance of Caamaño Sound, which separates the seven Network Zones from Hecate Strait.
- The second sill is further north within **Lax Ka'gaas**/Campania Sound, with its shallowest depth being about 200 m. This sill will be referred to throughout this section as "**Lax Ka'gaas**/Campania Sill" and runs east-west between **Lax Ka'gaas** and Princess Royal Island.

Most of the Caamaño Sound (Zone 310) is situated seaward of **Lax Ka'gaas**/Campania Sill along with two Network Zones: Dewdney & Glide Islands (Zone 311) and Estevan Island group (Zone 312; **Figure 11**). The remaining Network Zones, including **Lax Kwil Dziidz**/Fin Island, **Maxtaktsm'aa**/Union Passage, Douglas Channel, and Ursula Channel (Zones 313 to 316), are within the fjord-estuarine system to the north of **Lax Ka'gaas** Sill. Areas as deep as 425 m exist within the Rennison and Aristazabal Islands (Zone 310) between Hecate Strait and the 200 m deep sill in **Lax Ka'gaas** Sound (Kung et al. 2023). To enter these deeper areas, water must first cross over the 140 m shallow areas at the entrance of Caamaño Sound. These deeper areas also connect to Laredo Channel and Estevan Sound. Still, each has relatively shallow sills (<90 m and 60 m, respectively) compared to the broad 140 m deep entrance separating Zone 310 from Hecate Strait.

Of the Network Zones directly connected to Hecate Strait, the shallowest are the Dewdney and Glide Islands group (311) and the Estevan Island groups (312) (**Figure 12**, **Table 5**). These two Zones, along with Caamaño Sound (Zone 310) consist of low-lying islands compared to the mountain terrain of the fjords north of **Lax Ka'gaas** Sill. They encounter different wind patterns from the inlets (e.g., Zones 314 and 316), where the wind tends to blow parallel to the inlets' orientation because of the topography. The regions south of **Lax Ka'gaas** Sill are the most exposed to the winds and surface currents within Hecate Strait. The larger fetches would result in the shallower areas being impacted by the ocean swells and wind-generated waves. On the exposed, seaward side of the Estevan Island groups (Zone 312) and Dewdney and Glide Islands (Zone 311), the deepest water exchanges may be directly from the north via Hecate Strait or from the south through Caamaño Sound (**Figure 11B**).

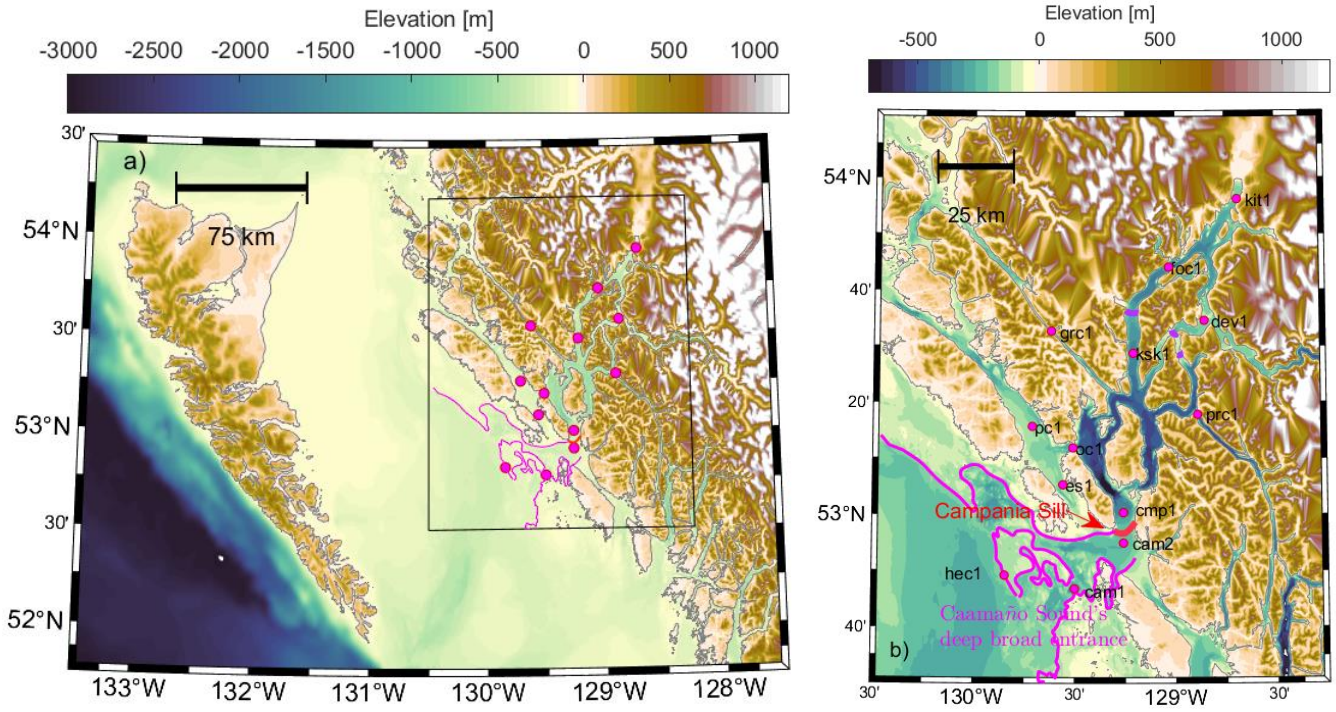

Figure 11. *(a) Topographical and bathymetric map of Hecate Strait and (b) Caamaño Sound region where instrumented moorings were deployed to collect ocean currents and water properties measurements for the World Class Tanker Safety Programme (Wright et al. 2015, 2016, 2017). The bathymetric maps were generated from a digital elevation model developed for research and science purposes (Kung et al. 2023). Note the different colour scales in (b) to illustrate the deep fjord waters and the shallow 140-m entrance around hec1 and cam1 moorings denoted with the magenta contour lines. The red line between cmp1 and cam2 denotes* ***Lax Ka'gaas****/Campania Sill, while those further north in (b) denote sills in Ursula and Douglas Channels.*

North of **Lax Ka'gaas**/Campania Sill is the fjord-estuarine system. Northwest across the sill is Squally Channel – the deepest area of the region in Zone 310, reaching almost 700 m (**Figure 12**, **Table 5**). Squally Channel connects to Nepean Sound via Otter Channel, which is nearly 200-m deep between **Lax Ka'gaas** and Pitt Islands. Nepean Sound provides another connection between Squally Channel and Hecate Strait, albeit much shallower (60 to 80 m deep) than the connection through **Lax Ka'gaas** and Caamaño Sound. Water from Hecate Strait can enter Nepean Sound via three routes. The first is from the northwest through Principe Channel, about 65 m deep at its northern end. The second route is from the southwest via Otter Passage, north of Trutch Island, about 80 m deep. The third route is southeast of Estevan Sound, which connects to Caamaño Sound via a 60 m deep sill at Estevan Sound's southern end. Moving north through Squally Channel, the channel splits into Passage and Cridge Passage to the south and north of **Lax Kwil Dziist**. The narrow and shallow **Maxtaktsm'aa** connects the **Lax Kwil Dziist** area with Grenville Channel — one of the six pathways to Wright Sound (**Figure 11Figure 14**). This Sound is located north of **K'ts'ats'aas**/Gil Island near **Txałgiu**/Hartley Bay (Zone 314) and connects six channels. Several other sills exist upstream of **Lax Ka'gaas** Sound: in particular, the sills at the northern end of Douglas Channel (Zone 314, 200 m) and the north end of Ursula Channel (Zone 316, 35 m). Their presence impacts the estuarine circulation and exchanges between Gardner Canal and Douglas Channel, in addition to the water properties near the sill and further afar in Douglas and Ursula Channel. The significant freshwater inputs from snowmelt and rainfall support the estuarine circulation throughout the region (section 3.2.3). The most notable rivers upstream of the fjord Network Zones are Kitimat and Kildala Rivers at the head of Douglas Channel and the Kemano and Kitlope Rivers that flow into Gardner Canal.

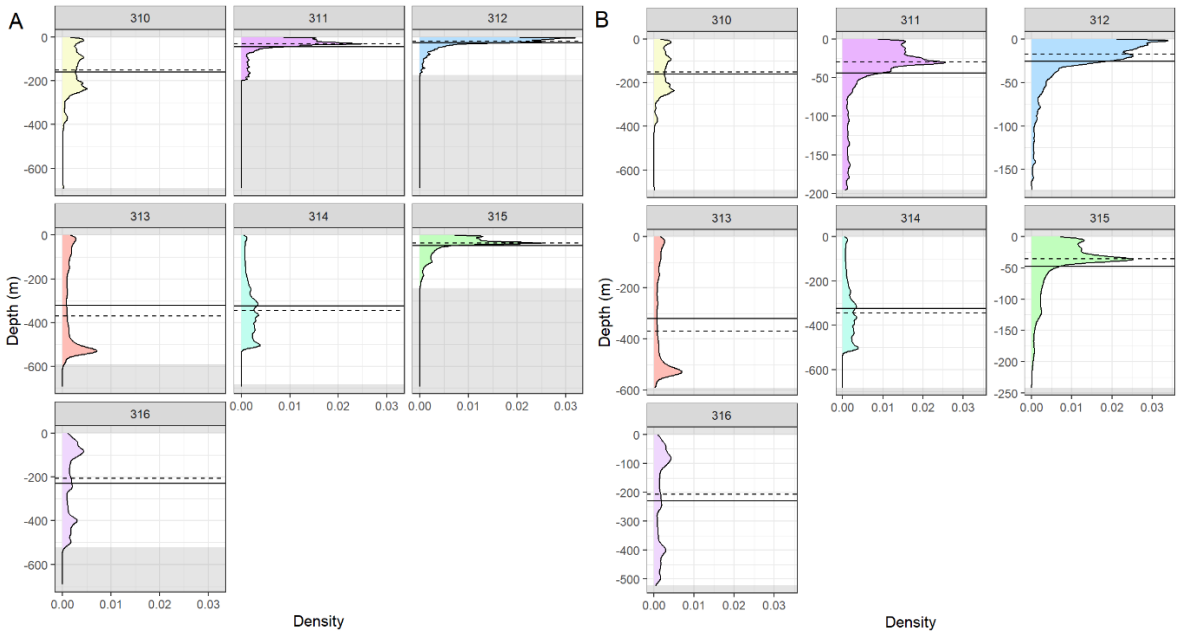

***Figure 12**. Density plot of bathymetry in each Zone shown to A) the same scale and y-axis and B) different scales and y-axis to show the distribution of each unique Zone. Mean depth indicated as a solid line and median as a dashed line. All Zones extend to the coastline, i.e., a depth of zero meters. Colours correspond to the seven Zones shown in **Figure 3**. The grid cell size of each individual point is 75 m by 75 m.*

***Table 5**. Bathymetric maximum, mean, and standard deviation depths in meters of the seven Caamaño Sound and Douglas Fjord System Network Zones. All Zones extend to the coastline, i.e., a minimum depth of zero meters.*

	Zone 310	**Zone 311**	**Zone 312**	**Zone 313**	**Zone 314**	**Zone 315**	**Zone 316**
Maximum depth (m)	691	195	173	591	682	241	522
Mean depth (m)	160.23	43.66	25.11	320.36	323.97	47.06	229.38
Standard Deviation	109.15	45.18	28.09	197.55	133.43	42.90	157.28

3.2.2 Geological setting

Douglas Channel has been an area of interest for geological hazards since the large submarine landslide and subsequent tsunami at Moon Bay near Kitimat and Kitamaat Village in 1974 and 1975 (Prior et al., 1982, 1983). The surficial geology and slope stability hazard have been mapped to a much greater extent than other margins of the BC coast. The Geological Survey of Canada produced a geomorphology map (Shaw and Lintern, 2016) showing extreme variability in surficial units of the marine environment throughout the Douglas Channel and Caamaño Sound area (**Figure 13A**). Caamaño Sound and Douglas Channel make up part of the dissected Coast Plutonic Complex. In this region, the predominant rock types are granitoid with lesser components of metasedimentary and meta-volcanic rocks (Roddick, 1970; Nelson et al., 2014). The outer coast, including Aristazabal Island, **Lax Ka'gaas**/Campania Island, and the Estevan Island groups, are part of the Milbanke Strandflat Zone of the Hecate Lowland (Holland, 1976). This coastal plain is characterized by low relief and rugged terrain with abundant faults and lineaments. Intense glaciation in this region left behind exposed bedrock showing characteristic linear ice erosion features (Holland, 1976). The Hecate Lowland transitions abruptly eastward to the Douglas Channel fjord, where relief is very high. Large-scale structural features trend northwest, with notable examples including the Grenville and Principe-Laredo faults, which significantly affect the location and orientation of waterways (Grenville and Principe Channels). Other faults crosscut this northwest fabric, and due to extensive faulting and deformation, exposed bedrock has a highly faulted and jointed texture. The offshore Queen Charlotte Fault is Canada's most active, producing large-magnitude seismic activity. However, seismicity in Douglas Channel is considered low, and activity along the Queen Charlotte Fault is unlikely to have major effects on the Douglas Channel region (Brillon 2016).

The region's terrain is extremely rugged and steep, owing much to Quaternary glacial cycles. At the last glacial maximum *ca.* 20 ka, the Cordilleran ice sheet covered much of the coast mountain range with ice. The glacial maximum corresponded with an eustatic sea level lowstand followed by further localized regression when much of the west coast shelf was subaerially exposed. At this time, ice flows from the cordilleran ice sheet extended from modern mainland coastal fjords and valleys, crossing the shelf and incising a series of deep glacial valleys between shallow banks (**Figure 14**, Shaw et al. 2020). Thick ice streams occupied low-topography areas, creating intense erosion and deepening fjord basins well beyond other margins on the continental shelf. Fjord walls were left at extreme slope gradients prone to slope stability events, and deglaciation was followed by a period of frequent and large-volume landslides and slope failures (Conway and Barrie, 2015; Stacey et al. 2020). In fjord environments along the BC coast, glacial remnants are represented as glacial diamicton, deposited by grounded ice, and glaciomarine sediment deposited in the marine environment by sediment-charged meltwater plumes. These units form many hard, sometimes mixed, gravel-to-boulder substrates important for benthic habitats.

Beginning c.16-15 ka, the ice retreated across the shelf, reaching the mainland coast by c.14.5-13.0 ka (Barrie and Conway, 1999; Hetherington et al., 2004). The weight of the cordilleran ice sheet produced a crustal forebulge, elevating the continental shelf and resulting in locally low sea levels and shallow banks that were subaerially exposed (Hetherington et al, 2004; Shugar et al., 2014). The effects were highly variable, with local sea level lowering of up to 95 m on Cook Bank north of Vancouver Island (Luternauer et al., 1989) and up to 150 m in Hecate Strait and Dixon Entrance (Barrie et al., 1991; Barrie and Conway, 1999; Heatherington et al., 2004).

The general effect of this dramatic sea-level lowering was the removal, or non-deposition, of fine sediment on the shelf in shallower areas that are currently less than 100 m deep.

3.2.2.1 Outer Coast Zones - Exposed shelf environment

Relict large-scale seabed features include exposed bedrock on much of the inner shelf, including Caamaño Sound and the exposed shelf to the west. Bedrock outcrop has a high rugosity and, in places, has been ice-sculped into relatively smooth streamlined ridges. This rugged seabed is common along much of the North Coast but is particularly widespread outside Caamaño Sound and Laredo Sound, with many shallow banks and small rocky islands (**Figure 14**A). Sinuous ridges trending NW-SE are interpreted as recessional moraines representing short-term standstill during the glacial recession through the region (Shaw et al, 2017). Although several rivers deliver substantial amounts of sediment to the heads of Douglas Channel (Kitimat River) and Gardner Canal (Kitlope River), minimal sediment reaches beyond the deep fjord basins and prominent sills to Caamaño Sound. This results in a sediment-starved environment on the exposed shelf where active sedimentation typically involves reworking glacial deposits by storm and tidal currents. **Lax Ka'gaas**/Campania Sound and Laredo Channel have thick sequences of glaciomarine sediments with a broad flat iceberg-scoured surface. These sequences are further evidence that negligible sedimentation has occurred here since the recession of the cordilleran ice sheet (**Figure 13**; **Figure 14B**). The same stratigraphic unit hosts immense glass sponge reefs in Hecate Strait and Queen Charlotte Sound (Conway and Barrie 2015). Coarse glaciomarine deposits fill local depressions in bedrock, reducing rugosity in places and resulting in interspersed bedrock and gravel (or coarser) substrate (**Figure 14**). Small mini-basins may contain very small post-glacial mud deposition patches in deep passages between islets, likely reworked from nearby glacial deposits. Data on seabed substrate is sparse in shallow water, particularly the rocky coast around the Estevan Group.

3.2.2.2 Inner Zones - Fjord environments

During deglaciation in Douglas Channel, ice halted in several locations, producing recessional moraines at Aranzazu Banks (outer Caamaño Sound), Squally Channel, Kitkiata, Ursula Channel, Verney Passage and Devastation Channel (**Figure 13**; Shaw and Lintern, 2016; Shaw et al., 2017). The typical sedimentary sequence in the Douglas Channel fjord starts with a glacial unit over bedrock, either diamicton or glaciomarine mud, or both, followed by a postglacial mud unit. Diamicton exposures are relatively rare. However, they stand out as prominent moraines or sills (listed above) and may have discontinuous, thin mud cover. Moraine structures have been known to provide suitable substrate and ocean conditions for glass sponge reefs as seen in Howe Sound and Portland Inlet. Potential glass sponge reefs have been observed on the sills in Devastation Channel and Gardner Canal as well as on glacial features at Markland Point (Kitimat Arm), although further ground truthing is needed to confirm this presence. The glaciomarine unit is exposed in areas with low sedimentation due to distance from the source or elevated bottom currents (see winnowed/scoured unit, **Figure 13**). These exposures are typically characterized by a course lag surface (gravel-to-boulder) as bottom currents winnow fines.

Glaciomarine exposure is widespread outside Douglas Channel (**Figure 13**, **Figure 14B**) on the flat seabed, where postglacial sediment is generally absent. Postglacial sediment is supplied by fluvial input and, to some extent, by redistribution of glacial deposits. Postglacial mud is widely distributed in Kitimat Arm, Kildala Arm, and Gardner Canal and often forms thick, mounded drift

deposits elsewhere, reaching thicknesses above 60 m in places. Due to dynamic oceanographic conditions, sediment accumulation is highly variable, with areas of non-deposition immediately adjacent to thick mud drifts with high accumulation rates within a span of several kilometers. This results in highly variable bottom conditions (**Figure 13**; Shaw and Lintern, 2016). Fjord walls are very steep and tend to be characterized by bedrock outcrops. Fine, unconsolidated sediment cover is present in areas with lower slope gradients (western Hawkesbury Island and **Lax Kwil Dziist**/Fin Island) and may infill and smooth irregular surfaces with fine sediment. Due to the high slope and high precipitation, slope stability processes are active, particularly where streams or gullies meet the marine environment (**Figure 13**, **Figure 14B, Figure 15**). In these locations, fan deltas build up at the base of the fjord wall with a tendency to favour mixed class sizes ranging from gravel to boulder (**Figure 13**, **Figure 14A, Figure 15**). These surfaces remain highly active and unstable despite having small catchment areas, experiencing the bulk of their activity during the rainy winter months.

Several substrate resources can be found in the Open Government Portal which includes 1) a continuous extrapolated bottom patches model (Nearshore Bottom Patches for Pacific Canada. Version 1.0 - Open Government Portal) and 2) a predicted substrate bottom type model (Nearshore Bottom Patches for Pacific Canada. Version 1.0 - Open Government Portal). For “observed” and “mechanical grab” type data assembled in substrate points, please refer to Gregr et al. (2013), and Gregr (2016).

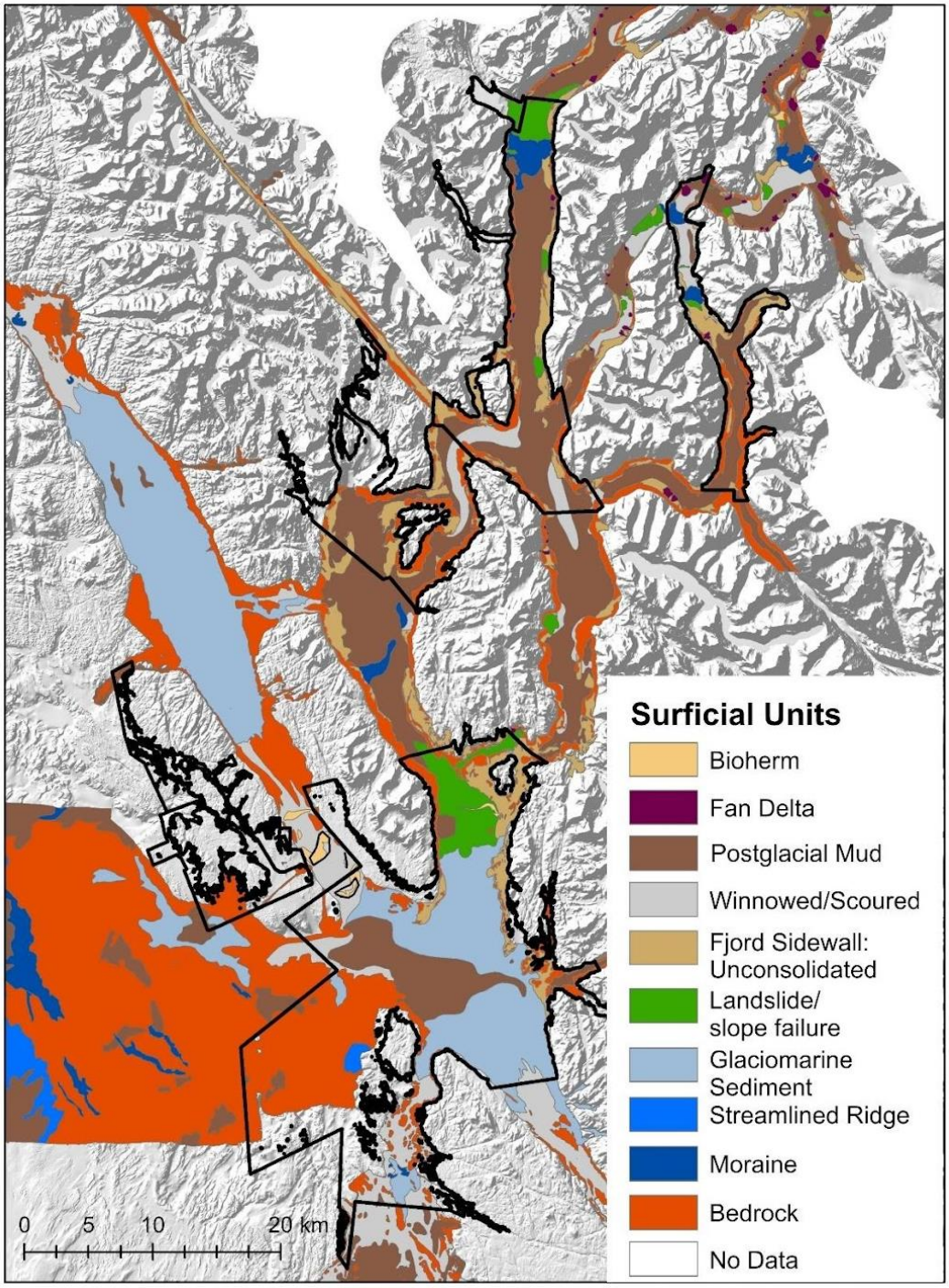

***Figure 13**. Geomorphology of the Caamaño-Douglas area (modified from Shaw and Lintern, 2016).*

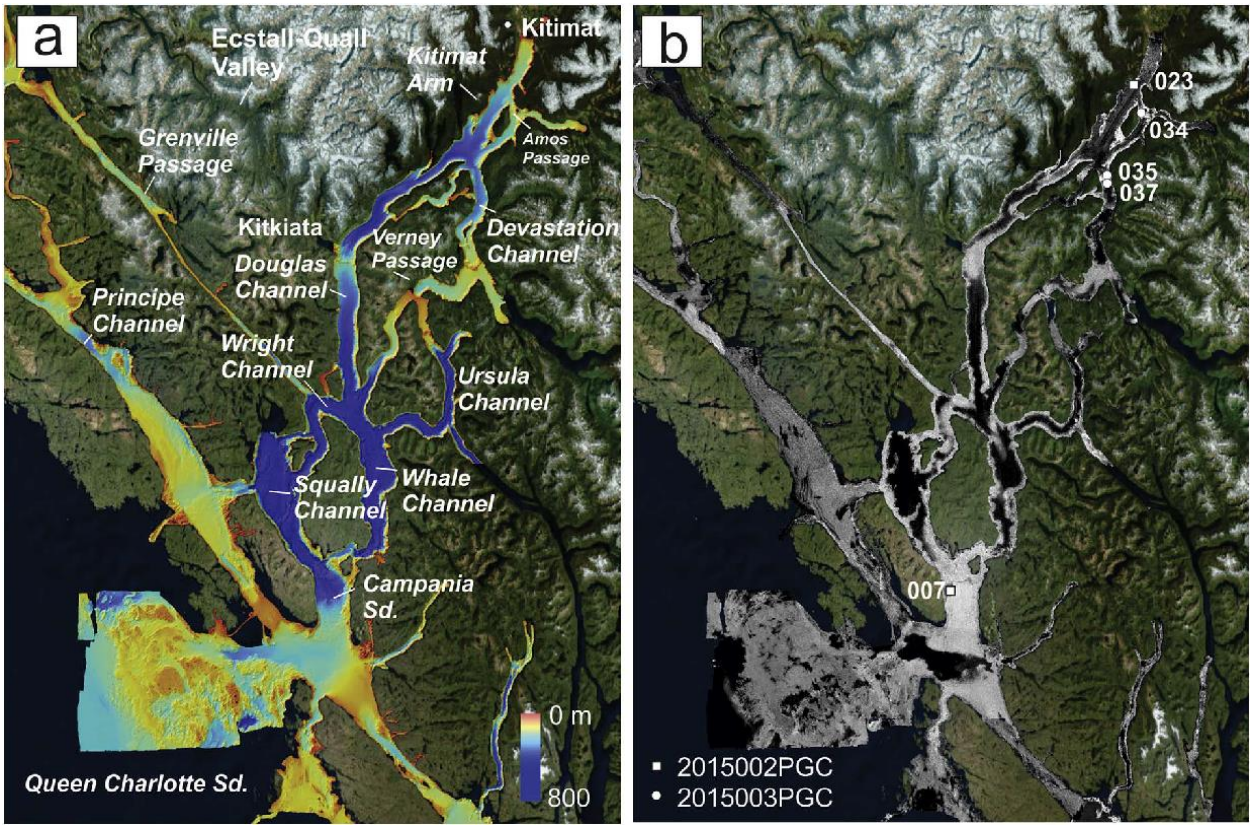

***Figure 14**. a) Shaded-relief image showing bathymetry of the Caamaño-Douglas area and adjacent inner continental shelf; b) backscatter strength. Light tone= high backscatter (bedrock, gravel), dark tone= low backscatter (mud, sandy mud). From Shaw et al. (2017). For specific bathymetry depth please refer to **Table 6**.*

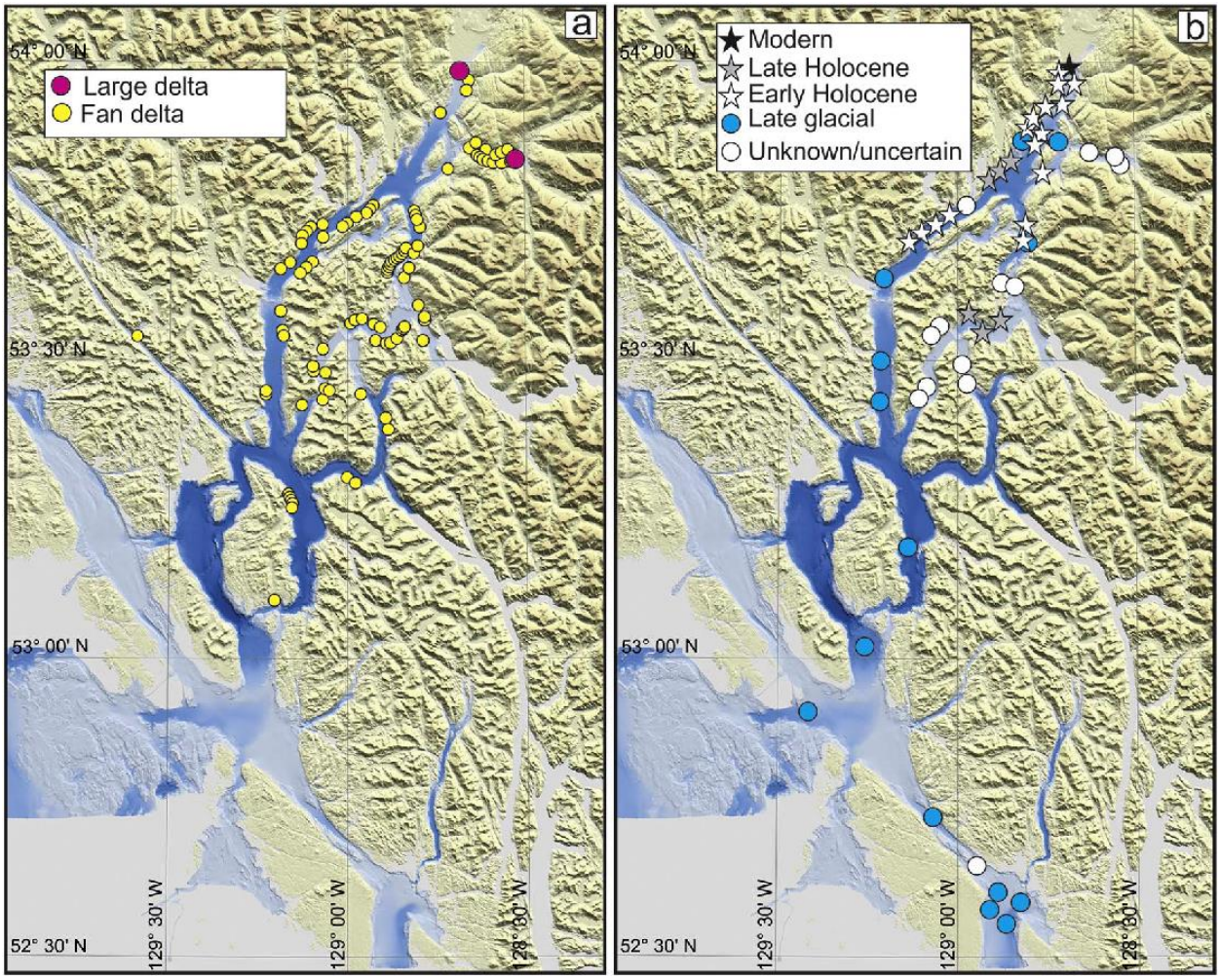

Figure 15. *a) Distribution of deltas; b) distribution of landslide and slope failure deposits, classified according to age (from Shaw et al., 2017).*

3.2.3 Climate and freshwater inputs

3.2.3.1 Winds

The wind patterns impact the physical dynamics in the region. At a large scale, Queen Charlotte Sound is at the northern end of the California Current System. In this region, the summertime winds are generally from the northwest (towards the southeast), leading to upwelling along the coast ('coastal upwelling Zone' in **Figure 8**). Upwelling is the process by which the winds from the northwest push the surface water offshore, which causes the underlying water to move upwards near the coast and at the shelf break (called upwelling). Upwelling winds are more prevalent during summer as the Aleutian low atmospheric system weakens, especially further south along the California and Oregon coasts (see the 42 N curve in (**Figure 16**). The upwelling winds are much weaker along the BC coast (**Figure 16**). The upwelling winds are more prevalent in the summer because the Aleutian Low weakens, and the North Pacific High

strengthens. When the wind blows towards the northeast, surface water is pushed onshore, resulting in downward transport near the coast. These downwelling-favourable winds are prevalent along the entire BC coast during winter (**Figure 16**) and are a year-round feature off Alaska ('coastal downwelling Zone' in **Figure 8**). BC's North Coast is transitioning between these two large-scale regimes.

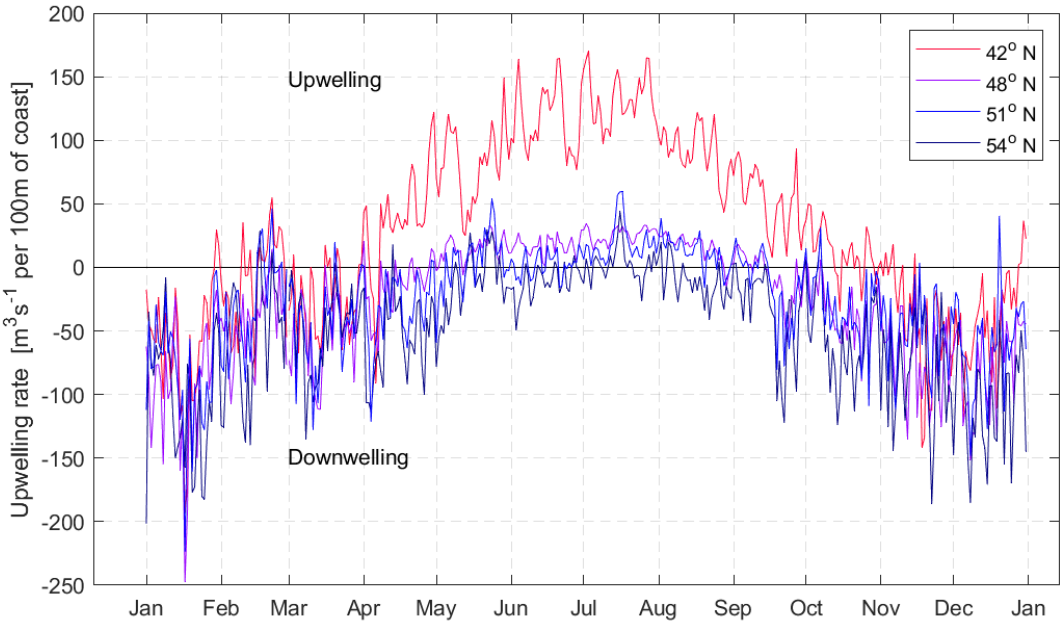

Figure 16. *Daily Bakun upwelling index averaged over ten years (2011-2020) estimated at different latitudes along the North American coastline (Bakun 1975). These indices are based on geostrophic winds calculated from six-hourly atmospheric pressure fields from U.S. Navy Fleet Numerical Meteorological and Oceanographic Center. They are available as a data product through NOAA's Environmental Research Division (Schwing et al. 1996).*

Around the Caamaño-Douglas area, the Bakun index indicates that downwelling winds relax around April, and the winds are only slightly conducive to upwelling during summer (**Figure 16**, 51° N). At the North and South Hecate weather buoys, the winter winds are generally from the southeast, with speeds often exceeding 10 m/s (**Figure 17**); these are downwelling winds. Differences in wind statistics at the buoys appear in the summer. At the North Hecate buoy, offshore of the north end of **Lax k'naga dzol**/Banks Island, the summer winds from the southeast and northwest occur with equal frequency and strength. At South Hecate, offshore of Aristazabal Island, summer winds from the northwest occur more often and are stronger than at North Hecate (**Figure 17**). Within the fjords, the wind patterns can differ remarkedly from the exposed coastline; the high mountains steer the wind to blow almost along the axis of the fjords. At the Nanakwa Shoal buoy near Kitimat, the winter winds are almost always from the northeast, i.e., blowing down Douglas Channel (**Figure 17**). The strongest winter winds are associated with outbreaks of cold air from the Arctic, which flows down mountain valleys to the sea. These winds are sometimes called katabatic winds. In summer, the wind patterns resemble a sea breeze with air blowing landwards during the day (**Figure 17**). The wind pattern is spatially variable within the Caamaño-Douglas area, particularly during summer.

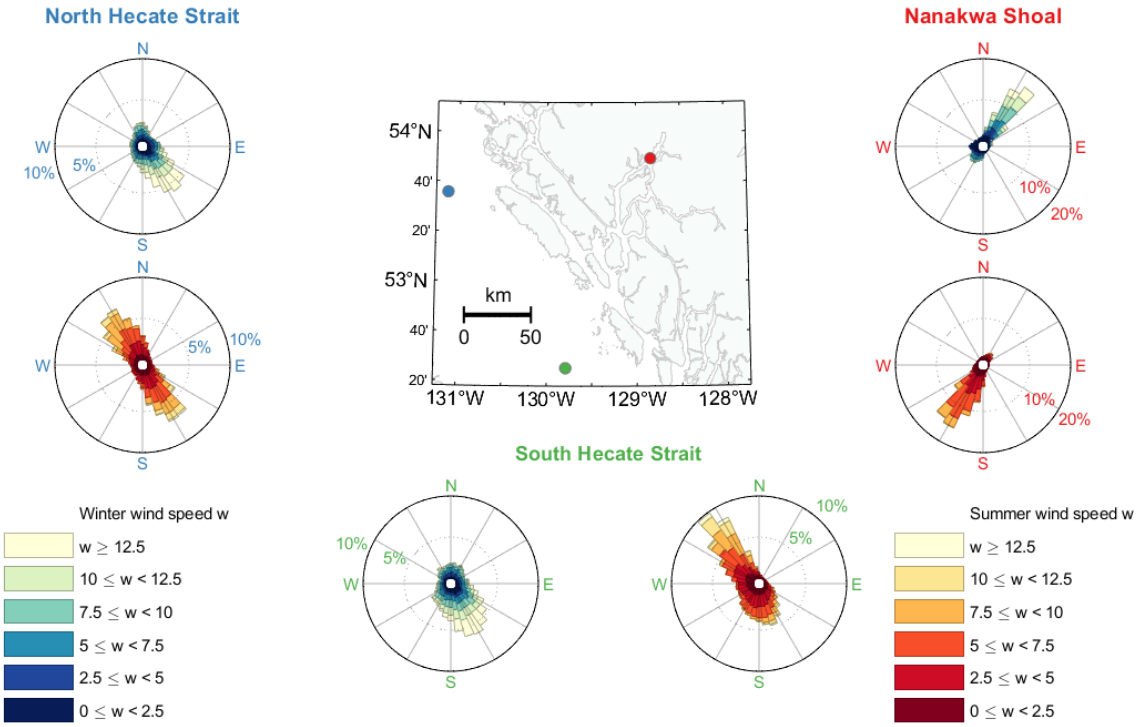

***Figure 17**. Local wind roses obtained from marine weather buoys measurements during winter (January) and summer (July) from 1991-2022 across the Caamaño-Douglas area. The spokes length indicates how often the wind blows from that direction. The spokes' color shows how often the wind blows at those speeds from that direction. Winds are generally weaker during summer than in winter. Downwelling-favorable winds blow from the SSE, and upwelling-favorable from the NNW.*

3.2.3.2 Freshwater

Local precipitation and surrounding mountains, which store winter precipitation as snow cover, provide the freshwater input to Caamaño Sound. Total annual precipitation is higher along the coast, with higher snowfall in the watershed's upper reaches (**Figure 18**). The Caamaño and Douglas Fjord System Network Zones are within the larger Caamaño watershed, which extends north to **Tgii Xsw'aanx**/Porcher Island and south of Milbanke Sound. This entire watershed is 30,858 km^2, with over two-thirds draining pluvial rivers (Morrison et al. 2012). The pluvial rivers' discharge tracks the local rainfall, which increases during late fall and winter (e.g., Laredo Sound in **Figure 19**). The remaining third of the watershed drains nival rivers, characterized by large discharges in late spring because of the melting snowpack (**Figure 19**, Kemano River). The freshwater inputs into Caamaño Sound increase during spring and late summer because of snowmelt, with peak runoff during the rainy fall and winter.

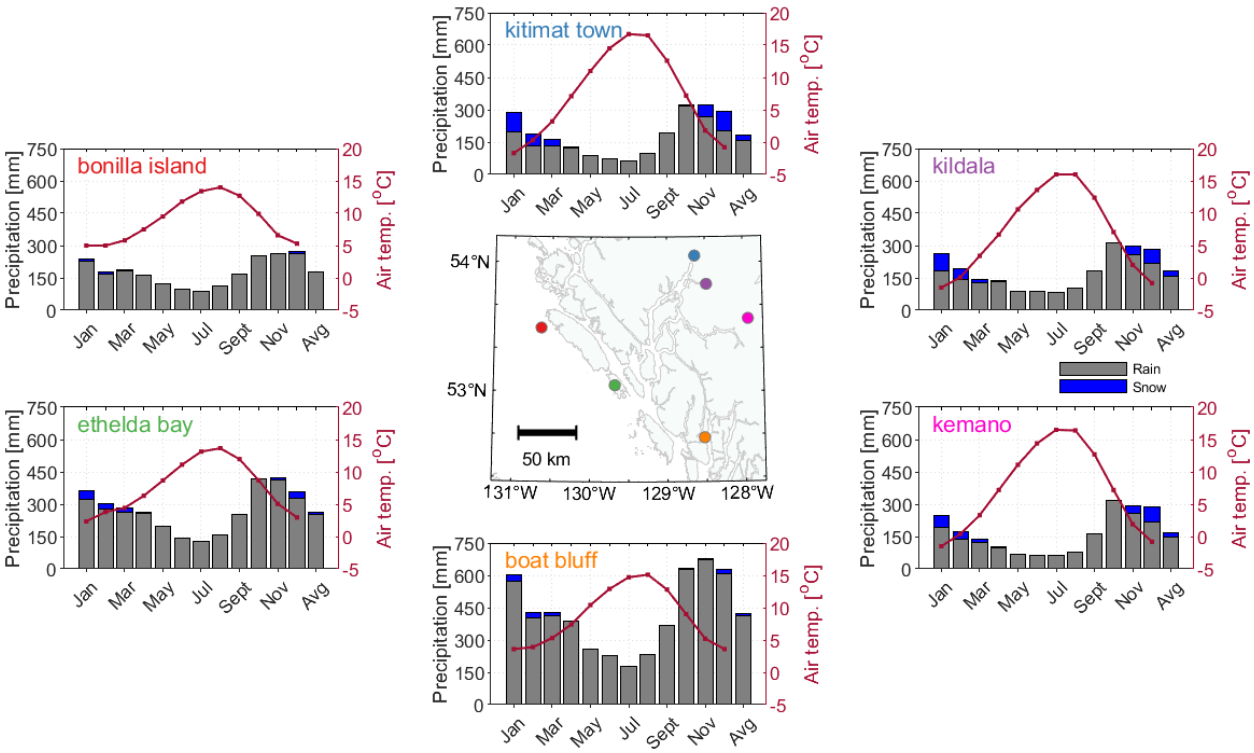

***Figure 18**. Monthly average precipitation and air temperatures from ECCC's climatic normals (1981-2010), except for station Ethelda Bay, which shows the available monthly averages from 1957 to 1994. Snowfall is presented as equivalent water, i.e., 10 cm snow = 10 mm water.*

The Caamaño Sound receives annually an average of almost 2500 m^3s^{-1} of freshwater (Morrison et al. 2012). The major tributaries in the Caamaño-Douglas area are Kitimat and Kildala Rivers at the head of Douglas Channel and the Kemano and Kitlope Rivers that flow into Gardner Canal. These tributaries contribute roughly, on average, a third of Caamaño's watershed total annual discharge. Thus, a significant fraction of the freshwater input to the system comes from small streams and directly off the land. The total freshwater inputs for Caamaño's watershed are quite large, especially considering its catchment's size. For example, the **Ksyen**/Skeena River catchment north of Caamaño Sound discharges about 1800 m^3s^{-1} of freshwater into the ocean despite being 80% larger than Caamaño's. The Caamaño watershed generates about 2.5 m of freshwater inputs annually per km^2 compared to 1.8 m and 0.9 m for the Nass and Skeena watersheds further north and 1.5 m further south for Hakai watershed (Morrison et al. 2012). The Fraser River catchment provides, on average, 0.5 m of freshwater per km^2 of watershed per year, which translates to about 3500 m^3s^{-1} due to its large catchment.

During a typical year, the highest freshwater inputs in Caamaño Sound are in October, followed by June (**Figure 19**). The freshwater inputs of areas further landwards, such as Douglas Channel and Gardner Canal, tend to have a significant portion associated with the spring snowmelt (**Figure 19**). Numerical hydrodynamic modelling showed that about 60% of the freshwater in Gardner Canal flows northwards through Devastation Channel before joining the freshwater outflow in Douglas Channel (Shan et al. 2019). The rest goes south through Verney Passage and Ursula Channel. Across all regions, the lowest freshwater inputs are in February and March due to lower precipitation and because the mountain snowpack has not yet begun to melt. The large freshwater inputs are significant for the marine environment since they support estuarine circulation throughout the year. This circulation results in a relatively fresh surface layer flowing towards Hecate Strait with a compensating, more saline inflow entering the fjord system across **Lax Ka'gaas**/Campania Sill and various vertical exchanges throughout the region.

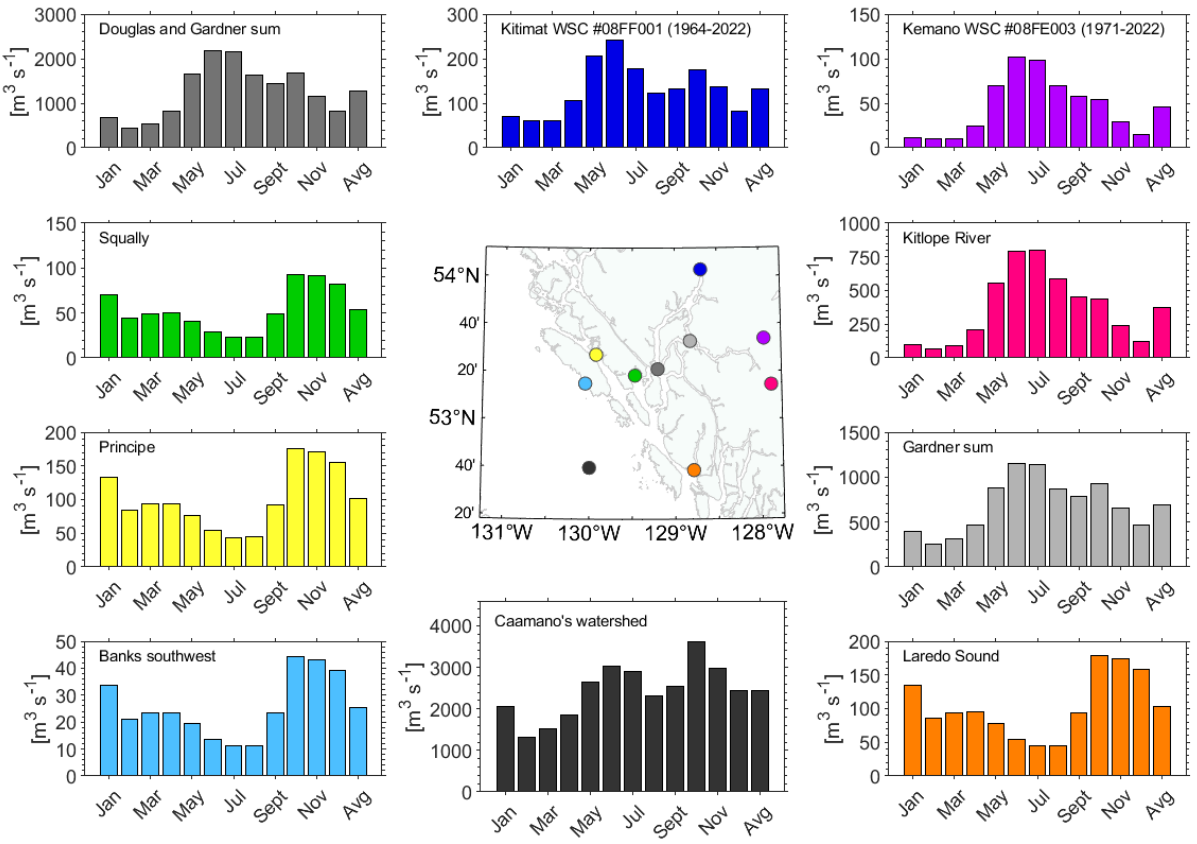

***Figure 19**. Summary of estimated climatological monthly mean freshwater runoff into Caamaño Sound based on Morrison et al. 2012 or historical averages measured by the Water Survey of Canada (WSC). The total runoff reconstructed for Caamaño Sound's watershed is shown in the bottom panel (Morrison et al. 2012). The remaining figures give per-watershed runoff, with the markers showing a central location of the watershed. Note the differing scale between the different panels. The Kemano Water Survey of Canada Station is upstream of the powerhouse and thus excludes the additional 100 m^3/s of water that flows from the Nechako reservoir.*

3.2.3.3 Tides

Tides in the region are classified as mixed with larger amplitudes associated with the semi-diurnal (twice/day) constituents than the diurnal (once/day) ones. The tidal range increases from 2 to 6 m over the 14-day spring and neap tidal cycles. The main semidiurnal constituent (M2) has an amplitude of 1.4 m in Caamaño Sound. It increases landwards to about 1.6 m in Ursula and Douglas Channels and 1.75 m at the head of Gardner Canal (see Figure 10 of Shan et al. 2020). The main diurnal (K1) constituent is weaker, with amplitudes of about 0.5 m. The K1 constituent's magnitude varies much less than the semidiurnal constituent throughout the system. The K1 tidal amplitudes increase a few cm between the Sound and the head of Gardner Canal. The time required for the tides to reach the head of the channels is short. It takes about 6 min and 4 min for the semidiurnal (M2) and diurnal (K1) tidal wave to travel between Caamaño Sound and the head of the fjord system, respectively (Shan et al. 2020). Tidal variations at higher frequencies (3, 4, 5, and 6 cycles per day) are also present in the measurements in Douglas Channel (Rabinovich et al. 2017). These nonlinear tidal variations are also present in the current measurements in **Lax Ka'gaas**/Campania Sound, Estevan Sound, and Otter Channel and are expected anywhere that constricts the flow and increases friction.

From the analysis in Douglas Channel, much of the measured currents' variability is attributed to the tidal currents. However, wind stress contributes the most to variations in the surface layer (Rabinovich et al. 2017). Near the bottom, a larger proportion of the variance was associated with the tides. The analysis in Douglas Channel further supported the notion that the tides interact with topography and sills to generate internal waves (Webster 1983). The internal wave generation process depends on the background stratification and currents' variability at tidal frequencies (both semidiurnal and higher nonlinear frequencies), so their impact on mixing and vertical exchanges should vary among the seasons. The main contributors to the current variability in the region are thus the tides, winds, and the estuarine circulation supported by the large inflows of freshwater (Webster 1983; Wan et al. 2017)

3.2.4 General estuarine circulation

The water properties in Caamaño Sound and the fjord-estuarine system are tightly connected with those in Hecate Strait. The significant snowmelt and rainfall in the region support an estuarine circulation throughout the year, although the fjord-estuarine system north of **Lax Ka'gaas**/Campania Sound differs from the simplest of estuaries. Without sills, most estuaries can be described as two-layer systems with relatively fresh surface water outflowing towards the ocean, with a deep inflow moving in the opposite direction. The depth-averaged net flow is directed out to sea and equal to the freshwater input. The surface waters become increasingly more saline as they move downstream through the system via the entrainment of deeper water below. In contrast, bottom waters become fresher as they move upstream because of mixing and exchanges with the surface layer above. The depth-averaged salt content increases towards the sea. Strong winds (e.g., storms) and atmospheric cooling may further erode the stratification between the relatively fresh surface layer and deep water below, enabling vertical exchanges across layers.

These exchanges are not limited to heat and salt but include vertical transfers of nutrients and dissolved oxygen across the layers. In many stratified ocean environments, the deepest waters

have relatively low oxygen and are nutrient-rich. This distribution results from the sinking of dead organisms. Their biogeochemical breakdown consumes oxygen while providing sources of nutrients such as nitrate, phosphate, and silicate. In contrast, the surface-most layers of the Caamaño Sound area are relatively oxygen-rich because of their direct contact with the atmosphere. The well-lit surface waters are relatively nutrient-poor, especially during summer, as plankton consumes nutrients. However, rivers and creeks may provide land-based nutrients in the surface layer. When this nutrient supply is low, like in the Caamaño region (Macdonald et al. 1983), the estuarine circulation can replenish some of the lost dissolved oxygen in deeper layers while transporting nutrients toward the surface.

The broad sill at the entrance of Caamaño Sound complexifies the estuarine circulation. It presents an obstacle for dense water to enter from Hecate Strait and generates a third layer in the estuarine circulation. The first is a relatively thin and fresh surface layer (<30 m) that outflows to the ocean above the second intermediate layer. This second inflowing layer has a maximum depth controlled by the sill's depth (~140 m), tides, and mixing processes around the sill. The intermediate layer's lower boundary is typically less than 150 m deep across the region and thinner during summer (Wan et al. 2017 and **Figure 20**). It intrudes into the fjord system year-round and shares similar salinities, temperatures and dissolved oxygen concentration with the source water in Hecate Strait (**Figure 20**). The third, bottom layer, comprises the deepest water on the landward side of the sill, which exceeds 400 m in Caamaño Sound and 600 m in Squally Channel. These fjord waters generally exhibit very weak currents except during the annual renewal event during spring and summer when dense water enters Caamaño Sound for several months (Wan et al. 2017). This renewal begins once downwelling conditions in Hecate Strait relax and is facilitated by the winter "freshening" that reduces the density of intermediate and deep waters throughout the region. Overall, the surface, intermediate and deep waters are strongly connected across the Network Zones.

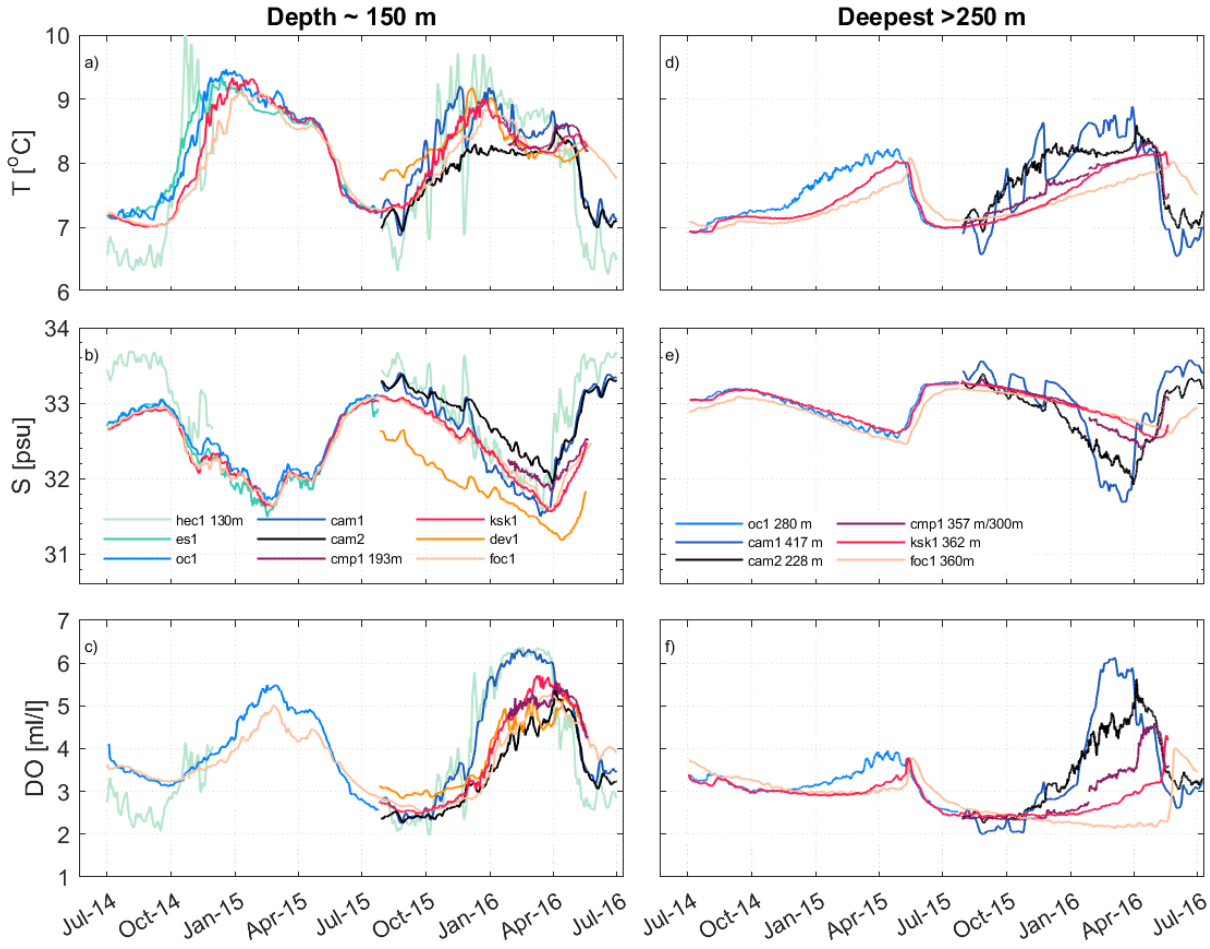

***Figure 20**. Daily moored water properties across the network below the outflowing surface layer presented for two years of the World Class Tanker Safety Programme (Wright et al. 2015, 2016, 2017). The left panels (a-c) are temperature, salinity, and dissolved oxygen (DO) in the intermediate layer around 150-m depth. The right panels (d-f) are the corresponding properties recorded from the deepest sensors throughout the region. The blue-green shades are stations seawards from **Lax Ka'gaas**/Campania Sill, while the warmer magenta-orange shades are landwards from the sill within the fjord system. Figure **11** shows the mooring locations.*

The second sill, in **Lax Ka'gaas**/Campania Sound, complexifies the circulation further in the region. At about 220 m, this sill is deeper than the broad sill at the entrance of Caamaño Sound. However, **Lax Ka'gaas**/Campania Sill isolates further the deepest parts of **Lax Kwil Dziist**/Fin Island, **Maxtaktsm'aa**/Union Passage, Douglas and Ursula Channels (Zones 313 to 316) from Hecate Strait. Temporal variations of the water properties below the surface layer are dampened north of the **Lax Ka'gaas** Sill, especially at time scales shorter than one day. The sill also creates a fourth layer sandwiched between the intermediate layer and the deepest waters below **Lax Ka'gaas** Sill --- located around 150 to 220 m depth. This layer flows towards Hecate Strait in winter rather than landwards like most estuarine systems. This exchange occurs because of Ekman downwelling, atmospheric cooling, and storm-induced mixing in Hecate Strait, which leads to a winter freshening (density reduction) of intermediate and deep waters across the entire region. This reduction of lateral density gradients across the network facilitates

the re-oxygenation of intermediate waters and even deep waters on the landward side of **Lax Ka'gaas** Sill.

Other sills within the network hinder the lateral exchanges of deep water, although some may help redistribute heat, salinity, dissolved oxygen, and nutrients vertically through local mixing processes. For example, Ursula Channel has a maximum depth of 522 m and becomes very shallow at its northern extent, where it meets Verney Passage (**Figure 11**). The 35-m deep sill extends completely across both channels. The tidal currents over the sill are powerful, and the resulting mixing tends to erode the stratification across layers and may even create a relatively well-mixed water column.

3.2.5 Surface connectivity

Modelling and drifter studies indicate that the surface waters are connected year-round throughout the system (Blanken et al. 2020, 2023). Because of the estuarine circulation, the relatively fresh surface water in the fjords flows out to sea. The network of islands and channels within the region provides several pathways for surface waters to make their way toward Hecate Strait. For example, about 60% of the freshwater in Gardner Canal flows towards Douglas Channel, and the remaining 40% goes south through Verney Passage and Ursula Channel (Shan et al. 2019). As a result, surface waters in Douglas Channel are typically fresher and move faster than in Ursula Channel (**Figure 21**), despite the higher freshwater inputs in Gardner Canal than in Kitimat Arm upstream of Douglas Channel (**Figure 19**). An extensive field campaign involving over 200 drifters deployed in spring, summer and fall between 2014 and 2016 showed that the median distance travelled was 105 km seawards over a median time of 7 days at sea (Hourston et al. 2021). However, drifters were as likely to travel 25 km upstream (towards Kitimat), 75 km downstream (towards Hecate Strait), or return to where they started after seven days at sea (Blanken et al. 2020). The combination of the winds, the tides, and the estuarine flow, leads to complex flow patterns, even though the mean surface flow is seaward.

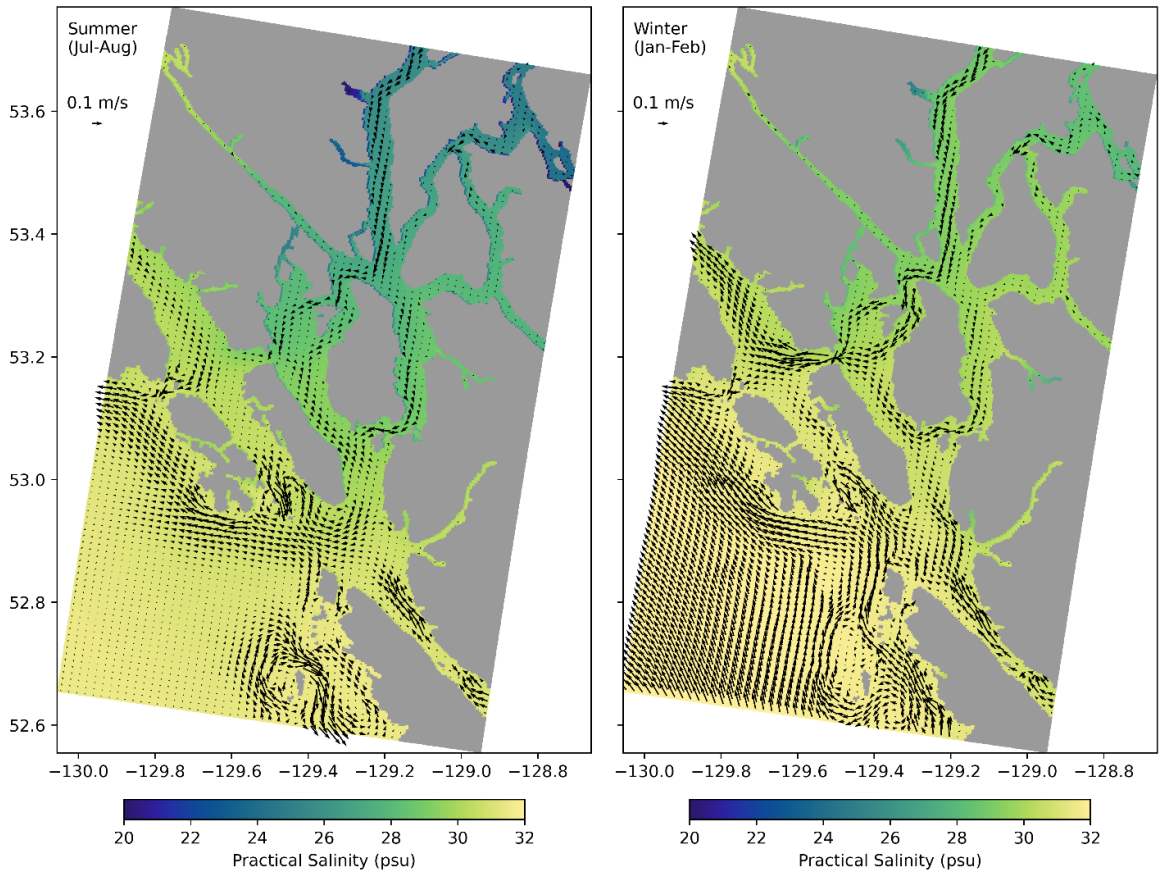

***Figure 21**. Modelled surface currents depth-averaged over the top 20 m of the water column (Blanken et al. 2023) and time-averaged during summer (left panel) and during winter (right panel). The colours indicate the modelled salinities averaged over the same time and depth ranges.*

As the relatively fresh surface layers move south in Douglas (Zone 314) and Ursula Channel (Zone 316), surface waters eventually reach Wright Sound. This sound is north of **K'ts'ats'aas** /Gil Island near **Txałgiu**/Hartley Bay (Zone 314) and connects six channels. The circulation pattern within Wright Sound is likely complex, given the winds funneling through each channel and the six potential pathways for the tides and the currents (sections 3.2.3). Depending on the tidal phase, the wind may arrest the surface outflow throughout the fjords (Wan et al. 2017). The primary pathway for surface water to exit Wright Sound seems to be towards the **Lax Kwil Dziist**/Fin Island (Zone 313) and Squally Channel along the west side of **K'ts'ats'aas**. A second pathway is through Whale Channel on the east side of **K'ts'ats'aas**. Other routes are through Verney Passage and McKay Reach, connecting with Ursula Channel (Zone 316), and another is north through Douglas Channel (Zone 314). In addition, moored current observations (*unpublished*) and drifter studies (Page et al. 2019; Blanken et al. 2020) show that surface water tends to flow northwest from Wright Sound into Grenville Channel towards the entrance of **Maxtaktsm'aa**/Union Passage. Surface drifters deployed in Ursula Channel and Verney Passage tend to flow through Wright Sound into Whale Channel, while those deployed in Douglas Channel tend to flow out of Wright Sound into Squally Channel (Page et al. 2019). In the fall, there was more variability, with drifters deployed near the intersection of Verney Passage and Ursula Channel (Zone 316) occasionally flowing around Gribbell Island or entering

Squally Channel (Zone 313) instead of Whale Channel. In addition, fall drifters in Douglas Channel entered Whale Channel just as often as in Squally Channel. Overall, the drifter observations show more variable surface flow pathways in Wright Sound during fall than in spring and summer (no measurements were collected in winter).

Further south from Wright Sound, surface waters along the east and west side of **K'ts'ats'aas** then exit through two possible routes: Otter Channel and **Lax Ka'gaas**/Campania Sound. The preferred route appears to vary with the seasons. During summer, numerical modelling shows that the upper 25-m of the water column around **K'ts'ats'aas** flows towards **Lax Ka'gaas** Sound (**Figure 21**). Drifters entering Squally Channel also tend to exit through **Lax Ka'gaas** Sound instead of Otter Channel (Page et al. 2019). During late fall and winter, stronger surface currents are present in Otter Channel than in **Lax Ka'gaas** Sound (**Figure 22**). In winter, the surface water along the east side of **K'ts'ats'aas** flows towards **Lax Ka'gaas** Sound, while the water along the south and west side of **K'ts'ats'aas** flows towards Otter Channel (**Figure 21**). During an extensive fall campaign in 2015, no drifter travelled along the south side of Gill Island (Page et al. 2019). Those entering Whale Channel exited through **Lax Ka'gaas** Sound, while those travelling along the west side of **K'ts'ats'aas** remained trapped within Zone 313 or exited through Otter Channel.

Once the surface water exits the fjord system, it becomes more sensitive to the prevailing winds in Hecate Strait, the earth's rotation, and topographical features. Within the Estevan and Dewdney and Glide Islands Network Zones (311 and 312), surface waters are more likely to originate from **Lax Ka'gaas** Sound than from Otter Channel (Page et al. 2019). In winter, the prevailing northwards currents cause this flow pattern, while in summer, it is due to the stronger surface outflows through **Lax Ka'gaas** Sound relative to Otter Channel (**Figure 21**).

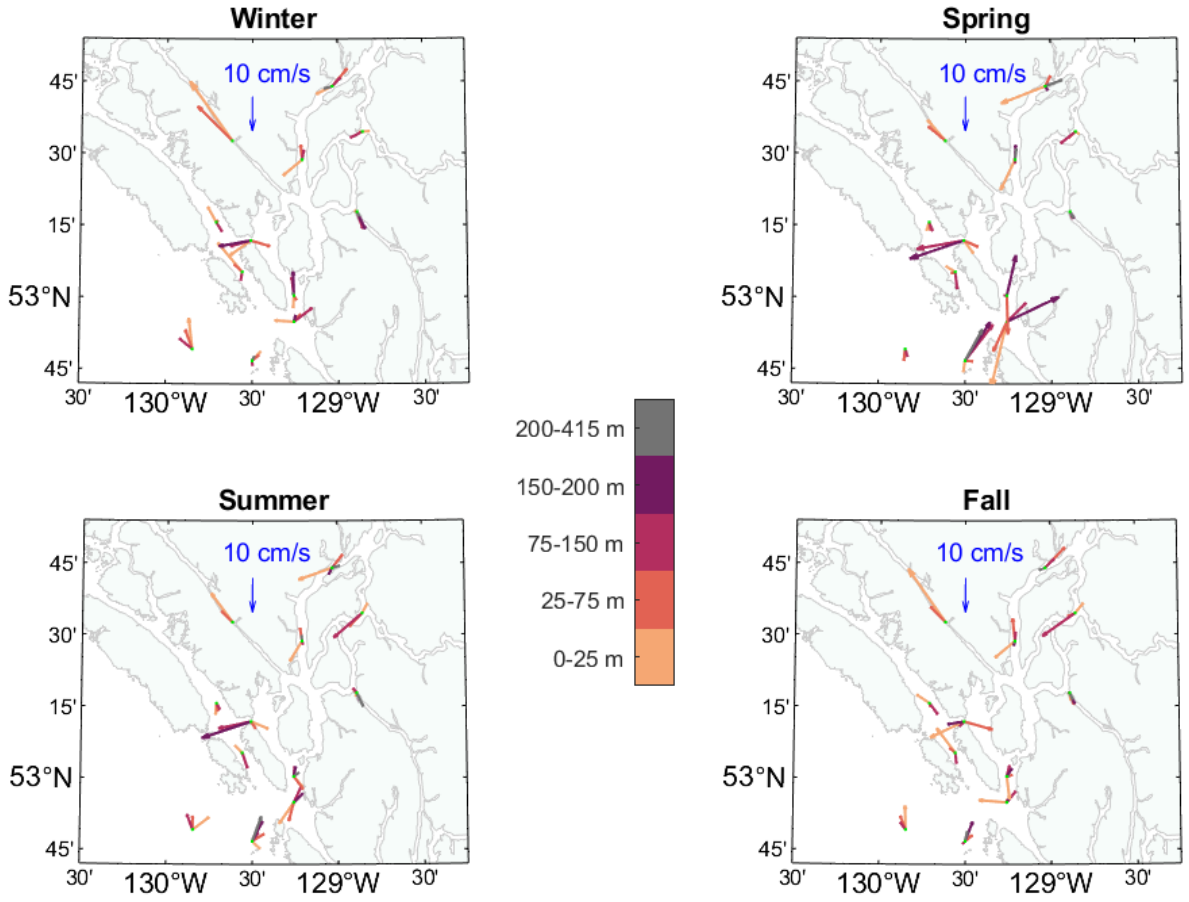

***Figure 22**. Median currents (arrows) from principal component analysis on a seasonal basis. The winter, spring, summer, and fall months include January to March, April to June, July to September, and October to December, respectively. The different colours indicate the depth ranges used for the analysis, provided the measurements cover at least 40% of the depth range. These analyses were done on one year of continuous currents measured between 2014 and 2016 for the World Class Tanker Safety Programme (Wright et al. 2017), except for those in Grenville and Princess Channel collected from 2019 to 2020.*

In Caamaño Sound (Zone 310), surface waters originate mainly from the fjord-estuarine system exiting through **Lax Ka'gaas** Sound, although some freshwater will come from Laredo Channel (**Figure 21**). This channel has significant freshwater inputs (**Figure 19**), with surface waters flowing toward Caamaño Sound throughout the year. Zone 310 has the most spatially variable surface currents, especially along the west coast of Aristazabal Island (**Figure 21**). The modelled surface waters flow persistently counter-clockwise between Aristazabal and the Moore Islands (Blanken et al. 2023), as the rotation of the Earth forces the current to flow with shallower topography to its right in the northern hemisphere. This flow feature strengthens over the winter. The model also predicts surface water to be transported clockwise around Moore Islands (**Figure 21**). Thus, on the west coast of Aristazabal, surface water typically enters from the west through Willis passage or **Lax Ka'gaas** Sound as surface water moves south through Rennison and Aristazabal Islands (Zone 310), as confirmed by drifter tracks (Page et al. 2019).

3.2.6 Surface water properties from satellite imagery

3.2.6.1 Analysis methods

Sea surface temperature (SST) and chlorophyll-a concentration are Essential Ocean Variables (WMO, 2016) monitored by satellites for operational purposes. Remotely sensed SST is often called “skin temperature” since it represents a thin surface ocean layer. These measurements help monitor long-term trends and events such as Marine Heatwaves (MHW). Chlorophyll-a concentration (Chl-a), another parameter measured by optical satellites, is used as a proxy for phytoplankton biomass and can be used to monitor phytoplankton phenology in the upper ocean.

Several studies have analyzed remotely sensed SST and Chl-a in the BC Exclusive Economic Zone (i.e., Clay et al. 2019; Hardy et al. 2021), but few summaries have addressed the fjords and narrow inlets in the Caamaño-Douglas area due to limitations in spatial resolution. The Caamaño Sound and Douglas Fjord System Network Zones have a wide range of surface areas (see **Table 2**). Thus, satellite data from multiple sources with different spatial resolution were compared and summarized for each potential Network Zone. For example, the open-ocean Caamaño Sound Zone (311), as well as **Lax Kwil Dziist**/Fin Island (Zone 313) and Douglas Channel (Zone 314), can be at least partially resolved with moderate-resolution (e.g., 300-4000 m per pixel resolution) satellite sensors that revisit frequently (i.e., daily) the region. However, the smaller Zones require higher spatial resolution in order to resolve surface ocean features.

Higher resolution SST are available from the Thermal InfraRed Sensor (TIRS) sensor on the Landsat-8 satellite, in operation since 2013 and the TIRS-2 sensor on Landsat-9, which was launched in October of 2021. These sensors acquire images at 100 m spatial resolution which is extrapolated to the 30 m resolution grid of the Operational Land Imager (OLI) instrument mounted on the same satellite. This higher spatial resolution enables imaging the dynamics and SST fronts within the fjords and across the inlets' channel width, and validation studies in other regions have shown accurate satellite SST measurements when compared to *in situ* surface temperatures (Vanhellemont 2020), especially during windy and clear conditions (Jang and Park 2019). A drawback of these datasets, however, is their low imaging frequency. Landsat-8 alone acquired images of the Caamaño-Douglas area at minimum every 5 days, and on average every 10 days. Overall, the Caamaño-Douglas area had some visibility of the ocean surface on average every 15 days because of the region's low number of clear, cloud-free days. Nevertheless, with the inclusion of Landsat-9, the temporal coverage has increased significantly in the last two years, with images acquired multiple times per week.

The region’s results from TIRS and TIRS-2 can also be compared against the MODerate Resolution Imaging Spectroradiometer on the Aqua satellite (MODISA) which images the region on a daily basis at 1100 m per pixel spatial resolution. The areal statistics for Zones 311 (Dewdney), 310 (Caamaño), 313 (**Lax Kwil Dziist**/Fin Island), and 314 (**Txałgiu**/Hartley Bay/Douglas Channel) from MODISA were very similar to those from TIRS, except in winter where MODISA’s temperatures were generally higher (where, in this region MODISA’s SSTs in February were on average ~1.6^{o}C warmer than TIRS). MODISA spatial resolution is thus sufficient for monitoring the larger Network Zones. When also comparing TIRS SSTs to buoy temperature measurements, there was a slight cold bias (< 1 ^{o}C), indicating that more comparison is needed.

Finally, satellite SSTs were correlated with the **Lax Kul**/Bonilla Island lighthouse station, where daily water temperature measurements have been taken from shore for nearly a century. While **Lax Kul**/Bonilla Island is outside of the Caamaño-Douglas area, the daily surface temperature is highly correlated with Zones 310, 311 and 312 respectively (Caamaño Sound, Dewdney and Glide Islands, and Estevan Island); the agreement slightly declines moving inward from the Outer Coast Zones. In both the satellite and in-water SST measurements from this area the impacts of “the Blob” were evident when the minimum temperature reached during winter was warmer than the climatological minimum.

3.2.6.2 Spatial surface temperature patterns

The surface flow patterns discussed in section 3.2.5 are visible in individual remotely sensed SST images (e.g., **Figure 23**). In particular, the summer SST satellite images show warmer water in the northern inlets and fjords (Zone 316 and 314) compared to the lower-lying outer regions (Zone 310 to 312). Within the warmer fjords, sill-induced mixing is also noticeable in the observations. Surface waters in Ursula Channel and Verney Passage are colder than those just west in Douglas Channel (314), whose sill is much shallower --- 200 m at its northern end compared to 35 m in Ursula Channel (316; **Figure 11**). The cold water generated by sill-mixing in Ursula tends to flow seawards because of the estuarine circulation, which explains the colder surface water southeast of the sill than north of the Ursula Channel Network Zone (**Figure 23**). As surface waters move seawards, the surrounding topography progressively lowers, allowing the stronger offshore winds (**Figure 17**) to enhance exchanges between the surface layer and water below. These exchanges make surface waters colder in Wright Sound, Squally Channel and Whale Channel than in Douglas and Ursula Channels (**Figure 23**). Eventually, surface waters exit into Caamaño Sound via Otter Channel and **Lax Ka'gaas**/Campania Sound, where the impact of sills is again notable as water is colder seaward of the sills than landwards. The local topography is even lower-lying and shallower than in Squally and Whale Channels, contributing further to cooling surface waters. However, further offshore into Hecate Strait, the ocean surface is warmer than in the Caamaño, Dewdney and Glide Islands, and Estevan Island groups Network Zones. The region’s ocean conditions are distinctly different from Hecate Strait because of the freshwater outflows, vertical mixing from sills and internal waves, and locally-varying winds.

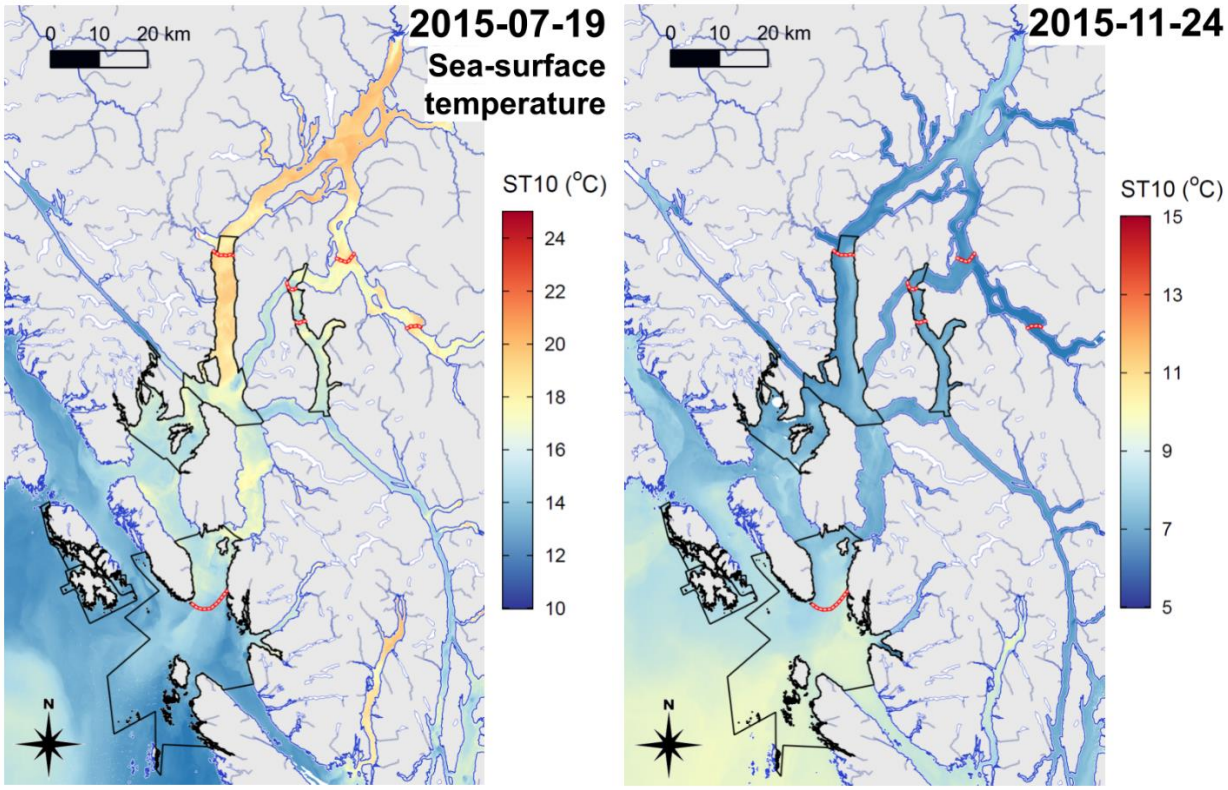

***Figure 23**. Landsat-8 TIRS SST image from July 19th, 2015 (left) and November 24th, 2015 (right; note the differing colour scales). The red lines indicate sills, and the black line outlines the Network Zones.*

3.2.6.3 Sea surface temperature monthly statistics across the Zones

The long-term monthly statistics of SSTs show similar trends to the daily snapshots. During summer, the SSTs in the outer regions (311 Dewdney, 312 Estevan, 310 Caamaño Sound) are lower than the Inner Fjord Zones, particularly when compared with Douglas Channel and the very shallow **Maxtaktsm'aa**/Union Passage (**Figure 24**). Ursula Channel is slightly colder than Douglas Channel and **Maxtaktsm'aa**, albeit still warmer and more variable than the outer regions during summer.

The annual variability also differs amongst Zones. The outer regions (311 Dewdney and Glide, 312 Estevan, 310 Caamaño Sound) have the lowest variability over the year and have similar monthly SSTs (monthly average SST differences <= 0.75°C). The summer temperatures in the Outer Coast Zones peak in July and are lower than in the Inner Fjord Zones. These three Outer Coast Zones are also the warmest SSTs during winter (i.e., Zone 310, Caamaño Sound, had an average SST in February of 5.2°C followed by Zones 312 Estevan and 311 Dewdney at 4.7°C) owing to the lower air temperatures compared to the Inner Fjord Zones (**Figure 18**).

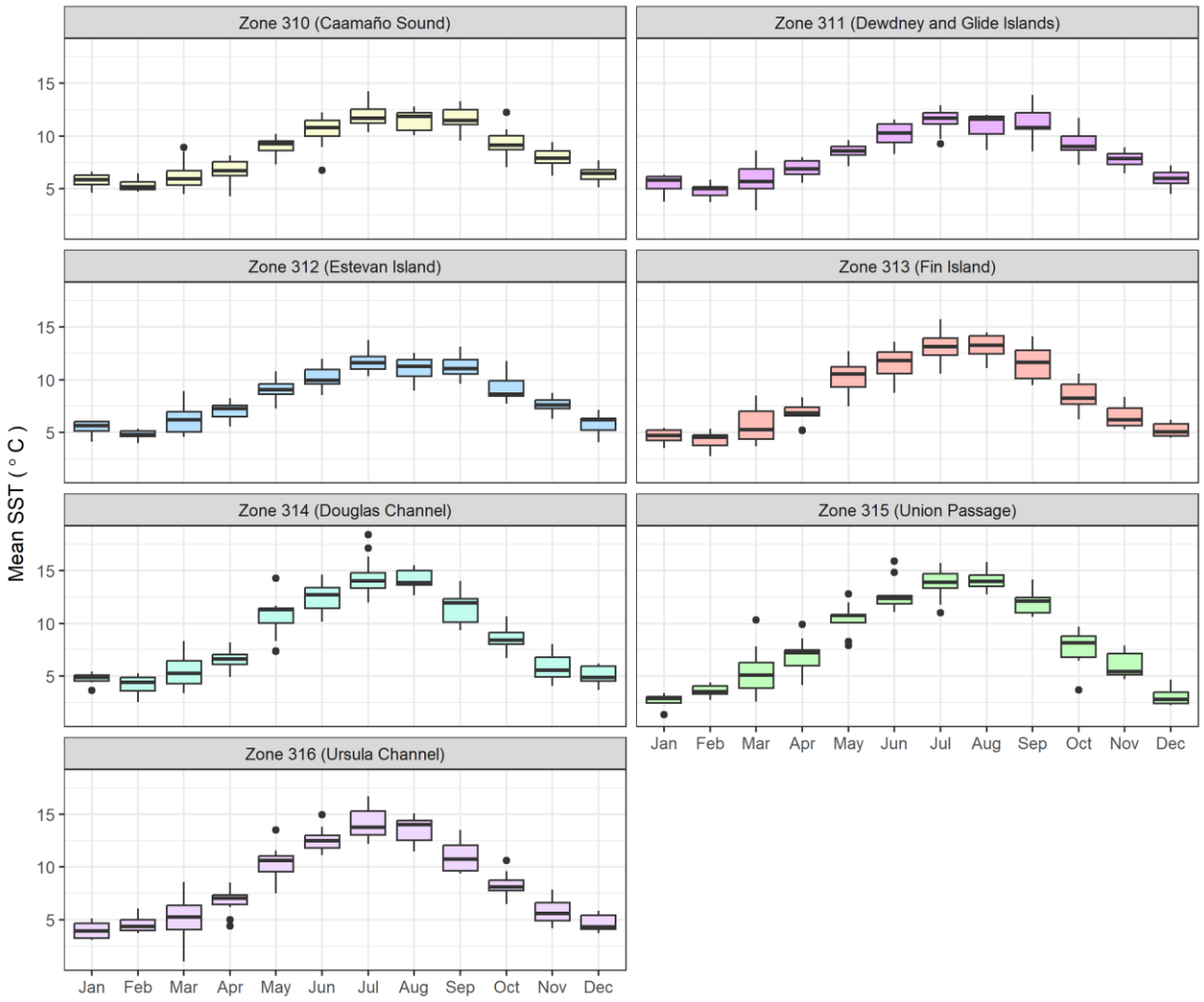

Figure 24*. TIRS SST climatology of the Zones, with boxplots indicating the monthly range of Zone mean daily ocean surface temperature spanning 2013-2022.*

The SST climatology of the Inner Fjord Zones fluctuates based on size and distance from Hecate Strait. For example, Zone 315 **Maxtaktsm'aa**/Union Passage is small and shallow, leading to significant temperature variations. Of the four Inner Fjord Zones, the climatologies are divided into pairs; Zones 313 and 314 (**Lax Kwil Dziist**/Fin Island and Douglas Channel) are physically connected and have very similar SST during winter, though 314 (Douglas Channel) is >0.5ºC warmer during July and August. These Zones reach their SST minimum in February. On the other hand, Zones 316 (Ursula Channel) and 315 (**Maxtaktsm'aa**/Union Passage) have the coldest SSTs occurring in January (mean of 2.6ºC and 3.8ºC, respectively).

Of all seven Zones, 314 (Douglas Channel) and 316 (Ursula Channel) reach the highest temperatures in July, on average 14.2ºC, with Douglas Channel remaining high in August while 316 begins to decline. Zone 315 (**Maxtaktsm'aa**/Union Passage) peaks in August and is typically slightly warmer than Ursula Channel this month.

3.2.7 Intermediate and deep-water exchanges

3.2.7.1 Salinity and dissolved oxygen

Exchanges between the deeper layers and the well-lit surface layer constantly occur throughout the year because of vertical mixing processes such as shear-induced entrainment, sill-induced mixing, and mixing from wind and waves. During the intermediate waters' winter freshening intruding into the fjord system, dissolved oxygen is transported into the deeper layers, but the transport rate weakens landwards from **Lax Ka'gaas**/Campania Sill (Zone 310). This transport increases dissolved oxygen concentrations over time on the seaward side of **Lax Ka'gaas** Sill. Still, it is insufficient to replenish the oxygen consumed far from **Lax Ka'gaas** Sill (e.g., Zone 314 Douglas Channel, **Figure 20**). Therefore, the deep fjord waters depend on an annual renewal event to replenish some of the consumed oxygen.

This renewal begins in late spring when the deep and intermediate waters are at their freshest, and highest in dissolved oxygen throughout the whole region (**Figure 20**). The prevailing winds change direction in the Northeast Pacific, and the downwelling-favourable conditions in Hecate Strait subside (**Figure 16**). Because of the winter freshening, the deep water throughout the Network has become relatively less dense than the water on the shelf. Hence, dense water from Hecate Strait can more easily flood the deepest portions of Caamaño and **Lax Ka'gaas** /Campania Sounds (**Figure 22**). This dense water is relatively cooler, saltier, nutrient-rich, and relatively oxygen-poor than water on the shelf during winter. The density current nonetheless “flushes” the accumulated oxygen into the intermediate waters down into the deepest layers of Douglas Channel (ex: KSK1 in Zone 314, and FOC1 north of Zone 314, **Figure 20**). Over a few months, the density current continues to bring shelf waters into Douglas (Zone 314) and Ursula Channels (Zone 316; **Figure 22**). By the end of spring, the deep fjord waters in Douglas Channel (and Ursula) have reached their highest salinity and dissolved oxygen concentrations (**Figure 20**). These deep waters have been completely renewed.

During summer, intermediate waters on the network are still connected with Hecate Strait. Water salinities continue to increase until late summer, while temperature and dissolved oxygen decrease throughout the region (**Figure 17**). However, the deepest fjord waters become more isolated. The salinity remains relatively constant over time, while dissolved oxygen drops at its fastest rate of the year because of the utilization by biological processes such as biological respiration, bacteria consumption, etc. (Hannah et al. 2024). In fall, the freshening cycle of intermediate and deep fjord waters begins again. The intense winter mixing on the shelf, followed by a spring renewal event, prevents the deep fjord waters in **Lax Kwil Dziist**/Fin Island (Zone 313), Douglas Channel (Zone 314), and Ursula Channel (Zone 316) from becoming anoxic despite being isolated throughout parts of the year.

3.2.7.2 Nutrients

The sill-induced mixing and spring lateral exchanges in **Lax Ka'gaas**/Campania Sound impact the nutrient composition of the fjord waters, especially the deepwater below the sill depths. The availability of nutrients, such as nitrate, phosphate, and silicate, in the well-lit surface layer depends on whether deep nutrient-rich waters can be transported upwards locally and on the nutrient composition of shelf waters in Hecate Strait. The inflowing intermediate layer transporting waters from Hecate Strait into the region tends to generate a subsurface nutrient minimum within the fjord system (Macdonald et al. 1983), particularly at locations closest to **Lax**

Ka'gaas Sill (**Figure 25**). Nutrient inputs from land-based sources are generally low (Johannessen et al. 2015), but their presence is perceptible in the ratios of phosphate and silicate with nitrate. Phosphate and silicate represent a more significant proportion of the total nutrients towards the head of Kitimat and Gardner Canals, given the large river discharges (Macdonald et al. 1983).

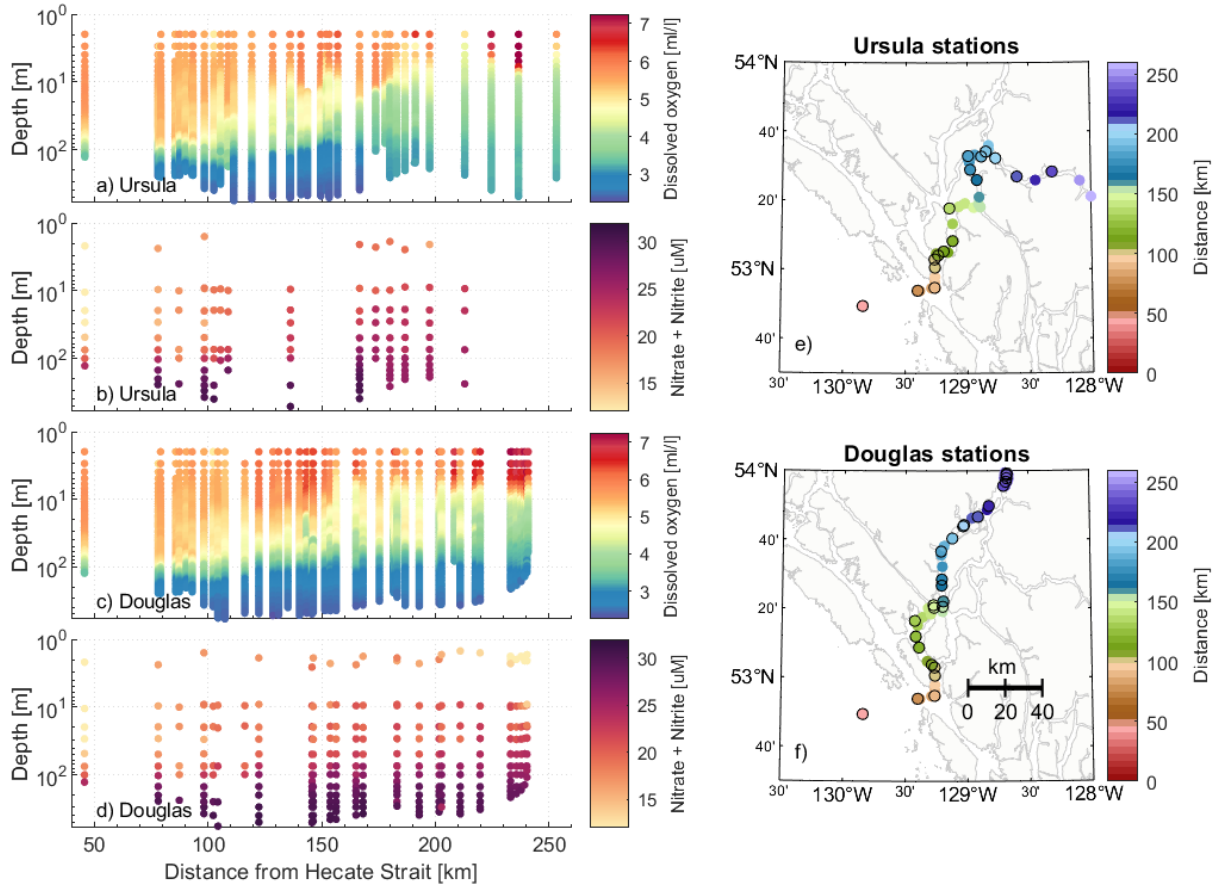

***Figure 25**. Dissolved oxygen (a and c) and nitrate+nitrite concentrations (b and d) during fall for two separate transects during the extensive field campaign undertaken in October 2015 (Wright et al. 2017). Panels a and b relate to measurements collected through Whale and Ursula Channel illustrated by the station map in panel e. Panel c and d pass through Squally and Douglas Channel, as shown by the station map in panel f. The stations circled in black indicate when nutrient bottles were collected.*

The primary sources of nutrients in the surface layer are mostly from vertical mixing processes, either entrainment from the deeper, nutrient-rich layers or tidal mixing at sills throughout the network of fjords. There are more nutrients in the deep fjords than Hecate Strait at comparable depths (**Figure 25** b,d). Nutrient concentrations in the Caamaño-Douglas region are more tightly coupled with salinity than temperature since salinity is the main contributor to density. During winter, there are unstable temperature gradients making it a poor predictor of water properties. The sill at the northern end of Ursula Channel (Zone 316) and the intersection between Gardner and Devastation is highly turbulent from the strong tidal flows passing through. These processes allow for large exchanges across layers. For example, during an extensive field campaign at the end of fall 2015 (Wright et al. 2017), the surface waters at the northern end of Ursula Channel

(Zone 316) were relatively cooler, saltier, lower in dissolved oxygen, and nutrient-rich than at the southern end (**Figure 25**). Below the surface, at around 100 m depth, the dissolved oxygen (nutrients) was higher at the north end than at the south end of Ursula Channel. Oxygen is replenished at depth, while nutrients are transported into the well-lit surface layers. These spatial variations are less striking within Douglas Channel (Zone 314), partly because of the less dramatic sill-induced tidal mixing from its much deeper sill. Elevated nutrients are measurable in Wright Sound near **Txałgiu**/Hartley Bay in Douglas Channel (Zone 314), most likely because of the high mixing at the junction of Ursula and Verney Passage. Ursula Channel is expected to have higher primary productivity because the mixing processes at its northern sill help nutrients reach the euphotic zone (Macdonald et al. 1983).

3.2.7.3 Interannual variations

The renewal's impact on deep water properties landwards of **Lax Ka'gaas**/Campania Sill varies from year to year. For example, north of Zone 314 (Douglas Channel), the increase in dissolved oxygen during late spring was more pronounced during 2016 than in 2015 (e.g., **Figure 20**, foc1). There was also a significant drop in nutrient concentrations after the 2016 renewal. Each renewal shifts the relationship between salinity and other water properties such as temperature, nutrients, and dissolved oxygen (**Figure 26**). These shifts indicate inter-annual variations in the deep waters' composition. The composition reflects the mixture of spring water entering from Hecate Strait over **Lax Ka'gaas** Sill during spring, the previous winter's intermediate layer flushed out during the renewal, and the deep-water composition before renewal. The nutrients and dissolved oxygen properties would also vary between renewal events because of biogeochemical cycling. It's unclear which of these processes drives the most water properties changes in the deepest waters landward of **Lax Ka'gaas** Sill. What's certain is that anoxic conditions do not develop in these deep waters, unlike many other fjords worldwide. The main factors that prevent anoxic conditions from developing are the following, although not in this particular order:

- Significant freshwater inputs that can support an estuarine circulation throughout the year, in particular during the stormy winter.

- Downwelling and stormy conditions in Hecate Strait capable of mixing down highly oxygenated and relatively fresh surface waters into the intermediate layer.

- Entrainment from the estuarine circulation that gradually reduces deep lateral density gradient across the network of fjords and channels through the continual vertical exchanges between the intermediate and deep layers.

- "Downwelling relaxation" enables relatively dense water to arrive on the shelf during spring. The dense inflows across Caamaño Sound's entrance may have low oxygen content, but they mix down intermediate waters that have accumulated oxygen throughout the winter.

It's currently unclear whether the higher oxygen content in the dense inflows relative to the bottom waters prevents anoxia throughout the Douglas Fjord System. However, the water

composition in Hecate Strait does influences water properties below the outflowing surface layer throughout the Network Zones.

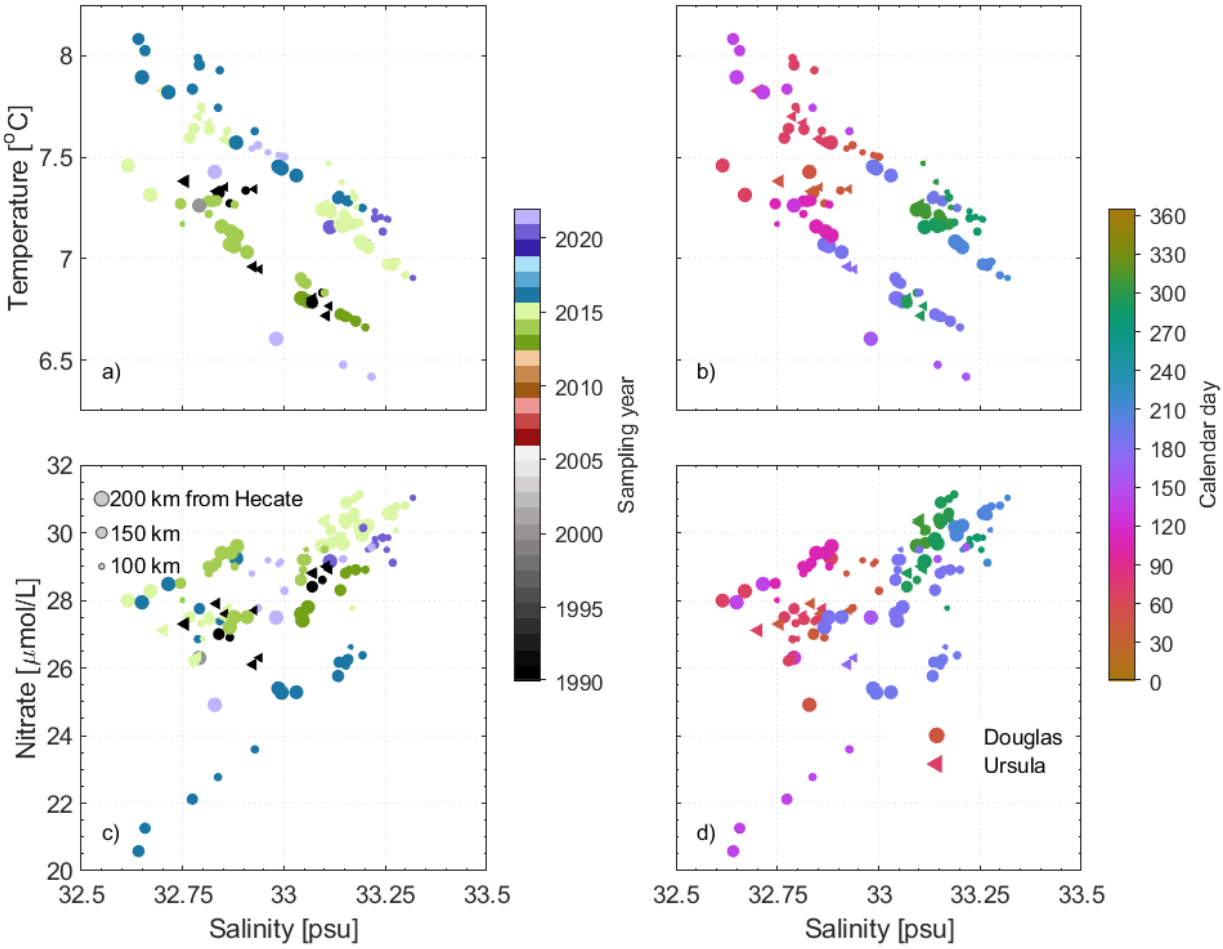

***Figure 26**. Property diagrams of (a-b) of potential temperature (at atmospheric pressure) and (c-d) nitrate+nitrite illustrated against salinity. Only bottle samples below 350 m depth are shown for stations along either transect shown in **Figure 25**. Data in the left panels are coloured by year, with the black ones being from the late 1970s (Macdonald et al. 1983). Data in the right panels are coloured by calendar day (season) to illustrate the timing of when water properties change because of the late spring/early summer renewals. The size of the symbols indicates the landward distance from Hecate Strait as per the maps in **Figure 25**. Nitrate and oxygen are presented against salinity as it's the main contributor to density along the BC coast.*

3.2.8 Plankton and suspended particles

3.2.8.1 Phytoplankton

Phytoplankton samples have been collected at numerous stations in the Caamaño-Douglas area since 2013 as part of the World Class Tanker Safety Program. Wright et al. (2015, 2016, 2017) summarize the cruises and sampling. Most of the phytoplankton stations were located

throughout Douglas Channel, Gardner Canal and Squally Channel, with some stations adjacent to the **Lax Kwil Dziist**/Fin Island (Zone 313) in Squally Channel and Wright Sound and others north of Zone 314 (Douglas Channel Zone boundaries), e.g., DOUG4 near the head of Douglas Channel and FOC1 (**Figure 11B**). Phytoplankton samples were also collected near Zone 316 (Ursula Channel) within Devastation Channel and Verney Passage. Another station in Hecate Strait (HEC1), near the Network Zone 310 (Caamaño Sound), was also sampled multiple times during these cruises.

Some phytoplankton species were present during all sampling cruises. For example, unidentified Choanoflagellates, although not photosynthetic, were present in almost all samples in varying concentrations. Flagellates from the genus, *Teleaulax* spp., were typically the most abundant species throughout all stations and samples. Flagellate, centric diatom, and pennate diatom species varied throughout the samples across seasons. Freshwater species were observed at many stations, with the greatest diversity near Gardner Canal's head. For example, during a month-long cruise in October and November 2015, many stations were visited multiple times, which detected freshwater species throughout the Network Zones extending to the offshore station at HEC1.

During the sampling years, diatom counts were generally low in the autumn and winter. However, in October 2014, many centric diatoms and flagellate species were present at stations in the Douglas Channel. *Rhizosolenia setigera* ranged from 26 Cells /mL at DOUG4 to more than 1100 Cells / mL at FOC1. The observed diatom species were typically highest in the March and May cruises. Diatoms were also observed during the summer of 2015, with the highest number of pennate species observed at station HEC1 (west of Zone 310). In July 2015, more than 300 Cells / mL of *Leptocylindrus minimus* were observed near the head of Douglas Channel (DOUG4). Annual variations also exist, with more centric diatoms observed in July 2016 than in July 2015, with *Pseudo-nitzschia* spp. present throughout the sampled stations.

In May 2016, a *Skeletonema spp.* bloom occurred at all stations except at Gardner Canal's head. Though, the highest counts (~2000 to > 14,000 Cells / mL) were within 50 km of the Canal's head (GC57 and GC31). This species was observed throughout the rest of the Caamaño-Douglas area during this cruise. *Skeletonema* spp. were also observed earlier in the previous year (March 2015) at four stations ranging from 0.4 to > 600 Cells / L, coinciding with *Pseudo-nitzschia* spp. observed at the same stations (7 to >50 Cells / L), the highest counts being just south of the **Lax Kwil Dziist**/Fin Island groups Network Zone 313 in Squally Channel (station SC61).

Satellite measurements provide longer-term trends and higher temporal resolution than field sampling. These measurements use chlorophyll-a (Chl-a) as a proxy for phytoplankton biomass in the upper optical depth of the ocean. Chl-a (in mg m^{-3}) was calculated from satellite data using the OC3 band-ratio algorithm for the satellite sensors mentioned in section 3.2.6.1 for SST. The Landsat-8 and Landsat-9 optical bands can produce Chl-a images concurrent with these SST images. Like the remotely-sensed SST, the Caamaño-Douglas area is challenging for satellite imaging of Chl-a. Although, optical satellite measurements are typically more negatively impacted by clouds, topographical shadows, and glint than the SST bands. There were larger discrepancies when comparing the Landsat to MODISA Chl-a than with the SST, so the Chl-a products from Landsat-8 and -9 Chl-a were compared to *in situ* samples collected further south near Vancouver Island.

Additionally, images from November, December and January were discarded because of the low sun angle and long shadows cast by the nearby topography onto the fjord's surface waters. For regional statistics, the geometric mean and standard deviation factor were calculated due to the log-normal distribution of chlorophyll-a in oceanic waters. Here, Chl-a is represented by month with boxplots showing each region's quartiles and outliers from the time series (**Figure 27**).

As phytoplankton events are spatially and temporally sporadic, consistent patterns (like in the SST data) are harder to retrieve. However, the outer regions near Hecate Strait had lower Chl-a consistently throughout the year than the Inner Fjord Zones (**Figure 27**). Douglas Channel and Ursula Channel, in particular, showed a recurring pattern of higher Chl-a later in the summer than the outer regions. On average, Douglas Channel (Zone 314) had its highest Chl-a in August, while Ursula Channel (Zone 316) peaked in July. Chl-a in **Maxtaktsm'aa**/Union Passage (Zone 315) and Dewdney and Glide (Zone 311) peaked in May. The values in the Caamaño-Douglas area are consistent with the satellite-retrieved Chl-a (Jackson et al. 2015). However, that study used coarser resolution imagery which cannot provide reliable measurements for the inlets.

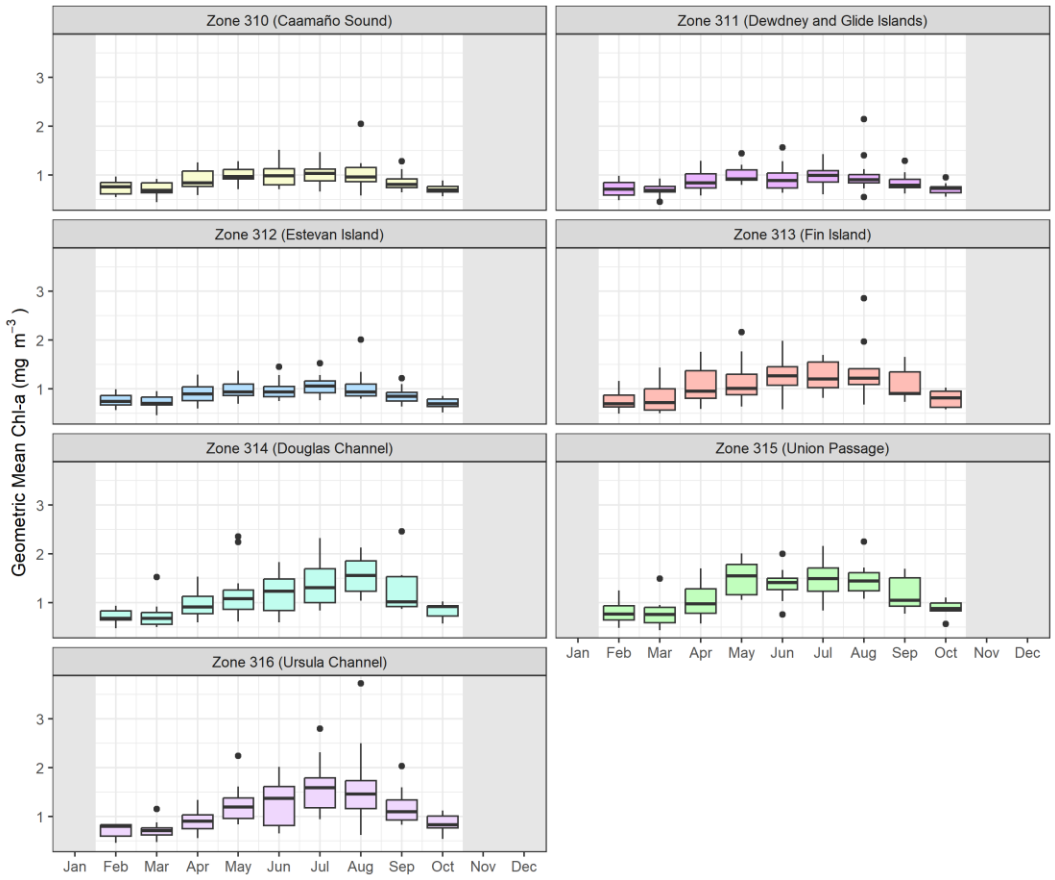

***Figure 27**. Boxplots of monthly Landsat-8 OLI Chl-a from the period 2013-2022. Chl-a observations in January, November and December were excluded because of the low sun angle and shadows cast by the surrounding topography on many of the Network Zones.*

Satellite images across the Caamaño-Douglas area captured large phytoplankton blooms. For example, **Figure 28**, acquired on July 19, 2015, demonstrates the high spatial variability of biomass throughout the region's surface waters. Nearby, in Finlayson Channel, the satellite estimated a very high biomass event with concentrations exceeding 20 mg m^{-3}. Similarly, a satellite image acquired one week before the *Skeletonema costatum* event captured by the in-situ phytoplankton sampling (May 2016) shows high Chl-a in many Network Zones.

Other years with significant localized events in the system include 2017, where Chl-a increased rapidly in the final week of July in Ursula Channel (Zone 316), Douglas Channel (Zone 314) and **Maxtaktsm'aa**/Union Passage (Zone 315). The following year, a high Chl-a event (Chl-a > 1 mg m^{-3}) was observed in many of the regions in mid-May, followed by a high Chl-a event in **Lax Kwil Dziist**/Fin Island (Zone 313) and Ursula Channel (Zone 316) later in mid-August.

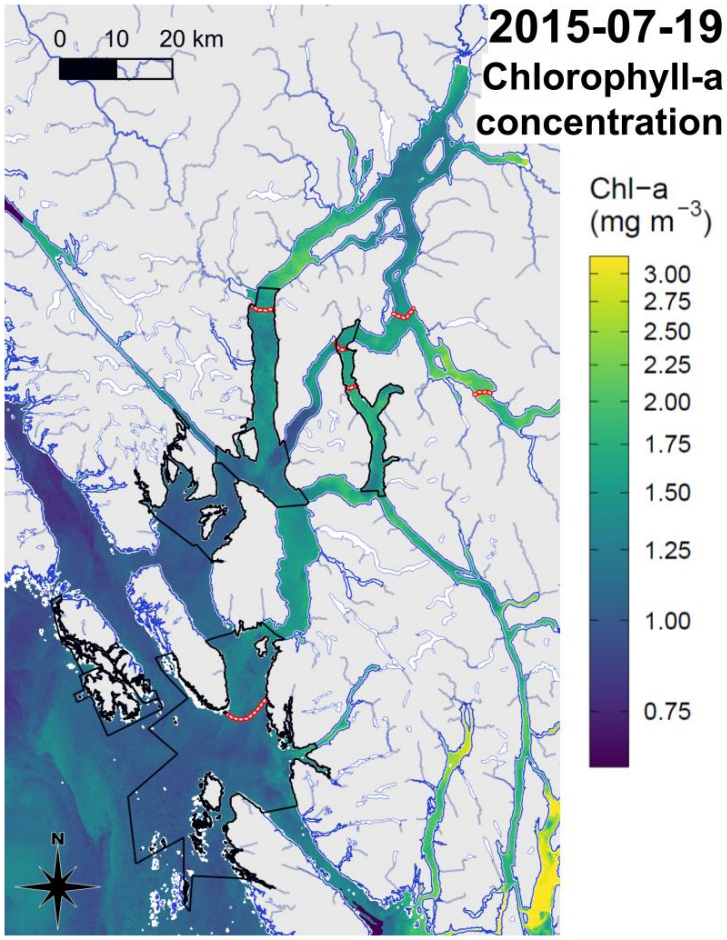

***Figure 28**. Landsat-8 OLI Chl-a image from July 19th, 2015. The red lines indicate sills, while the black lines outline the Network Zones. Chl-a in the southeast, in Finlayson Channel, is high due to an exceptional bloom that year.*

3.2.8.2 Suspended and sinking particles

Particles suspended in surface water can provide food for zooplankton, reduce the intensity of underwater light, and, in very high concentrations, act as nuclei for oil-particle aggregates. In the Inner Fjord system, particle concentrations are generally low, except at the mouths of rivers and following heavy rainfall. Concentrations estimated from satellite imagery were generally lower (average 0.5 - 2 g m^{-3}; Lazin et al. 2017) than those measured in situ (6-9 g m^{-3}; Johannessen et al. 2020). Both satellite and in situ data found occasional very high values (50-60 g m^{-3}) nearshore following heavy rain. These concentrations are several orders of magnitude lower than those re to form oil-particle aggregates, implying that it would be unlikely for particle aggregation to cause spilled oil to sink in this area (Johannessen et al. 2020).

Organic and inorganic particles settle through the water column, giving rise to a kind of underwater weather. The rain of particles varies from daily to seasonal timescales. It is affected by events in the atmosphere (rainstorms, windstorms); on land (snowmelt, river discharge, erosion); and in the surface ocean (blooms of phytoplankton, zooplankton, and jellyfish). Sinking particles have not been measured in Caamaño Sound, but the seasonality there is likely similar to that measured in the nearby Douglas Channel using sediment traps during 2013-2016 (Johannessen et al. 2019).

In Douglas Channel, the maximum flux of sinking particles coincided with the summertime peak flow of the local snow-fed rivers in the first year of deployment (Johannessen et al. 2019). However, in the second year, a marine heat wave brought heavy rain to the fjord system in October 2014, resulting in a heavy rain of particles that lasted for a month. Future heat waves and warming could increase the frequency of such events. In December – January of 2014-15, a heavy flux of mainly-empty phytoplankton frustules marked a large winter phytoplankton bloom. The empty frustules suggested that the bloom was supported by plentiful silicate washed in from the land, while the other nutrients were in short supply and were recycled rapidly near the surface (Johannessen et al. 2019).

3.2.8.3 Zooplankton

Zooplankton distribution and abundance in the NSB is less studied than in the Southern Shelf and Strait of Georgia bioregions that for decades have had sustained monitoring through La Perouse Program and the Strait of Georgia Program. The best-studied part of the NSB is the southern end of Queen Charlotte Sound, where the La Perouse program has made routine measurements twice a year since 1990. However, the DFO Pacific plankton program has been able to piece together a zooplankton time series (1980 and 2000-present) in the Network Zones from various sources (

Table 7, **Figure 29**). For instance, this synthesis includes zooplankton abundance from in-depth oceanographic surveys in the region during the World Class Tanker Program (Wright et al. 2017).

***Table 7**. Number of unique zooplankton sampling events within and near the seven Camaaño Sound Network Zones 1980-2022. Note: no sampling in Zones 311-313 and 315.*

	Zone 310	Zone 311	Zone 312	Zone 313	Zone 314	Zone 315	Zone 316	Vicinity of Network Zones
Sampling events	5	0	0	0	10	0	5	**51**

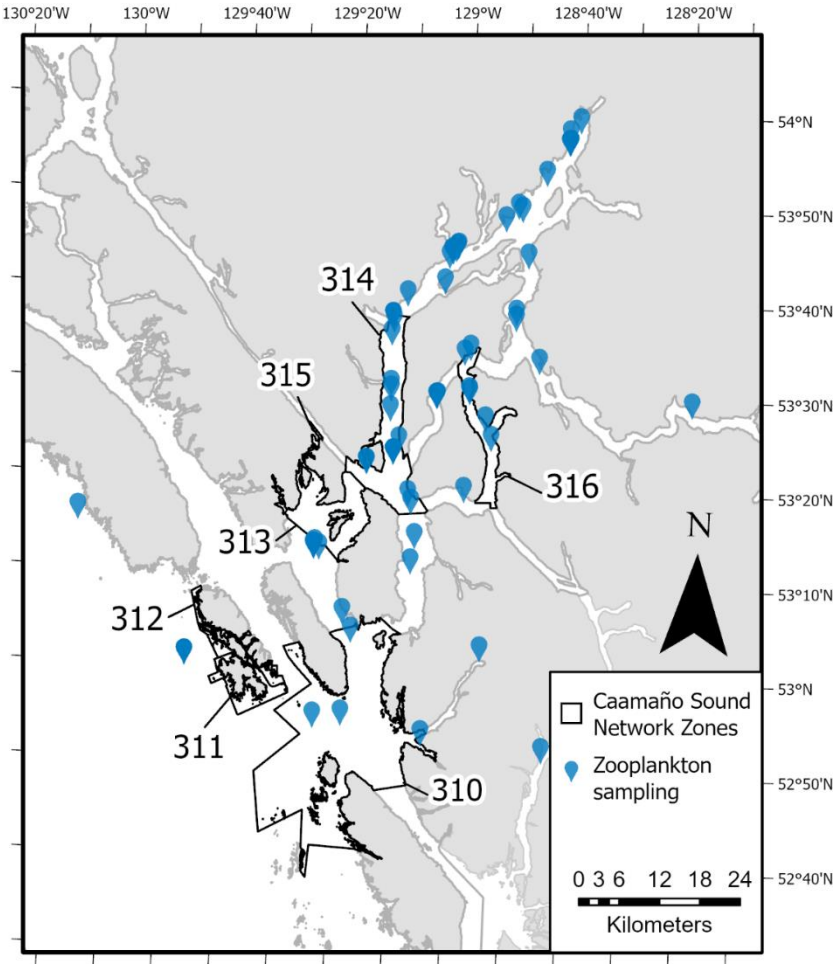

***Figure 29**. Spatial patterns of DFO zooplankton sampling events (Blue pin symbols) within and near the seven Camaaño Sound and Douglas Fjord System Network Zones 1980-2022.*

Species composition in the vicinity and within the seven Caamaño Sound and Douglas Fjord System Network Zones is similar to the Queen Charlotte Sound and broadly characteristic of other deep inlets along the BC coast (Gardner 1982). Within-group biomass for the broad area was averaged within each survey and seasons across years to construct a composite seasonal cycle without correcting for varying sampling efforts. Medium-sized calanoid copepods

dominated zooplankton biomass (~50%; **Figure 30**) across all seasons. The mean seasonal biomass for total zooplankton is lowest in the fall, followed by winter (**Figure 30**), 4.92 and 6.11 g dry weight m^{-2}, respectively. On average, biomass in the fall is dominated by medium-sized calanoid copepods (2.56 g dry weight m^{-2}), amphipods (0.96 g dry weight m^{-2}), and small copepods and euphausiids (0.25 g dry weight m^{-2}). The winter biomass of medium calanoids (3.14 g dry weight m^{-2}) is slightly increased relative to the fall, and euphausiid biomass is also relatively high (26%) and comprised mostly of adults. The mean annual biomass maximum (11.97 g dry weight m^{-2}) in the Camaaño-Douglas area occurs during summer (July and August). Crustacean zooplankton dominates this yearly maximum and is an important part of the diets of forage fish and early marine juvenile **hoon**/**qeqapela**/salmon, medium-sized calanoid copepods, euphausiids, decapods (mostly larvae), and amphipods. Broad gelatinous groups, cnidarians, and ctenophores are also seasonally important, making up 5.5% of the total zooplankton biomass. Large calanoid copepod biomass reaches its seasonal maximum during the spring and summer (0.37 and 0.5 g dry weight m^{-2}) but only contributes ~4% of the total biomass during both seasons. This group includes late-stage, large, lipid-rich subarctic copepods such as *Neocalanus spp.,* which is important to the breeding success of auklets in the NSB (Bertram et al. 2017; Hipfner et al. 2020). These large lipid-rich calanoid copepods are associated with the shelf-break and offshore Gulf of Alaska, where they dominate the annual zooplankton biomass (Mackas and Coyle 2005). However, these animals are frequently sampled on the shelf in association with onshore transport, with some populations reproducing in deep inlets and the Strait of Georgia. Gardner (1982) conducted a broad-scale survey in 1977 that found only late-stage copepodites of *Neocalanus spp.* and *Eucalanus bungii bungii* in Douglas Channel and concluded these animals were transported from offshore across the shelf. However, the longer-term analysis presented here finds eggs, nauplii, and copepodite stages present during the late spring and early summer, indicating that local reproduction occurs at least during some years.

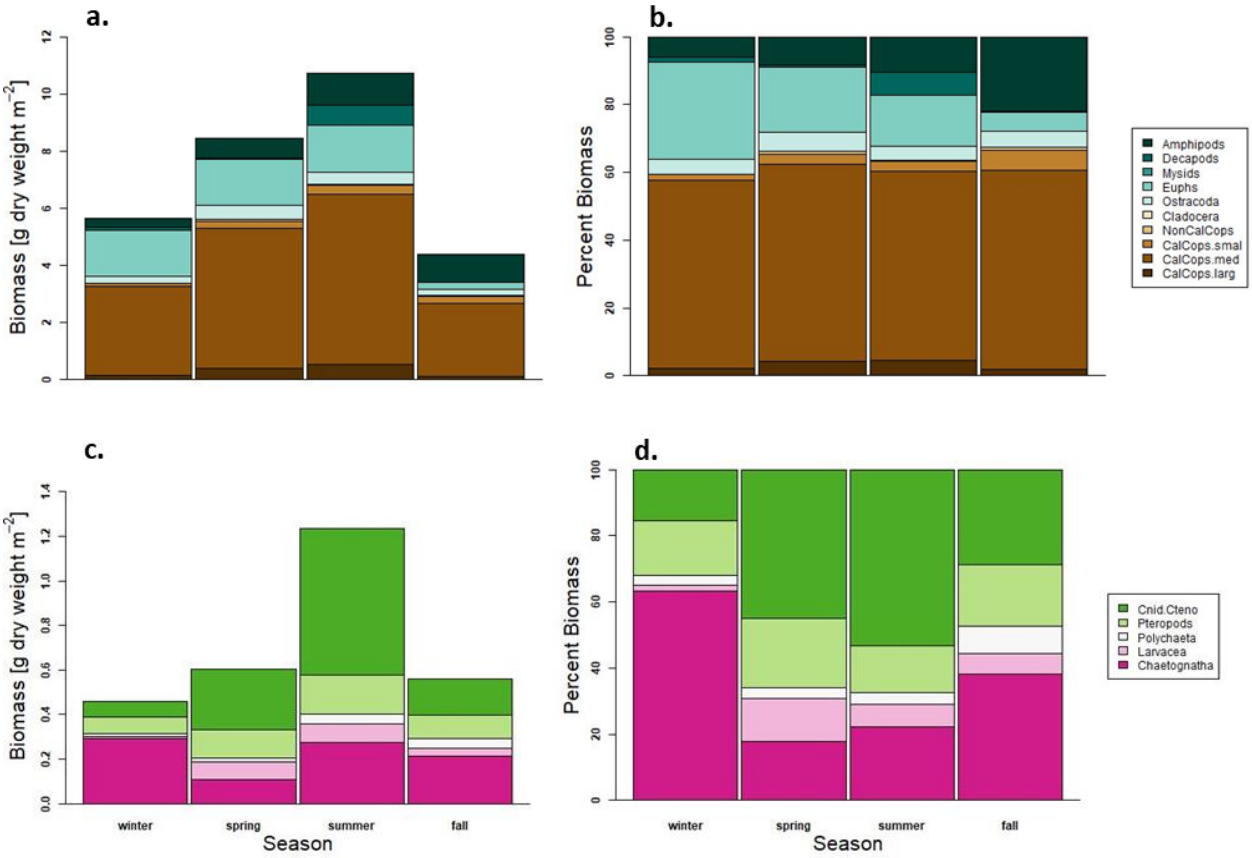

***Figure 30**. Seasonally averaged biomass (g dry weight m^{-2}) and relative biomass (%) of major crustacean (a,b) and non-crustacean (c,d) zooplankton groups sampled periodically within and in the vicinity of the seven Camaaño Sound and Douglas Fjord System Network Zones 1980-2022.*

The seasonal cycle of euphausiid production, species-specific spatial patterns, and aggregation behaviour in the Camaaño-Douglas area was studied in detail in 2015 by Qualls (2019) and is important to the foraging success of baleen **łbuun**/**g̱ʷey̓ém**/**łpuun**/whales (Keen 2017) and more generally for early marine phase juvenile **hoon**/**qeqapela** in the area. Both *Euphausia pacifica* and *Thysannoessa spinifera* dominated abundance in these studies and the DFO dataset presented herein. Euphausiids are second to medium-sized calanoid copepods in relative biomass during the winter, spring, and summer, representing 27, 18, and 14% of the total zooplankton biomass, respectively. Fall biomass is relatively low, with 0.25 g dry weight m^{-2}, representing 4% of the total zooplankton biomass. The average non-crustacean zooplankton biomass is low relative to crustaceans in the Camaaño-Douglas area, representing between 7.1 and 12.8% of total zooplankton biomass across seasons (**Figure 30**). However, the average seasonal cycle (**Figure 30** c, d) is broadly similar, with the seasonal minimum in winter (0.46 g dry weight m^{-2}) increasing through spring to a seasonal maximum in summer (1.24 g dry weight m^{-2}). The biomass of cnidarians/ctenophores and chaetognaths dominates through most seasons, varying between ~4% (winter) and 7-8% (summer and fall) of the total zooplankton biomass.

Groupings of copepods based primarily on shared geographic affinity have been used as climate-ocean-food web indicators along Canada's west coast (Mackas et al. 2004). The biomass of boreal copepods indicative of average or 'cool' conditions on the exposed outer BC shelf dominates the biomass of all copepods across all sampled years in the Camaaño-Douglas area. However, the varied sampling effort and composite nature of the dataset make it challenging to identify if the group's biomass is 'anomalously' high or low in any given year. Similarly, copepods with a 'southern' California Current affinity are sensitive indicators of warmer than average conditions along the southern Vancouver Island shelf (see Galbraith and Young 2021). Members of this indicator group were identified at low biomass in at least some samples in all years and with greater biomass (up to 20 times) in multiple samples collected during the extreme marine heatwave and ENSO events between 2014-2016. Note, however, that sampling effort was higher starting in 2012, and the biomass of copepods indicative of 'cool' conditions (boreal and large subarctic animals) was not diminished in 'warm' relative to those 'cool' years captured in this dataset. Ultimately, the data set available here is not sufficiently resolved with season through enough 'warm' and 'cool' years/periods to confidently: 1) identify whether zooplankton-climate indicator groups used for the exposed outer BC coast are meaningful for this fjord system; and 2) to calculate their annual biomass anomalies.

4 CLIMATE CHANGE

Climate change alters the ocean's heat, alkalinity and oxygen distribution as global temperatures increase and atmospheric carbon dioxide increases. These changes will have notable consequences for marine life, impacting their distribution, fitness and survival, and phenology (Cheung et al. 2009, Poloczanska et al. 2016). Warming and freshening trends have been observed at numerous lighthouse stations along the BC coast (where water samples have been collected daily for decades; Cummins and Masson 2014). The long-term warming rate of stations with data beginning in 1935 is estimated to be 0.9˚C per century. The most recent decade of temperatures measured at these stations have exceeded the long-term mean, and a greater number demonstrate statistically significant warming compared to Cummins and Masson (2014; Boldt et al. 2023). Additionally, a warming trend is projected into 2070 by two separate climate change models (Peña et al. 2019; Holdsworth et al. 2021) detailed below. As air and water temperatures rise, the dissolved oxygen content of the ocean declines and oxygen demand from organisms increases; further, rising atmospheric carbon dioxide levels increase the acidity of oceanic waters as it is absorbed, lowering the pH. Marine species generally shift their habitats towards deeper, colder waters at higher latitudes, where their physiological tolerances and dispersal abilities allow, but low oxygen will limit how deep they can shift (Magris et al. 2016; Thompson et al. 2023a). The Caamaño Sound and Douglas Fjord System Network Zones are located on the continental shelf within a narrow bathymetric depth range of 0 to 691 m max depth, with mean depths between 25 and 324 m (see earlier Bathymetry section 3.2.1). Depth-related oxygen loss between 300 and 1000 m is projected to impact marine species negatively, causing some species to shift to shallower depths (Thompson et al. 2023a).

As described earlier, the Caamaño Sound and Douglas Fjord System Network Zones are characterized by two continental sills, a deeper outer region at the western edge of Caamaño Sound and a series of inland fjords and inlets. Two climate models have been used within the Pacific Region to investigate projected changes to oceanic physical variables under two different climate change scenarios (Peña et al. 2019, Holdsworth et al. 2021), detailed below. However, these models are limited in their spatial coverage and are reliable only the outermost zones of the Caamaño Sound and Douglas Fjord System Network Zones. Consequently, we present both projected future seasonal environmental conditions and a brief literature review of the changes that might occur within the ecoregions present within the Caamaño Sound and Douglas Fjord System Network Zones with a warming climate.

4.1 Projected changes to ocean environmental variables

Projected future seasonal environmental conditions in the Caamaño Sound and Douglas Fjord System Network Zones were calculated using four models, depending on the variable: one Canada-wide sea level change model based on increases in the volume of water in the oceans under a Representative Concentration Pathways (RCP) emissions scenario (RCP 8.5) and the vertical motion of the Canadian coastline (CanCoast 2.0; Manson et al. 2019), one Canada-wide significant wave height model that included the effect of sea ice projected for 2090-2099, which is an ensemble model of five projections of climate variables under a RCP 8.5 emissions scenario (Manson et al. 2019); and two regional ocean models that downscale the global climate model projection under two RCP emissions scenarios (RCP 4.5 and RCP 8.5) while considering the complex bathymetry and ocean currents in this region. The Northeastern Pacific Canadian Ocean Ecosystem Model (NEP36-CanOE; Holdsworth et al. 2021) provides a

historical baseline for 1986-2005 and a future projection for 2046-2065. The BC Continental Margin Model (BCCM; Peña et al. 2019) provides a historical baseline for 1981-2010 and a future projection for 2041-2070. Model outputs include potential temperature and aragonite saturation state for each Zone's benthic and sea surface layers and dissolved oxygen for the benthic layer (*sensu* Friesen et al. 2021). We only report model outputs for the outermost Zones (310, 311, and 312) due to the uncertainty involved with the models in nearshore areas not accounting well for bathymetry, narrow channels between islands, and varying flow. Furthermore, the BCCM and NEP36-CanOE models are at a spatial resolution of 3 km, which is wider than the distance between land edges within the inland areas of the Caamaño Sound and Douglas Fjord System Network Zones region. RCP 4.5 is a moderate scenario in which emissions peak around 2040 and decline. RCP 8.5 is the highest baseline emissions scenario in which emissions continue to rise throughout the twenty-first century. A subsequent analysis of these four models was run for each Zone and is detailed below.

4.1.1 Sea level rise and wave height

Sea level rise threatens intertidal areas and associated estuaries worldwide (Elmilady et al. 2019). The current global rate of sea level rise is the highest in 200 years and is expected to increase by another 0.2 to ~ 2.0 m by 2100 (Elmilady et al. 2019). These rates are expected to cause permanent submersion, increased salinity in salt marshes (Thorne et al. 2012), and the decline of intertidal area (Elmilady et al. 2019). Other impacts include the conversion of wetland habitat types (e.g., palustrine wetlands to estuarine wetlands, unconsolidated shore, or open water; Gittman et al. 2019; Thorne et al. 2018; Elmilady et al. 2019), shoreline erosion (Thorne et al. 2012), and increased inundation and flooding (Thorne et al. 2012). Within the Caamaño Sound and Douglas Fjord System Network Zones, sea level rises of between 0.596 and 0.645 m are projected for 2099 compared to the base year of 2006 (**Figure 31A**). The westernmost coastal areas experience the highest sea level rise within Zones 310, 311, 312, 313, and 315. The CanCoast dataset also includes a Coastal Sensitivity Index, a relative measure based on the coastal area's geomorphic conditions (coastal materials, slope, presence of ground ice) and potential climate forcings (sea-level change, wave height change including the effects of changing sea ice). In comparison to other places in the Pacific Region and the rest of coastal Canada, the range of sea level rise increases projected for the Network Zones have a Coastal Sensitivity Index of 4 (with 5 being the highest sensitivity) for sea level rises between 0.21 and 0.70 m (Manson et al. 2019).

Wave height is a potentially changing environmental variable with climate change. Warming ocean temperatures and extreme wind speeds increase wave energy with increased coastal erosion, flooding and habitat modification (Reguero et al. 2019). Globally, wave power has increased by 0.4% per year since 1948 (Reguero et al. 2019). The highest projected mean decadal coastal wave heights in Canada are in the Pacific Region and the Eastern Maritime provinces (Figure 5 in Manson et al. 2019). Mean decadal coastal wave heights are projected for 2090-2099 to be between 1.70 to 2.06 m for the Caamaño Sound and Douglas Fjord System Network Zones (**Figure 31B**) and have a Coastal Sensitivity Index of 4 for wave heights between 1.51 and 2.25 m (Manson et al. 2019). This is a neutral to a slight decrease in significant wave heights modelled for 1996 to 2005 of 1.70 to 2.07 m for the Network Zones. Projected wave heights are lowest for the northern coastline edges in Zones 315, 312, 314, and 316. Note that additional coastal features, including the slope of the coast, tidal ranges, and

coastal materials, will influence the degree to which wave action will affect these coastal regions (Manson et al. 2019).

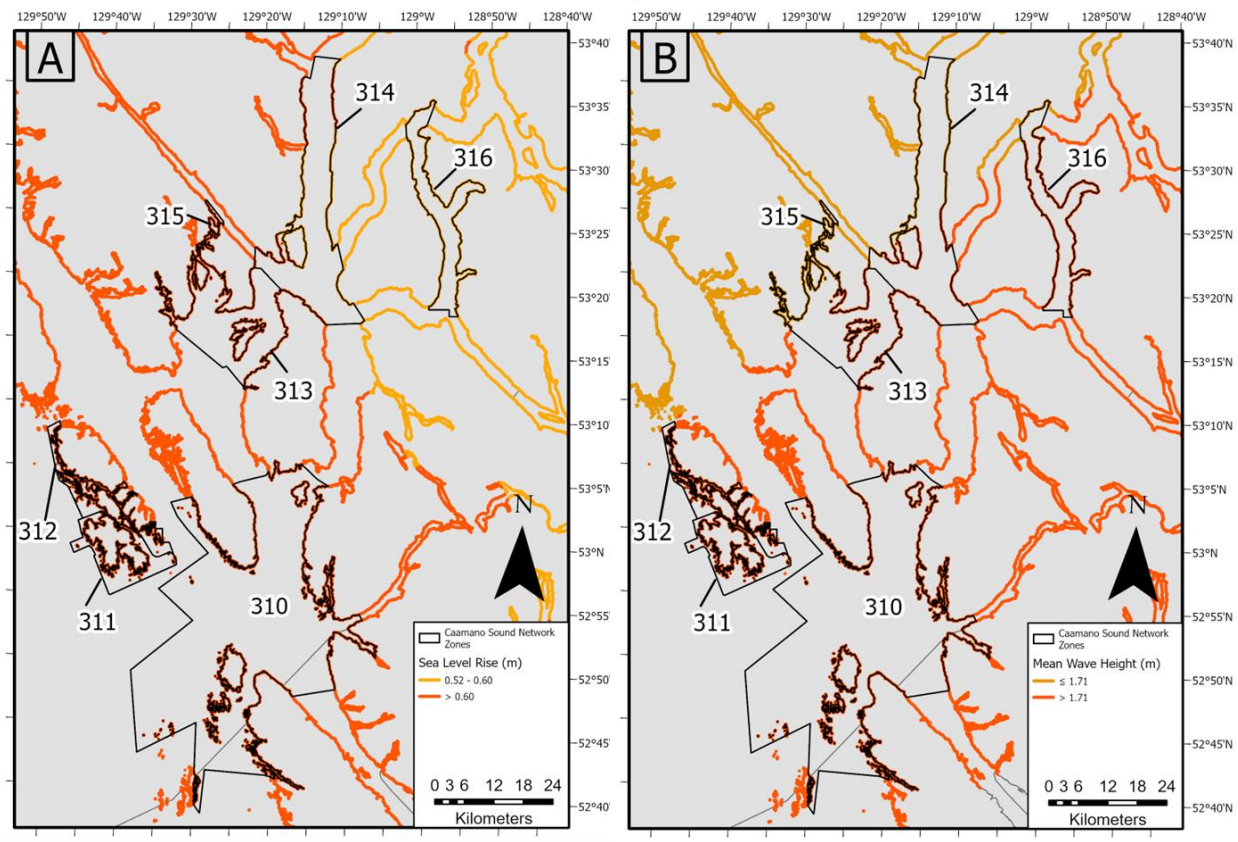

Figure 31. *(A) Sea level rise, in meters, between 2006 and 2099, for the Caamaño Sound Zones region. The sea-level change used here combines a global sea-level change model (RCP 8.5) and a model of vertical land motion for Canada (CanCoast 2.0; Manson et al. 2019). (B) Decadal mean significant wave height, in meters, projected for 2090 to 2099 based on an RCP 8.5 high-emission scenario from CanCoast 2.0. Black-outlined polygons and numbered text indicate the locations of the Caamaño Sound and Douglas Fjord System Network Zones.*

4.1.2 Ocean temperature

Ocean temperatures are warming, and temperature affects the physiology of many marine organisms (Huey et al. 2012) that are already living close to their thermal tolerances (Pinsky et al. 2019), potentially negatively impacting their performance and survival. Consequently, marine organisms will have to acclimate or adjust their geographic distributions to match their physiological tolerances and habitat requirements to rising water temperatures. Increasingly, range shifts are being observed across multiple marine taxa, including marine birds (Poloczanska et al. 2013), fishes (Kleisner et al. 2017) and benthic invertebrates (Hiddink et al. 2015). However, increasing ocean temperatures do not affect marine fauna and flora in isolation. Instead, the synergistic effects of temperature, hypoxia, and other climate-related properties lead to ecosystem shifts and varied impacts on the abundance and distribution of marine taxa. For example, a meta-analysis of climate change studies (Hu et al. 2022) suggests that higher trophic level marine species have a higher tolerance for ocean acidification but greater sensitivity to increasing ocean temperatures. Furthermore, marine herbivores are the most vulnerable to acidification and warming (Hu et al. 2022).

Projections from the BCCM regional ocean model (Peña et al 2019) predict temperature changes greater than at least 0.83°C in the benthic layer and 1.37°C in the surface layer for all four seasons of Zones 310, 311, and 312 under the RCP 4.5 and RCP 8.5 emissions scenario (**Table 8**). The RCP 4.5 scenario is more conservative, so the water's bottom and surface layers have lower projected warming. However, projected values are still higher than threshold values for most seasons. The NEP36-CanOE model projects higher temperature increases for the RCP 4.5 scenario (**Table 9**) than the BCCM model (**Table 8**). More conservative temperature increases for the RCP 8.5 scenario in both the benthic and surface layers, and temperature change values are higher than threshold values. Despite these differences, both models show a warming trend in the Caamaño Sound and Douglas Fjord System Network Zones (in Zones 310, 311, and 312).

***Table 8**. Seasonal mean sea temperature (ºC; sea bottom and sea surface) within the outermost Caamaño Sound and Douglas Fjord System Network Zones using BCCM (Peña et al. 2019) regional ocean model outputs. The historical period is 1981-2010, for which mean sea temperature values are provided. The projected future period is 2041-2070 under the RCP 4.5 and RCP 8.5 emissions scenarios, for which the projected change in mean sea temperature is provided. Seasons were delineated as spring (Spr; Mar-Apr-May), summer (Sum; Jun-Jul-Aug), fall (Sep-Oct-Nov), and winter (Win; Dec-Jan-Feb). Red shading highlights Zones with a temperature change of> 2 ºC for surface waters and > 1 ºC for bottom waters between the historical and projected future values. Yellow shading highlights Zones with a temperature change of> 1 ºC and < 2 ºC for surface waters between the historical and projected future values.*

	Sea Bottom Temperature (˚C)								Sea Surface Temperature (˚C)							
	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win
Zone	Historical Value (1981-2010)				Projected Future Change (2041-2070; RCP 4.5)				Historical Value (1981-2010)				Projected Future Change (2041-2070; RCP 4.5)			
310	7.22	7.08	7.66	7.87	+1.28	+0.83	+0.90	+1.18	8.37	12.58	10.86	7.59	+1.58	+1.37	+1.65	+1.46
311	7.86	8.90	9.35	7.99	+1.49	+0.91	+1.13	+1.38	8.50	12.90	11.03	7.56	+1.60	+1.37	+1.74	+1.49
312	7.87	8.79	9.32	8.02	+1.50	+0.93	+1.12	+1.39	8.60	13.10	11.18	7.66	+1.60	+1.27	+1.75	+1.50
	Historical Value (1981-2010)				Projected Future Change (2041-2070; RCP 8.5)				Historical Value (1981-2010)				Projected Future Change (2041-2070; RCP 8.5)			
310	7.22	7.08	7.66	7.87	+1.60	+1.11	+1.27	+1.70	8.37	12.58	10.86	7.59	+2.14	+2.32	+2.47	+2.10
311	7.86	8.90	9.35	7.99	+1.92	+1.29	+1.68	+1.99	8.50	12.90	11.03	7.56	+2.15	+2.35	+2.63	+2.15
312	7.87	8.79	9.32	8.02	+1.93	+1.28	+1.65	+2.03	8.60	13.10	11.18	7.66	+2.14	+2.19	+2.65	+2.15

***Table 9**. Seasonal mean sea temperature (˚C; sea bottom and sea surface) within the seven Zones of the Caamaño Sound and Douglas Fjord System Network Zones using NEP36-CanOE (Holdsworth et al. 2021) regional ocean model outputs. The historical period is 1986-2005, for which mean sea temperature values are provided. The projected future period is 2046-2065 under the RCP 4.5 and RCP 8.5 emissions scenarios, for which the projected change in mean sea temperature is provided. Seasons were delineated as spring (Spr; Mar-Apr-May), summer (Sum; Jun-Jul-Aug), fall (Sep-Oct-Nov), and winter (Win; Dec-Jan-Feb). Red shading highlights Zones with a temperature change of > 2 ºC for surface waters and > 1 ºC for bottom waters between the historical and projected future values.*

	Sea Bottom Temperature (˚C)								Sea Surface Temperature (˚C)							
	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win
Zone	Historical Value (1986-2005)				Projected Future Change (2046-2065; RCP 4.5)				Historical Value (1986-2005)				Projected Future Change (2046-2065; RCP 4.5)			
310	6.81	6.80	7.64	7.45	+1.63	+1.16	+1.11	+1.42	7.35	12.04	11.06	7.37	+1.84	+1.56	+1.91	+1.78
311	7.07	8.98	9.70	7.27	+1.89	+1.48	+1.64	+1.78	7.23	11.16	10.59	7.15	+1.88	+1.70	+1.89	+1.83
312	7.17	9.90	10.20	7.07	+1.91	+1.53	+1.78	+1.83	7.24	11.27	10.49	7.01	+1.88	+1.72	+1.83	+1.84
	Historical Value (1986-2005)				Projected Future Change (2046-2065; RCP 4.5)				Historical Value (1986-2005)				Projected Future Change (2046-2065; RCP 4.5)			
310	6.81	6.80	7.64	7.45	+1.97	+1.47	+1.54	+1.94	7.35	12.04	11.06	7.37	+2.44	+1.92	+2.57	+2.33
311	7.07	8.98	9.70	7.27	+2.33	+1.77	+2.08	+2.29	7.23	11.16	10.59	7.15	+2.42	+2.01	+2.51	+2.33
312	7.17	9.90	10.20	7.07	+2.39	+1.82	+2.27	+2.34	7.24	11.27	10.49	7.01	+2.42	+1.99	+2.45	+2.34

4.1.3 Ocean acidification and aragonite

As excess carbon dioxide enters marine waters and forms carbonic acid, water acidifies (pH declines) and lowers carbonate ion concentrations (Fabry et al. 2008). Aragonite, a biogenic form of calcium carbonate, is widely used by marine organisms with calcium carbonate structures to create their shells and skeletons; a decrease in carbonate ions decreases these organisms' ability to form hard carbonate structures, particularly for juveniles (Fabry et al. 2008). Consequently, aragonite serves both as a measure of ocean acidification (in relation to carbon dioxide levels) and as a measure of available carbonate ions to organisms such as corals, **ts’a’ax**/**č̓íkʷa**/**ts'a'a̱x**/clams, oysters, and some plankton. Corals and other calcifiers are more likely to have their shells and other carbonate structures dissolve when aragonite levels drop below one (undersaturation; Miller et al. 2009). Saturation states also change with latitude (highest in the tropics) and because the solubility of calcium carbonate increases with increasing pressure and decreasing temperature (Fabry et al. 2008). The impact of a particular aragonite saturation state may also vary by species (Miller et al. 2009).

Aragonite levels are projected to decrease the most in the bottom layer. The BCCM regional ocean model projected a more significant decrease than the NEP36-CanOE regional ocean model. For example, the BCCM model projected aragonite levels below threshold values in Zone 310 during the summer and fall months under the RCP 4.5 scenario and all seasons under RCP 8.5 (**Table 10.**), while for NEP36-CanOE this drop occurred only during the summer months under the RCP 8.5 scenario (**Table 11**.). The BCCM and NEP36-CanOE model results do not cover the Caamaño Sound and Douglas Fjord System Network Zones fjords and inlets. However, given the strong circulation links between the deep waters in Douglas Channel and the deep water in Hecate Strait, one should expect declining pH on the shelf to manifest in the deep water of the inlets. Thus, the species in the coastal fjords may be susceptible to acidification, especially for the larval stages of shellfish species (DFO 2021a).

Table 10. *Seasonal mean aragonite saturation state (sea bottom and sea surface) within the outermost Caamaño Sound and Douglas Fjord System Network Zones using BCCM (Peña et al. 2019) regional ocean model outputs. The historical time period is 1981-2010, for which mean aragonite saturation state values are provided. The projected future time period is 2041-2070 under the RCP 4.5 emissions (no climate mitigation) scenario, for which the projected change in mean aragonite saturation state is provided. Seasons were delineated as: spring (Spr; Mar-Apr-May), summer (Sum; Jun-Jul-Aug), fall (Sep-Oct-Nov), and winter (Win; Dec-Jan-Feb). Red shading highlights Zones with* $W_A < 1$.

	Sea Bottom Aragonite Saturation State								Sea Surface Aragonite Saturation State							
	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win
Zone	Historical Value (1981-2010)				Projected Future Change (2041-2070; RCP 4.5)				Historical Value (1981-2010)				Projected Future Change (2041-2070; RCP 4.5)			
310	1.31	1.11	1.11	1.33	-0.23	-0.23	-0.23	-0.26	1.81	1.97	1.70	1.45	-0.26	-0.31	-0.25	-0.25
311	1.59	1.41	1.42	1.52	-0.26	-0.30	-0.28	-0.27	1.98	2.23	1.92	1.56	-0.28	-0.33	-0.27	-0.26
312	1.61	1.41	1.41	1.54	-0.26	-0.30	-0.28	-0.27	2.02	2.29	2.00	1.59	-0.29	-0.35	-0.28	-0.27
	Historical Value (1981-2010)				Projected Future Change (2041-2070; RCP 8.5)				Historical Value (1981-2010)				Projected Future Change (2041-2070; RCP 8.5)			
310	1.31	1.11	1.11	1.33	-0.34	-0.31	-0.29	-0.34	1.81	1.97	1.70	1.45	-0.38	-0.38	-0.34	-0.34
311	1.61	1.41	1.42	1.52	-0.40	-0.40	-0.36	-0.37	1.98	2.23	1.92	1.56	-0.41	-0.41	-0.37	-0.36
312	1.59	1.41	1.41	1.54	-0.41	-0.41	-0.37	-0.36	2.02	2.29	2.00	1.59	-0.43	-0.45	-0.39	-0.37

***Table 11**. Seasonal mean aragonite saturation state (sea bottom and sea surface) within the outermost Caamaño Sound and Douglas Fjord System Network Zones using NEP36-CanOE (Holdsworth et al. 2021) regional ocean model outputs. The historical period is 1986-2005, for which mean aragonite saturation state values are provided. The projected future period is 2046-2065 under the RCP 4.5 and RCP 8.5 emissions scenarios, for which the projected change in mean aragonite saturation state is provided. Seasons were delineated as spring (Spr; Mar-Apr-May), summer (Sum; Jun-Jul-Aug), fall (Sep-Oct-Nov), and winter (Win; Dec-Jan-Feb). Red shading highlights Zones with $W_A < 1$.*

	Sea Bottom Aragonite Saturation State								Sea Surface Aragonite Saturation State							
	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win
Zone	Historical (1986-2005)				Projected Future (2046-2065; RCP 4.5)				Historical (1986-2005)				Projected Future (2046-2065; RCP 4.5)			
310	1.57	1.33	1.44	1.62	-0.31	-0.30	-0.34	-0.36	1.57	1.33	1.44	1.62	-0.3.5	-0.36	-0.34	-0.35
311	1.74	1.71	1.75	1.69	-0.32	-0.33	-0.33	-0.33	1.74	1.71	1.75	1.69	-0.33	-0.32	-0.32	0.34
312	1.78	1.83	1.82	1.68	-0.33	-0.34	-0.33	-0.34	1.78	1.83	1.82	1.68	-0.33	-0.32	-0.33	-0.33
	Historical (1986-2005)				Projected Future (2046-2065; RCP 8.5)				Historical (1986-2005)				Projected Future (2046-2065; RCP 8.5)			
310	1.57	1.33	1.44	1.62	-0.44	-0.39	-0.43	-0.46	1.57	1.33	1.44	1.62	-0.48	-0.50	-0.45	-0.47
311	1.74	1.71	1.75	1.69	-0.46	-0.47	-0.46	-0.46	1.74	1.71	1.75	1.69	-0.46	-0.48	-0.45	-0.46
312	1.78	1.83	1.82	1.68	-0.46	-0.48	-0.46	-0.45	1.78	1.83	1.82	1.68	-0.46	-0.48	-0.45	-0.45

4.1.4 Oceanic oxygen conditions and hypoxia

Most water-breathing animals have a specific oxygen level required to meet aerobic requirements (Seibel 2011). Below this level, impairment of physiological processes (e.g., cell growth) may occur. Hypoxia effects differ among species, as their physiological threshold varies greatly (Rabalais et al. 2010) and can differ between areas (e.g., crustaceans in different areas have different tolerances). However, the upper threshold of hypoxic conditions for marine life ranges from 62.5–157 µM, depending on the taxa used for defining the threshold (Gobler and Baumann 2016). This report uses two measures to describe hypoxic bottom waters, a lower critical value of < 62.5 µmol/L and an upper value of < 157 µmol/L, although higher or lower oxygen levels will varyingly impact marine life (Rabalais et al. 2010). Hypoxic bottom waters <62.5 µmol/L are not observed in the historical period, nor are they projected to occur in future periods (Table 12)

Since the Caamaño Sound and Douglas Fjord System Network Zones (310, 311, 312) are located on the continental shelf, the benthic oxygen concentrations do not drop below the 62.5 µmol/L threshold. However, thresholds could be as high as 157 µmol/L, in which case historic values drop below this value during the fall in Zone 310 and are projected to occur in the summer and fall of Zone 310 for the BCCM model (Table12). Model selection influences the projected oxygen changes, and considerable uncertainty exists for this region regarding projected bottom-layer oxygen levels (Thompson et al. 2023a). Furthermore, changes in sedimentation in inner fjords and inlets can lead to hypoxic habitat (see Climate change impacts on fjords and inlets, Section 4.2).

***Table 12**. Seasonal mean sea bottom dissolved oxygen (µmol/L) within the Caamaño Sound and Douglas Fjord System Network Zones using BCCM (Peña et al. 2019) regional ocean model outputs. The historical period is 1981-2010, for which mean aragonite saturation state values are provided. The projected future period is 2041-2070 under the RCP 4.5 and RCP 8.5 emissions scenarios, for which the projected change in mean sea bottom dissolved oxygen is provided. Seasons were delineated as spring (Spr; Mar-Apr-May), summer (Sum; Jun-Jul-Aug), fall (Sep-Oct-Nov), and winter (Win; Dec-Jan-Feb). Yellow cells highlight dissolved oxygen < 157 µmol/L.*

	Sea Bottom Dissolved Oxygen (µmol/L)							
	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win
Zone	Historical Value (1981-2010)				Projected Future Change (2041-2070; RCP 4.5)			
310	219.42	161.57	156.40	222.25	-3.22	-7.26	-6.58	-7.11
311	266.65	206.34	202.41	266.25	-6.16	-10.24	-8.67	-7.49
312	268.88	205.69	200.35	267.81	-5.90	-10.00	-8.84	-6.67
	Historical Value (1981-2010)				Projected Future Change (2041-2070; RCP 8.5)			
310	219.42	161.57	156.40	222.25	-11.05	-10.52	-9.51	-9.07
311	266.65	206.34	202.41	266.25	-13.18	-16.65	-12.38	-9.48
312	268.88	205.69	200.35	267.81	-13.03	-16.46	-12.97	-8.22

***Table 13**. Seasonal mean sea bottom dissolved oxygen (µmol/L) within the Caamaño Sound and Douglas Fjord System Network Zones using NEP36-CanOE (Holdsworth et al. 2021) regional ocean model outputs. The historical period is 1986-2005, for which mean bottom dissolved oxygen values are provided. The projected future period is 2046-2065 under the RCP 4.5 and RCP 8.5 emissions scenarios, for which the projected change in mean sea bottom dissolved oxygen is provided. Seasons were delineated as spring (Spr; Mar-Apr-May), summer (Sum; Jun-Jul-Aug), fall (Sep-Oct-Nov), and winter (Win; Dec-Jan-Feb). Yellow cells highlight dissolved oxygen < 157 µmol/L.*

	Sea Bottom Dissolved Oxygen (µmol/L)							
	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win
Zone	Historical Value (1986-2005)				Projected Future Change (2046-2065; RCP 4.5)			
310	271.14	206.05	220.49	278.43	-7.34	-17.31	-22.18	-17.86
311	304.41	259.49	260.98	297.22	-10.21	-11.73	-14.95	-12.61
312	310.97	273.11	271.21	300.89	-11.30	-9.32	-12.79	-12.14
	Historical Value (1986-2005)				Projected Future Change (2046-2065; RCP 8.5)			
310	271.14	206.05	220.49	278.43	-12.18	-16.99	-19.82	-15.97
311	304.41	259.49	260.98	297.22	-14.19	-16.25	-16.69	-14.07
312	310.97	273.11	271.21	300.89	-14.48	-14.57	-15.67	-14.22

The biological consequences of hypoxia (coupled with marine temperature and pH changes) result in reduced fitness, altered behaviour, local extirpation, and shifts in species distributions (Breitburg et al. 2018). Species redistributions have cascading ecological effects, including forming new ecological communities and altering food webs (Doney et al. 2012). Within benthic marine communities, severe hypoxia on continental shelves and in coastal zones can result in an expansion of microbial mats, the emergence of infauna, species migration and species attrition in extreme events (Levin et al. 2009). Mobile fish species can often avoid the deleterious effects of hypoxia through migration. However, migration to shallower and more oxygenated water is energetically expensive and can make them vulnerable to fishing or predators (Stramma et al. 2012, Gilly et al. 2013). Climate-induced species redistributions and diminishing size result in a global reduction in fish biomass (14 to 24%) and a shift in species distributions away from lower latitudes (Cheung et al. 2013). Furthermore, climate-induced changes in fish size structure may potentially destabilize trophic interactions (e.g., Audzijonyte et al. 2013) and reduce per-capita fecundity (Marshall et al. 2021), eroding the resilience of affected communities. However, if fishing is able to preserve body size diversity (Wootton et al. 2021) and fecundity (Marshall et al. 2021) and if periods of favourable temperature occur, resilience of wild fish populations may be higher than expected otherwise (Wootton et al. 2021).

Increasing ocean temperatures do not affect marine fauna and flora in isolation. Instead, synergistic effects of temperature, hypoxia and other climate-related properties result in ecosystem shifts and varied impacts on marine taxa. These climate variables should not be measured or understood in isolation but instead viewed as a combination of effects to which varied distributional responses are expected. Protected area design that accounts for fishing management, habitat refugia, and environmental variation to mitigate the effects of climate warming is an important step in building this resilience.

4.2 Climate change impacts on fjords and inlets

The fjords and inlets of the Caamaño Sound and Douglas Fjord System Network Zones have unique oceanographic and topographic features that influence their responses to anthropogenically-driven climate change. As stated in earlier sections, we do not have sufficient models of projected changes to physical environmental variables with a warming climate and increased atmospheric carbon dioxide within these environments because of the narrowness of the inlets and low data resolution. However, we can draw general expectations for the area using the literature and our current understanding of this region. The fjords of the North Coast Fjords ecoregion are expected to experience a range of impacts, including ocean and continental warming, an increase in terrestrial runoff, and a decrease in water salinity (Okey et al. 2012). These changes would increase stratification, decreasing oxygen concentration in fjord waters due to climate change (*sensu* Okey et al. 2012). Temperature changes can generally influence terrestrial runoff by shifting the snowmelt earlier, reducing the snowpack, and increasing runoff volume (Wild et al. 2023). The hydrological cycle heavily influences the region's fjords because of the estuarine circulation that the freshwater supports, and the material carried into the inlets from runoff. An increase in rain and snowmelt/glacial runoff increases siltation and nutrient/organic enrichment (Okey et al. 2012).

Furthermore, the fjords and inlets are vulnerable to reductions in oxygen, and the deep hypoxic/anoxic basins of the inlets have delicate water chemistry that already exists near tipping points for resident species' ecological tolerances (Okey et al. 2012). It is important to note that

the fjords are currently not as anoxic as they could be because of the winter freshening and reoxygenation. However, we don't know enough about the relative importance of each component in initiating deep water renewals (see Interannual variations).

The Caamaño Sound and Douglas Fjord System Network Zones region is an area that connects large volumes of freshwater runoff flowing towards Hecate Strait, compensated by intermediate and deep inflows from Hecate Strait. The region's relative influence of terrestrial runoff and snow melt varies. Snowmelt dominates freshwater inputs near headwaters, whereas those closer to the coast (and even Squally Channel) are more rain dominated. Consequently, there isn't a strong spring peak, except at the upstream reaches of the catchments (Climate and freshwater inputs section; **Figure 19**). A recent analysis of climate change impacts for the nearby **Ksyen/**Skeena River watershed, similar to some of the Caamaño Sound and Douglas Fjord System Network Zones rivers, using RCP 4.5 and RCP 8.5 climate scenarios, projected an increased mean annual flow by 2100 due to increased glacial ice melt, precipitation, and subsurface flow. In addition, an earlier onset of the spring freshet is projected (Wild et al. 2023). Furthermore, the magnitude of the fall peak relative to the spring freshet peak may amplify because of the increase in fall precipitation, followed by a decrease in summer discharge due to drier and hotter summers (Wild et al. 2023). Finally, the rate of extreme weather events may increase with climate change, resulting in changes to water flow patterns by increasing peak flows, and thus sediment transport, in the region.

A comparative study of four coastal inlets in the Pacific Region (including the Douglas Channel) showed deep-water temperatures in the fjords had increased significantly over 70 years (1.2 to 1.3˚C) at twice the global average rate for open ocean waters at the same depths. Furthermore, oxygen levels have dropped by up to 20%, necessitating the redistribution of species pushed to their physiological limits (Jackson et al. 2021). Climate change impacts on environmental variables do not act in isolation from each other or other forms of anthropogenic disturbance. They are coupled with the effects of additional stressors (see Cumulative impacts section 5.2). Impacts should not be considered in isolation from each other or in isolation of the increased warming rates the region is projected to experience.

5 HUMAN USES OF AREA

A key design principle in the Canada-BC MPA network strategy is to “recognize and consider the full range of uses, activities and values supported by marine environments”. This section summarizes human uses (i.e., Indigenous, social, recreational, research and commercial) of the Caamaño-Douglas area and Network Zones boundaries.

5.1 First Nations Activities

“The harvesting, processing, consumption, use, sharing and trade of natural resources in accordance with our own customs remains a cornerstone of our people’s culture and daily livelihood.”

Quote from Hartley Bay Council (2012).

First Nations in the Caamaño-Douglas area are historical and contemporary stewards of the environment. Prosperity, identity, and health of local communities have depended on the services, richness, and abundance of marine areas and their resources for generations. The Caamaño-Douglas area contains many sites (Table 14) used for key cultural values and practices such as recreation (see Section 5.4.3), food harvesting, feasting, knowledge transmission, and cultural landscapes (e.g. ancestral sites, locations associated with oral history and legends) (Satterfield et al. 2012). The MPA Network planning process and the selection of Network Zones has been informed by cultural and spiritual significance of the area, identified as Cultural Conservation Priorities (C-CPs) (See Section 2.3.1 and **Appendix B**. Caamaño-Douglas Network Zones Boundaries for details). This section describes some of the important uses for First Nations communities outside of the Network planning process.

Laxsgiik S’moogyet/Eagle Chief Sn Axe’et/Ernie Hill summarizes the importance of traditional harvests, gatherings, and feasts to Gitga’at culture: “We welcome people by feeding them”(Satterfied et al. 2012). Coastal First Nations harvest from many habitats in the Caamaño-Douglas area including estuaries, salt marshes, **gadza k’aw**/eelgrass beds, kelp forests, beaches, shorelines, the intertidal, and subtidal. Species identified as important for cultural use and food security include **ła’ask**/**lhlaˈq̓s**/**ła̱'a̱sk**/seaweed, groundfish, **hoon**/**qeqapela**/salmon, invertebrates, **łbuun**/**g̃ʷey̓ém**/**łpuun**/whales (Killer, Fin), seabirds and their eggs (MPA Network BC Northern Shelf Initiative 2023; Thompson et al. 2019). Many organisms inspire cultural identity such as clan naming and symbology, art and storytelling. For more information about species ecology and harvest uses, please refer to Section 6: Ecological Setting.

The Moore Islands Paleoenvironments and Archaeology Project explore human and environmental history on Moore Island in Zone 310 (Letham et al. 2022). This area has been described in oral histories as the lineage origin for several Tsimshian Nations (including Gitga’at and Kitasoo), Gitxaała, and Haisla. The shared Moore islands are an important place for harvest and historic travels (M. Jacobs, pers. comm. 2023; Letham et al. 2022). Rock carvings from human origins (hereafter petroglyphs) were discovered on Moore Island and on rocks along the beach in **Lax Galtsa’ap**/Old Town (west of Zone 314).

Marine waters of the community of **Txałgiu** /Hartley Bay are located within Douglas Channel (Zone 314). A new Search and Rescue facility and Canadian Coast Guard Residence building is

currently in development (Canadian Impact Assessment Registry Reference number 80772, 2020). Economic development for the Gitga'at community in the Caamaño-Douglas area includes shellfish and fish commercial catch, logging, ecotourism, and potential for aquaculture operations such as geoducks and **gyenti**/**'éllas**/sea cucumber (Hartley Bay Council 2012; K. Clifton, pers. comm. 2023). There is one operational **hoon**/**qeqapela**/Salmon hatchery situated on the Gabion River in **Txałgiu**/Hartley Bay (Hartley Bay Salmon Hatchery 2015).

Resources for detailed First Nations use of the Caamaño-Douglas area include, but are not limited to: the Hartley Bay Council (2012), a report by Satterfield et al. (2012) describing **Gitga'ata** cultural practices and impacts from tanker traffic increase, a report by Marsden (2012) summarizing **Gitga'ata** history and territories, the Kitasoo Xai'xais Integrated Marine Use Plan (2011), the Feathers and Feast-Fires book for Kitasoo Xai'xais culture (2017), various Gitxaała Nation use and occupancy studies, and respective First Nation websites and articles. The absence of information within this report or other resources describing First Nations uses do not necessarily indicate an absence of knowledge.

Table 14. *Important sites for local First Nations use within and near the Caamaño Sound and Douglas Fjord System Network Zones. Shellfish in this context refers to many taxonomic groups of invertebrates. This table is not meant to be an exhaustive list of key locations for First Nations activities. Information sources include: Hartley Bay Council (2012), Satterfield et al. (2012), Marsden (2012), Gitxaała Nation GIS database, and personal communications.*

Location	Name	Usage
Zone 310	Moore Islands	Archaeological and cultural sites, harvest (marine birds, **ła'ask/lhlaˈq̓s/łą̱'ą̱sk**/ seaweed, shellfish), **yee/ḱáp̓i/xyi'i**/ chinook salmon, **misoo/hísen/miso'o**/sockeye salmon, **hadanii/hadanii** /sablefish, **gyels/gyels**/ mussels, **ts'a'ax**/ **c̓íkʷa/ts'a'ą̱x**/clams, **gaboox/zuáli/gą̱boox**/cockles, travel routes. **Nuganaks** or '**Ngwünaks** village/camp site on Gander Island known in Ts'mysen oral history as the origin place for the Ginuganuks (people of Nuganaks), also the site of what is known in **adaawx**/true telling of sacred history as the Underwater Big House story.
	Kdad-eesh/Borrowman Bay	Important village site with archaeological, cultural and economic importance and connected to a key Ts'msyen (Tsimhian) origin place and story. Harvest area (salmon, groundfish (**txaw/mumegʷezu/txaw**/halibut and **ts'mhoon/**rockfish), **ła'ask/lhlaˈq̓s/łą̱'ą̱sk**/seaweed, marine invertebrates (**bilhaa/g̱elhg̱enaiq**/abalone, **gyenti/'éllas**/sea cucumber, **aswit/'emdém/ą̱ws**/urchin, **q̓eq̓ánas**/chitons, some bivalves).
	Rennison Islands	Harvest area (salmon, groundfish (**txaw/mumegʷezu/txaw**/halibut and **ts'mhoon/**rockfish), **ła'ask/lhlaˈq̓s/łą̱'ą̱sk**/seaweed, marine invertebrates (**bilhaa/g̱elhg̱enaiq**/abalone, **gyenti/'éllas**/sea cucumber, **aswit/'emdém/ą̱ws**/urchin, **q̓eq̓ánas**/chitons, some bivalves).
East of Zone 310	Kiel	Harvest (**ła'ask/lhlaˈq̓s/łą̱'ą̱sk**/seaweed, shellfish, groundfish, marine mammals)
Zone 311	Dewdney Island groups	Recreation, harvest (**txaw/mumegʷezu/ txaw**/halibut, **yee/ḱáp̓i/xyi'i**/chinook salmon, **ts'a'ax/c̓íkʷa/ts'a'ą̱x**/clams and **gaboox/ zuáli/g̱ą̱boox**/cockles), field trip sites, travel routes
Zone 312	Estevan Island groups	Recreation, harvest (**txaw/mumegʷezu/ txaw**/halibut, **yee/ḱáp̓i/xyi'i**/chinook salmon, **ts'a'ax/ c̓íkʷa/ts'a'ą̱x**/clams and **gaboox/zuáli/g̱ą̱boox**/cockles, **łgümet**/seagull eggs, **ła'ask/lhlaˈq̓s/ łą̱'ą̱sk**/seaweed), field trip sites, travel routes, non-consumptive species of importance (porpoise)
Zone 313	**K'duwaadz**/Tuwartz Inlet	Harvest (**üüla/sag̱ʷam**/seal)

Location	Name	Usage
	Cherry islets	Harvest
	Clamstown, **Lax Kwil Dziist**/ Fin Island	Cultural sites, Harvest (shellfish)
	K'ts'ats'aas/Gil Island	Cultural sites, Harvest
	Crane Bay	Harvest
	General	(**misoo**/**hísen**/**miso'o**/sockeye salmon, **yee**/**ḵáp̓i**/**xyi'i**/chinook salmon, **sti'moon**/**qábes**/**sti'moon**/pink salmon, **gayniis**/ **gʷaxenis**/**gaayniis**/chum salmon, **üük**/**zúen**/**üüxs**/coho salmon, **k'almoos**/**klnákʷ**/**k̲'a̲lmoos**/crab, and **hadanii**/**hadanii**/sablefish
Zone 314	**Txałgiu** /Hartley Bay	Community center, harvest (shellfish, herring, marine mammals)
	Promise Island	Harvest (kelp)
	General	Travel routes, harvest (**txaw**/**mumegʷezu**/ **txaw**/halibut, **misoo**/**hísen**/**miso'o**/ sockeye salmon, **yee**/**ḵáp̓i**/**xyi'i**/chinook salmon, **sti'moon**/**qábes**/**sti'moon**/pink salmon, **meliit**/steelhead trout, **üük**/**zúen**/**üüxs**/coho salmon)
West of Zone 314	**Lax Galtsa'ap** (Old Town)/ Kitkiata Inlet	Harvest, historical village site, archaeological site
West of Zone 314	Kishkosh Inlet	Harvest (**üüla**/**sa̱g̱ʷam**/seal, shellfish)
Zone 315	**Maxtaktsm'aa**/Union passage	Beaches, boat anchors and recreation, harvest (shellfish, groundfish), historical village sites
Zone 316	Bishop Bay	Recreation
	Monkey Beach	Recreation

5.2 Cumulative impacts

Ongoing cumulative effects mapping at DFO estimates the impact of multiple stressors to aid ecosystem-based management and spatial planning to protect biodiversity and ecosystem services (Sala et al. 2000, Crain et al. 2008). Spatial data on the location and intensity of marine, coastal and land-based human activities and climate change stressors were compiled previously by Clarke Murray and co-authors (2015a) and have recently been updated (Agbayani et al. 2024). Data layers included 48 human activities and the climate change variables of sea surface temperature (SST), acidification, and ultraviolet (UV) light. They found that most human activities affecting the Pacific region's marine environment occur in coastal areas, on the continental shelf, or within watersheds near the ocean. Furthermore, the biggest change in potential cumulative effects was due to climate change stressors. Regionally, cumulative effects scores from climate were highest in the Strait of Georgia and Southern Shelf Bioregions. The highest scores for human activities were restricted to the shelf region, including a small area around Vancouver and Prince Rupert (Figure 1 in Clarke Murray et al. 2015a). Data on planned development was limited to terrestrial activities that possibly influenced marine systems. Consequently, the highest cumulative effect scores from planned developments were mainly restricted to coastal and marine areas within the boundaries of estuaries (Clarke Murray et al. 2015a), as would be expected for the Caamaño Sound and Douglas Fjord System Network Zones.

We present the activities and stressors that have more than five percent area coverage in the Caamaño Sound and Douglas Fjord System Network Zones identified through the latest cumulative effect assessment (

Table 15). Cumulative effect scores are not reported as they are currently being updated, instead activities with more than 5 percent area coverage are indicated as present in the Network Zones. For further details on the datasets refer to Clarke Murray et al. (2015a and their Supplementary tables). Note that the data presented in Table 11 are current from 2011 to October 2021, depending on the data layer. SST impacts all the Network Zones, as does the commercial harvest of **k'almoos**/**klnákʷ**/**ḵ'a̱lmoos**/crab and **txaw**/**mumegʷezu**/ **txaw**/halibut. Zones 310 and 313 have the highest number of potential activities within their bounds, for a total of 15 (

Table 15). As shown by Clarke Murray et al. (2015a), development activities (i.e., coastal development) occur predominantly in the inland Zones (Zone 313-316). While only the presence of activities is reported here, this information provides hints regarding the potential cumulative impacts each Zone is exposed to and the stressors that future protection may be able to mitigate (see Table 1 in Clarke Murray et al. 2015b).

***Table 15**. Marine, coastal and land-based human activities and climate change stressors documented in the Caamaño Sound and Douglas Fjord System Network Zones, based on the data compiled for cumulative effects assessments by Clarke Murray et al. 2015a. Only those human activities that impact > 5% of the surface area of each Zone are included in the table below. X indicates the presence of that activity in each Zone.*

	Zones						
Human Activities and Climate Change Stressors	310	311	312	313	314	315	316
Climate Change							
Sea Surface Temperature	X	X	X	X	X	X	X
Coastal							
Log Booms				X			X
Industrial Tenures	X	X	X	X			
Cutblocks	X			X	X	X	X
Ports				X	X	X	X
Inorganic Sewage				X	X	X	X
Organic Sewage				X	X	X	X
Fishing							
Commercial: **hadanii/hadanii**/Sablefish Trap				X			
Commercial: Midwater Groundfish Trawl	X						
Commercial: **g̲agaats/q̓ʷaḡʷina/g̲a̲sgaatsk**/Dogfish	X						
Commercial: Geoduck	X		X				
Commercial: **hoon/qeqapela**/Salmon Gillnet					X		
Commercial: **gyenti/’éllas**/Sea Cucumber	X		X	X	X	X	X
Commercial: **wa̲t’ukw/núłem/wa̲t'ukw**/Lingcod	X	X	X				
Commercial: **ts'akwe'ats**/Red Urchin	X	X	X				
Commercial: **hoon/qeqapela** /Salmon Seine	X			X	X		
Commercial: **ts'mhoon**/Rockfish	X	X	X	X		X	X
Commercial: **gasgos/sísíuɬ**/Prawn	X		X	X	X	X	X
Commercial: **k'almoos/klnákʷ/k̲'a̲lmoos**/Crab	X	X	X	X	X	X	X
Commercial: **Txaw/Mumegʷezu/Txaw**/Halibut	X	X	X	X	X	X	X
Marine							
Recreational Boat Routes	X	X	X	X	X		X
Total Number of Activities	**15**	**8**	**11**	**15**	**12**	**10**	**12**

5.3 Fisheries and Subsistence Activities

5.3.1 Commercial Fishery

Currently, the waters in and around the Caamaño Sound and Douglas Fjord System Network Zones support diverse commercial fisheries for groundfish, all **hoon**/**qeqapela**/salmon species, and a variety of crustaceans and invertebrates. Within the Network Zones, 20 commercial fisheries have operated since at least 2012 (Table 15), the **hoon**/**qeqapela** troll species have been counted separately). While the majority of NSB's fishing occurs outside of the Network Zones, all the Zones are fished to some extent (see **Figure 32** to **35** for fishing areas within the Network Zones). **txaw**/**mumegʷezu**/**txaw**/Halibut, **ts'mhoon**/Rockfish, **gyenti**/**'éllas**/Sea Cucumber and **gasgos**/**sísíuɬ**/Prawn are commercially fished in all seven Zones of the Caamaño Sound and Douglas Fjord System Network Zones (Table 15). Zone 310 is fished by the most types of fishing groups (18, Table 15), and Zone 316 is fished by the least (5, Table 15). There are no documented aquaculture sites within the Caamaño Sound and Douglas Fjord System Network Zones region.

Table 16. *Presence of different types of commercial fishing in the Caamaño Sound and Douglas Fjord System Network Zones. with fishing periods provided in parentheses. Data for groundfish comes from validated logbook records on a 1km x 1km planning grid with a privacy filtering Rule of Five. Tuna data comes from expert interviews regarding validated logbook records to determine "important fishing areas for commercial tuna." **Hoon**/**qeqapela**/salmon data is from Salmon Fishery Catch and Landings provided by DFO. 'P' indicates presence of commercial fishing, and 'A' denotes absence of fishing activity during the period.*

	Zone 310	Zone 311	Zone 312	Zone 313	Zone 314	Zone 315	Zone 316	Total # Zones with Fishery
Groundfish Trawls								
Bottom (2014-2018)	P	A	A	A	A	A	A	**1**
Midwater (2014-2018)	P	A	A	A	A	A	A	**1**
Groundfish Hook and Line, and Trap								
txaw/**mumegʷezu**/**txaw**/Halibut Hook and Line (2007-2018)	P	P	P	P	P	P	P	**7**
wa̲t'ukw/**núłem**/**wa̲t'ukw**/Lingcod Hook and Line (2014-2018)	P	P	P	A	A	A	A	**3**
ts'mhoon/Rockfish Hook and Line (2007-2018)	P	P	P	P	P	P	P	**7**
hadanii/**hadanii**/Sablefish Hook and Line (2014-2018)	A	A	A	P	A	A	A	**1**
hadanii/**hadanii**/Sablefish Trap (2007-2018)	P	A	A	A	A	A	A	**1**
Trolling								
yee/**ǩáp̓i**/**xyi'i**/Chinook Salmon (2007-2016)*	P	P	P	P	P	P	A	**6**
gayniis/**gʷaxenis**/**ga̲yniis**/Chum Salmon (2007-2016)*	P	A	A	P	P	P	A	**4**
üüx/**zúen**/**üüxs**/Coho Salmon (2007-2016)*	P	P	P	P	P	P	A	**6**
sti'moon/ **qábes**/**sti'moon**/Pink Salmon (2007-	P	P	P	P	P	P	A	**6**

	Zone 310	Zone 311	Zone 312	Zone 313	Zone 314	Zone 315	Zone 316	Total # Zones with Fishery
2016)*								
misoo/hísen/miso'o/Sockeye Salmon (2007-2016)*	P	P	P	P	P	P	A	**6**
Seine								
Hoon/qeqapela/salmon (2009-2018)	P	A	A	P	P	A	A	**3**
Other								
gasgos/sísíuɬ/Shrimp Trawl (2007-2018)	A	A	A	P	A	A	A	**1**
Sardines (BCMCA)	A	A	A	P	P	A	A	**2**
gyenti/'éllas/Sea Cucumber dive (2007-2018)	P	P	P	P	P	P	P	**7**
ts'akwe'ats/Red Sea Urchin dive (2007-2018)	P	P	P	A	A	A	A	**3**
gasgos/sísíuɬ/Prawn trap (2007-2018)	P	P	P	P	P	P	P	**7**
xs'waanx/'á'ent/xs'waanx/Herring Roe Seine (BCMCA)	P	A	A	A	A	A	A	**1**
Geoduck dive (2007-2018)	P	P	P	A	A	A	A	**3**
k'almoos/klnákʷ/k̲'a̲lmoos/Crab trap (2007-2018)	P	P	A	P	P	P	P	**6**
Total # Fishing Groups per Zone	**18**	**12**	**11**	**14**	**12**	**10**	**5**	

Note that the commercial **hoon/qeqapela/salmon data does not have fine-scale spatial resolution, as data is spatialized at the Pacific Fisheries Management Area Subarea level, which represent large areas.*

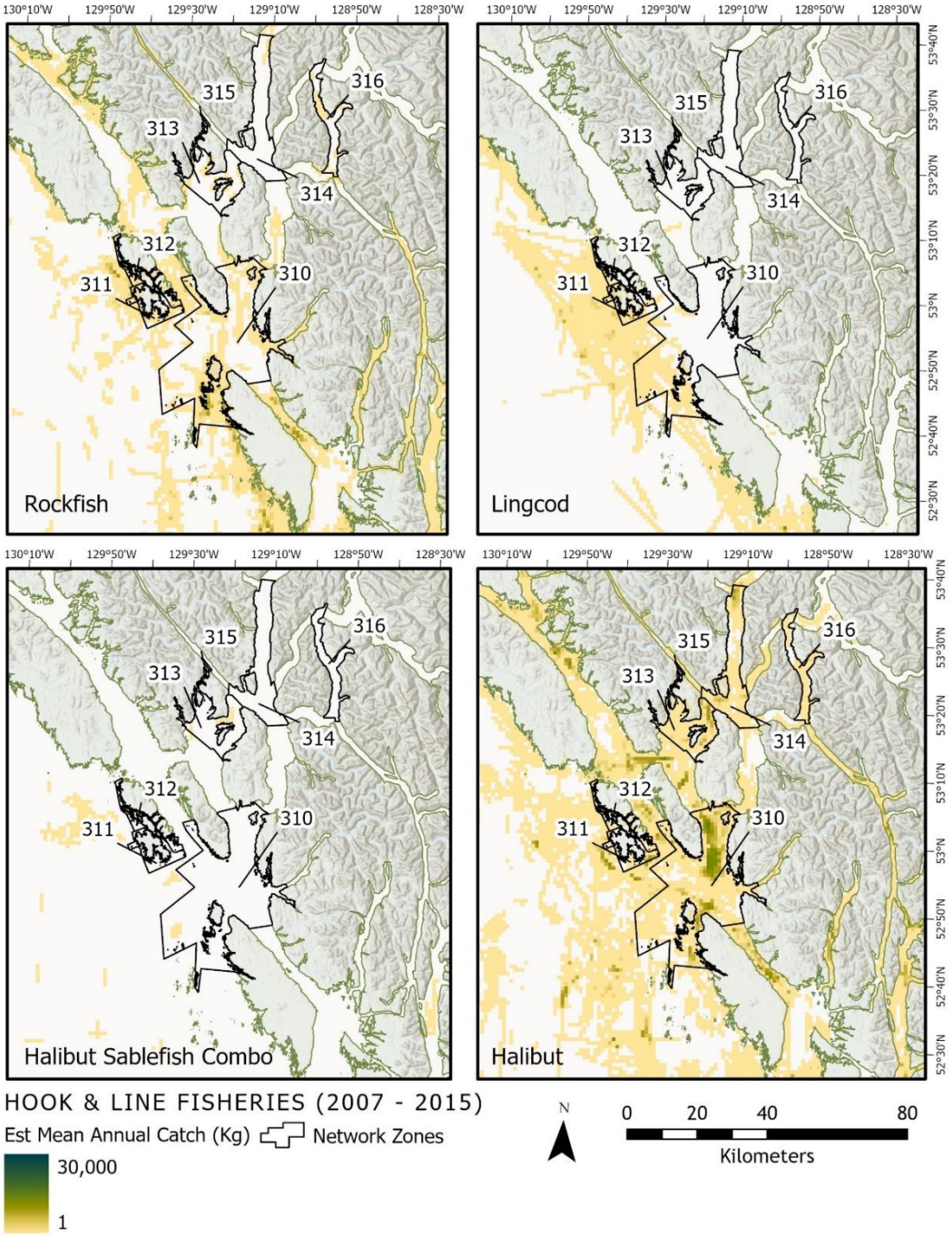

Figure 32. *Presence and distribution of commercial fishing for groundfish in Caamaño Sound and Douglas Fjord System Network Zones using hook and line from 2007 to 2015. Data comes from validated logbook records. A privacy filtering Rule of Five has been applied. This is the same data that is visible on Seasketch.*

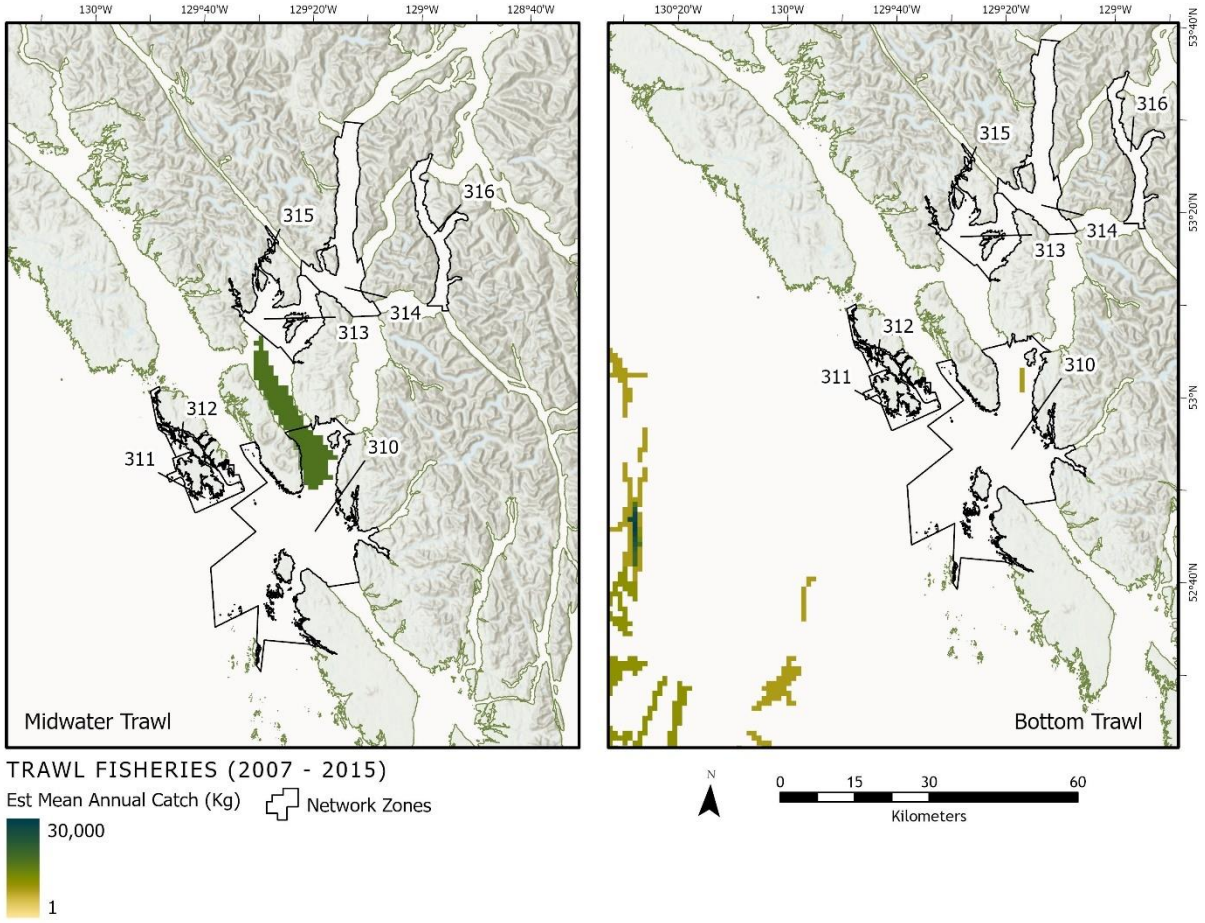

Figure 33. *Presence and distribution of commercial fishing for groundfish in Caamaño Sound and Douglas Fjord System Network Zones using trawl from 2012 to 2015. Data comes from validated logbook records. A privacy filtering Rule of Five has been applied. This is the same data that is visible on Seasketch.*

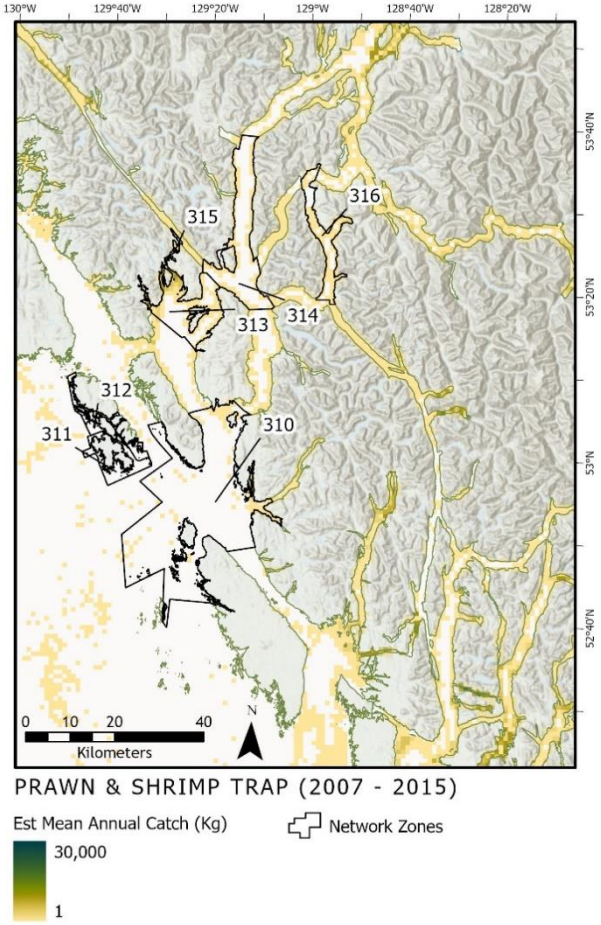

Figure 34. *Presence and distribution of commercial prawn and shrimp trap fishing in Caamaño Sound and Douglas Fjord System Network Zones from 2007 to 2016. Data comes from validated logbook records. A privacy filtering Rule of Five has been applied. This is the same data that is visible on Seasketch.*

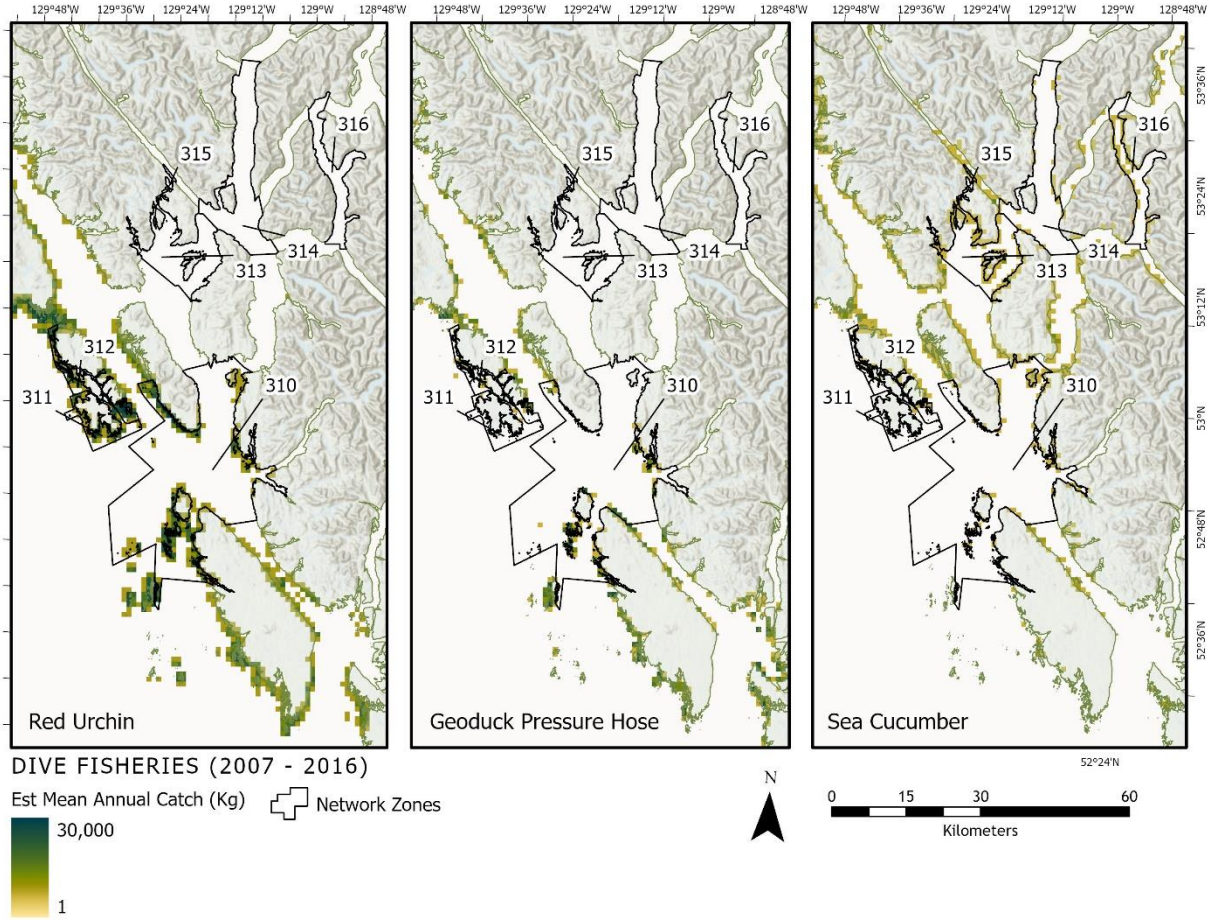

Figure 35. *Presence and distribution of commercial dive fishing in Caamaño Sound and Douglas Fjord System Network Zones from 2007 to 2016. Data comes from validated logbook records. A privacy filtering Rule of Five has been applied. This is the same data that is visible on Seasketch.*

The highest mean annual commercial harvests are from the Seine and **ts'akwe'ats**/ Red Sea Urchin fisheries (

Table 17 to **17**), with the highest landing recorded for Zone 310 in the Caamaño Sound and Douglas Fjord System Network Zones (

Table 17). Note that for the analyses of the DFO Commercial Logbook data presented in **Tables 16** to **17**, annual means are presented calculated for the date ranges DFO has access to. Additionally, not all fisheries are present at fishing grounds each year, such as rotational dive fisheries, this preserves the average distinct count of vessels present when fishing is occurring. For example, Geoduck in Zone 310 Averages 46,000 KG per year (over 9 years;

Table 17) but is not present every year of the 9-year period, as beds grow the next cohort for harvest. In the average year when fishing occurs, geoduck has an average of 11.4 distinct vessels present (

Table 18).

Table 17. *Mean annual vessel harvest (rounded to the nearest 1000 kg) for 2012 to 2021 (range depends on fishery†) by fishery class within each of the Caamaño Sound and Douglas Fjord System Network Zones as reported in spatialized DFO Commercial Logbooks (Fisheries and Oceans Canada 2023)††. Dashes indicate no data. * indicates where the fishery in that zone does not meet the criteria for public release of information as there are fewer than 5 vessels reporting. Bolded values indicate highest values by fishery.*

Fishery	Zone 310	Zone 311	Zone 312	Zone 313	Zone 314	Zone 315	Zone 316
txaw/mumegʷezu/txaw/ Halibut	**37,000**	3,000	1,000	6,000	2000	*	3000
wa̲t'ukw/núłem/ wa̱t'ukw/Lingcod	**2,000**	1,000	*	-	-	-	-
Midwater Trawl	*	-	-	*	*	-	-
ts'mhoon/Rockfish	**5,000**	*	*	*	*	-	*
hadanii/hadanii/ Sablefish	*	-	-	*	-	-	-
Seine	**353,000**	-	-	181,000	244,000	-	-
Troll	**5,000**	< 1,000	-	-	-	-	-
k'almoos/klnákʷ/ k̲'a̲lmoos/Crab	1,000	*	*	**4,000**	< 1,000	1000	2000
Geoduck	**46,000**	*	7,000	-	-	-	-
gasgos/sísíuł/Prawn	1,000	-	*	**8,000**	4,000	1000	4000
ts'akwe'ats/ Red Sea Urchin	**207,000**	63,000	129,000	-	-	-	-
gyenti/'éllas/ Sea Cucumber	**19,000**	*	10,000	28,000	9,000	3,000	26,000
gasgos/sísíuł/Shrimp Trawl	*	-	-	*	*	-	-

† Date ranges for each fishery: Halibut (2017-2021), Lingcod (2017-2021), Midwater Trawl (2017-2021), Rockfish (2017-2021), Sablefish (2017-2021), Seine (2012-2021), Troll (2012-2021), Crab (2012-2021), Geoduck (2013-2021), Prawn (2012-2021), Red Sea Urchin (2013-2021), Sea Cucumber (2012-2021), Shrimp Trawl (2012-2021)

††These results are from an overlap of commercial fisheries data with the Caamaño zones provided in the Network Action Plan (NAP) Scenario 2 - Q. The overlap completed follows the methodologies laid out in Compendium 3 appendices (https://mpanetwork.ca/wp-content/uploads/2022/11/NAP-Compendium-3-web.pdf), with updated 2021 fishing geometries. Fisheries geometries are updated to a 2021 final year, or most recent available. Sea cucumber logbooks were not fully populated for 2021 at the time of geometry creation and use an offset year span from other fisheries. Then fishing event geometries are aggregated to the presented results. Herring and Tuna data is not included due to lack of spatial information in DFO records. Tuna likely has zero overlap, due to the proximity to the coast. For more information on Herring please contact the fisheries managers, as they hold the data and may be able to give more specific information.

Table 18. *Mean annual vessel harvest (rounded to the nearest 1000 kg) and number of unique fishing vessels (Vessel Registration Number (VRN)) in each fishery class operating for 2012 to 2021 (years depend on fishery†) in the Caamaño Sound and Douglas Fjord System Network Zones as reported in spatialized DFO Commercial Logbooks (Fisheries and Oceans Canada 2023). * indicates where the fishery in that zone does not meet the criteria for public release of information as there are fewer than 5 vessels reporting. Note "All Fisheries" sum includes harvest from those fisheries with fewer than 5 vessels reporting.*

Fishery	# Total Distinct VRNs	Annual Mean Landed kg	Annual Mean # VRNs (years with recorded fishing)
txaw/**mumegʷezu**/**txaw**/Halibut	50	55,000	18.2
wa̲t'ukw/**núłem**/**wa̱t'ukw**/Lingcod	10	2,000	4.4
Midwater Trawl	2	*	1.3
ts'mhoon/Rockfish	16	6,000	5.4
hadanii/**hadanii**/Sablefish	4	*	1.7
Seine	71	778,000	32.3
Troll	48	5,000	9.2
k'almoos/**klnákʷ**/**k̲'a̱lmoos**/Crab	19	8,000	4.7
Geoduck	32	53,000	11.4
gasgos/**sísíuł**/Prawn	42	18,000	11.1
ts'akwe'ats/Red Sea Urchin	48	398,000	24.1
gyenti/**'éllas**/Sea Cucumber	27	95,000	11.1
gasgos/**sísíuł**/Shrimp Trawl	4	*	2.0
Fisheries will < 5 vessels	**31**	**76,000**	**-**
All Fisheries	**317**	**1,494,000**	**88.1**

† Date ranges for each fishery: Halibut (2017-2021), Lingcod (2017-2021), Midwater Trawl (2017-2021), Rockfish (2017-2021), Sablefish (2017-2021), Seine (2012-2021), Troll (2012-2021), Crab (2012-2021), Geoduck (2013-2021), Prawn (2012-2021), Red Sea Urchin (2013-2021), Sea Cucumber (2012-2021), Shrimp Trawl (2012-2021)

Table 19. *Mean annual vessel harvest (rounded to the nearest 1000 kg) and number of unique fishing vessels (Vessel Registration Number (VRN)) in each fishery class operating for 2012 to 2021 (years depend on fishery†) operating in the Pacific Fisheries Management Area Subareas†† that touch the Caamaño Sound and Douglas Fjord System Network Zones as reported in spatialized DFO Commercial Logbooks (Fisheries and Oceans Canada 2023). * indicates where the fishery in that zone does not meet the criteria for public release of information as there are fewer than 5 vessels reporting. Note "All Fisheries" sum includes harvest from those fisheries with fewer than 5 vessels reporting.*

Fishery	# Total Distinct VRNs	Annual Mean Landed kg	Annual Mean # VRNs (years with recorded fishing)
Bottom Trawl	12	323,000	6.2
txaw/**mumegʷezu**/**txaw**/Halibut	76	142,000	28.2
wa̲t'ukw/**núłem**/**wa̲t'ukw**/Lingcod	17	19,000	7.8
Midwater Trawl	4	*	1.4
ts'mhoon/Rockfish	22	15,000	8.6
hadanii/**hadanii**/Sablefish	5	1,000	2.0
Seine	71	1,546,000	32.3
Troll	48	10,000	9.2
k'almoos/**klnákʷ**/**k̲'a̲lmoos**/Crab	24	14,000	5.7
Geoduck	38	173,000	13.8
gasgos/**sísíuł**/Prawn	50	39,000	15.0
ts'akwe'ats/Red Sea Urchin	51	700,000	25.8
gyenti/**'éllas**/Sea Cucumber	27	219,000	14.6
gasgos/**sísíuł**/Shrimp Trawl	4	*	2.0
All Fisheries	**366**	**3,279,000**	**106.8**

† Date ranges for each fishery: Halibut (2017-2021), Lingcod (2017-2021), Midwater Trawl (2017-2021), Rockfish (2017-2021), Sablefish (2017-2021), Seine (2012-2021), Troll (2012-2021), Crab (2012-2021), Geoduck (2013-2021), Prawn (2012-2021), Red Sea Urchin (2013-2021), Sea Cucumber (2012-2021), Shrimp Trawl (2012-2021)

††This table shows the PFMA-SUBAREA average harvest for the commercial harvest species, based on the list of sub areas overlapping subareas. The list was created by overlaying the Caamaño Zones with the DFO PFMA SUBAREAS geodatabase (5-24, 6-2, 6-3, 6-5, 6-6,6-7, 6-9, 6-10, 6-11, 6-12, 6-13, 6-14, 6-20, 6-26, 6-27, 6-28, 106-1, 106-2). This table includes all of the sub area space outside of the Zone boundaries, resulting in a higher average harvest as more space is included.

5.3.2 Recreational Fishing

Recreational and sustenance fisheries occur throughout the Caamaño Sound and Douglas Fjord System Network Zones. Three data sources provided information about the intensity of recreational fishing activities in the Caamaño-Douglas Network Zones: BC Marine Conservation Analysis (BCMCA), the DFO's Internet Recreational Effort and Catch (iREC) database, and the DFO Conservation & Protection Aerial Surveillance Program (ASP). These three sources are the best for indicating the species groups and relative intensity of recreational fishing in the area despite the outdated BCMCA data. The BCMCA data (BCMCA Project Team 2011) identifies broad regions of recreational fishing based on expert and local knowledge. The data shows recreational fishing activities for anadromous fishes, groundfishes, and **k'almoos**/**klnákʷ**/**k̲'a̲lmoos**/crabs throughout the Caamaño Sound and Douglas Fjord System Network Zones (**Figure 36**). Recreational **Hoon**/**qeqapela**/salmon fishing occurs throughout the region. Groundfish recreational fishing is mainly limited to the Outer Coast Zones in the deeper offshore waters, and **k'almoos**/**klnákʷ**/**k̲'a̲lmoos**/crab fishing is limited to inner coastal areas.

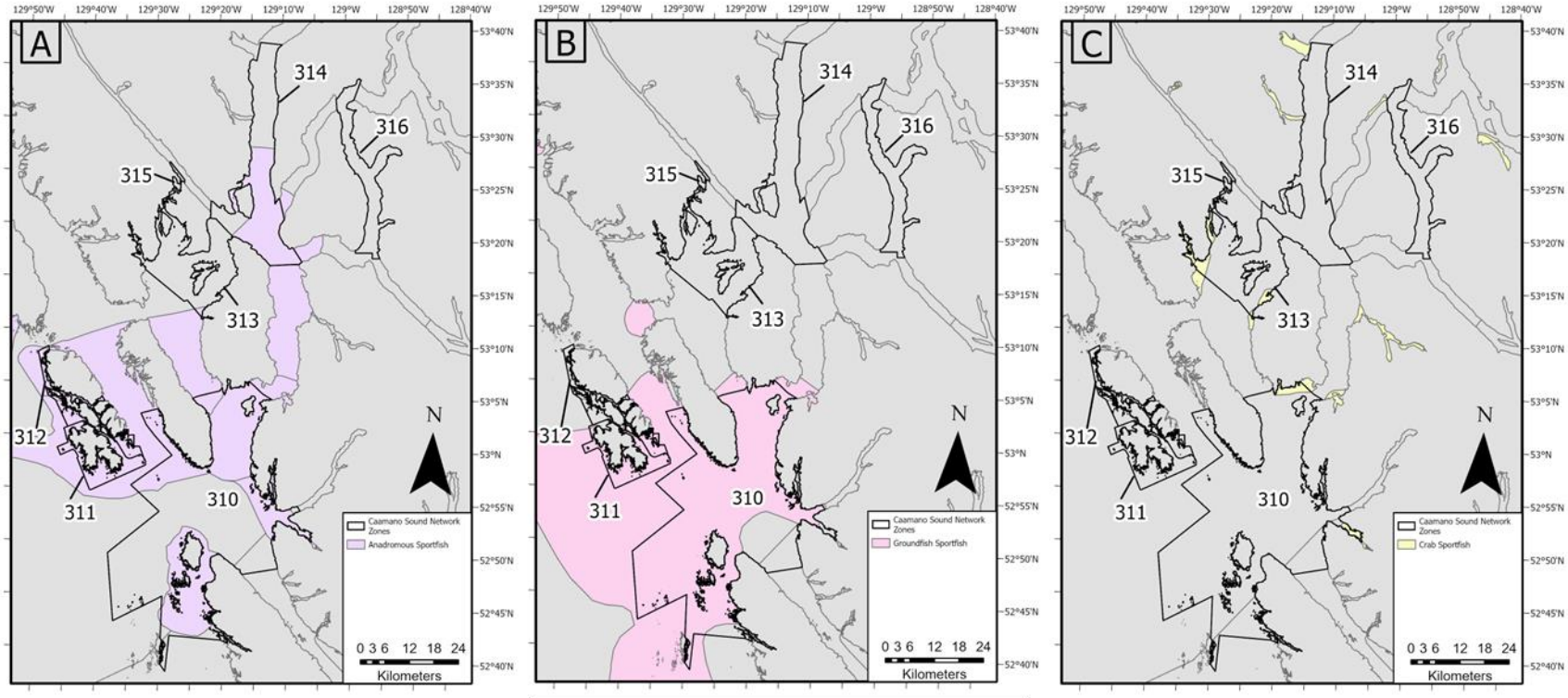

Figure 36. Overlap of areas where recreational (sport) fishing for (A) **Hoon**/**qeqapela**/salmon and other anadromous finfish, (B) groundfish (primarily **txaw**/**mumegʷezu**/**txaw**/halibut, **wa̲t'ukw**/**núłem**/**wa̱t'ukw**/lingcod and **ts'mhoon**/rockfish), or (C) **k'almoos**/**klnákʷ**/**k̲'a̱lmoos**/crab occurs with the Caamaño Sound and Douglas Fjord System Network Zones. Recreational fishing areas were identified by participants in 19 local and regional Sport Fishing Advisory Board meetings and through other local knowledge (BCMCA Project Team 2011).

The Caamaño-Douglas area occurs in the Pacific Fishery Management Areas (PFMAs) 106 and 6 (**Figure 37**). DFO's iREC is a mandatory reporting system for recreational fishers, which requires holders of sport fishing licenses to report their catch for one month. Recreational fishing data (iRec) included angling from a boat, angling from the shore, beach digging, dive-based, shellfish trapping from the boat and shellfish trapping from shore/dock (**Table 20**). 946 recreational fishing days (reported as licensee days) were documented between January 2020 and June 2022 within both PFMAs. However, specific fishing locations are not known. PFMA 6 is a popular recreational and sustenance fishing region compared to PFMA 106 and was fished more often in 2020 and 2021 than in 2022. Angling and shellfish trapping from boats were the most common recreational fishing activities.

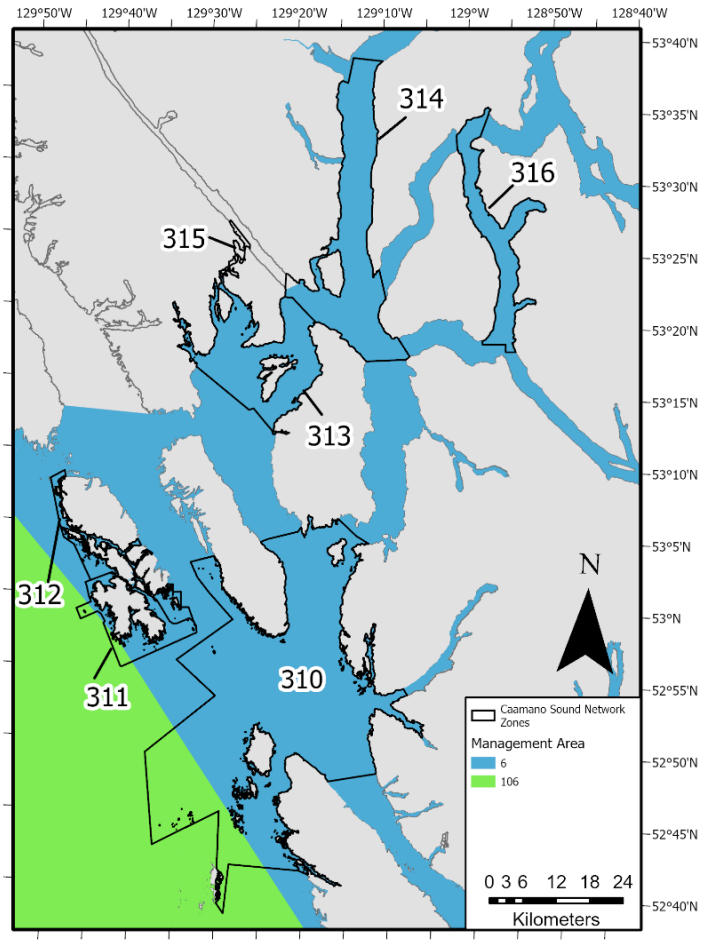

***Figure 37**. Pacific Fishery Management Areas within the Caamaño Sound and Douglas Fjord System Network Zones area.*

Table 20. *iREC fishing effort estimates for the period between January 2020 and June 2022. Fisher days are the total number of licensee days reported by licensees. The Caamaño Sound Zones overlap two Pacific Fishery Management Areas (PFMAs), and each fishing estimate is for the entire shaded region, however, it is understood that these fishing activities do not occur throughout each shaded area due to the limitations of recreational fishing boats and fish distributions. Licensee days = 1 day trip by one licensee to fish via one method in one area and are not mutually exclusive (i.e., the same licensee can participate in more than one method in the same day, or in multiple areas in one day). Note the majority of the Caamaño Sound Zones and their surface area is within PFMA 6.*

	PFMA 106			PFMA 6		
Fishing Activity	**2020**	**2021**	**2022**	**2020**	**2021**	**2022**
Angling from boat	18	17	9	202	264	97
Angling from shore	-	-	3	33	19	4
Beach digging or hand picking	-	-	-	3	4	-
Dive-based or other	-	-	-	2	1	-
Shellfish trapping from boat	1	3	3	73	101	44
Shellfish trapping from shore or dock			2	11	21	11
Total Fishing Days	**19**	**20**	**17**	**324**	**410**	**156**

Additionally, DFO's Conservation & Protection program runs the ASP to enforce fisheries closures regulated by DFO. The ASP provides observations of recreational fishing vessels through transmissions received by Automatic Identification Systems, radar detection, and visual observations (Burke et al. 2022). From 2018 to 2020, aerial surveillance detected recreational fishing vessels in the Caamaño-Douglas area, with the highest numbers of recreational vessels in Zones 310 and 316 and the least in Zones 312 and 315 (Burke et al. 2022; see also **Figure 47** in the Vessel traffic and vessel types section).

5.4 Human coastal and nearshore activities

5.4.1 Forestry cutblocks, log storage and log tenures

Forestry activities have a long history in BC's coastal regions and watersheds. Forestry cutblocks, access roads, and associated log handling and storage result in pollution, sedimentation, and nutrient flushing (Shah et al. 2022). Logging has been an important local economy along the North Coast since the early 1900s (North Coast Marine Plan 2015). Logging activities are variable in their ecological impact, as they can be seasonal, have terrestrial and marine components, and may still influence downstream habitat after the logging activities have ceased (Shah et al. 2022). Within the Caamaño Sound and Douglas Fjord System Network Zones forestry cutblocks are located on the coast of Zones 310, and 313 to 316 (**Figure 38**). Log handling (including log booms, log dumps, log sorting, and log storage) occurs in the coastal areas of Zones 310, 313, and 316 (**Figure 38**).

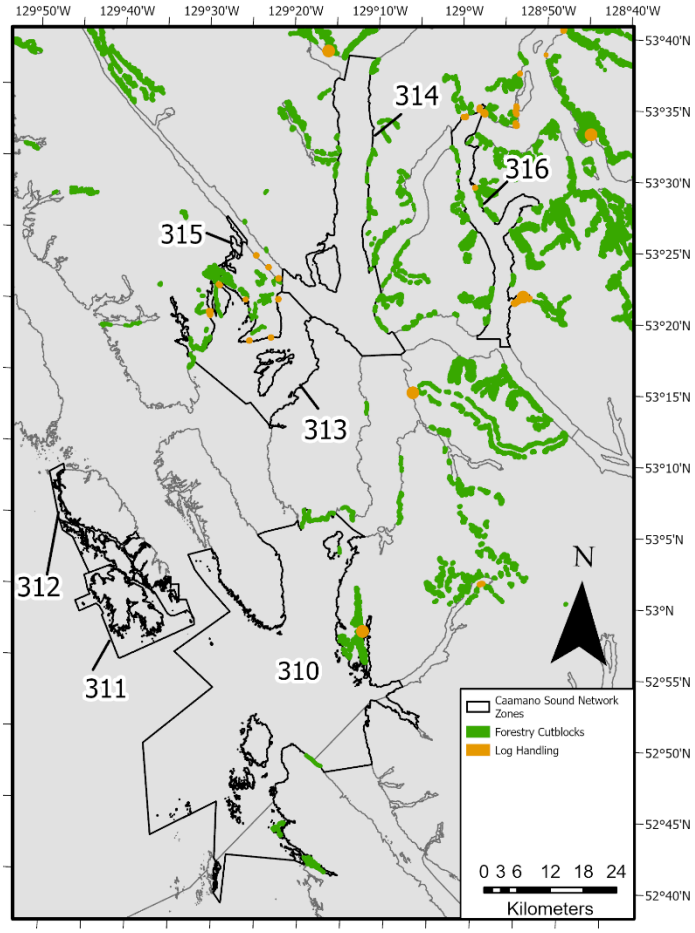

***Figure 38**. Log handling and storage (including log booms, log dumps and log sorting areas) and forestry cutblocks within the Caamaño Sound Zones region. Data on log handling areas comes from Province of BC – Lands Branch current until 2022, Economics and Trade Branch current until 2018, and GeoBC current until 1998. Data on forestry cutblocks comes from the Province of BC - Forest Analysis and Inventory current until 2022. Note that features are shown larger than their actual spatial area for ease of viewing.*

5.4.2 Underwater development

Provincial utility tenures are distributed throughout the province for underwater developments to connect remote communities to power grids and other services. It is important to note these structures as they could impact local biodiversity. For example, underwater submarine cables can result in magnetic field alteration, although they have low confidence for negative effects on juvenile ***hoon***/***qeqapela***/salmon in estuaries (Hodgson et al. 2020). Underwater development can also contribute to benthic habitat modification, habitat disturbance and pollution. Underwater development within the Caamaño Sound and Douglas Fjord System Network Zones has occurred in Zones 316, 314, and near Zone 315 (**Figure 39**). An underwater electric power line, water line, and telecommunication line are clustered near the community of **Txałgiu**/Hartley Bay (Zone 314).

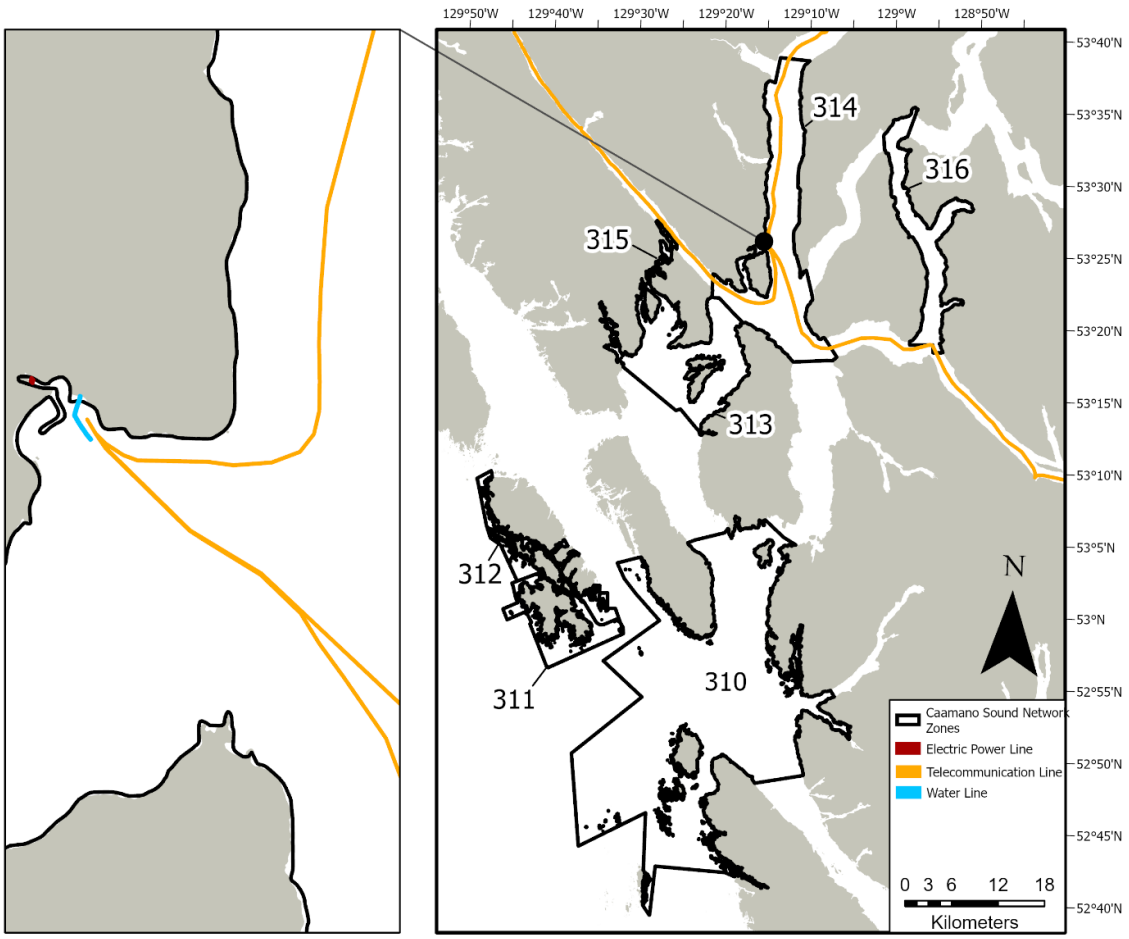

***Figure 39**. Tenures for underwater development near the Caamaño Sound and Douglas Fjord System Network Zones. Data comes from the BC Marine Conservation Atlas. It includes Utility Crown land tenures for telecommunication lines, submerged power lines, sewer effluent lines, oil and gas pipelines, water lines, and transmission line tenures issued for waterpower purposes overlapping marine BC areas as of October 2012.*

5.4.3 Tourism and recreation

Tourism is one of the main economic activities in BC (Province of BC Tourism Research[6], Big River Analytics 2021), and is the fourth largest marine-based sector in the NSB, after seafood, coastal forestry, and marine transportation (Big River Analytics 2021). In the North Coast regional district, local tourism and recreation is an emerging sector with a growing interest in ecotourism and cultural tourism (North Coast Marine Plan, 2015). Marine recreational activities in this area include scuba diving, kayaking, recreational boating, and fishing. Trutch Island (Zones 311 and 312), in particular, was identified as a MaPP protection management zone for

[6] https://www2.gov.bc.ca/gov/content/tourism-immigration/tourism-resources/tourism-research

maintaining recreation and ecotourism opportunities (See Table 28 in North Coast Marine Plan, 2015).

To visualize the extent of tourism activities of the Caamaño-Douglas area, spatial layers from various sources were compiled by the BCMCA Project Team (BCMCA Project Team 2011; **Figure 40A**). Please see the BCMCA Atlas[7] for a complete list of data sources for each layer and feature, including original data, interviews, and surveys from 1992 to 2009. Relative importance (low, medium, high) of recreational boating and kayak routes in the Caamaño-Douglas area is not shown in the figures (to prevent cluttering) but is described in the following paragraph. The Feature Count spatial layer summarized and tallied 45 tourism and recreation features from BCMCA (BCMCA Project Team 2011) in 2 km by 2 km units (**Figure 40B**). Certain spatial features may not represent the current distribution of tourism and recreation activities.

All Network Zones within the Caamaño-Douglas area, with the exception of 311, have areas with relatively high tourism and recreation feature counts (5-7), although no unit in the Network Zones have a feature count about 7 (**Figure 40B**). These Zones include Borrowman Bay on Aristazabel Island in Zone 310, Trutch Island site in Zone 312, **Lax Kwil Dziist**/Fin Island in Zone 313, **Txałgiu**/Hartley Bay in Zone 314, **Maxtaktsm'aa**/Union Passage site in Zone 315, and the northern end of Ursula Channel in Zone 316. Outside the Network Zones, there are noted areas with higher feature counts in Whale Channel.

Within the Network Zones, recreational dive sites and anchorages were noted in almost every Zone, generally with more dive sites on the outer coast around Caamaño Sound and Estevan Sound. Recreational boating routes were noted to be of high relative importance throughout **Maxtaktsm'aa**/Union Passage (Zone 315 and outside), Princess Royal Channel (outside the Network Zones), and Douglas Channel (Zone 314). Grenville Channel and Princess Royal Channel are routes within the Inside Passage, a popular coastal route used by recreational and commercial ships that extends throughout BC's coast up to southeastern Alaska (see Section 5.5). Relative to the area, high usage of sea kayaking routes was mapped in Estevan Sound (Outside Zone 311), near **K'nabiyaaxl**/Ashdown Island (Zone 310), around **Lax Kwil Dziist**/Fin Island (Zone 313) and Wright Sound (Zone 314), and through Grenville Channel (Zone 315). Sea kayaking is associated with other activities such as wildlife and wildlife viewing, **łbuun**/**g̃ʷey̓ém**/**łpuun**/whale watching, camping, hiking, and fishing. Several kayak campsites and haul-outs are also noted throughout the Caamaño Sound and Douglas Fjord System Network Zones, particularly around the Inside Passage channels near Zone 314 and 316 (BCMCA Project Team 2011).The most popular hot springs on the North Coast are located in Bishop Bay - Monkey Beach Conservancy in Zone 315. Infrastructure for this prominent destination includes docks, a walkway, tent pads, cabins, a hot springs shelter and bath house on-site (BC Parks News, 2022[8]). Other popular destinations include Zones 311 and 312 for

[7] https://bcmca.ca/maps-data/atlas/

[8] https://engage.gov.bc.ca/bcparksblog/2022/01/14/a-magical-place-bishop-bay-monkey-beach-conservancy/

school field trips and knowledge transmission (K. Clifton, pers. comm. 2023), and the scenic **Maxtaktsm'aa**/Union Passage Marine Park (Zone 315) where boaters can find calm places to anchor and sheltered beaches (North Coast Marine Use Plan).

After checking for ongoing operations, several marinas were manually edited out of the map, assuming they were out of order or closed. Known operational marinas within the Caamaño Sound and Douglas Fjord System Network Zones include North King Lodge in Borrowman Bay, Aristzabel Island (Zone 310), the Small Craft Harbour public wharf and the Transport Canada public wharf both located in **Txałgiu**/Hartley Bay within Zone 314. The Butedale Lodge in Princess Royal Channel is located nearby outside of the Network Zones.

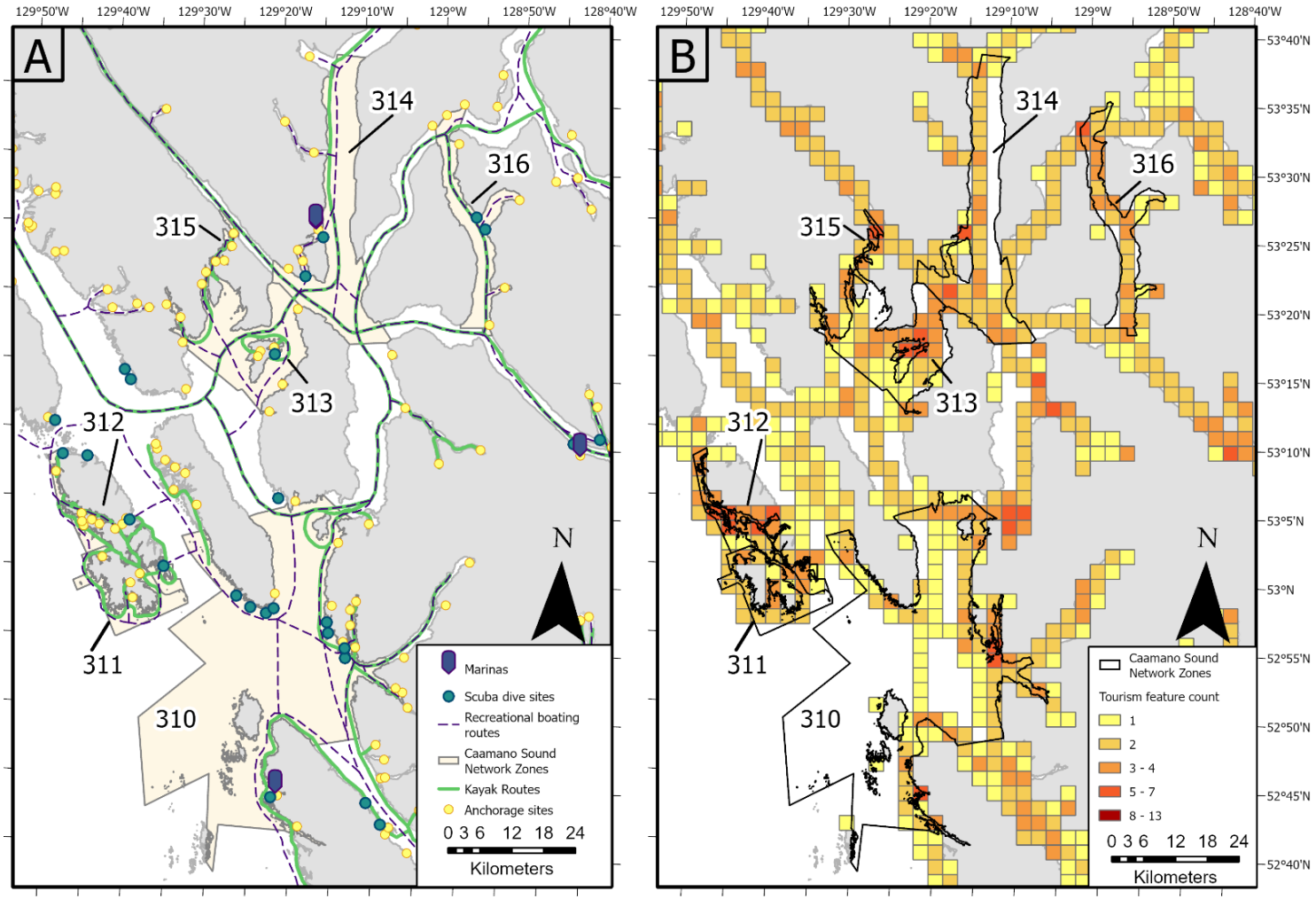

Figure 40. *Several tourism and recreational features in the Caamaño-Douglas area showing their A) general distribution and B) total counts in a 2 km by 2 km unit. These feature layers originate from BCMCA (BCMCA Project Team 2011) with datasets merged from 1992-2009.*

5.4.4 Ocean Energy

Natural energy resources in the NSB, such as areas with high winds, tides, and waves, can be potentially used for renewable energy development (BCMCA Project Team 2011). Tidal energy projects in BC remains in their inception due to infrastructure costs and a lack of supporting policy (Dahlquist-Axe 2020), although a few areas of interest have been identified in the NSB. Wave energy was investigated as a resource by the West Coast Wave Initiative project team. No publicly available data for tide or wave energy exists for the Caamaño Sound and Douglas Fjord System Network Zones.

In contrast, there are currently nine wind turbine sites in terrestrial locations across BC (Canada Wind Turbine Database[9]). High annual mean wind energy potential (measured in watts per m^2) was identified on the outer areas of the Caamaño Sound and Douglas Fjord System Network Zones such as Hecate Strait (BCMCA Project Team 2011, **Figure 41**). The annual wind speed and power was measured at 30 meters above earth's surface in 5 km resolution tiles. The full methodology is described on the federal Wind Atlas site[10]. A crown tenure for wind energy exists on Western Aristazabal Island with an expiration date of 2027 and the current purpose of this tenure is investigation and monitoring (BC Geographic Warehouse 2023, Data Catalogue)[11]. Elsewhere in the NSB, an offshore wind turbine project in Hecate Strait[12] is in development connecting Haida Gwaii and Prince Rupert through renewable wind energy.

Other non-renewable energy resources in the NSB include petroleum and offshore oil and gas, in which the provincial and federal government issued tenures to various companies in the 1960s. A federal and provincial moratorium was imposed in 1972 and 1989 respectively, which halted issuing permits for oil and gas exploration in BC. In June 2019, the federal *Oil Tanker Moratorium Act* prohibited tankers carrying more than 12,500 metric tons of crude or persistent oil from docking, loading, unloading, and stopping in ports or marine installments in the NSB. Several companies that historically held federal tenures overlapping with the Caamaño Sound and Douglas Fjord System Network Zones have recently relinquished their licenses to the Federal Government[13].

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[9] Canadian Wind Turbine Database - Open Government Portal

[10] Methodology - Wind Atlas - Environment and Climate Change Canada

[11] TANTALIS - Crown Tenures - BC Geographic Warehouse Custom Download - Data Catalogue

[12] https://oceanicwind.ca/

[13] Feds secure surrender of last oil and gas permits off B.C. coast | CBC News

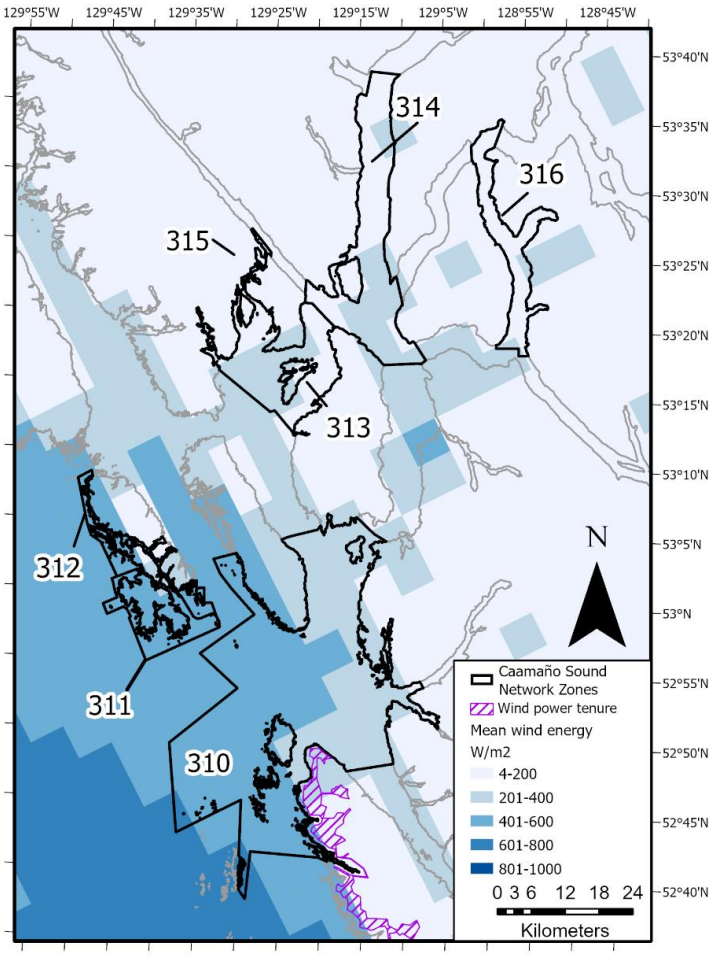


***Figure 41**. Mean wind energy in watts per meter squared (W/m^2) and wind power tenure locations in the Caamaño-Douglas area.*

5.5 Vessel traffic and vessel types

The Caamaño-Douglas area is a thoroughfare for vessel traffic as it is situated south of the busy ports of Prince Rupert and Kitimat. The Port of Prince Rupert is the third largest seaport in size in Canada (Big River Analytics 2021), whereas the private Port of Kitimat is the third largest port in BC, after Vancouver and Prince Rupert, and the development site for a new terminal. Both ports are gateways for trade between North America and Asia. However, ships travelling to and from Kitimat traverse Douglas Channel, Caamaño Sound, and the waterways connecting the two areas. In addition, the Inside Passage is a popular recreational travel route through coastal BC that runs adjacent to Zones 313 - 316 and passes through Wright Sound in Zone 314. Vessels traveling through the Inside Passage range from kayaks and recreational vessels to larger ferries and cruise ships.

As economic growth and trade are poised to expand, shipping traffic and vessel size are expected to grow (GSGislason & Associates Ltd. 2007; Big River Analytics 2021). For example, the Caamaño-Douglas area may face additional traffic of large vessels from two Liquid Natural Gas (LNG) projects underway in Kitimat. The “LNG Canada” project aims to build Canada’s first

LNG export terminal in Kitimat, and the first phase is on track to ship by 2025[14]. By 2030, the LNG Canada project is predicted to bring 350 calls by LNG carriers (approximately 300 m in length) each year (700 transits per year; TERMPOL 2015). The “Cedar LNG” project will introduce an additional 50 calls (100 transits per year; Stantec 2019) (Keen et al. 2023). Each ship will be accompanied by at least one pilot tug (35m in length; TERMPOL 2015) (Keen et al. 2023).

In December 2022, the North Coast Waterway Management Guideline[15] was implemented for the waterways of the Gitga’at and Gitxaała Nations. The guideline applies to all vessels navigating the following areas: Douglas Channel (Zone 314), Wright Sound (Zone 314), Lewis Passage (Zone 313), Otter Channel, Nepean Sound, and Principe Channel (**Figure 42**). The proposed LNG shipping passage will also pass through some of these areas (See **Figure 104**). This document provides voluntary guidance for Gitga’at and Gitxaała areas of concern, and includes information on dates and times to avoid transit or vessel operations in certain areas, speed reduction for **łbuun**/**ḡʷey̓ém**/**łpuun**/whales and fishing gear, and direction on vessel routing and communications (e.g., passing and meeting), in addition to guidance on emergency response for vessel equipment failure (**Table 21**).

Harmful effects from vessel traffic includes ship strikes with marine animals, underwater noise pollution, the release of pollutants (e.g., oil, discharge such as sewage, greywater and scrubber washwater, and marine debris, see **section 5.6** for details), disruptions to fishing gear and **ła’ask**/**lhlaˈq̓s**/**łą̱'a̱sk**/seaweed harvest due to increased wave action on intertidal **ła’ask**/**lhlaˈq̓s**/**łą̱'a̱sk**/seaweed beds (Satterfield et al. 2012), and the introduction of nonindigenous or invasive species. Ship strikes are particularly harmful to larger animals, such as marine mammals (Nichol et al. 2017). Underwater noise pollution from vessels can also disturb the regular behaviours of animals that depend on acoustics for communication and foraging (Weilgart 2007; Wright et al. 2007). Cetaceans, particularly pinnipeds, are susceptible to the harmful byproducts of increased marine traffic (Kucey 2005; Johnson and Acevedo-Gutierrea 2007), especially when large vessels travel fast in areas where they aggregate (e.g., Squally Channel which is partially located in Zones 310 and 313, and Verney Passage, outside of the Network Zones polygons). Predicted increases vessel traffic in the Caamaño-Douglas area may increase the risk of ship-strike mortalities for baleen **łbuun**/**ḡʷey̓ém**/**łpuun**/whales in Zones where these **łbuun**/**ḡʷey̓ém**/**łpuun** are found in higher densities such as Wright Sound (Zone 314), Caamaño Sound (Zone 310), and Squally Channel (Keen et al. 2023). Mitigations for this risk is discussed in Keen et al. (2023) and can include limiting speeds to less than 10 knots and limiting LNG and other large vessel traffic (> 180 m) during nighttime (i.e., when **łbuun**/**ḡʷey̓ém**/**łpuun** are more likely to in shallow waters) and seasons when **łbuun**/**ḡʷey̓ém**/**łpuun** are most active in the area. Refer to section 6.2.5.4 (Marine Mammals - Vulnerabilities and Recoverability) and Keen et al. (2023) for more ship-strike information. Finally, ships can be a prominent method of introduction and connection for non-indigenous or invasive species into and between Marine Protected Areas (Iacarella et al. 2020). It was noted that vessel biofouling regulations were needed in addition to MPA network plans on invasive species monitoring and prevention (Iacarella et al. 2020).

[14] LNG Canada 70% complete - Business in Vancouver

[15] British Columbia North Coast Waterway Management Guidelines - SSB No.: 26/2023

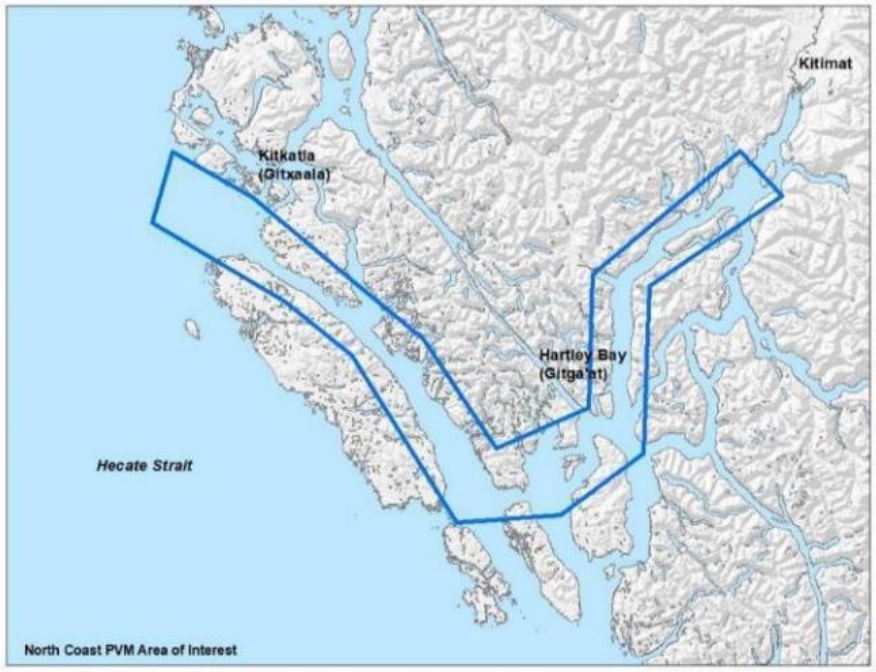


***Figure 42**. Areas under the North Coast Waterway Management Guidelines. Original figure from [British Columbia North Coast Waterway Management Guidelines - SSB No.: 26/2023]*.

***Table 21**. Coastal human and animal activities that are affected by vessel traffic in the Gitga'at Area of Concern by month. The area includes Douglas Channel to Wright Sound to Otter Passage (Network Zones 313 and 314). Original table source is from the Canadian Coast Guard North Coast Waterway Management Guidelines (September 2022).*

Activity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Small vessel traffic: transiting, fishing, hunting, ceremonial, and monitoring	X	X	X	X	X	X	X	X	X	X	X	X
Night Traffic and Beach Harvesting	X	X	X						X	X	X	X
Intertidal/shoreline harvesting – People onshore, vessels anchored nearshore	X	X	X		X	X			X	X	X	X
Community and Commercial Fishing Vessels and Gear				X	X	X	X	X	X	X		
High Whale Use					X	X	X	X	X	X	X	
Nearshore Hunting	X	X	X	X	X	X	X	X				X
Increased traffic between Hartley Bay and Seasonal Harvest Camps					X	X		X	X	X		
Vessel-Based Ecotourism								X	X	X		
Fin Island Research Station and Associated Vessel Surveys Active				X	X	X	X	X	X	X	X	

Data sources

Two methods, Automatic Identification System (AIS) and DFO's Conservation & Protection Aerial Surveillance Program (hereafter "C&P flyovers"), were used to summarize the amount and the type of vessel traffic in the Caamaño-Douglas area.

Many ships have AIS transponders that provide information such as the vessel's identity, position, and activity to other AIS devices and to satellite and terrestrial-based antennas. In Canada, large vessels are required to carry AIS (≥ 300 tons on an international voyage or ≥ 500 tons on a domestic voyage), vessels ≥ 150 tons carrying more than 12 passengers on an international voyage, vessels voyaging outside of sheltered waters certified to carry more than 12 passengers, and vessels that are ≥ 8 m in length and carrying passengers (Navigational Safety Regulations (Automatic Identification Systems): SOR/2019-100). Smaller commercial fishing and recreational vessels are not required to have AIS. Therefore, an absence of AIS data does not indicate an absence of vessels, and there can be significant vessel omissions in Canada's AIS data (Iacarella et al. 2023). For example, only 30% of vessels detected in a C&P flyover over the Salish Sea in BC transmitted AIS (Serra-Sogas et al. 2021). AIS data provided by Transport Canada from Terrestrial AIS via Canadian Coast Guard and Satellite AIS via Maerospace[16] were used to summarize total vessel counts and vessel types within each Network Zone in 2019 per 1 square kilometer.

[16] MPATT vessel traffic density grids 2015-2019 metadata

Flyovers, conducted by C&P, fill in gaps from AIS since flyovers can detect vessels with or without AIS transponder units on board. Flyovers use an AIS receiver attached to the plane to detect vessels with AIS, while vessels without AIS are detected by Inverse Synthetic Aperture Radar or by visual observation by an aircraft observer. C&P flyovers cover the entire BC coast, albeit in a non-continuous time span, and collect information on vessel's identity and position along with detailed information on vessel activity and type, including fishing gear types (Iacarella et al. 2020; Burke et al. 2022). C&P flyover data within the Network Zones were compiled from the C&P flyovers database for 2018 – 2020 and were used to summarize total AIS and non-AIS vessel counts and vessel types along with fishing gear type (**Appendix C**. Vessel Data Gear Class Definitions.

Vessel traffic density and type summary in the Caamaño-Douglas area

There are two routes in the Caamaño-Douglas area with dense: 1) an Outer Passage route that travels through Principe Channel to Estevan and Caamaño Sounds down to Loredo Channel, which is adjacent to Zones 312 and 311, and passes through Zone 310, and 2) an Inside Passage route that travels from Grenville Channel to Princess Royal Channel through Zone 314 and adjacent to Zones 313, 315, and 316 (**Figure 43**). Out of all vessel types in 2019 (with the exception of government/research vessels), most vessels were observed in Zone 314 using AIS data, which encompasses Douglas Channel, **Txałgiu**/Hartley Bay, and Wright Sound, whereas Zones 311 and 312 had the least amount of vessels (**Figure 44**). Tug and recreational (i.e., pleasure crafts) were the most common in all Network Zones. All vessel types were observed in each Zone except for cargo and ferry/car carrier vessels in Zone 311. Passenger vessels (which includes cruise ships) were observed in all Zones with the highest number in Zones 314 and 316. Keen et al. (2023) presented detailed vessel transits for the same 2019 AIS data in the Caamaño-Douglas area and recorded 167 total transits of vessels over 180 m in length, about an equal number of transits for cruise ships (n = 73) and cargo ships (n = 94).

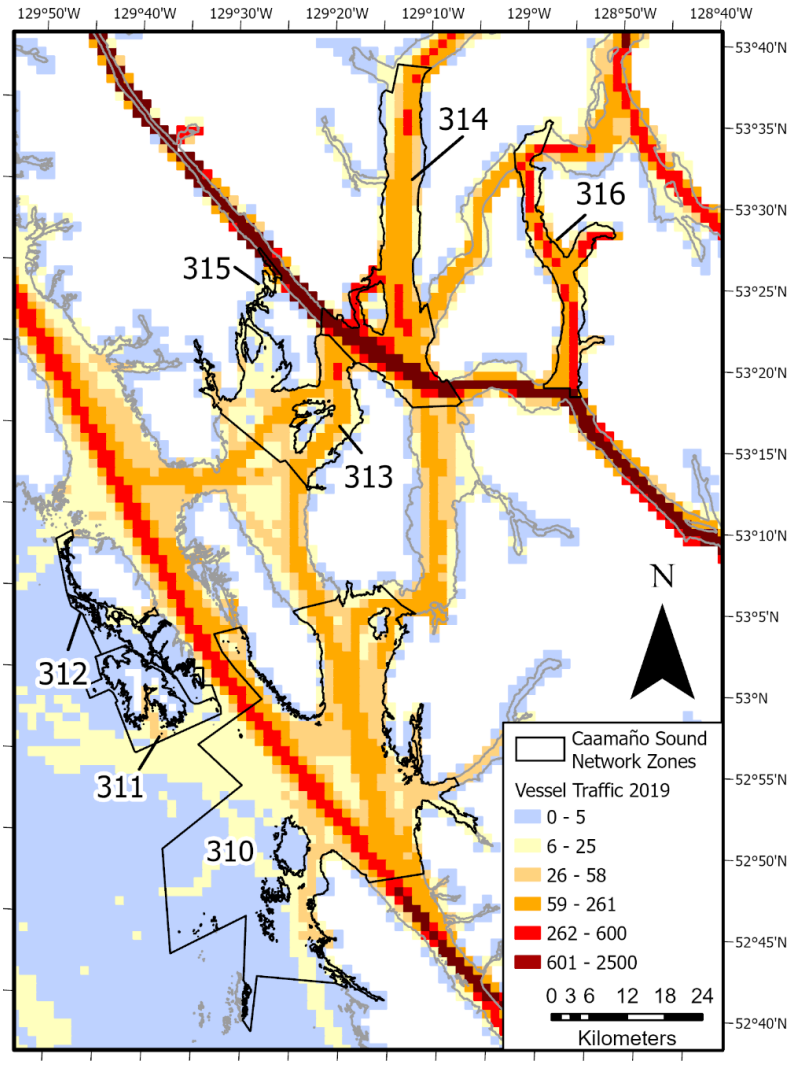


***Figure 43**. Total annual estimated vessel traffic in 2019 in the Caamaño-Douglas area of the Northern Shelf Bioregion, British Columbia. Vessel traffic counts are the total number of vessels per 1 km² grid cell. For a breakdown of each vessel type per Network Zone see **Figure 44**.*

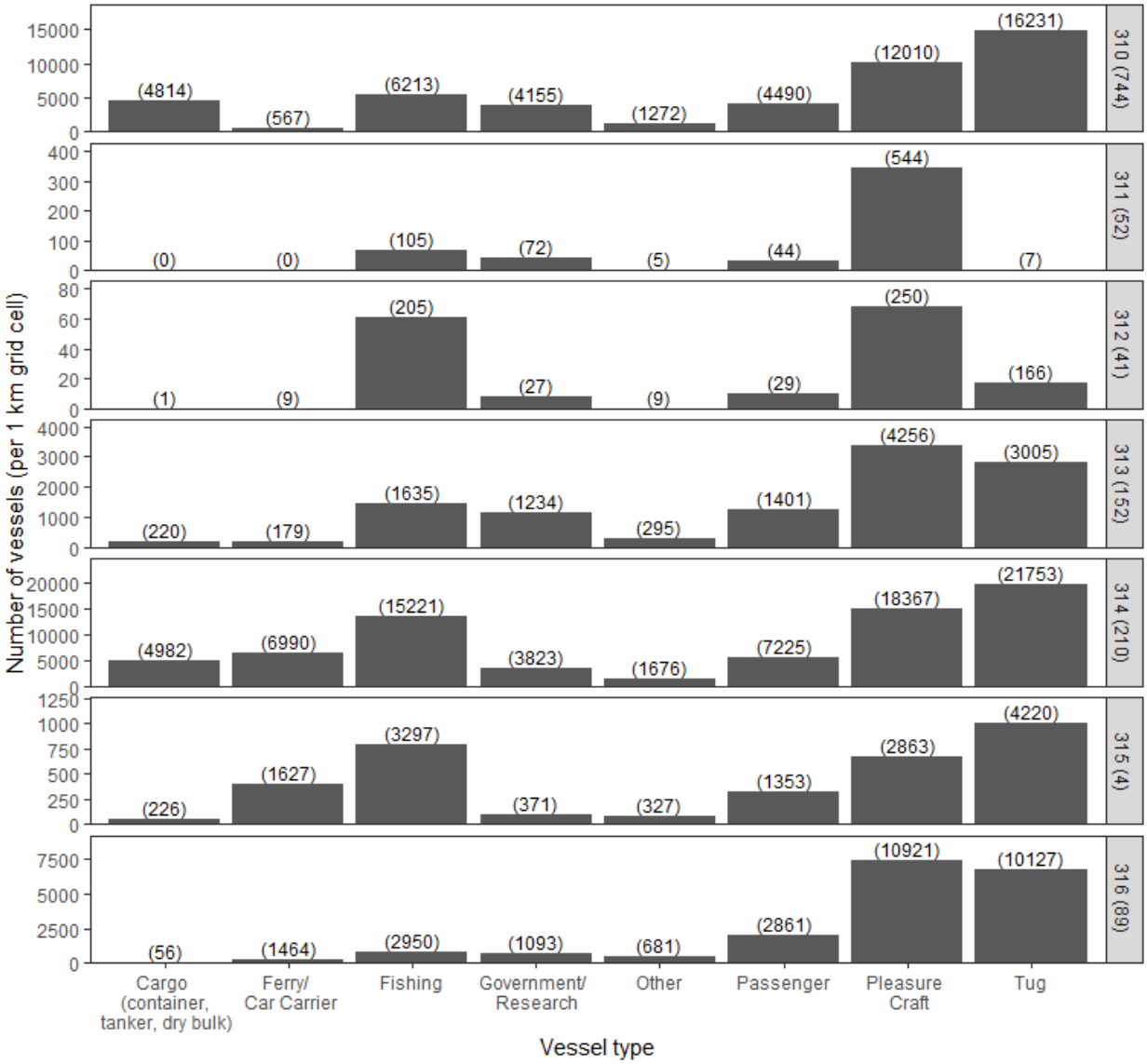


***Figure 44**. Number of vessels by type per 1 km grid cell in the Caamaño Sound and Douglas Fjord System Network Zones detected by Automatic Identification System). The total number of vessels is noted above the bars and the zone area is in parenthesis in square kilometer next to the Zone number. Note the different magnitudes of y-axis in each Zone and the different area size of each Zone. For attribute information on vessel types please refer to the metadata provided by the Marine Protected Area Network Technical Team. A visual summary of total vessel numbers detected in each Network Zone shown in **Figure 43**.*

C&P flyovers detected vessels in every Caamaño Sound and Douglas Fjord System Network Zones except for Zone 315 in 2019 (**Figure 45**). Total vessel count for 2019 was highest in Zone 310 followed by Zones 314, 316 and 313 (little vessel activity was observed in the remaining Zones. Most vessel types detected on flyovers were recreational fishing vessels, followed by commercial fishing, tourism, and commercial vessels (i.e., vessels other than commercial fishing vessels), and then government, First Nations fishing, and unknown/other fishing vessels.

From 2018 – 2020, vessel activity (**Figure 46**) detected on C&P flyovers was higher in the summer months (i.e., June - August), similar to the interpretations of Keen et al. (2023). Looking specifically at fishing vessels, the most common gear type was recreational, followed by dive (**Figure 47**). Few other fishing gear types were detected from 2018-2019, with less than 45 vessels per year for “other gear types” combined. This category includes dragger/trawler, gillnetter, hook and line, longliner, packer, seiner, trap, and troller. Due to the low number of vessels per fishing gear from 2018 - 2020, the data were not further examined on a Zone basis.

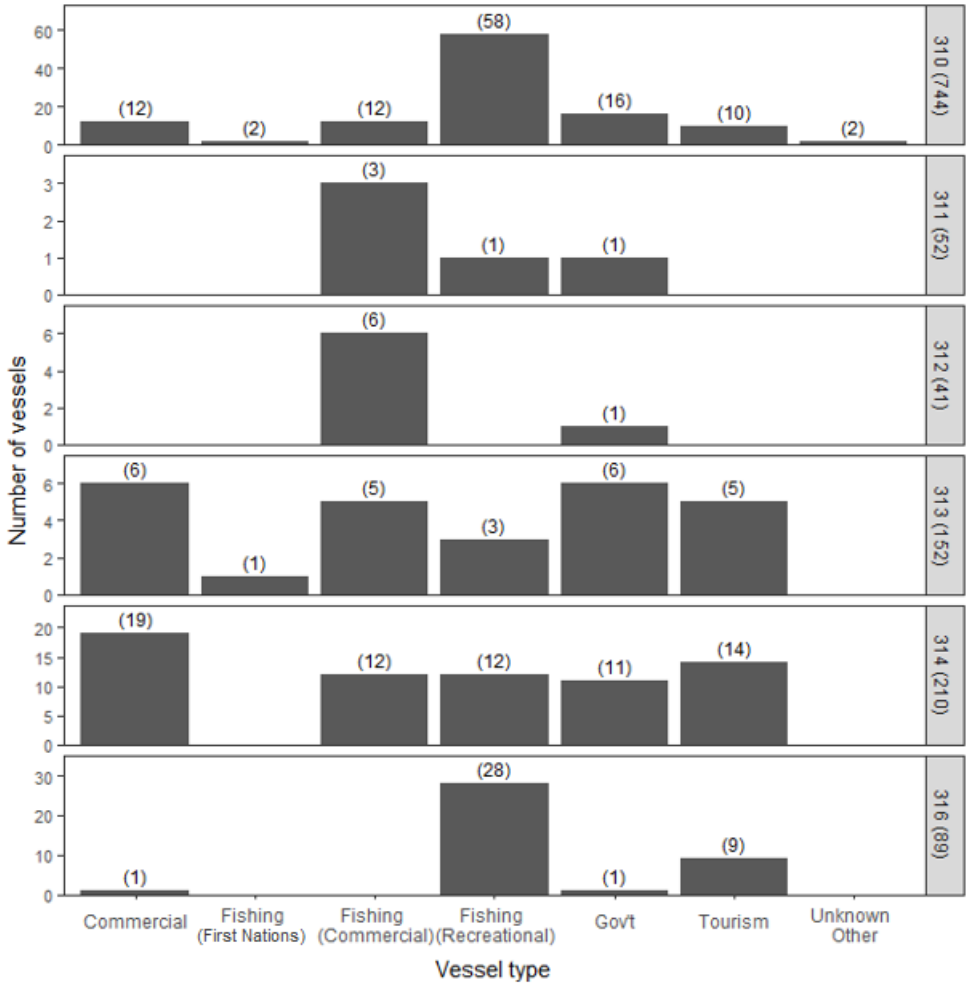


Figure 45. *Number of vessels by type in the Caamaño Sound and Douglas Fjord System Network Zones detected on C&P flyovers. The total number of vessels noted above the bars and the zone area is in parenthesis in square kilometer next to the Zone number. Note the different magnitudes of y-axis in each Zone and the different area size of each Zone. Data comes from the DFO Conservation & Protection Aerial Surveillance Program (Burke et al. 2022).*

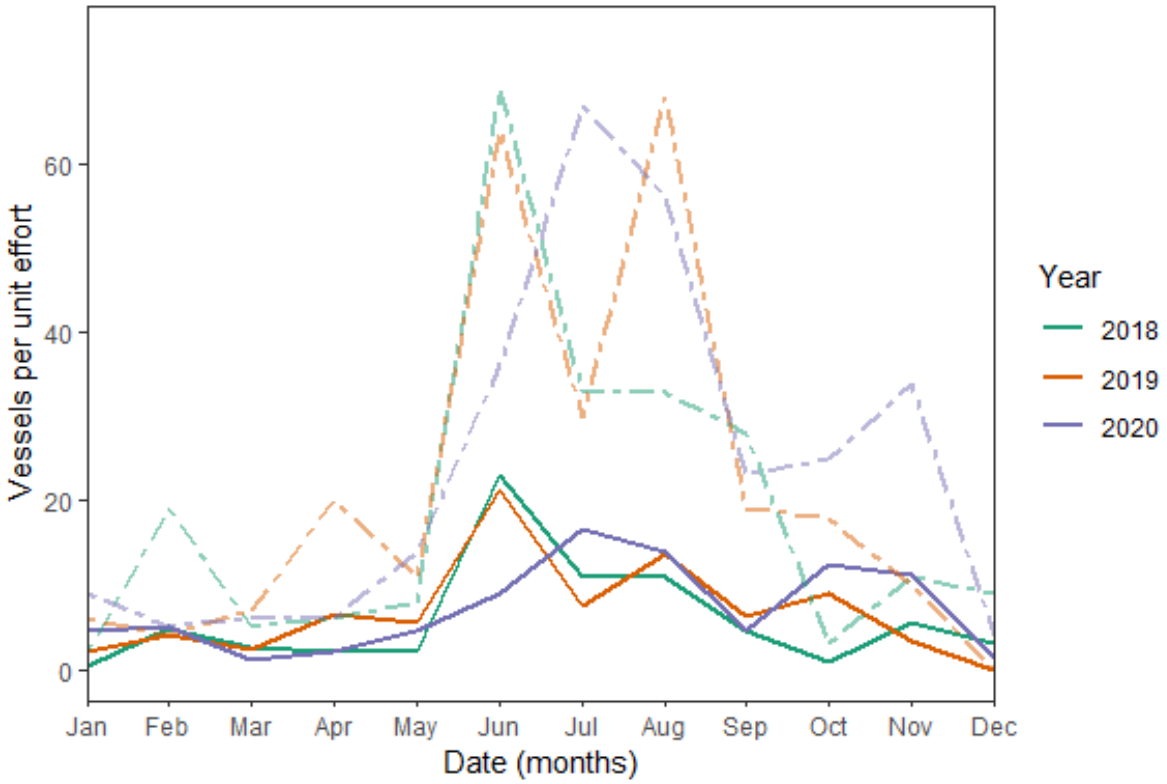


Figure 46. *Number of vessels per month in the Caamaño Sound and Douglas Fjord System Network Zones from 2018-2020. Solid lines are the total vessels per unit effort (i.e., number of flyovers per month) while dashed lines are the total vessels per month. Data comes from the DFO Conservation & Protection Aerial Surveillance Program (Burke et al. 2022).*

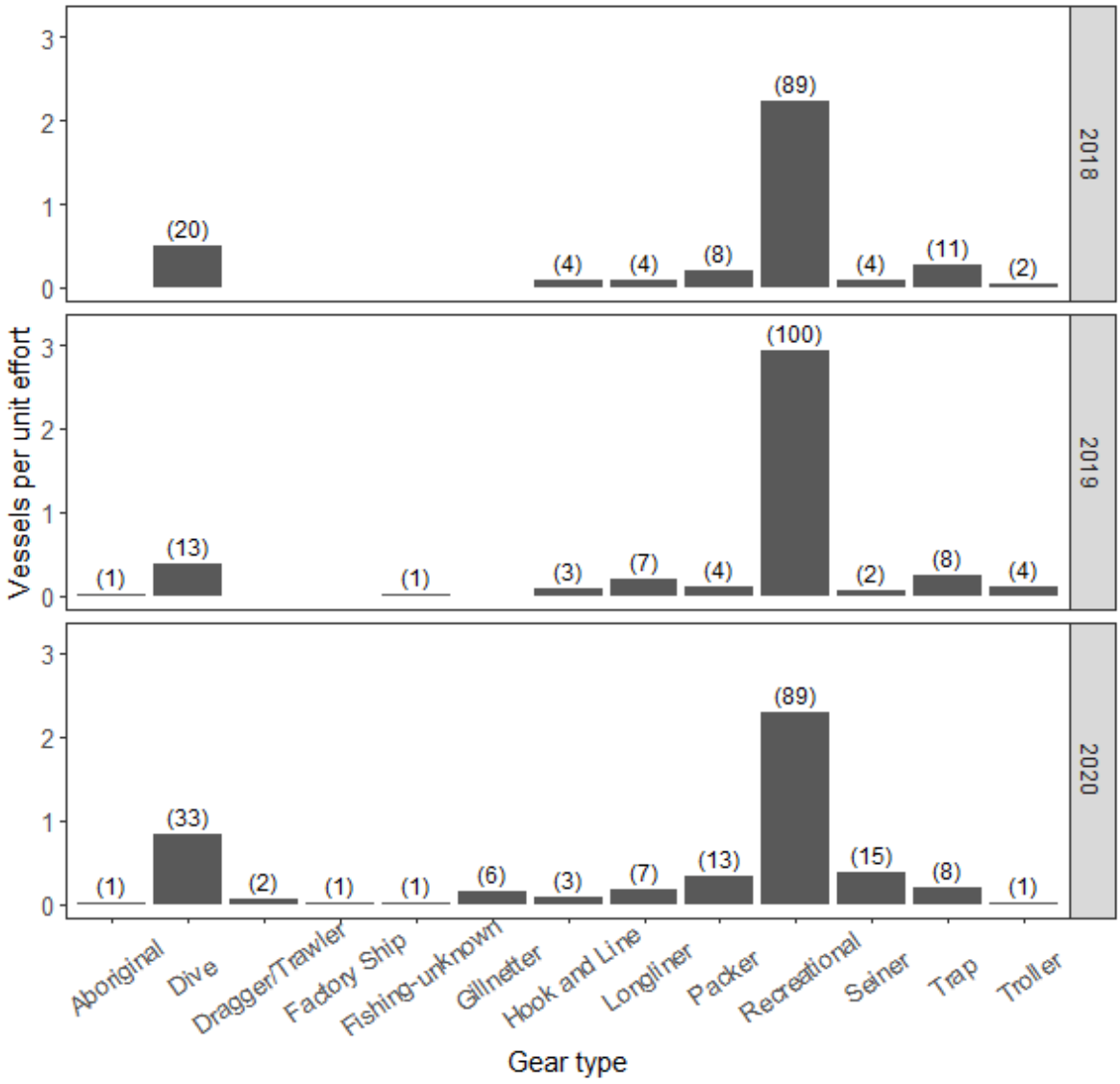


Figure 47*. Fishing vessel gear types per survey effort (i.e., number of flyovers per year) detected in the Caamaño Sound and Douglas Fjord System Network Zones from 2018-2020. Total vessel counts in parenthesis above bars. Data comes from the Conservation & Protection Aerial Surveillance Program flyovers per year (Burke et al. 2022).*

Knowledge gaps

While there are plenty of vessel tracking data in the Caamaño-Douglas area using combined AIS, C&P flyover, and other data sources (see below), there is a lack of knowledge on the direct and indirect effects of vessel traffic on the local ecosystem itself. Vessel traffic, and the disturbances that follow, may be the largest and most direct source of anthropogenic stressors on the habitats, species, and areas of cultural importance in the Network Zones. This is especially true following further construction and growth in the nearby ports of Prince Rupert and Kitimat. Analyzing vessel numbers, location density, and time (by month or year) would be

informative for predicting long-term trends. Taking into account those predictions and their effects on future research, surveys, and models may help close this knowledge gap and provide beneficial network conservation recommendations and policies.

5.6 Pollutants

Anthropogenic activities are the main source of pollutants that enter the marine environment. From recreational boats and kayaks to commercial cruises, high vessel traffic occurs through the Inside Passage crossing between Princess Royal Channel and Grenville Channel and from Douglas Channel, Estevan Sound, and Hecate Strait (**Figure 43** & **Figure 44**). Although the Caamaño Sound and Douglas Fjord System Network Zones area is sparsely populated, First Nations communities such as the Gitga'at, Gitxaała, Haisla and Kitasoo Xai'xais depend on the health of this marine environment for access to food, knowledge transmission, and preservation of cultural values (Satterfield et al. 2012). Pollutants that can negatively affect access and abundance of valuable habitats and resources include marine litter, vessel emissions and discharge, oil spills, sound pollution, and sewage. Most marine pollutants in the Caamaño-Douglas area originate from vessel traffic. Therefore, increased vessel traffic (particularly larger ships such as cargo and cruises) can lead to increased environmental stressors. Management, guidelines, and regulatory action can help reduce vessel pollution from their operations and accidents.

Marine litter is synthetic debris found in the marine environment with anthropogenic origins that may negatively affect local ecosystems. For example, lost, abandoned, or discarded fishing gear (also called ghost gear) are hazardous obstacles for biogenic habitats, marine species and divers (Huntington 2019). Threats to marine mammals and fishes include ingestion and entanglement from ghost gear and other marine litter. The proliferation of microplastics (< 5 mm) in the marine environment is an emerging global concern (Worm et al. 2017). The effects of microplastics bioaccumulation across the food web is a concern across the coast (Alava 2020), especially for First Nations and coastal communities that depend on local marine harvest (Provencher et al. 2023). Research by Covernton et al. (2022) found that larger microplastics (> 100 µm) were not accumulating up BC's marine food web. However, they acknowledged that research on smaller microplastics is lacking for risk assessments. A study by Williams et al. (2011) modelled the distribution of marine debris and overlap with marine mammal species in BC waters (see Section 6.2.5.5). The predicted density of marine debris in the Caamaño-Douglas area was highest in the Outer Coast Zones and Squally Channel (Zone 313). Styrofoam, plastic bags, and plastic bottles were the most common observed debris throughout the coast. Sightings of marine litter accumulating on beaches have been reported in the same areas (K. Clifton, E. Keen, B. Wright, pers. comm. 2023). Marine debris surveys conducted by the Marine Spatial Ecology and Analysis section of DFO in found litter on all intertidal sites throughout the Caamaño-Douglas area in 2023 (Proudfoot et al. 2025A).

Discharge from vessels into marine waters includes sewage, greywater, and scrubber washwater. Greywater is generated from human usage onboard, such as sinks and laundry, but excludes sewage. An onboard Marine Sanitation Device can treat both sewage and greywater. Per the *Canada Shipping Act* (2001), dumping untreated sewage from recreational boats is banned within three nautical miles of the shore for all vessels, while treated sewage cannot be discharged within one nautical mile of the shore. In contrast, small commercial and recreational boats can dispose of untreated greywater in marine environments. The BC coast is the largest cruise region in Canada, and modern cruise ships carry over 2,000 people, which can produce a

substantial amount of discharge. Recent environmental regulations[17] implemented rules for cruise ships to discharge treated sewage and greywater at least three nautical miles from shore.

Another source of water pollution is the washwater from “scrubbers” onboard many vessels. These ‘scrubbers’ aid in cleaning engine exhaust after burning heavy fuel oils but create washwater that is discharged to prevent atmospheric pollution (Teuchies et al. 2020). Scrubber washwater contains acidic compounds, such as sulfur and nitrogen oxides, which may contribute to ocean acidification and the leaching of metals from corroding discharge lines (Stips et al. 2016; Turner et al. 2018; Teuchies et al. 2020). The International Maritime Organization Discharge loosely regulates scrubber washwater. An assessment on scrubber washwaters by Clear Seas Centre for Responsible Marine Shipping (2022) supported limiting and restricting discharge from coastal and inlet waters. Sewage discharge threatens commercial and recreational shellfish beds, water quality issues, and waters with low tidal exchange and depleted dissolved oxygen levels (Campos and Lees 2014). Information is lacking regarding the extent of vessel discharge and its effects within the Network Zones area.

The proposed Enbridge northern gateway pipeline caused large concern due to the potential oil tankers transporting oil to Kitimat and pipeline failure. However, the project was cancelled in November 2016. At the time, risk analysis of the biophysical, economic, and cultural risks of oil spills was completed for the area. Impacts on the biophysical environment (e.g., Barron et al. 2020) ranged from immediate effects, such as mass wildlife mortality, and ongoing effects, such as oil persisting in sediments, substrates, and other connected ecosystems. The economic costs for oil spill cleanup are also expensive, and a report by Herunter et al. (2017) summarized the available literature on oil spill effects on BC’s marine organisms. Two major Liquid Natural Gas (LNG) developments exist in the District of Kitimat. The first is LNG Canada’s natural gas treatment and marine transport facilities (2018 - 2025, Active). The second is Cedar LNG Project’s proposed floating liquified natural gas facility[18] (see Current Major Projects - District of Kitimat). These developments are predicted to increase vessel traffic in the Caamaño-Douglas area. LNG is transported as a supercooled fluid, which should revert to gas when spilled. It is an alternative engine fuel for large vessels, such as containerships and cruise ships, with less carbon dioxide and sulfur dioxide emissions than bunker fuel, a typically heavy and environmentally persistent fuel (Nuka Research and Clear Seas 2016). An environmental assessment report (Nuka Research and Clear Seas 2016) for the Pacific Northwest LNG Project summarizes the potential effects on many physical, environmental, and cultural features.

Oil spills from vessel strikes are a concern considering the active vessel traffic of the Inside Passage within the Caamaño Sound and Douglas Fjord System Network Zones. The largest oil spill on the West Coast of Canada occurred in Wright Sound, involving the BC ferry *M/V The Queen of the North* striking the northern end of **K'ts'ats'aas**/Gil Island (Zone 314). Although 240 tonnes of spilled diesel dispersed and evaporated after the spill, the effects of ongoing oil leakage from the sunken ship are continual environmental concerns[19]*. The Brigadier General M.* G. Zalinski, a United States Army transport ship, sank in Grenville Channel in 1946, northwest

[17] Transport Canada now in force: Discharge requirements for cruise ships - SSB No.: 10/2025

[18] https://www.kitimat.ca/en/business-and-development/current-major-projects.aspx

[19] Past spill incidents - Province of British Columbia

of Zone 315 and less than 40 km from **Txałgiu**[20]. The ship was reported to carry 700 tonnes of bunker fuel, a marine commercial engine fuel known to be toxic to aquatic life, along with other pollutants, military cargo and ammunition. In 2013, the federal government spent over $50 million CAD to remove the oil over five years. Sheens of oil continue to be sighted in waters around the shipwrecks of *The Queen of the North* and the *General Zalinski* (K. Clifton, pers. comm. 2023).

Many traditional and contemporary practices and values of coastal First Nations are entwined with marine resources. Consequently, oil spills can also significantly impact local community members' livelihoods, health, and identity. Haisla and Gitga'at communities have voiced concerns about oil spills disrupting key cultural practices and values such as harvesting, feasting, and intergenerational knowledge transmission. A report by Satterfield et al. (2012) interviewed the Gitga'at community to identify the cultural consequences of local oil spills (small, medium, or large spill scenarios; Bocking et al. 2011). Small spills were predicted to adversely affect at least 50% of harvest sites, all marine foods, and the health of several cultural keystone species, including **ła'ask/lhlaˈq̓s/łą̱'ą̱sk**/seaweed, **gaboox/zuáli/gą̱boox**/cockles and **k'almoos/klnákʷ/k̲'ą̱lmoos**/ crabs. Medium spills affected more resources, including ***hoon/qeqapela***/salmon, **xs'waanx/'á'ent/xs'waanx**/herring roe, **k'almoos/klnákʷ**, and **üüla/sa̱g̱ʷam**/seals, whereas large spills were discussed to have potentially irreparable cultural impacts. Interviews documented in Written Evidence of the Haisla Nation (2010)[21] discussed oil spill impacts on the community and common worries included being financially strained and reliant on more expensive grocery purchases, being unable to pass down traditional harvest knowledge to younger generations and being unable to engage in recreational activities like swimming in Douglas Channel.

Underwater noise pollution from marine transportation is a growing concern which can interfere with and impair animal behaviours. Ship propellers generate most of this pollution, and noise disturbance is correlated with vessel speed. This pollution threatens marine mammals such as **łbuun/g̱ʷeẏ́ém/łpuun**/whales and **dziiẅ/ǩáła**/dolphins that rely on acoustic signals for communication, foraging, and navigation (see section 6.2.5.5 for Vulnerabilities and Recoverability of marine mammals). Other sources of underwater sound that could negatively impact marine animals, such as **'naaxł/hélx̄'inix̄ʷ/niixł**/killer whales, include military and commercial sonars, seismic survey airguns, tidal turbines, underwater explosions, acoustic deterrent devices used for pinniped deterrence, pile-driving operations (Ford et al. 2013).

Wastewater treatment is through a municipal septic tank in the community of **Txałgiu** (Permit PE08851, Ministry of Environment, Province of BC, 1994). Septic tanks are simple treatment systems that use primary and secondary treatment methods (Municipal wastewater effluent in Canada, 2006). Sewage overflows of the system have led to past shellfish contamination closures (Fishery Notice, DFO, 2020). Inorganic and organic sewage are reported pollutants in Zones 313, 314, 315, and 316 as cumulative impacts (see

[20] The Tale of Dirty, Old, Leaky Zalinski | Hakai Magazine

[21] Written Evidence of the Haisla Nation for the Northern Gateway Pipelines 2010.pdf

Table 15).

6 ECOLOGICAL SETTING

One of the design principles for MPA network planning in the NSB is the representation of ecosystems within the planning region, unique natural features, and their associated biodiversity (BC Marine Protected Area Network Strategy, 2014). The Ecological Setting section describes the unique ecosystems (section 6.1) and taxonomic diversity (section 6.2) present at the scale of the Caamaño Sound and Douglas Fjord System Network Zones. This description includes the marine area within the boundaries of the Network Zones (310 - 316) and the surrounding marine area that may be affected by management within Network Zones to consider ecological linkages and connectivity.

Notably, this section also summarizes some of the vulnerabilities (including stressors and sensitivity) and recoverability of ecosystem habitats (e.g., estuaries, salt marshes, kelp forests), taxonomic groups, and species of interest as a start to guiding downstream decision-making processes. As of writing this report, there is no formal national standard for evaluating and describing vulnerabilities and recoverability of habitat features or taxonomic groups for Ecological and Biological Overview reports. There are, however, other vulnerability and ecological risk assessment science advice documents in DFO Pacific (See Hannah et al. 2017 and O et al. 2015) with definitions that can guide the “vulnerability and recoverability” summaries for this report.

Ecological **vulnerability** is generally described with several components: the exposure of a system to a **stressor**, the **sensitivity** of the system, and the potential to recover, also termed “resilience” (De Lange et al. 2010). **Stressors** are naturally occurring physical or environmental disturbances or anthropogenic disturbances – such as the effects of climate change (section 4) and other human activities (section 5) – that may negatively impact habitats or species (O et al. 2015). **Sensitivity** relates to the traits and variables (such as density, growth rate etc.) within a system that makes them susceptible to change (De Lange et al. 2010; Barabas et al. 2014). For example, a population be more vulnerable if they have low reproductive output (which makes the population more sensitive), and there are high levels of stressors occurring in the area.

Ecological resilience is defined by Walker et al. (2004) as the dynamic ability of a system to retain the same functionality while taking in stressors and disturbances. Full descriptions of ecosystem or community resilience in the Caamaño-Douglas Zones are out of scope for this report because they require extensive research into how these ecological systems are considered stable or in equilibrium, which is currently not available. Instead, the term **recoverability** is used for the purpose of this report as a component of resiliency. **Recoverability** is defined here as the time and capacity of a species or population to return to preexisting states once the stressor has been diminished or removed (O et al. 2015; see also “engineering resilience” in Walker et al. 2004).

In summary, the “Vulnerability and recoverability” subsections of the ecological setting section will briefly describe 1) common stressors of habitats and species and the extent these stressors are present within the area 2) specific traits that make habitats and species sensitive to change and 3) the recoverability of those species and habitats, if available. The information in each subsection for each habitat or taxa will vary due to different research efforts for each group and potential mismatch in geographic relevance – i.e., information may be taken from similar

habitats in different areas. These summaries are not meant to be all-encompassing, and the intention is to guide future ecological risk assessments and to inform readers and decision-makers about social-ecological impacts in this area.

6.1 Important ecosystems

Recognizing important ecological features and habitats and their associated biological assemblages across spatial scales is essential for informing marine spatial planning processes and subsequent monitoring and management decisions. Previous work has identified and categorized important features, habitats, and ecosystems in the NSB (DFO 2004, Clarke and Jamieson 2006, Rubidge et al. 2016, Gale et al. 2019). One framework used is the Pacific Marine Ecological Classification System (PMECS), which classifies the NSB using hierarchical categories of various scales delineated using physical, ecological, and biological properties (DFO 2013; DFO 2016a, Rubidge et al. 2016). Another important feature that are not included as a level in the PMECs framework are Areas of High Rugosity, which often support high species richness.

Another framework used to identify important areas is the designation of Ecologically and Biologically Significant Areas (EBSAs). EBSAs are areas with relatively high ecological and biological significance that warrant increased management and protection (DFO 2004). EBSAs are identified using eight criteria that are applied to the area, in comparison to the surrounding area. These criteria are uniqueness, special importance for life-history stages, importance for threatened, endangered, or declining species, vulnerability, productivity, biodiversity, naturalness, and aggregation (DFO 2004; Ban et al. 2016; Rubidge et al. 2020). One of 16 network design principles in the Canada-BC MPA Network Strategy (2014) states that EBSAs should be incorporated and represented in the MPA Network.

Several EBSAs are near, overlap, or exist within the Caamaño Sound and Douglas Fjord System Network Zones. The broadscale Central Mainland EBSA overlaps with three Zones (310 - 312). Nearshore habitats, including estuaries, canopy-forming kelps, and **gadza k'aw**/eelgrass beds have been recommended as designations for EBSAs (Rubidge et al. 2020). Reef-forming cold-water coral and sponges have been identified as EBSAs or MPAs. While cold-water corals and sponges occur in the Caamaño-Douglas area, currently there are no designated coral and sponge EBSAs within these Network Zones (see section 6.2.2.1 for details). The biogenic habitats of importance (kelp forests, **gadza k'aw** beds, coral and sponge aggregations) are summarized in the Taxonomic Diversity section 6.2.

6.1.1 Geomorphic units of the Continental Shelf

Geomorphic units are a level of PMECS at the scale of hundreds of kilometres representing seafloor characteristics (e.g., ridge, canyon, gentle slope, steep slope, mound). Abiotic factors such as geomorphic units are assumed to be correlated with different biological assemblages (e.g., Ferdaña 2006, Greene et al. 2008, Robinson and Royle 2008). Geomorphic units were applied to three broad areas of analysis: Continental Shelf, Continental Shelf (fjords), and Continental Slope, divided based on the boundaries of the marine ecoregions. The NSB was classified into geomorphic units using bathymetry data at 75 m^2 resolution comparing the grid cell's elevation to the mean elevation of surrounding grid cells (i.e., benthic positioning index). Overall, the NSB was classified into ten different geomorphic units: six classes for Continental

Shelf (including fjords) and four classes for Continental Slope (See Figure 22 in Rubidge et al. 2016).

The Caamaño Sound and Douglas Fjord System Network Zones are found within the Continental Shelf areas (

Table 22 for details). Zones 310, 311, and 312 have Continental Shelf and Continental Shelf (fjords) geomorphic units, whereas Zones 313 - 316 only have Continental Shelf (fjord) units. As such, biological assemblages associated with the Continental Shelf (fjords) may be present in all Zones, but those associated with only the Continental Shelf may not be present in Zones 313 – 316.

***Table 22**. Presence of geomorphic units in the Caamaño Sound and Douglas Fjord System Network Zones is marked with an "X". Geomorphic units are discrete geomorphological structures that are assumed to have distinctive biological assemblages (Rubidge et al. 2016). A dashed line indicates that variable was not present in the dataset used. Please note that the dataset does not cover the entire area of certain Zones, therefore the percentage total of each Zone may not add up to 100.*

Proportion of Zone	Zone 310	Zone 311	Zone 312	Zone 313	Zone 314	Zone 315	Zone 316
Continental Shelf – Gentle Slope	X	X	X	-	-	-	-
Continental Shelf - Lesser depression	X	X	-	-	-	-	-
Continental Shelf - Lesser rise	X	-	-	-	-	-	-
Continental Shelf - Trough bottom	X	-	-	-	-	-	-
Continental Shelf proportion of each Zones	*0.38*	*0.54*	*0.23*	*0*	*0*	*0*	*0*
Continental Shelf (fjords) - Crest or fjord wall	X	-	X	X	X	X	X
Continental Shelf (fjords) - Fjord or channel bottom	X	-	X	X	X	X	X
Continental Shelf (fjords) - Lesser depression	X	X	X	X	X	X	X
Continental Shelf (fjords) - Lesser rise	X	X	X	X	X	-	X
Continental Shelf (fjords) - Steep slope	X	X	X	X	X	X	X
Continental Shelf (fjords) proportion of each Zones	*0.59*	*0.35*	*0.59*	*0.93*	*0.95*	*0.80*	*0.86*

6.1.2 Areas of High Rugosity

Rugosity is a measure of the roughness of the benthic terrain that corresponds to complex heterogeneity and hard substrates. Areas of high rugosity are often correlated with increased abundance and/or diversity of invertebrates (Beck 2000) and fish, particularly **ts'mhoon**/rockfish assemblages (Yoklavich et al. 2000) and provides an indirect method for assessing positive biodiversity (Du Preez 2015; Du Preez et al. 2016; Frid et al. 2018).

The BC Marine Conservation Analysis (BCMCA) provided the data summarized in this report (BCMCA Project Team 2011). This analysis calculated coastwide areas of high rugosity using a

75-meter bathymetric model and the NOAA Benthic Terrain Modeler (BTM) toolbox[22] (BCMCA project team 2011). Rugosity is a ratio calculated by dividing surface area (or contoured area) to planar area, and the resulting measurement was divided into five quantiles. Areas of high rugosity corresponded with the top quantile (20%). Two caveats exist for this data, 1) rugosity results were done on a coast-wide scale and may not be relevant for providing exact information on regional and local scales (BCMCA Project Team 2011), and 2) the current rugosity calculation is confounded by slope since rugosity increases with slope. An arc-chord ratio rugosity index described by Du Preez (2015) decouples the relationship with slope and can be accessed as a layer as part of the Shallow substrate model (20m) of the Pacific Canadian Coast[23].

High rugosity areas are found within the Caamaño Sound and Douglas Fjord System Network Zones (**Table 23**) and throughout the Caamaño-Douglas area, especially near the coastline. Zones in the Douglas Fjord System (313 – 316) have high rugosity in over half of their surface area, with Zone 316 having the highest proportion. Zones 311 and 312 have the lowest areas of rugosity.

Table 23. *Area (km^2) classified as having high rugosity (upper of five quantiles) within the Caamaño Sound and Douglas Fjord System Network Zones. Bold text indicates the highest value for each metric.*

	Zone 310	**Zone 311**	**Zone 312**	**Zone 313**	**Zone 314**	**Zone 315**	**Zone 316**
Area of high rugosity (km^2)	**252.30**	7.94	9.14	99.95	106.31	2.63	68.47
Proportion of Zone	0.34	0.15	0.22	0.66	0.51	0.61	**0.77**

6.1.3 The Central Mainland Ecologically and Biologically Significant Area

The Central Mainland EBSA was first described and proposed in DFO (2013) and encompasses the boundaries of Zones 311 and 312 and much of Zone 310 (**Figure 6**). This EBSA overlaps with several Rockfish Conservation Areas and the northern Hecate Strait/Queen Charlotte Sound Glass Sponge Reefs MPA. More details about the designation of this EBSA can be found in several reports, including Jamieson and Levesque (2014) and Rubidge et al. (2018).

The Central Mainland EBSA met several of the 8 EBSA criteria according to the original expert delineation of the area and a reassessment using available empirical data in 2018 (Clarke and Jamieson 2006, DFO 2013, DFO 2018a, Rubidge et al. 2018). This area was identified as having strong tidal mixing, tidal fronts and freshwater plumes (DFO 2013; see Section 3 Oceanographic Setting). In addition, the Central Mainland EBSA is specifically important for marine mammals (**łbuun**/**ḡʷeẏém**/**łpuun**/whale feeding grounds, offshore **łbuun**/**ḡʷeẏém**/**łpuun** migrations, **płoon**/**nukʷ**/sea otter aggregations, stellar sea lion rookery), fish (**ts'mhoon**/rockfish diversity, spawning area for Walleye Pollock and **hadanii**/**hadanii**/sablefish), Marine birds

[22] Benthic Terrain Modeler https://coast.noaa.gov/digitalcoast/tools/btm.html

[23] Shallow substrate model (20m) of the Pacific Canadian coast - Open Government Portal

(moulting and sheltering areas, seabird aggregations notably Rhinoceros Auklet, shearwaters, and Pigeon Guillemot), and several benthic invertebrates (e.g. **ts'akwe'ats**/red sea urchin, red sea cucumber, **gasgos**/**sísíuɬ**/shrimp, geoduck, and Manilla clam) (Table 1 in DFO 2013; Table 2 in Rubidge et al. 2018). The details of these ecologically important areas are expanded in Section 6.2: Taxonomic Diversity.

6.1.4 Estuaries and salt marshes

Estuaries are geographic bottlenecks where freshwater from rivers transitions to the marine environment, creating a highly variable, productive, and biodiverse ecosystem. Estuaries are comprised of ecologically productive habitats, including **gadza k'aw**/eelgrass meadows, mud flats, wetlands, and salt marshes (Emmett et al. 2000). In BC, estuaries make up less than 3% of coastlines although more than 80% of coastal wildlife are known to use in these habitats in some capacity (National Round Table on the Environment and the Economy 2005).

As a result of the connection between land and marine ecosystems, nutrients and sediments are transferred, recycled, and deposited through estuaries, leading to high primary productivity and an abundance of vegetative habitats, including **gadza k'aw**/eelgrass and macroalgae. This highly productive and dynamic ecosystem results in an abundance of species across the food web, from phytoplankton to zooplankton and invertebrates, to terrestrial and aquatic secondary producers and tertiary consumers (Rubidge et al. 2020). Estuaries provide shelter, aggregating, and feeding grounds for many juvenile aquatic species and bird nesting grounds. Many anadromous fish (**hoon**/**qeqapela**/salmon, **ha'limootk**/**ƛ̓áti**/**ẅa̱h**/eulachon) and many marine birds use estuaries as migratory corridors for important life stages (Ryder et al. 2007).

Estuaries were previously identified as an EBSA due to positive fitness and aggregation importance for **hoon**/**qeqapela**/salmon smolts (Clarke and Jamieson 2006). Marine survival rates were found to be reduced for juvenile **hoon**/**qeqapela** populations that transit through disturbed estuaries compared to pristine estuaries (Magnusson and Hillborn 2003). Chalifour et al. (2021) examined the effects of estuary residency in the Fraser River during juvenile **yee**/**ḱáp̓i**/**xyi'i**/Chinook salmon migration and found consistent daily growth rates despite variable entry and residency dates. Their results suggest that estuary habitats, even highly modified ones such as those in the Fraser River, are critical for early marine growth before seaward migrations. Juvenile Dungeness crabs, an ecological conservation priority for the MPA network (Gale et al. 2019), were found to have higher growth rates in estuaries than in habitats outside of estuaries (Gunderson et al. 1990). A detailed summary of estuaries as an ESBA in the NSB can be found in Rubidge et al. (2020) and Table 6 in the same paper shows the known uses of estuaries to various species identified as network conservation priorities. Estuaries are found within three Caamaño Sound and Douglas Fjord System Network Zones: Zone 310, 313, and 316 (**Table 24**).

Salt marshes are coastal wetland habitats found within estuaries, which contain grasslands exposed at low tide and covered at high tide. These habitats require a constant supply of sediments to remain intact because of their location in a highly variable environment. Salt marshes contribute to ecosystem functions by preventing flooding and erosion of shorelines and providing water filtering and nutrient cycling. Thus, salt marsh habitats provide essential shelter, refuge, and food resources for many species, including juvenile fish and marine birds. Salt marshes were also found to be highly efficient carbon sinks for carbon sequestration relative to their area (Chmura 2013; Gailis et al. 2021). Despite the vast extent of salt marshes on BC's coast (area of 635 km^2; see Table 1 in Rabinowitz and Andrews 2022), these habitats have not

been evaluated as EBSAs in the Pacific Region and are instead categorized within the estuary EBSA (Rubidge et al. 2016).

Since estuaries and salt marsh habitats are associated with high biodiversity, humans have cultivated these ecosystems for habitation, food, and utility. Continued human uses within estuaries include fishing, hunting, trapping, harvesting, wildlife viewing, canoeing and kayaking. For example, Coastal Tsimshian Peoples have journeyed to important estuary sites (such as Kitkiata Inlet, Kitimat and Kemano rivers) to set up fishing camps for **Ha'limootk**/**X̱áti**/**ẅa̱h**.

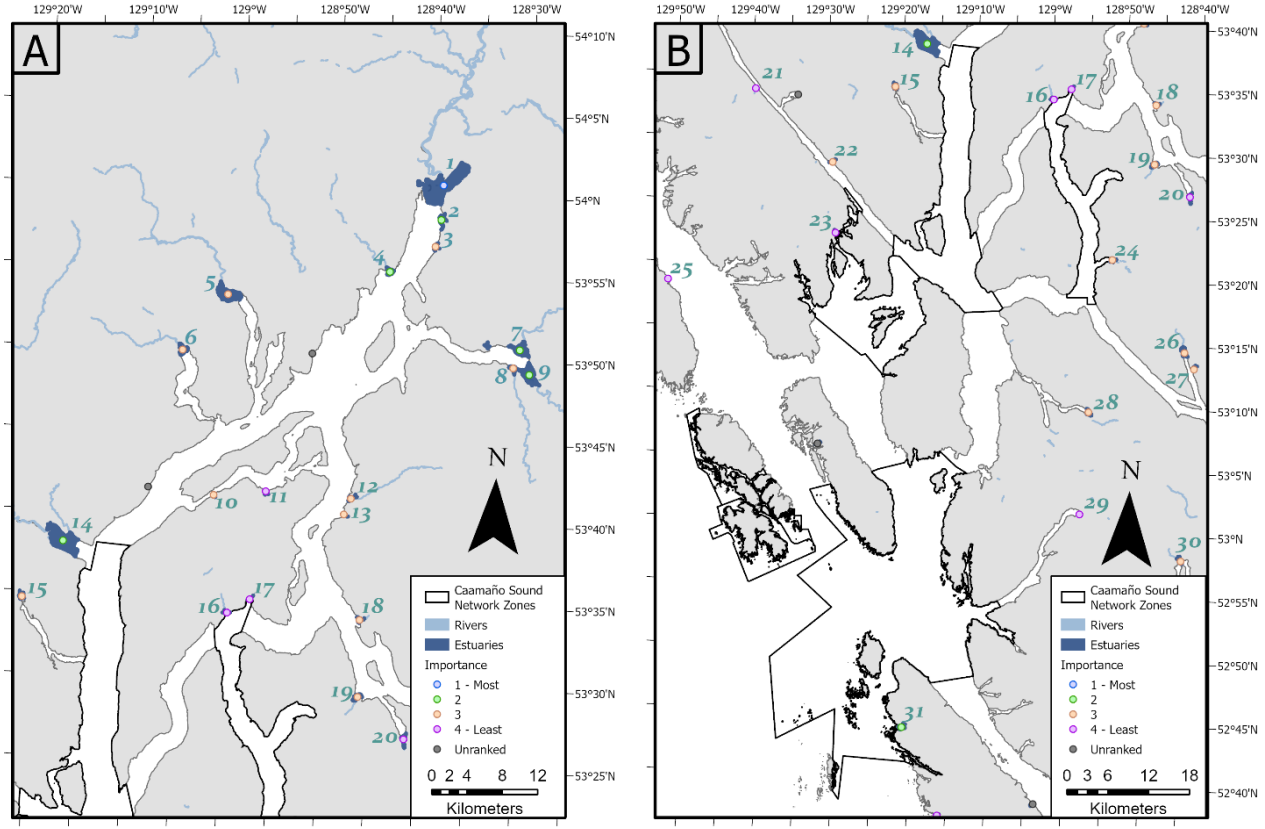
Data sources and distributions

Estuaries in BC have been identified and categorized based on their importance for waterbirds through the Pacific Estuary Conservation Program (PECP) Estuary Ranking Report from 1 (most important) to 5 (least important)[24]. The ranking system assessed estuaries based on the cumulative score on five biophysical variables: estuary size, species rarity, waterbird density, **Tskah**/**wáɬi**/herring spawn, and fish escapement (Pacific Birds, 2021). The spatial dataset compiled for this section uses the open source PECP geodatabase containing ranked estuaries throughout BC. Using the same estuary spatial data, the biomass and richness of Pacific **hoon**/**qeqapela**/salmon that migrate through BC's estuaries has also recently been assessed (Robb et al. 2025) and can be a future information source for estuaries in the Caamaño-Douglas area.

Thirty-one estuaries exist in the Caamaño-Douglas area, but only five are within the Network Zones polygons (**Figure 48** and **Table 24**). The highest ranking estuary for waterbirds (Pacific Birds Habitat Joint Venture 2021) within the Network Zones is Stannard Creek on Northern Aristazabal Island in Zone 310 (Rank 2), with an area of 0.04 km^2. Other estuaries include Tsimtack Lake in Zone 313 (Rank 4), Goat River (Rank 3) in southern Ursula Channel, Evelyn Creek (Rank 4) and an unnamed estuary (Rank 4) in northern Ursula Channel (Zone 316). The average size of the five estuaries within the Network Zones is 0.08 km^2. There is a unique **misoo**/**hísen**/**miso'o**/sockeye habitat in the Tsimtack Lake in Zone 313 including a salmon migration route to and from **Maxtaktsm'aa**/Union Passage Site (Zone 315) (North Coast Marine Plan, 2015).

Many estuaries are outside the polygons but still located within the broader Caamaño-Douglas area. These estuaries include the Betteridge Inlet Area on **Lax Ka'gaas**/Campania Island (Rank 5), Surf River in Surf Inlet that drains into Zone 310 (Rank 4), **Kwelts'uu**/Cornwall Inlet in Cornwall Channel (Rank 3), Belowe Creek in **Maxtaktsm'aa**/Union Passage (Rank 3), and Quaal River/Kitkiata Creek Complex (Rank 2) and KishKosh Creek (Rank 3) in Kitkiata inlet and Kishkosh inlet respectively. The most important estuary in the surrounding area is the Kitimat River system (Rank 1), with an area of 8.69 km^2, upstream from Douglas channel. The average size of the estuaries in the mapped Caamaño-Douglas area (**Figure 48**) is 0.77 km^2.

[24] An Updated Ranking of British Columbia's Estuaries - Pacific Birds Habitat Joint Venture



Notes: Where possible, estuaries were numbered left to right and north to south.
1. Kitimat River; 2. Wathl Creek; 3. Wathlsto Creek; 4. Bish Creek; 5. Gilttoyees River; 6. Foch Lagoon; 7. Dala River; 8. Falls River; 9. Kildala River; 10. Unnamed; 11. Unnamed; 12. Weewanie Creek; 13. Pike Creek; 14. Quaal River/Kitkiata Creek Complex; 15. Kiskosh Creek; 16. Unnamed; 17. Evelyn Creek; 18. Crab River; 19. Paril River; 20. Triumph River; 21. Salter Lake; 22. Belowe Creek; 23. Tsimtack Lake; 24. Goat River; 25. Keecha Creek; 26. Klekane River; 27. Scow Bay; 28. Cornwall Inlet; 29. Surf River; 30. Arnoup Creek; 31. Stannard Creek

***Figure 48**. Estuaries and their waterbird importance class (1 = highest) found around the **A)** Kitimat River and upper Douglas Channel down to **B)** the Caamaño Sound and Douglas Fjord System Network Zones area. Data is from the [Pacific Estuary Conservation Program (PECP) Estuary Ranking Report, 2021](#).*

***Table 24**. The name, area size (km²), and Importance class (1 = highest) of estuaries located from Caamaño Sound up to Kitimat River (and adjacent areas). Information of estuaries within the seven Caamaño Sound and Douglas Fjord System Network Zones are bolded. Data is from the Pacific Estuary Conservation Program (PECP) Estuary Ranking Report, 2021.*

Number on Figure 48	**Name**	**Size (km²)**	**Importance class**	**Zones present**
1	Kitimat River	8.69	1	Outside
2	Wathl Creek	0.27	2	Outside
3	Wathlsto Creek	0.11	3	Outside
4	Bish Creek	0.34	2	Outside
5	Gilttoyees River	2.60	3	Outside
6	Foch Lagoon	0.40	3	Outside
7	Dala River	1.30	2	Outside
8	Falls River	2.08	3	Outside
9	Kildala River	0.26	2	Outside
10	Unnamed	0.01	3	Outside
11	Unnamed	0.03	4	Outside
12	Weewanie Creek	0.16	3	Outside
13	Pike Creek	0.03	3	Outside
14	Quaal River/Kitkiata Creek complex	5.40	2	Outside
15	Kiskosh Creek	0.25	3	Outside
16	**Unnamed**	**0.03**	**4**	**316**
17	**Evelyn Creek**	**0.06**	**4**	**316**
18	Crab River	0.08	3	Outside
19	Paril River	0.20	3	Outside
20	Triumph River	0.20	4	Outside
21	Salter Lake	0.01	4	Outside
22	Belowe Creek	0.12	3	Outside
23	**Tsimtack Lake**	**0.06**	**4**	**315**
24	**Goat River**	**0.21**	**3**	**316**
25	Keecha Creek	0.007	4	Outside
26	Klekane River	0.37	3	Outside
27	Scow Bay	0.16	3	Outside
28	**Kwelts'uu**/Cornwall Inlet	0.20	3	Outside
29	Surf River	0.06	4	Outside
30	Arnoup Creek	0.18	3	Outside
31	**Stannard Creek**	**0.04**	**2**	**310**

ShoreZone is a system that uses aerial imaging surveys to identify and categorize biological and geomorphic attributes of the BC coastline. Biobands are spatial attributes of the ShoreZone dataset, generally describing the shoreline's dominant biologic species or assemblage. Imagery mapping in the Caamaño-Douglas area was conducted from 1994 to 2000 (Coastal and Ocean Resources, 2017). The salt marsh bioband feature from the BC Shorezone mapping system includes the Salicor*nia virginica ('goos*e grass' or 'pickleweed') and the dune grass biobands. These biobands were used as salt marsh indicator species, including salt-tolerant herbs,

grasses, and sedge[25] (BC Marine Conservation Analysis, 2011). Salt marsh habitats are found throughout the Caamaño-Douglas area and within the Network Zones (**Figure 49**).

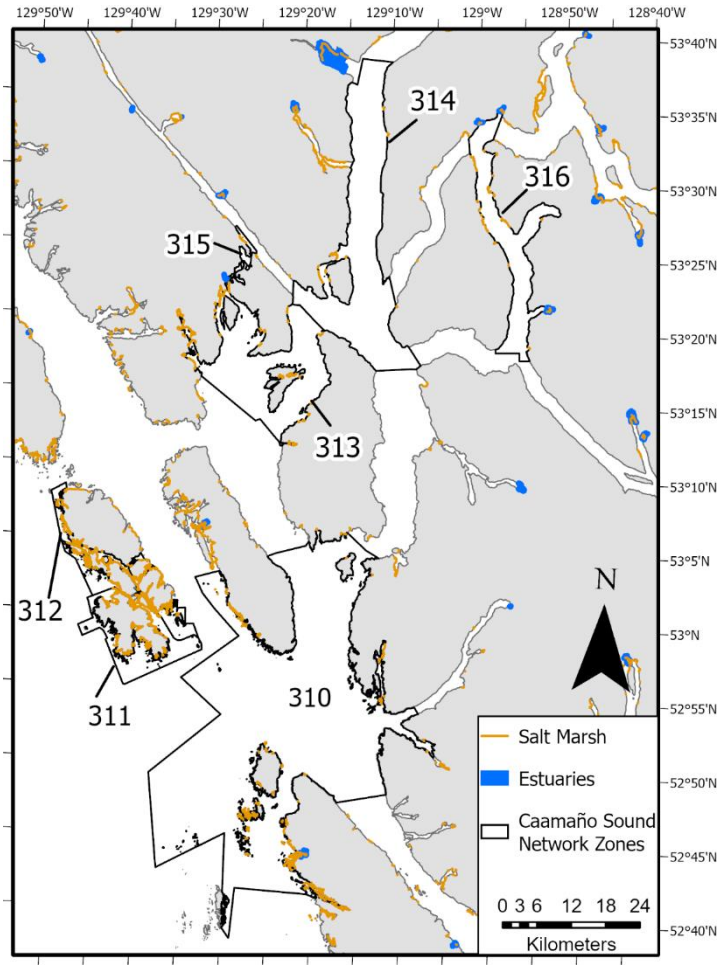


***Figure 49**. Salt marsh Shorezone biobands (in orange) present in the Caamaño-Douglas area and proximity to estuaries (in blue). See **Figure 48** and **Table 24** for information on estuaries.*

Vulnerabilities and Recoverability

Estuarine habitats such as salt marshes are considered one of the most threatened ecosystems in the world and similarly share sensitivities to natural and anthropogenic disturbances. Coastal erosion, disrupted sediment transport, sea-level rise, and natural stochastic events such as storm surges can threaten the structure and function of estuaries. These effects may intensify with climate change (Gedan et al. 2011). Similarly, increased human activity and density can disturb estuaries through agriculture, freshwater diversion, pollution, oil spills, habitat alteration, the introduction of invasive species (Meyerson et al. 2009), and historical logging activities (Hodgson et al. 2020). Due to the sparsely populated nature of the NSB and its higher

[25] BC Marine Conservation Analysis: https://bcmca.ca/data/eco_vascplants_saltmarshbioband/

proportion of conservation designation, human-related disturbances are generally reduced compared to the threats and stressors of estuaries in Southern BC (Robb 2014).

The dynamic properties of estuaries and salt marshes make these habitats naturally resilient and capable of rebounding from certain stressors (Gedan et al. 2011). In addition, salt marsh plant species can quickly grow and tolerate soils that are anoxic, saline, or contain metal contaminants (Weis and Weis 2004). The Nature Trust of BC launched a five-year assessment, monitoring and research project[26] to look at resilience to climate change for 15 estuaries on Vancouver Island, Haida Gwaii, and the Central Coast. This assessment project will use the Marsh Resilience to Sea-Level Rise (MARS) monitoring tool and approach[27].

Estuaries and their related habitats are slow to recover from compounding anthropogenic disturbances and often require decades to recover to a pre-existing state (Borja et al. 2010). However, previously degraded and restored habitats provided the same resources and biodiversity as an undisturbed ecosystem (Moore et al. 2016). While restoring estuary functions and biodiversity to a pre-disturbed and pristine condition may be a difficult and elusive task due to shifting baselines, many targets for effective restoration work for estuaries have identified maintaining key ecosystem functions, structures, and services (Elliott et al. 2007; Duarte et al. 2009). Both physical and biological factors are linked to determining estuarine communities' resilience and recoverability (Gedan et al. 2011). Restoration of estuaries includes many efforts and targets, such as planting native vegetation to recover **gadza k'aw**/eelgrass meadows and salt marsh diversity, removing invasive species, restoring biogenic communities such as shellfish and **kʷaas**/mussels, and stabilizing eroded shorelines.

Salt marsh habitats were ranked the highest vulnerability to oil spills (Jeffery et al. 2023). Studies examining the effects of the Deepwater Horizon oil spill on salt marsh areas found heavy erosion in oiled areas, heavily reduced above-ground plant cover, and a recovery time of over a decade (Zengel et al. 2022).

6.2 Taxonomic Diversity

Taxonomic diversity (section 6.2) describes a broad group of marine organisms of known ecological, cultural, conservation, or commercial significance in the area. Specific taxonomic groups identified by an ecological conservation priority (E-CP) framework (Gale et al. 2019), or by Zone-specific Proposed Conservation Objectives from the Network Action Plan (MPA Network BC Northern Shelf Initiative 2023), or noted as significant (i.e., socially/culturally significant species, depleted species), are highlighted throughout the report. These taxonomic groups include Macroalgae and plants, Invertebrates, Fishes, Marine Birds, and Marine Mammals. Here, each feature's ecological significance, occurrence and trends, and/or cultural usage information are described within the Network Zones and nearby Caamaño-Douglas area when available.

Due to the importance of the Caamaño-Douglas area to marine mammals, several groups have conducted extensive research in this area that was not included in the broad scale NSB regional

[26] https://www.estuaryresilience.ca/about/

[27] NOAA National Estuarine Research Reserve System, 2012 https://coast.noaa.gov/digitalcoast/data/marshresilience.html

network process. This includes long-term research by the North Coast Cetacean Society and DFO's Marine Mammal unit. Therefore, the Marine Mammals section (6.2.5) describes the extent and summary of this research in greater detail, with a focus on fin whales, humpback whales, and three ecotypes of **'naaxł** /**hélx̌'inix̌^{w}**/**niixł**/Killer Whales.

6.2.1 Macroalgae and plants

6.2.1.1 Canopy-forming kelps

Kelp is the common name for marine brown algae belonging to the order Laminariales found mainly in lower intertidal to subtidal zones with rocky or mixed substrates in temperate ecosystems. The two largest kelps found in the NSB, **mo'ox**/**wáudi**/**moox**/Bull Kelp (*Nereocystis leutkeana*) and **gyoós**/**q̓áq̓elḻis**/Giant Kelp (*Macrocystis pyrifera*), can grow to lengths of 30 – 80 m and form canopies visible at the surface, thus referred to as canopy-forming kelp in the context of the NSB. Both kelp species have been identified and recommended as E-CPs (Gale et al. 2019), and aggregations of canopy-forming kelp, known as kelp forests, are potential EBSAs (Rubidge et al. 2020). **Gyoós**/**q̓áq̓elḻis** prefer low- to moderate-energy areas of water, leading to their distribution in more semi-protected or protected areas. In contrast, **mo'ox**/**wáudi**/**moox** are found in more varied locations, preferring areas with moderate or strong currents (Springer et al. 2010). Where the two kelps co-occur, **gyoós**/**q̓áq̓elḻis** are typically found inshore surrounded by **mo'ox**/**wáudi**/**moox** in higher energy and exposed waters (Springer et al. 2010; Rubidge et al. 2020).

Kelp forests are among the world's most productive habitats (Mann, 1982), and their complex structures serve as valuable habitats for coastal marine organisms. Canopy-forming kelp are consumed by an abundance of lower trophic detritivores and grazers, which attract and feed higher trophic level organisms. In addition, the vast heterogenous structures of kelp forests serve as a substrate for microorganisms and small invertebrates, provide protection against predators, and offer ideal conditions for juvenile spawning and rearing (Rubidge et al. 2020). As such, kelp habitats are associated with higher species diversity, species density, and higher life stage density of species. A multiyear zooplankton drop net and snorkel survey conducted by Shaffer et al. (2020) compared the differences between kelp forest and open-water habitats in Washington state. They detected more presence and biomass of zooplankton, juvenile **hoon**/**qeqapela**/salmon (**yee**/**q̓áp̓i**/**xyi'i**/Chinook and **üük**/**zúen**/**üüxs**/Coho), and forage fishes (**tskah**/**wáṅi**/**tskaḥ**/ Pacific Herring, Surf Smelt, and Pacific Sand Lance) in kelp forests. Many other species identified as conservation priorities in the NSB (e.g., invertebrates, **hoon**/**qeqapela**, **ts'mhoon**/ rockfish, **'naaxł**/**hélx̌'inix̌^{w}**/orcas, **płoon**/**nuk^{w}**/sea otters)(Gale et al. 2019) depend on kelp forest ecosystems for crucial life history functions such as feeding, spawning, and rearing (Table 2, Rubidge et al., 2020).

In addition to their function as marine ecosystem engineers, kelp forests provide valued ecosystem services. They absorb excess nutrients and ameliorate local impacts of ocean acidification and hypoxia (Umanzor and Stephens, 2023; Hirsh et al. 2020). The high productivity of kelp forests suggests that they could play a substantial role in climate change mitigation by sequestering carbon dioxide from the atmosphere. However, there is still considerable uncertainty regarding the flux of kelp derived carbon in the marine environment and its fate in the global carbon cycle (Krause-Jensen and Duarte, 2016).

The high productivity of kelp forest ecosystems has led to many traditional and contemporary human uses in the Pacific Northwest. Kelp is harvested for cultural and commercial purposes, and the preservation of kelp forests leads to higher productivity of culturally and economically important species such as **yee**/**ḵáṗi**/Chinook and **üük**/**zúen**/**üüxs**/Coho salmon (Shaffer 2004; Daly et al. 2009). A traditional fishery practice called roe-on-kelp (ROK) allows the harvest of **xs'waanx**/**'á'ent**/**xs'waanx**/herring roe attached to **sia'ám**/Feather Boa kelp (*Egregia*) for food, social, and ceremonial (FSC) purposes and **gyoós**/**ḳáḳeli̱s** blades for both FSC and commercial fisheries, during spawning season. **Mo'ox**/**wáudi**/**moox**/bull kelp has been described as "the most valued marine plant material in traditional Northwest Coast technology" among its many uses in ceremonial, domestic, and substance practices (Turner 2001; Calloway et al. 2020). For example, the long stipe and bulb can be processed and shaped into various tools such as fishing lines, anchors, and containers for storing **ha'limootk**/**ƛ̓áti**/**ẅa̱h**/eulachon oil (Halpin and Seguin 1990; Turner 2001). Kelp forests are also vital habitats for the proliferation and recovery of culturally important and endangered or species of concern such as **bilhaa**/**g̱elhg̱enaiq**/Northern Abalone (Sloan and Breen, 1988; DFO 2012a) and **ts'mhoon**/rockfish (Markel and Shurin 2015; Tolimeieri et al. 2023). Managing and preserving kelp forest ecosystems ensures the connection for many important cultural and ecological practices.

Data sources and distribution

Six datasets from three different sources were merged to create the spatial layer for viewing the general distribution of canopy-forming kelp polygons in the Caamaño-Douglas area (Gale et al. 2025). These datasets included the ShoreZone Bull Kelp and Giant Kelp bioband lines[28] and the BC Marine Conservation Analysis (BCMCA) kelp bed polygons (BCMCA Project Team 2011). The BCMCA includes **mo'ox**/**wáudi**/**moox**/Bull Kelp, **gyoós**/**ḳáḳeli̱s**/Giant Kelp, general kelp, and occurrence points from DFO's Benthic Habitat Mapping (BHM) dive surveys. The third source is a digital map of canopy-forming kelp presence from 1858 and 1956 that shows the historical baseline and presence around the Caamaño-Douglas area (Costa et al. 2020). ShoreZone bioband imagery mapping in the Caamaño-Douglas area was conducted from 1994 to 2000 (ShoreZone Protocol, 2017).

The three kelp polygon layers from BCMCA, Giant Kelp[29], Bull Kelp[30], and general kelp[31], were compiled and merged from various sources, including the Province of BC Land Use Coordination Office, Living Oceans Society, Parks Canada, and the Capital Region District (BCMCA Project Team 2011). Most of these sources contain data collected previous to 2009 (see respective metadata). The general kelp layer includes data where species information was not always recorded, although it mainly includes canopy-forming kelp species, as well as polygons from understory kelps *Pterogophora* and *Laminaria* (BCMCA Project Team 2011).

The BHM dive surveys are ongoing DFO surveys conducted throughout BC's coast. Invertebrate and algae species and substrate were documented by SCUBA divers using transect lines and drop camera deployments in nearshore regions. Presence data for

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[28] Shorezone Biobanding Lines

[29] https://bcmca.ca/data/eco_kelp_giantkelp_polygons/

[30] https://bcmca.ca/data/eco_kelp_bullkelp_polygons/

[31] https://bcmca.ca/data/eco_kelp_generalkelp/

mo'ox/**wáudi**/**moox**/bull kelp and **yoós**/**q̓áq̓elḻis** in the Caamaño Sound area were collected in 2015 (Davies et al. 2018).

Several general caveats for these datasets exist. Data gaps may indicate a lack of surveillance in certain areas and not necessarily an absence of kelp. Multiple surveillance methods were used to compile these datasets, so direct comparisons between the data may be difficult. Much of the data represents the surface distribution of kelp, and therefore there is not much information about sub-surface distribution. In addition, kelp distributions are dynamic, meaning the presence of kelp forests and beds may change over time. Many distribution datasets were last updated over a decade ago.

The Marine Plan Partnership for the North Pacific Coast (MaPP) is monitoring canopy-forming kelps (both **gyoós**/**q̓áq̓elḻis** and **mo'ox**/**wáudi**/**moox**/bull kelp) in the NSB as part of a coordinated Regional Kelp Monitoring Program[32]. As part of this monitoring, satellite imagery was acquired to evaluate canopy-forming kelp extent in some sections of the Caamaño-Douglas area in 2018 and 2022.

Discrete areas with canopy-forming kelp forests are common throughout BC. Within the Caamaño-Douglas area, mapped areas of **mo'ox**/**wáudi**/**moox**/bull kelp and **gyoós**/**q̓áq̓elḻis** are concentrated in shallow regions. Examples are the shallow regions in Zone 310 (Southern end of **Lax Ka'gaas**/Campania Island, Moore island and Rennison island) and throughout Zones 311 and 312 (**Figure 50**), which list **mo'ox**/**wáudi**/**moox** and **gyoós**/**q̓áq̓elḻis** as network conservation objectives. **Mo'ox**/**wáudi**/**moox** presence from the 2015 BHM dive surveys are spread throughout the Network Zones except for the middle of Douglas Channel inlet in Zone 314. Notably, **gyoós**/**q̓áq̓elḻis** occurrence was only recorded in the Outer Coastal Zones (311 and 312) and around Estevan Sound on the northern half of **Lax Ka'gaas** island, outside of any Network Zones. **Gyoós**/**q̓áq̓elḻis** was not found in the Inner Fjord Zones. This observation was supported by local knowledge of the area (K. Clifton & C. Picard, pers. comm. 2023).

Historical mapping of the Caamaño-Douglas area showed canopy-forming kelp occurrence offshore in Zone 310, Northern Trutch Island in Zone 312, and outside of Kishkosh inlet in Zone 314 (**Figure 51**). Historical canopy-forming kelp abundance outside the Network Zones is concentrated in the Southern end of **Lax k'naga dzol**/Banks Island and Nepean Sound and Otter passage. These maps show that certain regions of the Caamaño-Douglas area, such as the outer islands, are known for historical canopy-forming kelp forest occurrence and are regions where these forests continue to persist.

[32] Regional Kelp Monitoring on the North Pacific Coast

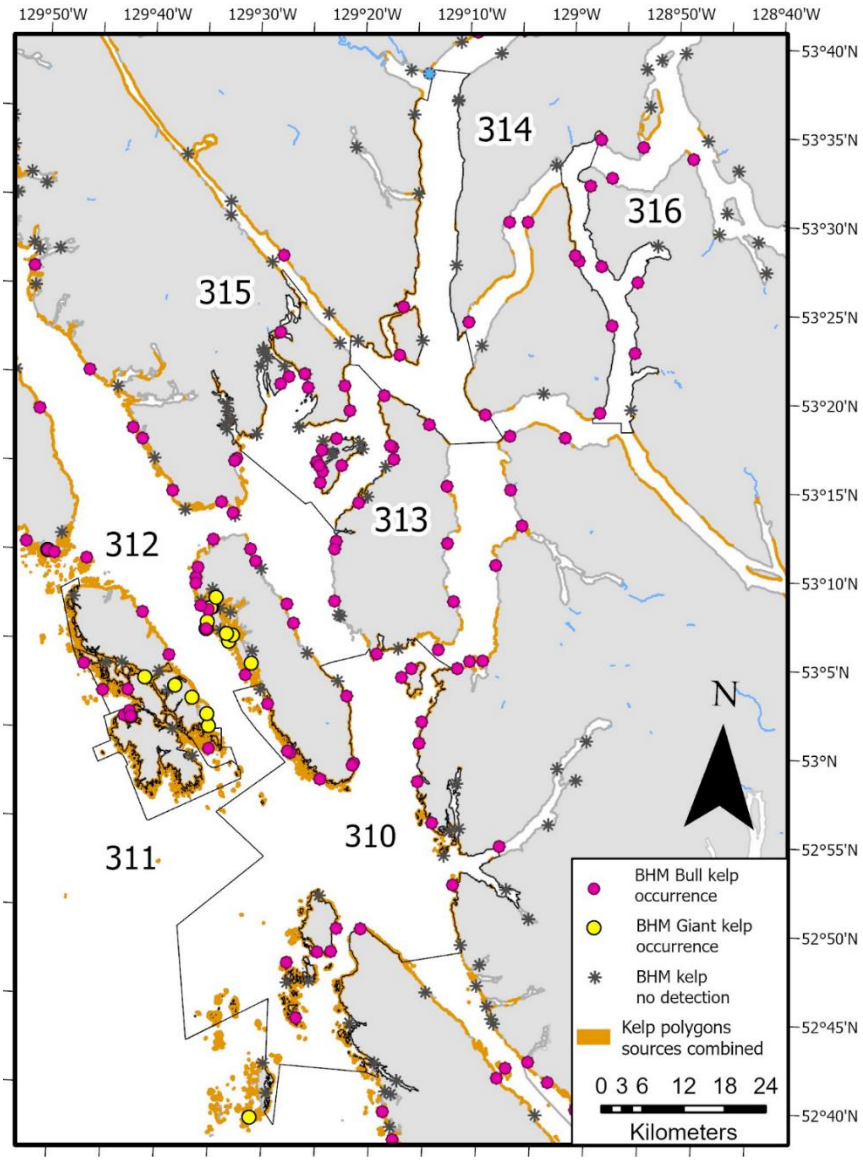

***Figure 50**.Canopy-forming kelp layers (**mo'ox**/**wáudi**/**moox**/Bull Kelp and **gyoós**/**q̓áq̓elḭis**/Giant Kelp) in the Caamaño-Douglas area. These layers include undescribed general kelp where species was not included. **Mo'ox**/ **wáudi**/**moox** and **gyoós**/**q̓áq̓elḭis** occurrences from 2015 Benthic Habitat Mapping (BHM) nearshore dive surveys are shown as circles, and sites with no kelp detected at the survey time are shown as gray asterisks (not the same as true absence). Dive survey sampling scale is done using transects along a maximum 300 meter line with alternating quadrats (Davies et al. 2018).*

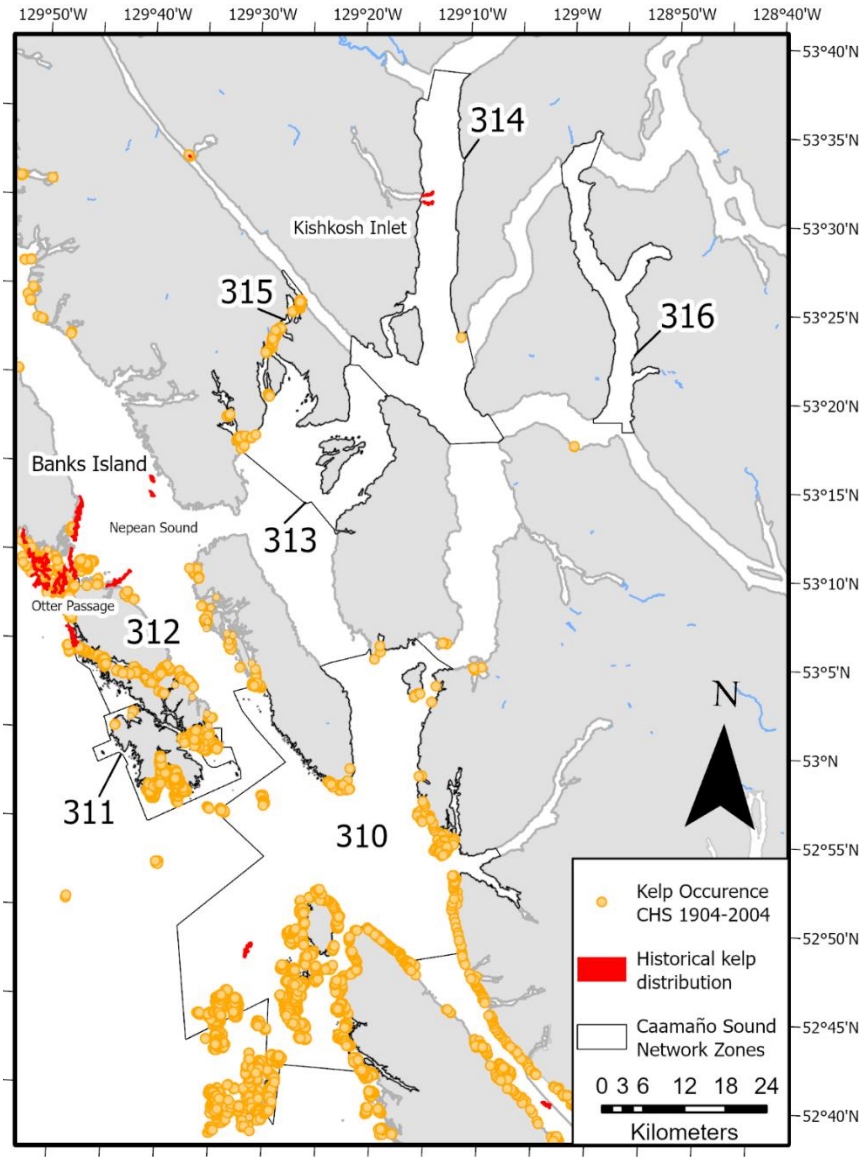

***Figure 51**. Historical distribution of kelp forests in the Caamaño-Douglas area, British Columbia 1856-1956 (Costa et al. 2020) and from the Canadian Hydrographic Service (CHS) 1904-2004 https://open.canada.ca/data/en/dataset/9a6f8.*

Knowledge and data gaps

Information on canopy-forming kelp persistence and drivers of change in BC is limited to geographically constrained case studies. More work is needed across larger spatial and temporal scales to understand how underlying environmental conditions and stressors at local to regional scales affect the resilience of canopy-forming kelp to global climate change (Hollarsmith et al. 2022). Updated species-specific information on the occurrence and abundance of canopy-forming kelp are lacking for much of the BC coast. Canopy-forming kelp forests exhibit high levels of natural variability both seasonally and interannually, especially the annual **mo'ox**/**wáudi**/**moox**/Bull Kelp. Consequently, detecting long-term trends of changes in

canopy-forming kelp density and extent requires dedicated annual surveys over multiple years supported by local and traditional ecological knowledge.

The impacts of salinity on kelp are not well studied. However, few species can tolerate low salinities, and canopy-forming kelps are not often found in estuaries (Dayton 1985). **Gyoós**/**ʔáʔɛlɨ̓is**/Giant Kelp spore production and early growth may benefit from higher salinities; however, the range of salinity tolerance appears to vary geographically (Buschmann et al. 2004). Importantly, the combined influence of seawater temperature and salinity on canopy-forming kelp requires further investigation (e.g., Druehl 1978, Foreman 1984). Given the potential for climate change to impact the amount and seasonal timing of freshwater inputs in the area (see Section 4.2 Climate change impacts on fjords and inlets), more work is needed to understand the range of optimal salinity conditions for kelp in BC and how it may vary with ocean temperature, including local variation in tolerance of low salinity environments.

Additionally, in regions influence by coastal upwelling like the Outer Coastal Zones, nutrient (nitrate) concentrations necessary for kelp growth have been shown to be inversely related to sea surface temperature (Snyder et al. 2020). However, whether this coupling of temperature and nutrients and their combined impact on kelp growth holds true for the Inner Fjord Zones requires further investigation.

6.2.1.2 Diversity of marine macroalgae

Marine macroalgae, also commonly known as **ła'ask**/**lhlaˈʔɛ̓s**/**łą̱'ą̱sk**/seaweed, are categorized into three broad groups consisting of red, green, and brown algae (which includes kelps). There are at least 615 described native species along the coast of BC. The functions of algae in the marine environment are similar to those of plants in the terrestrial ecosystem, including photosynthesis as primary producers at the base of the marine food web, forming habitats, regulating environmental conditions, and providing structural support against erosion and shelter against predators and disturbances. In evaluating E-CPs for the NSB (Gale et al. 2019), most algae species were assessed as “moderately fits, or fulfills only part of the criterion” or “not enough information to assess the criterion” for the categories of habitat-forming and nutrient subsidy. This section briefly describes the presence of several algae species or groups in the Network Zones, focusing on those evaluated by Gale et al. (2019) in recognizing their ecological contributions to habitat formation and nutrient subsidy. A project to create species distribution models for multiple algae species is currently underway by DFO (Davies et al. 2018; Nephin et al. 2020).

Other kelp genera such as *Laminaria, Alaria,* and *Pterygophora* make up understory kelp that likely provides similar ecosystem functions (Rubidge et al., 2020). Understory kelp in the NSB may serve similar ecosystem engineering functions when compared to canopy-forming species of **mo'ox**/**wáudi**/**moox**/Bull and **gyoós**/**ʔáʔɛlɨ̓is**/Giant Kelp. In other temperate waters, species of the genus *Laminaria* and *Saccharina* form dense beds in areas where they are the dominant kelp species (e.g., Arctic and North Atlantic) and provide complex habitats and feeding grounds for coastal biodiversity (Schoenrock et al. 2020; Kvile et al. 2022). Field manipulation studies that removed understory kelp species saw changes in abiotic conditions and some species assemblages (e.g., Kennelly 1989; Flukes et al. 2014). Additionally, Clark et al. (2004) noted that the responses of benthic algal communities to experimental removal of kelp forest (**gyoós**/**ʔáʔɛlɨ̓is**) canopy and understory *Pterygophora californica* canopy varied depending on whether the dominant kelp canopies were removed individually or together. These studies highlight the role of both canopy-forming and understory kelps in contributing to benthic

community composition and dynamics. Alternatively, a study by Hüne et al. (2021) measured fish species diversity and abundance in areas with **gyoós**/**ḵáḵelḷis** and co-existing understory kelp (*Lessonia spp.*) in Southern Chile. The study found a negative correlation in regions of denser *Lessonia spp.* and discussed that **gyoós**/**ḵáḵelḷis** fronds may provide more food and shelter for fishes than understory kelp. While only **gyoós**/**ḵáḵelḷis** and **mo'ox**/**wáudi**/**moox** kelp forests were identified as E-CPs (Gale et al. 2019), understory kelp was identified as a priority for future assessments of ecological importance in the NSB (Rubidge et al. 2020).

Corraline red algae (Order *Corallinales* and *Sporolithales*) have been described as habitat and reef-forming species due to their quick colonization of bare rock and ability to form complex structures with a high composition of calcium carbonate (Kelaher et al. 2001). Their presence has increased settlement and growth in many invertebrate larvae (e.g., Steller and Cáceres-Martínez 2009; Fisher and Martone, 2014). Notably, crustose coralline algae may play a role in settlement cues for **bilhaa**/**g̃elhg̃enaiq**/Northern Abalone, and adults were shown to prefer habitats with increased kelp and coralline algae cover (Rogers-Bennett et al. 2011). Abundant species of algae such as Rockweed (*Fucus sp.*) and Sea Lettuce (genus *Ulva*) can dominate rocky shorelines or beach wracks, contributing to marine and terrestrial nutrient transfer (Orr et al. 2005; Fox et al. 2015). Rockweed can form dense canopies, which can increase invertebrate diversity and abundance by providing refuge, whereas their removal can change those community assemblages (Jenkins et al. 2004; Martins et al. 2019). Sea lettuce provided habitat for fish and decapods (Sogard and Able 1991) and protection for larval **k'almoos**/**klnákʷ**/ **k̲'a̲lmoos**/crabs compared to unvegetated areas (Wilson et al. 1990).

Lastly, certain algae species have important uses for humans. The red algae, **ła'ask** *Pyropia abbottiae*, for example, grows on intertidal rocks and is commonly harvested, dried, and used as snacks and meals by many coastal First Nations, including the **Gitga'ata** (Turner 2003; Thompson et al. 2019; K. Clifton, pers. comm. 2023). **Ła'ask** has names across 16 language groups in five language families across the Pacific Coast of Canada and Alaska, indicating this seaweed's widespread usage and importance (Turner 2003). Other **ła'ask**/**lhlaʿḵs**/**ła̲'a̲sk**/ seaweeds traditionally or contemporarily eaten or that had food-related uses by nearby coastal First Nations include Rockweed, Sea lettuce, and Pacific Dulse (*Palmaria mollis*) (Kuhnlein and Turner, 1991).

Data sources and distribution

The Benthic Habitat Mapping (BHM) dive surveys recorded algae species per quadrat from the shore to a depth of 18 m (Davies et al. 2018). These algae species were limited to 59 species or functional groups (**Appendix E. Macroalgae Occurrence Table**; Davies et al. 2018). While additional species were noted, they were excluded from subsequent analyses. Dive surveys in the North Coast were conducted in 2015. Species and their groups (e.g., "Red Branched algae") were categorized into green (Chlorophyta), red (Rhodophyta), brown (Phaeophycaea), or brown (kelp; Order Laminariales) algae to contextualize their ecology for this report. These groupings are meant to be generalized, as algae function and diversity is highly variable even within groups. The Global Biodiversity Information Facility database also supplemented the occurrence data for the Network Zone polygons. A species distribution model for *Pterygophora californica* from Nephin et al. 2020 is also presented in **Figure 52**, where the highest probability of occurrence is found in Zones 310 - 312.

Results from the BHM dive surveys recorded a total of 50 macroalgae (37 species, and 13 groups) within the Caamaño Sound and Douglas Fjord System Network Zones (**Appendix E.**

Macroalgae Occurrence Table). This list excludes the two canopy-forming kelps: **mo'ox/wáudi/moox** /Bull Kelp and **gyoós/ḵáḵelḷis**/Giant Kelp. Zone 310 has the highest diversity of algae, with a total of 46 species and groups, followed by Zone 313 with 42 species and groups. The high species diversity in these Zones may be attributed to the presence of sheltered habitats such as bays and inlets in both areas. Both Zones 314 and 316 had the lowest count, with 23 species and groups recorded. These two Zones, Douglas Channel and Ursula Channel respectively, are further inland and deep, which may not be the most suitable habitat for many algae Zone 315 was not surveyed and therefore did not return any data. Brown algae was the most diverse in all Zones, followed by red algae and kelp, then green.

Habitat and reef-forming algae species and groups were found throughout the Caamaño-Douglas area. Rockweed, sea lettuce, and Articulated Coralline algae were present in all zones. The red edible algae **ła'ask/lhlaˈḵs/łą'ą̱sk/***pyropia sp.* was found in Zones 310 - 314, whereas Pacific Dulse was not present. As part of work completed for the LNG Canada TERMPOL process in 2015, modelling work done by the Gitxaała Nation observed red algae in zone 315 as well as the noted zones 310 - 314. The rapid-growing and invasive Japanese wireweed (*Sargassum muticum)* is present in many areas of BC, including Haida Gwaii. During the 2023 intertidal survey conducted by the Marine Spatial Ecology and Analysis team on the CCG Vector (Proudfoot et al. 2025A), *Sargassum* was spotted at intertidal sites in Zone 313 (A. Liu, Pers. Comm. 2023).

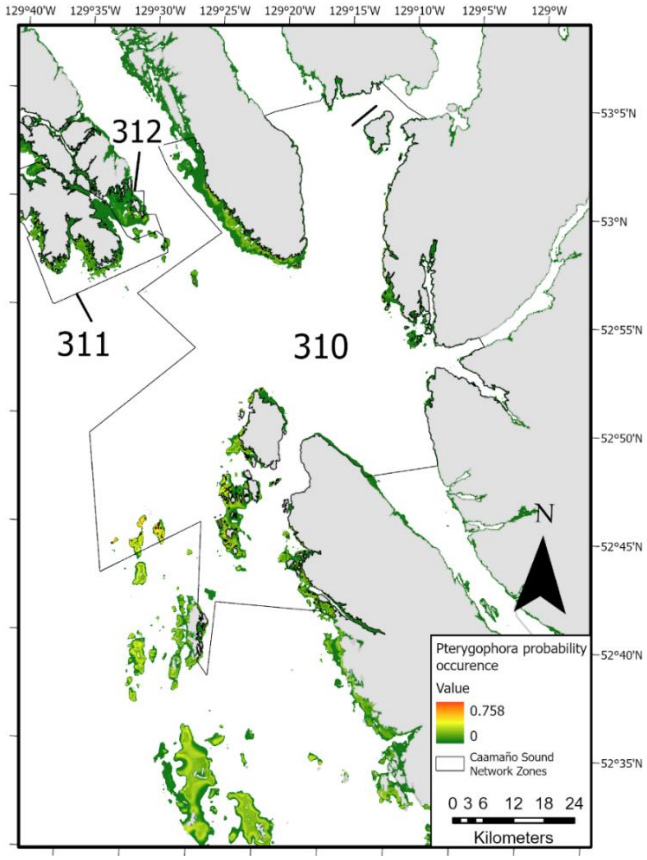

Figure 52. *Species distribution model of Pterygophora, an understory kelp. Probability of occurrence is shown in a zoomed in area of the Outer Coast of Caamaño-Sound to highlight areas with higher probability (See also Figure A.8 in Nephin et al. 2020 for more details on the model).*

Knowledge and data gaps

Many macroalgae research surveys focus on **mo'ox**/**wáudi**/**moox**/Bull Kelp and **gyoós**/**ʔáʔelḷis**/Giant Kelp distribution due to their visible canopy at the ocean surface. Surveys that record coastal macroalgae diversity tend to concentrate in the Southern portion of BC (see Levings and Stewart 2020 for details). There is a lack of local algae diversity and baseline studies in the Network Zones from a western science viewpoint aside from the BHM dive surveys. Few studies also compare the effects of **mo'ox**/**wáudi**/**moox** and **gyoós**/**ʔáʔelḷis** - dominated habitats to other macroalgae, such as understory kelp. Seasonal and annual variation in macroalgae distribution is also unclear when surveys are infrequent. Algae variation and trends can be supplemented through traditional knowledge, and local community surveys can inform baselines and long-term monitoring.

6.2.1.3 Gadza k'aw / Eelgrass and surfgrass

Seagrasses are a unique group of flowering plants that dominate shallow coastal marine and estuary ecosystems. Aggregations or communities of seagrasses are referred to as beds or meadows. Two seagrasses were identified as E-CPs in the NSB: **gadza k'aw**/eelgrass (*Zostera marina*) and surfgrass (*Phyllospadix sp.*). **Gadza k'aw** is usually found in soft substrates such as shallow flat sandy or muddy areas that have low exposure to waves (such as estuaries and bays), whereas surfgrass is uniquely found on rocky substrates with higher wave action (Balestri et al. 2015, Stephens et al. 2019). Both seagrasses are widespread throughout BC where they can be found from the intertidal to the shallow subtidal, depending on water clarity, and are important for various ecosystem services. Meadows provide biogenic habitats for sheltering juvenile fishes and invertebrates from wave exposure and predators and serve as settling substrates for pelagic larvae. The rhizomes and stems attach to their substrates to prevent coastal erosion. As blue carbon habitats, seagrasses oxygenate the surrounding water and store organic carbon as living biomass and, in the sediment, contributing to carbon sequestration (reviewed in Rubidge et al. 2020). However, carbon storage rates for temperate seagrass meadows in the Pacific Northwest may be less than for tropical seagrasses, and regionally specific data are needed to compare to global estimates (Prentice et al. 2020). The abundance of seagrasses also transfers nutrients from marine to terrestrial ecosystems by washing onshore on the beach as wrack. Decomposition of this wrack supplies food for herbivores and detrivores (Heck et al. 2008).

Two **gadza k'aw** species are found in BC, the native Common eelgrass (*Zostera marina)*, which is the primary **gadza k'aw** found throughout the NSB, and the introduced Dwarf eelgrass (*Zostera japonica)*. Dwarf eelgrass have not been documented to spread within NSB boundaries due to temperature limits (Shafer et al. 2014). The non-native Dwarf eelgrass would likely form mixed-species meadows with Common eelgrass if the spread of non-native Dwarf eelgrass continues (Rubidge et al. 2020). **Gadza k'aw** habitats have strong support for EBSA designation (Rubidge et al. 2020) and were identified as a Zone-level network conservation objective (MPA Network BC Northern Shelf Initiative 2023) for Zones 311, 312, 313, 314, and 315.

Gadza k'aw meadows serve many important functions for various life stages for many species. For example, these habitats are essential nursery grounds for many ecologically, culturally, and economically important species such as **hoon**/**qeqapela**/salmon (all species), **wa̲t'ukw**/ **núłem**/ **wa̲t'ukw**/ Lingcod, **Tskah**/**wáʔi**/**tska̲h**/Pacific Herring, Dungeness Crabs (Moore et al. 2015), and various waterfowl. Table 4 in Rubidge et al. (2020) shows known **gadza k'aw** functions to

species identified as conservation priorities in the NSB. Both commercial and small-scale fisheries benefit from **gadza k'aw** meadows as these habitats provide protection and supply food for many juvenile fish and invertebrates (Carr-Harris et al. 2015, Moore et al. 2015, Unsworth et al. 2019). The rhizome and stems of **gadza k'aw** meadows grow throughout and stabilize sediments, which prevents coastal erosion. Furthermore, **gadza k'aw** meadows oxygenate surrounding waters (Rasmusson et al. 2017), contribute directly and indirectly to nutrient cycling and transfer, and accumulate carbon in the marine environment (Greiner et al. 2013), among multiple other beneficial ecosystem services (Cole and Moksnes, 2016).

There are three species of *Phyllospadix* found in the NSB (*P. torreyi*, *P. scouleri*, and *P. serrulatis*; Phillips 1979), all referred to as surfgrass collectively. Surfgrass beds grow in rocky intertidal habitats, sometimes to the exclusion of other vegetation (Turner 1985; Turner and Lucas 1985). Aggregations of surfgrass meadows can provide refuge from waves in rocky shores and accumulate sediments in their rhizome and stem structure, supporting habitats for infaunal invertebrates (Phillips 1979). Surfgrass meadows are understudied in comparison to **gadza k'aw** because of their growth in wave-exposed areas that are inaccessible at times. Thus, surfgrass did not meet the criteria of a nearshore EBSA due to lack of information about its importance and usage by other E-CP species, besides **Tskah**/**wáṅi**/**tskaḥ**/Pacific herring, which uses both **gadza k'aw** and surfgrass as spawning habitats (Barto 2008; Rubidge et al. 2020).

Coastal First Nations depend on seagrass meadows to produce many fish and invertebrate resources, such as **xs'waanx**/**'á'ent**/**xs'waanx**/herring roe. Without seagrass meadows (especially **gadza k'aw**), harvest of many important marine resources and their associated cultural values would be lost (Satterfield et al. 2012).

Data sources and distribution

Spatial data for seagrasses in the Caamaño-Douglas area were provided as biobands[33] and polygons (Gale et al. 2025). While **gadza k'aw**/eelgrass surveys and polygon datasets have been updated throughout the years, no recent updates have been completed for the Caamaño-Douglas area. Shorezone biobands from the Caamaño-Douglas area is from 1994 to 2000 (ShoreZone Protocol 2017), and therefore, spatial datasets for **gadza k'aw** and surfgrass in the Caamaño-Douglas area are somewhat dated. **Gadza k'aw** beds that were surveyed for fish using beach seining in 2019 by DFO Marine Spatial Ecology and Analysis section (data unpublished) were also added to the map.

To supplement the original bioband spatial layers, a species distribution model (SDM) for **gadza k'aw** was also mapped for the area (Nephin et al. 2020). Briefly, the SDM considers species observations (e.g., spatial occurrence and life history traits) and environmental predictors (e.g., abiotic variables). **Gadza k'aw** occurrence data came from several sources from 2010 to 2017: the Benthic Habitat Mapping monitoring program, **bilhaa**/**g̱elhg̱enaiq**/sea cucumber survey, **ts'akwe'ats**/red sea urchin survey, and **bilhaa**/**g̱elhg̱enaiq**/abalone survey. Substrate, depth, salinity, temperature, tidal current speed, and exposure were included as variables for the **gadza k'aw** habitat suitability model which informs the predicted distribution. An updated SDM

[33] Coastal and Oceans Resources – Shorezone data repository

for **gadza k'aw** that considers freshwater input is currently in development (A. Park, pers. comm. 2023).

The outer Network Zones (310, 311, 312) show the most **gadza k'aw** and surfgrass bioband occurrence (**Figure 53**). The distribution of **gadza k'aw** and surfgrass in Zones 311 and 312 is similar to the cluster of salt marsh habitats found in those zones (see Section 6.1.4). Predictably, **gadza k'aw** also occurs in inlets such as **K'duwaadz**/Tuwartz Inlet (Zone 313) and estuaries such as Kishlosh Inlet (outside of Zone 314). Other areas of **gadza k'aw** observations in the area outside the boundaries of the Network Zones include: **Kwelts'uu**/Cornwall Inlet which branches off Whale Channel, southwest Aristazabal Island, and the western coastlines of **Lax Ka'gaas**/Campania Island. Unlike **gadza k'aw** biobands, surfgrass appears to be concentrated in the Outer Coast Zones, and does not occur in inlets, estuaries, and the Inner Fjord Zones as often. This may be because of nutrient upwelling in the Outer Coast Zones and that surfgrass prefers to colonize areas with higher wave exposure. For example, surfgrass biobands in **Figure 53B** show occurrence in the outer coasts of the islands in Zones 311 and 312, whereas **gadza k'aw** occurrence is sheltered in between the islands **Figure 53A**.

The **gadza k'aw** species distribution map predicts the highest probability of occurrence in sheltered areas such as between Zones 311 and 312, and **K'duwaadz**/Tuwartz Inlets in Zone 313 (**Figure 54**). Research conducted in 2019 surveyed **gadza k'aw** meadows for fish species in three areas within the Caamaño Sound and Douglas Fjord System Network Zones. A total of 32 fish species were detected among these four locations (Clam Town and Head of **K'duwaadz**/Tuwartz Bay in Zone 313, Danube Bay in Zone 316, and Kishkosh Inlet outside of the polygons) (Rubidge et al. unpublished). Two species of juvenile fish sampled (**sti'moon**/**qábes**/Pink salmon and **wat'ukw**/**núłem**/**wat'ukw**/Lingcod) are network conservation objectives. As part of baseline monitoring of this area, beach seines to characterize nearshore fish communities were also conducted in 2022 in several **gadza k'aw** meadows and included the deployment of baited underwater video systems nearby. These data are being processed and survey results are pending (Rubidge et al. unpublished.).

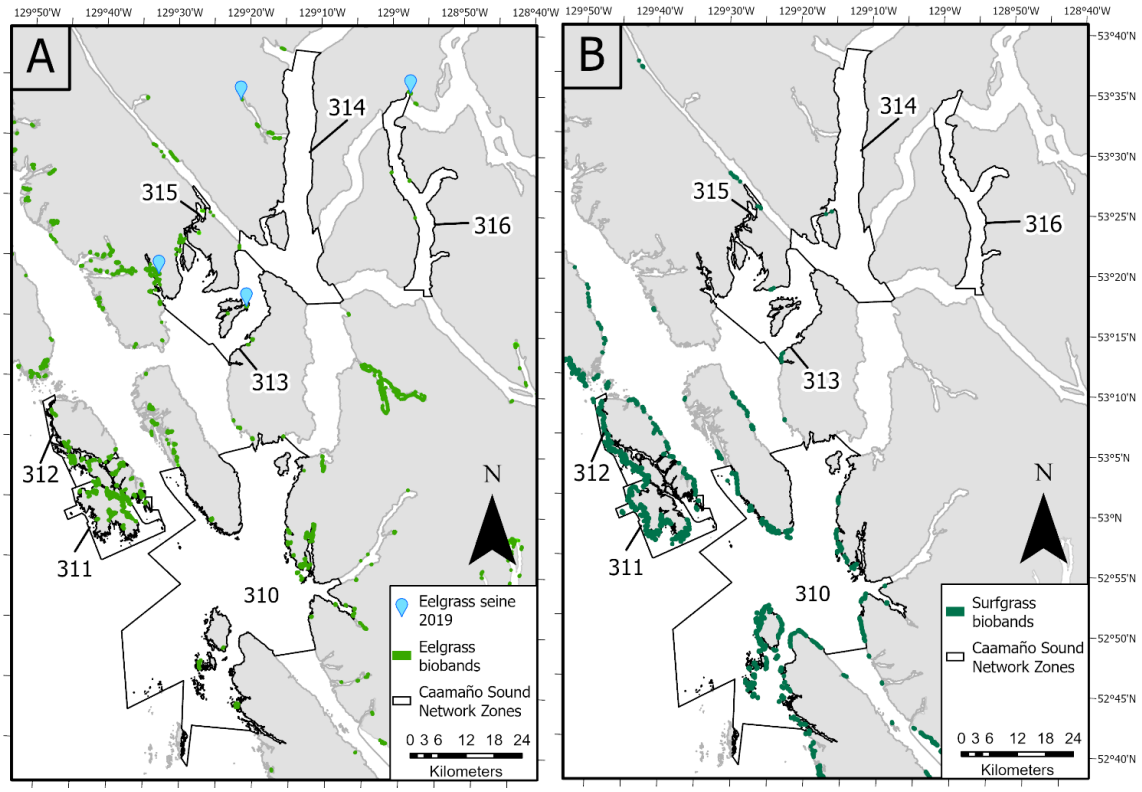

***Figure 53**. Shorezone Bioband data for A) **gadza k'aw**/eelgrass and B) surfgrass collected in the Caamaño-Douglas area from 1994 to 2000. Blue points denote eelgrass DFO beach seine survey areas from Summer 2019.*

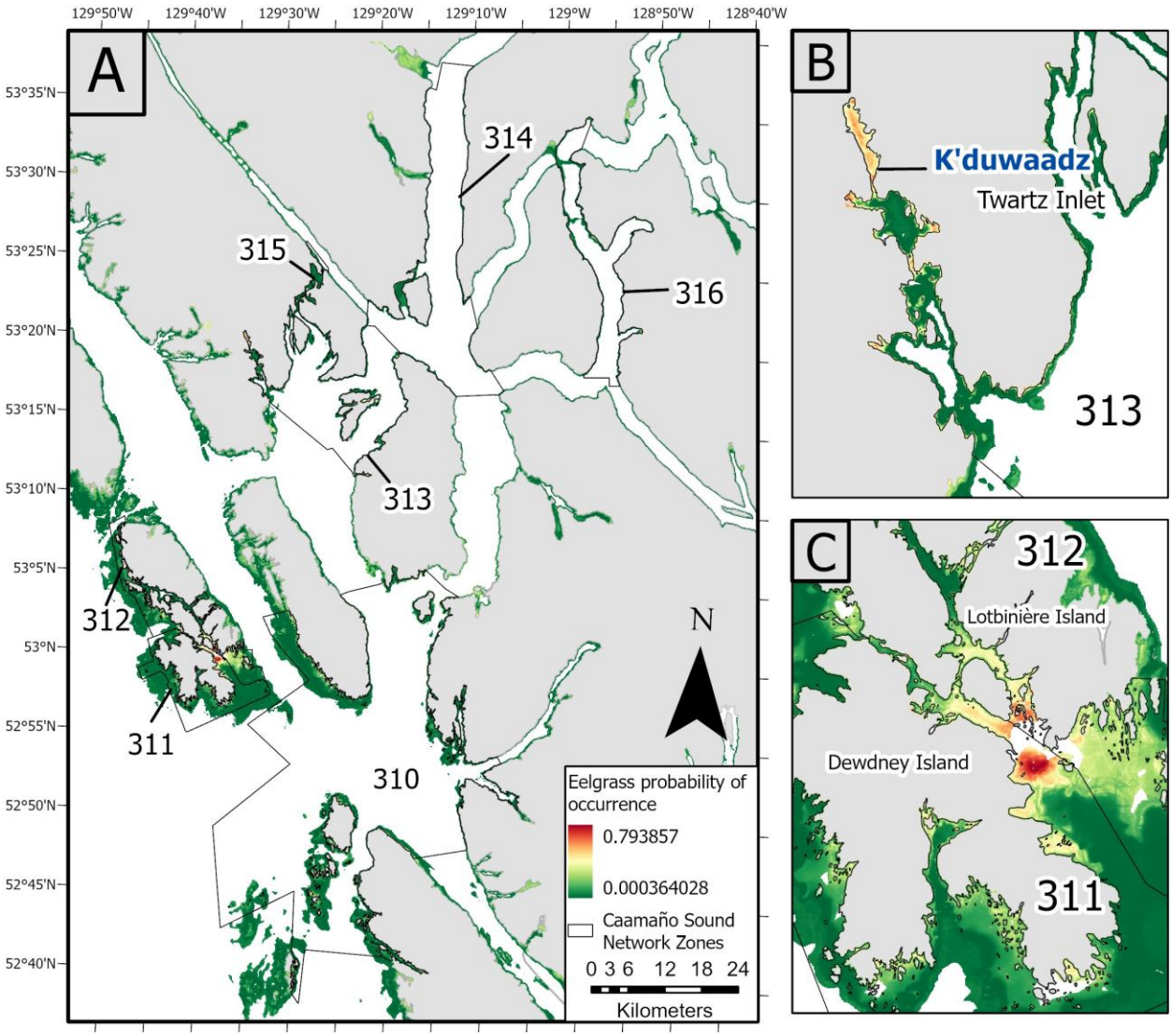

Figure 54. *Panel A shows* ***gadza k'aw****/eelgrass probability of occurrence throughout the Caamaño-Douglas area and all seven Network Zones. Panels B and C show areas of high likelihood of* ***gadza k'aw*** *in* ***K'duwaadz****/Tuwartz Inlet (Zone 313) and between Dewdney (Zone 311) and Lotbiniere Islands (Zone 312) respectively. Description of the species distribution model can be found in Nephin et al. 2020.*

Data and knowledge gaps

Further research on surfgrass in BC is needed to understand its habitat preference, environmental tolerance, and importance for species of conservation priorities. Similarly, there is a local knowledge gap in the Caamaño-Douglas area for **gadza k'aw** /eelgrass and surfgrass distribution in recent years. Species distribution models and occurrence information can be supported through local knowledge, spatial imagery, and monitoring programs. The National Eelgrass Task Force was created with the goal of producing dynamic maps of **gadza k'aw** distribution throughout Canada (Gomez et al. 2021). The group also identified Northern BC as a

data gap for **gadza k'aw**, although many projects are underway to update **gadza k'aw** spatial datasets.

6.2.1.4 Vulnerabilities and Recoverability

Canopy-forming kelps

Kelps are sensitive to multiple and potentially interacting stressors related to climate change and other human activities, including rising seawater temperatures and associated changes in nutrient availability, changing salinity regimes, increased herbivory, and decreasing water clarity and substrate availability due to land-use practices (Harley et al. 2012, Smale 2020).

Cool (≤12°C for **mo'ox**/**wáudi**/**moox**/Bull Kelp, ≤15°C for **gyoós**/**ʔáʔelḷis**/Giant Kelp), high salinity (≥28‰), low turbidity waters rich in nutrients (nitrogen, phosphorus) provide the optimal conditions for kelp recruitment and growth (Druehl 1978, Rogers-Bennett and Catton 2019). General warming trends and anomalous warming events (marine heat waves) associated with climate change can threaten kelp persistence because growth and recruitment are reduced at warmer temperatures (Buschmann et al. 2004, Krumhansl et al. 2017, Hollarsmith et al. 2020). In BC, the strength and timing of upwelling events and, thus the availability of nutrients that promote or limit kelp growth are variable. Climate change may also impact these events (Foreman et al. 2011).

Sedimentation can inhibit the establishment of kelp spores (Geange et al. 2014). The density of both canopy-forming (**gyoós**/**ʔáʔelḷis**/giant kelp) and understory kelps have been shown to decline in correlation with increasing turbidity across a gradient of land-derived sediment loads from rivers (Tait 2019).

While kelp forests can tolerate a range of water motion and energy, high wave action from increased storm intensity can restrict canopy-forming kelp distribution due to dislodgement from hard sturdy substrates (Springer et al. 2007). Kelp's vulnerability to stressors also varies by species and life cycle stage. The microscopic life stages are generally considered more vulnerable than the macroscopic habitat-forming stages of the kelp life cycle, and **mo'ox**/**wáudi**/**moox**/bull kelp may be more sensitive to warming ocean temperatures than **gyoós**/**ʔáʔelḷis**/giant kelp (Hollarsmith et al. 2020, Supratya et al. 2020).

Globally, canopy-forming kelp forests and understory kelp beds are declining by an average rate of 0.018 percent per year (Krumhansl et al. 2016). However, the direction and magnitude of this trend varies strongly across regions, suggesting that kelp dynamics are governed by local and regional conditions that impact the effects of global drivers of change. Some of the main drivers of recent (since ~1970s) trends in kelp abundance at sub-regional scales along the coast of BC are temperature (Krumhansl et al. 2017, Starko et al. 2019, 2022), the history of **płoon**/**nukʷ**/ sea otter occupation (Stevenson et al. 2016, Lee et al. 2016, 2019), and the loss of a key mid-level trophic predator, the sunflower sea star, due to **gamaats**/**g̱azea**/**g̱a̱maats**/sea star wasting disease (Burt et al. 2018).

Regionally coordinated monitoring of canopy-forming kelp forests in the NSB uses in situ and remote sensing data (Regional Kelp Monitoring on the North Pacific Coast , 2021[34]). This

[34] Regional Kelp Monitoring on the North Pacific Coast

monitoring reveals considerable annual variation in kelp abundance and that trends in kelp forest extent vary sub-regionally, highlighting the need for local-scale long-term monitoring to detect trends and identify drivers of change. Additionally, a recent BC coast-wide study found variable patterns of change in BC's canopy-forming kelp forests over decadal periods related to thermal microclimate, currents and wave exposure, and food chain length (Starko et al. 2023).

Local to regional scale environmental and biological conditions play an important role in determining the resilience of kelp forests to disturbance events. In BC, fine-scale (a few to 10s of kms) variation in seawater temperature of ~1-3°C drive the recovery of **gyoós/q̓áq̓elḭis** from harvest (Krumhansl et la. 2017) and the resistance of **gyoós/q̓áq̓elḭis** and **mo'ox/wáudi/moox**/ bull kelp to marine heatwaves (Starko et al. 2022). Cooler microclimates promote faster rates of biomass recovery following harvest and act as thermal refugia during anomalous warming events. Wind and tidal-driven mixing, coastal upwelling, and tidal currents can promote favourable conditions for kelp persistence by providing cooler, nutrient-rich water, potentially providing refugia for regional kelp diversity in the Outer Coast Zones (see Section 3.1.1 Large-scale circulation, currents and climate, and Section 3.2.3 Climate and freshwater inputs).

Local-scale variation in current speed, temperature, and substrate type may influence trends in **mo'ox/wáudi/moox**/bull kelp persistence over space and time (Schroeder et al. 2020). Intertidal understory kelp in locally wave-sheltered habitats may be at increased risk of loss of abundance and species diversity, while wave-exposed sites may act as refugia for preserving regional kelp diversity (Starko et al. 2019). Additionally, kelp in locally cooler and wave-exposed environments may be less at risk of encrustation by epiphytic bryozoans, which can impact kelp growth and survival and reduce the quality of kelp for harvest and related fisheries (Denley et al. 2022). However, the persistence of kelp in thermal refugia is constrained by biotic interactions, mainly intensive grazing by increasing **aswit/ʾemdém/a̱ws**/urchin populations (Starko et al. 2022).

Ecological success of kelp forest/bed restoration is highly variable and difficult to predict, with disturbance events like **aswit/ʾemdém/a̱ws**/sea urchin grazing often leading to failed restoration attempts (Eger et al. 2022). Stabilizing feedback mechanisms and hysteresis, a concept referring to the persistence of an alternative state even after the driver of the transition is removed, can make the recovery of a kelp forest/bed state challenging once a shift to **aswit/ʾemdém/a̱ws** barrens or turf algae has occurred (Filbee-Dexter and Scheibling 2014, Filbee-Dexter and Wernberg, 2018). Kelp recovery strategies suggest reducing nearby stressors, identifying priority sites for restoration, active planting at depleted sites, and increasing monitoring programs to establish baselines and trends (Calloway et al. 2020; Morris et al. 2020; Eger et al. 2022). Holistic and ecosystem-based approaches to restoration were recommended, such as accounting for positive species interactions and connectivity (Calloway et al. 2020). Interestingly, a recent global analysis found the best predictor of canopy-forming and understory kelp restoration success was the proximity of the restoration site to an existing kelp forest/bed (Eger et al. 2022). Establishing MPAs and reserves can enhance the resilience of kelp forest ecosystems by restoring populations of **aswit/ʾemdém/a̱ws** predators and maintaining trophic complexity and functional redundancy (Peleg et al. 2023).

Gadza k'aw / Eelgrass and surfgrass

Globally, seagrass ecosystems have declined by an estimated average rate of 1.7% per year (Dunic et al., 2021). Temperate **gadza k'aw**/eelgrass meadows are sensitive and vulnerable to changes in the ecosystem such as increased temperature, decreased salinity, lower light

conditions, wasting diseases, and increased herbivory (Orth et al. 2006, Salo et al. 2014). Both **gadza k'aw** and surfgrass meadows face pressures from pollution related to human development and activities such as oil spills, run-off and increased nutrient output from agriculture, aquaculture, sewage, and vessel discharge (reviewed in Rubidge et al. 2020). Although the Caamaño-Douglas area is sparsely populated, vessel traffic transiting between Kitimat, Prince Rupert, and other North American and Asian ports can impact local seagrass ecosystems (see Section 5.5 Vessel traffic and vessel types).

Invasive species, such as Green crabs (Garbary et al. 2014; Matheson et al. 2016) and introduced Pacific oysters (Kelly and Volpe, 2007), are known to impact **gadza k'aw** health by altering fish communities and water properties respectively. In BC, high densities of Green crabs can also directly contribute to declines in **gadza k'aw** shoot density by shredding **gadza k'aw** blades and consuming both blades and rhizomes. This mechanism of disturbance differs from that exerted by **płoon**/**nukʷ**/sea otters foraging in **gadza k'aw** meadows, which leads to bare patches and favors sexual reproduction from **gadza k'aw** in disturbed environments rather than clonal reproduction (Foster et al. 2021). This interaction can promote **gadza k'aw** genetic diversity (Foster et al. 2021). Physical disturbances relating to human activities such as frequent trampling, boating, logging, coastal construction, and coastline alterations, however, are known to negatively impact **gadza k'aw**. Zones 311 and 312, which are estimated to have the highest occurrence of both seagrasses, are affected by local recreational usage including boating, anchoring, and beachcombing. Natural disturbances such as winter storms can also alter and uproot **gadza k'aw**. In contrast dense and undisturbed surfgrass meadows are more resilient to these disturbances because of their natural preference for wave-exposed habitats (Turner and Lucas 1985). Surfgrass are, however, affected by desiccation and heat stress during low tides (Raimondi et al. 1999). Naturally occurring disturbances, such as storms and heatwaves, occurring with increased frequency and intensity exacerbated by climate change may be a cause of concern for the health and persistence of **gadza k'aw** and surfgrass meadows, particularly when interacting with other aforementioned stressors (Orth et al. 2006).

While **gadza k'aw** are perennial species and have high leaf turnover rates and growth in summer months, they are very selective in their habitats. Recovery efforts for altered **gadza k'aw** habitats in the Pacific Northwest can be difficult as vegetative growth of new meadows can be slow or non-existent. Environmental conditions, site suitability, and condition of neighboring sites of natural **gadza k'aw** meadows were found to be most important in predicting restoration success rather than restoration method type (Wright, 2005; Behesheti and Ward, 2021). Uprooted surfgrass beds have been slow to recover due to highly variable recruitment success and seed viability (Turner and Lucas 1985, Wyllie-Echeverria et al. 2007). Low seedling recruitment and high mortality rates in experimental plots were demonstrated in two studies (Turner 1983, Turner and Lucas 1985). This difficulty in recruitment may be partially explained by predation on seeds by **k'almoos**/**klnákʷ**/**ḵ'a̱lmoos**/crabs before germination (Holbrook et al. 2000). Surfgrass are poor colonizers that rely on algae growing on exposed rocks (such as coralline red algae) to aid in seed germination and prevent removal from the substrate (Turner 1983, Turner and Lucas 1985, Menge et al. 2005).

Transplanted **gadza k'aw** in suitable habitats or partially damaged meadows have been shown to be more effective than restoring meadows that have been completely lost. Notably, partially restored **gadza k'aw** ecosystems have been shown to increase presence of certain juvenile fish species (such as **sti'moon**/**qábes**/**sti'moon**/pink salmon) in areas of human disturbance (Hass et al. 2002). Resilience and recovery of many fish and invertebrate populations of conservation

concern depends on healthy **gadza k'aw** communities (Orth et al. 2006; Unsworth et al. 2019; Knutsen et al. 2022).

Gadza k'aw recovery and monitoring is sparse throughout the NSB. Conservation of **gadza k'aw** meadow ecosystems in BC is aided by long-term monitoring efforts, up-to-date spatial data collecting, consistent funding, and environments with low disturbance (Wright 2005). Community-based conservation is encouraged by national policies (United Nations Environment Programme 2020).

6.2.2 Invertebrates

Invertebrates are prolific and abundant organisms found in every marine ecosystem. Broad groups of marine invertebrates are separated by taxonomic grouping: Corals and sponges, Molluscs, Crustaceans, and Echinoderms. These diverse species are also referred to by the colloquial term 'shellfish'. Each section briefly summarizes the general ecological importance, life history, fishery or cultural uses, and occurrence within the Caamaño Sound and Douglas Fjord System Network Zones. Where available, recent population trends in the Caamaño-Douglas area or surrounding regions are presented. Occurrence tables are not indicative of true absence or the measure of abundance for a zone and should be used as a guideline for species distribution throughout the seven Network Zones. Finally, a summary of Vulnerabilities and Recoverability are reported for marine invertebrate groups and species of interest.

Data sources

The following occurrence records used in the subsequent invertebrate sections have been extracted from several sources (some of which are also summarized in Gale et al. 2025): The DFO shellfish survey database, which includes Commercial Harvest fishery logs (2000-2022), and research surveys (1963-2022), the DFO groundfish and other research surveys (2003-2017), DFO Benthic Habitat Mapping dive surveys (2015-ongoing; Davies et al. 2018), DFO Multispecies benthic marine invertebrate dive survey program (Lochead et al. 2023), the Global Biodiversity Information Facility (GBIF) and iNaturalist open databases, personal communications and local knowledge. Occurrences of species from surveys were pulled from many datasets (see above) unless specified differently, and therefore the scale of sampling may differ for each data point. Because only species *occurrences* were collated from multiple databases with different protocols, target species, and survey methods, survey areas where there with no detection are currently not shown in the gridded figures. Therefore, a knowledge gap in understanding invertebrate distributions in the Network Zones when using combined datasets is the difficulty in determining whether absences are true absences or an under-surveyed area. Details about DFO shellfish and groundfish survey databases used for occurrences are described in the SeaSketch metadata[35]. A notable data gap is the lack of occurrences in **Maxtaktsm'aa**/Union Passage Site (Zone 315) due to the small area and lack of survey effort. **Bilhaa**/**ǧelhǧenaiq**/Abalone and Geoduck occurrence data are only summarized within the Network Zones but are not included in maps due to *Species at Risk Act* clause, and a confidentiality clause, respectively.

[35] SeaSketch - Better decisions through global participation

6.2.2.1 Cold-water corals and sponges

Cold-water corals (Phylum Cnidaria, Class Anthozoa) and sponges (Phylum Porifera) are sessile long-living invertebrates that are found throughout the Northeast Pacific that can occur as reef forming communities or aggregating groups (also called “gardens”). Bioherms are created of thick, mounded corals or sponges on an underlying benthos, whereas reefs are formed when they are growing on the structural frame created by earlier corals and sponges.

Reefs and bioherms can form complex three-dimensional biogenic habitats for many species and provide ecosystem services such as nutrient and water column transport and cycling, boosting primary productivity, and facilitating key life-stages of many species (Henry and Roberts 2007; Cathalot et al. 2015; Rix et al. 2016). Therefore, areas with an abundance of coral and sponge habitats are often linked to high invertebrate and demersal fish biodiversity (Marliave et al. 2009; Chu and Leys 2010; Stone et al. 2015; Rooper et al. 2019). For example, certain groups of corals can help facilitate populations of species of conservation priority, such as sea pens (order Pennatulacea) providing nursery habitats for **ts'mhoon**/rockfish larvae (Baillon 2012), and stony corals (order Scleractinia) providing spawning habitats juvenile **ksaa**/**q̓ʷaqʷ-**/sharks (Henry et al. 2013). This includes coral structures that provide habitats to a plethora of benthic invertebrate species (Henry and Roberts 2007). BC is home to over 80 species of cold-water corals and over 250 species of sponges (Gardner 2009). Many corals and sponges distributed throughout the Northeast Pacific are typically found in depths on the continental slope characterized by areas of severely low dissolved oxygen levels (Chu et al. 2019), although many species can also be found in shallow and intertidal zones (ICES, 2009).

Data sources and distribution

Coral and sponge observations throughout BC were compiled by Nephin and Chu (2020) from DFO (Gale et al. 2025) and external databases through different survey methods and gear types including: dive, ROV, traps, longline, and bottom trawls. Because sampling efforts from different sources were not evenly distributed, the lack of occurrence does not necessarily equal absence in the area. Zone 315 has no survey data, and Zones 311 and 312 had 30 and 49 sample points compared to the thousands of data points in the other Zones. There is evidence of occurrence for all cold-water corals and sponges in the Caamaño-Douglas area (**Figure 56**) (Zone 310) except for two groups: black corals (Order Antipatharia) and calcareous sponges (Class Calcarean) (**Table 25**). Black corals are rare, typically found on the Canadian Pacific continental slope (Figure 6. in DFO 2010a), and likely absent in Zone 310. Calcareous sponges are mostly found offshore of the Central and North Coasts, although presence was detected outside of the Network Zones, 15 km offshore of the westernmost area of Zone 310 through ROV surveys (Nephin and Chu, 2020). Demosponges were more common in the Inner Fjord Zones (Zones 313, 314, 315, and 316; **Figure 57**), whereas stony corals, sea pens/sea whips, and soft corals were predominantly in the shallower areas of Dewdney and Glide Islands (Zone 311) and the Estevan Island groups (Zone 312), suggesting differences in coral and sponge composition may be due to the differences in between bathymetry depths.

Glass sponge reefs (Class Hexactinellida) are unique and fragile communities found in the Northeast Pacific Ocean (DFO 2010a; Shaw et al. 2018). The two closest glass sponge reef MPAs are approximately 80 km northwest and 50 km southwest of the Caamaño-Douglas area in the Hecate Strait/Queen Charlotte Sound Glass Sponge Reefs MPA (**Figure 6**). Recent ROV transects have also discovered a glass sponge reef to the south at the mouth of Finlayson Channel (Du Preez et al. in prep). Previous multibeam and backscatter data reported potential

glass sponge reefs in Estevan Sound, north of Zone 312, that showed patterns of narrow reef ridges (see Figure 1 and 9 in Shaw et al. 2018), and matched Chu et al. (2019) model predictions (**Figure 58**). The Network Zones also contains substrate from the same geological formation to other fjords with reefs using multibeam bathymetry and backscatter data (see Section 3.2.2.2). ROV transects surveys in 2019 did not reveal sponge reefs around Estevan Sound, although cold-water corals and sponges were observed (T. Norgard, pers. comm. 2022). ROV transects in 2022 around Caamaño Sound (Zone 310) found cold-water corals and sponges during all dives with highlights including remnants of a large glass-sponge reef (mostly dead with a few live species), small glass sponge reefs, and a field of hydrocorals (**Figure 55**; Proudfoot et al. 2025B). Seaward of Aristazabal island, large sponge reefs were also recorded during the survey (Proudfoot et al. 2025B; **Figure 55**).

Shaw et al. (2018) also identified Kitimat Arm as a potential area outside of Caamaño Sound for the presence of glass sponge reefs, and presence of glass sponges (along with soft coral) have been captured in ROV surveys on fjord walls near Maitland Island north of Douglas Channel (Zone 314) (Figure 4 in Gasbarro et al. 2018). There are also potential glass sponge reefs in Devastation channel and Gardner Canal in fjord inlets outside of the Network Zones, as Benthic Habitat Mapping surveys have identified potential glass sponge structures in Gardner Canal (Davies et al. 2018). Glass sponge reefs were confirmed in Bish Creek, further north in Douglas Channel (M. Jacobs, pers. comm. 2023). Additional ground truthing (i.e., direct observation, surveys, and measurements) is needed to confirm additional presence of coral and sponge reef communities within and surrounding the Network Zone boundaries.

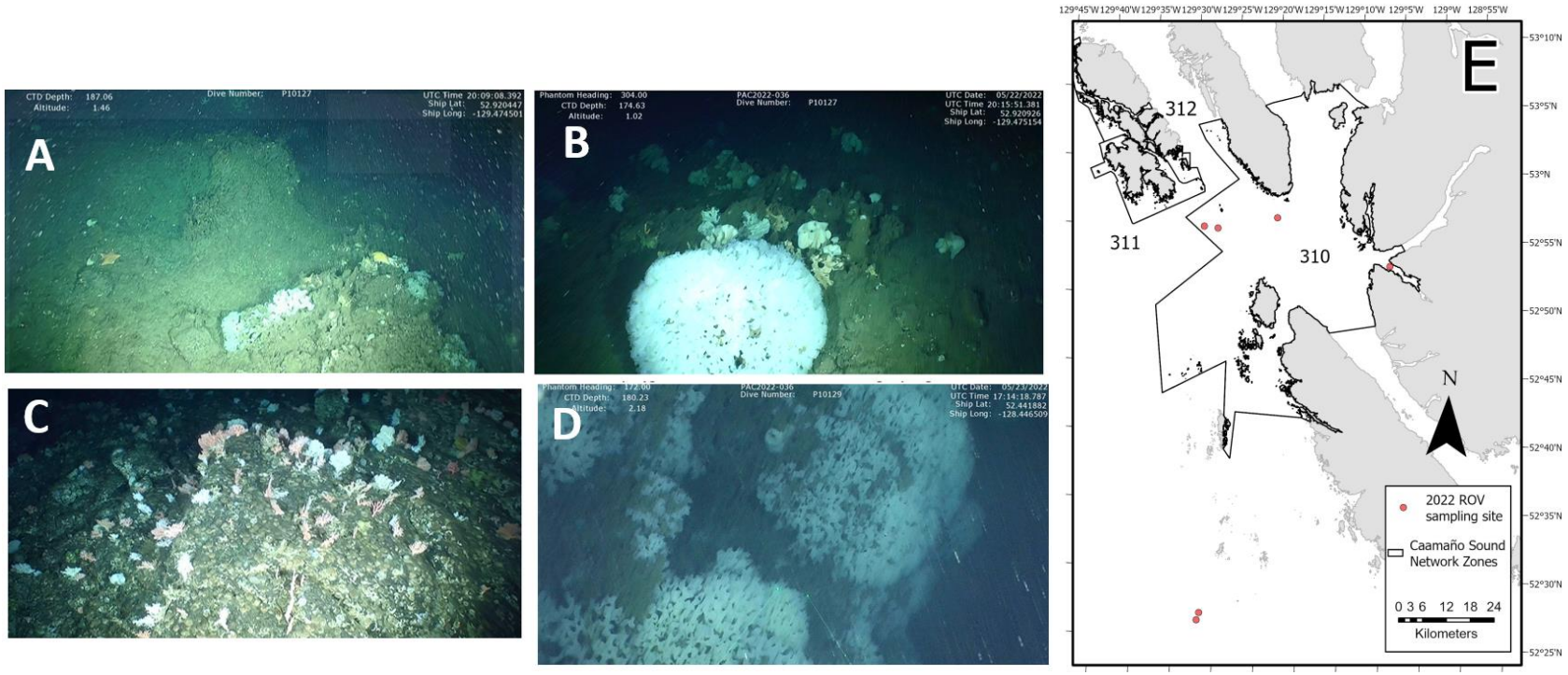

Figure 55. *ROV footage of cold-water corals and sponges in the Caamaño-Douglas area from DFO ROV dive transect surveys (2022). The following images portray waters within or adjacent to Zone 310; A) Remnants of large glass-sponge bioherm structures with some living sponge, B) small glass sponge reefs, C) hydrocoral fields, D) large sponge reefs outside of Zone 310, seaward of Aristazabal Island, and E) the red circles shows the 2022 survey locations – where abundant corals and sponges were recorded during dives (C. Du Preez, pers. comm. 2023; Proudfoot et al. 2025B).*

***Table 25**. Coral and sponge occurrences in the Caamaño Sound and Douglas Fjord System Network Zones obtained from occurrence point records from Fisheries and Ocean Canada (DFO) and external surveys and databases (Nephin and Chu, 2020). An 'X' indicates occurrence, a dash indicates no occurrence data (not the same as absence). There is no data for Zone 315. Common names and scientific groupings in bold are conservation priority species (see Gale et al. 2019).*

Common Name	Scientific grouping	Zone 310	Zone 311	Zone 312	Zone 313	Zone 314	Zone 315	Zone 316	Data Type	Source*
Soft corals	Order Alcyonacea	X	X	X	X	X	-	X		DFO database
Gorgonian	Order Alcyonacea	X	-	-	X	X	-	X		DFO database
Black Coral	Order Antipatharia	-	-	-	-	-	-	-		DFO database
Stony Corals	Order Scleractinia	X	X	X	X	X	-	X		DFO database
Hydrocorals	Order Stylasterina	X	-	-	X	X	-	X		DFO database
Calcareous Sponge	Class Calcarean	-	-	-	-	-	-	-		DFO database
Demosponges	Class Demospongiae	X	-	X	X	X	-	X		DFO database
Glass sponges	Class Hexactinellida	X	-	-	X	X	-	X		DFO database
Sea pens / Sea whips	Order Pennatulacea	X	X	X	X	X	-	-		DFO database

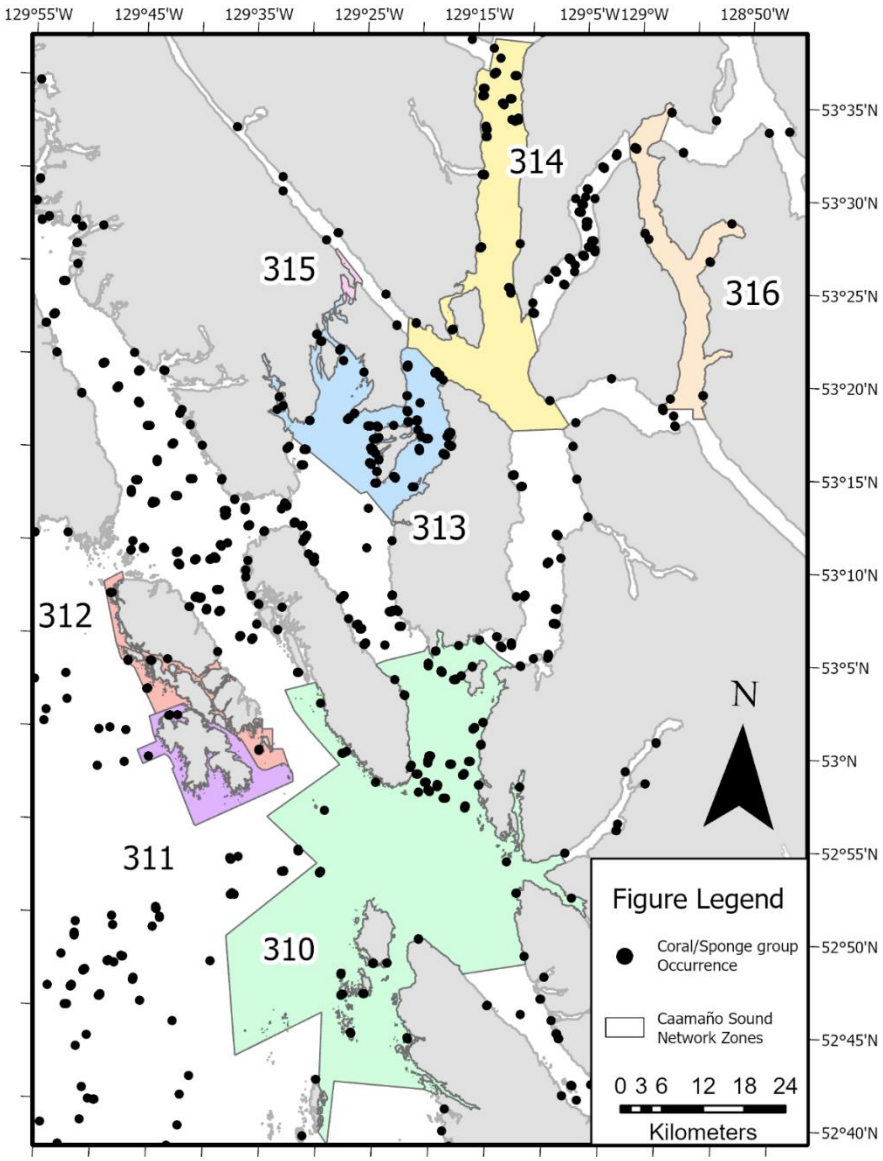

***Figure 56**. Occurrence counts of Sponge and Coral groups mapped in the Caamaño Sound Network Zones area. Black dots indicate point occurrence, although this figure does not differentiate between groups (See **Figure 57** for sponge/coral group counts within Polygon Zone). Data was collected from DFO and external surveys and databases by Nephin and Chu (2020). Zone 315, **Maxtaktsm'aa**/Union passage site, did not have any sampling points. Note that sampling distribution is not equal throughout the Zones, and lack of occurrence does not mean absence.*

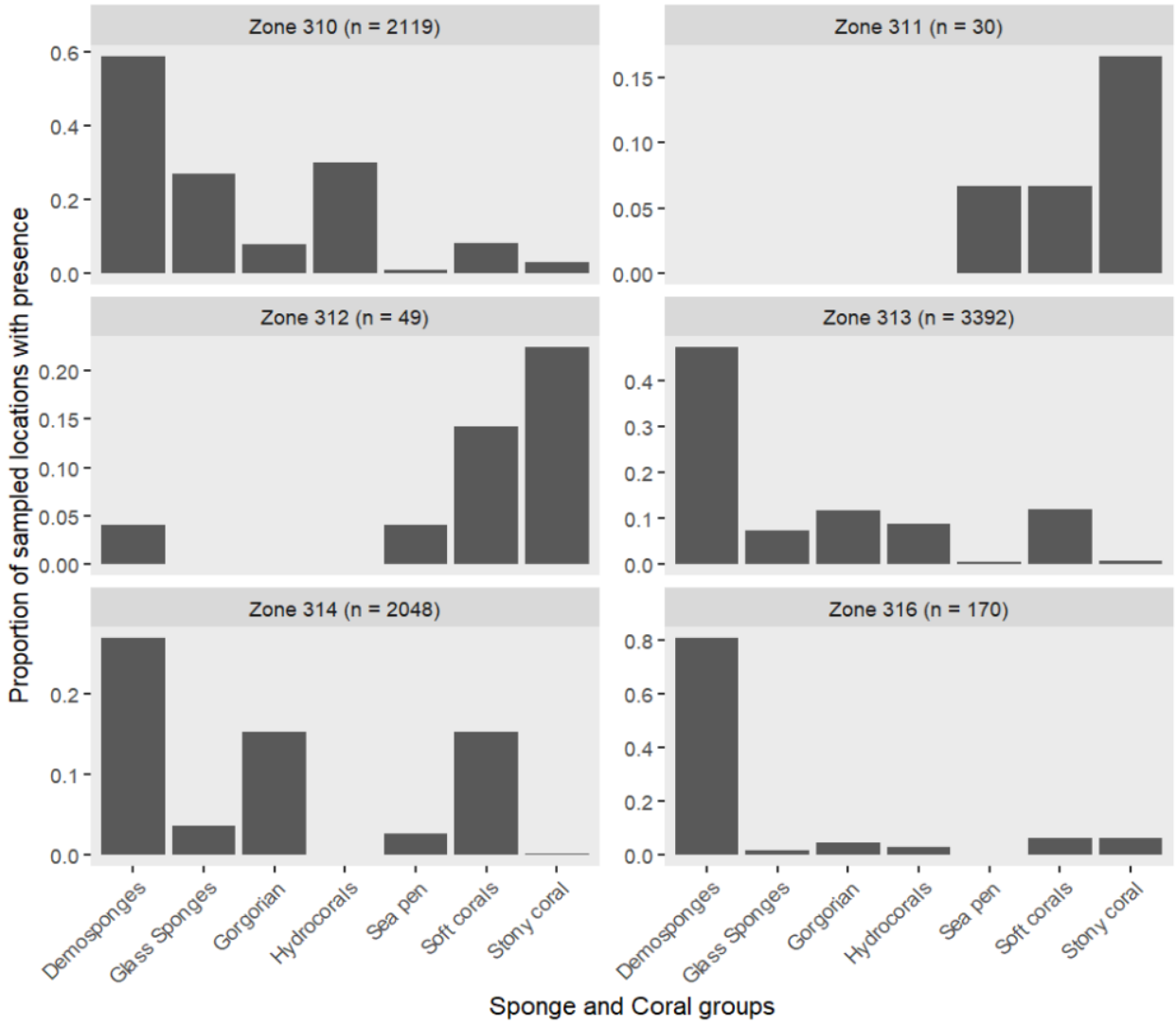

***Figure 57**. Proportion of sampled locations with presence of sponge and coral groups for each Caamaño Sound and Douglas Fjord System Network Zones polygon (n denotes total points sampled in each Zone). Data was collected from DFO and external surveys and databases by Nephin and Chu (2020). Two groups, black corals and calcareous sponges were not detected in all seven Network Zones. Zone 315, **Maxtaktsm'aa**/Union passage site, did not have any sampling points. Note the different y-axis scale on each plot. See **Figure 56** for aggregation of sponge and coral group presence in the area.*

Cold-water coral and sponge communities have been identified as vulnerable marine ecosystems (VME) by the Fisheries and Agriculture Organization of the United Nations due to their vulnerability to adverse impacts from fishing activities and habitat disturbances (FAO, 2009). With this knowledge, Chu et al. (2019) created a VME composite map for the Pacific Northwest using 30 environmental data layers indicating habitat suitability and potential distribution of the six habitat-forming sponge and coral groups. A vulnerable composite index (VCI) value of 6 indicates cells with suitable habitats for all cold-water sponge and coral groups used in the analysis. Furthermore, the model only covered Zones 310 and 313 and a tiny fraction at the edge of 312 and 311 (**Figure 58**). Patches of VME values over four outside of the model include Estevan Sound at the north of Zone 312, Squally Channel, south of Zone 313,

and west of Estevan Island groups, including Zones 311 and 312 (**Figure 58**, **Table 26**). There is uncertainty in predicting nearshore habitats due to estuarine and freshwater processes, which were not factored into the Chu et al. (2019) model.

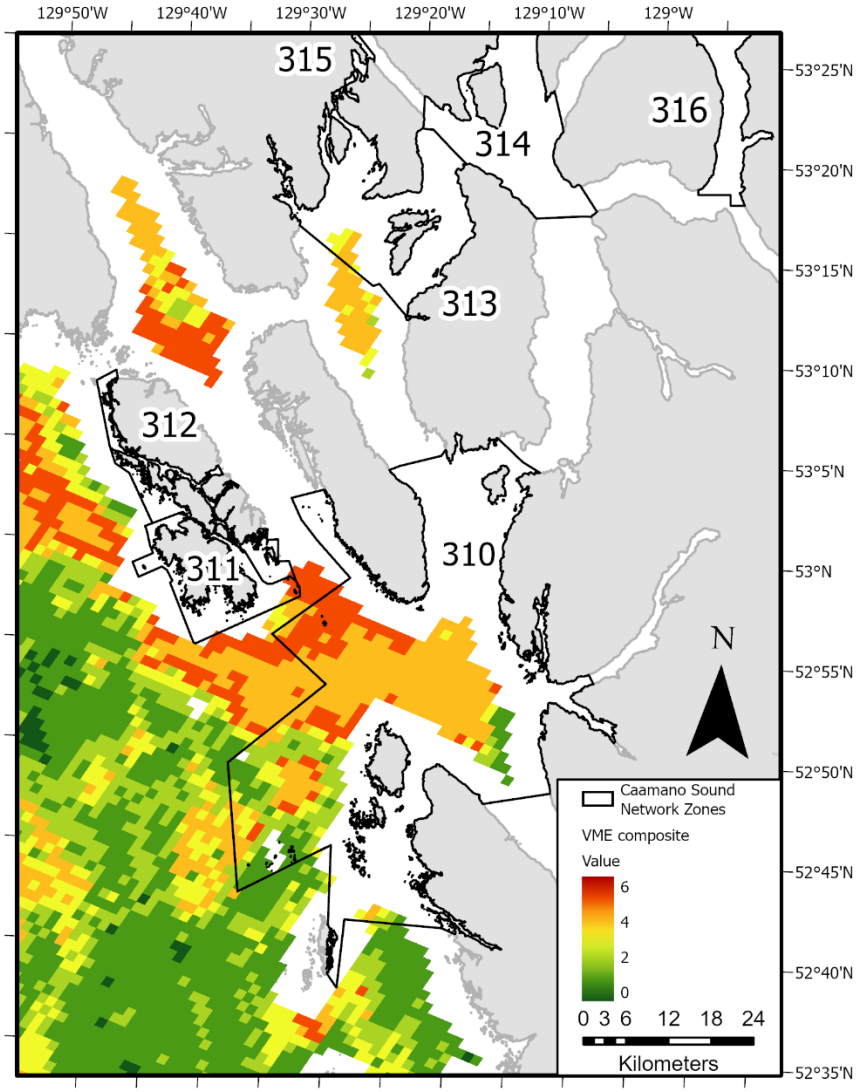

***Figure 58**. VME composite index of habitat suitability for cold-water coral and sponge groups at the 1km^2 grid cell size, from Chu et al. 2019. Values range from 0 to 6, indicating the number of cold-water coral/sponge groups that each raster is suitable habitat for, i.e., 6 is suitable habitat for all coral and sponge groups, and 0 is no suitable habitat. Note that only values 0 to 5 are shown in this figure.*

***Table 26**. Vulnerable Marine Ecosystem model coverage and Vulnerable Composite Index (VCI) value for corals and sponge species distribution (Chu et al. 2019) by Zone within the Caamaño Sound and Douglas Fjord System Network Zones. Bold text indicates the highest value for each metric. Note that the model coverage does not extend to Zones 312, 314, 315, 316, and is unequally distributed to the Zones it does cover.*

	Zone 310	**Zone 311**	**Zone 312**	**Zone 313**	**Zone 314**	**Zone 315**	**Zone 316**
Area (km^2) of Zone covered by model	395	3	X	9	X	X	X
Proportion of Zone covered by model	0.538	0.058	X	0.059	X	X	X
VCI mean value	3.44	4.67	X	3.44	X	X	X
VCI min-max	1-5	4-5	X	3-4	X	X	X
Proportion of the Zone with VCI value ≥5	0.093	0.038	X	0	X	X	X

6.2.2.2 Molluscs

6.2.2.2.1 Infauna and epibenthic bivalves

Class Bivalvia (hereafter bivalves) are a group of freshwater and marine Molluscs that have their bodies encased in two hinged shells. Infauna species such as **ts'a'ax**/**č̓íkʷa**/**ts'a'a̱x**/clams and **gaboox**/**zuáli**/**ga̱boox**/cockles spend most of their lives buried in benthic substrates such as sand and mud. Epibenthic species such as **k̲'a̲ɬ'on**/**k̲'aɬ'on**/scallops, **kʷaas**/mussels, and oysters, instead settle on top of hard benthic substrates. These species provide important roles in the coastal ecosystem such as benthic-pelagic coupling, nutrient cycling and water filtration. Bivalves can accumulate and retain biotoxins from algae blooms from filter feeding, which can cause harmful effects to humans and animals when consumed during these events. As highly efficient filter feeders, bivalves have been used locally for monitoring biotoxin levels (M. Jacobs, pers. comm. 2023). Certain epibenthic bivalves, such as **kʷaas**/mussels and oysters, aggregate and form hard, complex biogenic habitats that can influence abundance and diversity in intertidal and subtidal environments (Commito et al. 2008, Richardson et al. 2022). Spawning bivalves typically release gametes into the water column and pelagic larvae will settle and become sedentary. **Ts'a'ax**/**č̓íkʷa**/**ts'a'a̱x**/clams and **gaboox**/**zuáli**/**ga̱boox** settle on beaches, whereas **kʷaas**/mussels and **k̲'a̲ɬ'on**/**k̲'aɬ'on**/scallops can form beds or aggregations. Bivalves are found in the diet of many macrofauna, including marine birds (Cox et al. 2020a), **płoon**/**nukʷ**/sea otters (Ford 2014), Giant Pacific Octopus (Scheel and Anderson 2012), Dover and Rock Soles (Buckley et al. 1999), Dungeness crabs (Behrens Yamada and Boulding, 1998), which were all species identified as E-CPs (Gale et al. 2019). Bivalves and their marine-

derived nutrients were found to subsidize terrestrial environments after being transported on land by predators and people (Cox et al. 2020a).

Commercial, recreational, and First Nations fisheries exist for both infauna and epibenthic bivalves. Harvest for the **Sa'mx**/**ḵux^{w}**/butter clam (*Saxidomus gigantea*), littleneck clam (Leukoma *staminea*), and **gaboox**/**zuáli**/**g̱a̱boox** (*Clinocardium nuttalli*) is conducted by hand digging during low tide cycles. The Pink Scallop (*Chlamys rubida*) and Spiny Scallop (*Chlamys hastata*) are generally harvested using commercial trawl gear in Southern BC and are otherwise harvested by hand picking and diving (DFO 2022a). Stock assessment in DFO is extremely limited for populations outside of Scallop Management Areas (all found in Southern BC) and Clam Management Areas (Caamaño-Douglas area is considered outside these areas). Local knowledge may be more applicable for monitoring health and trends for bivalves in the Caamaño-Douglas area.

The largest **ts'a̱'a̱x**/clam species found in BC, Geoducks (*Panopea generosa*) and , **loon**/**ḡ^{w}énceḡawi**/**lo'on**/Horse clams (also known as gaper clams; *Tresus capax* and *T. nuttallii*), are commercially harvested by divers. Geoducks are assessed as a single genetic stock through Geoduck bed units, where they bury 1m below soft sediment layers (Miller et al. 2006). Notably, Geoducks are among the longest living animals in the world (at least 150 years old) and can reproduce for over a century (DFO 2023a). **Gadza k'aw**/eelgrass beds were identified as important habitats for their life cycles, and harvesting is prohibited in **gadza k'aw** beds (DFO 2023a). Geoduck harvest is separated into three areas throughout the coast of BC, rotating annually, whereas the West Coast of Vancouver Island is harvested annually (DFO 2021b). The rotation for harvest in the Caamaño-Douglas area is in 2023-2024, followed by 2026-2027, and every subsequent three years (DFO 2021b). According to the 2020 stock status update, total coastwide biomass for sub-beds were above the Limit Reference Point and placed in the Healthy Zone (DFO 2021b). There is a lack of information regarding stock assessments for **loon**, and the latest Integrated Fisheries Management Plan reports a sustainable fishery (DFO 2023a).

Both infauna and epibenthic bivalves are abundant throughout the coast of BC. Six **ts'a'ax**/**c̓íḵ^{w}a**/**ts'a'a̱x**/clams, one **gaboox**/**zuáli**/**g̱a̱boox** and eight epibenthic bivalves were identified as E-CPs for the NSB because of their ability to form aggregations, unpredictable recruitment, and long lifespans for certain species (Purple-hinged Rock Scallop, Geoducks) (Gale et al. 2019). Of these, nine species are known to occur around the Caamaño-Douglas area (**Table 26**). The Network Action Plan (MPA Network BC Northern Shelf Initiative 2023) prioritizes bivalves as Zone-level network conservation objectives in all Zones except for 316. Most species occur within the shallow Outer Coast Zones (310, 311, and 312), and inlets and beaches such as **K'duwaadz**/Tuwartz Inlet (Zone 313), **Lax Kwil Dziist**/Fin Island (Zone 313) and **Maxtaktsm'aa**/Union Passage (Zone 315) (**Figure 59**). These areas were also previously identified as more likely to have **gadza k'aw**/eelgrass bed habitats.

First Nations of the Pacific Northwest have harvested **ts'a̱'a̱x**/clam, **k^{w}aas**/mussel, oyster, snail, and **yaans**/**q̓eq̓ánas**/chiton species as food sources, utensils, currency, and decoration (Halpin and Seguin 1990; Kuhnlein and Humphries 2017). **K^{w}aas** and **k̲'a̲ł'on**/**k̲'ał'on**/scallops were identified as important culturally significant shellfish for Gitga'at family and community relations (Satterfield et al. 2012) and for the Gitxaała Nation. Indigenous harvest for food, social, and ceremonial purposes can occur year-round in areas open under the Canadian Shellfish Sanitation Program (DFO 2022a). Several shell middens and coastal archaeological settlements

have been documented within the Caamaño-Douglas Sound area (Figure 4 in McMillian and McKechnie 2015). **Ts'a'ax** and **gaboox/zuáli/gaboox** are harvested during the fall and winter season (Satterfield et al. 2012) and **kʷaas** in the spring (Hartley Bay Council 2012). **Sa'mx/kuxʷ**/Butter clam and **gaboox/zuáli/gaboox** harvest beaches in the Caamaño-Douglas area are found near **Lax Ka'gaas**/Campania Sound (Zone 310), Dewdney Island (Zone 311), Clamstown on **Lax Kwil Dziist**/Fin Island (Zone 313), **K'distsauk**/Turtle Point on **K'ts'ats'aas** /Gil Island (Zone 313 and 314), **K'duwaadz**/Tuwartz Inlet (Zone 313), **Maxtaktsm'aa**/Union Passage (Zone 315) and Kishkosh inlet (bordering Zone 314) (Satterfield et al. 2012; North Coast Marine Plan, 2015).

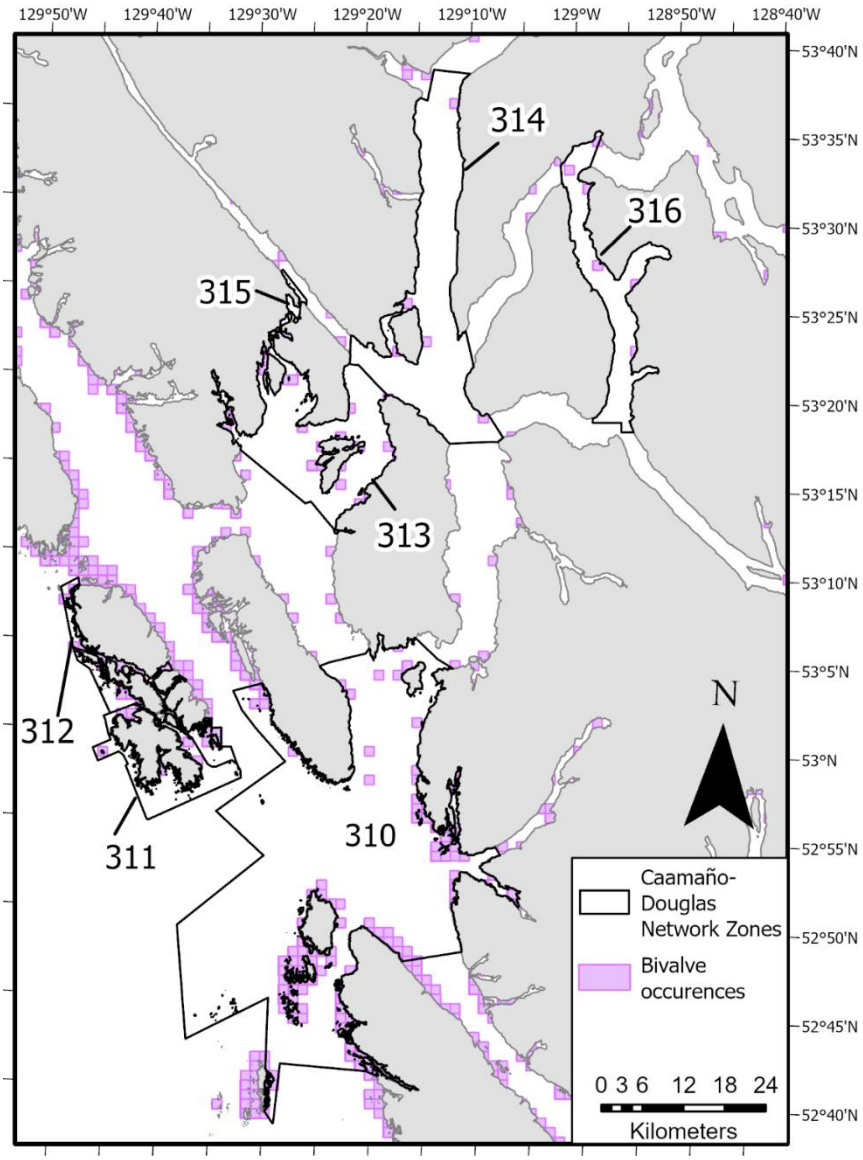

***Figure 59**. Occurrences from DFO surveys represented by 1 km x 1 km grids of infauna and epibenthic bivalves in the Caamaño-Douglas area.*

Table 27. *Infauna and epibenthic bivalve species occurrences (visual confirmation) for the Caamaño Sound and Douglas Fjord System Network Zones. Occurrence is indicated by an 'X', a dash indicates no occurrence data (not the same as an absence).* ***Maxtaktsm'aa****/ Union Passage Site (Zone 315) likely has many shellfish occurrences, although species-level information is limited (North Coast Marine Plan 2015, MPATT Network Action Plan 2023).*

Common name	Scientific Grouping	Zone 310	Zone 311	Zone 312	Zone 313	Zone 314	Zone 315	Zone 316	Data source
Geoduck	*Panopea abrupta*	X	X	X	X	X	-	X	DFO shellfish survey
Loon/Horse clam (Fat Gaper / Pacific Gaper)	*Tresus capax / Tresus nuttalli* respectively	X	X	X	X	X	-	X	DFO shellfish survey, BHM
Sa'mx/ǩux^{w} /Butter clam	*Saxidomus gigantea*	X	X	X	X	X	-	-	DFO shellfish survey
Littleneck clam	*Leukoma/ Protothaca Staminea*	X	X	X	X	-	-	-	DFO shellfish survey
Gaboox/Zuáli/Gą̲boox /Cockle	*Clinocardium nuttallii*	X	X	X	X	-	-	-	DFO shellfish survey
Gyels/gyels/Blue Mussel	*Mytilus sp.*	X	-	-	X	X	-	X	BHM
Hagwn/California Mussel*	*Mytilus californianus*	-	-	-	-	-	-	-	BHM
k̲'ał'on/Pink Scallop / Spiny Scallop	*Chlamys rubida / Chlamys hastata*	X	X	X	X	X	-	X	DFO shellfish survey, BHM
k̲'ał'on/Purple-hinged Rock Scallop	*Crassadoma gigantea*	X	X	X	X	X	-	X	DFO shellfish survey, BHM

***Not found within the Network Zones polygons but sparse observations around the Caamaño-Douglas and North Coast area. DFO shellfish database = commercial, logbook, and research surveys , BHM = Benthic Habitat Mapping.*

6.2.2.2.2 Marine snails and chitons

Marine snails (Class Gastropoda) and **yaans**/**ḍeḍánas**/chitons (Class Polyplacophora) have a variety of feeding behaviours, although many species are foragers and grazers, such as the Red Turban Snail (*Pomaulax gibberosus*) which feeds and seeks shelter on **gyoós**/**ḍáḍelḷis**/ Giant Kelp (Harbo, 2011). Many species of snails and **yaans** will graze on green algae, coralline algae, encrusting sponges, and a variety of kelps (O'Clair and O'Clair 1998; Pellegrin et al. 2007; Harbo, 2011). The Lewis' Moonsnail (*Neverita lewisii*) on the other hand, mainly preys on infaunal bivalves, such as butter, littleneck, and Pacific gaper clams (Harbo, 2011). In turn, marine snails and **yaans** are predated upon by a variety of other invertebrates such as **aswit**/**ʾemdém**/**a̱ws**/ urchins, **gamaats**/**g̱azea**/**g̱a̱maats**/sea stars, **hats'al**/**teḍʷá**/**ha̱ts'alt**/octopus, and vertebrates such as marine birds (O'Clair and O'Clair 1998), **ts'mhoon**/rockfish (Love et al. 2002), and **płoon**/**nukʷ**/sea otters (Pauly et al. 1998; Ford 2014) As benthic slow-moving creatures, most snails and **yaans** prefer rocky and hard substrates, with semi-exposed coastlines. The Lewis' Moonsnail is often found ploughing through finer substrates such as mud or sand (Harbo 2011).

Two **yaans**/**ḍeḍánas**/chiton species, **yaans**/Black leather chiton (*Katharina tunicata*) and **ts'ak**/Gumboot chiton (*Croptochiton stelleri*; also known as China Slipper), have important usages for coastal First Nations. They are regularly harvested and consumed as food, as well as being featured in stories and legends. The **ts'ak** in particular are very slow growing, living to 25 years, and have low recruitment rates which may cause populations to be susceptible to overharvesting (O'Clair and O'Clair 1998; Gotthardt and Jansen 2006). Less is known about **yaans**, although they may exhibit a similar life history, as a sample was estimated to be around 17 years old (Lord, 2012). **Yaans**/**ḍeḍánas**/chitons are commonly harvested during the winter and spring in areas such as Clamstown on **Lax Kwil Dziist**/Fin Island (Zone 313), Crane Bay (Zone 313), Kiel (Outside Zone 310), and Kishkosk inlet (outside Zone 314).

Yaans/Chitons are Zone-level network conservation objectives for the Outer Coast Zones 310, 311, and 312. In the Caamaño-Douglas area, most occurrence data for **yaans** and snails are in shallow areas close to the coastline, and fewer observations are in the deeper fjord areas such as Douglas and Ursula Channels (**Figure 60** and **Table 28**). Many marine snails listed as E-CPs are abundant throughout BC's coasts, especially those with strong aggregating behaviors such as the Littorina snail, and Black Turban (*Tegula funebralis*) snail (Gale et al. 2019). While there were no survey data for the Littorina snails (*Littorina sp.;* another E-CP), they are known to be abundant throughout the intertidal in the Pacific Northwest (Harbo 2011) and therefore, can be inferred that they occur in most, if not all, of the Network Zones.

Bilhaa/**g̱elhg̱enaiq**/Northern Abalone (*Haliotis kamtschatkana*), an ecologically and culturally important and highly vulnerable species for First Nations of the Pacific Northwest (COSEWIC 2009a), are present within the Caamaño Sound and Douglas Fjord System Network Zones. The North and Central Coast geospatial areas have been identified as critical habitats for survival and recovery efforts (DFO 2012a). **Bilhaa**/**g̱elhg̱enaiq** are consumed as food, depicted in traditional stories, and used as cultural symbols such as jewelry and decorations. **Bilhaa**/**g̱elhg̱enaiq** has been described as "worth its weight in gold" (Satterfield et al. 2012). Diet preferences for adult **bilhaa**/**g̱elhg̱enaiq** include **mo'ox**/**wáudi**/**moox**/Bull Kelp and **gyoós**/**ḍáḍelḷis**/Giant Kelp, both found extensively throughout the Caamaño-Douglas area, as well as diatoms and, algae, and kelps (Sloan and Breen, 1988; Neuman et al. 2018). Population genetics of **bilhaa**/**g̱elhg̱enaiq** using microsatellites indicated low differentiation throughout 16 coastal BC populations but higher variation among samples (Withler et al. 2001). **Bilhaa**/

ǧelhǧenaiq in BC likely had unimpeded gene flow and dispersal in historical populations and low inbreeding, representing one significant evolutionary unit (Withler et al. 2001). Spawning is observed to be more active at night and during the spring and summer months (Sloan and Breen, 1988). **Bilhaa**/**ǧelhǧenaiq** densities and average shell lengths have decreased considerably since 1978 to 2007. A survey in 2016 in the Central Coast region found decreased estimated mortality rate compared to 2006 and 2011 and increased mean total density for all sizes (J. Lessard pers. comm. from Neuman et al. 2018). Other surveys in the Central Coast and Haida Gwaii indicated that densities appeared stable despite low abundances (Lessard and Egli, 2011; Chandler et al. 2017). Anecdotal observation suggests localized populations may have increased in recent years (Neuman et al. 2018), including within the Caamaño-Douglas Sound (K. Clifton, pers. comm. 2022).

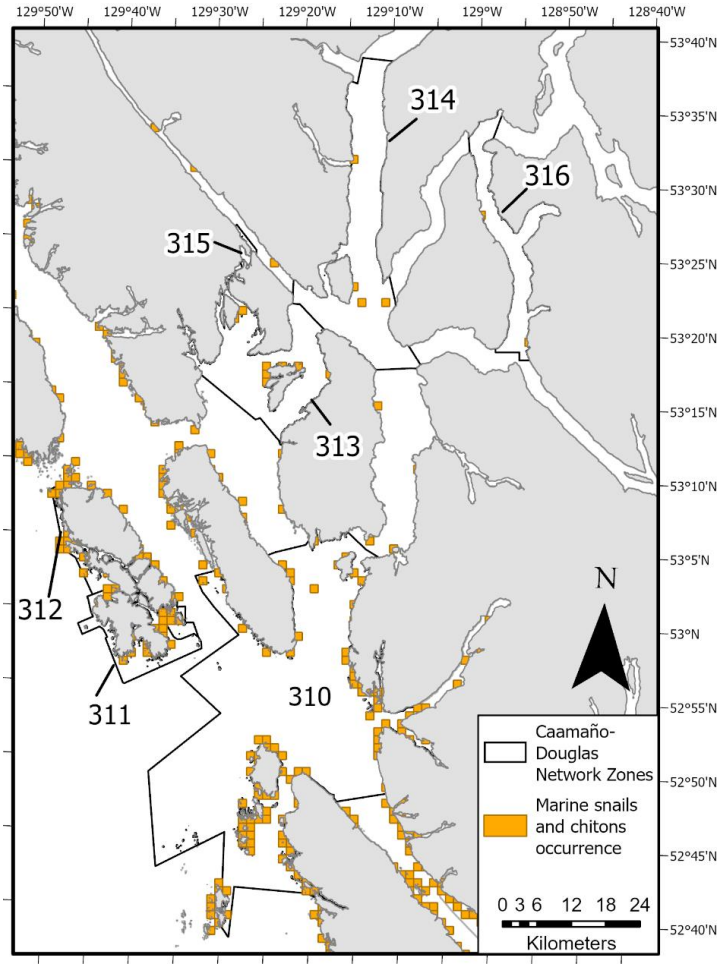

***Figure 60**.Occurrence represented by 1 km x 1 km grids of marine snails and **yaans**/**ḳeḳánas**/chitons in the Caamaño-Douglas area. Most occurrences are from the Benthic Habitat Dive Transect surveys.*

Table 28. *Snail and* ***yaans****/****q̓eq̓ánas****/chiton species occurrences (visual confirmation) for each Zone in the Caamaño Sound and Douglas Fjord System Network Zones. Occurrence is indicated by an 'X', a dash indicates no occurrence data (not the same as an absence). BHM = Benthic habitat monitoring dive surveys.*

Common name	Scientific Grouping	Zone 310	Zone 311	Zone 312	Zone 313	Zone 314	Zone 315	Zone 316	Data source
Red Turban Snail	*Pomaulax gibberosus*	X	X	X	X	-	-	-	BHM
Black Turban Snail	*Tegula funebralis*	X	X	X	-	X	-	X	BHM
Lewis' Moonsnail	*Neverita lewisii*	X	-	-	-	-	-	-	BHM
Ts'ak/Gumboot Chiton	*Cryptochiton stelleri*	X	X	X	X	X	-	X	BHM
Yaans/Black Leather Chiton	*Katharina tunicata*	X	X	X	X	X	-	X	BHM

6.2.2.2.3 Cephalopods

Class Cephalopoda (hereafter, cephalopods) includes **hats'al/teq̓ʷá/hạts'alt**/octopus and squids. Both the Giant Pacific Octopus and opal squids are abundant throughout BC's coasts. There are no current fisheries for opal squids and Giant Pacific Octopus in BC although opal squids were fished for bait in the 2000s (Wade and Curtis 2015). The Giant Pacific Octopus, the largest **hats'al** species in the world, is an upper-level predator that resides in rocky crevices and oxygen-rich cold waters. Their diet consists of mainly crustaceans (**k'almoos/klnákʷ/ḵ'ạlmoos** /crabs), bivalves, other cephalopods, and sometimes fish and fish eggs (Gillespie et al. 1998, Scheel and Anderson 2012). In turn, they are prey for **wạt'ukw/núłem/wạt'ukw**/Lingcod, **ts'mhoon**/Rockfish, Pacific Sleeper Shark, and Pinnipeds (Love et al. 2002, Love et al. 2011, Ford 2014). Opal squids (*Dorytheuthis opalescens*) are important forage prey in the diets of at least 51 species, including marine mammals, **t'iibn/ǰix̌'én**/sea lions, fish, and birds (Walthers and Gillespie 2002, Enticknap et al. 2011). Information about the distribution and movements of pelagic opal squids in BC are limited, although they are known to aggregate for mass spawning inshore (Walthers and Gillespie 2002). Both species were identified as E-CPs due to their low reproductive output and unpredictable recruitment in life history traits, and aggregating behavior for opal squids.

Hats'al/Teq̓ʷá/Hạts'alt/Octopus are harvested eastward of **K'nabiyaaxl**/Ashdown Island in Kiel (outside of Zone 310) during the spring, fall, and winter and are considered critically important invertebrates for family and community relations, harvesting, use, and distribution (Satterfield et al. 2012). They are Zone-level Network Conservation Objectives for Zones 316 for cultural use and food security (MPA Network BC Northern Shelf Initiative 2023). In the Caamaño-Douglas area, Giant Pacific Octopus are abundant in the Douglas Fjord System (Zones 310, 313, 314, 315, and 316), with most occurrences recorded as bycatch from **k'almoos/klnákʷ/ḵ'ạlmoos**/crab and **gasgos/sísiuł**/prawn traps (**Figure 61**). No occurrences

are known in the shallow waters of Zone 311. Opal squids occurrences were only recorded in Zone 314 and 310 (**Table 29**).

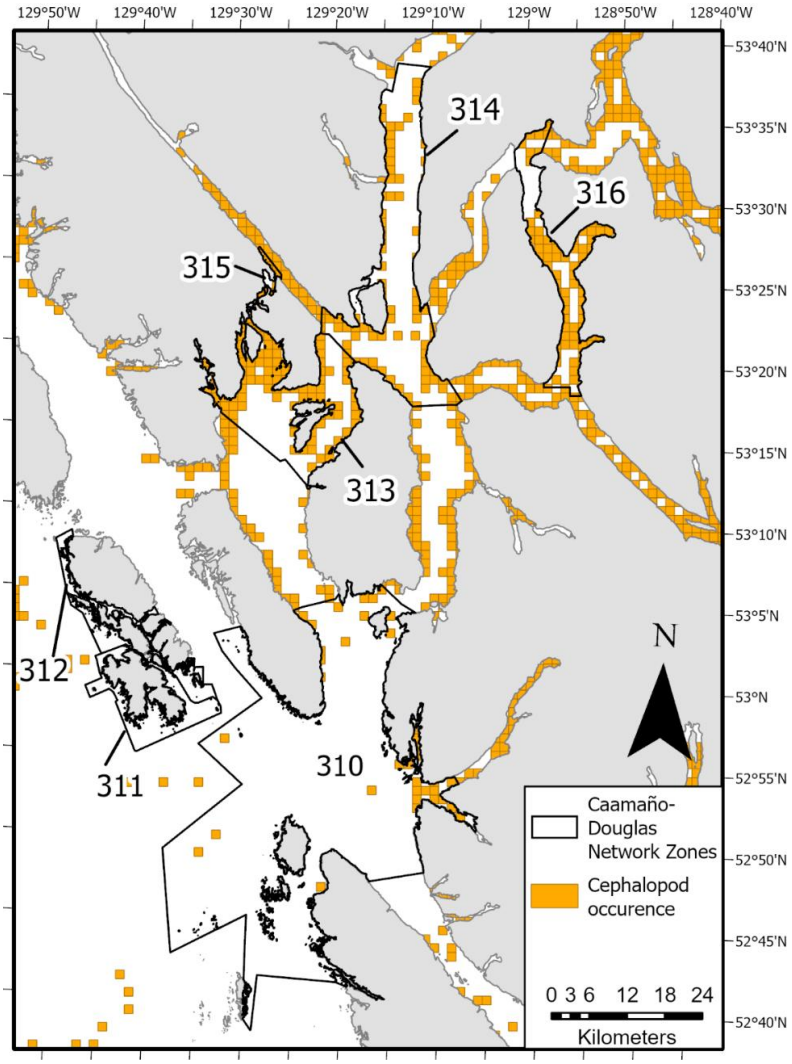

***Figure 61**. Occurrence represented by 1 km x 1 km grids of Giant Pacific Octopus and opal squid in the Caamaño-Douglas area. The majority of these occurrences are Giant Pacific Octopus.*

Table 29. *Cephalopod (Giant Pacific Octopus and opal squid) occurrences (visual confirmation) for each Zone in the Caamaño Sound and Douglas Fjord System Network Zones. Occurrence is indicated by an 'X', a dash indicates no occurrence data (not the same as an absence).*

Common name	Scientific Grouping	Zone 310	Zone 311	Zone 312	Zone 313	Zone 314	Zone 315	Zone 316	Data source
Giant Pacific Octopus	*Enteroctopus dofleini*	X	-	X	X	X	X	X	DFO shellfish database
Opal Squid	*Dorytheuthis opalescens*	X	-	-	-	X	-	-	DFO shellfish database

**DFO shellfish database = commercial, logbook, and research surveys.*

6.2.2.3 Crustaceans

The Subphylum Crustacea (hereafter crustaceans) include a diversity of species such as barnacles, **k'almoos**/**klnákʷ**/**ḵ'ą̱lmoos**/crabs, **gasgos**/**sísíuł**/prawns, and **gasgos**/**sísíuł**/ shrimps, characterized by their segmented bodies and a hard exterior (exoskeleton). Over 90 species of **gasgos**/**sísíuł** and 35 species of **k'almoos**/**klnákʷ**/**ḵ'ą̱lmoos** are found in BC (DFO 2022b, DFO 2022c). Crustacean larva dominate the zooplankton biomass of the Caamaño-Douglas area in the summer (see Section 3.2.8.3). For detailed summaries of Dungeness crab and spot prawns in BC, please refer to Hunter and Wade (2015).

6.2.2.3.1 **k'almoos** / **klnákʷ** / **ḵ'ą̱lmoos** / Crabs and the goose barnacle

K'almoos/**klnákʷ**/**ḵ'ą̱lmoos** /Crabs are important prey for many species including fish (flatfish, **ts'mhoon**/ rockfish, **balaas**/Pacific Hake, and **gandeh**/ **bakʷ-**/skates), **płoon**/**nukʷ**/sea otters, and **hats'al**/ **teq̓ʷá**/**hą̱ts'alt**/octopus (Pearcy and Hancock 1978, Buckley and Livingston 1997, Love et al. 2002, Brown et al. 2012). Dungeness crab (*Metacarcinus magister*) and Red Rock crab (*Cancer productus*) are prolific species throughout coastal BC and are targets for commercial, recreational, and First Nations fisheries. **K'almoos**/**klnákʷ**/**ḵ'ą̱lmoos** are critically important marine species for **Gitga'ata** knowledge transmission and community relations, use, and distribution (Satterfield et al. 2012), as well as for other Coastal First Nations including the Gitxaała. Dungeness crabs make up the largest proportion of catch for the commercial shellfish fishery in BC and 99.9% of the crab fishery (DFO 2022b). The North Coast region is one of the most abundant areas for **k'almoos**/**klnákʷ**/**ḵ'ą̱lmoos** (Hunter and Wade 2015). Stock assessment of Dungeness crabs are conducted using commercial **k'almoos**/**klnákʷ** trapping gear. Assessments in remote regions are usually outsourced and scarce (DFO 2022b).

Information from the Central Coast area reports a decline in Dungeness crab catch compared to decades prior (Central Coast Indigenous Resource Alliance Newsletter 2017). For example, Dungeness crab catch rates by Indigenous food fishers declined by 77% in recent years (1997-2016) relative to earlier years (1926-1996) (Ban et al. 2017), and spatial closures established under Indigenous law led to rapid recoveries of adult male Dungeness crab (Frid et al. 2016).

Less information is available for **k'almoos**/**klnákʷ**/**ḵ'ą̱lmoos**/crabs that do not have ongoing fisheries, such as the Puget Sound King Crab (*Lopholithodes mandtii*) and Inshore Tanner Crab (*Chionoecetes bairdi*). Both **k'almoos**/**klnákʷ**/**ḵ'ą̱lmoos** are found in *shallow to subtidal* waters (up to 137 m for Puget Sound King Crabs, and 10 - 475 m for Tanner crabs) (Jensen 1995,

Fong et al. 2005). European Green Crab surveys were conducted in Zone 310: South **Lax Ka'gaas**/Campania and Carne Bay in 2022 by the Marine Spatial Ecology and Analysis program, although no Green Crabs were sighted. Confirmed sightings have occurred in the Central Coast by the Heiltsuk Guardian's continuously sampled sites preceding 2021 (Coastal First Nations)[36] and eastern Haida Gwaii as of August 2021 (Strait of Georgia data center, University of British Columbia[37])

Dungeness crab larvae, a form of pelagic zooplankton, make up an important part of the diet of several animals, including Pacific **hoon**/**qeqapela**/salmon, flatfish, and Grey Whales (Pearcy and Hancock 1978; Quinn 2005; Ford 2014). **K'almoos**/**Klnákʷ** larvae are dispersed throughout May to September before settling on suitable bottom habitats and favour intertidal areas with large estuaries and freshwater input (Armstrong et al. 2003; Curtis and McGaw 2008). Juvenile **k'almoos**/**klnákʷ**/**ḵ'a̲lmoos**/crabs prefer these shallow coastal and estuarine areas as well as habitats with protective structures such as **gadza k'aw**/eelgrass, macroalgae, woody debris, and bivalve shells (Thayer and Phillips 1977; Dinnel et al. 1986). After reaching a carapace width of 30 mm, juveniles migrate to subtidal waters and sandy and silty substrates in search for prey such as small fish, Molluscs, **gasgos**/**sísíuɬ**/shrimps, bivalves, and other **k'almoos**/**klnákʷ** (Stevens et al. 1984; Pauley et al. 1989; DFO 2022b).

Inshore Tanner crabs are found throughout inlets and fjord systems in BC. In the Caamaño-Douglas area, Inshore Tanner crab occurrence was detected in Zone 310, Verney passage, and Gardner Canal (between Zones 314 and 316). Puget Sound King crabs also have scarce survey occurrence in the area. Dungeness crab, on the other hand, are abundant in inlets and sheltered areas such as **Kt'ii**/Racey and Surf inlet (Zone 310), the harvest site of Kiel (east of Zone 310), **K'duwaadz**/Tuwartz Inlet and **Lax Kwil Dziist**/Fin Island (Zone 313), **Maxtaktsm'aa** /Union Passage Site (Zone 315), and Kishkosh inlet and Kitkiata inlet (bordering Zone 314) (**Figure 62**). There are less occurrence data for red rock crabs despite their presence throughout the Network Zones. The invasive European Green Crab has not been sighted in the Caamaño-Douglas area as of August 2021, although there are confirmed sightings in the Central Coast and eastern Haida Gwaii (Strait of Georgia data center, University of British Columbia[28]).

The Goose barnacle (*Pollicipes polymerus*) was the only barnacle species identified as an E-CP in the NSB for its unpredictable recruitment, low reproductive output, and strong aggregating behaviour which can form epibenthic habitats, similar to **kʷaas**/mussels and oysters (Gale et al. 2019). Goose barnacles grow on rocky exposed coastlines in high-energy environments and are harvested using hand tools (Lauzier 1998). Barnacles were identified as Zone-level network conservation objectives in Zone 310 for conserving the diversity of species assemblages and for cultural use and food security (MPA Network BC Northern Shelf Initiative 2023). There is a lack of Goose barnacle occurrence information from DFO databases, although there were three sightings in 2021 within Zone 310 (iNaturalist and GBIF accessed 2023) (

[36] Keeping Invasive Green Crab out of Coastal Waters | Coastal First Nations

[37] European Green Crab - PSF Marine Data Centre

Table 30).

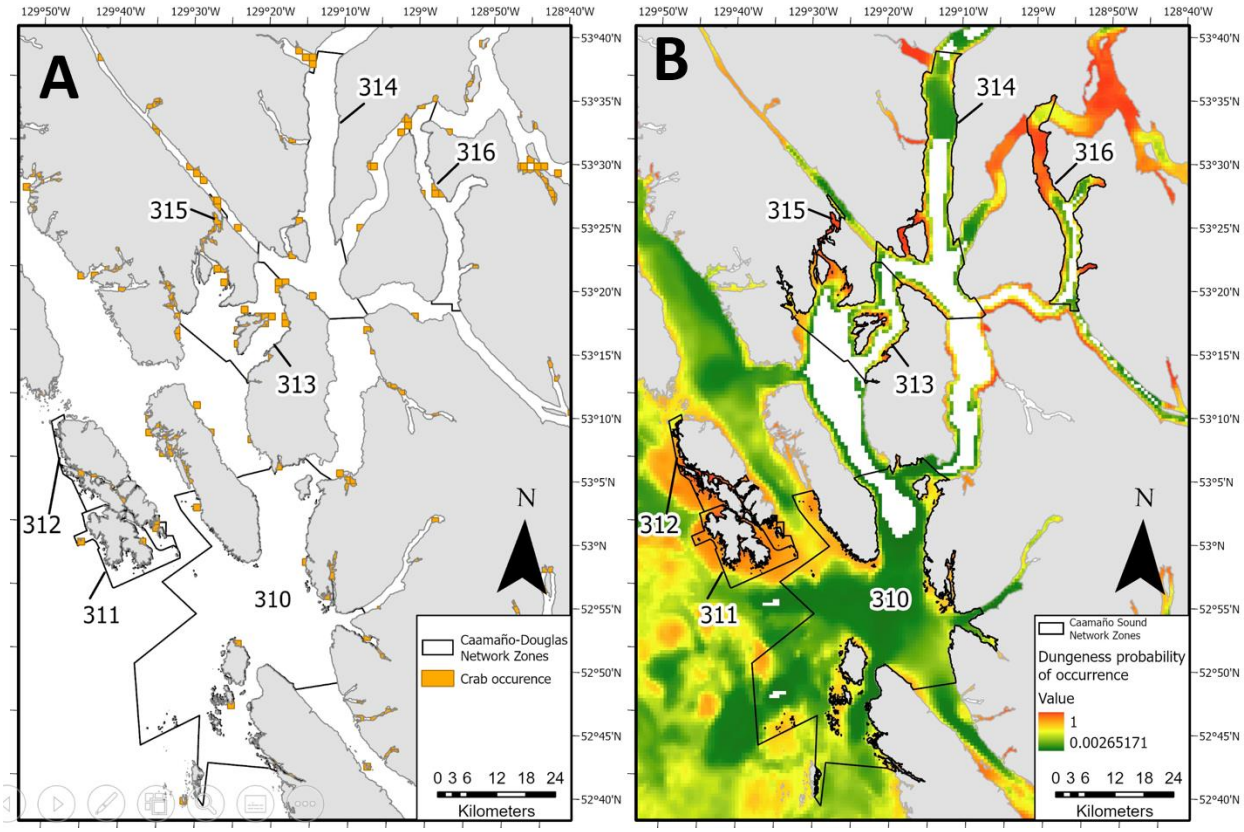

Figure 62. *A) Occurrence, represented by 1 km x 1 km grids, of four* ***k'almoos/klnákʷ/ḵ'ą̱lmoos****/crab species in the Caamaño-Douglas area. Most of these occurrences are aggregates of Dungeness crabs. B) Probability of occurrence of Dungeness crabs.*

Table 30. *Barnacle and crab species occurrences (visual confirmation) for the Caamaño Sound and Douglas Fjord System Network Zones. Occurrence is indicated by an 'X', a dash indicates no occurrence data (not the same as an absence).*

Common name	Scientific Grouping	Zone 310	Zone 311	Zone 312	Zone 313	Zone 314	Zone 315	Zone 316	Data source
Dungeness Crab	*Metacarcinus magister*	X	X	X	X	X	X	X	DFO shellfish database
Red Rock Crab	*Cancer productus*	X	-	X	X	X	-	X	DFO shellfish database, BHM
Puget Sound King Crab	*Lopholithodes mandtii*	X	-	-	X	-	-	-	DFO shellfish database
Inshore Tanner Crab	*Chionoecetes bairdi*	X	-	-	-	-	-	-	DFO shellfish database
Gooseneck barnacle	*Pollicipes polymerus*	X	X	X	-	-	-	-	GBIF, iNaturalist, Gitxaała

**DFO shellfish database = commercial, logbook, and research surveys. BHM = Benthic Habitat Monitoring dive survey, GBIF = Global Biodiversity Information Facility (accessed 2023), Gitxaała = Gitxaała work completed for the LNG Canada TERMPOL process*

6.2.2.3.2 **Gasgos**/**Sísíuɬ**/ Shrimps and Prawns

Seven **gasgos**/**sísíuɬ**/shrimp species (Family Pandalidae; hereafter Pandalids), including the spot prawn (*Pandalus platyceros*), are considered E-CPs and are Zone-level network conservation objectives in Zone 316: Ursula Channel. All seven species of **gasgos**/**sísíuɬ** are present within the seven Network Zones (

Table 31.). **Gasgos**/**sísíuł** are critically important Gitga'at and Gitxaała cultural keystones for knowledge transmission and food security and are traditionally harvested in the Winter and Spring. **Gasgos**/**sísíuł** fisheries in BC use trawl net and traps for harvest, whereas prawns are only harvested by trap. The most common targets for trawl are Spiny/Northern Pink Shrimp (*Pandalus borealis*) and Smooth Pink Shrimp (*Pandalus jordani*) (DFO 2023b). Over 97% of the trap gear fishery catches Spot Prawns (DFO 2023b).

Gasgos/**sísíuł** are opportunistic feeders, foraging for detritus, including other crustaceans, sponges, polychaete worms, and krill (Butler 1980). As forage species, they facilitate nutrient transfer for higher trophic species, including flatfish, **ts'mhoon**/rockfish, **balaas**/Pacific Hake, and **gandeh**/ **bak^{w}-**/skates (Pearcy and Hancock 1978, Buckley and Livingston 1997, Love et al. 2002, Yang et al. 2006, Brown et al. 2012). During the day, **gasgos**/**sísíuł** are found on benthic sand and muddy substrates (which includes the Fjord System) and swim through the water column at night to feed on pelagic zooplankton (DFO 2023b). Spot Prawns are BC's largest species of **gasgos**/**sísíuł** and prefer rocky or hard bottoms instead. All Pandalid species of **gasgos**/**sísíuł** start their lives as males, mature around 18-24 months, and eventually change sexes to females around three years (Butler 1980; DFO 2023b). Breeding occurs during the fall, and eggs hatch in the late winter, followed by a 3 – 4 month pelagic larval stage into the summer (Butler 1980; DFO 2023b).

Population surveys are conducted in the fall season to ensure enough female spawners are available (DFO 2023b). Annual estimated abundances have shown highly variable trends. The Caamaño-Douglas area overlaps with three Shrimp Management Areas: 5IN, 6IN, and 6OFF and is not considered a major **gasgos**/**sísíuł** production area in BC These areas are infrequently surveyed. Annual **gasgos**/**sísíuł** trawl surveys in the nearby Chatham Sound (DFO 2022c) assessing Smooth Pink, Spiny Pink, and Sidestripe shrimp (*Pandalopsis dispar*) showed biomass indices in the Healthy Zone for the past two years after falling below the Limit reference Point in 2019. Commercial prawn landings are used as a proxy for stock abundance and the Prawn spawner index from 1995 to 2020 for each Fishery Management Areas are available on the Canadian Open Government database[38].

Aggregations of **gasgos**/**sísíuł** are common in shallow inlets such as Surf Inlet (Zone 310), Tuwartz Inlet (Zone 313), Kishkosh Inlet (Zone 314), **Maxtaktsm'aa**/Union Passage (Zone 315), and Bishop Bay (Zone 316) (**Figure 63**). Beyond the Network Zones, they are commonly found on flat sandy or muddy substrates in the Kitimat Arm (Beckett and Munro, 2010). Spot prawns are most abundant in the Inner Fjord Zones. They are scarcer in Zones 311 and 312, with most occurrences in Langley Passage (Zone 312) (

[38] British Columbia Spot Prawn (Pandalus platyceros) Spawner Index - Open Government Portal

Table 31).

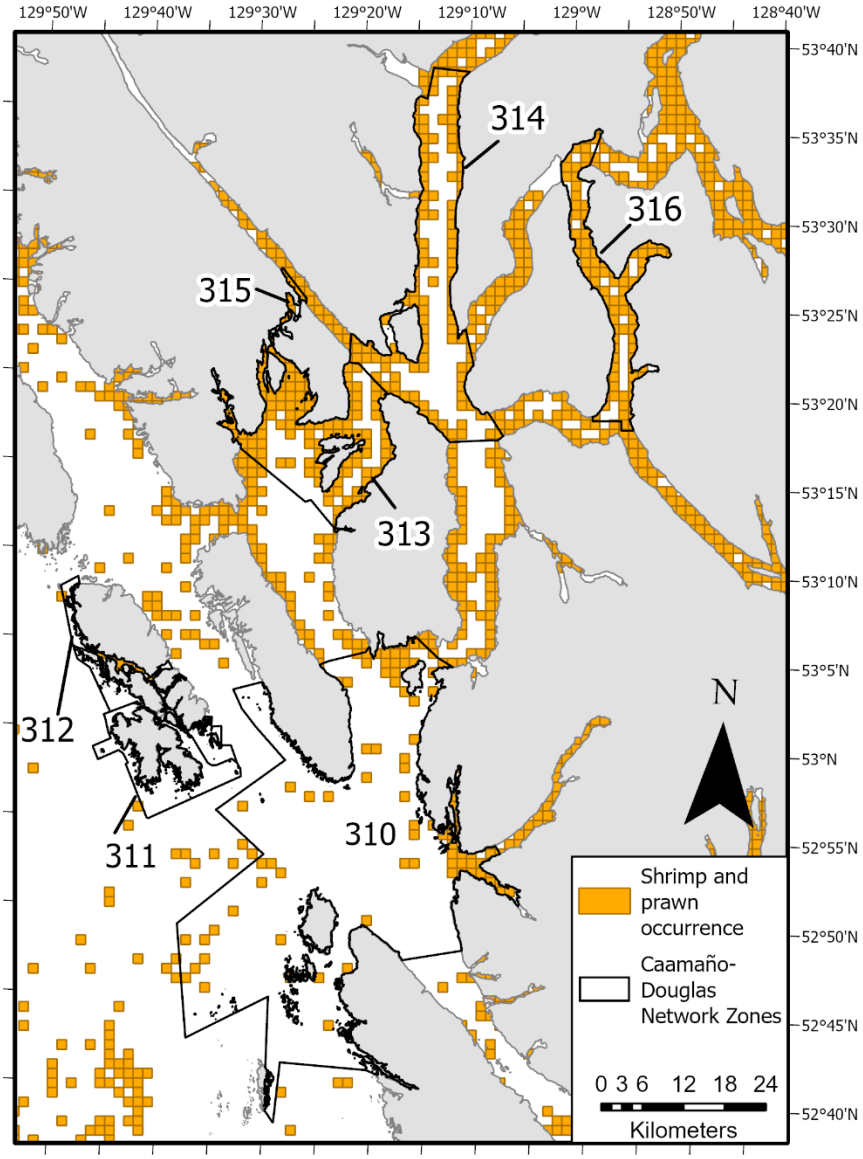

Figure 63. *Occurrence represented by 1 km x 1 km grids of seven* ***gasgos****/****sísiuł****/shrimp and prawn species in the Caamaño-Douglas area. The majority of these occurrences are spot prawn.*

Table 31. Gasgos/Sísíuł*/Shrimp and prawn species occurrence (visual confirmation) for each Caamaño Sound and Douglas Fjord System Network Zones. Occurrence is indicated by an 'X', a dash indicates no occurrence data (not the same as an absence).*

Common name	Scientific Grouping	Zone 310	Zone 311	Zone 312	Zone 313	Zone 314	Zone 315	Zone 316	Data source
Coonstripe/Dock Shrimp	*Pandalus danae*	-	-	X	X	-	-	X	DFO shellfish database
Humpback Shrimp	*Pandalus hypsinotus*	X	-	X	X	X	X	X	DFO shellfish database
Sidestripe Shrimp	*Pandalopsis dispar*	X	X	-	X	X	-	X	DFO shellfish database
Smooth Pink Shrimp	*Pandalus jordani*	X	X	-	X	-	-	-	DFO shellfish database
Spiny/Northern Pink Shrimp	*Pandalus borealis*	X	-	X	X	X	X	X	DFO shellfish database
Spot Prawn	*Pandalus platyceros*	X	X	X	X	X	X	X	DFO shellfish database

**DFO shellfish database = commercial, logbook, and research surveys.*

6.2.2.4 Echinoderms

Phylum Echinodermata (hereafter echinoderms) consists of prolific, slow-moving epibethic or benthic invertebrates, which include **gyenti**/**'éllas**/sea cucumbers (Class Holothuroidea), **gamaats**/**g̱azea**/**g̱a̱maats**/sea stars (Class Asteroidea), and **aswit**/**'emdém**/**a̱ws**/sea urchins (Class Echinoidea). Two **gamaats**/**g̱azea**/**g̱a̱maats** and two **aswit**/**'emdém**/**a̱ws** species were characterized as E-CPs (Gale et al. 2019) in the NSB. In addition, **gyenti** /giant California sea cucumber (*Apostichopus* californicus, formally *Parastichopus californicus*) was identified as Zone-level network conservation objectives in the Inner Fjord Zone (313 – 316) for cultural use and food security (MPA Network BC Northern Shelf Initiative 2023). Echinoderms serve many different ecosystem functions and niches, including shaping species distributions and diversity. When remaining unchecked by predators, for example, **aswit**/**'emdém**/**a̱ws** can overgraze algae and kelp beds, destroying important habitats, and leading to urchin barren patches or stretching kilometers across coastlines (Filbee-Dexter and Scheibling 2014). Voracious yet keystone predators such as Ochre sea stars (*Pisaster ochraceus*) and Sunflower sea stars (*Pycnopodia helianthoides*) help mediate invertebrate diversity, including preying upon **aswit**/**'emdém**/**a̱ws**, in the intertidal and subtidal respectively (Schultz et al. 2016). The excreted waste of detritivores such as **gyenti** redistribute sediment loads and provide inorganic nitrogen and phosphorus for nutrient cycling and increased productivity in benthic communities (Hughes et al. 2016) Echinoderms are prey to a variety of E-CP species including **płoon**/**nukʷ**/sea otters, **hats'al**/**teq̓ʷá**/**ha̱ts'alt**/octopus, fishes, and marine birds (Gale et al. 2019).

Since 2013, many **gamaats**/**g̱azea**/**g̱a̱maats**/sea star populations throughout the Pacific Northwest coast have been in decline as a result of sea star wasting disease, with areas as far north as Juneau, Alaska (Miner et al. 2018; Sea Star Map). Sunflower sea star populations' decline was reported to be over 87.8% from the Salish Sea to the Gulf of Alaska (Hamilton et al. 2021). In contrast to many locations in Southeastern Alaska and south of Vancouver Island, there is a shortage of long-term monitoring sites and subsequent trend data in BC's Central and North Coast areas. A species distribution model from Hamilton et al. (2021) revealed similar declines in the probability of Sunflower sea stars pre-2012 and current years (2017-2020) across the entire coastline. Despite this trend, recovery in certain **gamaats**/**g̱azea**/**g̱a̱maats** species has been shown in localized populations (Miner et al. 2018). Two subtidal dive surveys in 2021 near the Caamaño-Douglas area in Lowe Inlet Cannery and Borrowman Bay observed both Sunflower and Ochre sea stars with no sea star wasting disease (Sea star map – Multi-Agency Rocky Intertidal Network; accessed 2023[39]). The lack of information for this area highlights the need for monitoring **gamaats**/**g̱azea**/**g̱a̱maats** population size and their effects on the broader ecosystem.

Dive harvesting fisheries exist for **ts'akwe'ats**/red (*Mesocentrotus franciscanus*) and **aswit**/**'emdém**/**a̱ws**/green sea urchins (*Strongylocentrotus droebachiensis*) and **gyenti**/**'éllas**/sea cucumbers. **Ts'akwe'ats** are usually found in shallow areas with rocky substrates and moderate to strong currents. Quota Areas for harvesting **ts'akwe'ats** exist in the Caamaño-Douglas area including within Zones 310, 311, and 312 (Appendix 10 in **ts'akwe'ats** IMFP, DFO 2022d). Stock surveys to measure density, size, and populations throughout BC are being piloted through **Ts'akwe'ats** populations are considered to be abundant throughout the BC coast, except in areas with rapid **płoon**/**nukʷ**/sea otter expansions. **Aswit**/**'emdém**/**a̱ws** prefer rocky,

[39] Sea Star Map | MARINe https://marinedb.ucsc.edu/seastar/seastardisease.html

gravel, or shell substrates and aggregate in kelp forests (DFO 2022e). Commercial **aswit**/**’emdém**/**a̱ws** locations exist only for Vancouver Island, whereas First Nations and recreational harvest occur coastwide (DFO 2022e). The Pacific Urchin Harvesters Association identified **płoon**/**nukʷ**/sea otter predation as the primary concern on harvest stocks, although currently **płoon**/**nukʷ**/sea otter range does not overlap with the fishery (DFO 2022d, DFO 2022e). **Gyenti** are the largest in BC and abundant in complex hard substrates with moderate currents. **Gyenti** Quota Management Areas overlap with Zones 310, 311, 312, 313 and 314 (See Appendix 9 and 10 in **gyenti** IMFP, Fisheries and Oceans Canada 2022). Stocks are considered healthy at this time, with a baseline density of 6.0 **gyenti** per meter shoreline for the North and Central Coast (DFO 2022e).

Aswit/**’emdém**/**a̱ws**/Sea urchins and **gyenti**/**’éllas**/sea cucumbers have important cultural significance for Gitga’at and Gitxaała harvest, community relations, usage, and knowledge transmission (Satterfield et al. 2012). **Aswit**/**’emdém**/**a̱ws** are harvested in Kiel during the Fall and Winter, and **gyenti**/**’éllas** are harvested in **Lax gal’tsap**/Old town (located in Kitkiata Inlet), Clamstown on **Lax Kwil Dziist**/Fin Island (Zone 313) during the fall (Satterfield et al. 2012; Hartley Bay Council 2012). All six echinoderm species were present in many surveyed sites throughout the Network Zones (**Table 32**). Although there is a lack of survey information from Zone 315 due to the small area size, it can be inferred that echinoderms detected in nearby areas are likely to be present there.

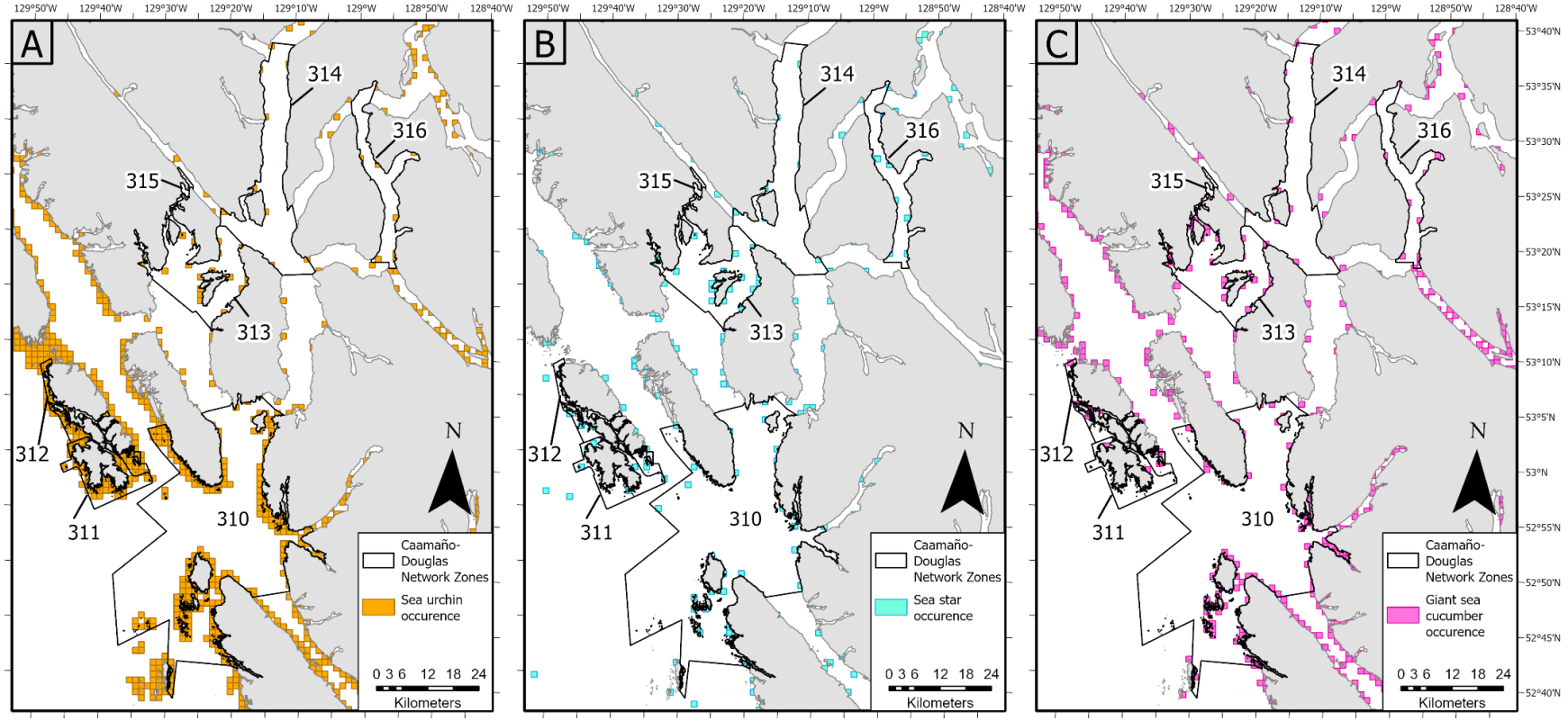

Figure 64. *Occurrence represented by 1 km x 1 km grids of five Echinoderm species: A)* ***aswit****/****'emdém****/* ***ą̱ws****/green and* ***ts'akwe'ats****/red sea urchin, B) ochre and sunflower sea star, C) giant sea cucumber in the Caamaño-Douglas area*

Table 32. *Echinoderm (**gamaats**/**g̱azea**/**g̱a̱maats**/sea star, **aswit**/**’emdém**/**a̱ws**/sea urchin, **gyenti**/**’éllas**/sea cucumber) occurrences (visual confirmation) for each Zone in the Caamaño Sound and Douglas Fjord System Network Zones. Occurrence is indicated by an ‘X’, a dash indicates no occurrence data (not the same as an absence).*

Common name	Scientific Grouping	Zone 310	Zone 311	Zone 312	Zone 313	Zone 314	Zone 315	Zone 316	Data source
Giant sea cucumber	*Apostichopus californicus* (formally *Parastichopus californicus*)	X	X	X	X	X	-	X	DFO shellfish database, BHM
Ts'akwe'ats Red sea urchin	*Mesocentrotus franciscanus*	X	X	X	X	X	-	X	DFO shellfish database, BHM
Aswit/’emdém / a̱ws Green sea urchin	*Stronglyocentrotus droebachiensis*	X	X	X	X	X	-	X	DFO shellfish database, BHM
Sunflower sea star	*Pycnopodia healianthoides*	X	X	X	X	X	-	X	DFO shellfish database, BHM
Ochre sea star	*Pisaster ochraceus*	X	X	X	X	X	-	X	DFO shellfish database, BHM

**DFO shellfish database = commercial, logbook, and research surveys. BHM = Benthic Habitat Monitoring dive survey*

6.2.2.5 Vulnerabilities and Recoverability

Marine invertebrates have different levels of sensitivity and resilience corresponding to their diverse life histories and unique forms. Natural and anthropogenic stressors affecting invertebrates include fishery activities, predation, disease, and various effects of climate change (e.g., ocean acidification). The Caamaño-Douglas area is sparsely populated, and the levels of human activities are low in comparison to lower mainland or Vancouver Island communities (See Section 5). Generally, species with high spawning, settling, and recruitment rates, and existing high population abundance are more resilient to compounding stressors. Recruitment in invertebrate populations is difficult to predict despite many species being broadcast spawners, due to the large scale of spawning, predation, disease, environmental variables, and oceanographic conditions (Hunter and Wade 2015).

Large-scale anthropogenic effects caused by carbon dioxide emissions, such as ocean acidification and increases in global mean sea surface temperature, pose many challenges to

marine organisms. Increased ocean acidification can directly affect the growth, survival, and development of invertebrates with hard structures such as certain corals and sponges, bivalves, snails, and crustaceans (Talmage and Gobler 2010). Rising sea levels and changing freshwater discharge may affect the health and accessibility of critical habitats for invertebrates, such as estuaries, **gadza k'aw**/eelgrass, and kelp beds (Bornhold and Thomson 2013). Please refer to Hunter and Wade (2015) for details on climate vulnerabilities in Dungeness Crab, Spot Prawn, and Geoduck throughout BC.

The risk of an oil spill from vessel traffic activity in the Caamaño-Douglas area is a concern for all invertebrate groups. An oil spill vulnerability score and ranking framework by Jeffery et al. (2023) divides vulnerability into exposure, sensitivity and recovery criteria. A majority of marine invertebrate species were scored moderate to high for oil vulnerability. Many invertebrate species have high aggregations and low mobility (corals and sponges, bivalves, snails), increasing their exposure criteria. Furthermore, filter-feeding increased the sensitivity score of the invertebrate groups. Recovery scores are mostly low, as there is a lack of evidence of population decline, low endemic populations, and many invertebrates are broadcast spawners with high reproductive output. However, there is a knowledge gap in understanding the unpredictable recruitment of many species and a general lack of local assessments to understand population trends in remote coastal regions.

Cold-water corals and sponges

Cold-water coral and sponge communities are vulnerable to physical and habitat disturbances such as bottom-contact fishing gear (Campbell and Simms 2009; Ragnarsson et al. 2016). Bottom trawling can dislodge sessile animals and stir up sediments in the water column, which can impair the ability to filter or suspension feed (Ragnarsson et al. 2016). The effects of marine litter, including lost and sunken fishing gear, can entangle and cause long-term damage to biogenic structures and habitats (Du Preez et al. 2020; Baco et al. 2019; Appah et al. 2022). Furthermore, Oil spills can also pose a risk with delayed health effects such as a higher branch rate loss for corals (Girard and Fisher 2018) and decreased larval settlement rates (Luter et al. 2019). Cold-water coral and sponge biomass recovery after habitat disturbance has been shown to take decades due to slow growth and settlement, and long lifespans of many species (Rooper et al. 2011; Baco et al. 2019).

For cold-water coral communities in particular, lowered seawater pH decreases the availability of carbonate ion concentrations and can affect recruitment, growth and development for calcifying species, such as Stony corals (Orr et al. 2005; Büscher et al. 2017). In contrast to the direct effects of warming temperatures leading to coral bleaching in warm-water corals, cold-water corals were found to tolerate a wider range of oceanic temperatures (Hanz et al. 2019; Dorey et al. 2020). Rather than relying on algae symbionts, cold-water coral communities were modeled to depend on deep-water food availability and transport from ocean circulations, which creates a more stable environment compared to shallow tropical waters (Büscher et al. 2017; Hanz et al. 2019; Portilho-Ramos et al. 2022). Nevertheless, oceanic processes and their effects on food transport and availability are continually influenced by climate-driven changes (Portilho-Ramos et al. 2022).

Management and regulatory measures, such as spatial closures, can be effective tools to reduce habitat disturbances and preserve cold-water sponge and coral communities (summarized in Appendix C of Pacific Region Cold-water Coral and Sponge Conservation Strategy; DFO 2010a). This has been demonstrated after the implementation of the Groundfish Trawl Habitat Agreement (DFO 2009a), where bottom-trawling fleets were shown to be avoiding

areas of high coral and sponge densities compared to years before the agreement (Gale et al. 2022).

Cold-water coral species have demonstrated variable responses and plasticity under different lab-controlled stressors and environments (Büscher et al. 2017, Lunden et al. 2014). This variability may be due to genetic diversity and connectivity (Lunden et al. 2014), highlighting the consideration for protecting a range of populations and networks (Addamo et al. 2021). Long term baseline monitoring is another recommendation for corals in potentially high stress areas (Girard and Fisher 2018). Spatial analysis, visual surveys, and identifying important coral and sponge communities remain important and non-invasive tools to mitigate exploitation and disturbance (Chu et al. 2019; Du Preez et al. 2020; Gale et al. 2022).

Molluscs

Infauna, epibenthic bivalves, marine snails, and **yaans**/**ḍeḍánas**/chitons mostly exhibit limited movement and aggregating behaviours. These traits make these groups of Molluscs more sensitive towards the local effects of pollution, such as oil spills and intense harvesting. The high abundance of most species and the low fishery pressures in the Caamaño-Douglas area does not likely make overharvesting an issue, although illegal poaching of Geoduck and **bilhaa**/**g̃elhg̃enaiq**/Abalone are concerns due to their high values (Zhang et al. 2007). Other natural events such as freezing conditions in the winter can affect clam abundance in local beaches (DFO 2023a). Geoducks embryos are indicated to have narrow tolerance for salinity (27.5 – 32.5 ppt) and temperature (6 – 16 °C) in laboratory studies (Goodwin 1973, Davis et al. 1999). Increased sea-surface temperature and positive phases of the Pacific Decadal Oscillation have been shown to correlate with recruitment growth in Geoducks (Hunter and Wade 2015).

As an Endangered species listed under the *Species at Risk Act* in 2009, **bilhaa**/**g̃elhg̃enaiq**/ Northern Abalone throughout the BC coast have received extra attention for their protection and recovery processes. A study by Zhang et al. (2007), identified that poaching was a major factor in preventing recovery populations around the Central Coast and Haida Gwaii. **Bilhaa**/ **g̃elhg̃enaiq** are particularly vulnerable to overharvesting because of their life history characteristics. These include slow growth and maturity, density-dependent larval recruitment success rate, and a tendency for adult **bilhaa**/**g̃elhg̃enaiq** to be found in shallow waters (Babcock and Keesing 1999; COSEWIC 2009a). The North Coast area, including the Caamaño Sound and Douglas Fjord System Network Zones, were identified as critical **bilhaa**/**g̃elhg̃enaiq** habitats which includes properties such as hard substrates and high rugosity for attachment, moderate to high wave exchange, and normal ocean salinity (> 30 ppt) (DFO 2012a). Encrusting coralline algae are thought to aid in larval settlement rates by providing food for juveniles and act as shelter (Roberts, 2001; DFO 2012a). The abundance of herbivores and grazers like **aswit**/**’emdém**/**a̱ws**/sea urchins, on the other hand, can prevent growth and settlement of algae and lead to reduced **bilhaa**/**g̃elhg̃enaiq** larval settlement (COSEWIC 2009a). The health and abundance of canopy-forming kelp forests has been shown to increase growth rates and may be linked to population recovery in **bilhaa**/**g̃elhg̃enaiq** (Sloan and Breen, 1988; COSEWIC 2009a; DFO 2012a).

Crustaceans

The abundance of crustaceans depend on the survival and recruitment of larval and juvenile life stages as mortality rates in adults are greatly reduced. These pelagic and planktonic stages are influenced by a variety of conditions including climate-related effects (e.g., currents, ocean

acidification) and biotic interactions (e.g., predation) (Brand et al. 2007). Recruitment and stock declines in offshore pandalid shrimps have been associated with warmer than usual oceanic conditions in both the Pacific (Anderson 2000) and Atlantic (Richards and Hunter 2021). Water temperatures can influence both larval, juvenile, and adult development, growth, survival, and reproductive capacities in **gasgos**/**sísíuɬ**/shrimps and **gasgos**/**sísíuɬ**/prawns (Lowry 2007, Koeller 2006). A mismatch in egg hatch and phytoplankton bloom timing from changing sea surface temperatures can lead to decreased recruitment in a given year (Hunter and Wade, 2015). Spot prawn fecundity is lower than other Pandalid shrimps (See table 2-2 in King 1997, Lowry 2007, Hunter and Wade 2015), although inshore fjord and inlet abundance have been relatively stable compared to offshore populations (Otto and Jamieson 2001).

Crustaceans depend on exoskeleton shell formation for protection and molting of that shell for growth. Therefore, ocean acidification can lead to an impairment for the development of calcareous structures (Feely et al. 2004). Decreased pH conditions impaired the development, growth, and survival of Dungeness crab adults and larvae (Bednaršek et al. 2020, Berger et al. 2021). Low oxygen, on the other hand, severely impacted adult life stages specifically which can affect population numbers (Berger et al. 2021). A study in the coast of Oregon showed higher **k'almoos**/**klnákʷ**/**ḵ'a̱lmoos**/crab mortality or migration away from areas with longer durations of hypoxic conditions (Chan et al. 2008). The health of habitats associated with juvenile development and protection should be considered when accounting for overall population survival and abundance. Notably, Dungeness crabs aggregate in estuaries (Gunderson et al. 1990; Rasmusson 2013), and spot prawns are commonly found on complex substrates such as sponge and coral reefs and beds, areas with high rugosity and drift macroalgae (Butler 1980, Lowry 2007, Britton-Simmons et al. 2012).

Echinoderms

Many echinoderms are shown to have a boom-and-bust population dynamic characterized by an explosion of abundance followed by a sharp decline. This cycle may be explained by the natural prey-predator population dynamic or exacerbated by anthropogenic activity such as intense harvesting (Uthicke et al. 2009, Schultz et al. 2016) and/or the spread of disease. In coastal BC, **aswit**/**'emdém**/**a̱ws**/sea urchin populations are highly correlated with rates of **płoon**/**nukʷ**/Sea Otter predation rather than harvesting. Furthermore, abundant echinoderm populations in the Caamaño-Douglas area are not likely to experience overharvesting because of low human population density.

Disease can make local populations more susceptible to other stressors. The most prevalent example of this is the recent coastwide decline of **gamaats**/**ḡazea**/**g̱a̱maats**/sea star populations from sea star wasting disease (Miner et al. 2018). Treatment studies have faster time between onset of disease and death with increased temperatures (Eisenlord et al. 2016; Kohl et al. 2016). Large high temperature anomalies correlate with mass die-offs in the summer of 2014 in the Pacific Northwest (Eisenlord et al. 2016), suggesting that frequent ocean warming events can lead to further population declines. As **gamaats**/**ḡazea**/**g̱a̱maats** are apex invertebrate predators, changes in their distribution and abundance may lead to cascading effects on prey abundance and assemblages in localized habitats and ecosystems (Paine 1966; Konar et al. 2019; Galloway et al. 2023).

6.2.3 Fish

This section features fish species previously identified as Zone-level network conservation objectives from the Network Action Plan (MPATT 2023). These species include **ts'mhoon**/rockfish (many species), **txaw**/**mumegʷezu**/**txaw**/halibut, **wa̲t'uk̲w**/**núłem**/**wa̲t'ukw**/ lingcod, **tskah**/**wáṅi**/**tska̲h**/herring, **hadanii**/**hadanii**/sablefish, **ha'limootk**/**ƛ̓áti**/**ẅa̲h**/eulachon, **hoon̓**/**qeqapela**/ salmon (**gayniis**/ **gʷaxenis**/**ga̲yniis**/chum, **misoo**/**hísen**/**miso'o**/sockeye, **yee**/**káp̓i**/**xyi'i**/ Chinook, **üüx**/**zúen**/**üüxs**/Coho̲, Pink), Pacific sleeper sharks, and six-gill sharks. Other fish species described within the scope of this section include species of E-CPs in the NSB (Gale et al. 2019) and species at risk. The details focused on in this section for each group of fish include known information on occurrence within the Network Zones or Caamaño-Douglas area, important ecological or life history traits, local or regional population trends and population genetics, and knowledge gaps. Occurrence tables are not indicative of true absence or the measure of abundance for a zone and should be used as a guideline for species distribution throughout the seven Network Zones. Finally, a summary of Vulnerabilities and Recoverability are reported for fish communities and species of interest.

Data sources

Fish species occurrence data for this section as a whole are retrieved from several sources: 1) observation data from DFO or external research surveys (such as seining data) or commercial fisheries (Gale et al. 2025), 2) published literature and reports, 3) sightings from open databases such as the Global Biodiversity Information Facility and iNaturalist, and/or 4) personal communications and local knowledge. Important and additional surveys and sources used for each fish group will be elaborated in those sections. Details about DFO groundfish survey data used for occurrences are described in the metadata of the SeaSketch – Marine Protected Area Network Planning layers[40]. Additional descriptions on the ecology, diet, migration, and life history traits of the fish species found in the NSB can be found in Gale et al. (2019). For detailed species profile on **txaw**/**mumegʷezu**/**txaw** /Pacific Halibut, **balaas**/Pacific Hake, **hadanii**/**hadanii**/sablefish, **Tskah**/**wáṅi**/**tska̲h**/Pacific Herring, and their climate vulnerabilities, please refer to Hunter and Wade (2015).

An important data gap to recognize for the Caamaño-Douglas area is the lack of information in the Inner Fjord Zones: 313, 314, 315 and 316 (See **Appendix D. Caamaño-Douglas Network Zones** Survey Extentfor survey extent of datasets used). Due to vessel traffic and the greater depths of the Douglas Fjord System Zones, fish assessment surveys are kept to shallow nearshore areas and do not sample extensively within the inlets.

When available, recent published documents describing the trends of fish stock and populations were summarized within the relevant management area that overlaps with the Caamaño-Douglas area. Different fisheries have different ways of categorizing their management areas and are described in their respective sections. Generally, the Pacific Fisheries Management Area (PFMA) of Princess Royal Island (Area 6)[41] overlaps with six of seven Network Zones and throughout the Caamaño-Douglas area. Specifically, PFMA subareas 6-13, 6-10, 6-11 overlaps with Zones 310, 311, 312, and areas 6-2, 6-3, 6-5, 6-6, 6-26, 6-27, overlaps with Zones 313,

[40] SeaSketch - Better decisions through global participation

[41] Fisheries management area 6 - Princess Royal Island | Pacific Region | Fisheries and Oceans Canada

314, and 316. The Greenville Channel, Principe Channel (Area 5)[42] PFMA, specifically 5-24 overlaps with Zone 315, **Maxtaktsm'aa**/Union Passage Site. Groundfish fisheries in DFO are separated into several management units. The Caamaño-Douglas area is covered by the Hecate Strait management unit 5C. For full details of the recent status of physical, biological, and selected fishery resources in BC please refer to Boldt et al. (2021).

Stock assessment summaries presented here are meant to portray a quick understanding of recently assessed trends, and the reports provided should be consulted for full details. As described in Bannar-Martin et al. (2025), caveats to be considered for interpreting generalized trends from these reports include time-sensitive series within the range of the latest reports, region-specific trends, dataset uncertainties, and changes that may occur from current or future temperature and environmental shifts. Species stock assessments should not be compared across species, as each model uses unique datasets with their own caveats, assumptions, and uncertainties.

6.2.3.1 Bony Fishes

6.2.3.1.1 Groundfish

Groundfish are comprised of benthic and/or demersal free-swimming species that live in or near the benthic layer of the marine environment. They are typically found on or near the continental shelf or slope, or around seamounts. They have been grouped below into four groups by ecological similarity: **ts'mhoon**/rockfish, flatfish, roundfish, and other.

A groundfish distribution model developed by Thompson et al. (2023b) was used to inform the probability of occurrence of 65 groundfish species in six Caamaño Sound and Douglas Fjord System Network Zones. Despite the term groundfish being used, there are non-groundfish species predicted in the model such as **tskah**/**wáṅi**/**tskᵱah**/herring and **ksaa**/ **q̓ʷaqʷ-**/sharks. The spatial extent of this model does not overlap with Zone 315, **Maxtaktsm'aa**/Union Passage Site, so does not provide a comprehensive assessment of predicted groundfish occurrence across all seven zones. The groundfish distribution model was created with the aim to predict the spatial coastwide distribution of groundfish species in the Canadian Pacific. The model integrated data from three fisheries-independent scientific surveys: the DFO Groundfish Synoptic Bottom Trawl Surveys (Sinclair et al. 2003; Anderson et al. 2019), the DFO Groundfish Hard Bottom Longline Surveys (Lochead and Yamanaka 2006, Lochead and Yamanaka 2007, Doherty et al. 2019), and the International Pacific Halibut Commission (IPHC) Fisheries Independent Setline Survey (Stewart and Hicks 2023). Presence-absence records of all groundfish species with at least 150 observations from 2003 to 2020 were used in this distribution model to produce predicted species densities per 3 km grid cell for each groundfish species. Groundfish species density was calculated as the sum of the estimated occurrence probabilities from the presence-absence model for each groundfish species per unit area (Thompson et al. 2023b; **Figure 65**). Within the Caamaño-Douglas area groundfish species density or species richness is modeled to be highest in Zone 310 and the coastal areas of Zone 313.

[42] Fisheries management area 5 - Greenville Channel, Principe Channel | Pacific Region | Fisheries and Oceans Canada

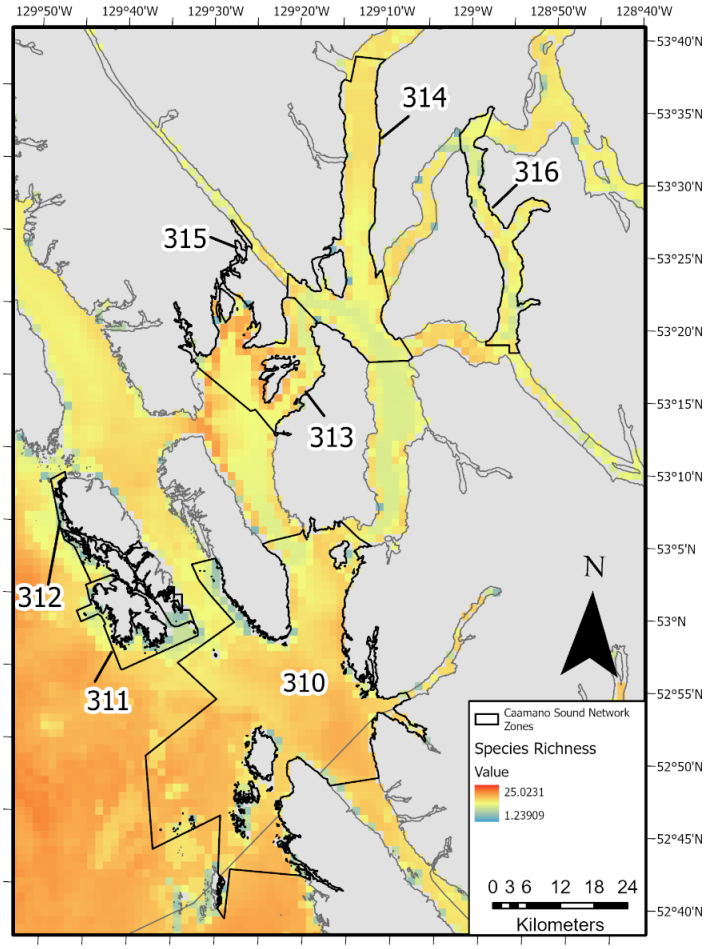

***Figure 65**. Estimated variation in species density values per grid cell (Species Richness) for all 64 groundfish species in the Caamaño Sound and Douglas Fjord System Network Zones using the Thompson et al. (2023b) groundfish species integrated model. The multi-species distribution model integrates presence-absence data across surveys and gear types, allowing predictions of coastwide distributions of 66 groundfish species in British Columbia. Presence-absence records of all groundfish species with at least 150 observations from 2003 to 2020 were used.*

There is uncertainty associated with species distribution models, particularly in areas with limited sampling. This includes the Caamaño-Douglas area, where survey data is limited to the outer waters. Therefore, predictions in the area are based on estimated species-environment relationships and spatial correlations. Validation of model predictions in areas with limited sampling can be done using local knowledge and other independent datasets. There are few DFO survey data of groundfish in the Caamaño Sound and Douglas Fjord System Network Zones (313-316), and open-source fishery survey databases only reach the extent of Zones 310, 311, and 312. Additional occurrence data would have to rely on local knowledge or available DFO commercial and recreational catch databases not mined for this report due to spatial resolution of management areas, and potential privacy concerns. Furthermore, many official stock assessments are generally done at a regional level and therefore, specific groundfish species trends are not clear at the inshore Caamaño-Douglas area scale.

*6.2.3.1.1.1 **Ts'mhoon** / Rockfish*

Ts'mhoon/Rockfish (*Sebastes* and *Sebastolobus spp.*) are ecologically, commercially, and culturally valued fishes in the West Coast of North America with a diversity of life histories and behaviors. There are at least 65 species described ranging from Alaska to Baja California (Love et al. 2002), and in BC, there are at least 36 species found throughout the coast (Love et al. 2002) and at least 23 species occur in the Caamaño Sound and Douglas Fjord System Network Zones. The conservation of multiple **ts'mhoon** species was identified as a Zone-level network conservation objective for Zone 312 by the Network Action Plan (MPATT 2023). Because the Network Action Plan did not define the list of species, **ts'mhoon** identified as important from other ecological and conservation assessments (e.g., Gale et al. 2019; COSEWIC; SARA) will be used to guide this section. **Ts'mhoon** occurrence in Zone 315 are informed by the Groundfish Fisheries Operations System database 2014 to 2018 catch data.

Ts'mhoon are classified into three groups for broad management purposes in Canada. Inshore rockfish describes nearshore species between 0 to 200 meters depth (Yamanaka and Logan, 2010). Whereas shelf and slope rockfish include species found deeper in the continental shelf, and both the continental shelf and slope respectively, although species lists for these categorizations are not always clear nor updated (Stanley 1999; Schnute et al. 1999). Due to the deep bathymetry (> 200 m depth) of the fjord system, there may be inshore and shelf **ts'mhoon** species in the Caamaño-Douglas area. Two distinct units of **ts'mhoon** populations in coastal BC are further categorized into inside waters (from Vancouver Island to the Vancouver mainland) and outside waters (rest of the coast, including the Caamaño-Douglas area). Similarly, there are the Outside and Inside commercial **ts'mhoon** sectors. Hook-and-line and trawl gear are used for commercial **ts'mhoon** catch (DFO 2023e).

Ts'mhoon can have maximum lifespans ranging from 22 years (Puget Sound Rockfish) to 205 years (Rougheye-Blackspotted complex) (Leaman 1991; Love et al. 2002). Trophic levels can range from planktivores (Pacific Ocean Perch) to piscivores (Quillback Rockfish) (Love et al. 2002, Olsen et al. 2020). **Ts'mhoon** are viviparious and yearly fecundity in species can range from thousands of larvae (Puget Sound Rockfish) to nearly three million (**ƛ̓áx̄ʷ'en ƛ̓áƛ̓ex̄ʷ'en**/Yelloweye Rockfish) (Love et al. 2002). Their distributions can differ by habitat type (e.g., rock type and biocover; Haggarty et al. 2016) and by depth from the intertidal zones to greater than 1,500 meters (Love et al. 2002). **Ts'mhoon** with long lifespans, slow growth and maturity can make those species vulnerable to the effects of overfishing and population collapse (Cheung et al. 2005, Haggarty et al. 2016, Gale et al. 2019). Juvenile **ts'mhoon** are prey to many ecologically important species (Gale et al. 2019). **Ts'mhoon** have also been a stable part of coastal First Nation diets for millennia and have important cultural significance for community relations and other usages (McKechnie and Moss, 2016). Inshore rockfish habitats were identified for Zones 313 (**K'duwaadz**/Tuwartz Inlet) and 315 (**Maxtaktsm'aa**/Union Passage) (North Coast Marine Plan, 2015). In addition, Clamtown, a camp site on **Lax Kwil Dziist**/Fin Island (Zone 313) was identified as an important site for harvesting **ts'mhoon** during the winter and spring (Satterfield et al. 2012).

Important habitats and Rockfish Conservation Areas in the Caamaño-Douglas area

Important **ts'mhoon**/rockfish habitats have been identified as structurally complex – which includes variation in physical characteristics like vertical reliefs, structures, rocks, and biogenic characteristics like marine vegetation proportion cover and invertebrates (Frid et al. 2018). These habitats can include rocky reefs, kelp forests, **gadza k'aw**/eelgrass beds, and a diverse

community of benthic invertebrates. These features are plentiful within the Caamaño Sound and Douglas Fjord System Network Zones. For example, **mo'ox**/**wáudi**/**moox**/Bull Kelp occurrence has been recorded throughout the Zones (**Figure 50**), whereas **gyoós**/**q̓áq̓elḭ̓is**/Giant Kelp (**Figure 50**) are known to occur in the Outer Coast Zones of 310, 311, and 312. These Network Zones, specifically the Inner Fjord Zones, also have a high proportion of high benthic complexity shown in high rugosity areas (**Table 23**). A study by Frid et al (2021) identified many coral species and gardens, and invertebrates are also present in the area (Section 6.2.2). From an ecosystem perspective, the Caamaño-Douglas area appears to be an important area for **ts'mhoon** habitat and biodiversity.

Rockfish Conservation Areas (RCA) were established by DFO from 2004 to 2006 to address the declining **ts'mhoon** populations. Certain bottom-contact fisheries are prohibited in RCAs (e.g., commercial and recreational hook and line and commercial groundfish bottom trawl fisheries), though others such as commercial groundfish mid-water trawls are permitted (See Table 2 in Haggarty 2013). Three RCAs are located near the Network Zones (See **Figure 6**). West Aristazabal Island RCA overlaps with Zone 310, and Otter Passage RCA is close to Zone 312, whereas North Danger Rocks RCA is adjacent north to Otter Passage. These RCAs will be integrated into the potential MPA Network as the West of Banks and Aristzabal Network Zones (MPA Network BC Northern Shelf Initiative 2023). A recent assessment on RCAs measured the effectiveness of Pacific region RCAs using four ecological attributes: connectivity, size, depth, and habitat. All three RCAs were identified among the twenty highest RCAs providing the most conservation benefits (Table 19 in Dunham et al. 2020).

The report also summarized that protected areas such as RCAs and MPAs between 50 km and 100 km would maintain **ts'mhoon** larvae dispersal distance and population connectivity. In addition, tagging studies of four adult **ts'mhoon** species - Black Rockfish (Freiwald 2012), Blue Rockfish (Freiwald 2012), Copper Rockfish (Buonaccorsi et al. 2002), Quillback Rockfish (Matthews 1990), reported movement of less than 5 km (Freiwald 2012; Buonaccorsi et al. 2002; Matthews 1990). Fishes with normally small home ranges have also been reported with longer ranges (e.g., Brown Rockfish; Matthews 1990). Altogether, these results indicated that an area of protection of at least 78.5 km^2 could be sufficient to account for movement (Dunham et al. 2020). Nonetheless, spatial protection can still provide benefits to **ts'mhoon** with high mobility (Claudet et al. 2010). The designation of the Caamaño Sound and Douglas Fjord System Network Zones would provide connectivity between the southern West Aristazabal Island RCA and the Otter Passage RCA. The combined areas and close proximity of the Outer Coast Zones 310, 311, and 312 could be large enough to protect dispersal and movement. An increased number of **ts'mhoon** in Zone 310 and surrounding areas has been noticed and attributed to the possible spillover effects from the Aristazabal Island RCA (K. Cripps, pers. Comm. 2023).

Occurrence and population trends

All **ts'mhoon**/rockfish with known occurrences in the Network Zones are E-CPs and have been assigned high or very high vulnerability status (Gale et al. 2019). The Outer Coast Zones (310, 311, 312) have occurrence records for at least 20 species of **ts'mhoon** (**Table 33**). Catch data are scarce for the Inner Fjord Zones (Zones 313 - 316), and although **ts'mhoon** have been observed and caught in those areas, species-level details are not always present. The multi-species distribution model (Thompson et al. 2023b) predicts higher species richness in the Outer Coast Zones near Hecate Strait and nearshore coasts along the Inner Fjord Zones (**Figure 66**).

***Table 33**. **Ts'mhoon**/Rockfish species occurrence in the Caamaño Sound and Douglas Fjord System Network Zones. Occurrence is presented as direct observation of the species within the boundaries of each Zone. Species occurrence is denoted by an X and shaded in green, a dash indicates no occurrence data (not the same as an absence).*

Common name	Scientific Grouping	Zone 310	Zone 311	Zone 312	Zone 313	Zone 314	Zone 315	Zone 316	Data source
Black Rockfish	*Sebastes melanops*	X	X	-	-	-	X	-	GBIF
Blackspotted Rockfish	*Sebastes melanostictus*	X	-	-	-	-	-	-	GBIF
Bocaccio	*Sebastes paucispinis*	X	X	-	-	-	-	-	GBIF and DFO survey
Canary Rockfish	*Sebastes pinniger*	X	X	X	-	-	-	-	GBIF and DFO survey
China Rockfish	*Sebastes nebulosus*	X	X	X	-	-	X	-	GBIF and DFO survey
Copper Rockfish	*Sebastes caurinus*	X	X	X	-	-	X	-	GBIF and DFO survey
Darkblotched Rockfish	*Sebastes crameri*	X	-	-	-	-	-	-	DFO survey
Greenstriped Rockfish	*Sebastes elongatus*	X	X	X	-	X	-	-	GBIF and DFO survey
Pacific Ocean Perch	*Sebastes alutus*	X	X	-	-	-	-	-	GBIF
Quillback Rockfish	*Sebastes maliger*	X	X	X	-	-	X	-	GBIF and DFO survey
Redstripe Rockfish	*Sebastes proriger*	X	-	X	-	X	X	-	GBIF and DFO survey
Rosethorn Rockfish	*Sebastes helvomaculatus*	X	X	X	-	-	-	-	GBIF and DFO survey
Rougheye Rockfish	*Sebastes aleutianus*	-	X	-	-	-	-	-	DFO survey
Shortraker Rockfish	*Sebastes borealis*	X	-	-	-	-	-	-	GBIF

Common name	Scientific Grouping	Zone 310	Zone 311	Zone 312	Zone 313	Zone 314	Zone 315	Zone 316	Data source
Silvergray Rockfish	*Sebastes brevispinis*	X	X	X	-	-	-	-	GBIF and DFO survey
Tiger Rockfish	*Sebastes nigrocinctus*	X	X	-	-	-	-	-	GBIF and DFO survey
Vermilion Rockfish	*Sebastes miniatus*	X	X	-	-	-	-	-	GBIF and DFO survey
ʔáx̄ʷ'en ʔáʔex̄ʷ'en Yelloweye Rockfish	*Sebastes ruberrimus*	X	X	X	-	-	-	-	GBIF and DFO survey
Yellowmouth Rockfish	*Sebastes reedi*	X	X	X	-	-	-	-	GBIF and DFO survey
Yellowtail Rockfish	*Sebastes flavidus*	X	X	X	-	X	X	-	GBIF and DFO survey
Shortspine Thornyhead	*Sebastes alascanus*	X	X	X	-	-	-	-	DFO survey

**DFO survey: Fisheries and Oceans synoptic trawl surveys (2003-2016) and outside hard-bottom longline surveys (2006-2016); GBIF: Global Biodiversity Information Facility (accessed 2023).*

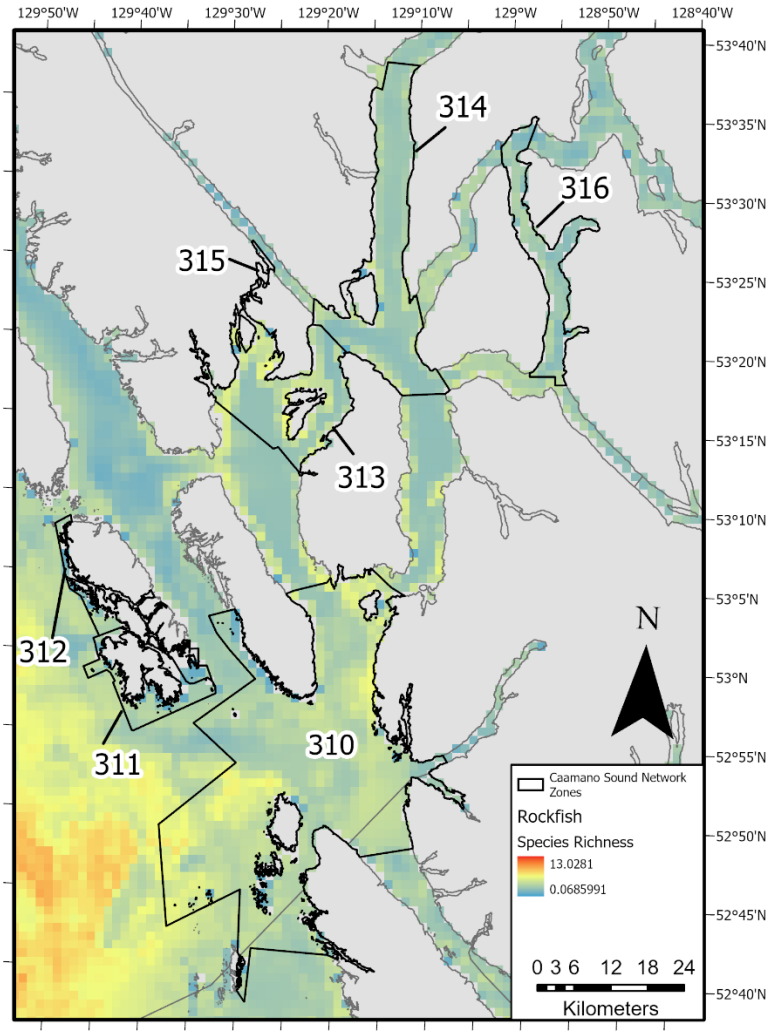

***Figure 66**. Summed predicted species density values per grid cell (Species Richness) for **ts'mhoon**/ rockfish in the Caamaño Sound and Douglas Fjord System Network Zones using the Thompson et al. (2023b) groundfish species integrated model. The multi-species distribution model integrates presence-absence data across surveys and gear types, allowing predictions of coastwide distributions of 66 groundfish species in British Columbia. Presence-absence records of all groundfish species with at least 150 observations from 2003 to 2020 were used. Only species that are ecological conservation priorities in the Northern Shelf Bioregion (Gale et al. 2019) are included in the species richness value reported here, for a maximum total of 23 species.*

Population trends and stock assessments of **ts'mhoon** are reported at the groundfish management area level (Hecate Strait, area 5C) or the provincial level. There are currently no official stock assessments for Longspine Thornyhead, Greenstriped, Vermilion, China, Tiger, or Rosethorn rockfish in BC. The following species were assessed to be data deficient to inform stock trends: Shortspine Thornyhead (DFO 2016b), Copper (Stocker and Fargo, 1995), Shortraker (Schnute et al. 1999), and Darkblotched rockfish (COSEWIC 2009b).

ƛáx̱ʷ'en ƛáƛex̱ʷ'en/Yelloweye rockfish, a commonly harvested species, showed drastic decreasing trends in the 1980s, but recent survey data indicate that the population may have been stable for 20 years and current exploitation levels in the outer coast of BC are considered sustainable in model projections to 2029 (Yamanaka et al. 2018). Both inside and outside **ƛáx̱ʷ'en ƛáƛex̱ʷ'en** populations have rebuilding strategies in place to guide management procedures (Haggarty et al. 2022; Cox et al. 2020b). These recent evaluations found that the **ƛáx̱ʷ'en ƛáƛex̱ʷ'en** stocks have high probability to be above their Limited Reference Points (the specific threshold between the cautious and critical zones) due to updated models and different approaches from previous papers (e.g., Yamanaka et al. 2018). Quillback rockfish, another targeted species for fisheries, was assessed as Threatened (COSEWIC 2009c) and assessed in the Cautious zone by DFO (2012b). The threatened Canary rockfish also showed 86% population declines over 30 years (COSEWIC 2007a). A recovery assessment document (DFO 2009b) included additional trawl survey observations and catch data was created as a response into their models, subsequently placing the stocks in the 'Healthy zone'. The most recent stock assessment predicts that the Canary Rockfish population would stay in DFO's 'Healthy zone' for the next 10 years with catch levels under 2000 tons per year (Table 12 in DFO 2023c).

Yellowtail and Pacific Ocean Perch have the largest species catch quota in BC, and both recent assessments place stocks as high probability in the healthy zone considering their current levels of catch, although Yellowtail stock are forecast to decline with current harvesting levels (DFO 2015). Silvergray (DFO 2014), Rougheye/Blackspotted (DFO 2020a), Bocaccio (DFO 2022f) and Redstripe (DFO 2018b) rockfish also showed high probability of healthy stocks.

Many population diversity studies show only one genetic population for many **ts'mhoon** throughout BC, indicating that dispersal is generally not limited by physical location for these species (Hicks et al. 2009, Yamanaka et al. 2006, Buonaccorsi et al. 2012). There is evidence for genetic differentiation with increasing geographic distance in Rosethorn, Darkblotched (COSEWIC 2009b) and Redstripe rockfish (Rocha-Olivares and Vetter, 1999). Copper rockfish showed fine-scale genetic variation between those found in heads of inlets and outer coast habitats in Vancouver Island, a trend that may be duplicated in other locations (Dick et al. 2014; Sykes, 2024). There is known hybridization in the Central Coast/Hecate strait stock assessment area (5C) for Blackspotted rockfish (DFO 2020a). The following **ts'mhoon** lack genetic assessments: Silvergray, Yellowtail, Shortspine and Longspine Thornyhead (COSEWIC 2007b), Tiger, Canary, and China rockfish.

6.2.3.1.1.2 Flatfish

Flatfish (Order *Pleuronectiformes*) are a group of benthic fish that live on continental shelf habitats generally in sandy and mud flat bottoms. Six species of ecological conservation priorities (Gale et al. 2019) occur within the Network Zones (**Table 34**), and flatfish species are

predicted to occur throughout the Network Zones and at the highest richness in Zone 310 (**Figure 67**). **Txaw/mumegʷezu/txaw**/Pacific Halibut is highlighted below for its cultural and ecological importance.

Table 34. *Flatfish species occurrence (visual confirmation) by Zone in the Caamaño Sound and Douglas Fjord System Network Zones. Occurrence is denoted by an X, whereas a dash indicates no occurrence data (not the same as an absence).*

Common name	Scientific Grouping	Zone 310	Zone 311	Zone 312	Zone 313	Zone 314	Zone 315	Zone 316	Data source
Arrowtooth flounder	*Atheresthes stomias*	X	X	X	-	X	-	-	GBIF and DFO survey
Dover Sole	*Solea solea*	X	X	X	-	-	-	-	GBIF and DFO survey
English Sole	*Parophrys vetulus*	X	X	X	-	-	-	-	DFO survey
Petrale Sole	*Eopsetta jordani*	X	X	-	-	-	-	-	GBIF and DFO survey
Rex Sole	*Glyptocephalus zachirus*	X	X	X	-	-	-	-	DFO survey
Southern rock Sole	*Lepidospetta Bilineata*	X	X	X	-	-	-	-	DFO survey
Txaw mumegʷezu txaw Pacific Halibut	*Hippoglosus stenolepis*	X	X	X	X	X	X	X	GBIF and DFO survey

DFO survey: DFO data from synoptic trawl surveys (2003-2016), outside hard-bottom longline surveys (2006-2016),* and *random-stratified **hadanii/hadanii/sablefish trap surveys (2003-2016). GBIF = Global Biodiversity Information Facility (Accessed 2023)*

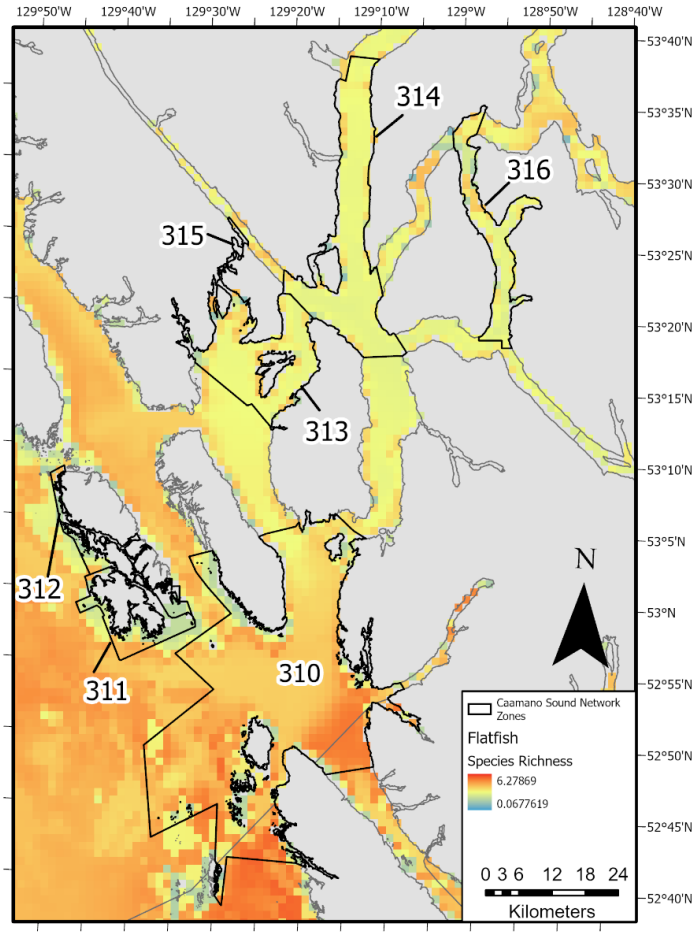

***Figure 67**. Summed predicted species density values per grid cell (Species Richness) for flatfish in the Caamaño Sound and Douglas Fjord System Network Zones using the Thompson et al. (2023b) groundfish species integrated model. The multi-species distribution model integrates presence-absence data across surveys and gear types, allowing predictions of coastwide distributions of 66 groundfish species in British Columbia. Presence-absence records of all groundfish species with at least 150 observations from 2003 to 2020 were used. Only species that are ecological conservation priorities in the Northern Shelf Bioregion are included in the species richness value reported here, for a maximum total of 7 flatfish species.*

Txaw / Mumegʷezu / Txaw / Pacific Halibut

Txaw/**mumegʷezu**/**txaw**/Pacific Halibut (*Hippoglossus stenolepis*), is a Zone-level ecological conservation objective in all seven Zones, as well as a Zone-level cultural conservation objective described as significant to First Nations and Coastal Communities in all Zones except 311 (MPA Network BC Northern Shelf Initiative 2023). A high trophic level predator, **txaw**/**mumegʷezu**/**txaw** are described by some as keystone species due to their wide variety of diets and importance as prey for larger animals. **Txaw**/**mumegʷezu**/**txaw** is a culturally, recreationally, and commercially valuable species for many groups of people within the

Caamaño-Douglas area (Satterfield et al. 2012) and are known to occur in all seven Network Zones (**Table 37**). For a detailed species profile on **txaw/mumegʷezu/txaw** please refer to Hunter and Wade (2015).

Txaw/mumegʷezu/txaw is one of the staple resources for Gitga'at culture and food security and harvested in the Winter, Spring, and Summer seasons (Gitga'at Marine Use Plan, 2015) and also resources for culture and food security for the Gitxaała Nation. In the spring harvest camp at Kiel (east of **K'nabiyaaxl**/Ashdown Island, outside of Zone 310), families catch **txaw/mumegʷezu/txaw** using a single line or set long line (Gitga'at First Nations website[43]). Processed dried fish (called **wooks**) is then stored to be eaten throughout the year. **Txaw/mumegʷezu/txaw** is also a common target for recreational fishing, although this activity was reported to be unmonitored and poorly regulated in the area (Gitga'at Marine Use Plan, 2015).

The largest of all flatfish species in BC, many adult **txaw/mumegʷezu/txaw** reside in demersal waters up to 1500 m in the outer continental shelf and slope. **Txaw/mumegʷezu/txaw** will use the inner continental shelves and inlets as nurseries and migrate into deeper waters as early as 2 years old. Hecate Strait was identified as an important spawning area for **txaw/mumegʷezu/txaw**, although this is outside of the Network Zones boundaries. The areas around the Central Mainland EBSA (including Zones 310, 311, and 312), however, show increased **txaw** density (See Figure 5 in Rubidge et al. 2016). Spawning season occurs from November to March. Recruitment of juvenile **txaw/mumegʷezu/txaw** has been shown to be variable in historical records, and this variability is thought to follow oceanic productivity cycles in the North Pacific (Clark et al. 1999). Diets of **txaw/mumegʷezu/txaw** in nearby Hecate straight include Pacific Sand Lance, **Tskah/wáṅi/tskaḵh**/Pacific Herring, and **k'almoos/klnákʷ/ḵ'aḵlmoos**/crabs (Best and St-Pierre 1986). Larval **txaw/mumegʷezu/txaw** feed on zooplankton, whereas juveniles feed on invertebrates and other small fish. During these stages, they are vulnerable to predation by other fishes, whereas adults will only be targeted by marine mammals and **ksaa/q̓ʷaqʷ-**/sharks.

Txaw/mumegʷezu/txaw is one of the seven major commercial groundfish fisheries in BC and Pacific stocks are assessed annually by the International Pacific Halibut Commission. Most **txaw/mumegʷezu/txaw** stocks in the Pacific region showed population decline and a decrease in size at catch from the 1990s to 2012, with a smaller decline from 2017 onwards. Still, the stock for BC (2B) is assessed as healthy, and stocks are assumed to repopulate in upcoming years when the 2012-age cohort matures (Stewart and Hicks, 2023). The standardized DFO groundfish hook-and-line stock survey, however, does not sample beyond Zones 310, 311, and 312. Thompson et al. (2023c) examined changes in **txaw/mumegʷezu/txaw** distribution according to future climate scenarios, specifically changes in temperature and dissolved oxygen concentration. Their results suggested a decrease in BC **txaw** populations as a response to decreased dissolve oxygen concentration in shallow coastal waters, similar to habitats found in the Outer Coastal Zones.

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[43] Gitga'at Spring Harvest Tradition at Kiel Camp

Other Flatfish

Many flatfish species occur throughout the Caamaño-Douglas area (K. Clifton, pers comm. 2023). Many flatfish species undergo seasonal migrations between deep-water spawning in the fall to winter, and shallow feeding areas in the summer. Recruitment for pelagic eggs and larvae have been shown to be affected by variable oceanographic conditions, which can cause unpredictable annual stock assessments. Juvenile flatfish (1 - 4 years) are more commonly found nearshore, whereas adult flatfish will inhabit deeper waters of the continental shelf and slope.

Although official surveys are limited throughout the extent, the Thompson et al. (2023b) model predicts highest species richness near Hecate Strait, in Zones 310, 311, and 312 (**Figure 67.** Summed predicted species density values per grid cell (Species Richness) for flatfish in the Caamaño Sound and Douglas Fjord System Network Zones using the Thompson et al. (2023b) groundfish species integrated model. The multi-species distribution model integrates presence-absence data across surveys and gear types, allowing predictions of coastwide distributions of 66 groundfish species in British Columbia. Presence-absence records of all groundfish species with at least 150 observations from 2003 to 2020 were used. Only species that are ecological conservation priorities in the Northern Shelf Bioregion are included in the species richness value reported here, for a maximum total of 7 flatfish species.). Dover and Rex soles are among commercial catch flatfish in the area. Many flatfish in Hecate Strait and BC are caught by commercial trawl fisheries, although trawling activities are very limited in the Caamaño-Douglas area (See **Table 35** and **Table 21**).

Population trends of flatfish species are limited. The Rex sole has no official stock assessments in BC. Stocks for Southern Rock soles were shown to be abundant and healthy in the Hecate Strait area 5C (Holt et al. 2016). The stock assessments for Dover Sole (DFO 1999), and Petrale Sole (Starr 2009) are currently outdated or have high data uncertainty. Recent declines in Arrowtooth Flounder have been observed in BC since 2014 (e.g., Thompson et al. 2023b), which are similar to observed declines in the Gulf of Alaska (Spies and Palsson 2019). The stock is currently considered to be in the cautious zone relative to the Limit Reference Point, and has had a low and declining recruitment from 2010-2019 coast-wide (DFO 2023f). A single stock has been identified along the BC coast based on a lack of observable differences in mean weight, length, or growth.

6.2.3.1.1.3 Roundfish

Roundfish species are generally categorized by their fusiform body shape – a rounded form in the middle that tapers off at both ends. Although roundfish are grouped into the groundfish section, these species utilize both the benthic and pelagic layers. Three species of ecologically and/or culturally significant roundfish occur in the NSB: **k’a’wts**/**ƛáx̄dala**/**k̲'a'w'ts**/Pacific Cod (*Gadus macrocephalus*), **balaas**/Pacific Hake (Merluccius productus), Walleye Pollock (*Theragra chalcogramma*) (Gale et al. 2019). All three species occur throughout the Network Zones (

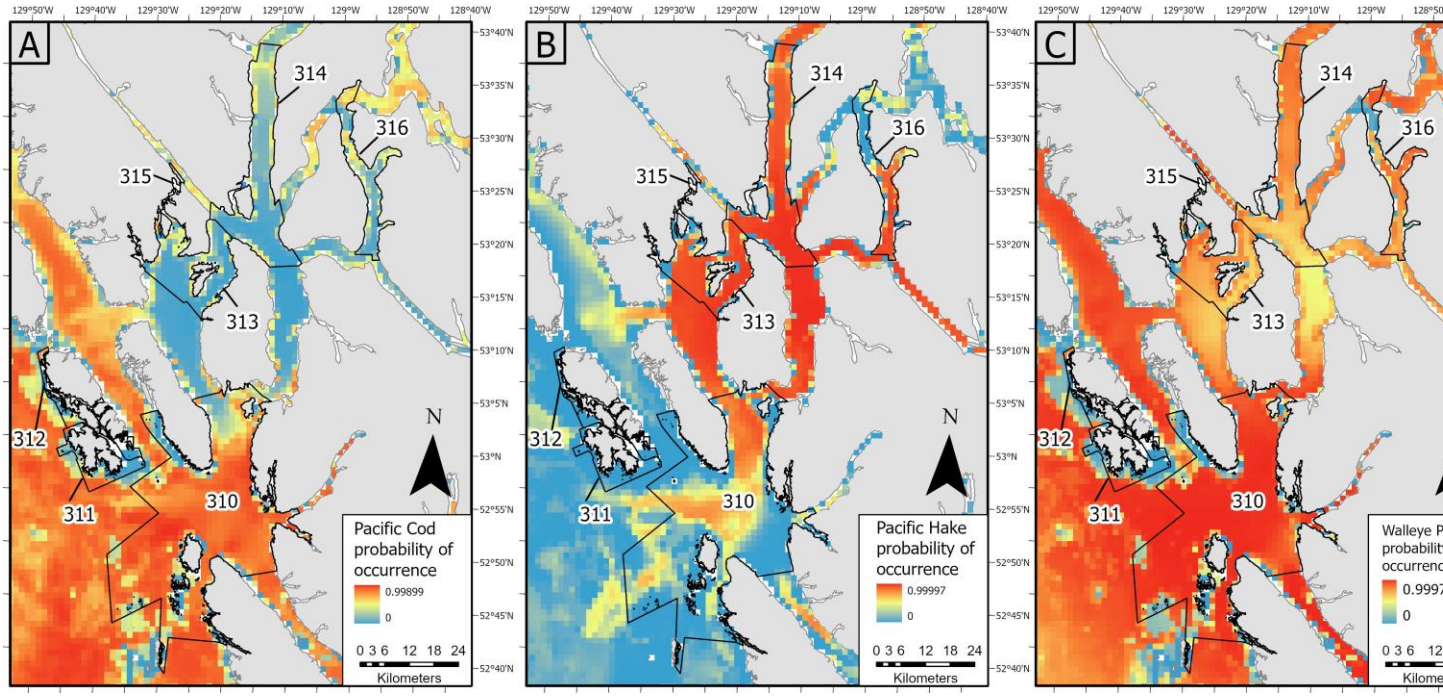

Figure 68, **Table 37**) and are considered E-CPs in the NSB. Although these three species are not Zone-level network conservation objectives, their variable abundance affects many other species in the ecosystem and are important stocks for commercial fisheries. Walleye Pollock, **k'a'wts**, are mainly caught by midwater and bottom trawl gears, whereas **balaas** are caught mainly by midwater trawl in BC. Both trawl fisheries are infrequently found in the Caamaño-Douglas area (See **Table 36** and **Table 21**).

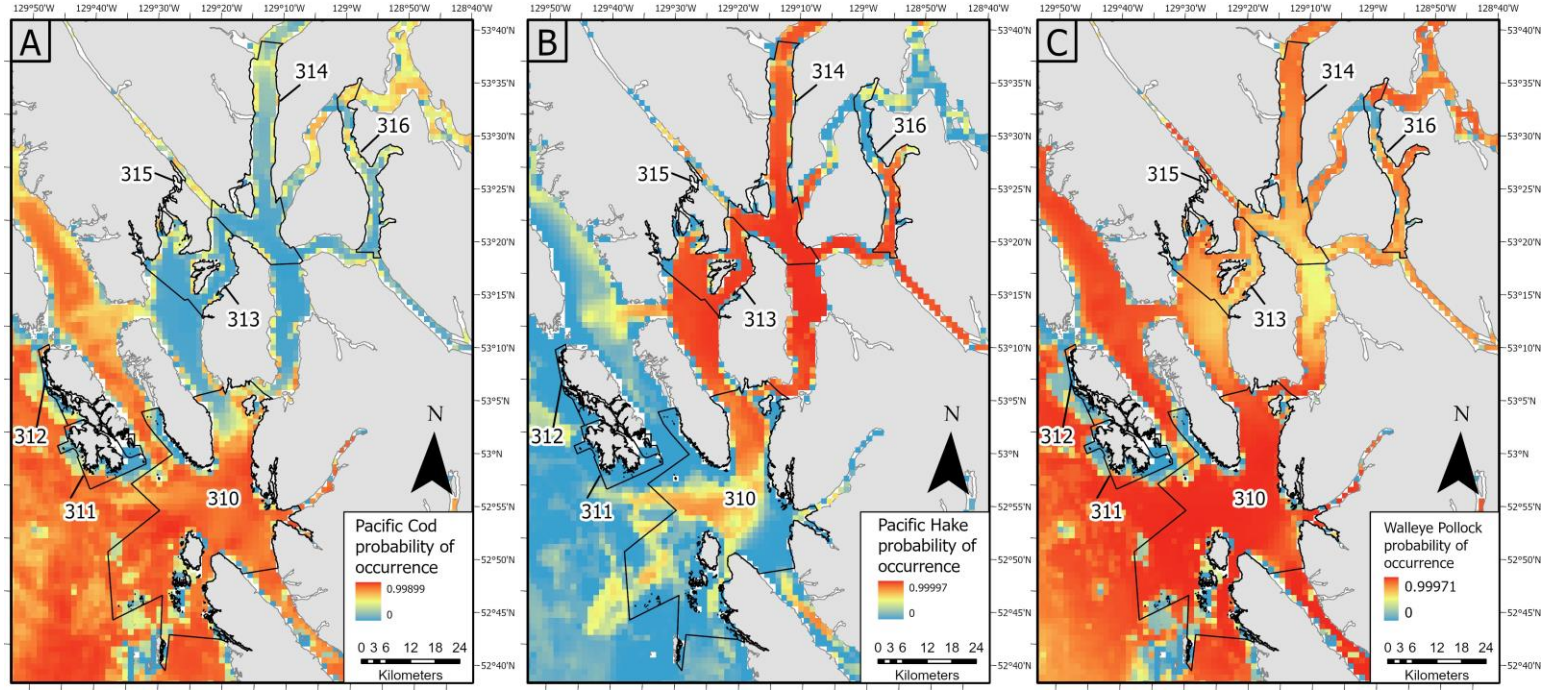

***Figure 68**. Summed predicted species density values per grid cell (Species Richness) for roundfish species in the Caamaño Sound and Douglas Fjord System Network Zones using the Thompson et al. (2023b) groundfish species integrated model. The multi-species distribution model integrates presence-absence data across surveys and gear types, allowing predictions of coastwide distributions of 66 groundfish species in British Columbia. Presence-absence records of all groundfish species with at least 150 observations from 2003 to 2020 were used. Only groundfish species that are ecological conservation priorities in the Northern Shelf Bioregion are included in the species richness value reported here: A) **k'a'wts/ƛáx̌dala/k'a'w'ts**/Pacific Cod, B) **Balaas**/Pacific Hake, and C) Walleye Pollock.*

Table 37. *Roundfish species occurrence in the Caamaño Sound and Douglas Fjord System Network Zones. Occurrence is presented as direct observation of the species within the boundaries of each Zone. Species occurrence is denoted by an X and shaded in green, a dash indicates no occurrence data (not the same as an absence).*

Common name	Scientific Grouping	Zone 310	Zone 311	Zone 312	Zone 313	Zone 314	Zone 315	Zone 316	Data source
k'a'wts/ ƛáx̌dala/ ḵ'a'w'ts/ Pacific Cod	*Gadus macrocephalus*	X	X	X	X	X	X	X	DFO survey, K. Clifton, Pers. Comm
Balaas Pacific Hake	*Merluccius productus*	X	X	X	X	-	-	-	DFO survey
Walleye Pollock	*Theragra chalcogrammus*	X	X	X	X	-	-	-	DFO survey

DFO survey: DFO data from synoptic trawl surveys (2003-2016), outside hard-bottom longline surveys (2006-2016),* and *random*-stratified **hadanii/**hadanii***/sablefish trap surveys (2003-2016).*

K'a'wts / Walleye Pollock

K'a'wts/Walleye Pollock are known to undergo diurnal (daily) vertical migrations along the water column. Their prey species include crustaceans, hake, squid, sand lance, and **tskah**/**wáṅi**/ **tsk̲ah**/herring. In turn, they are prey species for at least 78 species in the NSB (Gale et al. 2019) including marine mammals, sea birds, and fish. Due to their influence on many species, **k'a'wts** population dynamics have been implicated to affect other important species such as marine birds and marine mammals (e.g., Springer 1992, Rosen and Trites 2000, Fritz and Hinckley 2005). An important area for **k'a'wts** spawning is located in Whale Channel which has a slight overlap with the boundaries of Zones 310 and 316 (Clarke and Jamieson, 2006). This spawning area was identified in 1985 by the West Coast Offshore Exploration Panel and by DFO groundfish expert opinion (Clarke and Jamieson, 2006), although follow-up research and anecdotes on the importance of the area to **k'a'wts** is lacking. Status for the BC North stock (which includes area 5C) in 2017 indicated high probability of being above the Limited Reference Point and Upper Stock Reference, meaning conservation action is not yet considered necessary by federal management (DFO 2018c). Despite this, population abundance was projected to decline in subsequent years. As of this report, an updated population assessment of **k'a'wts** has not yet been conducted; therefore, these projections are less certain for recent years.

Balaas / Pacific Hake

Balaas/Pacific Hake is the most abundant commercial stock in the California Current system (Edwards et al. 2022) and was the most abundant species commercially caught in the Caamaño-Douglas area (PFMA 6) between 1998 and 2008 (Watson et al. 2010). **Balaas** are

highly migratory and are important for nutrient transport in and out of the NSB region, although not much is known about their contributions to the Caamaño-Douglas area specifically. Spawning occurs during the winter season in coastal areas and aggregations are found in the mid-water continental shelf and slope. The highest densities are located in bottom depths of 200-300 m. Juveniles are found in nearshore waters whereas older individuals are found in deeper waters. During El Nino (warmer) events, a larger proportion of stock migrates into BC waters, whereas a smaller population is found during La Nina (cooler) years. There are at least 60 known predator species of **balaas** (Coad 1995, Love 2011). Of note, studies have examined the decreased abundance of **balaas** in relation to increased abundance of their predator, Humboldt squid (Stewart et al. 2014, Taylor et al. 2015). This population is modelled as a single stock throughout the west coast of Canada and the United States. Coastwide stock assessments for both countries were found in the healthy zone with respect to reference metrics set by DFO (Edwards et al. 2022). The highly variable recruitment rate of **balaas** and the fluctuations in population biomass were sources of high uncertainty for population modelling (Edwards et al. 2022). For a detailed species profile on **balaas** please refer to Hunter and Wade (2015).

K’a̲’wts/ ƛáx̌dala/ K'a'w'ts/ Pacific Cod

K’a̲’wts/ ƛáx̌dala/ k̲'a'w'ts/Pacific Cod is a fast-growing generalist predator found in depths below 200 m and have limited migrations. Their diets include marine invertebrates (**k'almoos/ kɬnákʷ/k̲'a̲lmoos**/crabs and **gasgos/sísíuɬ**/shrimps), and Pacific Sand Lance, and **Tskah/wáṅi/tska̲h**/Pacific Herring (Westrheim 1996). Variation in **k’a̲’wts/ ƛáx̌dala/ k̲'a'w'ts/** predation may affect **Tskah/wáṅi/tska̲h** abundance and recruitment (Walters et al. 1986). In turn, they are eaten by **txaw/mumegʷezu/txaw**, **ga̲gaats/q̓ʷaǧʷina/ga̲sgaatsk**/dogfish, and pinnipeds (Westrheim 1996). **K’a̲’wts/ ƛáx̌dala/ k̲'a'w'ts/** was one of the most abundant species (after Walleye Pollock) commercially caught in Pacific Fisheries Management Area 6 between 1998 and 2008 (Watson et al. 2010). Poor recruitment since the 1990s may be linked to a recent decline in Hecate Strait stocks, and the most recent assessment placed **k’a̲’wts/ ƛáx̌dala/ k̲'a'w'ts/** stocks in the Cautious Zone (Forrest et al. 2020). Genetic population differentiation was found to be uncertain for BC stocks (Forrest et al. 2015).

6.2.3.1.1.4 Other Groundfish

In addition to the **ts'mhoon**/rockfish, flatfish and roundfish, other groundfish species live and feed on or near the bottom of the Pacific Ocean, utilizing mud, sand, or gravel habitats. Two species found within the Network Zones (**Table 35**) are E-CPs and Zone-level network conservation objectives in the MPA Network, **wa̲t’ukw/núɬem/wa̲t'ukw**/Lingcod and **hadanii/hadanii**/Sablefish (Gale et al. 2019). The species are distributed throughout the Network Zones, particularly in the coastal areas of Zone 313 according to the model by Thompson et al. (2023b) (**Figure 69**). More details for these two species are provided below.

Table 38. *Other groundfish species occurrence in the Caamaño Sound and Douglas Fjord System Network Zones. Occurrence is presented as direct observation of the species within the boundaries of each Zone. Species occurrence is denoted by an X and shaded in green, a dash indicates no occurrence data (not the same as an absence).*

**DFO survey: DFO data from synoptic trawl surveys (2003-2016), outside hard-bottom longline surveys (2006-2016), and random-stratified hadanii/hadanii/sablefish trap surveys (2003-2016).*

Common name	Scientific Grouping	Zone 310	Zone 311	Zone 312	Zone 313	Zone 314	Zone 315	Zone 316	Data source
Wat'ukw Núłem Wat'ukw Lingcod	Gadus macrocephalus	X	X	X	-	-	-	X	DFO survey
Hadanii Hadanii Sablefish	Merluccius productus	X	X	X	X	X	-	X	DFO survey

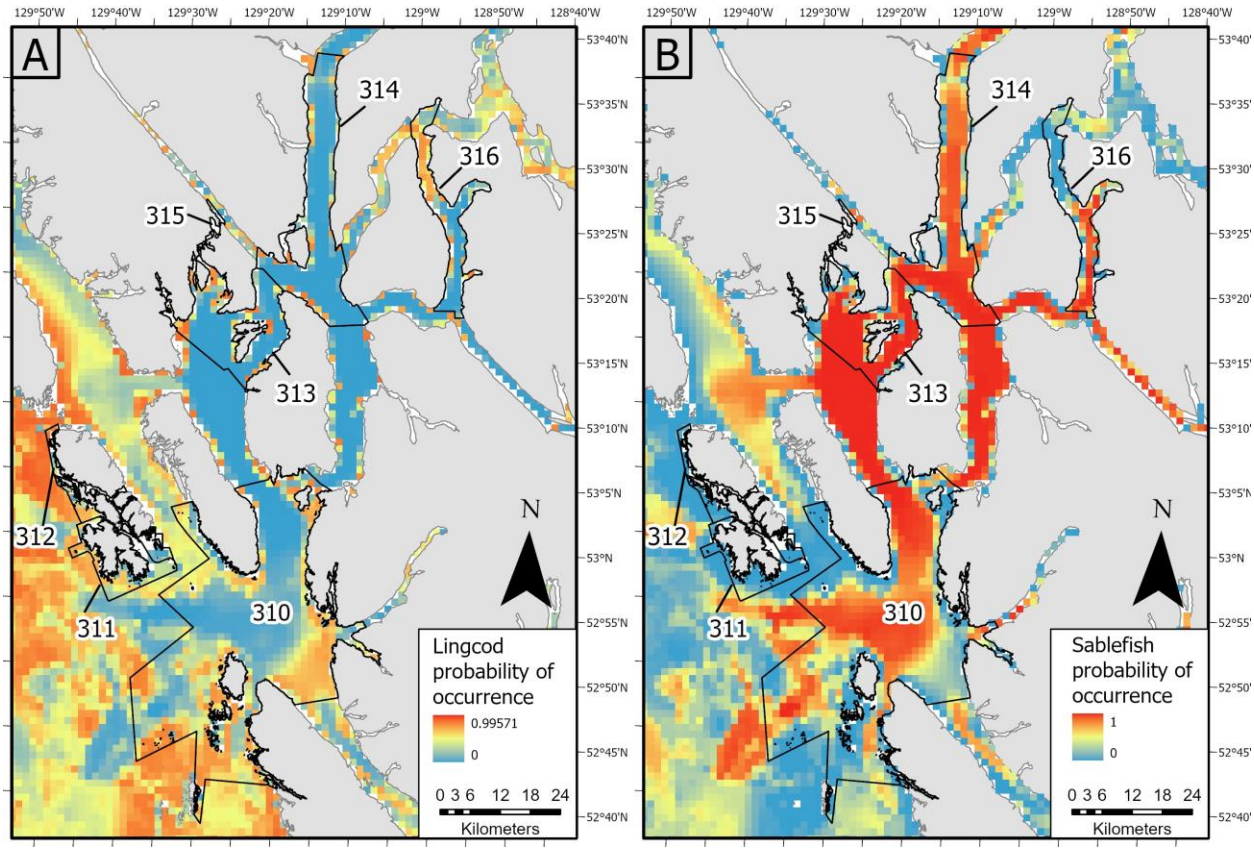

Figure 69*. Summed predicted species density values per grid cell (Species Richness) for other groundfish species in the Caamaño Sound and Douglas Fjord System Network Zones using the Thompson et al. (2023b) groundfish species integrated model. The multi-species distribution model integrates presence-absence data across surveys and gear types, allowing predictions of coastwide distributions of 66 groundfish species in British Columbia. Presence-absence records of all groundfish species with at least 150 observations from 2003 to 2020 were used. Only other groundfish species that are ecological conservation priorities in the Northern Shelf Bioregion are included in the species richness value reported here: A) Lingcod and B) Hadanii/hadanii/sablefish.*

Wa̲t’ukw/ Núłem/ Wa̲t'ukw / Lingcod

Wa̲t’ukw/núłem/wa̲t'ukw/Lingcod (*Ophiodon elongatus*) are commonly found in nearshore rocky habitats between 10 to 100 m, although their range goes to 450 m in depth. Tagging studies of **wa̲t’ukw/núłem/wa̲t'ukw** revealed a majority of high site fidelity to their spawning grounds alongside other behaviours including frequent and large-scale movement (Starr et al. 2011; Freiwald 2012). **Wa̲t’ukw/núłem/wa̲t'ukw** diet was found to be highly variable and includes many fish species, including **Tskah/wáṅi/tska̲h**/Pacific herring and English Sole in Hecate Strait (Pearsall and Fargo 2007), crustaceans, cephalopods, and other lingcod (Cass et al. 1990, Beaudreau and Essington 2007). Predators include **üüla/sa̲g̃ʷam**/seals and **t’iibn/ƛ̓ix̌’én**/sea lions (Cass et al. 1990). A unique characteristic of **wa̲t’ukw/núłem/wa̲t'ukw** is parental care for their egg masses, which are deposited in shallow (< 100 m) nearshore waters from December until March. **Wa̲t’ukw/núłem/wa̲t'ukw** larvae hatch between March and April, and drift as plankton for 3 to 9 weeks before settling on flat benthic habitats as juveniles (Phillips and Barraclough 1977, Marko et al. 2007). Habitats with structural complexity, such as areas with high rugosity, **gadza k’aw**/eelgrass, and kelp beds, are important for juvenile and adult **wa̲t’ukw/núłem/wa̲t'ukw** (Cass et al. 1990, Petrie and Ryer 2006). Zones 310, 311, and 312 may be important habitats for **wa̲t’ukw/núłem/wa̲t'ukw**, as those Zones have similar depth and habitat complexity presence.

Tagging studies in BC have shown strong site fidelity (King and Withler 2005; Freiwald 2012). For example, Cass et al. (1990) showed a majority (95%) of fish staying within 10 km of their tagging locations, and only a few migrated over 50 km. Juveniles tend to migrate further than adults (Cass et al. 1990, Smith et al. 1990), although specific details within the NSB are unknown (Gale et al. 2019). Male **wa̲t’ukw/núłem/wa̲t'ukw** will aggregate during winter inshore spawning grounds and migrate back to nearshore areas in the summer seasons (Cass et al. 1990; Martell et al. 2000). Females spend shorter time in spawning grounds (Cass et al. 1990). **Wa̲t’ukw/núłem/wa̲t'ukw** is a traditional and commercial harvest species for the Gitga’at nation that is harvested in winter (Gitga’at Marine Use Plan, 2015).

Wa̲t’ukw/núłem/wa̲t'ukw/lingcod are primarily caught using trawl gear, which has limited presence within the Caamaño-Douglas area (See **Table 21**). The other catch method is using hook and line gear (including handline, longline, and troll), which are present within Zones 310, 311, and 312. Population stocks in area 5C were last assessed over a decade ago and determined to be in the Healthy Zone (King et al. 2012). Although it is unlikely that inside (Strait of Georgia) stocks mix with outside Northern Shelf Bioregion stocks (Cass et al. 1990), genetic population structuring for **wa̲t’ukw/núłem/wa̲t'ukw** in BC waters are unknown.

Hadanii / Hadanii / Sablefish

Hadanii/hadanii/sablefish (also known as black cod; *Anoplopoma fimbria*) are one of the seven main BC commercial groundfish sectors and mainly caught by longline hook and trap gear (Lacko et al. 2020). Annual surveys are conducted by the BC Sablefish Research and Assessment Survey Program. One survey component is the tag and release at standardized locations in four mainland inlet locations – including **K'ts'ats'aas**/Gil Island (Zone 313; very close to Zones 310 and 316). The Central Mainland EBSA was identified as an important **hadanii/hadanii** spawning areas (See Map 19 in Clarke and Jamieson 2006). This location is westward of the boundaries of Zones 310, 311, and 312. **Lax Kwil Dziist**/Fin Island and Blossom Point (Farrant Island) surrounding Zone 313 was described as an important are for fishing **hadanii/hadanii** (Marsden, 2012).

Juvenile **hadanii/hadanii** feed on crustaceans, midwater fish, and importantly, **Tskah/wáṉi/tsk̲ah**/Pacific Herring (Laidig et al. 1997, Buckley et al. 1999, Coutré et al. 2015). Adult **hadanii/hadanii** will feed on demersal fish, cephalopods, and other fish species including juvenile **hoon/qeqapela**/salmon, **ts'mhoon** /rockfish, and **balaas**/Pacific Hake (Coutré et al. 2015). While adult **hadanii/ hadanii** tend to inhabit and spawn in depths of 300-500 m in the edge of the continental shelf, Larvae and juvenile (up to 12 weeks of growth) **hadanii/hadanii** drift shoreward to coasts and inlets like the Caamaño-Douglas area. Juvenile **hadanii/hadanii** remain over winter and migrate offshore to slope habitats in the late summer once they reach 400-600 mm (Rutecki and Varosi 1997). This pattern is confirmed by recent **hadanii/hadanii**/ Sablefish Research and Assessment surveys near **K'ts'ats'aas**/Gil Island (Zone 313) in October 2018 and November 2019 (Lacko et al. 2021). The mean fork length of **hadanii/hadanii** caught were 54.0 cm and 53.6 cm for the years 2018 and 2019 respectively, indicative of juvenile **hadanii/hadanii** lengths. Survey results for inlets, including **K'ts'ats'aas**/Gil Island, showed higher proportions of female **hadanii/hadanii** were caught compared to males (58-74% females) (Lacko et al. 2020). For a detailed species profile on **hadanii/hadanii** please refer to Hunter and Wade (2015).

Hadanii/hadanii population declines were seen in the past three decades, leading to reduced harvesting opportunities. The most recent fisheries management plan from DFO (2020b) showed an increase from a “Cautious” stock status to “Healthy” stock status under DFO’s Precautionary Approach Framework (DFO 2009c). Further updates to operating models and management procedures are scheduled for 2022 - 2024 (DFO 2020b). Previous BC **hadanii/ hadanii** assessments and management strategy evaluation work have demonstrated that low recruitment (on average) over the past three decades has contributed to a long-term decline in spawning stock biomass and harvest opportunities. Research by Stocker and Cass (2001) show one genetic population, although differences in recruitment and growth patterns may indicate two distinct stocks in BC waters, divided by northern Vancouver Island. More recent genetic analyses supported one genetic population throughout its range in the Pacific Northwest from Alaska to Baja, California (Tripp-Valdez et al. 2012).

6.2.3.1.2 Pelagic fishes

Pelagic fish are comprised of free swimming species that live in the water column of the coast or open ocean. They have been grouped below into three groups by ecological similarity: forage fish and salmonids.

6.2.3.1.2.1 Forage Fishes

Forage fish are small to intermediate-sized marine fish that generally occupy low to middle trophic levels (mostly consuming zooplankton) and are consumed by a wide variety of marine predators, including fish, marine mammals, reptiles, and marine birds. Other characteristics of forage fish include small body size, high fat content and energy density, and the ability to form dense aggregations, which makes it easy for predators and humans to capture in large quantities (Gale et al. 2019). As a result, their population may be drivers of diversity and health of the broader coastal ecosystem. Humans also have many commercial and cultural uses for forage fish, including for seasonal harvest as food, cooking, trade, bait, and use as animal feed.

Tskah/Wáṉi/Tsk̲ah/Herring and **ha'limootk/ƛ̓áti/ẅa̲h**/eulachon have been identified as E-CPs and Zone-level Ecological Conservation Objectives (Gale et al. 2019, MPA Network BC Northern Shelf Initiative 2023) and are further described below. Although their predicted occurrence in the Network Zones is predominantly limited to the outer regions of the Caamaño-

Douglas area (**Figure 70**) observations of both species occur throughout the Network Zones (**Table 41**). There is a large data gap in the occurrence, distribution, feeding ecology, and ecosystem interactions for other BC forage fish (e.g., Pacific Sand Lance, Surf Smelt, Pacific Sardine) throughout the NSB. A common trend observed in forage fish populations across the BC coast is their population decline. Research have pointed to multiple co-occurring factors to explain these broader trends, and future studies could also examine local stressors that may be affecting local populations within the Northern Shelf Bioregion. For a detailed species profile on **hadanii/hadanii**/sablefish please refer to Hunter and Wade (2015).

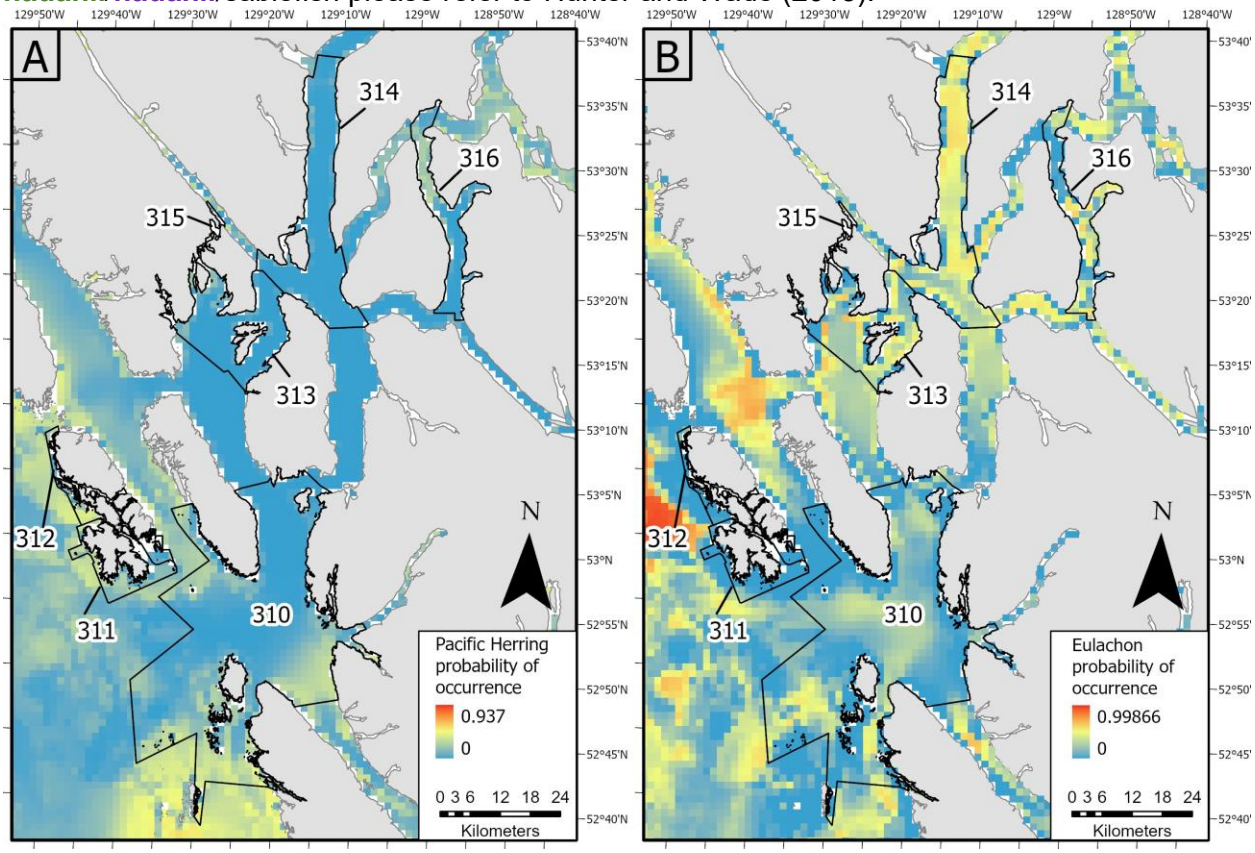

***Figure 70**. Summed predicted species density values per grid cell (Species Richness) for forage fish in the Caamaño Sound and Douglas Fjord System Network Zones using the Thompson et al. (2023b) groundfish species integrated model. The multi-species distribution model integrates presence-absence data across surveys and gear types, allowing predictions of coastwide distributions of 66 groundfish species in British Columbia. Presence-absence records of all groundfish species with at least 150 observations from 2003 to 2020 were used. Only forage fish species that are ecological conservation priorities in the Northern Shelf Bioregion are included in the probability of occurrence model here: A) **Tskah/wáṅi/tskaḵh**/Pacific Herring and B) **Ha'limootk/ƛ̓áti/ẅaḵh**/eulachon.*

Table 39. *Forage fish species occurrence in the Caamaño Sound and Douglas Fjord System Network Zones. Occurrence is presented as direct observation of the species within the boundaries of each Zone. Species occurrence is denoted by an X and shaded in green, a dash indicates no occurrence data (not the same as an absence).*

Common name	Scientific Grouping	Zone 310	Zone 311	Zone 312	Zone 313	Zone 314	Zone 315	Zone 316	Data source
Tskaḥ/ wáṅi/ tskaḥ/ Pacific Herring	Clupea pallasii	X	X	X	X	X	X	X	DFO survey, K. Clifton pers. Comm.
Ha'limootk/ ƛ̓áti/ ẅaḥ/ Eulachon	*Thaleichthys pacificus*	-	-	-	-	X	-	X	DFO survey

DFO survey: DFO data from synoptic trawl surveys (2003-2016), outside hard-bottom longline surveys (2006-2016), and random-stratified **hadanii/**hadanii**/sablefish trap surveys (2003-2016).*

Tskah/ wáṅi/ tskaḥ/ Herring

Tskah/**wáṅi**/**tskaḥ**/Pacific Herring (*Clupea pallasii*) are among the most important fish in the Pacific Northwest marine food web and for coastal First Nations. The high lipid content in every life stage makes **tskah**/**wáṅi**/**tskaḥ** important prey to many groundfish, marine mammals, and birds will prey on **tskah**/**wáṅi**/**tskaḥ** in all life stage forms due to their high lipid content (Logerwell and Schaufler 2005). There are at least 52 species that eat **tskah**/**wáṅi**/**tskaḥ** in the Northern California Current ecosystem (Szoboszlai et al. 2015). **Tskah**/**wáṅi**/**tskaḥ** are found in offshore Hecate Strait and Queen Charlotte Sound for feeding in the summer and migrate inshore to prepare for annual winter spawn in sheltered inlets and bays. Thus, **tskah**/**wáṅi**/ **tskaḥ** are harvested in the winter and **s'waanx**/**'á'ent**/**xs'waanx**/herring roe are harvested in the winter and early spring by Gitga'ata (Satterfield et al. 2012; Gitga'at Marine Use Plan, 2015). Annual **tskah**/**wáṅi**/**tskaḥ** spawns greatly contribute to the productivity of the ecosystem. Approximately 1.8% or around 300-600 km of BC's coastline are used by **tskah**/**wáṅi**/**tskaḥ** spawners in a typical season (Hay and McCarter, 2015). **Tskah**/**wáṅi**/**tskaḥ** will lay eggs on kelp, **gadza k'aw**/eelgrass, surfgrass, algae, and other nearshore surfaces. Species like black bears are known to scavenge for **xs'waanx**, transferring marine nutrients into the terrestrial ecosystem (Fox et al. 2014, Fox et al. 2015).

The **tskah**/**wáṅi**/**tskaḥ** fishery is made up of four components: 1) Roe, 2) Spawn on Kelp, 3) Food and bait, and 4) Special Use. Common gears for whole **tskah**/**wáṅi**/**tskaḥ** harvest include seine, gillnet, rake, dip net, and jig. The Caamaño-Douglas area is not one of the DFO **tskah**/**wáṅi**/**tskaḥ** stock assessment areas, although **tskah**/**wáṅi**/**tskaḥ** within Douglas Channel are assumed to belong to the southern Central Coast Stock (Watson et al. 2010). The surrounding Prince Rupert District area in the north borders Zones 314, and 315, whereas the Central Coast area in the south is near Zone 310. For both these stock assessment areas, stock biomass and growth have been reported as increasing, although biomass is low when compared to historic levels and have decreased in the past decade (DFO 2021d). Food, Social and Ceremonial fisheries and commercial fisheries with capped levels are open in the 2023 season in Prince Rupert District and Central Coast (DFO 2023g). In all management areas, the mean number of egg layers have decreased since mid-1980s (Hay et al. 2011) and a declining trend for weight-at-age has been observed (Irvine and Crawford 2013).

Known spawning locations were compiled from the DFO **Tskah**/**wáṅi**/**tsk̲ah**/Pacific Herring Spawn and Catch Records and the cumulative habitat spawn index for every spawning event from 1928 to 2016 were mapped for the Caamaño-Douglas area. Habitat spawn index is meant to represent habitat sensitivity along each sampled coastline kilometer, which takes into account magnitude of spawn on the shoreline and the long-term frequency (Hay and McCarter 2015). Spawn Habitat Index is calculated as the measured spawn length (m), product of spawn width (m), and egg layers as percent coverage. Frequency of spawn is factored into this calculation, as herring can spawn multiple times along the same stretch of shoreline over weeks in the same year. This figure is meant to give an overview of the sampled spawning areas, whereas the most recent and ongoing Herring Spawn database for relative biomass (Spawn Index) is available at Pacific Herring Spawn index data - Open Government Portal[44].

Zone 310 was identified as an important area for **tskah**/**wáṅi**/**tsk̲ah** by expert opinion[45] (Clarke and Jamieson 2006). Similarly, Chapple and Emily Carr Inlet within Zone 310 has the highest cumulative **tskah**/**wáṅi**/**tsk̲ah** spawning index in the Caamaño-Douglas area (**Figure 71**). **Tskah**/**wáṅi**/**tsk̲ah** spawn areas and harvest sites are known to be variable but include locations in Zones 310 (Princess Royal Island), 313 and 314 (Wright Sound, around Promise Island, **Txałgiu** /Hartley Bay, and northern tip of **K'ts'ats'aas**/Gil Island), and 316 (near Bishop Bay). **Kwelts'uu**/Cornwall inlet (Zone 310) is another **xs'waanx**/**'á'ent**/**xs'waanx**/herring roe harvesting site that is commonly used (Satterfield et al. 2012).

[44] Pacific Herring Spawn Index Data - Open Government Portal

[45] mpattmetadata.s3.amazonaws.com/mpatt_eco_fish_herring_ia.html

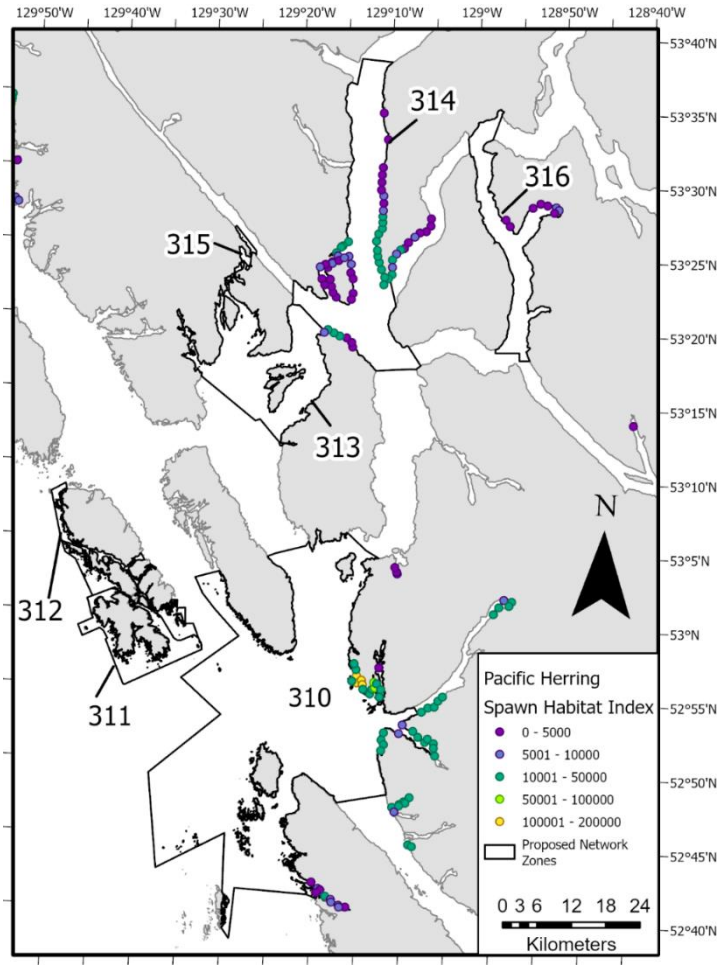

***Figure 71**. Known **Tskah**/**wáṅi**/**tsk̲ah**/Pacific Herring spawn habitats in the Caamaño-Douglas area. Cumulative Spawn Habitat Index from 1928-2015 are shown (Hay and McCarter 2015). Spawn Habitat Index is calculated as the measured spawn length (m), product of spawn width (m), and egg layers as percent coverage. Frequency of spawn is factored into this calculation, as herring can spawn multiple times along the same stretch of shoreline over weeks in the same year.*

Ha'limootk / X̌áti / ẅa̲h / Eulachon

The Sm'algyax name for Eulachon (also Oolichan and candlefish; *Thaleichthys pacificus*) is **ha'limootk**, which translates into 'Saviour fish', signifying the cultural importance of this fish for many coastal First Nations (Hartley Bay Council 2012).
An elder describes in Satterfield et al. (2012):

> "…Eulachon was known as a saviour fish because … - even though we live by the sea, often you can't get out in the wintertime to get anything because it's too bad out – and so many people were starving long ago when the spring came. And you would eat just the broth from the boiled eulachon and then you would put the bones back into the river or the water, the sea, to return them to their home."

High lipid content within their bodies (up to 15-20% of their body weight, making it the highest of any known marine species) makes **ha'limootk**/**X̌áti**/**ẅa̲h**/herring a highly desired fish for both

people and their predators (Willson et al. 2006). For many First Nations, **ha'limootk/ƛ̓áti/ẅa̱h** grease is used as a culinary and medicinal ingredient and trade item with inland Nations. They are also prey species for many fishes (**hoon/qeqapela**/salmon, **txaw/mumegʷezu/txaw**/Pacific Halibut, Walleye Pollock, **ts'mhoon**/Rockfish etc.), marine mammals (**replaceme/ƛ̓ix̌'én**/Sea lions, porpoises, Humpbacks), and marine birds. **Ha'limootk/ƛ̓áti/ẅa̱h** are anadromous and semelparous fish, which means they return to the same rivers to spawn and the vast majority die after a single spawning event (Willson et al. 2006). This site fidelity creates fine-scale genetic population structuring in BC (Beacham et al. 2005) and larger population differentiation among 1) Northern California to the Fraser River, 2) southeast Alaska and the central and north coast, and 3) the Gulf of Alaska (Sutherland et al. 2020). Non-spawning **ha'limootk/ƛ̓áti/ẅa̱h** are found in the continental shelf in depths of 50 to 200m.

In BC, there are 25 known **ha'limootk/ƛ̓áti/ẅa̱h** spawning rivers, with a possible additional 15 based on anecdotal information (DFO 2023d). Across the coast, **ha'limootk/ƛ̓áti/ẅa̱h** populations have been in decline in the past 30-40 years. While there are no Important Spawning areas within the seven Network Zones, the northern Douglas Channel and Kitimat River system have been ranked as highly important for **ha'limootk/ƛ̓áti/ẅa̱h** spawning by expert opinion[46] (Clarke and Jamieson 2006). **Ha'limootk/ƛ̓áti/ẅa̱h** spawning in the Kitimat River is culturally significant to the Haisla (North Coast Marine Plan, 2015). Unfortunately, there have been drastic declines in the Kitimat River, and spawning biomass was estimated to be at zero in 2011. There are many reasons that may explain coastwide population declines including bycatch, habitat degradation, changes in ocean and freshwater conditions, and predation (COSEWIC 2011a; Gustafson et al. 2012). The Central Pacific Coast population (i.e., south of the **Ksyen**/Skeena River and north of the Fraser River) was designated Endangered in 2011 (COSEWIC), whereas the Nass and **Ksyen** Rivers populations were described as stable and of special concern status (COSEWIC 2013a). There are ongoing survey efforts to detect **ha'limootk/ƛ̓áti/ẅa̱h** using environmental DNA through the Haisla Nation and university collaborators (M. Jacobs, pers. comm. 2023). Of the 12 systems that historically supported **ha'limootk/ƛ̓áti/ẅa̱h**, presence was detected in 9 systems and may be encouraging news for recovery (M. Jacobs, pers. comm. 2023).

In the spring and winter, Gitga'ata primarily travel to the Kemano River in the North Coast for **ha'limootk/ƛ̓áti/ẅa̱h** followed by preference for the Skeena then Nass River (K. Clifton, pers. comm. 2023). Nowadays, Gitga'ata trade their dried **txaw/mumegʷezu/txaw** and **ła'ask/lhlaˈq̓s/ła̱'a̱sk**/seaweed for **ha'limootk/ƛ̓áti/ẅa̱h** grease from the Nisga'a (Satterfield et al. 2012). Although **ha'limootk/ƛ̓áti/ẅa̱h** are still observed in certain rivers and throughout Caamaño-Douglas area, there aren't enough that return to rivers for harvesting (K. Clifton, pers comm.). **Ha'limootk/ƛ̓áti/ẅa̱h** continues to be desired, invoked, and mourned (Satterfield et al. 2012).

6.2.3.1.2.2 Salmonids

The five species of **Hoon/qeqapela**/Pacific Salmon (*Onchorynchus sp.*) are among the most recognizable and important species for the entire Pacific Northwest region. Hyatt et al. (2007) provides a comprehensive summary of **Hoon/qeqapela** in the NSB including details of their life histories, habitat context, ecological linkages, and information gaps. In summary, **hoon/qeqapela** are represented by five species, **yee/k̓áp̓i/xyi'i**/Chinook (*O. tshawytscha*),

[46] mpattmetadata.s3.amazonaws.com/mpatt_eco_fish_eulachon_spawn.html

gayniis/ **gʷaxenis**/**gaayniis**/Chum (*O. keta*), **üük**/**zúen**/**üüxs**/Coho (*O. kisutch*), **misoo**/**hísen**/**miso'o**/Sockeye (*O. nerka*), and **sti'moon**/Pink (*O. gorbuscha*), and are all E-CPs for the NSB and identified as Zone-level Conservation Objectives for the Inner Fjord Zones of 314 and 316. What makes **hoon**/**qeqapela** unique are their timely migrations and semelparous anadromy. These fishes are born in freshwater systems, then undergo marine migrations, and return to the same freshwater sites to spawn once and die. **Hoon**/**qeqapela** are important prey species to many charismatic mammals of the Pacific Northwest such as eagles, bears, and **'naaxł** /**hélx̄'inix̄ʷ**/**niixł**/killer whales. Northern and Southern Resident **'naaxł** /**hélx̄'inix̄ʷ**/**niixł**, for example, rely heavily on energy-rich **yee** for a majority of their diet in critical habitats (DFO 2010b). As much as 75% of BC's total **hoon**/**qeqapela** production are from the Northern Nass and **Ksyen**/Skeena River and the Fraser River in the South (DFO 2022g). Therefore, most information about migration patterns is from those areas. Not knowing the migration behavior of **hoon**/**qeqapela** from the Central and North Coast region presents a knowledge gap.

Throughout their life history, **hoon**/**qeqapela** will make use of many important habitats such as juveniles in estuaries, **gadza k'aw**/eelgrass, and kelp beds, adults in the pelagic ocean, and spawning adults and eggs in freshwater streams, rivers, and lakes. These habitats are found throughout the Caamaño-Douglas area and Network Zones. This extensive migration serves to transport many marine nutrients to freshwater and terrestrial ecosystems. Maintaining healthy **hoon**/**qeqapela** habitats in all life stages ensures a diverse and productive ecosystem (Hyatt et al. 2007).

Other Salmonids are differentiated by their diverse life histories within the same population and iteroparity – the ability to spawn multiple times. Along with the five Pacific **hoon**/**qeqapela**, **meliit**/Steelhead trout (*O. clarkii*), **laaẅ**/Rainbow trout (*O. mykiss*), and Dolly Varden char (*Salvelinus malma malma*) are also E-CPs identified for the NSB. Other Salmonids are also harvested as resources and mostly caught in recreational fisheries. Abundance, distribution, life history, and ecological research in the NSB for other salmonids is scarce compared to the **hoon**/**qeqapela**.

All five **hoon**/**qeqapela** are critically important food, ceremonial, and cultural resources for coastal First Nations. Processed **hoon**/**qeqapela** (i.e., smoked, canned, dried, and frozen) can sustain families over winter months (Satterfield et al. 2012). The **Txałgiu** /Hartley Bay hatchery situated in Zone 314 was established in 1982 and aids in the production of native **hoon**/**qeqapela** stocks for the surrounding lakes and areas (K. Clifton, pers. comm. 2023). The Kitimat Hatchery is a major operational Hatchery run by DFO's Salmonid Enhancement Program located far upstream of Douglas Channel and produces **hoon**/**qeqapela** for mostly Harvest Enhancement Objectives. In recent years, **hoon**/**qeqapela** across BC have experienced increased pressures from climate change, habitat loss, fishing, and a multitude of factors. Local populations in the Caamaño-Douglas area available for First Nations harvest may have also recently been stressed by fishery pressures (K. Clifton, K. Cripps, pers. comm. 2023) and annual local conditions.

The Salmon Integrated Fisheries Management Plan – Northern BC (DFO 2022g) has a recent comprehensive summary of the **hoon**/**qeqapela** fishery and management measures which includes Pacific Fishery Management Area (FMA) 6 (Caamaño-Douglas area). The Wild

Salmon Policy[47] classifies BC **hoon**/**qeqapela** populations into standardized Conservation Units (CU) which are informed by reproductive isolation, similar life history traits, and ecological diversity (DFO 2008). The CUs for each species are defined as “groups of wild salmon living in an area sufficiently isolated from other groups that, if extirpated, are very unlikely to be recolonized within an acceptable time frame” (DFO 2008). There are a total of two CUs each for **yee**/**ḵáp̓i**/**xyi'i**/Chinook, **üük**/**zúen**/**üüxs**/Coho, **gayniis**/**gʷaxenis**/**g̱a̱yniis**/Chum, river **misoo**/**hísen**/**miso'o**/Sockeye, and **sti’moon**/Pink (odd and even years) salmon in the Caamaño-Douglas area (**Figure 72**). Every lake **misoo**/**hísen**/**miso'o** population is a distinct unit and are outlined in **Figure 72**. The Pacific Salmon Foundation summarizes trends of CUs throughout BC and as of 2017, overall CUs in the Central Coast area, including the Caamaño-Douglas CUs, show four out of five **hoon** species experiencing declines or poor returns in run size and whereas **sti’moon** (odds and evens) shows an increasing trend (DFO 2022g). All five species of **hoon** likely traverse through all Zones of the Caamaño-Douglas area, although confirmed catch occurrence from surveys may not accessible for nearshore areas such as within the boundaries of Zones 311, 312, and 315 (**Table 40**).

[47] Canada's Policy for Conservation of Wild Pacific Salmon | Pacific Region | Fisheries and Oceans Canada

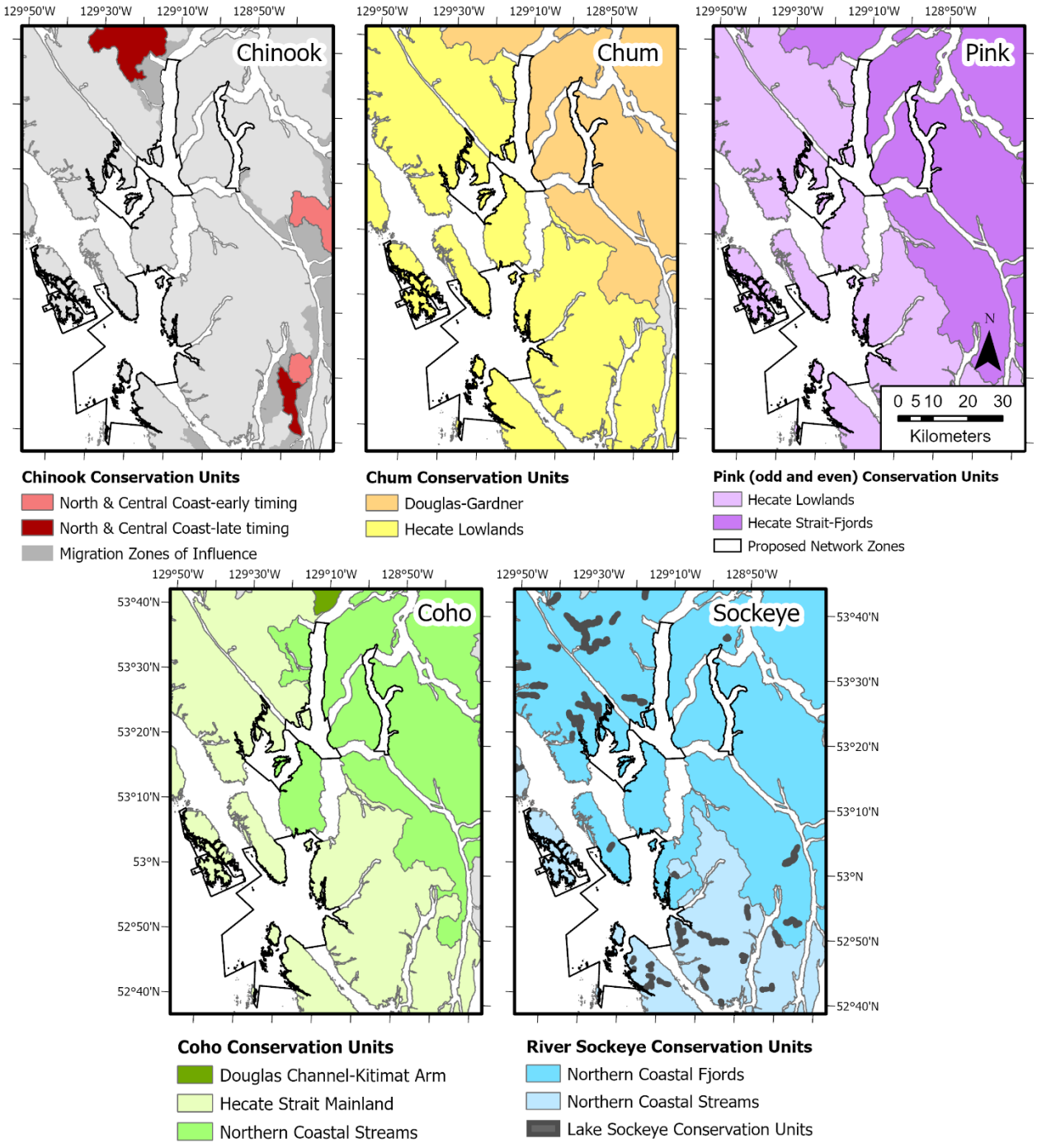

***Figure 72**. Conservation Units for Pacific Salmon in the Caamaño-Douglas area. Note that Lake Sockeye Conservation Units are distinct, and names are detailed in **Table 41.** Caamaño Sound and Douglas Fjord System Network Zones are outlined in black. Spatial data can be accessed from the [Pacific Salmon Foundation – Salmon Watersheds Program (2017)].*

Table 40. *Five Pacific* ***hoon/qeqapela****/Salmon species occurrence in the Caamaño Sound and Douglas Fjord System Network Zones. Occurrence is presented as direct observation of the species within the boundaries of each Zone. Species occurrence is denoted by an X and shaded in green, a dash indicates no occurrence data (not the same as an absence). There is an absent of sampling for Zone 312.*

Common name	Scientific Grouping	Zone 310	Zone 311	Zone 312	Zone 313	Zone 314	Zone 315	Zone 316	Data source
yee kápi xyi'i Chinook Salmon	*Onchorynchus tschawytscha*	X	-	-	X	X	-	-	DFO survey, recreational anecdote
gayniis gʷaxenis gayniis Chum salmon	*Onchorynchus keta*	X	X	-	X	X	X	X	DFO survey
üüx zúen üüxs Coho salmon	*Onchorynchus kisutch*	X	X	-	X	X	X	X	DFO survey
sti'moon qábes sti'moon Pink Salmon	*Onchorynchus gorbuscha*	X	X	-	X	X	X	X	DFO survey
Misoo hísen miso'o Sockeye Salmon	*Oncorhynchus nerka*	X	-	-	X	X	X	X	DFO survey
Species richness		5	3		5	5	4	4	

**DFO Survey: midwater trawl programs (High Seas Salmon 1995-2015, Basin and Coastal Scale Interactions 2016-Present).*

Canada's Wild Salmon Policy assesses the Biological status of Salmon CUs by measuring the spawner-recruitment relationship (Holt 2009; Holt et al. 2018). The "Good/Green" status is conferred to CU abundances predicted to result in 80% long-term maximum sustainable yield under favourable environmental conditions. The "Fair/Amber" status is given to CUs with abundances that would return to maximum sustainable yield levels within one generation with favourable environmental conditions and absence of fishing, and any abundances falling below that would receive a "Poor/Red" status. The New Salmon Escapement Database was used to summarize the total estimated spawning abundance in creeks and streams within the Caamaño-Douglas area (Pacific Fisheries Management Area 6) from 2019 - 2021. The status of the Salmon CUs in the Caamaño-Douglas area is summarized in **Table 41.**

Table 41. *Pacific Salmon Conservation Unit (CU), status of CUs (and year assessed), and total spawners within the CUs in Pacific Fisheries Management Area (PFMA) 6 which contains the whole Caamaño-Douglas area. CU status encompasses the entire spatial boundaries, which may include other FMAs. Spawners were summed from 2019 - 2021. Only Lake Sockeye CUs with data (and the Network Zones nearby) are described below. Please refer to* ***Figure 72*** *for spatial distributions of each CU.*

Species	Conservation Unit (CU) Name	Status of CU (Year)	CU PFMA 6 Spawners (2019-2021)
Yee kápi xyi'i Chinook	North and Central Coast early-timing	Good (2017)	2,677
	North and Central Coast late-timing	Data deficient (2021)	
gayniis gʷaxenis gayniis Chum	Douglas – Gardner	Good (2017)	92,032
	Hecate Lowlands	Fair (2017)	14,810
Üüx Zúen üüxs Coho	Douglas Channel-Kitimat Arm	Good (2017)	15,365
	Hecate Strait Mainland	Good (2017)	7,820
	Northern Coastal Streams	Good (2017)	40,820
sti'moon Pink (Odd)	Hecate Lowlands	Good (2021)	86,173
	Hecate Strait-Fjords	Good (2021)	926,753
sti'moon Pink (Even)	Hecate Lowlands	Poor (2021)	12,220
	Hecate Strait-Fjords	Good (2017)	2,329,641
River misoo/hísen/miso'o/ Sockeye	Northern Coastal Fjords	Data deficient (2021)	
	Northern Coastal Streams	Data deficient (2021)	
Lake misoo/hísen/miso'o/ Sockeye	Txałgiu /Hartley Bay (Zone 314)	Good (2017)	1,550

6.2.3.2 Cartilaginous Fishes

Ksaa/q̓ʷaqʷ-/sharks, gandeh/bakʷ-/skates, and Ratfish are cartilaginous fishes that belong to the Order Elasmobranchs. This group encompasses a wide range of ecological roles, from top level pelagic predators, benthic detritivores, and planktivorous filter feeders. Many cartilaginous fishes have slow growth rates, large sizes, long lifespans, and delayed sexual maturity. These characteristics make them vulnerable to exploitation and population declines. Historical killings

of large **ksaa**/**q̓ʷaqʷ-** as pests or for liver harvest were common in the 20th century and lead to declines in abundance. Population recovery of cartilaginous fishes may be limited due to their life history and population assessments are difficult due to limited survey data and the rarity of many species. For example, the abundance of the Endangered Basking Shark (*Cetorhinus maximus*) has been drastically reduced compared to the historical widespread population in Canada's Pacific and historical catch records have been relied on to inform modern estimates (COSEWIC 2007c).

Two species of Cartilaginous Fishes were identified as Zone-level Conservation Objectives for Zones 316: the Bluntnose Sixgill Shark (*Hexanchus griseus*; Special Concern, COSEWIC 2007d) and the Pacific Sleeper Shark (*Somniosus pacificus*). Pacific Sleeper Shark are known prey for Offshore **'naaxł**/**hélx̄'inix̄ʷ**/**niixł**/Killer Whales and are caught in waters surrounding **K'ts'ats'aas**/Gil Island (Whale & Squally Channels and Wright Sound (including Zones 310, 313 and 314) plus the southern end of the Estevan Group (Zones 311-312) (see Figure 19 in Ford et al. 2014; unpublished data courtesy of J. King, 1996-2012;

Table 42). Pacific Sleeper Sharks are also occasionally bycatch for longline fishing in the area. Local fishers have come to recognize the same individuals caught due to their unique scarring patterns (M. Jacobs, pers. comm. 2023).

There is not much known about the ecology of the Bluntnose Sixgill Shark, however, potential predators may include Stellar sea lions, **zemá**/Elephant Seals, and **‘naaxł/hélx̄’inix̄ʷ/niixł**/ (COSEWIC 2007d). The upwelling conditions and mixing of the Outer Coast Zones, and the large area of Zone 310, may be favourable habitats for the Bluntnose sixgill shark (Ebert 2003; COSEWIC 2007d) and Basking sharks. Indeed, two sightings of Basking sharks were recorded within Zone 310 (2016 and 2017) and two more sightings were recorded near Aristazabal Island (2018-2019) (DFO data courtesy of J. King, retrieved 2023). Previous tagging of Bluntnose Sixgill Sharks revealed that mature females may travel to shallow waters to give birth (Ebert 2003). Additionally, newborn and juvenile **ksaa/q̓ʷaqʷ-** and **gandeh/bakʷ-** may use inlets and shallow waters for protection before migrating to deeper waters in the continental slope (Ebert 2003).

Table 42. *Cartilaginous fish (**ksaa**/ **q̓ʷaqʷ-**/sharks, rays and ratfish) species occurrence in the Caamaño Sound and Douglas Fjord System Network Zones. Occurrence is presented as direct observation of the species within the boundaries of each Zone. Species occurrence is denoted by an X and shaded in green, a dash indicates no occurrence data (not the same as an absence).*

Common name	Scientific Grouping	Zone 310	Zone 311	Zone 312	Zone 313	Zone 314	Zone 315	Zone 316	Data source
Big Skate	*Raja binoculata*	X	X	X	-	-	-	-	DFO survey
Longnose Skate	*Raja rhina*	X	X	X	-	-	-	-	DFO survey
Sandpaper Skate	*Bathyraja interrupta*	X	X	X	-	-	-	-	DFO survey
gagaats/ Spiny Dogfish	*Squalus suckleyi*	X	X	X	X	X	X	X	DFO survey, Ford et al. 2014
Bluntnose sixgill shark	*Hexanthus griseus*	X	-	-	-	X	X	X	DFO survey
Pacific Sleeper Shark	*Somniosus pacificus*	X	X	-	X	X	X	X	DFO survey, Ford et al. 2014
Blue Shark	*Prionace glauca*	-	X	X	-	-	-	-	DFO survey
Salmon Shark	*Lamna ditropis*	-	-	-	X	-	-	-	K. Clifton, pers. comm. 2023
Basking Shark	*Cetorhinus maximus*	X	-	-	-	-	-	-	DFO survey
Species richness		7	6	5	3	3	3	3	

*DFO data = Outside North Hard Bottom Longline Surveys (2006-2016), and **ksaa**/ **q̓ʷaqʷ-**/shark incidental sightings (2010 – 2021).*

Other cartilaginous fish and skate species identified as ecological conservation priorities (Gale et al. 2019) have also been observed in the Network Zones (

Table 42). **Gagaats**/Pacific Spiny Dogfish (Special concern, COSEWIC 2011b) are also common prey for Offshore **‘naaxł/hélx̄’inix̄ʷ/niixł** and are regularly by-caught in longline fisheries in all Network Zones (Ford et al. 2014). Blue sharks (*Prionace glauca*) have been caught in surveys near the Outer Coast Zones (311, 312) and Salmon sharks (*Lamna ditropis*) were described as uncommon to the area (K. Clifton, pers. Comm. 2023). Skate species observed in the Caamaño-Douglas area include big skate (*Raja binoculata*), longnose skate (*Raja rhina*), and sandpaper skate (*Bathyraja interrupta*) (Occurrences in Zones 310, 311, 312). Multiple skate species and Spotted ratfish (*Hydrolagus colliei*) are reported throughout the Network Zones (K. Clifton, pers. comm. 2023). The Network Zones provide habitat for cartilaginous fish and skate species throughout their extent, with the highest specie richness occurring in Zone 310 (**Figure 73**).

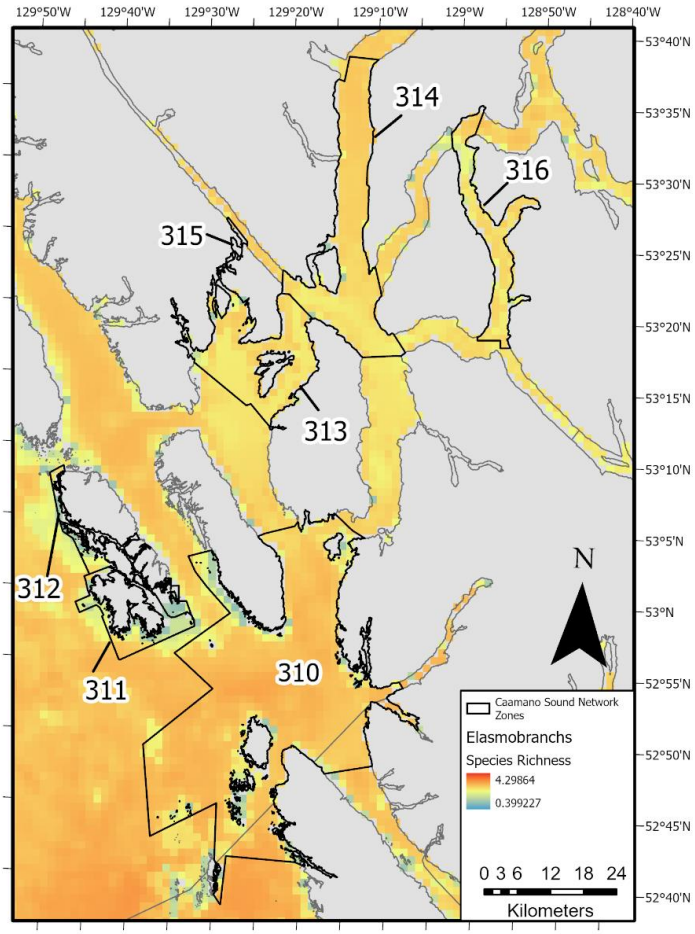

Figure 73*. Summed predicted species density values per grid cell (Species Richness) for elasmobranchs in the Caamaño Sound and Douglas Fjord System Network Zones using the Thompson et al. (2023b) groundfish species integrated model. The multi-species distribution model integrates presence-absence data across surveys and gear types, allowing predictions of coastwide distributions of 66 groundfish species in British Columbia. Presence-absence records of all groundfish species with at least 150 observations from 2003 to 2020 were used. Only species that are ecological conservation priorities in the Northern Shelf Bioregion are included in the species richness value reported here, for a maximum total of five elasmobranch species.*

6.2.3.3 Vulnerabilities and Recoverability

The Caamaño-Douglas area has comparatively less fishery and human activity compared to other regions in BC (See Section 5: Human uses of area). Sensitivities to fishing pressures depend on species' life history traits. **Ts'mhoon**/rockfish and cartilaginous fishes, for example, are highly vulnerable to fishing pressures and overexploitation because of their slow growth rate, slow sexual maturity, and long lifespans, which contribute to slow population recovery in the span of several decades as opposed to years. Both species groups have suffered population declines in the second half of the 20th century due to previously high levels of commercial and recreational pressures (**ts'mhoon**) or extermination efforts (**ksaa**/**q̓ʷaqʷ-**/sharks). **Ts'mhoon** and **hadanii**/**hadanii**/sablefish also have higher bycatch mortality rates for the Hook & Line and Trap gear (See Table 2 in Appendix 2 of DFO 2023e) when compared to other groundfish species such as **wat'ukw**/**núłem**/**wạt'ukw**/Lingcod, **gagaats**/**q̓ʷaḡʷina**/**gạsgaatsk**/Dogfish, **txaw**/**mumegʷezu**/**txaw**/Halibut and **gandeh**/ **bakʷ-**/skates. A Sablefish Fishing Mortality Working Group was formed in February 2021 to improve monitoring and reduce **hadanii**/**hadanii** discard mortality. High fecundity and periodic high recruitment events provide **ts'mhoon** populations with the chance of recovery.

In contrast, Roundfish and Flatfish tend to have intermediate life histories (early maturation, fast growth rate, long lifespans, and high reproductive outputs) which makes them more resilient to fishing pressures than **ts'mhoon** (Fargo et al. 2007). However, population abundances can often be unpredictable and linked to variable oceanic conditions with years of low recruitment contrasted with stronger year classes. Unlike many bony fishes, **ksaa**/**q̓ʷaqʷ-** and rays have comparatively low reproductive output and survey data and assessments are extremely limited. This combination of slow recovery and lack of information implicates high sensitivity for cartilaginous fishes. As the Caamaño-Douglas area is an important area for populations of marine mammal species (see Section 6.2.5), increased predation levels may also compound the stressors of prey fishes.

Most genetic studies have shown a majority of groundfish as one population in BC waters (e.g., Jasonowicz et al. 2016), perhaps due to extensive adult migrations and pelagic larval dispersal resulting in a lack of reproductive isolation in the NSB. This may be helpful for rescue effects, where healthy populations in one area could replenish depleted areas. The overall health of local nearshore habitats in the Caamaño-Douglas area (such as kelp forests, **gadza k'aw**/ eelgrass beds, and cold-water corals and sponges) can also aid in the recovery of local populations by supporting juvenile growth of species that migrate offshore and the productivity of adult **wat'ukw**/**núłem**/**wạt'ukw** and **ts'mhoon**.

Another threat to the fishes in the Caamaño-Douglas area comes from the effects of vessel traffic: ship strikes, vessel noise, and oil spills (Section 5.5 and 5.6). Increased development and density of marine traffic naturally will increase vulnerability for fishes. Larger species such as basking sharks are most vulnerable to ship strikes as they tend to stay near the surface for basking behaviours. Research on the effects of anthropogenic noise on Pacific **hoon**/**qeqapela**/ salmon and **tskah**/**wáṅi**/**tskạh** showed heightened anti-predatory behaviour (Van der Knaap et al. 2022). Oil spills on **gadza k'aw** and kelp habitats can harm the abundance of forage fishes and juvenile fishes (groundfish, salmonids). Fishes that are less mobile and rely on biogenic habitats such as adult **ts'mhoon**/rockfish and **wat'ukw**/**núłem**/**wạt'ukw** may have greater sensitivities to oil spill effects (Jeffery et al. 2023).

Both forage fishes and salmonids depend on the health of spawning habitat locations and are sensitive to human development and pollution in these areas. The Caamaño-Douglas area contains several **tskah**/**wáṅi**/**tsk̲ah** spawning sites, and the Network Zones are en route to several important estuaries including Kitkiata inlet, Kishkosh inlet, and Kitimat River. These estuaries and adjacent connecting habitats have been identified as productive habitats for anadromous fishes (**hoon**/**qeqapela**, and **ha'limootk**/**ƛ̓áti**/**ẅa̱h**), and spawning grounds for **Tskah**/**wáṅi**/**tsk̲ah**. Notably, **ha'limootk**/**ƛ̓áti**/**ẅa̱h** abundance in this area has been greatly reduced, although this may only be in part due to local human development, as this decline is observed throughout BC (COSEWIC 2011a).

Global and regional effects such as increased temperatures, ocean acidification, dissolved oxygen levels, and variable oceanic circulation can also cause fluctuations in prey abundances, spawning returns, and yearly recruitment rates. Fishes with life history events linked with environmental cues (e.g., **tskah**/**wáṅi**/**tsk̲ah** spawn and **k’a̱’wts**/**ƛáx̄dala**/**k̲'a'w'ts**/Pacific cod) have higher sensitivities than those with consistent recruitment (e.g., **hadanii**/**hadanii**). Strong correlations between zooplankton productivity and environmental conditions and timing were shown to affect populations and annual recruitment levels of fishes that rely on zooplankton prey, such as forage fishes and larval groundfish (Schweigert et al. 2013, Kimmel and Duffy-Anderson, 2020). A preliminary climate change sensitivity analysis for marine species in West Coast Vancouver Island identified cartilaginous fishes and pelagic fishes (notably **tskah**/**wáṅi**/**tsk̲ah**) with the highest average risk scores, and flatfish with the lowest scores (Hunter et al. 2014). Please refer to Hunter and Wade (2015) for a comprehensive summary of species profiles and climate vulnerabilities on **txaw**/**mumegʷezu**/**txaw**, **balaas**/Pacific Hake, **hadanii**/**hadanii**, **Tskah**/**wáṅi**/**tsk̲ah**, and Pacific Sardine in the waters of BC.

Projected changes in groundfish communities

Under a no-mitigation climate scenario (RCP 8.5), groundfish species are expected to shift their distribution by as much as 1000km by 2100 in Pacific North America due to climate change (Morley et al. 2018). A recent study by Thompson and colleagues (Thompson et al. 2023a) provided projections of groundfish community (for 34 groundfish species) change in the Pacific Region under two future (2046-2065) climate change scenarios (RCP 4.5 and RCP 8.5) accounting for the combined effects of temperature, dissolved oxygen, and depth distribution based on fisheries independent trawl surveys. For more details on the climate models used refer to the earlier section in this report (Projected changes to ocean environmental variables). They found that groundfish vary in their sensitivity to warming and dissolved oxygen (Thompson et al. 2023a). Consequently, some species’ distribution or occurrence may increase, while others will decrease.

In general, warming in shallow waters is projected to cause species to shift to deeper depths, but hypoxic conditions will limit how deep they can go (Thompson et al. 2023a). The net result is that the number of species in shallow (< 100 m) and deep (> 600 m) waters is projected to decrease, but more species are expected to occur at mid depths. Within the Caamaño Sound and Douglas Fjord System Network Zones, the redistribution of groundfish species due to climate change is projected to result in species richness changes from zero to more than 1.5 species lost per grid cell (**Figure 74**). The RCP 8.5 scenario in the NEP36-CanOE model project the highest species losses (**Figure 75**). While the model coverage for this groundfish model does not extend into the nearshore and inlet/fjord areas of the Caamaño-Douglas area, a conservative expectation is that groundfish will show similar projected shifts in depth as in the shelf and slope waters where the model is trained (Thompson P., pers. Comm, March 22,

2023). However, the extent to which they'll need to move from regions that are fed by cold-water inflows (i.e., snowmelt) may ameliorate their redistribution, although the associated freshening will also influence movement. Changes in flow and freshwater input seasonally, may lead to seasonal shifts in distributions as the anoxic layer changes, salinity changes, or sedimentation makes for inhospitable habitat. The freshwater inputs in Caamaño Sound currently get mixed back into intermediate waters during winter months in Hecate Strait and can circulate back into the estuary. This "freshening" may also create a reverse estuary where the deep water moves out, a very unique feature of the area. If future climate changes resulted in shutting down the freshwater input completely, the deep layers would likely become stagnant. Alternatively, with a lot of freshwater, the bottom might equilibrate faster and then start becoming stagnant. Finally, if the seasonal wind cycles disappeared, spring inflows and associated features would cease, and if the wind died down completely, the surface layer would not mix down enough altering patterns of water chemistry and consequently local species' distributions.

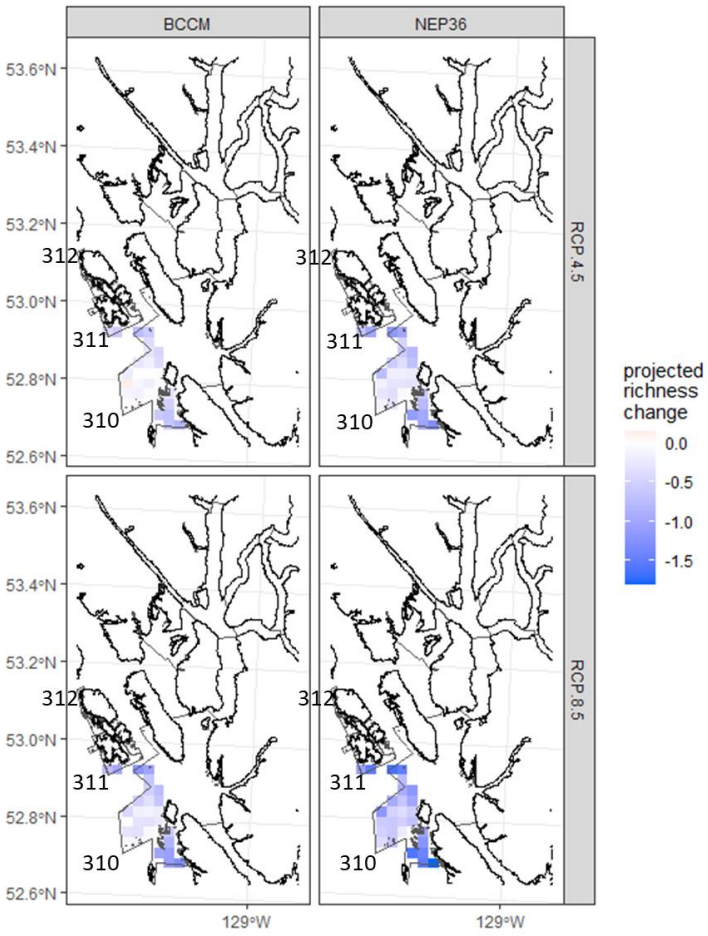

***Figure 74**. Projected species richness change in the groundfish communities (total of 40 groundfish species on the Pacific coast) in the outermost Caamaño Sound and Douglas Fjord System Network Zones based on a comparison of average conditions in 1986–2005 vs 2046–2065 under the RCP 4.5 emissions scenario (top row) and the RCP 8.5 emissions scenario (bottom row) for both the BCCM climate model (first column) and the NEP36-CanOE climate model (second column). Zone numbers are indicated on the outside of each polygon. Note the incomplete coverage of the models shown in the figure indicated by a white background within the polygons.*

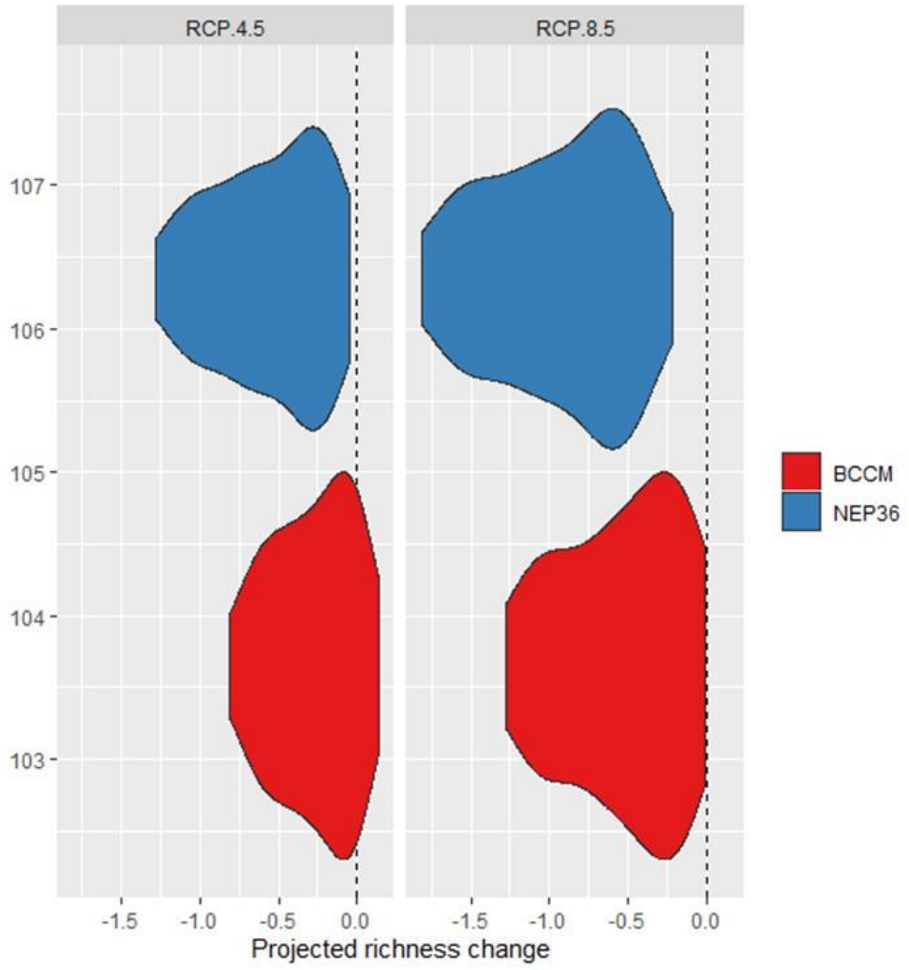

***Figure 75**. Distributions of projected change in occurrences across the outermost Caamaño Sound and Douglas Fjord System Network Zones for groundfish communities (total of 40 groundfish species on the Pacific coast) based on a comparison of average conditions in 1986–2005 vs 2046–2065 under the RCP 4.5 emissions scenario (left panel) and the RCP 8.5 emissions scenario (right panel) for both the BCCM climate model (in red) and the NEP36-CanOE climate model (in blue). Note that the projections only cover a portion of the area included in the Caamaño-Douglas area (**Figure 74**; Thompson et al. 2023a).*

6.2.4 Marine Birds

The diverse habitats of the Caamaño-Douglas area support globally, nationally, and regionally important concentrations of marine birds. The area is located within the Pacific Flyway, a major north-south flight path for migratory birds that extends from Alaska to Patagonia. Every year migratory birds travel some or all of this distance both in spring and in fall, following food to fuel their journeys while heading to breeding areas and returning to overwintering sites. During the spring and summer months, islands and islets along the Outer Coast Zones and the surrounding productive marine waters support approximately 100,000 breeding marine birds, including alcids (auklets, guillemots, murrelets, puffins), black oystercatchers, gulls, and storm-petrels. Fjord-estuarine habitats support seabirds, waterbirds, waterfowl, and shorebirds during migration, breeding, moulting, and non-breeding periods. At least 80 species of have been

observed within the Network Zones and 44 species are considered conservation priorities within the NSB (Gale et al. 2019; **Appendix F: Marine Bird Occurrence Table**).

The abundance and distribution of breeding marine birds have been documented to some extent in the Caamaño-Douglas area; however, there is an ongoing need for information on abundance, distribution, population trends, and foraging and movement ecology (Rodway 1991; Rodway et al. 2016). Baseline scientific data on the distribution, abundance, and species composition at sea within the Caamaño-Douglas area is not comprehensive, primarily due to variability in survey effort and methodology, as well as daily, seasonal, and annual fluctuations in numbers that are common for many marine bird species. Species occurrence data in the Network Zones (**Appendix F: Marine Bird Occurrence Table**) were obtained from several sources, including the North Pacific Pelagic Seabird Database (Drew et al. 2015), Environment and Climate Change Canada Canadian Wildlife Service (ECCC-CWS) Pelagic Seabird Atlas Database (Kenyon et al. 2009), ECCC-CWS Marine Bird Area of Interest database (Kenyon et al. 2007), and unpublished ECCC-CWS data. Data were also sourced from Global Biodiversity Information Facility (GBIF 2023). Species occurrence data were complemented by unpublished data[48] provided by E. Keen and the Gitga'at First Nation.

Marine bird abundance, distribution, and species richness is associated with areas of high productivity and bathymetric features that result in concentrations of prey, as well as proximity to breeding colonies (Yen et al. 2004; Clarke and Jamieson 2006; Kenyon et al. 2007; Kenyon et al. 2009; Santora et al. 2018). Common marine bird prey species include zooplankton, fish and fish eggs, crustaceans, bivalves, and other invertebrates. Zooplankton species are also prey for fish species eaten by marine birds such as Pacific Sand Lance, Pacific Saury, **Tskah**/**wáṅi**/**tskaḥ**/Pacific Herring, juvenile **ts'mhoon**/rockfish, and juvenile **hoon**/**qeqapela**/ salmon (Burger et al. 1997). The Caamaño-Douglas area includes a variety of habitats and sites of ecological value for marine birds throughout their annual cycles. These habitats include rocky shorelines, coastal islands, estuaries, **gadza k'aw**/eelgrass beds, and nearshore, inshore and offshore waters (Kenyon et al. 2007). Estuaries in particular are known to be particularly important habitats to a diverse complex of marine birds for breeding and foraging, and for associations with **gadza k'aw** beds and **Tskah**/**wáṅi**/**tskaḥ** spawning habitat; ecological importance of estuaries for waterbirds has been ranked by the Pacific Estuary Conservation Program (Pacific Habitat Joint Venture 2020). The highest-ranking estuary for waterbirds within the Network Zones is Stannard Creek on Northern Aristazabal Island in Zone 310 (Rank 2). The most highly ranked estuary in the surrounding area is the Kitimat River system (Rank 1), while high ranking estuaries immediately adjacent to the polygons include the Quaal River/Kitkiata Creek Complex (Rank 2) and KishKosh Creek (Rank 3). Additional information on estuaries and rankings is found in Section 6.2.3.1.2.1 titled "Forage Fishes". **Tskah**/**Wáṅi**/**Tskaḥ** spawn is an important food source for many bird species, and the relative seasonal predictability of **tskah**/**wáṅi**/**tskaḥ** spawn events and seasonal pulse of energy-rich food makes them important habitats for large numbers of both migrating and wintering marine birds (Willson and Womble 2006). Records of **Tskah**/**wáṅi**/ **tskaḥ** spawn occur in Zones 310, 313, 314, and 316 (see **Figure 71**) (Hay and McCarter 2013).

During the boreal breeding season (April to September), most of the marine bird species that nest in Caamaño-Douglas area are considered central place foragers that feed at sea and then

[48] Seabird diversity, abundance, and distribution – State of the Gitga'at Ocean 2015 - Keen-SOGO-Seabirds-20160512.docx

return to colonies to provision young, so foraging areas are often associated with terrestrial breeding colonies. Several of the Network Zones (310, 311, 312) surround islands and islets with known observations of breeding individuals or nesting pairs, with all relatively large colonies occurring within Zone 310. Species breeding on these islands includes Cassin's Auklet, Glaucous-winged Gull, Fork-tailed and Leach's Storm-petrels, Pigeon Guillemot, Rhinoceros Auklet, and Tufted Puffin. Using the data compiled for this report (**Appendix F: Marine Bird Occurrence Table**), Zone 310 has a marine bird species richness of 75 species, the highest of all the Zones. Zone 310 also overlaps with part of the marine component of the internationally recognized Moore and Byers Islands and Banks Important Bird Area[49]. Although many of the colonies included in this IBA are not within the boundaries of the Network Zone, the birds breeding on these colonies are likely using the marine habitats within the Network Zone based on known foraging ranges of Cassin's Auklet, Rhinoceros Auklet, Fork-tailed Storm-petrel, and Leach's Storm-petrel in BC (Halpin et al. 2018; Domalik 2018). Although there are no recorded marine bird breeding colonies in Zones 313, 314, 315, and 316, these Network Zones are characterized by inlets and fjords with numerous estuaries that support many other marine bird species.

Throughout the Caamaño-Douglas area, adjacent forests provide critical habitat for breeding Marbled Murrelet (*Brachyramphus marmoratus*). These small seabirds spend most of their time at sea close to shore while nesting as solitary pairs at low densities, typically in old-growth forests within 50 km of the ocean (Environment and Climate Change Canada 2023). Kernel density estimates based on locations of satellite-tagged Marbled Murrelets in the Caamaño-Douglas area predicted marine habitat in Zones 310, 311, 312, and 313 (Bertram et al. 2016). Proximity to nesting habitats has been identified as a key variable in predicting Marbled Murrelet marine distribution patterns during breeding in the nearshore waters of BC, and they show high forage site fidelity with spatially fixed habitat components such as streams (Ronconi 2008; Pastran et al. 2021).

Seabird colonies, seabird eggs, Scoters and Tuften Puffins were identified as Zone-level Network Conservation Objectives for Zones 310, 311, and 312 (MPA Network BC Northern Shelf Initiative 2023). Various seabirds are harvested for food by local First Nations. Species of important cultural values include Goldeneye, Mallard, **gaguum**/**ċigilaxs**/**gaguum**/Seagull, Scoter, Harlequin duck, Tufted Puffin, **haʼaxʼ**/**henḡax**/**haʼaxʼ**/Canada Goose, **łii'wn**/**x̌íx̌ix̌i**/Snow Goose, and Oystercatcher (Satterfield et al. 2012). Common harvest locations include Moore Islands (Zone 310), Kishkosh inlet, **Lax gal'tsap**/Old Town in Kitkiata inlet, and Kiel (Satterfield et al. 2012, M. Jacobs pers. comm.)

[49] Important Bird Areas (IBAs) in Canada Site Listing

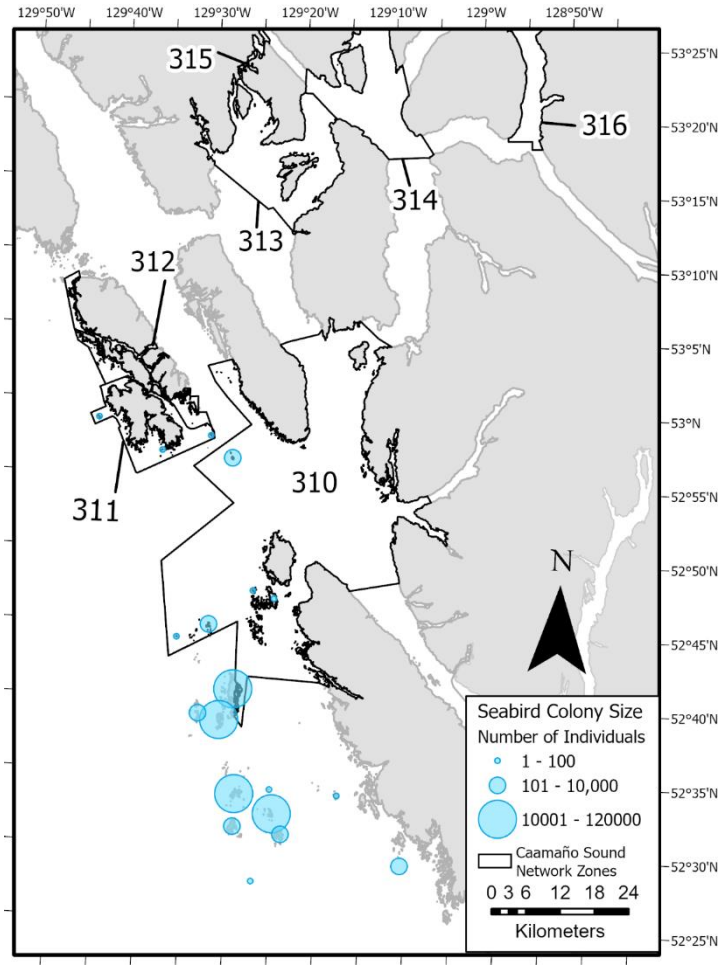

Figure 76*. Spatial distribution and breeding colony population estimates of the 15 species of seabirds and one shorebird. Data in the Caamaño-Douglas area are from 1976 – 1988. Size of symbols correspond to seabird colony size.*

Vulnerabilities and Recoverability

Marine birds have diverse life history strategies, including use of terrestrial and marine environments. Therefore, marine birds are vulnerable to changes in multiple ecosystems, such as shifting availability of prey or forage species in their ocean feeding areas, and habitat degradation and invasive species impacts on their nesting sites. Ocean warming events impact food webs and have population consequences for marine birds, with some alcid species experiencing significant mortality events in recent marine heatwaves (Jones et al. 2018; Piatt et al. 2020). Marine birds are subject to other threats, including physical disturbance from human activities, impacts from chronic and accidental marine pollution, and entanglement and ingestion of marine debris and plastics. Fishing activities may threaten some marine bird species, including Common Murre, Marbled Murrelet, and Rhinoceros Auklet, which are killed incidentally as bycatch in gill net fisheries and are likely slow to recover from population declines due to low reproductive rates (Bertram et al. 2021). While protecting all sections of migratory species' life cycles is important, resilience to climate change and recovery from previous impacts can be supported by reducing pressure wherever possible. Marine protections can ensure populations

of threatened bird species aren't further impacted by being caught as bycatch in fisheries and can reduce pressures on forage species and forage species habitat.

Marine birds are upper-level predators within marine food webs. Their habitat use is reflective of ocean productivity and the distribution and availability of lower trophic prey, across both temporal and spatial scales (Serratosa et al. 2020). Consequently, climate-driven variation in the distribution, abundance, and phenology of low trophic-level organisms can have cascading effects within marine food webs (Hipfner et al. 2020). Marine birds provide an integrated response to climate change because their breeding phenology, productivity, and distribution are so closely linked to marine resources. Similarly, marine birds can be valuable indicators of ocean health because their breeding habitats remain static, while the availability of their food resources is dynamic in both time and distribution (Sydeman et al. 2021).

6.2.5 Marine Mammals

The Caamaño-Douglas area provides habitat for a wide variety of marine mammal species. Cetacean species found within this region include the fin whale (*Balaenoptera physalus*), humpback whale (*Megaptera novaeangliae*), minke whale (*B. acutorostrata*), grey whale (*Eschrichtius robustus*), **‘‘naaxł/hélx̄’inix̄ʷ/niixł**/killer whale (*Orcinus orca*), Pacific white-sided dolphin (*Lagenorhynchus obliquidens*), Dall's porpoise (*Phocenoides dalli*), and harbour porpoise (*Phocoena phocoena*). Three other large **łbuun/ḡʷeẏém/łpuun**/whale species (sperm whale *Physeter macrocephalus*, blue whale *B. musculus*, and sei whale *B. borealis*) were historically harvested by whalers in the Caamaño-Douglas area, and record of one north Pacific right whale (*Eubalaena japonica*) was killed off Price Island, near the outside of the Network Zones boundary (See supplementary material to Keen et al. 2021). Although these **łbuun/ḡʷeẏém/łpuun** species are not currently found in the region, they occurred in the area historically and may return to these habitats as their populations recover from over-harvesting (Keen et al. 2021, supplementary appendix). A rare, incidental sighting of a juvenile bowhead whale (*Balaena mysticetus*) also occurred in May 2016 near the north end of Aristazabal Island (Towers et al. 2022), well outside of the normal range for this typically Arctic species.

More detailed information about the use of the general Caamaño-Douglas area (and also the specific Network Zones) by fin, humpback and **‘naaxł/hélx̄’inix̄ʷ/niixł** are presented here. These species are the focus of dedicated research effort and also may be more vulnerable to anthropogenic impacts in the region. In contrast, there is limited information on the use of the Caamaño-Douglas area by porpoises, **dziiẅ/x̌áła**/dolphins, grey whales, and minke whales[50]. Due to the accumulated knowledge on fin humpback, and **‘naaxł/hélx̄’inix̄ʷ/niixł**, they are thus the most likely to benefit from a marine protected area network that seeks to protect this ecosystem's physical and biological underpinnings from anthropogenic threats. In contrast, there is limited information on the use of the Pinniped species that regularly occur in the Caamaño-Douglas area include the Harbour seal (*Phoca vitulina*), northern elephant seal (*Mirounga angustirostris*), and Steller sea lion (*Eumetopias jubatus*). More detailed information will be provided for Harbour seals and Stellar sea lions, as these two species are numerous

[50] Data on Porpoises, Pacific White-sided Dolphins, Grey Whales, and Minke whales in the Caamano area are limited as these species have not been the focus of research attention in this region outside of opportunistic sightings and general cetacean surveys conducted by DFO and others. The North Coast Cetacean Society devotes most of their research focus to Fin and Humpback Whales that are more prevalent in the Caamano-Douglas area than Grey and Minke Whales.

throughout the Caamaño-Douglas area and maintain year-round haul-outs in all of the Caamaño Sound and Douglas Fjord System Network Zones as well as other parts of the Kitimat Fjord System. A single species of marine mammal from the mustelid family, the **płoon**/**nukʷ**/sea otter (*Enhydra lutris*), is also found in the Caamaño-Douglas area. The region is currently at the edge of the **płoon**/**nukʷ** expanding range in BC.

6.2.5.1 Cetaceans

6.2.5.1.1 Fin whales

The Fin whales using the Caamaño-Douglas area belong to the northeast Pacific subspecies (*Balaenoptera physalus velifera*), which is managed multinationally as several stocks (COSEWIC 2019, Archer et al. 2019). Fin whales were once the most common baleen whale in the ocean (Christenson 2006), including in Canada's waters, but today the Canadian Pacific stock remains depleted at less than 50% of historical levels prior to commercial whaling (1908-1967 in Canadian waters; COSEWIC 2019; Nichol et al. 2002). During this time, the Fin whale was the most harvested **łbuun**/**ḡʷey̓ém**/**łpuun**/whale species in Canada and worldwide (Gregr et al. 2000, Aguilar 2009).

While most Canadian Pacific stock occurs far offshore, several hundred individuals use the northern continental shelf (Queen Charlotte Sound, Hecate Strait, and Dixon Entrance; Wright et al. 2021b). Based upon photo-identification, satellite-linked tags, and passive acoustic monitoring, the Fin whales occurring on the shelf are known to exhibit interannual site fidelity, limited summertime movements, year-round presence, and little interchange, if any, with aggregations further offshore (Koot 2015, Pilkington et al. 2018, Archer et al. 2019, Hendricks et al. 2021, Frouin-Mouy et al. 2022).

Roughly a quarter of the ~400 shelf individuals use the Caamaño-Douglas area on a regular basis and is noteworthy as an atypical habitat for an otherwise offshore and oceanic species (Keen et al. 2021). It is currently the world's only fjord system that Fin whales regularly use, and it is the only place where they are frequently photo-identified from shore (Keen et al. 2021). The Caamaño-Douglas area is also the only BC fjord system in which Fin whales were regularly found during the commercial whaling era (Gregr et al. 2001, Nichol et al. 2002), pointing to its long-term importance for the Canadian Pacific stock. The Caamaño-Douglas area was first federally identified as an important habitat site for Fin whales by Nichol and Ford (2012), and further included in the area of proposed critical habitat for the species in 2017 (Nichol and Ford, 2018).

Population abundance & trends

Fin whales were extirpated from the Caamaño-Douglas area by commercial whaling (of the 129 **łbuun**/**ḡʷey̓ém**/**łpuun**/whales taken from this area between 1908 and 1967, 75% were fin whales), and they did not return until the mid-2000's (Keen et al. 2021). Since the first sighting in 2006, fin whales have increased in terms of local abundance, seasonal presence, and site fidelity (Keen et al. 2021). Photo-identification mark-recapture analysis indicates that the Caamaño-Douglas area was used by over 100 Fin whales as of 2019 (Keen et al. 2021), representing 27% of the shelf population size, as estimated by Nichol and Ford (2018).

Rates of return (both year-to-year, as well as from any previous year) to the Caamaño-Douglas area since the 2000's have increased over time and exceeded 70% from 2014 to 2019 (the

most recent year studied; Keen et al. 2021). These return rates exceed those in all other Fin whale habitats studied worldwide (Falcone et al. 2022; Tershy 1992, Ramp et al. 2014).

Fin whales occur regularly in the outer waterways of the Caamaño-Douglas area, primarily within Caamaño Sound, **Lax Ka'gaas**/Campania Sound, south Whale Channel, Squally Channel, Otter Channel, Lewis Passage, and Cridge Passage (**Figure 77** and **Figure 78**; Keen et al. 2021, Keen et al. 2023). On rare occasions, sightings have also been reported in Wright Sound, south Douglas Channel, McKay Reach, and central Whale Channel. This present-day distribution is similar to that indicated by the historical commercial catch record (Keen et al. 2021).

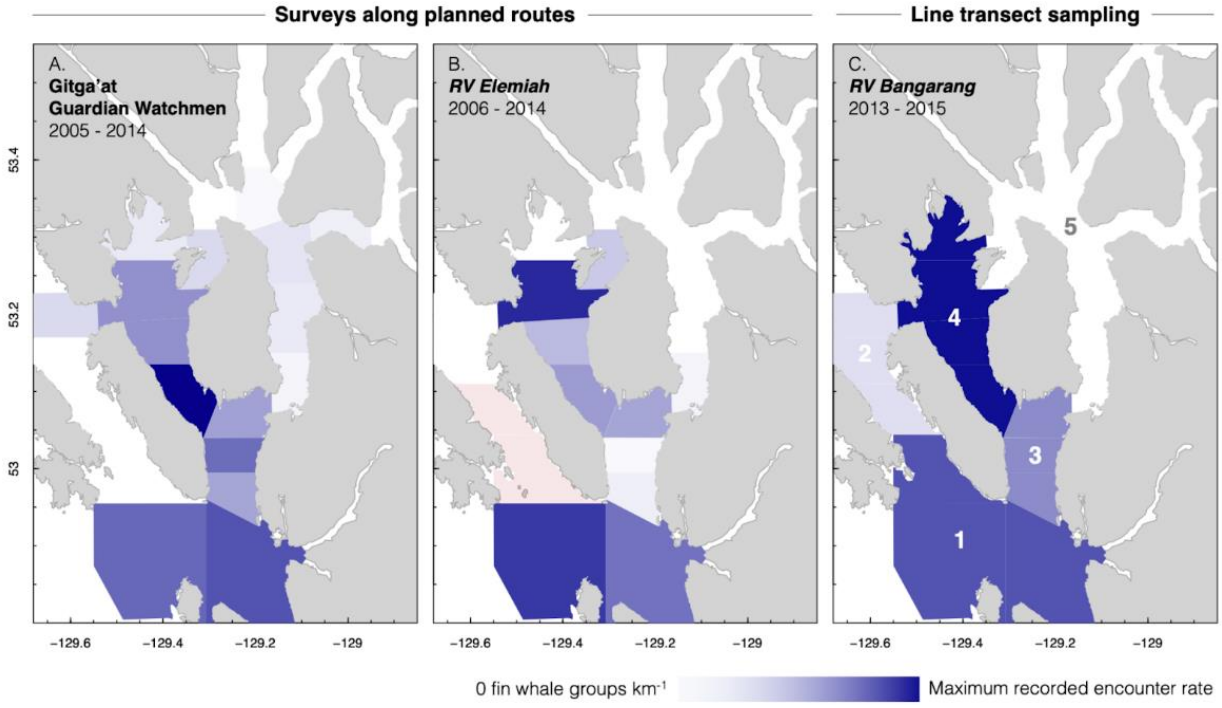

Figure 77. *Fin in whale distribution based on effort-corrected surveys by (a) the Gitga'at Guardian Watchmen (2006-2014); (b) North Coast Cetacean Society (2006-2014); (c) RV Bangarang (2013-2015). Adapted from Keen et al. (2021) PLOS ONE. Region IDs: 1 = Caamaño Sound; 2 = Estevan Sound; 3 =* ***Lax Ka'gaas****/Campania Sound; 4 = Squally Channel; 5 = interior waterways. The colour scale in each map is scaled by the maximum recorded encounter rate by the respective research platform. Pink colouration indicates no survey effort.*

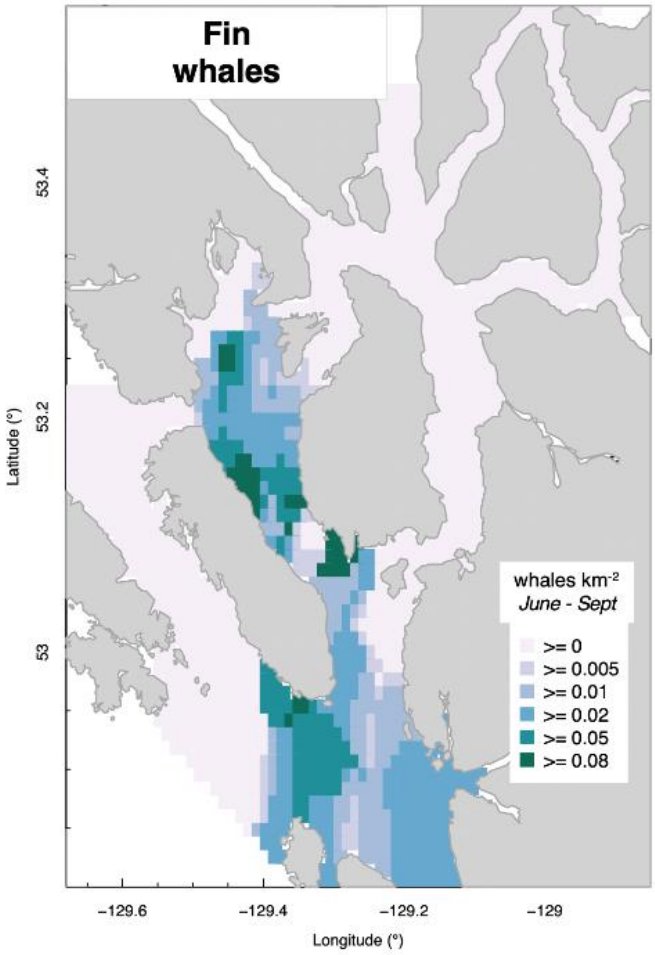

***Figure 78**. Fin whale densities (**łbuun/ḡʷeẏém/łpuun**/whales/km²) predicted by a multivariate density surface model (adapted from Keen et al. 2023), based upon systematic line-transect surveys (2013-2015).*

Habitat associations

Fin whales occur in a variety of habitats within the Caamaño-Douglas area, ranging from narrow waterways relatively far into the Kitimat Fjord System (e.g., Lewis Passage and Cridge Passage), to deep fjordic waters in Squally Channel (>700 m maximum depth, the deepest waterway on BC's continental shelf), to the broad and relatively shallow (<300 m) expanse of Caamaño Sound (Keen et al. 2021). Habitat association models indicate that Fin whales associate more with waterway-specific physiographic features of the Caamaño-Douglas area than with dynamic oceanographic variables, and those habitat associations appear to be seasonally stable (Keen et al. 2018, Keen et al. 2021). This associative pattern differs strongly from the Humpback whales in this area, whose habitat associations are more diverse, oceanographically linked and seasonally dynamic (Keen et al. 2017, Keen et al. 2018).

Seasonality

Research teams have visually observed **łbuun/ḡʷeẏém/łpuun**/whales in most months of the year, with regular detections in June-October and the highest encounter rates in late August and

early September (Keen et al. 2021). The species has been detected acoustically within the Caamaño-Douglas area during all months of the year as shown by calls detected per month (**Figure 79**; Pilkington et al. 2018, Hendricks et al. 2021).

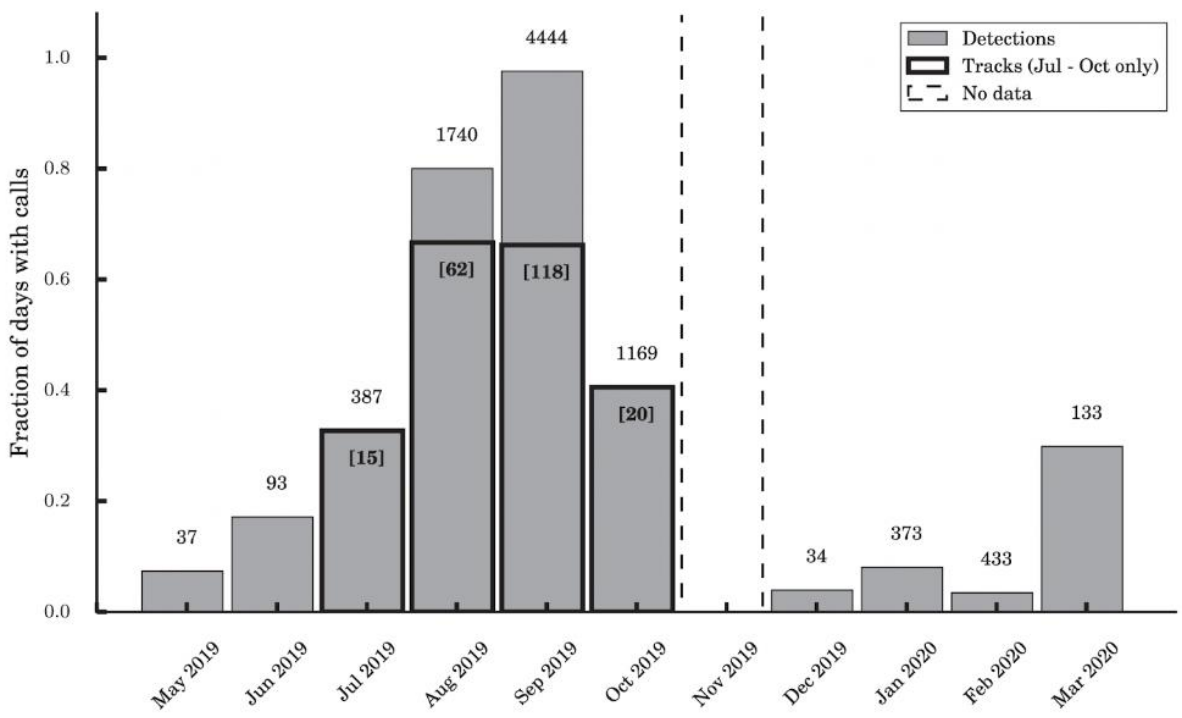

Figure 79. *Fin whale 20 Hz call seasonality (2019-2020) shown as the fraction of net observation days during a month with 20 Hz Fin whale call presence, in northern Squally Channel. Grey bars are call detections, and black outlines represent call clusters that were used to track* ***ƛbuun/g̱ʷey̓ém/ƛpuun****/whale movements acoustically. The number above the bar is the total number of calls detected and the number of call clusters is shown in square brackets within the histogram. No data were collected in November 2019. Figure originally from Hendricks et al. (2021).*

Movements

Satellite-linked tagging studies, shore-based surveys, and Lagged Identification Rate analysis of photo-identification records indicate that Fin whales intermittently return to the Caamaño-Douglas area throughout the summer-fall (Keen et al. 2021; Nichol and Ford 2018). They remain for only a few days during each visit but do not venture far from the entrance to Caamaño Sound while away (Keen et al. 2021; Nichol and Ford 2018). The patterns suggest that the Caamaño-Douglas area serves as an important stopover site on a foraging circuit in and around southern Hecate Strait (Keen et al. 2021).

Diet & habitat function

The majority of what is known directly about North Pacific Fin whale diet in Canadian Pacific waters comes from studies based on stomach analyses from commercial whaling efforts in

offshore waters of the Canadian Pacific during the 1960s (Flinn et al. 2002). Those stomachs contained mainly (sometimes exclusively) euphausiids, but the relative proportion of this prey in the diet could change significantly among years (Flinn et al. 2002). Other prey species include copepods, fish, and cephalopods. The euphausiids preyed upon by Fin whales included *Euphausia pacifica*, *Thysanoessa spinifera*, *T. longipes*, and *T. inermis* (Flinn et al. 2002). Stomach contents of Fin whales taken within the Caamaño-Douglas area (n = 44) likely represent fin whales that were feeding in or near this area during summer in those years. The only type of prey noted for these stomachs was euphausiids (Keen et al. 2021).
Recent behavioural studies (2013 - 2019), some of which included concurrent active acoustic sampling of the prey field (2013 - 2015), support the hypothesis that Fin whales use the Caamaño-Douglas area during the summer primarily as a social feeding area (Keen 2017, Keen et al. 2021). Echogram traces, zooplankton tows, and observations of surface feeding events indicate that the primary prey for fin whales in the Caamaño-Douglas area are euphausiids (Keen 2017, Qualls 2019). Most euphausiid schools associated with apparent feeding behaviour were observed at depths of 60 m – 168 m (Keen 2017; Qualls 2019).

A study from the same field effort determined that Fin whales (and Humpback whales) in the Caamaño-Douglas area practice threshold feeding behaviour (Keen 2017). This feeding is a form of energy-conserving optimal foraging in which **łbuun**/**g̃ʷey̓ém**/**łpuun**/whales engage in feeding behaviour only when prey densities exceed certain thresholds (Keen 2017). For threshold foragers, finding satisfactory prey patches requires extensive searching in which only a small portion of the habitat accessible to the predator will actually prove useful (Keen 2017). These behaviours are congruent with the movement patterns described previously. Dive-tag analysis indicates that Fin whales in the Caamaño-Douglas area exhibit diel differences in diving behaviour, with deeper, longer dives occurring during daytime versus night (Nichol and Ford 2018). This behaviour is consistent with the strategy observed in rorqual whales (family Balaenopteridae) elsewhere of feeding upon deep swarms of euphausiids during the day and engaging in other behaviours or using other feeding techniques at night (Friedlaender et al. 2009, Friedlaender et al. 2013, Calambokidis et al. 2019, Keen et al. 2019).

Knowledge gaps

The largest knowledge gaps in our effort to understand Fin whale habitat use and vulnerabilities to anthropogenic threats in the Caamaño-Douglas area are:

1. Wintertime movements of Fin whales using the Caamaño-Douglas area

2. Movements and connectivity, if any, between the inshore aggregation of fin whales and those further offshore and further south (near Juan de Fuca Strait) – this knowledge is needed to contextualize risks posed to fin whales in the Caamaño-Douglas area; and

3. Movements and connectivity, if any, between Canadian Pacific Fin whales and the US stocks to the north and south are needed to contextualize risks in the Caamaño-Douglas area for the greater population.

6.2.5.1.2 Humpback whales

The Caamaño-Douglas area supports a population of seasonally resident Humpback whales (*Megaptera novaeangliae*) that exhibit high rates of site fidelity (68% of individuals photo-

identified between 2004 - 2020 have returned in at least one additional year) (Wray and Keen 2021). Much of the Caamaño-Douglas area has been identified as critical feeding habitat for humpback whales (DFO 2013). Seventeen years of dedicated study of this population has revealed potentially globally unique trends in spatiotemporal habitat usage (Keen et al. 2017) and the prevalence of behaviours like bubble net feeding. Additionally, Squally Channel and Verney Passage, which are currently outside of the Caamaño Sound and Douglas Fjord System Network Zones boundaries, are key areas for foraging and large group aggregations.

Population abundance & trends

In recent decades, a portion of the depleted north Pacific Humpback whale population in BC began to recover following the end of commercial whaling for this species in 1965 (Nichol et al. 2002) and experienced population growth (Fisheries and Oceans Canada 2013) with province-wide population estimates increasing from 2,145 individuals in 2006 (Ford et al. 2009) to 7,030 individuals in 2018 (Wright et al. 2021b). Total population estimates for the north coast of BC (spanning northern Vancouver Island, the north and central mainland coasts, and Haida Gwaii) estimate an abundance of 1,816 Humpback whales (Wright et al. 2021b), indicating an increase from a 2015 estimate of 1,092 Humpback whales in this region (Best et al. 2015).

Mark recapture models based upon photo-identification data estimated that the super-population (i.e., the population of **łbuun**/**ḡʷey̓ém**/**łpuun**/whales that could use the study area, but not necessarily all in the same year) of Humpback whales using the Caamaño-Douglas area was 583 as of 2019, with an average of 256 **łbuun**/**ḡʷey̓ém**/**łpuun** using the area in a given year (Wray and Keen 2021; **Figure 74**). The area's population grew steadily from less than 80 individuals in 2005 to 480 - 530 **łbuun**/**ḡʷey̓ém**/**łpuun** in 2016. The annual number of **łbuun**/**ḡʷey̓ém**/**łpuun** using the area appears to have stabilized, with a temporary decline in 2017 - 2018 (Wray and Keen 2021).

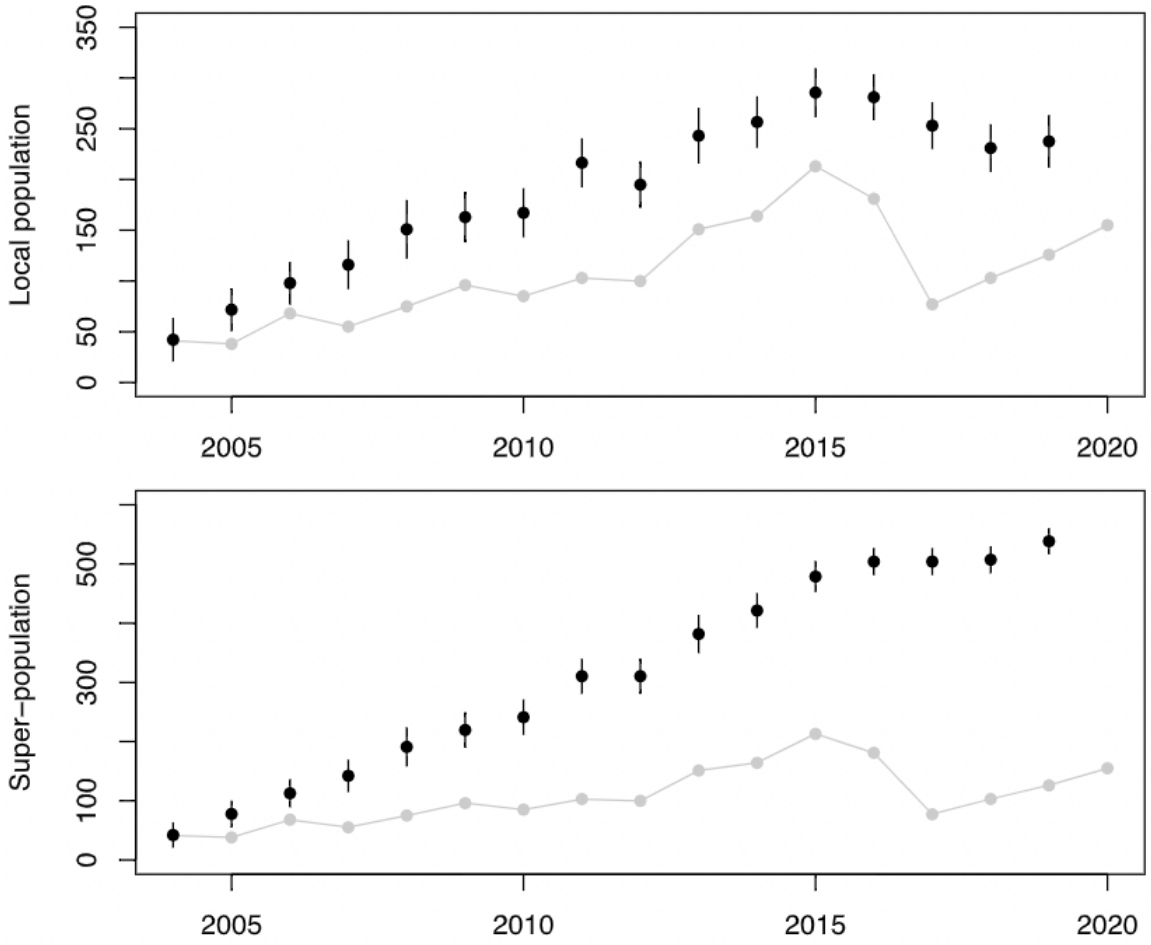

***Figure 80**. Modeled abundance trends (black dots with bars representing 95% confidence intervals) in the size of the local population (top panel) and super-population (bottom panel) of Humpback whales in the Caamaño-Douglas area, 2004-2019. Grey dots represent the annual size of the photo-identification catalogue.*

Logistic regressions fit to annual calving rates (both per capita and per mother) rose from 2004 to 2013, and then declined from 2014 to 2018 (Wray and Keen 2020; see **Figure 81**). Calving rates in 2019 were among the lowest observed to date since 2004 (per capita = 0.014, per mother = 0.040); however, rates increased again in 2020 (per capita = 0.069, per mother = 0.196) and were comparable to those observed in 2015 - 2016 just after the decline began. The "warm blob" – an anomaly in sea water temperature rise from 2013 to 2015 (Cavole et al. 2016) – and its impact on the prey base has been suggested as a potential underlying cause of the calving rate decline within the Caamaño-Douglas area (Wray and Keen 2020) and may offer insights into population level impacts of climate change on Humpback whales.

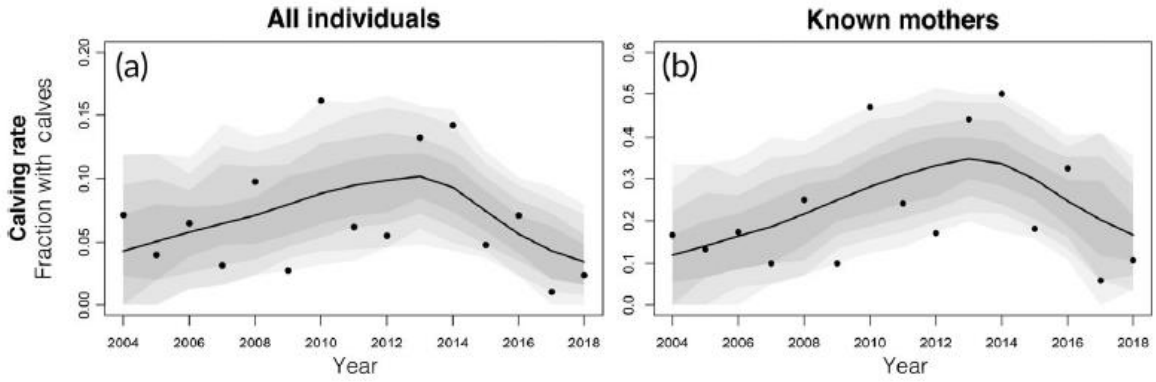

Figure 81. *Bayesian logistic regressions (black lines) of annual trends (2004-2018) in the fraction of Humpback whales seen with calves (black dots) in the Caamaño-Douglas area, tested for (a) all unique individuals identified in the study area (i.e., per capita) and (b) all known mothers (per mother). Grey shaded regions represent 95%, 90%, 75% and 50% prediction percentiles. Adapted from Wray and Keen 2020.*

Site fidelity

The resighting rate for Humpback whales that were previously observed in the Caamaño-Douglas area is 68% on average (2004 - 2020), with a high of 98% between 2017 and 2018. Of all identified individuals within the Caamaño-Douglas area population, 51% have been documented in more than one year, 24% in 5 or more years, 11% in 10 or more years, and two individuals have been documented every year for 17 y (2004 - 2020) (Wray and Keen 2021).

Seasonality, distribution & movement patterns

Humpback whales occur regularly in both the outer and inner waterways of the Caamaño-Douglas area (Williams and Thomas 2007; Ford et al. 2010; Best et al. 2015; Wright et al. 2021b), including Caamaño Sound, **Lax Ka'gaas**/Campania Sound, Estevan Sound, Squally Channel, Whale Channel, Lewis Passage, Cridge Passage, Otter Channel, Nepean Sound, Wright Sound, Verney Passage, Douglas Channel, Ursula Channel, and Bishop Bay (**Figure 76**). Line transect surveys conducted during summer 2018 estimated high Humpback whale densities (≥ 2 - 3 individuals per 25 km^2; **Figure 77**, Wright et al. 2021b) in the Caamaño-Douglas area. Opportunistic photo-identification surveys conducted by the North Coast Cetacean Society (NCCS) from 2021 and 2022 similarly show high densities and broad spatial habitat use of humpback whales throughout the Caamaño-Douglas area (**Figure 76**).

Humpback whales exhibit seasonality in their presence in BC waters because they migrate to warm water, low-latitude habitats in winter and return to temperate waters at higher latitudes the following late spring or early summer for the primary purpose of feeding. The majority of humpback whales from the Caamaño-Douglas area migrate to and from Hawaii (McMillan et al. 2023). Humpback whales begin to arrive in the Caamaño-Douglas area from their warm water habitats in May and continue to occupy the area throughout the summer and fall. Abundance declines in the late fall and winter as Humpback whales begin their southward migration to

breeding and calving grounds.

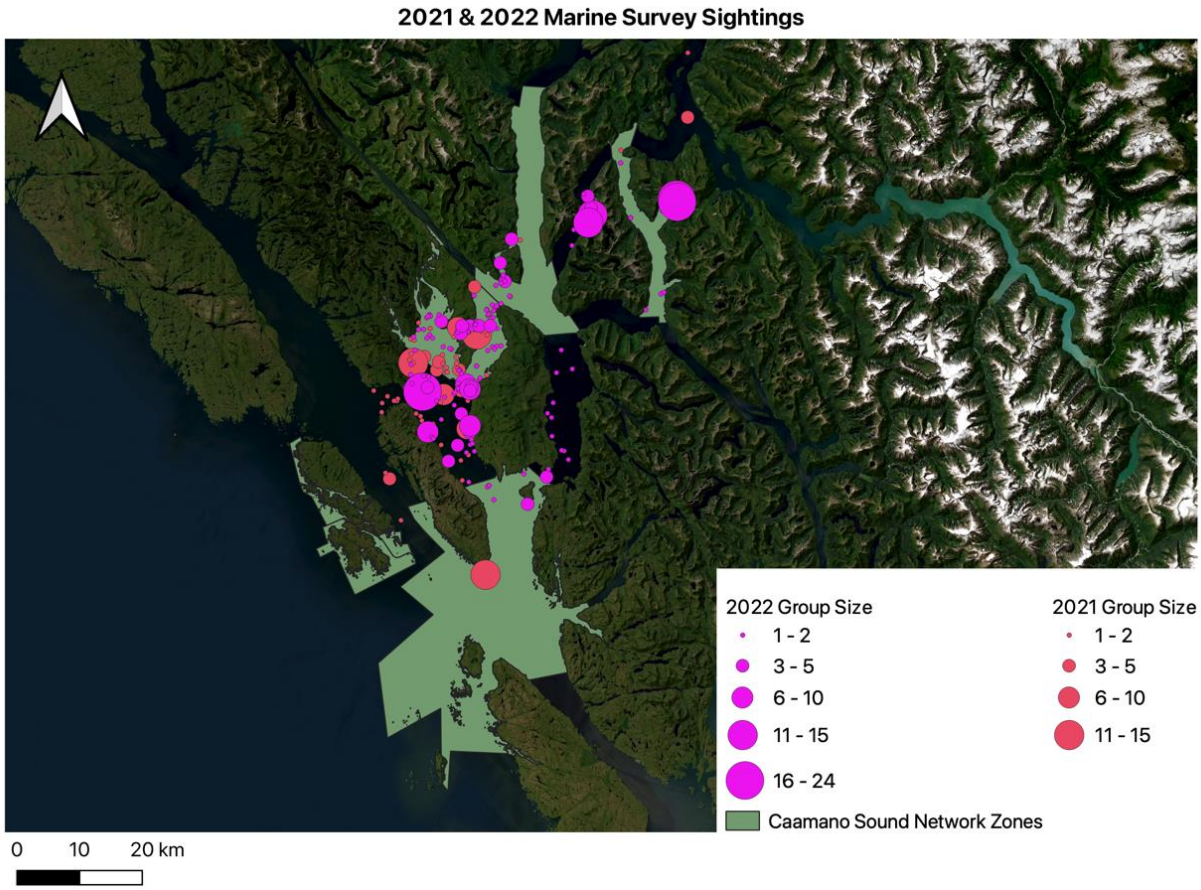

***Figure 82**. Photo-identification encounters of Humpback whales in the Caamaño-Douglas area from 2 years of opportunistic surveys (2021 and 2022). Photo-identification data are not corrected for observer effort.*

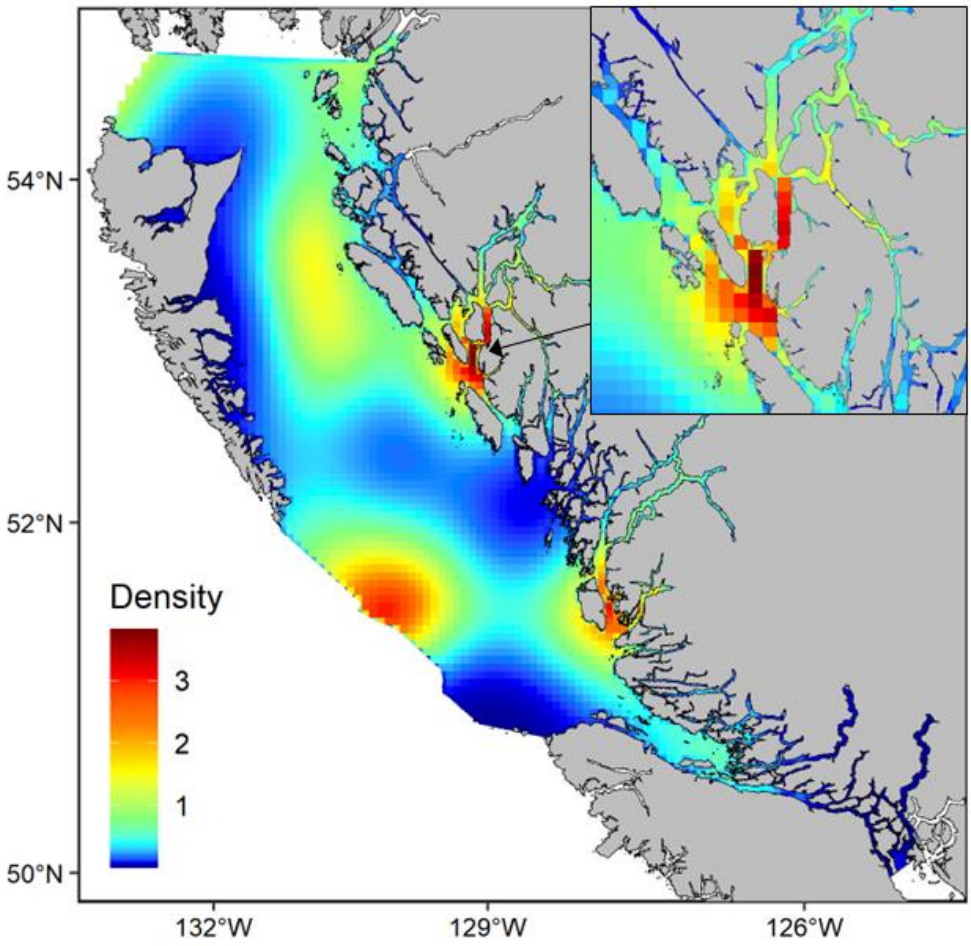

***Figure 83**. Estimated densities (fill colour indicates the number of individuals per 25 km² grid cell) of humpback whales in the North Coast of British Columbia, based on predictions from a best-fit Generalized Additive Model fit to ship-based visual survey data collected in the summer of 2018. Total model-predicted abundance of humpback whales for the entire North Coast region was 1,816 (95% CI: 1,403 - 2,351). Inset at the upper right corner shows the Caamaño-Douglas Area in greater detail. Adapted from Wright et al. 2021b.*

In the early summer months, Humpback whales are concentrated in the outermost channels and waterways of the Caamaño-Douglas area (i.e., **Lax Ka'gaas**/Campania Sound, Caamaño Sound, and Otter Channel) and as the year progresses into late fall, groups of Humpback whales trend towards occupying deep inland waterways (**Figure 84**) including Verney Passage, Whale Channel, and Bishop Bay (Keen et al. 2017). Bubble net feeding is observed among humpback whales foraging in the Caamaño-Douglas area including Squally Channel (**Figure 85**).

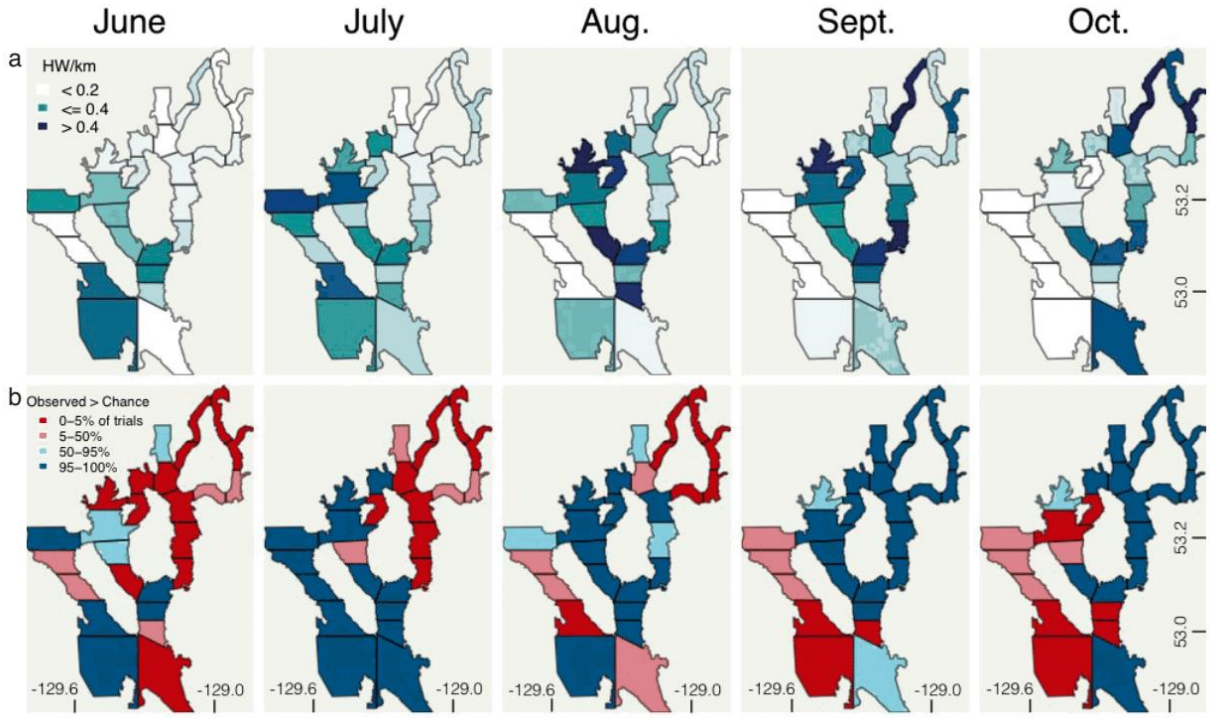

Figure 84. *The 'whale wave' is (a) evident in Humpback whale sighting rate (**ɬbuun/ḡʷeẏém/ɬpuun/** whales per km) estimates and (b) verified by Monte Carlo randomization tests in the Caamaño-Douglas area of British Columbia. The 2004 to 2014 surveys from Gitga'at and North Coast Cetacean Society platforms were pooled and then spatially stratified (n = 26 strata). Randomization results (b) are colour-graded for each stratum as dark red: observed **ɬbuun/ḡʷeẏém/ɬpuun** sighting rate was lower than at least 95% of the random trials; pink: observed sighting rate was lower than the randomization median; light blue: observed was higher than randomization median; dark blue: observed was higher than 95% of random trials. Original figure from Keen et al. (2017).*

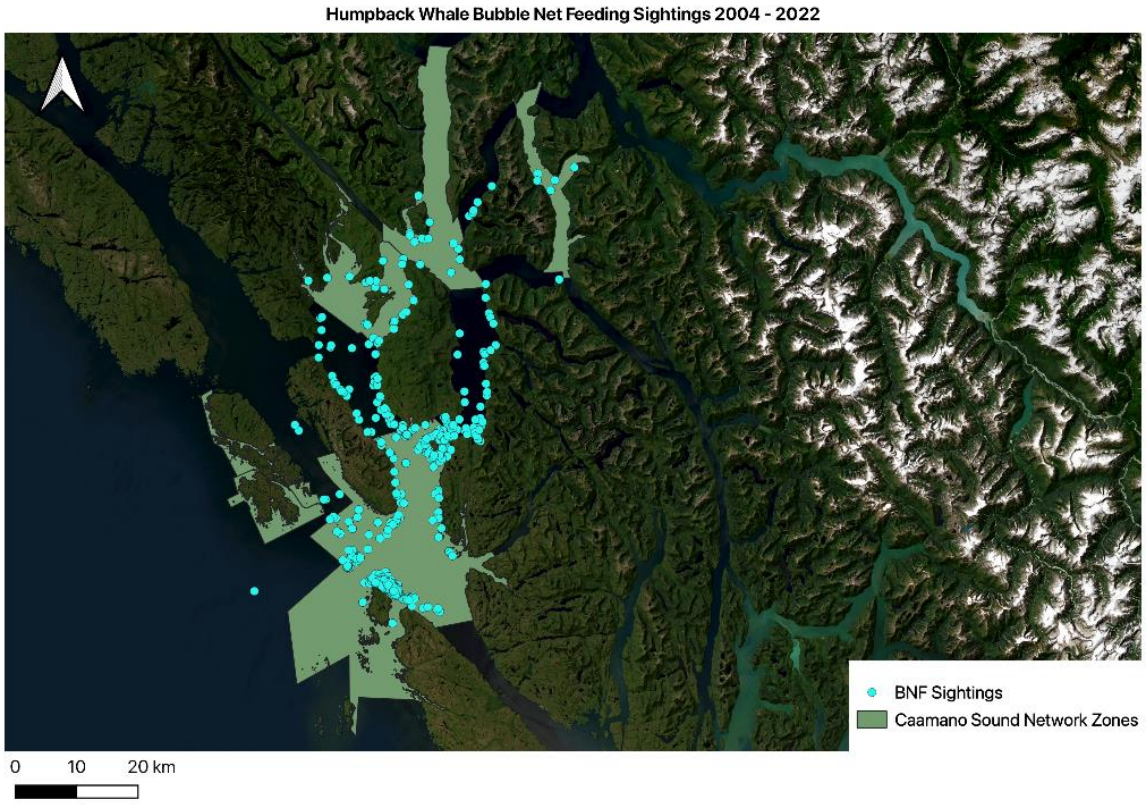

***Figure 85**. Location of opportunistically photo-identified bubble net feeding Humpback whales documented from 2004 - 2022 by the North Coast Cetacean Society. Photo-identification data are not corrected for observer effort and are not reflective of group size.*

Social niche partitioning is evident among Humpback whales in the Caamaño-Douglas area and results in differential feeding habitat usage within a year (Wray et al. 2021). Individual **łbuun**/**ḡʷey̓ém**/**łpuun**/whales that arrive early in a feeding season display a preference for the area's outer channels, mid-season arrivals tend to prefer mid-channel habitats or do not display strong habitat preferences, and late-season arrivals have a stronger than expected preference for the inner fjord channels (Wray et al. 2021).

Habitat function

The Caamaño-Douglas area supports a variety of unique behaviours and group compositions that have been less frequently documented in other regions of the BC coast, including bubble net feeding, resting, and social feeding aggregations. Bubble net feeding (BNF) behaviour is common among Humpback whales in the Caamaño-Douglas area (**Figure 80**) and has been observed throughout the region from southern Douglas Channel to Caamaño Sound, Estevan Sound, and eastern Hecate Strait from spring through late fall. BNF typically entails a group of 2 - 15 individuals that coordinate their behaviour, including swimming in ascending spirals while bubble blowing and emitting feeding calls into the water column to trap and prey upon schools of **Tskah**/**wáṅi**/**tsk̲ah**/Pacific Herring (D'Vincent et al. 1985; Leighton et al. 2007; Wiley et al. 2011). Single **łbuun**/**ḡʷey̓ém**/**łpuun**/whales have also been documented to bubble net feed and during these events these individuals potentially perform all roles that would typically be

partitioned among larger groups. Sightings data (2004 – 2022) have documented an increase in the number of individuals that participate in BNF (18 – 220, respectively) in the Caamaño-Douglas area (**Figure 80**) (North Coast Cetacean Society, unpublished data). The average proportion of photo-identified Humpback whales known to bubble net feed is 0.40 per year. Preliminary results from network-based diffusion analyses suggest cultural transmission of this cooperative bubble net feeding behaviour within the Caamaño-Douglas area (North Coast Cetacean Society, unpublished data).

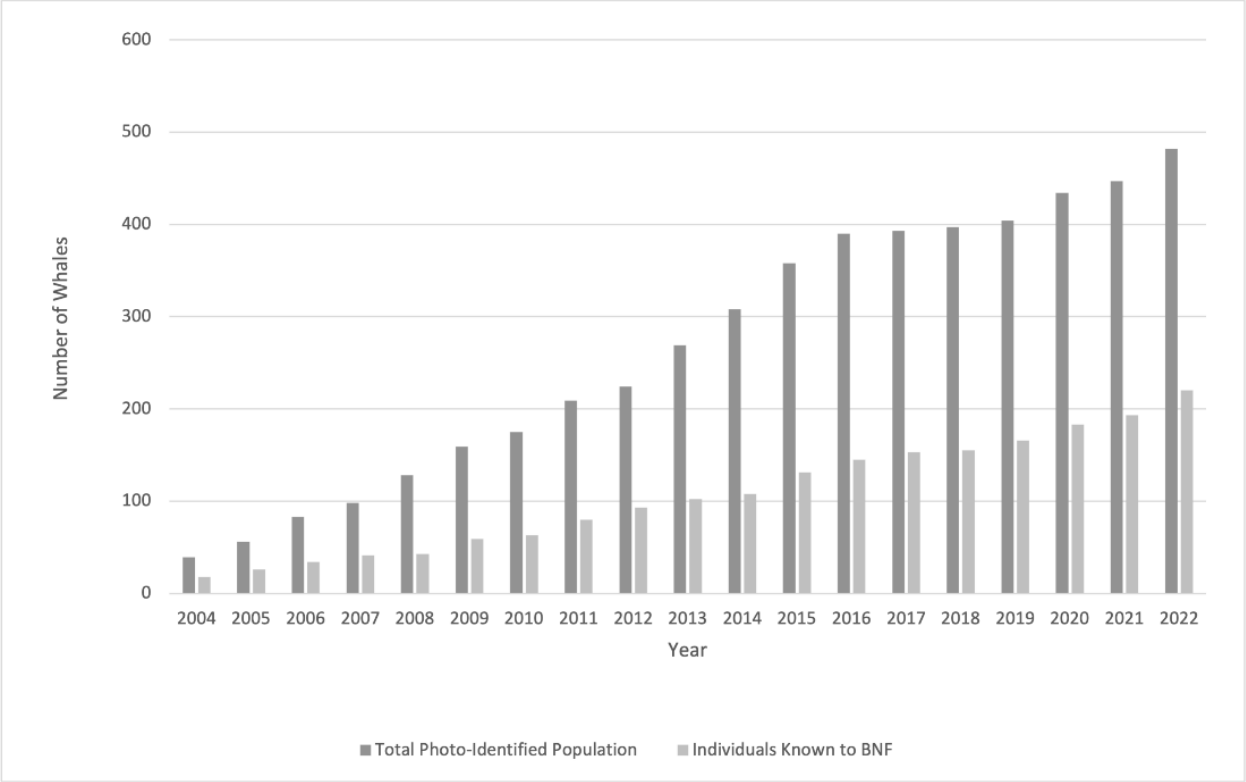

***Figure 86**. The total number of Humpback whales photo-identified by North Coast Cetacean Society and the total number of Humpback whales known to bubble net feed within the Caamaño-Douglas area from 2004-2022.*

Łbuun/**g̱ʷey̓ém**/**ɬ**puun/whales that participate in cooperative group BNF display higher degrees of site fidelity than humpbacks that do not and are more likely to arrive earlier in the season and spend longer periods of time within the fjordal waters of the Caamaño-Douglas area. These humpback whales also tend to maintain longer-term and stronger social bonds compared to **ɬ**buun/**g̱ʷey̓ém**/**ɬ**puun that are not known to bubble net feed (Wray et al. 2021). Using an array of four hydrophones (**Figure 81**) in northern Squally Channel, humpback whale presence, localized movements and behaviour were monitored acoustically 24 hours a day from May to October (2021 and 2022).

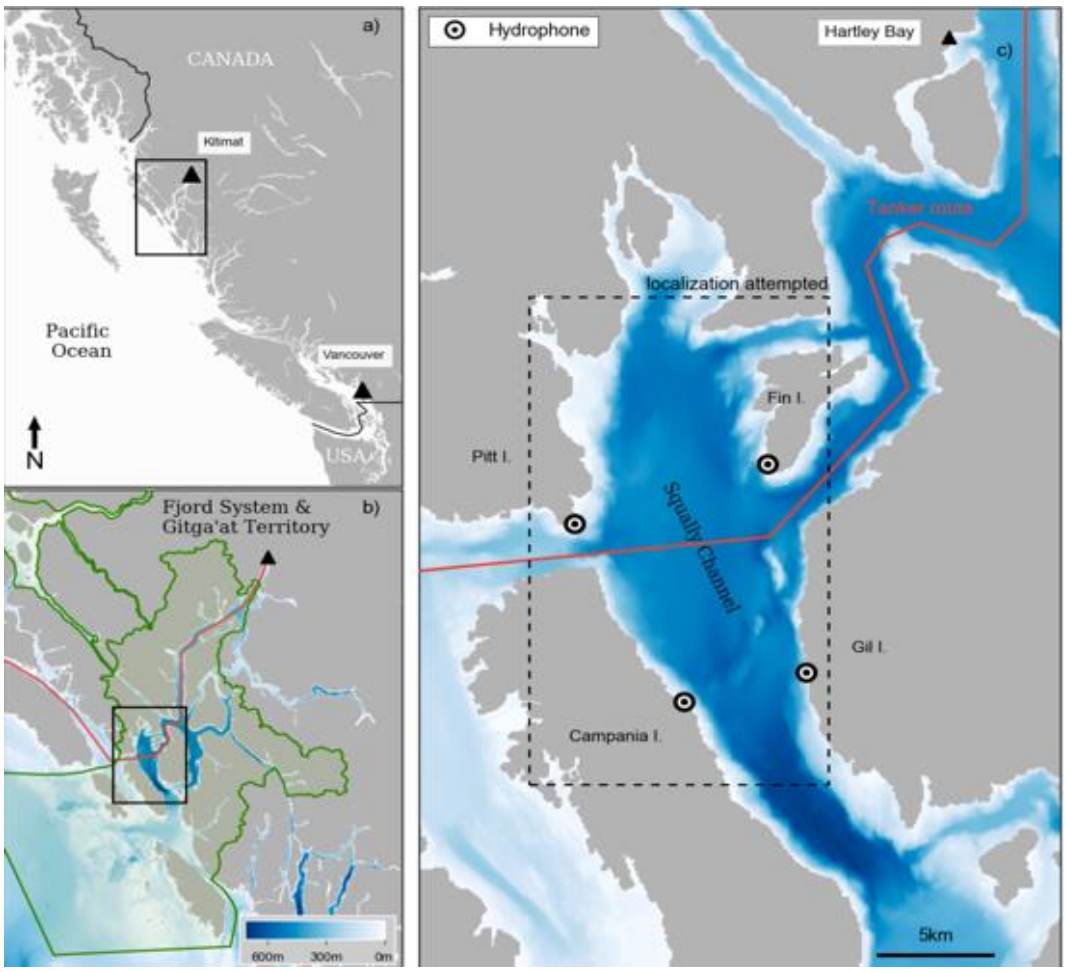

***Figure 87**. Overview of the monitoring area on the west coast of Canada (a), the location in the Caamaño-Douglas area fjord system (b), and the hydrophone configuration in Squally Channel in proximity to **Txałgiu**/Hartley Bay. The red line in frames (b) and (c) is the projected route for LNG tankers to and from the Kitimat terminus. Modified from figure previously published in Hendricks et al. 2021.*

This acoustic monitoring recorded BNF calls in northern Squally Channel from the beginning of May through the end of October in both 2021 and 2022 (60% and 51% of 106 and 78 recording days, respectively). The greatest number of days per month with BNF calls occurred in August in 2021 (25 of 31 recording days, or 81%) and September in 2022 (24 of 30 d, or 80%). BNF calls were present predominantly during daylight hours in both years; the vocalization rate peaked in the early morning hours and gradually dropped during the course of the day. BNF calls were localized in both mid-channel and nearshore locations but were detected more often close to the shorelines around the entrance of Otter Channel, the eastern **Lax Ka'gaas**/ Campania shoreline, and the entrance to Lewis Passage (**Figure 82**). Note that the proposed tanker route for LNG is through Otter Channel and Lewis Passage.

These acoustic results are specific to Squally Channel, vary annually, and do not include other regions of the Caamaño-Douglas area where bubble net feeding is also common.

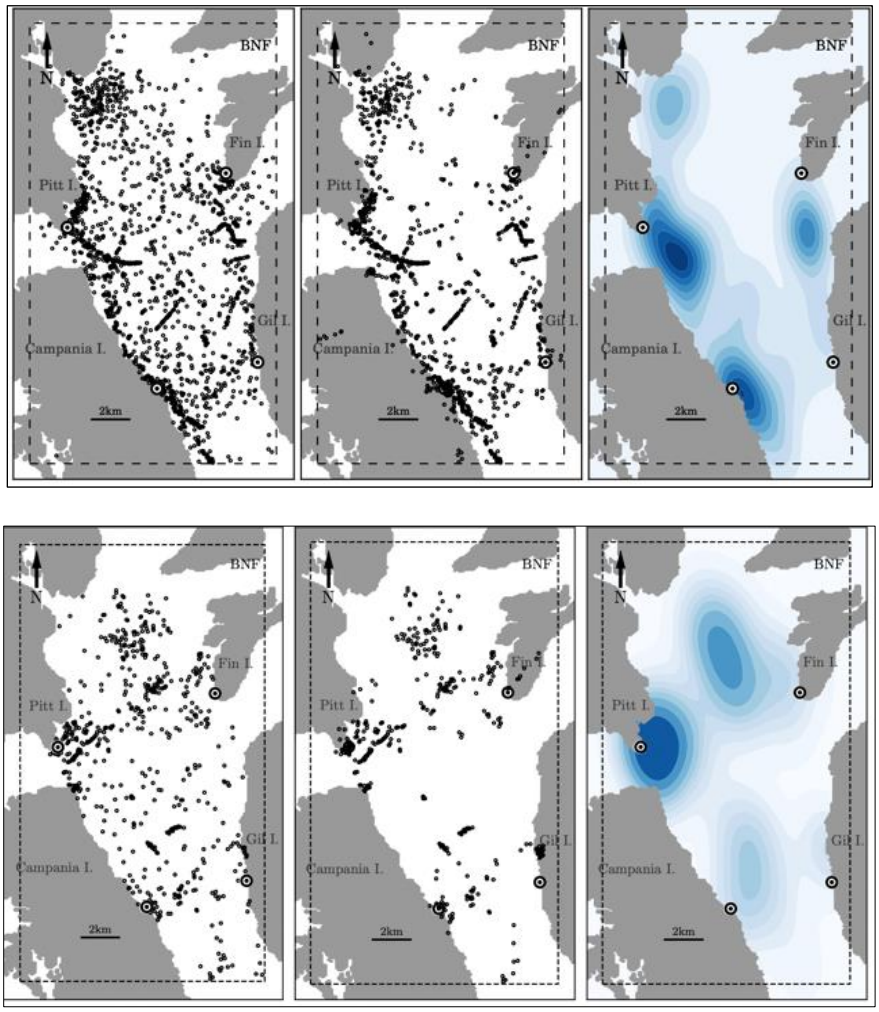

***Figure 88**. 2021 (top panel) and 2022 (bottom panel) localized Humpback whale bubble net feeding (BNF) calls in Squally Channel, British Columbia. Left: all localized BNF calls. Middle: BNF calls were grouped into clusters when a sequence of calls within a 10-minute interval were localized in direct proximity to each other, confirming the feeding location. Right: Normalized density distribution of BNF calls intended only as a visual aid to highlight vocal hotspots.*

Resting behavior states

Humpback whale surface resting behaviour occurs at many breeding and calving habitats across the globe and at migration stopovers (Bejder et al. 2019; Ejrnæs and Sprogis 2021; McCulloch et al. 2021; Sprogis et al. 2020). However, to the best of our knowledge, surface resting behaviours in Humpback whales have not been formally described in higher latitude feeding areas like BC. Within the Caamaño-Douglas area, both “surface resting” as well as “resting-travel” behaviour states were routinely documented, in which Humpback whales rest for extended periods of time (> 5 minutes, occasionally >1 hour) either at the surface, or travelling at slow speeds at depths less than approximately 5 - 10 m while making infrequent surfacings to breathe (**Figure 83**).

There were 43 instances of Humpback whales engaged in resting behaviour states (**Figure 84**) documented across 49 opportunistic survey days from May to October 2022. This behaviour puts Humpback whales at considerable risk of ship-strike. Specific risks to resting Humpback whales are further discussed in Section 6.2.5.4.

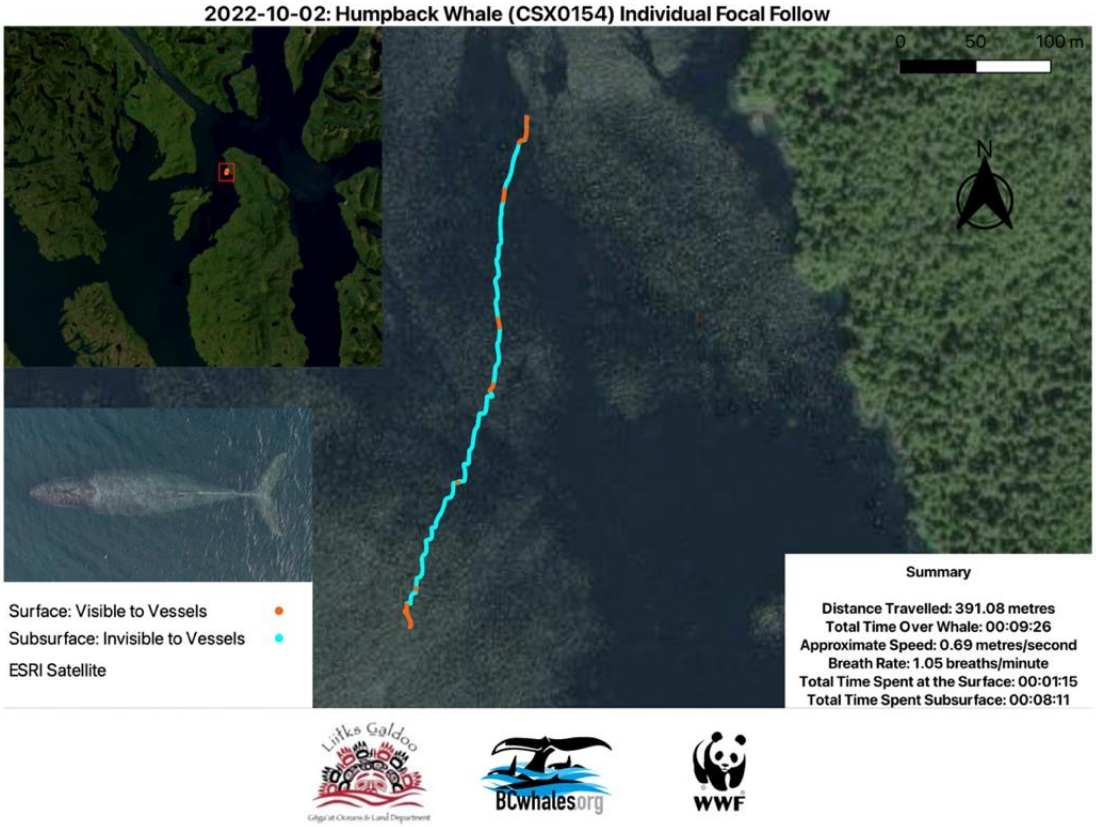

***Figure 89**. Unmanned aerial vehicle (UAV) focal follow track of Humpback whale CSX0154 in a resting-travel behaviour state for almost ten minutes in Wright Sound, British Columbia. This individual was visible to the UAV camera both at the surface and sub-surface for the entire plotted track. However, it spent approximately 1 minute at the surface and the rest of the time just below the surface where it was still visible from the UAV.*

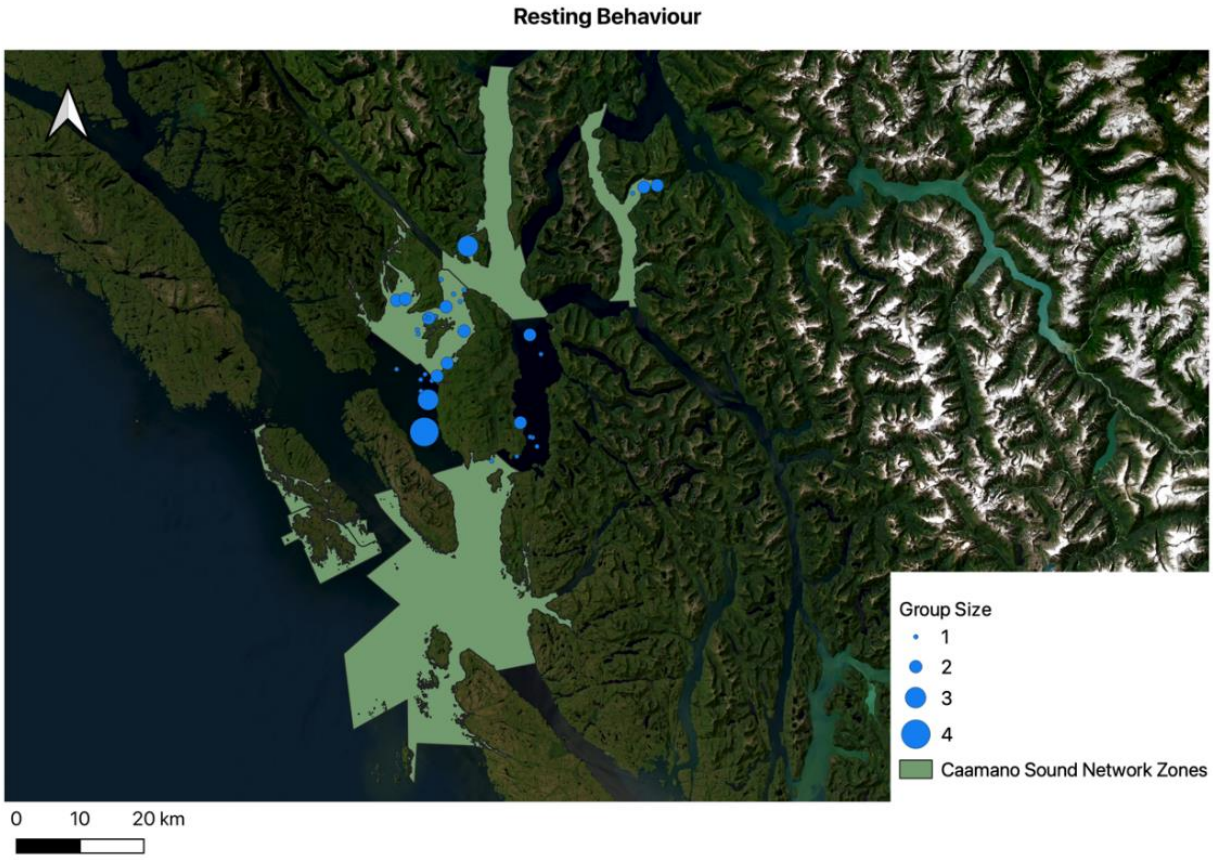

***Figure 90**. Locations where Humpback whales were observed in resting behaviour states in 2022 during opportunistic vessel surveys in the Caamaño-Douglas area. Encounters with resting Humpback whales are not corrected for observer effort.*

Social Feeding Groups

In the fall months, Humpback whales that travel to the inner fjord waterways and eastern Caamaño Sound demonstrate a seasonal shift in predominant group behaviours. In the early months of the feeding season (June – August), large groups of Humpback whales (> 5 individuals) are primarily concentrated in the outer waterways of Caamaño Sound, **Lax Ka'gaas** /Campania Sound, and Squally Channel (Keen et al. 2017). Bubble net feeding is the predominant behaviour observed (Wray et al. 2021). However, in autumn, specific “hotspot” areas in eastern Caamaño Sound, Verney Passage, and Bishop Bay are used by Humpback whales and BNF is not the predominant group behaviour in these locations. Autumn aggregations can include more than 30 Humpback whales engaging in interactive social behaviours and displaying fluid group dynamics with **łbuun**/**ḡʷeẏ́ém**/**łpuun**/whales spending extended periods of time at or near the surface, engaging in close contact, and producing tonal blows and complex vocalizations (Wray et al. 2021). These surface-active periods alternate with long dives, which we infer as feeding at depth. Additionally, it is common for the individuals involved in autumnal aggregations to solely be documented in these specific regions (beginning in September for Verney Passage and Bishop Bay), and to be undocumented in other areas of the Caamaño-Douglas area.

Diet

Humpback whales have a broad diet. A recent study of foraging humpback whales in southern BC indicates **Tskah**/**wáṅi**/**tsk̲ah**/Pacific herring and euphausiids (*Euphausia pacifica*, *Thysanoessa spinifera*, and *T. raschii*) are primary prey species and additional prey species include **gasgos**/**sísíuɬ**/shrimp (*Sergestes similis* and *Eualus avinus*), juvenile **balaas**/Pacific hake, **Ha'limootk**/**ƛ̓áti**/**ẅa̲h**/eulachon, juvenile **hoon**/**qeqapela**/salmon, and juvenile **hadanii**/**hadanii**/sablefish (Reidy et al. 2022). **Tskah**/**wáṅi**/**tsk̲ah** and euphausiids are important prey species for humpback whales in the Caamaño-Douglas area as evidenced by observations of BNF and by the distribution of feeding individuals and the diving behaviour they exhibit, respectively (Keen 2017).

Knowledge gaps

1. Prey preferences and diet composition of Humpback whales in the local Caamaño-Douglas area.

2. Wintertime (November – April) habitat usage by Humpback whales in the Caamaño-that do not migrate to breeding habitats.

3. The effect of vessel noise on Humpback whale acoustic behaviours (including BNF and song) within the area.

4. The effect of vessel noise on the cultural transmission of acoustic traditions including song and BNF vocalizations.

5. Quantify the level of mortality from and the pervasiveness of threats, particularly vessel strikes.

6.2.5.1.3 **‘naaxɬ** / **hélx̄’inix̄ʷ** / **niixɬ** / Killer whales

6.2.5.1.3.1 Northern Resident Killer whale

Population abundance & trends

The Northern Resident **‘naaxɬ**/**hélx̄’inix̄ʷ**/**niixɬ**/Killer whale (NRKW) population ranges coastally from southeast Alaska to Washington state (Ford 2006). As a whole, the population is small but increasing in size (2.5% growth from 2020 to 2021) and was estimated at 332 individuals as of the 2021 photo-identification census (DFO 2022h). All 16 NRKW pods have been detected in the Caamaño-Douglas Area (Ford 2006; Pilkington et al. 2011), and on average, 11 of the 16 pods used the area annually between 2006 - 2011 (Pilkington et al. 2011). Substantial portions of the Caamaño-Douglas area, including Network Zones 310, 312, 313, 314 and 315, as well as the south end of Estevan Sound and Otter, Squally and Whale Channels, were previously proposed as potential critical habitat for NRKW (see Figure 12 in Ford 2006). This designation was never made official, however, citing a need for more data. Because it is difficult to quantify the impact of annual differences in observer effort on acoustic and photo-identification encounter data, it is not known if use of the Caamaño-Douglas area by NRKW is changing over time. Nonetheless, it is evident that portions of the NRKW population use the Caamaño-Douglas area on an annual basis.

Seasonality, distribution & movement patterns

Combined long-term passive acoustic monitoring (PAM) and photo-identification surveys by both the North Coast Cetacean Society (NCCS) and DFO show that NRKW are found in the Caamaño-Douglas area during most months, but are present on the highest percentage of days with research effort from May to July (**Figure 91**; Pilkington et al. 2011; Ford 2006; DFO, unpublished data). Between May-August in the years 2009 - 2011, intensive visual and acoustic survey effort by NCCS in the inner waters of the Caamaño-Douglas area from Ulric Point on Aristazabal Island to **Txałgiu**/Hartley Bay at the south end of Douglas Channel (Zones 310, 313 and 314) detected NRKW on 58% of effort days (Pilkington et al. 2011). Within this period, the highest monthly percentage of effort days with NRKW detections occurred in June (78%) (Pilkington et al. 2011). Of the various hydrophones maintained by NCCS between 2006-2011, NRKW were detected most often at the Ulric Point recorder in Zone 310 (29% of days with acoustic effort across all months examined, see **Figure 92** for location). A hydrophone deployed by DFO between mid-October 2011 and June 2012 off of Rennison Island (also in Zone 310, see **Figure 92** for location) recorded NRKW on nearly 16% of effort days (36 of 228 days; J. Pilkington, DFO, unpublished report), indicating that this population is also present in the Caamaño-Douglas area during fall, winter and spring, albeit at lower rates than during the summer. Of the acoustically sampled (i.e., non-summer) months at Rennison Island, NRKW were detected most often in May and November (approximately 30% of monthly days), which supports the pattern of increasing NRKW presence in the Caamaño-Douglas area as the summer approaches and a subsequent decline beginning in autumn. Combined visual and acoustic data from NCCS (**Figure 91**) also indicate a smaller uptick in NRKW presence in the Caamaño-Douglas area during the late fall (Pilkington et al. 2011).

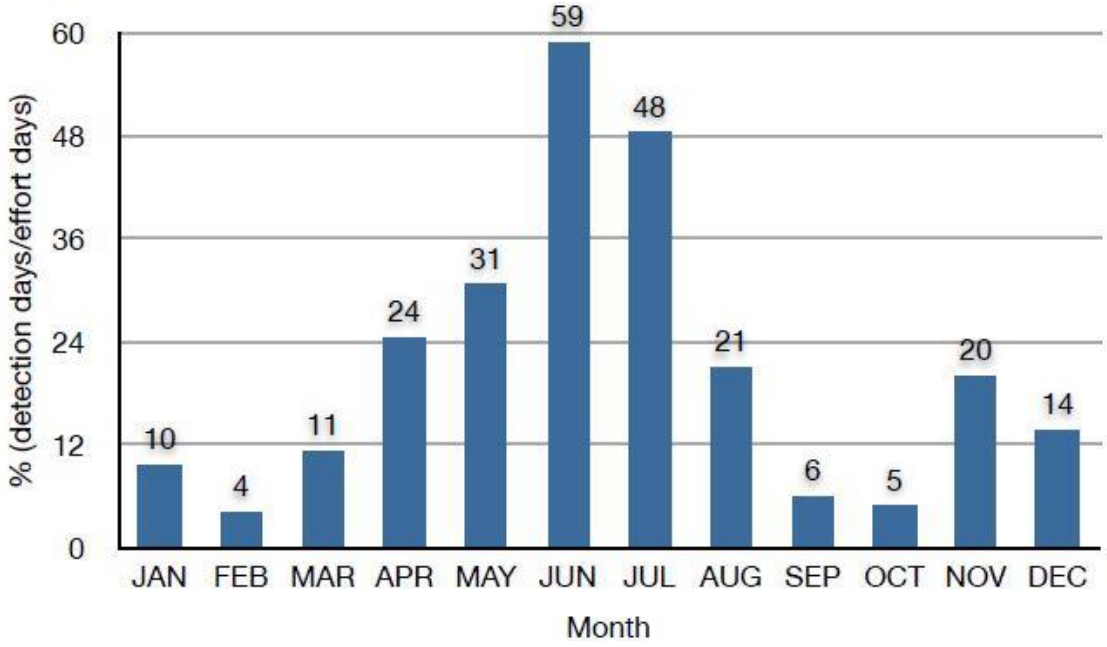

Figure 91. *Detection days with northern resident* ***'naaxɬ/hélx̄'inix̄ʷ/niixɬ/****Killer whales in the Caamaño-Douglas area as a percentage of total effort days by month (visual and acoustic methods), from 2006 - 2011, North Coast Cetacean Society (reproduced from Figure 6 in Pilkington et al. 2011).*

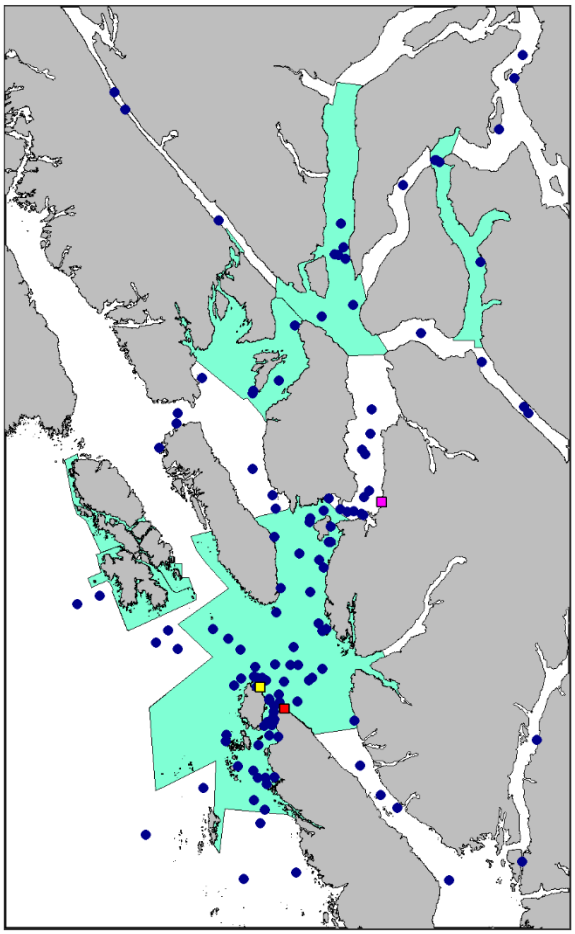

Figure 92. *Photo-identification encounters (blue dots) with northern Resident* ***'naaxɬ/hélx̄'inix̄ʷ/niixɬ/****Killer whales in the Caamaño-Douglas area, collected between 1976-2021 (n = 128, DFO, unpublished data). The location of the Rennison Island hydrophone (deployed annually by DFO since 2011) is indicated by the yellow square, the Whale Channel hydrophone (deployed by North Coast Cetacean Society (NCCS) between 2004 -2015) by the magenta square, and the Ulric Point hydrophone (deployed by NCCS between 2008 - 2011) by the red square. Proposed Caamaño Sound and Douglas Fjord System Network Zones are shown in green. Photo-identification encounters were collected opportunistically and have not been corrected for observer effort.*

Acoustic detections by NCCS (2006 - 2011) show a seasonal pattern of NRKW movement within the Caamaño-Douglas area, with this ecotype primarily using the area around **K'ts'ats'aas**/Gil Island (Zones 310 & 313) and some limited use of Caamaño Sound (Zone 310) in the early spring (Pilkington et al. 2011). By late spring and throughout the summer until mid-August, most NRKW acoustic detections occur farther south in Caamaño Sound itself and around Aristazabal Island (Zone 310; Pilkington et al. 2011). Sporadic acoustic detections in the late summer give way to another smaller peak in NRKW activity between October and January that has returned to the north around **K'ts'ats'aas** (Whale Channel hydrophone, see **Figure 92** for location), after which detections drop off until spring (Pilkington et al. 2011). **Figure 92** also shows the locations of opportunistic photo-identification encounters with NRKW collected by DFO between 1976 - 2021. The vast majority of these boat-based encounters (82%) occurred between May and August, primarily as a result of effort bias favouring months with better

weather conditions. Photo-identification encounters have occurred in Caamaño–Douglas Fjord System Network Zones 310, 313, 314, and 316 as well as in Squally, Whale, Otter, Laredo and Princess Royal Channels, Verney Passage, and off of the west side of Aristazabal Island.

Diet & habitat function

The higher summertime occurrence of NRKW in the Caamaño-Douglas area coincides with the migration of **yee/ḵáp̓i/xyi'i**/Chinook salmon from outer coastal waters to spawning rivers, and thus this region is considered an important foraging habitat for **‘naaxɬ/hélx̄’inix̄ʷ/niixɬ**/Killer whales (Ford 2006). In particular, the Caamaño-Douglas area may provide important foraging grounds for NRKW in the early summer, before returning **hoon/qeqapela**/salmon reach coastal areas farther to the south, such as Johnstone Strait (Ford 2006). **yee/ḵáp̓i/xyi'i** are the preferred prey of Resident **‘naaxɬ/hélx̄’inix̄ʷ/niixɬ** due to their large size and high lipid content (Ford et al. 1998; Ford and Ellis 2006), and the abundance of **yee/ḵáp̓i/xyi'i** is vital to their ongoing survival and long-term population viability (Ford et al. 2010; Clarke Murray et al. 2021). Summer collection of prey sample remains (June-August, plus 1 sample collected in October, n = 75 total, **Figure 93**) from NRKW predation events confirms that the majority of prey consumed in the Caamaño-Douglas area are **yee/ḵáp̓i/xyi'l** (77%, n = 58), with **gayniis/gʷaxenis/g̱a̱yniis**/chum salmon (*O. keta*) being of secondary importance (20%, n = 15). Most **yee/ḵáp̓i/xyi'i** and **gayniis/gʷaxenis/g̱a̱yniis** captured by NRKW within the Caamaño-Douglas area were 4- or 5-year-old fish, consistent with a coast-wide diet analysis that found that **‘naaxɬ/hélx̄’inix̄ʷ/niixɬ** preferentially target older, larger **hoon/qeqapela** (Ford and Ellis 2006). For those **yee/ḵáp̓i/xyi'i** predation samples that could be genetically identified to stock (n = 53), 34.0% originated from northern BC and southeast Alaskan runs, 30.2% originated from the west coast of Vancouver Island, and 20.8% originated from the Fraser River. The remainder of these predation samples (15.1%) came from **yee/ḵáp̓i/xyi'i** runs in the Strait of Georgia, Puget Sound and coastal Oregon. A state-space model describing the relationship between the geographic origin of fall-run **yee/ḵáp̓i/xyi'i** versus their seasonal ocean distributions (Shelton et al. 2019), corroborates the stock composition findings we describe above for fish preyed upon by NRKW in the Caamaño-Douglas area. In other words, **yee/ḵáp̓i/xyi'i** from more southerly river systems (e.g., southwest Vancouver Island, Strait of Georgia/Fraser River and Puget Sound) are often prevalent in northern regions (e.g., the Caamaño-Douglas area) in the summer (June - July), prior to making their way to their natal streams for the fall spawn, at which time **yee/ḵáp̓i/xyi'i** are typically distributed closer to their region of origin (Shelton et al. 2019).

Most observations of **hoon/qeqapela** predation by NRKW were made by DFO along shorelines within the Caamaño-Douglas area. In particular, the eastern shore of **Lax Ka'gaas** /Campania Island, western shore of Princess Royal Island (both south and north of Surf Inlet), as well as Beauchemin Channel between Rennison and Aristazabal Islands are considered of high importance for foraging (Zone 310; **Figure 93**). NCCS data combined with consultations with local knowledge keepers (First Nations and fishers) also indicated that foraging by NRKW is most common along the shorelines extending from lower Douglas Channel to Caamaño Sound (Zones 310, 312, 313 and 314) and is especially prevalent around Rennison Island (**Figure 93**; Pilkington et al. 2011),. Foraging by NRKW in more open water also occurs regularly, mainly in central Squally Channel and **Lax Ka'gaas**/Campania and Caamaño Sounds (Zone 310; **Figure 94**). Foraging is one of the main behaviours exhibited by NRKW in the Caamaño-Douglas area during the early summer, and their presence in the region in late fall and winter is probably also related to foraging, when they are likely accessing **gayniis/gʷaxenis/g̱a̱yniis**/chum and winter

yee/**ḵáp̓i**/**xyi'i** (Pilkington et al. 2011). However, no winter predation samples have been collected to verify NRKW dietary composition in the Caamaño-Douglas area during this season.

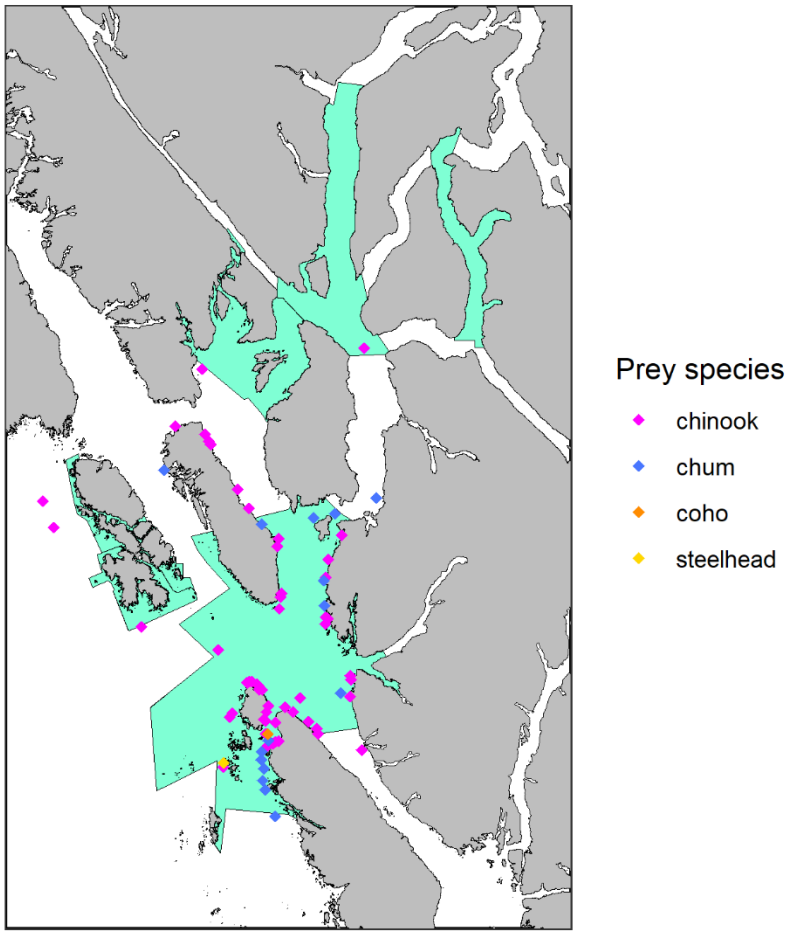

Figure 93. *Predation events (n = 75) by northern Resident* ***'naaxɬ/hélx̄'inix̄ʷ/niixɬ****/Killer whales that have been successfully identified to prey species (indicated by point colour) using schlerochronology or genetic analysis of fish scales and tissue fragments (collected by DFO from 2003-2018, unpublished data). Proposed Caamaño Sound and Douglas Fjord System Network Zones are shown in green. Predation observations were opportunistic and have not been corrected for effort.*

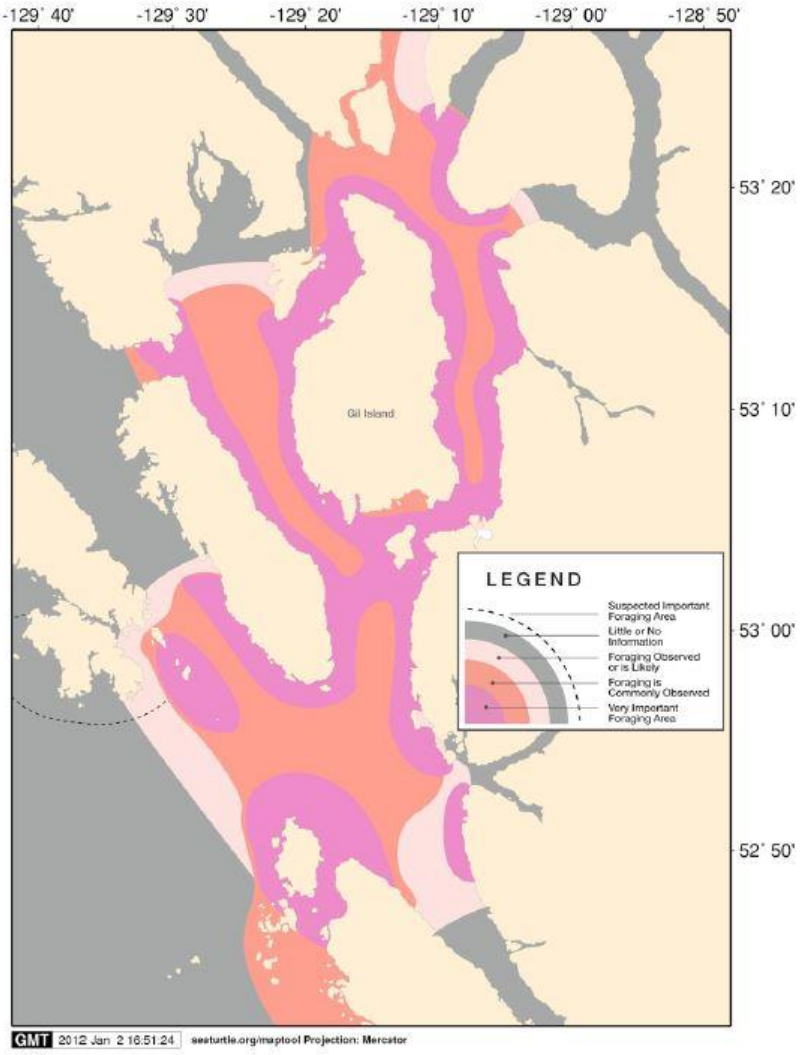

***Figure 94**. Areas of importance for foraging by Northern Resident 'naaxł/hélx̄'inix̄^{w}/niixł/Killer Whales in the Caamaño-Douglas area, qualitatively identified based on North Coast Cetacean Society observations and local knowledge collected since 2001; members of the Gitga'at First Nation, as well as commercial and sport fishers were consulted (reproduced from Figure 11 in Pilkington et al. 2011).*

All three acoustic clans of northern residents have been encountered in the Caamaño-Douglas area, with A clan (the largest) being the most common in the region (Ford 2006; Pilkington et al. 2011). Both DFO's Rennison Island hydrophone (Zone 310, see **Figure 91**, recording winter-spring) and the wider NCCS hydrophone network (2006-2011, generally recording year-round) detected A clan calls on > 85% of recording days that had NRKW (Pilkington et al. 2011; J. Pilkington, DFO, unpublished report). G clan and R clan were far less common (11 - 25% and 6 - 11% of days with NRKW, respectively). Although the acoustic detections suggest that G and R clan do not use the Caamaño-Douglas area as extensively as A clan, over 20% of DFO's photo-identification encounters in the region (see **Figure 92**) were comprised of individuals from multiple clans. Similarly, NCCS data have shown that encounters with groups comprised of multiple clans are common from April-September (Pilkington et al. 2011). Since NRKW tend to exhibit clan and pod exogamy when selecting mates (Barrett-Lennard 2000), and are thought to breed during multi-clan aggregations that peak in frequency during the summer, the

Caamaño-Douglas area is likely important for reproduction and social behaviours of NRKW, in addition to providing vital foraging habitat.

*6.2.5.1.3.2 Bigg's **‘naaxɬ/ hélx̄’inix̄ʷ/ niixɬ/** Killer Whale*

Population abundance & trends

Several genetically distinct and partially sympatric populations of Bigg's (also known as Transient) **‘naaxɬ/hélx̄’inix̄ʷ/niixɬ**/killer whales (BKW) have been described in the eastern North Pacific (Barrett-Lennard and Ellis 2001; Towers et al. 2019; Parsons et al. 2013). Based on acoustic and photo-identification data, all BKW that typically frequent the Caamaño-Douglas area belong to the putative "inner-coast" sub-population of the larger West Coast Transient population (DFO, unpublished data), which ranges coastally from southern California to southeast Alaska (Towers et al. 2019). Inner-coast BKW were estimated to number 349 individuals as of 2018, and average annual growth has increased from 2.7% (2006 - 2011) to 4.1% (2012 - 2018), due to steady reproduction and lower relative mortality, likely resulting from greater prey availability (Towers et al. 2019). It is not currently known what proportion of the inner-coast BKW sub-population uses the Caamaño-Douglas area on a regular basis.

Seasonality, distribution & movement patterns

Combined acoustic and photo-identification data indicate that BKW are present year-round in the Caamaño-Douglas area. The vast majority of photo-identification encounters with BKW in the region (74%, n = 55; **Figure 95**) occur from June - October, largely due to greater observer effort during the summer months. The hydrophone deployed off of Rennison Island (see **Figure 92**) from the fall of 2011 until the spring of 2012 detected BKW on approximately 15% of effort days (J. Pilkington, DFO, unpublished report) and use of the area was relatively even across sampled months (October - May). However, it is difficult to estimate the presence of BKW in a region solely based on acoustic recordings because they are often silent, particularly when foraging (Deecke et al. 2005). Like resident **‘naaxɬ/hélx̄’inix̄ʷ/niixɬ**/killer whales, BKW are highly mobile and traverse long distances across their range, but many groups also show a high degree of site fidelity and repeatedly visit particular areas as they make these movements – probably to access familiar foraging grounds (Towers et al. 2019; Ford et al. 2013). The Caamaño-Douglas area was included in critical habitat proposed for inner-coast BKW in 2013 (see Figure 26 in Ford et al. 2013), but to date, no critical habitat has been designated for this sub-population.

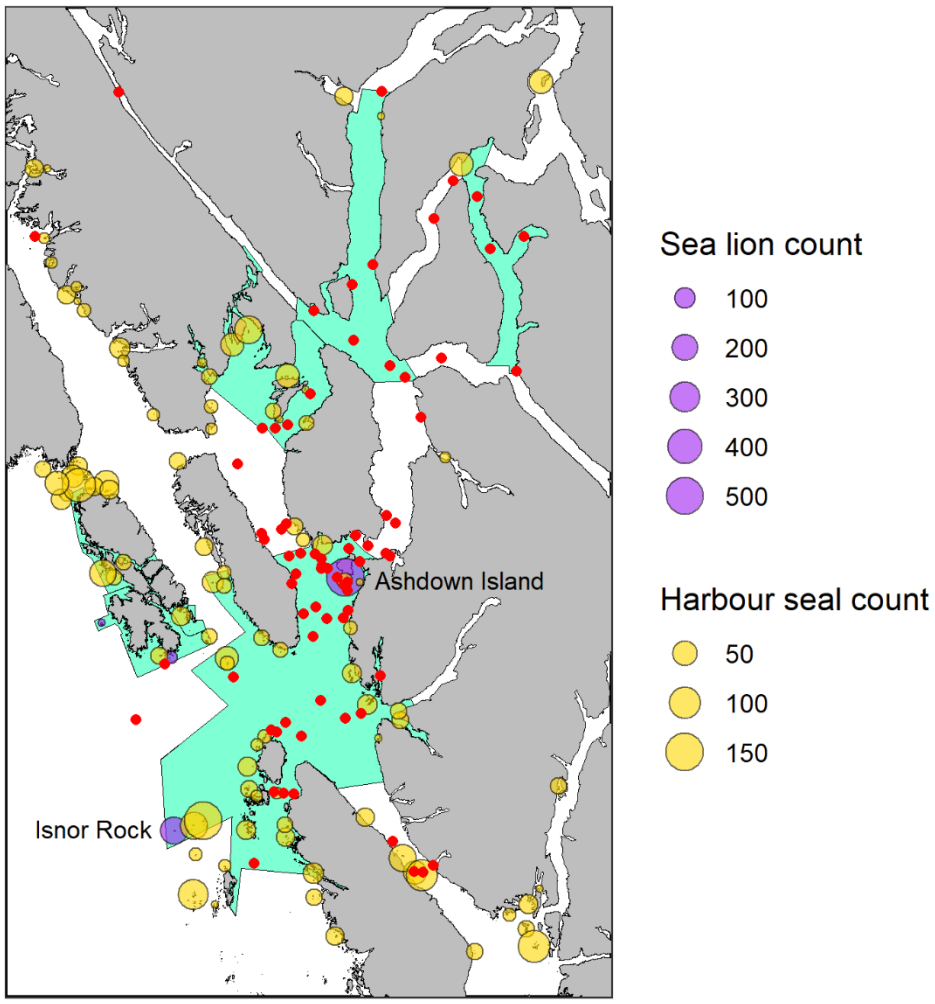

***Figure 95**. Photo-identification encounters (red dots) with Bigg's **'naaxɬ/hélx̄'inix̄ʷ/niixɬ**/Killer whales in the Caamaño-Douglas area, collected between 1994 - 2018 (n = 74, DFO, unpublished data). Encounters are opportunistic and not corrected for observer effort. Recent non-pup counts (indicated by circle size) from summer aerial surveys of Harbour seal (yellow circles) and Steller sea lion (purple circles) haul-outs are also shown (the two largest Steller sea lion haul-outs in the region, **K'nabiyaaxl**/Ashdown Island and Isnor Rock, are labelled accordingly). Proposed Caamaño Sound and Douglas Fjord System Network Zones are indicated in green. Steller sea lion haul-out counts are from 2010 and 2013 aerial survey data, as described by Olesiuk (2018) and available on the Government of Canada data portal (Steller sea lion (Eumetopias jubatus) counts and haul-out locations across the British Columbia coast - Open Government Portal (canada.ca), accessed December 19, 2022), and **üüla** haul-out counts are from aerial survey data collected between 2005-2018 and available on the Government of Canada data portal (Harbour seal (Phoca vitulina) counts and haul-out locations along BC coast - Open Government Portal (canada.ca), accessed December 19, 2022).*

Opportunistic photo-identification encounters with BKW in the Caamaño-Douglas area occurred in the southern portions of Whale and Squally Channels, **Lax Ka'gaas**/Campania Sound, and in Caamaño Sound itself (Zones 310; **Figure 96**). BKW were also observed in more northerly parts of the Caamaño-Douglas area, including around **Lax Kwil Dziist**/Fin Island, Wright Sound and Gribbell Island (Zones 313, 314 & 316; **Figure 96**). Generally, inner coast BKW are encountered close to shorelines (mean = 2.1 km), where they conduct the majority of their foraging (Ford et al. 2013). As with NRKW, the impact of observer effort on the number and distribution of recorded photo-identification encounters is difficult to quantify, and therefore the spatial distribution of these encounters is inherently biased. It is not known if use of the Caamaño-Douglas area by inner coast BKW is changing over time.

Diet & habitat function

BKWs primarily feed on marine mammals (but occasionally also consume squid and seabirds), with Harbour seals comprising over 50% of documented kills and harassments (Ford et al. 1998; Ford et al. 2013; Hanson and Walker 2014). The next most-commonly recorded prey species are the harbour porpoise, Steller sea lion, and Dall's porpoise (Ford et al. 2013), all of which are present in the Caamaño-Douglas Area. There are numerous haul-outs throughout the region (**Figure 95**) and it is likely that BKW hunt **üüla**/**sa̱g̱ʷam**/seals when moving through the area, although they tend to take **üüla**/**sa̱g̱ʷam** that are dispersed in open water rather than close proximity to the haul-outs themselves (Ford et al. 2013). Peaks in BKW presence during periods of consistent summer effort in southeast Alaska and southeast Vancouver Island have been tied to the timing of Harbour seal pupping in those regions (Ford et al. 2013), and a similar pattern could also exist within the Caamaño-Douglas area. Naïve newly weaned Harbour seal pups likely constitute an easily obtained and reliable seasonal prey resource for BKW. In addition to **üüla**/**sa̱g̱ʷam**, there are four Steller sea lion haul-outs within the Caamaño-Douglas area; the two largest are located at **K'nabiyaaxl**/Ashdown Island and Isnor Rock (both in Zone 310, **Figure 95**), with summer non-pup counts of 525 and 229 **t'iibn**/**X̱iX̱'én**/sea lions in 2013, respectively. Prey samples opportunistically collected by DFO in the Caamaño-Douglas area were identified to species using genetic analysis (2005 - 2017, **Figure 96**) and indicate that BKW prey upon both pinnipeds, including Steller sea lions (n = 2) and northern elephant seals (n = 1), and small cetaceans, such as Dall's porpoises (n = 6) and Pacific white-sided dolphins (n = 2). Most predation events by BKW observed within the Caamaño-Douglas area occurred in the waterways around **K'ts'ats'aas**/Gil Island (i.e., Zones 310 & 314; also, Whale and Squally Channels and Verney Passage; **Figure 96**). The inlets of the Caamaño-Douglas area support a diversity of marine mammal prey with sufficient spatial separation to allow BKW to forage continuously as they move through the region, even though local resource depression may occur as prey become alerted to their presence (Ford et al. 2013). A high to moderate diversity of unique individual BKW have been sighted in the Caamaño-Douglas area (Towers et al. 2019; Ford et al. 2013), so it is probable that this habitat also provides important breeding and other social opportunities that arise when different maternal groups encounter and interact with one another.

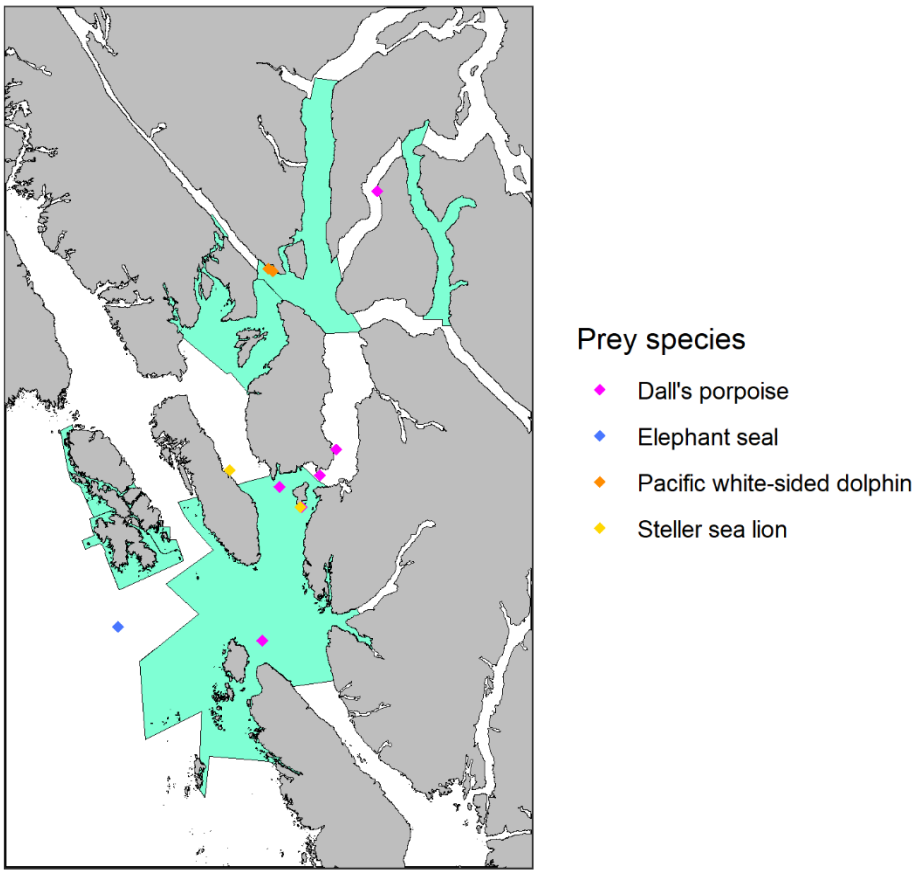

***Figure 96**. Predation events (n = 11) by Bigg's **‘naaxɬ/hélx̄’inix̄ʷ/niixɬ**/Killer whales that were successfully identified to prey species (indicated by point colour) using genetic analysis of prey tissue fragments (collected by DFO from 2005-2017, unpublished data). Proposed Caamaño Sound and Douglas Fjord System Network Zones are shown in green. Predation observations are opportunistic in nature and have not been corrected for effort.*

6.2.5.1.3.3 Offshore Killer Whale

Population abundance & trends

Offshore killer whales (OKW) are the least well known and least encountered (representing only ~1% of >10,000 photo-identification encounters archived by DFO) of the three **‘naaxɬ/hélx̄’inix̄ʷ/niixɬ**/Killer whale ecotypes found in BC (Ford et al. 2014). An average annual range-wide (southern California to the Aleutian Islands, Alaska) population abundance of 300 **łbuun/g̓ʷeyə́m/łpuun**/whales was estimated from 1988-2012 photo-identification data (Ford et al. 2014). Population modelling of photo-identification data suggests that the population has been stable over that time frame (Ford et al. 2014).

Seasonality, distribution & movement patterns

Offshore **‘naaxɬ/hélx̄’inix̄ʷ/niixɬ**/Killer whales are typically encountered in southern latitudes near California during the winter and northern latitudes in Alaska during the summer (Ford et al. 2014; Dahlheim et al. 2008). In northern BC, which includes the Caamaño-Douglas area, visual

encounters with OKW occurred in most months but were more frequent between May and August (Ford et al. 2014). However, these data are likely biased by increased effort in northern waters during the summer.

The six photo-identification encounters of OKW that occurred within the Caamaño-Douglas area itself (**Figure 97**) included three in May (2007 & 2008) and one each in February (2005), June (1999) and July (2015; DFO, unpublished data). OKW were also photo-identified just south of the region, indicated in **Figure 97**, at Mason Rocks on the west side of Aristazabal Island (June 2012, > 50 animals) and in nearby Laredo Sound (September 2014, ~6 animals). Acoustically, effort-corrected detections of OKW at PAM stations across BC were highest in March, with secondary peaks in August and December (Ford et al. 2014). More specifically within the Caamaño-Douglas area, OKW were detected on 16 of 343 effort days over two PAM deployments off of Rennison Island (Zone 310, hydrophone location indicated on **Figure 97**), covering the periods of October 2011 - June 2012 and October 2013 - February 2014.

This location has one of the highest annual occurrences of OKW acoustic detections of any PAM deployment on the BC coast by DFO. Acoustic detections of OKW at Rennision Island in 2011-2012 occurred in December, April and May, and in 2013 - 2014 occurred in November and December (J. Pilkington, DFO, unpublished report). North Coast Cetacean Society (NCCS) also acoustically detected OKW on two occasions, once in April 2009 (Whale Channel) and again in October 2011 (Ulric Point; both hydrophone locations indicated in **Figure 97**).

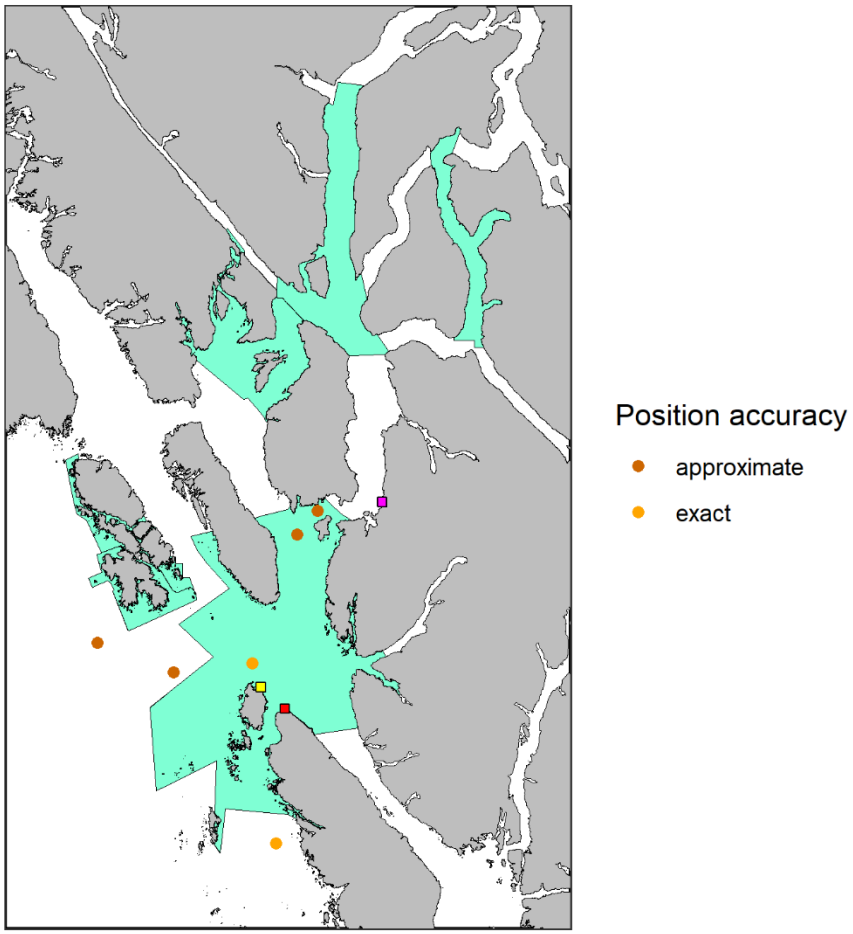

***Figure 97**. Photo-identification encounters (orange dots) with Offshore **‘naaxɬ/hélx̄’inix̄ʷ/niixɬ**/Killer whales in the Caamaño-Douglas area, collected between 1999-2015 (n = 6, Fisheries and Oceans Canada (DFO) & North Coast Cetacean Society (NCCS), unpublished data). The accuracy of location data associated with the encounters is indicated by point shading (light: exact coordinates, dark: approximate locations based on local placenames). The location of the Rennison Island hydrophone (deployed annually by DFO since 2011) is indicated by the yellow square, the Ulric Point hydrophone (deployed by NCCS between 2008 - 2011) by the red square, and the Whale Channel hydrophone (deployed by NCCS between 2004 - 2015) by the magenta square. Proposed Caamaño Sound and Douglas Fjord System Network Zones are shown in green. Photo-identification encounters are opportunistic and have not been corrected for observer effort.*

Diet & habitat function

Elasmobranchs make up the majority of prey consumed range wide by OKW, with some additional predation on bony fishes (Dahlheim et al. 2008; Ford et al. 2011; Ford et al. 2014; DFO unpublished data). To date, no predation events by OKW have been observed in the Caamaño-Douglas area; however, when OKW are detected in the region, they are often present for multiple days in a row, so it is likely that the area is used for foraging. The Caamaño-Douglas area contains prey species that are regularly consumed by OKW in other regions of BC. For instance, the Pacific sleeper shark and the **g̲a̲gaats/ǫ̓ʷaḡʷina/g̲a̲sgaatsk**/Pacific spiny dogfish are regularly by-caught in longline fisheries (Ford et al. 2014). **G̲a̲gaats/ǫ̓ʷaḡʷina/g̲a̲sgaatsk**/dogfish are caught by longliners throughout the entire area,

whereas sleeper shark by-catch is primarily restricted to the deep waters surrounding **K'ts'ats'aas**/Gil Island (Whale & Squally Channels and Wright Sound, including Zones 310, 313 and 314) plus the southern end of the Estevan Group (Zones 311 - 312) (see Figure 19 in Ford et al. 2014; from unpublished data courtesy of J. King, 1996 - 2012). OKW are also known to consume **yee**/**ḵáṗi**/**xyi'i**/Chinook salmon and **txaw**/**mumegʷezu**/**txaw**/Pacific halibut in nearby Hecate Strait (Ford et al. 2014; Dahlheim et al. 2008; DFO, unpublished data), both of which are also seasonally abundant in the Caamaño-Douglas Area. Additionally, there were two opportunistic encounters with basking sharks (*Cetorhinus maximus*) in the Caamaño-Douglas area during **‘naaxł**/**hélx̄’inix̄ʷ**/**niixł**/Killer whale surveys (in 2017 and 2019), and although they are not a currently documented prey species of OKW (likely due to their rarity after near-extirpation from BC in the 1900s), it is possible OKW may hunt basking sharks in the region. The proximity of the Caamaño-Douglas area to the Moresby Trough submarine canyon in Hecate Strait probably provides connectivity between this area and the deeper, more pelagic habitats these **‘naaxł**/**hélx̄’inix̄ʷ**/**niixł** often frequent.

Knowledge gaps

The main shortcoming of the **‘naaxł**/**hélx̄’inix̄ʷ**/**niixł**/Killer whale data presented here is that most of it has not been effort-corrected (aside from acoustic detections, which are given as proportions of total effort/recording days). Photo-identification encounters and predation data are shown as presence-only, opportunistic point data, meaning that they are biased both spatially and temporally due to differences in survey effort. Effort-corrected spatial density estimates for **‘naaxł**/**hélx̄’inix̄ʷ**/**niixł** in the Caamaño-Douglas area would allow for better characterization of habitat use, as well as quantification of the overlap between **‘naaxł**/**hélx̄’inix̄ʷ**/**niixł** and anthropogenic threats, such as vessel traffic. More information on the winter presence of the three **‘naaxł**/**hélx̄’inix̄ʷ**/**niixł** ecotypes in the Caamaño-Douglas area would also be beneficial, including predation data to assess diet composition outside of the more commonly sampled summer months. These data are extremely challenging to collect given weather conditions in the winter but would allow for better analysis of seasonal trends in habitat use and also a more accurate assessment of changes in **‘naaxł**/**hélx̄’inix̄ʷ**/**niixł** presence over multiple years.

6.2.5.1.4 Other cetaceans

Effort-corrected density surface models built using visual, ship-based survey data (largely collected during the summer months) suggest that Dall’s and harbour porpoises occur at intermediate densities in the Caamaño-Douglas area relative to the rest of BC’s continental shelf waters (Best et al. 2015; Wright et al. 2021b). Dall’s porpoises are seen frequently throughout the broader Caamaño-Douglas area, and were the most commonly sighted cetacean species observed from shore at Ulric Point and Rennison Island in the summers of 2010 - 2011 (n = 950 sightings collected over 179 effort days **Figure 98**). Sightings of harbour porpoises were less frequent (n = 33 over the same effort time frame), but they were also seen from shore around Rennison Island and the north end of Aristazabal Island (Zone 310; **Figure 99**). Unlike Dall’s porpoises, however, harbour porpoises are rarely observed in the inlets north of Caamaño Sound (J. Pilkington, pers. comm. 2023). Minke whales are regularly sighted along the west side of Aristazabal Island but appear to infrequently use the inner part of Caamaño Sound or the inlets of the Kitimat Fjord System (J. Pilkington, pers. comm. 2023). Minke whales tend to occur at lower densities in the inner waters of the Caamaño-Douglas area as compared to nearby open waters such as Hecate Strait and Dixon Entrance (Best et al. 2015). Grey whales are occasionally seen in the outer portions of the Caamaño-Douglas area off the west side of

Aristazabal Island and the Estevan Group (Gavrilchuk and Doniol-Valcroze 2021, Rechsteiner et al. 2013, J. Pilkington, pers. comm. 2023), likely because the population passes through Hecate Strait during their northward migration from March - June (Ford et al. 2013), and some individuals cross the outer portion of Caamaño Sound (Zones 310 - 312) during this time. A subadult grey whale was also seen using **Kwelts'uu**/Cornwall Inlet (accessed via tidal rapids through Whale Channel) in August 2013; the grey whale was observed entering the inlet on a slack tide and was later seen repeatedly diving off the estuary at the head of the inlet, presumably foraging. However, this sighting appears to be an anomaly and grey whales do not typically remain in the region outside of the migratory period.

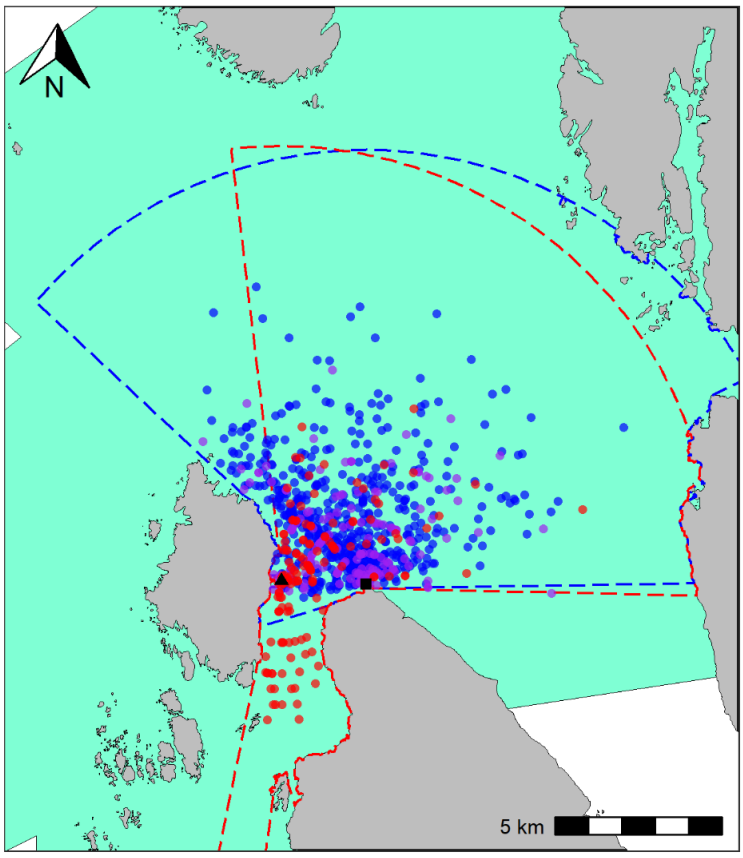

***Figure 98**. Sightings of groups of Dall's porpoises collected from shore at Ulric Point (black square) in 2010 (purple dots, n = 175, May - July) and 2011 (blue dots, n = 615, May - August) and from Rennison Island (black triangle) in 2010 (red dots, n = 160, July - August). All sightings collected by North Coast Cetacean Society (NCCS). Caamaño Sound and Douglas Fjord System Network Zone 310 is indicated by green shading. The area visible to shore-based observers at low tide under the best possible observation conditions is outlined in blue dashed lines for the Ulric Point site and red d lines for the Rennison Island site (maximum sighting distance for both sites is ~13 km). Detection probability is expected to diminish (i.e., more groups will be missed by observers) at greater distances; the exact relationship between distance and detection probability will vary by species.*

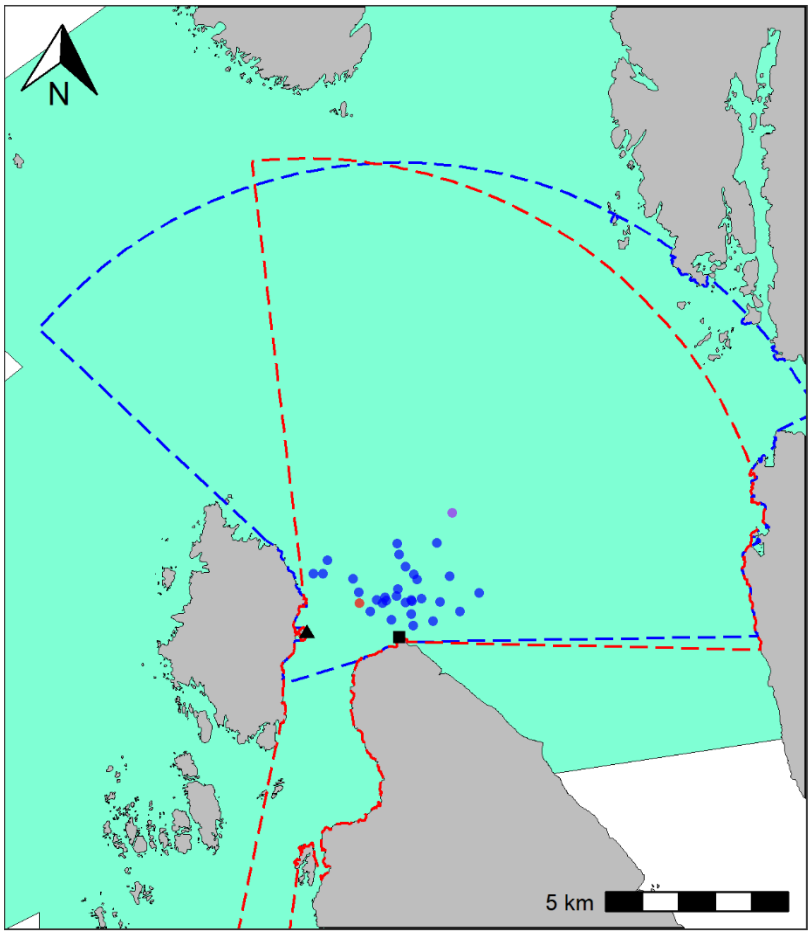

***Figure 99**. Sightings of groups of harbour porpoises collected from shore at Ulric Point (black square) in 2010 (purple dots, n = 1, July) and 2011 (blue dots, n = 31, July) and from Rennison Island (black triangle) in 2010 (red dots, n = 1, July-August). All sightings collected by North Coast Cetacean Society (NCCS). Caamaño Sound and Douglas Fjord System Network Zone 310 is indicated by green shading. The area visible to shore-based observers at low tide under the best possible observation conditions is outlined in blue dashed lines for the Ulric Point site and red dashed lines for the Rennison Island site (maximum sighting distance for both sites is ~13 km). Detection probability is expected to diminish (i.e., more groups will be missed by observers) at greater distances; the exact relationship between distance and detection probability will vary by species.*

Sighting densities per unit effort (based on visual surveys) of Pacific white-sided dolphins (PWSD) within the general Caamaño-Douglas area (in all seven Network Zones) appear to be highest in the winter (January - March), when hotspots were detected around **K'ts'ats'aas**/Gil Island in Whale and Squally Channels and in **Lax Ka'gaas**/Campania and Caamaño Sounds (Rechsteiner 2012; **Figure 100**). Acoustic data collected off Rennison Island from fall 2011 to spring 2012 support this finding, as PWSD detections occurred on 87%, 68% and 62% of monthly effort days from December through February (Zone 310, see **Figure 92** for hydrophone location; J. Pilkington, Fisheries and Oceans Canada, unpublished report). Detections of PWSD decreased after this period to <50% of monthly effort days in March, <20% in April, and none at all in May. The Rennison hydrophone did not record during the summer months (June - September), however, dedicated visual and acoustic effort from nearby Ulric Point (see **Figure 98** for location) throughout the summers of 2009 - 2011 produced just eight sightings of PWSD

across years, and sightings from the **Lax Kwil Dziidz**/Fin Island research station (see **Figure 102** for location) during the spring and summer are also rare (NCCS, unpublished data). Taken together, this evidence supports the conclusion that PWSD are primarily present in the Caamaño-Douglas area in the winter rather than the summer. Presence of PWSD may be related to the winter arrival of **tskah**/ **wáṅi**/ **tskaḵh**/Pacific Herring preparing for an early spring spawn, as this species is the most common (by % occurrence) in **dziiẅ**/**ƛ̓áła**/dolphin diet (Heise 1997). Spawning **ha'limootk**/**ƛ̓áti**/**ẅaḵh**/eulachon bound for the Kitimat River or rivers off of Gardner Canal (Hay and McCarter 2000) may also provide an important prey resource for PWSD in the late winter and early spring. Although not as prevalent in **dziiẅ**/**ƛ̓áła** diet as **Tskah**/**wáṅi**/**tskaḵh**, **ha'limootk**/**ƛ̓áti**/**ẅaḵh** is a known prey species of PWSD confirmed by stomach content analysis (Rechsteiner 2012). PWSD typically move out of nearshore waters into offshore regions during the summer (Rechsteiner 2012), although the reasons for this pattern remain unknown.

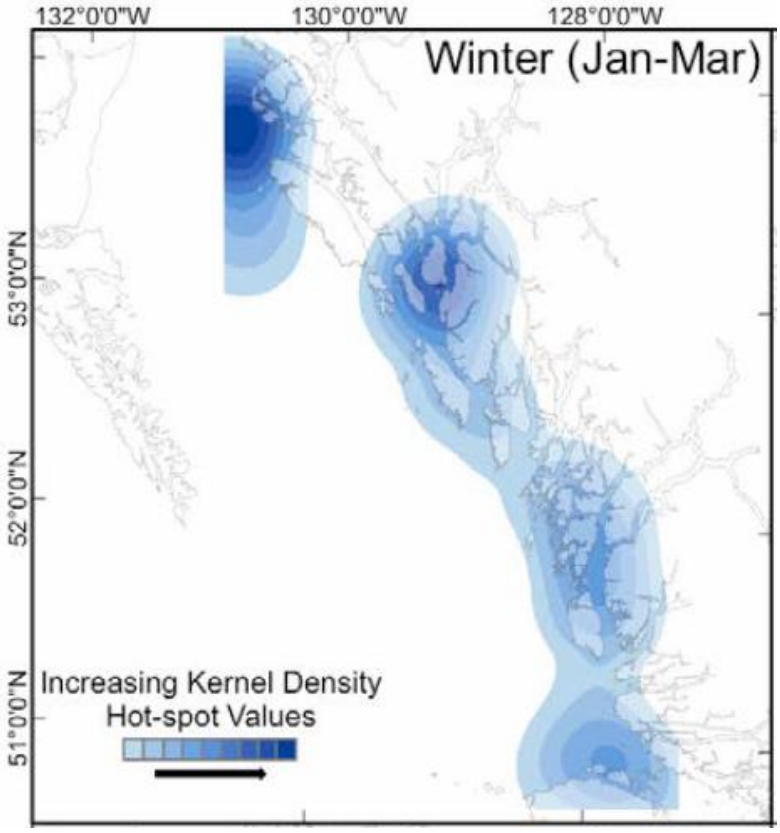

***Figure 100**. Winter (January-March) hot-spots of sightings of Pacific white-sided dolphin groups obtained from kernel density analyses of survey data collected by DFO along the central coast of British Columbia from 2002-2010 (reproduced from Figure 2.4 in Rechsteiner 2012).*

6.2.5.2 Pinnipeds

6.2.5.2.1 Harbour seals

Population abundance & trends

Harbour seals (*Phoca vitulina*) are one of the most abundant pinniped species in BC and are not considered at risk by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Haul-outs are terrestrial sites used by pinnipeds to temporarily leave the water to rest, molt, and give birth. Haul-outs in BC include sand bars, mud banks, and boulders but are most often located in the rocky intertidal zone of isolated islands, islets, or reefs. Hunting for **üüla**/**saḡʷam**/seals is an occasion for harvest feast celebrations and a cultural keystone for the Gitga'ata (Satterfield et al. 2012). **Üüla**/**saḡʷam** are harvested in many places around the Caamaño-Douglas area in the Spring and Fall including Kiel (near Zone 310), Clamstown on **Lax Kwil Dziist**/Fin Island and **K'duwaadz**/Tuwartz Inlet (Zone 313), **Txałgiu**/Hartley Bay (Zone 314), Farrant Island (Zone 313 and 314), and Kishkosh inlet (bordering Zone 314) (Satterfield et al. 2012).

Harbour seals were most recently assessed in BC following a multi-year aerial survey covering 90% of the coast from 2015 – 2019 (DFO 2022i). Surveys were completed using a Cessna 180 float plane flying all visible shorelines and rocks during standardized low-tide windows at the end of pupping season when most haul-outs are visible, and the largest number of Harbour seals are expected to be hauled-out. Digital photographs were taken from 600 - 900 ft and **üüla**/**saḡʷam** were later counted on high-resolution monitors.

The majority of the haul-out sites within the proposed MPA blocks were surveyed 3 - 4 times each over the course of the survey program. The Caamaño-Douglas area is a particularly challenging stretch of coastline to survey given the distance to re-fuel aircraft. As such, not all blocks within the proposed MPA were surveyed at the same time, which makes it difficult to establish population trends for the proposed MPA proper.

Surveys in 2015 & 2018 produced a joint count of 812 **üüla**/**saḡʷam** in the Network Zones, similar to count of 887 **üüla**/**saḡʷam** derived from flights in 2010. A notable number of additional **üüla**/**saḡʷam** haul-outs are situated just outside or between Network Zones (**Figure 101**). Individual **üüla**/**saḡʷam** likely make use of a series of haul-outs both within and adjacent to the Network Zones. Therefore, waters within the Zones likely support a larger number of **üüla**/**saḡʷam** than counts solely obtained from haul-outs within the polygons. Adding counts from neighboring haul-outs increases the total number to 1,477 animals in the Caamaño-Douglas area from the 2015/2018 surveys. Given the sparse nature of surveys within the Network Zones, it's more appropriate to look to larger Northern Mainland Coast region data compilation for trends. Using all available regional data and appropriate corrections, the **üüla**/**saḡʷam** population is either stable or has declined slightly relative to surveys completed from 2003-2008 (DFO 2022i).

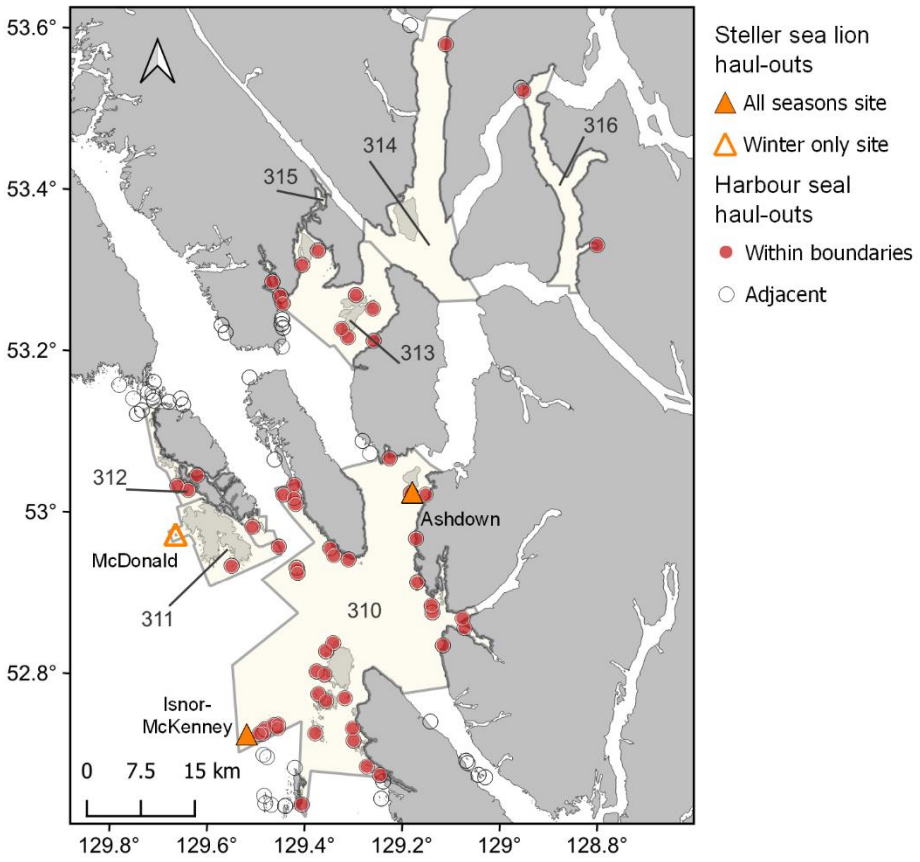

***Figure 101**. Steller sea lion haul-outs (all seasons & winter only) and Harbour seal haul-outs in the Caamaño-Douglas area.*

Seasonality, distribution & movement patterns

While **üüla/sağʷam** are capable of long-distance movements (> 100 km, see Peterson et al. 2012), they typically show a high-degree of site fidelity and routinely make-use of a limited number of haul-out sites (e.g., Cordes et al. 2011, Dietz et al. 2013, London et al. 2012). Localized foraging movements (tens of km) are characteristically interspersed with resting bouts centered around low-tides when haul-out substrates are available.

Recent telemetry data from 33 **üüla/sağʷam** instrumented in the spring/summer in the central Strait of Georgia (2019 - 2021) show **üüla/sağʷam** typically remain with 10 - 15 km of the haul-out at which they were tagged (DFO, unpublished) with only three **üüla/sağʷam** making trips > 25 km and only one **üüla/sağʷam** emigrating from the study area (following an extreme temperature event). Harbour seals tagged in nearby Puget Sound show similar patterns (Washington Department of Fish & Wildlife, unpublished). While no tagging data are available for BC Harbour seals outside the Strait of Georgia, there is no current reason to suspect movement patterns for **üüla/sağʷam** in the Network Zones to deviate dramatically from the norms observed in southern BC or from other Harbour seal studies globally. Winter movements and distribution are poorly described in BC as aerial surveys are conducted in summer during

the peak pupping season and telemetry packages attached to the Harbour seal fur are shed during the fall molt.

Diet & habitat function

The diets of pinnipeds in BC are described from prey remains recovered from scat collections. Traditional hard parts identification techniques used to match otoliths, beaks, and other diagnostic structures to prey reference libraries are increasingly complimented with DNA metabarcoding techniques to identify prey via their genetic signature. Studies in southern BC and Washington State show Harbour seals to be generalist feeders consuming a wide variety of fish and cephalopod prey (Thomas et al. 2022; DFO, unpublished). Gadids (e.g., **balaas**/Pacific hake) and small forage fish (e.g., **Tskah**/**wáṅi**/**tskaa̱h**/Pacific herring) make-up the bulk of their diet with flat-fish and salmonids being seasonally important. There are no specific diet studies of Harbour seals north of Vancouver Island and winter diets, in addition to any potential seasonal effects of their prey on the movements or population dynamics of **üüla**/**saḡʷam**, are a knowledge gap throughout BC. As marine mammals, Harbour seals are among the top piscivorous predators in the ecosystem but are themselves the main prey species for *Bigg's* **'naaxɬ**/**hélx̄'inix̄ʷ**/**niixɬ**/Killer Whales and occasional prey for larger **ksaa**/**q̓ʷaqʷ-**/shark species.

6.2.5.2.2 Sea lions

Population abundance & trends

Steller sea lions in BC are part of the eastern stock / population in the North Pacific. They are designated as a Species of Special Concern in Canada (COSEWIC 2013b) and listed as threatened in the US. **T'iibn**/**ƛ̓ix̄'én**/Sea lion haul-outs can be classified based on their usage as either rookeries (sites with > 50 pups born annually), year-round (all seasons) sites, and winter only sites. Population monitoring via standardized aerial surveys has been conducted regularly during the summer breeding season at all known and suspected **t'iibn**/**ƛ̓ix̄'én** haul-outs since the early 1970's with additional periodic winter surveys to examine changes in abundance and distribution of **t'iibn**/**ƛ̓ix̄'én** overwintering in BC (DFO 2021c). The most recent survey results from the area include the 2017 winter (Jan/Feb) survey and the 2017 summer breeding survey (DFO 2021c).

There are currently no rookery sites within the Caamaño Sound and Douglas Fjord System Network Zones. Historically, Isnor Rock *may* have been a rookery site as it was first noted in 1913 when records were typically made only for rookeries (Bigg, 1985). Subsequent observations referred to Isnor as a year-round haul-out, and the haul-out site was abandoned as of the mid-1960's (Bigg, 1985) possibly due to repeated culling that took place at all year-round sites until protections were enacted in 1970. Current Year-round sites, confirmed on survey, include haul-outs at Isnor/McKenney Rocks (regularly re-occupied since 2002) and off **K'nabiyaaxl**/Ashdown Island (regular survey counts since 1992) which was first observed as a winter-only site in 1960 (**Figure 101***)* Combined counts for the two sites were of 389 **t'iibn**/**ƛ̓ix̄'én** in the winter and 605 **t'iibn**/**ƛ̓ix̄'én** in the summer of 2017. Stellar sea lions have occasionally been observed in the summer at McDonald Island and at Goodacre Point but are more typically seen at McDonald in the winter (**Figure 101**) with 169 **t'iibn**/**ƛ̓ix̄'én** counted in 2017. While not as populous as haul-out sites to the north or south of Caamaño Sound, the population trends for Stellar sea lions counted within the network mirrors the increasing

population trend observed province-wide and which is currently estimated at 4.3% per year for non-pups (DFO 2021c).

Seasonality, distribution & movement patterns

Seasonal changes in distribution are common for Steller sea lions with increased concentration at rookeries and select year-round sites occurring from May through August followed by a general diffusion in fall to occupy additional sites through the winter months. Winter abundance is typically higher than during the breeding season which suggests there is a net immigration of Steller sea lions into BC during the non-breeding season. This trend, however, has not yet been observed in the Caamaño-Douglas area. There are a few possible reasons for the anomaly in the area: 1) overall fewer winter surveys in the area (fewer opportunities to count fall/winter aggregations), 2) the presence of several major winter and year-round sites between the Caamaño-Douglas area and neighboring BC rookeries (Steller sea lions dispersing from rookeries select other locations before reaching Caamaño), or 3) the relative isolation from the contribution of animals immigrating from neighboring rookeries in South East Alaska, Washington, Oregon and California.

Diet & habitat function

There have been no diet studies conducted within the Caamaño-Douglas area and only limited scat collections at neighboring sites along the northern and central mainland coasts during winter and spring. Data from 2013 & 2015 show that in general, Steller sea lions have a diverse diet, with major contributions from gadids (e.g., walleye pollock, **k'a̲'wts/ƛáx̄dala/ḵ'a'w'ts**/Pacific cod), forage fish (e.g., **Tskah/wáńi/tskaḥ**/Pacific herring, **ha'limootk/x̌áti/ẅaḥ**/eulachon), cephalopods (e.g., Giant Pacific octopus), flat-fish (e.g., Starry Flounder, English sole, Sand sole) and lesser contributions from salmonids (Pink, **gayniis/gʷaxenis/ga̲yniis**/chum, **misoo/hísen/miso'o**/sockeye) and **ts'mhoon**/rockfish (various species) (DFO, unpublished). Similar to Harbour seals, Stellar sea lions are top piscivorous predators in the ecosystem while also being an important prey species for *Bigg's* **'naaxł/hélx̄'inix̄ʷ/niixł**/Killer whales and occasional prey for larger **ksaa/q̓ʷaqʷ-**/shark species. Summer diets of Stellar sea lions along the central coast have not been previously described.

6.2.5.2.3 Other pinnipeds

Over-wintering male California sea lions (*Zalophus californianus*) often haul-out alongside Steller sea lions in BC. Winter surveys have yet to document California sea lions at **K'nabiyaaxl**/Ashdown Island (Zone 310) during their non-breeding season, but anecdotal evidence suggests a small number of individuals were observed at **K'nabiyaaxl**/Ashdown in the past (Ford 2014). Like California sea lions, **zemá**/Elephant seal (*Mirounga angustirostris*) sightings in the region are typically of males. These sightings are usually of single animals seen resting in a nose-up, vertical posture after surfacing from deep dives (Ford 2014). Visual sightings collected from shore at **Lax Kwil Dziist**/Fin Island (**Figure 102**) between 2017 - 2022 (May - October) and from Ulric Point/Rennison Island between 2010-2011 suggest that northern elephant seals make regular use of Zones 310 and 313 during the summer. Additional sightings summarized by Ford (2014) and Best et al. (2015) indicate that **zemá** are also seen in other, more northerly regions of the Caamaño-Douglas area such as the inlets around Gribbell and Hawkesbury Islands (Zones 314 & 316).

Zemá do not haul-out in the Caamaño-Douglas area but are known to forage in the area. As a species, **zemá** feed on a wide variety of prey, including bony fishes such as **ts'mhoon**/rockfishes and **balaas**/Pacific hake, small **ksaa**/ **q̓ʷaqʷ-**/sharks and rays, oceanic squid and cyclostomes (Ford 2014). Shore-based observations of a single male **zemá** feeding on two small **ksaa**/ **q̓ʷaqʷ-**/sharks in succession were made in May 2010 from Ulric Point (J. Pilkington, pers. comm.). There is no information about winter use of the Caamaño-Douglas area by **zemá**, as visual surveys are typically limited to the period between late spring and early fall.

Northern Fur Seals (*Callorhinus ursinus*) are another abundant pinniped in BC, although categorized as threatened (COSEWIC 2010). They are often sighted offshore travelling through BC between California and their breeding colonies in Alaska and Russia (Ford 2014). In 2013, a juvenile Northern Fur Seal was sighted in Beauchemin Channel (Southern end of Zone 310) and therefore Northern Fur Seal occur in the area, but little is known (J. Pilkington and G. Ellis, pers. comm. 2023).

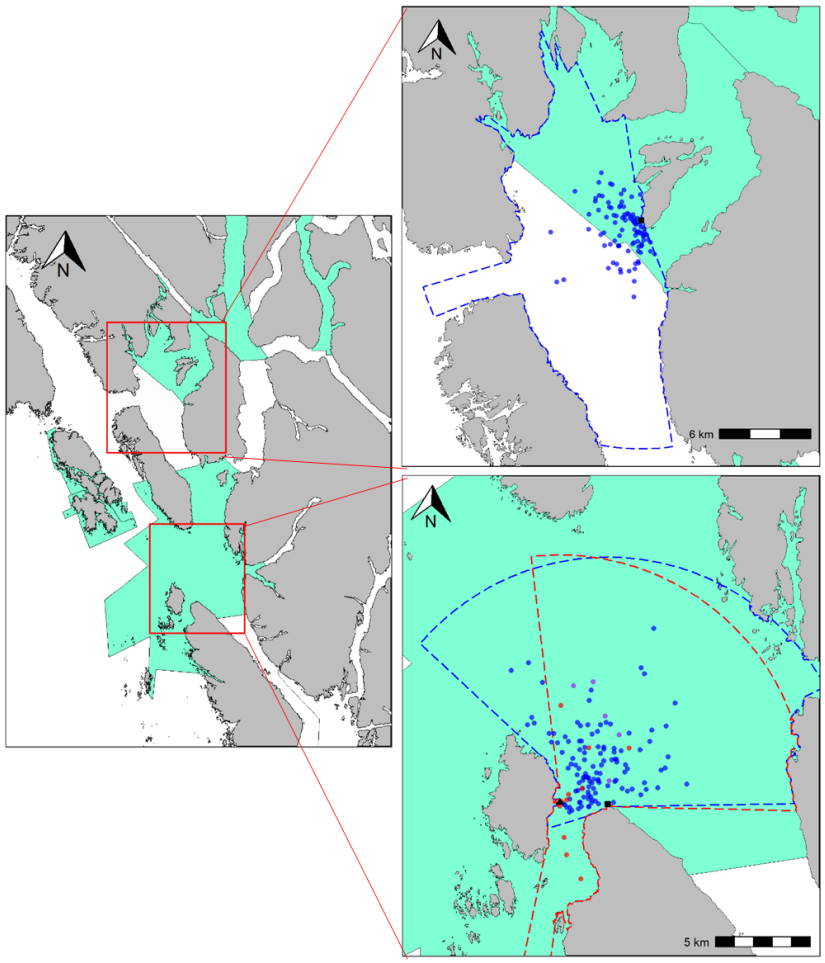

***Figure 102**. Top right panel: Sightings of northern elephant seals (blue points) collected from shore at the **Lax Kwil Dziidz**/Fin Island research station (black square) between 2017-2022 (n = 100, May - October). The area visible to shore-based observers at low tide under the best possible observation conditions is outlined in blue dashed lines (maximum sighting distance of 15 km). Bottom right panel: Sightings of northern elephant seals collected from shore at Ulric Point (black square) in 2010 (purple dots, n = 6, May - June) and 2011 (blue dots, n = 120, May - August) and from Rennison Island (black triangle) in 2010 (red dots, n = 11, July-August). The area visible to shore-based observers at low tide under the best possible observation conditions is outlined in blue dashed lines for the Ulric Point site and red dashed lines for the Rennison Island site (maximum sighting distance for both sites is 13 km). Caamaño Sound and Douglas Fjord System Network Zones are indicated by green shading and the wider region is shown on the right (red squares denote boundaries of the two areas shown in the lefthand panels). All sightings were collected by North Coast Cetacean Society (NCCS). Detection probability is expected to diminish (i.e., more **üüla**/**sa̱g̱ʷam**/seals will be missed by observers) at greater distances; the exact relationship between distance and detection probability will vary by species.*

6.2.5.3 Płoon / Nukʷ / Sea otters

Płoon/**Nukʷ**/Sea otters are recognized as a keystone species because they alter nearshore subtidal community structure by their metabolic need to consume large quantities of food. In rocky exposed areas, the relationship between **płoon**/**nukʷ**, **aswit**/**'emdém**/**a̱ws**/sea urchins, and kelps is well documented (Estes and Palmisano 1974, Estes and Duggins 1995, Watson and Estes 2011). In the absence of **płoon**/**nukʷ**, **aswit**/**'emdém**/**a̱ws** graze heavily on kelp and

the seafloor becomes carpeted with **aswit/ʾemdém/q̓aws** and no fleshy kelp is visible. When **płoon/nukʷ** are present, they consume the readily available **aswit/ʾemdém/q̓aws** prey and reduce the abundance of **aswit/ʾemdém/q̓aws** and thereby release fleshy kelps from intense grazing pressure to the point where kelp biomass can become a major habitat feature. A study in BC found that kelp beds in sea-otter-occupied areas extended further out from the nearshore and were almost 4 times deeper and 19 times larger than those in areas without **płoon/nukʷ** (Markel and Shurin 2015). The ecological benefits of kelp forests are highlighted in section 6.2.1.1, “Canopy-forming kelps”.

In soft-sediment habitats, **płoon/nukʷ**/sea otters have effects both as predators and as substrate disturbers, with consequent changes to soft sediment communities. **Płoon/Nukʷ** dig to excavate **tsʾaʾax/c̓íkʷa/ ts'a'q̓ax**/clams, and the discarded shell litter becomes hard substrate for settling clam larvae, sea anemones, and algae (Kvitek and Oliver 1992, Kvitek et al. 1992). Disturbance in **gadza kʾaw**/ eelgrass beds generated by foraging **płoon/nukʷ** has been demonstrated in BC to increase **gadza kʾaw** genetic diversity within the bed (Foster et al. 2021).

The intense maritime fur trade of the 17th and 18th centuries during which American and European traders exchanged trade goods with the Indigenous peoples for **płoon/nukʷ**/sea otter pelts resulted in the near extinction of the species throughout its range which was the nearshore of the Northeast Pacific from northern Mexico to Alaska and across to Russia and the most northerly islands of Japan. In BC, the maritime trade began after 1778 and was over by the 1850s (less than 100 years) because **płoon/nukʷ** were no longer abundant. By 1911, less than 2,000 animals were estimated to remain throughout the species entire North Pacific range and most of these were in the remote Aleutian Islands (Kenyon 1969). The last **płoon/nukʷ** endemic to BC were extirpated by 1931 (Kenyon 1969). Canada’s current **płoon/nukʷ** population is comprised of descendants of animals from Alaska reintroduced to Checleset Bay on the west coast of Vancouver Island during three translocation efforts in 1969, 1970 and 1972 (Bigg and MacAskie 1978).

Płoon/Nukʷ /Sea otters occupy relatively shallow coastal areas and are limited, with respect to habitat, by their diving abilities and preferred foraging depth (<40 m) with the result that most **płoon/nukʷ** are found within 1 to 2 km of shore. Their habitat extends from the intertidal to depths of about 40 m, although **płoon/nukʷ** have occasionally been recorded foraging to depths of nearly 100 m (Riedman and Estes 1990; Bodkin et al. 2004).

Płoon/Nukʷ/Sea otters occupy small overlapping home ranges throughout their lives and exhibit strong site fidelity (Bodkin 2015). Within their home ranges they forage, breed and form resting aggregations called rafts. These are floating sexually segregated aggregations that can include well over 100 animals. Because rafts form habitually in the same location, the distribution of rafts is an indicator of range of occupancy and rafts can also be an indicator of range expansion events in BC’s recovering **płoon/nukʷ** population. The periphery, or frontal edge of the range, tends to be occupied first by a male raft. In subsequent years, females appear and form rafts in the new area (Garshelis et al. 1984; Jameson 1989; Lafferty and Tinker 2014).

As of 2017, BC’s **płoon/nukʷ** population included 8,110 **płoon/nukʷ** of which 6,263 were counted along the west and north coast of Vancouver Island, the remainder (1,847) occur along the central and northern BC coast (Nichol et al. 2020).

Distribution in the Caamaño-Douglas area

During DFO's 2017 **płoon**/**nuk^{w}**/sea otter surveys, over 200 animals were counted off the west side of Aristizabal Island, part of which is within the Caamaño Sound and Douglas Fjord System Network area 310 (**Figure 103**, Nichol et al. 2020).

In time, it is likely that the **płoon**/**nuk^{w}** population and range will expand northward and could include the nearshore habitat associated with the Estevan Island Group (Zones 311 & 312) and other adjacent habitats. In time, **płoon**/**nuk^{w}** could be expected to occur along **Lax k'naga dzol**/Banks Island and into Chatham Sound as well.

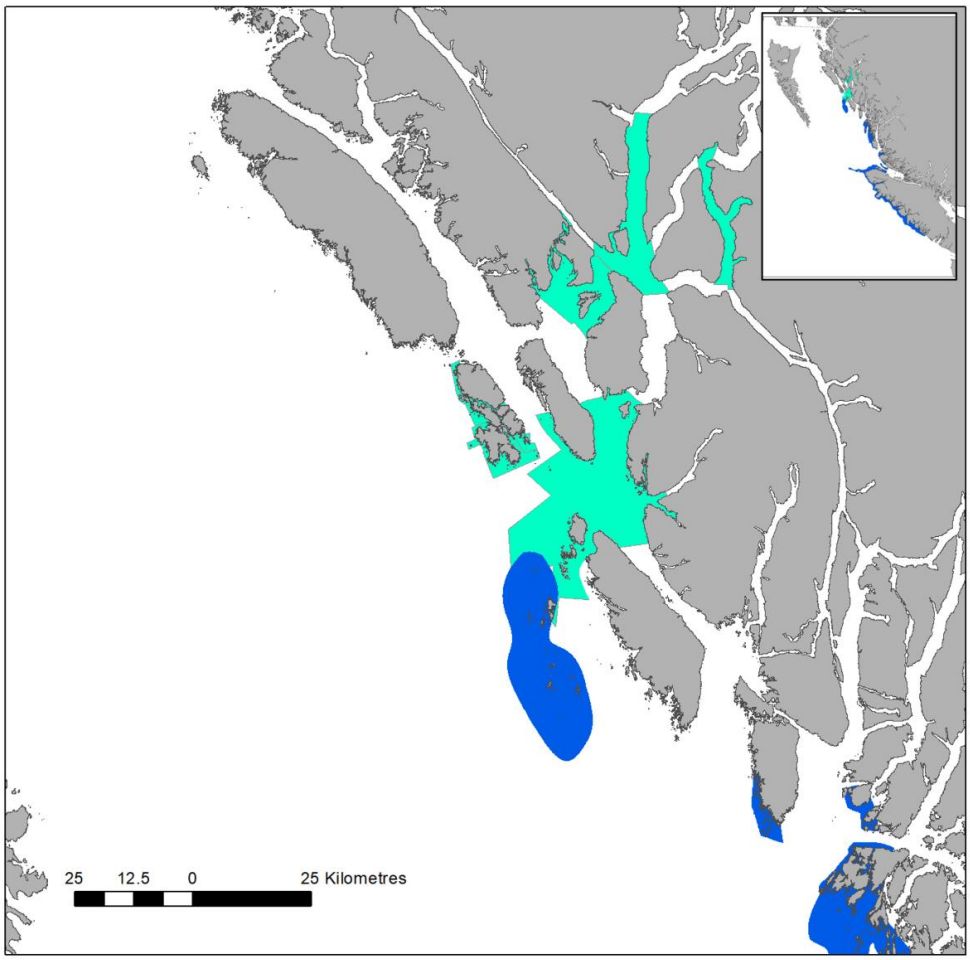

***Figure 103**. **Płoon**/**nuk^{w}**/Sea otter population range (blue polygons) in British Columbia and the overlap with the Caamaño Sound Douglas Fjord System Network Zones (turquoise). Inset map presents the whole range of the **płoon**/**nuk^{w}**/sea otter in BC as of 2017 and the Caamaño Sound Douglas Fjord System Network Zones. The **płoon**/**nuk^{w}**/sea otter range is represented by large contiguous polygons that include broad areas around observed raft locations.*

Habitat Associations

Płoon/**Nuk^{w}**/Sea otters inhabit a variety of marine environments within the nearshore. Areas of exposed coast with complex coastlines characterized by rocky islets and rock reefs are especially likely to be occupied by **płoon**/**nuk^{w}** (Gregr et al. 2008). In these regions, depths tend to be variable, and the substrate is rocky but with patches of soft sediment, providing habitat for various benthic and infaunal prey species. **Poon**/**Nuk^{w}** rafts often form near clusters of rock reefs, tiny islets and within the associated kelp beds, which provide wind protection. Canopy-forming kelps dampen swells and provide a means of anchoring so that **płoon**/**nuk^{w}** can rest without the need to reposition themselves repeatedly. However, rafts of **płoon**/**nuk^{w}** also occur in areas without kelp canopy. Embayments where the substrate is mixed or soft sediment and where **ts'a'ax**/**čík^{w}a**/**ts'a'a̱x**/clams predominate are also used.

Płoon/**Nuk^{w}**/sea otters in the Caamaño Sound and Douglas Fjord System are predominantly associated with shallow areas interspersed amongst various small islet groups and in the outer areas of the Caamaño-Douglas area. There is, however, an intriguing observation made by Archibald Menzies, naturalist aboard Captain Vancouver's ship in 1793 that describes **płoon**/**nuk^{w}**/sea otters much further inland - somewhere between Wright Sound and Lewis and Cridge Passages (Zones 313-314) which does not seem like typical **płoon**/**nuk^{w}**/sea otter habitat. These waterways are deep with fairly narrow bands of shallow habitat. This observation suggests that **płoon**/**nuk^{w}** may have historically occupied a broader array of habitats in BC than observed today.

6.2.5.4 Areas of importance for marine mammals outside of the current Network Zones

Marine mammals are large and often migratory species. While it is recognized that there are significant areas outside of the Network Zones that are important to multiple non-mammal species, we describe below areas of high importance to marine mammals outside the Network Zones which could be considered for protection, in addition to the areas covered by the Network Zones.

1. **Otter, Squally and Whale Channels**: Squally and Otter Channel are the two waterways within the Caamaño-Douglas Area with the greatest fin whale density and activity (Keen et al. 2021), as well as the areas facing the most dramatic changes in marine traffic volume in the years to come (Keen et al. 2023). Squally and Whale Channels support the highest predicted summertime densities (per 25 km^2 grid cell) of humpback whales of any region along the north and central coast of BC, as indicated by a density surface model of effort-corrected visual survey data from 2018 (**Figure 83**). Squally Channel supports Humpback whale presence and bubble net feeding throughout the length of their typical foraging season with sightings spanning all months of study (June-October; **Figure 84**, **Figure 86**, **Figure 88**). The proposed increase in marine traffic that Squally Channel will experience with the onset of Liquid Natural Gas (LNG) transport projects based out of Kitimat, BC will expose both Fin and Humpback whales making use of this productive habitat to a higher risk of collision, and to more anthropogenic noise than occurs now. The inclusion of these channels in the Caamaño Sound Douglas Fjord System Network Zones is critical for the ongoing health of the fin and humpback whale populations in the Caamaño-Douglas Area. Otter, Squally and Whale Channels are also frequented by Bigg's and Northern Resident **'naaxł**/**hélx̄'inix̄^{w}**/**niixł**/Killer whales, and

the north and east sides of **Lax Ka'gaas**/Campania Island (in Squally Channel) are of particular importance to NRKW for foraging (**Figure 93**). These areas also provide important travel corridors for **‘naaxł**/**hélx̄’inix̄ʷ**/**niixł** moving between the northern inlets of the Kitimat Fjord System and Caamaño Sound itself (and vice versa). These channels are also known hotspots used by Pacific white-sided dolphins during the winter (**Figure 100**) and Squally Channel is used by **zemá**/Elephant seals (**Figure 102**) in the summer.

2. **Verney Passage:** Verney Passage is unique in that it supports seasonal congregations of Humpback whales in the late fall and supports unique social elements of autumnal Humpback feeding aggregations – where surface behaviour between long foraging dives includes **łbuun**/**gʷeẏém**/**łpuun**/whales engaging in close contact, displaying high variability and turnover in social associations, displaying complex vocalizations and tonal blows, and thereby indicating that this area may be of particular cultural importance to humpback whales. Douglas Channel, Verney Passage, and Ursula Channel are the three routes mariners may take to travel to Kitimat, BC. With LNG transport traffic routes proposed to transit via Douglas Channel, we recognize a potential for recreational traffic to avoid Douglas Channel and be re-routed into either Verney or Ursula. This poses a considerable risk, especially in the autumn months, of increasing **łbuun**/**gʷeẏém**/**łpuun**-vessel interactions and may place both **łbuun**/**gʷeẏém**/**łpuun** and mariners at risk of collision. For these reasons, special protection should be considered for Verney Passage, particularly during the fall.

3. **Western side of Aristazabal Island including outer island groups:** While most of Caamaño Sound, including the waters around Rennison Island and Beauchemin Channel, are already encompassed by the existing Caamaño Sound Douglas Fjord System Network Zone 310, NRKW and likely also OKW, **płoon**/**nukʷ**/sea otters, and Steller sea lions would benefit from an extension of the protected area southward along the western shore of Aristazabal Island, including Willis, Leadman and Wright Passages, and the outer island groups (Anderson, Moore, McKenney, Conroy, Sinnet, and Harvey Islands). This subarea is an important foraging ground for NRKW (**Figure 93**), humpback whales, and minke whales and is also the location of several past OKW encounters and basking shark encounters. The outer island provides important foraging and pup-rearing habitat for **płoon**/**nukʷ**/sea otters in the region, and most of this habitat is not currently included in any Network Zone (**Figure 103**).

6.2.5.5 Vulnerabilities and Recoverability

Compared to marine mammals found in offshore waters of the Canadian Pacific, many marine mammal populations found in continental shelf waters tend to have greater sensitivities due to their increased overlap with and frequency of exposure to human activities in nearshore habitats. The following paragraphs provide a brief overview of the characteristics of marine mammal populations found within the Caamaño-Douglas Area that make them sensitive to and resilient to anthropogenic stressors.

The relatively long generation time and low fecundity of all **łbuun**/**ḡʷey̓ém**/**łpuun**/whale species makes them particularly sensitive to the impacts of anthropogenic stressors. Baleen whales, such as fin and humpback whales, are found throughout the northern BC coast and broader Canadian Pacific (Dalla Rosa et al. 2012; Best et al. 2015; Wright et al. 2021b), but portions of these populations rely on the Caamaño-Douglas Area as a unique and critical region for feeding, resting, and socializing (DFO 2013), which exposes them to human activities that may cause disturbance or increased risk of injury or mortality. In addition to the sensitivities caused by generation time and fecundity, all three ecotypes of **‘naaxł**/**hélx̄’inix̄ʷ**/**niixł**/Killer whales that use the Caamaño-Douglas Area also have small population sizes (several hundred or less) that make them less resilient to anthropogenic threats. Offshore **‘naaxł**/**hélx̄’inix̄ʷ**/**niixł**, for instance, have a very small estimated Potential Biological Removal (PBR = 0.55) and often travel in large groups of 50 - 100 animals (Ford et al. 2014), so exposure to anthropogenic stressors in the Caamaño-Douglas Area could have a large effect on the population as a whole. Northern Resident **‘naaxł**/ **hélx̄’inix̄ʷ**/**niixł**/Killer Whales (NRKW) also assemble in large groups in the Caamaño-Douglas Area. Threats in the region may similarly result in population-level impacts for this ecotype. While pinnipeds and **płoon**/**nukʷ**/Sea otters have shorter generation times and higher fecundity than cetaceans, they also aggregate in large groups (on haul-outs or in rafts) and thus could be disproportionately impacted by anthropogenic stressors compared to less gregarious species.

Notable stressors for marine mammals in the Caamaño-Douglas Area include increased vessel traffic (Williams et al. 2015, Nichol et al. 2017), anthropogenic noise (Williams et al. 2015, Erbe et al. 2012, Erbe et al. 2014), entanglement (Williams et al. 2011) and hydrocarbon spills. Pinnipeds are most vulnerable to anthropogenic disturbances when stressors are near rookeries and haul-outs, or during breeding season (COSEWIC 2013b). Other threats that are broadly known to impact marine mammal populations, and likely also have an impact in this area, include climate-related ecosystem perturbations (McCabe et al. 2016), fisheries competition, microplastic ingestion, oil spills, and persistent pollutants. Because marine mammals are often at or near the top of marine food webs, stressors that negatively impact key prey species can also decrease their survivability.

The resilience of marine mammal populations to the current and emerging anthropogenic stressors listed above is extremely difficult, if not impossible, to quantify. However, some insight on the recoverability of these species may be gained from examining how populations that were depleted or extirpated by commercial whaling or the maritime fur trade responded after these sources of mortality were removed. For instance, humpback whales and fin whales both experienced severe declines in the Canadian Pacific as a result of commercial whaling, but have since increased in numbers and have even returned to areas from which they were completely extirpated by whalers (e.g., the Salish Sea for humpback whales and the Caamaño-Douglas Area for fin whales). Coastwide, Harbour seals were also depleted in BC as a result of predator control programs and harvesting in the late 1800s through mid-1900s (reduced to an estimated ~10,000 animals; Olesiuk 1999). This population had fully recovered by the early 2000’s to just over 100,000 animals, following a complete ban on hunting which began in the 1970s. Harbour seal populations have since been stable or declining slightly likely having reached carrying capacity in most regions of BC. Juvenile Steller sea lions have high mortality rates, which may have contributed to delayed population recovery in BC (Hastings et al. 2011; COSEWIC 2013b). The abundance and trophic level of both Harbour seals and Steller sea lions have the potential to influence and be influenced by the population dynamics of both their primary prey and their main predators. For example, the recovery of Harbour seals would have added predation pressure on their primary prey while also notably increasing the prey base available to mammal-eating **‘naaxł**/**hélx̄’inix̄ʷ**/**niixł**

Płoon/nukʷ were similarly able to recolonize large portions of the BC coast in only about 50 y, although this timeline is likely considerably shorter than that achievable by natural range expansion, given that otters were artificially translocated from Alaska to BC. In fact, without translocation of animals from western Alaska to BC, and Washington state, it is highly unlikely that BC would have a **płoon/nukʷ** population of its current size and distribution today. **Płoon/nukʷ** exhibit very restricted lifetime movements and it is likely this sedentary characteristic that allowed for the serial depletion and near extinction of the species during the fur trade and their subsequent slow recovery (Bodkin 2015). Despite these examples of successful and continuing population recovery, it is also is worth keeping in mind that habitat quality (for instance, in terms of prey availability, anthropogenic noise, or habitat contamination such as an oil spill) may be significantly degraded in recent times compared to what was available to recovering marine mammal populations released from hunting pressures in the early to mid-20th century. As such, population growth rates that are currently achievable under various threat mitigation scenarios may not be as high as those observed after the cessation of marine mammal harvesting. Additionally, the recovery and long-term viability of very small populations is likely to be negatively impacted by other issues, such as drift and genetic bottlenecks (i.e., inbreeding depression). For this reason, the precautionary principle should be kept front of mind when considering the recoverability of marine mammal stocks to current threat impact scenarios.

The rest of this section will describe the aforementioned anthropogenic stressors in detail and how they specifically affect marine mammals. Stressors where data or trends are available in the Caamaño-Douglas Area are presented first, followed by stressors with less area-specific data. The majority of this information comes from research on fin whales, humpback whales, and **'naaxł/hélx̄'inix̄ʷ/niixł**. Details for other cetaceans, pinnipeds and **płoon/nukʷ** /sea otters is provided where available.

Marine traffic: ship strikes, physical disturbance and underwater noise

Anywhere marine traffic overlaps with marine mammal habitat, there is a risk of collision (Nichol et al. 2017). While the Caamaño-Douglas Area is relatively remote and has lower levels of marine traffic than waters to its north and south, it is positioned along the Inside Passage route, and the volume of traffic in the region is increasing steadily (9 - 15% year^{-1}, depending on vessel type) according to 2014 - 2019 AIS data (Keen et al. 2023). Currently, most of this traffic is concentrated in Wright Sound and Caamaño Sound, with relatively little traffic in Squally Channel where fin and humpback whale densities are high (e.g., only 23 transits by ships > 180 m in 2019; Keen et al. 2023). Vessel strikes are a major source of mortality and injury for baleen **łbuun/g̱ʷey̓ém/łpuun**/whales globally (Laist et al. 2001, Pirotta et al. 2018). Increased Liquefied Natural Gas (LNG) Canada ship traffic proposed to commence in 2025 will be routed through Squally Channel (Keen et al. 2023), which poses significant threats to **łbuun/g̱ʷey̓ém/łpuun** in terms of increased ship strikes, physical disturbance and acoustic disturbance.

In the Caamaño-Douglas Area, fin and humpback whale ship-strike rates have been predicted for the next decade (Keen et al. 2023). Collisions with large ships (>180m) are expected to increase 2.3x and 3.9x compared to 2019 levels, with an average rate of two and 18 mortalities per year for fin whales and humpback whales, respectively. These mortalities would match and possibly exceed Potential Biological Removal (PBR) for the ~400 fin whales belonging to the

continental shelf population and represent 13% of PBR for the Canadian Pacific population, despite the fact that the Caamaño-Douglas Area represents less than 0.3% of its marine habitat.

For humpback whales, these mortalities in the Caamaño-Douglas Area will likely exceed PBR for the portion of this population found in the North Coast region of BC and will also exceed 50% of PBR for the entire Canadian population as a whole (Keen et al. 2023). By 2030, the waterway with greatest mortality risk for fin whales will be Squally Channel (as opposed to Caamaño Sound in 2019) and for humpback whales will be the route through Squally Channel-Verney Passage-Wright Sound (compared to Caamaño Sound and Whale Channel in 2019) (**Figure 104**). Given the seasonality of fin and humpback whale abundance in the Caamaño-Douglas Area, the months of greatest ship strike risk are July - September. Mitigation analyses indicate that preventing LNG traffic during those months would limit risk increases from LNG shipping to just 4% above 2019 levels.

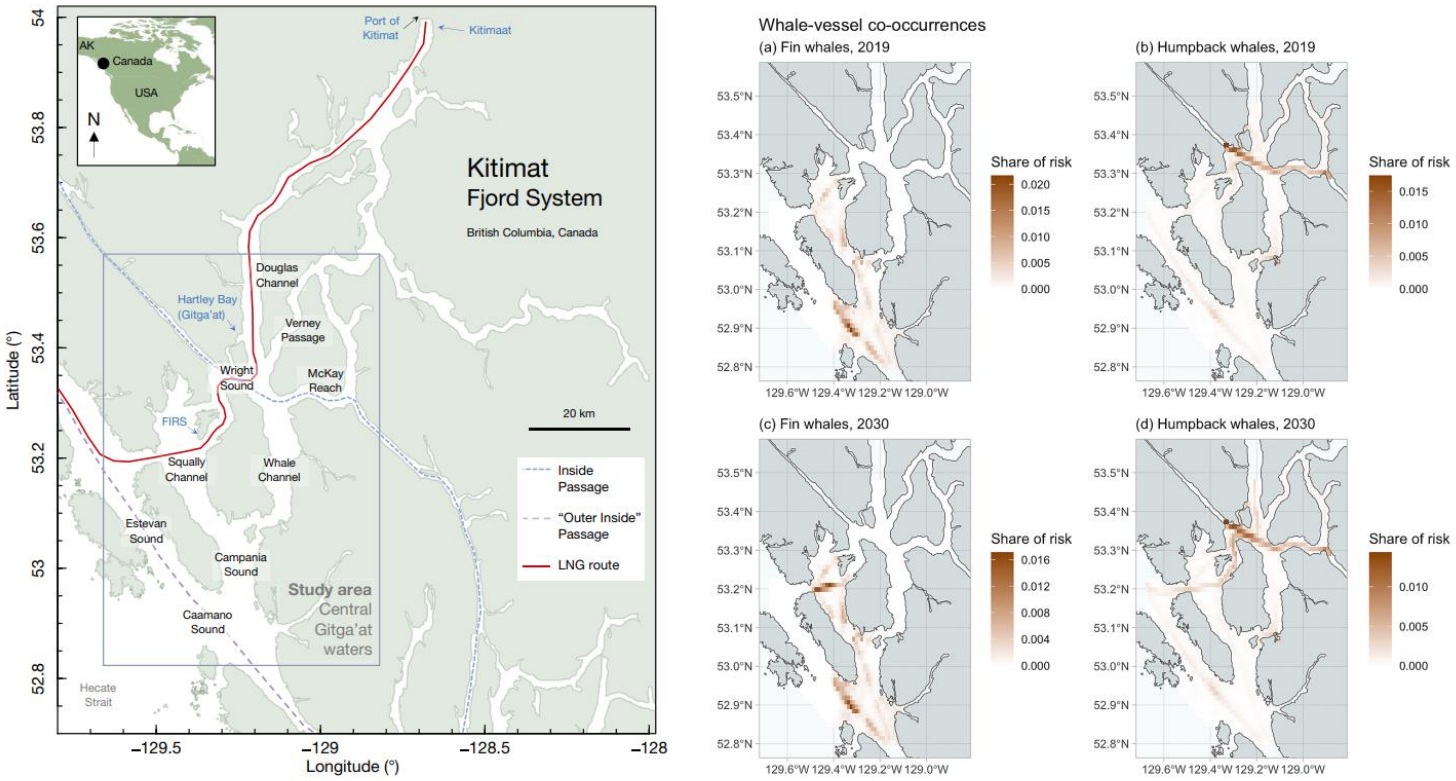

***Figure 104**. Adapted from Keen et al. 2023. 2019 AIS vessel traffic and proposed LNG tanker route (top panels) and associated mortality predictions for fin whales (middle panels) and humpback whales (bottom panels) under these conditions. Each grid cell is colourized according to its relative share of total mortalities predicted for the Caamaño-Douglas area, assuming the strike zone is 1.5x ship draft and that the probability of collision is a function of ship speed.*

Like Fin and Humpback whales, **‘naaxł/hélx̄’inix̄ʷ/niixł**/Killer whales are vulnerable to vessel strikes in the Caamaño-Douglas Area (Ford et al. 2014; Raverty et al. 2020), however strike risk has not been spatially or temporally quantified for this species. In the northeast Pacific, three Northern Resident **‘naaxł/hélx̄’inix̄ʷ/niixł** mortalities recorded between 1974 - 2016 (Clarke Murray et al. 2021) and one Bigg’s **‘naaxł/hélx̄’inix̄ʷ/niixł** mortality in 2007 were attributed to vessel strikes (Raverty et al. 2020). However, these records are likely a substantial underestimate, as most carcasses sink and cannot be recovered for necropsy. In addition to collision risk, the presence of vessels may result in physical disturbances by disrupting natural behaviours or causing **‘naaxł/hélx̄’inix̄ʷ/niixł** to leave an area.

Zemá/Elephant seals are also likely quite vulnerable to vessel strikes (a male weighing 2,000 kg that washed up near Nanaimo, BC in 2008 was killed by a collision with a large vessel; CBC News November 24, 2008) because they are deep divers that need to recover at the surface for extended time periods to replenish their oxygen stores. Other pinnipeds may be more disturbed by vessel noise and presence than vessel strikes, although strikes are still possible. Harbour seals and Steller sea lions show disturbance reactions and flush into the water when vessels (including unpowered craft, such as kayaks) approach their haul-outs (Erbe et al. 2019; Johnson and Acevedo-Gutiérrez 2007; Kucey 2005), which may have physiological implications related to energetics and stress. Likewise, close approaches of **płoon/nukʷ**/sea otter rafts by vessels will typically cause rafted animals to disperse and interrupts important behaviours such as resting, grooming and nursing of pups (L. Nichol, pers. comm. 2023). Low-flying aircraft, including Unmanned Aerial Vehicles (UAVs) may have similar disturbance impacts on hauled-out pinnipeds and **płoon/nukʷ** rafts.

Marine traffic: acoustic disturbances

The noise impacts of marine traffic have yet to be quantified for the Caamaño-Douglas Area, but noise disturbance is considered a significant threat for **łbuun/ḡʷeẏém/łpuun**/whales in general. Acute noise exposure is potentially lethal for baleen whales (Gailey et al. 2007, Dunlop et al. 2017, Harris et al. 2018), and chronic ambient noise can contribute a variety of issues ranging from stress, acoustic masking, and hearing loss to behavioural disturbance and displacement from habitat (Croll et al. 2001, Weilgart 2007, Wright et al. 2007). In particular, most ship noise energy is concentrated at a low frequency which is similar to the frequency at which fin whales communicate (< 100 Hz) (Clark et al. 2009, Erbe et al. 2016). Resting mother-calf pairs of humpback whales are sensitive to increases in anthropogenic noise and respond by spending less time resting, swimming faster, and increasing their respiration rates (Sprogis et al. 2020).

In the Caamaño-Douglas Area, Fin whales and marine traffic already interact closely (within 1 km) hundreds of times per year (mean = 509 events) and Humpback whales and marine traffic co-occur at an order of magnitude above that (mean = 5,959). These rates are expected to double for both species by 2030 (Fin whale: mean = 1,013 events; Humpback whale: mean = 11,375 events) (Keen et al. 2023). The noise exposures associated with these co-occurrences are likely to cause both chronic and acute effects.

Vessel noise, which includes both engine noise and high-frequency noise from echosounders (e.g., depth sounders & fish finders), is also likely to disrupt the behaviours of **‘naaxł/hélx̄’inix̄ʷ/niixł**/Killer whales (Burnham et al. 2022). In particular, RKW and OKW may experience reduced foraging efficiency, given their reliance on echolocation for finding and capturing fish (Wright et al. 2021a; Dahlheim et al. 2008). Resident **‘naaxł/hélx̄’inix̄ʷ/niixł** are known to alter their call amplitudes (Holt et al. 2009), movement patterns, swimming speeds and respiration rates

(Williams et al. 2002; 2009) and will increase surface active behaviours (Noren et al. 2009) and reduce the amount of time spent foraging (Lusseau et al. 2009) in response to vessel presence and associated underwater noise. Holt et al. (2021) found that individuals from the Southern Resident killer whale (SRKW) population (closely related to NRKW) made longer prey capture dives and descended more slowly when in the presence of vessels that were operating echosounders. SRKW also descended more quickly when vessel noise was greater and when approached more closely by vessels, and their probability of successfully capturing prey decreased as nearby vessel speed increased (Holt et al. 2021). Noise from both large and small vessels has also been shown to severely reduce the echolocation and communication ranges of SRKW (Thornton et al. 2022). Bigg's **ʻnaaxɬ/hélx̄'inix̄ʷ/niixɬ** rely on silence and stealth attacks for hunting marine mammals, so underwater noise impacts their foraging efficiency by interfering with prey detection via passive listening (Barrett-Lennard et al. 1996; Ford et al. 2013). Vessel noise could also disrupt communication calls between individuals (Holt et al. 2009) and thus prevent **ʻnaaxɬ/hélx̄'inix̄ʷ/niixɬ** from locating one another within the Caamaño-Douglas Area, potentially reducing reproductive opportunities and interfering with important cooperative behaviours, such as prey sharing or coordinated hunting.

Oil spills and marine pollution

Oil spills can threaten marine mammals directly or indirectly (Godard-Codding and Collier 2018), and are a significant risk given the shipping projects proposed for the Caamaño-Douglas Area. **Płoon/Nukʷ**/Sea otters in particular are highly vulnerable to mortality if contaminated with spilled petroleum products, as they rely on their dense fur for insulation. Oiled fur does not provide insulation, and without it, **płoon/nukʷ** die of hypothermia (Williams et al. 1988). **Płoon/Nukʷ** will also ingest oil when grooming if their coat is contaminated, resulting in acute toxicity. Long term, chronic exposure to hydrocarbon residues could also occur where **płoon/nukʷ** consume oiled benthic and infaunal prey. Long term studies following the 1989 *Exxon Valdez* oil spill in Prince William Sound, Alaska, indicated that elevated mortality rates of prime-age animals persisted in the **płoon/nukʷ** population for almost 20 y after the spill occurred (Monson et al. 2000, 2011; Bodkin et al. 2012; Esler et al. 2018). On the BC coast, **płoon/nukʷ** tend to occupy remote, exposed habitats where successful oil recovery and cleanup is exceedingly difficult. Kelp beds where **płoon/nukʷ** form large, sexually segregated rafts would collect and retain spilled oil, resulting in large numbers of simultaneously oiled animals. The loss of a raft of females could have a great impact, as it could represent a significant part of the reproductive potential of the population.

ʻnaaxɬ/Hélx̄'inix̄ʷ/Niixɬ/Killer whales are also vulnerable to pollution from marine spills. Exposure to hydrocarbons from the 1989 *Exxon Valdez* spill had devastating impacts on both RKW and BKW populations in Alaska, causing mortality and widespread reproductive failure (Matkin et al. 2008). A large oil spill is also likely to cause widespread mortality in the **üüla/saḡʷam**/seal and **t'iibn/ƛ̓ix̄'én**/sea lion populations that BKW rely on for prey (Ford et al. 2013). **ʻnaaxɬ/Hélx̄'inix̄ʷ/Niixɬ** may also be exposed to hazardous compounds called polycyclic aromatic hydrocarbons (PAHs) found in vessel exhaust (Lundin et al. 2018). Exposure to pollutants found in engine exhaust likely increases with increasing vessel traffic and with the proximity of vessels to **łbuun/ḡʷeẏ́ém/łpuun**/whales.

Given their long life spans and high trophic level in marine food webs, **ʻnaaxɬ/hélx̄'inix̄ʷ/niixɬ** in particular, and marine mammals in general, are also susceptible to health impacts from exposure to toxic, long-lived Persistent Organic Pollutants (POPs) - such as PCBs (polychlorinated biphenyls) and PBDEs (polybrominated diphenyl ethers) (Ross 2006, Alava

et al. 2012, Alava et al. 2016), as well as from heavy metals, pesticides, and pharmaceuticals (Garrett and Ross 2010). The impacts of these pollutants can include effects on reproductive health, immunity, and development (Ross 2006). While they are present at higher concentrations in marine habitats closer to urban and industrialized areas (Kim et al. 2022), such as Victoria harbour, Prince Rupert harbour, and Burrard Inlet (see https://pollutiontracker.org/contaminants), these chemicals are still likely to impact cetaceans in the Caamaño-Douglas Area, given the large home ranges and/or migratory routes of these species, and may add to cumulative impacts on populations that are experiencing multiple stressors simultaneously (e.g., Clarke Murray et al. 2021). In addition, persistent and mobile contaminants may reach the northern coast of BC from Asia within 5 - 8 days due to prevailing winds, so even remote habitats are not immune to the accumulation of these chemicals (Johannessen et al. 2007).

Interactions with fishing gear (entanglement and depredation)

Entanglement in active or derelict fishing gear is a serious threat to baleen whales globally (Volgenau et al. 1995; Clapham et al. 1999; Robbins 2009; Knowlton et al. 2012). However, similar to ship strikes, the fact that most cases go unreported or unnoticed makes the problem difficult to quantify (COSEWIC 2019). No case of fin whale entanglement has been reported for BC waters to date, but photographic studies in other Canadian regions indicate that rates of entanglement may be high (COSEWIC 2019). Evidence of entanglement has been well documented in many populations of humpback whales worldwide (Basran et al. 2019; Neilson et al. 2009; Robbins 2012; Félix et al. 2020) and an investigation of entanglement scars on humpback whales in BC determined that >40% of analyzed individuals displayed signs of having been entangled at least once (Christie McMillan[51], unpublished report). However, all investigations of entanglement scarring on the bodies of living **łbuun**/**ḡʷey̓ém**/**łpuun**/whales inherently underestimate the true scale of the threat and do not indicate the frequency with which entanglement events lead to mortality.

‘naaxł /**Hélx̄’inix̄ʷ**/**niixł** Killer whales are typically less vulnerable than baleen **łbuun**/**ḡʷey̓ém**/**łpuun**/whales to entanglement in fishing gear, however, in areas of prey concentration where both fishers and **‘naaxł** /**hélx̄’inix̄ʷ**/**niixł** are accessing the same resource, the potential for **‘naaxł** /**hélx̄’inix̄ʷ**/ **niixł** to be injured or killed by gear entanglement (and vessel disturbance and strikes) increases (Government of Canada 2011). Ingestion of fishing gear is possible if **‘naaxł** /**hélx̄’inix̄ʷ**/ **niixł** engage in fisheries depredation (i.e., taking fish off of lines), which some matrilines of NRKW have been observed doing in Beauchemin Channel (J. Hildering, pers. comm. 2009) in the Caamaño-Douglas Area. The necropsy of an Alaskan resident **‘naaxł**/**hélx̄’inix̄ʷ**/**niixł** (a population closely related to NRKW) determined that it died from an infection caused by ingesting a **txaw**/**mumegʷezu**/**txaw**/halibut hook (Raverty et al. 2020). A barbless fishhook was also recovered from the stomach of a male NRKW in BC, although the exact cause of death could not be determined for that animal (Raverty et al. 2020). Depredation likely proliferates through social learning in **‘naaxł** /**hélx̄’inix̄ʷ**/**niixł** (Fearnbach et al. 2014), and so it may become a greater issue over time as more **łbuun**/**ḡʷey̓ém**/**łpuun** learn the behaviour. BKW also have a propensity to play with and become entangled in vertical lines and floats

[51] Report was produced on contract for DFO with data from DFO and the Marine Education and Research Society.

attached to **k'almoos/klnákʷ/ḵ'a̱lmoos**/crab and **gasgos/sísíuɬ**/prawn traps (J. Pilkington, pers. comm. 2023; CTV Vancouver Island, 2018[52]).

Pinnipeds in BC (and worldwide) also frequently become entangled in fishing gear and marine debris (Jepsen and de Bruyn 2019). Steller sea lions in particular are susceptible to becoming entangled around the neck with plastic packing bands, ropes and fishing line. However, the overall incidence of reported entanglement throughout southeast Alaska and northern BC is relatively low at 0.26% of surveyed animals. Still, given the remoteness of the coast, it is likely under-reported compared to more accessible areas (Raum-Suryan et al. 2009). Steller sea lions may also engage in fisheries depredation and can ingest fishing gear, such as **hoon/qeqapela**/salmon flashers and longline hooks (Raum-Suryan et al. 2009).

Fisheries competition and prey availability

Fisheries can induce indirect ecological effects on prey availability and interspecific competition among predators (Guilpin et al. 2020), both locally within the Caamaño-Douglas Area and elsewhere. NRKW and OKW may be impacted in the Caamaño-Douglas Area by competition from commercial, sport and subsistence fisheries that affect the availability of key prey resources, such as **yee/ḱáp̓i/xyi'i**/Chinook salmon. A recreational fishing lodge operates in summer months in Caamaño Sound, at the same time that NRKW are most likely to be present and targets the same age classes of large **yee/ḱáp̓i/xyi'i** as the **‘naaxɬ /hélx̄’inix̄ʷ/niixɬ**/Killer whales. Sport fishing vessels are therefore often using the same nearshore habitats that constitute important foraging grounds for NRKW. While the marine-mammal prey of BKW are not currently harvested other than for subsistence, recent public pressure for pinniped culls and the resumption of widespread hunting could reduce BKW prey availability and negatively impact the population (as occurred historically during large-scale culls of pinnipeds from the late 1800s to mid-1900s) (Ford et al. 2013).

Microplastics and marine debris

The extent of microplastic ingestion by marine mammals found in the Caamaño-Douglas Area is unknown, but plastic debris frequently accumulates on beaches in the area (E. Keen and B. Wright, pers. comm. 2023). This observation is similar to the findings of the Marine Debris intertidal survey conducted by DFO’s Marine Spatial Ecology and Analysis section in 2023, where debris was found in a majority of intertidal sites visited (Proudfoot et al. 2025). A spatial model of the distribution of at-sea synthetic debris (which pose both an entanglement and ingestion risk) throughout coastal BC predicted a high incidence of interactions between debris and both humpback whales and Dall’s porpoises in the Caamaño-Douglas Area (Williams et al. 2011). Fin whales are also likely at increased risk of interactions with debris in the region, however, the line-transect surveys used to conduct this analysis were done between 2004 and 2006, before fin whales had returned to the Caamaño-Douglas Area (first post-whaling sighting was in 2006). Recent studies indicate that the prevalence of plastic ingestion by baleen whales is much more severe than anticipated (Fossi et al. 2016, Im et al. 2020, Kahane-Rapport et al. 2022), but this has not been quantified for BC waters specifically. Microplastics have been reported in the digestive tracts of stranded **‘naaxɬ /hélx̄’inix̄ʷ/niixɬ**/Killer whales from other regions worldwide (Lusher et al. 2018) and were present in all but one of 33 analysed fecal

[52] https://vancouverisland.ctvnews.ca/free-willy-moment-dfo-rescues-entangled-transient-orca-off-salt-spring-island-1.3954469

samples from individuals belonging to the SRKW and Alaskan Resident populations of the northeast Pacific (Harlacher and Kelly 2020).

Climate change and prey availability

Broad climate change predictions for the Caamaño-Douglas Area and the resulting impacts on various habitats and species have already been described in Section 4: Climate change. For marine mammals globally, climate change can affect population health in various ways. Although the numerous impacts of climate change in the Caamaño-Douglas Area on each marine mammal species are difficult to predict directly, this section briefly describes the effects of climate change on marine mammal prey availability.

The effects of climate change can cause potential decreased recruitment or survival of key prey species that may result in a decrease in survivorship of marine mammals. For example, ocean acidification is expected to negatively affect a broad range of marine organisms that have calcareous shell structures. This includes crustaceans such as **k'almoos**/**klnákʷ**/**k̲'a̲lmoos**/ crabs, **gasgos**/**sísíuɬ**/prawns, marine snails, and **aswit**/**'emdém**/**a̲ws**/sea urchins, which are all important prey for **płoon**/**nukʷ**/sea otters. Additionally, one of the key prey species of fin whales and humpback whales, krill, prefer cool waters and populations of krill in BC decline with higher temperatures (Okey et al. 2015). **Tskah**/**Wáṅi**/**Tska̲h**/Herring – an important prey species of pinnipeds, **dziiẅ**/**ƛáła**/dolphins, porpoises and humpback whales - have embryos that are sensitive to temperature and mortality is higher under warmer conditions (Villalobos et al. 2020). Declines in survival for both species may be exacerbated by the effects of rising sea surface temperatures (Intergovernmental Panel on Climate Change 2019). The ability of humpback whales to undergo a prey preference shift and buffer the effects of climate change may not be possible should the populations of two taxa of key importance to their diet (krill and **tskah**/**wáṅi**/ **tska̲h**) experience simultaneous declines.

NRKW may also be particularly vulnerable to reduced prey availability caused by climate change, as rising sea surface temperatures are projected to cause a ~90% decline in the marine survival of their preferred **yee**/**káṗi**/**xyi'i**/Chinook salmon prey (Crozier et al. 2021), as well as reductions in the total area of high seas **hoon**/**qeqapela**/salmon habitat (Abdul-Aziz et al. 2011). Climate change may also cause changes in water flow and temperature in freshwater **hoon**/**qeqapela** spawning habitats, effecting smolt survival (Crozier et al. 2021).

7 SUMMARY, KNOWLEDGE GAPS, AND RECOMMENDATIONS

The purpose of this biophysical and ecological overview was to compile available knowledge and data on the physical and biological oceanography, climate change projections, human uses, and ecological diversity present within the seven Caamaño Sound and Douglas Fjord System Network Zones. Another objective was to document the Vulnerabilities and Recoverability of ecological features and taxonomic groups. Below is a summary of the oceanographic and ecological connections among these seven Network Zones, and its contribution to the whole Northern Shelf Bioregion Marine Protected Area Network. This summary is followed by conclusions, knowledge gaps, and recommendations for future research activities for the seven Network Zones.

7.1 Summary

The seven Network Zones can be separated into three sub-groups based on their biophysical characteristics: the Outer Coast Zones (310, 311, 312), located in and around Caamaño Sound, the Inner Fjord Zones (313, 314, 315), and Ursula Channel (Zone 316). These three subgroups have differences in oceanographic conditions, habitat availability and species distributions, and important cultural and human uses. As an aggregate, these Network Zones can offer protection to a diverse coastal ecosystem, which spans deep fjords and inlets to shallow inlets and estuaries. The Network Zones contain spawning and rearing habitats for commercially and ecologically important invertebrates and fish, and an abundance of marine birds and marine mammals (notably Killer, Fin, and Humpback whales). In addition, many traditional and contemporary First Nation areas of cultural and spiritual significance, such as harvest sites, archaeological sites, and recreational areas, are represented within these Network Zones. Existing protected areas in the MPA Network include several provincial parks, marine parks, and conservancies, as well as two nearby Rockfish Conservation Areas. Given the ecological significance of marine areas outside the boundaries and in between the zones, other management measures, such as seasonal closures or vessel speed restrictions, could be considered to ensure protection and connectivity for mobile or seasonal species such as fishes and marine mammals in the area.

The Caamaño-Douglas area is a significant source of freshwater compared to neighbouring watersheds. Surface waters flow from the Caamaño-Douglas area towards adjoining protected areas. For example, surface waters entering Grenville Channel from Wright Sound (Zone 314) flow towards **Tgii Xsw'aanx**/Porcher Island and the Kitkatla area. Similarly, deep water in Ursula Channel (Zone 316) connects to proposed category 2 Network Zones on the Central Coast (See yellow polygons in **Figure 1**). Therefore, the Inner Fjord Zones (313 Wright Sound, 314 Douglas Channel, and 316 Ursula Channel) are linked directly with future protected areas.

The seven Network Zones are connected by the intermediate inflows year-round, with the deep water renewals entering the Network Zones from Hecate Strait through **Lax Ka'gaas**/Campania Sill during spring and summer (Zone 310), and the surface waters flowing from the Inner to the Outer Coast Zones because of the estuarine circulation active year-round. The elevated nutrients in surface waters within Zones landwards of **Lax Ka'gaas**/Campania Sill compared to the Outer Coast Zones (Zone 310, 311, 312) is also noteworthy. If not wholly consumed locally through primary productivity, the Inner Fjord Zones may contribute nutrients to the Outer Coast Zones and other adjoining protected areas. In the Outer Coast Zones, invertebrates such as **aswit**/**ʾemdém**/**a̱ws**/Sea urchins and marine snails gather in shallow island coastlines. Juvenile **hoon**/**qeqapela**/Salmon, **ts'mhoon**/Rockfish, and **wa̱t'ukw**/**núłem**/**wa̱t'ukw**/Lingcod rely on **gadza k'aw**/eelgrass and kelp beds for protection and spawning. Implementing protective measures in the Network Zones would allow refuge for many species of cultural, commercial, and ecological significance that could increase productivity and diversity in local and eventually regional scales.

The estuarine circulation also connects the surface layer (< 20 to 50 m) that flows seawards through the Zones and the intermediate layer (50 to 150 m) that flows landwards from Hecate Strait year-round. For instance, surface waters from Ursula Channel (Zone 316) generally flow through Whale Channel, an important area for **łbuun**/**g̃ʷey̓ém**/**łpuun**/whales, although surface water may also flow into Squally Channel via Zones 313 and 314. Water from Hecate Strait will eventually reenter the surface layer through the numerous sills, particularly those at the northern end of Ursula Channel (Zone 316). These sills, therefore, are important ecological areas, as

they increase oxygenation levels of deeper layers and nutrient availability in the euphotic zone. Invertebrates are often found in deeper areas of the Inner Fjord System Zones, such as Squally Channel, Douglas Channel (Zone 315), and Ursula Channel (Zone 316). These areas have high density and diverse invertebrate coverage on subtidal walls and cliffsides, notably sponge and coral and benthic invertebrate communities including brittle stars (Gasbarro et al. 2018). Hard substrates from fjord walls and low sediment loading increase invertebrate settlement rates (Smith and Witman 1999). Areas with benthic complexity (i.e., high rugosity, varied sediment sizes, and diverse sponge and coral communities) are also preferred habitats for **ts'mhoon** and other groundfish. Nutrients transported toward the surface can sustain suspension-feeders. Deep renewals from Hecate Strait enable the increased oxygen in intermediate waters to replenish oxygen in the deepest waters, preventing hypoxia (Johannessen et al. 2015; Gasbarro et al. 2018). Furthermore, the depths the fjord walls extend to may offer protection from predators and anthropogenic disturbances (Huvenne et al. 2011). Preserving both the outer coast and inner fjord ecosystems within Marine Protected Area Network boundaries accounts for the interdependent nature of diverse habitats and species.

The Caamaño-Douglas area with its unique land-sea connection, complex bathymetry, and seasonal flow patterns has resulted in important habitat for an array of taxonomic groups of ecological and conservation importance. The natural productivity of the area attracts large seasonal populations of highly mobile marine birds and marine mammals, further connecting marine and terrestrial ecosystems beyond the Northern Shelf Bioregion. Nearshore waters, islands, and fjord systems of the Network Zones provide areas of refuge and foraging for large colonies of marine birds (Rodway 1991, Rodway et al. 2016) and recovering populations of marine mammals (Wright et al. 2021b). Notably, Humpback whales use this area for social aggregations, and exhibit behaviors such as bubble net feeding more frequently than other parts of the BC coast (Section 6.2.1.1.3.3.1). Not only would protective measures help conserve the plethora of marine habitats and species, the health of the marine environment also sustains the livelihood of the people that depend on its resources. This area’s long history of cultural importance to local first nations further supports prioritizing these Network Zones for conservation.

Table 43. *Report summary highlights for each zone within the Caamaño Sound and Douglas Inlet Network Zones.*

Zone	Oceanographic Setting	Ecological Setting	Human Use	Climate Change and Conservation
Caamaño Sound (Zone 310)	• Deepest maximum depth along with Zone 314. • Two sills are present in this Zone. A broad and wide 140 m deep sill separates the seven Network Zones from Hecate Strait. Campania Sill is present at 200 m, which impacts estuarine circulation and exchanges deeper into the fjord system. • Steep fjord walls from postglacial retreat with surficial units including postglacial mud, bedrock, and glaciomarine sediment. • Has similar monthly SSTs as other Outer Coast Zones with low variability	• Overlap with the Central Mainland Ecologically and Biologically Significant Area and the West Aristazabal Island Rockfish Conservation Area. • Overlap with Stannard Creek Estuary (Importance class 2) • High species richness of macroalgae compared to other Zones, presence of **gadza k'aw** /Eelgrass, Surfgrass, and canopy-forming kelp. • E-CPs include but are not limited to: Corals and Sponges, Invertebrates (**ts'a'ax**/ **ċíkʷa**/ **ts'a'a̱x**/ Clams, Giant Pacific **hats'al**/ **teq̓ʷá**/ **ha̱ts'alt**/ Octopus, Dungeness **k'almoos**/ **klnákʷ**/ **k̲'a̱lmoos**/ Crabs, **gasgos**/ **sísíuł**/Shrimps and Echinoderms), **ts'mhoon**/Rockfish, Groundfish (**txaw**/ **mumegʷezu**/ **txaw**/ Halibut, **k'a'wts**/ **ƛáx̌dala**/ **k̲'a'w'ts**/ Pacific Cod, **balaas**/Pacific Hake, Walleye Pollock, **wa̱t'ukw**/ **núłem**/ **wa̱t'ukw**/	• Overlap of recreational fishing areas with **hoon**/ **qeqapela**/Salmon, Groundfish, and **k'almoos**/ **klnákʷ**/ **k̲'a̱lmoos**/ Crab sportfish. • Human use stressors include: many commercial fisheries, cutblocks, industrial tenures, log boom stressors, recreational boat routes. • Overlap with area of high vessel traffic. • Important First Nations sites include: Moore Island (an archaeological and cultural site for harvest and travel routes). • Cultural use and food security include	• Area affected by projected climate change: sea level rise and rising sea bottom and sea surface temperature. • Projected sea bottom aragonite undersaturation (declining pH). • Projected future decrease in oxygen concentrations. • Overlap with existing protected areas: **Lax Ka'gaas**/ Campania marine Conservancy. Western Aristazabal Island Rockfish Conservation Area. Moore/McKenney/Whitmore Islands Ecological Reserve. • Habitat E-CPs: The most in all of the Zones including: Aristazabal Banks Upwelling Upper Ocean Region, Fjord Ecosections, Fjord Upper Ocean Region, Coastal Classes (Channel, Sandflat, Rock Platform and Rock Ramp), both Continental Shelf and

Zone	Oceanographic Setting	Ecological Setting	Human Use	Climate Change and Conservation
	over the year. Summer temperatures peak in July and are lower than Inner Fjord Zones. Warmest SSTs in winter.	Lingcod, **Hadanii**/ **Hadanii**/ Sablefish), **Tskah**/ **wáṅi**/ **tskaḵh**/ Pacific Herring, **hoon**/ **qeqapela**/Salmon, and Marine Birds (Black Scoter, Rhinoceros Auklet, Tufted Puffin, Marbled Murrelet). • Overlap with islands and islets with known observations of Marine Bird breeding or nesting pairs, and large colonies, as well as the internationally recognized Moore and Byers Islands and Banks Important Bird Area. Highest bird species richness of all Zones (75 species). • Important area for Fin, Humpback, and **'naaxł**/ **hélx̄'inix̄ʷ**/ **niixł**/ Killer Whales, in addition to other cetaceans, pinnipeds, and overlaps with **płoon**/ **nukʷ**/ Sea Otter populations.	but not limited to: **hoon**/ **qeqapela**/ Salmon, **s'waanx**/ **'á'ent**/ **xs'waanx**/ Herring Roe, Groundfish (**waḵ'ukw**/ **núłem**/ **waḵ'ukw**/ Lingcod and **txaw**/ **mumegʷezu**/**txaw**/ Halibut), Shellfish, Marine Birds, **ła'ask**/ **lhlaˈq̓s**/ **łaḵ'aḵsk**/ Seaweed.	Continental Shelf (Fjords) Geomorphic Units. • C-CPs: Aristazabal Island North (Critical), Moore Islands (Very high), **Lax Ka'gaas**/Campania Sound & Whale Channel (Critical), Squally Channel (Very high)
Dewdney and Glide Islands (Zone 311)	• Shallow maximum and mean depth (along with Zone 312). • Has similar monthly SSTs as other	• Overlap with the Central Mainland Ecologically and Biologically Significant Area	• Overlap of recreational fishing areas with **hoon**/ **qeqapela**/ salmon, and groundfish sportfish.	• Area affected by projected climate change: sea level rise and rising sea bottom and sea surface temperature.

Zone	Oceanographic Setting	Ecological Setting	Human Use	Climate Change and Conservation
	Outer Coast Zones with low variability over the year. Summer temperatures peak in July and are lower than Inner Fjord Zones. Warmest SSTs in winter. • Data on seabed substrate is sparse in shallow water around the rocky coast of the Estevan Group. Surficial units include Bedrock and Glaciomarine Sediments.	• Presence of **gadza k'aw** /Eelgrass, Surfgrass, and canopy-forming Kelp biobands. • E-CPs include but are not limited to: corals and sponges, invertebrates (**ts'a'ax**/ **c̓íkʷa**/ **ts'a'a̱x**/ Clams, Dungeness **k'almoos**/ **klnákʷ**/ **k̲'a̱lmoos**/ Crabs, **gasgos**/ **sísíuł**/Shrimps and Echinoderms), **ts'mhoon**/Rockfish, Groundfish (**txaw**/ **mumegʷezu**/ **txaw**/ Halibut, **k'a'wts**/ **ƛáx̌dala**/ **k̲'a'w'ts**/ Pacific Cod, **balaas**/Pacific Hake, Walleye Pollock, **wa̱t'ukw**/ **núłem**/ **wa̱t'ukw**/ Lingcod, **Hadanii**/ **Hadanii**/ Sablefish), **Tskah**/ **wáṅi**/ **tska̱h**/ Pacific Herring, **hoon**/ **qeqapela**/Salmon and Marine Birds (Pigeon Guillemot, Rhinoceros Auklet, Marbled Murrelet). • Overlap with islands and islets with known observations of Marine Bird breeding or nesting pairs.	• Human use stressors include industrial tenures, commercial fisheries (**wa̱t'ukw**/ **núłem**/ **wa̱t'ukw**/ Lingcod, **ts'akwe'ats**/ Red Urchin, **ts'mhoon**/ Rockfish, **k'almoos**/ **klnákʷ**/ **k̲'a̱lmoos**/ Crab, **txaw**/ **mumegʷezu**/ **txaw** /Halibut), recreational boat routes, high recreation activities count compared to other Zones. • Important First Nation sites include: Dewdney Island groups (recreation, harvest, field trip sites, travel routes). • Cultural use and food security include but not limited to: **txaw**/ **mumegʷezu**/ **txaw**/ Halibut, **wa̱t'ukw**/ **núłem**/ **wa̱t'ukw**/ Lingcod,	• Projected sea bottom aragonite undersaturation (declining pH). • Projected future decrease in oxygen concentrations. • Habitat E-CPs: Aristazabal Banks Upwelling Upper Ocean Region, Fjord Ecosection, Fjord Upper Ocean Region, Coastal Classes (Sandflat, Rock Platform and Rock Ramp). Both Continental Shelf and Continental Shelf (Fjords) Geomorphic Units. • C-CPs: Dewdney Island (Very high), Trutch Island (Very high)

Zone	Oceanographic Setting	Ecological Setting	Human Use	Climate Change and Conservation
		• Important area for Fin and **ʻnaaxł**/ **hélx̄ʼinix̄ʷ**/ **niixł**/ Killer Whales, and Pinnipeds.	**ts'mhoon**/ Rockfish, **ła'ask**/ **lhlaˈq̓s**/ **łą'ą̱sk**/ Seaweed, **hoon**/ **qeqapela**/ Salmon, **k'almoos**/ **klnákʷ**/ **k̲'ą̱lmoos**/ Crab.	
Estevan Island groups (Zone 312)	• Shallow maximum and mean depth (along with Zone 311). • Has similar monthly SSTs as other Outer Coast Zones with low variability over the year. Summer temperatures peak in July and are lower than Inner Fjord Zones. Warmest SSTs in winter. • Data on seabed substrate is sparse in shallow water around the rocky coast of the Estevan Group. Surficial units include	• Overlap with the Central Mainland Ecologically and Biologically Significant Area. • Presence of **gadza kʼaw**/ Eelgrass, Surfgrass, and canopy-forming Kelp biobands. • E-CPs include but are not limited to: Corals and Sponges, invertebrates (**tsʼaʼax**/ **c̓íkʷa**/ **ts'a'ą̱x**/ Clams, Giant Pacific **hatsʼal**/ **teq̓ʷá**/ **hą̱ts'alt**/ Octopus, Dungeness **k'almoos**/ **klnákʷ**/ **k̲'ą̱lmoos**/ Crabs, **gasgos**/ **sísíuł**/Shrimps and Echinoderms), **tsʼmhoon**/Rockfish, Groundfish (**txaw**/ **mumegʷezu**/**txaw**/ Halibut, **kʼaʼwts**/ **ƛáx̄dala**/ **k̲'a'w'ts**/ Pacific Cod, **balaas**/Pacific Hake, Walleye Pollock, **wą̱tʼukw**/ **núłem**/ **wą̱t'ukw**/ Lingcod, **Hadanii**/ **Hadanii**/	• Overlap of recreational fishing areas overlap with **hoon**/ **qeqapela**/ Salmon, and Groundfish sportfish. • Human use stressors include industrial tenures, commercial fisheries (many), recreational boat routes, high recreation activities count compared to other Zones. • Cultural use and food security include but not limited to: **txaw**/ **mumegʷezu**/ **txaw**/ Halibut, **ts'mhoon**/ Rockfish, **ła'ask**/ **lhlaˈq̓s**/ **łą'ą̱sk**/ Seaweed,	• Habitat E-CPs: Aristazabal Banks Upwelling Upper Ocean Region, Fjord Ecosection, Fjord Upper Ocean Region, Coastal Classes (Sandflat, Rock Platform and Rock Ramp). Both Continental Shelf and Continental Shelf (Fjords) Geomorphic Units. • C-CPs: Dewdney Island (Very high), Trutch Island (Very high)

Zone	Oceanographic Setting	Ecological Setting	Human Use	Climate Change and Conservation
	Bedrock and Glaciomarine Sediments.	Sablefish), **Tskah**/ **wáńi**/ **tskaḥ**/ Pacific Herring, and Marine Birds (Rhinoceros Auklet, Marbled Murrelet). • Overlap with islands and islets with known observations of Marine Bird breeding or nesting pairs. Important area for Fin and **'naaxł**/ **hélx̄'inix̄ʷ**/ **niixł**/ Killer Whales, and Pinnipeds.	**hoon**/ **qeqapela**/ Salmon, Shellfish, Seabird eggs, **tskah**/**wáńi**/**tskaḥ**/ Herring. • Important First Nation sites include: Estevan Island groups (Recreation, harvest, field trip sites, travel routes, and includes non-consumptive species of importance).	
Fin Island Groups (Zone 313)	• Deepest mean depth along with Zone 314. • Steep fjord walls from postglacial retreat with surficial units including postglacial mud, and glaciomarine sediment. • Deep fjord waters depend on annual renewal in spring to replenish dissolved oxygen and salinity, preventing anoxic	• High species richness of macroalgae compared to other Zones, presence of **gadza k'aw**/ Eelgrass and Surfgrass biobands, and canopy-forming Kelp. • E-CPs include but are not limited to: Corals and Sponges, Invertebrates (**ts'a'ax**/ **c̓íkʷa**/ **ts'a'a̱x**/ Clams, Giant Pacific **hats'al**/ **teq̓ʷá**/ **ha̱ts'alt**/ Octopus, Dungeness **k'almoos**/ **klnákʷ**/ **k̲'a̱lmoos**/ Crabs, **gasgos**/ **sísíuł**/Shrimps and Echinoderms), **ts'mhoon**/Rockfish,	• Overlap of recreational fishing areas overlap with **hoon**/ **qeqapela**/ Salmon, and **k'almoos**/ **klnákʷ**/ **k̲'a̱lmoos**/ Crab sportfish. • Human use stressors include: industrial tenures, log booms, cutblocks, ports and sewage, commercial fisheries (**hadanii**/ **hadanii**/Sablefish,	• Linkage to existing **ts'mhoon**/ Rockfish Conservation Area (toe of slope to nearshore) • Habitat E-CPs: Fjord Ecosection, Fjord Upper Ocean Region, Coastal Classes (Channel, Sandflat, Rock Platform and Rock Ramp), Continental Shelf (Fjords) Geomorphic Units. • C-CPs: **Maxtaktsm'aa**/Union Passage and **K'duwaadz**/ Tuwartz Inlet (Critical),

Zone	Oceanographic Setting	Ecological Setting	Human Use	Climate Change and Conservation
	conditions throughout parts of the year. • Relatively fresh surface water in the fjords flow into the Outer Coast Zones (310, 311, 312) and towards sea. Elevated nutrients compared to Hecate Strait and Outer Zones at similar depths due to mixing and lateral exchanges.	Groundfish (**txaw**/ **mumegʷezu**/**txaw**/ Halibut, **k'a'wts**/ **ƛáx̌dala**/ **k̲'a'w'ts**/ Pacific Cod, **balaas**/Pacific Hake, Walleye Pollock, **Hadanii**/ **Hadanii**/ Sablefish), **Tskah**/ **wáṁi**/ **tskaḵh**/ Pacific Herring, **hoon**/ **qeqapela**/Salmon, and Marine Birds (Black Scoter, Rhinoceros Auklet, Marbled Murrelet). • Important area for Fin, Humpback and **'naaxł**/ **hélx̄'inix̄ʷ**/ **niixł**/ Killer Whales, and Pinnipeds.	**gyenti**/ **'éllas**/Sea Cucumber, **hoon**/ **qeqapela**/ Salmon Seine, **ts'mhoon**/ Rockfish, **gasgos**/ **sísíuł**/ Prawn, **k'almoos**/ **klnákʷ**/ **k̲'a̲lmoos**/ Crab, **txaw**/ **mumegʷezu**/**txaw**/ Halibut), recreational boat routes, high recreation activities count compared to other Zones. • Overlap with area of high vessel traffic. • Cultural use and food security include but not limited to halibut, **hoon**/ **qeqapela**/ salmon, shellfish, **sa̲g̲ʷam**/ **üüla** / seal • Important First Nation sites include: **K'duwaadz**/Tuwartz Inlet (harvest), Cherry islets (harvest), Clamstown, **Lax**	**Laxkwildziist**/ Fin Island & **Ktisgaidz**/MacDonald Bay (Critical)

Zone	Oceanographic Setting	Ecological Setting	Human Use	Climate Change and Conservation
			Kwil Dziist/Fin Island (cultural sites, harvest), Gil Island (cultural sites, harvest), Crane Bay (harvest).	
Douglas Channel (Zone 314)	• Deepest mean depth along with Zone 313 and absolute depth along with Zone 310. • Presence of sill at 200 m deep which impacts estuarine circulation and exchanges in nearby channels. • Steep fjord walls from postglacial retreat with surficial units including postglacial mud, streamlined ridge, landslide/slope failure, and glaciomarine sediment. • Deep fjord waters depend on annual	• Presence of **gadza k'aw**/ Eelgrass and canopy-forming Kelp biobands. • E-CPs include but are not limited to: Corals and Sponges, Invertebrates (**ts'a'ax**/ **c̓íkʷa**/ **ts'a'a̱x**/ Clams, Giant Pacific **hats'al**/**teq̓ʷá**/**ha̱ts'alt**/Octopus, Dungeness **k'almoos**/ **klnákʷ**/ **k̲'a̱lmoos**/ Crabs, **gasgos**/ **sísíuł**/Shrimps and Echinoderms), **ts'mhoon**/Rockfish, Groundfish (**txaw**/ **mumegʷezu**/**txaw**/ Halibut, **k'a'wts**/ **λáx̄dala**/ **k̲'a'w'ts**/ Pacific Cod, **Hadanii**/ **Hadanii**/ Sablefish), **Tskah**/ **wáṅi**/ **tska̱h**/ Pacific Herring, **hoon**/ **qeqapela**/Salmon, and Marine Birds (Rhinoceros Auklet, Marbled Murrelet). • Important area for Fin, Humpback and **'naaxł**/	• Overlap of recreational fishing areas overlap with **hoon**/ **qeqapela** / Salmon, and nearby **k'almoos**/ **klnákʷ**/ **k̲'a̱lmoos**/ Crab sportfish. • Human use stressors include: cutblocks, ports, sewage, commercial fisheries (**hoon**/ **qeqapela**/ Salmon Gillnet and Seine, **gyenti**/ **'éllas** / Sea Cucumber, **gasgos**/ **sísíuł**/ Prawn, **k'almoos**/ **klnákʷ**/ **k̲'a̱lmoos**/ Crab, **txaw**/ **mumegʷezu**/ **txaw**/ Halibut), Recreational Boat Routes.	• Habitat E-CPs: Fjord Ecosection, Fjord Upper Ocean Region, Coastal Classes (Channel, Sandflat, Rock Platform and Rock Ramp), Continental Shelf (Fjords) Geomorphic Units. • C-CPs: Wright Sound & Lower Douglas Channel (Critical) and Squally Channel* (Very high)

Zone	Oceanographic Setting	Ecological Setting	Human Use	Climate Change and Conservation
	renewal in spring to replenish dissolved oxygen and salinity, preventing anoxic conditions throughout parts of the year. • Relatively fresh surface water in the fjords flow into the Outer Coast Zones (310, 311, 312) and towards sea. Elevated nutrients compared to Hecate Strait and Outer Zones at similar depths due to mixing and lateral exchanges.	**hélx̄'inix̄^{w}**/ **niixł**/ Killer Whales, and Pinnipeds.	• Overlap with area of high vessel traffic. • Cultural use and food security include but not limited to: **hoon**/ **qeqapela**/ salmon, **txaw**/ **mumeg^{w}ezu** /**txaw**/ halibut, **tskah**/**wáṅi**/ **tskaḵh**/ Herring, Shellfish, Marine Mammals, **ła'ask**/ **lhlaʾq̓s**/ **łaḵ'aḵsk**/ Seaweed. • Important First Nation sites include: **Txałgiu** /Hartley Bay (community center, harvest), Promise Island (harvest)	
Union Passage Site (Zone 315)	• Limited Zone-specific Oceanographic data due to size and lack of sampling.	• Overlap with Tsimtack Lake estuary (Importance class 4) • Presence of **gadza k'aw**/ Eelgrass and Surfgrass and canopy-forming Kelp biobands. • Ecological Knowledge gap due to lack of sampling in this Zone. E-CPs include but are not limited to: invertebrates (Giant	• Human use stressors include: cutblocks, ports, sewage, commercial fisheries (**gyenti**/ **'éllas**/ Sea Cucumber, **ts'mhoon**/ Rockfish, **gasgos**/ **sísíuł**/ Prawn, **k'almoos**/	• C-CPs: **Maxtaktsm'aa**/Union Passage & **K'duwaadz**/Tuwartz Inlet (Critical)

Zone	Oceanographic Setting	Ecological Setting	Human Use	Climate Change and Conservation
		Pacific **hats'al**/ **teq̓ʷá**/ **hat̲s'alt**/Octopus, Dungeness **k'almoos**/ **klnákʷ**/ **k̲'a̲lmoos**/ Crabs, **gasgos**/ **sísíuɬ**/Shrimps), **ts'mhoon**/Rockfish, Groundfish (**txaw**/ **mumegʷezu**/**txaw**/ Halibut, **k'a'wts**/ **ƛáx̌dala**/ **k̲'a'w'ts**/ Pacific Cod), **Tskah**/ **wáṅi**/ **tska̲h**/ Pacific Herring, **hoon**/ **qeqapela**/Salmon, and Marine Birds (Common Murre, Double-crested Cormorant).	**klnákʷ**/ **k̲'a̲lmoos**/ Crab, **txaw**/ **mumegʷezu**/ **txaw**/ Halibut). • Cultural use and food security include but not limited to: **hoon**/ **qeqapela**/ Salmon, **txaw**/ **mumegʷezu**/ **txaw**/ Halibut, **hadanii**/ **hadani**/ Sablefish, **ts'mhoon**/ Rockfish, and Shellfish. • Important First Nation sites includes: **Maxtaktsm'aa**/Union passage (Beaches, boat anchors, recreation, harvest, historical village)	
Ursula Channel (Zone 316)	• Presence of sill at 35 m deep which impacts estuarine circulation and exchanges in nearby channels. • Steep fjord walls from postglacial	• Overlap with Evelyn Creek and Goat River (Importance class 4 and 3 respectively), and an unnamed estuary with Importance class 4.	• Human use stressors include log booms, cutblocks, ports, sewage, commercial fisheries (**gyenti**/ **'éllas**/ Sea Cucumber, **ts'mhoon**/ Rockfish,	• Habitat E-CPs: Fjord Ecosection, Fjord Upper Ocean Region, Coastal Classes (Channel, Sandflat, Rock Platform and Rock Ramp), Continental Shelf (Fjords) Geomorphic Units.

Zone	Oceanographic Setting	Ecological Setting	Human Use	Climate Change and Conservation
	retreat with surficial units including postglacial mud, streamlined ridge, landslide/slope failure, and glaciomarine sediment. • Deep fjord waters depend on annual renewal in spring to replenish dissolved oxygen and salinity, preventing anoxic conditions throughout parts of the year. • Relatively fresh surface water in the fjords flow into the Outer Coast Zones (310, 311, 312) and towards sea. Elevated nutrients compared to Hecate Strait and Outer Zones at similar depths due to mixing and lateral exchanges.	• Presence of **gadza k'aw**/ Eelgrass and canopy-forming Kelp biobands. • E-CPs include but are not limited to: Corals and Sponges, Invertebrates (**ts'a'ax**/ **ć́ík^{w}a**/ **ts'a'a̱x**/ Clams, Giant Pacific **hats'al**/ **teq̓^{w}á**/ **ha̱ts'alt**/ Octopus, Dungeness **k'almoos**/ **klnák^{w}**/ **k̲'a̱lmoos**/ Crabs, **gasgos**/ **sísíuł**/Shrimps and Echinoderms), **ts'mhoon**/Rockfish, Groundfish (**txaw**/ **mumeg^{w}ezu**/**txaw**/ Halibut, **k'a'wts**/ **λáx̄dala**/ **k̲'a'w'ts**/ Pacific Cod, Lingcod, **Hadanii**/ **Hadanii**/ Sablefish), **Tskah**/ **wáṅi**/ **tska̱h**/ Pacific Herring, **hoon**/ **qeqapela**/ Salmon, and Marine Birds (Rhinoceros Auklet, Black Scoter) • Important area for Fin, Humpback and **'naaxł**/ **hélx̄'inix̄^{w}**/ **niixł**/ Killer whales, and Pinnipeds.	**gasgos**/ **sísíuł**/ Prawn, **k'almoos**/ **klnák^{w}**/ **k̲'a̱lmoos**/ Crab, **txaw**/ **mumeg^{w}ezu**/ **txaw**/ Halibut), recreational boat routes. • Overlap with area of high vessel traffic. • Cultural use and food security include but not limited to: **hoon**/ **qeqapela**/ Salmon, **txaw**/ **mumeg^{w}ezu**/ **txaw**/ Halibut, Shellfish. • Important First Nation sites includes: Bishop Bay (recreation), Monkey Beach (recreation)	• C-CP: Ursula Channel (Critical)

7.2 Knowledge gaps and recommendations

This report aimed to compile the knowledge and available ecological, oceanographic and human use data of the area. Despite the comprehensiveness of the report, several knowledge gaps and uncertainties remain. In this section we summarize those gaps and provide some recommendations for future work to address these gaps.

Given the focused oceanographic research in the area as part of the "World Class Tanker Safety System" from approximately 2013 - 2016, the physical oceanography and currents of this area is relatively well understood when compared to other coastal fjord systems. The extent of local data for the ecology of the area varies with taxa. For example, extensive research on cetaceans led by the North Coast Cetacean Society, provides an excellent foundation for **łbuun**/**ḡʷey̓ém**/**łpuun**/whale populations and important **łbuun**/ **ḡʷey̓ém**/**łpuun** areas for the area, however for fish and invertebrates, the report relies on regional DFO surveys that have limited spatial overlap with the Network Zones. The annual stocks of many invertebrates, such as **gasgos**/**sísíuł**/shrimp (Ouellet et al. 2011), and fishes such as **txaw**/**mumegʷezu**/**txaw**/halibut (Clark et al. 1999) and **ha'limootk**/**ƛ̓áti**/**ẅa̱h**/eulachon (COSEWIC 2011a), are highly variable due to offshore conditions affecting oceanic life stages, such as pelagic larva or adult survivability. Little is known about the offshore migratory pattern of many fishes, including **hoon**/**qeqapela**/salmon, and the compounding effects of oceanic conditions (current, temperature) can influence local stocks in the Caamaño-Douglas area. The Caamaño-Douglas area has no ongoing systematic and spatially comprehensive surveys covering all network zones and many of the available datasets are outdated (e.g., kelp, **gadza k'aw**/eelgrass, surfgrass) or limited in spatial extent (e.g., surveys conducted to support fish and invertebrate stock assessments). This knowledge gap could be supplemented with local and traditional knowledge, modelled data (e.g., Thompson et al 2023b) and increased and targeted survey effort as part of monitoring the new Marine Protected Areas.

Knowledge Gaps - Outer Coast Zones (310, 311, 312)

Oceanographic setting

- Data gap on seabed substrate is sparse in shallow water, particularly the rocky coast around the Estevan Group.
- Local flow patterns in the shallow areas (~ 10 to 30 m) near the shoreline are mainly unknown.
    - Moored observations in deeper areas in Zone 310 suggest strong internal wave activity, which may deliver nutrients in these areas.
- Water properties in shallow nearshore areas (1 to 10 m) are largely unknown. Local freshwater plumes, surface waves induced mixing and sediment transport will influence local conditions.
- Mixing over the sills between the Estevan Island Group and **Lax Ka'gaas** /Campania Island and the sill between the Estevan Island Group and **K'ts'ats'aas**/Gil Island are likely important for the nutrient fluxes into the surface layer. However, their importance has never been investigated.
- Lack of zooplankton data across the entire Caamaño-Douglas area. Most observations are from the World Tanker Safety Programme

Climate change

- Projected climate models (BCCM and NEP36-CanOE) have limited resolution near the coast, where bathymetric changes occur over short spatial scales. Historical temperature trends should be analyzed from the available data at depth in Zone 310.
- Lack of knowledge about ocean waves' impact on nearshore ecosystems. Thus, how those systems would be affected by a changing wave climate is also unknown.
- Process-based studies are recommended to relate nearshore water properties with offshore conditions and satellite-derived products (e.g., surface temperature, suspended particles and phytoplankton).

Ecological setting

- Spatial coverage of biological data of fish and invertebrate observations are patchy across these Outer Coast Zones. Due to its larger size and proximity to Hecate Strait, Zone 310 is likely the best surveyed Zone from the available data. The boundaries of Zones 311 and 312 are much smaller and closer to shore.
- Information regarding biogenic habitats such as **gadza k'aw**/eelgrass, surfgrass, kelp, and salt marshes are also limited, and many available spatial datasets require updates. There is little to no information about seasonal and annual habitat variability or baseline conditions in the Caamaño-Douglas area. Insights from oral history, traditional knowledge, community surveys, and long-term monitoring efforts can inform the health of these ecosystems.
- Marine bird colonies in the Outer Coast Zones abundance, distribution, trends, foraging, and movement behavior are hindered by variability in survey effort and methodology.

Knowledge Gaps - Inner Coast Zones (313, 314, 315) and Ursula Channel (316)

Oceanographic setting

- Water exchanges between Zone 315 and the shallower areas of Zone 313 are unknown, in addition to water exchanges between **Maxtaktsm'aa**/Union Passage and Grenville Channel.
  For example:
  - There is no information about the flow patterns in shallow (<1-10 m) and nearshore zones (310, 311, 312)
  - **Maxtaktsm'aa**/Union Passage (Zone 313) may provide nutrients to **Lax Kwil Dziidz**/Fin Island and Squally Channel (Zone 315).
  - Process-based studies are recommended to relate nearshore water properties with offshore conditions and satellite-derived products.
- Nutrients cycling within adjoining estuaries and the Outer Network Zones are unknown. For instance, high nutrients found in Douglas Channel (Zone 316) may be caused by local mixing at the northern sill (~200 m deep) or transported into the area from the intense-mixing region in Devastation Channel. Another possibility is flushing nutrients out of smaller estuaries that line the channels.

Therefore, additional analysis and sampling is recommended to identify the main sources of nutrients.
    - This analysis may be achieved in a first instance by sampling nutrients in adjoining estuaries and estimating freshwater runoff from the smaller catchments flowing through these estuaries.
    - Alternatively, vertical nutrient fluxes could be quantified at sills, requiring dedicated field campaigns and specialized turbulence equipment.
- No moorings have been deployed in the Ursula Channel, so there are few winter observations and no observations of subsurface currents. A mean flow south at the surface and north at intermediate depth is expected, as shown in Zone 310 and 314 (Douglas Channel), but knowledge is limited at this time.
- The shallow sill at its northern end likely generates unique exchanges of nutrients and oxygen, especially given existing work about the other sills in Devastation Channel.
- Existing profiles of water properties suggest Zone 316 may supply nutrients to other areas (e.g., Zone 314) and perhaps even further seawards in Whale Channel. However, nutrient cycling is currently unknown, as is the vertical flux caused by mixing processes at the northern end of Ursula Channel.
- Nutrient inputs from adjoining estuaries and bays (e.g., Bishop Bay).

Climate change

- Climate projections with higher resolution at small spatial scales, incorporating bathymetric variation and terrestrial flow, are required to better understand the variety of physical changes that may be expected with a warming climate and increased carbon dioxide in the Inner Fjord systems and Ursula Channel. Work in Pacific Region fjords (e.g., Jackson et al. 2021, Lin and Bianucci 2023) incorporating additional oceanographic components has shown that these terrestrial-marine interfaces are complex and require extra consideration when considering climate change impacts.

Ecological setting

- Zone 315, **Maxtaktsm'aa**/Union Passage Site is rarely surveyed, primarily due to its small area size (4.28 km^2). This Network Zone is, therefore, the most consistent knowledge gap for many species.
- Dive and ROV surveys were conducted within the Inner Fjord Zones for observing invertebrates and fishes. While these surveys can help with monitoring biodiversity, the depths and steep slopes of the fjords and inlets presents a barrier for larger survey methods using research vessels. In addition, nearshore invertebrate surveys are limited to shallow waters, inlets, and estuaries. This in turn, leads to limited data for local population assessments and trends on the spatial scale of the Caamaño-Douglas area for the Inner Fjord Zones.
- Standardized surveys and trends for fishes are limited, although this is a gap identified for many fjords or inlets areas in BC. Ongoing environmental DNA approaches can help to assess fish and invertebrate diversity (e.g., Rubidge et

al, current research) and detect the presence and relative abundance of depleted and rare species (e.g., collaborative research led by First Nations and academics).

- Due to the high density of **łbuun**/ **ḡʷey̓ém**/**łpuun**/whales in the Inner Fjord Zones, understanding their spatial and temporal distribution and habitat preference is important to reduce vulnerabilities to anthropogenic threats such as vessel traffic. Continual research is needed to quantify the threats from vessel strikes, vessel noise on regular behaviors, and other pollutants in the area.

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10 APPENDICES

10.1 Appendix A. Indigenous languages and sources

Online languages resources:

Sm’algyax Living Legacy Talking Dictionary (Last updated 2018)

Sm’algyax Dictionary - (webonary.org)

Sm'algyax (smalgyax.ca)

Sguux FirstVoices

Haisla Webonary

Additional references used:

Gitga’at Marine Use Plan 2012.

Marsden, S. 2012. The Gitk’a’ata, their history, and their territories. Report submitted to the Gitk’a’ata

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Appendix Table 1. Indigenous languages and use in this report. The lack of a word in the table should not be interpreted to mean that the respective word does not exist. This table and accompanying document is not meant to be an Indigenous languages reference.

Sm'algyax name	Haisla name	Sgüüx̲s name	English name	Category
hą̲'ą̲x	henḡax	hą̲'ą̲x	Canada goose	Bird
ga̲guum	c̓igilaxs	gaguum	Seagull	Bird
łii'wn	x̄íx̄ix̄i		Snow goose	Bird
yee	k̓áp̓i	xyi'i	Chinook (Spring) (King)	Fish
gayniis	gʷaxenis	gą̲yniis	Chum	Fish
üüx	zúen	üüxs	Coho	Fish
ga̲gaats	q̓ʷaḡʷina	gą̲sgaatsk	Dogfish	Fish
Ha'limootk	ƛ̓áti	ẅą̲h	Eulachon	Fish
txaw	mumegʷezu	txaw	Halibut	Fish
xs'waanx	'á'ent	xs'waanx	Herring roe	Fish
wa̲t'ukw	núłem	wą̲t'ukw	Lingcod	Fish
k'a̲'wts	ƛáx̄dala	k̲'a'w'ts	Pacific cod (grey cod)	Fish
balaas			Pacific hake	Fish
Tskah	wáṅ̓i	tskąh	Pacific herring	Fish
sti'moon	qábes	sti'moon	Pink salmon	Fish
ts'mhoon			Rockfish	Fish
Hadanii		Hadanii	Sablefish (Black Cod)	Fish
hoon	qeqapela		Salmon	Fish
ksaa	q̓ʷaqʷ-		Shark	Fish
gandeh	bakʷ-		Skates	Fish
misoo	hísen	miso'o	Sockeye	Fish
meliit			Steelhead trout	Fish
	ƛ̓áx̄ʷ'en ƛ̓áƛ̓ex̄ʷ'en		Yelloweye rockfish	Fish
K'nabiyaaxl			Ashdown Island	Geography
Lax k'naga dzol			Banks Island	Geography

Sm'algyax name	Haisla name	Sgüüx̲s name	English name	Category
Lax Kul			Bonilla Island	Geography
Lax Ka'gaas			Campania	Geography
Kwelts’uu			Cornwall Inlet	Geography
Lach Klan			Dolphin Island	Geography
Lax Kwil Dziidz			Fin Island	Geography
K'ts'ats'aas			Gil Island	Geography
Txałgiu			Hartley bay	Geography
Ktisgaidz			MacDonald Bay	Geography
Lax gal’tsap			Old Town in Kitkiata Inlet	Geography
Tgii Xsw'aanx			Porcher Island	Geography
Ksyen/Ksiyeen			Skeena River	Geography
K’distsauk			Turtle Point	Geography
K’duwaadz			Tuwartz Inlets	Geography
Maxtaktsm’aa			Union Passage	Geography
bilhaa	ḡelhḡenaiq		Abalone	Invertebrate
yaans			Chiton (general), and Black leather chiton	Invertebrate
gyels		gyels	Blue mussel	Invertebrate
sa'mx	ḵuxʷ		Butter clam	Invertebrate
hagwn			California mussel	Invertebrate
	ḳeḳánas		Chiton	Invertebrate
ts’a’ax	ć́ikʷa	ts'a'a̲x	Clams (general)	Invertebrate
gaboox	zuáli	g̲a̲boox	Cockles	Invertebrate
k'almoos	klnákʷ	k̲'a̲lmoos	Crab	Invertebrate
Ts'ak			Gumboot chiton	Invertebrate
loon	ḡʷénceḡawi	lo'on	Horse clam	Invertebrate
	kʷaas		Mussel	Invertebrate
hats’al	teḳʷá	ha̲ts'alt	Octopus	Invertebrate
	ć́eḳʷíć́		Purple sea urchin	Invertebrate
ts'akwe'ats			Red sea urchin	Invertebrate

Sm'algyax name	Haisla name	Sgüüx̱s name	English name	Category
k̲'ał'on		k̲'ał'on	Scallops	Invertebrate
gyenti	’éllas		Sea cucumber	Invertebrate
gamaats	ḡazea	g̲a̲maats	Sea star	Invertebrate
gasgos		sísíuł	Shrimp and prawn	Invertebrate
aswit	’emdém	a̲ws	Urchin (general), green sea urchin	Invertebrate
	sia’ám		Boa Kelp (*Egresia sp.*)	Marine algae and plants
mo'ox	wáudi	moox	Bull kelp	Marine algae and plants
gadza k’aw			Eelgrass	Marine algae and plants
gyoós	q̓áq̓elḭ̓is		Giant kelp	Marine algae and plants
ła’ask	lhlaˈq̓s	ła'a̲sk	Seaweed (general)	Marine algae and plants
dziiẅ	ʎ̓áła		Dolphin	Marine mammal
	zemá		Elephant seal	Marine mammal
‘naaxł	hélx̄’inix̄ʷ	niixł	Killer whale	Marine mammal
	ʎ̓ix̄’én	t'iibn	Sea lion	Marine mammal
płoon	nukʷ		Sea otter	Marine mammal
üüla	sag̃ʷam	üüla	Seal	Marine mammal
t'iibn			Stellar sea lion	Marine mammal
łbuun	g̃ʷey̓ém	łpuun	Whale (general)	Marine mammal

10.2 Appendix B. Caamaño-Douglas Network Zones Boundaries

Please see the MPA Network Action Plan[53] for more details.

Below are high-level descriptions of some of the drivers and rational behind the current zone boundaries for the Caamaño Sound and Douglas Fjord System site. Contributions of the areas towards meeting representational targets for both cultural and ecological values were a key factor, often supported by outputs from Marxan analysis, the presence of First Nation Cultural Conservation Priority areas, and/or Protection Management Zones identified in the North Coast Marin Plan (Marine Plan Partnership). Another important consideration was the presence of existing conservation efforts in the area, including a range of provincial Marine Parks, Ecological Reserves, and Conservancies.

Zone 310:

The boundaries for this zone capture a marine area that contributes towards the representation of a number of ecological and cultural conservation priorities, evidenced by a large Marxan 'hotspot' present in both the ecological only and combined ecological and cultural (FNCCP) Marxan analysis outputs. The majority of this zone covers area identified as 'critical' or 'very high' ranked cultural conservation priorities. In addition to being an area of importance for multiple marine mammals, fish, invertebrates, marine birds and plants, the area also contributes towards the replication targets of network habitats and areas, including the Central Mainland EBSA, North Coast Fjords Ecosection, and both the Mainland Fjords and Aristazabal Banks Upwelling Upper Ocean Subregions. The area builds on existing conservation efforts in the region including significant overlap with two individual North Coast Marine Plan (MaPP) Protection Management Zones: Aristazabal Island North (PMZ-2, IUCN Type IV) and **Lax Ka'gaas**/Campania and Whale Channel (PMZ-4, IUCN Type IV). The area also contains the marine portion of **K'nabiyaaxl**/Ashdown Conservancy, partial overlap with southern marine portion of **Lax Ka'Gaas** Conservancy, and is adjacent to portions of the terrestrial **Moksgm'ol**/ Chapple – Cornwall Conservancy, providing opportunity to enhance protection in these areas, including intertidal areas and the terrestrial/marine interface. The southern boundary is adjacent to another MPA Network aggregation of zones which are comprised of existing Rockfish Conservation Areas and an Ecological Reserve and currently identified in the MPA Network as a potential Marine Refuge possibly in combination with a Marine National Wildlife Area designation.

Zone 311:

The boundaries for this zone are adjacent to the existing Dewdney and Glide Islands Ecological Reserve, and have significant overlap and alignment with an existing North Coast Marine Plan (MaPP) Protection Management Zone: Dewdney Island (PMZ-3, IUCN Type Ib) seeking to protect the diversity of marine life in the surrounding waters and intertidal zone. This underlying PMZ also aligns with the boundaries of a cultural conservation priority with a 'very high' ranking. Building on the conservation efforts in the immediate area, this zone provides an opportunity to enhance existing marine protection and complement the adjacent terrestrial protection. The area contributes towards representation targets of many nearshore ecological conservation priorities (e.g. **gadza k'aw**/eelgrass meadows, **mo'ox**/**wáudi**/**moox**/bull and

[53] https://mpanetwork.ca/wp-content/uploads/2025/10/MPA_Network-Action-Plan_web.pdf

gyoós/**q̓áq̓elḻis**/giant kelp beds) and captures the northern end of a large Marxan 'hotspot' present in both the ecological only and combined ecological and cultural (FNCCP) Marxan analysis outputs.

Zone 312:

The boundaries for this zone are adjacent to the Ethelda Bay-Tennant Island Conservancy, which protects a small group of islands in the Estevan group, and have significant overlap and alignment with an existing North Coast Marine Plan (MaPP) Protection Management Zone: Trutch Island (PMZ-29, IUCN Type IV). This underlying PMZ also aligns with the boundaries of a cultural conservation priority with a 'very high' ranking. This zone contributes towards representation targets of network cultural and ecological features, and represents an opportunity to protect cultural values while seeking to maintain access for sustainable uses and activities. This is a zone with many similar ecological values but potentially less restrictive than Zone 311 to the immediate south, which seeks to enhance the existing terrestrial ecological reserve.

Zone 313:

The boundaries for this zone capture a marine area that contributes towards the representation of a number of ecological and cultural conservation priorities, capturing moderate and more significant Marxan 'hotspots' present in both the ecological only and combined ecological and cultural (FNCCP) Marxan analysis outputs respectively. In addition to being an area of particular importance for multiple marine mammals, the area also contributes towards the replication targets of network habitats and areas, including the North Coast Fjords Ecosection and the Mainland Fjords Upper Ocean Subregion. It is a region of significant cultural value, overlapping multiple 'critical' cultural conservation priority areas. The zone is adjacent to, and overlaps the marine portion of, multiple conservancies, providing opportunity to enhance existing conservation in the region and complement terrestrial protection. There is also significant overlap with two individual North Coast Marine Plan (MaPP) Protection Management Zones: **Maxtaktsm'aa**/Union Passage and **K'duwaadz**/Tuwartz Inlet (PMZ-7, IUCN Type IV) and **Lax Kwil Dziidz**/Fin Island and **Ktisgaidz**/MacDonald Bay (PMZ-18, IUCN Type IV).

Zone 314:

The boundaries for this zone align with an area identified as a cultural conservation priority with a 'critical' ranking. A portion of the zone is adjacent to the Gitga'at First Nation community of **Txałgiu**/Hartley Bay. The boundaries for this zone capture a marine area that contributes towards the representation of a number of ecological and cultural conservation priorities, capturing moderate and more significant Marxan 'hotspots' present in both the ecological only and combined ecological and cultural (FNCCP) Marxan analysis outputs respectively. As with much of the Caamaño Sound region, this zone is notable for the presence of a range of marine mammals, including Humpback and **'naaxł**/**hélx̄'inix̄ʷ**/**niixł**/Killer Whales. Zone 314 is adjacent to two other MPA Network zones in Kitkiata and Kiskosh Inlets which are proposed to be protected by a combination of Fisheries Act tools and BC tools and contain overlap with marine portions of the existing Alty and K'waa Conservancies

Zone 315:

The boundaries for this zone align with those of the existing Provincial **Maxtaktsm'aa**/Union Passage Provincial Marine Park boundary (marine portion). This zone provides an opportunity to build on existing protection, with potential to address activities outside provincial jurisdiction is

this area. The area contributes to meeting network targets for a range of nearshore conservation priorities, including marine plants and invertebrates.

Zone 316:

The boundaries for this zone align with the combined boundaries of the existing Bishop Bay / Monkey Beach Conservancy and a North Coast Marine Plan (MaPP) Protection Management Zone: Ursula Channel (PMZ-8, IUCN Type IV). This zone capture a marine area that contributes towards the representation of a number of ecological and cultural conservation priorities, capturing moderate Marxan 'hotspots' present in both the ecological only and combined ecological and cultural (FNCCP) Marxan analysis outputs. The majority of Zone 316 has been identified as a cultural conservation priority with a 'critical' ranking.

Note regarding cetacean values throughout the broader Caamaño-Douglas region:

It is recognized that the overall area is important to a number of 'at-risk' cetaceans including Northern Resident **'naaxł/hélx̄'inix̄ʷ/niixł**/Killer Whales, Humpback Whales and Fin Whales. This includes portions of Verney Passage, and both Whale and Squally Channels. These areas have not been incorporated into the zoning plan for the potential MPA, however the proposed MPA footprint and the broader area surrounding it has been identified for the development of strategies (inside and outside MPAs) to address both shipping/vessel traffic concerns and potential entanglement impacts on whales, in particular in the fall aggregation period. MPAs are not the 'only tool in the toolbox' and it is hoped that additional management can be incorporated in the region using complimentary tools and best practices, informed by parallel initiatives such as Transport Canada's Proactive Vessel Management project under the Ocean Protection Plan.

10.3 Appendix C. Vessel Data Gear Class Definitions

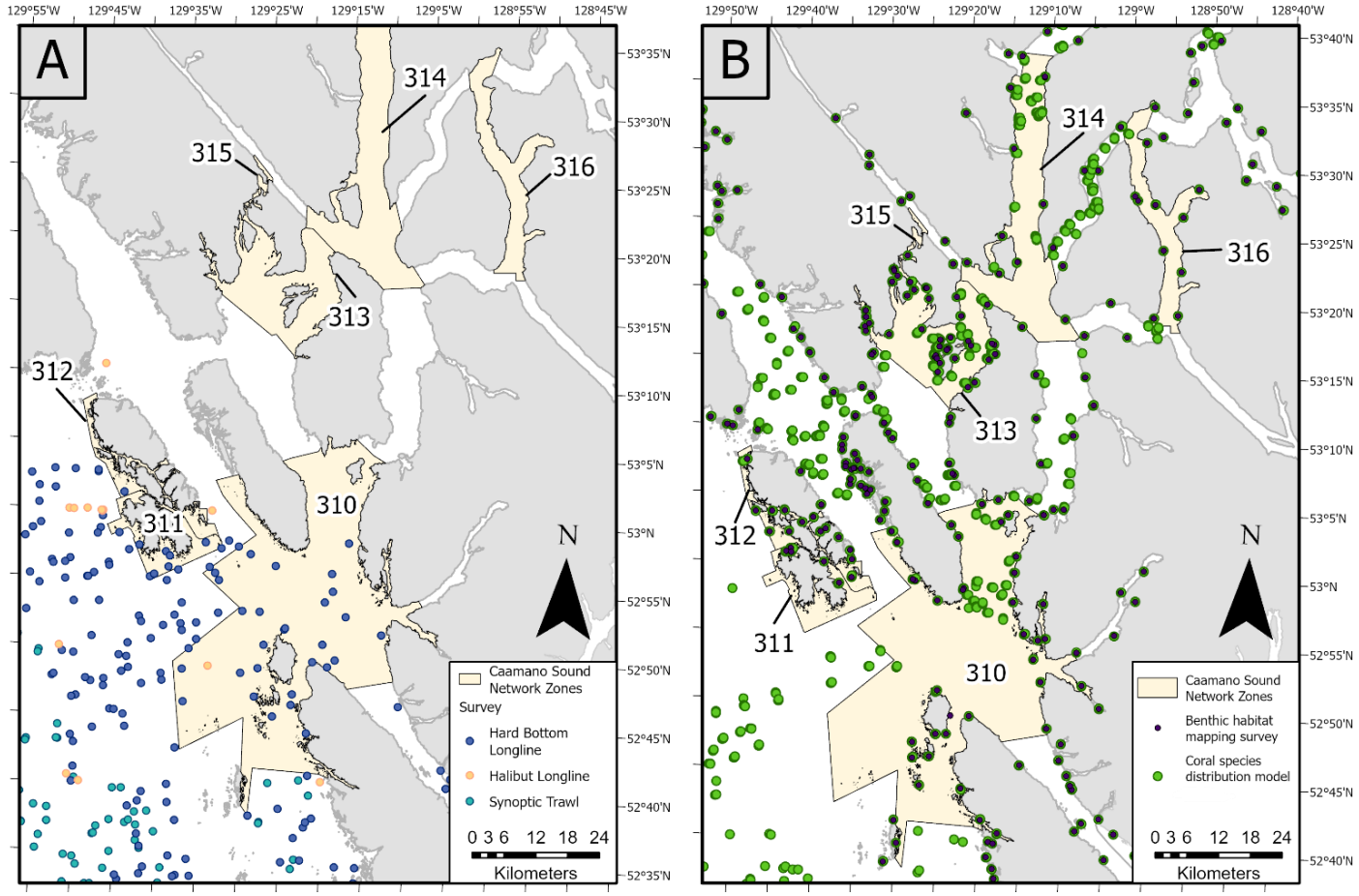
Convolutional neural network algorithms were used to predict whether a vessel was fishing and, together with vessel registries, what gear type it was using for 16 gear classes. Global Fishing Watch uses the below vessel class hierarchy to reflect increasing levels of confidence. More specific gear classes were applied when there was high confidence from the model predictions and vessel registries, otherwise umbrella classes were used.

Gear classes (not all are relevant to map and table):

1. Squid jigger: Squid jiggers and other vessels fishing with lights while stationary, notably lift-net vessels fishing for Pacific Saury.
2. Drifting longlines: Vessel that fishes by deploying longlines that drift, attached to buoys. These lines have shorter hooked, typically baited, lines hanging from them.
3. Pole and line: Vessel from which people fish with pole and line.
4. Trollers: Vessel that tows multiple fishing lines.
5. Fixed gear: Umbrella category including pots and traps, set longlines, and set gillnets.
6. Pots and traps: Vessel that deploys pots (small, portable traps) or traps to catch fish.
7. Set longlines: Vessel that fishes by setting longlines anchored to the seafloor. These lines have shorter hooked, typically baited, lines hanging from them.
8. Set gillnets: Vessel that fishes by setting gillnets anchored to the seafloor.
9. Trawlers: Vessel that fishes by towing a net through the water.
10. Dredge fishing: Vessel that tows a dredge the scrapes up edible bottom dwellers such as scallops or oysters.
11. Seines: Umbrella category including purse seines and other seines.
12. Purse seines: Sub-category including tuna purse seines and other purse seines.
13. Tuna purse seines: Large purse seines primarily fishing for tuna.
14. Other purse seines: Purse seiners fishing for mackerel, anchovies, etc., often smaller and operating nearer the coast than tuna purse seines.
15. Other seines: Danish seines and other seiners not using purse seines.

Other fishing: Fishing vessel that does not fall into one of the categories specified above.

10.4 Appendix D. Caamaño-Douglas Network Zones Survey Extent



Appendix Figure 1. *Sampling extent of surveys for the Caamaño-Douglas. Panel A shows the sampling points for the Hard Bottom Longline, Halibut Longline, and Synoptic Trawl Surveys. Panel B shows the sampling points for the Benthic habitat mapping survey and multiple DFO surveys used to create the coral species distribution model (See MSEA code / corals-sponges-dataset · GitLab). Fisheries-independent scientific surveys conducted within Canadian Pacific Waters: the Fisheries and Oceans Canada (DFO) Groundfish Synoptic Bottom Trawl Surveys (Sinclair et al. 2003; Anderson et al. 2019), the DFO Groundfish Hard bottom Longline Surveys (Lochead and Yamanaka 2006, Lochead and Yamanaka 2007, Doherty et al. 2019), and the International Pacific Halibut Commission Fisheries Independent Setline Survey (Stewart and Hicks 2022).*

10.5 Appendix E. Macroalgae Occurrence Table

Appendix Table 2. *Macroalgal taxa observed in the Caamaño Sound and Douglas Fjord System Network Zones and documented in this report. If the species has been observed in a zone it is denoted by an 'X'. Occurrence data comes from Benthic Habitat Monitoring (BHM) dive surveys collected in the North Coast area in 2015 (Davies et al. 2018).*

BHM Species Code	Species Name	Category	Algae group	Zone 310	Zone 311	Zone 312	Zone 313	Zone 314	Zone 316
A_AA	Alaria nana	Species	Brown (kelp)	X	X	X	X		X
A_AB	Agarum clathratum	Species	Brown (kelp)	X	X	X	X	X	
A_AC	Articulated Corraline Algae	Group	Red	X	X	X	X	X	X
A_AF	Agarum fimbriatum	Species	Brown (kelp)	X	X	X	X	X	X
A_AM	Alaria marginata	Species	Brown (kelp)	X	X	X	X	X	X
A_AP	Acrosiphonia	Species	Green	X			X		
A_BB	Brown Branched	Group	Brown	X		X	X	X	
A_BF	Brown Foliose	Group	Brown	X	X	X	X		X
A_BH	Brown Filamentous (includes Diatom Mats)	Group	Brown	X	X	X	X	X	X
A_CF	Codium fragile	Species	Green	X			X		
A_CL	Cladophora	Species	Green	X		X	X	X	X
A_CN	Constantinea sp	Species	Red	X			X	X	X
A_CO	Costaria costata	Species	Brown (kelp)	X	X	X	X	X	X
A_CP	Colpomenia	Species	Brown	X	X	X	X	X	
A_CR	Cryptopleura sp; Polyneura sp	Group	Red	X	X	X	X		X
A_CS	Codium setchellii	Species	Green	X	X	X	X	X	
A_CY	Cymathere triplicata	Species	Brown	X	X	X	X		X
A_DA	Desmarestia aculeata	Species	Brown	X					X
A_DB	Dictyota binghamiae	Species	Brown	X	X				
A_DF	Desmarestia foliacea	Species	Brown	X	X		X		X
A_DL	Desmarestia ligulata	Species	Brown	X	X	X	X		
A_DM	Desmarestia munda	Species	Brown	X	X	X	X		X
A_DN	Dictyoneurum californicum	Species	Brown			X	X		
A_DV	Desmarestia viridis	Species	Brown	X	X	X	X	X	
A_EG	Egregia menziesii	Species	Brown (kelp)	X					
A_FA	Gloiocladia	Species	Red	X	X	X	X	X	X
A_FU	Fucus distichus	Species	Brown	X	X	X	X	X	X
A_GB	Green Branched	Group	Green	X					

BHM Species Code	Species Name	Category	Algae group	Zone 310	Zone 311	Zone 312	Zone 313	Zone 314	Zone 316
A_GF	Green Foliose	Group	Green				X		
A_GH	Green Filamentous	Group	Green	X			X	X	
A_GI	Chondracanthus	Species	Red	X	X	X	X		X
A_GR	Gracilaria pacifica; Sarcodiotheca spp	Group	Red	X	X	X	X		
A_HA	Haloscaccion glandiforme	Species	Red	X		X	X		X
A_HE	Saccharina sessilis	Species	Brown (kelp)	X		X	X		
A_IR	Mazzaella sp	Species	Red	X	X	X	X		
A_LE	Leathesia difformis	Species	Brown				X		
A_LG	Saccharina groenlandica	Species	Brown (kelp)	X	X	X	X		
A_LO	Lessoniopsis littoralis	Species	Brown			X			
A_LS	Saccharina latissima	Species	Brown (kelp)	X	X	X	X	X	X
A_LT	Laminaria setchelii	Species	Brown (kelp)	X	X	X	X		
A_LY	Laminaria yezoensis	Species	Brown (kelp)	X			X	X	
A_PL	Pleurophycus garderni	Species	Brown	X	X	X			
A_PO	Porphyra sp	Species	Red	X	X	X	X	X	
A_PT	Pterygophora californica	Species	Brown (kelp)	X					
A_PV	Pelvetiopsis limitata	Species	Brown	X		X	X		
A_RB	Red Branched	Group	Red	X	X	X	X	X	X
A_RF	Red Foliose	Group	Red	X	X	X	X	X	X
A_RH	Red Filamentous	Group	Red	X		X	X	X	X
A_SL	Scytosiphon lomentaria	Species	Brown	X				X	
A_UL	Ulva sp; Monostroma sp; Ulvaria sp; Enteromorpha sp	Group	Green	X	X	X	X	X	X
Total	50			46	30	36	42	23	23

10.6 Appendix F: Marine Bird Occurrence Table

Appendix Table 3. *Marine bird species observed in the Caamaño Sound and Douglas Fjord System Network Zones and documented in this report. Species that have been identified as an Ecological Conservation Priority by Gale et al. 2019 within the Northern Shelf Bioregion are indicated with a "Yes". If the species has been observed in a zone it is denoted by an 'X'.*

Common Name	Scientific Name	Ecological-Conservation Priority	Zone 310	Zone 311	Zone 312	Zone 313	Zone 314	Zone 315	Zone 316
Albatrosses, petrels, storm-petrels, and shearwaters									
Buller's Shearwater	*Ardenna bulleri*	*Yes*	**X**						
Fork-tailed Storm-petrel	*Hydrobates furcatus*	*Yes*	**X**			**X**	**X**		**X**
Leach's Storm-petrel	*Hydrobates leucorhous*	*Yes*	**X**						
Northern Fulmar	*Fulmarus glacialis*	*Yes*	**X**						
Pink-footed Shearwater	*Ardenna creatopus*	*Yes*	**X**						
Short-tailed Shearwater	*Ardenna tenuirostris*	*Yes*	**X**						
Sooty Shearwater	*Ardenna grisea*	*Yes*	**X**			**X**			
Alcids									
Ancient Murrelet	*Synthliboramphus antiquus*	*Yes*	**X**	**X**		**X**	**X**		
Cassin's Auklet	*Ptychoramphus aleuticus*	*Yes*	**X**			**X**			**X**
Common Murre	*Uria aalge*	*Yes*	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Marbled Murrelet	*Brachyramphus marmoratus*	*Yes*	**X**	**X**	**X**	**X**	**X**		**X**
Pigeon Guillemot	*Cepphus columba*	*Yes*	**X**	**X**		**X**	**X**		**X**
Rhinoceros Auklet	*Cerorhinca monocerata*	*Yes*	**X**	**X**	**X**	**X**	**X**		**X**
Tufted Puffin	*Fratercula cirrhata*	*Yes*	**X**						
Cormorants									
Brandt's Cormorant	*Urile penicillatus*	*Yes*	**X**			**X**			
Double-crested Cormorant	*Nannopterum auritum*	*Yes*	**X**			**X**	**X**	**X**	**X**
Pelagic Cormorant	*Urile pelagicus*	*Yes*	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Waterfowl									
American Wigeon	*Mareca americana*		**X**	**X**			**X**		
Barrow's Goldeneye	*Bucephala islandica*	*Yes*	**X**			**X**	**X**	**X**	
Black Scoter	*Melanitta americana*	*Yes*	**X**			**X**			**X**
Blue-winged Teal	*Spatula discors*		**X**						

Common Name	Scientific Name	Ecological-Conservation Priority	Zone 310	Zone 311	Zone 312	Zone 313	Zone 314	Zone 315	Zone 316
Brant	*Branta bernicla*		X						
Bufflehead	*Bucephala albeola*		X			X	X	X	X
Cackling Goose	*Branta hutchinsii*	*Yes*	X						
hą'ą̲x/ **henǧax**/ **hą'ą̲x**/ Canada Goose	*Branta canadensis*	*Yes*	X	X		X	X	X	X
Common Goldeneye	*Bucephala clangula*	*Yes*					X		
Common Merganser	*Mergus merganser*		X			X	X	X	X
Eurasian teal	*Anas crecca*		X						
Greater White-fronted Goose	*Anser albifrons*		X						
Harlequin Duck	*Histrionicus histrionicus*	*Yes*	X	X		X	X	X	X
Long-tailed Duck	*Clangula hyemalis*	*Yes*	X						X
Mallard	*Anas platyrhynchos*		X	X		X	X	X	X
Northern Pintail	*Anas acuta*		X	X					
Northern Shoveler	*Spatula clypeata*		X						
Red-breasted Merganser	*Mergus serrator*		X			X	X	X	X
ɬii'wn/**x̌íx̌ix̌i**/ Snow Goose	*Anser caerulescens*		X						
Surf Scoter	*Melanitta perspicillata*	*Yes*	X	X	X	X	X	X	X
Trumpeter Swan	*Cygnus buccinator*	*Yes*	X				X		X
White-winged Scoter	*Melanitta deglandi*	*Yes*	X	X	X	X	X		X
Ga̲guum/ċigilaxs/gaguum/Gulls, kittiwakes, skuas, terns, and jaegers									
Arctic Tern	*Sterna paradisaea*		X						
Black-legged Kittiwake	*Rissa tridactyla*		X			X	X		X
Bonaparte's Gull	*Chroicocephalus philadelphia*		X			X	X		X
California Gull	*Larus californicus*	*Yes*	X	X	X	X	X		X
Caspian Tern	*Hydroprogne caspia*		X						

Common Name	Scientific Name	Ecological-Conservation Priority	Zone 310	Zone 311	Zone 312	Zone 313	Zone 314	Zone 315	Zone 316
Glaucous Gull	*Larus hyperboreus*		X				X		
Glaucous-winged Gull	*Larus glaucescens*		X	X		X	X	X	X
Herring Gull	*Larus argentatus*		X	X		X	X		X
Iceland/Thayer's Gull	*Larus glaucoides*	*Yes*	X			X			X
Parasitic Jaeger	*Stercorarius parasiticus*		X				X		X
Pomarine Jaeger	*Stercorarius pomarinus*		X						X
Ring-billed Gull	*Larus delawarensis*						X		
Short-billed/Mew Gull	*Larus brachyrhynchus*		X		X	X	X		X
Western Gull	*Larus occidentalis*		X			X	X		X
Loons and grebes									
Common Loon	*Gavia immer*	*Yes*	X			X	X		X
Horned Grebe	*Podiceps auritus*	*Yes*	X			X			
Pacific Loon	*Gavia pacifica*	*Yes*	X	X	X	X	X		X
Red-necked Grebe	*Podiceps grisegena*		X			X	X		X
Red-throated Loon	*Gavia stellata*		X	X		X	X		X
Western Grebe	*Aechmophorus occidentalis*	*Yes*	X			X	X	X	X
Yellow-billed Loon	*Gavia adamsii*	*Yes*	X						
Birds of prey									
Bald Eagle	*Haliaeetus leucocephalus*		X	X	X	X	X	X	X
Peregrine Falcon	*Falco peregrinus*		X			X	X		X
Shorebirds and waders									
Black Oystercatcher	*Haematopus bachmani*	*Yes*	X	X		X	X		X
Black Turnstone	*Arenaria melanocephala*	*Yes*	X			X	X		X
Greater Yellowlegs	*Tringa melanoleuca*		X						
Great Blue Heron	*Ardea herodias*	*Yes*		X					X
Least Sandpiper	*Calidris minutilla*		X						

Common Name	Scientific Name	Ecological-Conservation Priority	Zone 310	Zone 311	Zone 312	Zone 313	Zone 314	Zone 315	Zone 316
Lesser Yellowlegs	*Tringa flavipes*		**X**						
Long-billed Dowitcher	*Limnodromus scolopaceus*		**X**						
Marbled Godwit	*Limosa fedoa*		**X**						
Red Phalarope	*Phalaropus fulicarius*	*Yes*				**X**	**X**		
Red-necked Phalarope	*Phalaropus lobatus*	*Yes*	**X**	**X**		**X**	**X**		**X**
Sanderling	*Calidris alba*	*Yes*	**X**						
Semiplamated Plover	*Charadrius semipalmatus*		**X**						
Spotted Sandpiper	*Actitis macularius*		**X**				**X**		**X**
Surfbird	*Calidris virgata*	*Yes*	**X**			**X**	**X**		
Wandering Tattler	*Tringa incana*	*Yes*	**X**			**X**			
Western Sandpiper	*Calidris mauri*	*Yes*	**X**						
Wilson's Phalarope	*Phalaropus tricolor*								**X**
Ruddy Turnstone	*Arenaria interpres*	*Yes*	**X**						

10.7 Appendix G: E-CP data sources

***Appendix Table 4**. Ecological Conservation Priority (E-CP) data sources for **Table 437** in the report.*

Spatial Feature Name	Brief Description	Date Range	Institutional Source	Citation
Species Features				
Marbled Murrelet density	Effort-corrected density of Marbled Murrelet displayed using 6 quantiles	1982-2017	Canadian Wildlife Service (CWS)	
Rhinoceros Auklet colonies	Colony locations for Rhinoceros Auklets, classified by relative importance	historical - 2011	Canadian Wildlife Service (CWS)	
China Rockfish CPUE (CCIRA Surveys)	CPUE of China Rockfish from research surveys (CCIRA), displayed as deciles of catch per unit effort	2006-2017	Central Coast Indigenous Resource Alliance (CCIRA)	Frid et al. 2018
Quillback Rockfish CPUE (CCIRA Surveys)	CPUE of Quillback Rockfish from research surveys (CCIRA), displayed as deciles of catch per unit effort	2006-2017	Central Coast Indigenous Resource Alliance (CCIRA)	Frid et al. 2018
Sa'mx/ḱux^{w}/Butter Clam locations	Presence-only records of Butter Clam, collated from a variety of research and commercial sources.	1990-2016	DFO	
Geoduck locations	Presence-only records of Geoduck, collated from a variety of research and commercial sources.	1992-2016	DFO	
Horse Clam locations	Presence-only records of Horse Clam, collated from a variety of research and commercial sources.	1990-2016	DFO	
Ochre Sea Star locations	Presence-only records of Ochre Sea Star, collated from a variety of research and commercial sources.	2006-2016	DFO	
Purple-hinged Rock Scallop locations	Presence-only records of Purple-hinged Rock Scallop, collated from a variety of research and commercial sources.	1990-2016	DFO	
Ts'akwe'ats/Red Sea Urchin locations	Presence-only records of Red Sea Urchin, collated from a variety of research and commercial sources.	1967-2016	DFO	
Harbour Seal Haul-outs	Locations of haul-outs used by Harbour Seals	up to 2016	DFO	
ɬbuun/ḡ^{w}eẏém/ ɬpuun/Humpback Whale Critical Habitat (2009-2013)	Critical habitat for humpback whales (2009-2013). Critical habitat in the NSB includes: 1) the waters surrounding Langara Island; 2)	2009	DFO	Nichol et al. 2010

	coastal waters along the south eastern side of Moresby Island and Kunghit Island; 3) the mainand channels around Gil Island and Gribbel Island. An additional area outside the NSB (waters off southwest Vancouver Island including Barkley Sound, La Perouse Bank, Swiftsure Banks and Barkley Canyon) is not included in this version of the layer.			
‘naaxł/hélx̌’inix̌ʷ/ niixł/Killer Whale (Northern Resident) Potential Critical Habitat (2006)	Potential critical habitat for northern resident killer whales (Chatham Sound, Caamaño Sound, Fitz Hugh Sound)	up to 2006	DFO	Ford 2006
Steller Sea Lion Haul-outs (Winter)	Locations of haul-outs used by Steller Sea Lions in winter months	2013	DFO	Olesiuk 2018
mo'ox/wáudi/ moox/Bull Kelp Beds	Polygons delineating Bull Kelp (Nereocystis integrifolia) beds compiled by the BCMCA.	1976-2004	British Columbia Marine Conservation Analysis (BCMCA)	
mo'ox/wáudi/ moox/Bull Kelp Biobands	Coastline segment surveyed for patchy or continuous presence of bull kelp by the Province of BC.	1995-2002	ShoreZone, Province of BC, BCMCA	
General Kelp Beds	Polygons delineating kelp beds where species was not identified, compiled by the BCMCA.	1976-2004	British Columbia Marine Conservation Analysis (BCMCA)	
gyoós/q̓áq̓elĺis /Giant Kelp Biobands	Coastline segment surveyed for patchy or continuous presence of giant kelp by the Province of BC.	1979-2012	ShoreZone, Province of BC, BCMCA	
Surfgrass Biobands	Coastline segment surveyed for patchy or continuous presence of surfgrass by the Province of BC.	1979-2012	ShoreZone, Province of BC, BCMCA	
Habitat Features				
Coastal classes (12 classes)	Coastline classification based on alongshore morphology and substrate	1995-2002	ShoreZone, Province of BC, BCMCA	
Ecosections (8 classes)	Marine ecosections based on physical, oceanographic, and biological characteristics from the BC Marine Ecological Classification (BCMEC)		Province of BC	

Pacific Marine Ecological Classification System (PMECS) Geomorphic Units (14 classes)	Areas of unique geomorphological structures assumed to have distinctive biological assemblages	2016	DFO	Rubidge et al. 2016
Upper ocean subregions (15 classes)	Upper ocean subregions derived from expert knowledge, literature, satellite imagery, and oceanographic models	2013	Parks Canada, BCMCA	
EBSAs (13 classes)	EBSAs are geographical areas that warrant enhanced management. Areas being identified as EBSAs are those that rank highly in one or more of five criteria (Uniqueness, Aggregation, Fitness Consequences, Naturalness and Resilience).	2004-2017	DFO	Clarke and Jamieson 2006

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